PARTIAL TEST REPORT

Test report no.: TELI2_011_23001_FCC15_255

Testing laboratory

cetecom advanced GmbH
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Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12047-01.
IC Lab company No. / CAB ID: 3462D / DE0005

Applicant

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Sanger CA 93657, USA
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Fax:
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Phone: +1 559-270-7121

Manufacturer

Same as applicant

Test standard/s

47 CFR Part 15	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
	Subpart 15.255

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

Test Item

Kind of test item:	**tank sensor monitoring device**
Model name:	**AGN3**
FCC ID:	**2BBS4AGN3**
Frequency:	57 GHz – 64 GHz
Antenna:	2 embedded folded Dipole Antennas dielectric Lens FZP
Power supply:	3 V DC
Temperature range:	-20 °C to +75 °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:

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2024.01.26 11:00:01 +01'00'

Thomas Volger
Lab Manager
Radio Labs

Test performed:

Guangcheng Huang
Lab Manager
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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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2.2 Application details

Date of receipt of order:	2023-07-07
Date of receipt of test item:	2023-07-11
Start of test:	2023-09-04
End of test:	2024-01-23
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

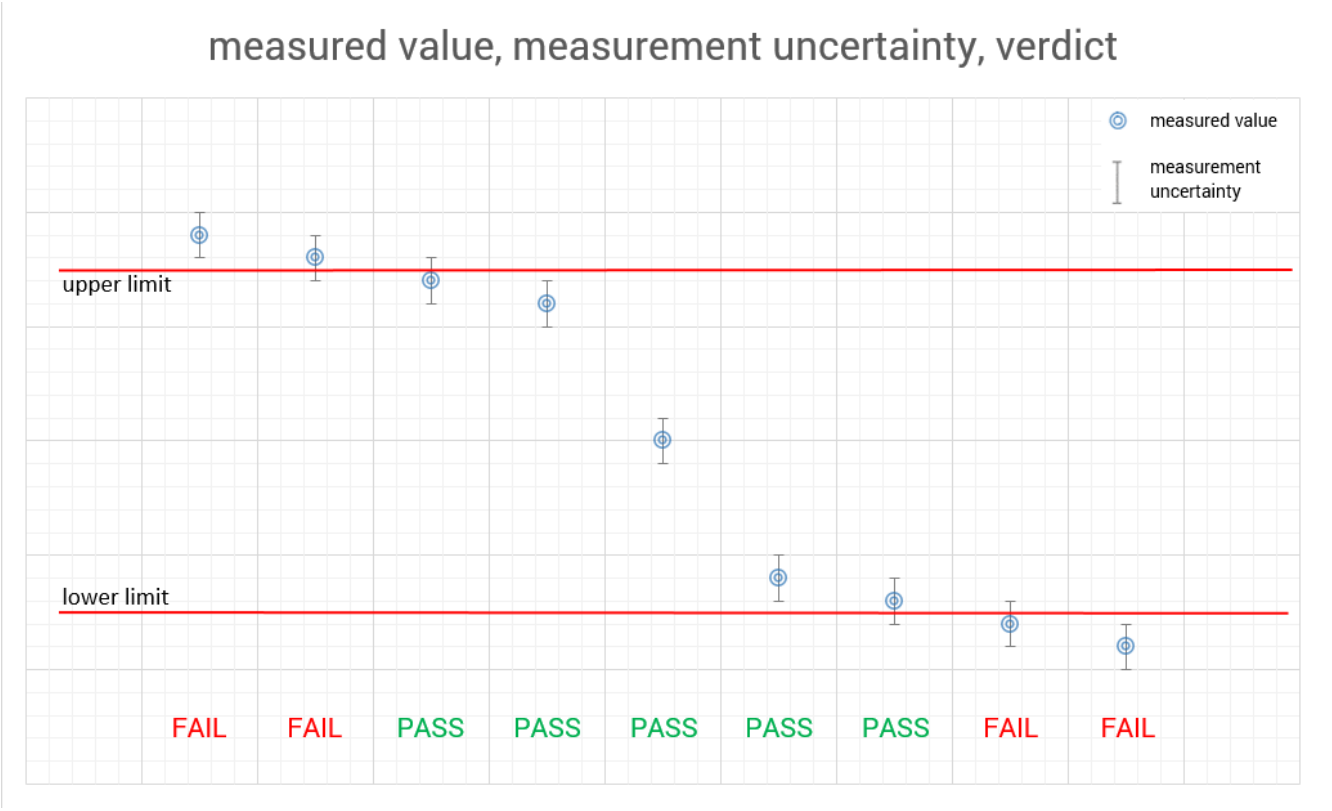
3 Test standard/s and references

Test standard	Date	Description
47 CFR Part 15		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 N/A N/A
Relative humidity content	:		55 %
Barometric pressure	:		1016 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.6 V DC by internal battery - -

6 Test item

6.1 General description

Kind of test item	:	Tank sensor monitoring device
Type identification	:	AGN3
S/N serial number	:	n.a.
hardware version	:	0.3
software version	:	1.0.9
firmware version	:	n.a.
Frequency band	:	57 GHz – 64 GHz
Type of modulation	:	Pulse Modulation
Number of channels	:	1
Antenna	:	2 embedded folded Dipole Antennas dielectric lens FZP
Power supply	:	3.6 V DC internal battery
Auxiliary equipment	:	Test laptop
Temperature range	:	-20 °C to +75 °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: TELI2_011_23001_FCC15_255_A1

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).

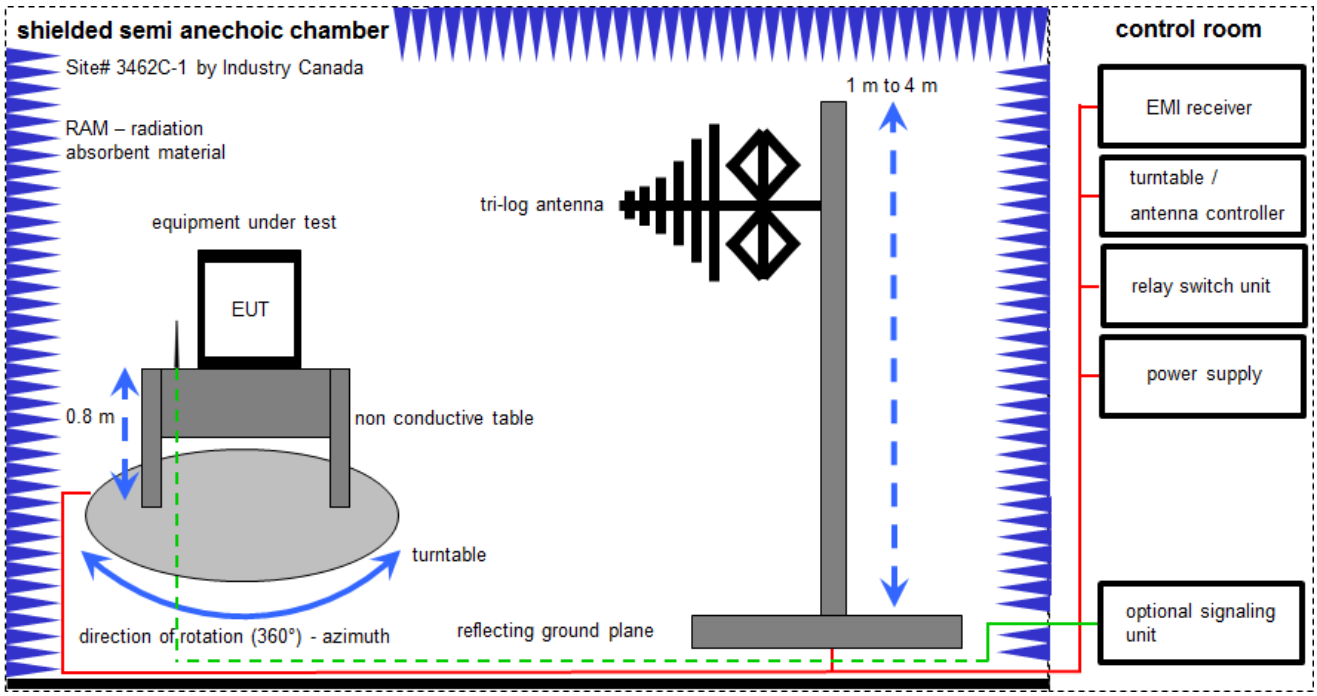
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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 9 kHz 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 3 meter
EMC32 software version: 10.30.0

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

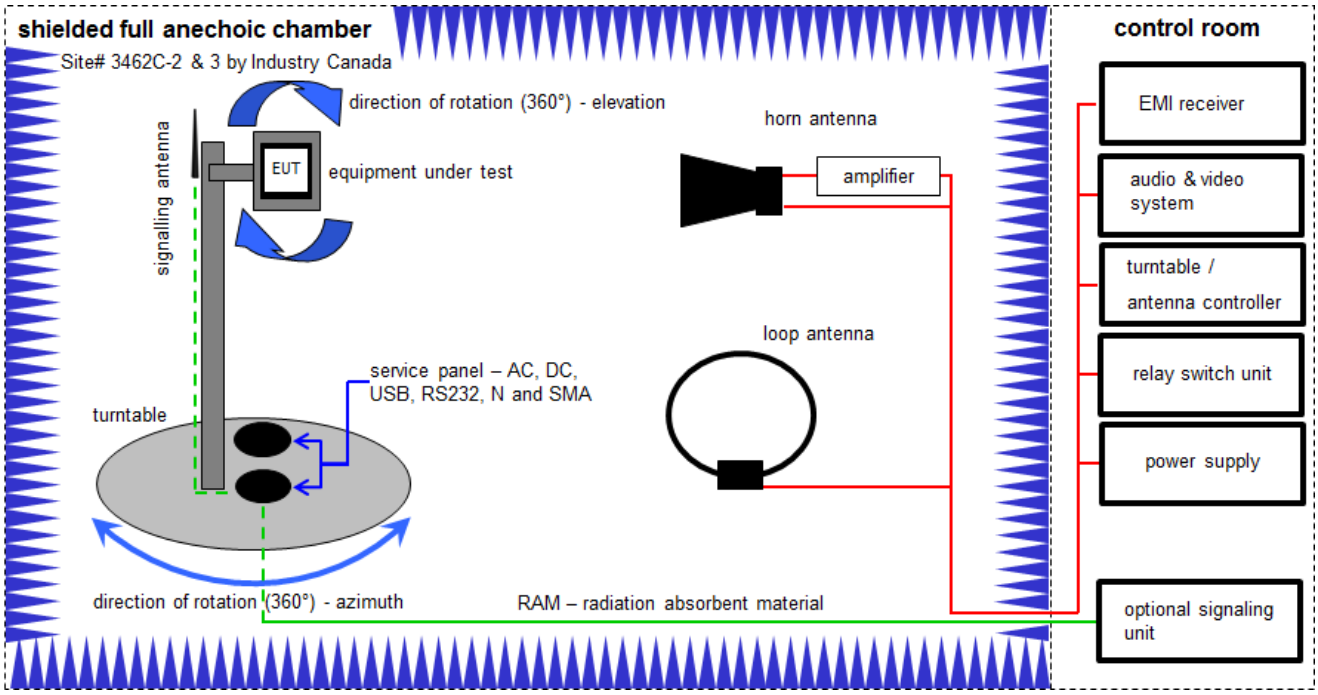
Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

ID	Description	Manufacturer	SerNo	Cal date	Cal interval	Cal due date
	120904 - FAC1 - Radiated Emissions					
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	2022-May-18	24/12M	2024-May-18
20549	Log. Per. Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	2021-Aug-18	36/21M	2024-Aug-18
20720	Measurement Software EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	-	-	-
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	-	Pre-m	-

ID	Description	Manufacturer	SerNo	Cal date	Cal interval	Cal due date
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	2023-Aug-23	12M	2024-Aug-23
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	2023-Aug-23	12M	2024-Aug-23
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	2023-May-25	24/12M	2025-May-25
20608	Ultrabroadband-Antenna HL562	Rohde & Schwarz Messgerätebau GmbH	830547/008	2023-Jul-04	36/12M	2026-Jul-04

7.2 Shielded fully anechoic chamber



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

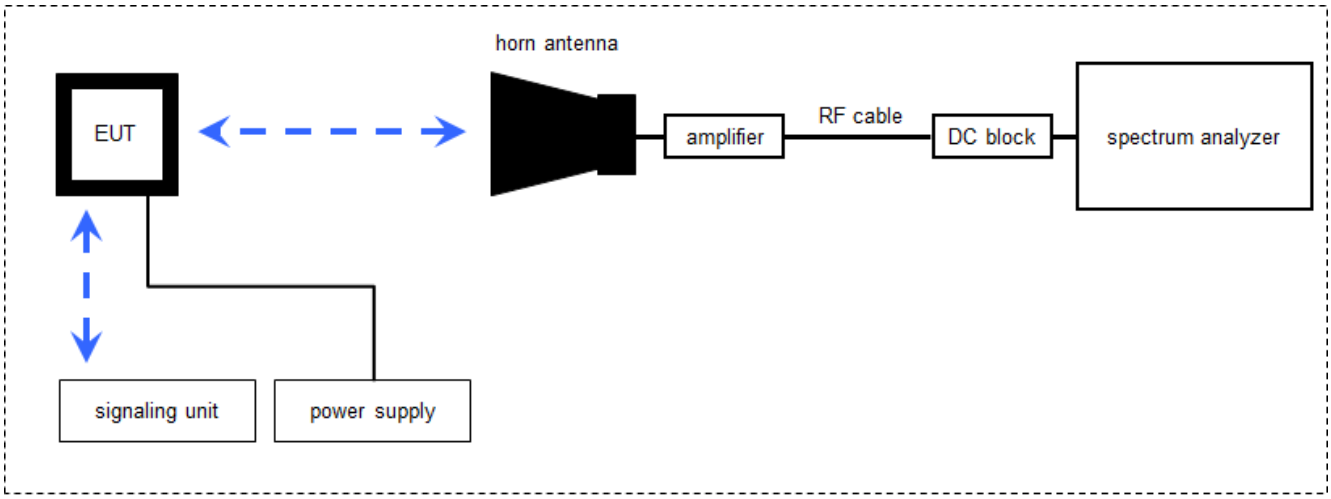
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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

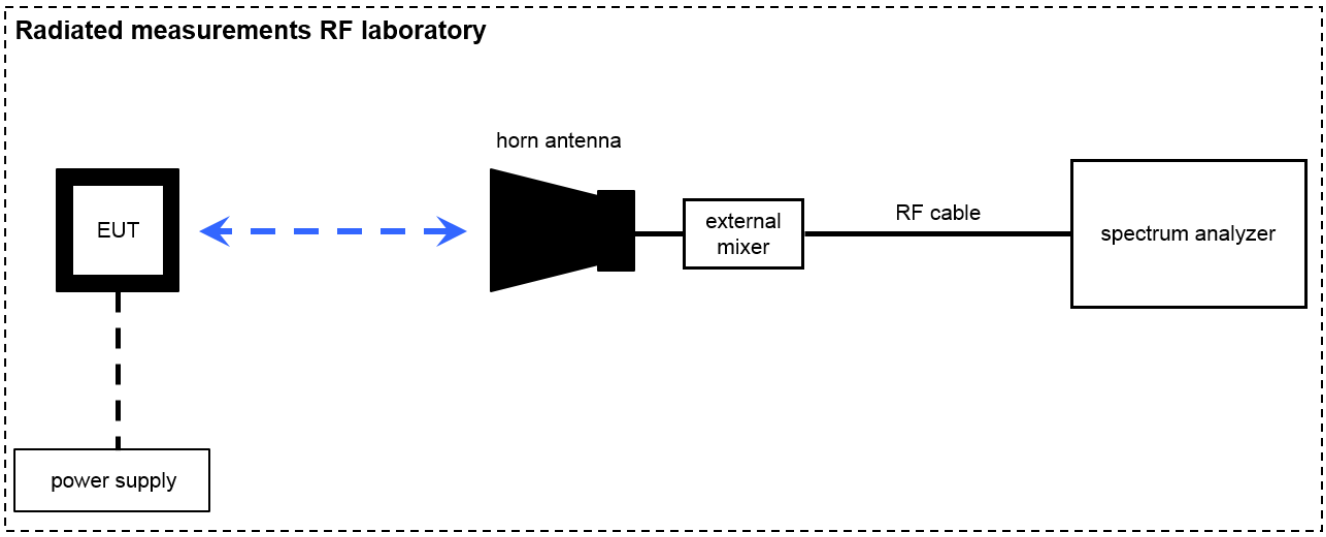
Equipment table:

ID	Description	Manufacturer	SerNo	Cal date	Cal interval	Cal due date
	120904 - FAC1 - Radiated Emissions					
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	2022-May-18	24/12M	2024-May-18
20549	Log. Per. Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	2021-Aug-18	36/21M	2024-Aug-18
20720	Measurement Software EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	-	-	-
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	-	Pre-m	-
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	2023-Aug-23	12M	2024-Aug-23
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	2023-Aug-23	12M	2024-Aug-23
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	2023-May-25	24/12M	2025-May-25
20608	Ultrabroadband-Antenna HL562	Rohde & Schwarz Messgerätebau GmbH	830547/008	2023-Jul-04	36/12M	2026-Jul-04

7.3 Radiated measurements, 18 GHz – 50 GHz



7.4 Radiated measurements > 50 GHz

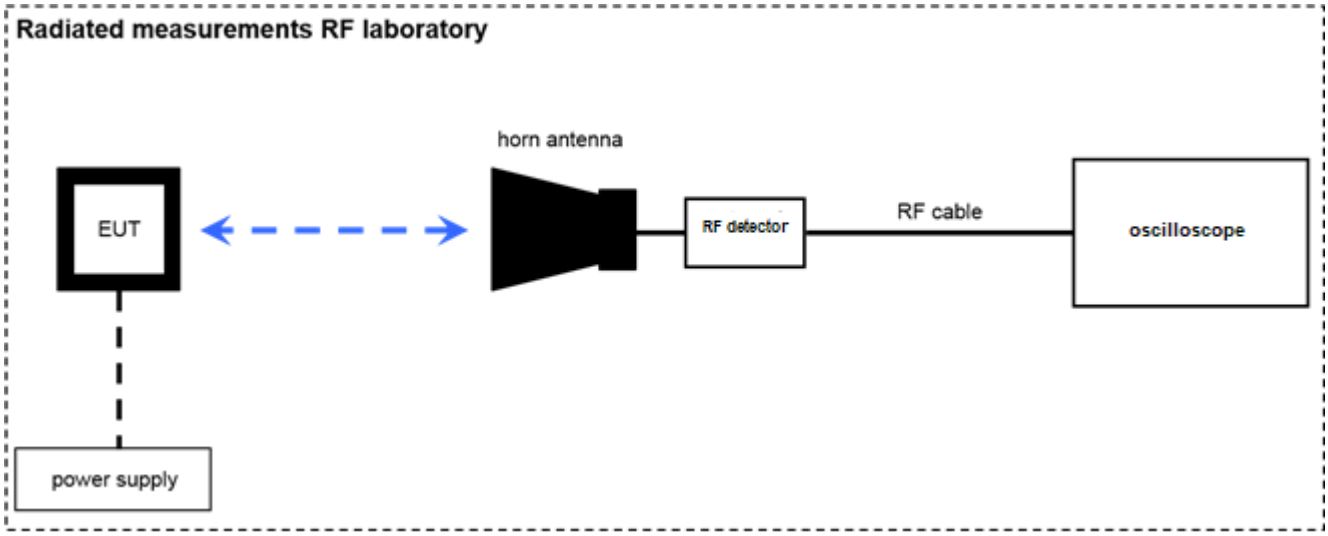


OP = AV + D - G
(OP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

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.

7.5 Radiated measurements > 50 GHz



Note: EUT is replaced by reference source for substitution measurement

Equipment table:

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Intervall	Next Check
	120907 - FAC2 - Radiated Emissions			chk	chk: 2023-Feb-21	chk:12M	chk: 2024-Feb-21
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	861741/005	cal	cal: 2023-May-25	cal: 12M	cal: 2024-May-25
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH / Gilching	9012-3629	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG / Schönau	155	cpu	chk: 2020-Apr-15	chk:12M	
20412	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	chk	chk: 2023-Apr-14	chk:6M	chk: 2023-Oct-14
20729	FS-Z140	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101004	cal	cal: 2023-Jun-16	cal: 36M	cal: 2026-Jun-16
20730	FS-Z110	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101468	cal	cal: 2023-Jun-02	cal: 36M	cal: 2026-Jun-02
20731	FS-Z75	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101022	cal	cal: 2022-May-18	cal: 36M	cal: 2025-May-18
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH / Memmingen	104023	cal	cal: 2023-May-25	cal: 12M	cal: 2024-May-25
20733	Harmonic Mixer FS-Z220	RPG-Radiometer Physics GmbH	101009	cal	cal: 2021-May-27	cal: 36M	cal: 2024-May-27
20734	Harmonic Mixer FS-Z325	RPG-Radiometer Physics GmbH	101005	cal	cal: 2021-May-27	cal: 36M	cal: 2024-May-27
20765	Pickett-Potter Horn Antenna FH-PP 40-60	RPG-Radiometer Physics GmbH / Meckenheim	010001	cal	cal: 2020-Sep-15	cal: 36M	cal: 2023-Sep-15
20767	Pickett-Potter Horn Antenna FH-PP 140-220	RPG-Radiometer Physics GmbH / Meckenheim	010011	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 2021-Oct-20	cal: 36M	cal: 2024-Oct-20
20812	Pickett-Potter Horn Antenna FH-PP-325	RPG-Radiometer Physics GmbH	10024	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20813	Pickett-Potter Horn Antenna FH-PP 075	RPG-Radiometer Physics GmbH / Meckenheim	10006	cal	cal: 2020-Sep-09	cal: 36M	cal: 2023-Sep-09
20814	Pickett-Potter Horn Antenna FH-PP 140	RPG-Radiometer Physics GmbH	10008	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20815	Pickett-Potter Horn Antenna FH-PP 110	RPG-Radiometer Physics GmbH	10014	cal	cal: 2020-Sep-04	cal: 36M	cal: 2023-Sep-04
20816	SGH Antenna SGH-26-WR10	Anteral S.L.	1144	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc. / Roseville	0001	chk		chk:36M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 2023-Feb-27	chk:6M	chk: 2023-Aug-27
20907	Waveguide WR-15 attenuator STA-30-15-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20908	Waveguide WR 10 attenuator STA-30-10-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20909	Waveguide Horn Antenna PE9881-24	Pasternack Enterprises, Inc.	37/2016	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20910	Frequency Multiplier 936VF-10/385	MI-Wave, Millimeter Wave Products Inc.	142	cnn	cal: -	cal: -	cal: -

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Intervall	Next Check
					chk: -	chk:-	chk: -
20911	Frequency Multiplier 938WF-10/387	MI-Wave, Millimeter Wave Products Inc.	141	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
20913	Phase Amplitude Stable Cable Assembly DC-40GHz	RF-Lambda Europe GmbH	AC19040001	cnn	cal: - chk: -	cal: - chk:-	cal: - chk: -
25457	DRG Horn Antenna SAS-574	A.H. Systems, Inc. / Chatsworth	383	cal	cal: 2022-Mar-28	cal: 36M	cal: 2025-Mar-28
20757	Thermal Power Sensor NRP110T	Rohde & Schwarz Messgerätebau GmbH / Memmingen	1424.6215K02-100984-nm	cal	cal: 2022-May-31	cal: 36M	cal: 2025-May-31
-	V Full Band Low Noise Amplifier	Ducommun Inc.	1026151-01	cnn	cal: 2023-Mar-08	chk: 12M	chk: 2024-Mar-08

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

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor k, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it contribution to the overall uncertainty according its statistical distribution calculated.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U CISPR)	CISPR 16-2-1	9 kHz - 150 kHz 150 kHz - 30	4.0 dB 3.6 dB						-
Radiated emissions Enclosure	CISPR 16-2-3	30 - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 - 300	-						-
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2	--	
		9 kHz - 12.75 GHz	N/A	0.60	0.7	0.25	N/A	--	-
		12.75 GHz - 26.5 GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75 GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz – 18 GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5 GHz	1.83	N/A	1.85	N/A	1.79	--	
Occupied bandwidth	-	For range 75-90 GHz	24.545 kHz						Frequency error
			4.24 dB						Power
Frequency stability	-	For range 75-90 GHz	24.545 kHz						-
RF-output power (eirp) Radiated emissions Enclosure	-	150 kHz - 30 MHz	5.0 dB						Magnetic field
		30 MHz - 1 GHz	4.2 dB						E-field
		1 GHz - 18 GHz	4.67 dB						Substitution Method
		18-33 GHz	4.79dB						
		33-50 GHz	4.02 dB						
		40-60 GHz	4.55 dB						
		50-75 GHz	4.02 dB						External Mixer
		75-90 GHz	4.24 dB						
		90-140 GHz	5.29 dB						
		140-225 GHz	6.02 dB						
		225-325 GHz	6.67 dB						

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
110-170	170	0.85	0.18	8.19
170-220	220	0.68	0.14	6.78

In band measurement (EIRP, OBW):

Antenna frequency range in GHz	Highest measured frequency in GHz	Antenna dimension in cm	Wavelength in cm	far field distance in cm
50-75	64	1.85	0.47	14.6

11 Summary of measurement results

☒	**No deviations from the technical specifications were ascertained**
☐	There were deviations from the technical specifications ascertained

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	FCC 47 CFR Part 15	Passed	2024-01-25	-/-

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Results
§15.215(c)	Occupied bandwidth	Nominal	Nominal	☐	☐	☐	☒	Note 2
§15.255(c)(3)	Maximum E.I.R.P.	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255(d)	Spurious Emissions	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255(f)	Frequency stability	Nominal	Nominal	☐	☐	☐	☒	Note 3

Note 1: NA = Not Applicable; NP = Not Performed.
Note 2: Test results are leveraged from test report 1-5794_23-01-03.pdf
Note 3: Test results are leveraged from test report 1-5794_23-01-03.pdf. The test case is assessed against the host environment.

12 Measurement results

12.1 Maximum E.I.R.P. / Transmitter Output Power

Description:

Measurement of the maximum radiated e.i.r.p. of the wanted signal.

Limits: **FCC Part 15.255**

The requirements of Part 15.255 (c) (3) for pulsed field disturbance sensors are as follows:

- Pulse duration not to exceed 6 ns
- Duty factor ≤ 10% within any 0.3 µs time window
- Averaged EIRP ≤ 13 dBm
- Peak EIRP ≤ 33 dBm
- Averaged integrated EIRP <= 5 dBm in any 0.3 µs time window within 61.5 and 64 GHz

Measurement:

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

Measurement results:

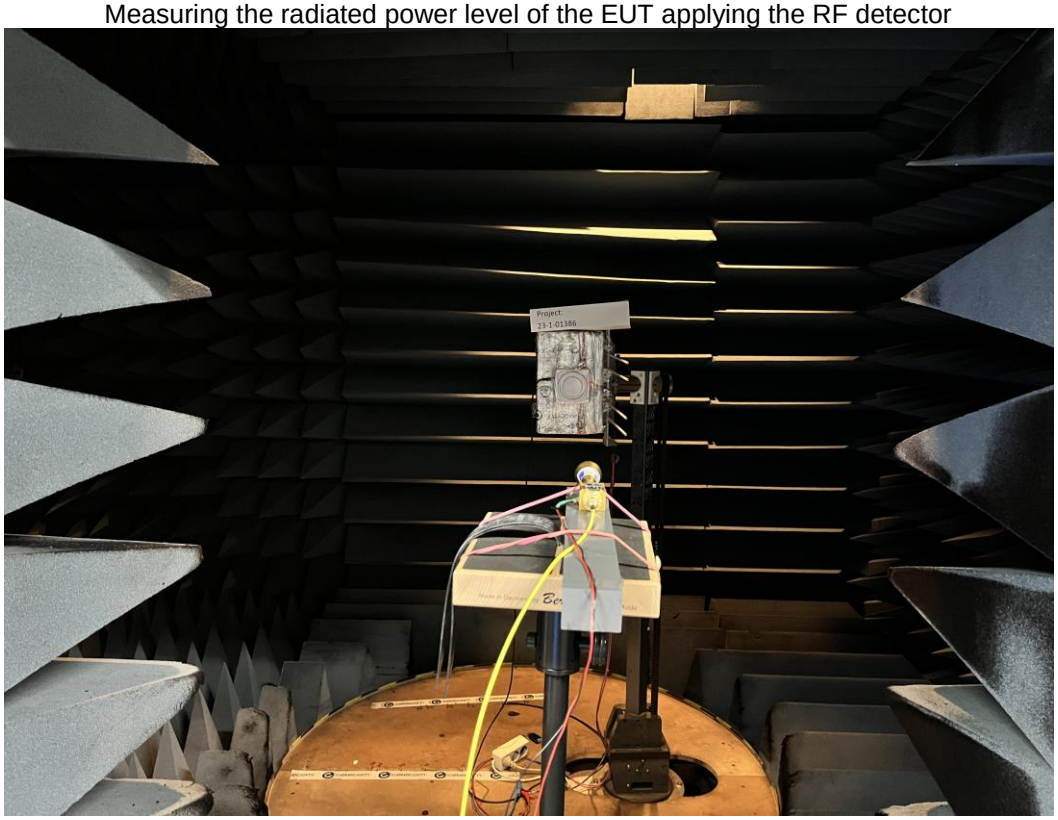
	with Lens	limit
Average E.I.R.P. 10 MHz VBW	3.85 dBm	13 dBm
Peak E.I.R.P. 10 MHz VBW	17.72 dBm	33 dBm
Maximum Pulse duration	2.48 ns *	6 ns
Duty factor within 0.3µs time window	4.1% *	10%
Averaged integrated E.I.R.P. within 61.5 – 64 GHz within 0.3µs	-9.79 dBm **	5 dBm

*) refer module test report No. 1-5794_23-01-03.pdf
**) no emission detected (noise floor)

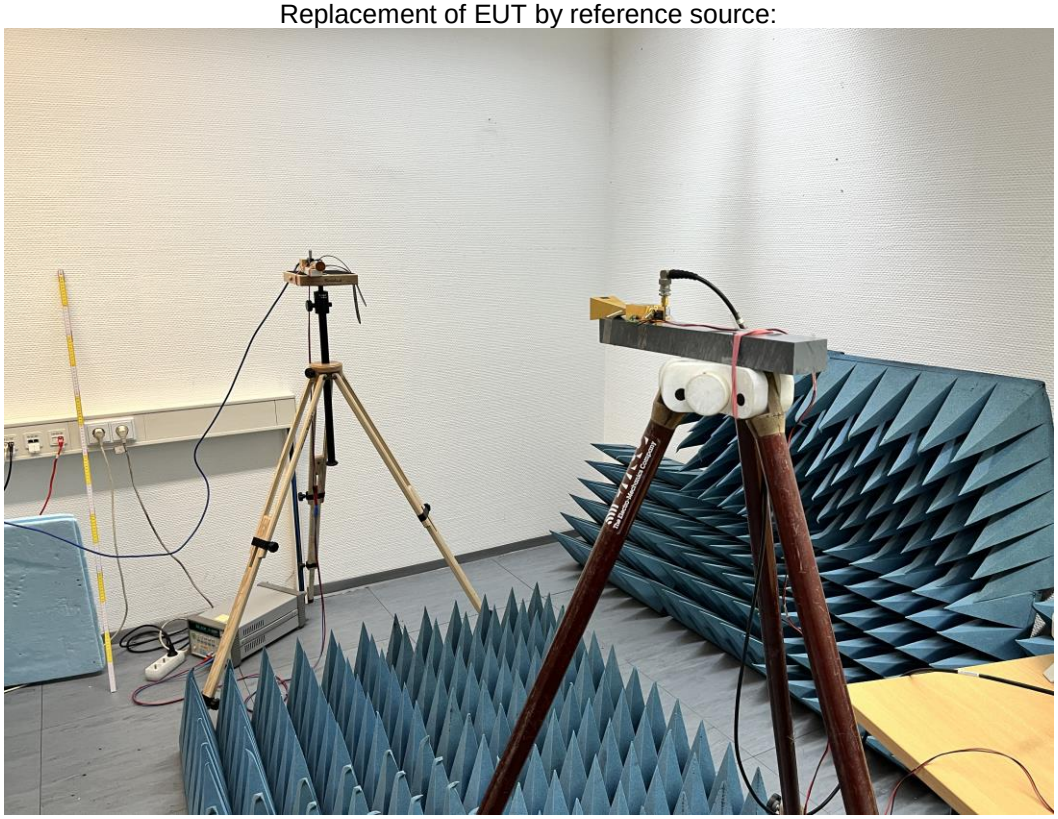
Result: **The measurement is passed.**

12.1.1 Radiated RF-detector and power measurement

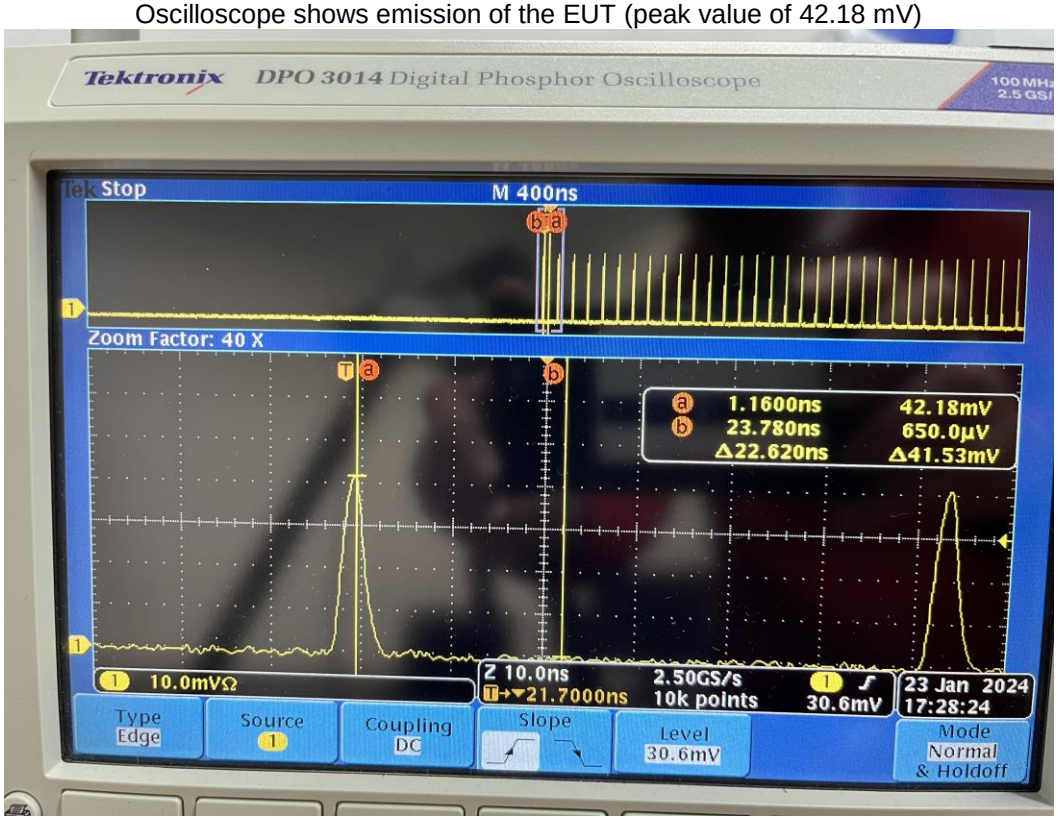
Measuring the radiated power level of the EUT applying the RF detector



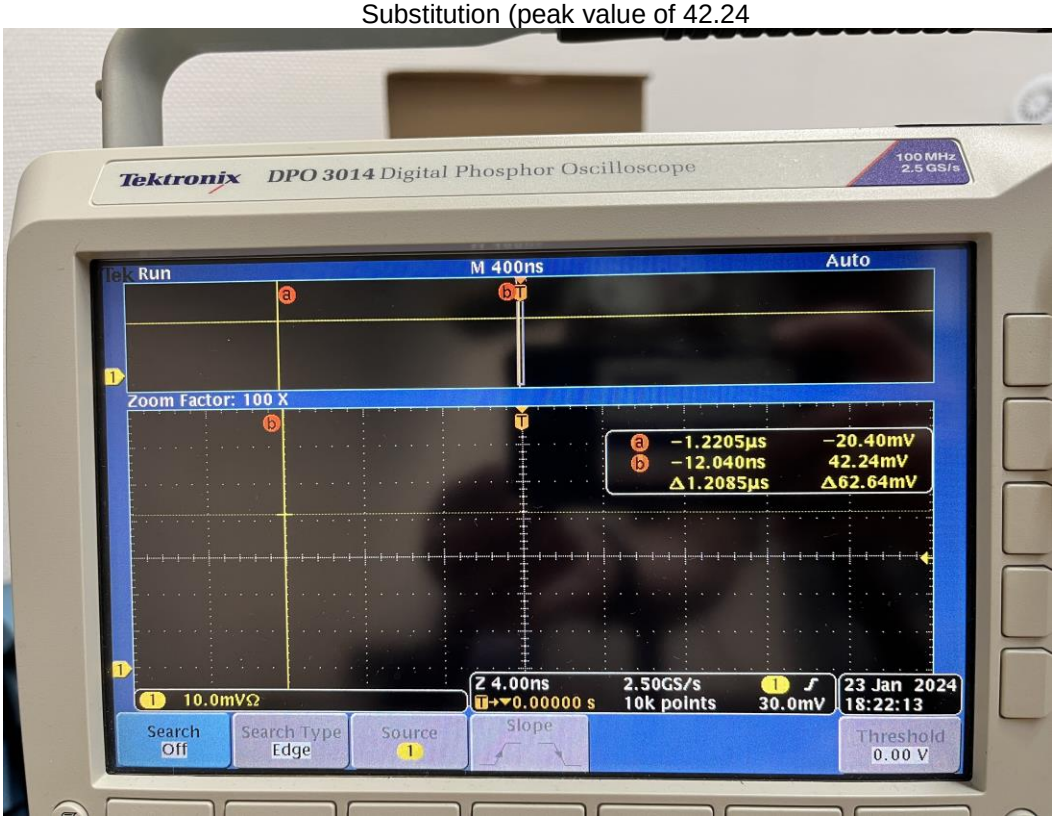
Replacement of EUT by reference source:



Oscilloscope shows emission of the EUT (peak value of 42.18 mV)

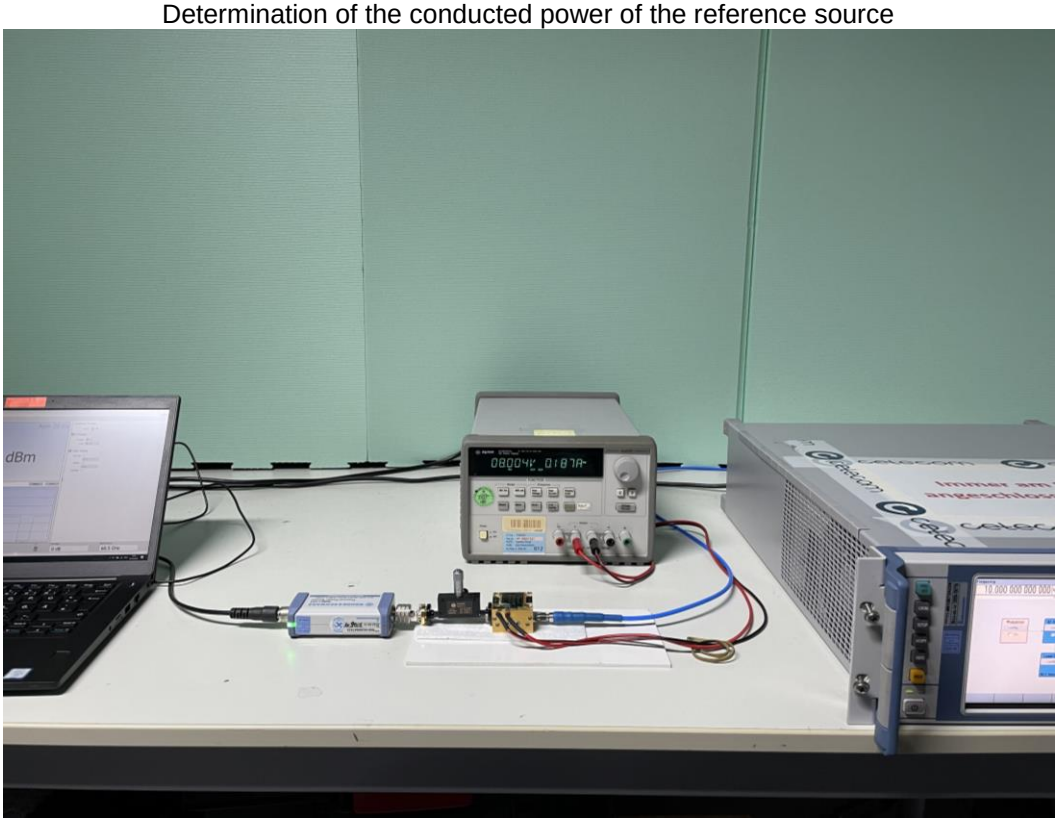


Substitution (peak value of 42.24



mV)

Determination of the conducted power of the reference source

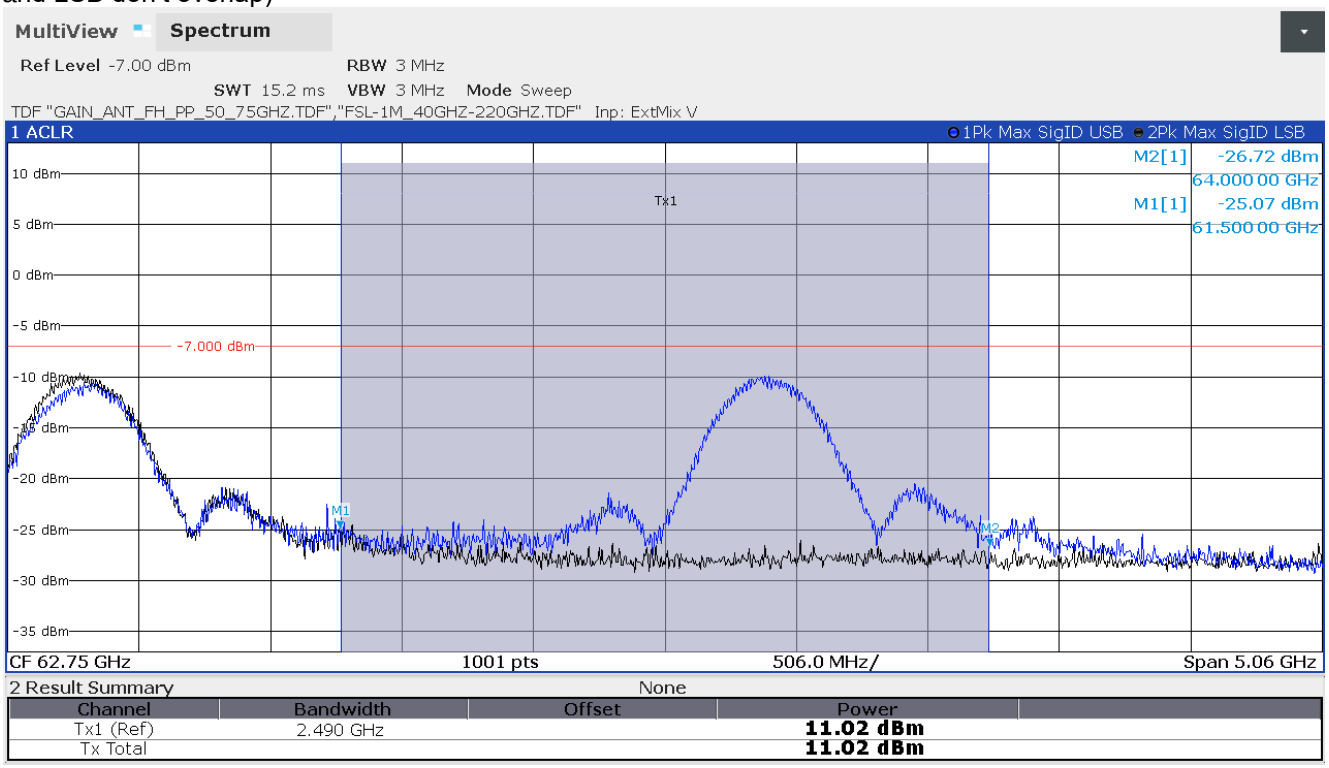


Antenna gain of the TX antenna AG_{TX}, which is attached to the signal generator: 22.46 dBi,
Free space loss FSL1 of a signal at 60.5 GHz at a distance of 150 cm: 71.61 dB,
Free space loss FSL2 of a signal at 60.5 GHz at a distance of 150 cm: 71.61 dB,
Thus, the equivalent radiated power of the EUT calculates:

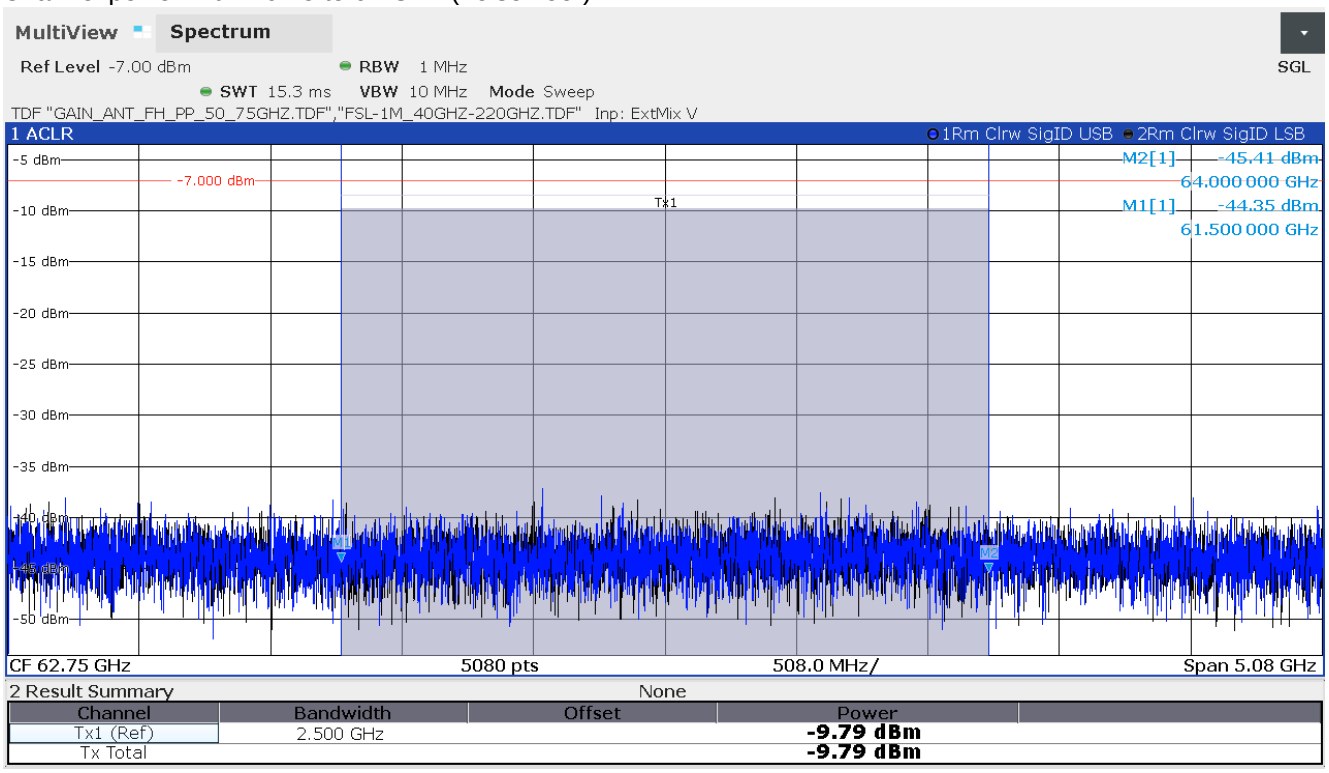
Peak $EIRP_{EUT}$ = P_{sensor} + AG_{TX} – FSL2 + FSL1
= -4.74 dBm + 22.46 dB – 71.61 dB + 71.61 dB
= **17.72 dBm**

Average $EIRP_{EUT}$ = Peak $EIRP_{EUT}$ * duty cycle factor (4.1%)
= **3.85 dBm**

Pre-scan: Channel power within 61.5 to 64 GHz (the emission peaks are ghost signal because Signal ID USB and LSB don't overlap)



Channel power within 61.5 to 64 GHz (noise floor)



12.2 Spurious emissions radiated

Description:

Measurement of the radiated spurious emissions in transmit mode.

Limits: **FCC Part 15.255**

(c) Limits on spurious emissions:

(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm² (-10 dBm) at a distance of 3 meters.

(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

FCC		
CFR Part 15.209(a)		
Radiated Spurious Emissions		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

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

$EIRP[dBm] = 10 \times \log(4 \times \pi \times d^2 \times PD[W/m^2])$

- PD [W/m²] Power density at the distance specified by the limit
- EIRP [dBm] Equivalent isotropically radiated power
- d [m] Distance at which the power density limit is specified

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.

Limit conversion (ANSI C63.10-2013 9.5):

EIRP[dBm] = E_{Meas} + 20log(d_{Meas}) – 104.7

- E_{Meas} The field strength of the emission at the measurement distance, in dBµV/m
- d_{Meas} The measurement distance

According to this formula, the emission limit of the field strength 54 dBµV/m at 3 m measurement distance is equivalent to an EIRP of 41.2 dBm average and 21.2 dBm peak.

Measurement:

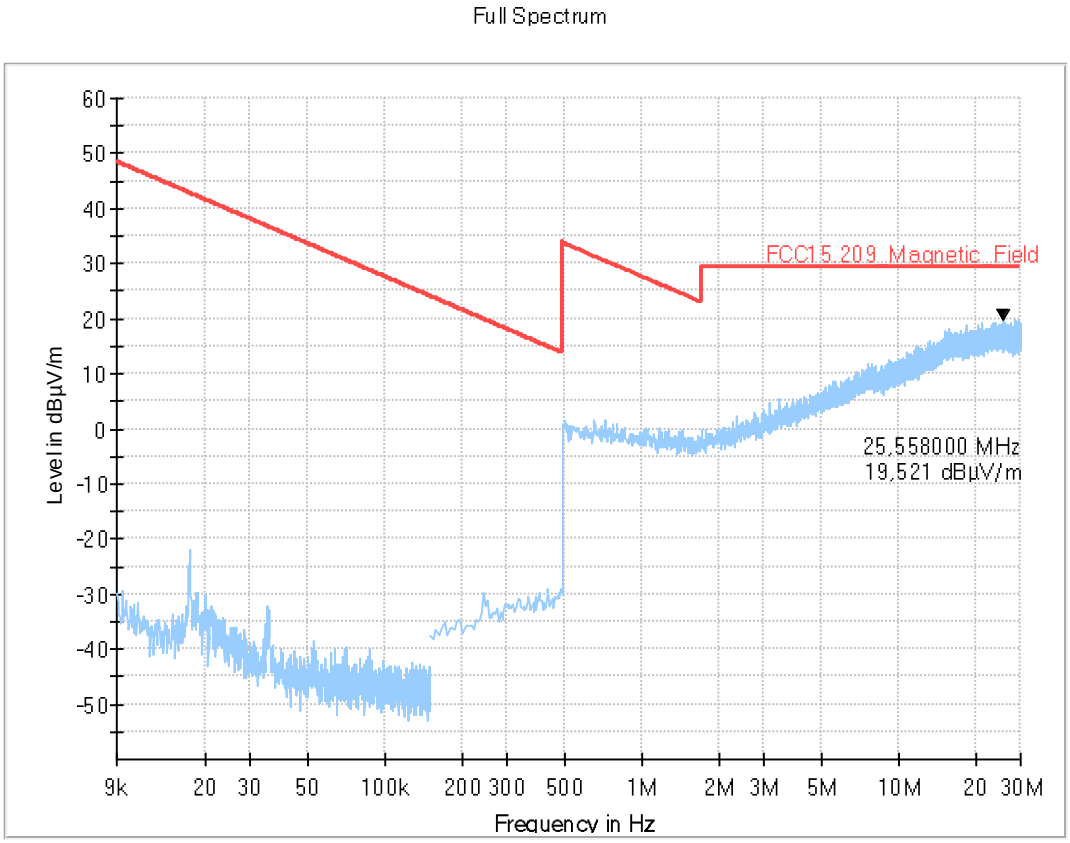
Measurement parameter	
Detector:	Quasi Peak / Pos-Peak / RMS
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Video bandwidth:	F < 1 GHz: 300 kHz F > 1 GHz: 3 MHz
Trace-Mode:	Max Hold

Measurement results:

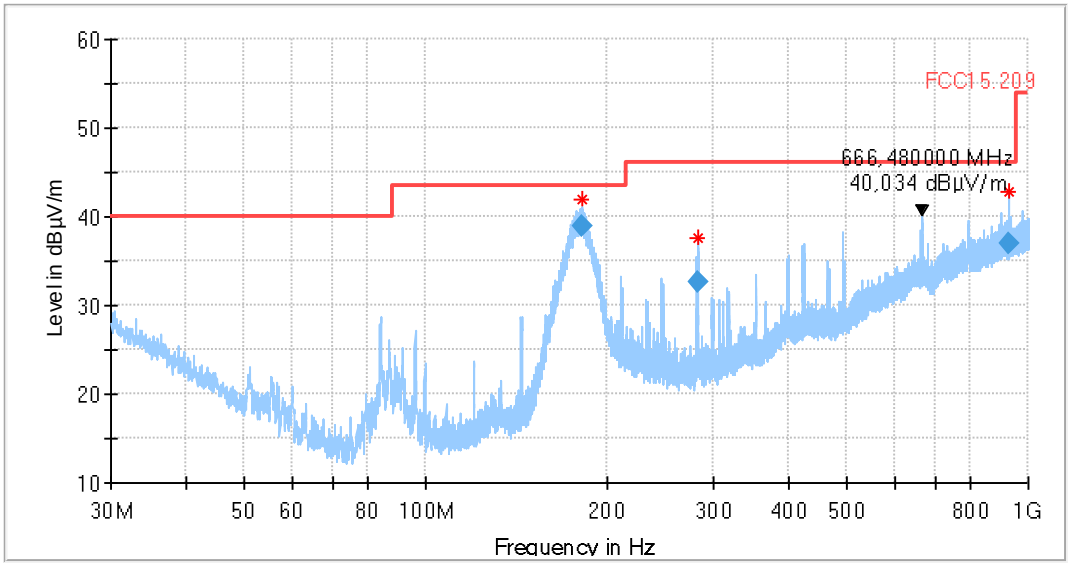
Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
0.181	**QPK**	**0.12**	**38.97**	**43.50**	**4.53**
2.484	**RMS**	**1**	**53.61**	**54.00**	**1.39**
-					
Please refer to the following plots for more information on the level of spurious emissions					

Result: The measurement is passed.

Plot 1: 9 kHz – 30 MHz, horizontal / vertical polarization



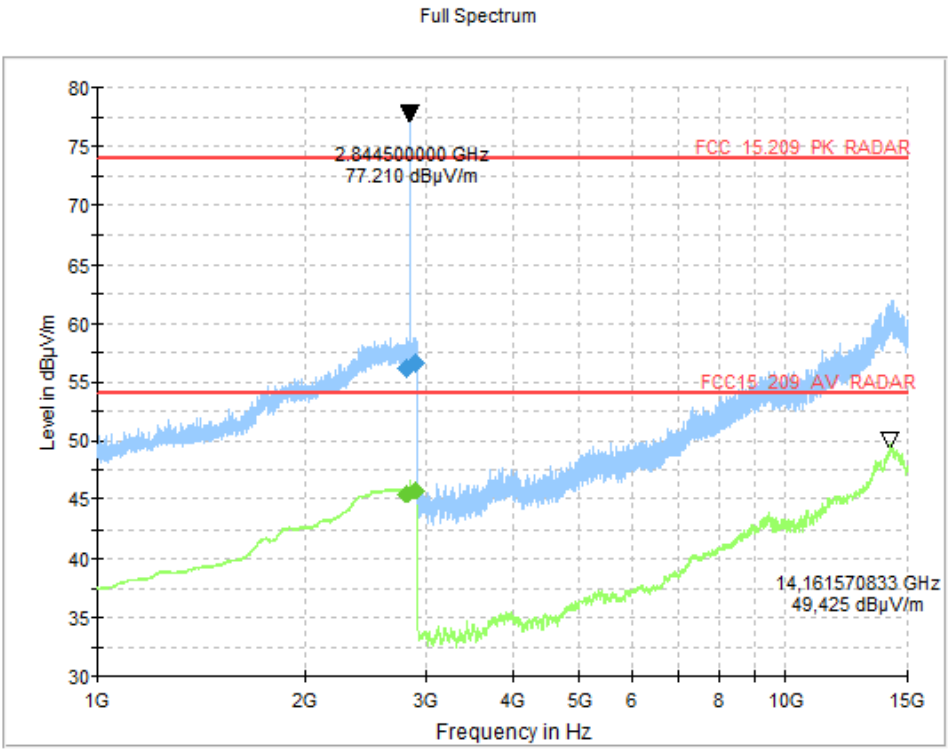
Plot 2: 30 MHz – 1 GHz, horizontal / vertical polarization



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
181.110000	38.97	43.50	4.53	120.000	105.0	V	341.0	10.6	0.0	1.2	9.3	28.4
282.310000	32.52	46.00	13.48	120.000	112.0	V	257.0	14.4	0.0	1.6	12.8	18.1
926.990000	36.99	46.00	9.01	120.000	120.0	H	34.0	27.0	0.0	3.4	23.6	10.0

Plot 3: 1 GHz – 15 GHz, horizontal / vertical polarization



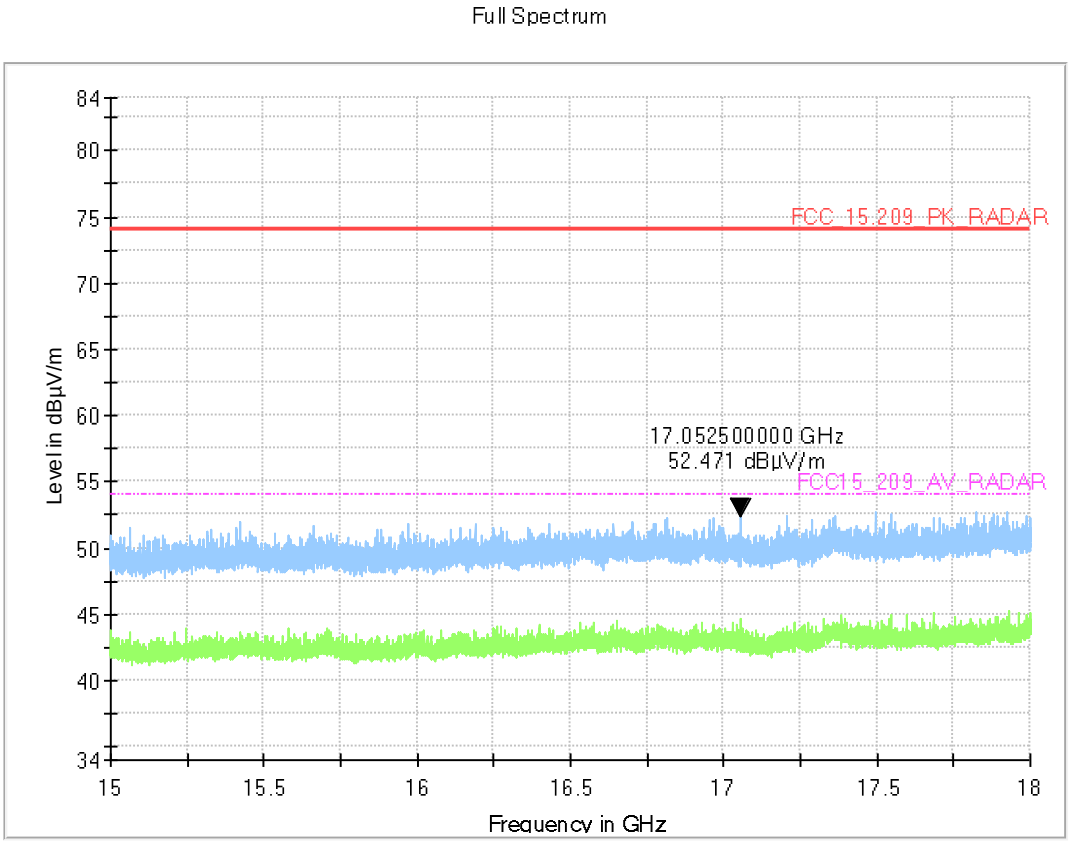
Final_Result

Frequency (MHz)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
2804.273333	---	74.00	17.80	100.0	155.0	V	150.0	90.0	34.7
2804.273333	45.43	54.00	8.57	100.0	155.0	V	150.0	90.0	34.7
2886.390000	---	74.00	17.40	100.0	155.0	V	144.0	90.0	34.9
2886.390000	45.81	54.00	8.19	100.0	155.0	V	144.0	90.0	34.9

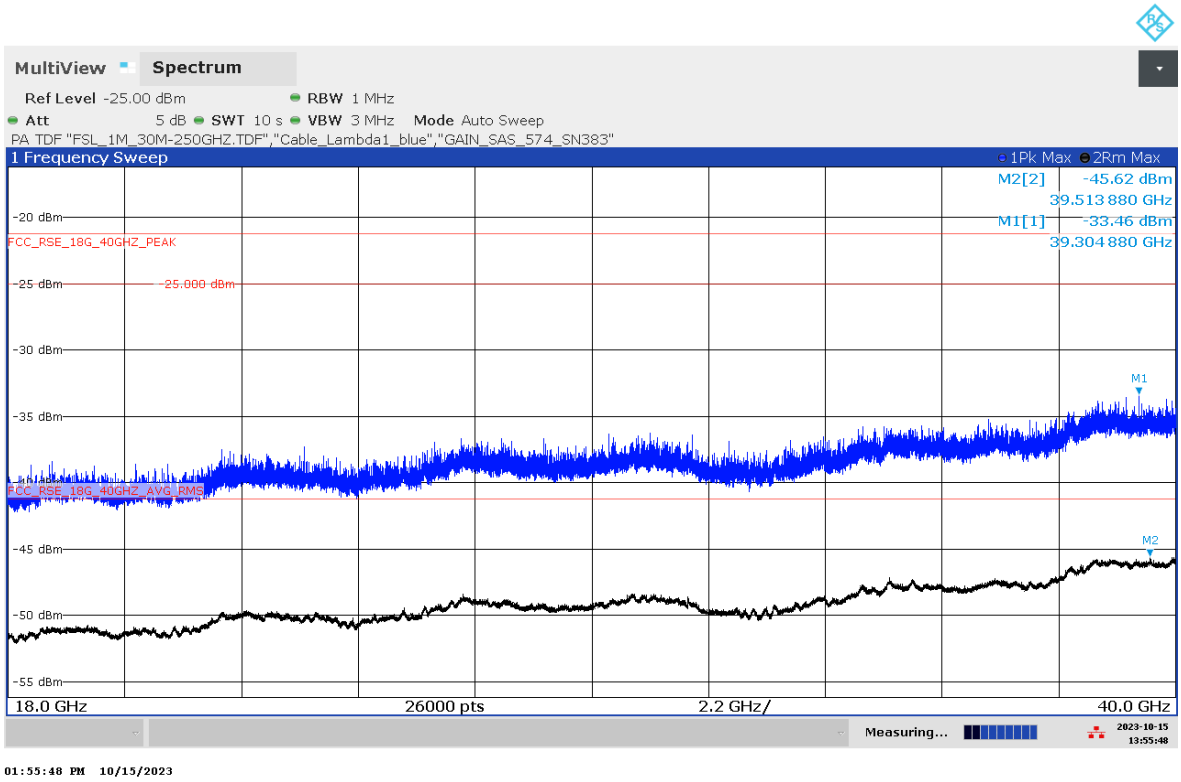
(continuation of the "Final_Result" table from column 17 ...)

Frequency (MHz)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)	Comment
2804.273333	5.4	0.0	29.3	21.5	20:45:45 - 12.01.2024
2804.273333	5.4	0.0	29.3	10.7	20:45:45 - 12.01.2024
2886.390000	5.4	0.0	29.5	21.7	20:44:38 - 12.01.2024
2886.390000	5.4	0.0	29.5	10.9	20:44:39 - 12.01.2024

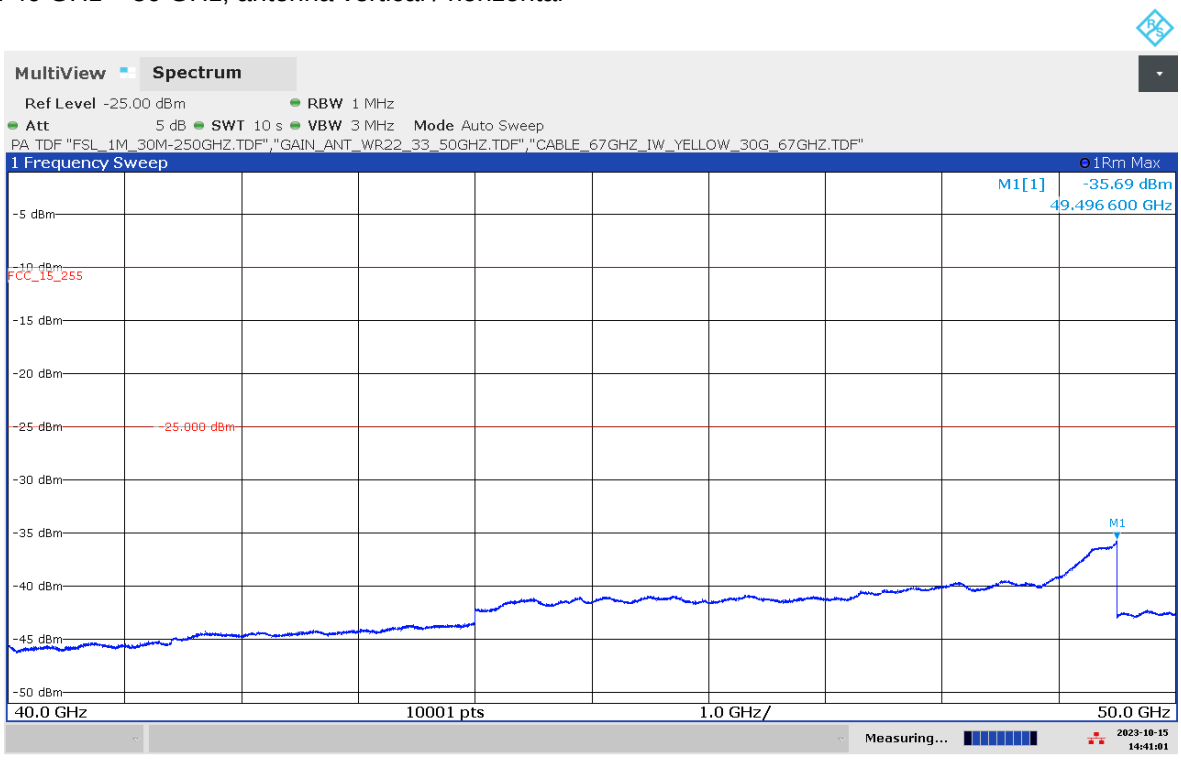
Plot 4: 15 GHz – 18 GHz, horizontal / vertical polarization



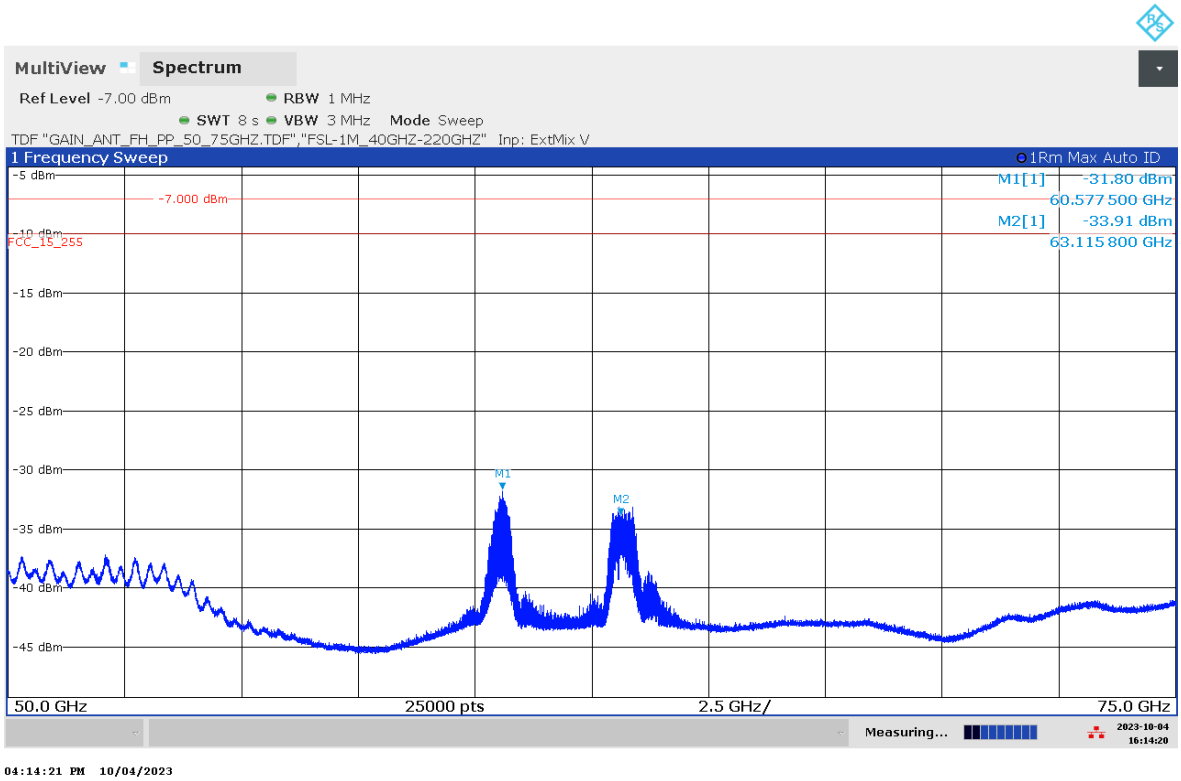
Plot 5: 18 GHz – 40 GHz, horizontal / vertical polarization



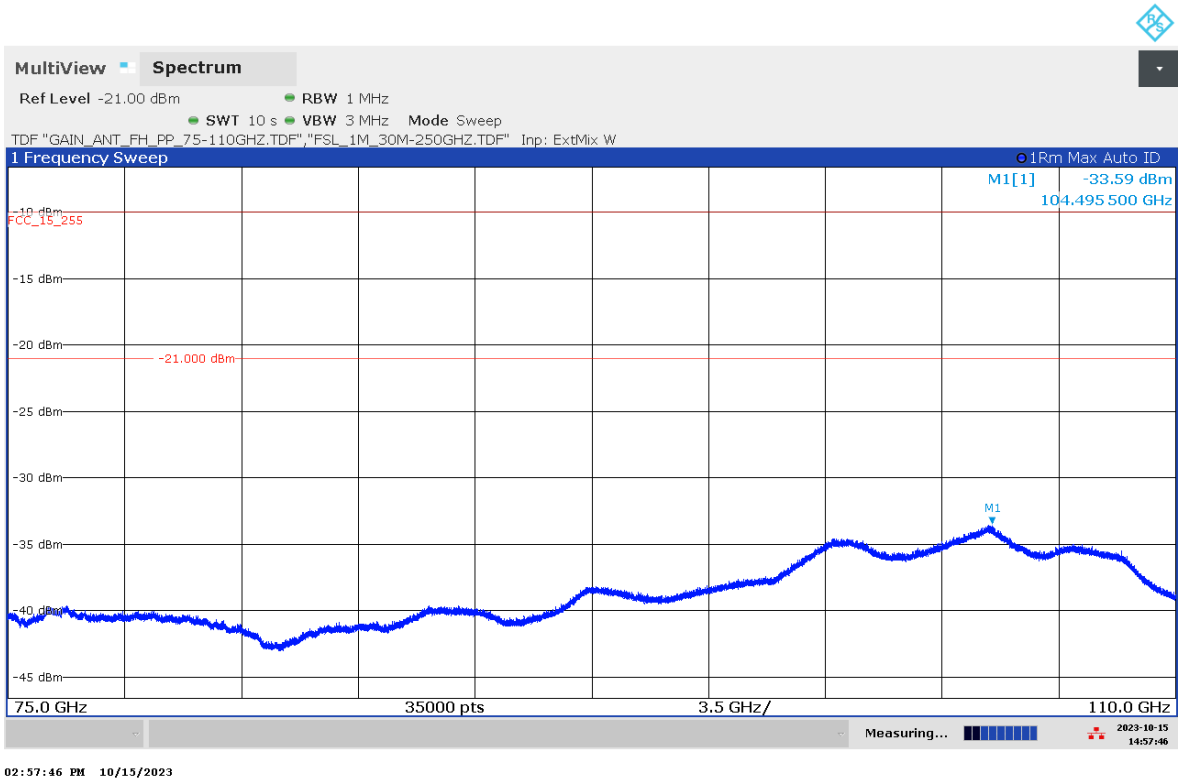
Plot 6: 40 GHz – 50 GHz, antenna vertical / horizontal



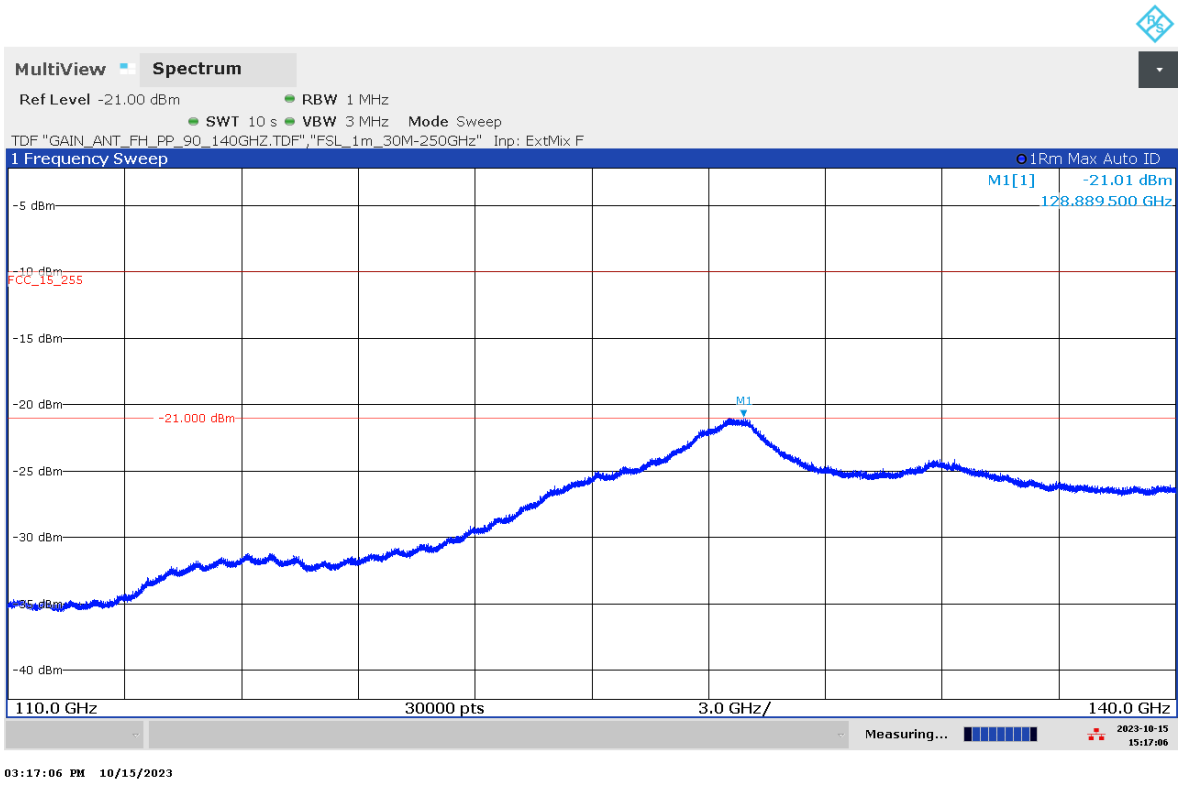
Plot 7: Out of Band 50 GHz – 75 GHz, antenna vertical / horizontal, final scan with RMS detector



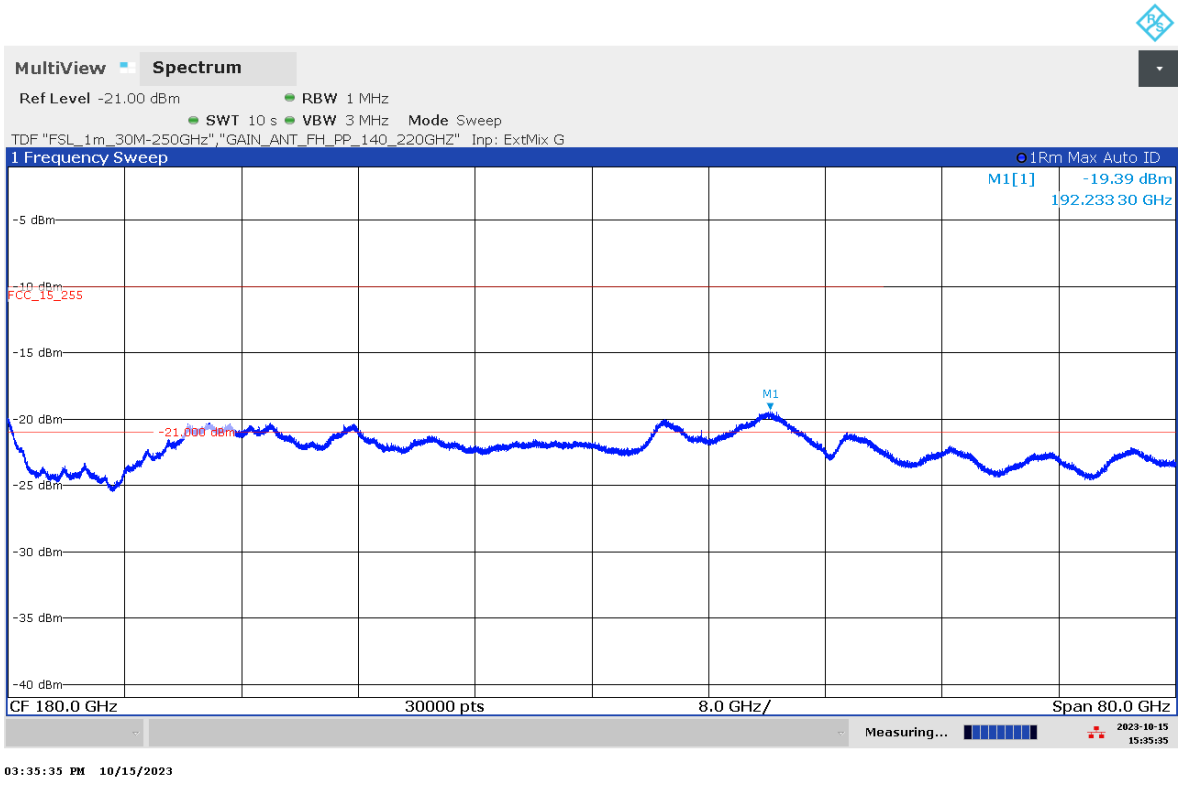
Plot 8: 75 GHz – 110 GHz, antenna vertical / horizontal



Plot 9: 110 GHz – 140 GHz, antenna vertical / horizontal



Plot 10: 140 GHz – 220 GHz, antenna vertical / horizontal



13 Glossary

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

14 Document history

Version	Applied changes	Date of release
-/-	Initial release	2024-01-25

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