
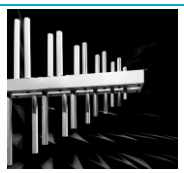
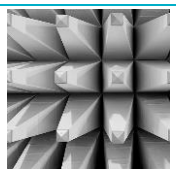

TEST REPORT

Test report no.: 1-8068-24-01-02_TR1-R01

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

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://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

OPTEX CO., LTD
5-8-12 Ogoto
520-0101, Otsu / JAPAN
Phone: +81(77)579-8000
Contact: Miho Iwaki
e-mail: m-iwaki@optex.co.jp

Manufacturer

InnoSenT GmbH Innovative Sensor-Technik
Am Rödertor 30
97499 Donnersdorf / 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:	**K-band Radar Transceiver**
Model name:	**IPS-965_UK**
FCC ID:	**DC9-IPS-965UK**
Frequency:	24.0 GHz – 24.25 GHz
Antenna:	Integrated patch antenna
Power supply:	4.25 V to 5.75 V DC from power supply
Temperature range:	-20°C to +60°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
2024.09.10 12:47:08 +02'00'

Thomas Vogler
Lab Manager
Radio Labs

Test performed:

M. Walla

cn=Meheza Walla, o=cetecom advanced GmbH, ou=WAL-230706, email=Meheza.Walla@cetecomadvanced.com, c=DE
2024.09.10 12:39:44 +02'00'

Meheza Walla
Lab Manager
Radio Labs

1 Table of contents

2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. 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.

2.2 Application details

Date of receipt of order:	2024-07-02
Date of receipt of test item:	2024-07-29
Start of test:*	2024-07-31
End of test:*	2024-08-16
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

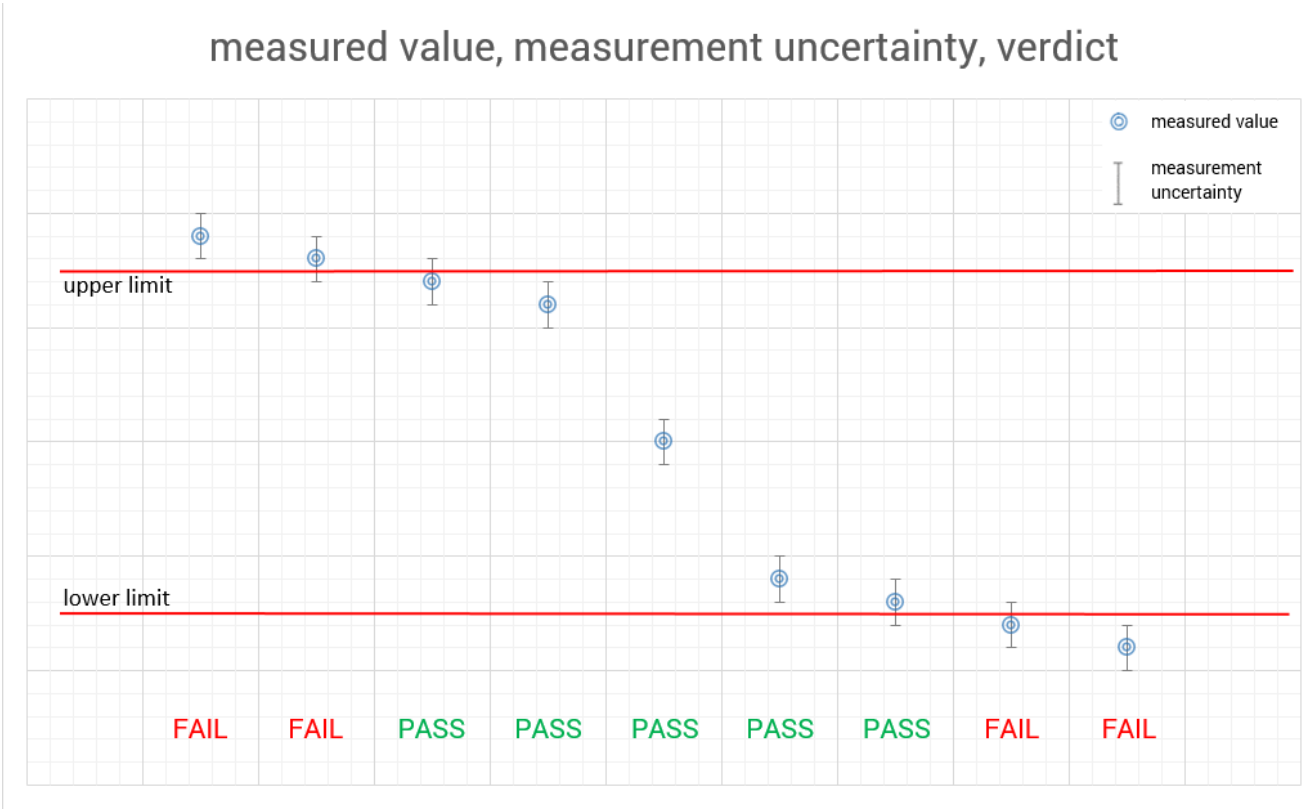
3 Test standard/s, references and accreditations

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
ANSI C63.26-2015	-/-	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

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 +60 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	5.0 V DC from power supply 5.75 V DC 4.25 V DC

6 Test item

6.1 General description

Kind of test item	:	K-band Radar Transceiver
Model name	:	IPS-965_UK
S/N serial number	:	00041350
Hardware status	:	965_2V1
Software status	:	-/-
Frequency band	:	24.0 GHz – 24.25 GHz
Type of modulation	:	CW
Number of channels	:	1
Antenna	:	Integrated patch antenna
Power supply	:	4.25 V to 5.75 V DC from power supply
Temperature range	:	-20°C to +60°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: 1-8068-24-01-02_TR1-A101-R01
1-8068-24-01-02_TR1-A102-R01
1-8068-24-01-02_TR1-A103-R01

Note: The referenced photos show EUT delivered by the customer in this project, not necessarily the exact one used for the specific tests. EUT identification shown in the photos may differ.

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).

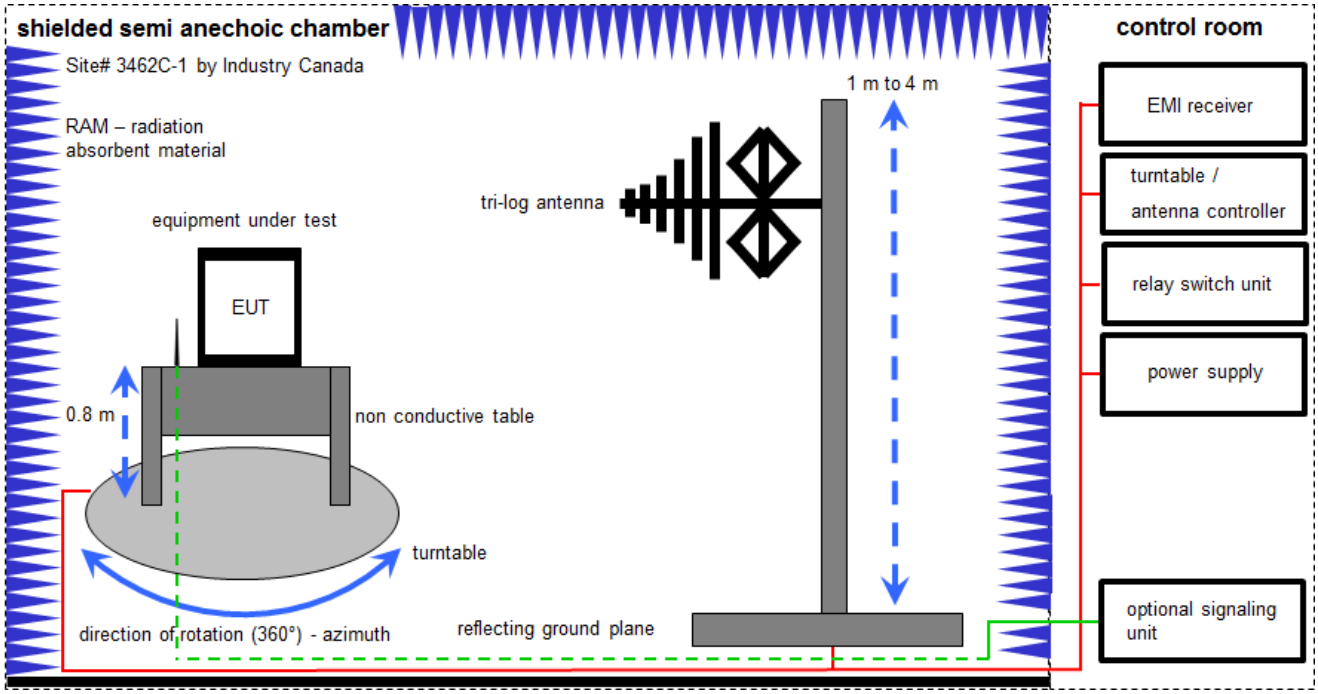
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

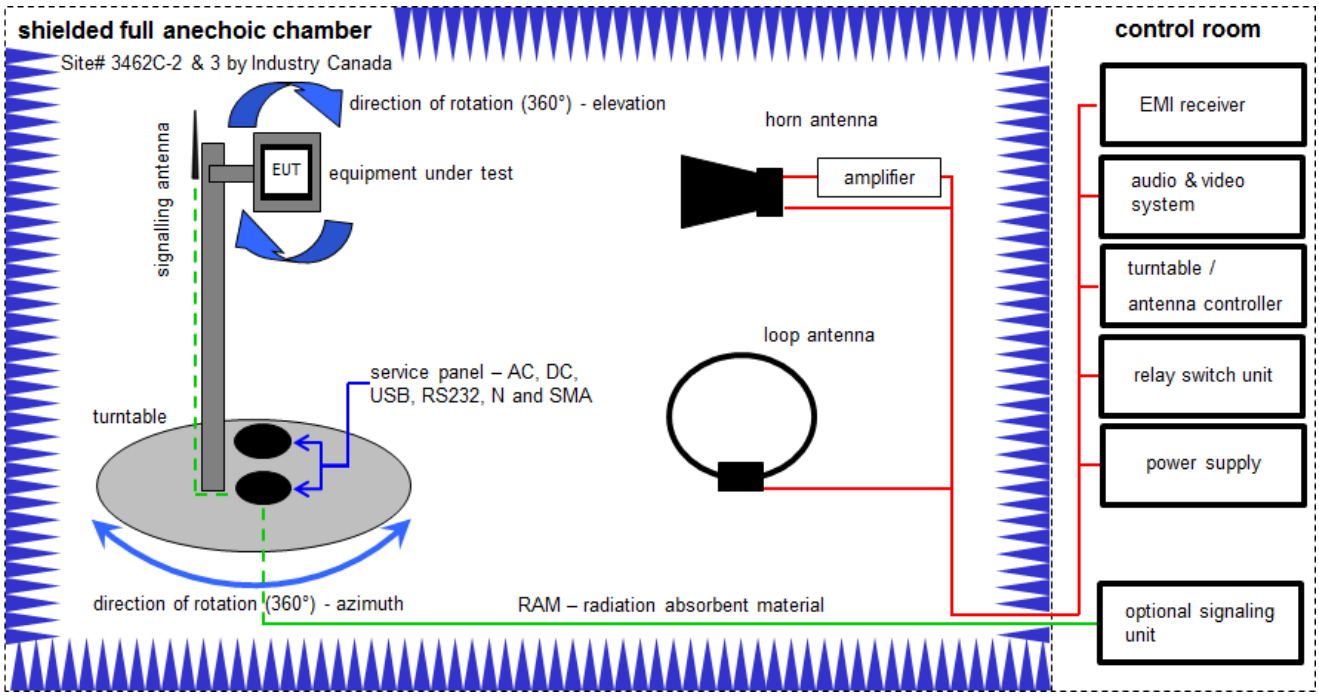
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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.	Meßkabine 1	HF-Absorberhalle	MWB AG 300023		300000551	ne	-/-	-/-
4	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
5	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
7	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	216	300003288	vlKl!	31.08.2023	31.08.2025
8	n. a.	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
9	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	06.12.2023	31.12.2024

7.2 Shielded fully anechoic chamber



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

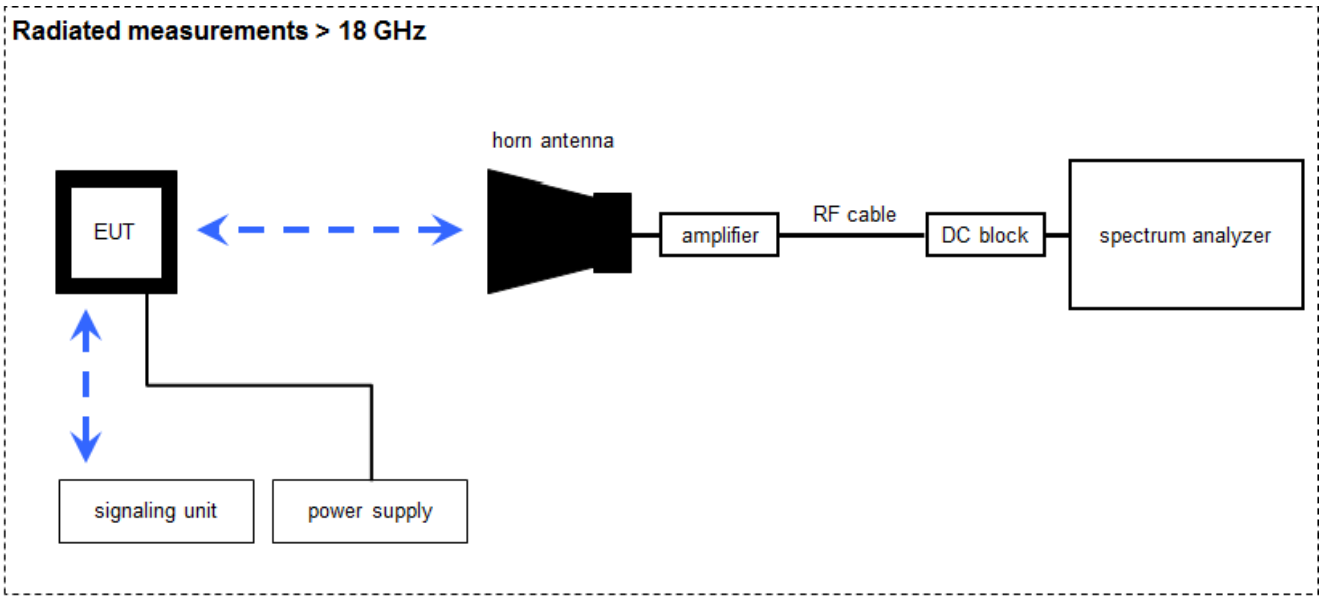
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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

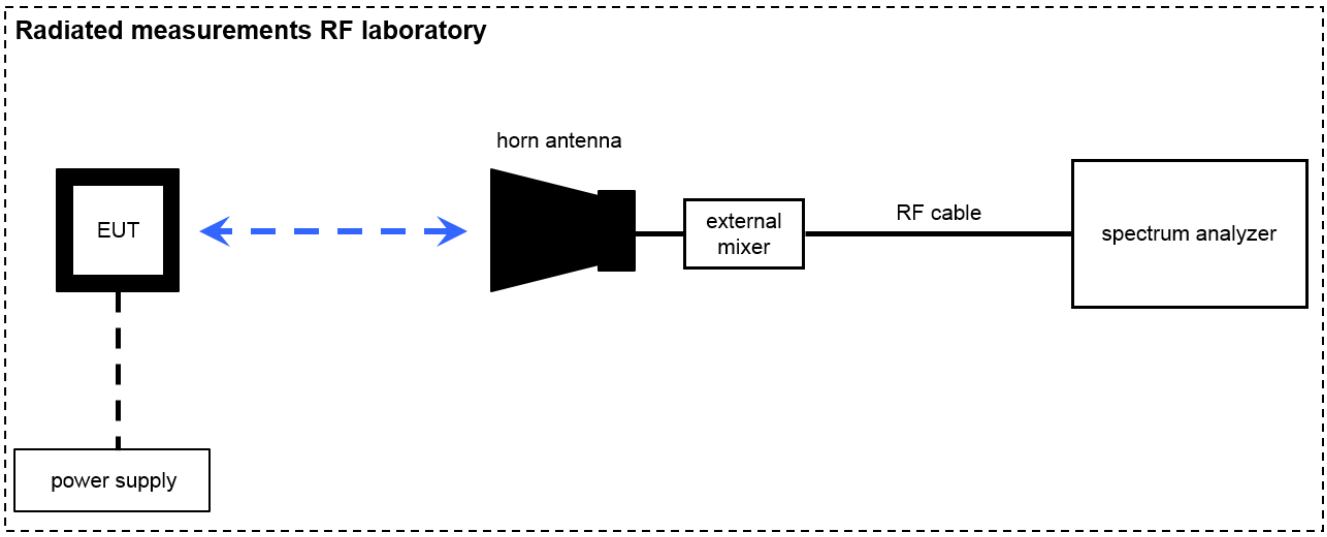
Equipment table:

No.	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3696	300001604	vlKl!	20.03.2023	19.03.2025
2	Highpass Filter	WHK1.1/15G-10SS	Wainwright	37	400000148	ne	-/-	-/-
3	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne	-/-	-/-
4	Band Reject Filter	WRCG2400/2483-2375/2505-50/10SS	Wainwright	26	300003792	ne	-/-	-/-
5	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vlKl!	23.05.2023	31.05.2025
6	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22051	300004483	ev	-/-	-/-
7	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne	-/-	-/-
8	NEXIO EMV-Software	BAT EMC V2022.0.22.0	Nexio	-/-	300004682	ne	-/-	-/-
9	Anechoic chamber	-/-	TDK	-/-	300003726	ne	-/-	-/-
10	EMI Test Receiver 9kHz-26,5GHz	ESR26	Rohde & Schwarz	101376	300005063	k	15.01.2024	31.01.2025

7.3 Radiated measurements > 18 GHz



7.4 Radiated measurements > 50/85 GHz



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

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

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n.a.	Horn Antenna 18.0-40.0 GHz	LHAF180	Microw.Devel	39180-103-021	300001747	vIKI!	24.01.2024	23.01.2026
2	n. a.	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda		300000486	vIKI!	24.01.2024	23.01.2026
3	n. a.	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	vIKI!	24.01.2024	23.01.2026
4	n.a.	Std. Gain Horn Antenna 40-60 GHz	2424-20	Flann	76	400001981	ne	-/-	-/-
5	n. a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
6	n. a.	Std. Gain Horn Antenna 60-90 GHz	COR 60_90	Thomson CSF		300000814	ev	-/-	-/-
7	n. a.	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-
8	n.a.	Std. Gain Horn Antenna 92.3-140 GHz	2824-20	Flann		300001993	ne	-/-	-/-
12	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	22.04.2024	21.04.2026
13	n. a.	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	Rohde & Schwarz	101578	300005788	k	23.07.2024	31.07.2025
14	n. a.	Harmonic Mixer 3-Port, 60-90 GHz	FS-Z90	R&S	101555	300004691	k	01.08.2024	31.08.2025
16	n.a.	Harmonic Mixer 3-port, 90-140 GHz	FS-Z140	Rohde & Schwarz	101119	300005581	k	01.08.2024	31.08.2025
17	n. a.	Spectrum Analyzer 2 Hz - 50 GHz	FSW50	R&S	101560	300006179	k	30.01.2024	31.01.2025
18	n.a.	Power Supply	E3632A	Agilent Technologies	MY40001320	400000396	ev	14.12.2021	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 50/85 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 40 GHz)	± 1 dB
Radiated unwanted emissions in the spurious domain (up to 40 GHz)	± 3 dB
Conducted unwanted emissions in the spurious domain (40 to 50 GHz)	± 4 dB
Radiated unwanted emissions in the spurious domain (40 to 50 GHz)	± 4 dB
Conducted unwanted emissions in the spurious domain (50 to 300 GHz)	± 5 dB
Radiated unwanted emissions in the spurious domain (50 to 300 GHz)	± 5 dB
DC and low frequency voltages	± 3 %
Temperature	± 1 °C
Humidity	± 3 %

10 Far field consideration for measurements above 18 GHz

Far field distance calculation:

$D_{ff} = 2 \times D^2 / \lambda$

with
D_{ff} Far field distance
D Antenna dimension
λ wavelength

Spurious emission measurements:

Antenna frequency Range in GHz	Highest measured frequency in GHz	D in cm	λ in cm	D_{ff} in cm
18-26	26	3.4	1.15	20.04
26-40	40	2.2	0.75	12.91
40-50	50	2.77	0.60	25.58
50-75	75	1.85	0.40	17.11
75-110	110	1.24	0.27	11.28

11 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	2024-09-10	-/-

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
§15.215(c) / §15.249 (b)(2)	99% Occupied Bandwidth and frequency stability of the wanted signal	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies
§15.249(a), (c), (e),	Field strength of fundamental emission	Nominal	Nominal	☒	☐	☐	☐	complies
§15.209(a) / §15.249(d)	Field strength of emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207(a)	Conducted emissions < 30 MHz	Nominal	Nominal	☐	☐	☒	☐	complies

Note: NA = Not applicable; NP = Not performed

12 Additional comments

Reference documents:
- None

Special test descriptions:
- None

Configuration descriptions:
- None

Kind of device:

☐ Fixed, point-to-point operation system

☐ Point-to-multipoint system, omnidirectional application or multiple co-located intentional radiators transmitting the same information

☒ Other

Note:
- §15.249(a): Operation within the band 24.0-24.25 GHz.

Test devices (EUT):
- EUT : CW modulation

Associated equipment (AE):
- None

Additional test modes:

☒ No test modes available

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

☐ Stop-Modes (see description below)

Description of special test modes as declared by customer:
- None

Details on test mode settings:
- None

Software provided by the manufacturer:
- None

13 Measurement results

13.1 Occupied bandwidth (99% bandwidth) and frequency stability of the wanted signal

Description:

§15.249 (a):

Measurement of the 99% bandwidth and the frequency stability of the wanted signal (fundamental emission) under temperature and supply voltage variations.

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs. […]

§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.

Frequency range	f_L	f_H
250 MHz	> 24.0 GHz	< 24.25 GHz

Measurement:

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

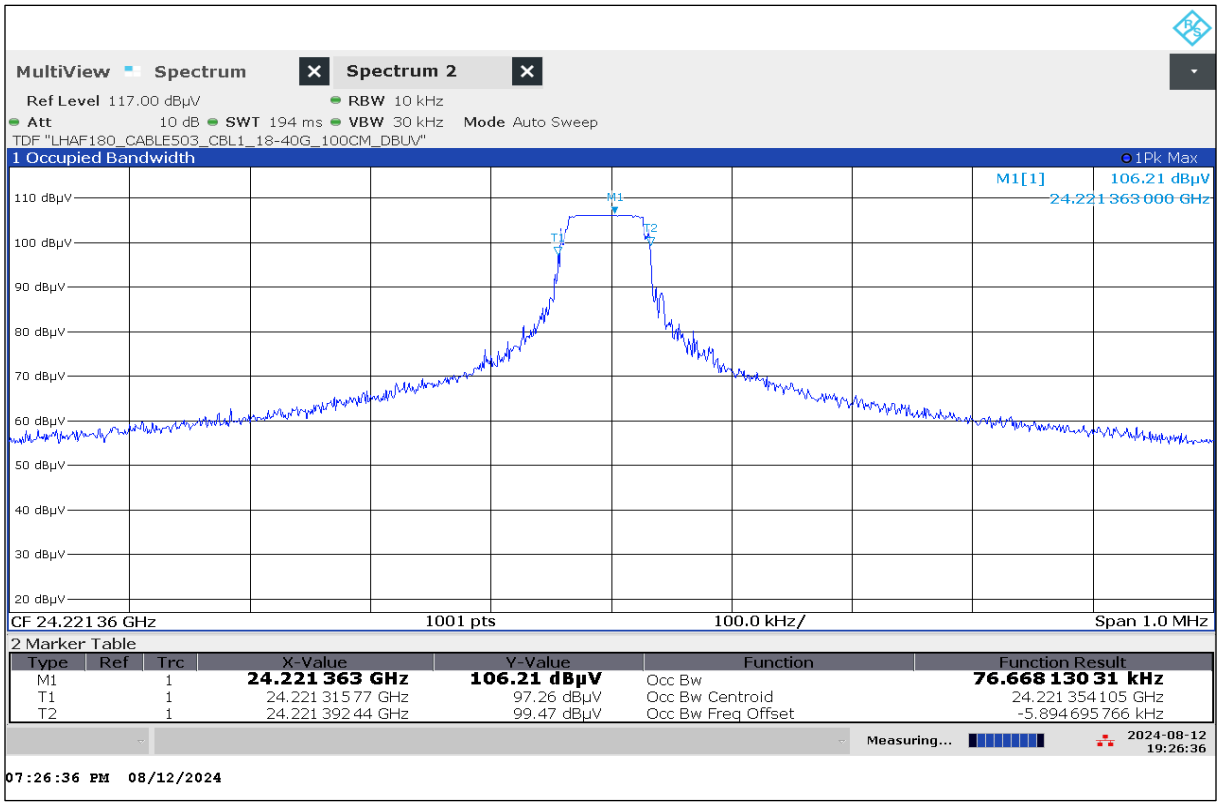
Measurement results:

Frequency stability / tolerance: 99% bandwidth:

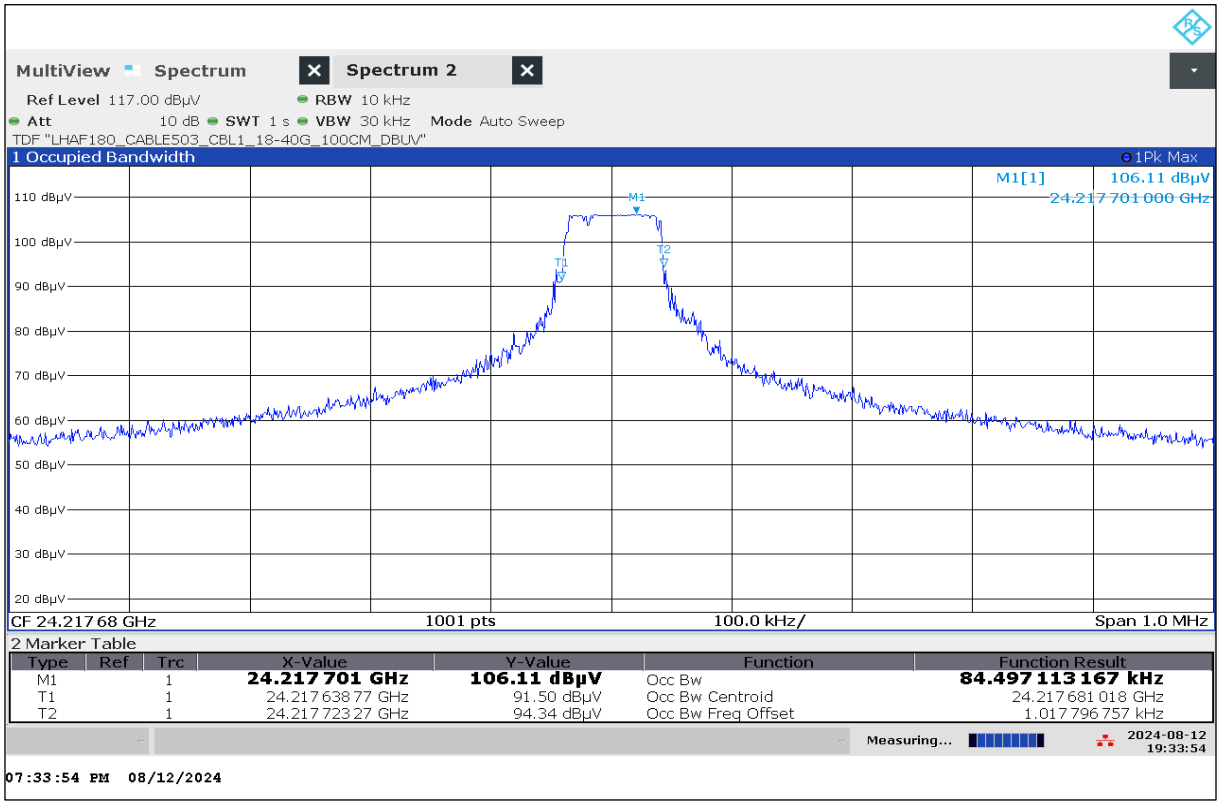
Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [kHz]
-20 °C / V_{nom}	24.221 315 770	24.221 392 440	77
-10 °C / V_{nom}	24.217 638 770	24.217 723 270	84
0 °C / V_{nom}	24.213 006 290	24.213 083 810	78
10 °C / V_{nom}	24.207 086 860	24.207 163 280	76
20 °C / $V_{min-max}$	24.201 931 110	24.202 011 750	81
30 °C / V_{nom}	24.195 519 530	24.195 613 760	94
40 °C / V_{nom}	24.189 620 630	24.189 696 350	76
50 °C / V_{nom}	24.183 972 730	24.184 057 750	85

Verdict: **Compliant**

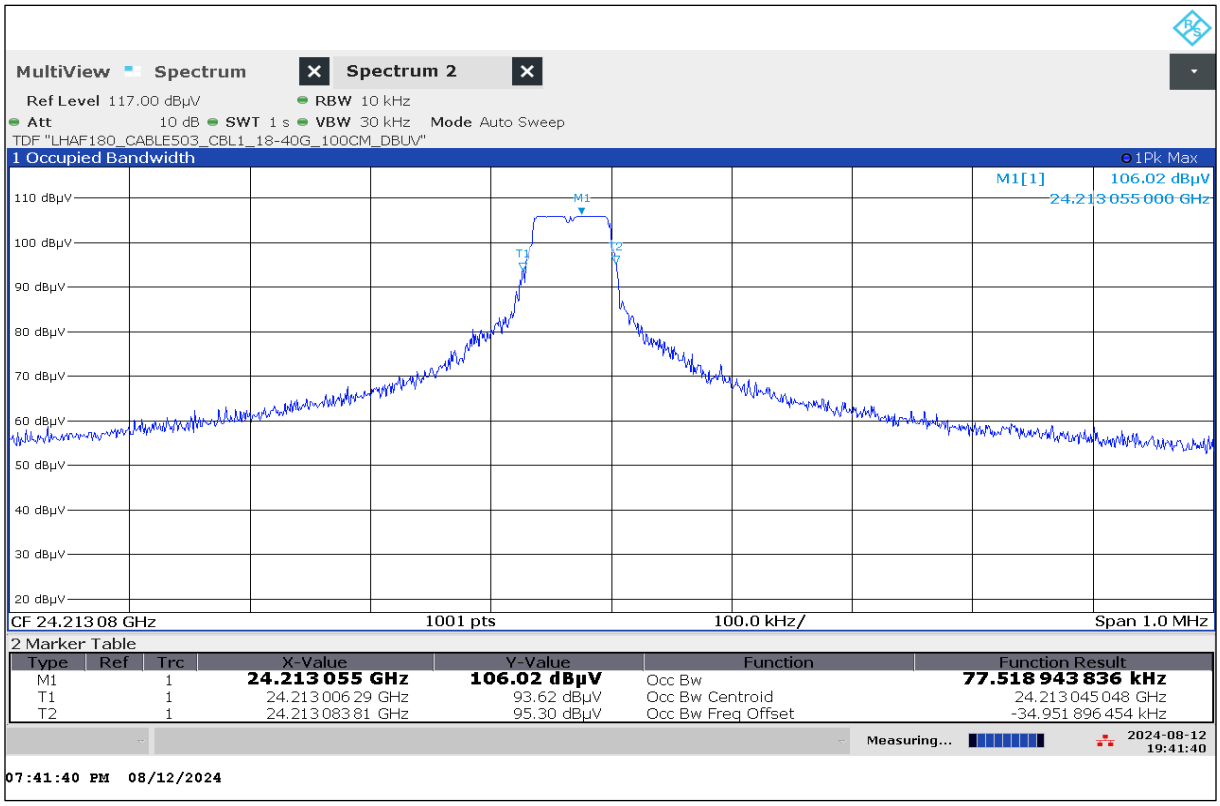
Plot No. 1: OBW, -20 °C / V_{nom}



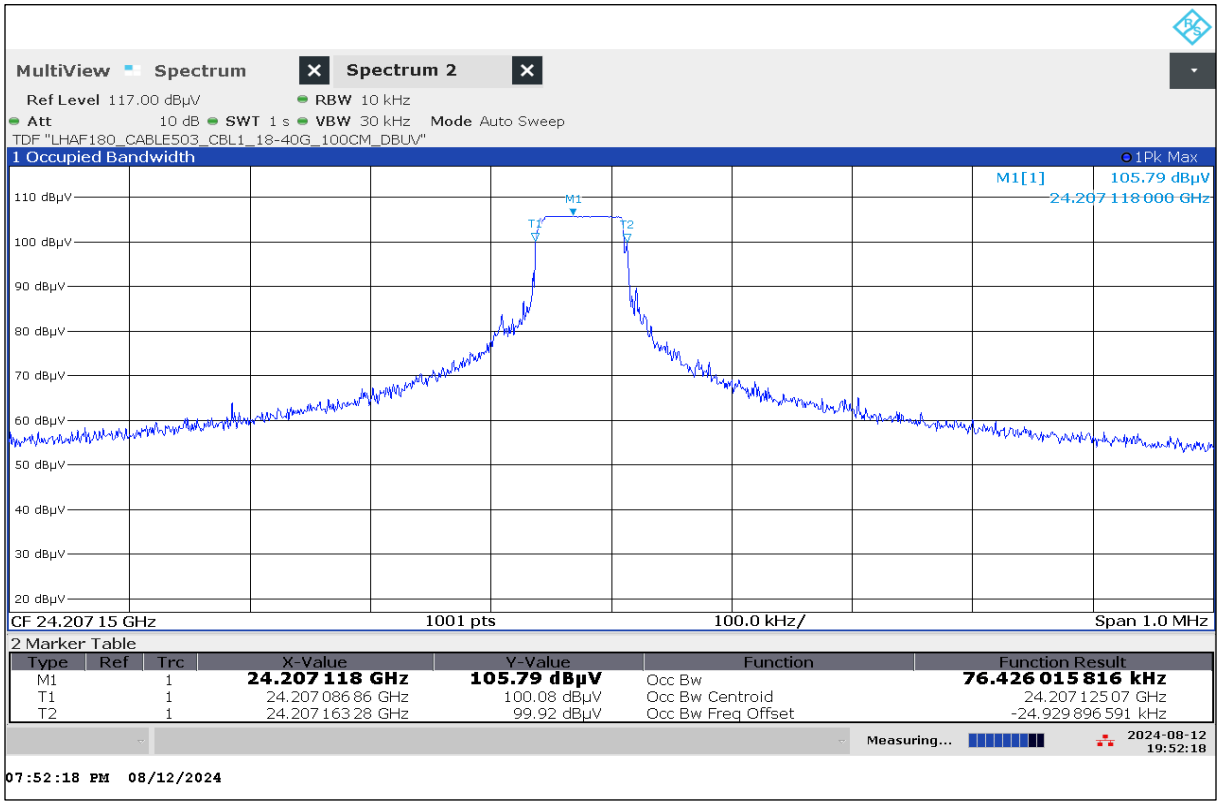
Plot No. 2: OBW, -10 °C / V_{nom}



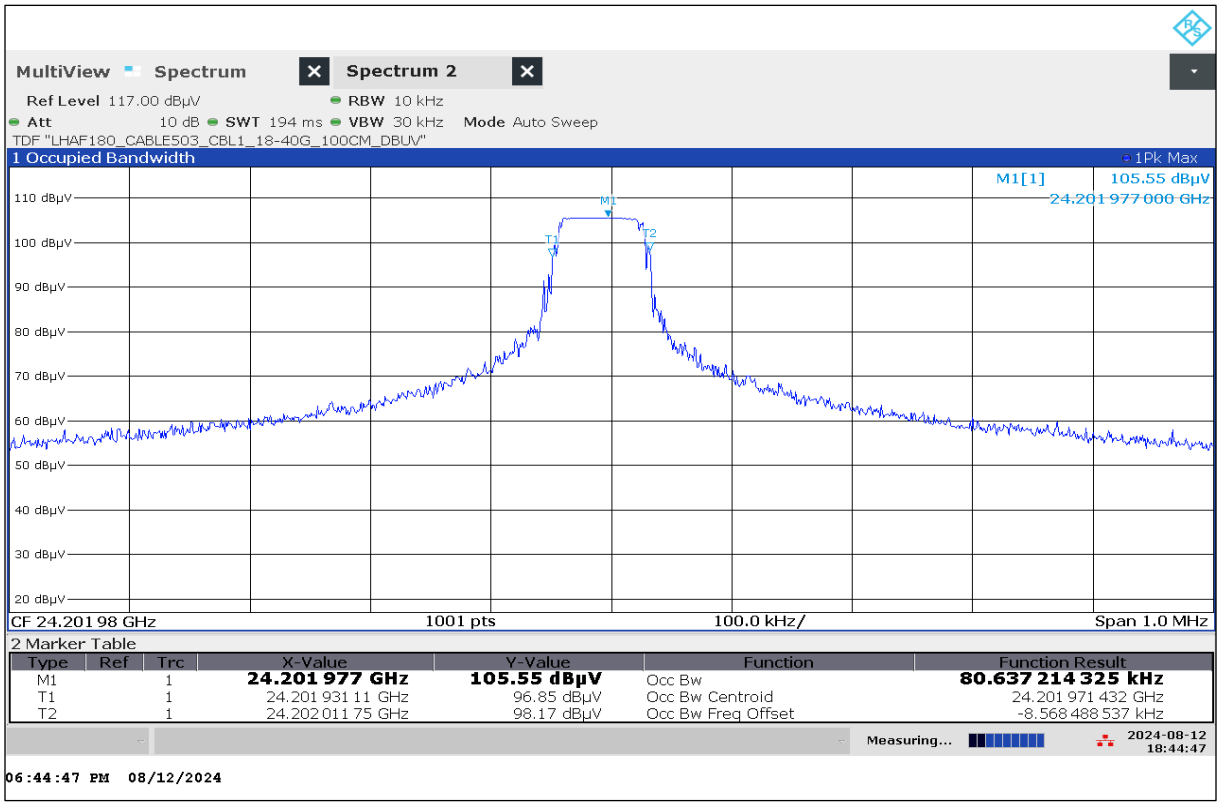
Plot No. 3: OBW, 0 °C / V_{nom}



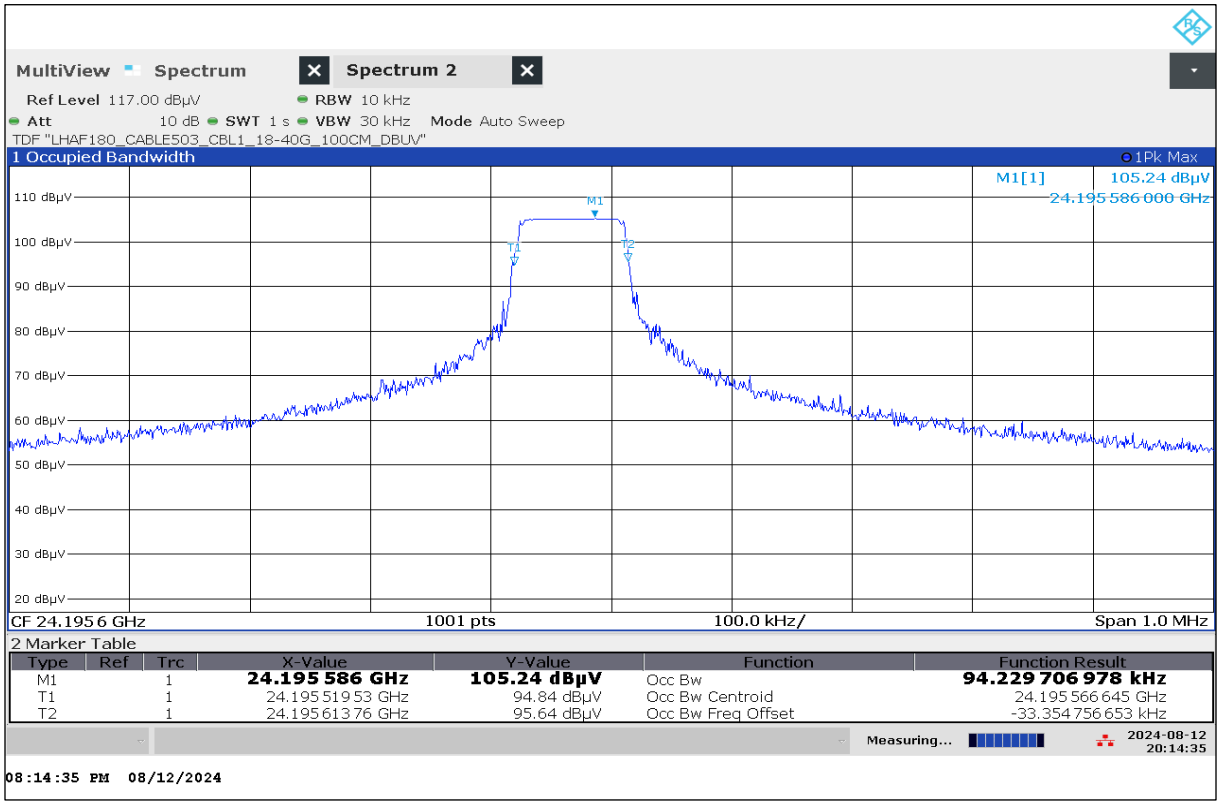
Plot No. 4: OBW, 10 °C / V_{nom}



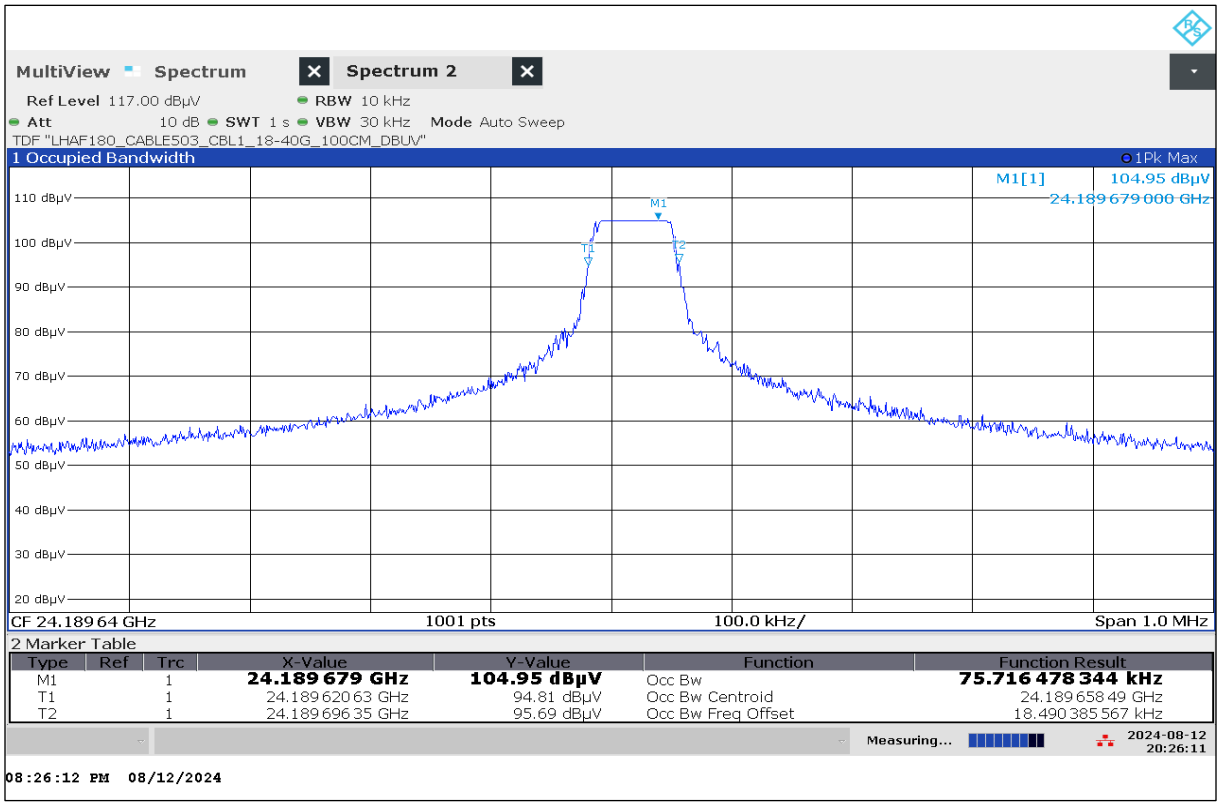
Plot No. 5: OBW, 20 °C / $V_{min-max}$



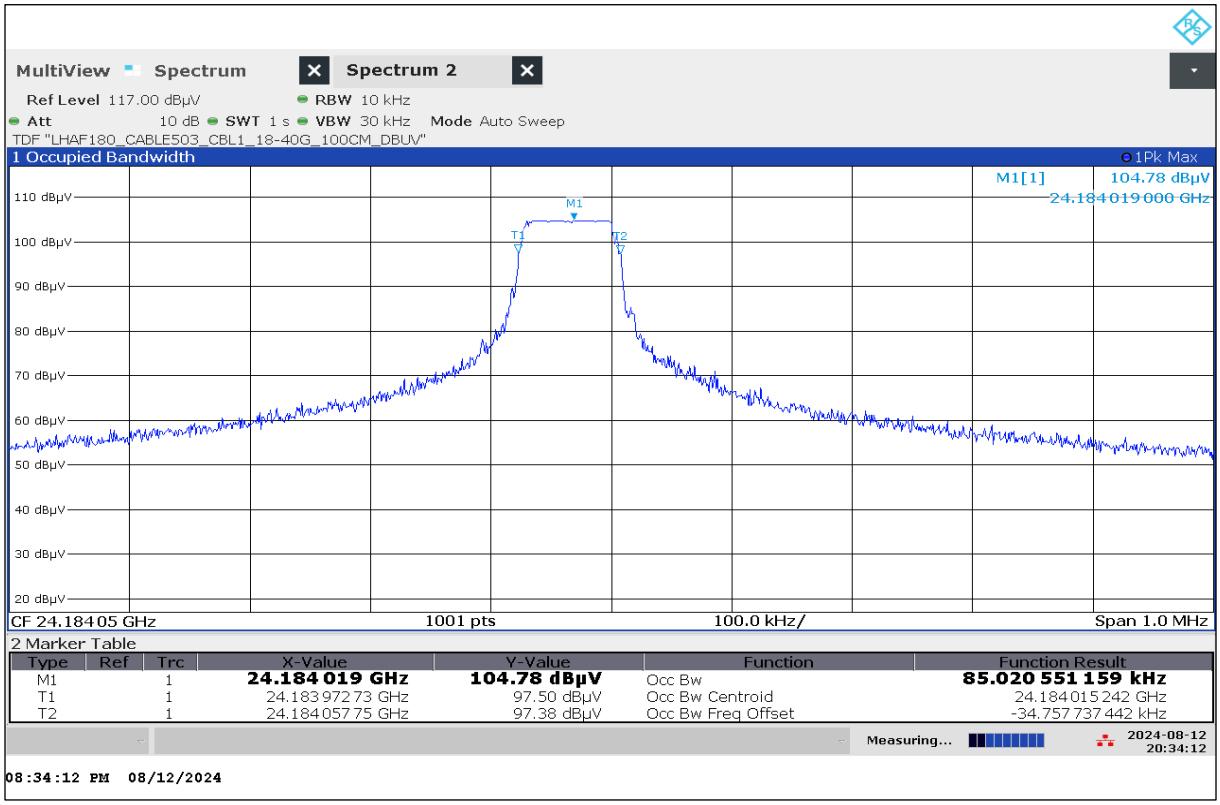
Plot No. 6: OBW, 30 °C / V_{nom}



Plot No. 7: OBW, 40 °C / V_{nom}



Plot No. 8: OBW, 50 °C / V_{nom}



13.2 Field strength of fundamental emission

Description:

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

Limits and provisions:

§15.249 (a):
Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Kind of device	Fundamental frequency (GHz)	Field strength of fundamental (mV/m)
Other	24.0-24.25	250

§15.249 (c):
Field strength limits are specified at a distance of 3 meters.

§15.249 (e):
As shown in § 15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the **peak field strength** of any emission shall not exceed the maximum permitted average limits specified above by more than **20 dB** under any condition of modulation.

Frequency	Field Strength	Measurement distance
24.0 GHz – 24.25 GHz	108 dBµV/m (Average) 128 dBµV/m (PEAK)	3 m

Measurement:

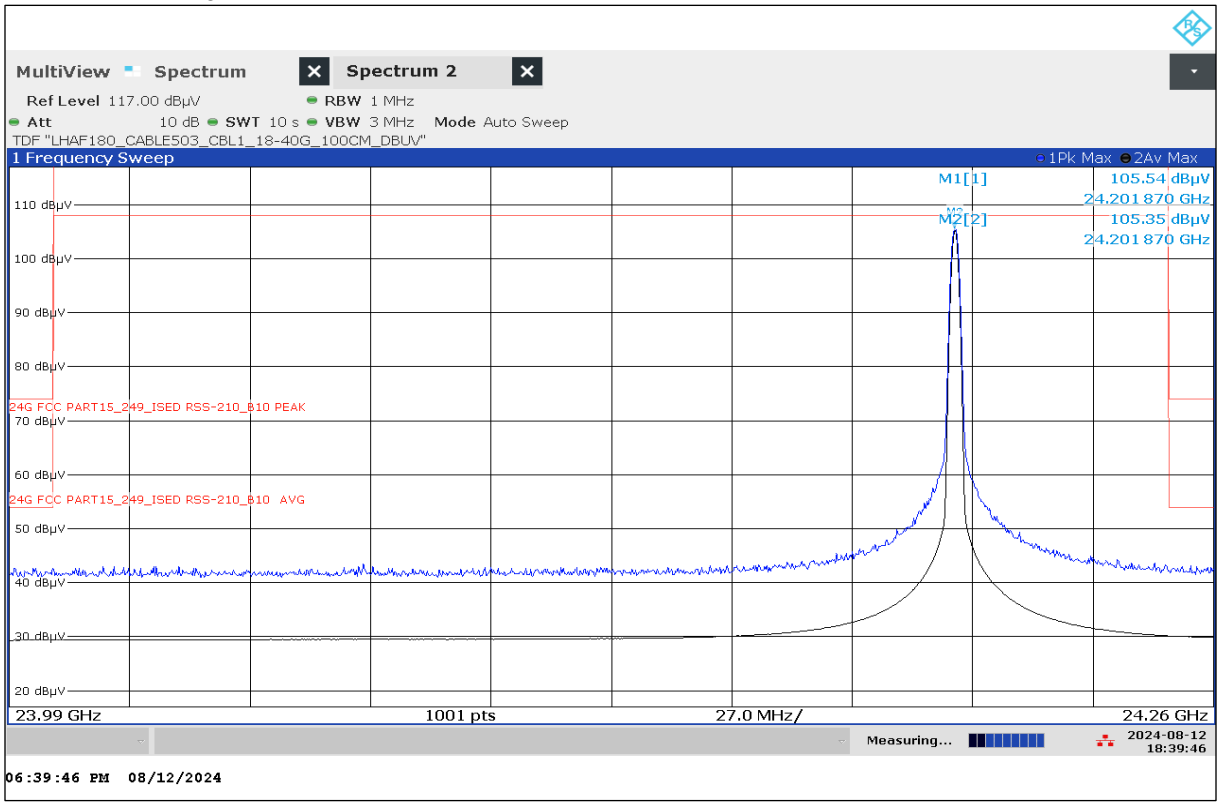
Measurement parameter	
Detector:	Peak / Linear average
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

Measurement results:

Test condition	Maximum field strength (Peak) (dBµV/m @3m)	Maximum field strength (Average) (dBµV/m @3m)
T_{nom} / V_{nom}	105.5	105.4

Verdict: **Compliant**

Plot No. 9: Field Strength, T_{nom} / V_{nom}



13.3 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:

§15.209 (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

§15.249 (d):
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.

Measurement:

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

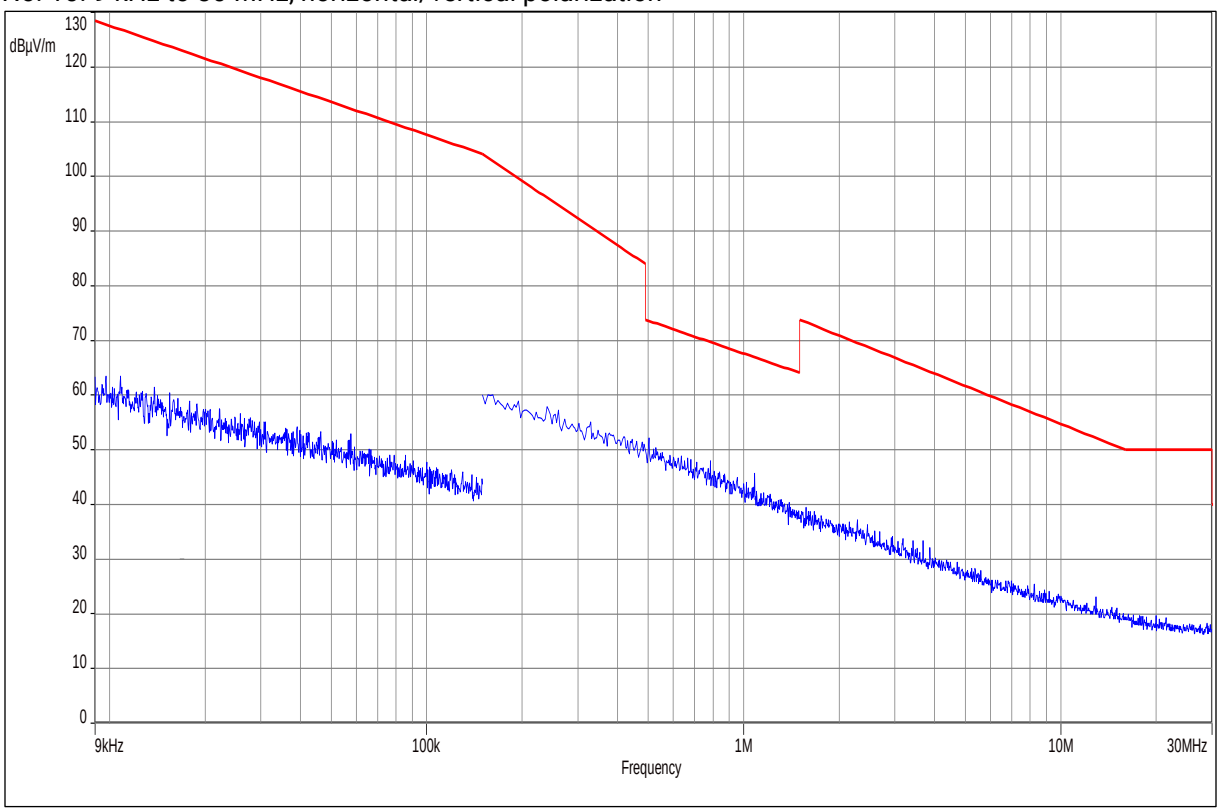
Measurement results:

Emissions radiated outside of the specified frequency bands:

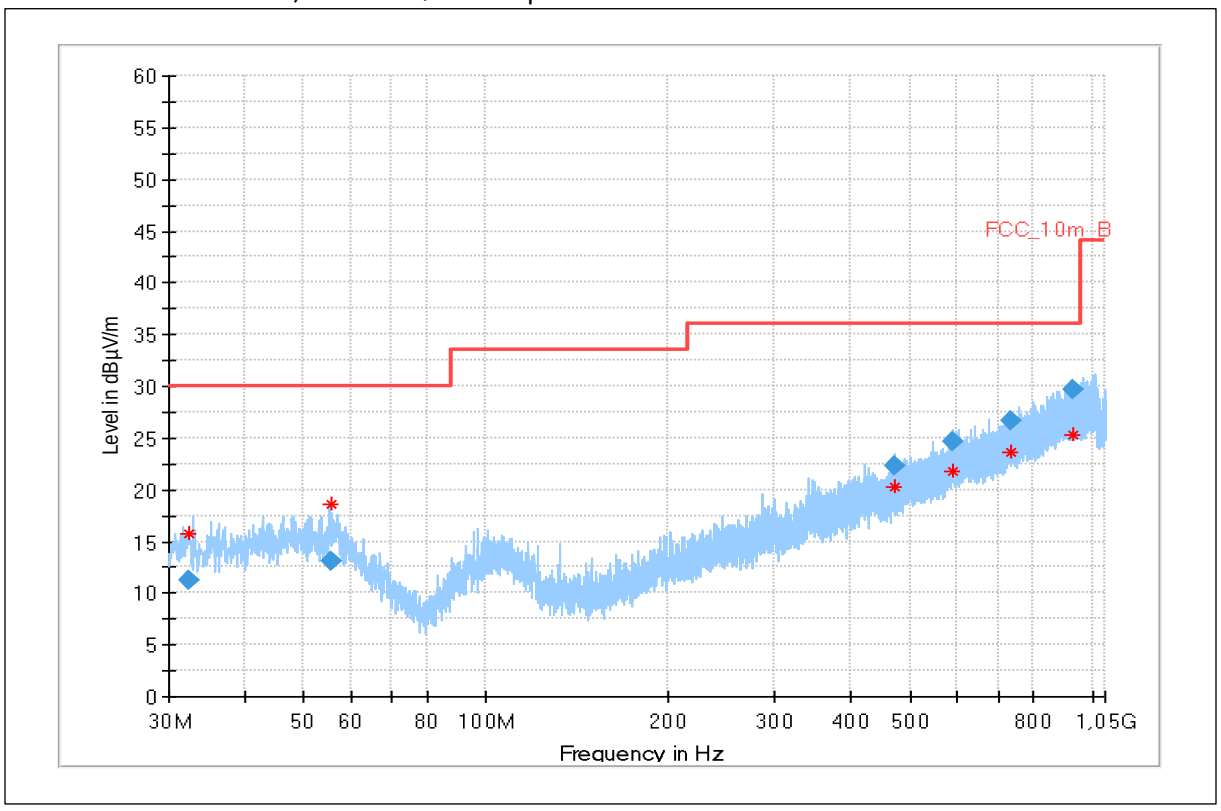
Frequency f [MHz]	Detector	Measured level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
Please refer to the following plots for more information on the level of spurious emissions				
-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-

Verdict: Compliant

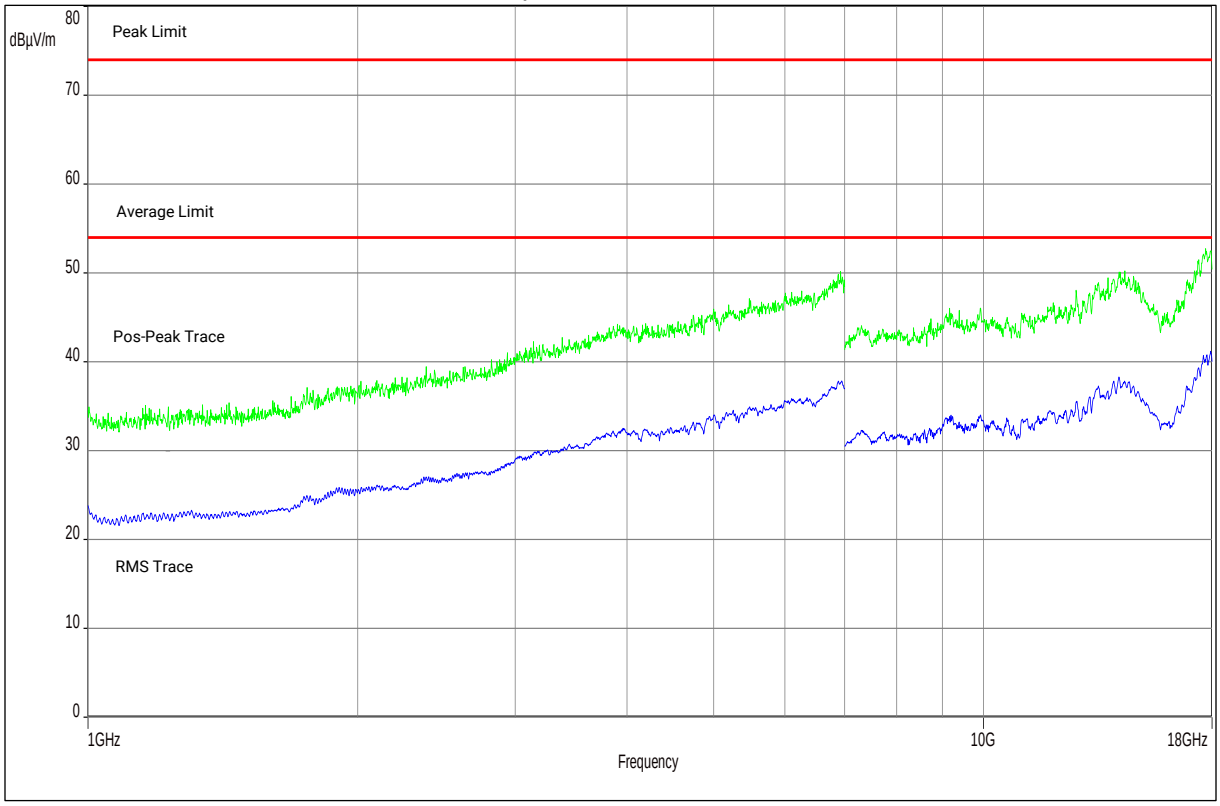
Plot No. 10: 9 kHz to 30 MHz, horizontal/vertical polarization



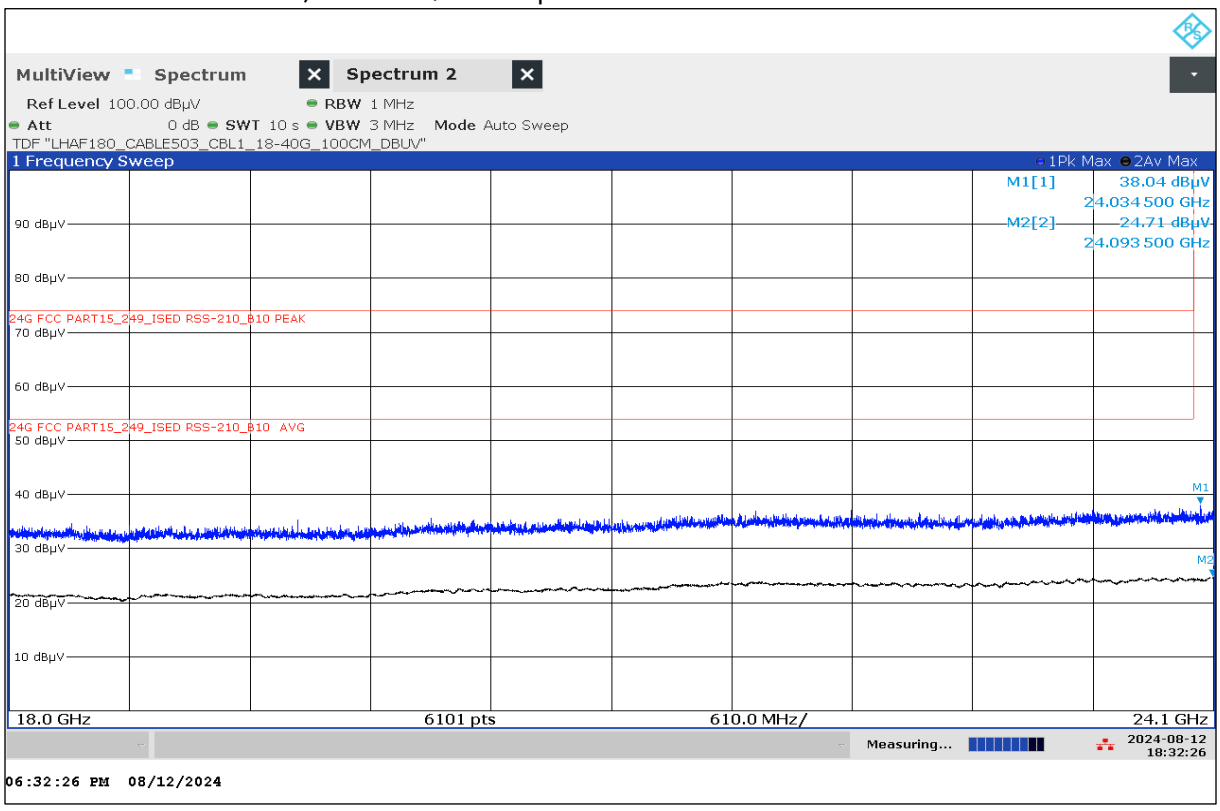
Plot No. 11: 30 MHz to 1 GHz, horizontal/vertical polarization



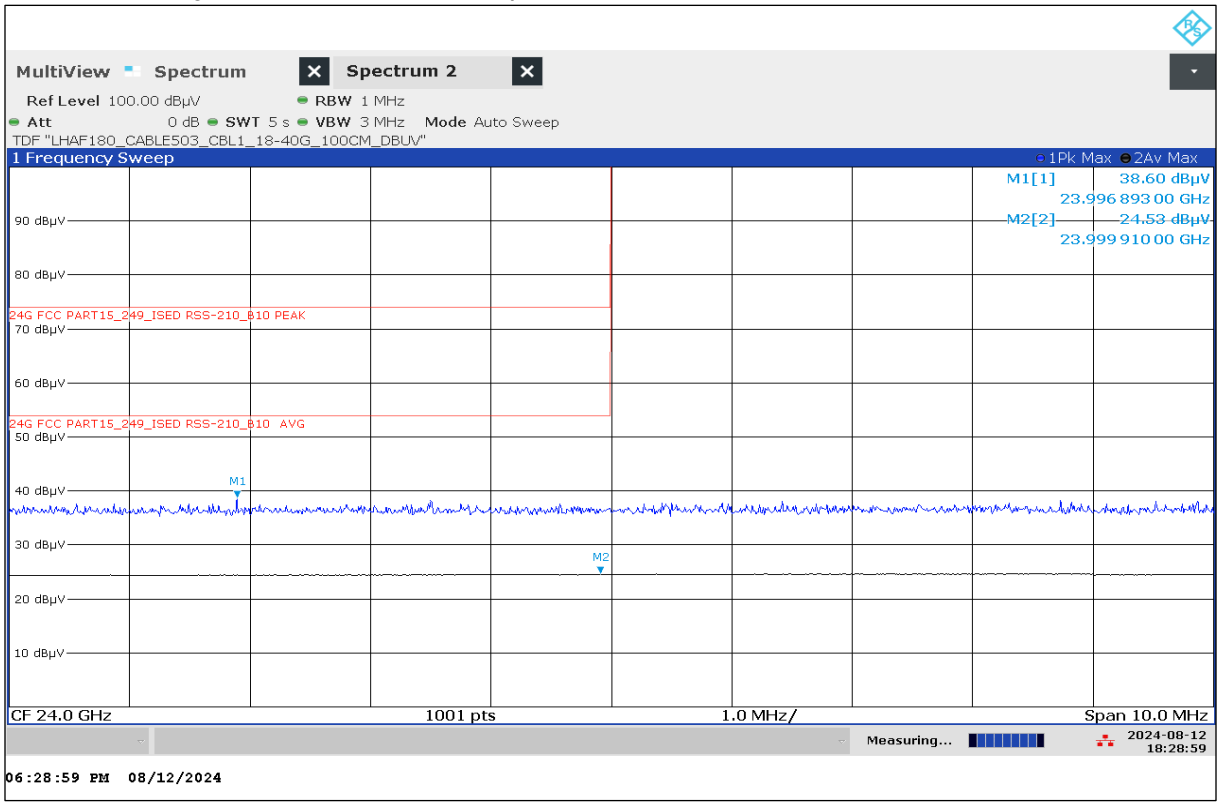
Plot No. 12: 1 GHz to 18 GHz, horizontal/vertical polarization



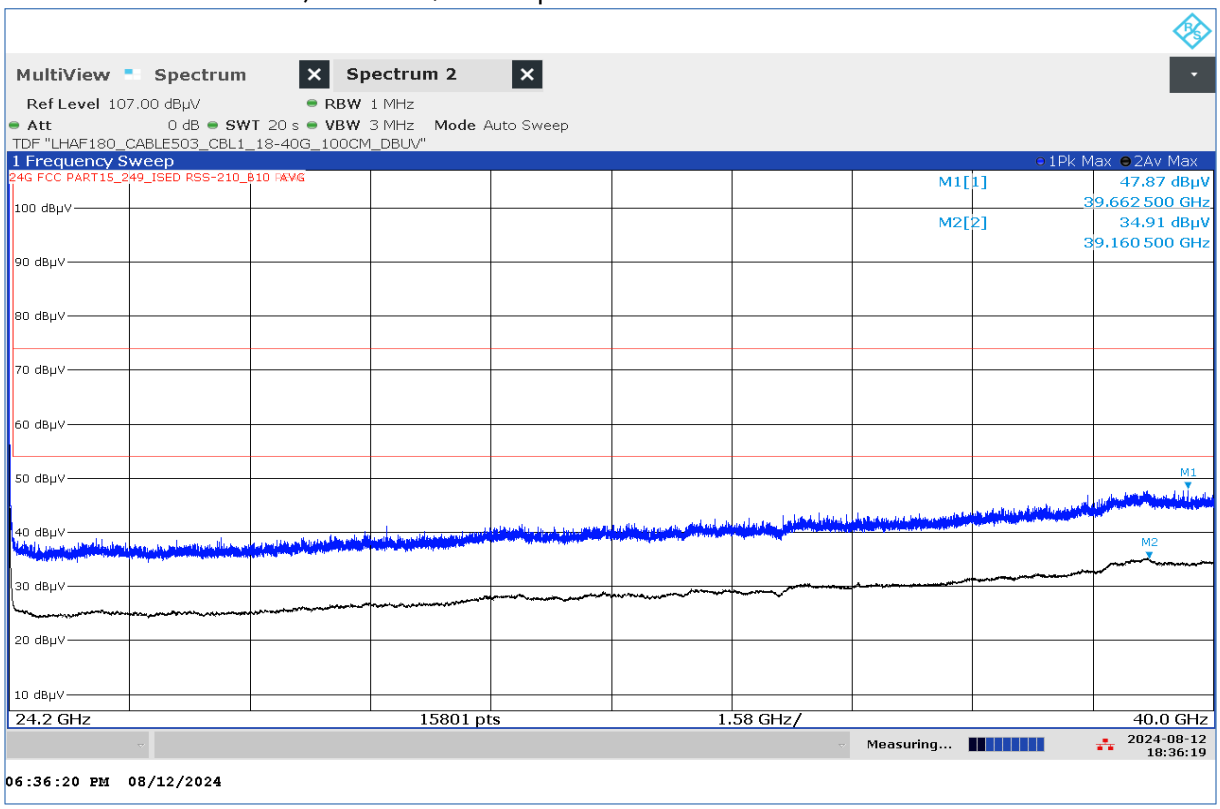
Plot No. 13: 18 GHz to 24 GHz, horizontal/vertical polarization



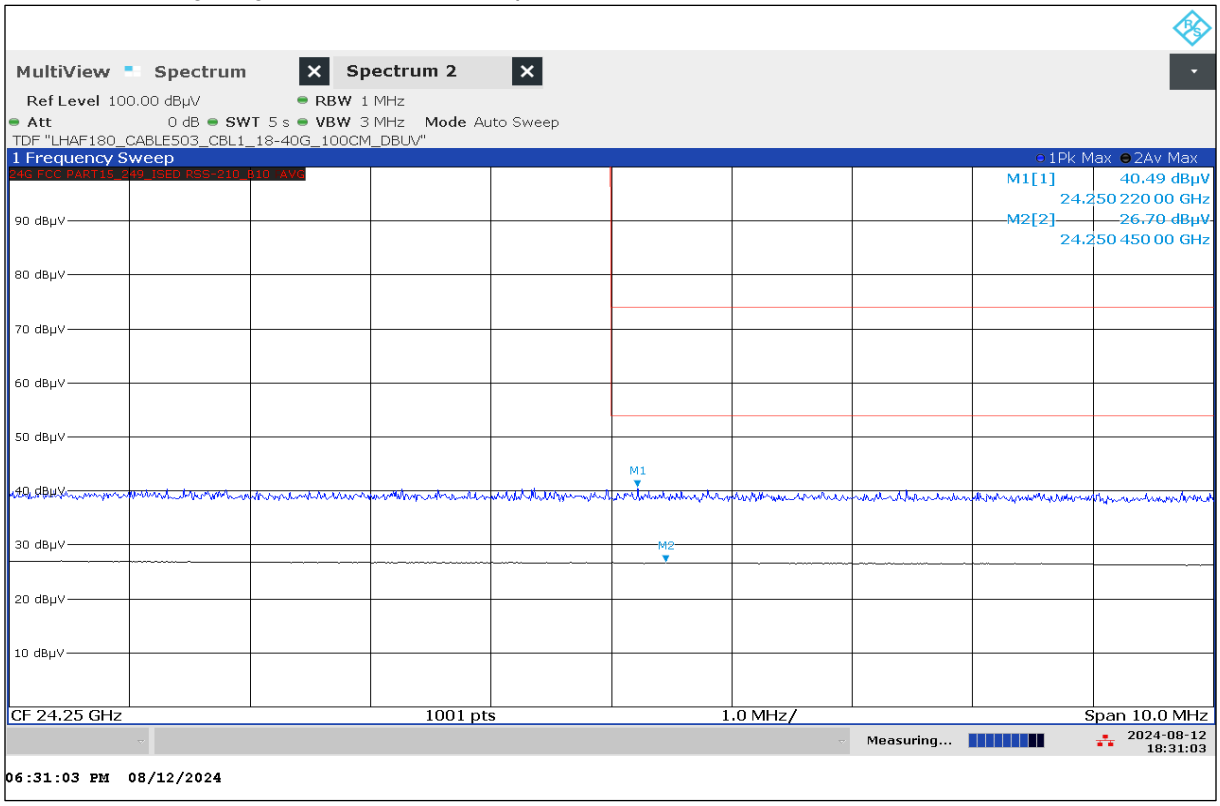
Plot No. 14: Band Edge Low, horizontal/vertical polarization



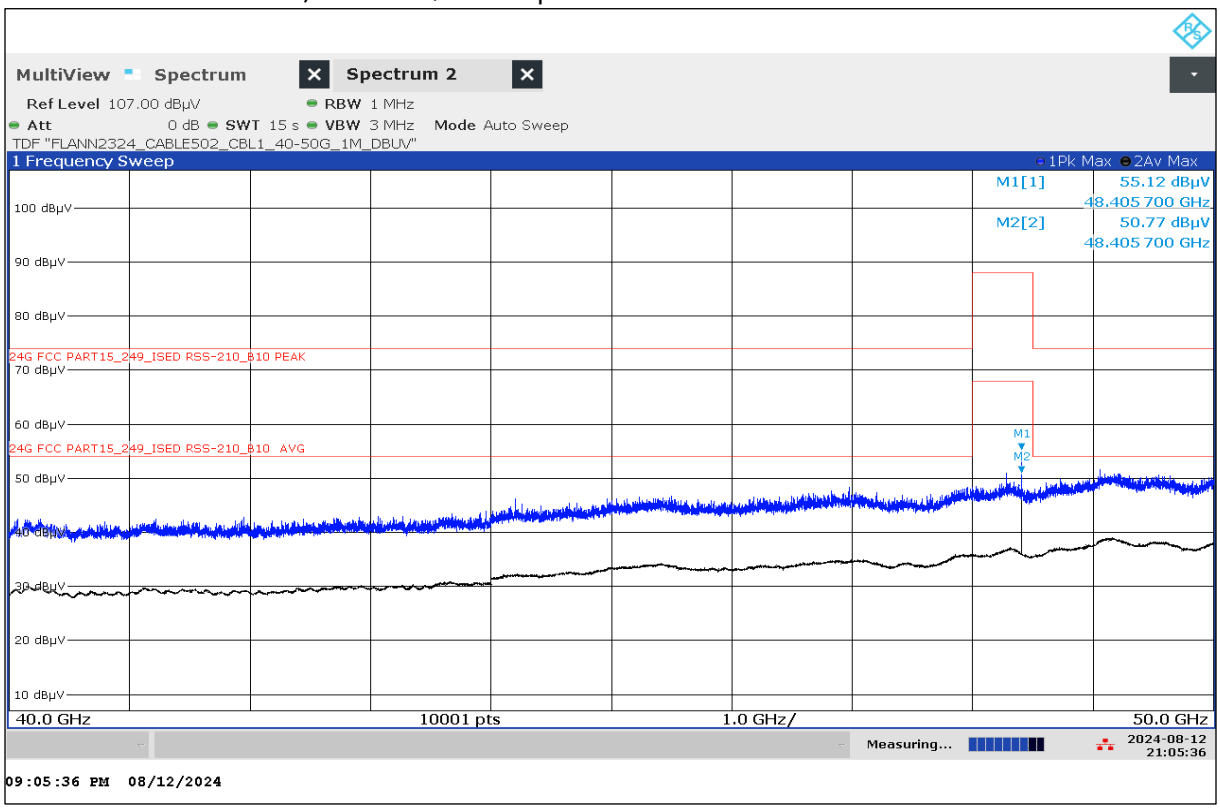
Plot No. 15: 24 GHz to 40 GHz, horizontal/vertical polarization



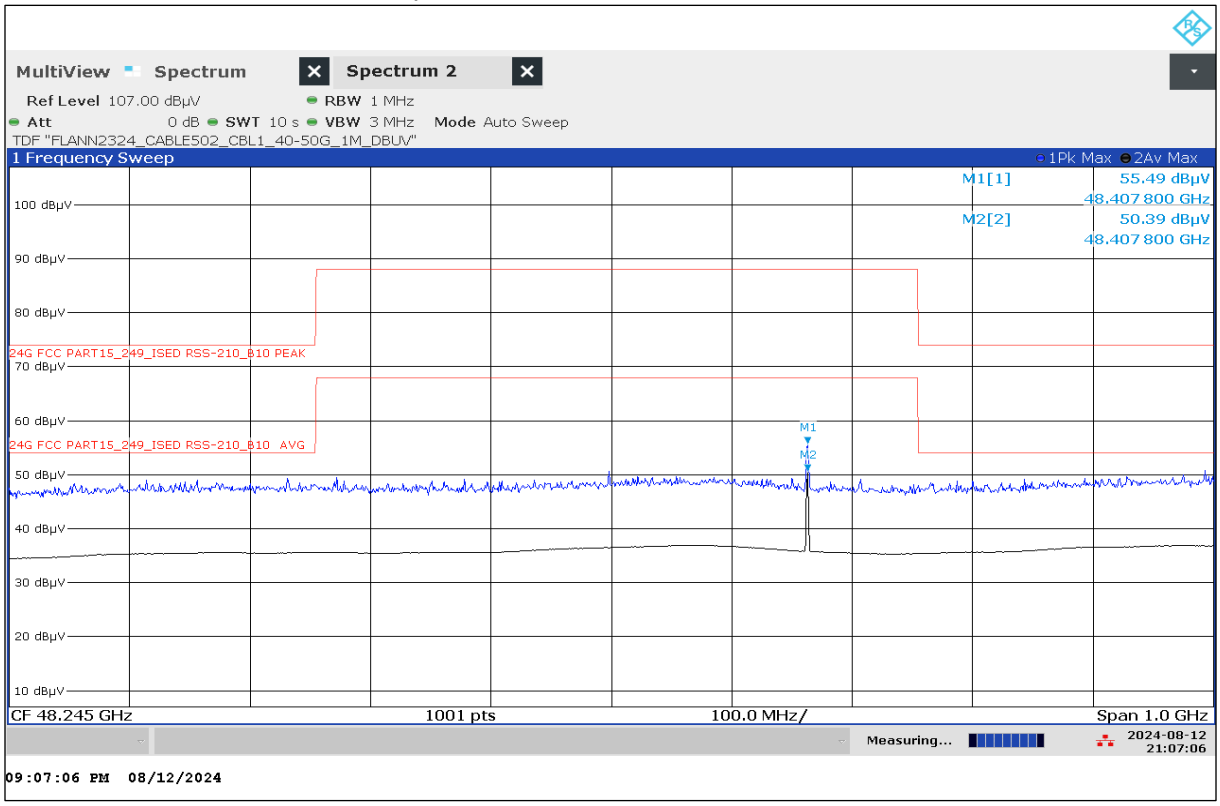
Plot No. 16: Band Edge High, horizontal/vertical polarization



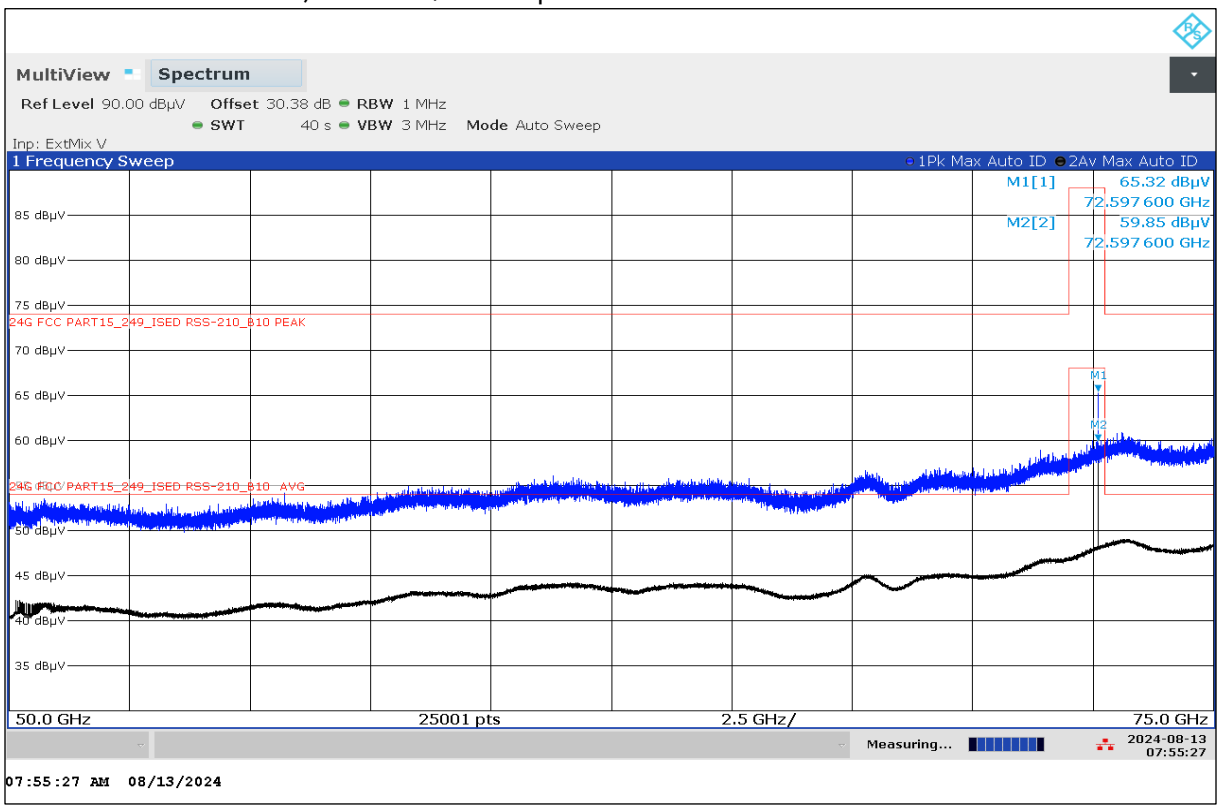
Plot No. 17: 40 GHz to 50 GHz, horizontal/vertical polarization



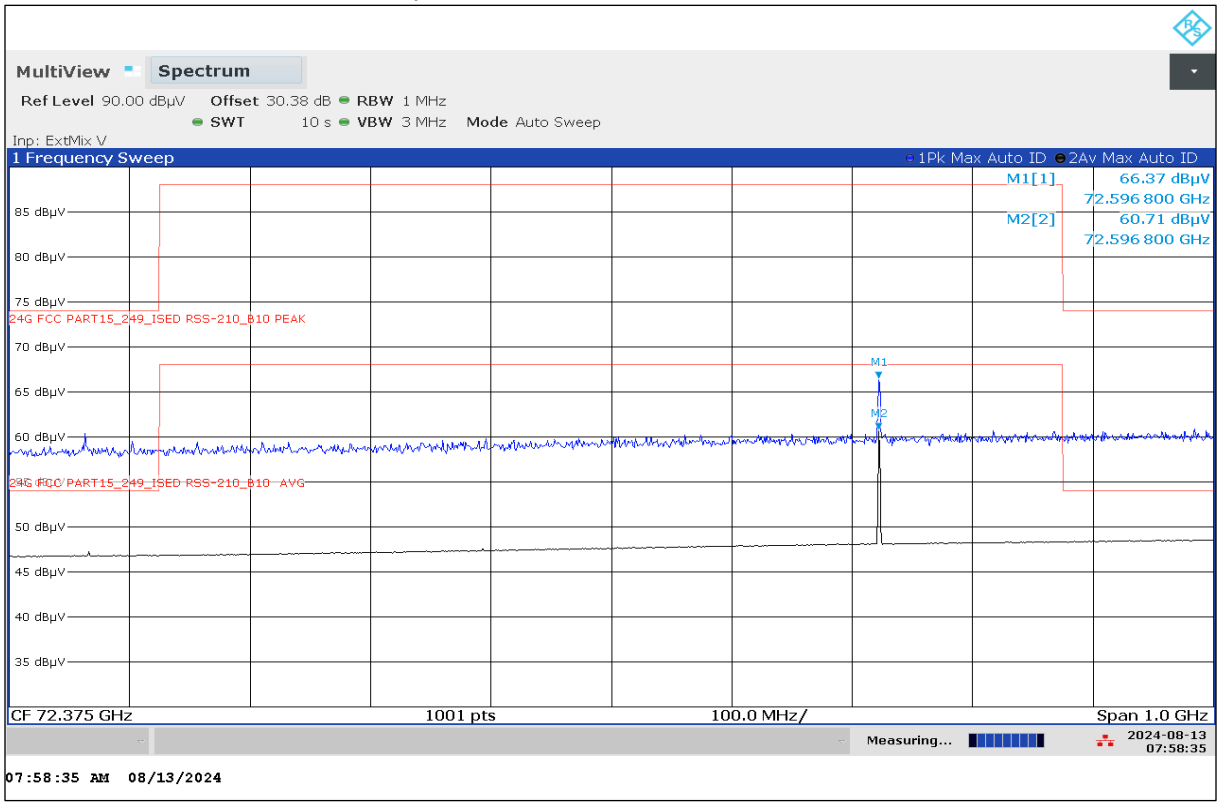
Plot No. 18: 48 GHz, horizontal/vertical polarization



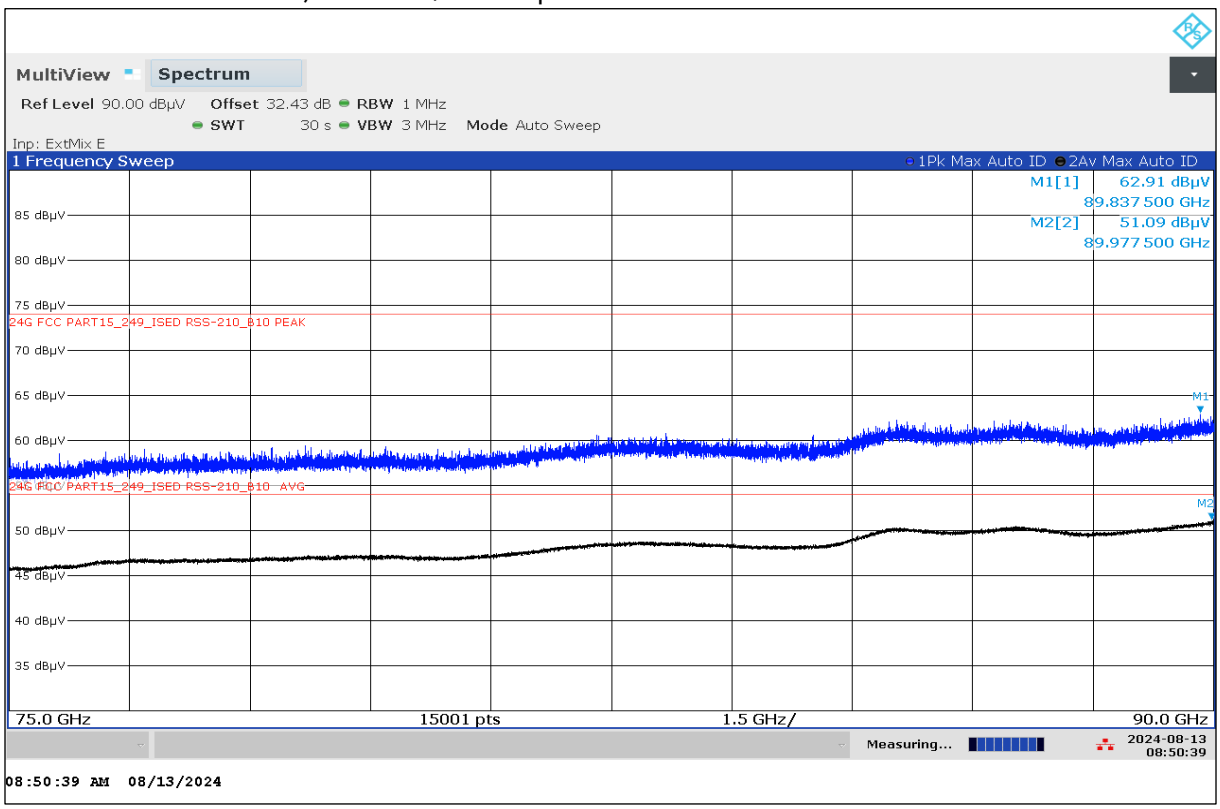
Plot No. 19: 50 GHz to 75 GHz, horizontal/vertical polarization



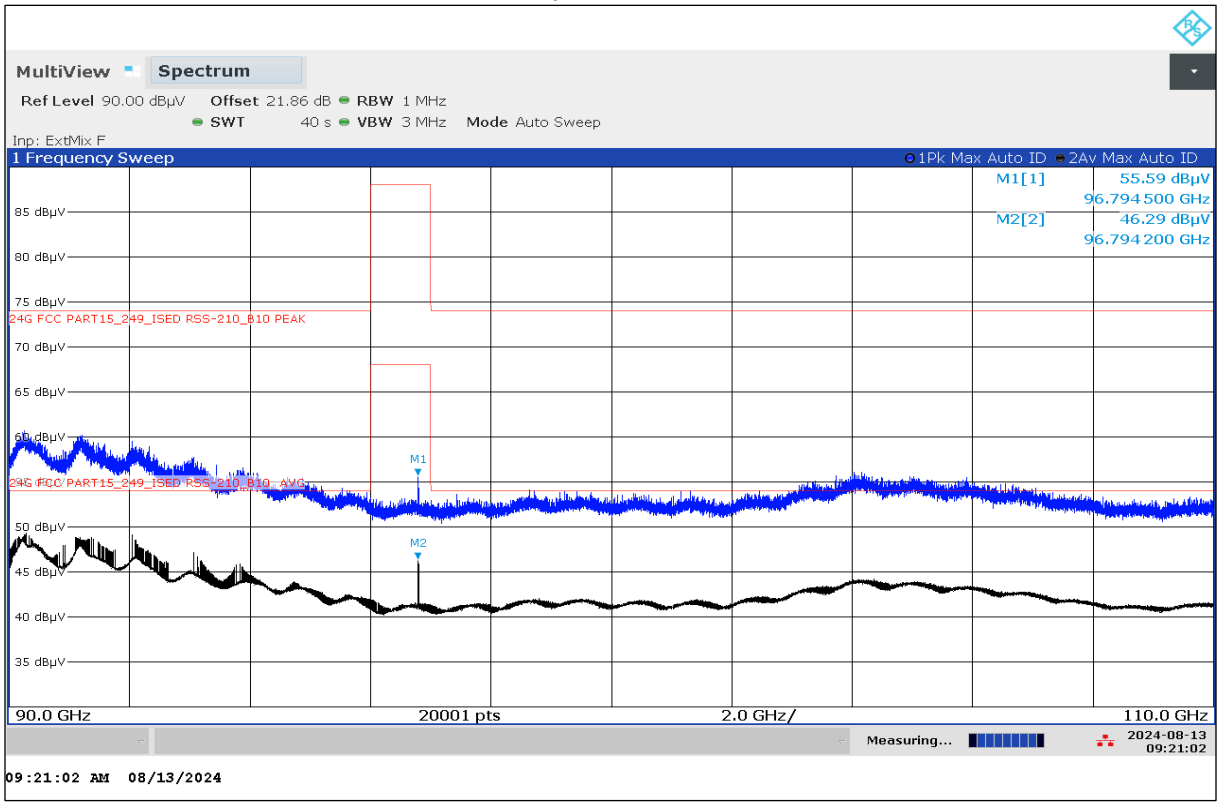
Plot No. 20: 72 GHz, horizontal/vertical polarization



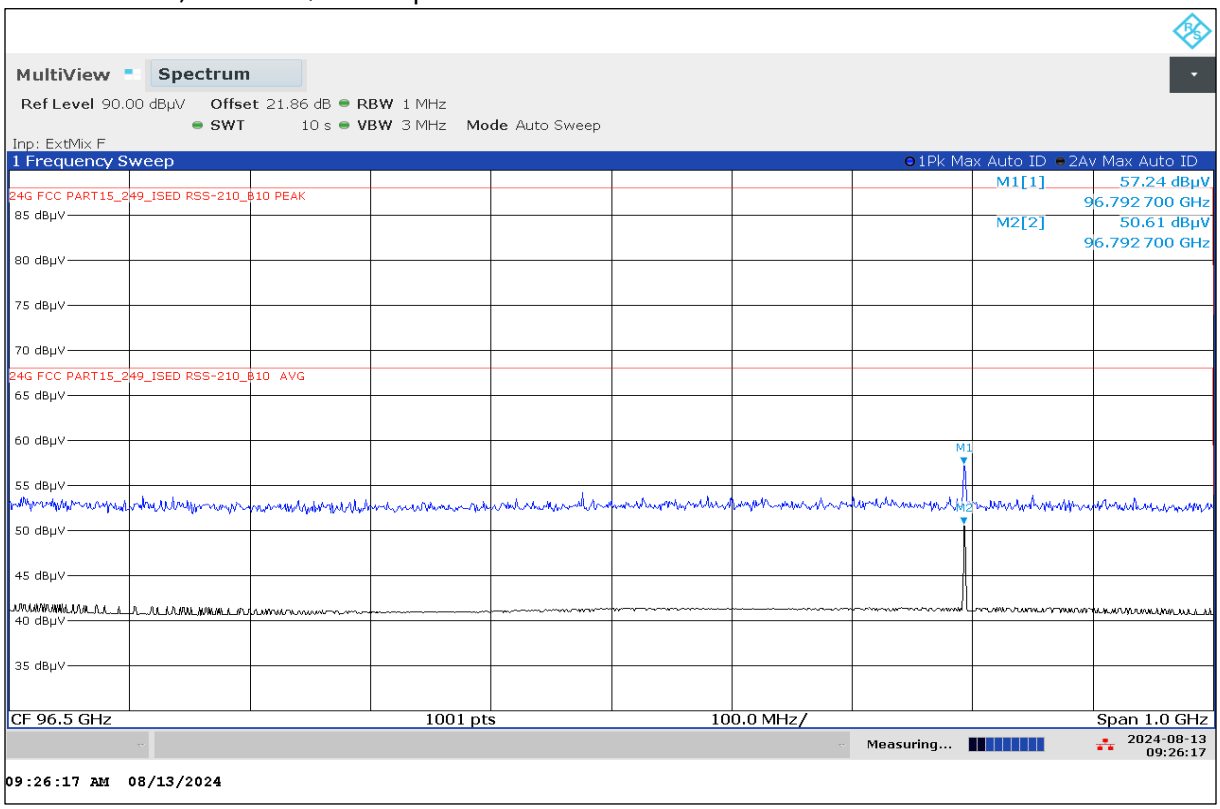
Plot No. 21: 75 GHz to 90 GHz, horizontal/vertical polarization



Plot No. 22: 90 GHz to 110 GHz, horizontal/vertical polarization



Plot No. 23: 96 GHz, horizontal/vertical polarization



13.4 Conducted emissions < 30MHz (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:

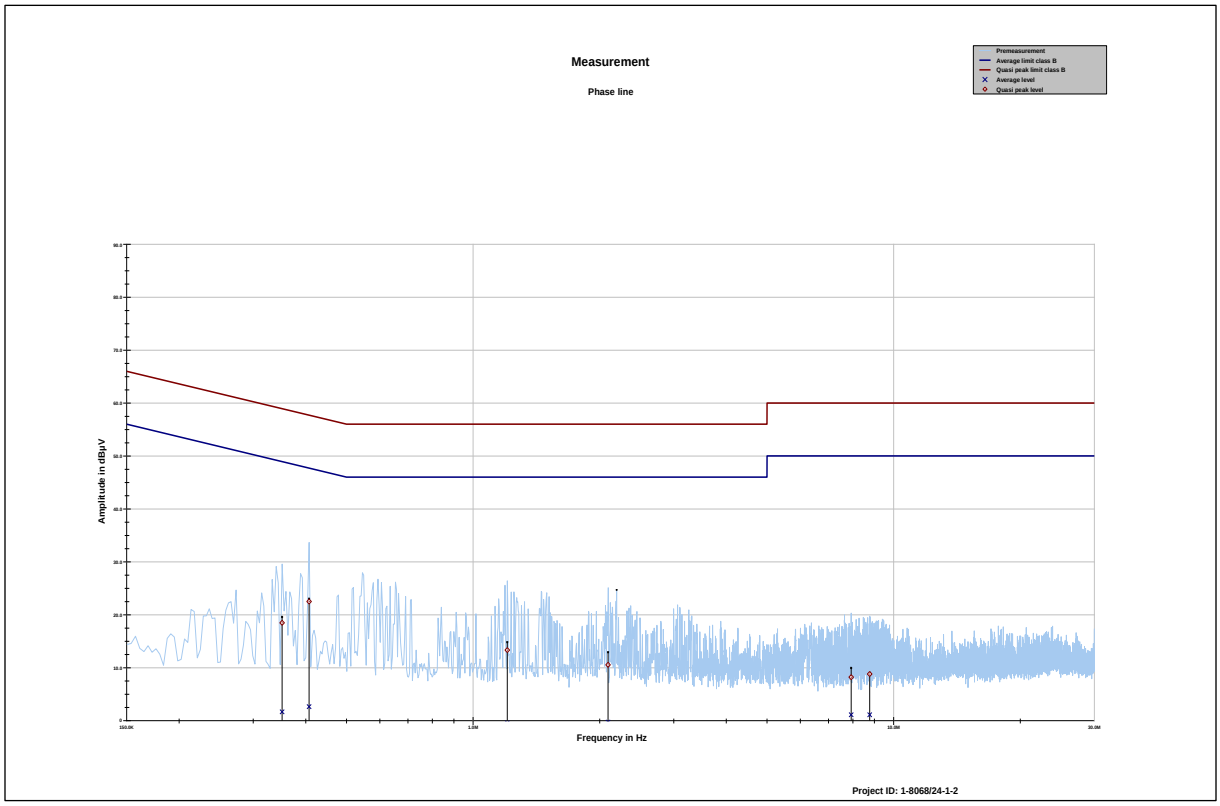
Parameter	
Detector:	Peak - Quasi Peak / Average
Sweep time:	Auto
Video bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Resolution bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold

Measurement results:

See plots below.

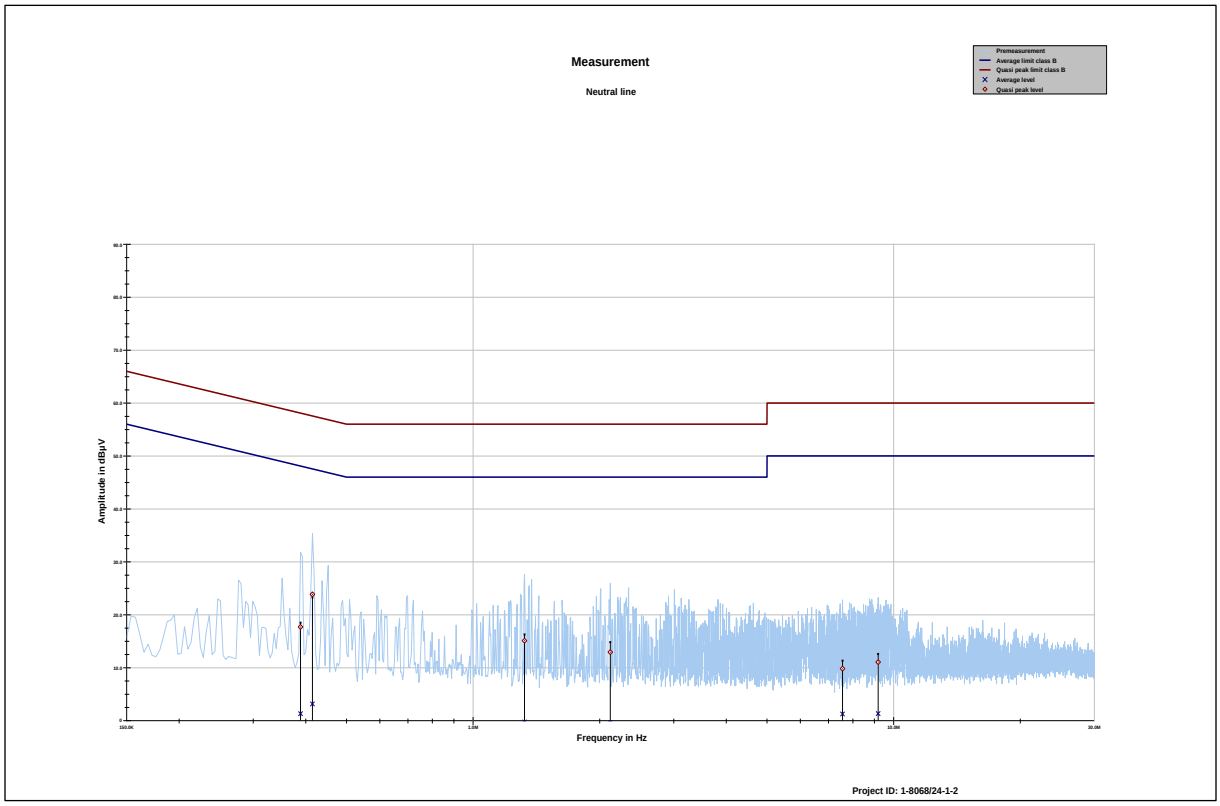
Verdict: Compliant

Plot No. 24: Phase line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AVG
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.351488	18.48	40.45	58.927	1.66	48.58	50.243
0.407456	22.49	35.21	57.700	2.63	46.01	48.644
1.205944	13.31	42.69	56.000	-0.45	46.45	46.000
2.093981	10.54	45.46	56.000	-0.28	46.28	46.000
7.925925	8.20	51.80	60.000	1.09	48.91	50.000

Plot No. 25: Neutral line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AVG
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.388800	17.70	40.39	58.089	1.30	47.88	49.177
0.414919	23.86	33.69	57.549	3.16	45.27	48.431
1.325344	15.09	40.91	56.000	-0.26	46.26	46.000
2.120100	12.93	43.07	56.000	-0.37	46.37	46.000
7.560263	9.82	50.18	60.000	1.25	48.75	50.000
9.187088	11.04	48.96	60.000	1.32	48.68	50.000

14 Glossary

AVG	Average
C	Compliant
C/N_0	Carrier to noise-density ratio, expressed in dB-Hz
CAC	Channel availability check
CW	Clean wave
DC	Duty cycle
DFS	Dynamic frequency selection
DSSS	Dynamic sequence spread spectrum
DUT	Device under test
EN	European Standard
ETSI	European Telecommunications Standards Institute
EMC	Electromagnetic Compatibility
EUT	Equipment under test
FCC	Federal Communications Commission
FCC ID	Company Identifier at FCC
FHSS	Frequency hopping spread spectrum
FVIN	Firmware version identification number
GNSS	Global Navigation Satellite System
GUE	GNSS User Equipment
HMN	Host marketing name
HVIN	Hardware version identification number
HW	Hardware
IC	Industry Canada
Inv. No.	Inventory number
MC	Modulated carrier
NA	Not applicable
NC	Not compliant
NOP	Non occupancy period
NP	Not performed
OBW	Occupied bandwidth
OC	Operating channel
OCW	Operating channel bandwidth
OFDM	Orthogonal frequency division multiplexing
OOB	Out of band
OP	Occupancy period
PER	Packet error rate
PMN	Product marketing name
PP	Positive peak
QP	Quasi peak
RLAN	Radio local area network
S/N or SN	Serial number
SW	Software
UUT	Unit under test
WLAN	Wireless local area network

15 Document history

Version	Applied changes	Date of release
R01	Initial release	2024-09-10

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