
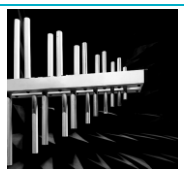
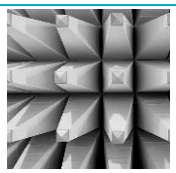

cetecom advanced

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-00

Test report no.: 1-5343_22-01-04-A

Testing laboratory

cetecom advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: https://www.cetecomadvanced.com
e-mail: mail@cetecomadvanced.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 with the registration number: D-PL-12047-01-00.
ISED Testing Laboratory Recognized Listing Number: DE0001
FCC designation number: DE0002

Applicant

VALEO North America
150 Stephenson Highway
Troy, MI 48083 / USA
Contact: Dr.-Ing. Dirk SCHULTE
e-mail: dirk.schulte@valeo.com
Phone: +1 248 619-8566

Manufacturer

Valeo Klimasysteme GmbH
Werner-von-Siemens-Strasse 6
96476 Bad Rodach / 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

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

Test Item

Kind of test item:	**Interior radar**
Model name:	**CPD001**
FCC ID:	**2BAHD-EC30693**
Frequency:	57GHz to 71 GHz
Technology tested:	FMCW radar
Antenna:	Integrated antenna
Power supply:	9 V to 18 V DC by external power supply
Temperature range:	-40°C to +90°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=cetecom advanced GmbH, ou=VOG-230609, email=thomas.vogler@cetecomadvanced.com, c=DE
2023.10.10 15:17:28 +02'00'

Thomas Vogler
Lab Manager
Radio Labs

Test performed:

F. Heussner

cn=Frank Heussner, o=cetecom advanced GmbH, ou=HNR-230605, email=Frank.Heussner@cetecomadvanced.com, c=DE
2023.10.10 12:52:50 +02'00'

Frank Heussner
Lab Manager
Radio Labs

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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. cetecom 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.

This test report replaces the test report with the number 1-5343_22-01-04 and dated 2023-10-09.

2.2 Application details

Date of receipt of order:	2022-12-13
Date of receipt of test item:	2023-02-07
Start of test:*	2023-02-08
End of test:*	2023-09-25
Person(s) present during the test:	Christian EIBL (2023-02-07 & 08)

*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

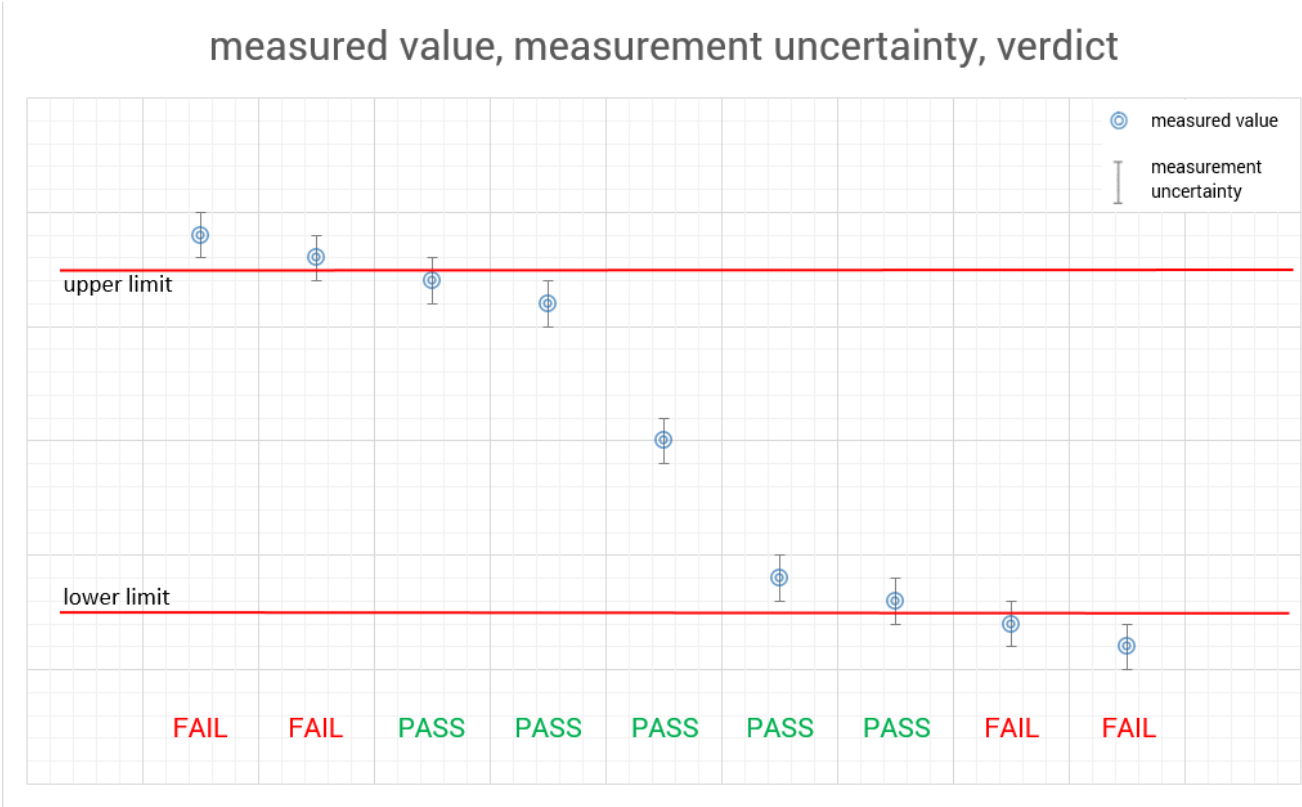
3 Test standard/s, references and accreditations

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

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

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 +50 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		49 %
Barometric pressure	:		990 hPa to 1010 hPa
Power supply	:	V_{nom} V_{max} V_{min}	14.0 V DC by external power supply 16.1 V DC by external power supply 11.9 V DC by external power supply

6 Test item

6.1 General description

Kind of test item	:	Interior radar
Model name	:	CPD001
S/N serial number	:	EUT1: 4HK-SHZ16.01.23SH010055 (Label: E453 6dBm conducted) EUT2: 4HK-SHZ17.02.23SH010017 (Label: LLST V010 FCC/EN/JAPAN) EUT3: 4HK-SHZ17.02.23SH010013 (Label: LLST V010 FCC/EN/JAPAN)
Hardware status	:	EUT1: 006 EUT2 & EUT 3: 006
Software status	:	EUT1: E453 (X450) EUT2 & EUT 3: V010 (LLST)
Firmware status	:	EUT1: E453 (X450) EUT2 & EUT 3: V010 (LLST)
Frequency band	:	57GHz to 71 GHz
Type of modulation	:	FMCW
Number of channels	:	1
Antenna	:	Integrated antenna
Power supply	:	9 V to 18 V DC by external power supply
Temperature range	:	-40°C to +90°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:	1-5343/22-01-01_AnnexA1 1-5343/22-01-01_AnnexB1 1-5343/22-01-01_AnnexD2
Measurement results are included in the test report:	1-5343_22-01-02MR_FCC-ISED1

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).

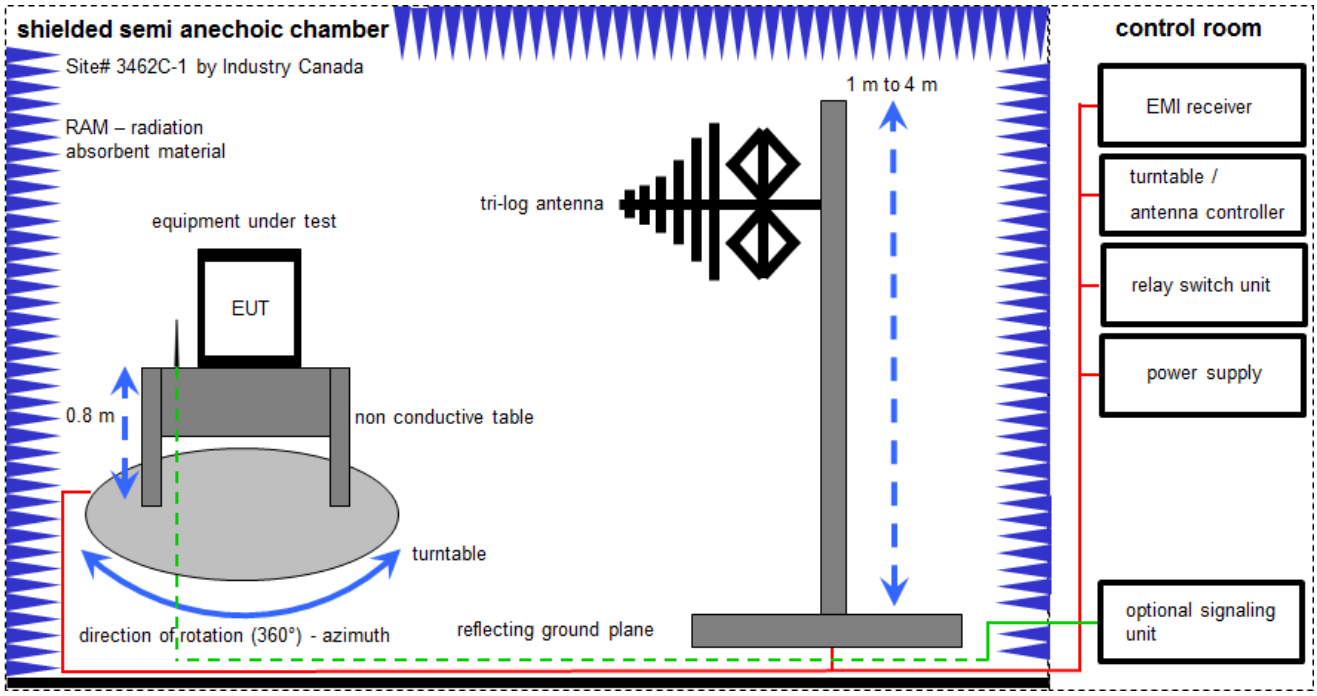
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

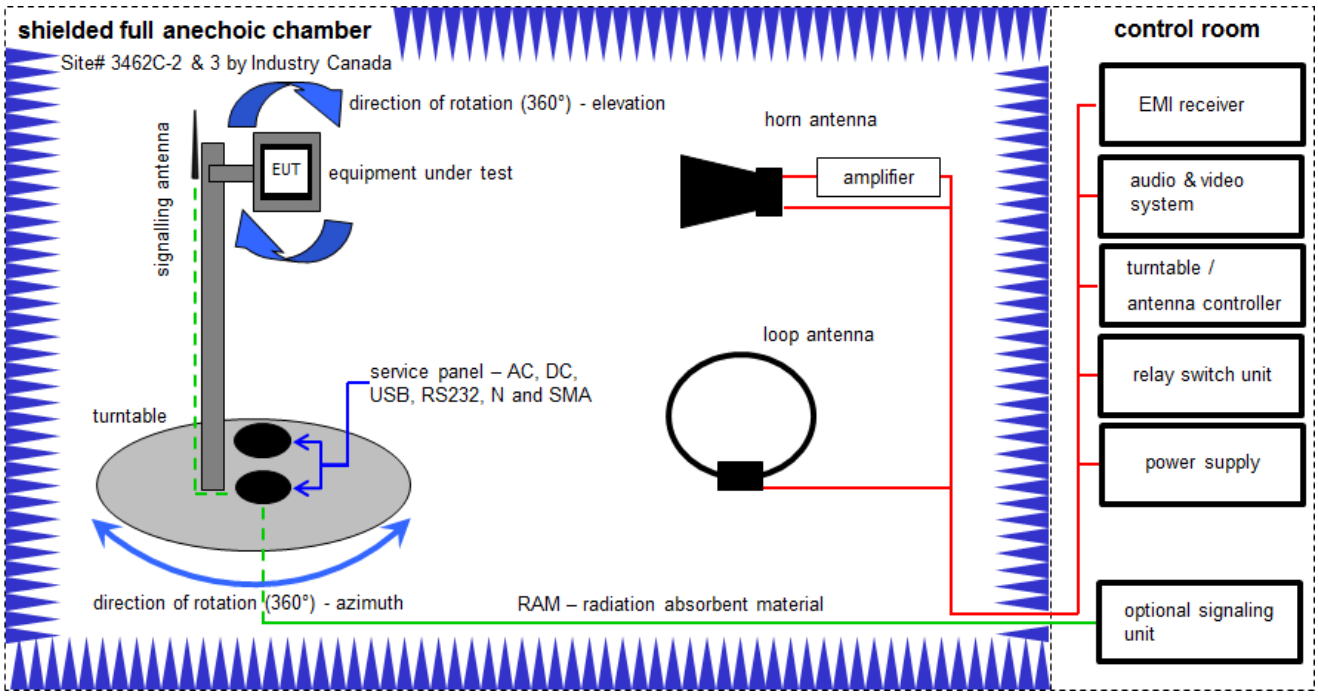
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	09.12.2022	31.12.2023
8	n. a.	PC	TecLine	F+W	-/-	300003303	ne	-/-	-/-
9	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vIKI!	12.04.2021 23.05.2023	30.04.2023 31.05.2025

7.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter ; loop antenna 3 meter

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

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

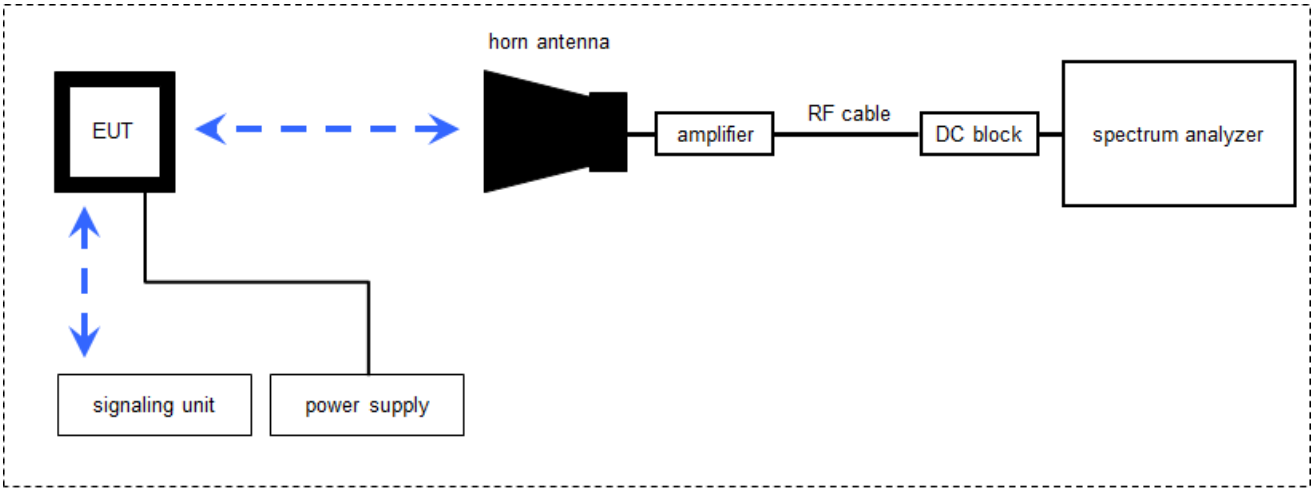
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

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

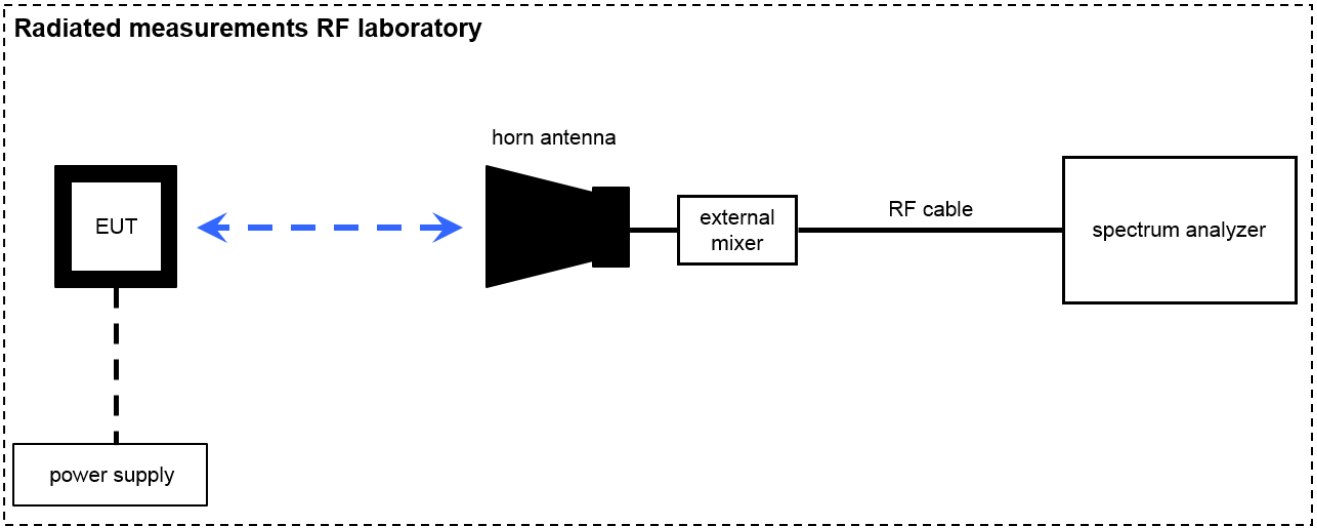
Equipment table (Chamber C):

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A,B,C	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	vIKI!	09.12.2020	08.12.2023
2	A,B,C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A,B,C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
4	A,B,C	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
5	A,B,C	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	07.12.2022	31.12.2023
6	A,B,C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
7	A,B,C	NEXIO EMV-Software	BAT EMC V2022.0.22.0	EMCO		300004682	ne	-/-	-/-
8	A,B,C	PC	ExOne	F+W		300004703	ne	-/-	-/-
9	B,C	MXG Microwave Analog Signal Generator	N5183A	Agilent Technologies	MY47420220	300003813	vIKI!	07.12.2022	31.12.2025
10	B	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
11	B	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
12	B	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
13	B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3089	300000307	vIKI!	11.02.2022	29.02.2024
14	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	8905-2342	300000256	vIKI!	17.06.2021 19.07.2023	30.06.2023 31.07.2025

7.3 Radiated measurements > 18 GHz



7.4 Radiated measurements > 50/85 GHz



Measurement distance: horn antenna e.g. 75 cm

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

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

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

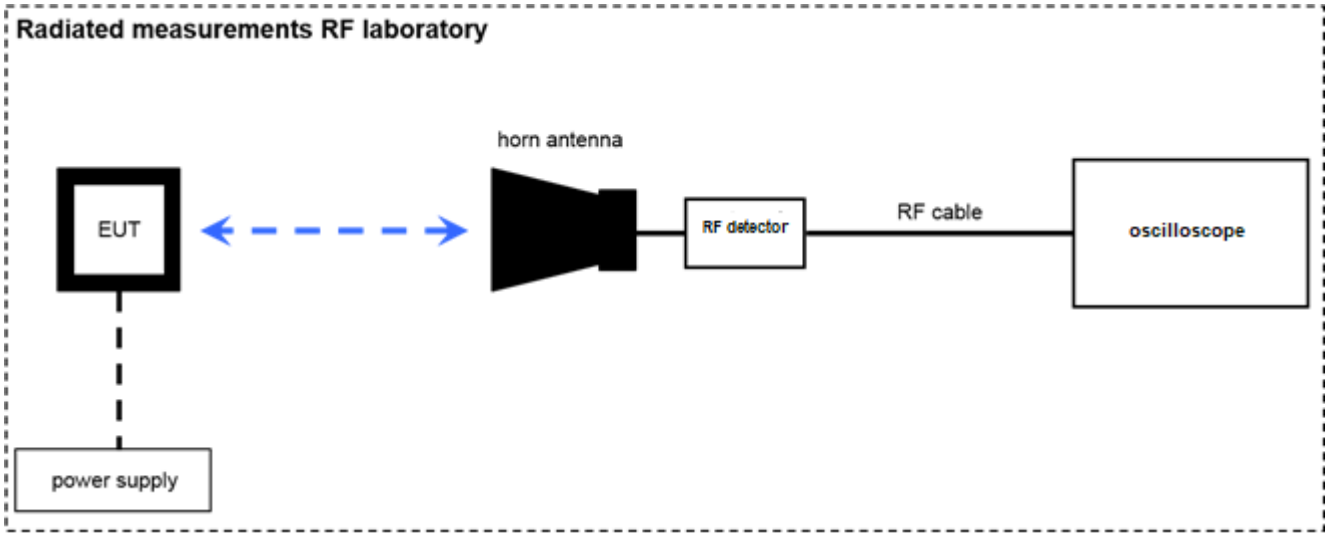
Example calculation:
OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Spectrum Analyzer	FSW50	Rohde & Schwarz	101332	300005935	k	03.01.2023	31.01.2024
2	n. a.	Spectrum Analyzer	FSW50	Rohde & Schwarz	101560	300006179	k	07.03.2022 04.04.2023	31.03.2023 30.04.2024
3	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	08.05.2024
4	n. a.	Power supply	N5767A	Agilent Technologies	US14J1569P	300004851	vIKI!	08.12.2020	31.12.2023
5	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2022	08.03.2024
6	n. a.	Horn Antenna 18,0-40,0 GHz	LHAF180	Microw.Devel	39180-103-021	300001747	vIKI!	17.01.2022	31.01.2024
7	n. a.	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda		300000486	vIKI!	17.01.2022	31.01.2024
8	n. a.	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	vIKI!	17.01.2022	31.01.2024
9	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
10	n. a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
11	n. a.	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	Rohde & Schwarz	101578	300005788	k	07.07.2022 19.07.2023	31.07.2024
12	n. a.	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-
13	n. a.	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	R&S	101411	300004959	k	07.07.2022 21.07.2023	31.07.2023 31.07.2024
14	n. a.	Std. Gain Horn Antenna 114-173 GHz	2924-20	Flann	*	300001999	ne	-/-	-/-
15	n. a.	Harmonic Mixer 3-Port, 110-170 GHz	FS-Z170	Radiometer Physics GmbH	100014	300004156	k	01.07.2022 21.07.2023	31.07.2023 31.07.2024
16	n. a.	Std. Gain Horn Antenna 145-220 GHz	3024-20	Flann	*	300002000	ne	-/-	-/-
17	n. a.	Harmonic Mixer 3-Port, 140-220 GHz	SAM-220	Radiometer Physics GmbH	200001	300004157	k	21.07.2022 02.08.2023	31.07.2023 31.08.2024

7.1 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.	V-Band Positive Amplitude Detector	SFD-503753-15SF-P1	Sage Millimeter Inc.	07353-1	300006118	ev	-/-	-/-
2	n. a.	Low Noise Amplifier, Waveguide, 50-75 GHz	AFB-V30LN-02	Ducommun Incorporated	1026151-01	300005899	ev	-/-	-/-
3	n. a.	Std. Gain Horn Antenna 50-75 GHz	COR 50_75	Thomson CSF	-/-	300000813	ev	-/-	-/-
4	n.a.	SG Extension Module 50 - 75 GHz	E8257DV15	VDI	US54250124	300005541	ev	-/-	-/-
5	n. a.	WG Rotary Attenuator	25110 UG-385/U-AC	Flann Microwave	266740	300005798	ev	-/-	-/-
6	n.a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
7	n. a.	Signal Generator 100 kHz - 40 GHz	SMB100A	Rohde & Schwarz	183320	300006330	k	21.06.2022	20.06.2025
8	n. a.	Thermal Power Sensor, DC-110GHz, 300nW-100mW	NRP-Z58	R&S	100913	300004808	vlKl!	04.01.2022	31.01.2024
9	n.a.	2.5 GHz Digital Phosphor Oscilloscope	DPO7254	Tektronix	B022702	300003573	vlKl!	07.12.2022	31.12.2024

8 Sequence of testing

8.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

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

Premeasurement*

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

Final measurement

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

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

8.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

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

Premeasurement

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

Final measurement

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

8.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

8.4 Sequence of testing radiated spurious above 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

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

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate for far field (e.g. 0.25 m).
- The EUT is set into operation.

Premeasurement

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

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- As external mixers may generate false images care is taken to ensure that any emission measured by the spectrum analyzer does indeed originate in the EUT. Signal identification feature of spectrum analyzer is used to eliminate false mixer images (i.e., it is not the fundamental emission or a harmonic falling precisely at the measured frequency).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

9 Measurement uncertainty

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

10 Summary of measurement results

☒	**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	see below	2023-10-10	-/-

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
§15.255 (f)* §15.215 (c)*	Occupied bandwidth	Nominal	Nominal	☒	☐	☐	☐	complies
DA 21-407 IV. 53 §15.255 (c)*	Maximum E.I.R.P.	Nominal	Nominal	☒	☐	☐	☐	complies with waiver conditions
DA 21-407 IV. 53 §15.255 (c)(3*) §15.255 (e)*	Maximum conducted output power	Nominal	Nominal	☒	☐	☐	☐	complies with waiver conditions
DA 21-407 IV. 53	Maximum transmit duty cycle	Nominal	Nominal	☒	☐	☐	☐	complies with waiver conditions
§15.255 (d)*	Spurious Emissions	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255 (f)*	Frequency stability	Extreme Nominal	Extreme Nominal	☒	☐	☐	☐	complies
§15.207	Conducted emissions < 30 MHz (AC power line)	Nominal	Nominal	☐	☐	☒	☐	-/-
§15.255 (h)*	Beamforming	Nominal	Nominal	☐	☐	☐	☒	-/-

*Version of rule part published on June 1, 2020.

Note: NA = Not applicable; NP = Not performed

11 Additional comments

Reference documents: 1) Antenna information: 2023-03-07_Design Justification Audi Interior Radar Antennas_v01.docx

2) Antenna information: CPD001_FCC_Antenna_gain_rev1.pdf

3) Waiver: ORDER DA 21-407

Special test descriptions: None

Configuration descriptions: None

Test devices (EUT):

- EUT1: The normal operation mode (intended use) is used.
- EUT2 & EUT3: The below described Stop-Modes are used.

Additional test modes:

☐ No test modes available

☐ Special test modes/special software (see description below)

☒ Stop-Modes (see description below)

Stop-Modes:

In addition to the normal operation mode, Stop-Modes are 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: 60.011 GHz
- Stop-Mode, middle frequency: 61.597 GHz
- Stop-Mode, high frequency: 63.197 GHz

Software provided by the manufacturer:

- “LPD_Testing_Tool_V06.00_x64.exe”
- “PEAK_CAN_MESSAGES_FCC.xmt” & “PEAK_CAN_MESSAGES_FCC_2.xmt” for “PCAN-View (PEAK-System_Driver-Setup)”

12 Measurement results

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

Description:

Measurement of the bandwidth of the wanted signal.

Limits:

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

§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) (June 1, 2020):
Frequency stability: 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.

Note: please also see chapter 12.5.

Measurement:

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

Measurement results:

20 dB bandwidth:

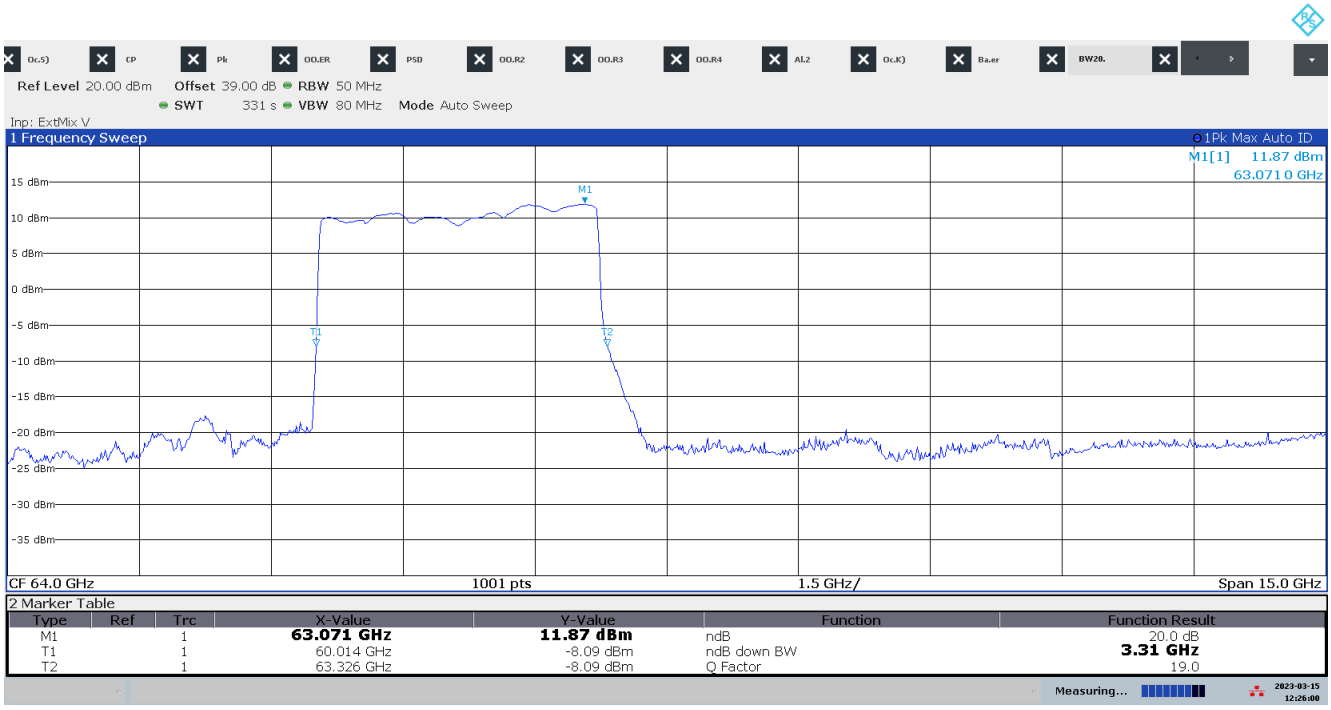
EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [GHz]
1	Normal mode	T_{nom} / V_{nom}	60.014	63.326	3.312

99% bandwidth:

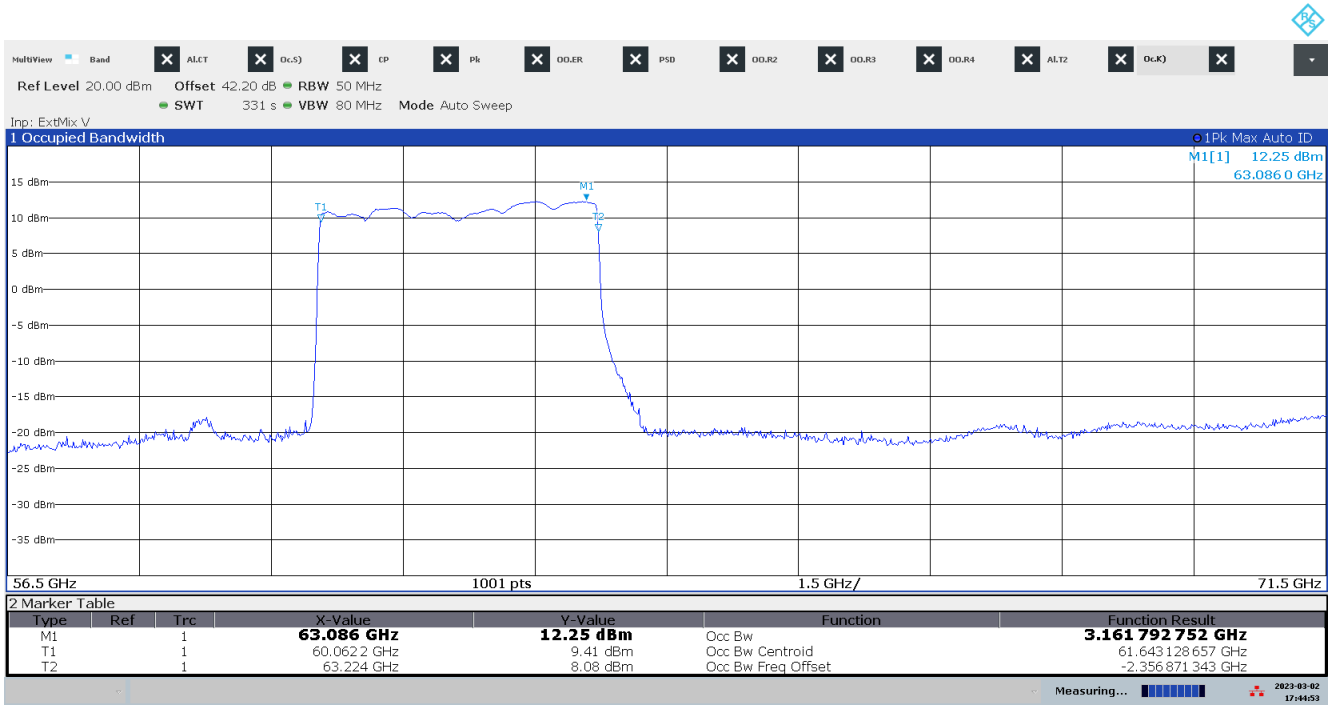
EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [GHz]
1	Normal mode	T_{nom} / V_{nom}	60.062	63.224	3.162

Verdict: Complies

Plot 1: 20 dB Bandwidth, T_{nom} / V_{nom}



Plot 2: 99% OBW, T_{nom} / V_{nom}



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 and calculation of the peak transmitter conducted output power.

Limits:

DA 21-407 IV. 53. - Waiver Conditions:
To ensure that harmful interference to authorized operations and other spectrum users will not occur, we impose explicit conditions on the installation, operation, and certification of the device(s) under this waiver, as follows:

- The radar shall be certified for compliance with all the technical specifications applicable to operation under 47 CFR Part 15, with the exception of the following provisions in 47 CFR §§ 15.255(a)(2) and (c)(3), which are waived to allow the device to operate as a radar on new passenger motor vehicles in the **57-64 GHz band** at a **maximum +13 dBm EIRP, +10 dBm transmitter conducted output power, and +13 dBm/MHz power spectral density**.

- Each individual radar device shall not exceed a maximum transmit duty cycle of 10% in any 33 milliseconds (ms) interval (i.e., the device will not transmit longer than a total of 3.3 ms in any 33 ms time period).

§15.255 (c) (June 1, 2020):
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.

§15.255 (e) (June 1, 2020):
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.

Measurement:

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

Measurement results:

EUT	Mode	Test condition	Peak E.I.R.P.	Limit* Peak E.I.R.P
1	Normal mode	T_{nom} / V_{nom}	+12.8 dBm	+13 dBm

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EUT	Mode	Test condition	Gain of EUT antenna G_{EUT}	Peak transmitter conducted output power	Limit* Peak transmitter conducted output power
1	Normal mode	T_{nom} / V_{nom}	+6.7 dBi	+6.1 dBm	+10 dBm

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EUT	Mode	Test condition	Peak power spectral density	Limit* Peak power spectral density
1	Normal mode	T_{nom} / V_{nom}	12.25 dBm/50MHz	+13 dBm/MHz

*** DA 21-407 IV. 53**

Note:

1) Peak transmitter conducted output power = Peak E.I.R.P – Gain of EUT antenna G_{EUT}
2) Gain of EUT antenna:
   - Declaration by customer: 6.7 dBi
     (see documents mentioned in chapter 11)
3) The uncertainty of the conducted output power arises taking into account the measurement uncertainty of the Peak E.I.R.P (due to the calculation).
4) Peak power spectral density, see **Plot 2**: The RBW has been increased to 50 MHz so that a stable peak power reading is obtained. (Measurements using a RBW of 50 MHz are a worst-case estimate. At most, there may be an overestimation compared to a measurement with RBW = 1 MHz.)

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: $V_{max,CW} = V_{max,EUT}$

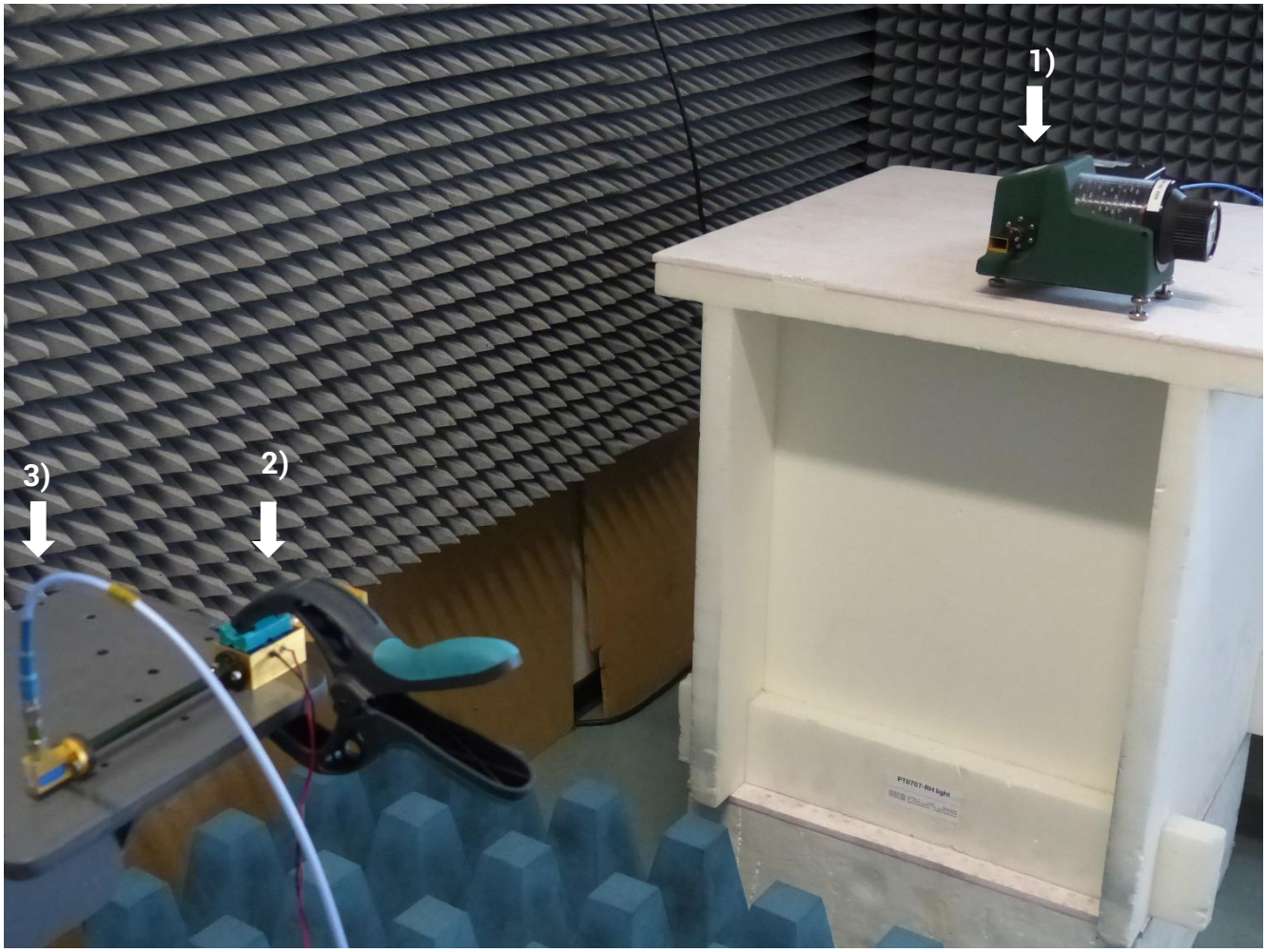
3) Measurement of the conducted output power $P_{cond,CW}$ of the cw reference source (without horn antenna) using the power meter

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
			Normal mode
1	d_{EUT}	[m]	1
	$V_{max,EUT}$	[mV]	21
2	f_{REF}	[GHz]	61.65
3	$P_{cond,CW}$	[dBm]	-7.3
4	G_{CW}	[dBi]	+20.1
	$P_{Peak\ E.I.R.P.}$	[dBm]	+12.8
5	G_{EUT}	[dBi]	+6.7
	$P_{con,EUT}$	[dBm]	+6.1

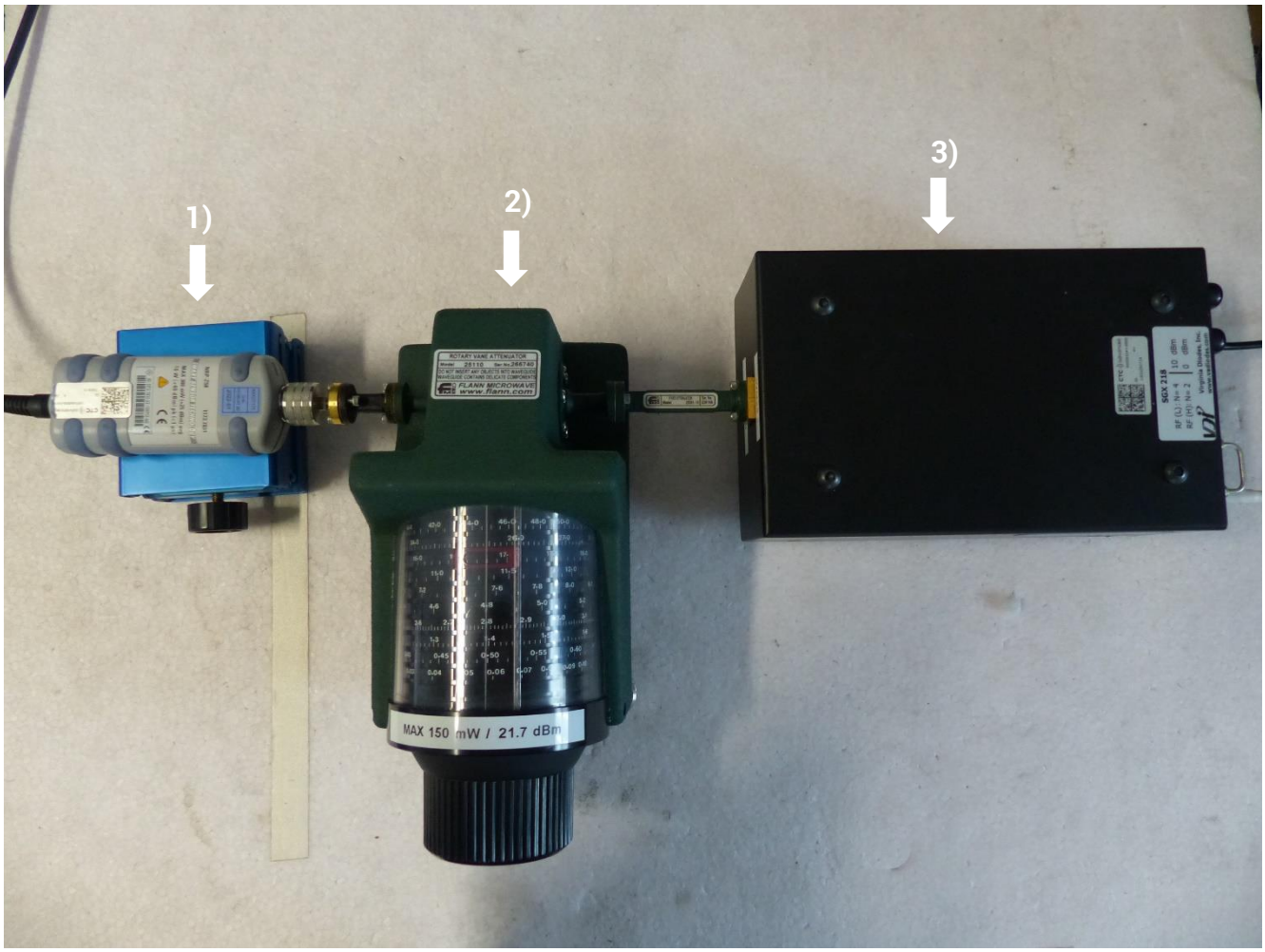
Setup of the substitution:



1) CW reference source:
SG Extension Module 50 - 75 GHz & Rotary Attenuator & Std. Gain Horn Antenna 49.9-75.8 GHz

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

3) RF-Detector (V-Band Amplitude Detector)

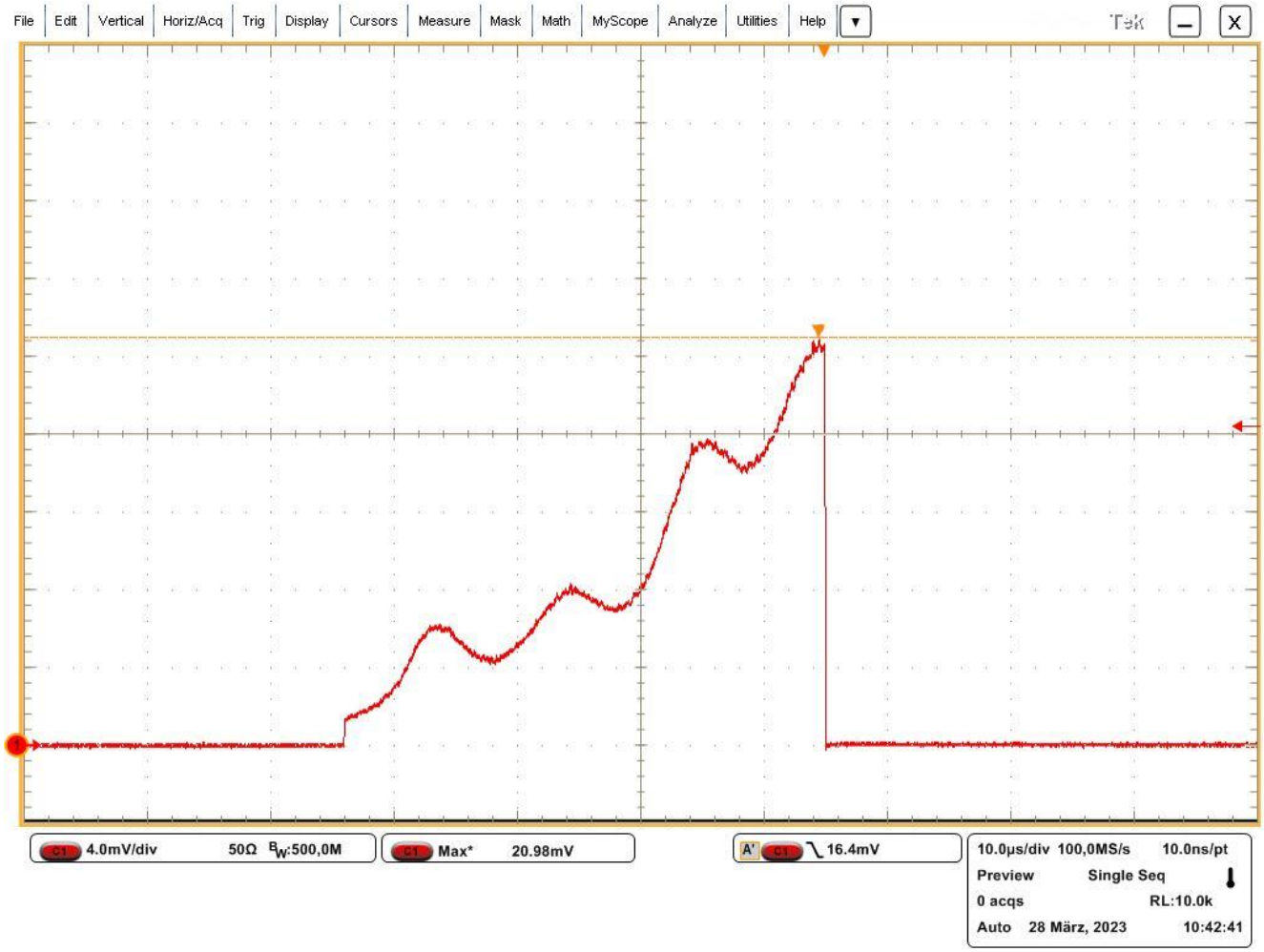


1) Power meter

2) Rotary Attenuator

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

Plot 3: Normal mode, EUT emission



12.3 Maximum transmit duty cycle

Description:

Measurement of the maximum transmit duty cycle.

Limits:

DA 21-407 IV. 53. - Waiver Conditions:
To ensure that harmful interference to authorized operations and other spectrum users will not occur, we impose explicit conditions on the installation, operation, and certification of the device(s) under this waiver, as follows:

- The radar shall be certified for compliance with all the technical specifications applicable to operation under 47 CFR Part 15, with the exception of the following provisions in 47 CFR §§ 15.255(a)(2) and (c)(3), which are waived to allow the device to operate as a radar on new passenger motor vehicles in the 57-64 GHz band at a maximum +13 dBm EIRP, +10 dBm transmitter conducted output power, and +13 dBm/MHz power spectral density.
- Each individual radar device shall not exceed a **maximum transmit duty cycle of 10% in any 33 milliseconds (ms) interval** (i.e., the device will **not transmit longer than a total of 3.3 ms in any 33 ms time period**).

Measurement:

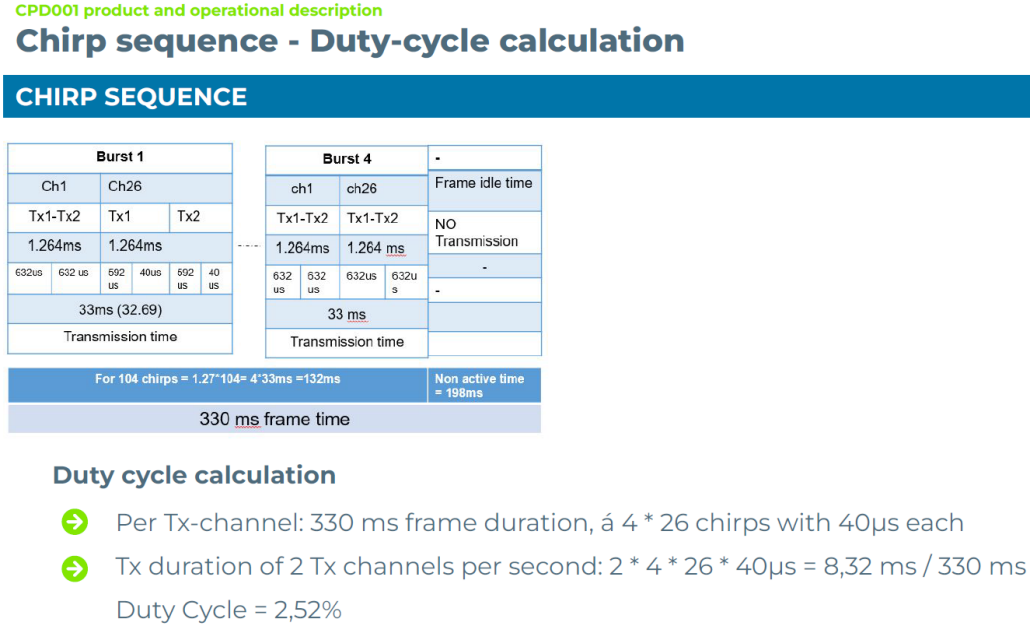
An RF diode detector connected to an oscilloscope is used to measure the envelope of the transmitted signal. The results can be used to determine the on- and off-times and to compare it to the values declared by the Customer.

Results:

Temporal characteristics declared by the customer:

Declaration from customer:

- Name of document: Operational_Description.pdf
- Title: Audi CPD, CPD001 Product and operational description, 09.02.2023
- Page 16:



Measured temporal characteristics:

- On-time of chirp: 39.1 µs
- Repetition time of chirps within burst: 632 µs
- On-time of chirp sequence (frame on time): 132 ms
- Off-time between chirp sequence (frame idle time/ frame off time): 198 ms
- Repetition time of whole chirp sequence: 330 ms
- See plots below

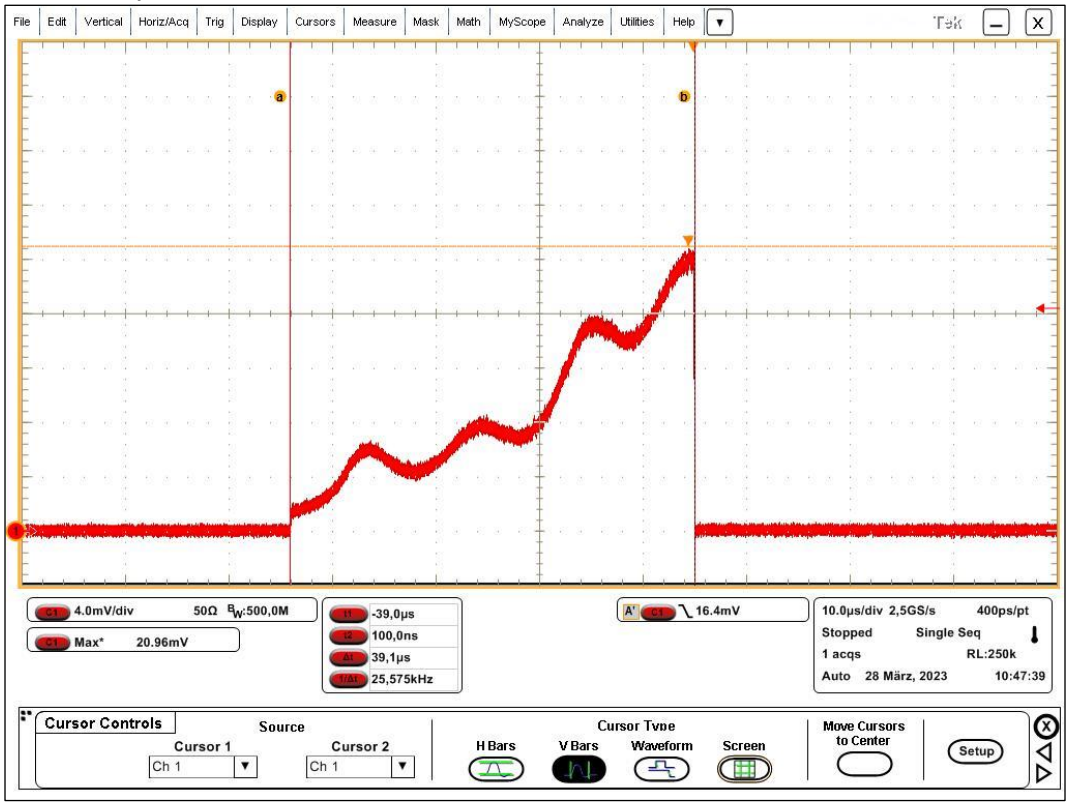
➔ Measured temporal characteristics confirms characteristic declared by customer
➔ Maximum transmission time per 33 ms:
  - 33 ms / Repetition time of chirps within burst = 33ms / 632 µs < 53
  - 53 * On-time of chirp (as declared by customer) = 53 * 40 µs = 2.12ms
➔ Maximum transmission time of **2.12 ms per 33 ms**.

EUT	Mode	Test condition	Maximum transmitter on-time in any 33 ms time period	Maximum transmit duty cycle in any 33 ms interval	
				Result	Limit*
1	Normal mode	T_{nom} / V_{nom}	2.12 ms	6.4%	10 %

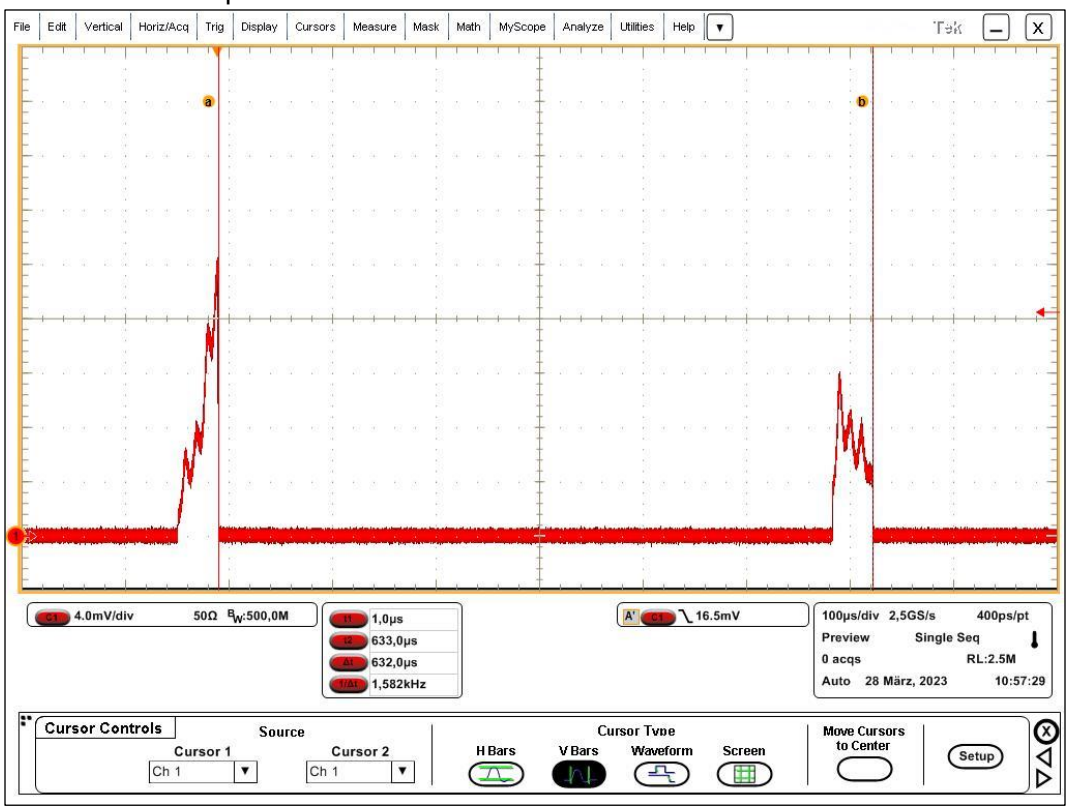
*** DA 21-407 IV. 53**

Verdict: **Complies**

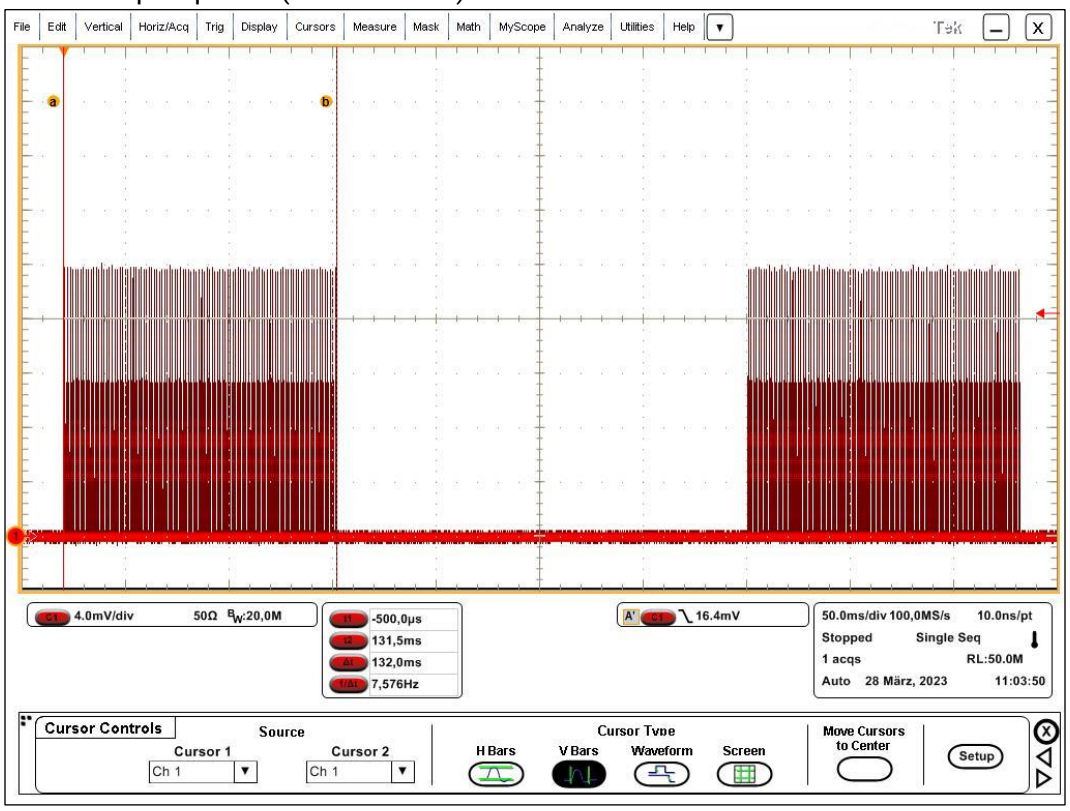
Plot 4: On-time of chirp



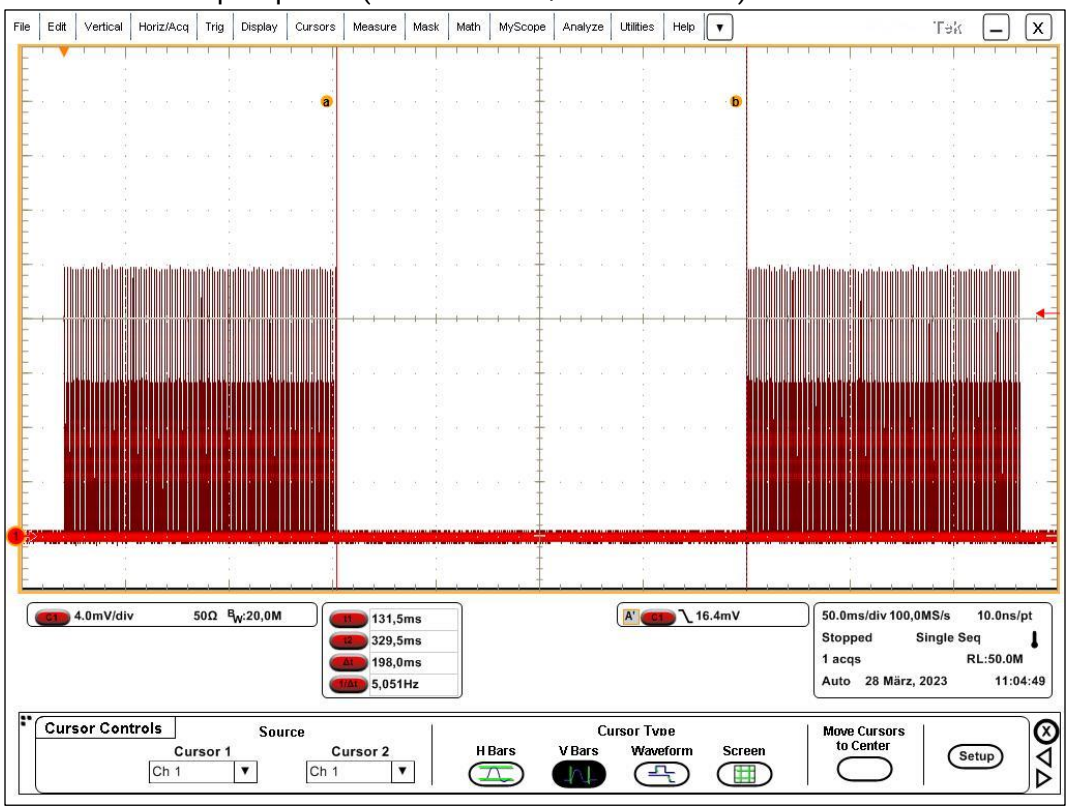
Plot 5: Repetition time of chirps within burst



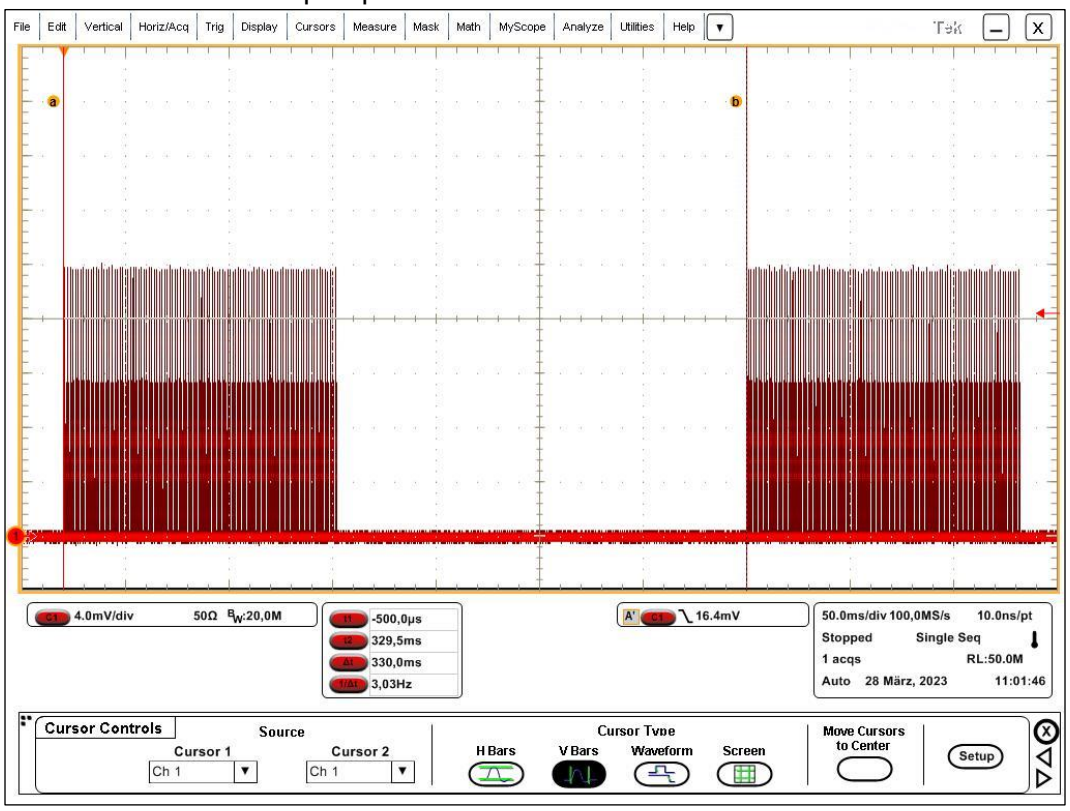
Plot 6: On-time of chirp sequence (frame on time)



Plot 7: Off-time between chirp sequence (frame idle time/ frame off time):



Plot 8: Repetition time of whole chirp sequence



12.4 Spurious emissions radiated

Description:

Measurement of the radiated spurious emissions.

Limits:

FCC §15.255 (c) (June 1, 2020):
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.

FCC		
CFR Part 15.209(a)		
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:

Note:
In stop mode (frequency sweep stopped at three positions within the range of operation: near top, near middle, near bottom) in accordance with §15.31(c), (m).

Stop mode, low frequency:

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
2.4	Peak	1	49.3 dBµV/m	74 dBµV/m	24.7
2.4	Average	1	34.1 dBµV/m	54 dBµV/m	19.9
14.399	Peak	1	54.8 dBµV/m	74 dBµV/m	19.2
14.399	Average	1	47.3 dBµV/m	54 dBµV/m	6.7
28.799	Average	1	49.6 dBµV/m	54 dBµV/m	4.4
Please refer to the following plots for more information on the level of spurious emissions					

Stop mode, middle frequency:

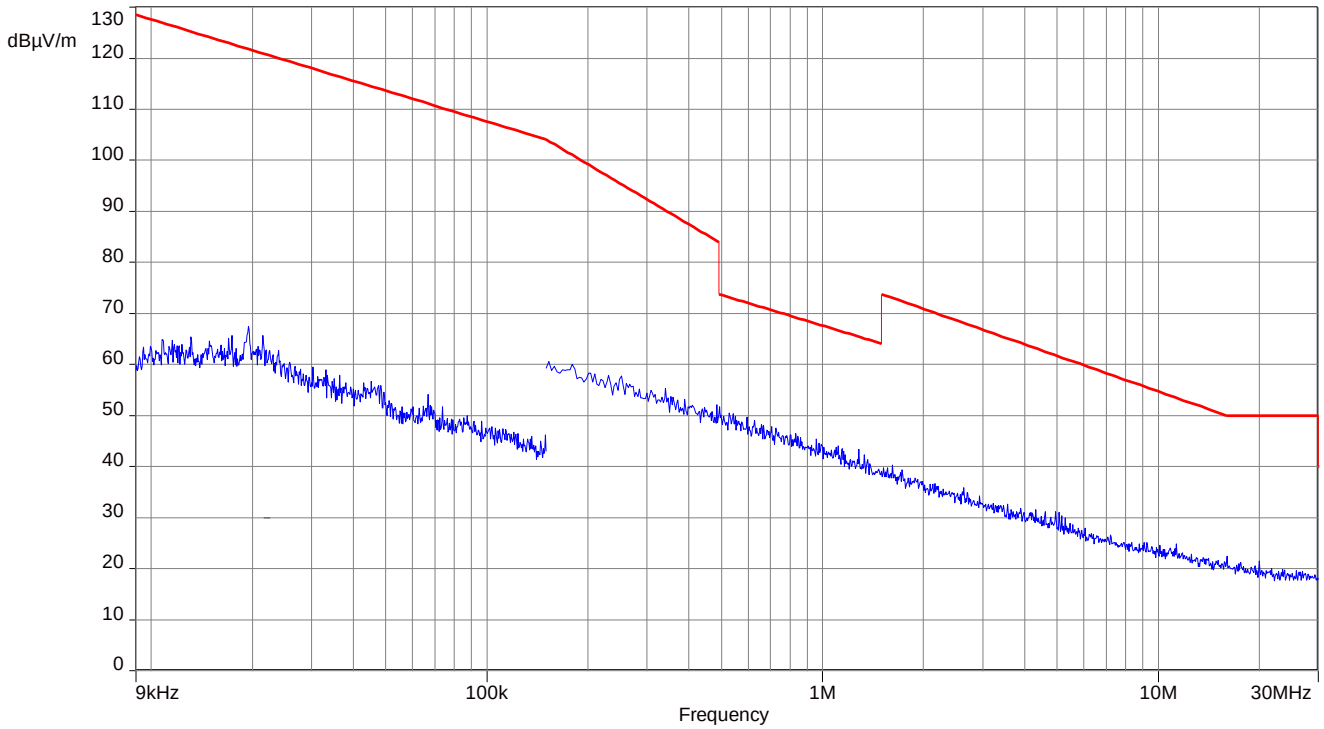
Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
2.4	Peak	1	47.5 dBµV/m	74 dBµV/m	26.5
2.4	Average	1	35.0 dBµV/m	54 dBµV/m	19.0
14.399	Peak	1	55.0 dBµV/m	74 dBµV/m	19.0
14.399	Average	1	48.1 dBµV/m	54 dBµV/m	5.9
28.799	Average	1	51.1 dBµV/m	54 dBµV/m	2.9
Please refer to the following plots for more information on the level of spurious emissions					

Stop mode, high frequency:

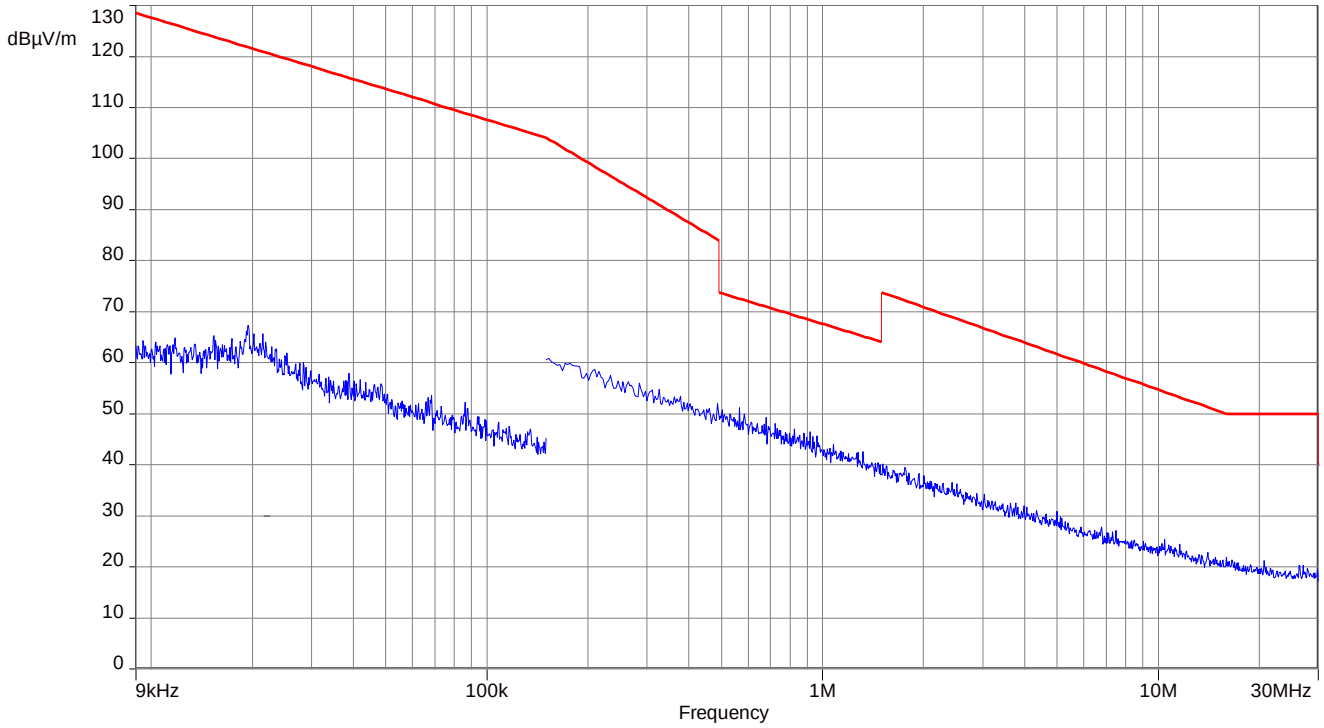
Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
14.399	Peak	1	54.9 dBµV/m	74 dBµV/m	19.1
14.399	Average	1	48.2 dBµV/m	54 dBµV/m	5.8
28.799	Average	1	51.0 dBµV/m	54 dBµV/m	3.0
Please refer to the following plots for more information on the level of spurious emissions					

Verdict: Complies

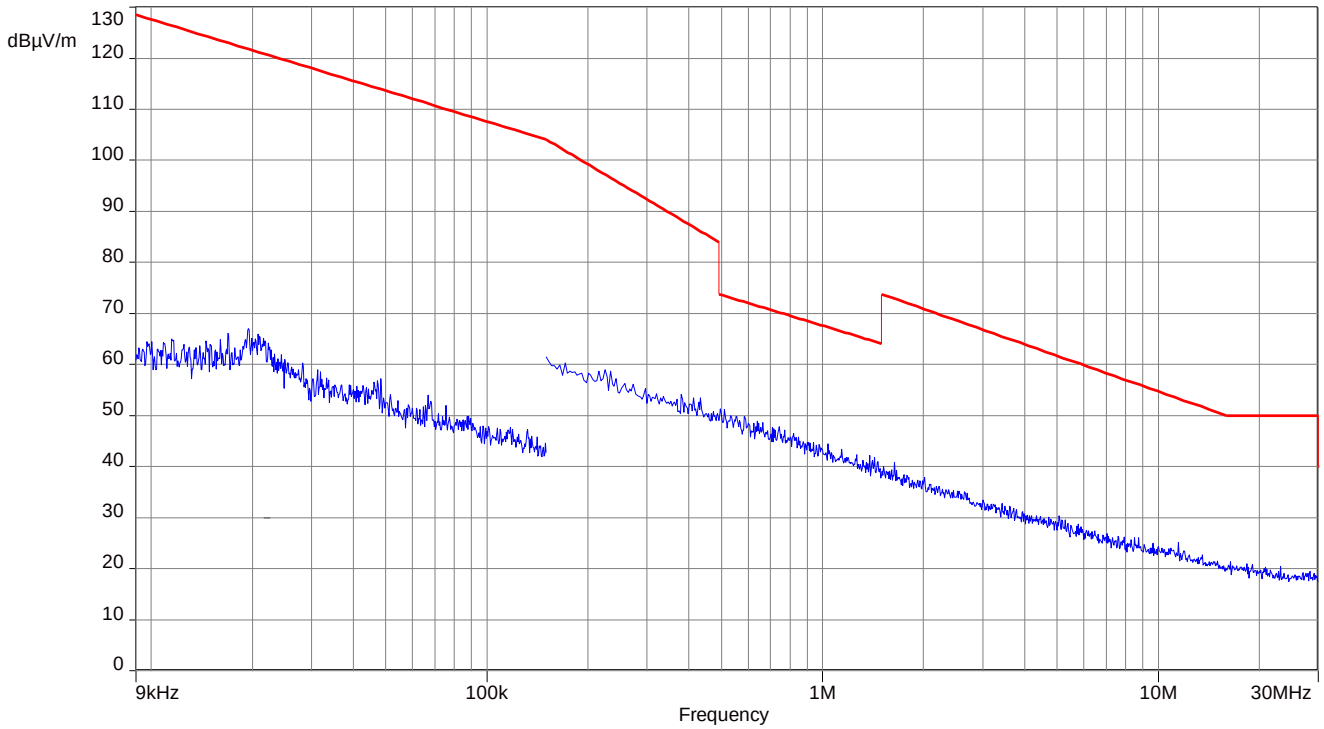
Plot 9: 9 kHz – 30 MHz, stop mode, low frequency



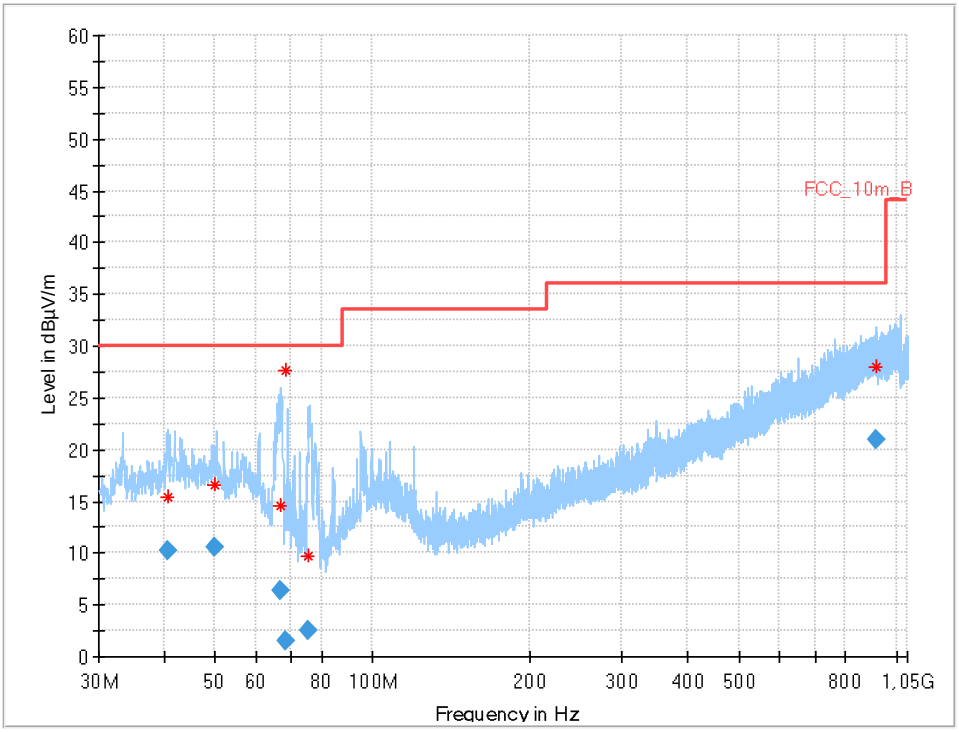
Plot 10: 9 kHz – 30 MHz, stop mode, middle frequency



Plot 11: 9 kHz – 30 MHz, stop mode, high frequency

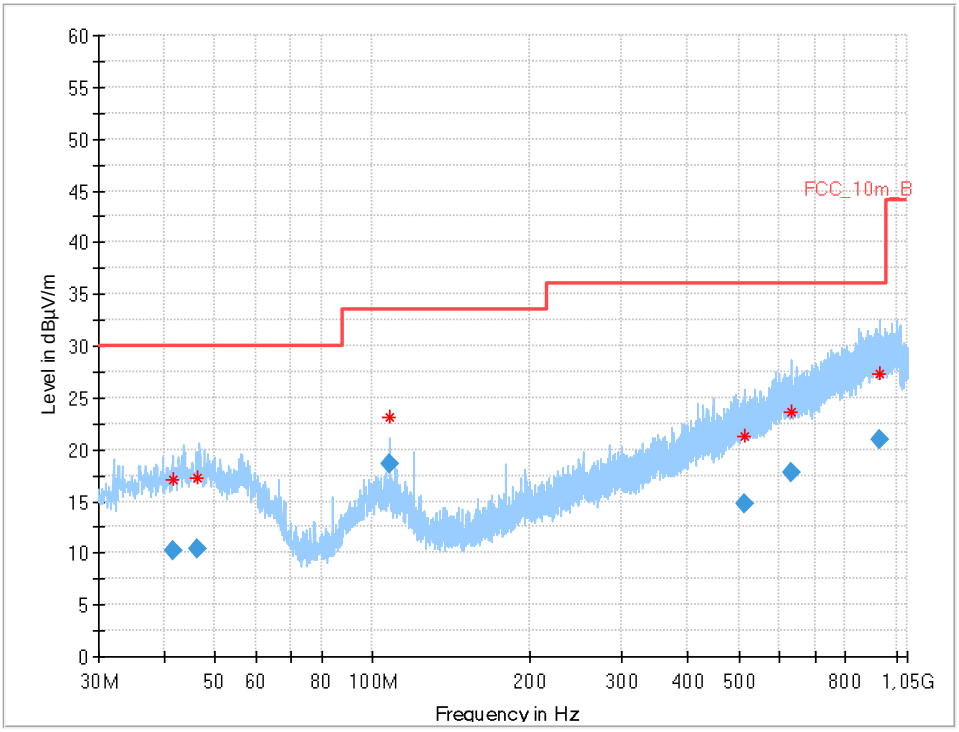


Plot 12: 30 MHz – 1GHz, stop mode, low frequency



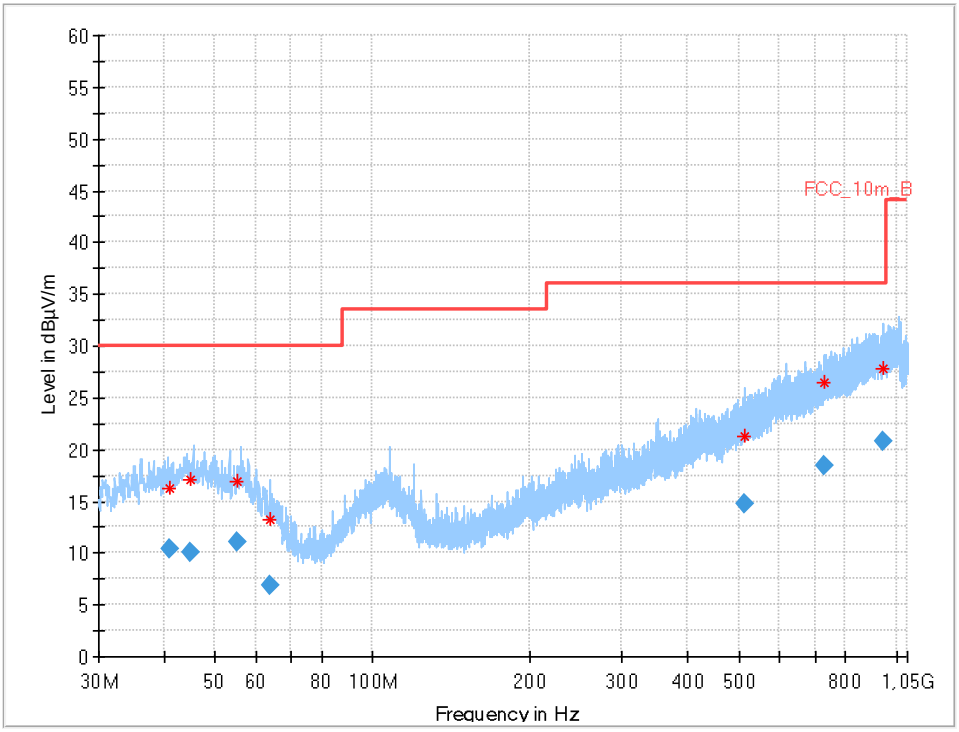
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
40.743	10.17	30.0	19.8	1000	120.0	188.0	V	45	15
49.896	10.49	30.0	19.5	1000	120.0	131.0	V	53	16
66.776	6.40	30.0	23.6	1000	120.0	295.0	V	57	11
68.480	1.46	30.0	28.5	1000	120.0	396.0	V	77	10
75.366	2.59	30.0	27.4	1000	120.0	165.0	V	45	8
915.960	20.89	36.0	15.1	1000	120.0	400.0	H	289	26

Plot 13: 30 MHz – 1GHz, stop mode, middle frequency



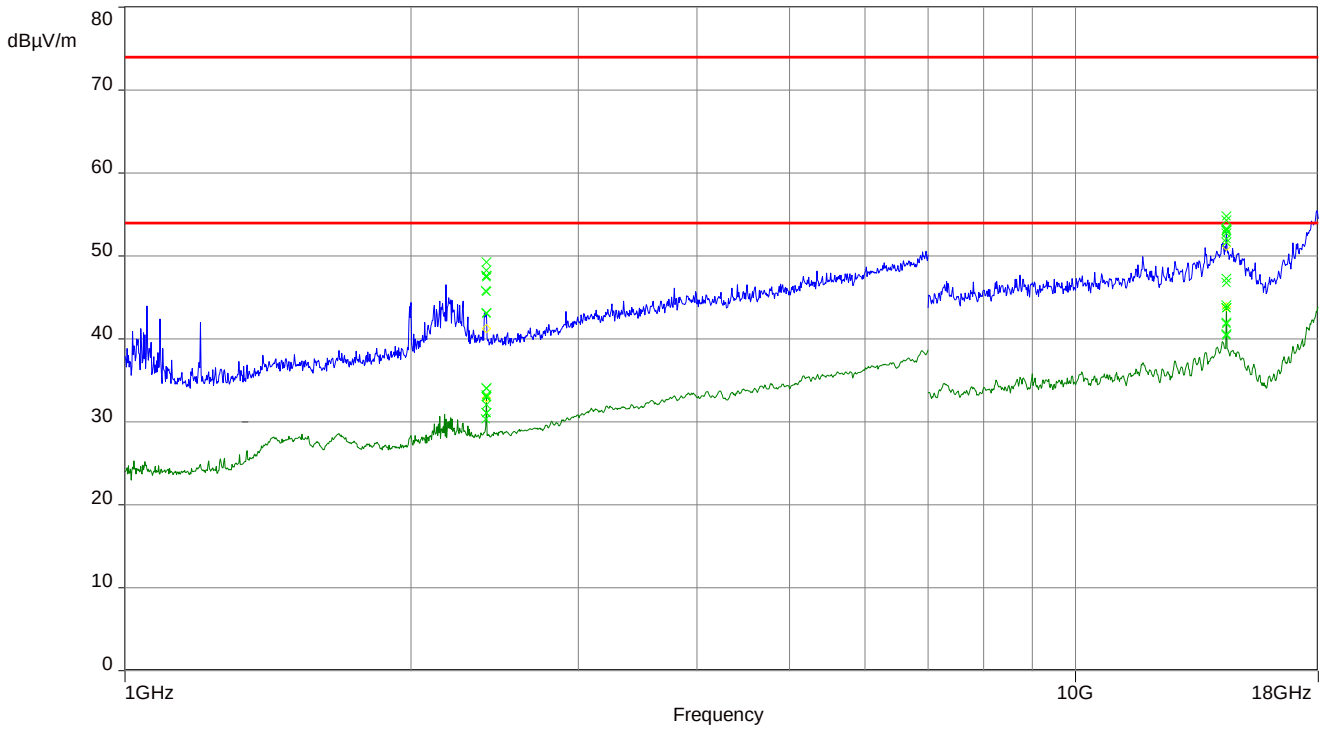
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
41.763	10.27	30.0	19.7	1000	120.0	255.0	H	135	16
46.216	10.43	30.0	19.6	1000	120.0	163.0	H	90	16
107.998	18.65	33.5	14.9	1000	120.0	147.0	V	78	14
512.229	14.67	36.0	21.3	1000	120.0	187.0	H	56	20
630.395	17.84	36.0	18.2	1000	120.0	200.0	H	225	22
928.285	20.91	36.0	15.1	1000	120.0	395.0	V	45	26

Plot 14: 30 MHz – 1GHz, stop mode, high frequency

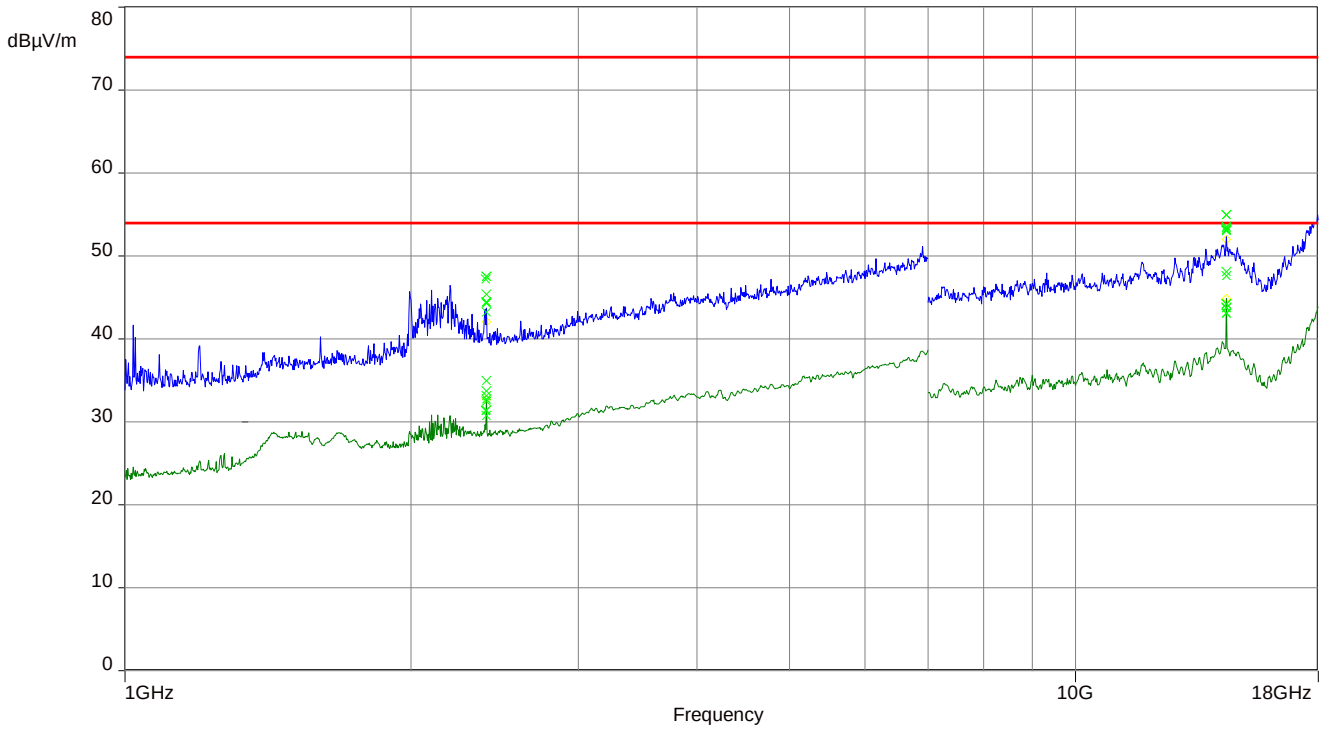


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
41.067	10.47	30.0	19.5	1000	120.0	200.0	V	63	15
44.874	10.02	30.0	20.0	1000	120.0	355.0	H	300	16
55.325	11.03	30.0	19.0	1000	120.0	116.0	V	351	16
63.590	6.82	30.0	23.2	1000	120.0	280.0	V	158	13
511.803	14.69	36.0	21.3	1000	120.0	400.0	H	180	20
731.079	18.42	36.0	17.6	1000	120.0	400.0	H	142	23
945.095	20.82	36.0	15.2	1000	120.0	400.0	H	90	25

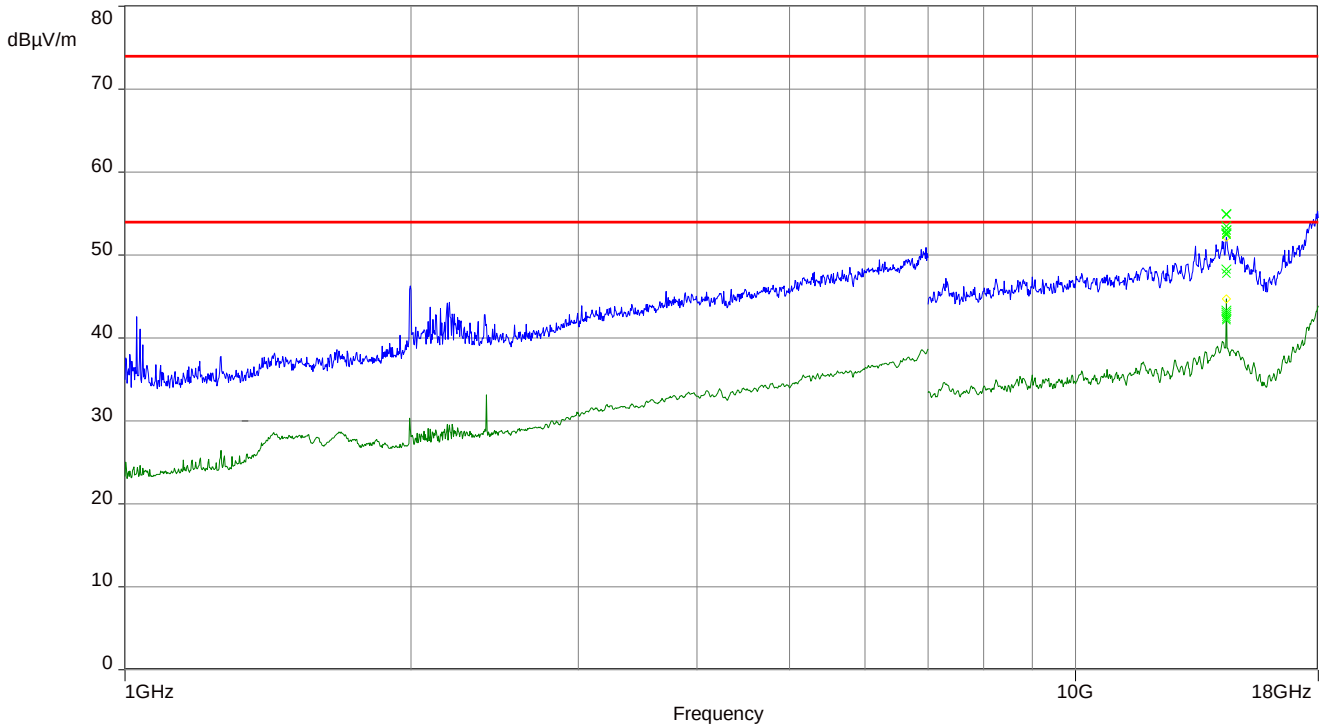
Plot 15: 1GHz – 18 GHz, stop mode, low frequency



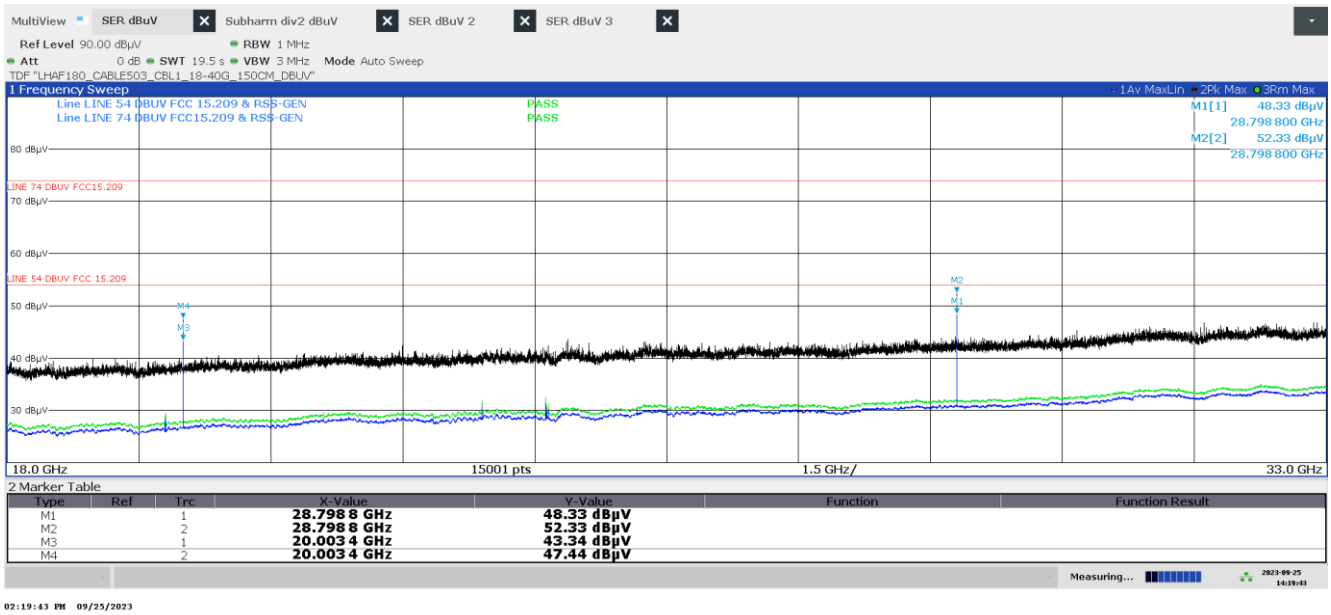
Plot 16: 1GHz – 18 GHz, stop mode, middle frequency



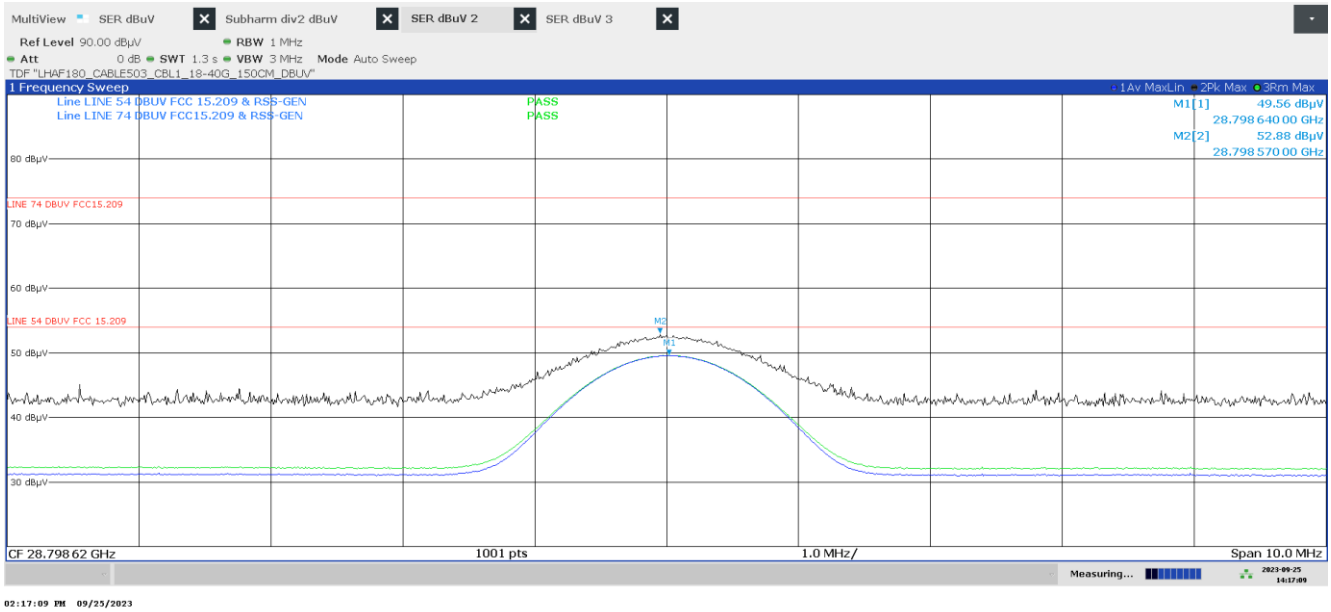
Plot 17: 1GHz – 18 GHz, stop mode, high frequency



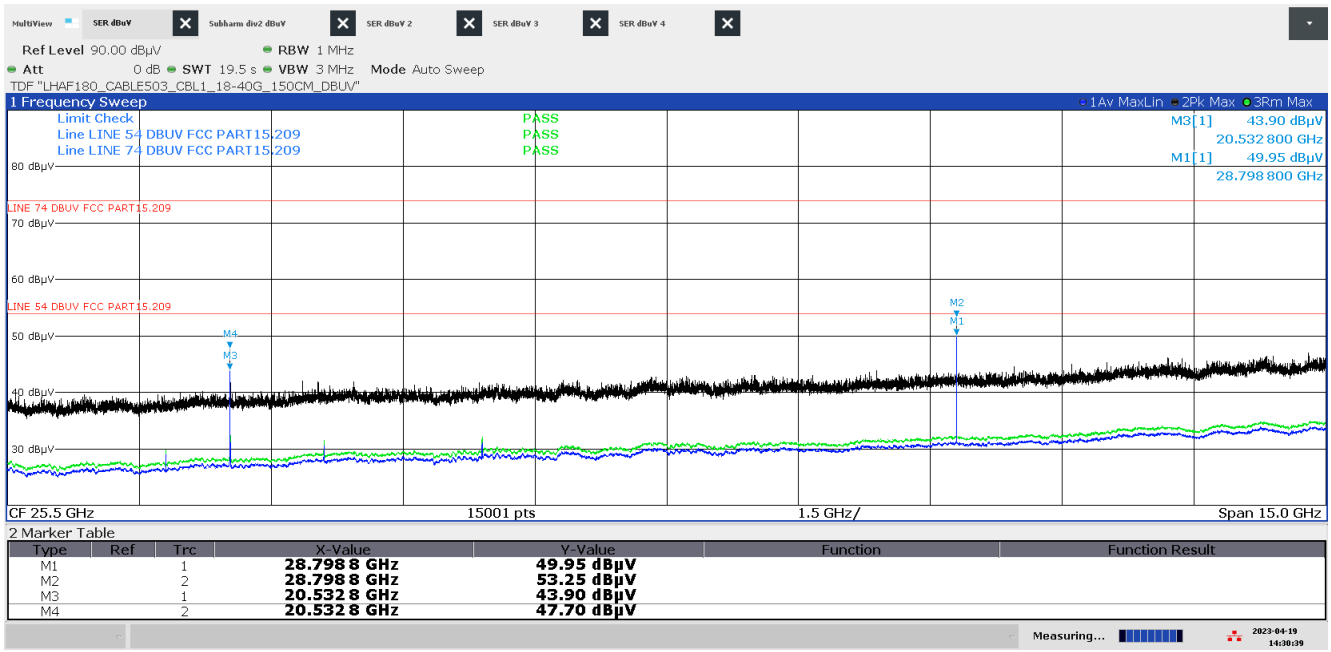
Plot 18: 18 GHz – 33 GHz, stop mode, low frequency



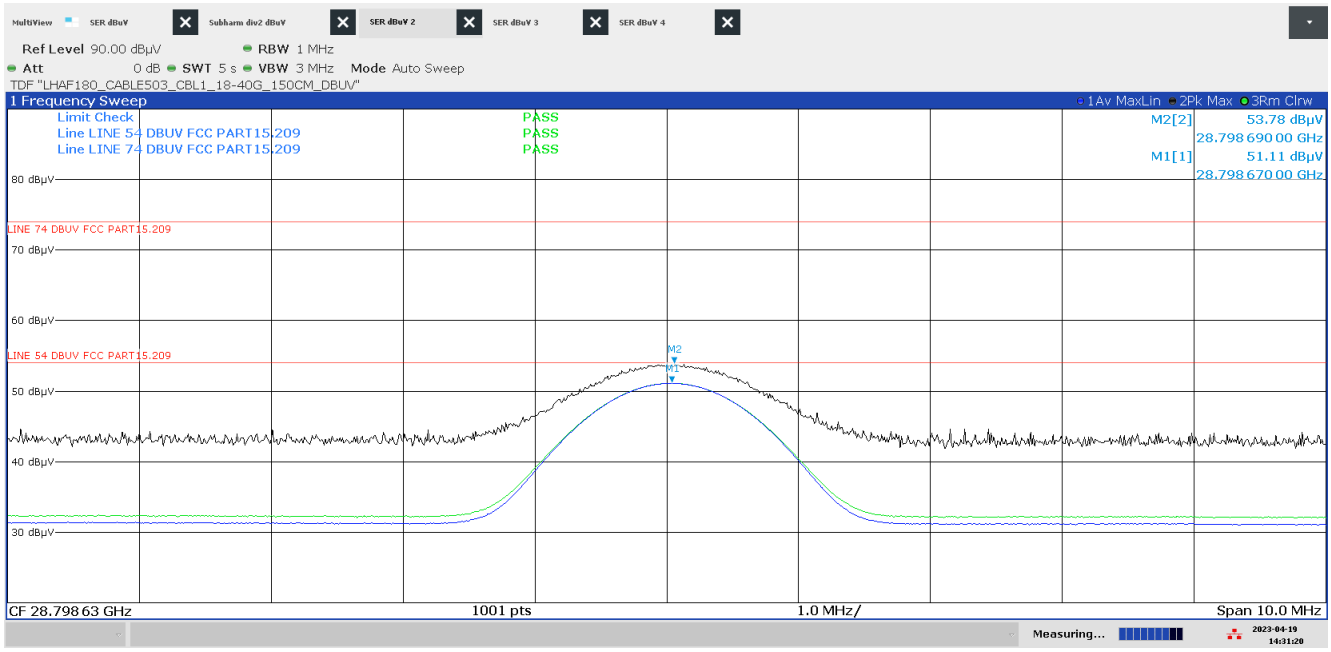
Plot 19: 18 GHz – 33 GHz, stop mode, low frequency, detail



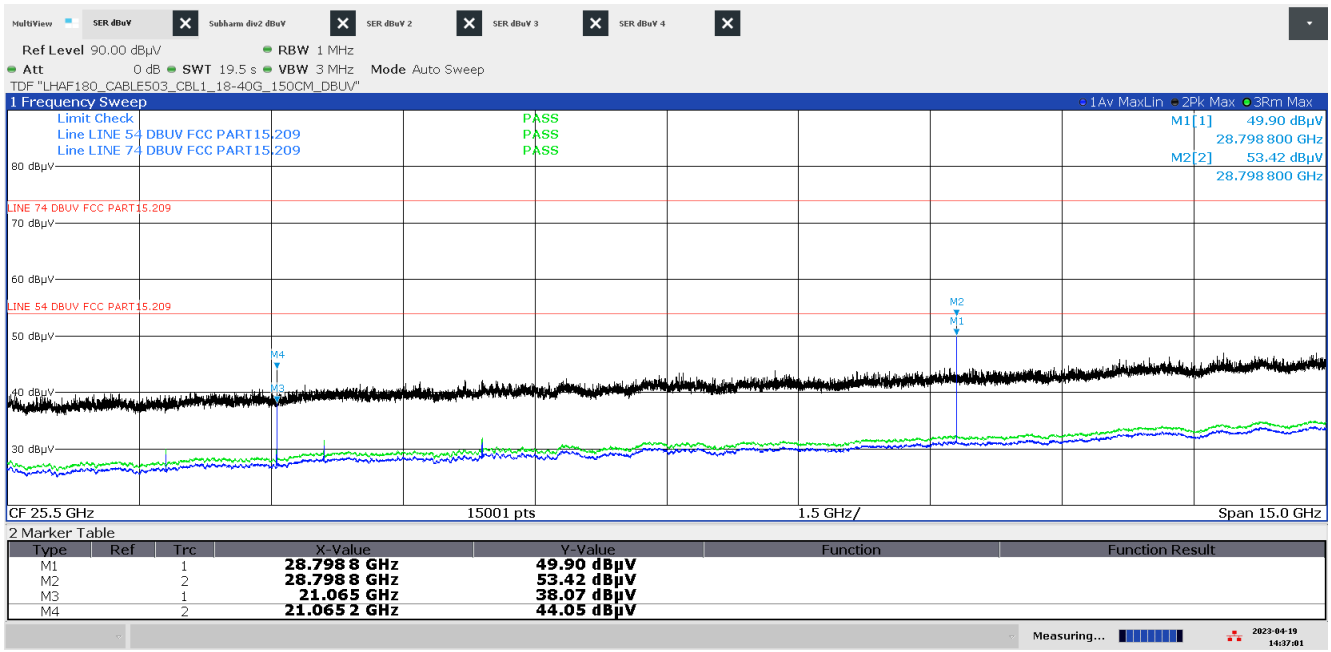
Plot 20: 18 GHz – 33 GHz, stop mode, middle frequency



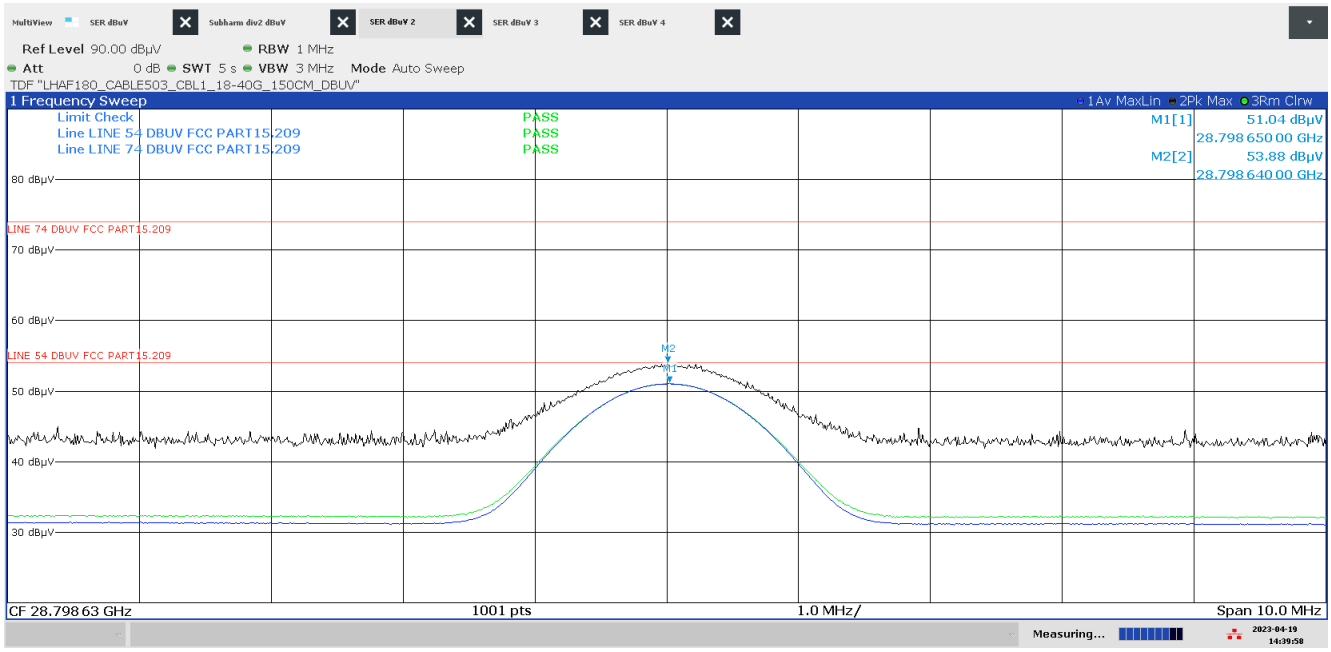
Plot 21: 18 GHz – 33 GHz, stop mode, middle frequency, detail



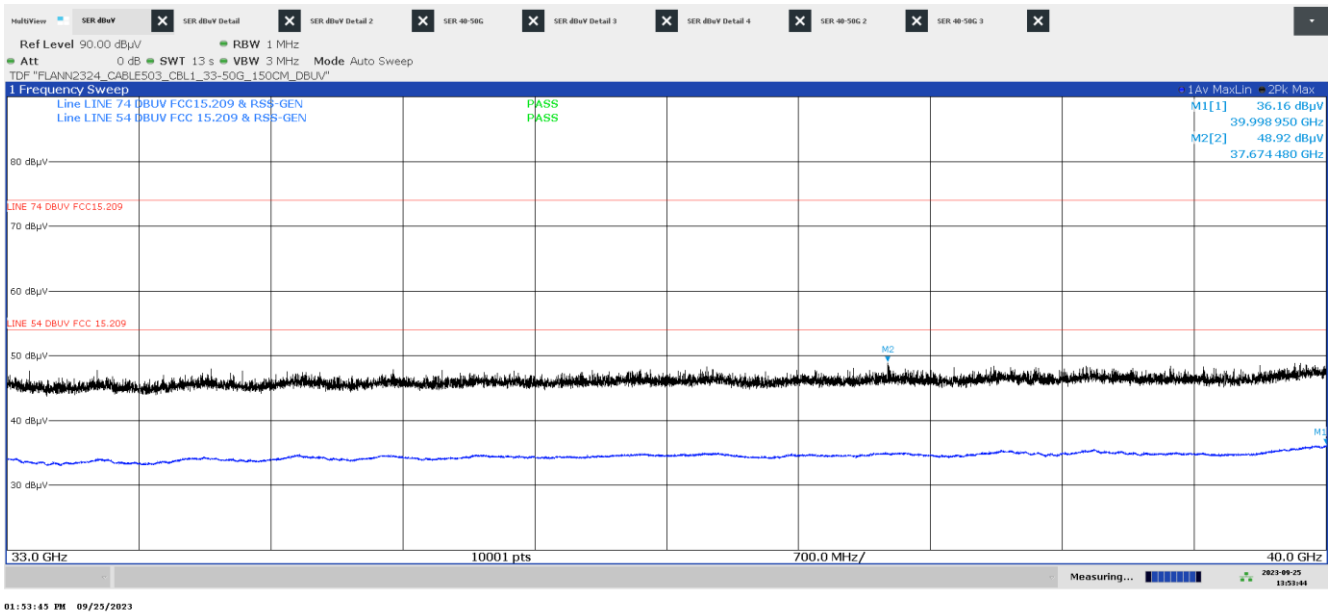
Plot 22: 18 GHz – 33 GHz, stop mode, high frequency



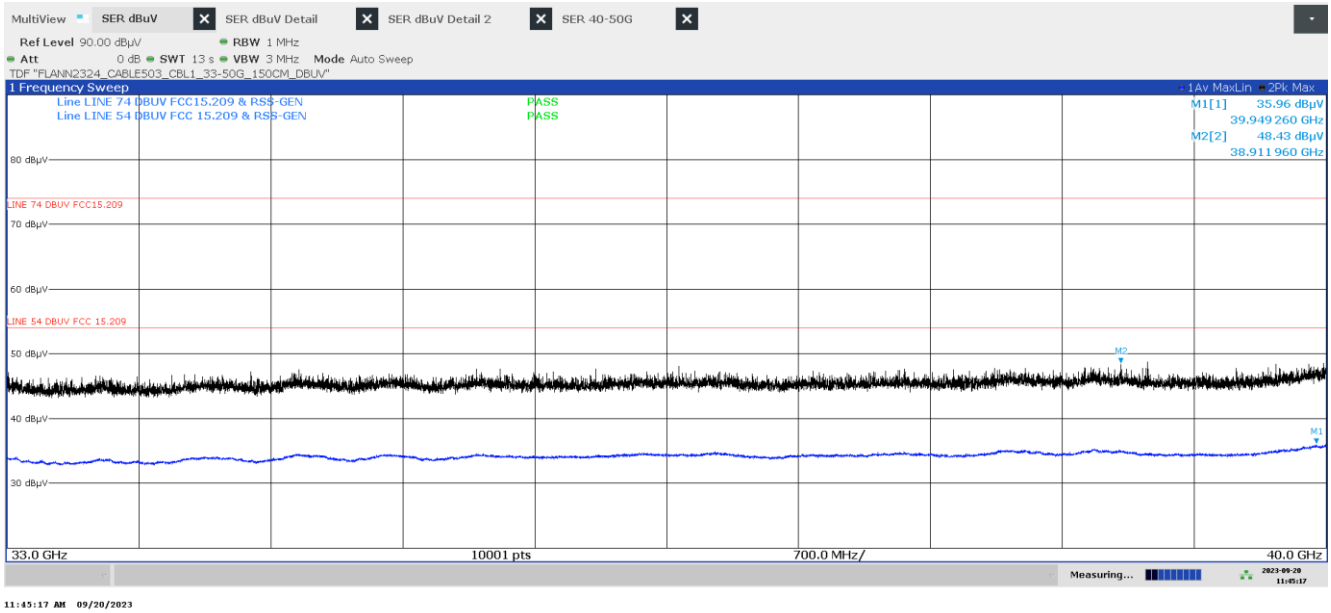
Plot 23: 18 GHz – 33 GHz, stop mode, high frequency, detail



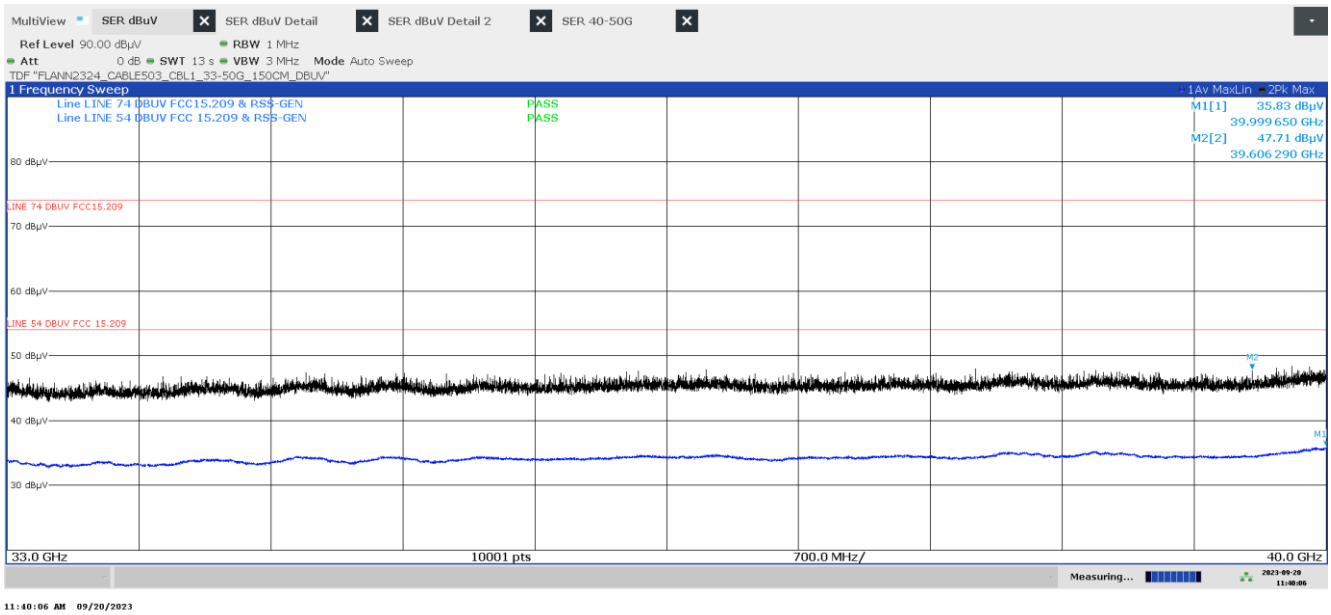
Plot 24: 33 GHz – 40 GHz, stop mode, low frequency



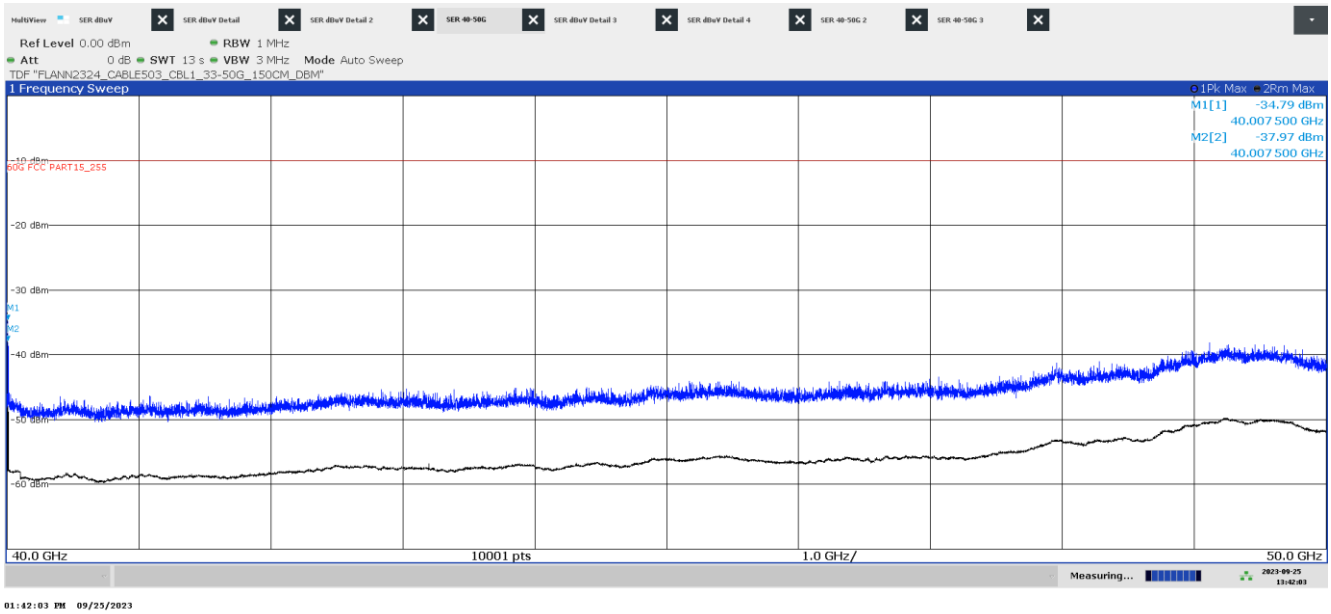
Plot 25: 33 GHz – 40 GHz, stop mode, middle frequency



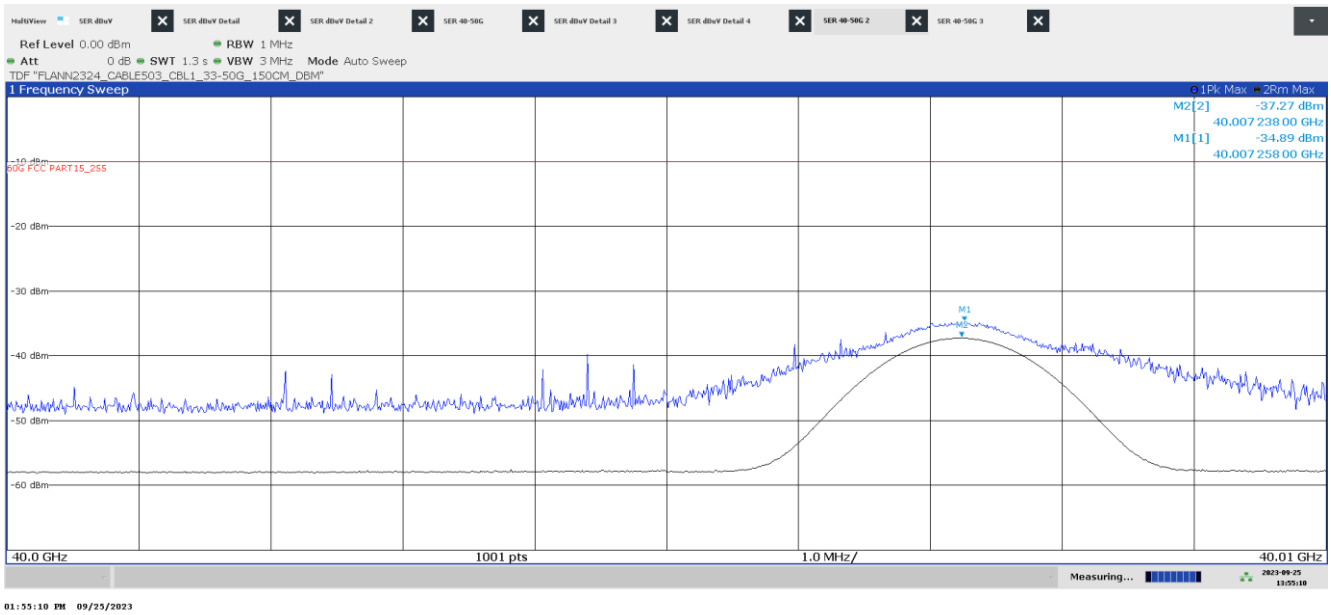
Plot 26: 33 GHz – 40 GHz, stop mode, high frequency



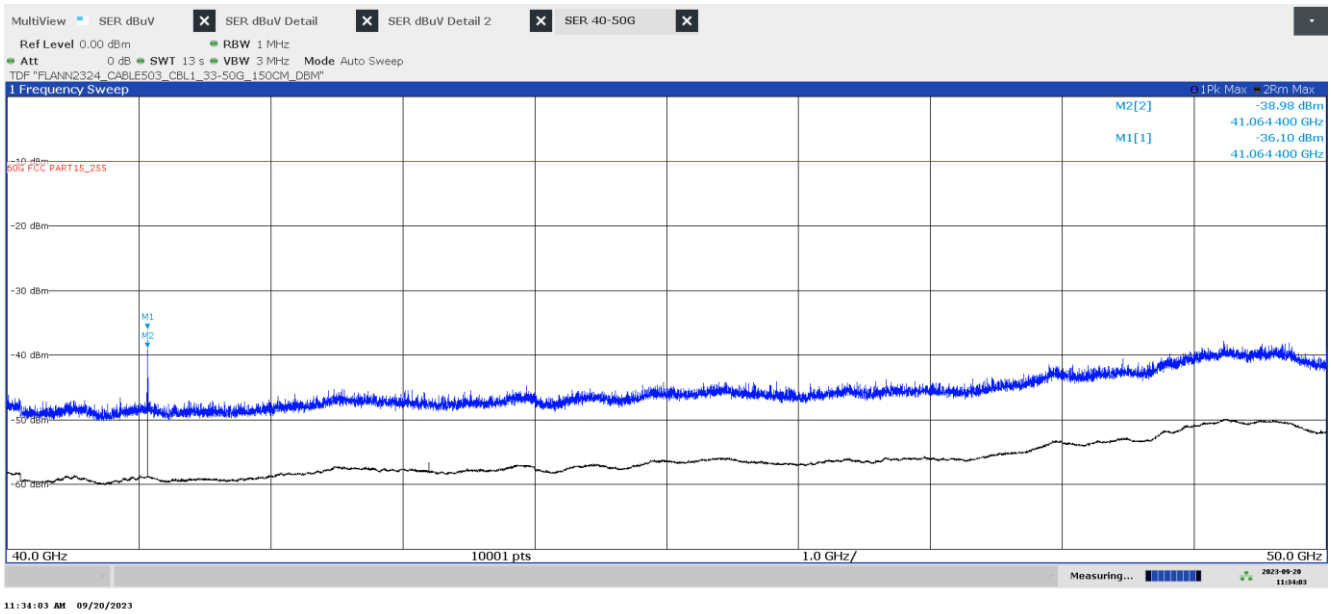
Plot 27: 40 GHz – 50 GHz, stop mode, low frequency



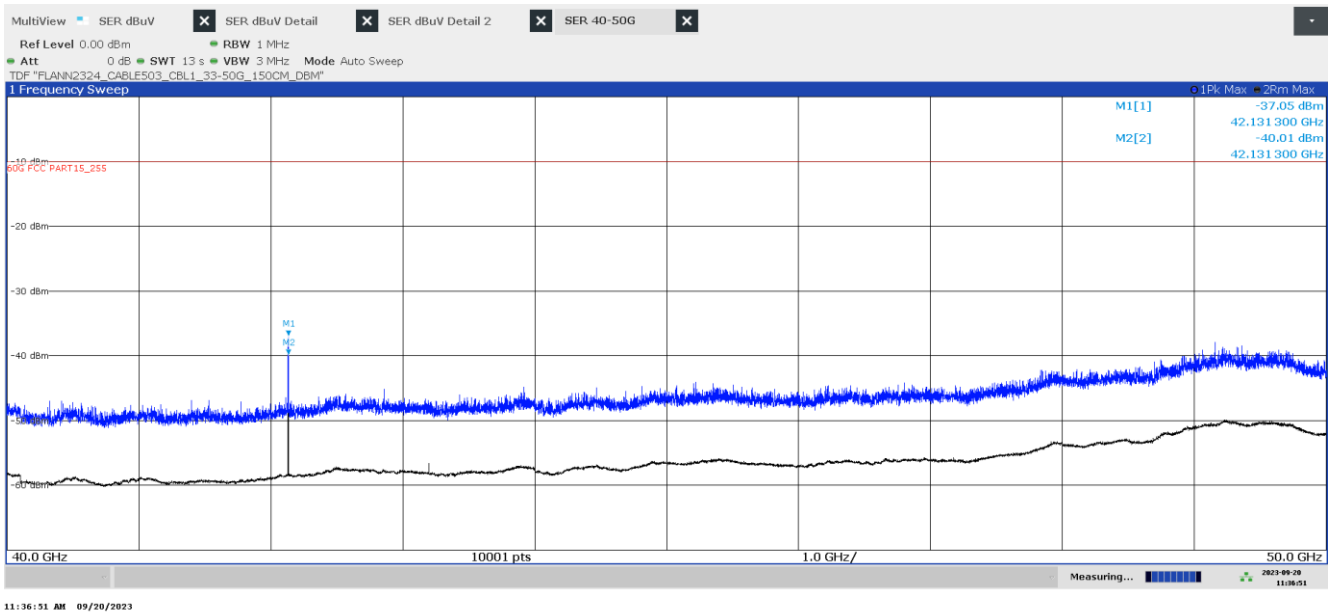
Plot 28: 40 GHz – 50 GHz, stop mode, low frequency, detail



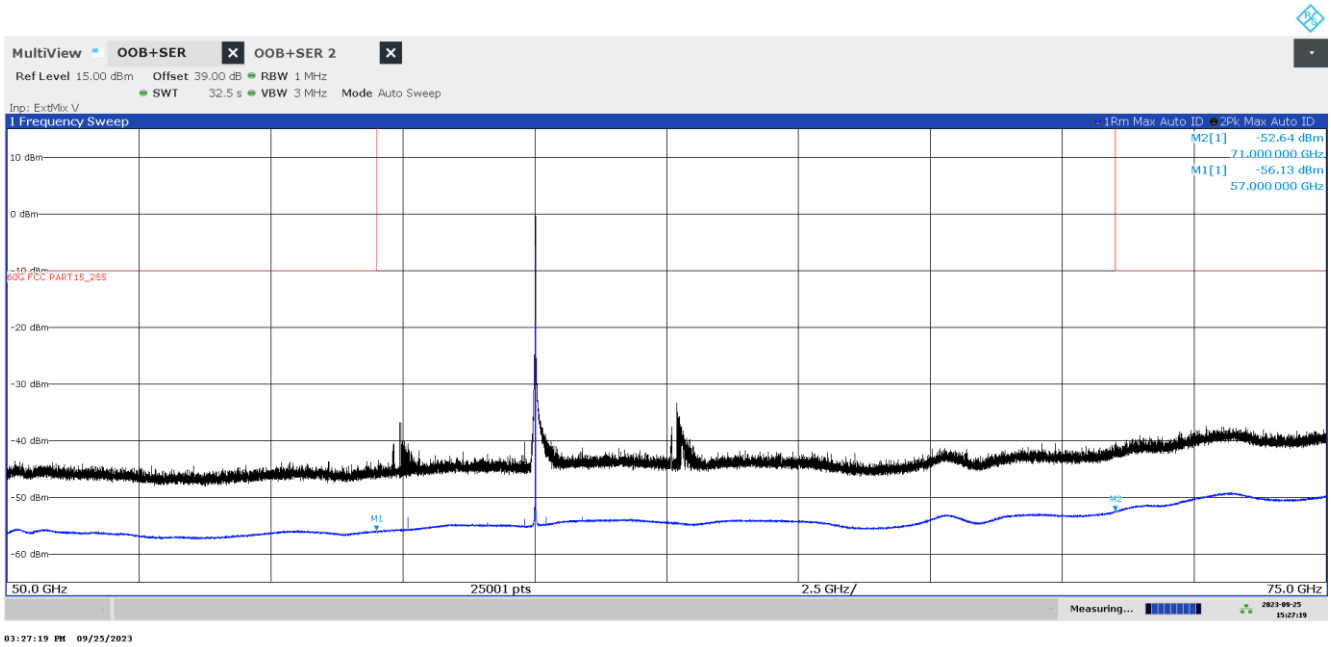
Plot 29: 40 GHz – 50 GHz, stop mode, middle frequency



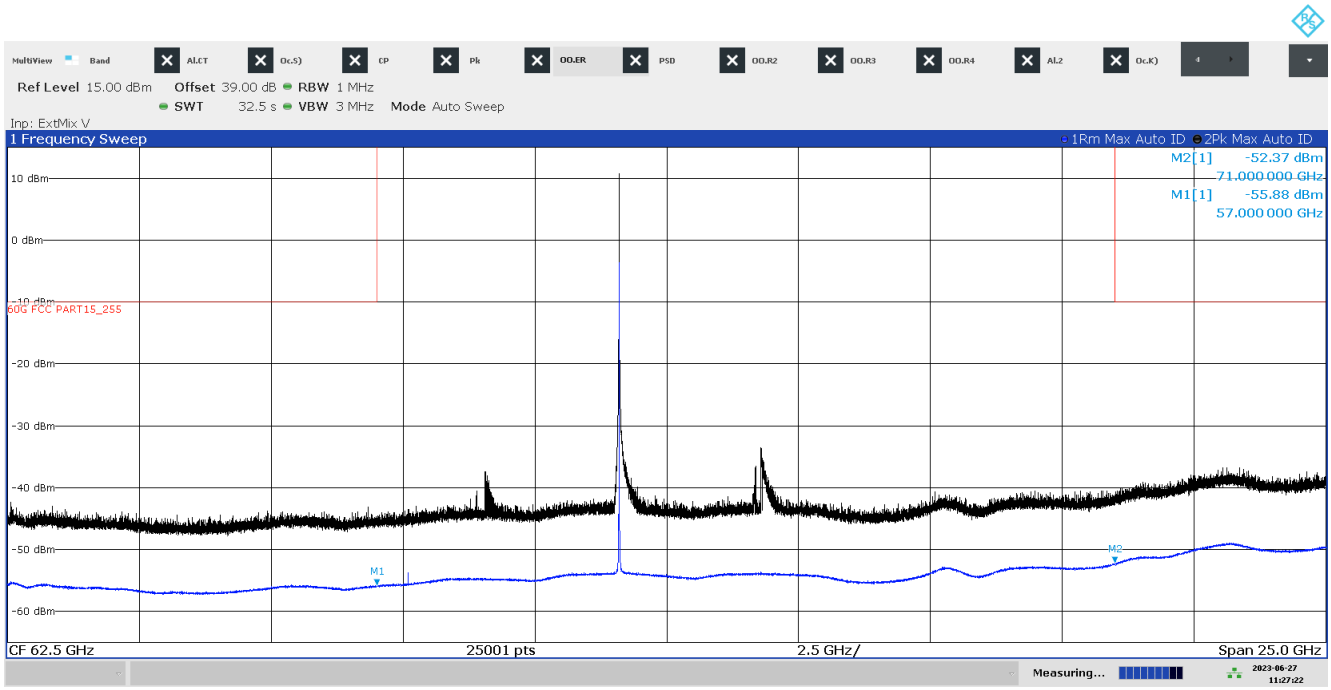
Plot 30: 40 GHz – 50 GHz, stop mode, high frequency



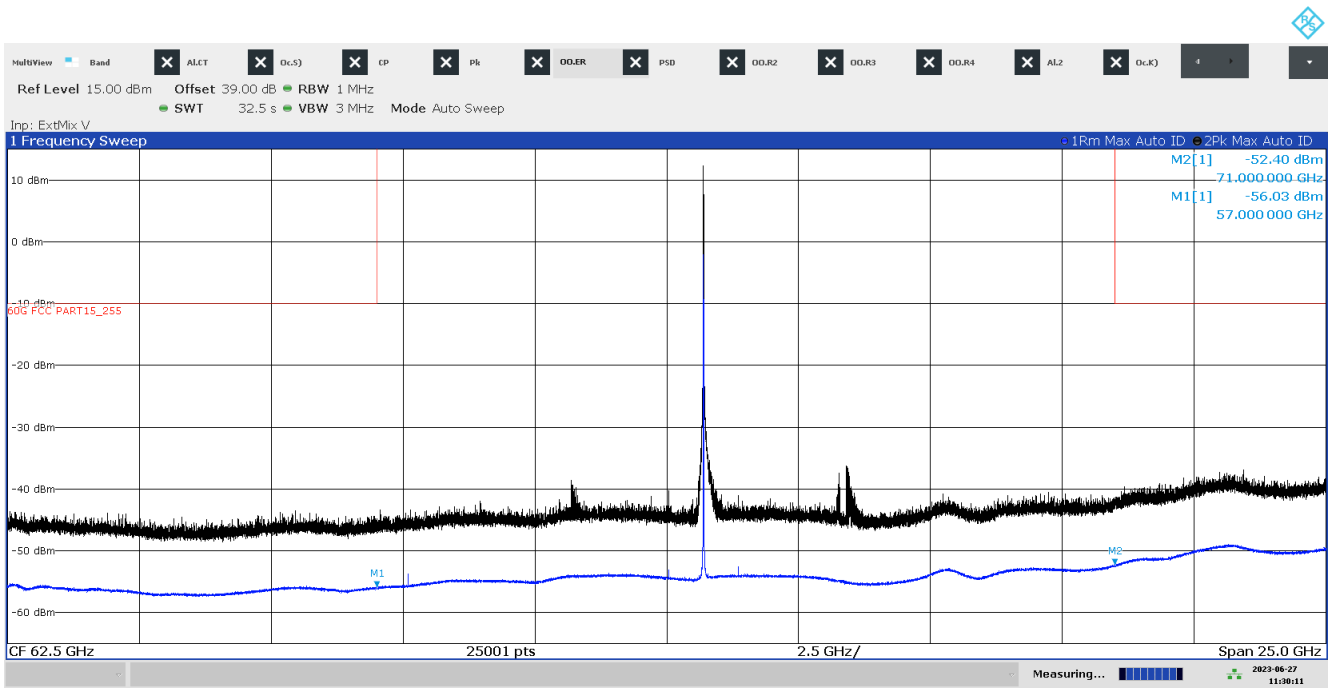
Plot 31: 50 GHz – 75 GHz, stop mode, low frequency



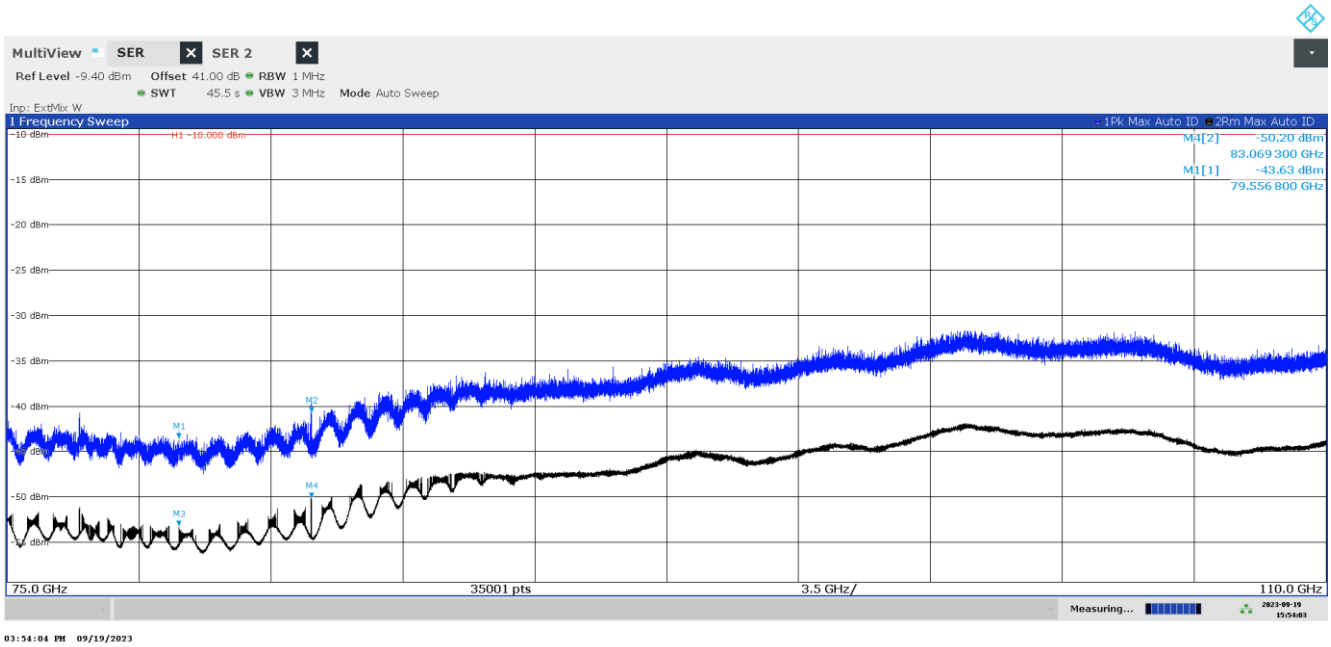
Plot 32: 50 GHz – 75 GHz, stop mode, middle frequency



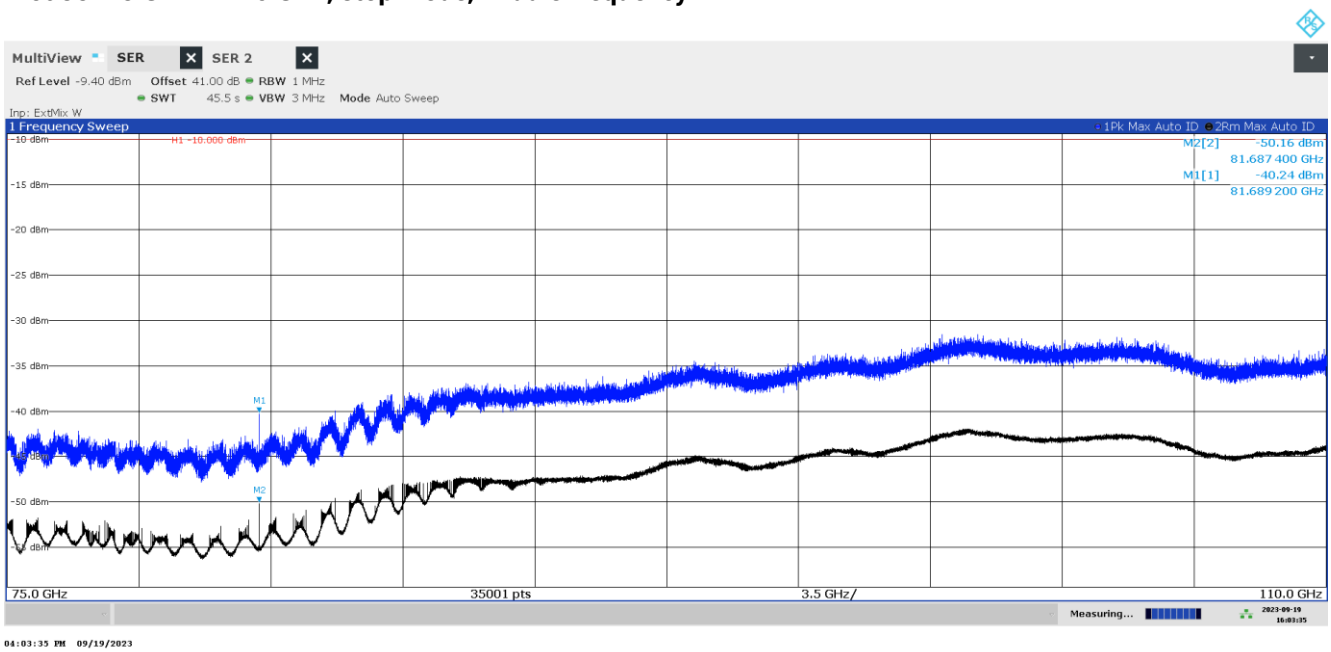
Plot 33: 50 GHz – 75 GHz, stop mode, high frequency



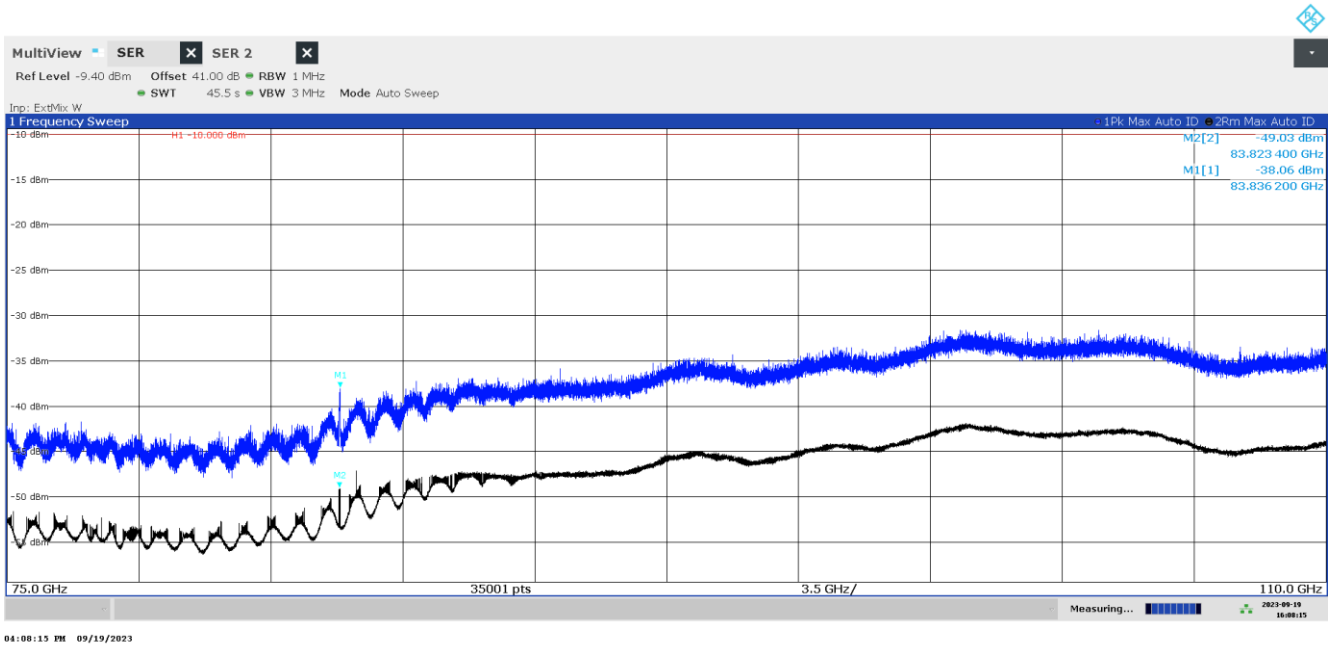
Plot 34: 75 GHz – 110 GHz, stop mode, low frequency



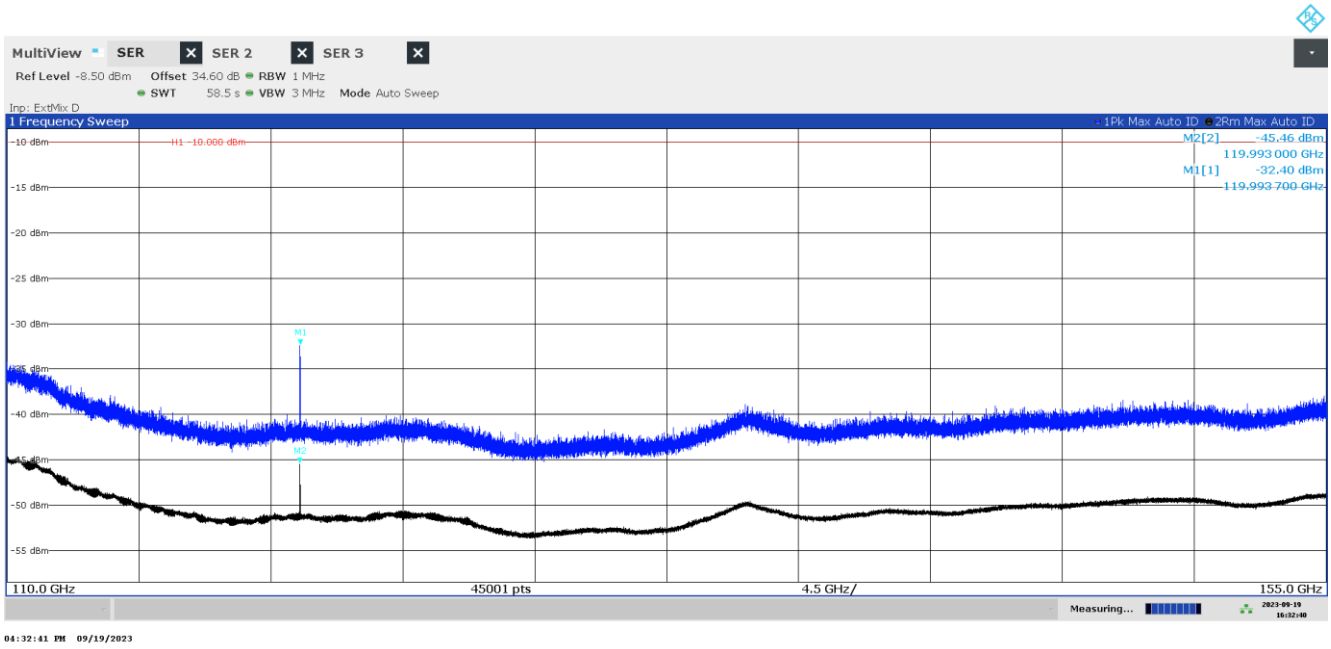
Plot 35: 75 GHz – 110 GHz, stop mode, middle frequency



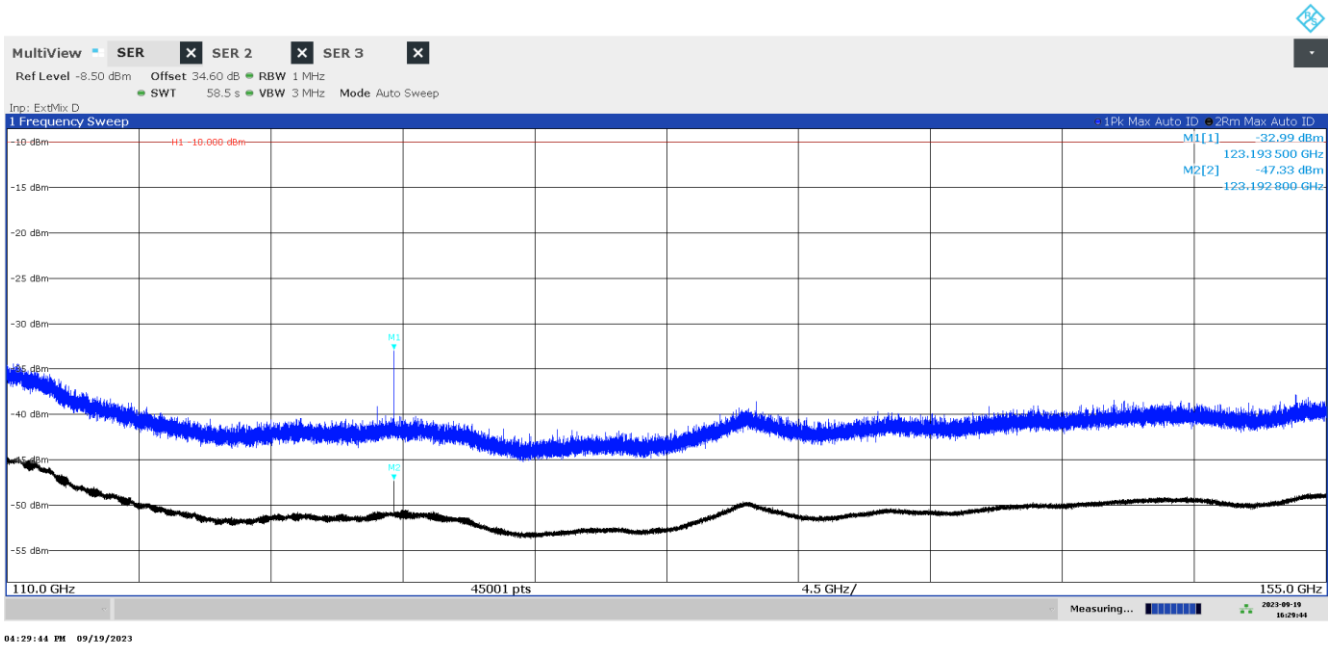
Plot 36: 75 GHz – 110 GHz, stop mode, high frequency



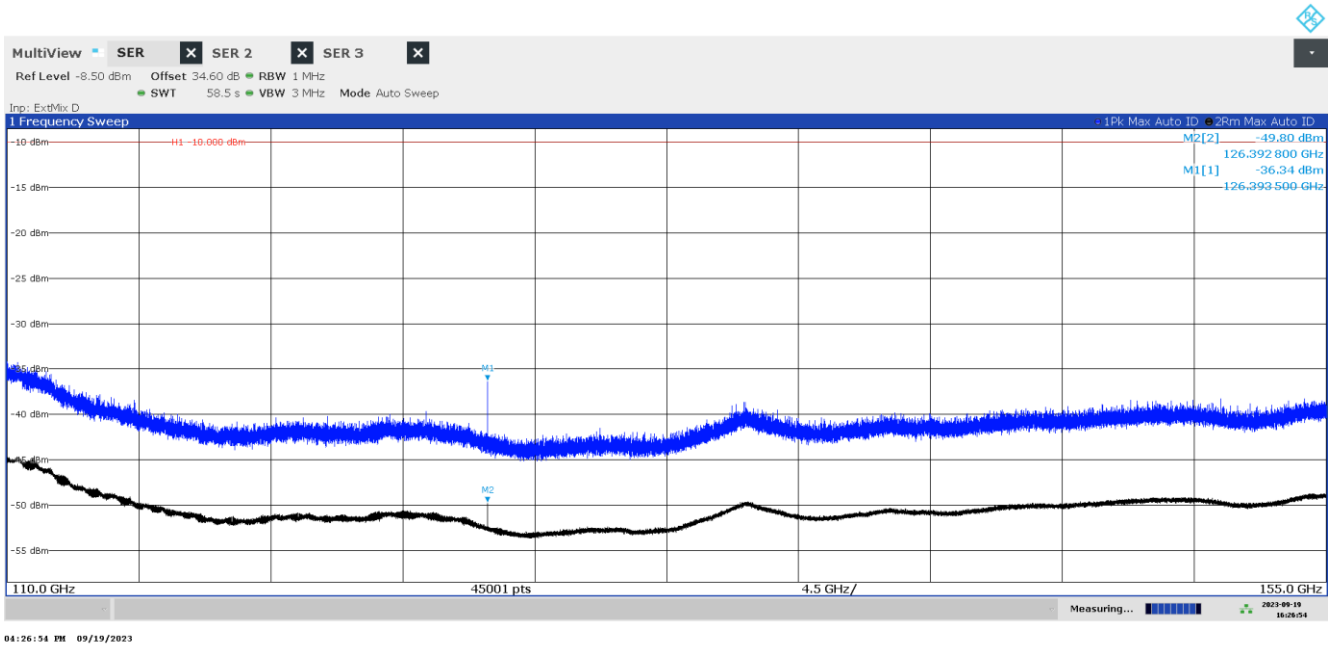
Plot 37: 110 GHz – 155 GHz, stop mode, low frequency



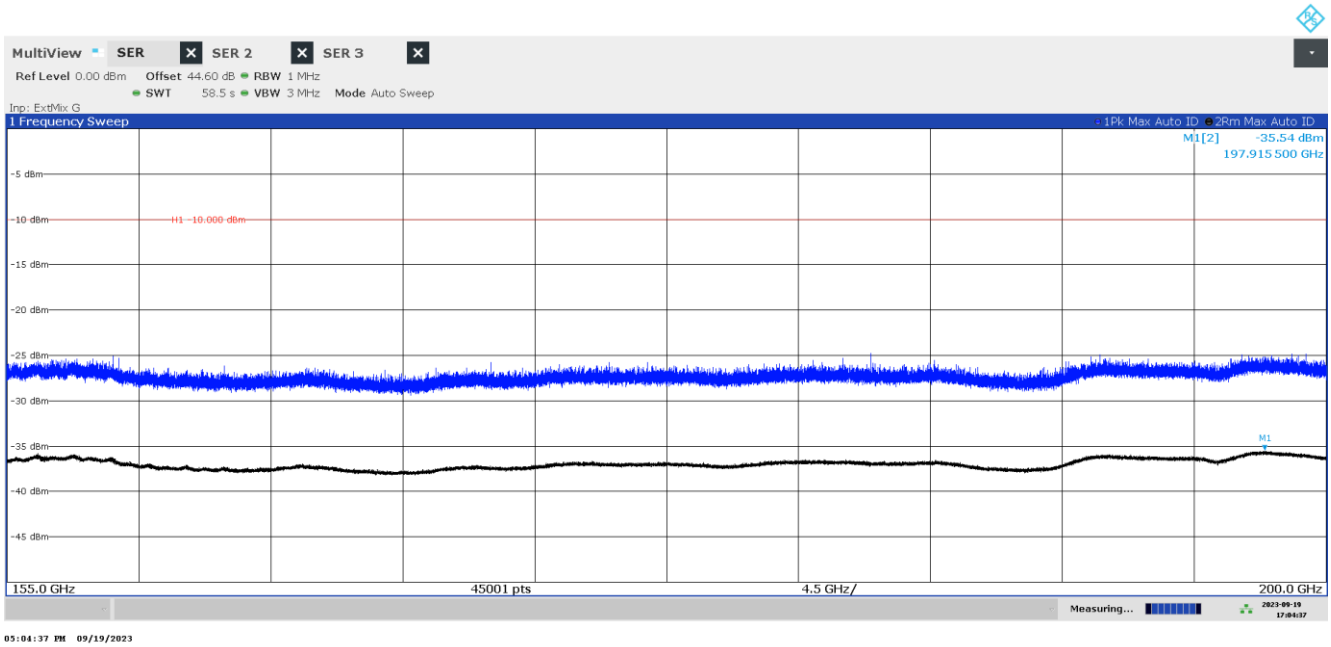
Plot 38: 110 GHz – 155 GHz, stop mode, middle frequency



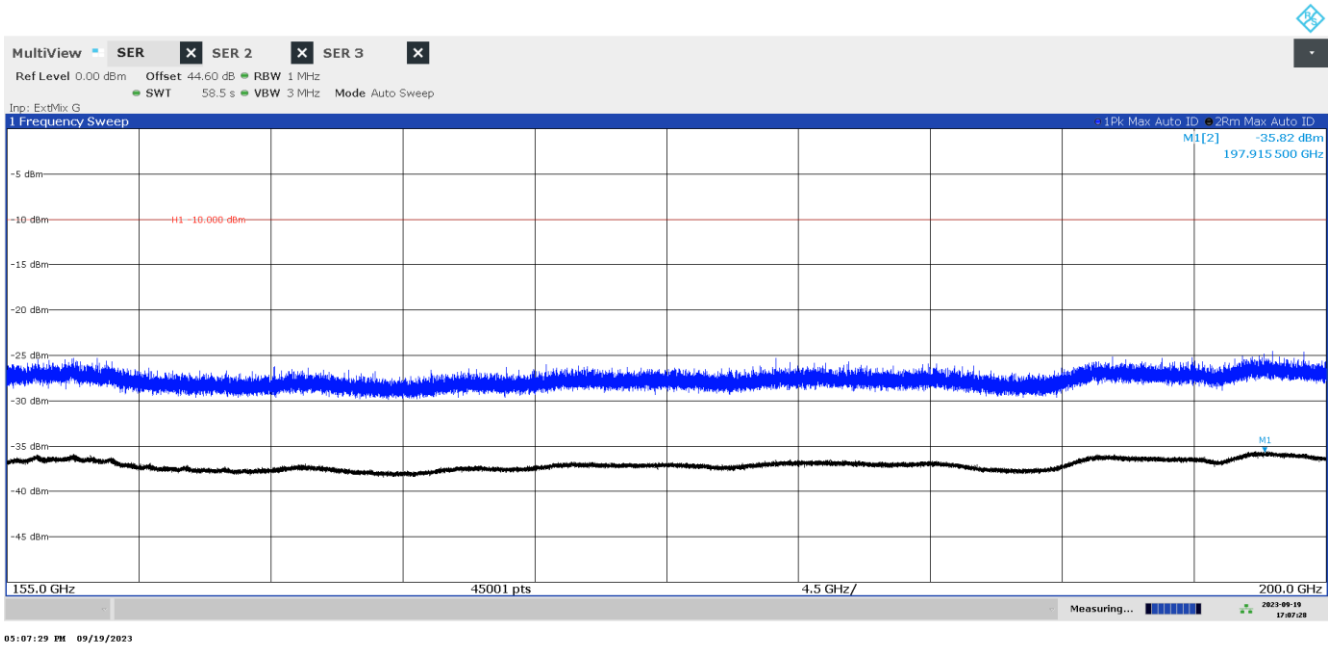
Plot 39: 110 GHz – 155 GHz, stop mode, high frequency



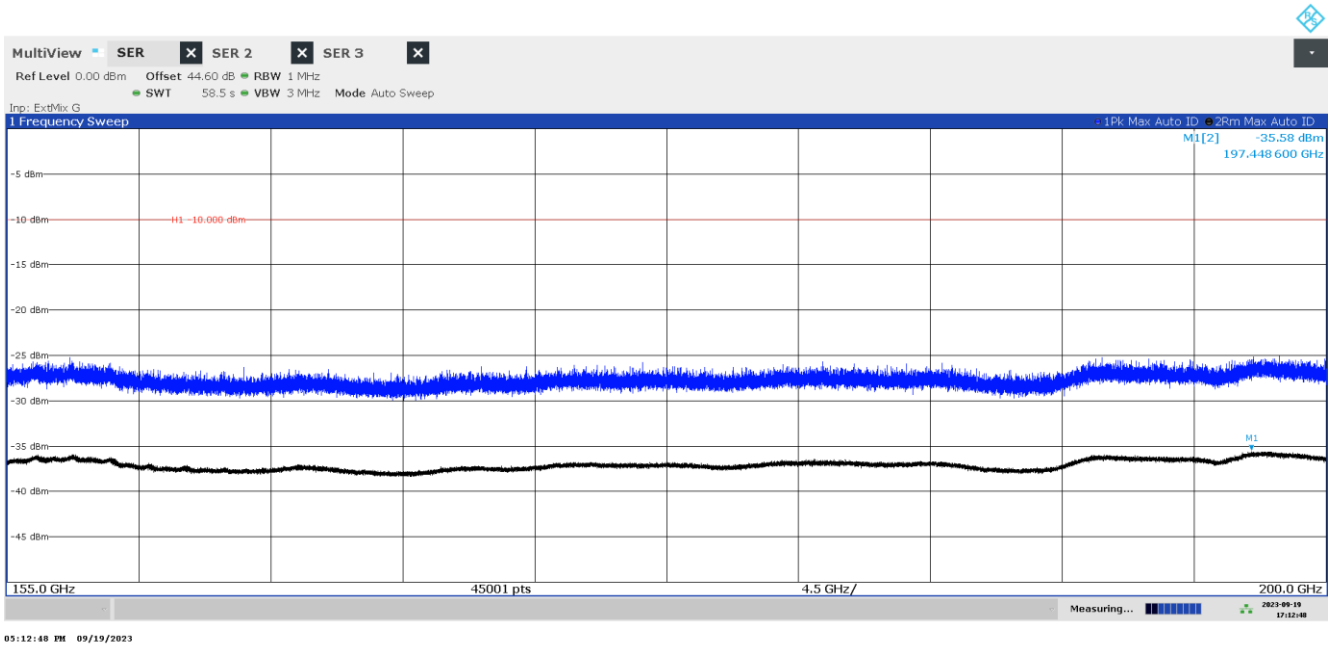
Plot 40: 155 GHz – 200 GHz, stop mode, low frequency



Plot 41: 155 GHz – 200 GHz, stop mode, middle frequency



Plot 42: 155 GHz – 120 GHz, stop mode, high frequency



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) (June 1, 2020):
Frequency stability. 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
CFR Part 15.255 (f)
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:

Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [GHz]
-20 °C / V_{nom}	60.066	63.228	3.162
-10 °C / V_{nom}	60.065	63.225	3.160
0 °C / V_{nom}	60.061	63.221	3.161
10 °C / V_{nom}	60.060	63.220	3.159
20 °C / V_{nom}	60.056	63.227	3.172
20 °C / V_{min}	60.055	63.228	3.173
20 °C / V_{max}	60.055	63.228	3.172
30 °C / V_{nom}	60.062	63.221	3.159
40 °C / V_{nom}	60.054	63.226	3.172
50 °C / V_{nom}	60.057	63.213	3.156

Note:

- Detailed measurement results: see 1-5343_22-01-02MR_FCC-ISED1.pdf

Verdict: Compliant

12.6 Conducted emissions < 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 and provisions:

§15.207(a):
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	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:

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

Results:

The device only employs battery power for operation (as declared by manufacturer).

Verdict: Not applicable

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	2023-10-09
-A	Gain of EUT antenna updated according to customer declaration	2023-10-10

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