
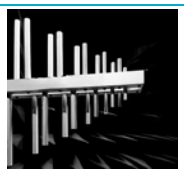
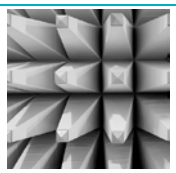

TEST REPORT

Test report no.: 1-6998-23-01-10_TR1-R01

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

Testing laboratory

cetecom advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: https://cetecomadvanced.com
e-mail: mail@cetecomadvanced.com

Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS).
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number:
D-PL-12047-01-00.
ISED Testing Laboratory Recognized Listing Number: DE0001
FCC designation number: DE0002

Applicant

Leica Geosystems AG
Heinrich-Wild-Straße
9435 Heerbrugg / SWITZERLAND
Phone: +41 71 727 3640
Contact: Özcan Tepeli
e-mail: oezcan.tepeli@leica-geosystems.com

Manufacturer

Leica Geosystems AG
Heinrich-Wild-Straße
9435 Heerbrugg / SWITZERLAND

Test standard/s

FCC - Title 47 CFR Part 90	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 90 - Private Land Mobile Radio Services
RSS - 119 Issue 12	Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz

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

Test Item

Kind of test item:	**GNSS sensor**
Model name:	**LG1001**
FCC ID:	RFD-LG1001
ISED certification number:	3177A-LG1001
Frequency:	464.5 MHz
Technology tested:	proprietary
Antenna:	external antenna
Power supply:	5 V DC by battery
Temperature range:	-30°C to +60°C

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

Test report authorized:

cn=Christoph Schneider, o=cetecom advanced GmbH, ou=SND-230601, email=christoph.schneider@cetecomadvanced.com, c=DE
2024.09.03 06:49:16 +02'00'

Christoph Schneider
Lab Manager
Radio Labs

Test performed:

cn=Joachim Wolsdorfer, o=cetecom advanced GmbH, ou=WLD-230605, email=joachim.wolsdorfer@cetecomadvanced.com, c=DE
2024.09.03 07:23:34 +02'00'

Hans-Joachim Wolsdorfer
Lab Manager
Radio Labs

1 Table of contents

2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. cetecom advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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2.2 Application details

Date of receipt of order:	2023-12-13
Date of receipt of test item:	2024-03-18
Start of test:*	2024-07-22
End of test:*	2024-07-31
Person(s) present during the test:	-/-

*Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

2.3 Test laboratories sub-contracted

None

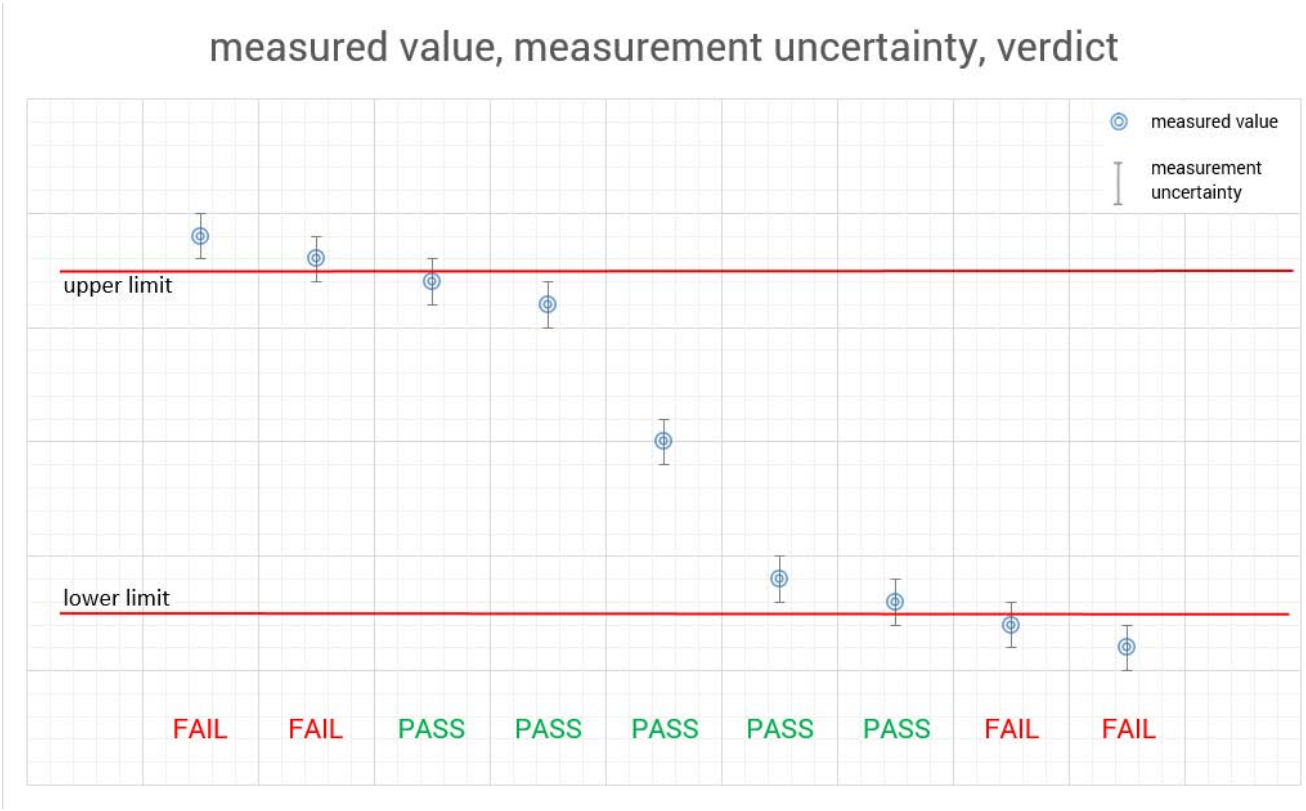
3 Test standard/s, references and accreditations

Test standard	Date	Description
FCC - Title 47 CFR Part 90		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 90 - Private Land Mobile Radio Services
RSS - 119 Issue 12	01.05.2015	Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz

Guidance	Version	Description
ANSI C63.4-2014	-/-	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	-/-	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.
The measurement uncertainty is mentioned in this test report, see chapter 8 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}	+20 °C during room temperature tests +60 °C during high temperature tests -30 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	5.00 V DC by battery -/- V No voltage variation possible due to missing access to -/- V internal battery

6 Test item

6.1 General description

Kind of test item	:	GNSS sensor
Model name	:	LG1001
HMN	:	N/A
PMN	:	GS05 UHF
HVIN	:	LG1001
FVIN	:	N/A
S/N serial number	:	3800116
Hardware status	:	C
Software status	:	0.1
Firmware status	:	BSP v4.0.20
Frequency band	:	464.5 MHz
Type of radio transmission Use of frequency spectrum	: :	modulated carrier
Type of modulation	:	G2FSK modulation with BT = 0.5
Number of channels	:	1
Antenna	:	external antenna
Power supply	:	5 V DC by battery
Temperature range	:	-30°C to +60°C

6.2 Additional information

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

Test setup and EUT photos are included in test report: 1-6998-23-01-01_TR1-A101-R01
1-6998-23-01-01_TR1-A102-R01
1-6998-23-01-01_TR1-A103-R01

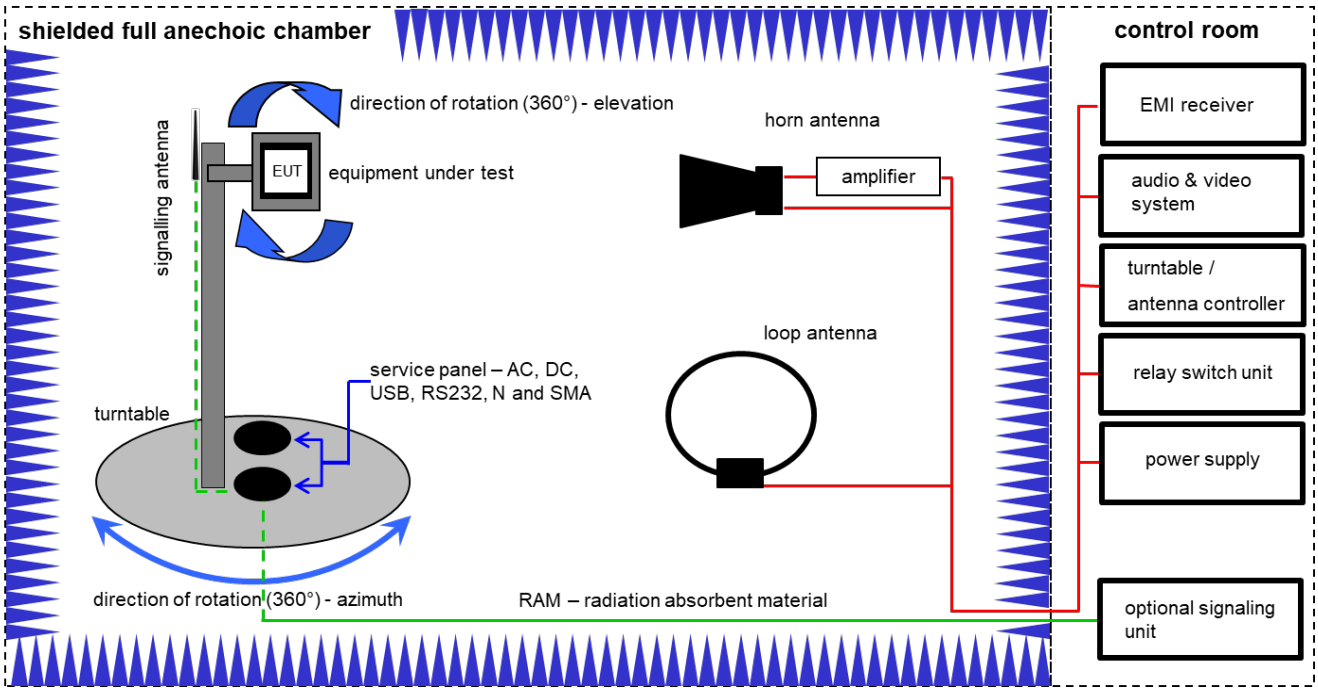
7 Description of the test setup

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).

Each block diagram listed can contain several test setup configurations. All devices belonging to a test setup are identified with the same letter syntax. For example: Column Setup and all devices with an A.

7.1 Shielded fully anechoic chamber



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

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)

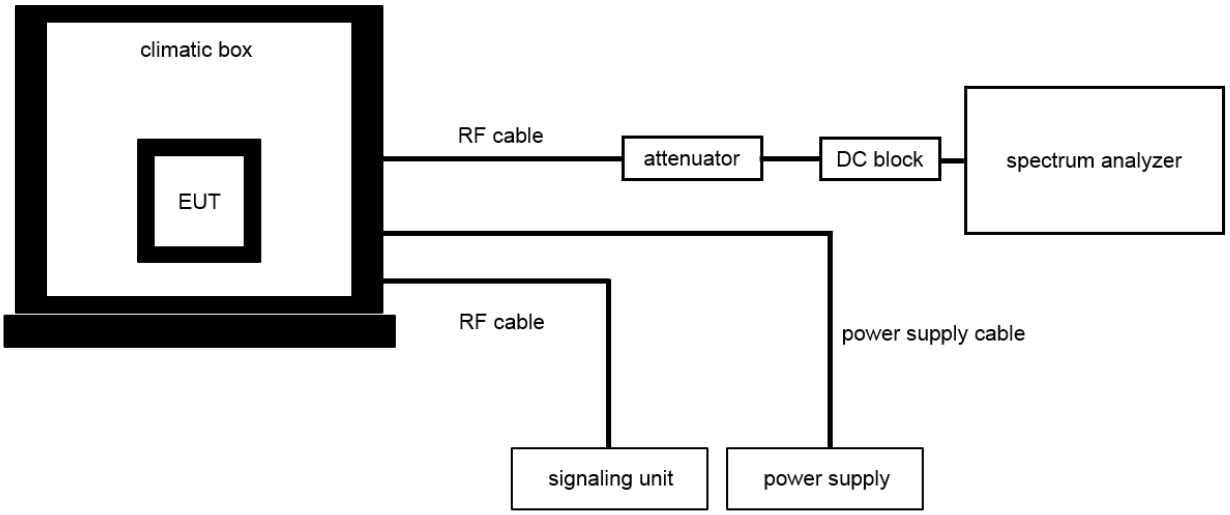
Example calculation:
OP [dBm] = -39.0 [dBm] + 57.0 [dB] - 12.0 [dBi] + (-36.0) [dB] = -30 [dBm] (1 µW)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vlKl!	02.08.2023	31.08.2025
2	B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3696	300001604	vlKl!	20.03.2023	19.03.2025
3	B	Highpass Filter	WHK1.1/15G-10SS	Wainwright	37	400000148	ne	-/-	-/-
4	B	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne	-/-	-/-
5	C	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	318	300003696	vlKl!	31.01.2024	30.01.2026
6	B, C	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22050	300004482	ev	-/-	-/-
7	A, B, C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne	-/-	-/-
8	A, B, C	NEXIO EMV-Software	BAT EMC V2022.0.32.0	Nexio		300004682	ne	-/-	-/-
9	A, B, C	Anechoic chamber		TDK		300003726	ne	-/-	-/-
10	A, B, C	EMI Test Receiver 9kHz-26,5GHz	ESR26	Rohde & Schwarz	101376	300005063	k	15.01.2024	31.01.2025

7.2 Conducted measurements normal and extreme conditions

Conducted measurements normal & extreme conditions



OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

Example calculation:
OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Temperature Test Chamber	VT 4011	Voetsch Industrietechnik	585662306000 10	300005363	ev	09.05.2022	31.08.2024
2	A	Signal analyzer	FSW26	Rohde&Schwarz	101371	300005697	k	07.12.2023	31.12.2024

8 Measurement uncertainty

Measurement uncertainty	
Occupied channel bandwidth	±5 %
RF power, conducted	±1.5 dB
Conducted spurious emission of transmitter, valid up to 6 GHz	±3 dB
Conducted emission of receivers	±3 dB
Radiated emission of transmitter, valid up to 6 GHz	±6 dB
Radiated emission of receiver, valid up to 6 GHz	±6 dB
RF level uncertainty for a given BER	±1.5 dB
Occupied channel bandwidth	±5 %
Temperature	±2.5 °C
Humidity	±10 %

9 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	47 CFR Part 2 47 CFR Part 90	See table	2024-09-03	-/-

Test Specification Clause	Test Case	Temperature Conditions	Power Source Voltages	C	NC	NA	NP	Remark
FCC 47 CFR § 90.217	Transmitter output power	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90. 90.217	Occupied bandwidth	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90. 90.217 (a)	Spectrum Mask	Nominal	Nominal	☒	☐	☐	☐	
FCC 47 CFR § 2.1055 (a)(1) § 90.213	Frequency stability	Nominal	Extreme	☐	☐	☐	☒	No voltage variation possible
		Extreme	Nominal	☒	☐	☐	☐	
FCC 47 CFR § 90.217	Transmitter spurious emissions conducted	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90.217	Transmitter spurious emissions (radiated)	Nominal	Nominal	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions < 30 MHz	Nominal	Nominal	☐	☐	☒	☐	-/-

Note: C = Compliant
NC = Not compliant
NA = Not applicable
NP = Not performed

9.1 Additional comments

No voltage variation possible due to missing access to internal battery.
Voltage variation at RF module smaller than +/- 2% (according customer declaration)

10 Measurement results

10.1 Radiated output power / Antenna gain

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	5 MHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.1 C; 7.2 A
Measurement uncertainty:	See chapter 8

Limits:

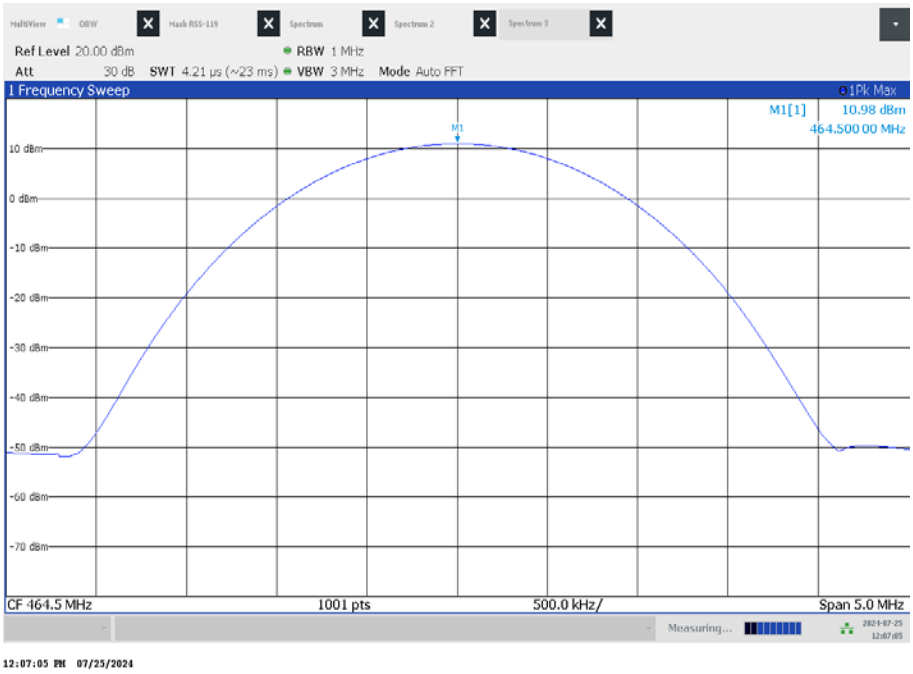
FCC 47 CFR § 90.217 / RSS 119 5.10
120 mW / 20.8 dBm

Result:

Frequency	output power	
464.5 MHz	conducted	10.98 dBm
	Radiated (e.i.r.p.)	13.74 dBm
	Antenna gain	2.76 dBi

Plots:

Plot 1:


Ref Level 20.00 dBm
RBW 1 MHz
Att 30 dB SWT 4.21 µs (~23 ms) VBW 3 MHz Mode Auto FFT
1 Frequency Sweep
1Pk Max
M1[1] 10.98 dBm
464.500 00 MHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 464.5 MHz
1001 pts
500.0 kHz/
Span 5.0 MHz
Measuring...
12:07:05 PM 07/25/2024

10.2 Occupied bandwidth

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	See Plots
Video bandwidth	See plots
Span	See plots
Measurement procedure:	OBW 99 %
Trace mode	Max hold
Test setup	See sub clause 7.2 A
Measurement uncertainty	See sub clause 8

Limits:

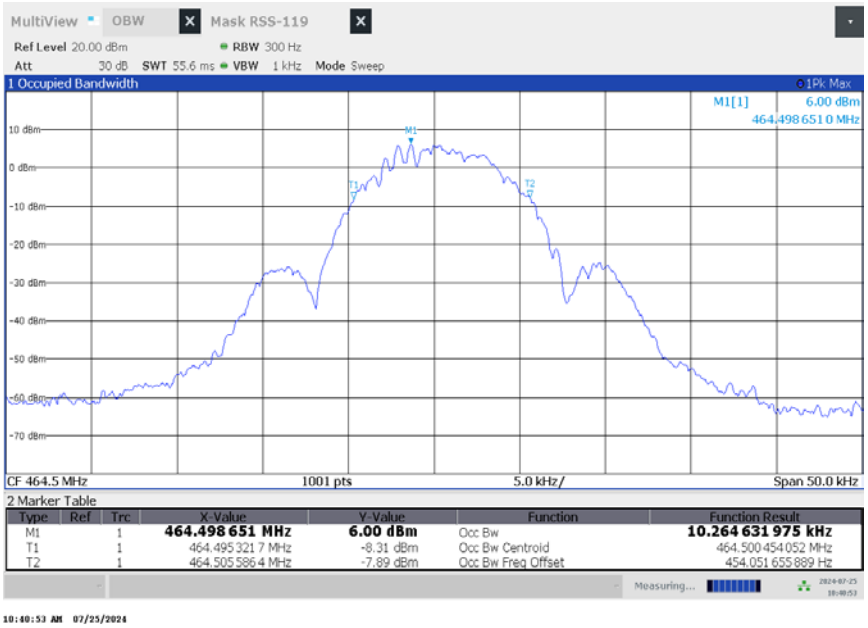
FCC 47 CFR§ 90.209 (b)(5) / RSS 119 5.10
a) Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth

Result:

Test Conditions		99% BANDWIDTH
T_{nom}	V_{nom}	10.27 kHz

Plots:

Plot 1:



10.3 Spectrum Mask

Measurement:

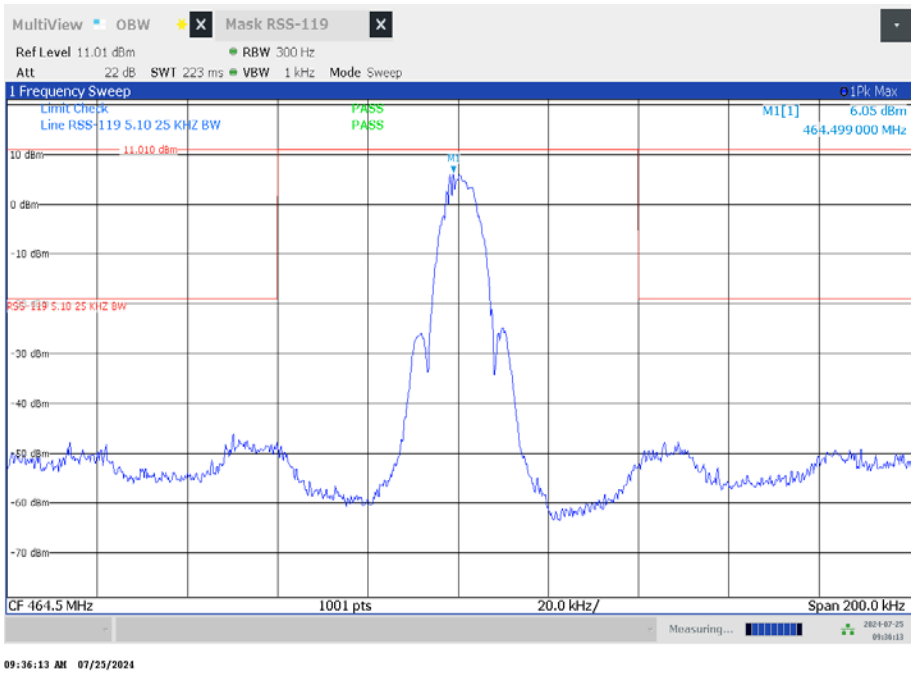
Measurement parameter for emission mask	
Detector:	Peak
Sweep time:	auto
Resolution bandwidth:	300 Hz
Video bandwidth:	1 kHz
Span:	200 kHz
Trace-Mode:	Max. hold
Test setup	See sub clause 7.2 A
Measurement uncertainty	See sub clause 8

Limits:

FCC 47 CFR § 90.217 / RSS 119 5.10
(a) For equipment designed to operate with a 25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 40 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

Plots:

Plot 1: Emission Mask (for frequency stability information see 10.4)



10.4 Frequency stability

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	10 Hz
Video bandwidth:	100 Hz
Span:	10 kHz
Trace mode:	Max. hold
Test setup:	See sub clause 7.2 A
Measurement uncertainty	See sub clause 8

Limits:

FCC 47 CFR § 90.217
No limit specified

Results:

Temperature	Deviation	
-30 °C	3.20 ppm	1.49 kHz
-20 °C	3.17 ppm	1.47 kHz
-10 °C	4.91 ppm	2.28 kHz
0 °C	5.19 ppm	2.41 kHz
10 °C	4.29 ppm	1.99 kHz
20 °C (V nom)	2.65 ppm	1.23 kHz
30 °C	0.85 ppm	0.39 kHz
40 °C	0.73 ppm	-0.34 kHz
50 °C	1.59 ppm	-0.74 kHz
Voltage	Deviation	
85 %	No access to internal battery connectors	
115 %		

10.5 Transmitter spurious emissions conducted

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Video bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Span:	See plots
Trace-Mode:	Max. hold
Test setup:	See sub clause 7.2 A
Measurement uncertainty	See sub clause 8

Limits:

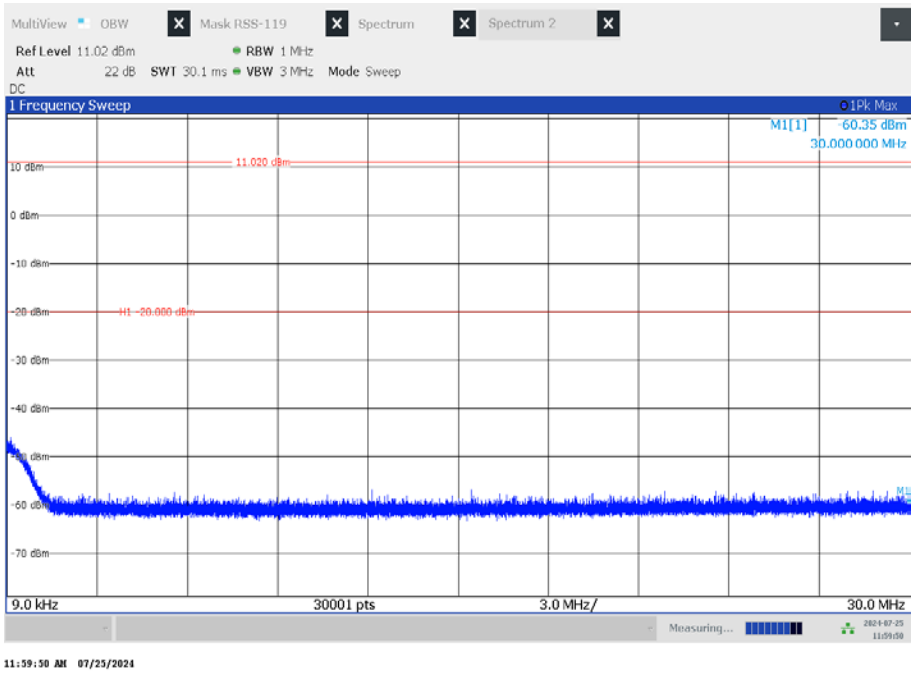
FCC 47 CFR § 90.217 / RSS 119 5.10
a) For equipment designed to operate with a 25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 40 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

Results:

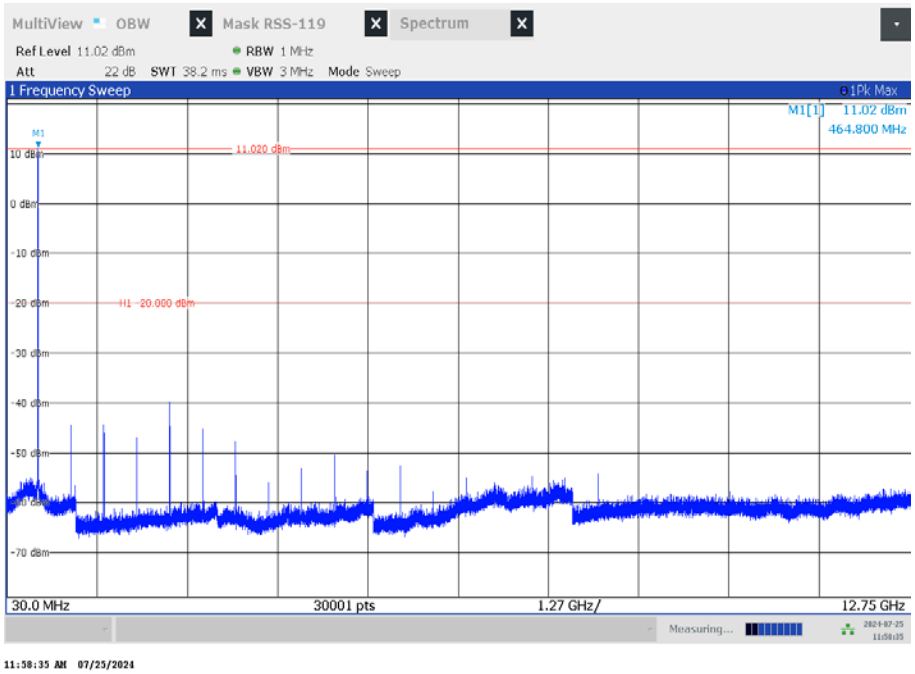
Spurious Emission Level		
Harmonic	Ch. low Freq. (MHz)	Level [dBm]
No peaks closer 10 dB to the limit detecteed		

Plots:

Plot 1: 9 kHz to 30 MHz



Plot 2: 30 MHz to 12.75 GHz



10.6 Transmitter spurious emissions (radiated)

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Video bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Span:	See plots
Trace mode:	Max. hold
Test setup:	See sub clause 7.1 B; 7.1 C
Measurement uncertainty	See sub clause 8

Limits:

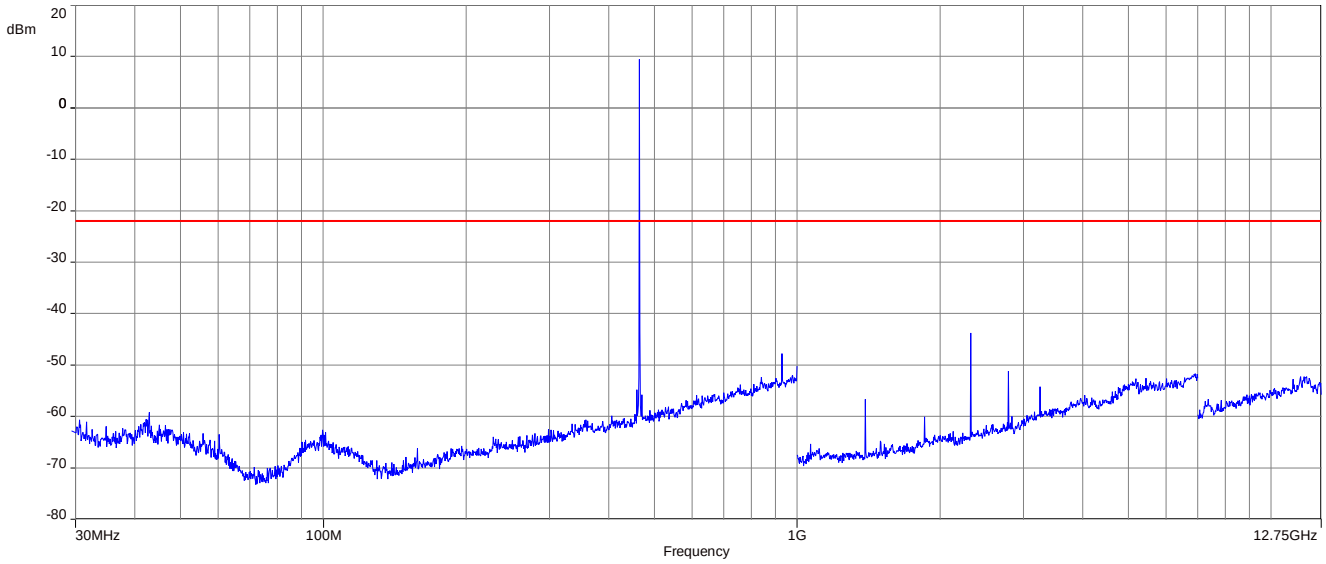
FCC 47 CFR § 90.217 / RSS 119 5.10
a) For equipment designed to operate with a 25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 40 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

Results:

Transmitter spurious emissions								
Lowest channel			Middle channel			Highest channel		
Frequency	Detector	Level	Frequency	Detector	Level	Frequency	Detector	Level
All detected spurious emissions are more than 10 dB below the limit.			All detected spurious emissions are more than 10 dB below the limit.			All detected spurious emissions are more than 10 dB below the limit.		
Measurement uncertainty ± 3 dB								

Plots:

Plot 1: 30 MHz – 12.75 GHz, middle channel, antenna vertical/horizontal



10.7 Spurious emissions radiated < 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The limits are recalculated to a measurement distance of 3 m with 40 dB/decade according CFR Part 2.

Measurement:

Measurement parameter	
Detector:	Peak / Quasi peak
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
Test setup:	See sub clause 7.1 A
Measurement uncertainty	See sub clause 8

Limits:

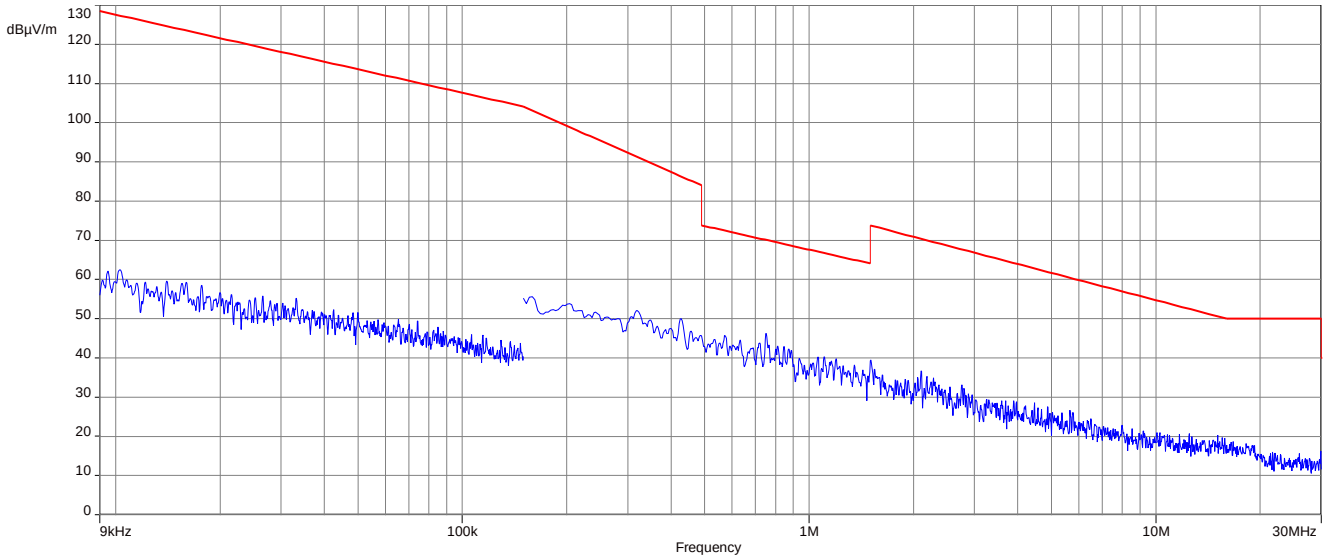
FCC		
TX Spurious Emissions Radiated < 30 MHz		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
IC		
Frequency (MHz)	Field strength (µA/m)	Measurement distance (m)
0.009 – 0.490	6.37/F (F in kHz)	300
0.490 – 1.705	63.7/F (F in kHz)	30
1.705 – 30	0.08 (-22 dBµA/m)	30

Results:

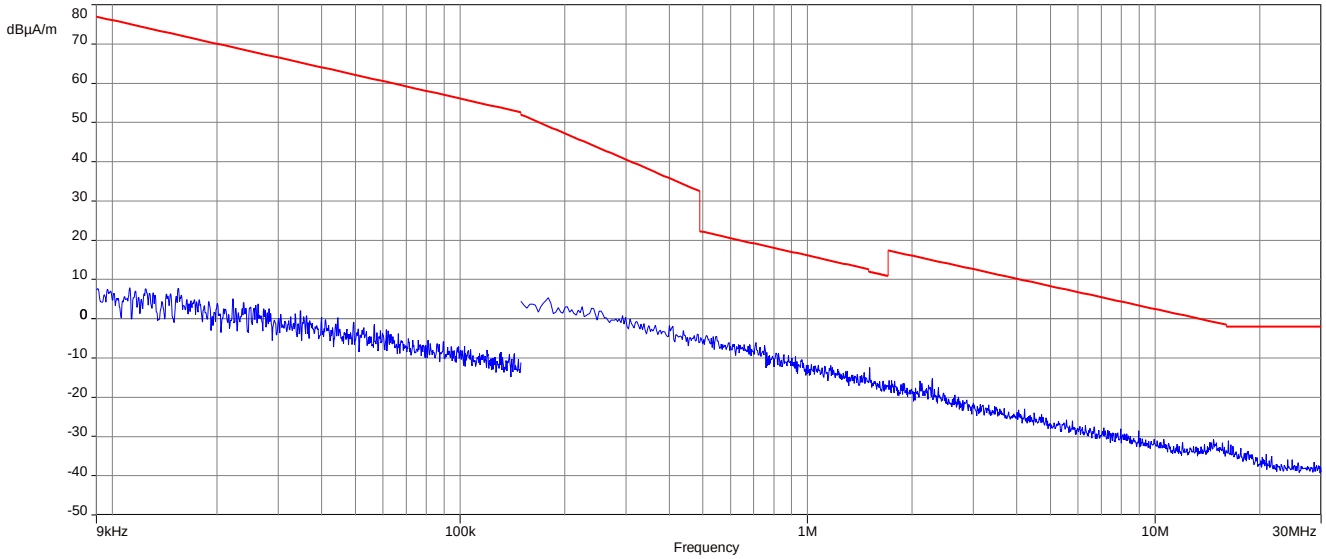
TX mode			
Frequency	RBW	Detector	Power
No peaks detected.			

Plots: TX mode

Plot 1: 9 kHz to 30 MHz, FCC



Plot 2: 9 kHz to 30 MHz, IC



11 Observations

No observations except those reported with the single test cases have been made.

12 Glossary

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

13 Document history

Version	Applied changes	Date of release
R01	Initial release	2024-09-03

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