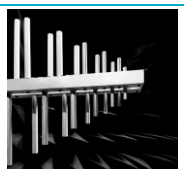
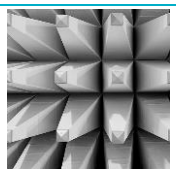

cetecom advanced

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-5252_22-01-02-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

CIAS Elettronica s.r.l.
Via Durando, 38
20158 Milano / ITALY
Phone: +39-02-3767161
Contact: Romano Manzoli
e-mail: manzoli.romano@cias.it

Manufacturer

CIAS Elettronica s.r.l.
Via Durando, 38
20158 Milano / ITALY

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:	**External Microwave Protection Barrier (24GHz)**
Model name:	**ERMO482X3PROF5**
FCC ID:	OIFERMO-482X3PROK
Frequency:	24.075 GHz – 24.175 GHz
Antenna:	Integrated antenna
Power supply:	11.5 V to 16.0 V DC by external power supply
Temperature range:	-35°C to +70°C

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

Test report authorized:

cn=Frank Heussner, o=cetecom advanced GmbH, ou=HNR-230605, email=Frank.Heussner@cetecomadvanced.com, c=DE
2023.10.09 11:35:12 +02'00'

Frank Heussner
Lab Manager
Radio Labs

Test performed:

cn=Stephan Thiel, o=cetecom advanced GmbH, ou=THL-230601, email=Stephan.Thiel@cetecomadvanced.com, c=DE
2023.10.09 11:50:11 +02'00'

Stephan Thiel
Testing 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 1-5252/22-01-02 and dated 2023-06-27

2.2 Application details

Date of receipt of order:	2022-11-22
Date of receipt of test item:	2023-01-24
Start of test:*	2023-02-09
End of test:*	2023-05-15
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

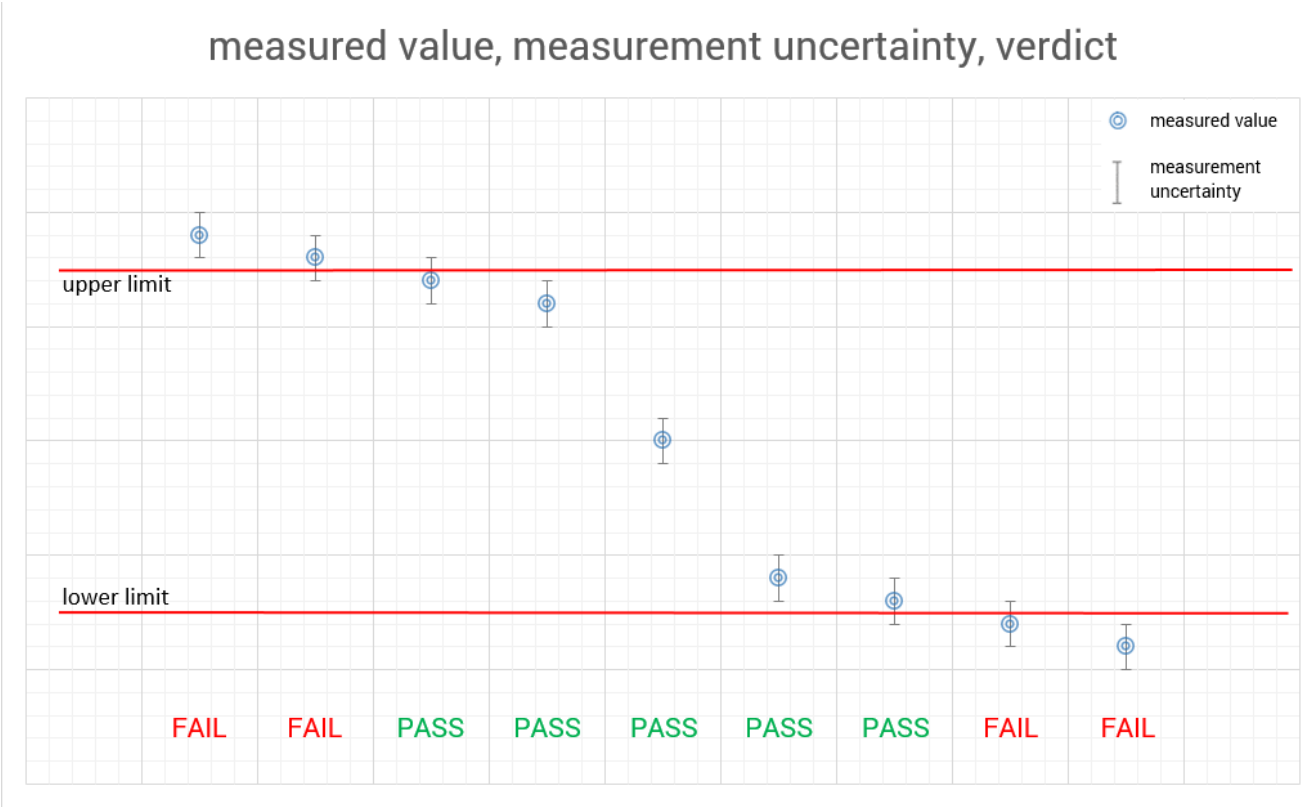
3 Test standard/s, references and accreditations

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

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}	13.8 V DC by external power supply 16.0 V 11.5 V

6 Test item

6.1 General description

Kind of test item	:	External Microwave Protection Barrier (24GHz)
Model name	:	ERMO482X3PROF5
S/N serial number	:	P23030980001
Hardware status	:	TX HEAD = N003 ; RX HEAD = N004
Software status	:	-/-
Firmware status	:	9.07
Frequency band	:	24.075 GHz – 24.175 GHz
Type of modulation	:	ASK
Number of channels	:	16 (All within 1MHz bandwidth)
Antenna	:	Integrated antenna
Power supply	:	11.5 V to 16.0 V DC by external power supply
Temperature range	:	-35°C to +70°C

6.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup and EUT photos are included in test report: 1-5252/22-01-01_AnnexA
1-5252/22-01-01_AnnexB
1-5252/22-01-01_AnnexD

Additional test report:

- Frequency stability: 1-5252_22-01-02_Annex_MR_1

7 Description of the test setup

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

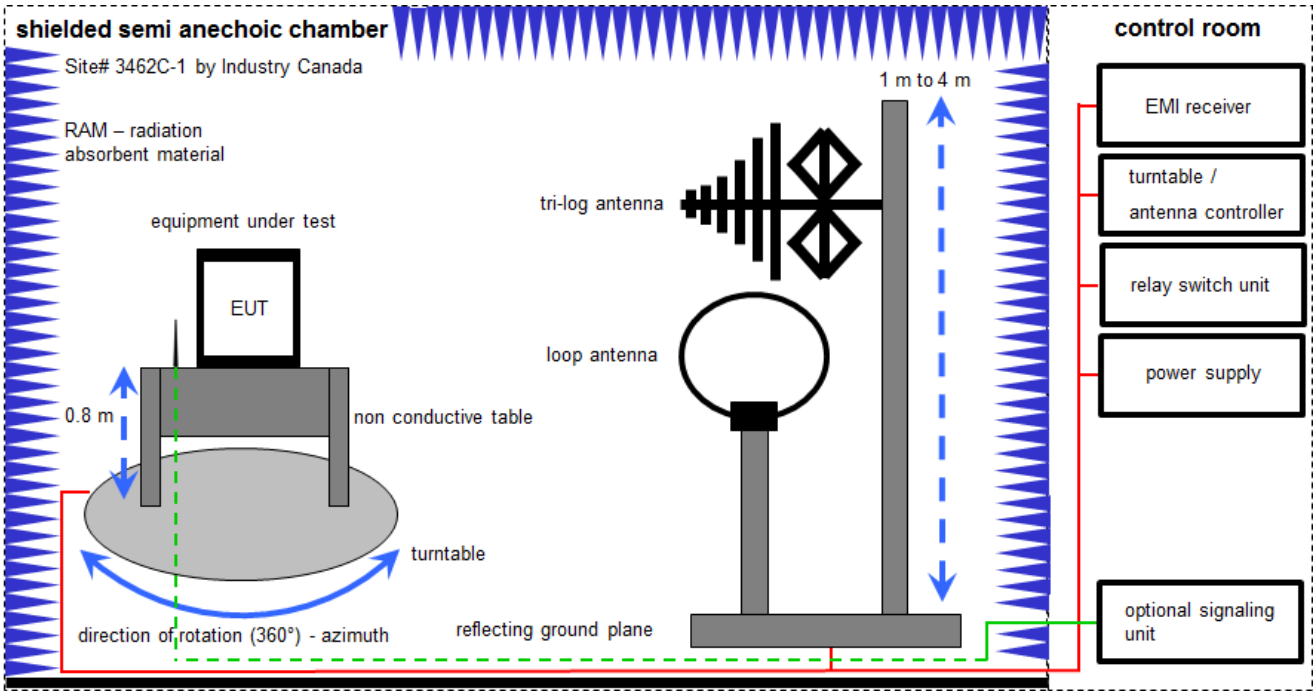
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Agenda: Kind of Calibration

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

7.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specification ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter

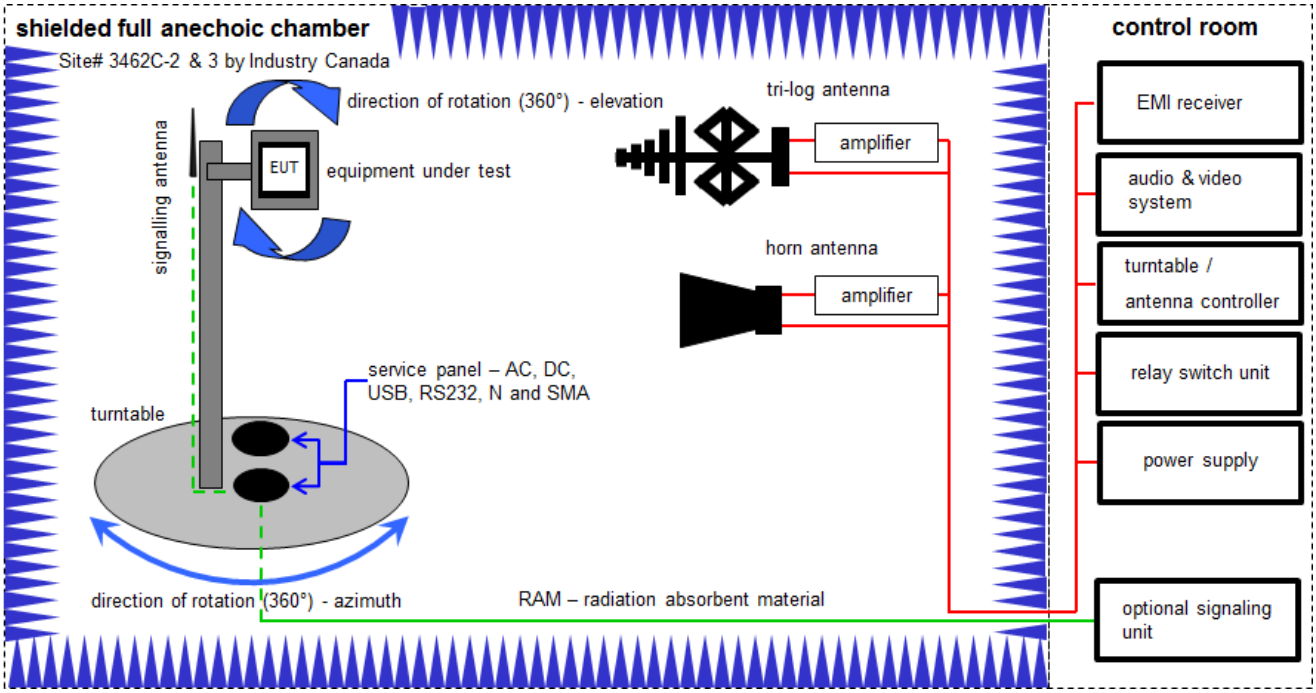
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
2	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
3	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
4	n. a.	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	09.12.2022	31.12.2023
5	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	01029	300005379	vlKl!	18.08.2021	30.08.2023
6	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	09.12.2022	31.12.2023
7	n. a.	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
8	n. a.	Semi anechoic chamber	300023	MWB AG	-/-	300000551	ne	-/-	-/-
9	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-

7.2 Shielded fully anechoic chamber



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

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

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

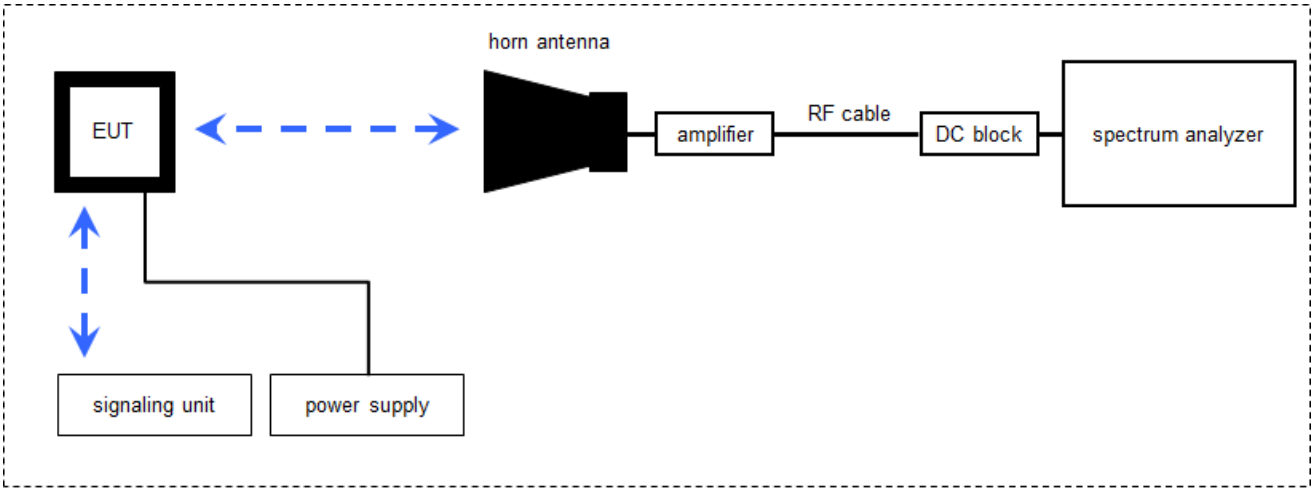
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

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

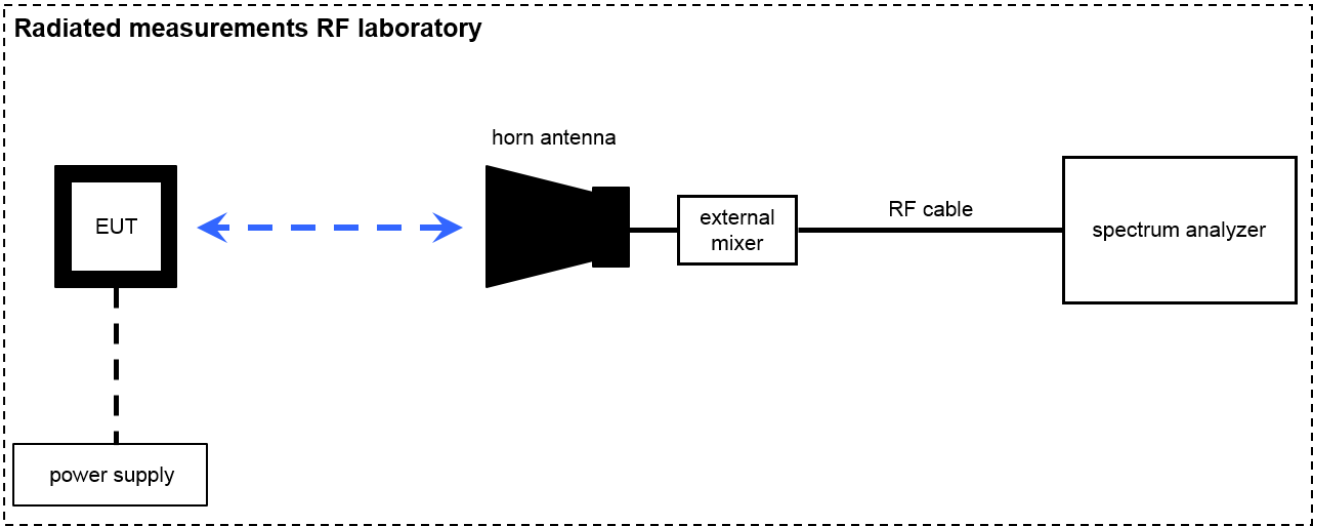
Equipment table:

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

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)

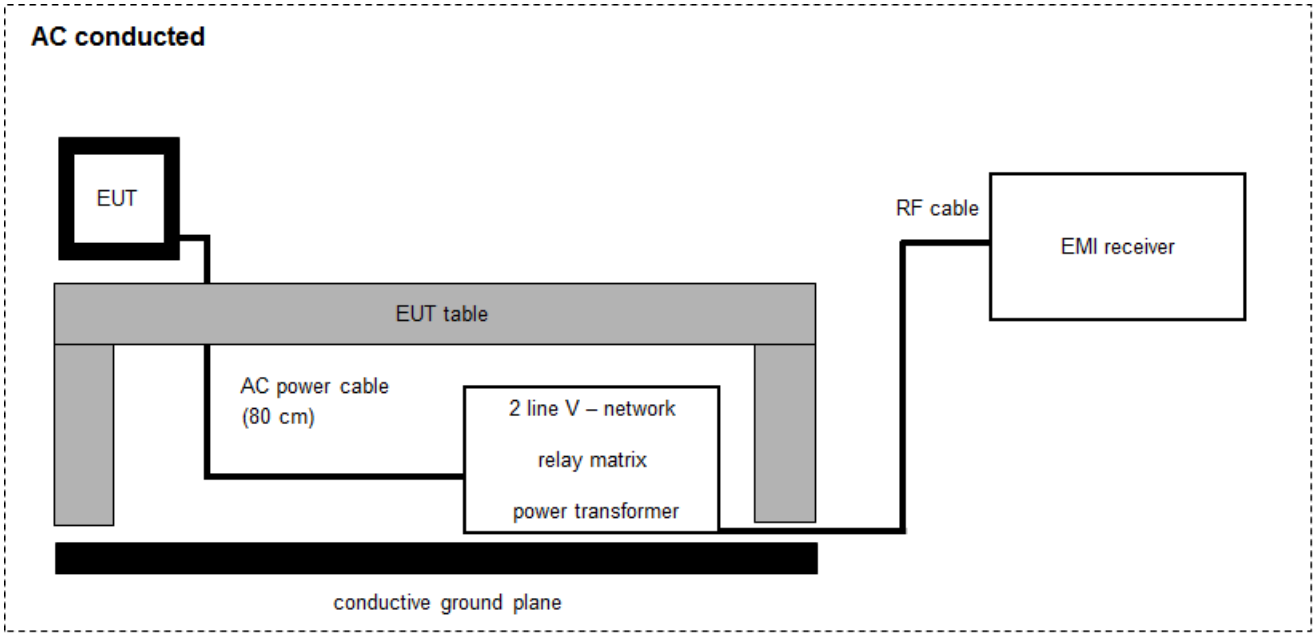
Example calculation:
OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

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	A039	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300002338	ne	-/-	-/-
2	CR 79	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	7911	300001751	ne	-/-	-/-
3	A025	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
4	A027	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vlKl!	17.01.2022	31.01.2024
5	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
6	n. a.	Harmonic Mixer 3-Port, 60-90 GHz	FS-Z90	R&S	101555	300004691	k	21.07.2022	31.07.2023
7	n. a.	Std. Gain Horn Antenna 60-90 GHz	COR 60_90	Thomson CSF		300000814	ev	-/-	-/-
8	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2022	08.03.2024
9	n. a.	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	Rohde & Schwarz	101411	300004959	k	07.07.2022	31.07.2023
10	n. a.	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	Rohde & Schwarz	101578	300005788	k	07.07.2022	31.07.2023
11	n. a.	Signal- and Spectrum Analyzer 2 Hz - 50 GHz	FSW50	Rohde&Schwarz	101332	300005935	k	23.03.2023	31.03.2024
12	n. a.	DC Power Supply	N5767A	Agilent Technologies	US26F7337F	300003840	ev	-/-	-/-
13	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	31.05.2024

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	n. a.	EMI Test Receiver 3.6 GHz	ESR3	Rohde & Schwarz	102981	300006318	k	09.12.2022	31.12.2023
2	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vIKI!	29.12.2021	31.12.2023
3	n. a.	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	Rohde & Schwarz	892475/017	300002209	vIKI!	14.12.2021	31.12.2023
4	n. a.	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 %

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 table	2023-10-09	-/-

Test specification clause	Test case	Temperature conditions	Power source	Pass	Fail	NA	NP	Remark
§15.245(b) /	Field strength of fundamental emission	Nominal	Nominal	☒	☐	☐	☐	complies
§15.215(c) /	Bandwidth and frequency stability of the wanted signal	Nominal	Nominal	☒	☐	☐	☐	complies
§15.209(a) / §15.245(b)	Field strength of emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207(a) / §15.207(c) /	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	complies
§15.245(b)(1)(iii) /	Prevention of continuous operation	Nominal	Nominal	☐	☐	☐	☒	see note 2

Note:

1) NA = Not Applicable; NP = Not Performed
2) Only required for field disturbance sensors

11 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: None

Kind of device: ☒ Field disturbance sensor (not for use in motor vehicles or aircraft)

☐ Field disturbance sensors designed to be used in motor vehicles or aircraft

☐ Speed radar meter

Note:

- §15.245(a): Operation under the provisions of this section is limited to intentional radiators used as field disturbance sensors, excluding perimeter protection systems.

Test mode: ☒ No test mode available.

☐ Special test mode/software is used.

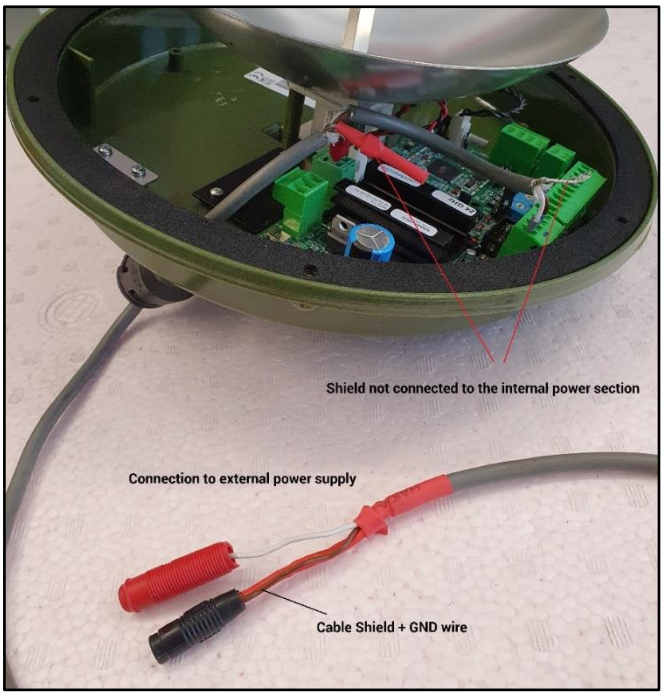
Test device (EUT):

- EUT 1: TX test device
- EUT 2: RX test device not needed for FCC and RSS

Hardware device configuration:

- The EUT is tested with a shielded power cable as requested by the customer.
- The shield is connected to GND on the power supply source
- The shield is not connected inside the EUT see **Plot 1**
- The conducted emissions < 30 MHz was performed with an 12V commercially available power supply

Plot 1: Connection to external power supply



12 Measurement results

12.1 Field strength of fundamental emission

Description:

Measurement of the maximum radiated field strength of the wanted signal (fundamental emission).

Limits and provisions:

§15.245 (b):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (mV/m)
902-928	500
2435-2465	500
5785-5815	500
10500-10550	2500
24075-24175	2500

§15.245 (b)(2):
Field strength limits are specified at a distance of 3 meters.

§15.245 (b)(4):
The emission limits shown above are based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply.

§15.35(b):
Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g., see §§ 15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

§15.31 (c):
Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

Applicable limits according to §15.245 (b)

Fundamental frequency (MHz)	Field strength of fundamental		Measurement distance
	average value	peak value	
24075-24175	2500 mV/m (128 dBµV/m)	25000 mV/m (148 dBµV/m)	3 m

Measurement:

Measurement parameter	
Detector:	Peak / Linear average
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

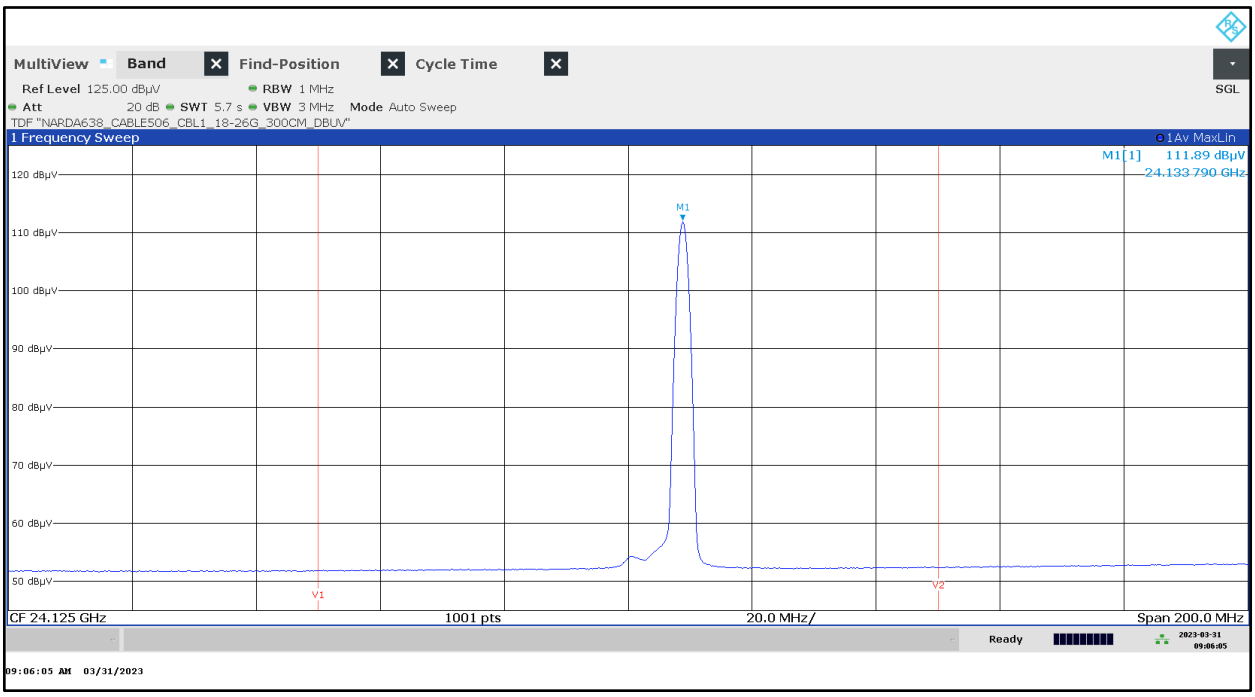
Measurement results:

EUT	Frequency [GHz]	Field strength of fundamental @ 3m [dBµV/m]	Applicable limit	Margin [dB]	Plot
		Average value			
1	24.1338	111.9	128 dBµV/m	16.1	Plot **2**

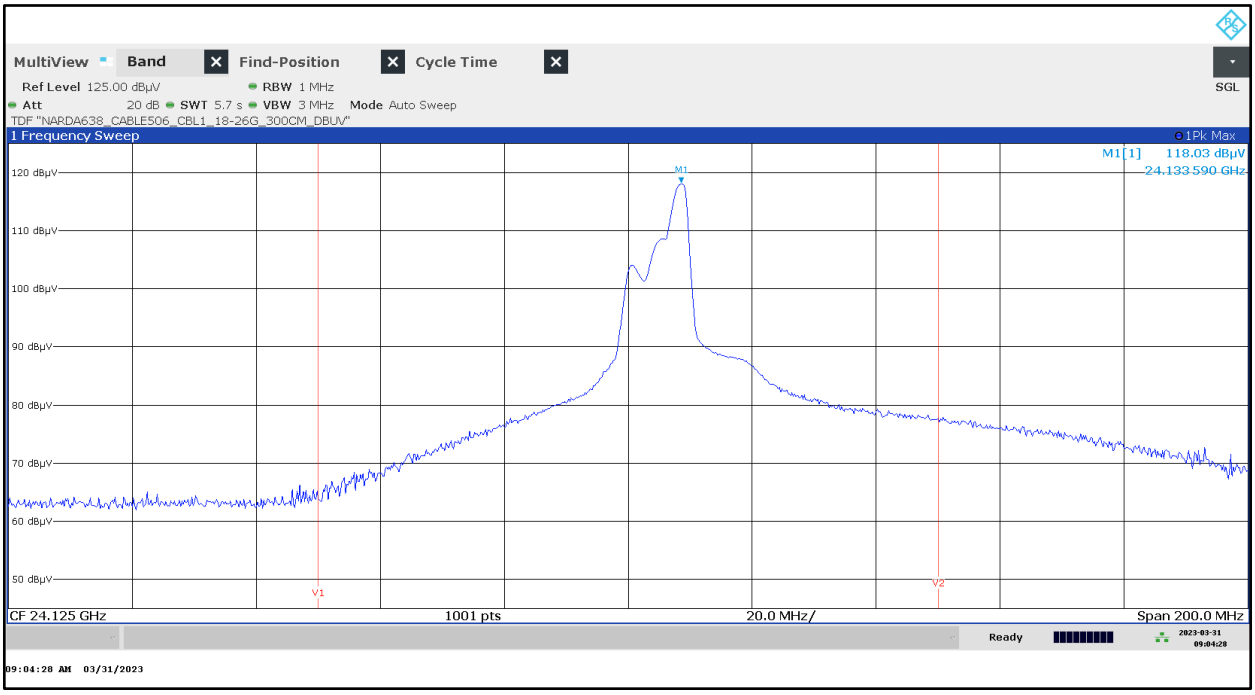
EUT	Frequency [GHz]	Field strength of fundamental @ 3m [dBµV/m]	Applicable limit	Margin [dB]	Plot
		Peak value			
1	24.1336	118.0	148 dBµV/m	30	Plot 3

Verdict: Compliant

Plot 2: Fundamental emission in the 24 GHz Band: Average value



Plot 3: Fundamental emission in the 24 GHz Band: Peak value



Note: For Plot 2 & 3

- Vertical line V1 = 24.075 GHz
- Vertical line V2 = 24.175 GHz

12.2 Bandwidth and frequency stability of the wanted signal

Description:

Measurement of the bandwidth and the frequency stability of the wanted signal (fundamental emission) under temperature and supply voltage variations.

Limits and provisions:

§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.

Designated frequency bands of §15.245			
Fundamental frequency [GHz]	f_L [GHz]	f_H [GHz]	Bandwidth [MHz]
0.902 – 0.928	> 0.902	< 0.928	< 26 MHz
2.435 – 2.465	> 2.435	< 2.465	< 30 MHz
5.785 – 5.815	> 5.785	< 5.815	< 30 MHz
10.500 – 10.550	> 10.500	< 10.550	< 50 MHz
24.075 – 24.175	> 24.075	< 24.175	<100 MHz

Measurement:

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	10 kHz
Video bandwidth:	30 kHz
Trace-Mode:	Max Hold

Measurement procedures:

- Bandwidth: ANSI C61.10-2013 6.9
- Frequency stability: ANSI C61.10-2013 6.8

Results:

20dB bandwidth at normal conditions:

EUT	F_{low} [GHz]	F_{high} [GHz]	Occupied bandwidth [MHz]	Plot
1	24.13416	24.13431	0.15	Plot 4

Frequency stability:

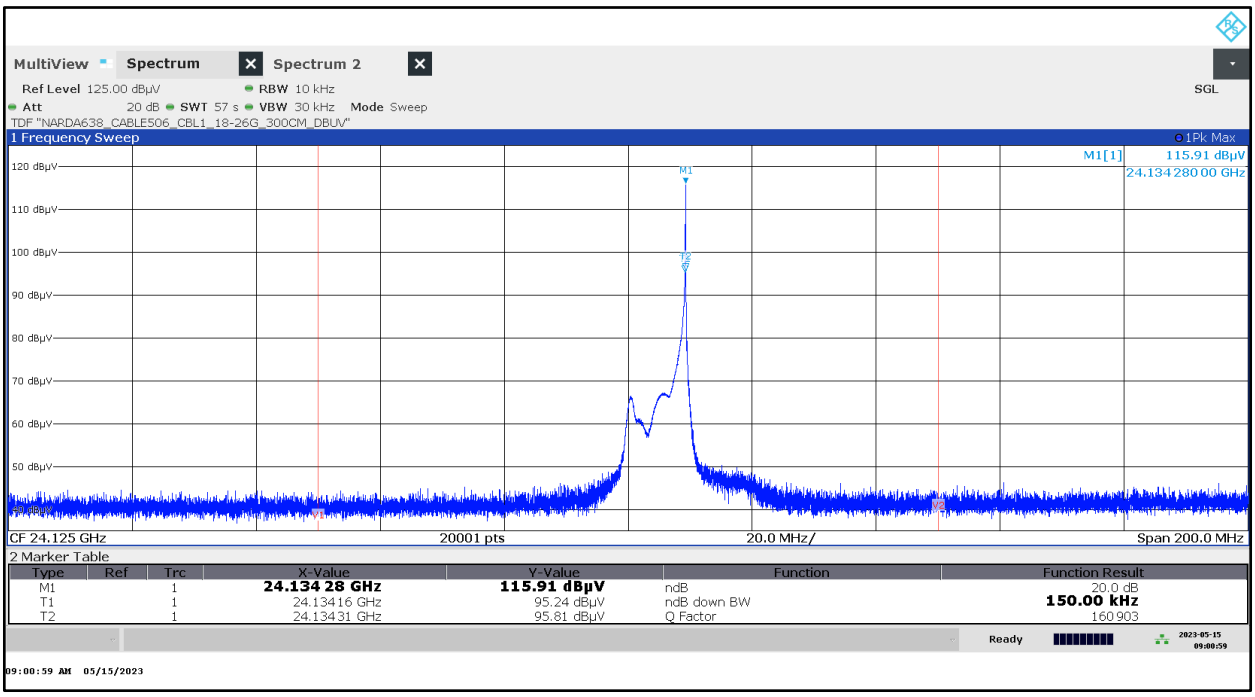
Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [MHz]
-20 °C / V_{nom}	24.130	24.131	0.795
-10 °C / V_{nom}	24.130	24.131	0.915
0 °C / V_{nom}	24.130	24.130	0.816
10 °C / V_{nom}	24.130	24.130	0.765
20 °C / V_{nom}	24.133	24.134	0.594
20 °C / V_{min}	24.133	24.134	0.505
20 °C / V_{max}	24.133	24.134	0.574
30 °C / V_{nom}	24.133	24.133	0.553
40 °C / V_{nom}	24.134	24.135	0.431
50 °C / V_{nom}	24.134	24.135	0.509

Note:

- Details to the test can be found in the additional test report „1-5252_22-01-02_Annex_MR_1“.

Verdict: Compliant

Plot 4: 20dB bandwidth at normal conditions



Note:

- Vertical line V1 = 24.075 GHz
- Vertical line V2 = 24.175 GHz

12.3 Field strength of emissions (radiated outside of the specified frequency bands)

Description:

Measurement of the field strength of emissions radiated outside of the specified frequency bands (in transmit mode).

Limits and provisions:

§15.245 (b):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (mV/m)	Field strength of harmonics (mV/m)
902-928	500	1.6
2435-2465	500	1.6
5785-5815	500	1.6
10500-10550	2500	25.0
24075-24175	2500	25.0

(1) Regardless of the limits shown in the table of §15.245 (b), harmonic emissions in the restricted bands below 17.7 GHz, as specified in §15.205, shall not exceed the field strength limits shown in §15.209. Harmonic emissions in the restricted bands at and above 17.7 GHz shall not exceed the following field strength limits:

(i) For the second and third harmonics of field disturbance sensors operating in the 24075-24175 MHz band and for other field disturbance sensors designed for use only within a building or to open building doors, 25.0 mV/m.

(ii) For all other field disturbance sensors, 7.5 mV/m.

(iii) Field disturbance sensors designed to be used in motor vehicles or aircraft must include features to prevent continuous operation unless their emissions in the restricted bands, other than the second and third harmonics from devices operating in the 24075-24175 MHz band, fully comply with the limits given in § 15.209. Continuous operation of field disturbance sensors designed to be used in farm equipment, vehicles such as fork lifts that are intended primarily for use indoors or for very specialized operations, or railroad locomotives, railroad cars and other equipment which travels on fixed tracks is permitted. A field disturbance sensor will be considered not to be operating in a continuous mode if its operation is limited to specific activities of limited duration (e.g., putting a vehicle into reverse gear, activating a turn signal, etc.).

(2) Field strength limits are specified at a distance of 3 meters.

(3) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

(4) The emission limits shown in §15.245 (b) are based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply.

§15.205(d)(8):
Devices operated in the 24.075–24.175 GHz band under § 15.245 are exempt from complying with the requirements of this section for the 48.15–48.35 GHz and 72.225–72.525 GHz bands only, and shall not exceed the limits specified in § 15.245(b).

§15.205(e):
Harmonic emissions appearing in the restricted bands above 17.7 GHz from field disturbance sensors operating under the provisions of § 15.245 shall not exceed the limits specified in § 15.245(b).

§15.209 (a):
Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (µV/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 88	100**	3
88 – 216	150**	3
216 – 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241

§15.209(b):
In the emission table above, the tighter limit applies at the band edges.

§15.209(c):
The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

§15.209(d):
The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

§15.31 (c):
Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

§15.33(a):
For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

Calculation according to §15.245 (b)(3):

$$E_{pot} = E_{fund} - 50\ dB$$

- E_{pot}: Potential limit according to §15.245 (b)(3)
- E_{fund}: Measured field strength of fundamental emission @ 3m (see chapter 12.1)

EUT	Measured field strength of fundamental emission @ 3m [dBµV/m]	Potential limit according to §15.245 (b)(3) [dBµV/m]	Limit according to §15.209 [dBµV/m]
	average value	average value	average value
1	111.9	61.9	54 (f > 1GHz)

Note:
- The limit value with the lesser attenuation compared to the fundamental field strength applies.
- The level of any unwanted emissions shall not exceed the level of the fundamental frequency.

Final limits according to §15.245 (b):

EUT	Harmonics		Emissions radiated outside of the specified frequency bands (except for harmonics)	
	average value	peak value	average value	peak value
1	88	108	61.9	81.9

<u>Measurement:</u>

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

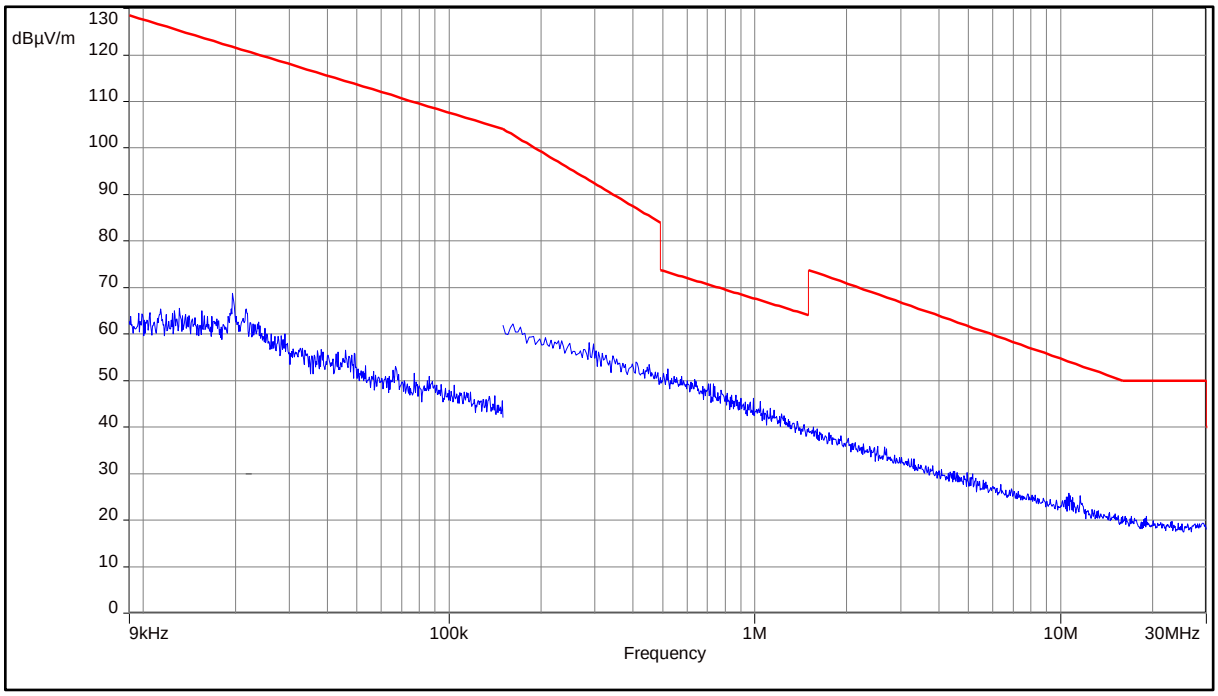
Results:

Emissions outside the band:

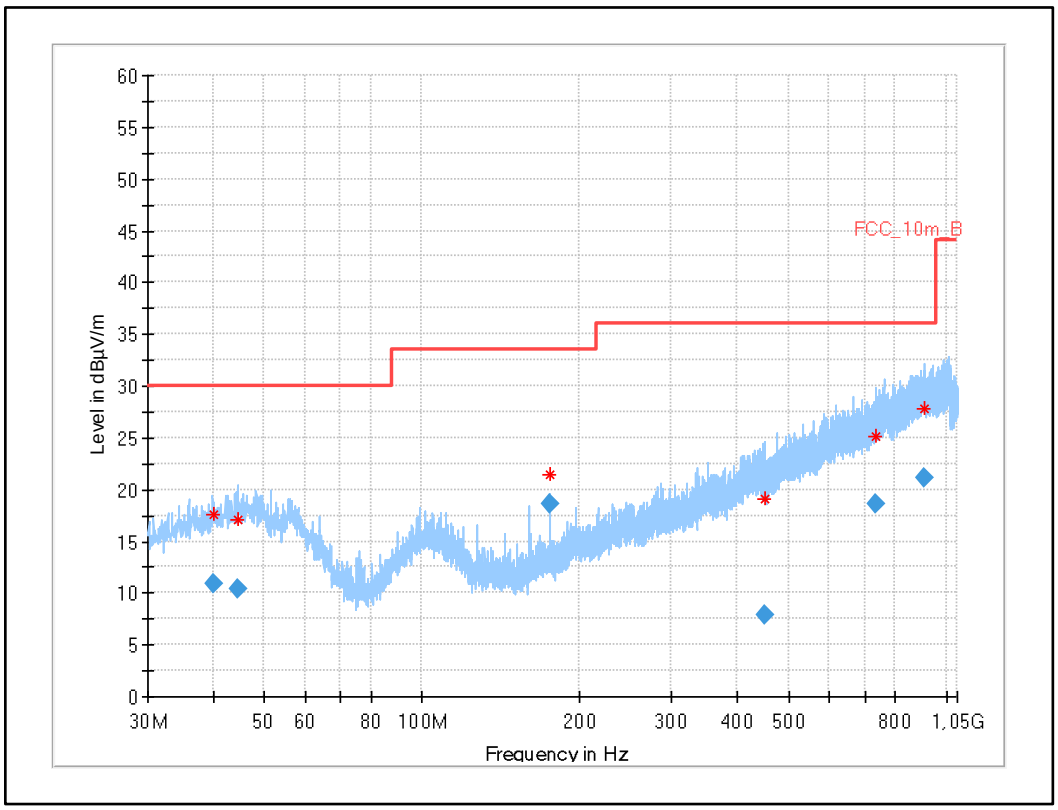
Frequency f [MHz]	Detector	Measured level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
Please refer to the following plots for more information on the level of spurious emissions				
-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-

Verdict: Compliant

Plot 5: 9 kHz to 30 MHz

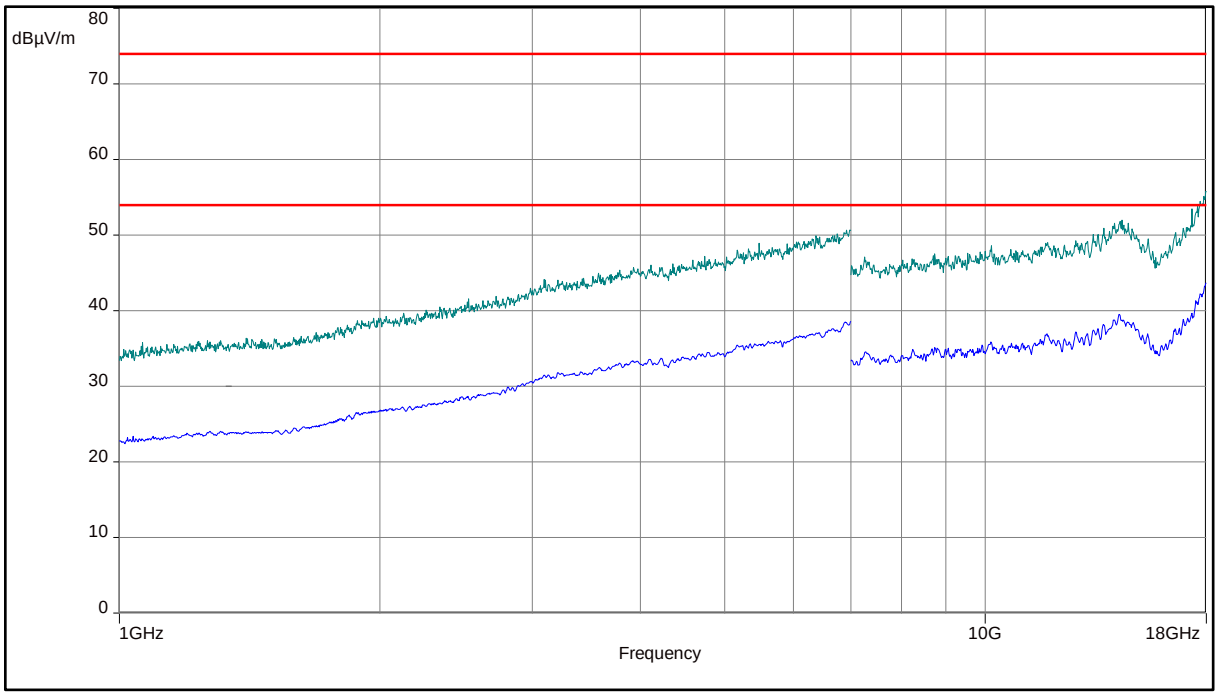


Plot 6: 30 MHz to 1 GHz

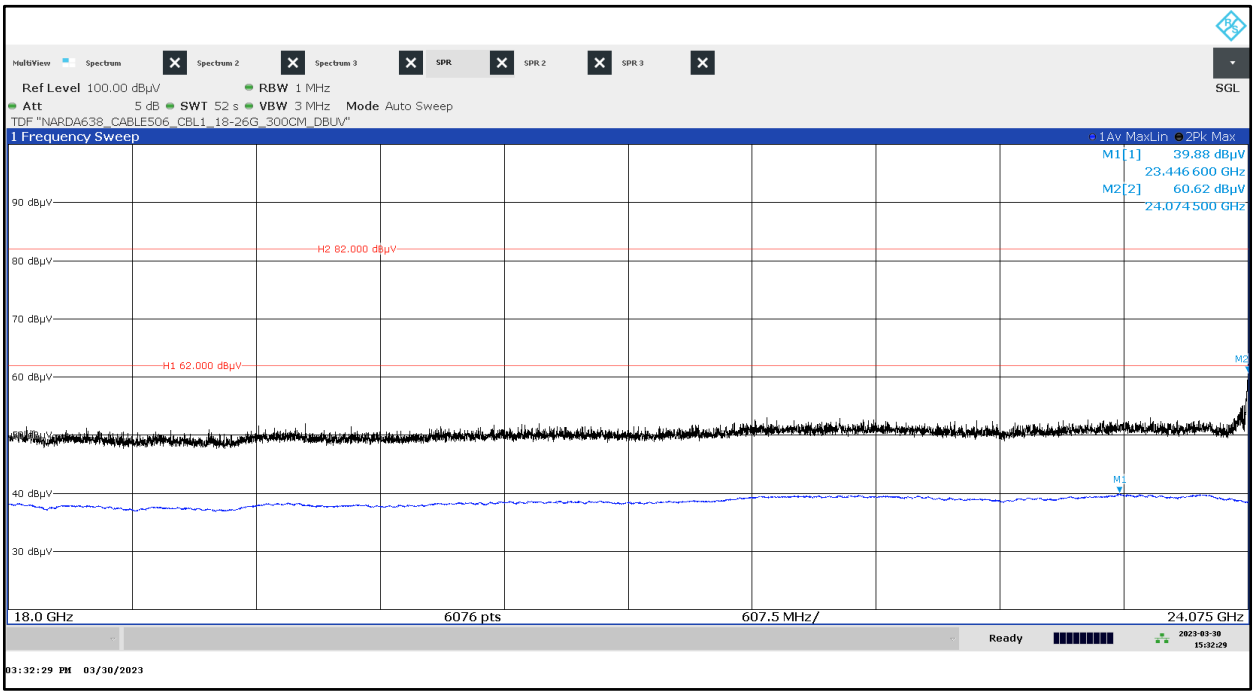


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
39.974	10.88	30.0	19.1	1000	120.0	400.0	V	3	15
44.663	10.47	30.0	19.5	1000	120.0	104.0	V	263	16
175.624	18.62	33.5	14.9	1000	120.0	146.0	V	5	11
450.227	7.80	36.0	28.2	1000	120.0	171.0	H	45	18
732.453	18.53	36.0	17.5	1000	120.0	195.0	H	0	23
905.208	21.10	36.0	14.9	1000	120.0	200.0	V	90	26

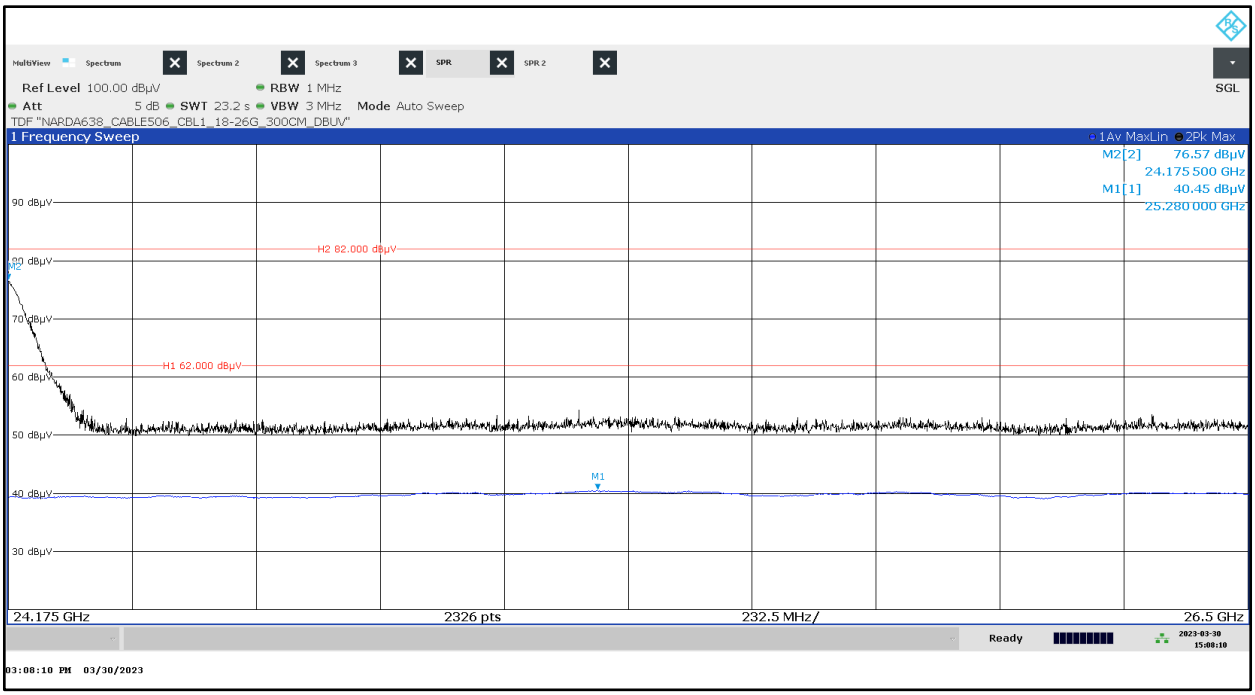
Plot 7: 1 GHz to 18 GHz



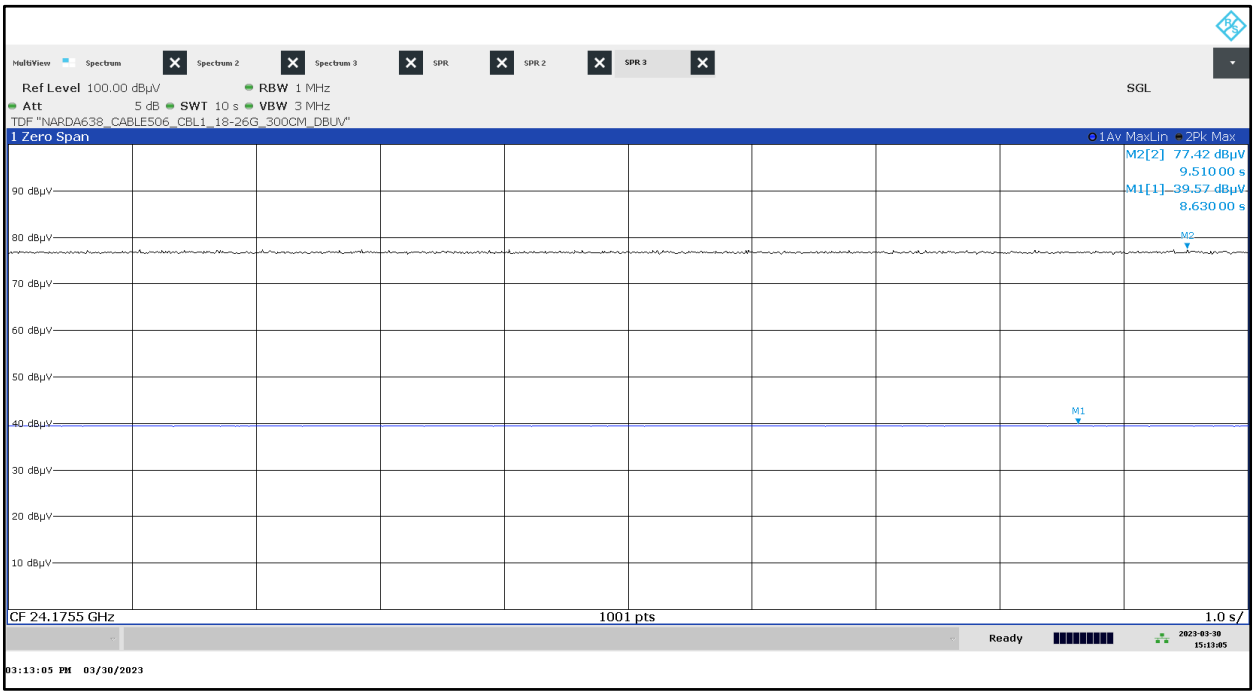
Plot 8: 18 GHz to 24.075 GHz up to lower band edge



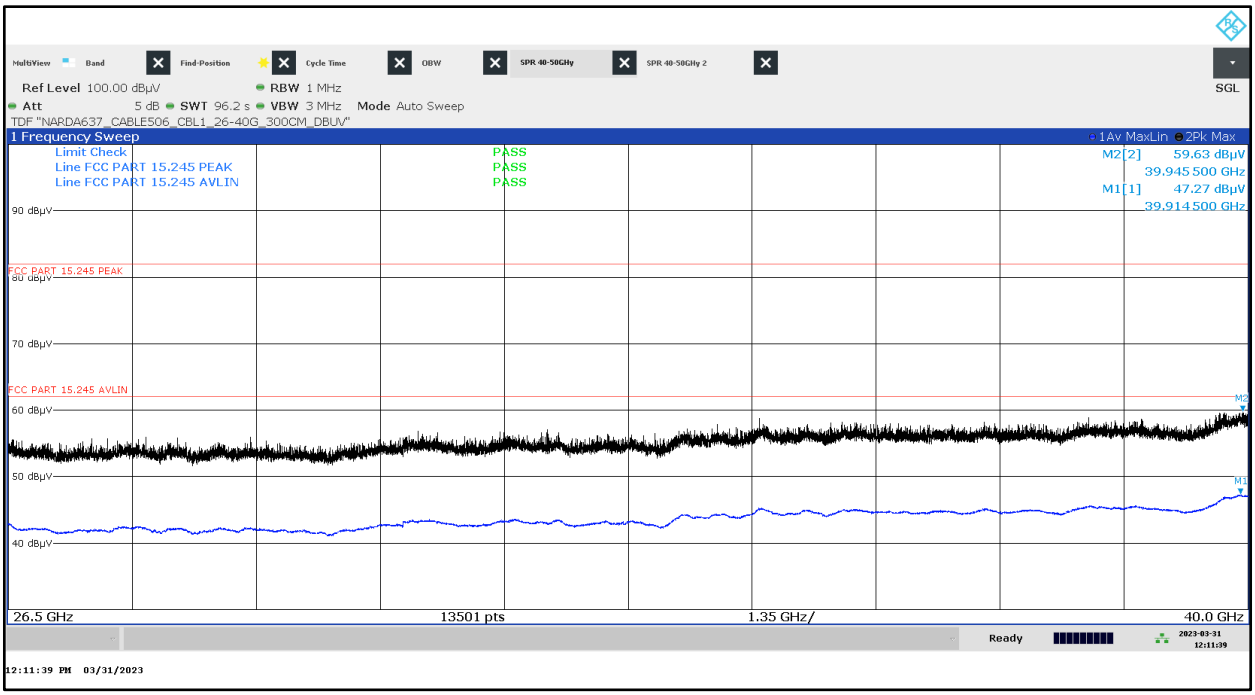
Plot 9: 24.175 GHz to 26.5 GHz



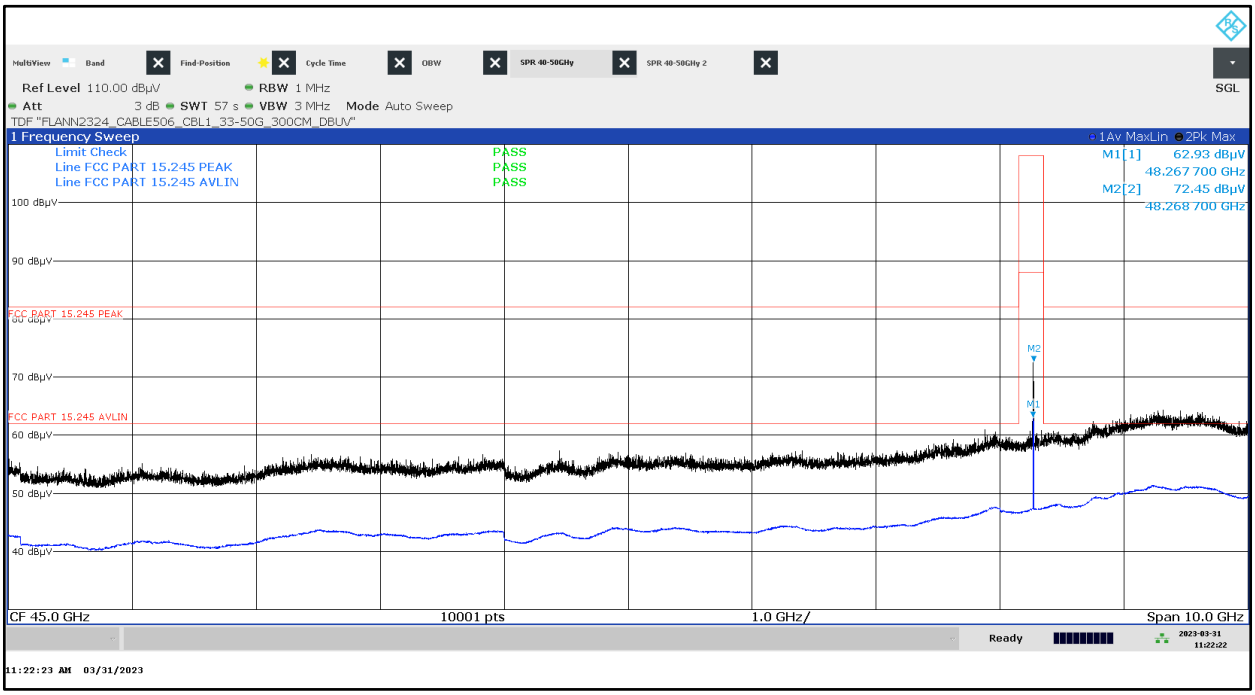
Plot 10: 24.175 GHz band edge



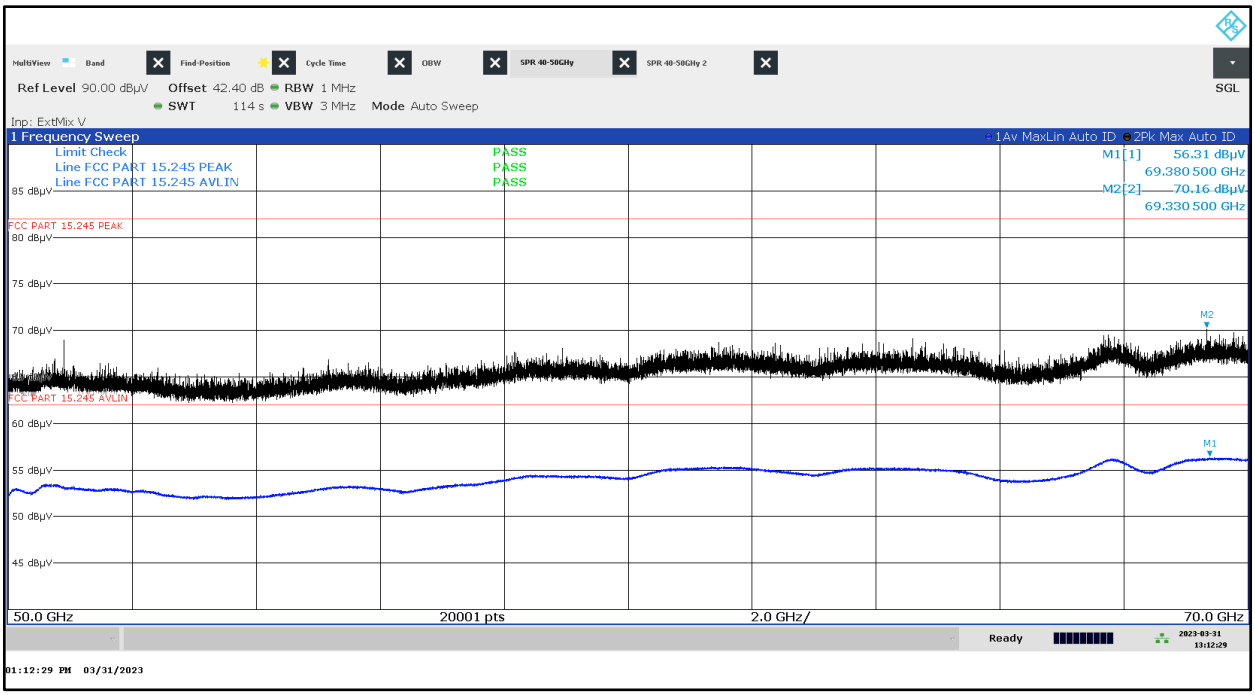
Plot 11: 26.5 GHz to 40 GHz



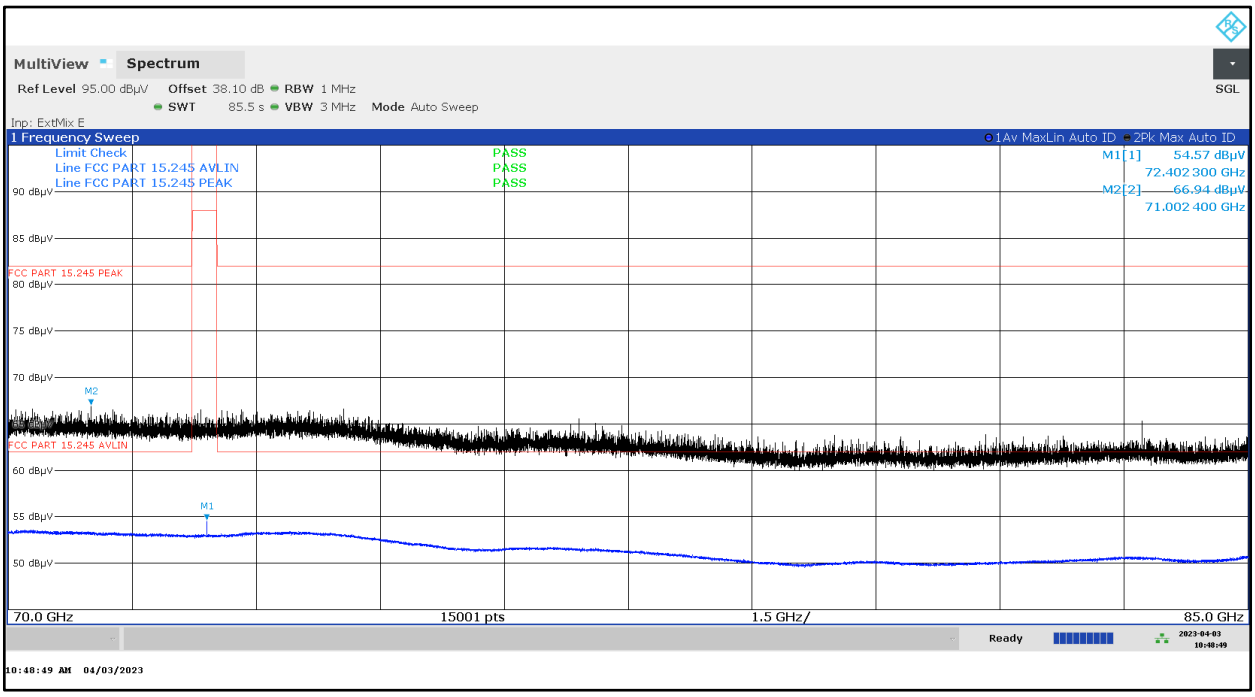
Plot 12: 40 GHz to 50 GHz



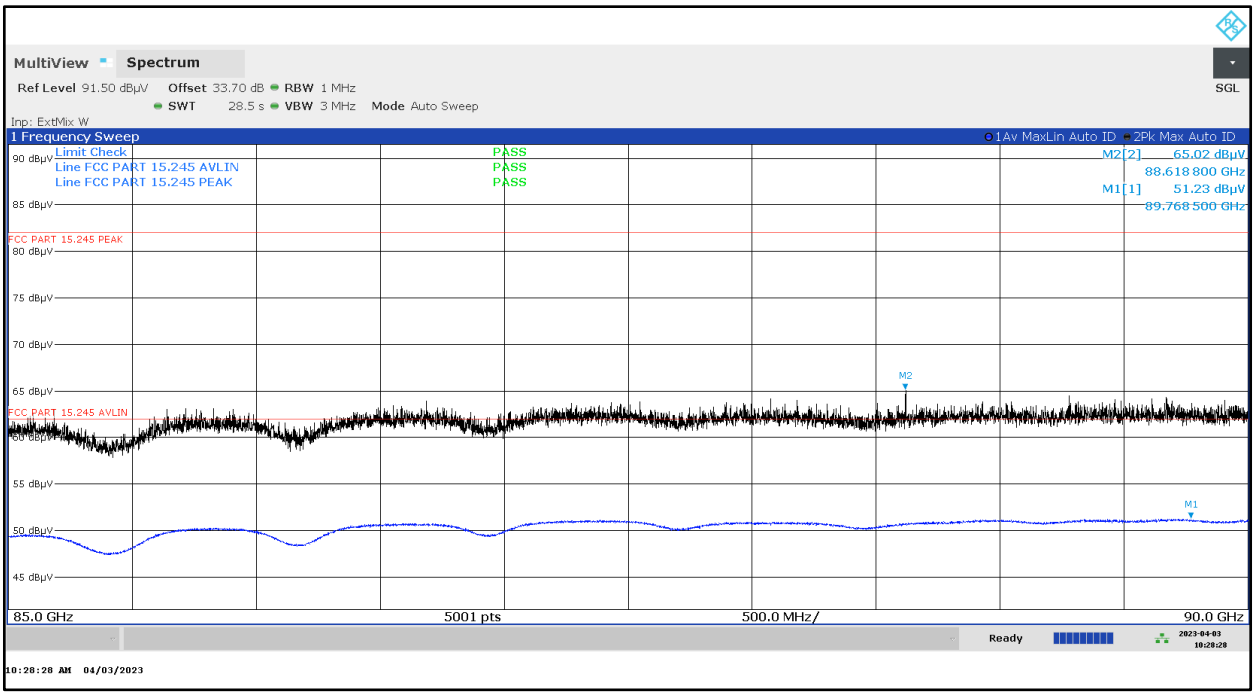
Plot 13: 50 GHz to 70 GHz



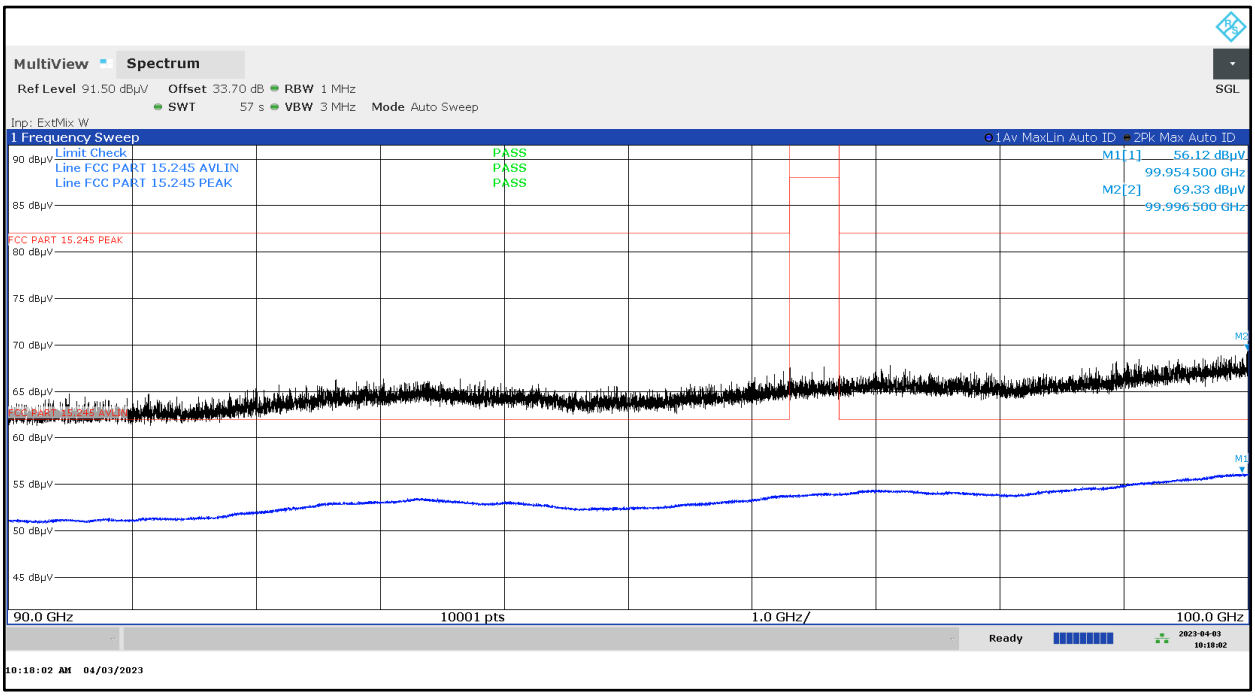
Plot 14: 70 GHz to 85 GHz



Plot 15: 85 GHz to 90 GHz



Plot 16: 90 GHz to 100 GHz



12.4 Conducted emissions < 30MHz

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

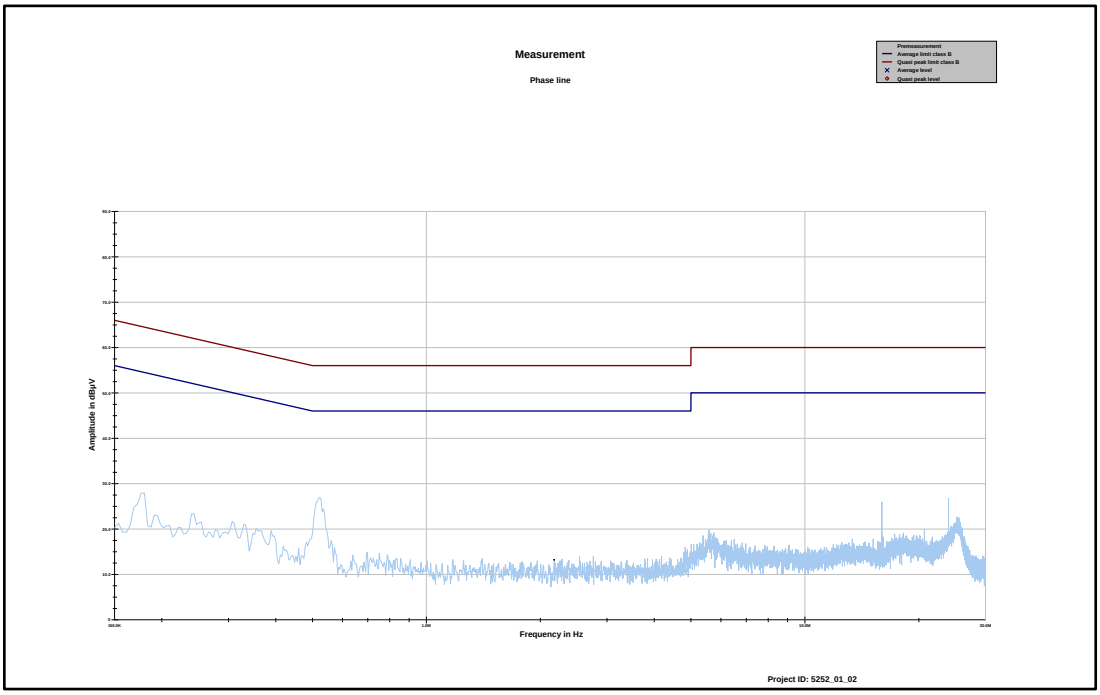
§15.207(c):
Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or 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:

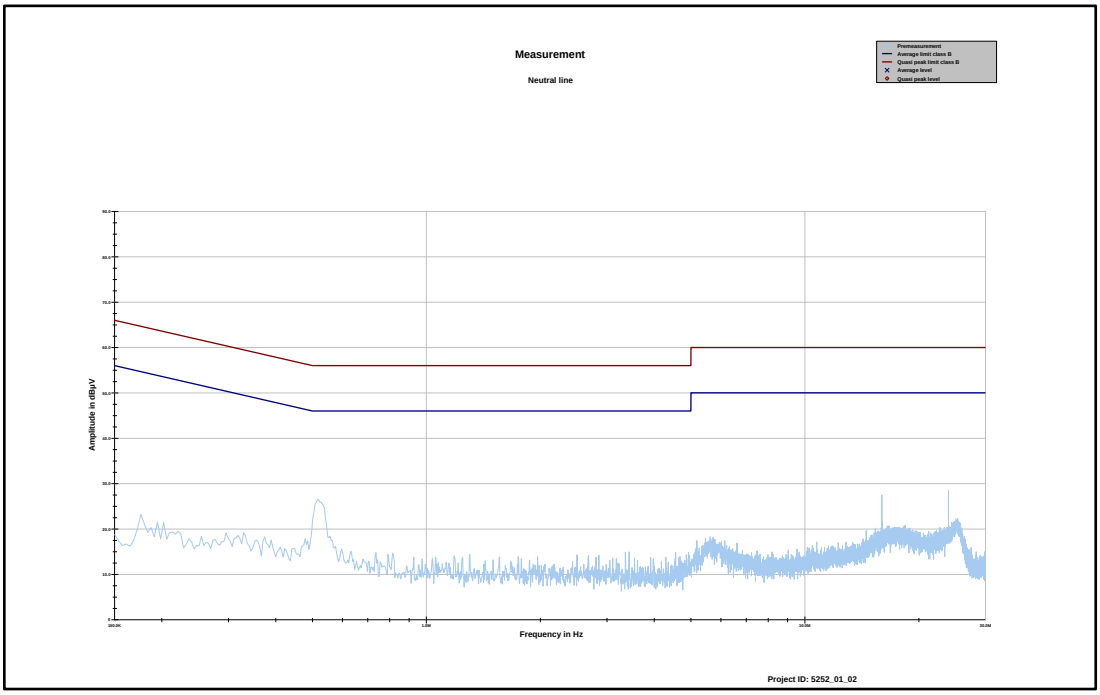
Parameter	
Detector:	Peak - Quasi Peak / Average
Sweep time:	Auto
Video bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Resolution bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold

Results:

Plot 17: Phase line



Plot 18: Neutral line



Verdict: Compliant

12.5 Prevention of continuous operation

Description:

Field disturbance sensors must include features to prevent continuous operation under certain conditions.

Limits and provisions:

§15.245(b)(1)(iii):
Field disturbance sensors designed to be used in motor vehicles or aircraft must include features to prevent continuous operation unless their emissions in the restricted bands, other than the second and third harmonics from devices operating in the 24075–24175 MHz band, fully comply with the limits given in § 15.209.
Continuous operation of field disturbance sensors designed to be used in farm equipment, vehicles such as fork lifts that are intended primarily for use indoors or for very specialized operations, or railroad locomotives, railroad cars and other equipment which travels on fixed tracks is permitted.
A field disturbance sensor will be considered not to be operating in a continuous mode if its operation is limited to specific activities of limited duration (e.g., putting a vehicle into reverse gear, activating a turn signal, etc.).

Results:

The provisions depend on the use case and the operation during specific activities. Ensuring compliance with these provisions is the responsibility of the manufacturer and cannot be verified in the laboratory environment.

Verdict: Not performed

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	2023-06-27
-A	FCC ID corrected, certificate information updated	2023-10-09

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