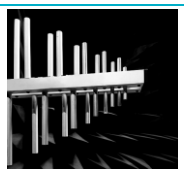
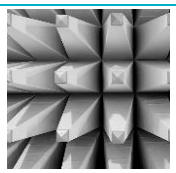

cetecom advanced

TEST REPORT

Test report no.: 1-6186-23-02-07_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://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

Aspara Energy LLC
1350 Avenue of the Americas 2nd Floor
100 19 NY New York / UNITED STATES
Contact: Ravi Jeyaratnam
e-mail: rjeyarat@apsararesearch.com
Phone: +1 646 596 2934

Manufacturer

JSE s.r.o.
Prumyslová 190
53701 Chrudim / CZECH REPUBLIC

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:	**Industrial Positioning System 60GHz**
Model name:	**P-108-061/10G/60G**
FCC ID:	**2BC5M-061E60**
Frequency:	57 GHz to 64 GHz
Technology tested:	FMCW & BPSK system
Antenna:	Integrated antenna
Power supply:	10 V to 14V DC by external power supply
Temperature range:	+20°C to +35°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
2024.06.25 13:59:47 +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
2024.06.25 13:57:45 +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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In no case this test report can be considered as a Letter of Approval.

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

2.2 Application details

Date of receipt of order:	2023-12-14
Date of receipt of test item:	2024-01-15
Start of test:*	2024-01-15
End of test:*	2024-04-24
Person(s) present during the test:	Jiří Škapa , Jakub Pilař (2024-01-15 to 2024-01-17)

*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

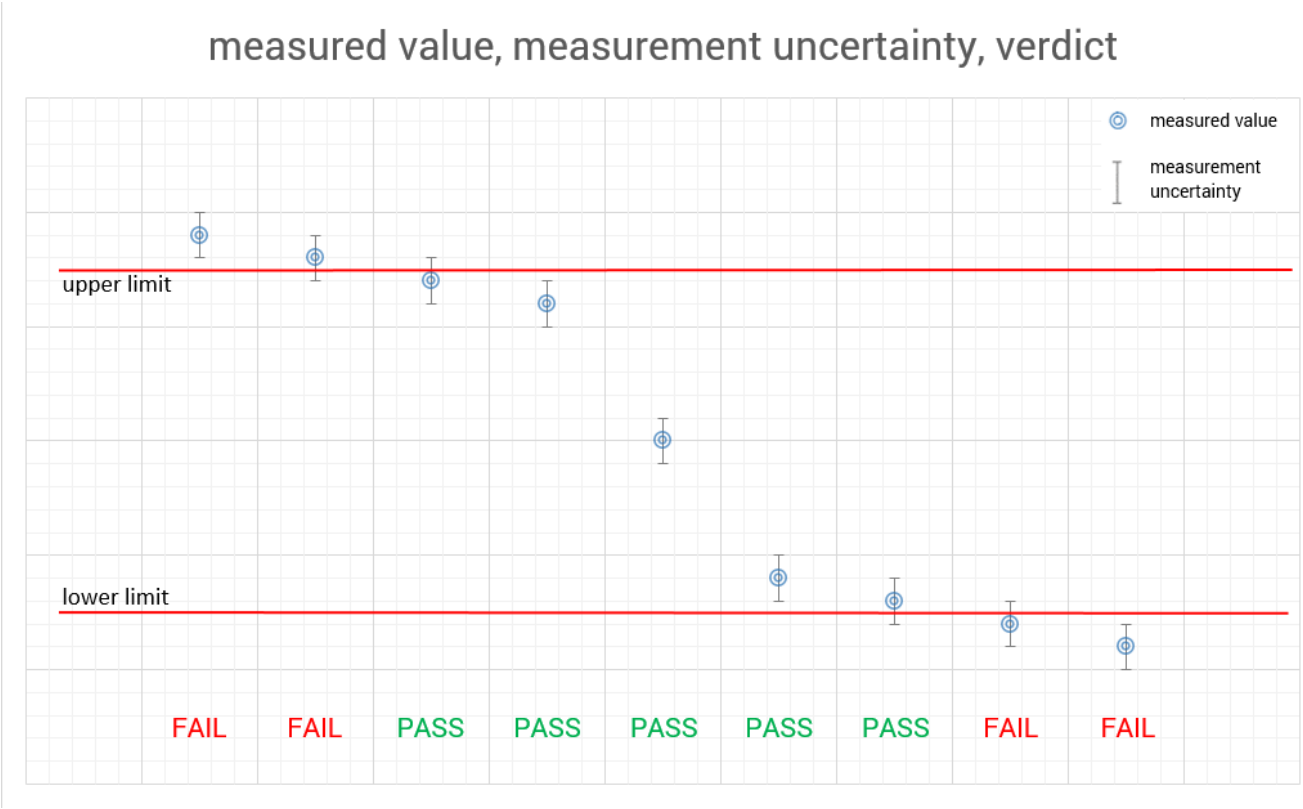
3 Test standard/s, references and accreditations

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 C63.10-2020	-/-	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}	12 V DC by external power supply 13.8 V DC (85% of V_{nom}) 10.2 V DC (115% of V_{nom})

6 Test item

6.1 General description

Kind of test item :	Industrial Positioning System 60GHz
Model name :	P-108-061/10G/60G
S/N serial number :	EUT1: 003 (102-05E/05 061-04E/05 065-04E/05 066-03C/05)
Power setting	IF variable gain amplifier attenuation 10 dB; RF variable gain amplifier attenuation 12dB
Hardware status :	1.00
Software status :	1.10
Firmware status :	v1.05 (until 2024-01-22, used for testing), v1.06 (2024-01-22 to 2024-03-26, used for testing), v1.07 to v1.09 (2024-03-26 to 2024-04-18, not used for final testing), v1.10 (since 2024-04-18, used for testing)
Frequency band :	57 GHz to 64 GHz
Type of modulation :	FMCW & BPSK
Number of normal operation modes :	1
Antenna :	Integrated antenna
Power supply :	10 V to 14 V DC by external power supply
Temperature range :	+20°C to +35°C

Notes – Test item:

- Further settings:
  - Signal repetition rate = 25 Hz (→ Cycle time 40ms)
- Firmware versions:
  - v1.05: First version used for certification-relevant tests
  - v1.06: Test mode “BPSK only” implemented
  - v1.07 to v1.09: not used for final testing
  - v1.10: Operational temperature range changed (emissions are switched off outside of the operational temperature range)
  - Declared by customer:
    - The output power (power setting) is identical for all software versions used for testing.
    - None of the modifications between the firmware versions change the spectrum or the transmitted signal
- Roles (as declared by the customer):
  The device can be used in two different roles (“Master 6ID” or “Slave 6XD”). The hardware is identical. As declared by the customer, the emissions of both roles are identical.

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:

- 1-6186-23-02-07_TR1-A101-R01 (External photographs of EUT)
- 1-6186-23-02-07_TR1-A102-R01 (Internal photographs of EUT)
- 1-6186-23-02-07_TR1-A103-R01 (Test set-up photographs)
- 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.

Additional measurement reports:

- none

Additional declarations (manufacturer's declarations, declarations of conformity, etc.):

- 1-6186-23-02-07_TR1-A301-R01 (HW-108-066-REV03_Antenna_Test_Report_JSE)

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).

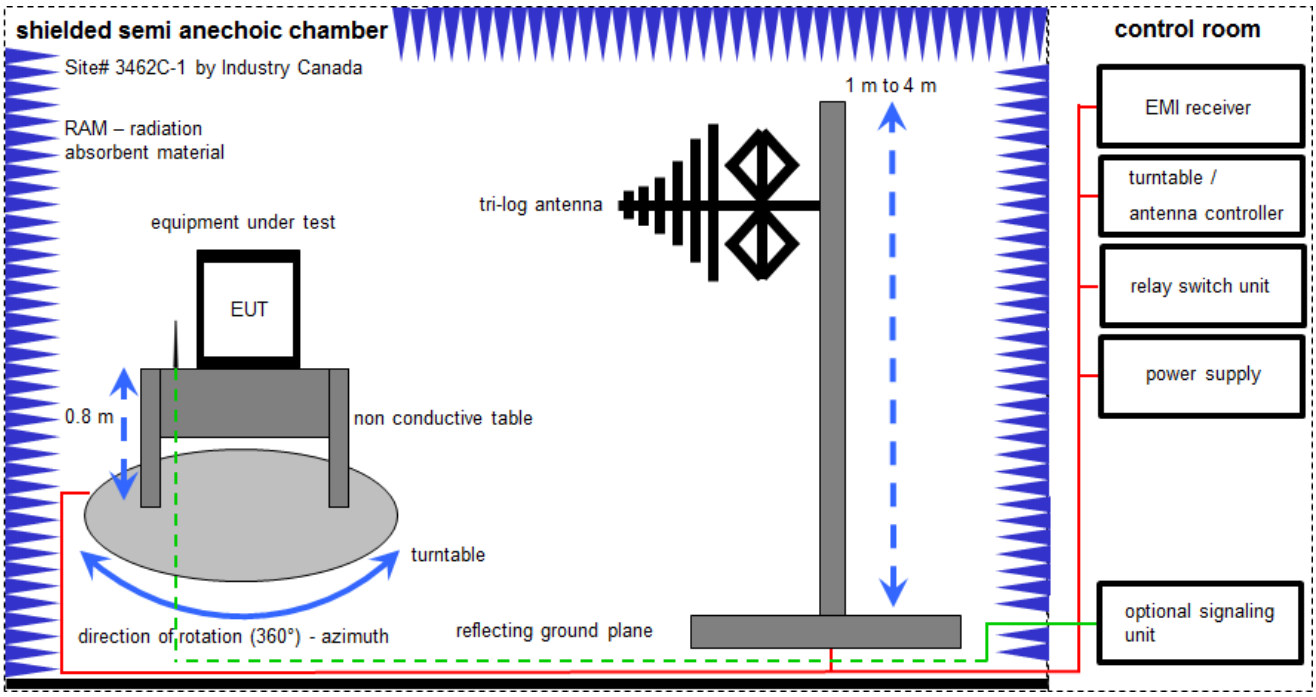
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

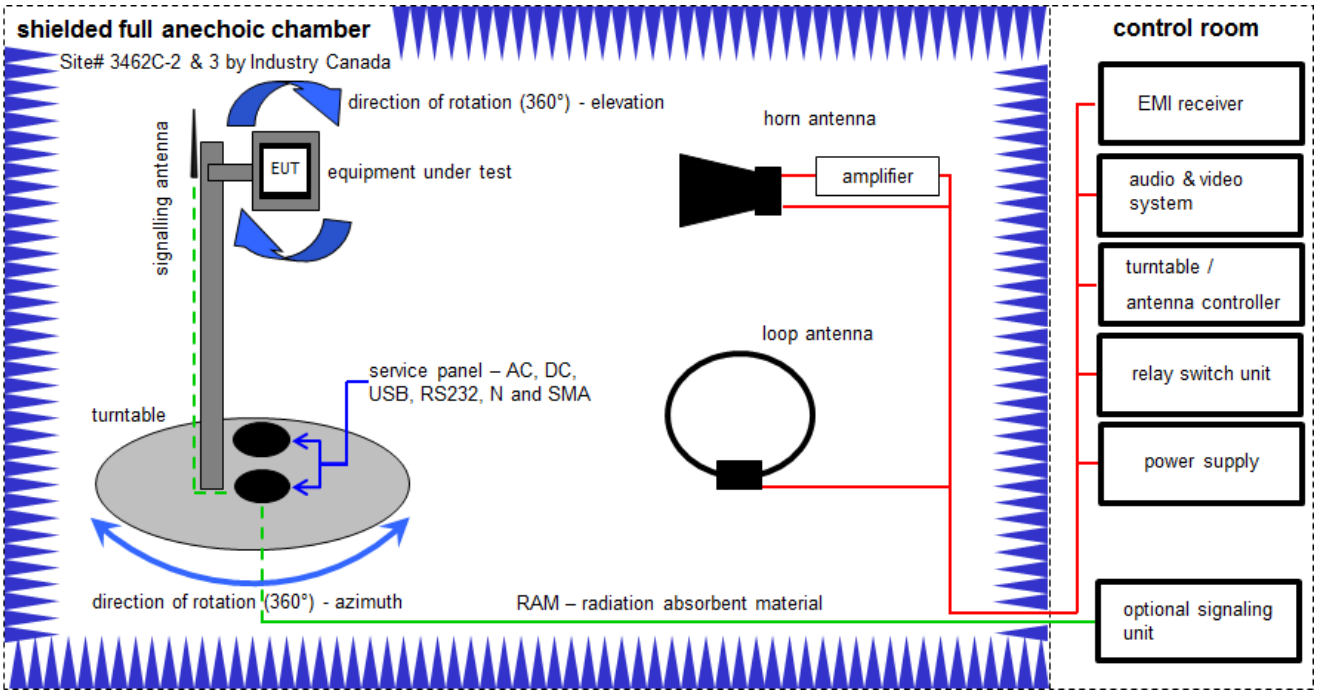
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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.	Analyzer-Impedence-System	AIS16/1	Spitzenberger + Spies GmbH & Co. KG	UO2076 07/0 1023	400001751	k	19.10.2023	31.10.2025
2	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
3	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
4	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	06.12.2023	31.12.2024
5	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	n. a.	Semi anechoic chamber	3000023	MWB AG		300000551	ne	-/-	-/-
7	n. a.	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
8	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	216	300003288	vlKl!	31.08.2023	31.08.2025
9	n. a.	Turntable	2089-4.0	EMCO		300004394	ne	-/-	-/-
10	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-

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)

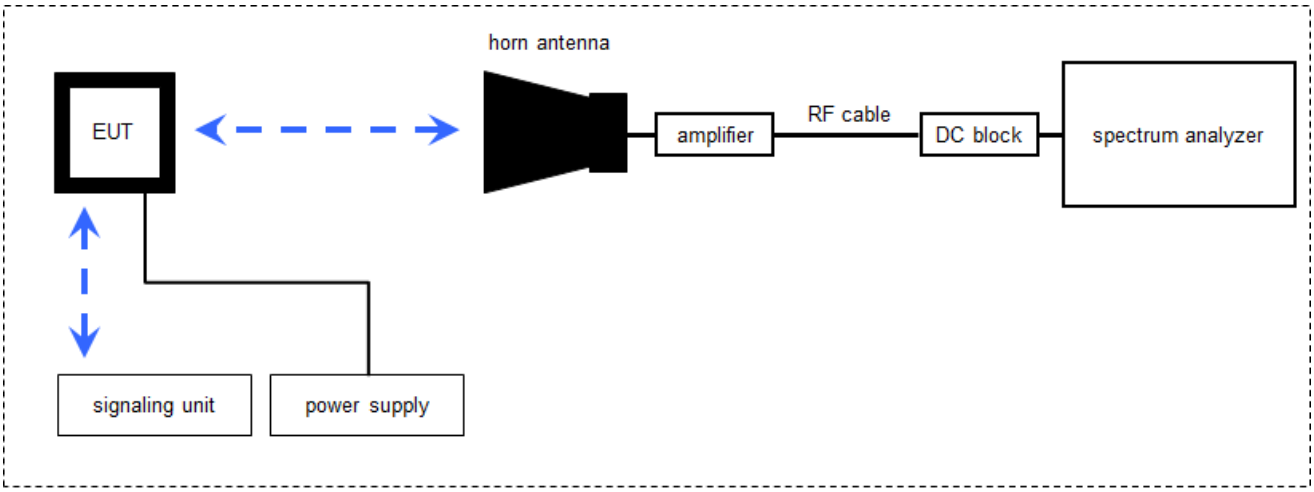
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

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

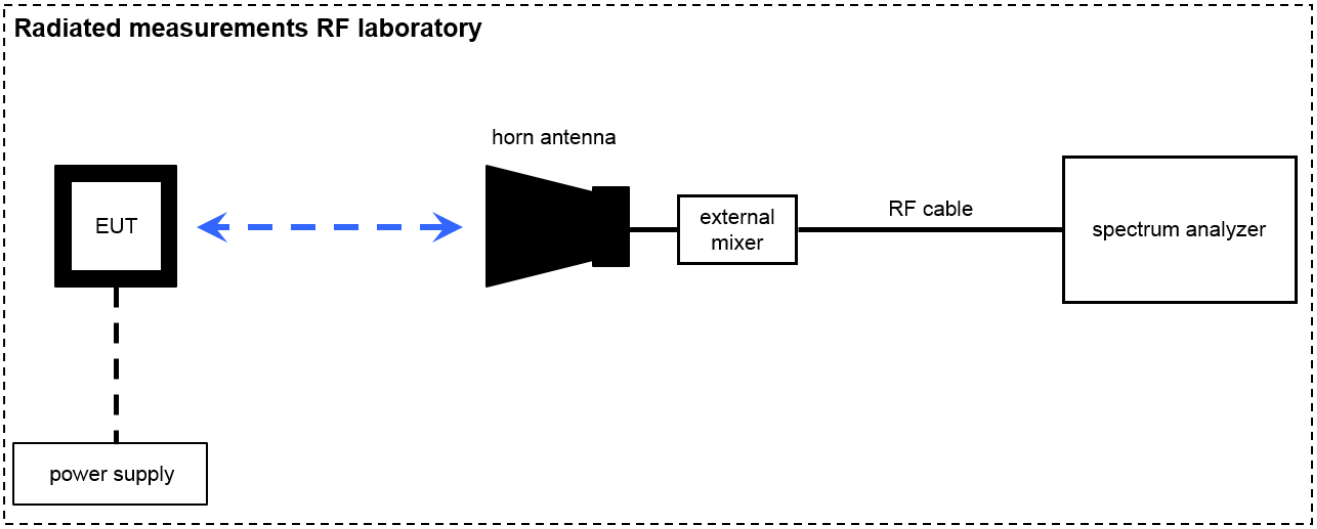
Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
2	n. a.	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO/2	8905-2342	300000256	vlKl!	19.07.2023	31.07.2025
3	n. a.	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
4	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
5	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	vlKl!	05.12.2023	31.12.2026
6	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	11.12.2023	31.12.2024
7	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
8	n. a.	NEXIO EMV-Software	BAT EMC V2022.0.32.0	Nexio		300004682	ne	-/-	-/-
9	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
10	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
11	n. a.	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
12	n. a.	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3088	300001032	vlKl!	10.10.2023	31.10.2025

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)

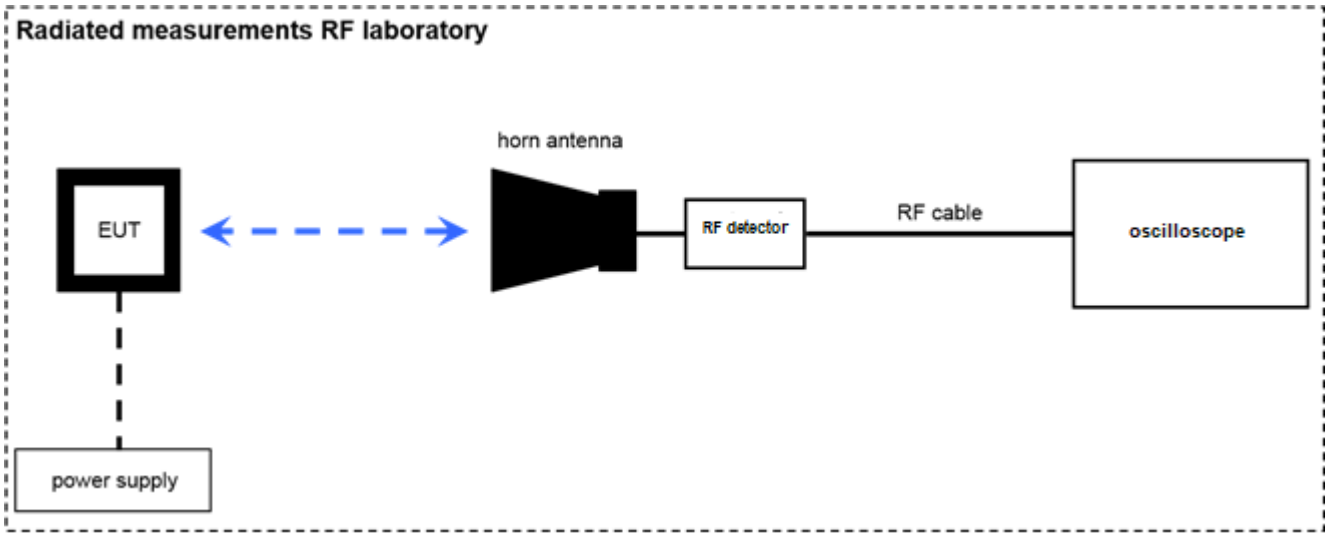
Example calculation:
OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

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.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2022 22.04.2024	21.04.2026
2	n. a.	Harmonic Mixer 3-Port, 110-170 GHz	FS-Z170	Radiometer Physics GmbH	100014	300004156	k	21.07.2023	31.07.2024
3	n. a.	Harmonic Mixer 3-Port, 140-220 GHz	SAM-220	Radiometer Physics GmbH	200001	300004157	k	02.08.2023	31.08.2024
4	n. a.	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	Rohde & Schwarz	101578	300005788	k	19.07.2023	31.07.2024
5	n. a.	Harmonic Mixer 3-Port, 60-90 GHz	FS-Z90	R&S	101555	300004691	k	25.08.2023	31.08.2024
6	n. a.	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	Rohde & Schwarz	101411	300004959	k	21.07.2023	31.07.2024
7	n. a.	Harmonic Mixer 3-port, 90-140 GHz	FS-Z140	Rohde & Schwarz	101119	300005581	k	03.08.2023	31.08.2024
8	n. a.	Horn Antenna 18,0-40,0 GHz	LHAF180	Microw.Devel	39180-103-021	300001747	vlKl!	24.01.2024	23.01.2026
9	n. a.	Power supply	N5767A	Agilent Technologies	US14J1569P	300004851	vlKl!	06.12.2023	31.12.2026
10	n. a.	Signal- and Spectrum Analyzer 2 Hz - 50 GHz	FSW50	Rohde&Schwarz	101560	300006179	k	17.01.2024	31.01.2025
11	n. a.	Std. Gain Horn Antenna 114-173 GHz	2924-20	Flann	*	300001999	ne	-/-	-/-
12	n. a.	Std. Gain Horn Antenna 145-220 GHz	3024-20	Flann	*	300002000	ne	-/-	-/-
13	n. a.	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vlKl!	24.01.2024	23.01.2026
14	n. a.	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	vlKl!	24.01.2024	23.01.2026
15	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
16	n. a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
17	n. a.	Std. Gain Horn Antenna 60-90 GHz	COR 60_90	Thomson CSF		300000814	ev	-/-	-/-
18	n. a.	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-
19	n. a.	Std. Gain Horn Antenna 92.3-140 GHz	2824-20	Flann	*	300001993	ne	-/-	-/-
20	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	31.05.2024

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



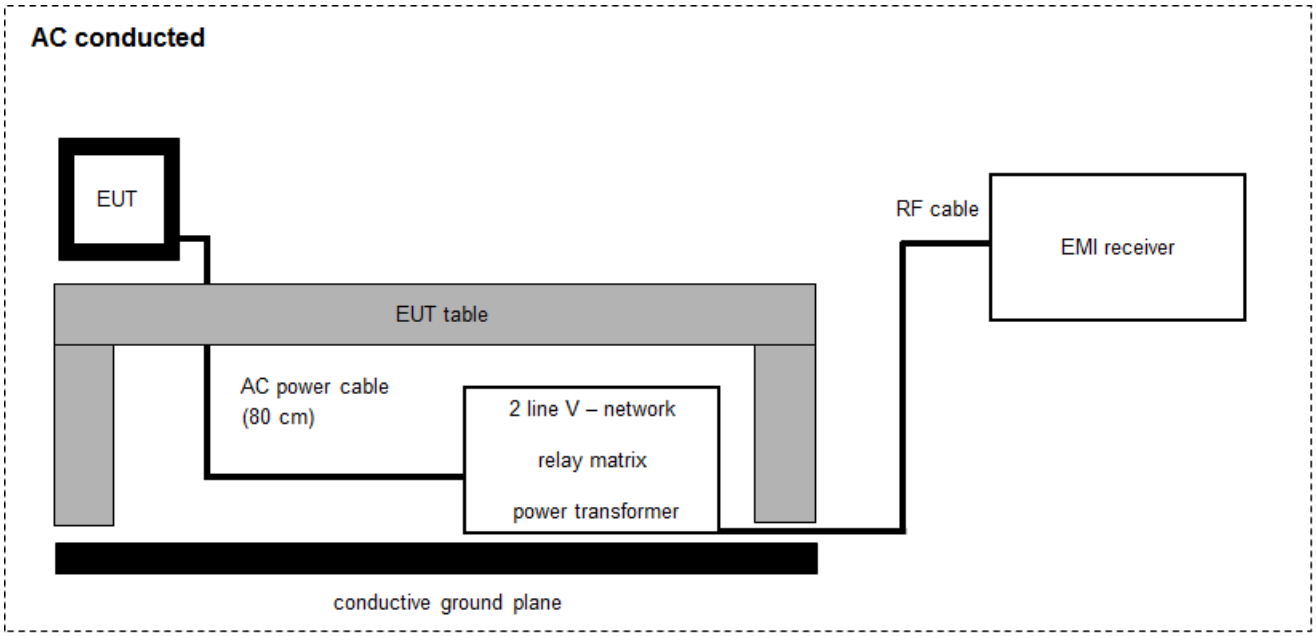
Note: EUT is replaced by reference source for substitution measurement

Measurement distance: horn antenna e.g. 50 cm

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Synthesized Sweeper 10 MHz - 40 GHz	83640A	HP	3119A00458	300002266	vIKI!	05.12.2023	31.12.2025
2	n. a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
3	n. a.	Std. Gain Horn Antenna 50-75 GHz	COR 50_75	Thomson CSF		300000813	ne	-/-	-/-
4	n. a.	2.5 GHz Digital Phosphor Oscilloscope	DPO7254	Tektronix	B022702	300003573	vIKI!	07.12.2022	31.12.2024
5	n. a.	Oscilloscope	DPO5054	Tektronix	C010174	300004169	k	05.12.2023	31.12.2025
6	n. a.	Thermal Power Sensor, DC-110GHz, 300nW-100mW	NRP-Z58	R&S	100913	300004808	vIKI!	19.12.2023	18.12.2025
7	n. a.	Power supply	N5767A	Agilent Technologies	US14J1569P	300004851	vIKI!	06.12.2023	31.12.2026
8	n. a.	SG Extension Module 50 - 75 GHz	E8257DV15	VDI	US54250124	300005541	ev	-/-	-/-
9	n. a.	Low Noise Amplifier, Waveguide, 50-75 GHz	AFB-V30LN-02	Ducommun Incorporated	1026151-01	300005899	ev	-/-	-/-
10	n. a.	WG Rotary Attenuator	25110 UG-385/U-AC	Flann Microwave	266740	300005798	ev	-/-	-/-
11	n. a.	V-Band Positive Amplitude Detector	SFD-503753-15SF-P1	Sage Millimeter Inc.	07353-1	300006118	ev	-/-	-/-
12	n. a.	Signal Generator 100 kHz - 40 GHz	SMB100A	Rohde & Schwarz	183320	300006330	k	21.06.2022	20.06.2025

7.6 AC conducted



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

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	Rohde & Schwarz	892475/017	300002209	vlKl!	12.12.2023	31.12.2025
2	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
3	n. a.	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
4	n. a.	PC	TecLine	F+W		300003532	ne	-/-	-/-
5	n. a.	Analyzer-Impedence-System	AIS16/1	Spitzenberger + Spies GmbH & Co. KG	UO2076 07/0 1023	400001751	k	19.10.2023	31.10.2025
6	n. a.	EMI Test Receiver 3.6 GHz	ESR3	Rohde & Schwarz	102981	300006318	k	08.12.2023	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	2024-06-25	-/-

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
47 CFR 15.215(c): 47 CFR 15.255(f):	Occupied bandwidth & Frequency stability	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies
47 CFR 15.255(c)	Radiated power (EIRP)	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.255(c)(2) 47 CFR 15.255(e)	Peak transmitter conducted output power	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.255(b)(3) 47 CFR 15.255(c):	Time domain requirements	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.255(d)	Spurious emissions radiated	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.207	Conducted emissions < 30 MHz (AC power line)	Nominal	Nominal	☒	☐	☐	☐	complies

Note: NA = Not applicable; NP = Not performed

11 Additional comments

Reference documents: see chapter 6.2

Special test descriptions: None

Configuration descriptions: None

12 Basic information of the DUT & selection of applicable rule parts

Basic information of the DUT:

General: see chapter "6 Test item"

Modes:

- Normal operation mode:
  - FMCW & BPSK modulation is (sequentially) active.
    The FMCW and BPSK signals are emitted one after the other within a single cycle time.
    This mode is used in normal operation.
- Test mode (not used in normal operation):
  - BPSK only: Test mode where only the BPSK signal is active. FMCW signal emission is deactivated.

Operation condition:

☐ Operation on aircraft (47 CFR 15.255(b))

☐ Unmanned aircraft (47 CFR 15.255(b)(3))

☐ Not unmanned aircraft

☒ No operation on aircraft

Note: Operation under the provisions of this section is not permitted for equipment used on satellites (47 CFR 15.255(a)).

Kind of DUT:

☒ Devices other than field disturbance sensors and other than fixed point-to-point transmitters located outdoors
Note: BPSK signal

☐ Fixed point-to-point transmitters located outdoors

☒ Field disturbance sensors/radars

☐ Pulsed field disturbance sensors/radars

☒ Other than pulsed field disturbance sensors/radars
Note: FMCW signal

Frequency band:

☒ Operating within band 57 – 71 GHz (47 CFR 15.255 / 47 CFR 15.255(c))
Note: BPSK signal

☐ Operating within band 59.3 – 71.0 GHz (47 CFR 15.255(b)(2)(iii))

☐ Operating within band 60 – 64 GHz (47 CFR 15.255(b)(3))

☒ Operating within band 57 – 64 GHz (47 CFR 15.255(c)(3) / 47 CFR 15.255(c)(2)(iii))
Note: FMCW signal

☐ Operating within band 57 – 71 GHz (47 CFR 15.255(c)(2))

☐ Operating within band 57.0 – 59.4 GHz (47 CFR 15.255(c)(2)(i))

☐ Operating within band 57.0 – 61.56 GHz (47 CFR 15.255(c)(2)(ii))

☐ Operating within band 61.0 – 61.5 GHz (47 CFR 15.255(c)(2)(v))

Note: See results in chapter 13.1

Selection of applicable rule parts:

Applicable rule parts and limits depend on the basic information of the DUT (see chapter 12).
The comparison of the basic information of the DUT with the rule parts lead to the following conclusions:

Note: If a difference for the FMCW and the BPSK signal has to be taken into account, the corresponding signal has been added as a remark in the table below. If the rule part is valid for FMCW and BPSK signal, the remark "Both" is added

Rule Part	Applicable?	
	Yes	No
47 CFR 15.255:		
(a) **General:** Operation under the provisions of this section is not permitted for equipment used on satellites.	☒ **Both**	
(b) **Operation on aircraft:** Operation on aircraft is permitted under the following conditions:	☐	☒
(1) When the aircraft is on the ground.	☐	☒
(2) While airborne, only in closed exclusive on-board communication networks within the aircraft, with the following exceptions:	☐	☒
(i) Equipment shall not be used in wireless avionics intra-communication (WAIC) applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure.	☐	☒
(ii) Except as permitted in paragraph (b)(3) of this section, equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft.	☐	☒
(iii) **Field disturbance sensor/radar** devices may only operate in the frequency band **59.3–71.0 GHz** while installed in passengers' personal portable electronic equipment (e.g., smartphones, tablets) and shall comply with paragraph (b)(2)(i) of this section, and relevant requirements of paragraphs (c)(2) through (c)(4) of this section.	☐	☒
(3) **Field disturbance sensors/radar** devices deployed on **unmanned aircraft** may operate within the frequency band **60–64 GHz**, provided that the transmitter not exceed 20 dBm peak EIRP. The sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds. Operation shall be limited to a maximum of 121.92 meters (400 feet) above ground level.	☐	☒
(c) **Radiated power limits:** Within the **57–71 GHz band**, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):	☒ **Both**	
(1) **Devices other than field disturbance sensors** shall comply with one of the following power limits, as measured during the transmit interval:	☒ **BPSK**	☐
(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	☒ **BPSK**	☐
(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 (c) for reducing transmit power based on antenna gain shall not require that the power levels be reduced below the limits specified in paragraph (c)(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) **Field disturbance sensors/radars** shall not exceed −10 dBm peak conducted output power and 10 dBm peak EIRP except that field disturbance sensors/radars that limit their operation to all or part of the specified frequency band may operate without being subject to a transmitter conducted output power limit if they operate in compliance with paragraph (b)(3) of this section or with one or more of the provisions below:	☒ **FMCW**	☐
(i) **57.0–59.4 GHz**: the peak EIRP level shall not exceed 20 dBm for **indoor operation** or 30 dBm for **outdoor operation**;	☐	☒
(ii) **57.0–61.56 GHz**: the peak EIRP shall not exceed 3 dBm except that the peak EIRP shall not exceed 20 dBm if the sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds;	☐	☒
(iii) **57.0–64.0 GHz:**	☒ **FMCW**	☐
(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;	☒ **FMCW**	☐
(B) The peak EIRP shall not exceed 20 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds when operated outdoors:	☐	☒
(1) As part of a **temporary or permanently fixed application**; or	☐	☒
(2) When being used in **vehicular applications to perform specific tasks of moving something or someone, except for in-cabin applications**;	☐	☒
(iv) A **field disturbance sensor** may operate in any of the modes in the above sub-sections so long as the device operates in only one mode at any time and does so for at least 33 milliseconds before switching to another mode.	☒ **FMCW**	☐
(v) **61.0–61.5 GHz:** For **field disturbance sensors/radars** that occupy 500 MHz bandwidth or less 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 **pulsed field disturbance sensors/radars** operating in the 57–64 GHz band that have a maximum pulse duration of 6 ns, the average EIRP shall not exceed 13 dBm and the transmit duty cycle shall not exceed 10% during any 0.3 µs time window. In addition, the average integrated EIRP within the frequency band **61.5–64.0 GHz** shall not exceed 5 dBm in any 0.3 µs time window. Peak emissions shall not exceed 20 dB above the maximum permitted average emission limit applicable to the equipment under test. The radar bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna	☐	☒
(4) The provisions in § 15.35(b) and (c) that require emissions to be averaged over a 100 millisecond period and that limits the peak power to 20 dB above the average limit do not apply to devices operating under paragraphs (c)(2) and (3) of this section.	☒ **FMCW**	☐
(d) Limits on spurious emissions:	☒ **Both**	
(1) The power density of any emissions outside the 57–71 GHz band shall consist solely of spurious emissions.	☒ **Both**	

(2) Radiated emissions below 40 GHz shall not exceed the general limits in § 15.209.	☒ **Both**	
(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.	☒ **Both**	
(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.	☒ **Both**	
(e) Limits on transmitter conducted output power.	☒ **BPSK**	☐
(1) Except as specified in paragraph (e)(2) of this section, the peak transmitter conducted output power of **devices other than field disturbance sensors/radars** 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 (c) of this section.	☐	☒
(2) **Devices other than field disturbance sensors/radars** with an emission bandwidth of less than 100 megahertz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 megahertz. 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 kilohertz 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).	☒ **BPSK**	☐
(f) 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.	☒ **Both**	
(g) Radio frequency radiation exposure: Radio frequency devices operating under the provisions of this part are subject to the radio frequency radiation exposure requirements specified in §§ 1.1307(b), 1.1310, 2.1091, and 2.1093 of this chapter, as appropriate. Applications for equipment authorization of mobile or portable devices operating under this section must contain a statement confirming compliance with these requirements. Technical information showing the basis for this statement must be submitted to the Commission upon request.	☒ **Both**	
(h) Group installation: Any transmitter that has received the necessary FCC equipment authorization under the rules of this chapter may be mounted in a group installation for simultaneous operation with one or more other transmitter(s) that have received the necessary FCC equipment authorization, without any additional equipment authorization. However, no transmitter operating under the provisions of this section may be equipped with external phase-locking inputs that permit beam-forming arrays to be realized.	☒ **Both**	
(i) Compliance measurement. Measurement procedures that have been found to be acceptable to the Commission in accordance with § 2.947 of this chapter may be used to demonstrate compliance.	☒ **Both**	
(1) For purposes of demonstrating compliance with this section, corrections to the transmitter conducted output power may be made due to the antenna and circuit loss.	☒ **Both**	
(2) Compliance measurements of **frequency-agile field disturbance sensors/radars** shall be performed with any related frequency sweep, step, or hop function activated.	☒ **Both**	☐
47 CFR 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	☒ **Both**	☐

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.		
47 CFR 15.209	☒	
47 CFR 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 table of this paragraph (see chapter 13.6), 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.	☒ **Both**	
(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.	☒ **Both**	☐

13 Measurement results

Note:
According to chapter "12 Basic information of the DUT & selection of applicable rule parts", some rule parts are applicable for both signal types FMCW and BPSK, and some rule parts (and, hence, some measurements) are only applicable to one of them.

In the following sections, this is taken into account by adding the following information:

- Both: Valid for FMCW & BPSK
- BPSK: Valid for BPSK
- FMCW: Valid for FMCW

13.1 Occupied bandwidth & emission bandwidth & Frequency stability

Description:

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

Limits and provisions:

Selection of applicable rule parts: see 12

Designated frequency band of 47 CFR 15.215
57 GHz – 71 GHz

Bandwidth to be measured		
Applicable	**Rule part**	**Bandwidth**
☒ **Both**	15.215(c)	20 dB bandwidth
☐	15.255(c)(3)	10 dB bandwidth
☒ **BPSK**	15.255(e)(2)	6 dB emission bandwidth

Note:

- Definition of 6dB emission bandwidth (15.255(e)(2)): 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 kilohertz 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).

Measurement:

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	50 MHz (Normal mode) 100 kHz (BPSKonly mode)
Video bandwidth:	80 MHz (Normal mode) 300 kHz (BPSKonly mode)
Trace-Mode:	Max Hold

Measurement procedures:

- Bandwidth: ANSI C63.10-2013 6.9 / 9.3
- Frequency stability: ANSI C63.10-2013 6.8 / 9.4

Measurement results:

20 dB bandwidth at normal conditions:

EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [MHz]
1	Normal mode	T_{nom} / V_{nom}	61.11	63.85	2750
1	BPSKonly	T_{nom} / V_{nom}	62.4688	62.4733	4.5

6 dB emission bandwidth at normal conditions:

EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [MHz]
1	BPSKonly	T_{nom} / V_{nom}	62.470769	62.471419	0.65

Frequency stability:

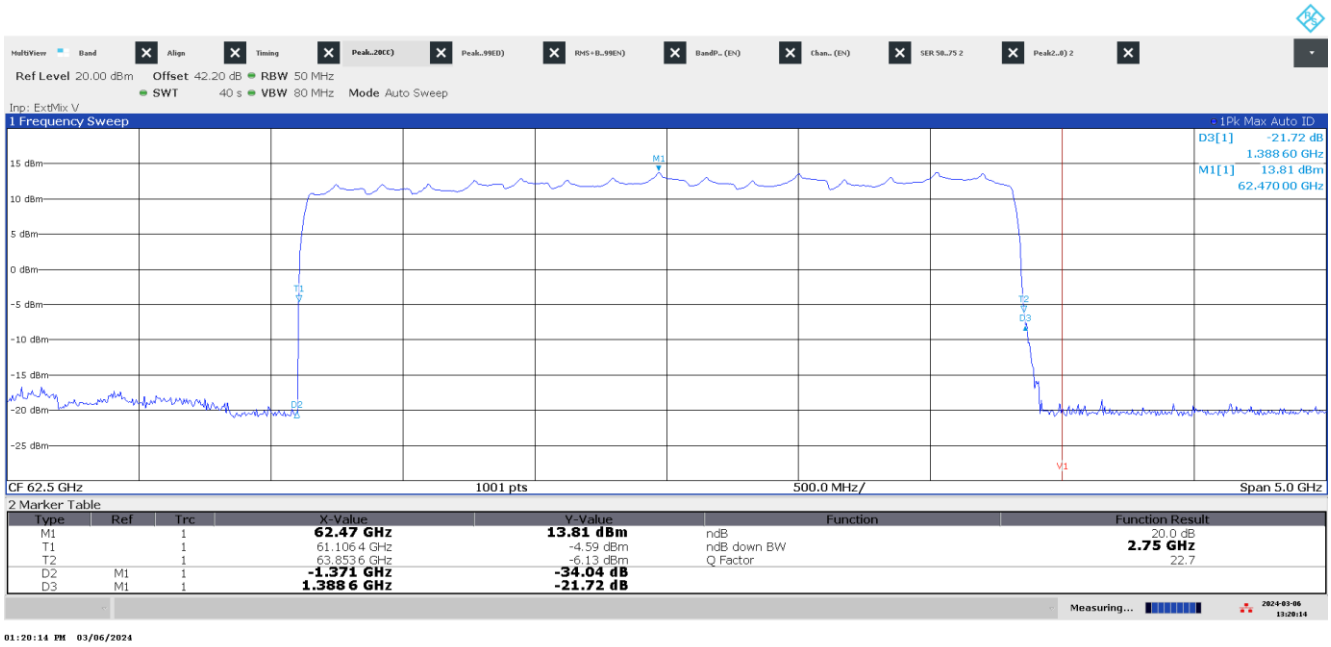
Mode for frequency stability tests: **Normal operation mode** (Mode with the widest bandwidth, ANSI C63.10-2020 5.6.2.2)

Bandwidth measurement for frequency stability tests: **20 dB bandwidth**

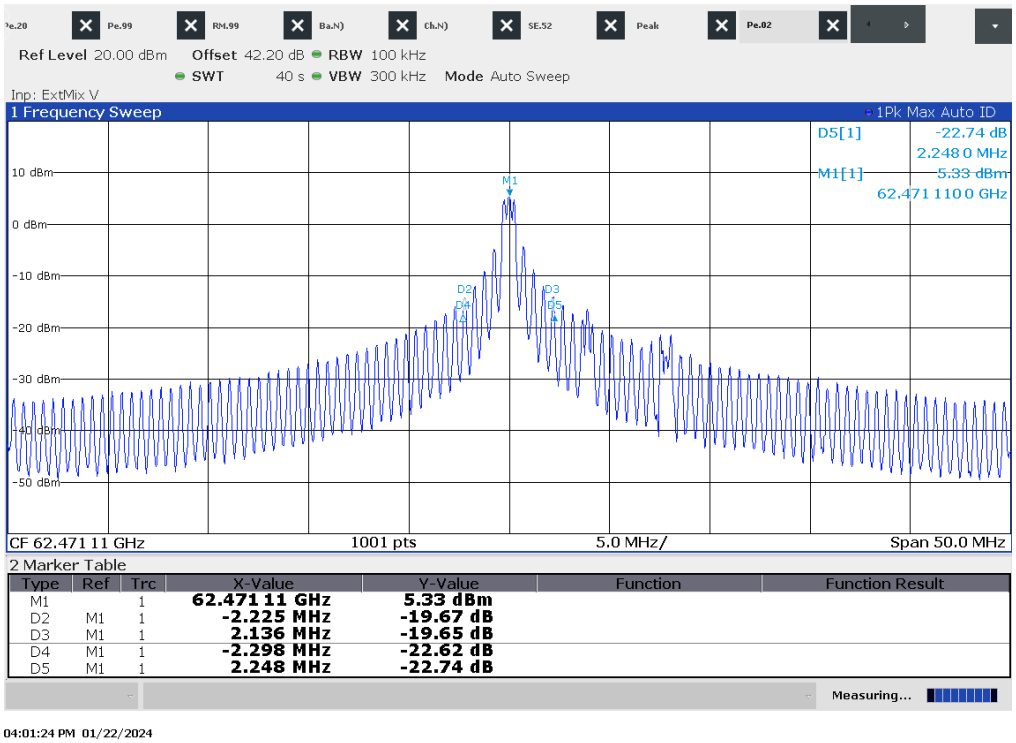
Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [MHz]
-20 °C / V_{nom}	Out of operating temperature range → emissions switched off		
-10 °C / V_{nom}			
0 °C / V_{nom}			
10 °C / V_{nom}			
20 °C / V_{nom}	61.11	63.86	2750
20 °C / V_{min}	61.11	63.86	2750
20 °C / V_{max}	61.11	63.86	2750
30 °C / V_{nom}	61.10	63.86	2760
35 °C / V_{nom}	61.11	63.86	2750
40 °C / V_{nom}	Out of operating temperature range → emissions switched off		
50 °C / V_{nom}			

Verdict: Compliant

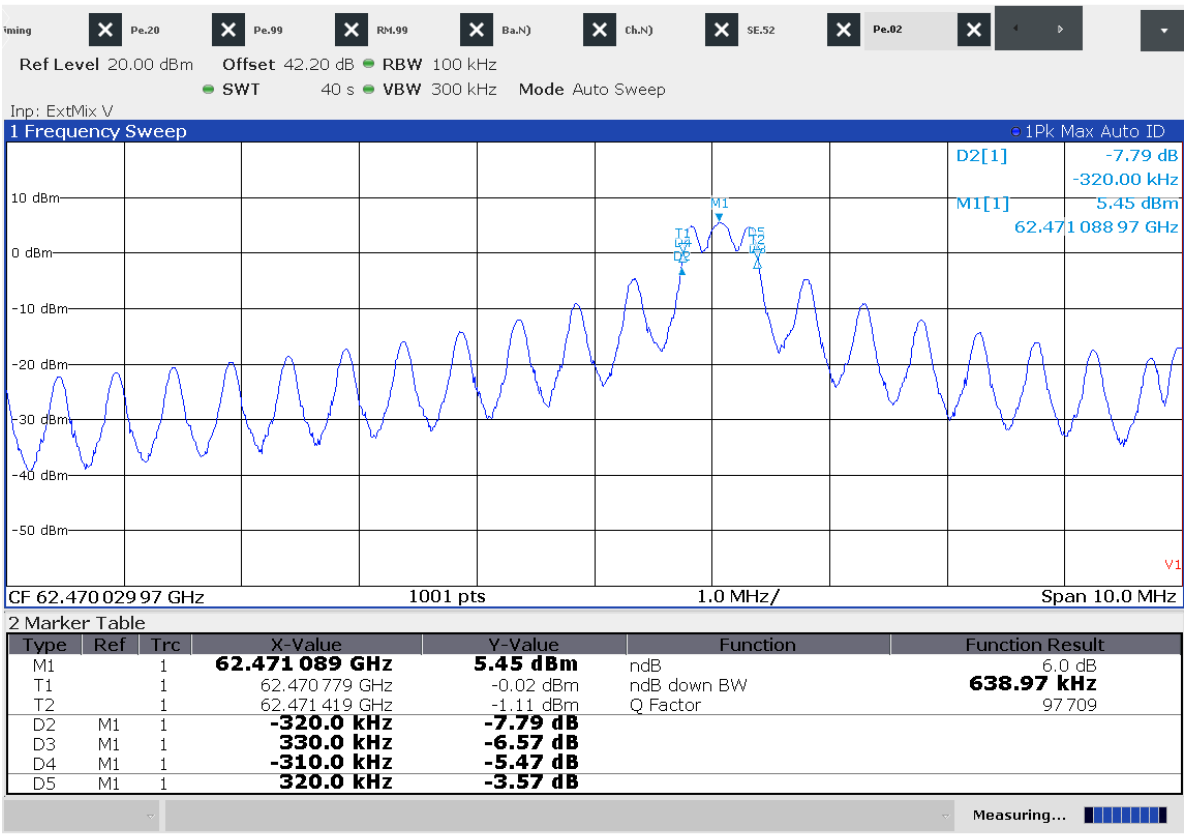
Plot 1: 20dB bandwidth at normal condition, Normal mode, FWv1.06



Plot 2: 20dB bandwidth at normal condition, BPSKonly mode, FWv1.06



Plot 3: 6dB bandwidth at normal condition, BPSKonly mode, FWv1.06



Plot 4: 20dB bandwidth at 20°C / Vnom, Normal mode, FWv1.10

Plot 5: 20dB bandwidth at 20°C / Vmin, Normal mode, FWv1.10

Plot 6: 20dB bandwidth at 20°C / Vmax, Normal mode, FWv1.10

Plot 7: 20dB bandwidth at 30°C / Vnom, Normal mode, FWv1.10

Plot 8: 20dB bandwidth at 35°C / Vnom, Normal mode, FWv1.10

13.2 Radiated power (EIRP)

Description:

Measurement of the maximum radiated E.I.R.P. of the wanted signal.

Limits and provisions:

Selection of applicable rule parts: see 12

Applicable limits for radiated power (EIRP)			
Applicable	**Rule part**	**Limit average EIRP**	**Limit peak EIRP**
☒ **BPSK**	15.255(c)(1)(i)	40 dBm (see note 1)	43 dBm
☐	15.255(c)(1)(ii)	(see note 1 & 2.1)	(see note 1 & 2.2)
☐	15.255(c)(2)	none	10 dBm
☐	15.255(c)(2)(i)	none	20 dBm (indoor) 30 dBm (outdoor)
☐	15.255(c)(2)(ii)	none	3 dBm (general) 20 dBm (+ off-time requirement)
☒ **FMCW**	15.255(c)(2)(iii)(A)	none	14 dBm (+ off-time requirement)
☐	15.255(c)(2)(iii)(B)	none	20 dBm (+ off-time requirement)
☐	15.255(c)(2)(v)	40 dBm (within 61-61.5 GHz) (see note 1)	43 dBm (within 61.0-61.5 GHz)
		10 dBm (outside 61-61.5 GHz) (see note 1)	13 dBm (outside 61-61.5 GHz)
☐	15.255(c)(3)	13 dBm (+ time domain requirement)	applicable average limit + 20 dB
		5 dBm (average integrated EIRP within 61.5–64.0 GHz in any 0.3 µs time window)	

Note:
1. Measured during the transmit interval
2. Calculation:
   2.1. 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.
   2.2. 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.

Measurement:

Method used for FMCW signal (Normal mode tested):

Spectrum analyzer:

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

Method used for BPSK signal (BPSKonly mode tested):

RF detector:

Measurement parameter	
Detector:	Pos-Peak (RF-Detector)
Video bandwidth:	≥ 10 MHz

Measurement procedures:

- Fundamental emission using an RF detector: ANSI C63.10-2013 9.11

Measurement results:

EUT	Mode	Test condition	Peak E.I.R.P.	Limit peak E.I.R.P	Average E.I.R.P	Limit average EIRP
1	Normal mode*	T_{nom} / V_{nom}	13.8 dBm	14 dBm	none	none
1	BPSKonly mode	T_{nom} / V_{nom}	10.1 dBm	43 dBm	10 dBm	40 dBm

Note:

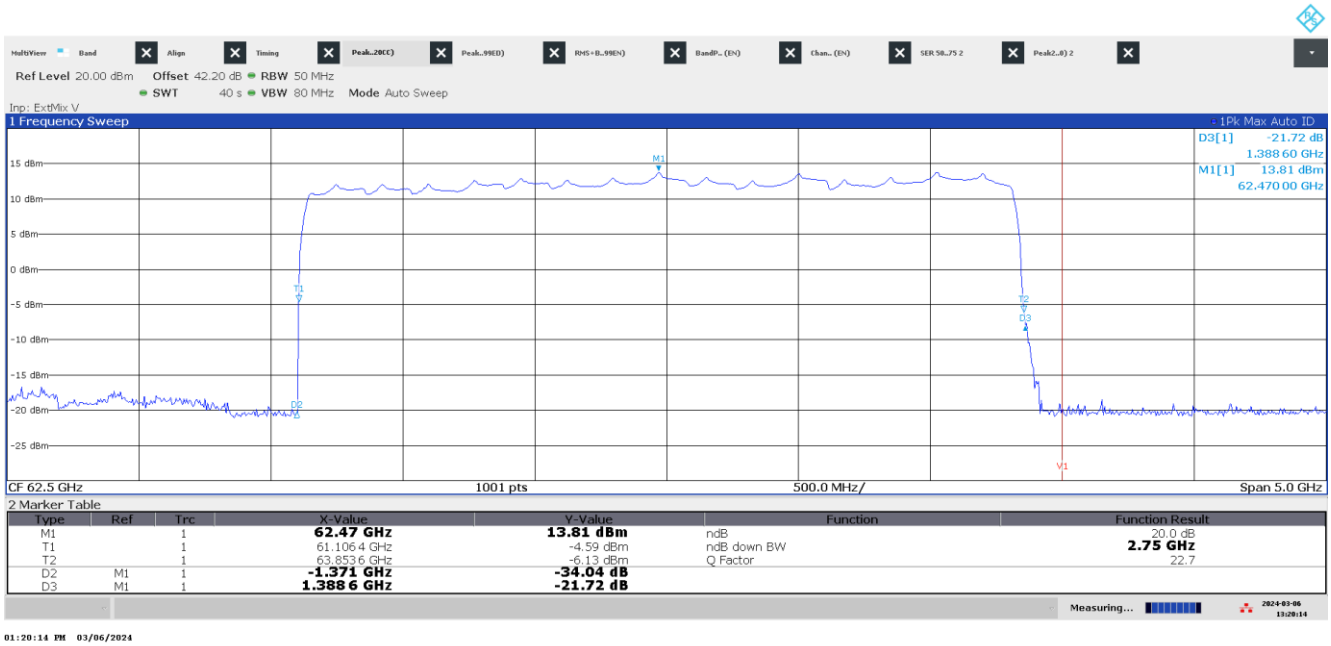
- *Valid for FMCW signal (In normal mode, the FMCW signal and the BPSK signal is present sequentially → the normal mode is the worst-case mode to demonstrate compliance for the FCMW signal)

Verdict: Compliant

Method used for FMCW signal (Normal mode tested):

Spectrum analyzer:

Plot 9: Peak EIRP, Normal Mode, FWv1.06



Method used for BPSK signal (BPSKonly mode tested):

RF detector: 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: $V_{max,EUT}$

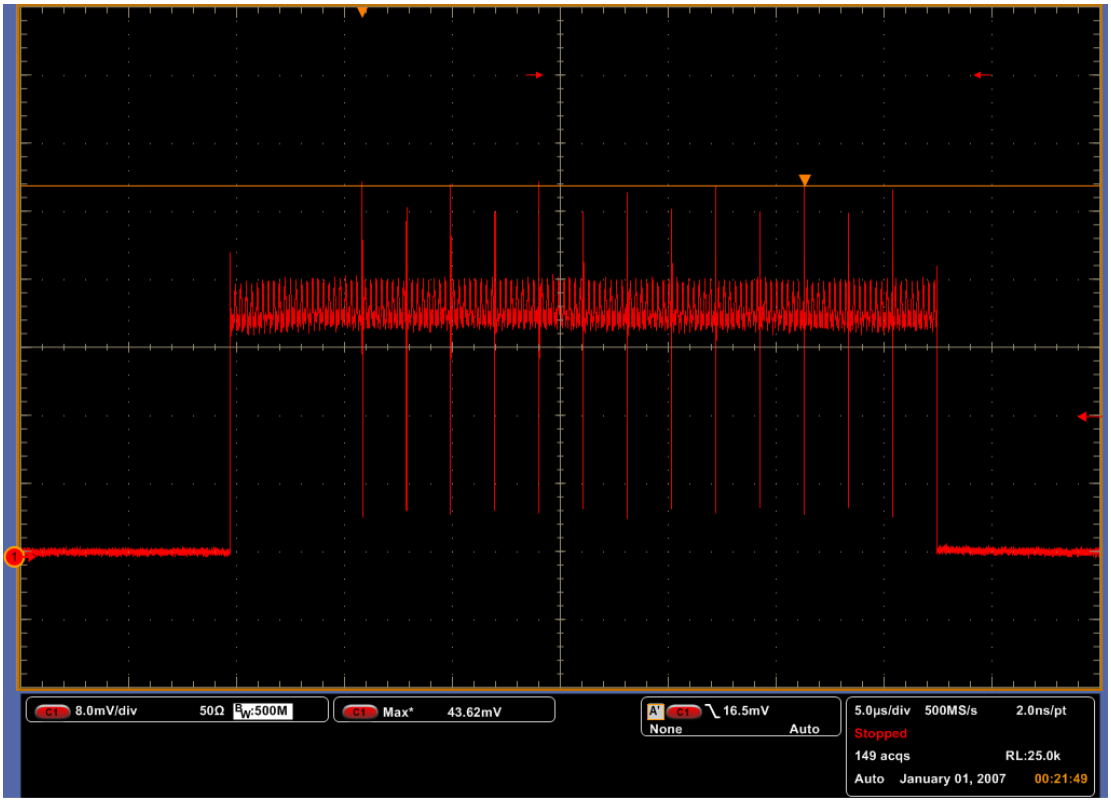
2) Substitution of EUT by a cw reference source with a frequency of f_{REF} and a fixed output power of P_{REF}
   - Positioning of the cw reference source at distance: d_{EUT}
   - Adjustment of the readout value on oscilloscope to V_{max} via the variable attenuator of the source: $V_{max,CW} = V_{max,EUT}$

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

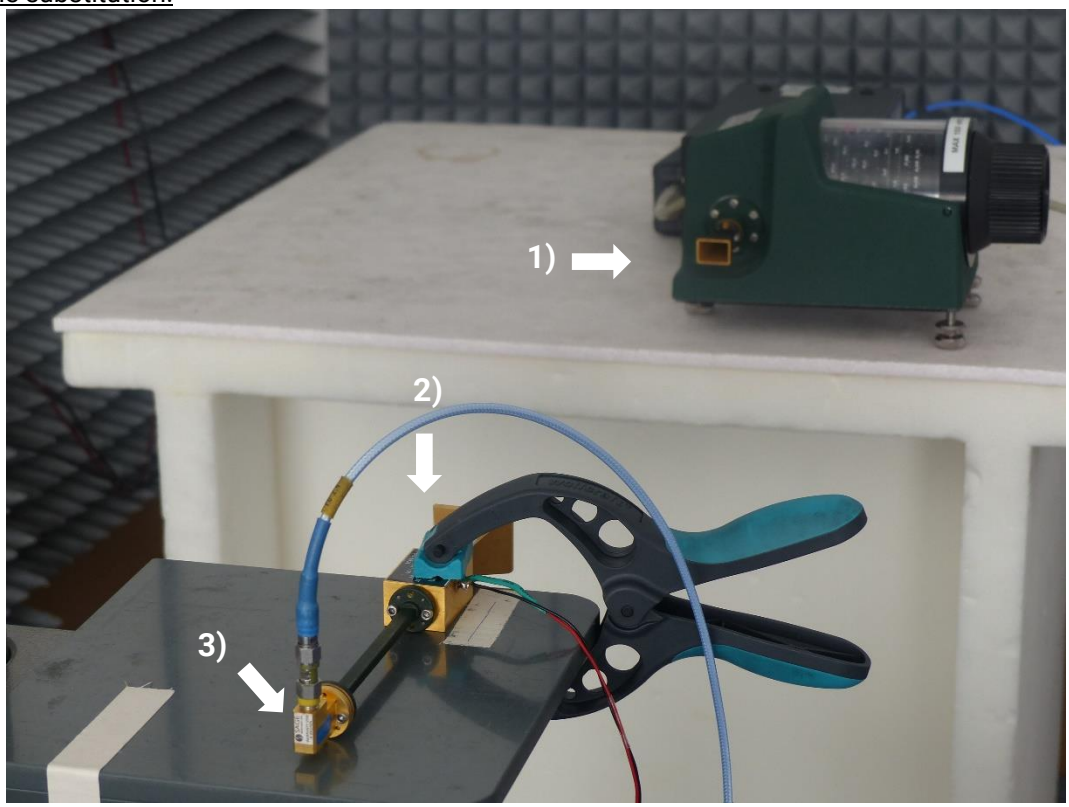
4) Calculation of the Peak E.I.R.P. of the EUT taking into account the gain of the substitution antenna G_{CW}:
   - $P_{Peak\ E.I.R.P.} = P_{cond,CW} + G_{CW}$

Measurement step	Measurement parameter		EUT Mode			
			BPSKonly	-/-	-/-	-/-
1	d_{EUT}	[m]	0.5	-/-	-/-	-/-
	$V_{max,EUT}$	[mV]	44	-/-	-/-	-/-
2	f_{REF}	[GHz]	62.471	-/-	-/-	-/-
3	$P_{cond,CW}$	[dBm]	-10	-/-	-/-	-/-
4	G_{CW}	[dBi]	20.1	-/-	-/-	-/-
	$P_{Peak\ E.I.R.P.}$	[dBm]	10.1	-/-	-/-	-/-

Plot 10: EUT emission, BPSKonly mode, FWv1.10



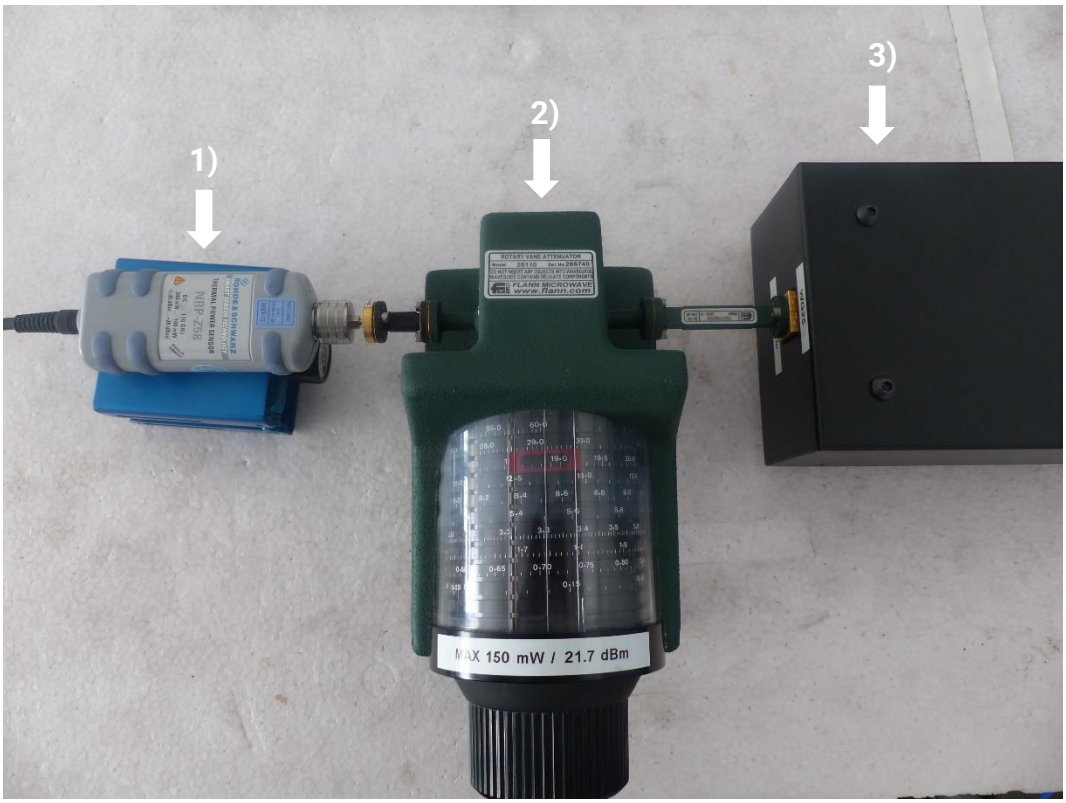
Setup of the substitution:



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)

13.3 Peak transmitter conducted output power

Description:

Measurement or calculation of the transmitter conducted output power.

Limits and provisions:

Selection of applicable rule parts: see 12

Applicable limits for peak transmitter conducted output power		
Applicable	**Rule part**	**Limit peak transmitter conducted output power**
☐	15.255(c)(2)	-10 dBm
☐	15.255(e)(1)	500 mW
☒ **BPSK**	15.255(e)(2)	500 mW * (emission bandwidth/100 MHz)
☒ **FMCW**		none

Note:
- Emission bandwidth: see chapter 13.1

Results:

EUT	Mode	Test condition	Peak E.I.R.P.	Gain of EUT antenna G_{EUT}	Peak transmitter conducted output power	Limit Peak transmitter conducted output power
1	BPSKonly	T_{nom} / V_{nom}	10.1 dBm	6.6 dBi	3.5 dBm	5.1 dBm

Note:
- Peak transmitter conducted output power = Peak E.I.R.P – Gain of EUT antenna G_{EUT}
- Peak EIRP: see chapter 13.2
- Gain of EUT antenna:
  - External report provided by customer:
    1-6186-23-02-07_TR1-A301-R01 (HW-108-066-REV03_Antenna_Test_Report_JSE)
  - Antenna gain at 62.47 GHz (centre frequency of BPSK signal): 6.6 dBi
- Limit Peak transmitter conducted output power:
  - Emission bandwidth: 0.65 MHz
  - Limit = 500 mW * (0.65MHz/100 MHz) = 3.25 mW → 5.1 dBm

Verdict: Compliant

13.4 Time domain requirements: Continous transmitter off-times & transmit duty cycle

Description:

Measurement of the time domain parameter.

Limits and provisions:

Selection of applicable rule parts: see 12

Applicable time domain requirements		
Applicable	**Rule part**	**Time domain requirement**
☐	15.255(b)(3)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(2)(i)	Peak EIRP ≤ 3 dBm: none
		Peak EIRP ≤ 20 dBm: sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☒ **FMCW**	15.255(c)(2)(iii)(A)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(2)(iii)(B)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(3)	maximum pulse duration of 6 ns; transmit duty cycle shall not exceed 10% during any 0.3 µs time window
☒ **BPSK**		none

Note:

- Continous transmitter off-times:
  Off-times are only taken into account if they are larger than the specified minimum value (e.g. 2 ms).
  Off-times smaller than the specified minimum value are not considered when checking the specified limit (e.g. "at least 25.5 ms within any contiguous interval of 33 ms").

Measurement:

Measurement parameter	
Detector:	Pos-Peak (RF-Detector)
Video bandwidth:	Video bandwidth:

Measurement results:

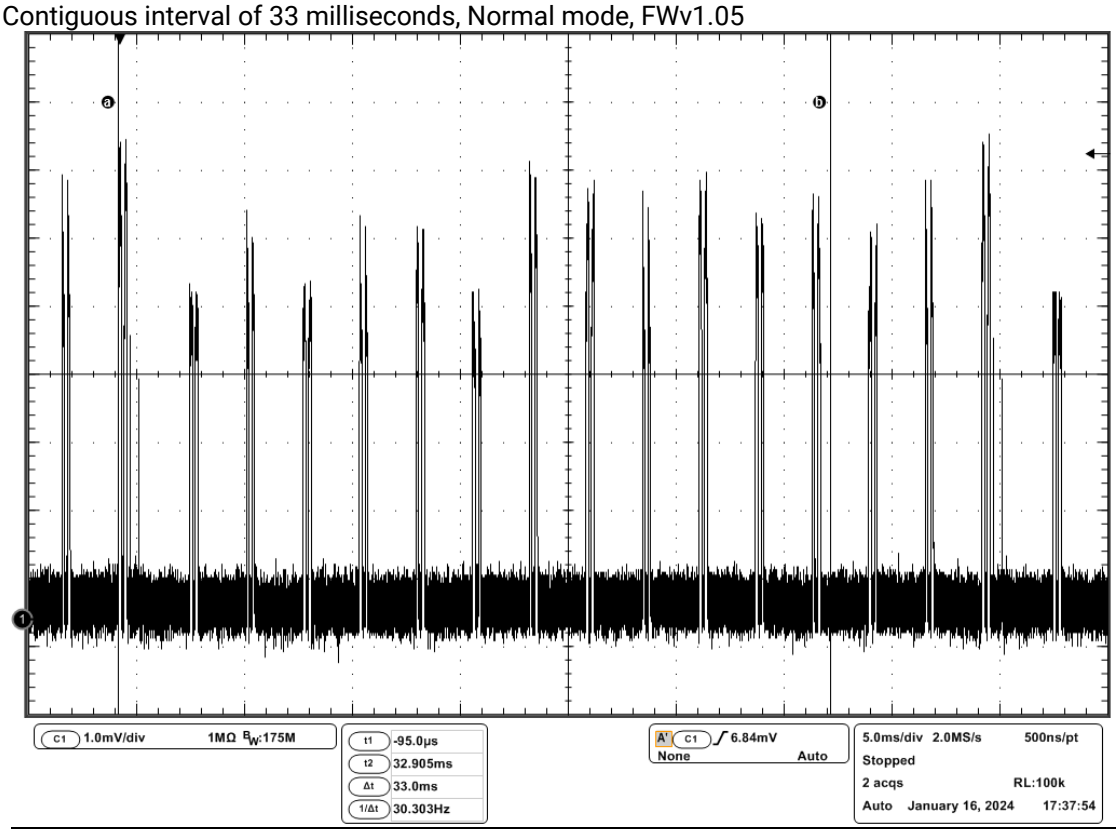
EUT	Mode	Test condition	Maximum sum of continuous transmitter off-times of at least two milliseconds within any contiguous interval of 33 milliseconds.	
1	Normal mode	T_{nom} / V_{nom}	Measured value	Limit
			26.88 ms	25.5 ms

Note:

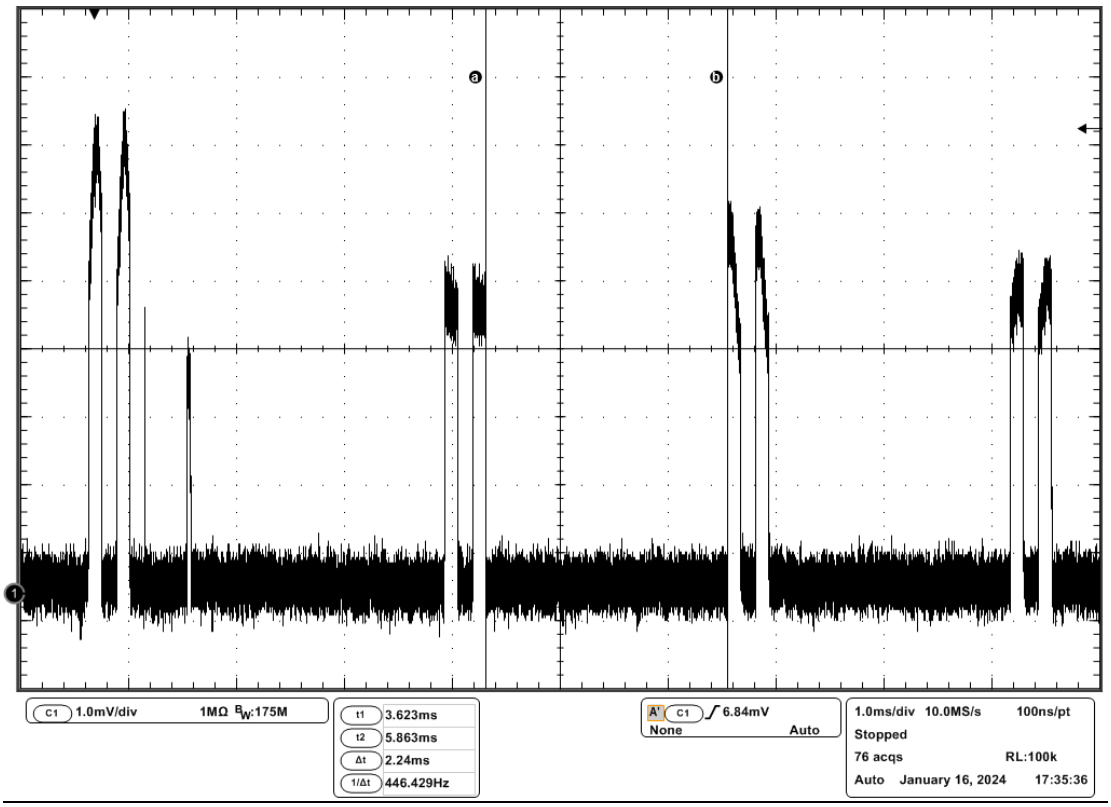
- Number of continuous transmitter off-times within 33 ms: 12 (see Plot 11)
- Minimum duration of continuous transmitter off-time: 2.24 ms
- Maximum sum of continuous transmitter off-times within any contiguous interval of 33 milliseconds: 12 * 2.24 ms = 26.88 ms

Verdict: Compliant

Plot 11: Contiguous interval of 33 milliseconds, Normal mode, FWv1.05



Plot 12: Minimum duration of continous transmitter off-time, Normal mode, FWv1.05



13.5 Spurious emissions radiated

Description:

Measurement of the radiated spurious emissions.

Limits and provisions:

Selection of applicable rule parts: see 12

47CFR Part 15.209(a)		
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
47 CFR 15.255(d)		
Frequency (GHz)	Power density [pW/cm2]	Equivalent isotropically radiated power: EIRP [dBm]
Below 40	See §15.209	
40 - 200	90 @ distance of 3 m	-10
The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.		
The levels of the spurious emissions shall not exceed the level of the fundamental emission.		
47 CFR 15.255(i)(2)		
Compliance measurements of frequency-agile field disturbance sensors/radars shall be performed with any related frequency sweep, step, or hop function activated.		
47 CFR 15.33(a)(3)		
If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.		

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

EIRP[dBm] = 10 × log(4 × π × d² × PD[W/m²])

- 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 / Average (linear) / 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

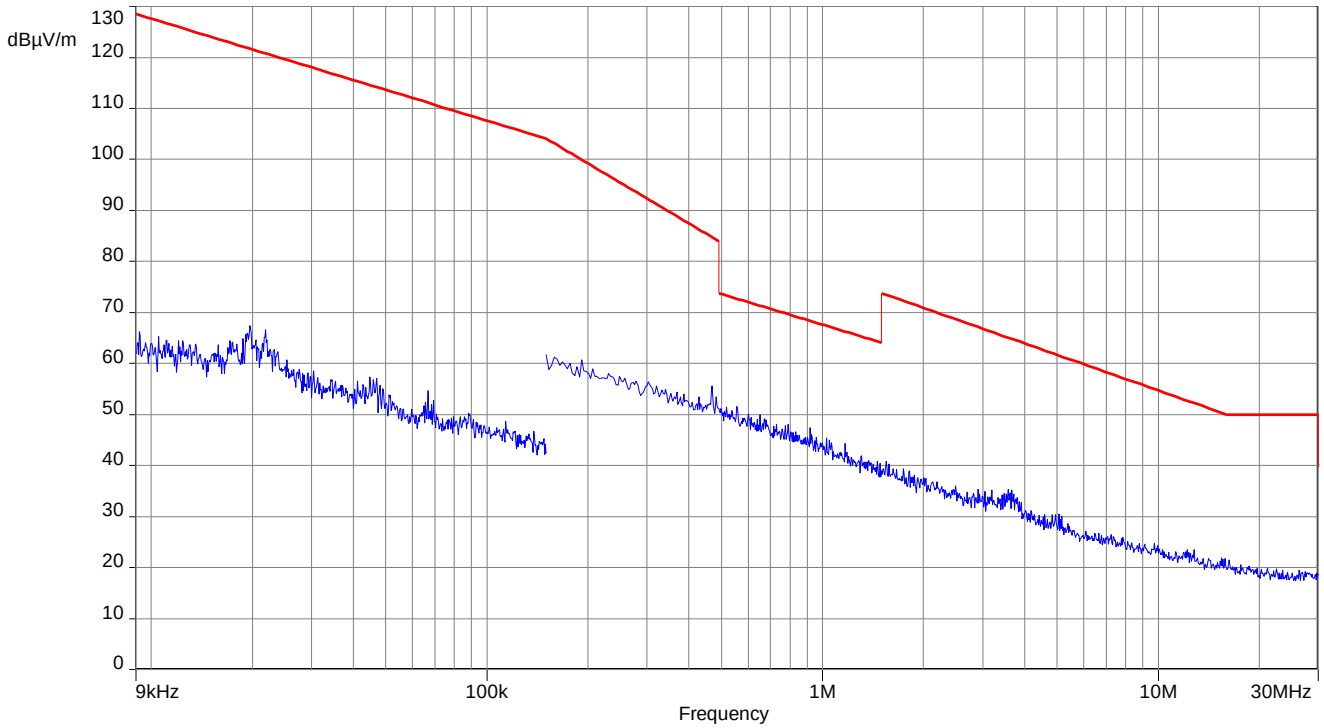
Measurement results:

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
1.440	Peak	1	61.8 dBµV/m	74 dBµV/m	12.2
1.440	Average	1	46.6 dBµV/m	54 dBµV/m	7.4
8.825	Peak	1	71.6 dBµV/m	74 dBµV/m	2.4
8.825	Average	1	48.9 dBµV/m	54 dBµV/m	5.1
8.828	Peak	1	73.7 dBµV/m	74 dBµV/m	0.3
8.828	Average	1	51.3 dBµV/m	54 dBµV/m	2.7
35.700	Peak	1	65.6 dBµV/m	74 dBµV/m	8.4
35.700	Average	1	47.9 dBµV/m	54 dBµV/m	6.1
Please refer to the following plots for more information on the level of spurious emissions					

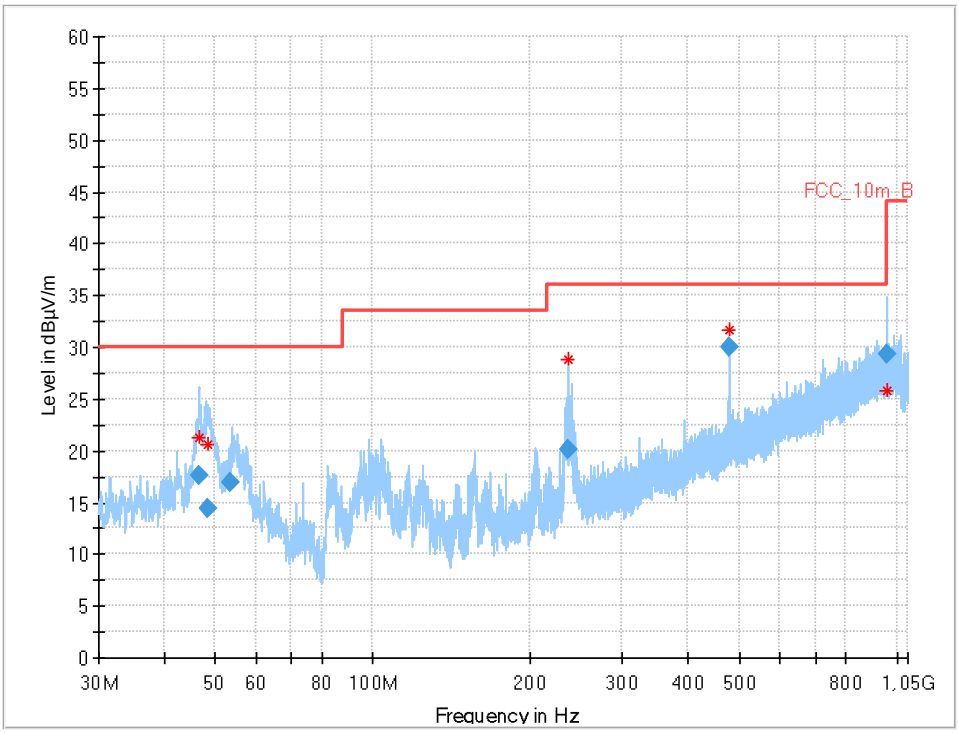
Note:
The normal mode is used for the spurious emission measurements.
In normal mode, the FMCW signal and the BPSK signal is present
→ The normal mode is the worst-case mode to demonstrate compliance for the FCMW signal and the BPSK signal

Verdict: Compliant

Plot 13: 9 kHz – 30 MHz, Normal mode, FWv1.06

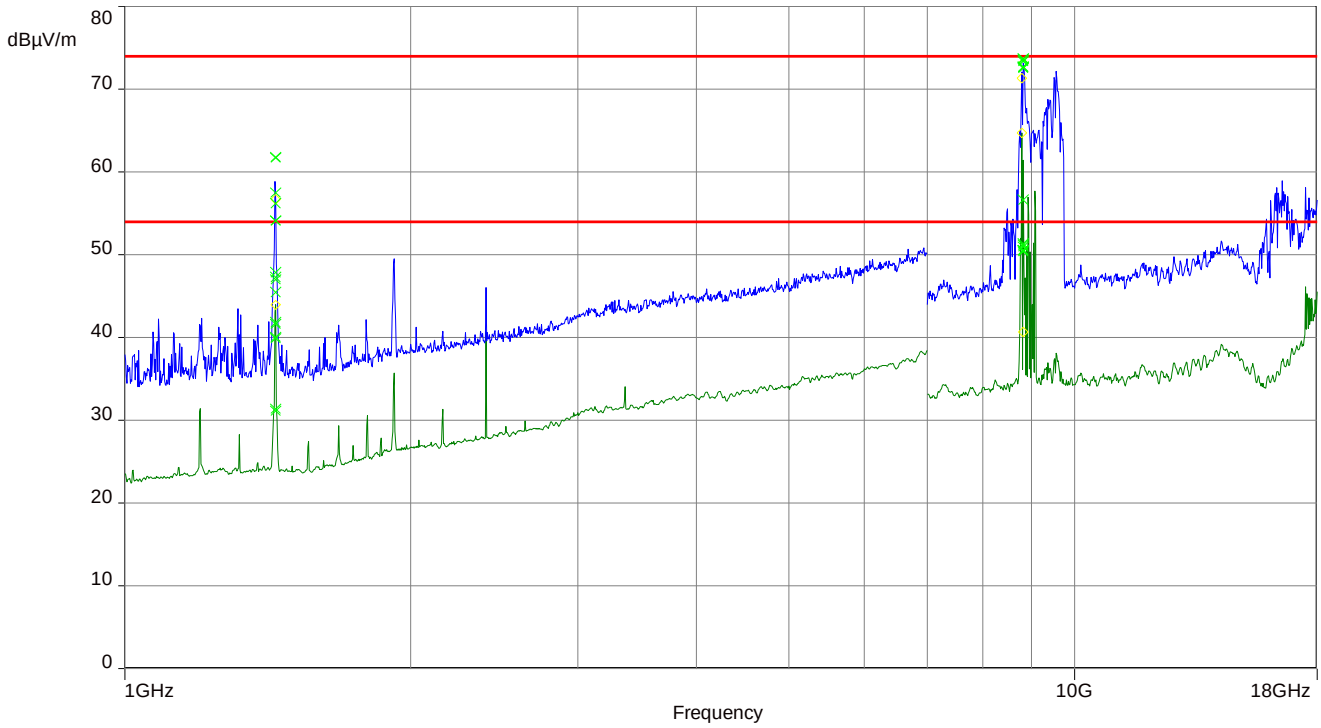


Plot 14: 30 MHz – 1GHz



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
46.583	17.66	30.0	12.3	1000	120.0	106.0	V	217	15
48.289	14.37	30.0	15.6	1000	120.0	110.0	V	204	15
53.505	16.98	30.0	13.0	1000	120.0	121.0	V	142	15
235.536	20.15	36.0	15.9	1000	120.0	114.0	V	81	14
480.000	29.94	36.0	6.1	1000	120.0	195.0	H	-36	19
960.509	29.40	44.0	14.6	1000	120.0	195.0	H	142	25

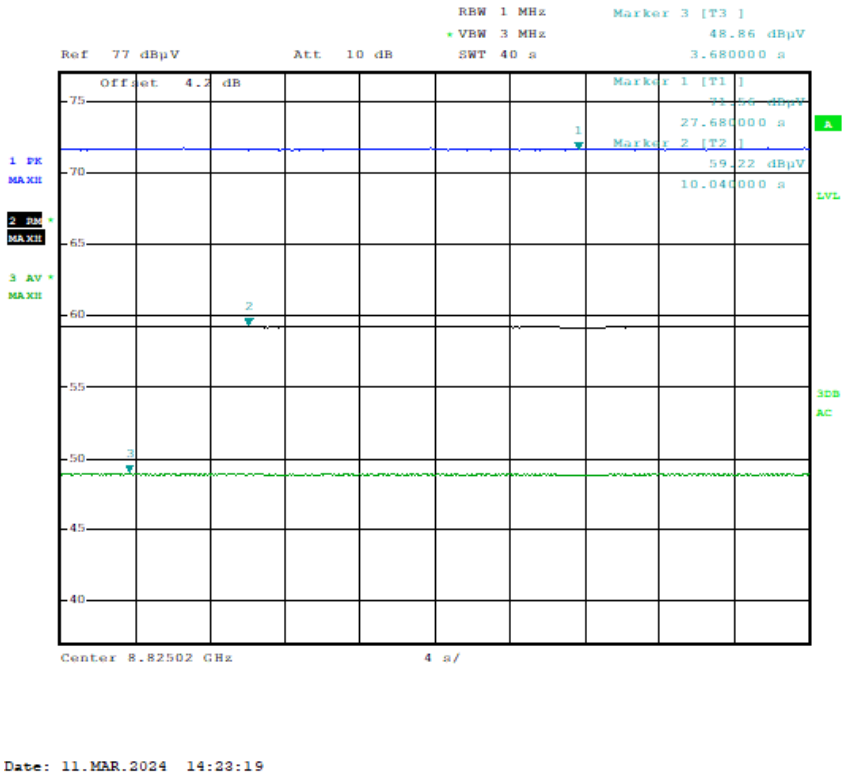
Plot 15: 1GHz – 18 GHz, Normal mode, FWv1.06



Note:

- Upper red line: Peak emission limit
- Lower red line: Average (linear) emission limit

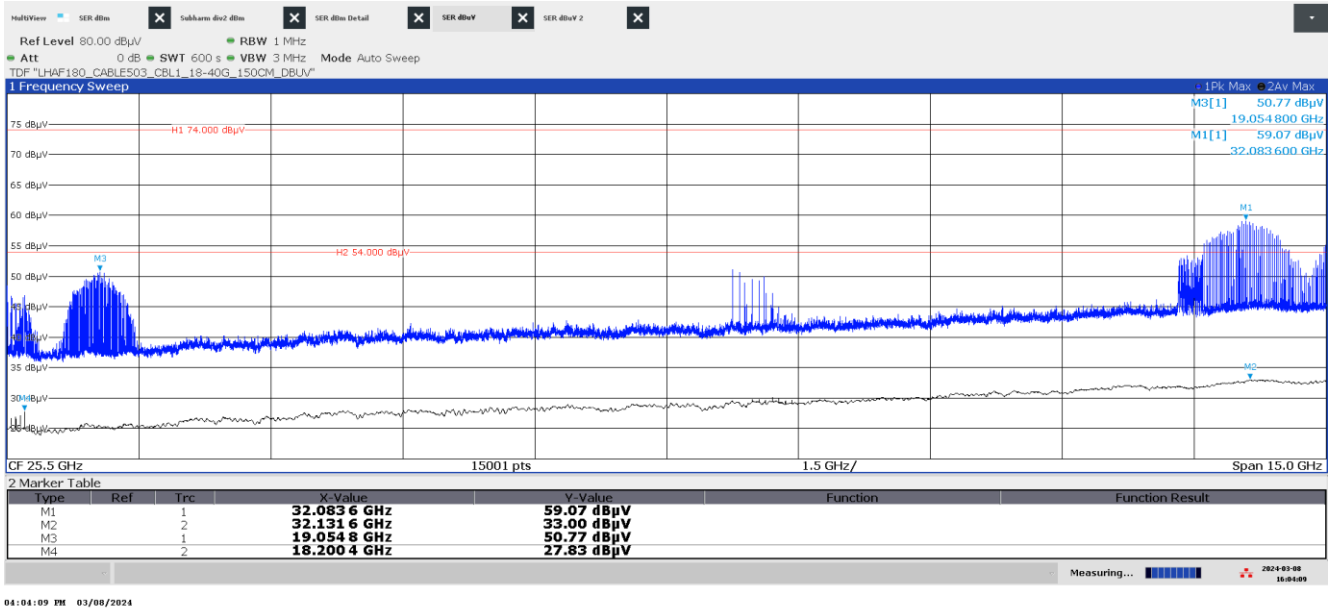
Plot 16: 1GHz – 18 GHz, Normal mode, FWv1.06, detail



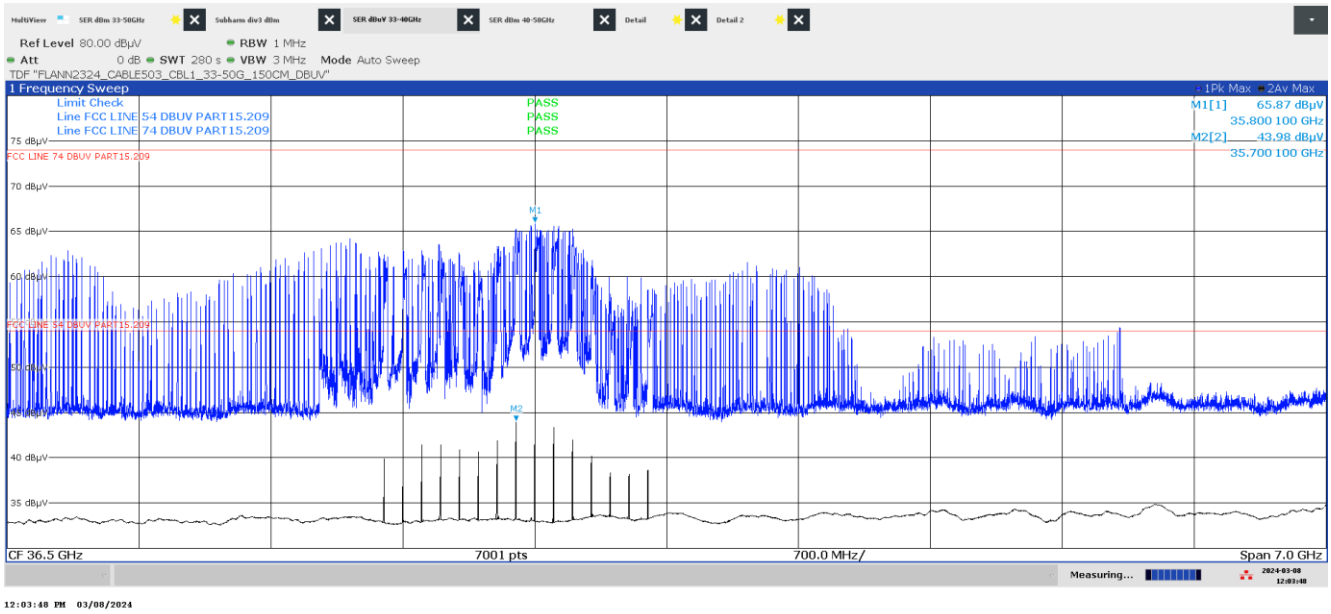
Note: Relevant results

- Trace 1: Peak
- Trace 3: Average

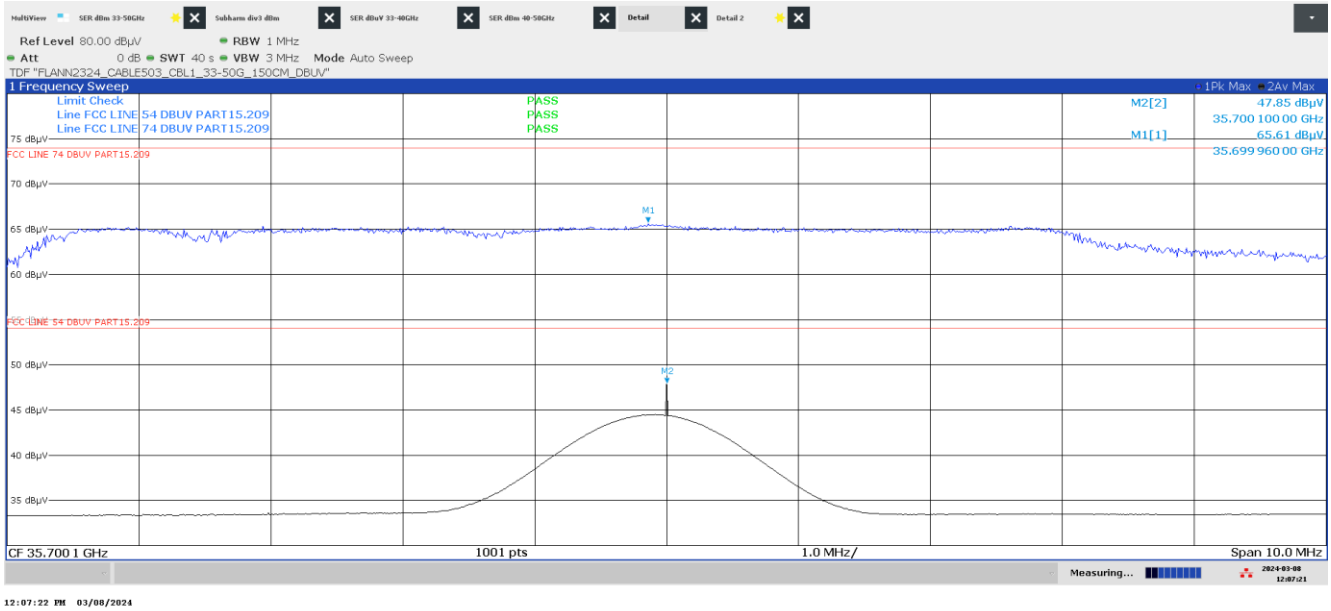
Plot 17: 18 GHz – 33 GHz, Normal mode, FWv1.06



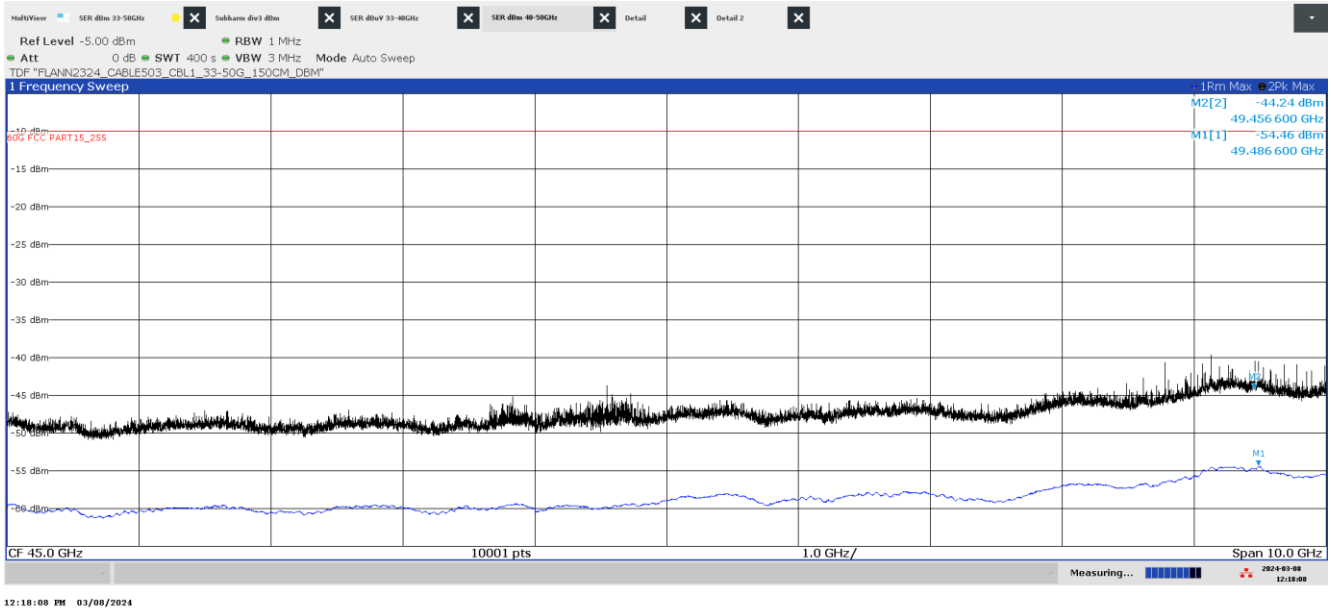
Plot 18: 33 GHz – 40 GHz, Normal mode, FWv1.06



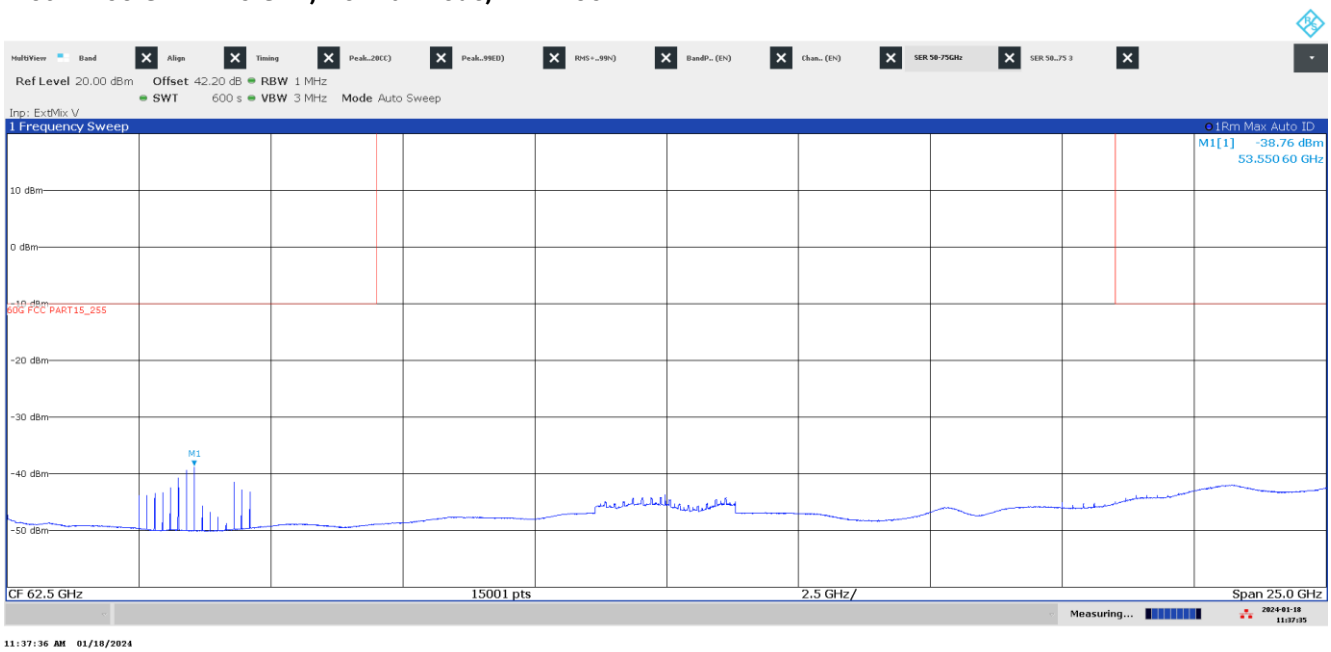
Plot 19: 33 GHz – 40 GHz, Normal mode, FWv1.06, detail



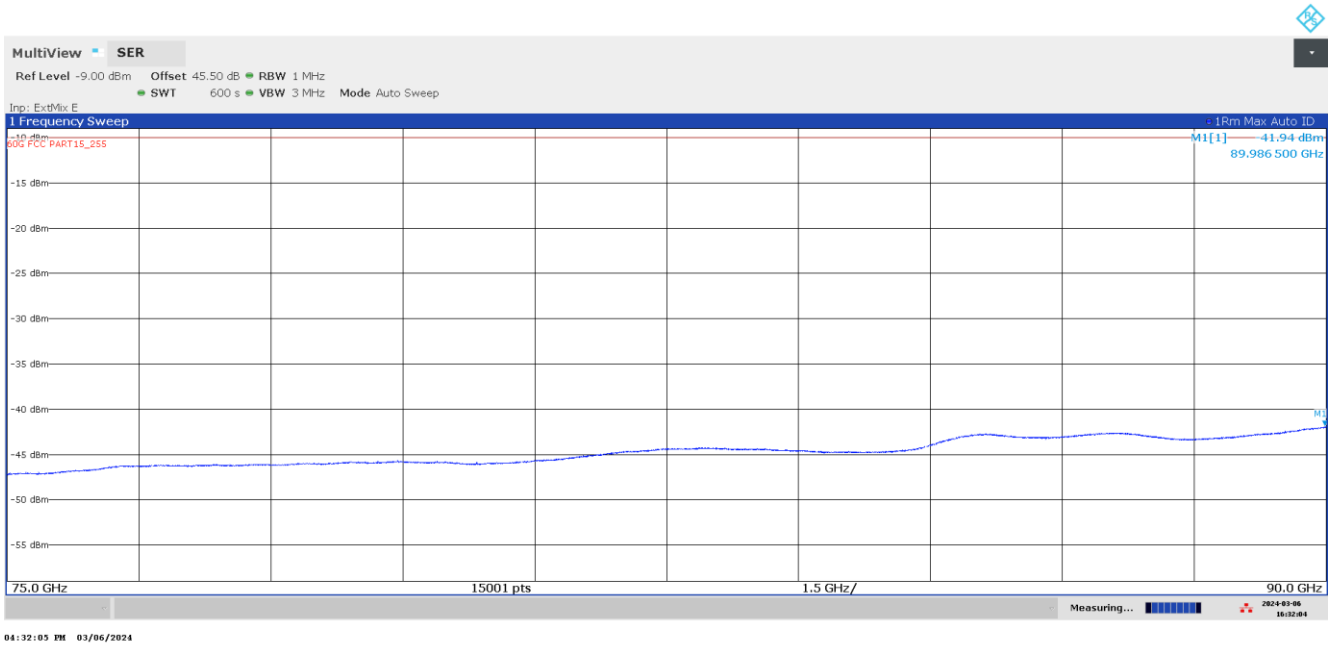
Plot 20: 40 GHz – 50 GHz, Normal mode, FWv1.06



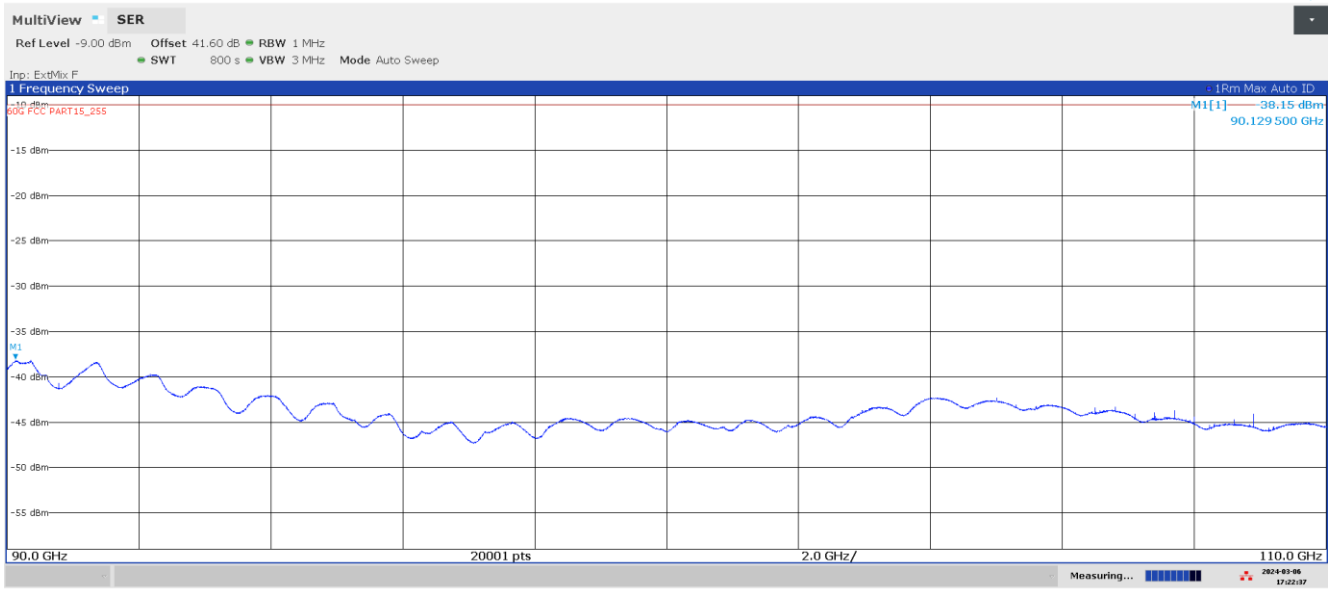
Plot 21: 50 GHz – 75 GHz, Normal mode, FWv1.05



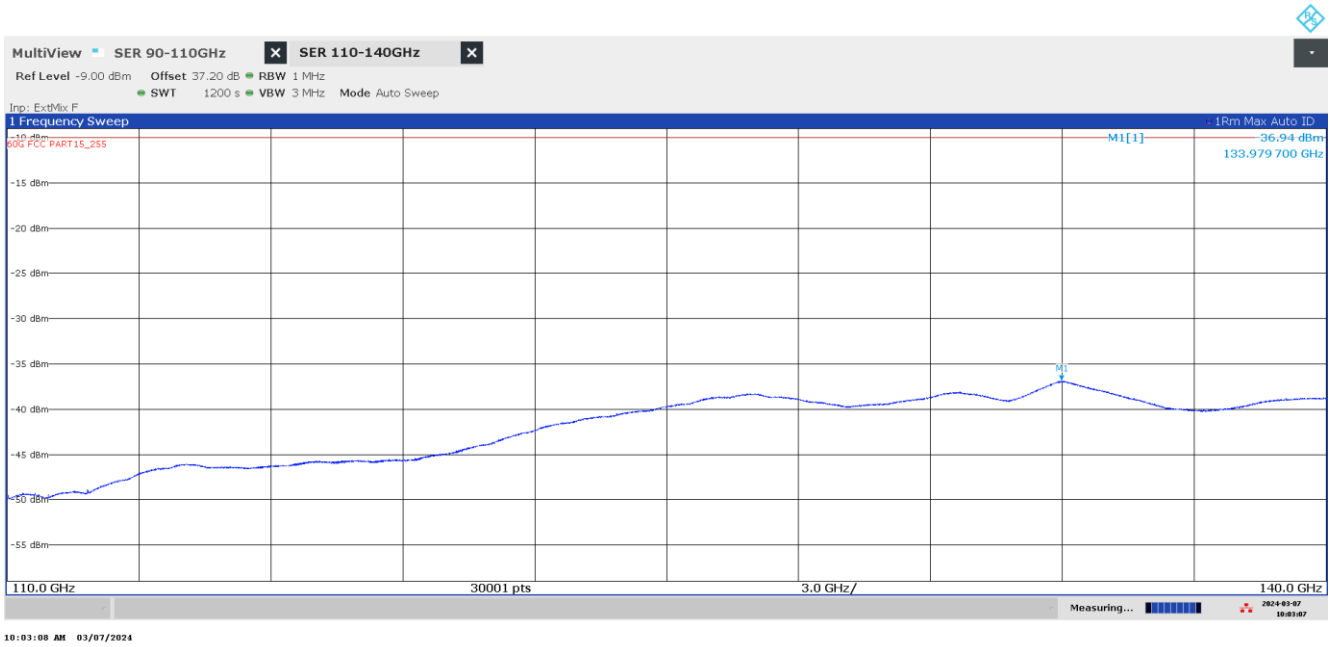
Plot 22: 75 GHz – 90 GHz, Normal mode, FWv1.06



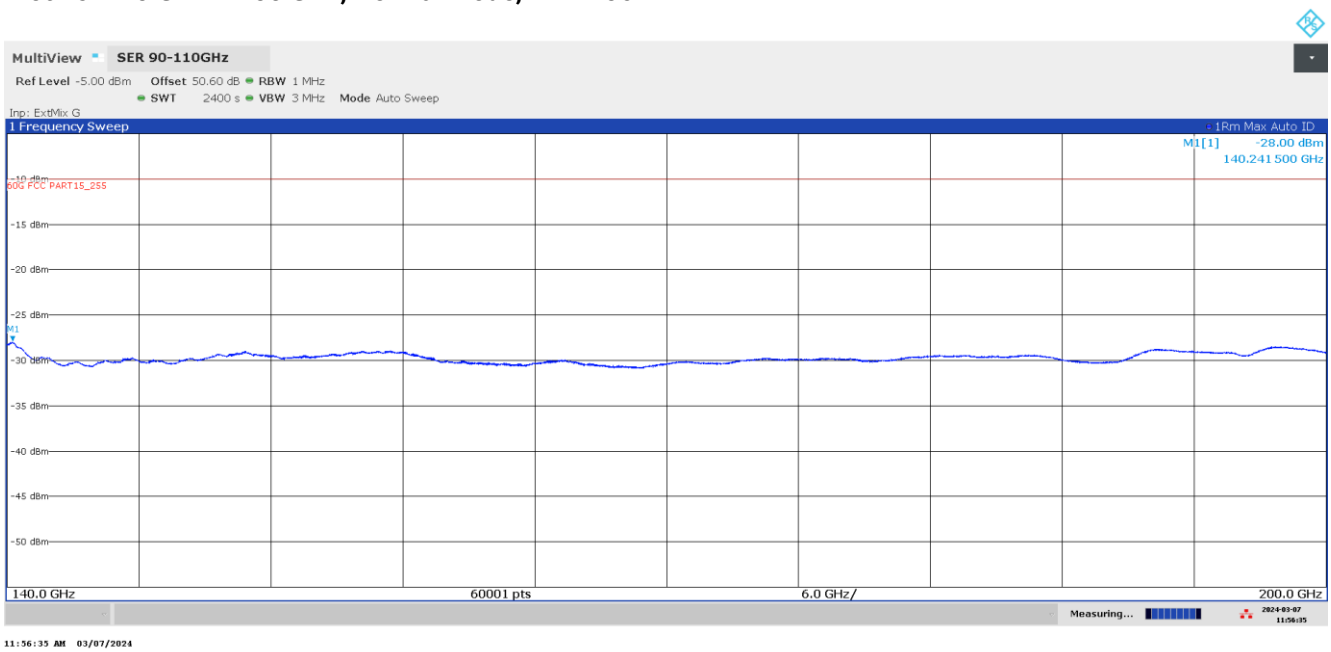
Plot 23: 90 GHz – 110 GHz, Normal mode, FWv1.06



Plot 24: 110 GHz – 140 GHz, Normal mode, FWv1.06



Plot 25: 140 GHz – 200 GHz, Normal mode, FWv1.06



13.6 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:

Selection of applicable rule parts: see 12

47 CFR 15.207(a)		
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

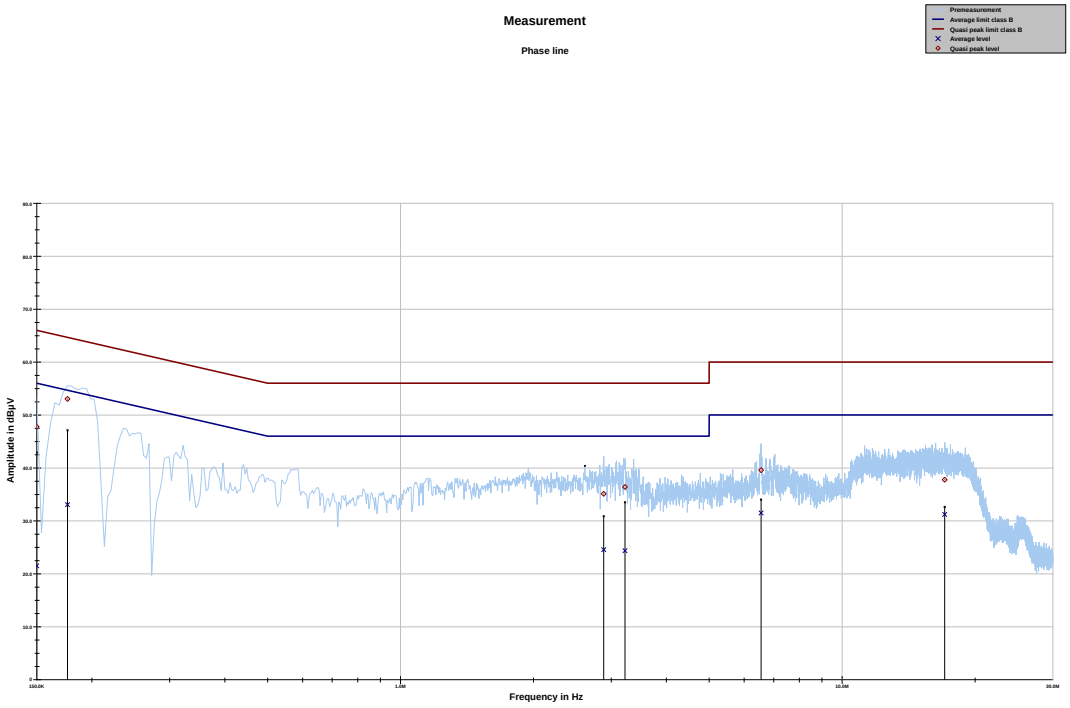
* Decreases with the logarithm of the frequency

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

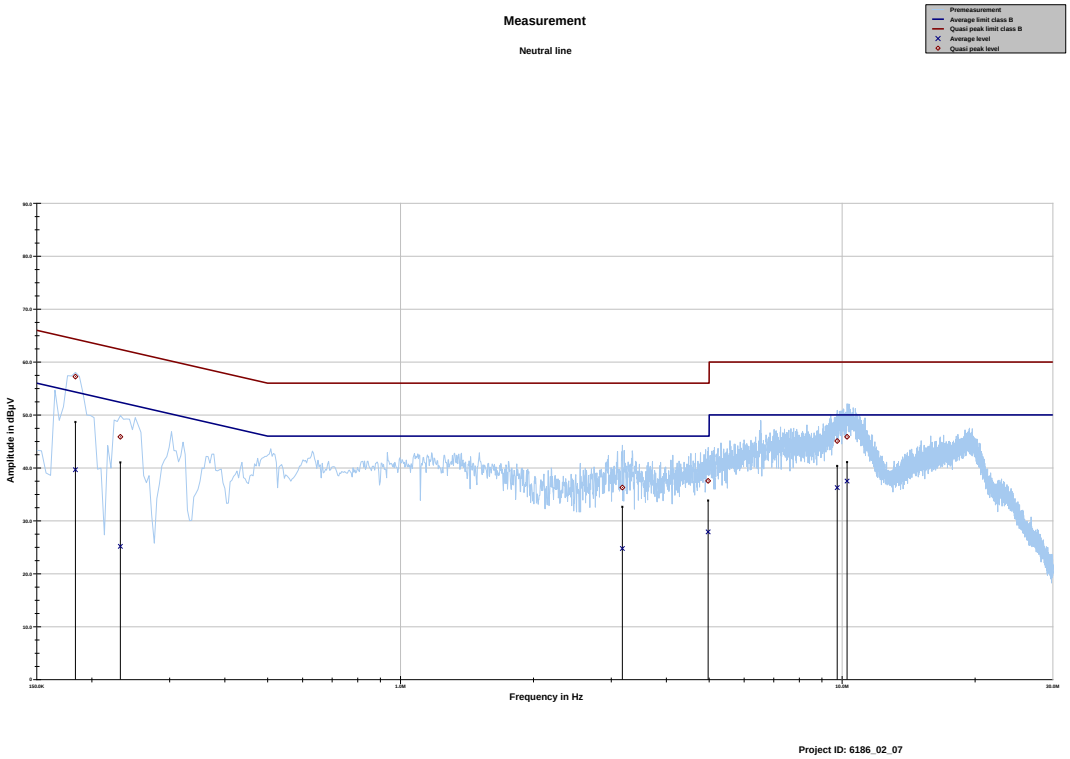
Measurement results:

Plot 26: Phase line, Normal mode, FWv1.10



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150000	47.76	18.24	66.000	21.50	34.50	56.000
0.176119	53.04	11.63	64.667	33.05	22.21	55.254
2.885006	35.11	20.89	56.000	24.55	21.45	46.000
3.224550	36.39	19.61	56.000	24.36	21.64	46.000
6.556556	39.57	20.43	60.000	31.49	18.51	50.000
17.074950	37.77	22.23	60.000	31.21	18.79	50.000

Plot 27: Neutral line, Normal mode, FWv1.10



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.183581	57.24	7.08	64.322	39.65	15.39	55.041
0.232088	45.86	16.51	62.375	25.17	28.49	53.655
3.179775	36.29	19.71	56.000	24.77	21.23	46.000
4.974506	37.53	18.47	56.000	27.91	18.09	46.000
9.746775	45.07	14.93	60.000	36.26	13.74	50.000
10.261688	45.88	14.12	60.000	37.51	12.49	50.000

Note:

- Used power supply unit: velleman, PSSEMV26 (see test setup photographs)
- Measurements valid for FMCW & BPSK

Verdict: Compliant

14 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

15 Document history

Version	Applied changes	Date of release
-/-	Initial release	2024-06-25

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