Radio Test Report

Senceive Ltd

LoRa module installed in L3N PCB

CMWX1ZZABZ

47 CFR Part 15.247 Effective Date 1st October 2022
DSS: Part 15 Spread Spectrum Transmitter
Test Date: 23rd October 2023 to 8th February 2024
Report Number: 02-14492-1-24 Issue 02
Supersedes report: 02-14492-1-24 Issue 01

The testing was carried out by Kiwa Ltd t/a Kiwa Electrical Compliance, an independent test house, at their test facility located at:

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Arnolds Court
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This laboratory is accredited in accordance with the recognised International Standard ISO/IEC 17025. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communiqué dated April 2017).

Arnolds Court, Arnolds Farm Lane, Mountnessing, Brentwood Essex, CM13 1UT

Certificate of Test 14492-1

The equipment noted below has been partially tested and, where appropriate, conforms to the relevant subpart of 47 CFR Part 15C. This is a certificate of test only and should not be confused with an equipment authorisation. Other standards may also apply.

Equipment:	LoRa module installed in L3N PCB
Model Number:	CMWX1ZZABZ
Unique Serial Number:	001BC50AA8002449
Applicant:	Senceive Ltd Davy Avenue, Knowlhill Milton Keynes MK5 8PB
Proposed FCC ID	2AMFBLR3N
Full measurement results are detailed in Report Number:	02-14492-1-24 Issue 02
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2022 DSS: Part 15 Spread Spectrum Transmitter

NOTE:
With reference to the Rule part detailed, not all tests within the Rule part have been applied at the request of the applicant. The following tests have not been performed at the applicant's request: Maximum Average conducted output power, Average time of occupancy, Band Edge Compliance, Antenna power conducted emissions, Duty cycle, FHSS carrier frequency separation, Number of Hop Channels, Occupied bandwidth, Maximum Peak conducted output power, Maximum Power Spectral Density.
Certain tests were not performed based upon applicant's declarations. Certain other requirements are subject to applicant's declaration only and have not been tested/verified. For details refer to section 3 of this report.

DEVIATIONS:
No deviations applied to tests performed.

This certificate relates only to the unit tested as identified by a unique serial number and in the condition at the time it was tested. It does not relate to any other similar equipment and performance of the product before or after the test cannot be guaranteed. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of unit not meeting the intentions of the standard or the requirements of the Federal Regulations, particularly under different conditions to those during testing. Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Date of Test: 23rd October 2023 to 8th February 2024

Test Engineer:
Jack Chilvers

Jack Chilvers
Digitally signed by: Jack Chilvers
DN: CN = Jack Chilvers email = jack.chilvers@kiwa.com C = GB OU = Kiwa Electrical Compliance
Date: 2024.04.09 10:04:13 Z

Approved By:
Radio Manager

Digitally signed by: Daniel Sims
DN: CN = Daniel Sims email = Daniel.Sims@kiwa.com C = GB O = Kiwa Electrical Compliance - Brentwood
Date: 2024.04.09 09:46:35 Z

Customer
Representative:

ilac-MRA UKAS TESTING 2360

0 Revision History

Issue Number	Revision History	Page Reference(s)
01	First Issue	-
02	Removed all references to RN Electronics due to Company name change to Kiwa Ltd t/a Kiwa Electrical Compliance and UKAS/FCC test lab listing requirements.	1, 2, 10, 88, 104 - 107 and all footers.

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Senceive Ltd Davy Avenue Knowlhill Milton Keynes MK5 8PB	
Manufacturer of EUT	Senceive Ltd	
Full Name of EUT	LoRa module installed in L3N PCB	
Model Number of EUT	CMWX1ZZABZ	
Serial Number of EUT	001BC50AA8002449	
Date Received	16th October 2023	
Date of Test:	23rd October 2023 to 8th February 2024	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	8th April 2024	
Main Function	The GeoWAN Digital Node is an addition to Senceive's 'Interface Node' portfolio, which will provide system integration capability for instruments with digital serial interfaces (RS485, RS422, RS232 and SDI-12, CAN) and potential higher power requirements, as is the case for many In-Place Inclinometers, Weather stations, voidmeters, liquid levelling cells and many more.	
Information Specification	Height	250 mm
	Width	140 mm
	Depth	120 mm
	Weight	1.4 kg
	Voltage	3.6 VDC (Internal Battery)
	Current	Not Declared

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Pole Mounted
Choice of model(s) for type tests	Production PCB
Antenna details	GTT Wireless (+1.0dBi)
Antenna port	N-Type
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	927.5 MHz
Lowest Signal generated in EUT	Not Declared
Hardware Version (HVIN)	L3N BAC
Software Version	V0.1.101.
Firmware Version (FVIN)	Node Firmware version: 00.00-12 Radio: Murata Firmware version 1.0.2
Type of Equipment	Stand-alone sensor
Technology Type	LoRa
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	902-928 MHz Band
EUT Declared Modulation Parameters	LoRa
EUT Declared Power level	20 dBm ERP (18 dBm conducted)
EUT Declared Signal Bandwidths	125 kHz and 500 kHz
EUT Declared Channel Spacing's	200kHz (125kHz BW), 1.6MHz (500kHz BW)
EUT Declared Duty Cycle	Not Declared
Unmodulated carrier available?	No
Declared frequency stability	Not Declared
RX Parameters	
Alignment range – receiver	902-928 MHz Band
EUT Declared RX Signal Bandwidth	125 kHz
FCC Parameters	
FCC Transmitter Class	DSS: Part 15 Spread Spectrum Transmitter

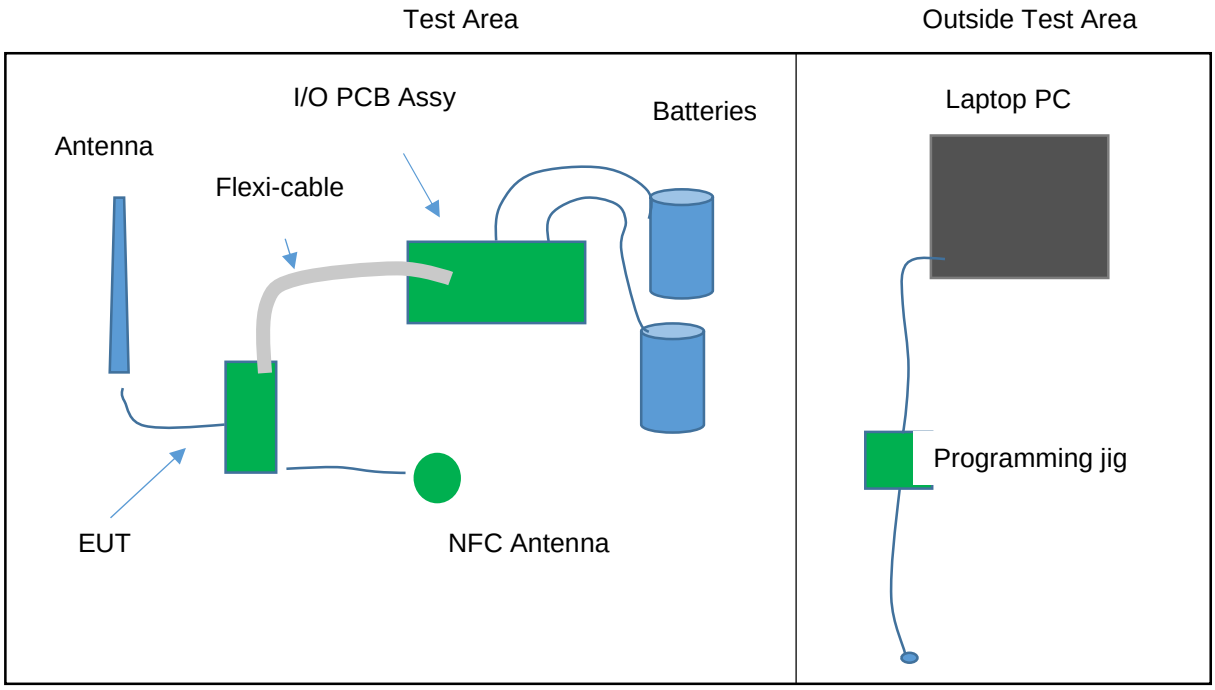
2.3 Functional description

The internal battery powered GeoWAN Digital Node can autonomously sample a connected sensor or chain of sensors with digital serial interfaces (RS485, RS422, RS232 and SDI-12, CAN) and potential higher power requirements, and will transfer data via LoRa wireless connection to a GeoWAN LTE Gateway for Senceive's clients to access via Senceive's secure Webmonitor portal.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Low Chan 125 kHz	Transmitting continuously modulated signal at 902.3 MHz with 125 kHz band width. 20 dBm power set.	Yes
Mid Chan 125 kHz	Transmitting continuously modulated signal at 915.1 MHz with 125 kHz band width. 20 dBm power set.	Yes
High Chan 125 kHz	Transmitting continuously modulated signal at 927.5 MHz with 125 kHz band width. 20 dBm power set.	Yes
Low Chan 500 kHz	Transmitting continuously modulated signal at 903 MHz with 500 kHz band width. 20 dBm power set.	Yes
Mid Chan 500 kHz	Transmitting continuously modulated signal at 914.2 MHz with 500 kHz band width. 20 dBm power set.	Yes
High Chan 500 kHz	Transmitting continuously modulated signal at 927.5 MHz with 500 kHz band width. 20 dBm power set.	Yes

2.5 Emissions configuration



The EUT was connected to typical ancillary equipment so that each of the EUT's ports was populated and functional. The EUT and all ancillary equipment was pinned to a Styrofoam block and 10 cm separation between items was maintained as can be seen in section 8.1 of this report to meet modular approval testing requirements. The EUT was connected to the I/O PCB assembly using a flexi cable. The EUT was powered using two brand new batteries via the I/O PCB assembly. The supplied antenna was connected to the EUT via a UFL to N-type coax cable. An NFC coil antenna was connected to the EUT using a 4-way cable assembly.

The EUT was configured into the test modes stated in section 2.4 using a laptop PC and programming jig running 'Putty' terminal software. The applicant provided the commands to set low, mid and high channels. A fixed power level of +20 dBm (conducted) was used throughout testing. Radiated tests were performed with the antenna in place.

The transmit mode was 100% continuous with modulation and the power settings for each channel were as stated below:-

Low Channel (902.3 MHz) +20 dBm power setting 125 kHz bandwidth
Mid Channel (915.1 MHz) +20 dBm power setting 125 kHz bandwidth
High Channel (927.5 MHz) +20 dBm power setting 125 kHz bandwidth

Low Channel (902.3 MHz) +20 dBm power setting 500 kHz bandwidth
Mid Channel (915.1 MHz) +20 dBm power setting 500 kHz bandwidth
High Channel (927.5 MHz) +20 dBm power setting 500 kHz bandwidth

2.5.1 Signal leads

Port Name	Cable Type	Connected
RF	UFL to N-Type coax	Yes
Battery	2-core	Yes
I/O & Power	14-Way flexi	Yes
NFC	4 way ribbon	Yes

3 Summary of test results

The LoRa module installed in L3N PCB, CMWX1ZZABZ was tested for compliance to the following standard(s):

47 CFR Part 15.247 Effective Date 1st October 2022
DSS: Part 15 Spread Spectrum Transmitter

Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of equipment not meeting the intentions of the standard or the essential requirements of the directive, particularly under different conditions to those during testing. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	NOT APPLICABLE[1]
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
6. Effective radiated power field strength	47 CFR Part 15C Part 15.247(d)	NOT APPLICABLE[3]
7. Band Edge Compliance	47 CFR Part 15C Part 15.215 & 15.247(d)	PASSED
8. Occupied bandwidth	47 CFR Part 15C Part 15.247(a)(1)(i)/ (ii)/(iii)/ 15.247(a)(2)/15.215	NOT TESTED[2]
9. Maximum Average conducted output power	47 CFR Part 15C Part 15.247(b3)	NOT APPLICABLE[3]
10. Maximum Peak conducted output power	47 CFR Part 15C Part 15.247(b)(1)/(b)(2)/(b)(3)	PASSED
11. Maximum Power Spectral Density	47 CFR Part 15C Part 15.247I	NOT TESTED[2]
12. Antenna power conducted emissions	47 CFR Part 15C Part 15.247(d)	NOT TESTED[2]
13. Duty cycle	47 CFR Part 15C Part 15.35I	NOT TESTED[2]
14. FHSS carrier frequency separation	47 CFR Part 15C Part 15.247(a1)	NOT TESTED[2]
15. Average time of occupancy	47 CFR Part 15C Part 15.247(a)(1)(i)/(ii)/(iii)	NOT TESTED[2]
16. Number of Hop Channels	47 CFR Part 15C Part 15.247(a)(1)(i)/(ii)/(iii)	NOT TESTED[2]

[1] EUT does not operate from the AC power lines nor contain provisions for operation while connected to AC power lines.

[2] Not tested at the request of the applicant.

[3] Maximum peak conducted power measured instead.

4 Specifications

The tests were performed and operated in accordance with Kiwa Electrical Compliance procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	47 CFR Part 15C	2022	Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES
4.1.2	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
4.1.3	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
4.1.4	KDB 558074 D01 v05r02	2019	Federal Communications Commission Office of Engineering and Technology Laboratory Division; Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules

4.2 Deviations

Deviations have not been applied.

5 Tests, methods and results

5.1 AC power line conducted emissions

NOT APPLICABLE: EUT does not operate from the AC power lines nor contain provisions for operation while connected to AC power lines.

5.2 Radiated emissions 9 - 150 kHz

5.2.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a new internal battery.

The EUT was operated in Low Chan 125 kHz, Mid Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz, Mid Chan 500 kHz and High Chan 500 kHz modes.

5.2.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Measurements were made in a semi-anechoic chamber. The antenna was placed 1m above the ground.
The equipment was rotated 360 degrees to record the worst-case emissions.
Any signals within 20dB of the limit were investigated.
Tests were performed using Test Site M.

5.2.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz

Plot refs
14492-1 Rad 1 9k-150kHz Para
14492-1 Rad 1 9k-150kHz Perp

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Mid channel	915.1 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903 MHz

Plot refs
14492-1 Rad 2 9k-150kHz Para
14492-1 Rad 2 9k-150kHz Perp

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Mid channel	914.2 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
High channel	927.5MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line can be found in Section 6 of this report.

Note: Low, middle and high channels where fully tested but only low channel plotted as this was worst case for emissions. No emissions were observed within 20dB of limits on any mode/channel setting.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
9kHz - 30MHz ±3.9dB

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a new internal battery.

The EUT was operated in Low Chan 125 kHz, Mid Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz, Mid Chan 500 kHz and High Chan 500 kHz modes.

5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst case emissions.

Any signals within 20dB of the limit were investigated.

Tests were performed using Test Site M.

5.3.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz

Plot refs
14492-1 Rad 1 150k-30MHz Para
14492-1 Rad 1 150k-30MHz Perp

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Mid channel	915.1 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan

High channel	927.5 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903 MHz

Plot refs
14492-1 Rad 2 150k-30MHz Para
14492-1 Rad 2 150k-30MHz Perp

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Mid channel	914.2 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as this was worst case for emissions.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

Note: Low, middle and high channels where fully tested but only low channel plotted as was worst case for emissions. No emissions were observed within 20dB of limits on any mode/channel setting.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
9kHz - 30MHz ±3.9dB

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a new internal battery.

The EUT was operated in Low Chan 125 kHz, Mid Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz, Mid Chan 500 kHz and High Chan 500 kHz modes.

5.4.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Measurements were made in a semi-anechoic chamber. The antenna was height scanned 1-4m above the ground plane to maximise emissions. The equipment was rotated 360 degrees to record the worst-case emissions.

Any signals within 20dB of the limit were investigated.

Tests were performed using Test Site M.

5.4.4 Test equipment

LPE364, E743, NSA-M, ZSW1, E412, E411

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz

Plot refs
14492-1 Rad 1 VHF Horiz
14492-1 Rad 1 VHF Vert
14492-1 Rad 1 UHF Horiz
14492-1 Rad 1 UHF Vert

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	33.370	33.8	29.1	-10.9
2	89.100	30.9	28.0	-15.5
3	91.300	30.8	27.2	-16.3
4	93.500	33.5	30.6	-12.9
5	115.164	30.5	24.9	-18.6
6	308.471	32.8	28.2	-17.8
7	382.311	34.8	29.5	-16.5
8	520.920	37.3	32.3	-13.7
9	622.641	39.1	34.3	-11.7
10	630.390	40.3	35.3	-10.7
11	631.381	40.3	35.1	-10.9
12	647.411	41.3	35.4	-10.6
13	688.350	40.7	34.6	-11.4
14	735.978	42.2	37.0	-9.0
15	809.110	40.6	35.4	-10.6
16	948.420	42.1	36.4	-9.6

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	37.730	32.2	26.7	-13.3
2	665.171	41.3	35.7	-10.3
3	682.621	40.8	35.5	-10.5
4	684.520	41.2	35.1	-10.9

Note: These are generic emissions that were present for low, middle & high 125kHz BW channels.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Mid channel	915.1 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903 MHz

Plot refs
14492-1 Rad 2 VHF Horiz
14492-1 Rad 2 VHF Vert
14492-1 Rad 2 UHF Horiz
14492-1 Rad 2 UHF Vert

Table of signals measured for Rad 2 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	46.437	29.9	25.4	-14.6
2	110.376	30.5	24.4	-19.1
3	180.810	28.4	23.1	-20.4
4	467.271	36.6	31.2	-14.8
5	626.120	40.3	34.9	-11.1
6	651.371	40.4	35.2	-10.8
7	682.620	41.3	35.7	-10.3
8	789.071	40.4	35.5	-10.5
9	804.621	41.3	35.3	-10.7

Table of signals measured for Rad 2 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	36.540	32.2	27.3	-12.7
2	43.330	29.2	23.8	-16.2
3	46.437	30.4	25.3	-14.7
4	46.942	28.4	23.3	-16.7
5	129.816	29.7	24.5	-19.0
6	627.840	41.0	35.2	-10.8
7	651.031	41.4	34.8	-11.2
8	665.711	40.7	35.2	-10.8
9	786.260	40.5	35.3	-10.7
10	938.431	41.2	36.0	-10.0
11	969.801	41.9	36.2	-17.8
12	969.837	41.5	36.3	-17.7

Note: These are generic emissions that were present for low, middle & high 500kHz BW channels.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Mid channel	914.2 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Plot refs
Low, middle and high channels tested but only low channel plotted as was worst case for emissions.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.
Note: Low, middle and high channels where fully tested but only low channel plotted as this was worst case for emissions. Final measurements are presented for TX Low channel for 125kHz and 500kHz BW modes only.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
30MHz - 1000MHz ±6.1dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]

5.5.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a new internal battery.

The EUT was operated in Low Chan 125 kHz, Mid Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz, Mid Chan 500 kHz and High Chan 500 kHz modes.

5.5.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. Horn antennas were used at heights where the whole of the EUT was contained within the main beam. The EUT was rotated through 360 degrees to record the worst case emissions. A measurement distance of 3m was used between the test range 1 - 6GHz, 1.2m was used in the test range 6 - 10GHz.

Any signals within 20dB of the limit were investigated.

Tests were performed using Test Site B.

5.5.4 Test equipment

E429, E755, E834, E904

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2706.9	47.49	-26.51	47.29	-6.71	Upright	Vertical
2706.9	45.63	-28.37	45.58	-8.42	Flat	Horizontal

Plots
Low Chan Horiz 125 kHz BW 1-2 GHz 1 MHz
Low Chan Horiz 125 kHz BW 1-2 GHz 100 kHz
Low Chan Vert 125 kHz BW 1-2 GHz 1 MHz
Low Chan Vert 125 kHz BW 1-2 GHz 100 kHz
Low Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
Low Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
Low Chan Horiz 125 kHz BW 2.7-5 GHz 1 MHz

Low Chan Vert 125 kHz BW 2.7-5 GHz 1 MHz
Low Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
Low Chan Vert 125 kHz BW 5-6 GHz 1 MHz
Low Chan Horiz 125 kHz BW 6-7.77 GHz 1 MHz
Low Chan Vert 125 kHz BW 6-7.77 GHz 1 MHz
Low Chan Horiz 125 kHz BW 7.77-10 GHz 1 MHz
Low Chan Vert 125 kHz BW 7.77-10 GHz 1 MHz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Mid channel	915.1 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1830.2	79.65	-18.15	79.6	-8.2	Flat	Horizontal
2745.3	45.04	-28.96	44.92	-9.08	Upright	Vertical
2745.3	45.59	-28.41	45.36	-8.64	Flat	Horizontal

Note: 2nd Harmonic had a non-restricted band limit applied in line with part 15.247(d) requirements. all other emissions comply to part 15.209 Limits.

Plots
Mid Chan Horiz 125 kHz BW 1-2 GHz 1 MHz
Mid Chan Horiz 125 kHz BW 1-2 GHz 100 kHz
Mid Chan Vert 125 kHz BW 1-2 GHz 1 MHz
Mid Chan Vert 125 kHz BW 1-2 GHz 100 kHz
Mid Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
Mid Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
Mid Chan Horiz 125 kHz BW 2.7-5 GHz 1 MHz
Mid Chan Vert 125 kHz BW 2.7-5 GHz 1 MHz
Mid Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
Mid Chan Vert 125 kHz BW 5-6 GHz 1 MHz
Mid Chan Horiz 125 kHz BW 6-7.77 GHz 1 MHz
Mid Chan Vert 125 kHz BW 6-7.77 GHz 1 MHz
Mid Chan Horiz 125 kHz BW 7.77-10 GHz 1 MHz
Mid Chan Vert 125 kHz BW 7.77-10 GHz 1 MHz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1855	73.44	-25.31	73.42	-15.33	Upright	Vertical
1855	73.98	-24.77	73.87	-14.88	Flat	Horizontal
2782.5	46.34	-27.66	46.25	-7.75	Upright	Vertical
2782.5	46.72	-27.28	46.67	-7.33	Flat	Horizontal

Note: 2nd Harmonic had a non-restricted band limit applied in line with part 15.247(d) requirements. all other emissions comply to part 15.209 Limits

Plots
High Chan Horiz 125 kHz BW 1-2 GHz 1 MHz
High Chan Horiz 125 kHz BW 1-2 GHz 100 kHz
High Chan Vert 125 kHz BW 1-2 GHz 1 MHz
High Chan Vert 125 kHz BW 1-2 GHz 100 kHz
High Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
High Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
High Chan Horiz 125 kHz BW 2.7-5 GHz 1 MHz
High Chan Vert 125 kHz BW 2.7-5 GHz 1 MHz
High Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
High Chan Vert 125 kHz BW 5-6 GHz 1 MHz
High Chan Horiz 125 kHz BW 6-7.77 GHz 1 MHz
High Chan Vert 125 kHz BW 6-7.77 GHz 1 MHz
High Chan Horiz 125 kHz BW 7.77-10 GHz 1 MHz
High Chan Vert 125 kHz BW 7.77-10 GHz 1 MHz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2709	46.75	-27.25	46.71	-7.29	Upright	Vertical
2709	46.24	-27.76	46.15	-7.85	Flat	Horizontal

Plots
Low Chan Horiz 500 kHz BW 1-2 GHz 1 MHz
Low Chan Horiz 500 kHz BW 1-2 GHz 100 kHz
Low Chan Vert 500 kHz BW 1-2 GHz 1 MHz
Low Chan Vert 500 kHz BW 1-2 GHz 100 kHz
Low Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
Low Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
Low Chan Horiz 500 kHz BW 2.7-5 GHz 1 MHz
Low Chan Vert 500 kHz BW 2.7-5 GHz 1 MHz
Low Chan Horiz 500 kHz BW 5-6 GHz 1 MHz
Low Chan Vert 500 kHz BW 5-6 GHz 1 MHz
Low Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
Low Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
Low Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
Low Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Mid channel	914.2 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2742.6	46.84	-27.16	46.76	-7.24	Upright	Vertical
2742.6	45.82	-28.18	45.79	-8.21	Flat	Horizontal

Plots
Mid Chan Horiz 500 kHz BW 1-2 GHz 1 MHz
Mid Chan Horiz 500 kHz BW 1-2 GHz 100 kHz
Mid Chan Vert 500 kHz BW 1-2 GHz 1 MHz
Mid Chan Vert 500 kHz BW 1-2 GHz 100 kHz
Mid Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
Mid Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
Mid Chan Horiz 500 kHz BW 2.7-5 GHz 1 MHz
Mid Chan Vert 500 kHz BW 2.7-5 GHz 1 MHz
Mid Chan Horiz 500 kHz BW 5-6 GHz 1 MHz
Mid Chan Vert 500 kHz BW 5-6 GHz 1 MHz
Mid Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
Mid Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
Mid Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
Mid Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
High channel	927.5 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1855	73.55	-25.06	73.34	-15.27	Upright	Vertical
1855	74.22	-24.39	74.12	-14.49	Flat	Horizontal
2782.5	46.42	-27.58	46.33	-7.67	Upright	Vertical
2782.5	47.31	-26.69	47.15	-6.85	Flat	Horizontal

Note: 2nd Harmonic had a non-restricted band limit applied in line with part 15.247(d) requirements. all other emissions comply to part 15.209 Limits.

Plots
High Chan Horiz 500 kHz BW 1-2 GHz 1 MHz
High Chan Horiz 500 kHz BW 1-2 GHz 100 kHz
High Chan Vert 500 kHz BW 1-2 GHz 1 MHz
High Chan Vert 500 kHz BW 1-2 GHz 100 kHz
High Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
High Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
High Chan Horiz 500 kHz BW 2.7-5 GHz 1 MHz
High Chan Vert 500 kHz BW 2.7-5 GHz 1 MHz
High Chan Horiz 500 kHz BW 5-6 GHz 1 MHz
High Chan Vert 500 kHz BW 5-6 GHz 1 MHz
High Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
High Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
High Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
High Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz

Peak detector “Max held” Analyser plots against the Average limit line can be found in Section 6 of this report. Only emissions within 20dB of the applicable limits are listed in each table.

LIMITS:

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
1 – 10 GHz ±3.5dB

5.6 Effective radiated power field strength

NOT TESTED: Not tested at the request of the applicant.

5.7 Band Edge Compliance

5.7.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.215 & 15.247(d) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.10 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209(a) & 15.247(d) [Reference 4.1.1 of this report]

5.7.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres.

The EUT was operated in Low Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz and High Chan 500 kHz modes.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The emission from the EUT was maximised in the chamber before taking the plots. Plots were taken in the required bandwidths showing fundamental emission and the relevant band edges. dBc points at band edges are indicated on the plots.
Tests were performed using Test Site M.

5.7.4 Test equipment

LPE364, E743, NSA-M, ZSW1, E412, E411

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz
High channel	927.5 MHz

Restricted Band Edges	Low channel	High channel
Restricted band edge Plot	Refer to radiated emissions plots	Refer to radiated emissions plots

Authorised Band Edges	Low channel	High channel
Authorised Band Edge (dBc) value measured	48.2	49.4
Authorised Band Edge Plot	Low Chan 125 kHz BW Horiz Flat Authorised Band Edge	High Chan 125 kHz BW Horiz Flat Authorised Band Edge.spt

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903.0 MHz
High channel	927.5 MHz

Restricted Band Edges	Low channel	High channel
Restricted band edge Plot	Refer to radiated emissions plots	Refer to radiated emissions plots

Authorised Band Edges	Low channel	High channel
Authorised Band Edge (dBc) value measured	47.0	25.4
Authorised Band Edge Plot	Low Chan 500 kHz BW Horiz Flat Authorised Band Edge	High Chan 500 kHz BW Horiz Flat Authorised Band Edge

Analyser plots for the Authorised Band edge Compliance can be found in section 6 of this report. These show the 20dBc Peak requirement of 15.247(d) are met at the band edges of 902 and 928 MHz. Restricted band edge plots are also shown in section 6 – see radiated emissions below 1GHz section. Field strengths observed in the adjacent restricted bands are required to meet the tighter limits of 15.209.

LIMITS: Restricted band limits of 15.205 with the relevant detector:
AV = 54dBuV/m at band edges
PK = 74dBuV/m at band edges

The restricted band edges closest to the EUT frequency of 902-928MHz are 614 & 960MHz.
Wide span plots have been taken under radiated emissions below 1GHz test to show the fact that there are no spurious emissions above the restricted limits of 15.209.
20dBc Peak requirement of 15.247(d) at the authorised band edges of 902 and 928 MHz.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 3.9 dB

5.8 Occupied bandwidth

NOT TESTED: Not tested at the request of the applicant.

5.9 Maximum Average conducted output power

NOT TESTED: Maximum peak conducted power measured instead.

5.10 Maximum Peak conducted output power

5.10.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247 (b)(2) [Reference 4.1.1 of this report]
	47 CFR Part 15C Part 15.247 (b)(3) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247 (b)(2) [Reference 4.1.1 of this report]
	47 CFR Part 15C Part 15.247 (b)(3) [Reference 4.1.1 of this report]

5.10.2 Configuration of EUT

The EUT's antenna was removed and measurements were made directly at the RF port of the EUT.

The EUT was operated in Low Chan 125 kHz, Mid Chan 125 kHz, High Chan 125 kHz, Low Chan 500 kHz, Mid Chan 500 kHz and High Chan 500 kHz modes for this test.

5.10.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Power meter reading stated is maximum power observed using a spectrum analyser. Measurements were made on a test bench in site B.

5.10.4 Test equipment

E301, E642

See Section 9 for more details

5.10.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	101kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz
Mod Scheme	GeoWan
Low channel	902.3 MHz
Mid channel	915.1 MHz
High channel	927.5 MHz

Nominal voltage result (dBm)	18.36	18.34	18.28
Single port Plot reference	14492-1 Conducted Peak Power - 902.3 MHz _ 125 kHz BW	14492-1 Conducted Peak Power - 915.1 MHz _ 125 kHz BW	14492-1 Conducted Peak Power - 927.5 MHz _ 125 kHz BW
Limit in dBm	30.0	30.0	30.0
Margin to Limit (dB)	-11.64	-11.66	-11.72
Result in (W)	0.069	0.068	0.067

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz
Mod Scheme	GeoWan
Low channel	903.0 MHz
Mid channel	914.2 MHz
High channel	927.5 MHz

Nominal voltage result (dBm)	18.42	18.31	18.24
Single port Plot reference	14492-1 Conducted Peak Power - 903 MHz _ 500 kHz BW	14492-1 Conducted Peak Power - 914.2 MHz _ 500 kHz BW	14492-1 Conducted Peak Power - 927.5 MHz _ 500 kHz BW
Limit in dBm	30.0	30.0	30.0
Margin to Limit (dB)	-11.58	-11.69	-11.76
Result in (W)	0.070	0.068	0.067

LIMITS:
15.247(b)(2)
For FHSS operating 902-928 MHz employing at least 50 channels 1 Watt /

15.247(b)(3)
For systems using digital modulation in the 902-928, 2400-2483.5 or 5725-5850 MHz bands 1 Watt.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 1.0 dB

5.11 Maximum Power Spectral Density

NOT TESTED: Not tested at the request of the applicant.

5.12 Antenna power conducted emissions

NOT TESTED: Not tested at the request of the applicant.

5.13 Duty cycle

NOT TESTED: Not tested at the request of the applicant.

5.14 FHSS carrier frequency separation

NOT TESTED: Not tested at the request of the applicant.

5.15 Average time of occupancy

NOT TESTED: Not tested at the request of the applicant.

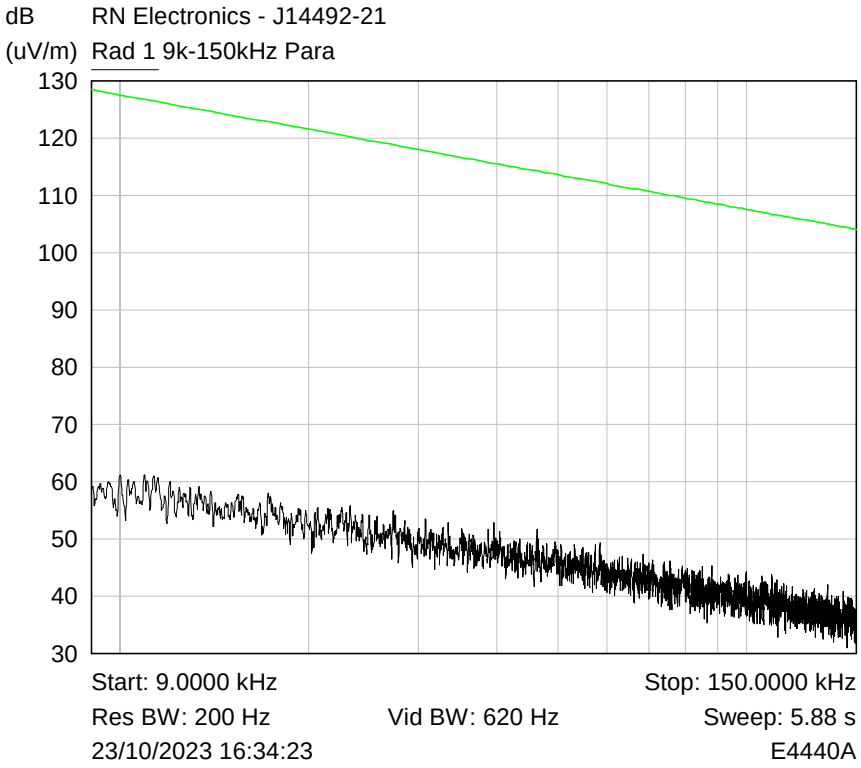
5.16 Number of Hop Channels

NOT TESTED: Not tested at the request of the applicant.

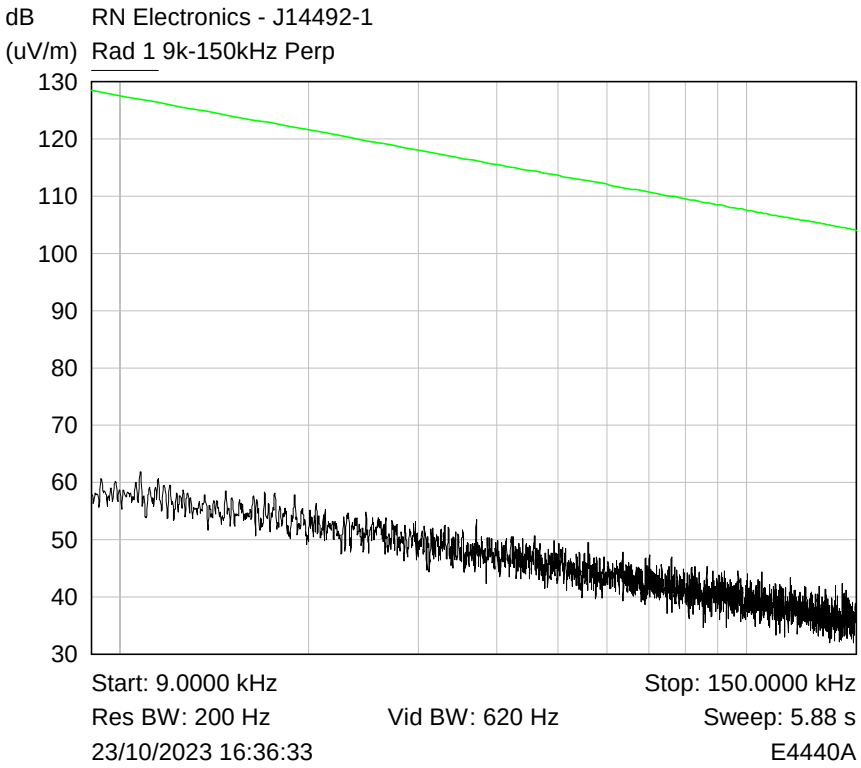
6 Plots/Graphical results

6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz

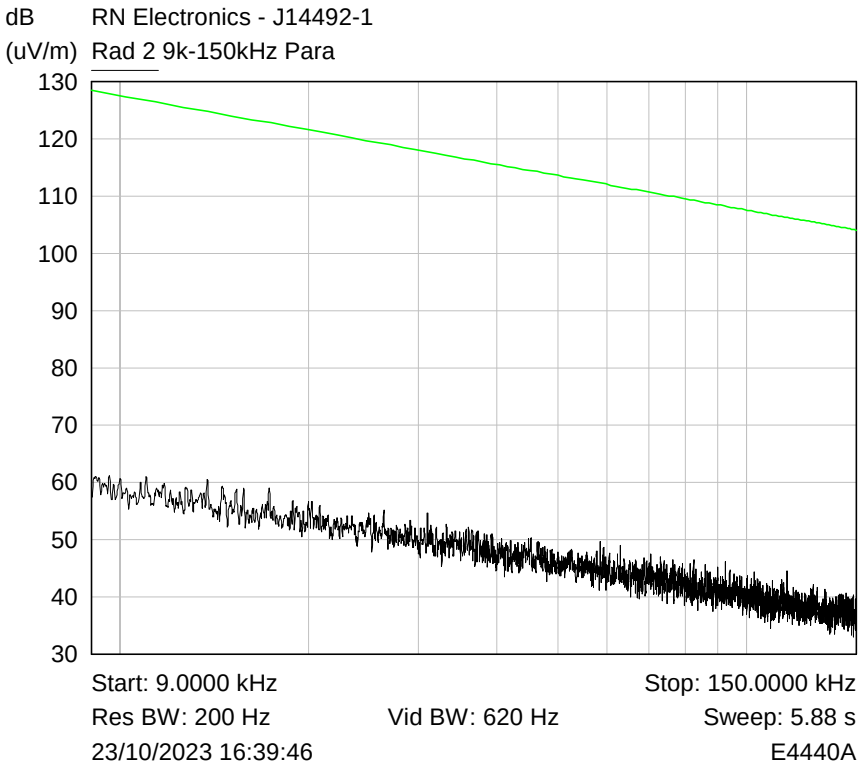


Plot of 9k-150kHz Parallel

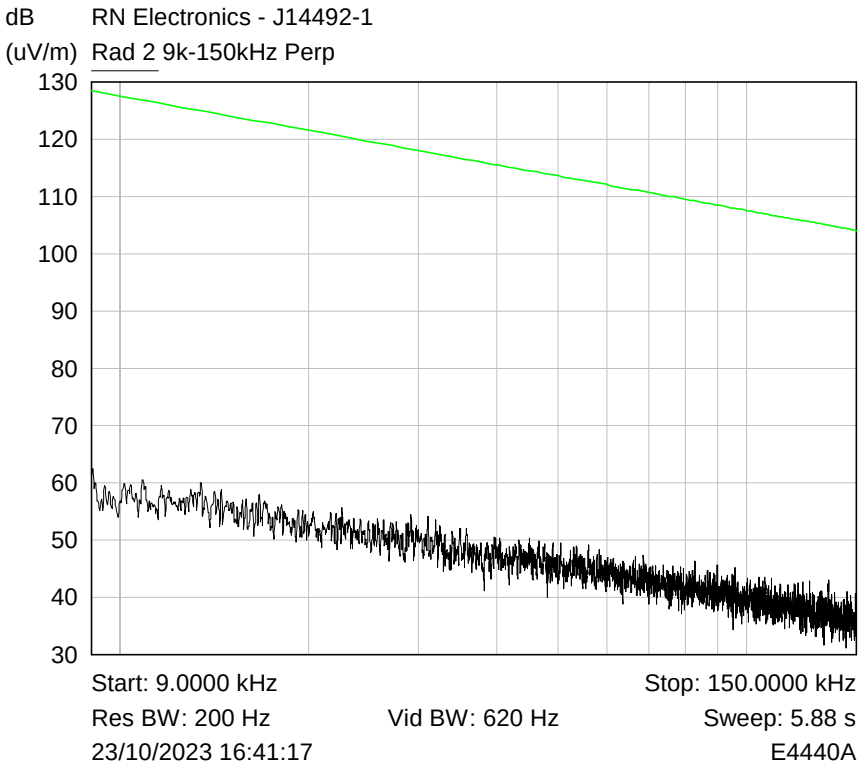


Plot of 9k-150kHz Perpendicular

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903 MHz



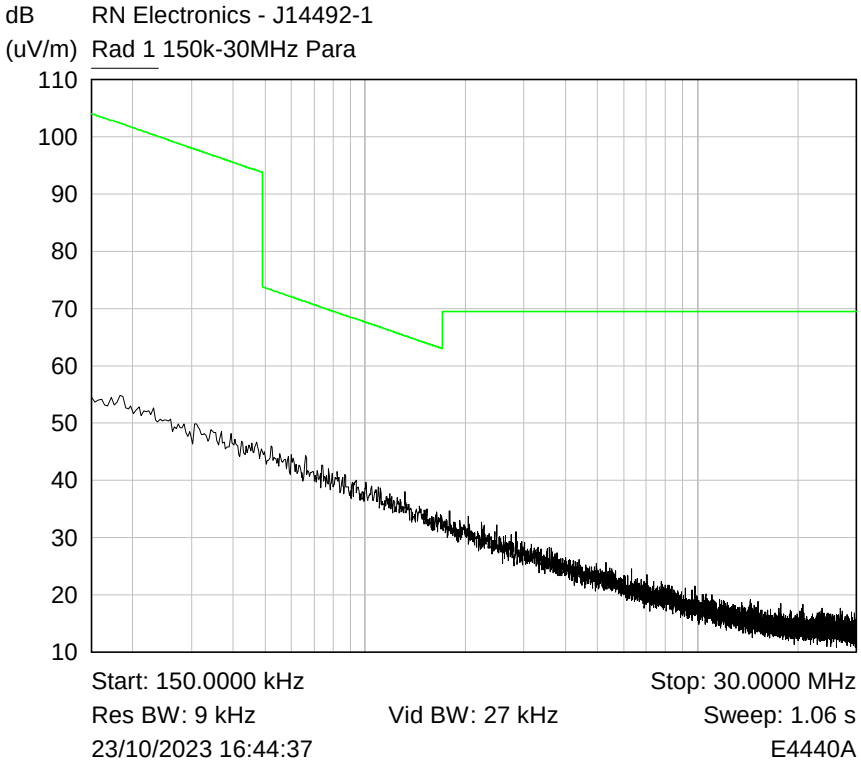
Plot of 9k-150kHz Parallel



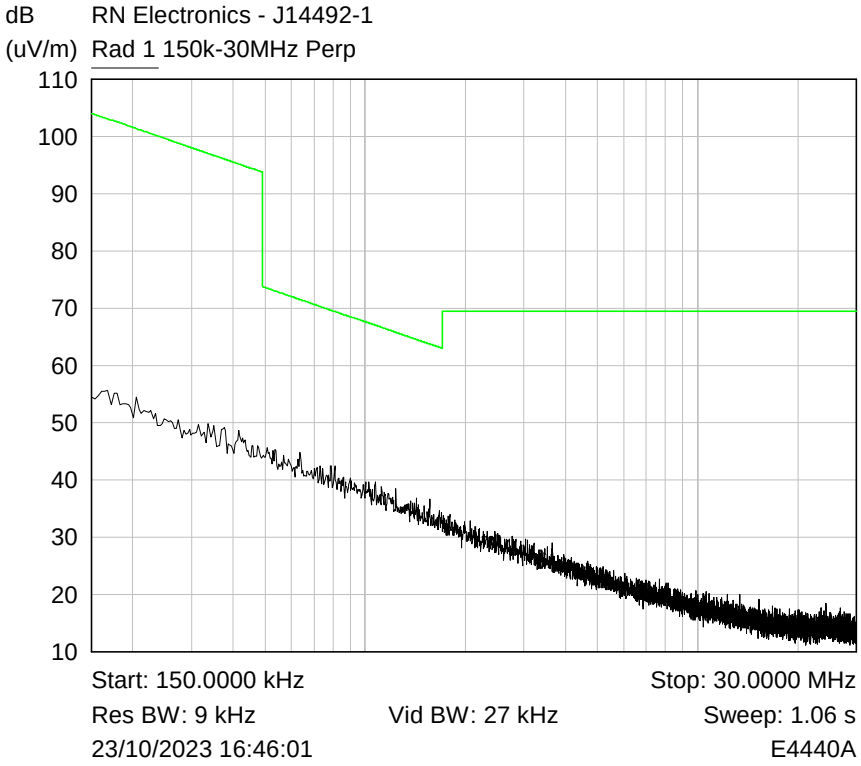
Plot of 9k-150kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz

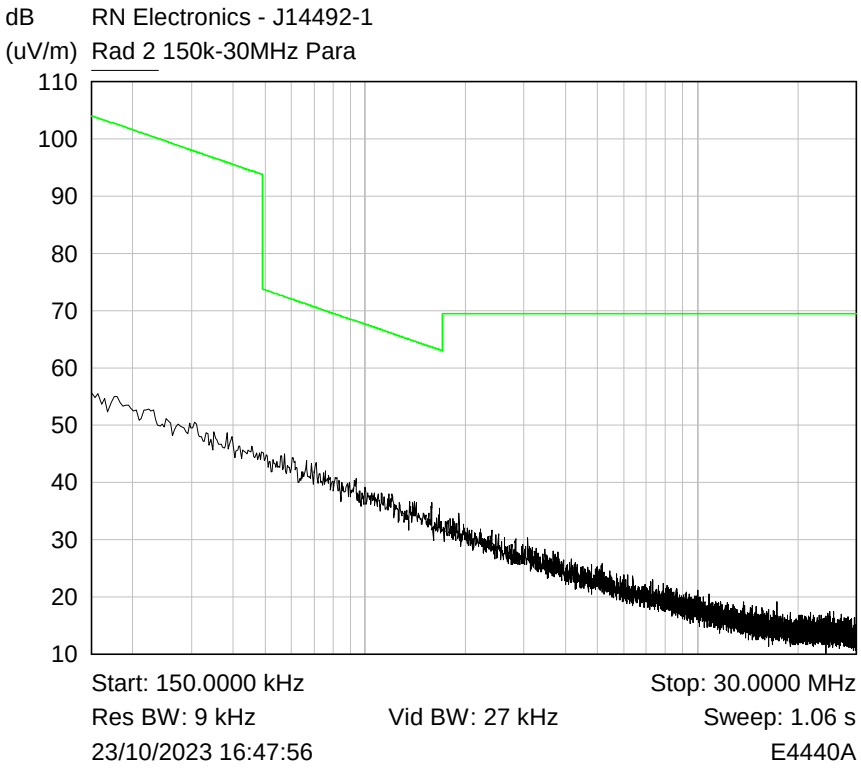


Plot of 150kHz-30MHz Parallel

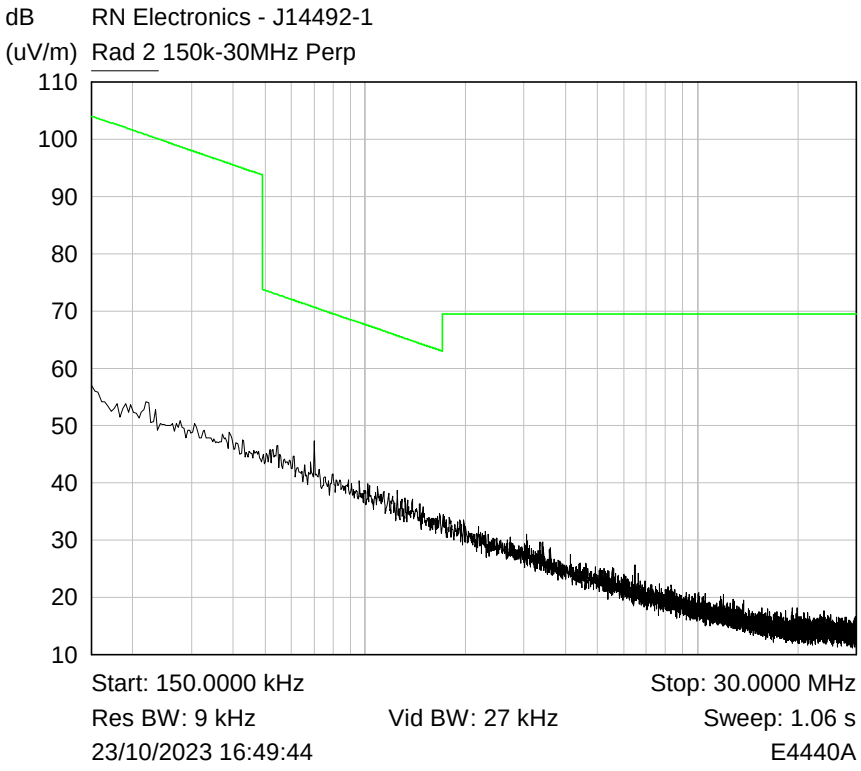


Plot of 150kHz-30MHz Perpendicular

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903 MHz



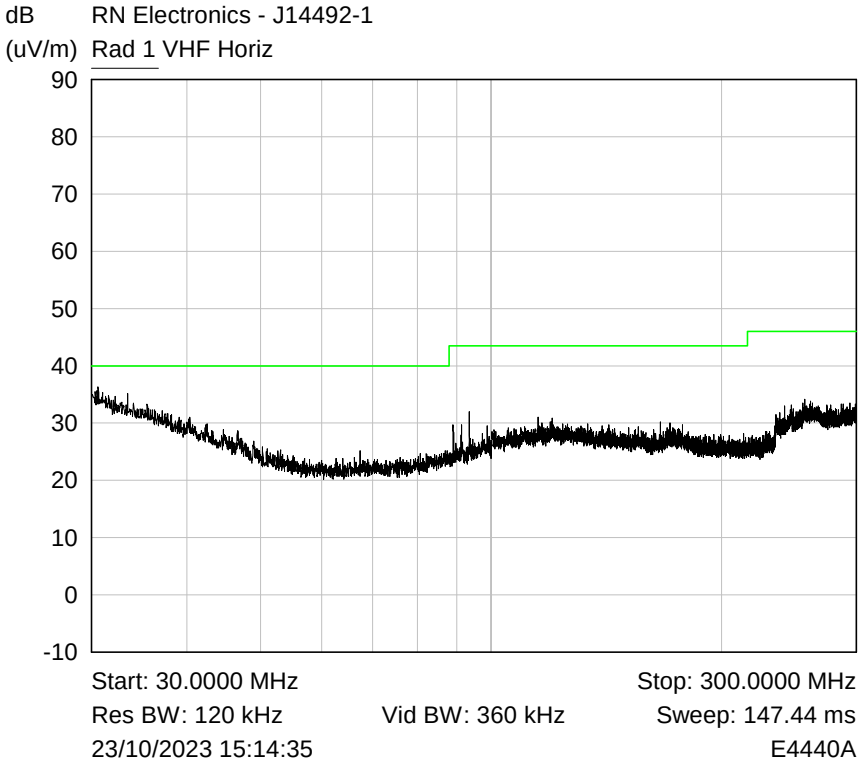
Plot of 150kHz-30MHz Parallel



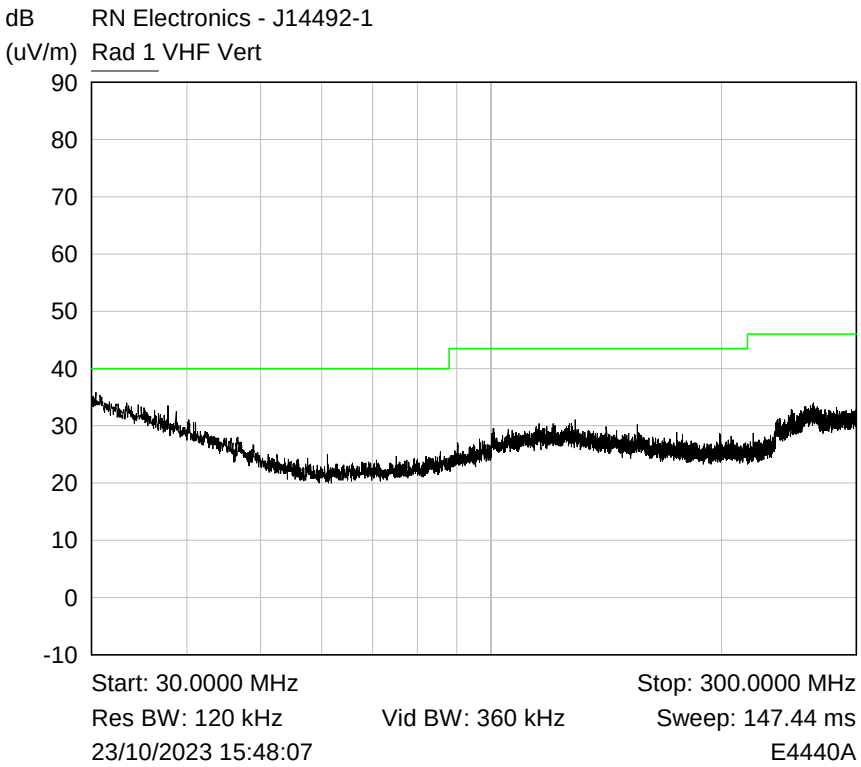
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

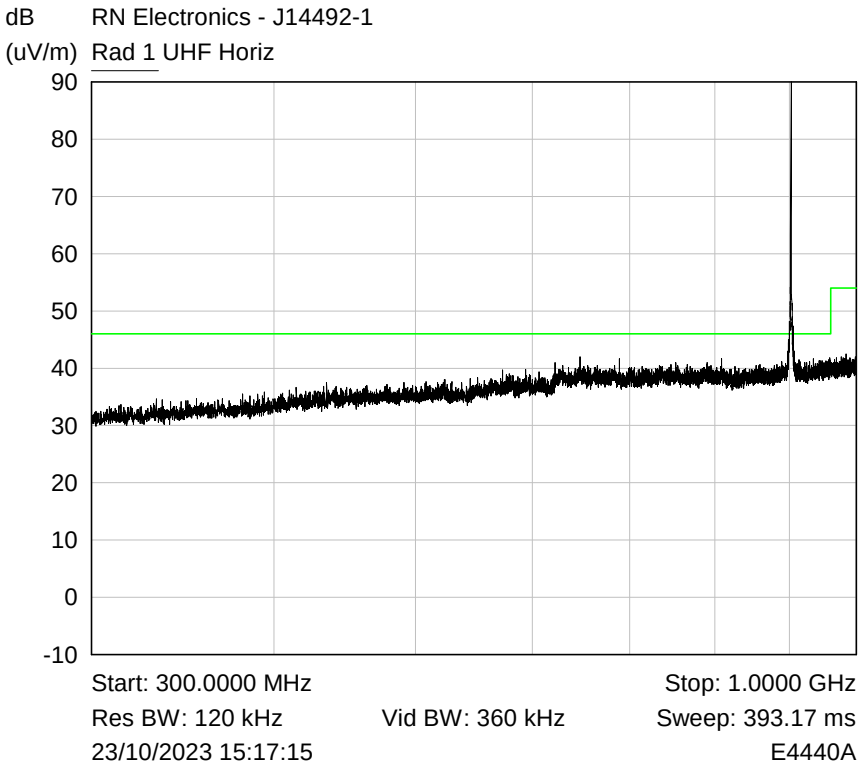
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz



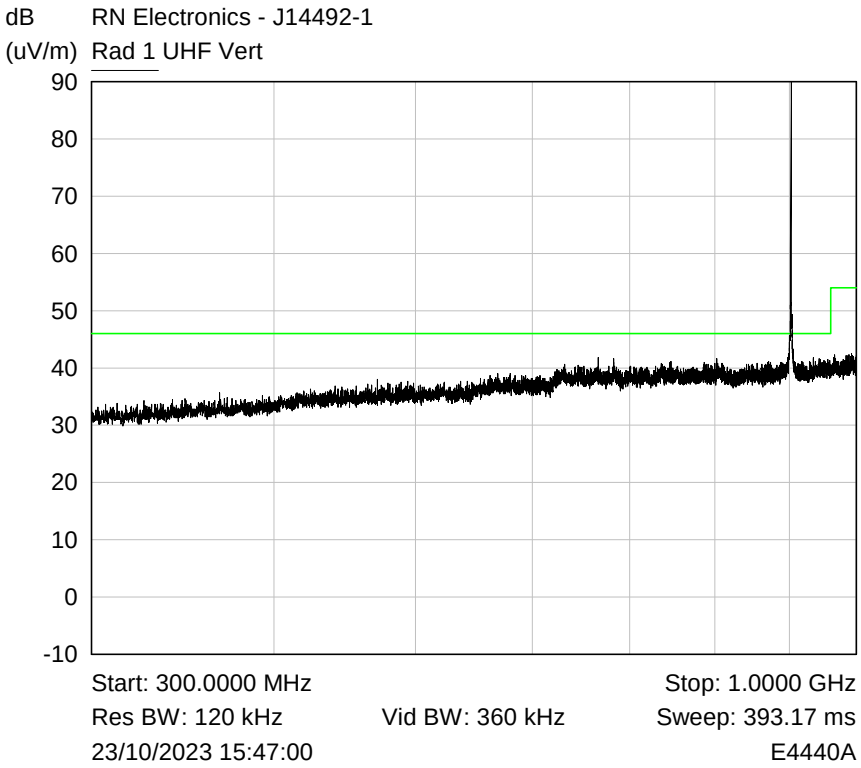
Plot of Peak emissions for VHF Horizontal against the QP limit line.



Plot of Peak emissions for VHF Vertical against the QP limit line.

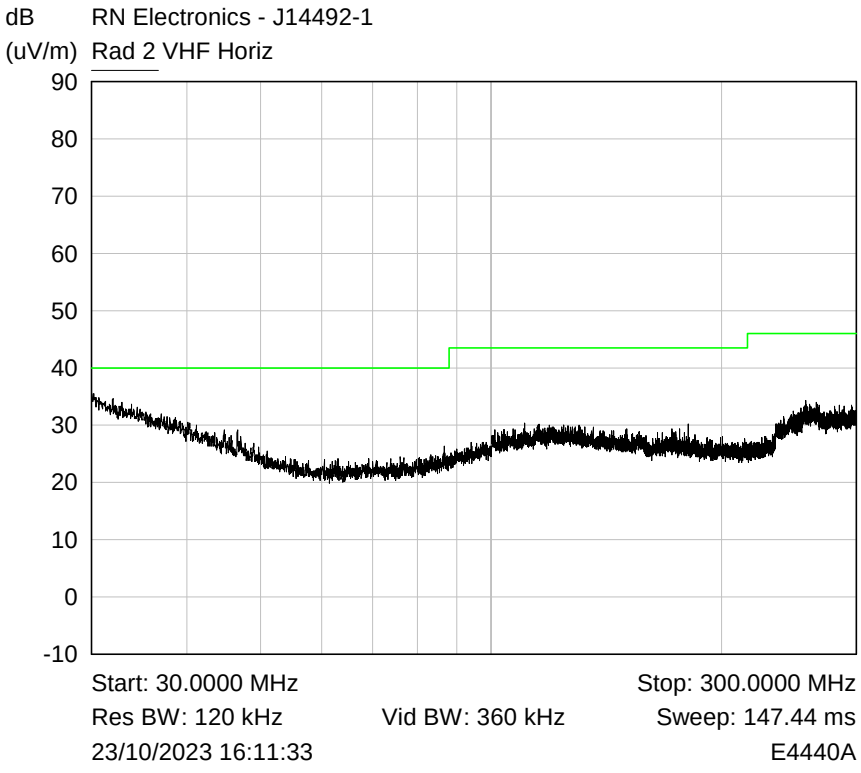


Plot of Peak emissions for UHF Horizontal against the QP limit line.
NOTE: The signal that exceeds the limit is the intentional transmission

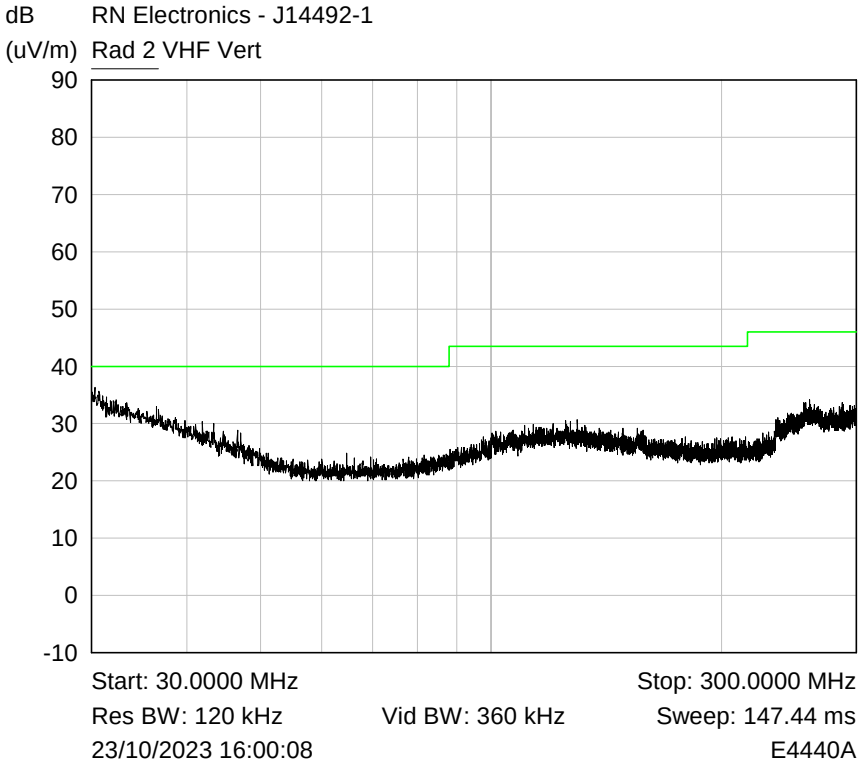


Plot of Peak emissions for UHF Vertical against the QP limit line.
NOTE: The signal that exceeds the limit is the intentional transmission

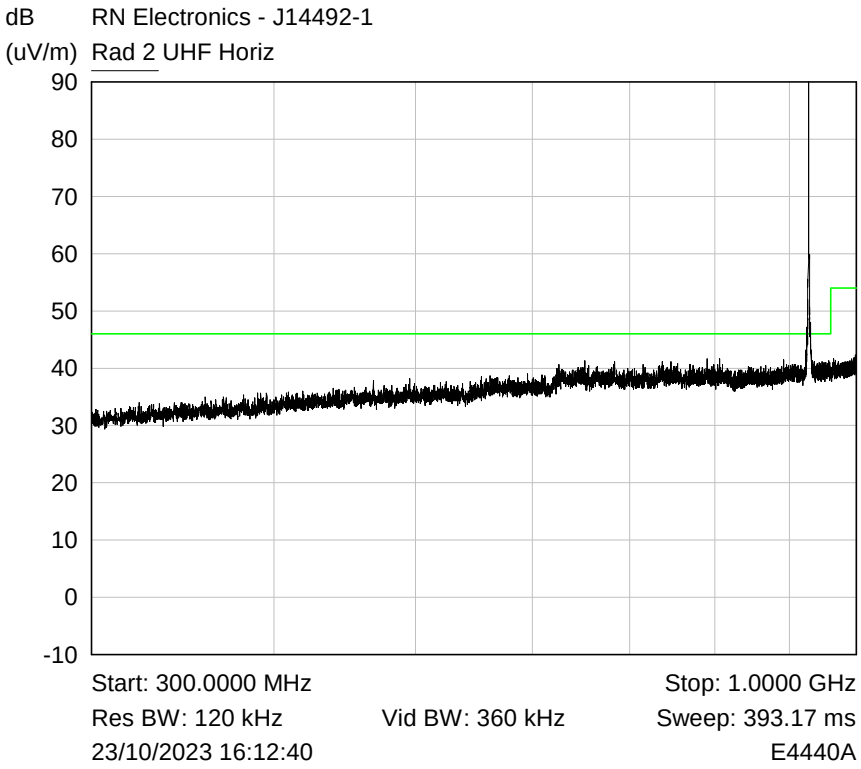
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903 MHz



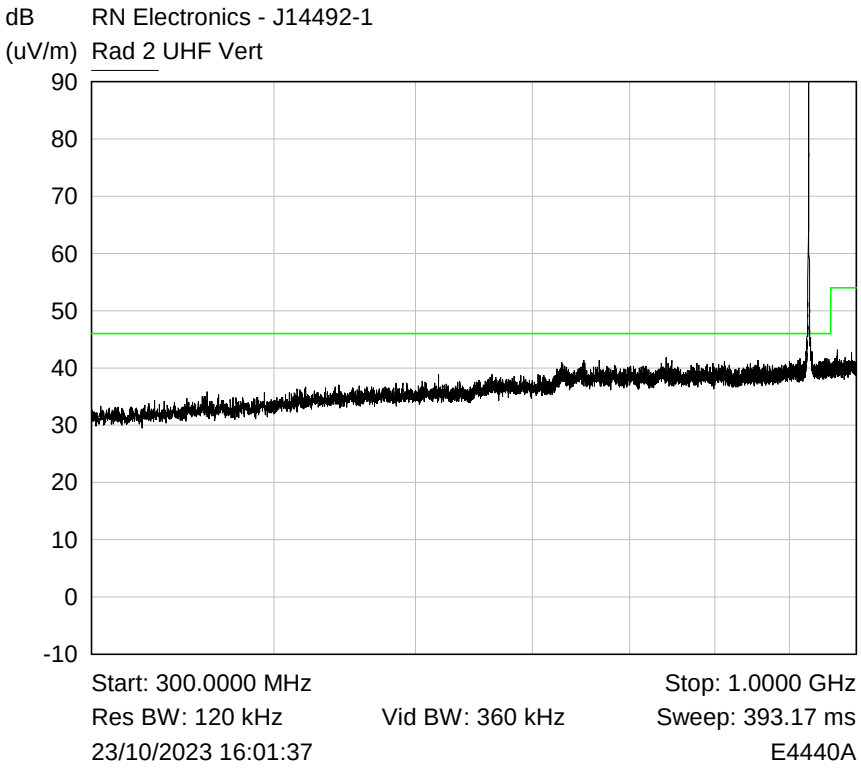
Plot of Peak emissions for VHF Horizontal against the QP limit line.



Plot of Peak emissions for VHF Vertical against the QP limit line.



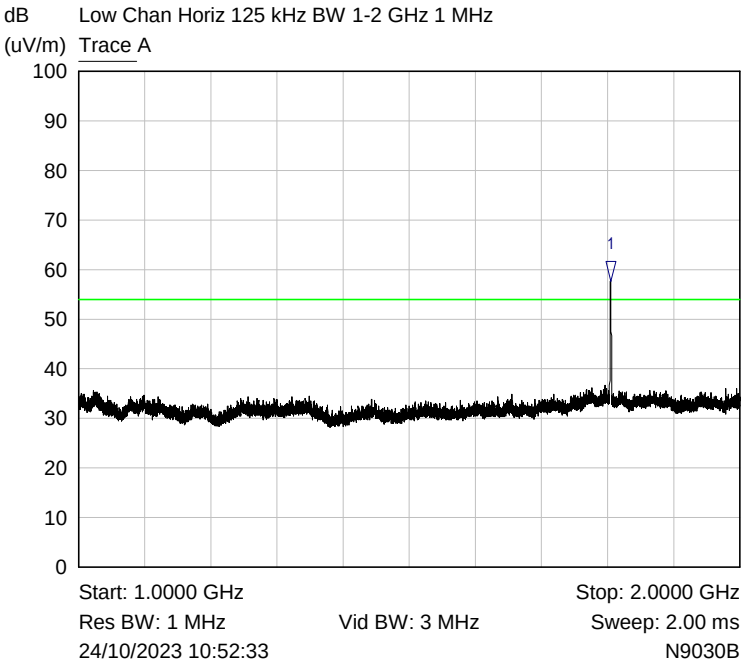
Plot of Peak emissions for UHF Horizontal against the QP limit line.
NOTE: The signal that exceeds the limit is the intentional transmission



Plot of Peak emissions for UHF Vertical against the QP limit line.
NOTE: The signal that exceeds the limit is the intentional transmission

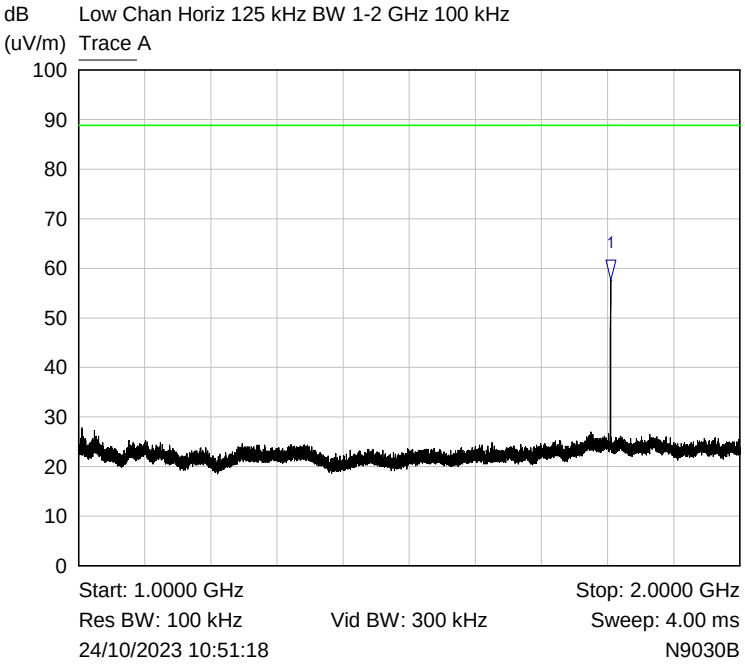
6.4 Radiated emissions above 1 GHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz



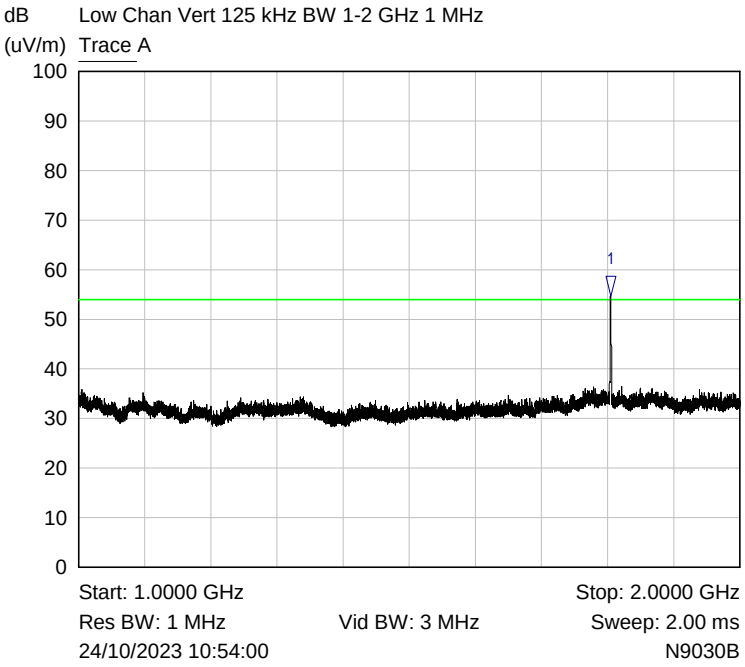
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8046 GHz	57.64 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below.



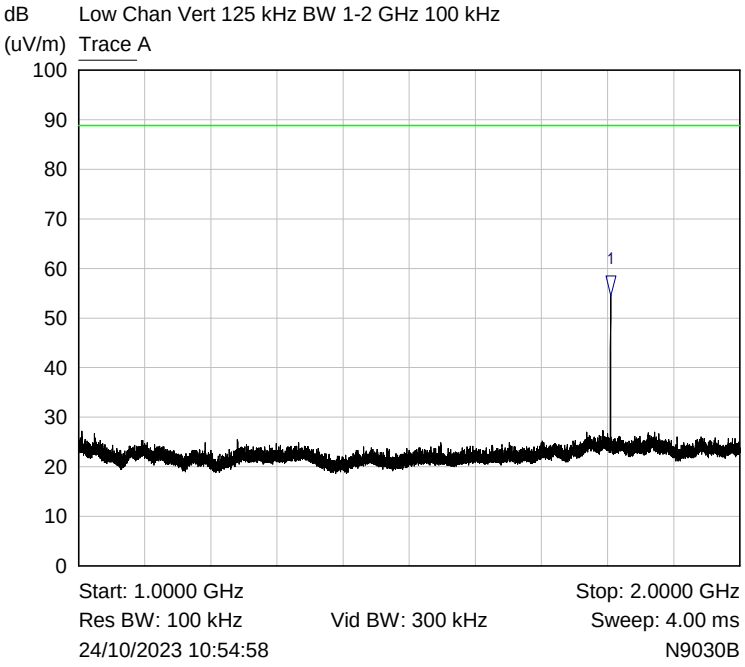
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8046 GHz	57.62 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



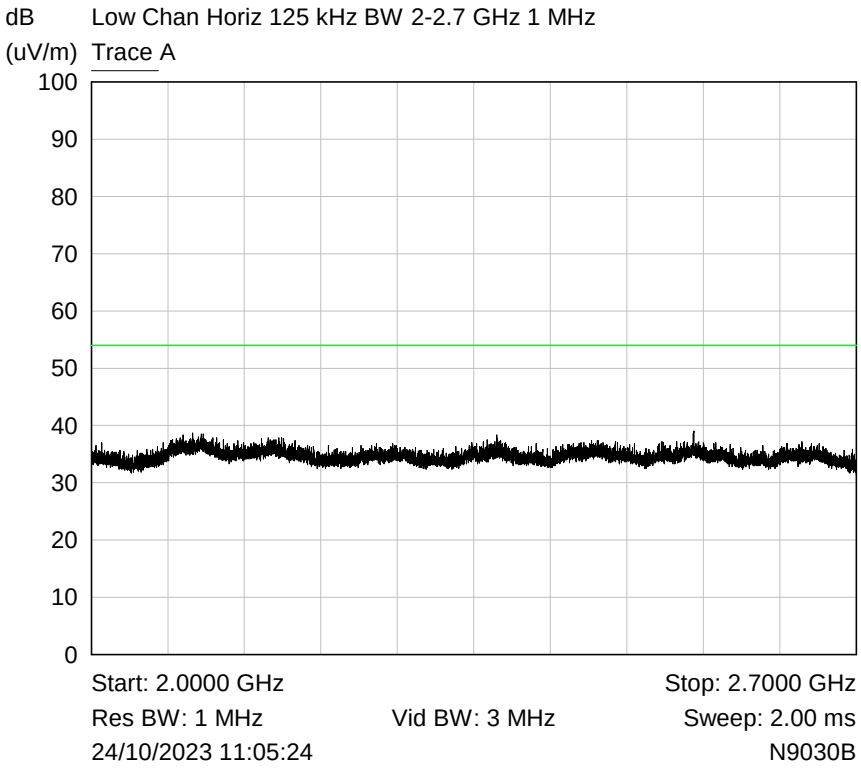
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8046 GHz	54.72 dB(uV/m)	

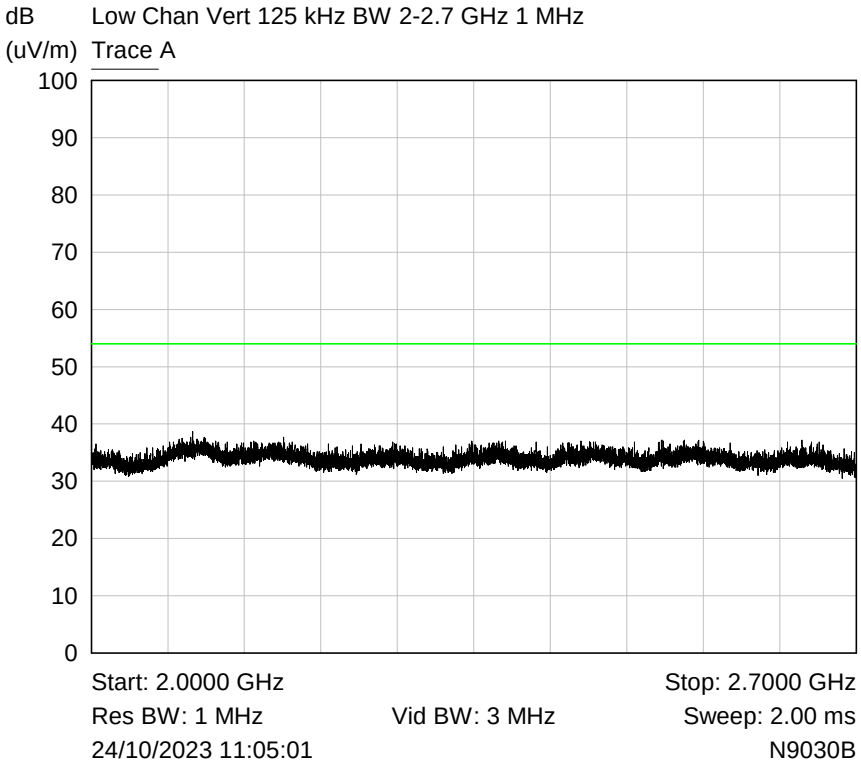
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below.

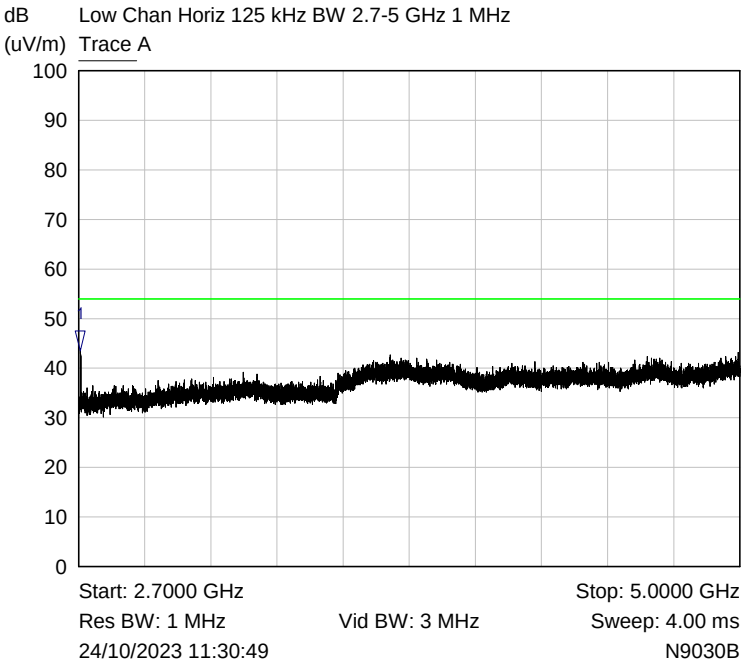


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8046 GHz	54.46 dB(uV/m)	

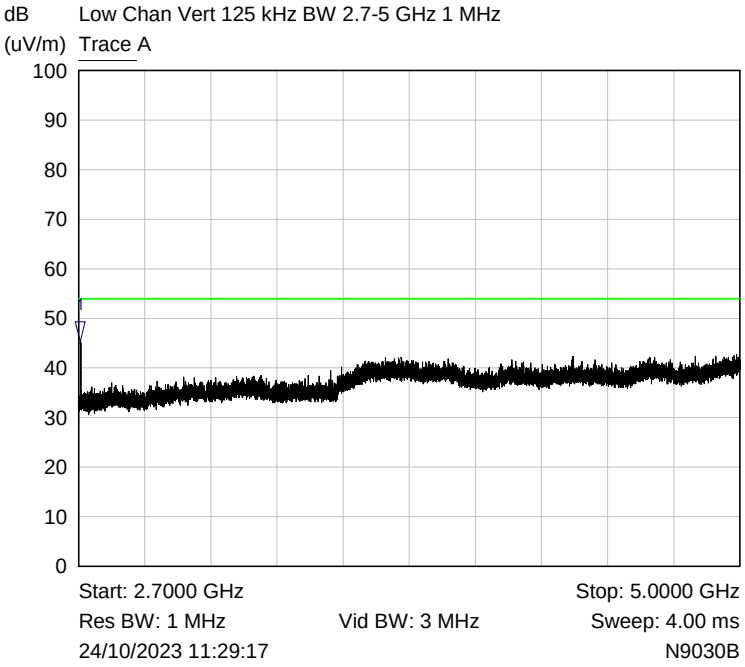
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
Low Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:05:24
N9030B

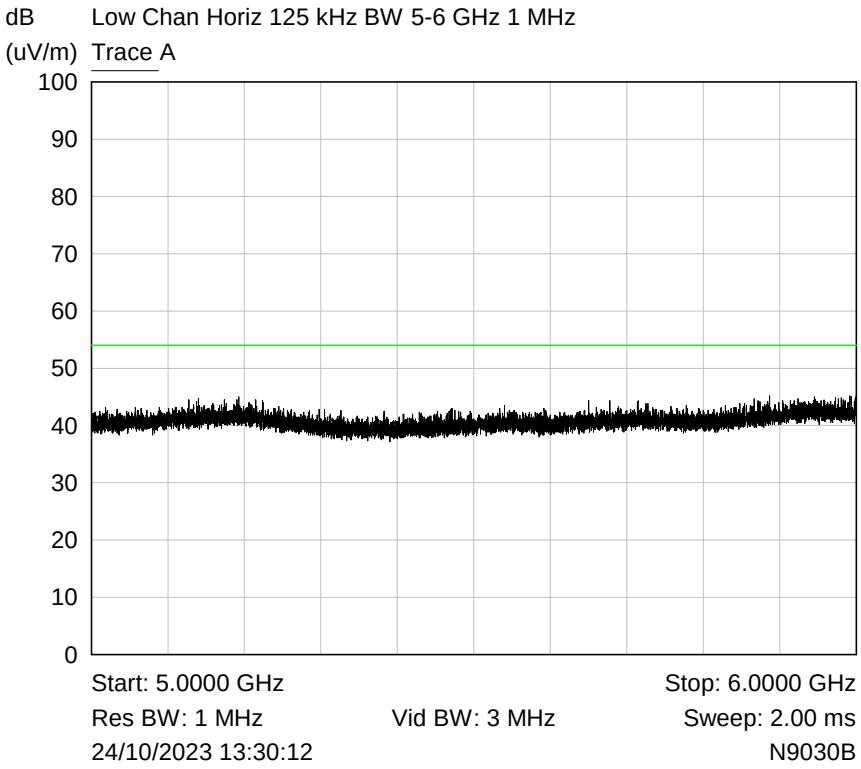

dB
(uV/m)
Low Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:05:01
N9030B

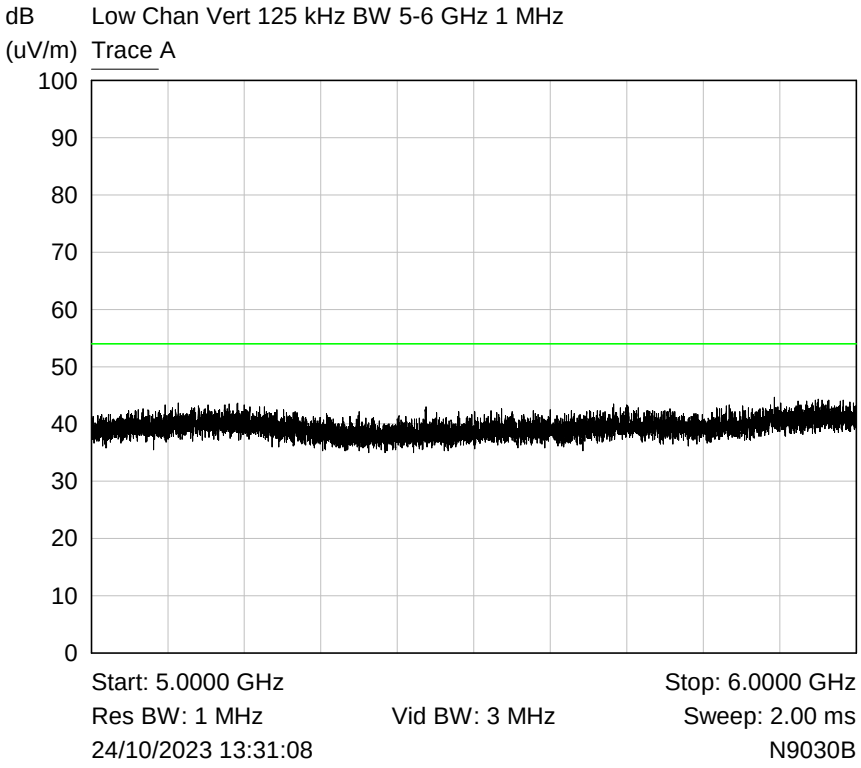


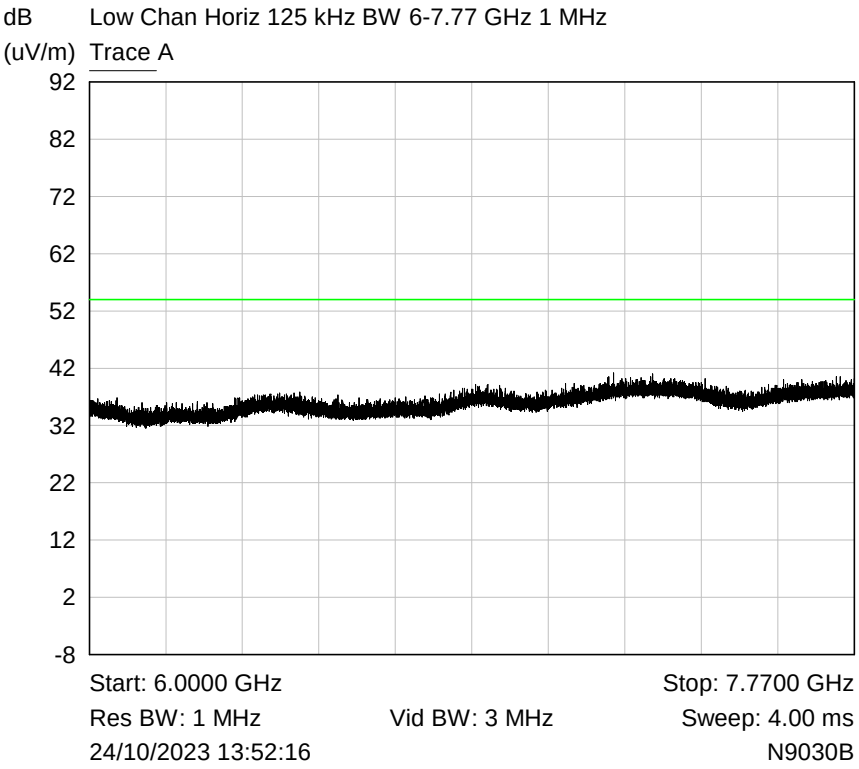
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7071 GHz	43.54 dB(uV/m)	

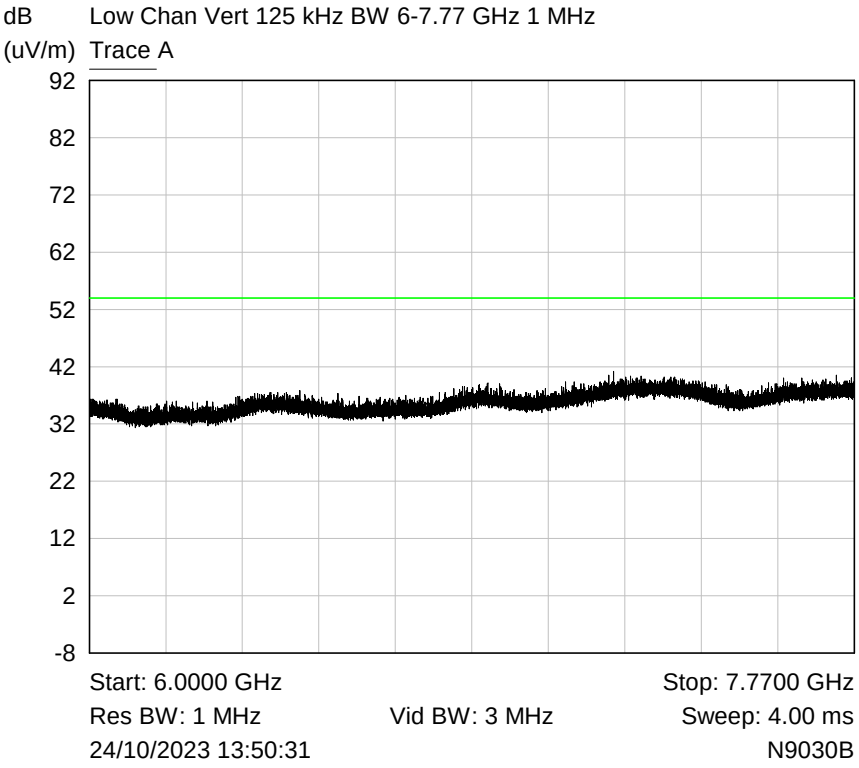


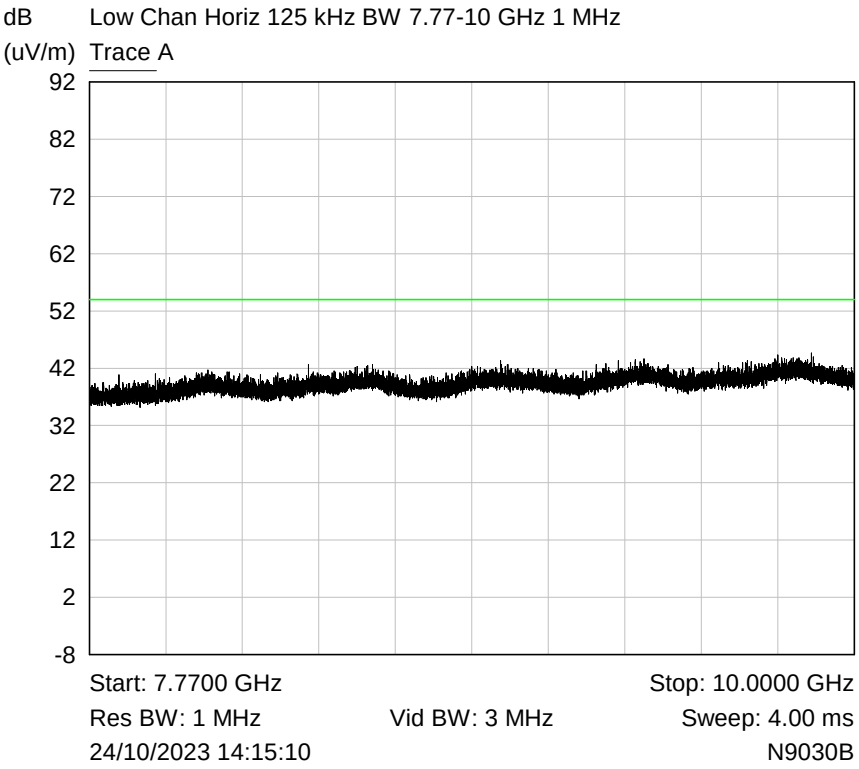
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7071 GHz	45.40 dB(uV/m)	

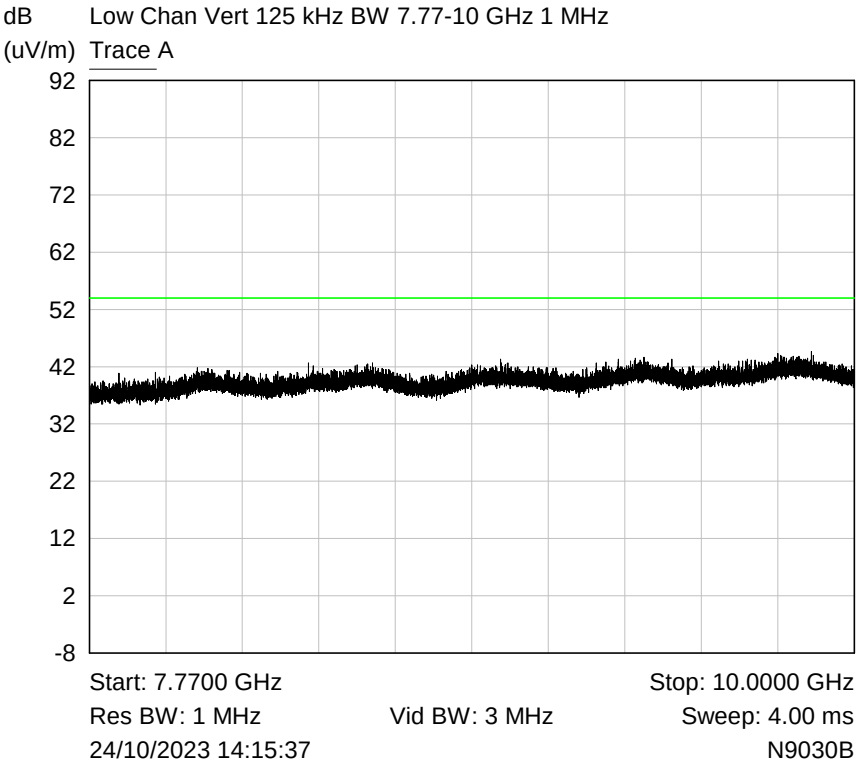

dB
(uV/m)
Low Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:30:12
N9030B


dB
(uV/m)
Low Chan Vert 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:31:08
N9030B

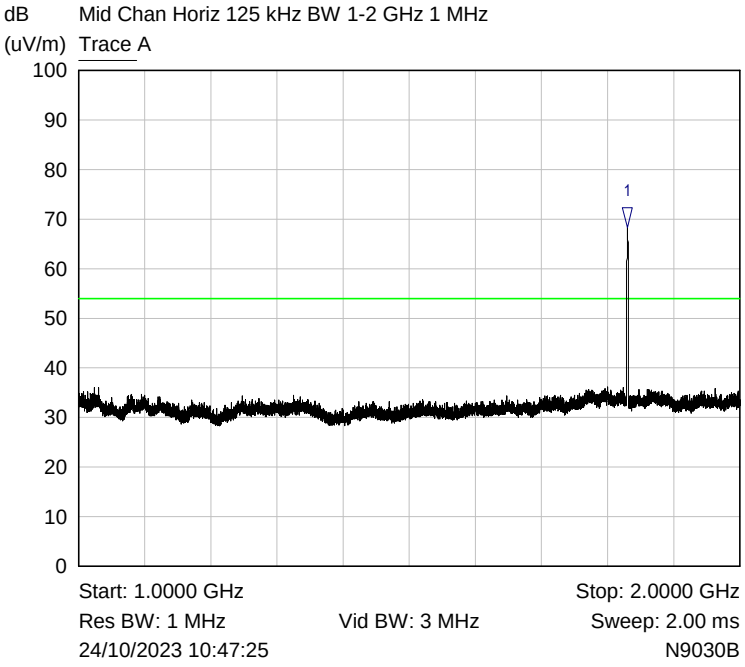





dB
(uV/m)
Low Chan Horiz 125 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:15:10
N9030B

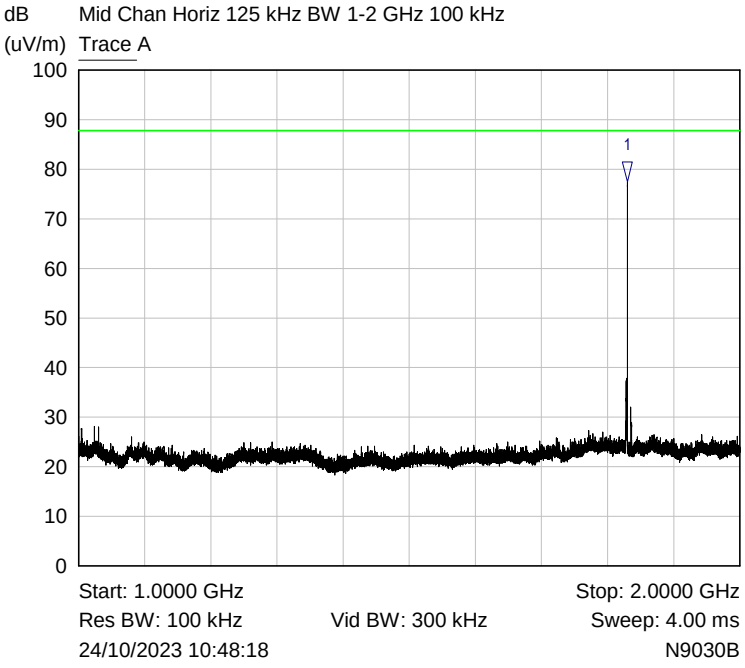

dB
(uV/m)
Low Chan Vert 125 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:15:37
N9030B

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 915.1 MHz



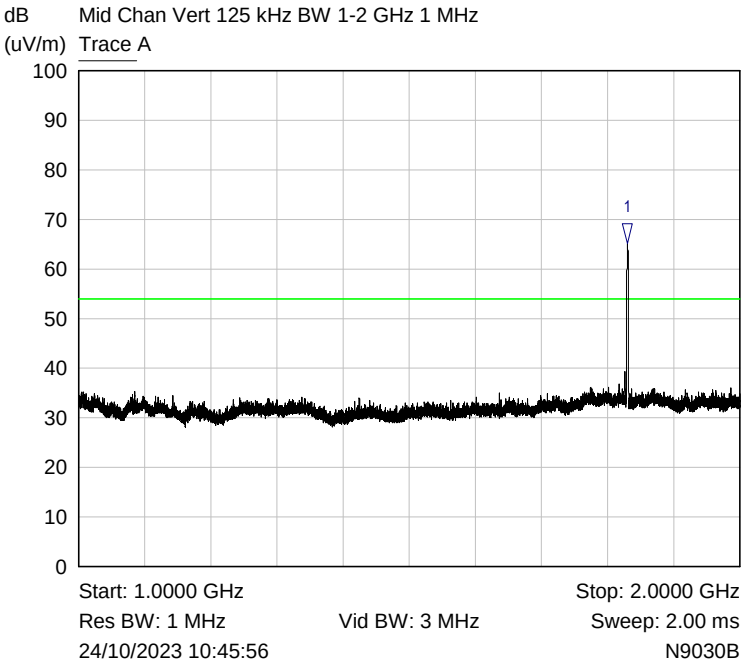
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8303 GHz	68.27 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below



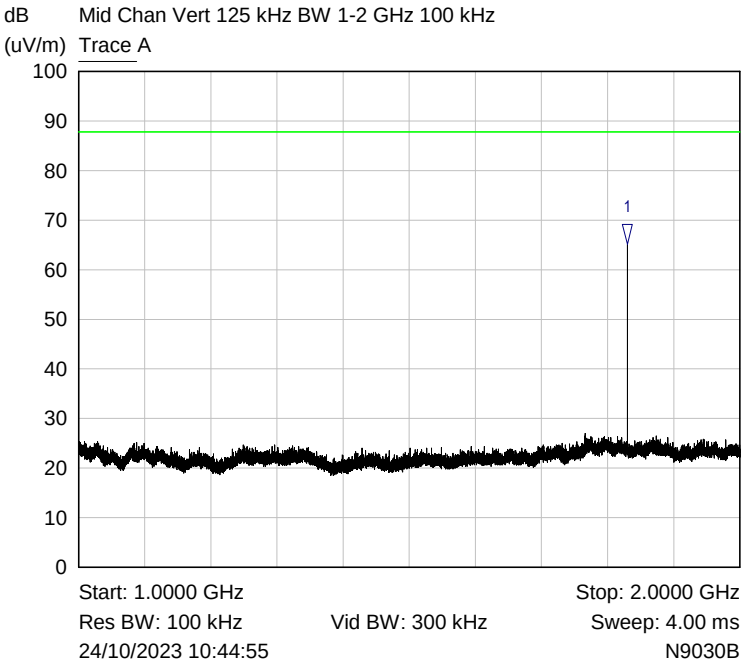
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8301 GHz	77.53 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



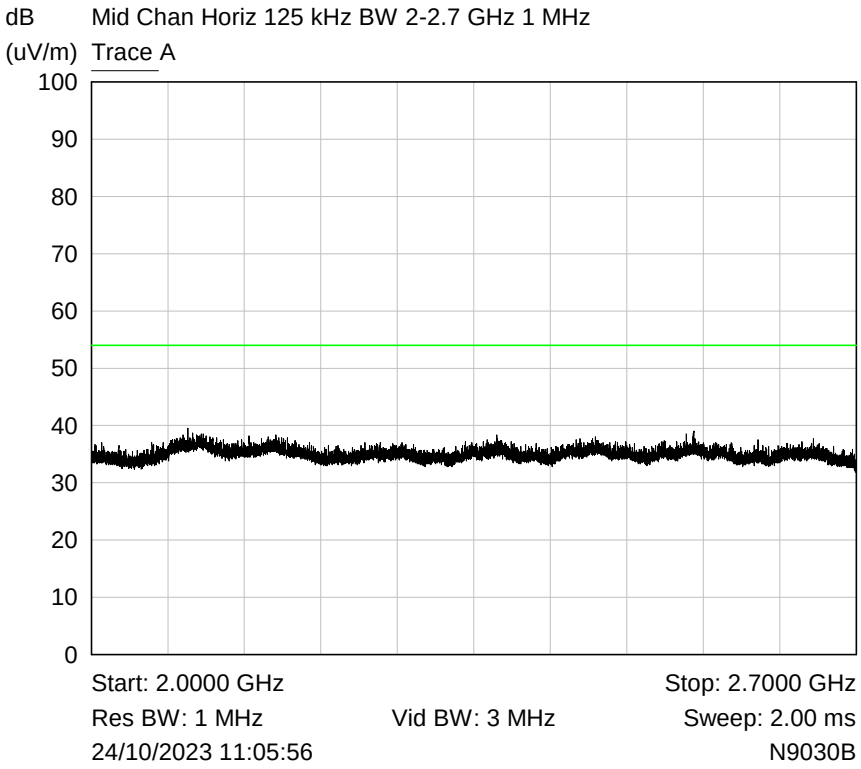
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8303 GHz	65.10 dB(uV/m)	

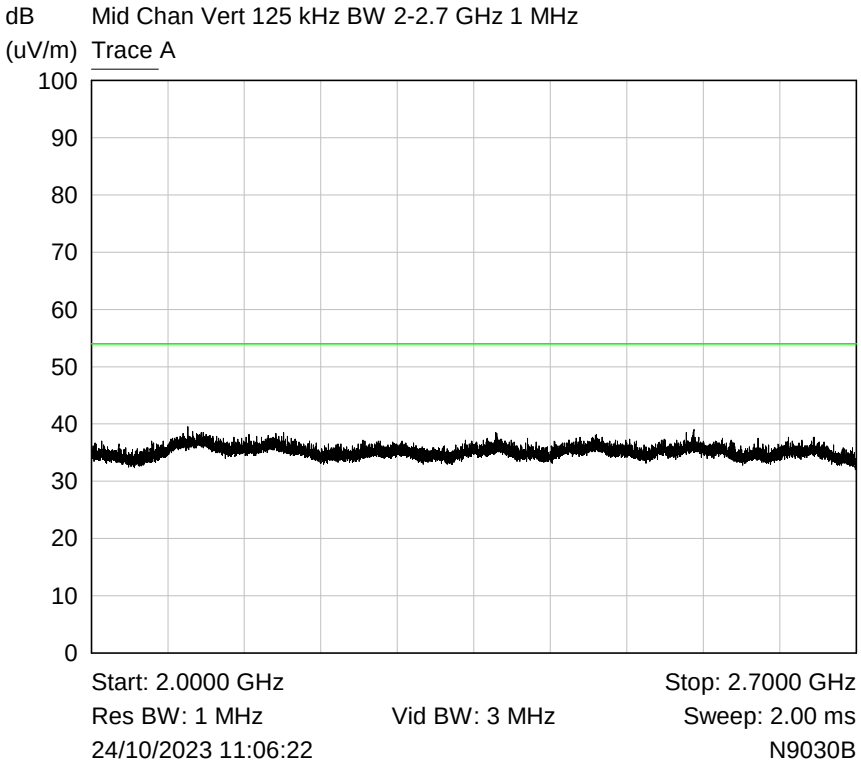
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below

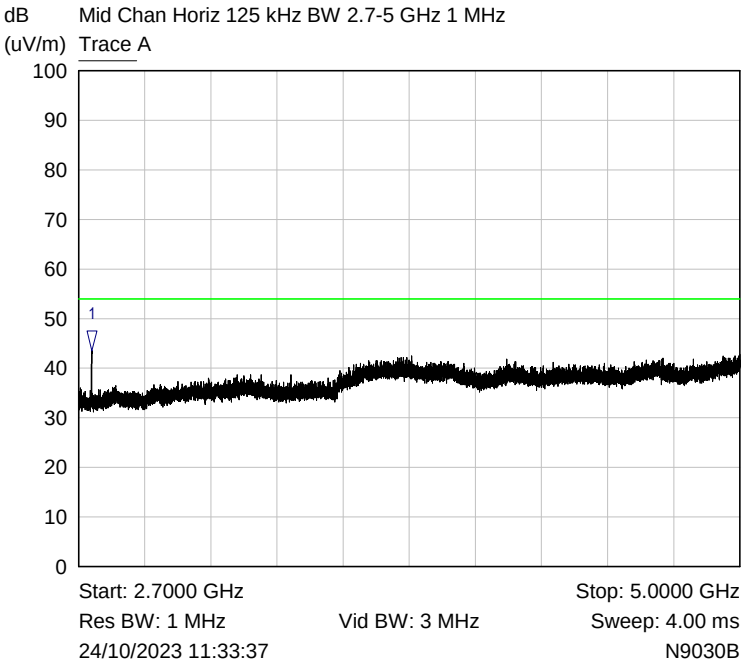


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8303 GHz	65.11 dB(uV/m)	

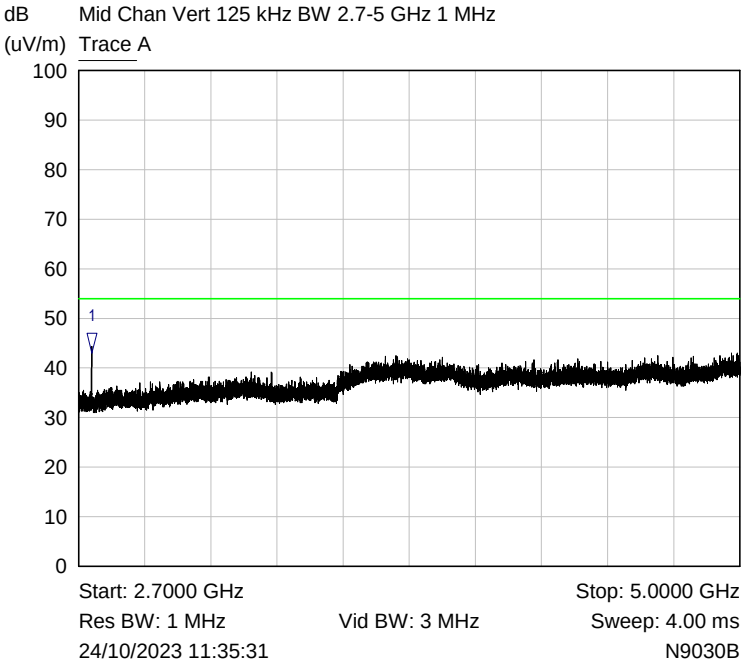
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
Mid Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:05:56
N9030B

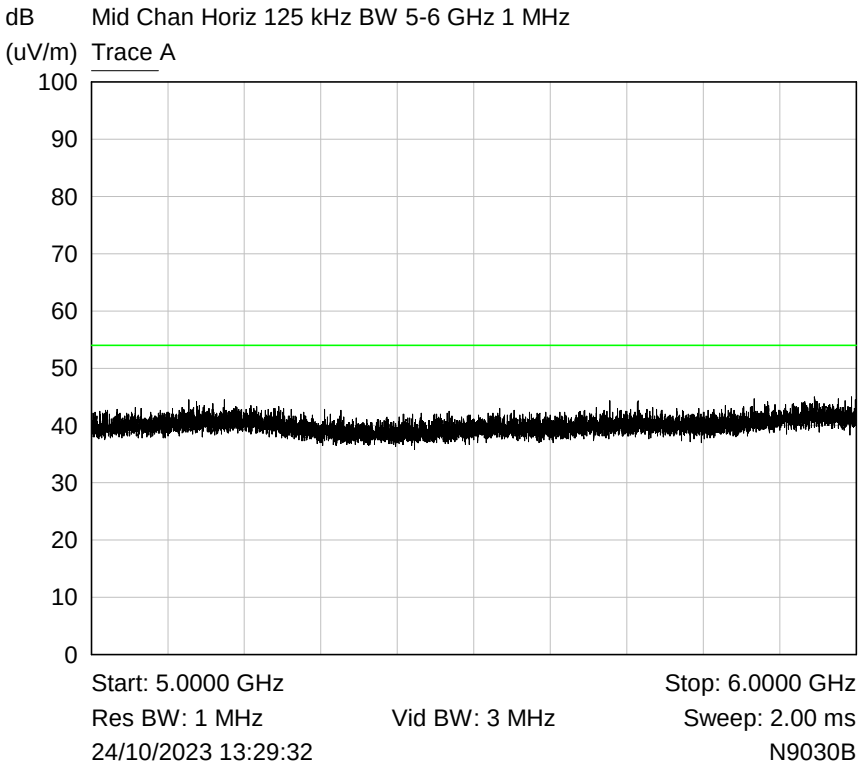

dB
(uV/m)
Mid Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:06:22
N9030B

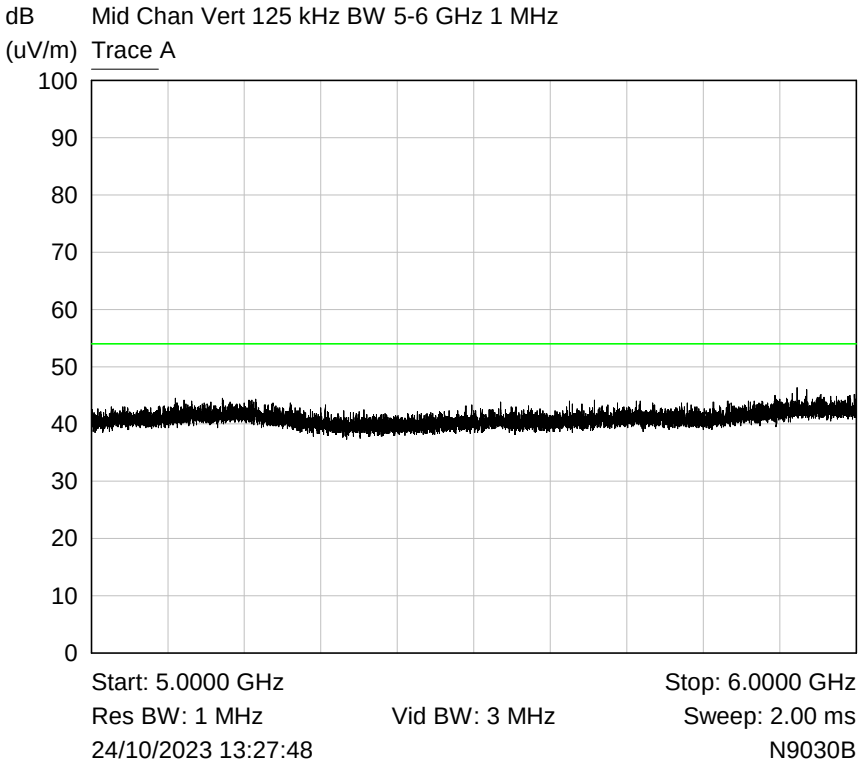


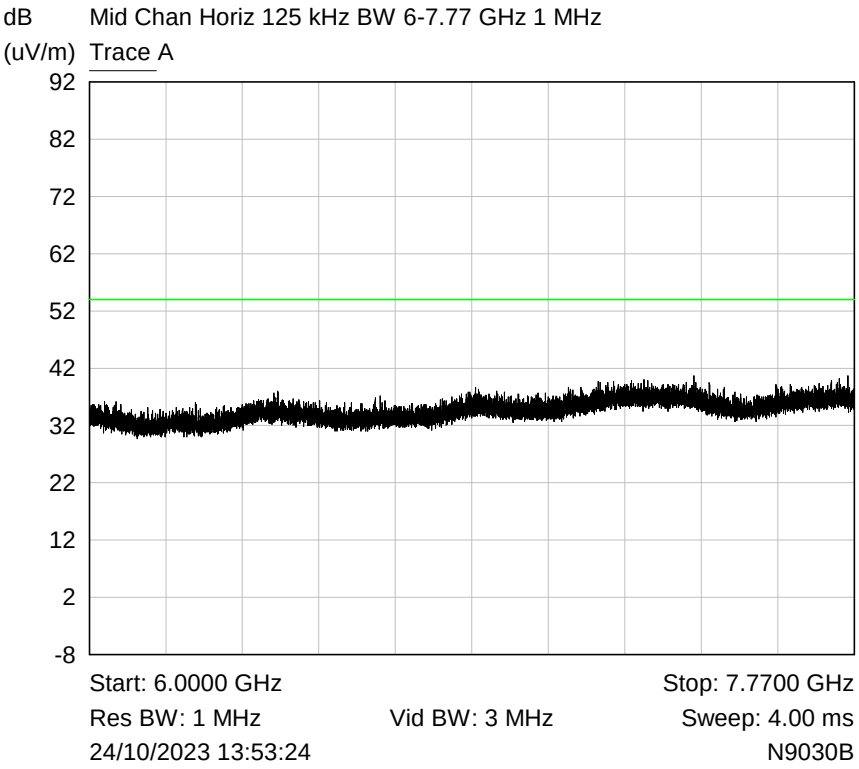
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7456 GHz	43.50 dB(uV/m)	

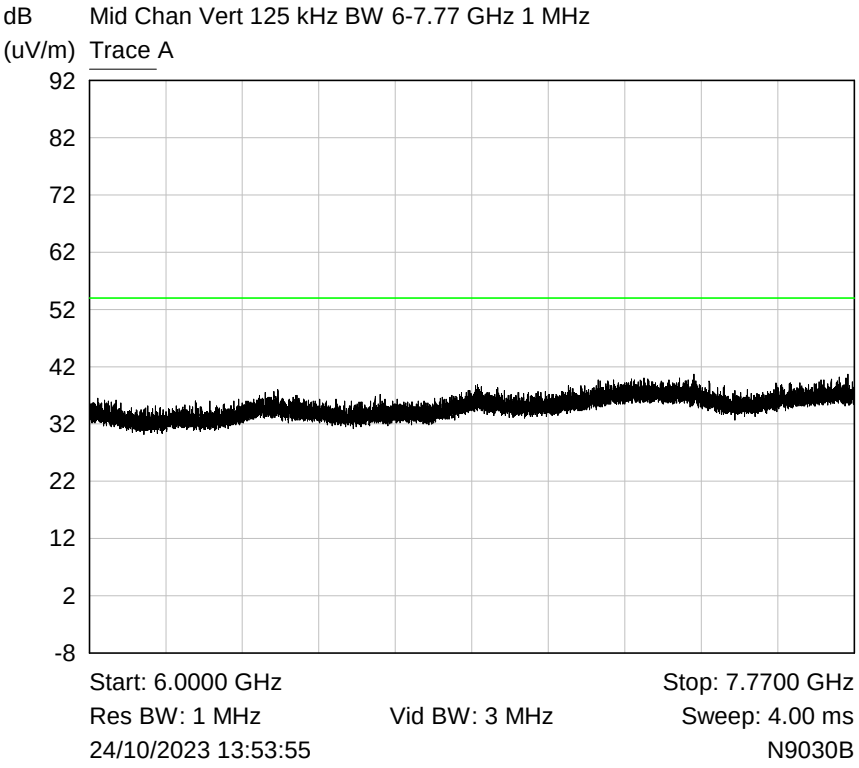


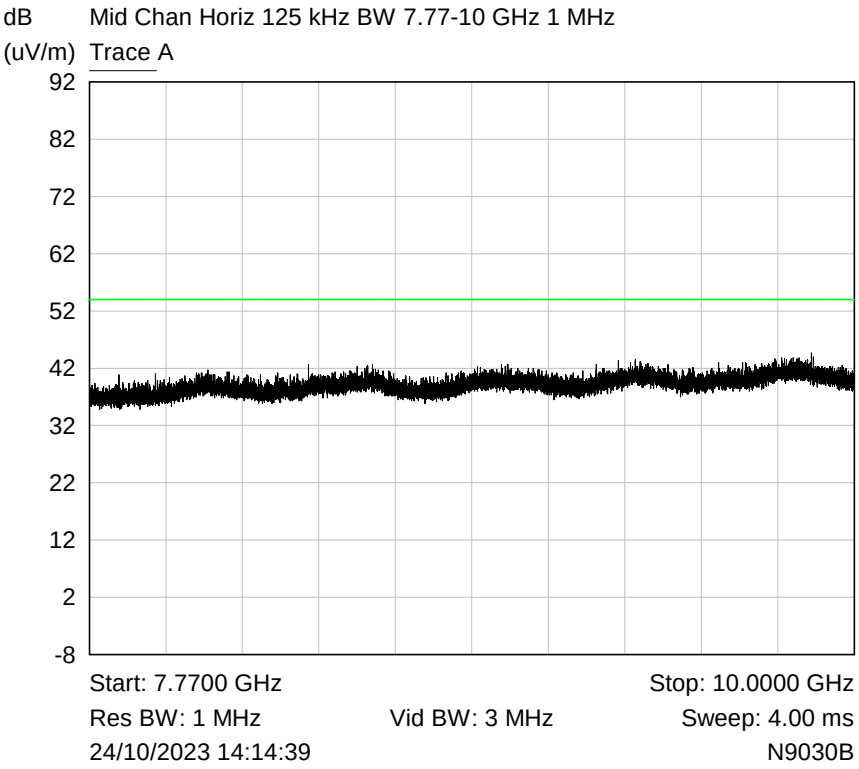
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7456 GHz	42.95 dB(uV/m)	

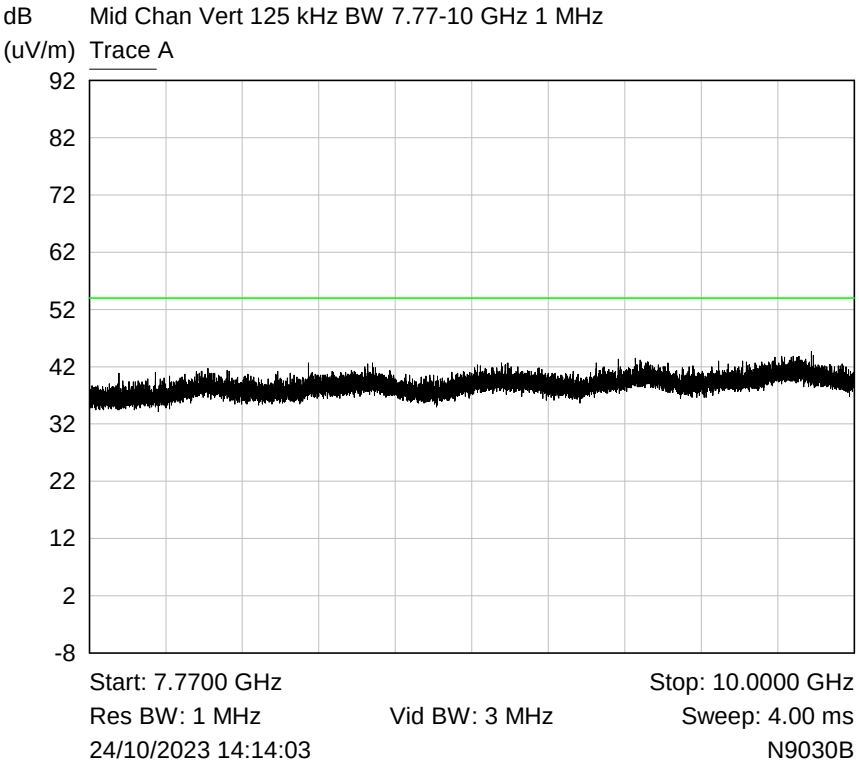

dB
(uV/m)
Mid Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:29:32
N9030B


dB
(uV/m)
Mid Chan Vert 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:27:48
N9030B

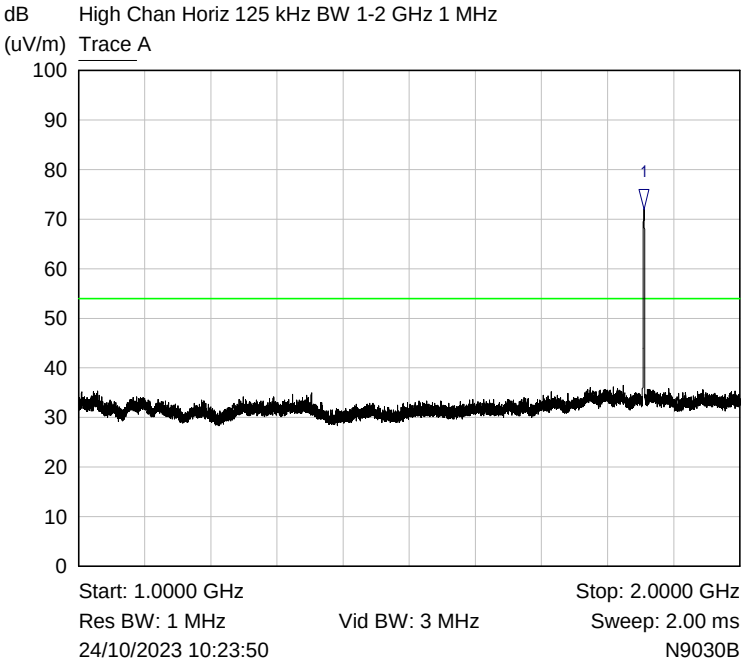

dB
(uV/m)
Mid Chan Horiz 125 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:53:24
N9030B


dB
(uV/m)
Mid Chan Vert 125 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:53:55
N9030B


dB
(uV/m)
Mid Chan Horiz 125 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:14:39
N9030B

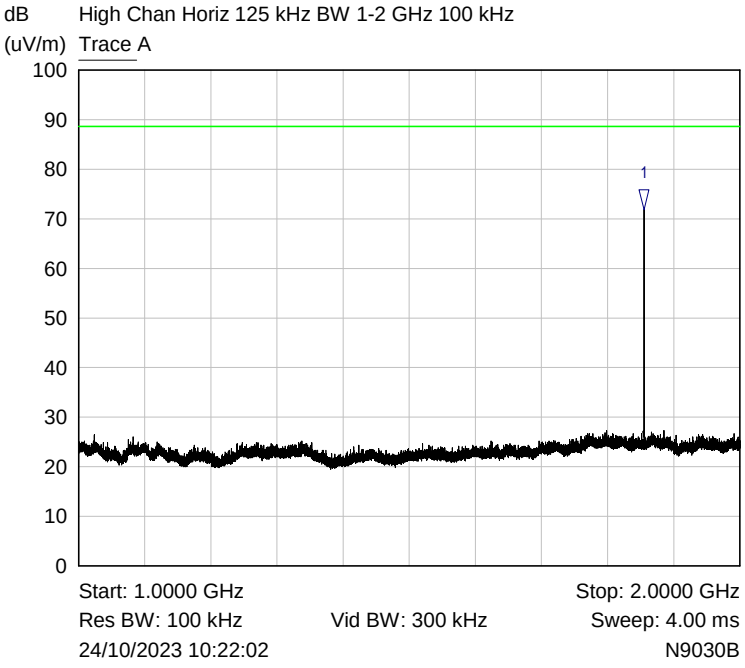

dB
(uV/m)
Mid Chan Vert 125 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:14:03
N9030B

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 927.5 MHz



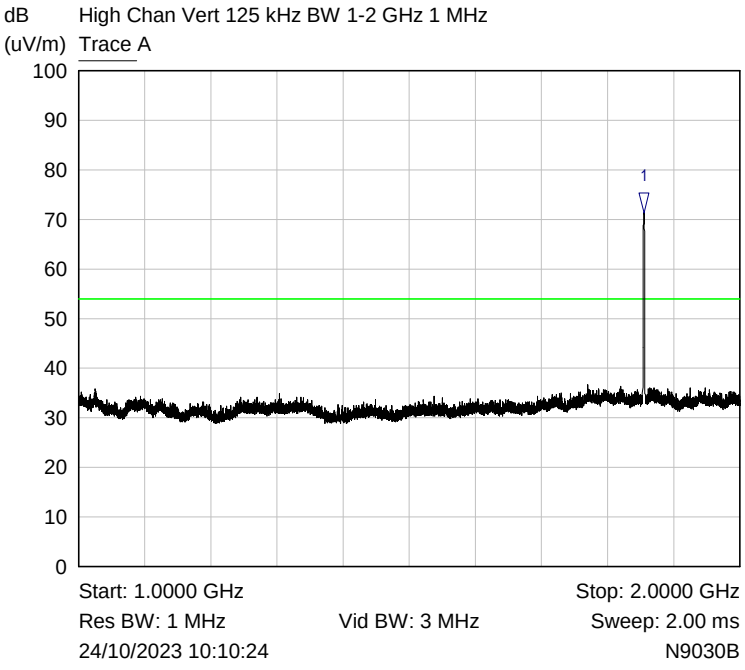
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	72.01 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below



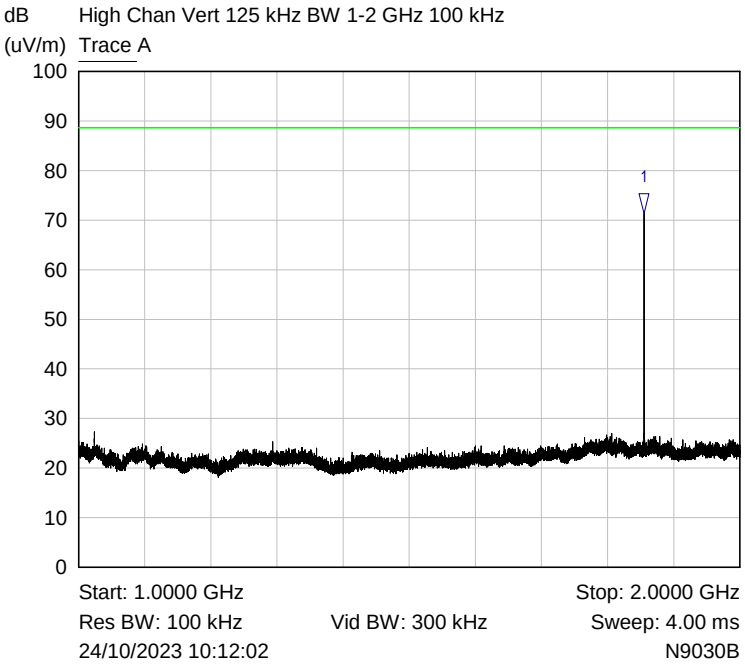
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	71.86 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



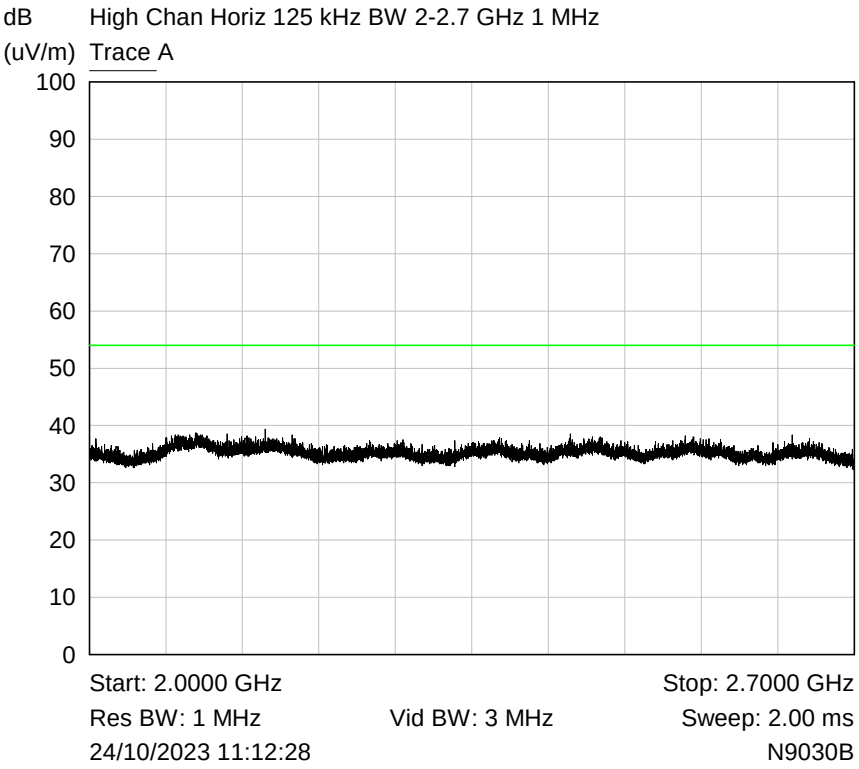
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	71.26 dB(uV/m)	

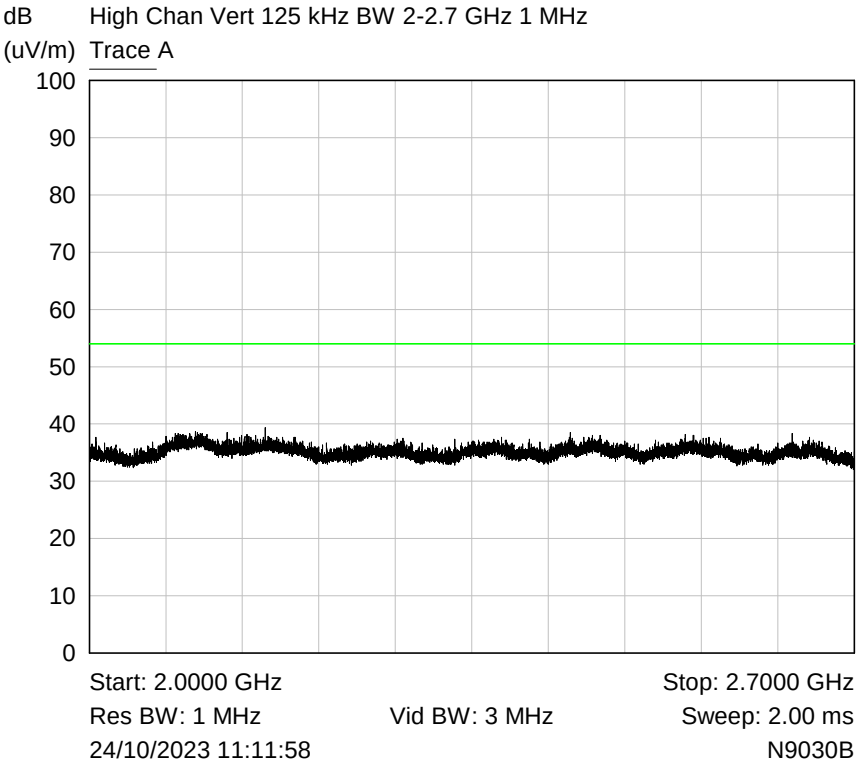
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below

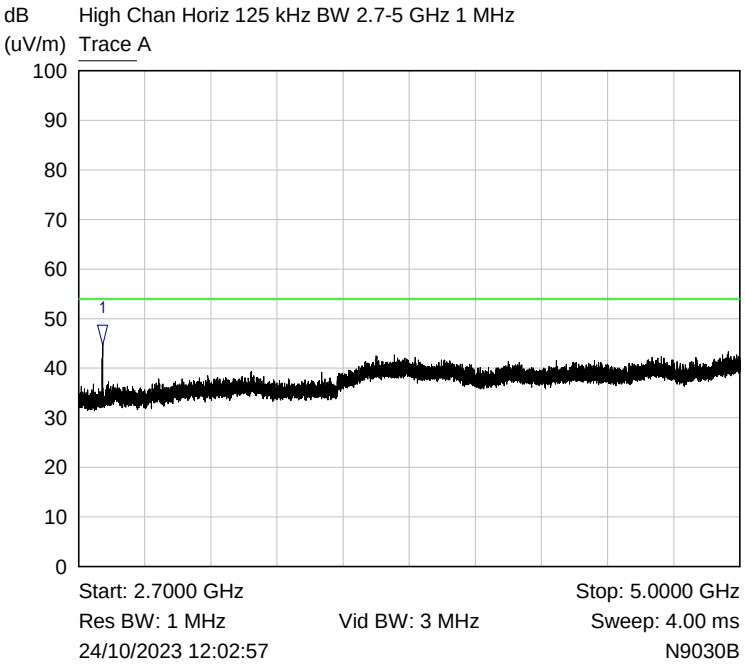


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	71.32 dB(uV/m)	

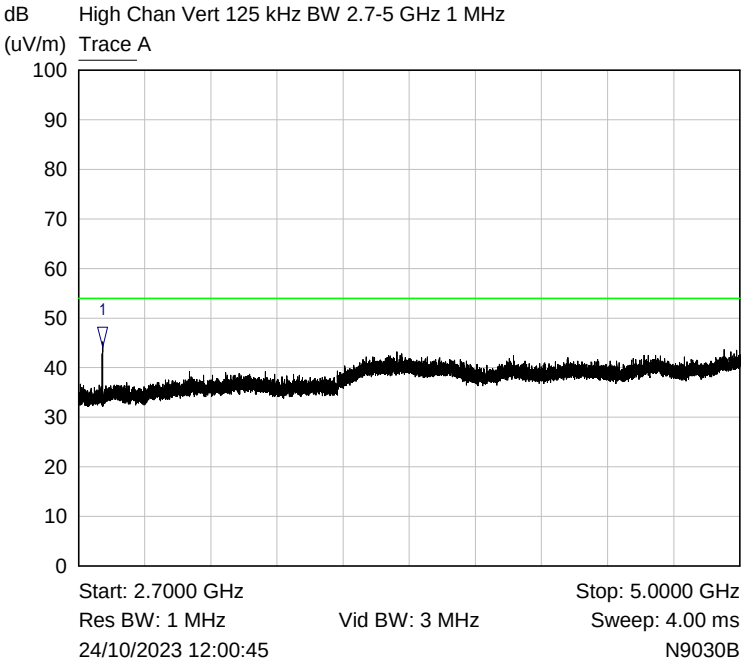
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
High Chan Horiz 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:12:28
N9030B

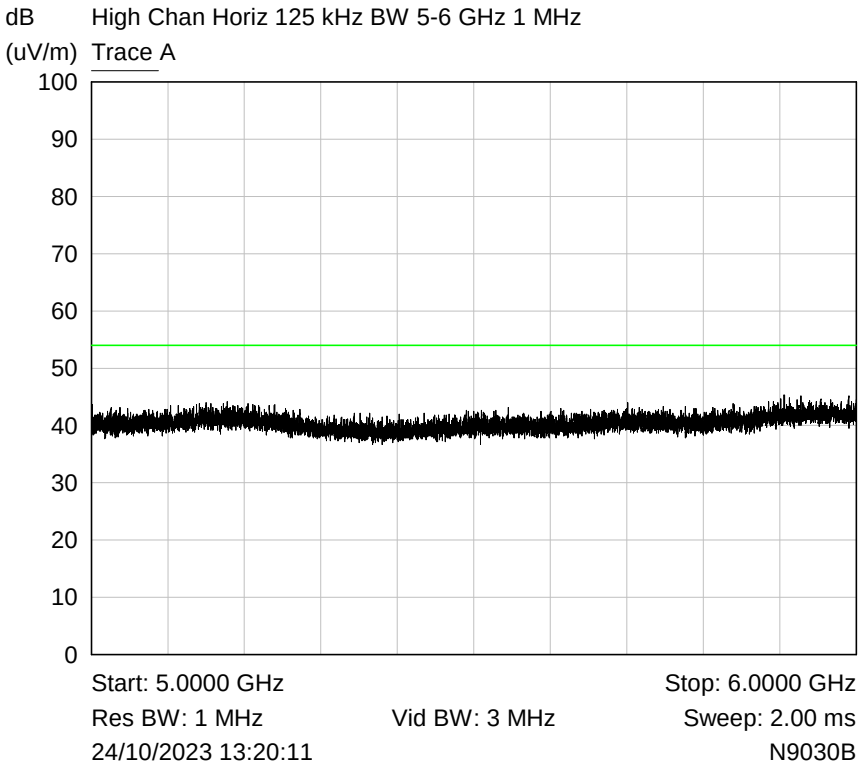

dB
(uV/m)
High Chan Vert 125 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:11:58
N9030B

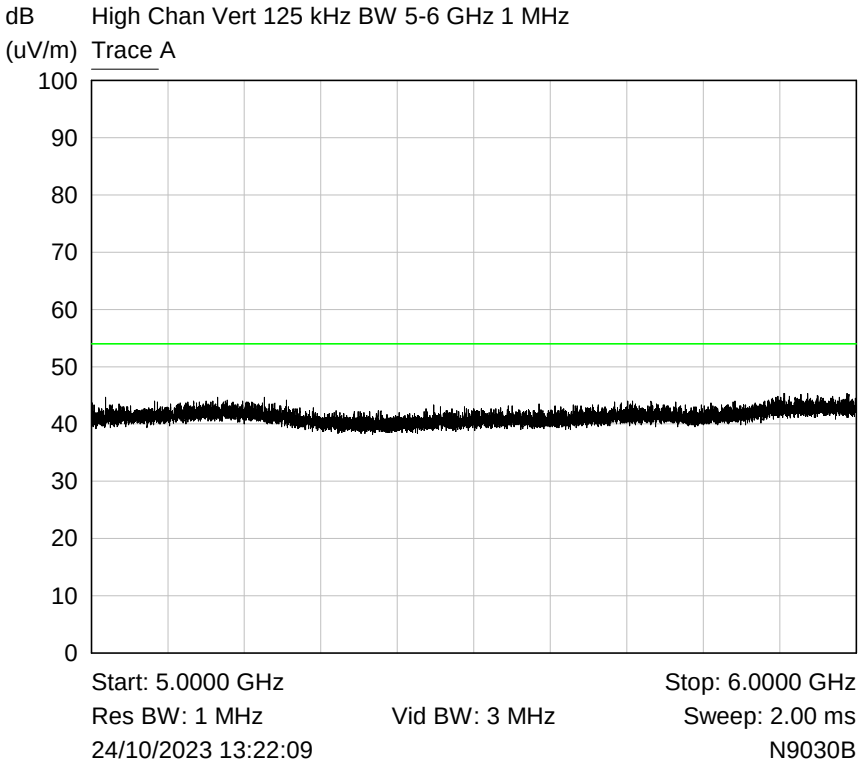


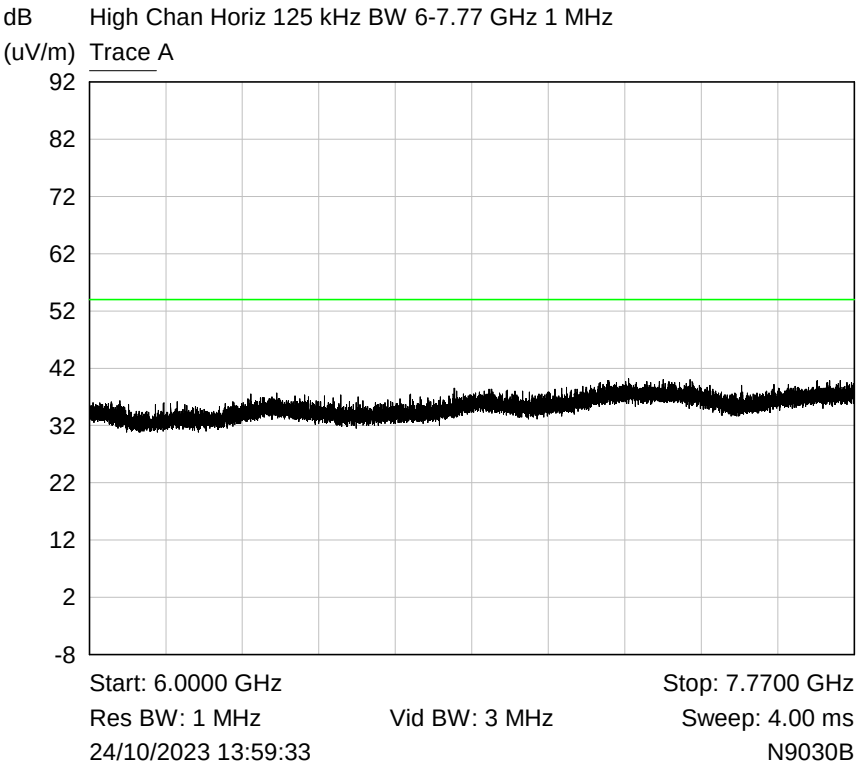
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7827 GHz	44.63 dB(uV/m)	

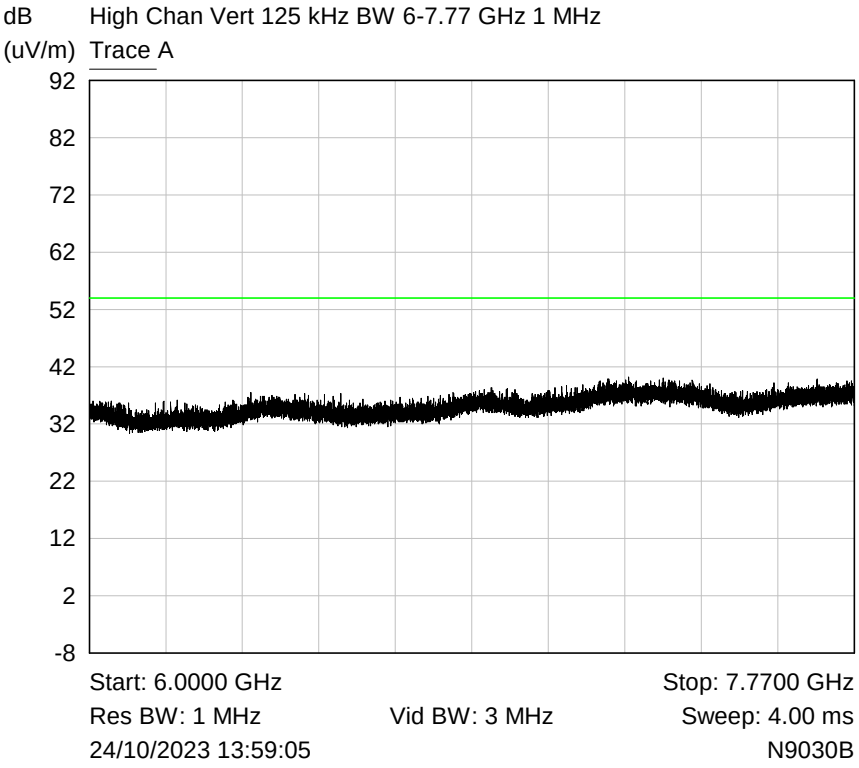


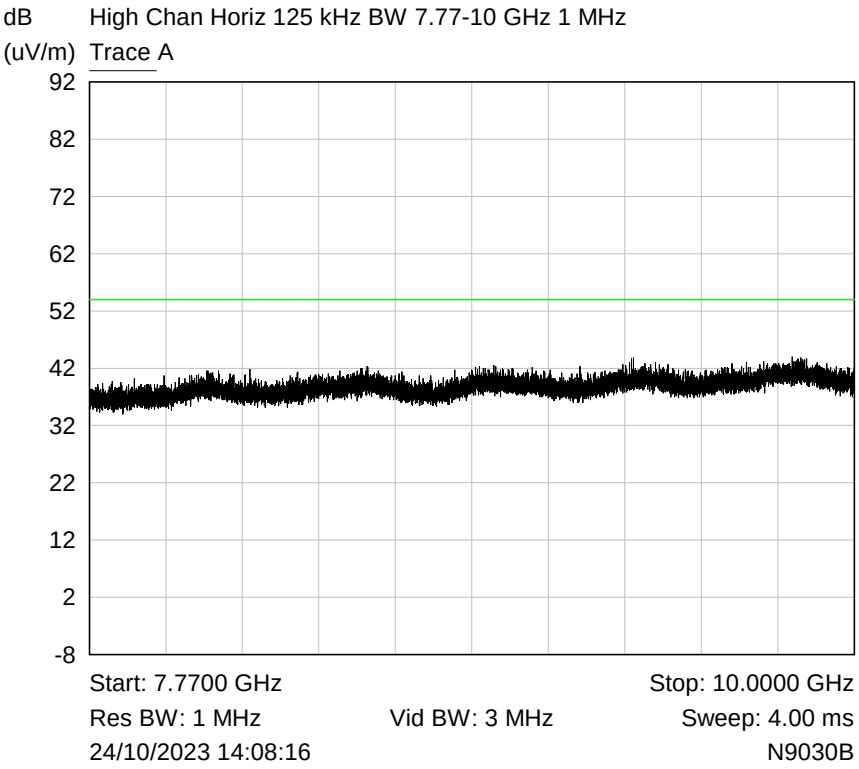
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7827 GHz	44.25 dB(uV/m)	

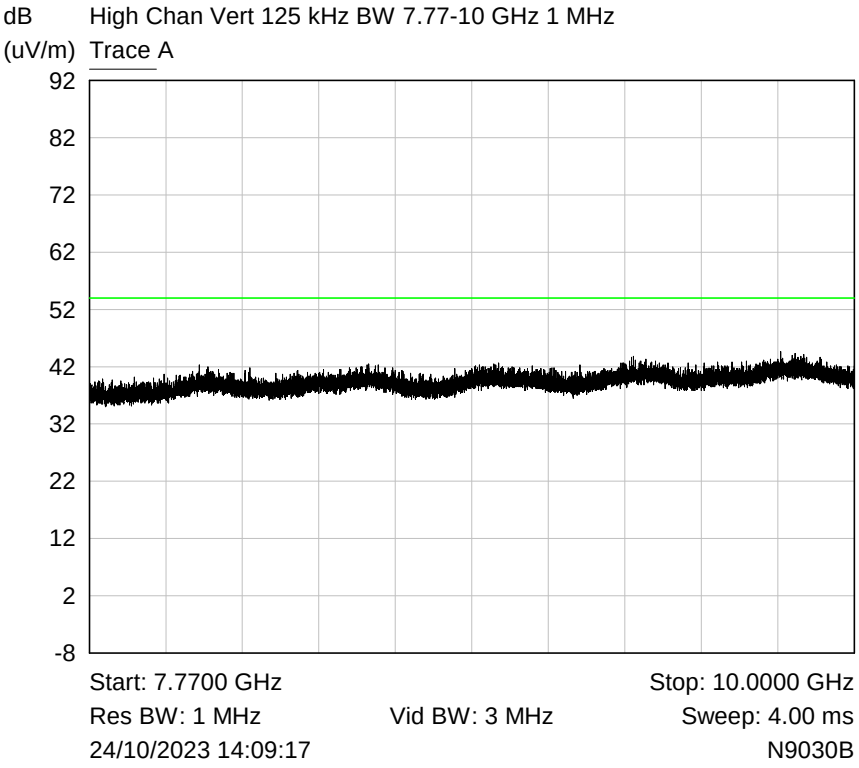

dB
(uV/m)
High Chan Horiz 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:20:11
N9030B


dB
(uV/m)
High Chan Vert 125 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:22:09
N9030B

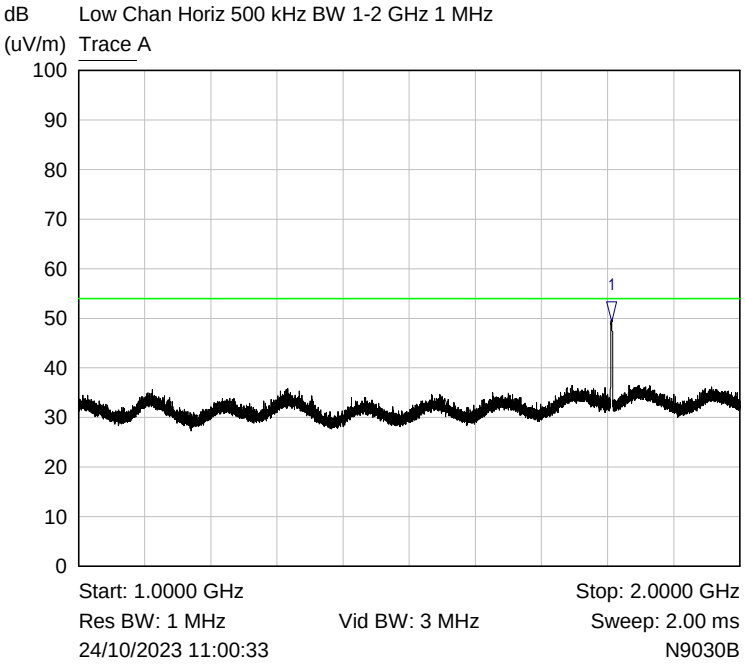

dB
(uV/m)
High Chan Horiz 125 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:59:33
N9030B


dB
(uV/m)
High Chan Vert 125 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:59:05
N9030B



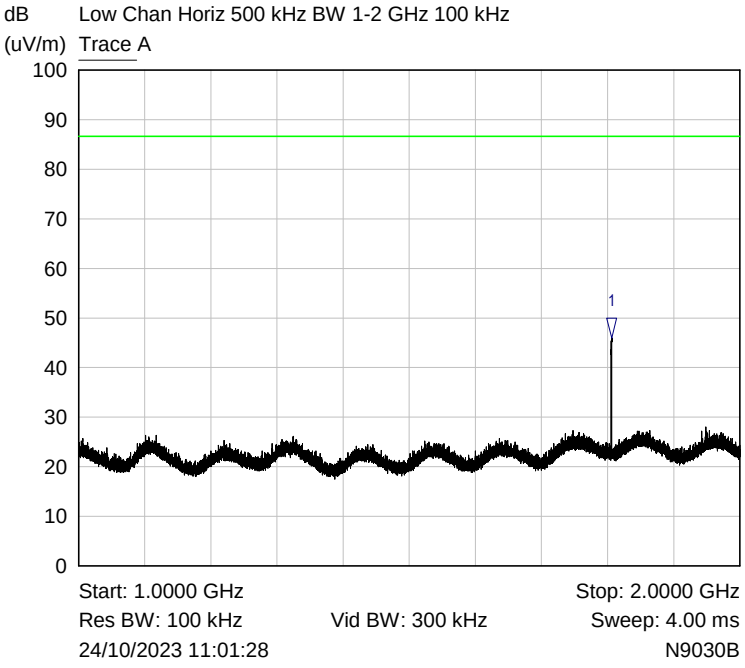


RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903 MHz



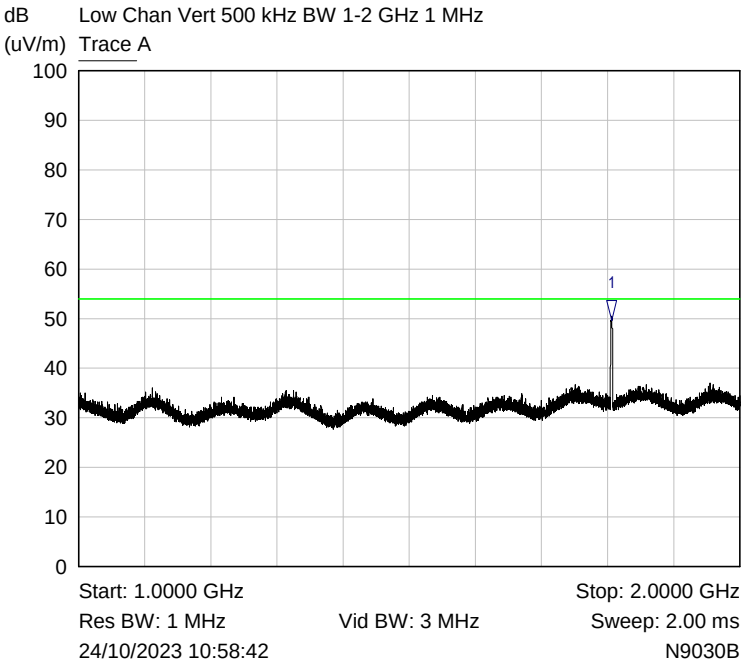
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8066 GHz	49.25 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below



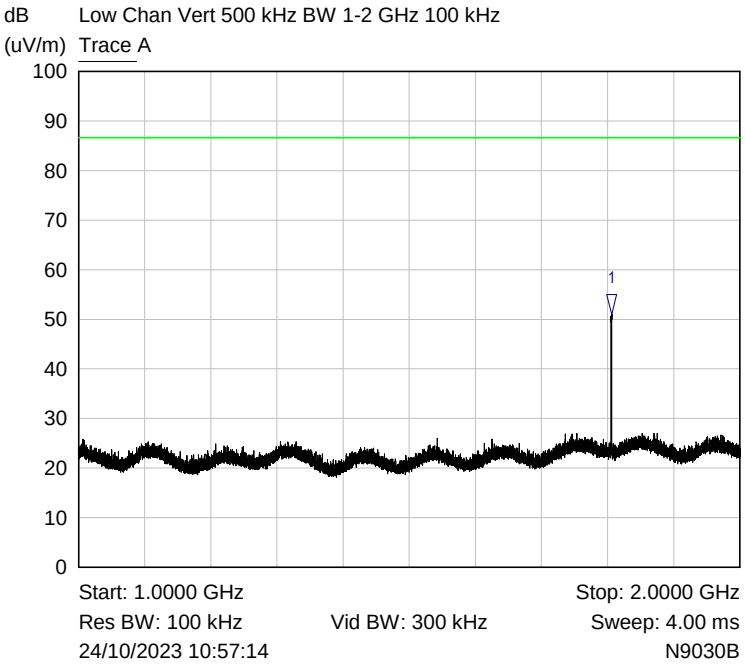
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8063 GHz	46.05 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



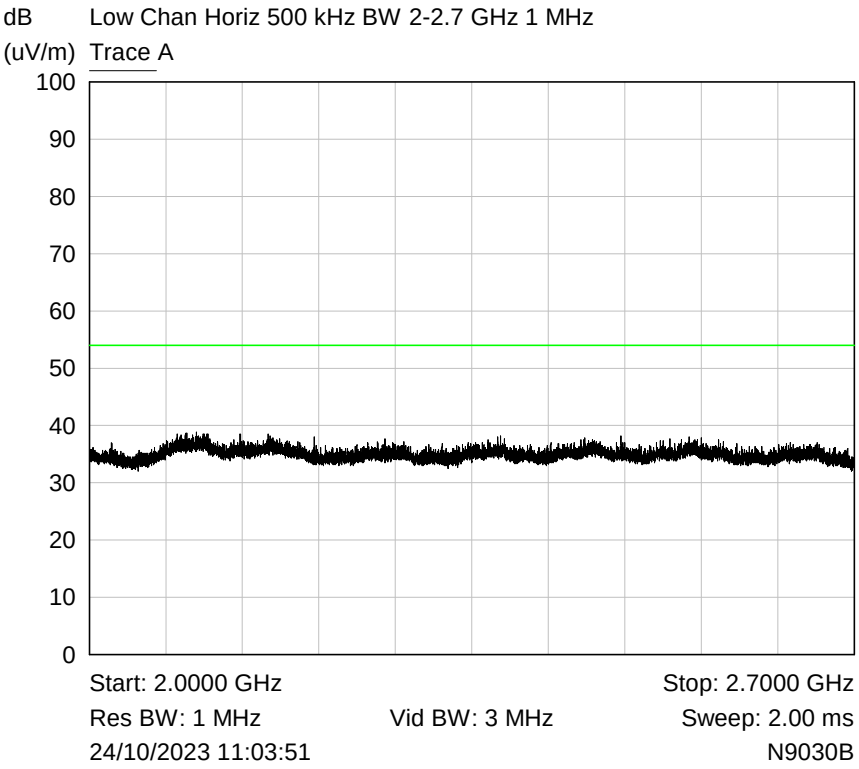
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8066 GHz	49.60 dB(uV/m)	

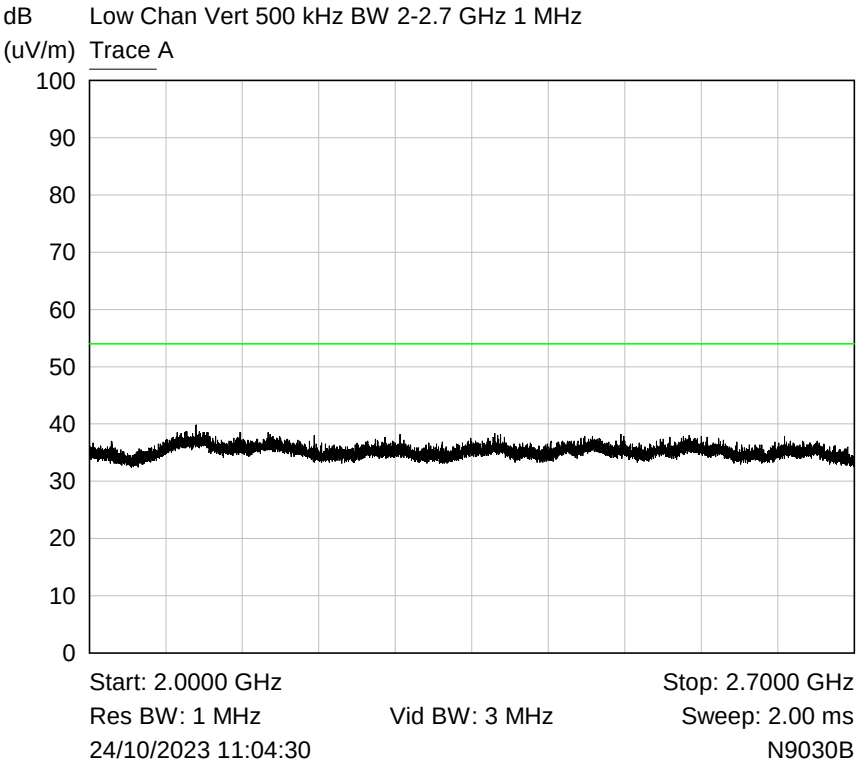
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below

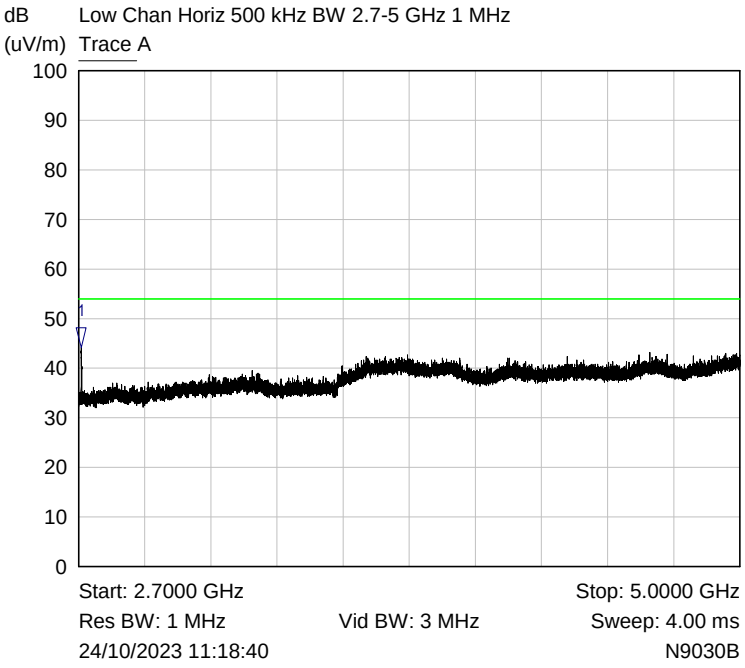


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8066 GHz	51.06 dB(uV/m)	

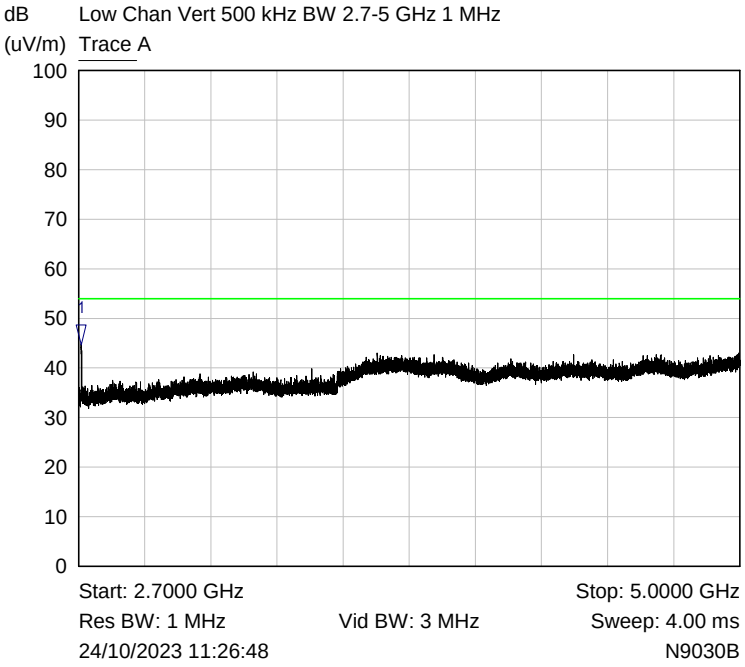
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
Low Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:03:51
N9030B

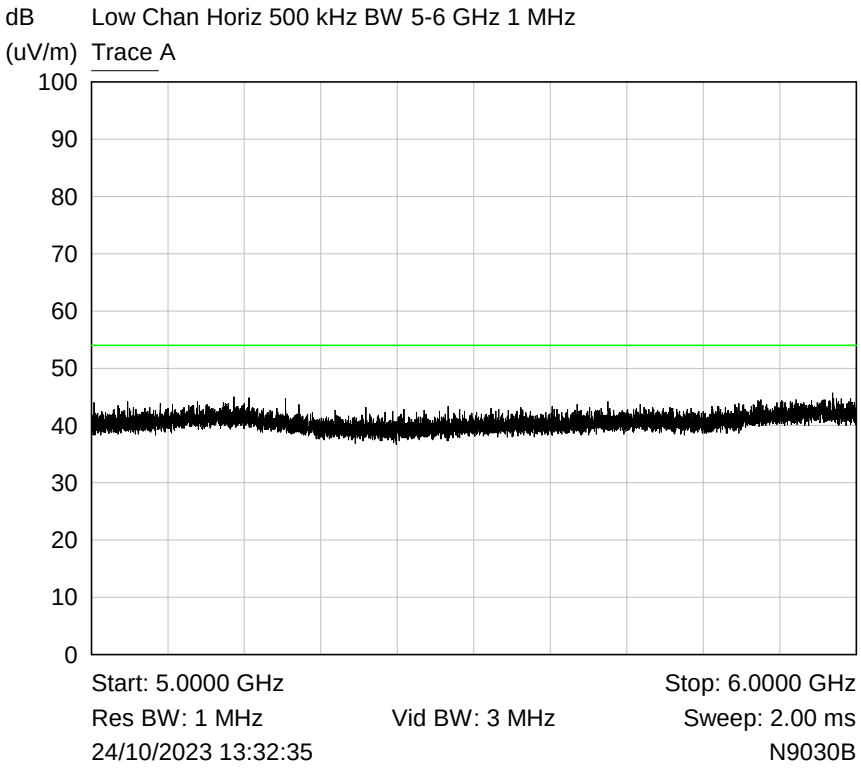

dB
(uV/m)
Low Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:04:30
N9030B

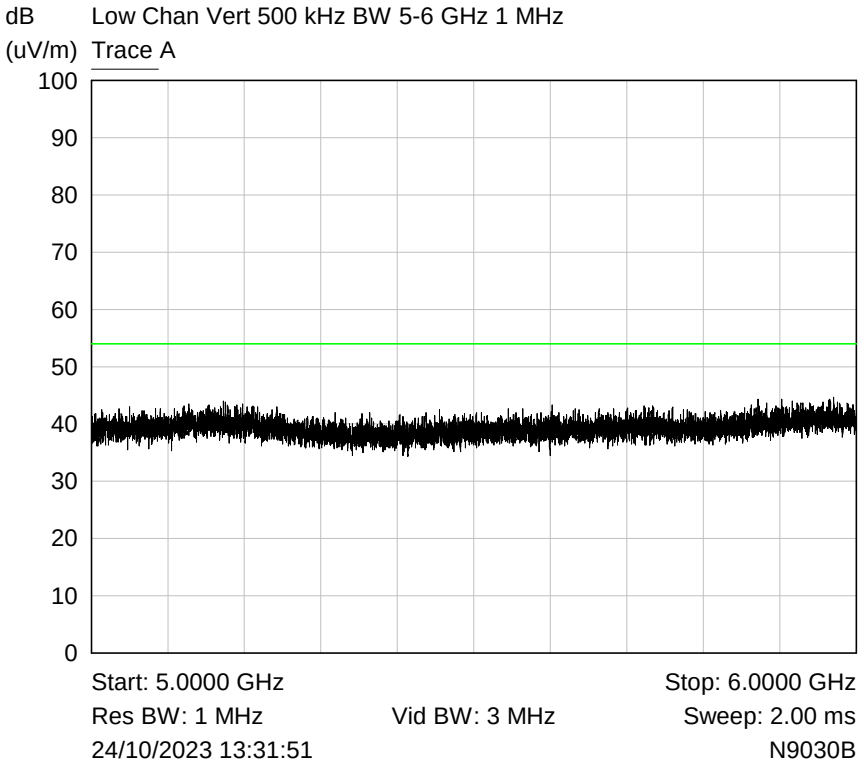


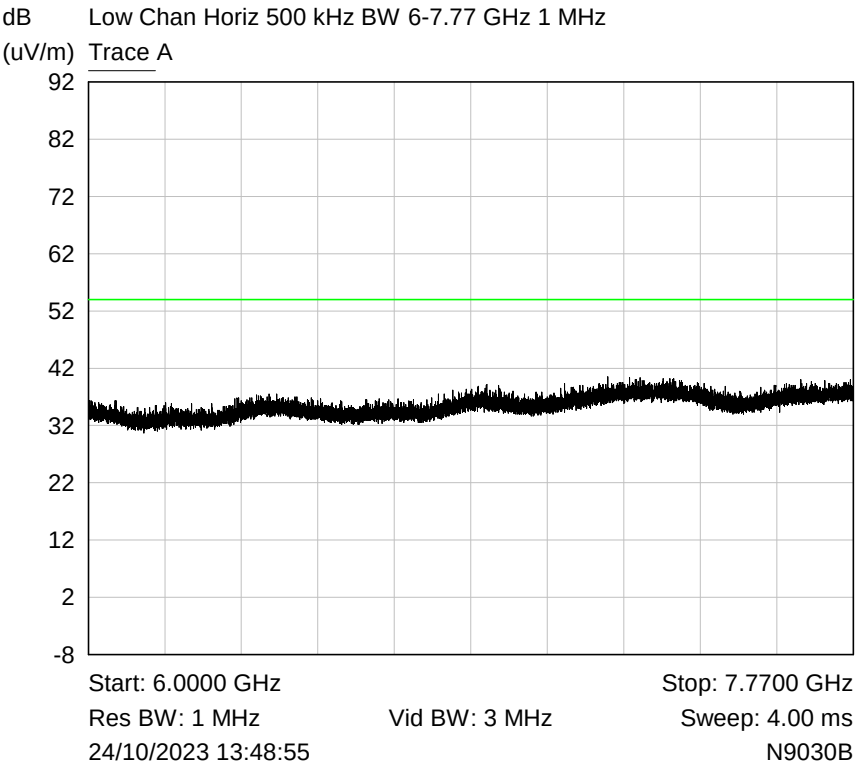
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7086 GHz	44.15 dB(uV/m)	

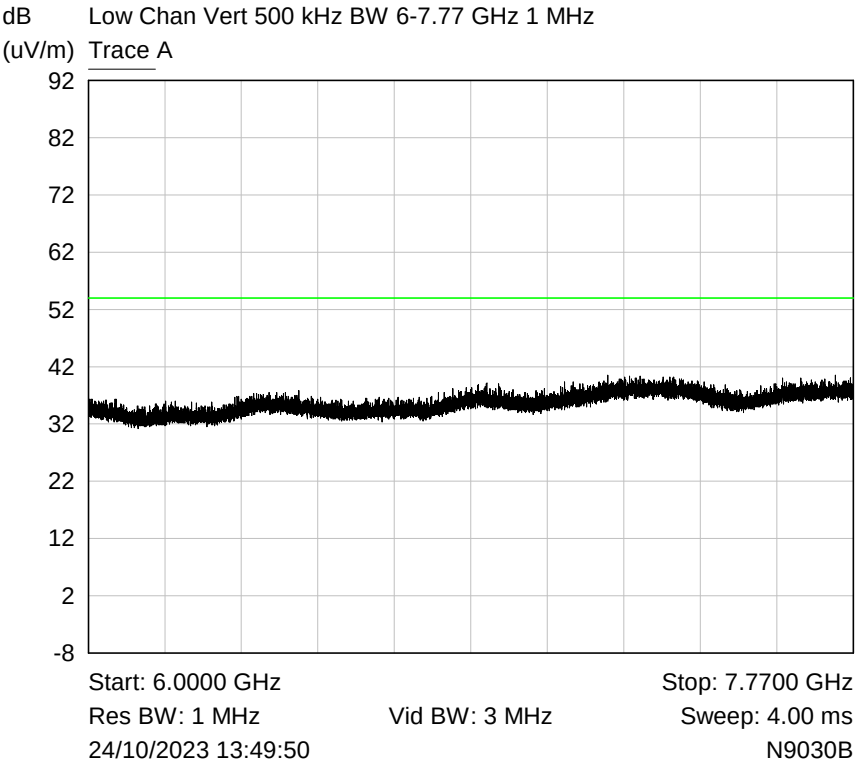


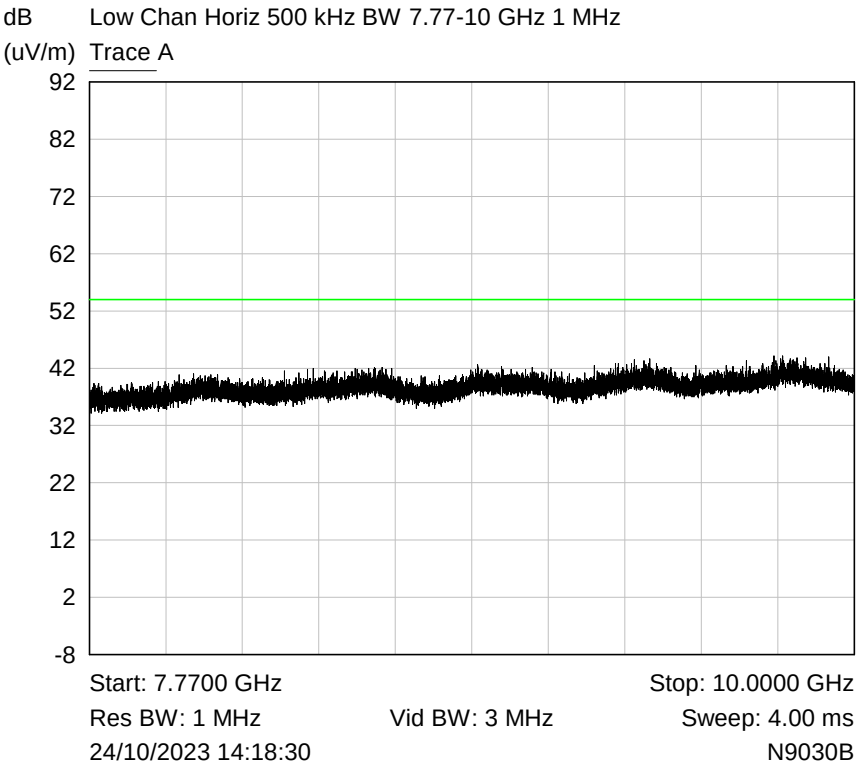
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7086 GHz	44.66 dB(uV/m)	

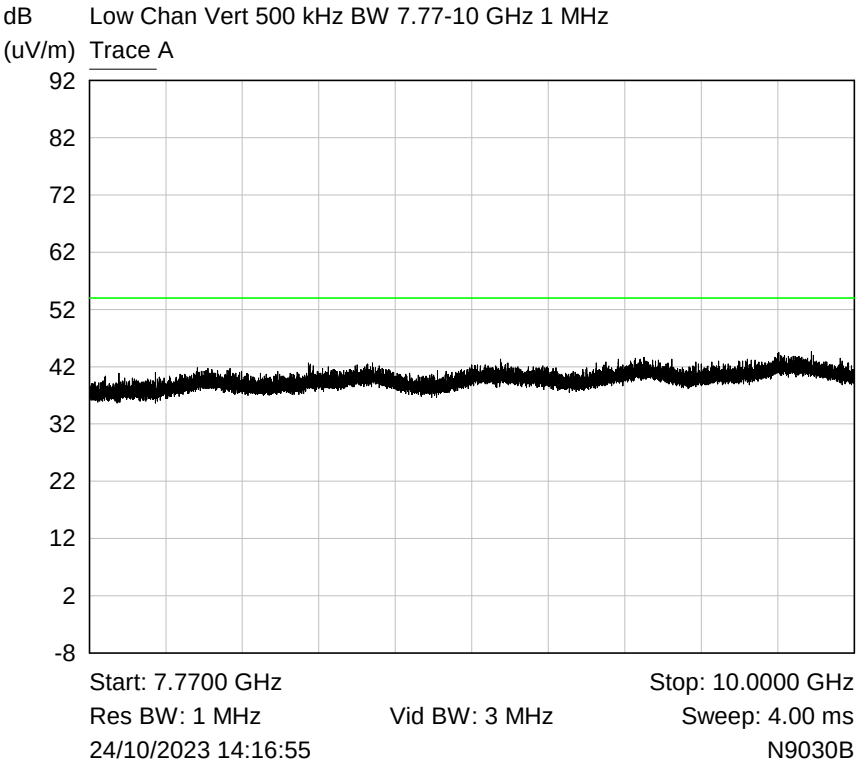

dB
(uV/m)
Low Chan Horiz 500 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:32:35
N9030B


dB
(uV/m)
Low Chan Vert 500 kHz BW 5-6 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 13:31:51
N9030B

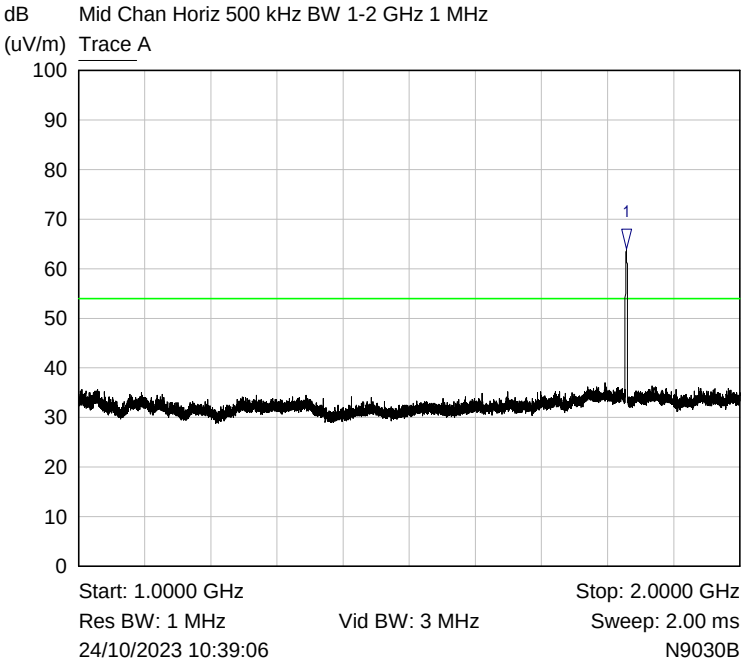

dB
(uV/m)
Low Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:48:55
N9030B


dB
(uV/m)
Low Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:49:50
N9030B


dB
(uV/m)
Low Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:18:30
N9030B

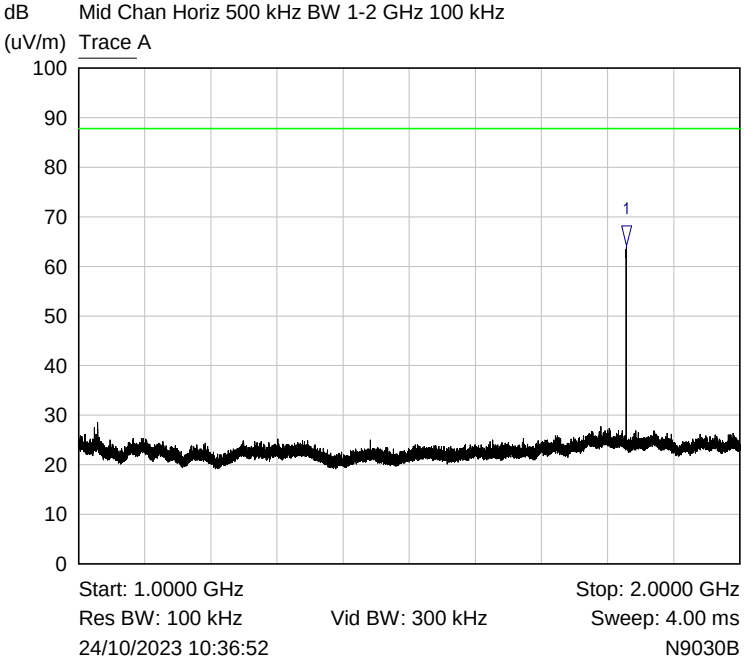

dB
(uV/m)
Low Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:16:55
N9030B

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 914.2 MHz



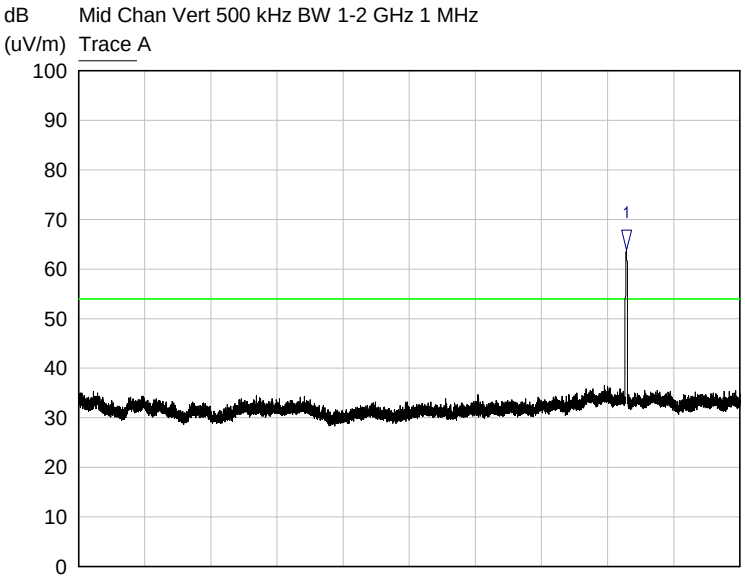
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8289 GHz	63.94 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below



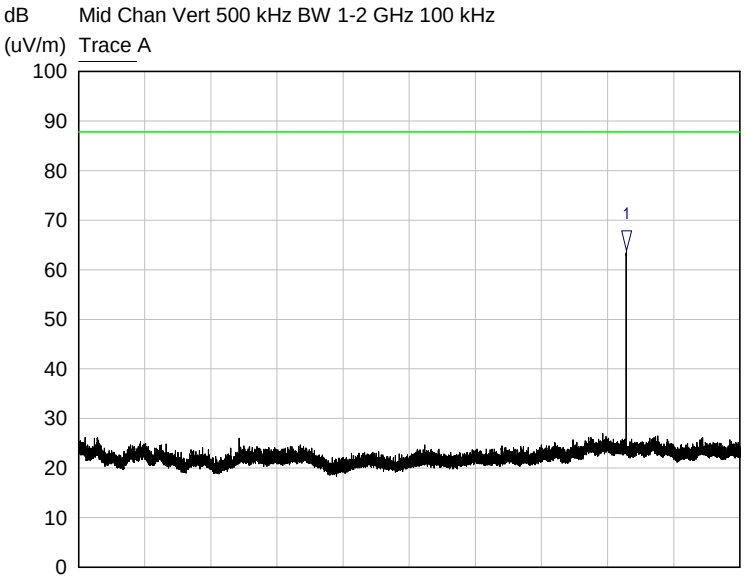
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8289 GHz	64.14 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



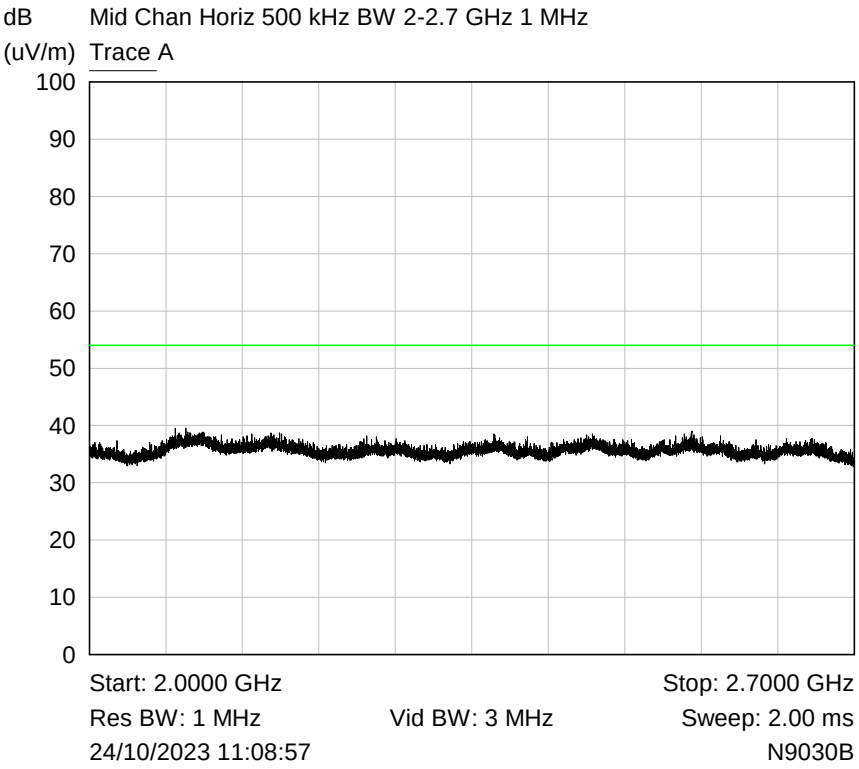
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8289 GHz	63.84 dB(uV/m)	

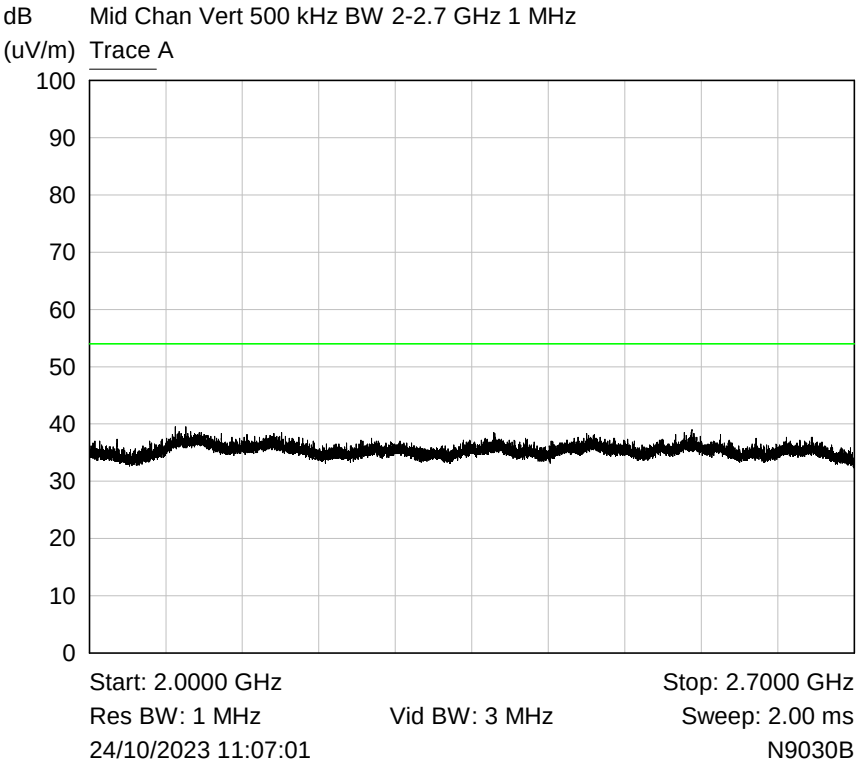
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below

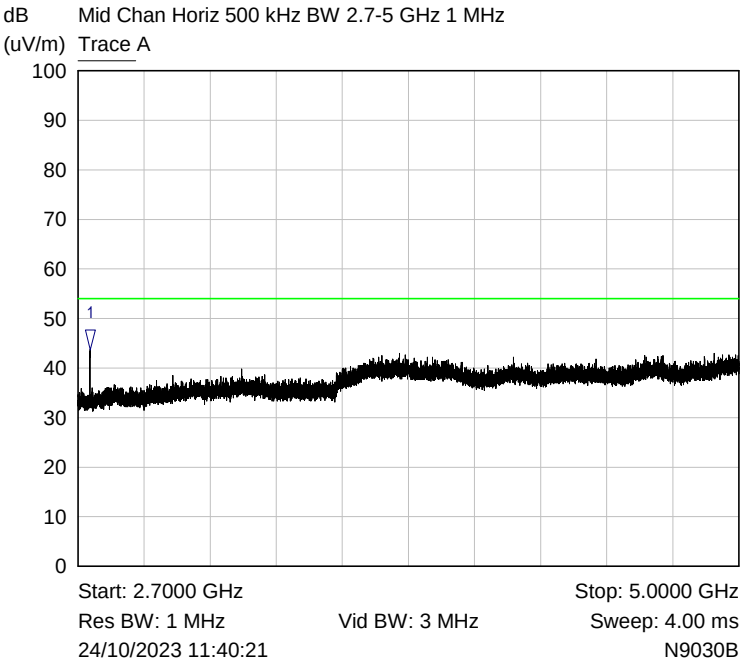


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8289 GHz	63.89 dB(uV/m)	

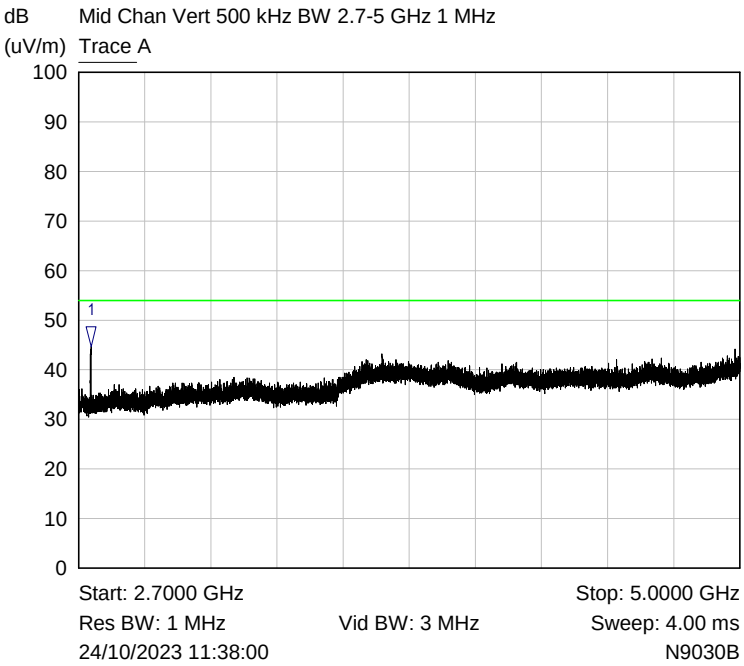
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
Mid Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:08:57
N9030B

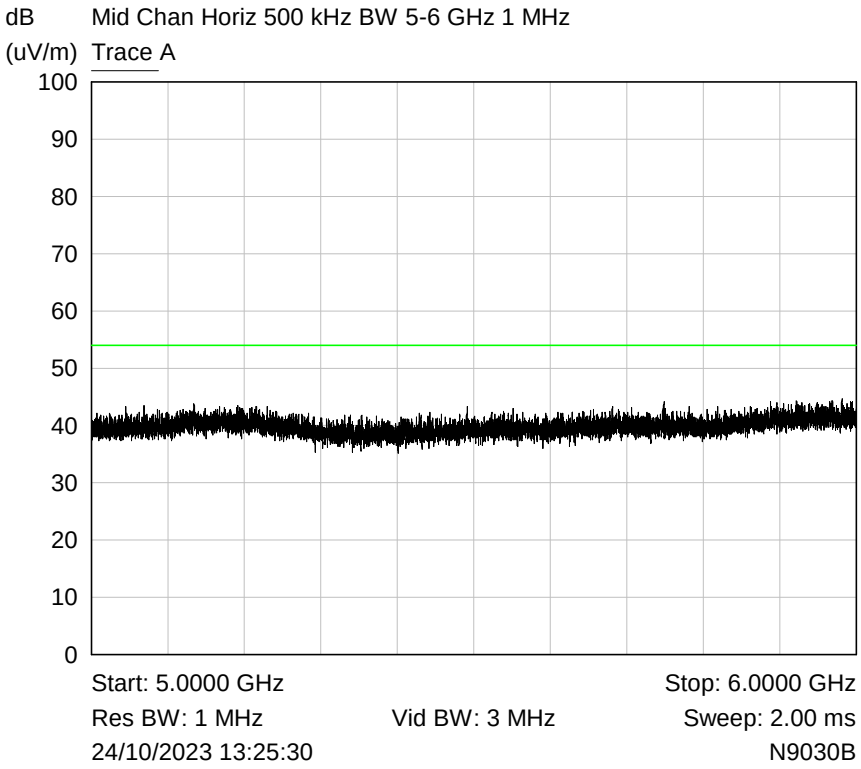

dB
(uV/m)
Mid Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:07:01
N9030B

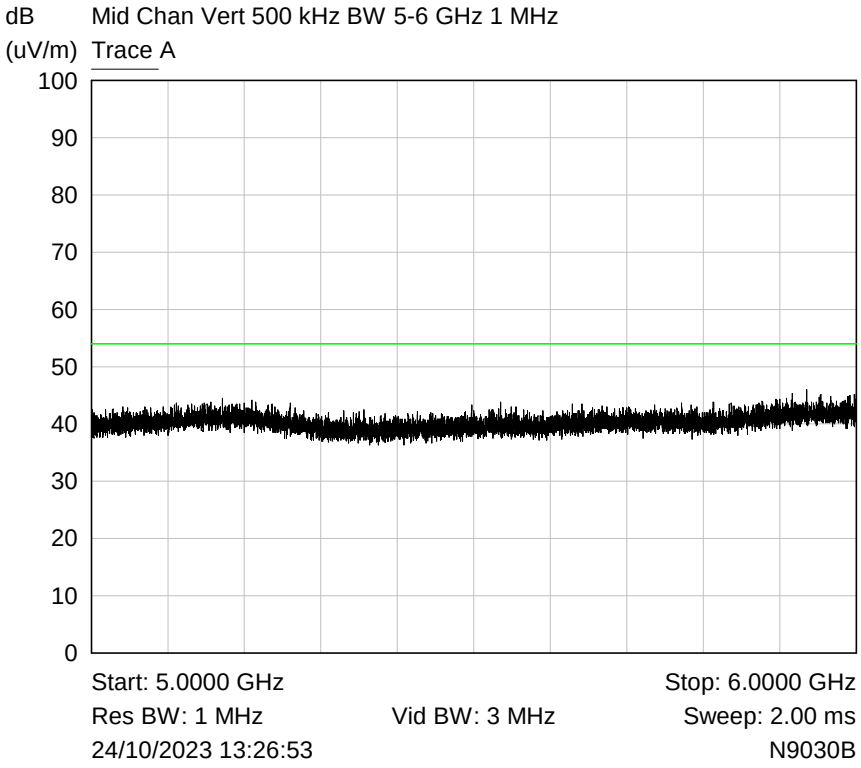


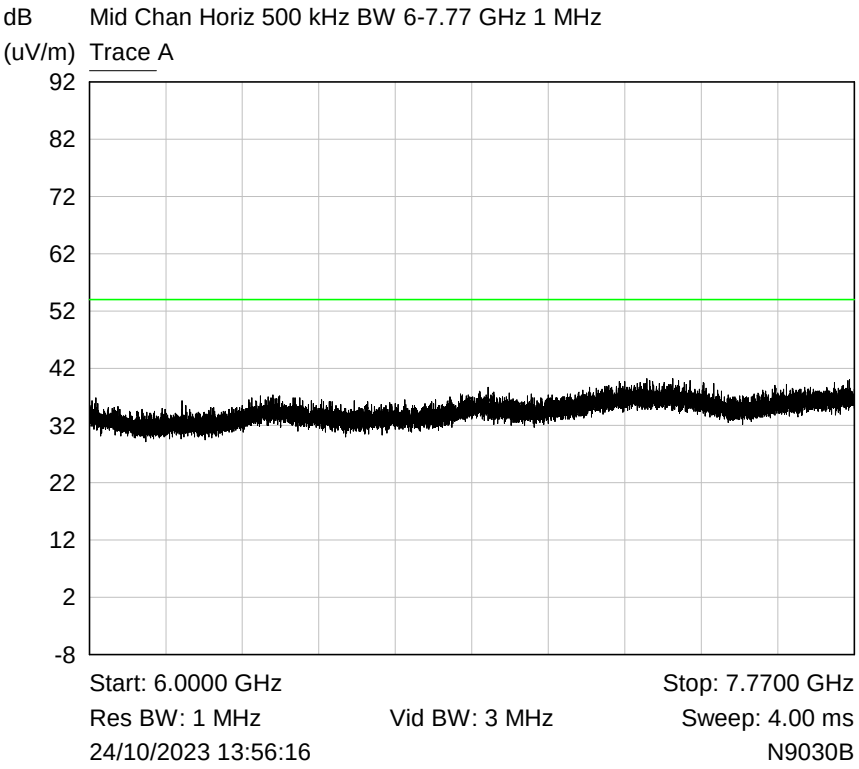
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7432 GHz	43.73 dB(uV/m)	

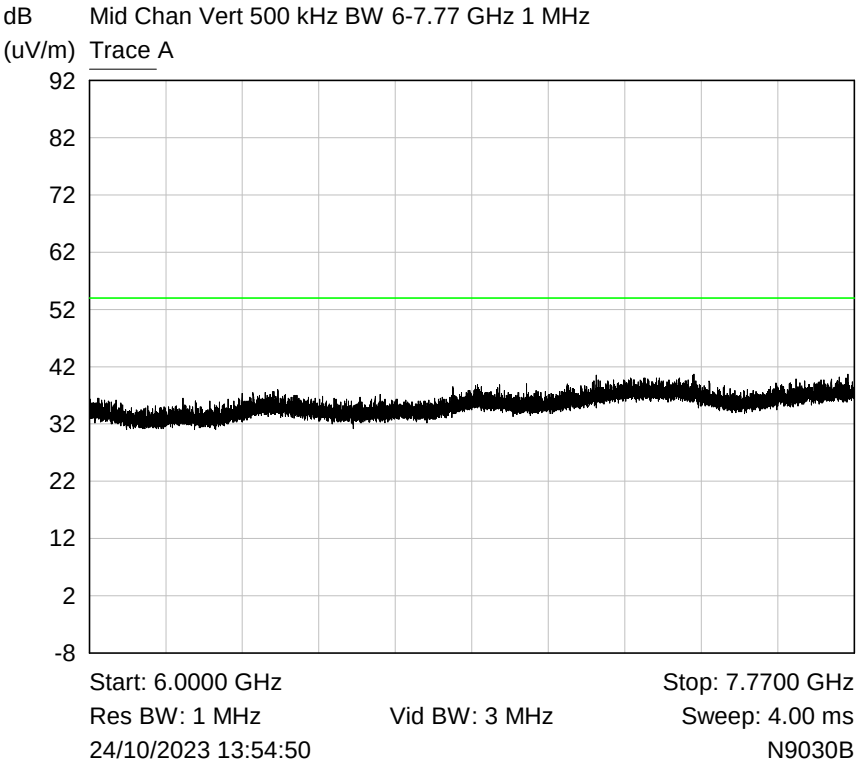


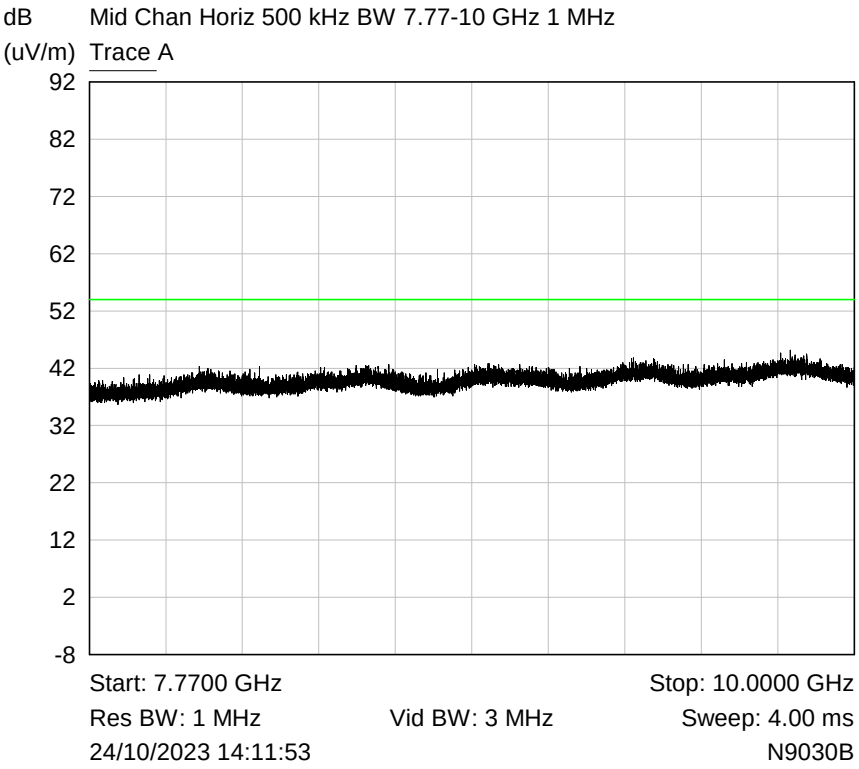
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7432 GHz	44.75 dB(uV/m)	

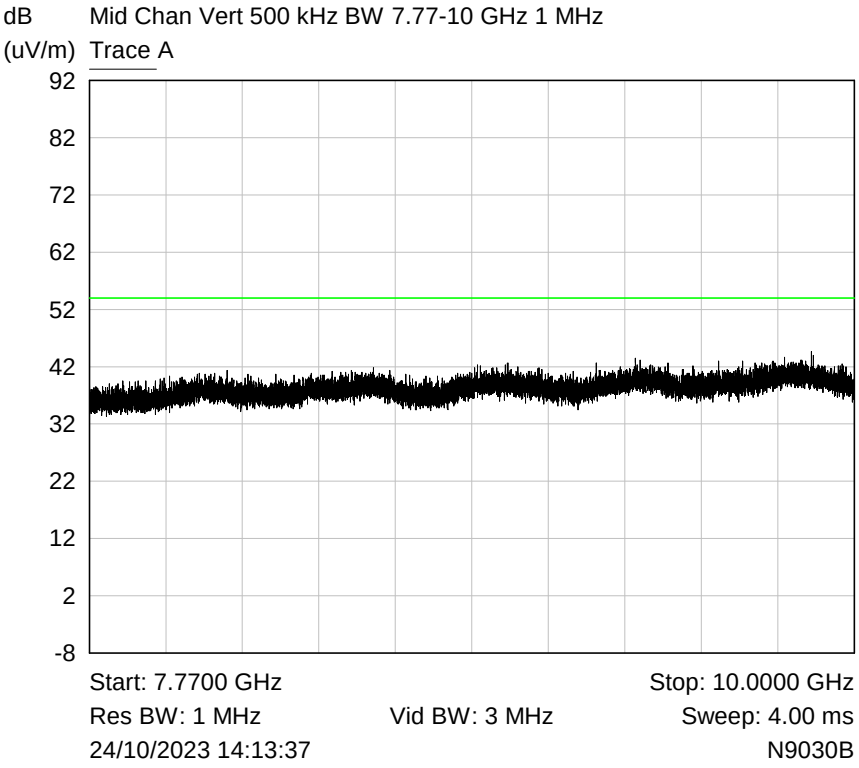




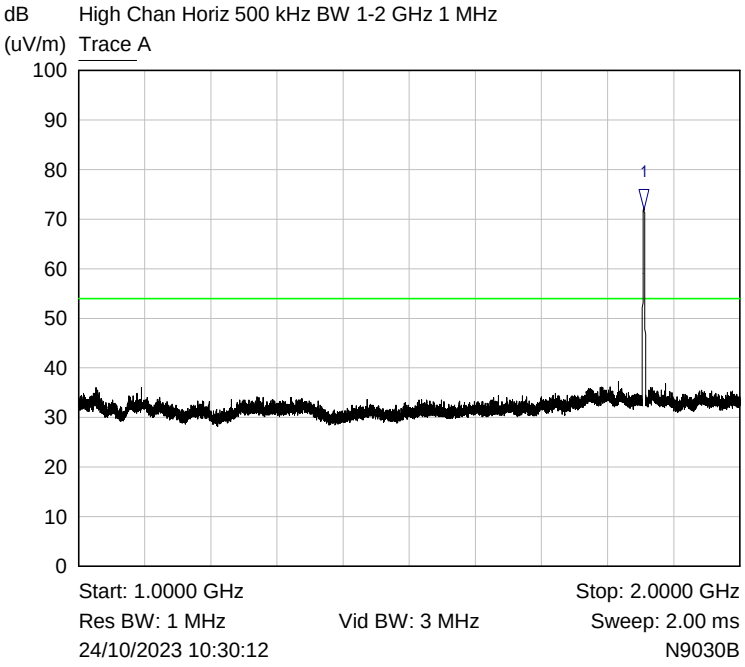

dB
(uV/m)
Mid Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:56:16
N9030B


dB
(uV/m)
Mid Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:54:50
N9030B


dB
(uV/m)
Mid Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:11:53
N9030B

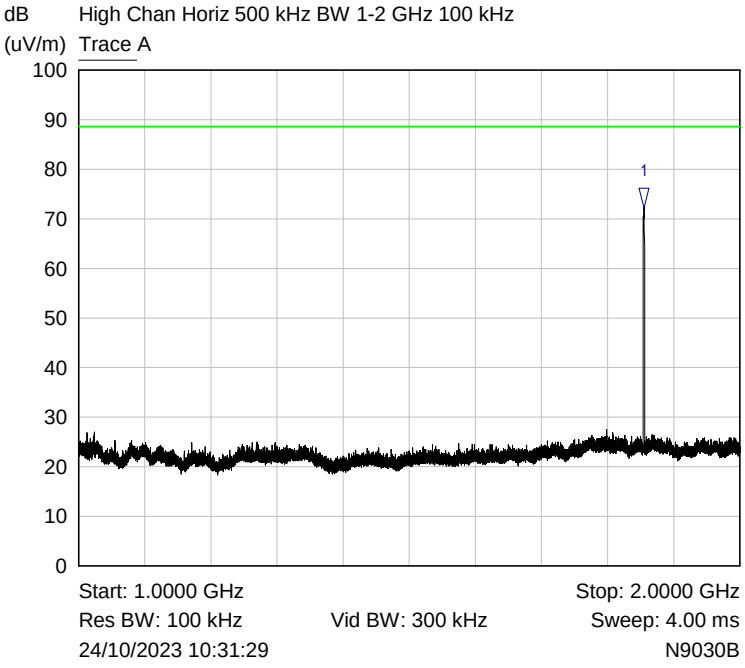

dB
(uV/m)
Mid Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:13:37
N9030B

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 927.5 MHz



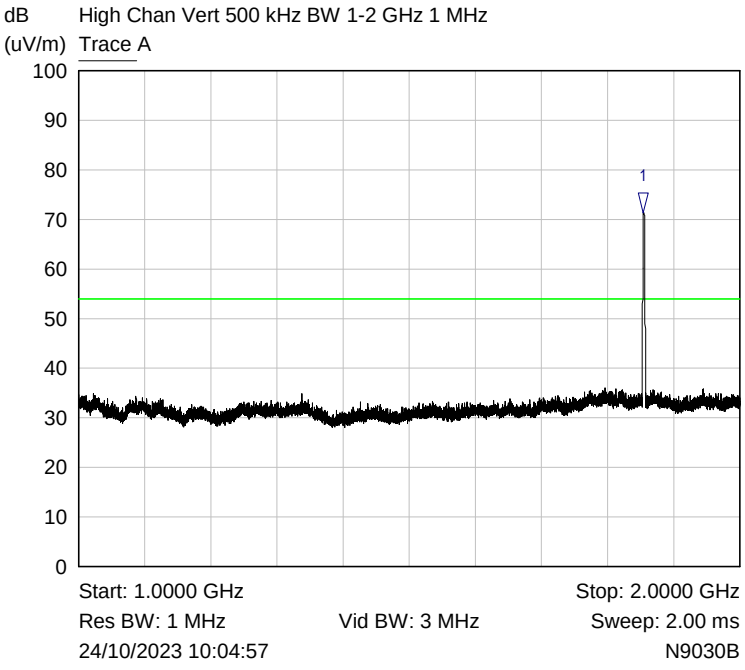
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	72.04 dB(uV/m)	

Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below



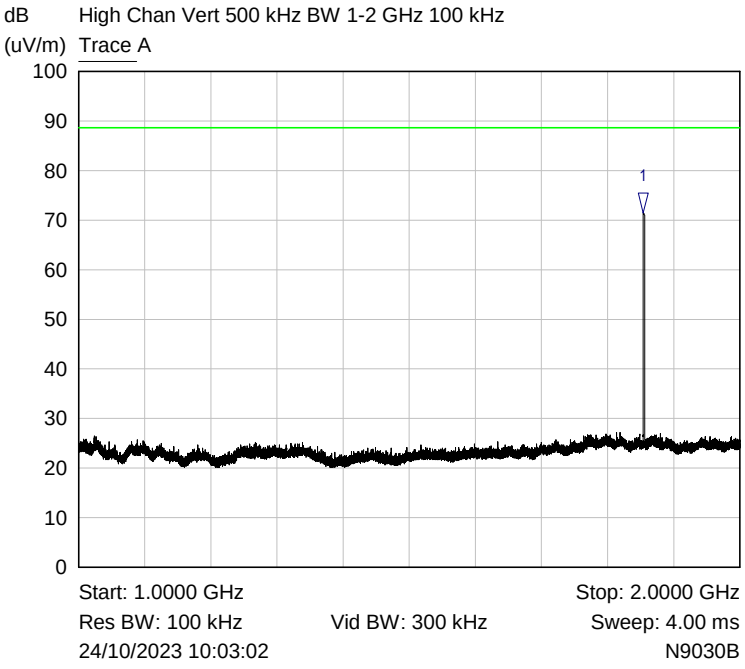
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8549 GHz	72.10 dB(uV/m)	

Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.



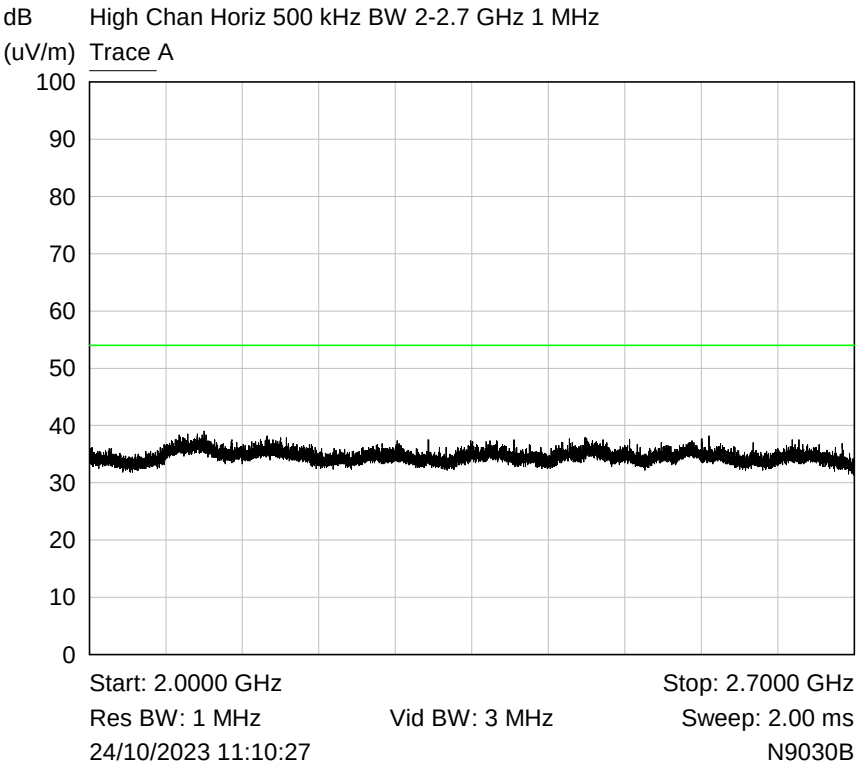
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8544 GHz	71.34 dB(uV/m)	

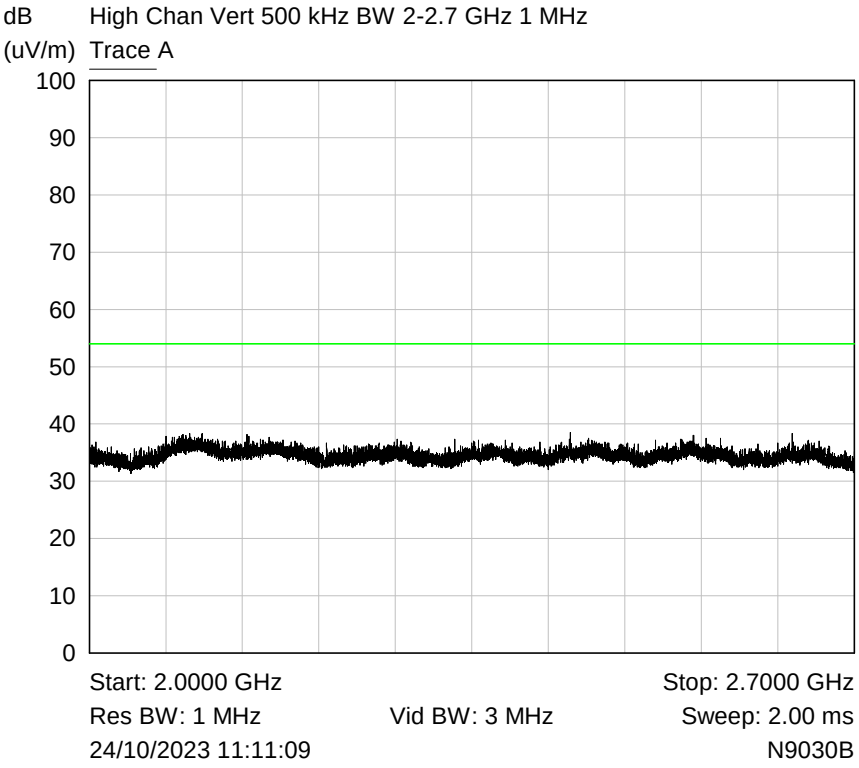
Note: The signal that fails the part 15.209 limit above was tested to the non-restricted band limits under part 15.247(d) i.e. 30dBc below fundamental power measured in 100kHz RBW, which can be seen below

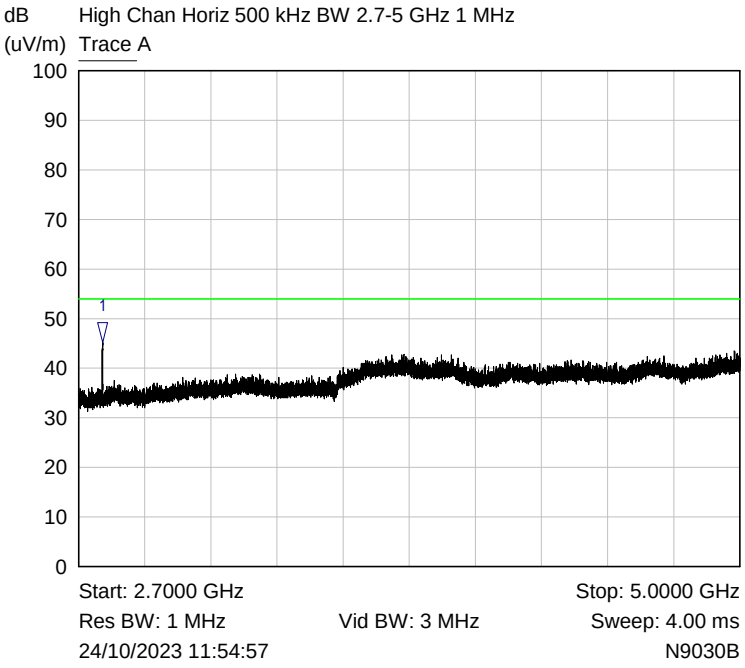


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	1.8544 GHz	71.43 dB(uV/m)	

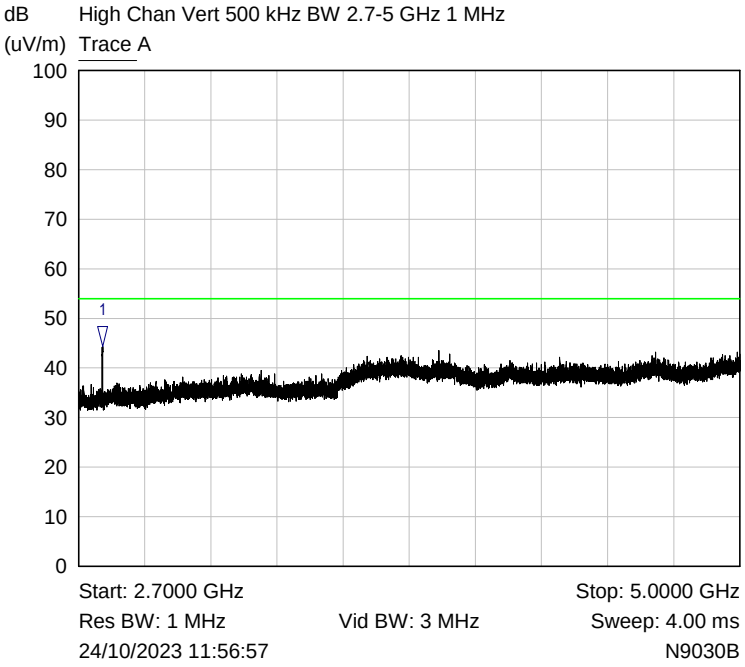
Note: Reference plot for 2nd Harmonic that had a non-restricted band limit applied from part 15.247(d) in 100 kHz. all other emissions comply to part 15.209 Limits, whether in restricted or non-restricted bands.


dB
(uV/m)
High Chan Horiz 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:10:27
N9030B

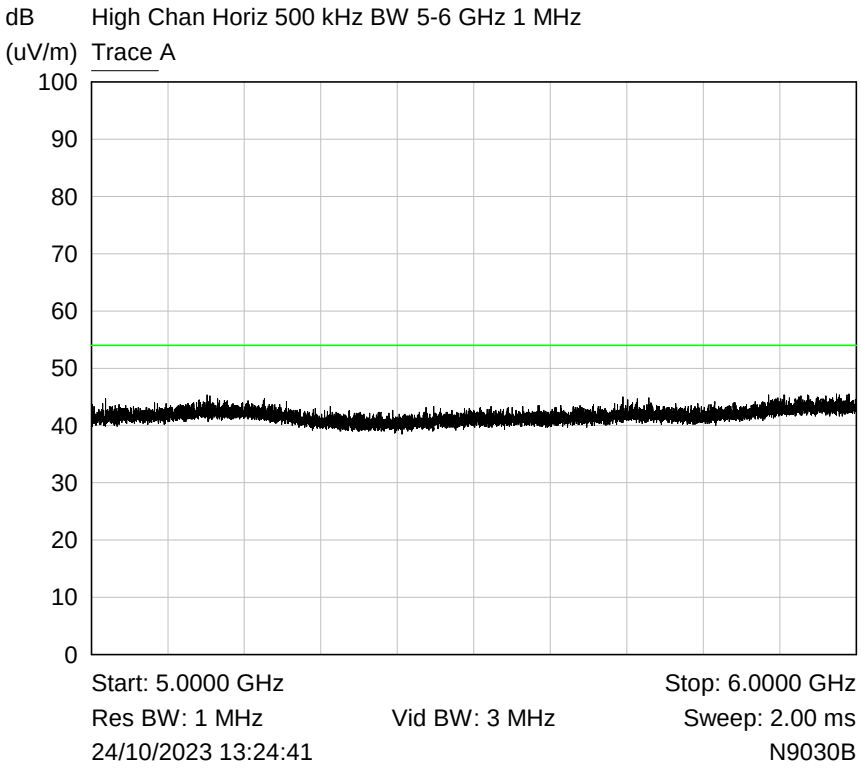

dB
(uV/m)
High Chan Vert 500 kHz BW 2-2.7 GHz 1 MHz
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
24/10/2023 11:11:09
N9030B

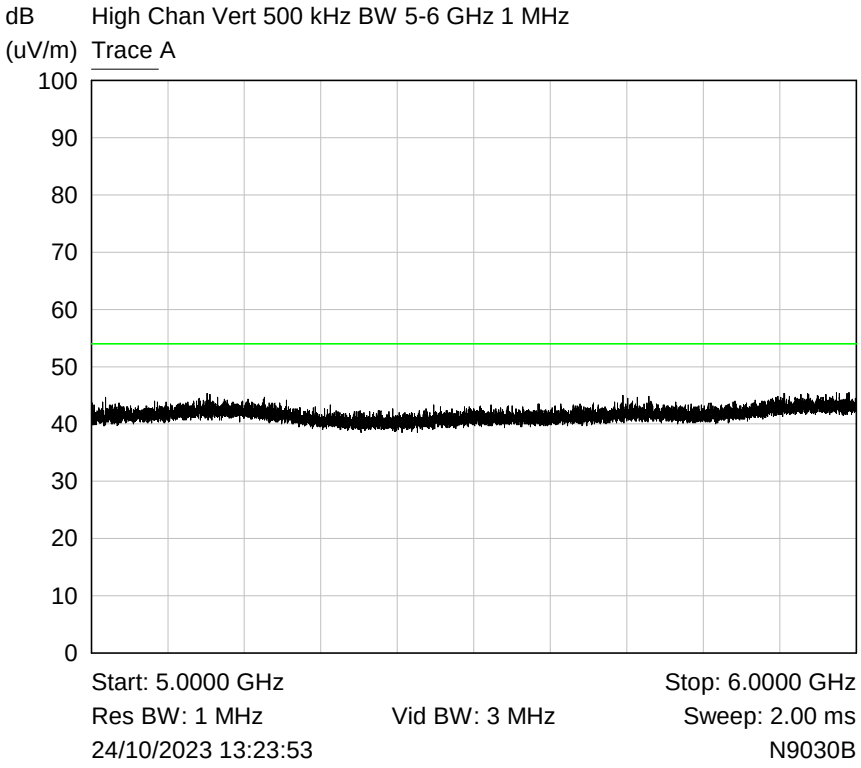


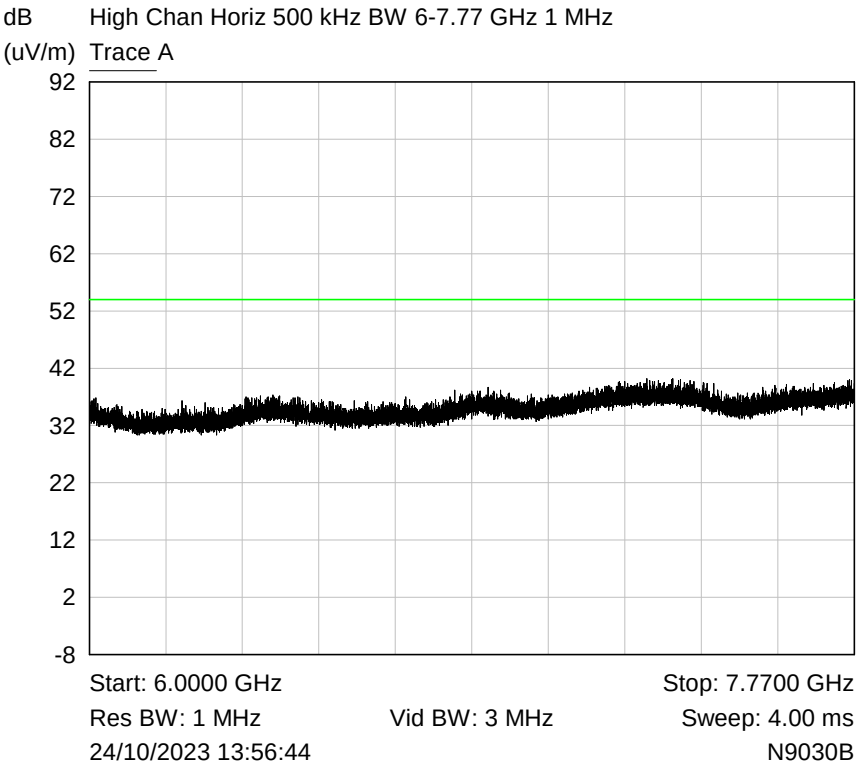
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7823 GHz	45.22 dB(uV/m)	

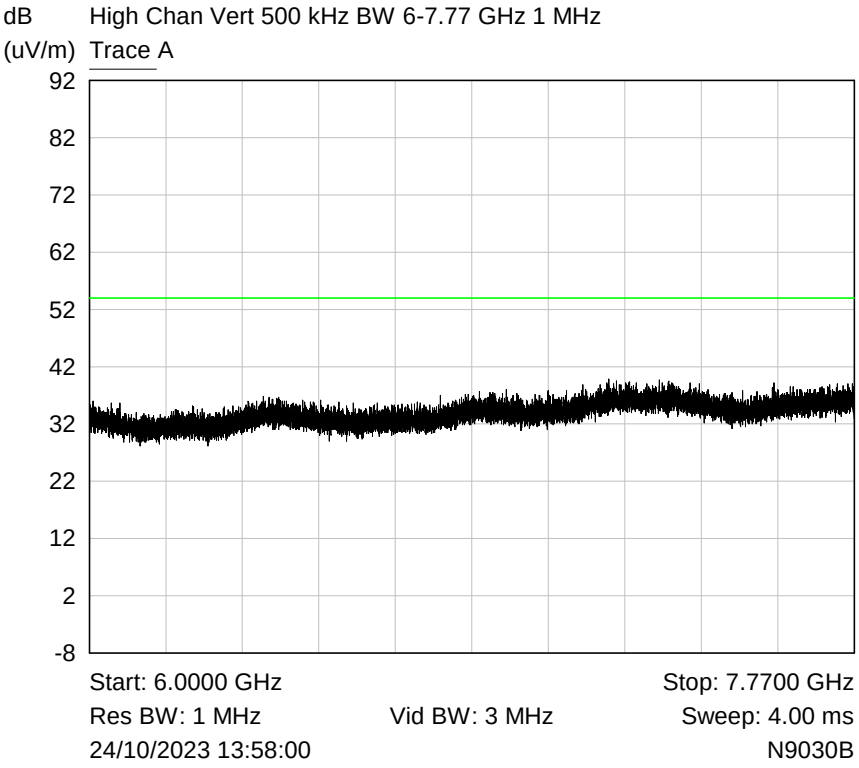


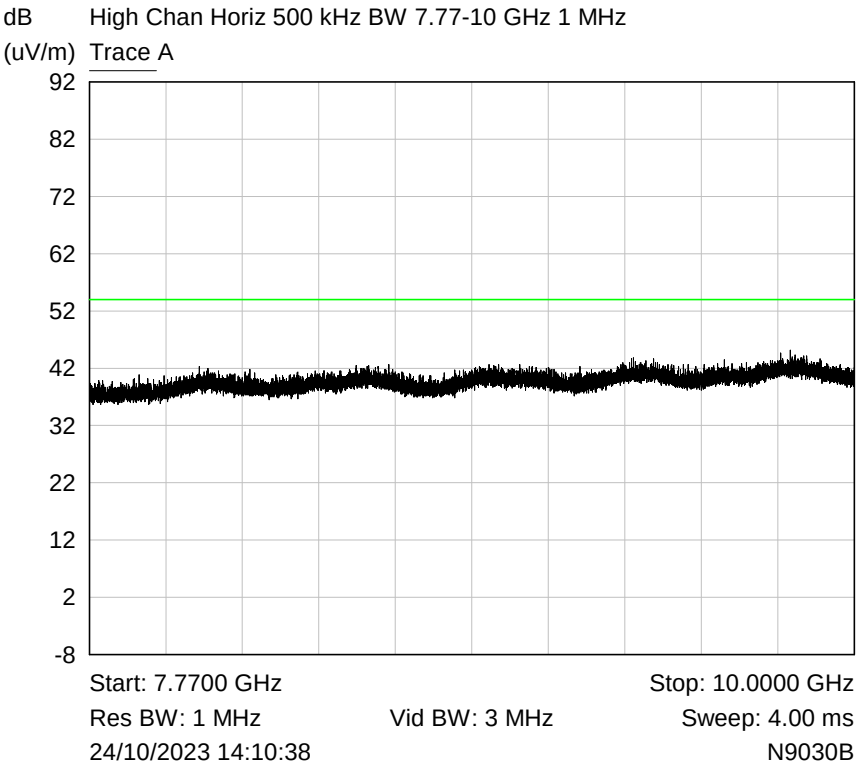
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.7827 GHz	44.33 dB(uV/m)	

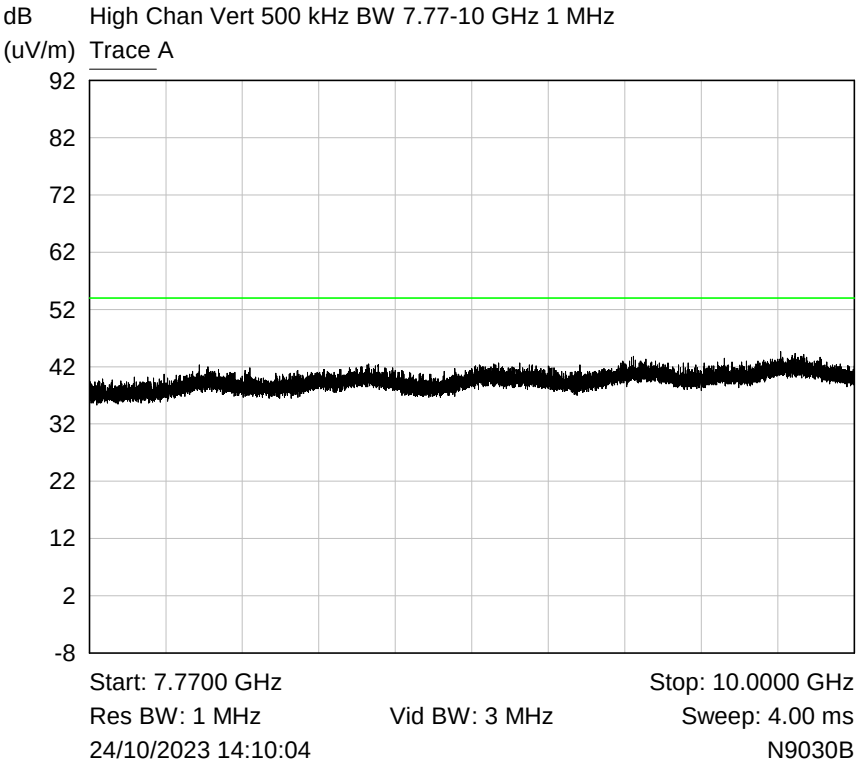





dB
(uV/m)
High Chan Horiz 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:56:44
N9030B

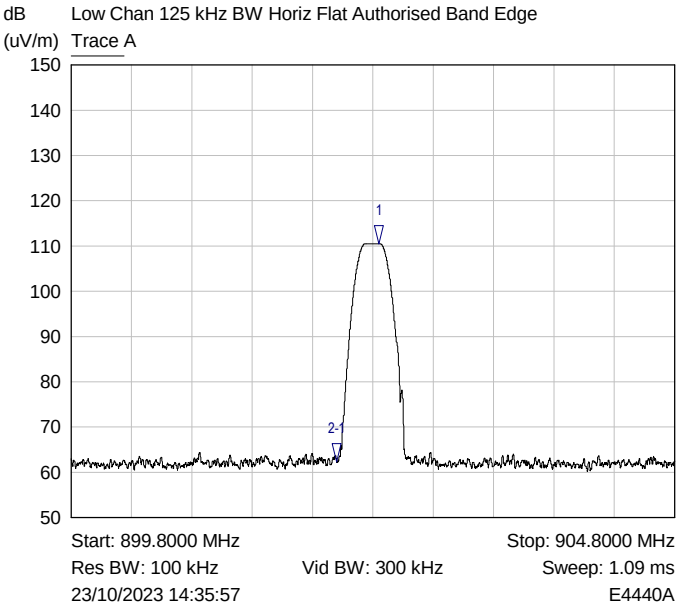

dB
(uV/m)
High Chan Vert 500 kHz BW 6-7.77 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 13:58:00
N9030B


dB
(uV/m)
High Chan Horiz 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:10:38
N9030B


dB
(uV/m)
High Chan Vert 500 kHz BW 7.77-10 GHz 1 MHz
Trace A
92
82
72
62
52
42
32
22
12
2
-8
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
24/10/2023 14:10:04
N9030B

6.5 Band edge compliance

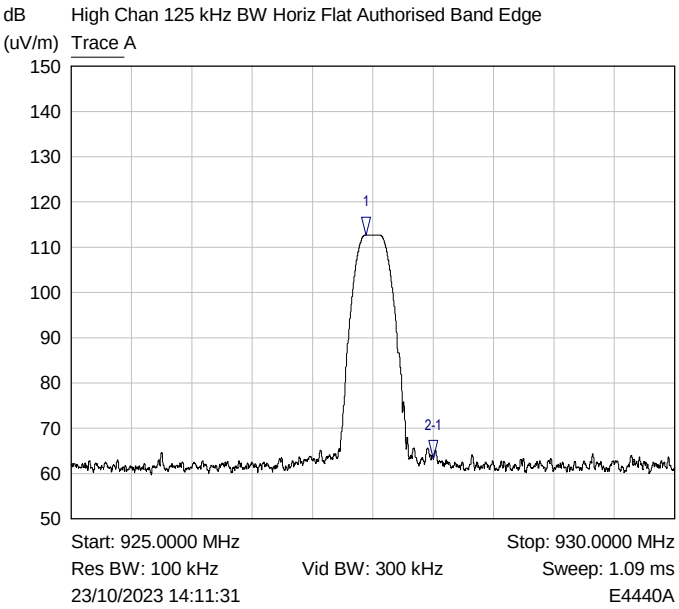
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	902.3485 MHz	110.53 dB(uV/m)	
2-1	Trace A	902.0000 MHz	-48.23 dB	

Low channel 125kHz BW Authorised Band edge plot

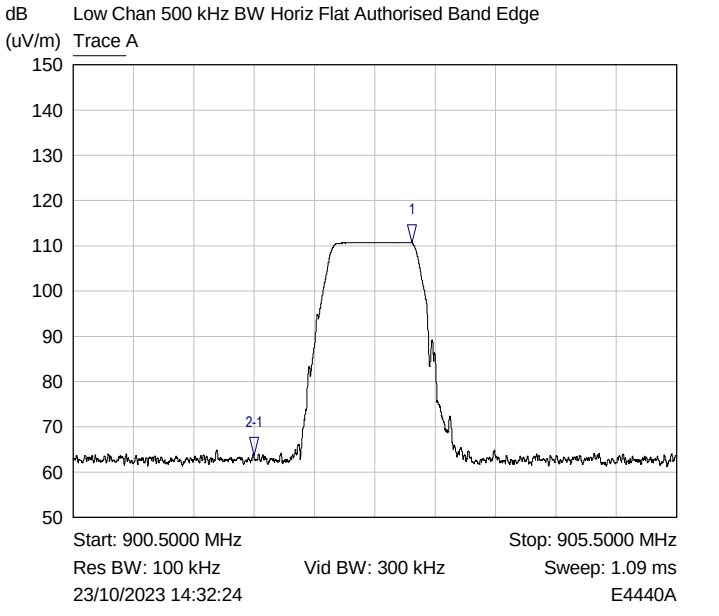
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 927.5 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	927.4441 MHz	112.70 dB(uV/m)	
2-1	Trace A	928.0002 MHz	-49.37 dB	

High channel 125kHz BW Authorised Band edge plot

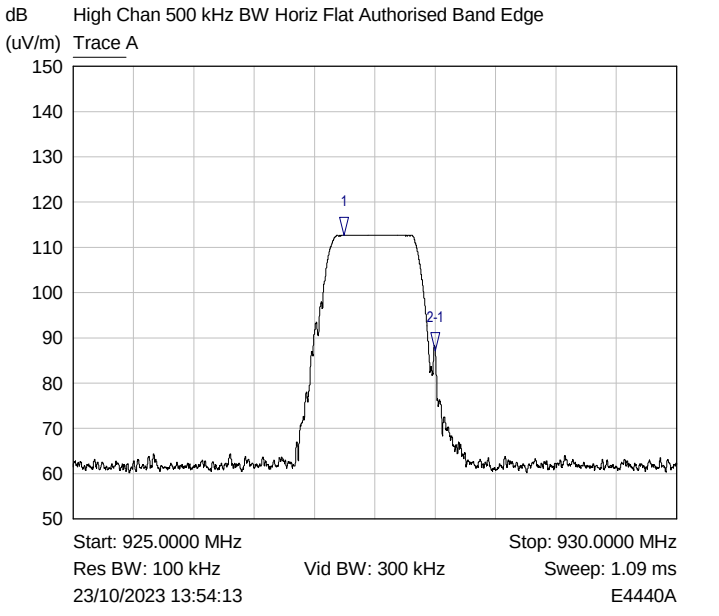
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	903.3037 MHz	110.66 dB(uV/m)	
2-1	Trace A	901.9998 MHz	-47.04 dB	

Low channel 500kHz BW Authorised Band edge plot

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 927.5 MHz

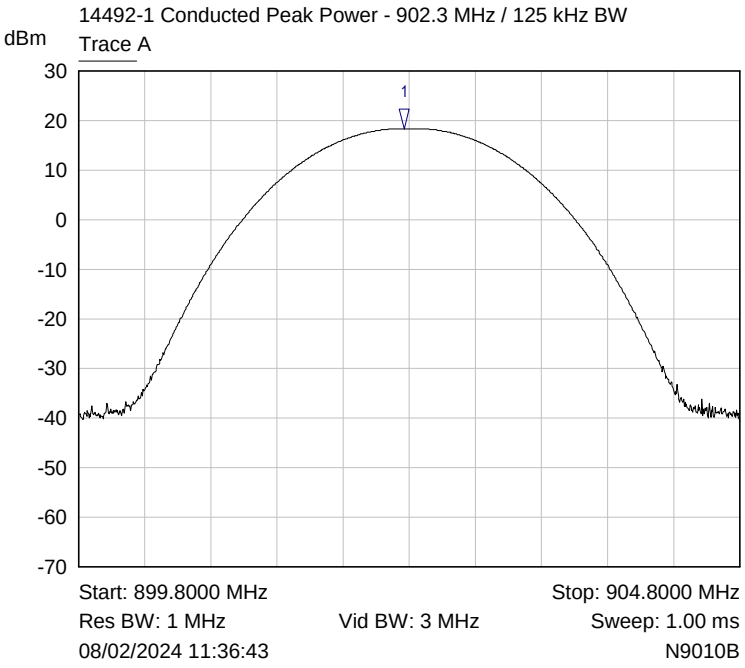


Mkr	Trace	X-Axis	Value	Notes
1	Trace A	927.2409 MHz	112.64 dB(uV/m)	
2-1	Trace A	928.0000 MHz	-25.39 dB	

High channel 500kHz BW Authorised Band edge plot

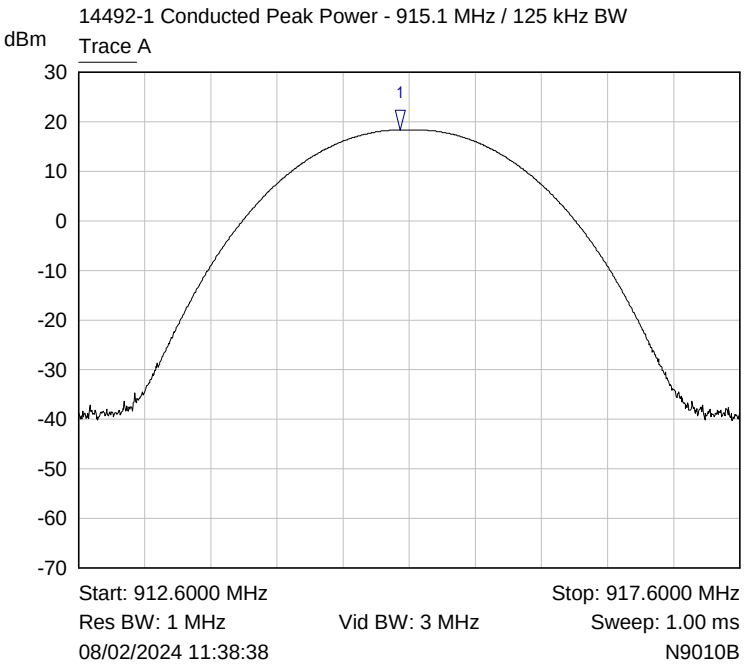
6.6 Maximum Peak Conducted Power

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 902.3 MHz



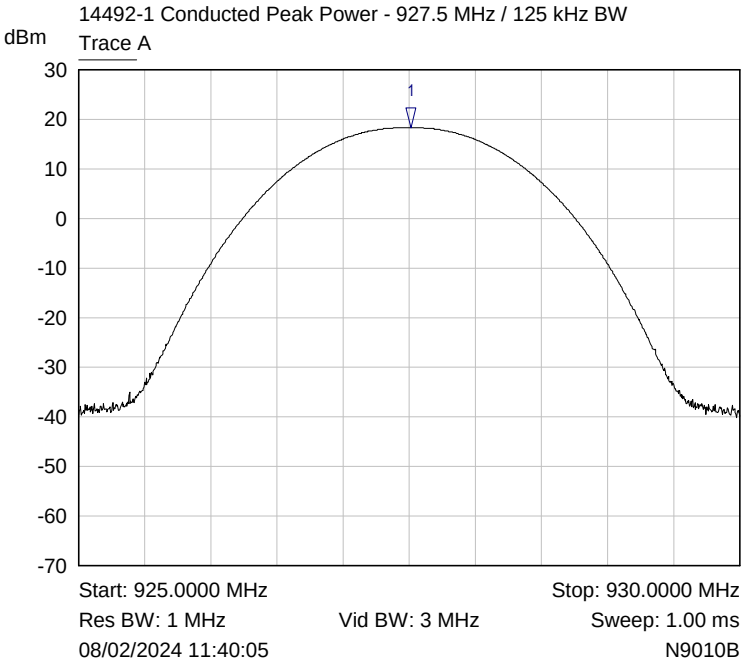
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	902.2650 MHz	18.36 dBm	

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 915.1 MHz



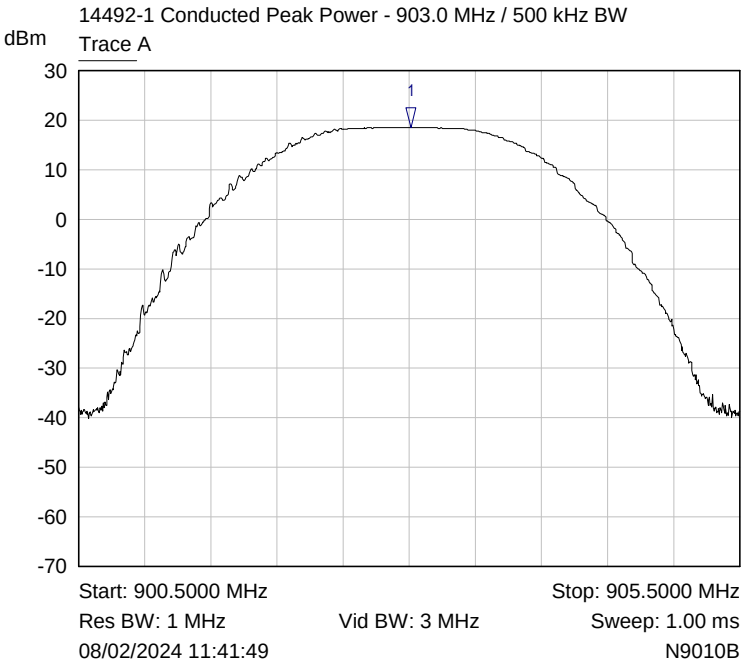
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	915.0300 MHz	18.34 dBm	

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz, Modulation GeoWan, Channel 927.5 MHz



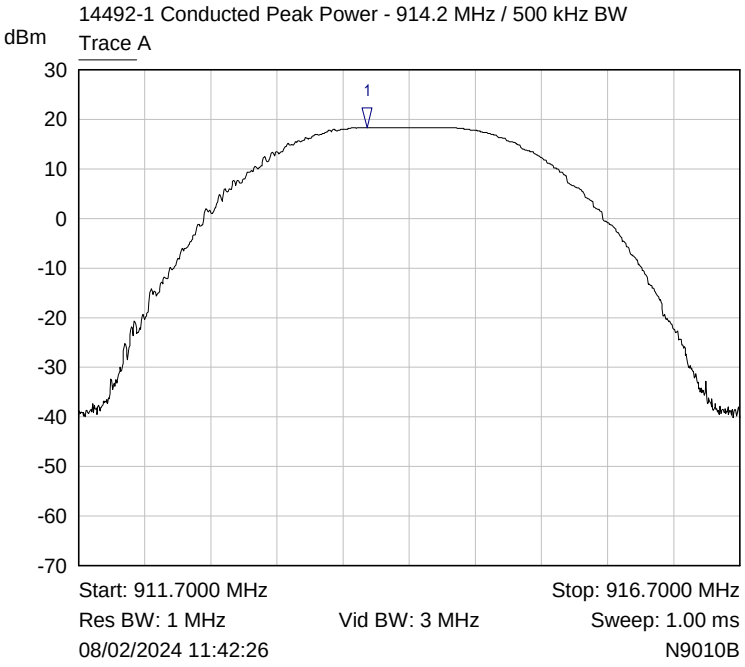
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	927.5150 MHz	18.28 dBm	

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 903.0 MHz



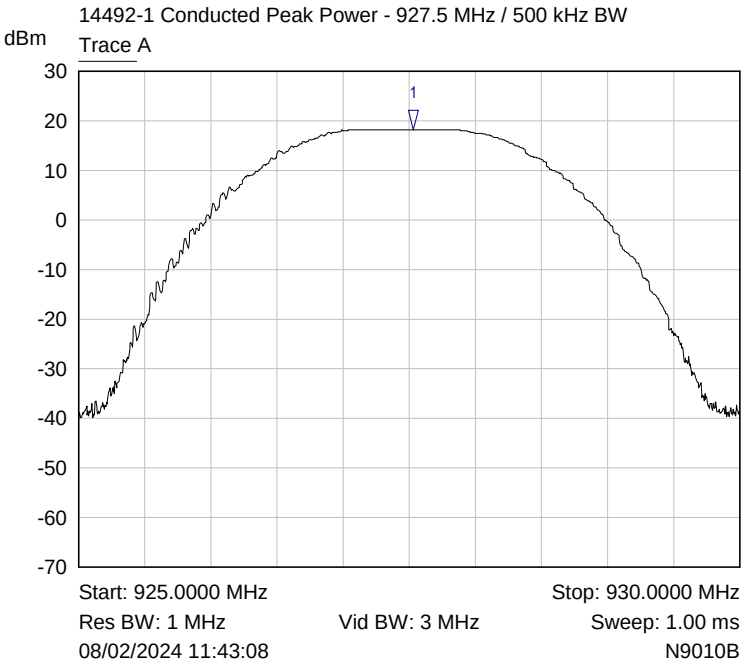
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	903.0150 MHz	18.42 dBm	

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 914.2 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	913.8800 MHz	18.31 dBm	

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz, Modulation GeoWan, Channel 927.5 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	927.5300 MHz	18.24 dBm	

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

Measurements are made as required by the standard. These measurements are made and recorded using detectors, either peak, quasi peak or average dependant on the test. A table of results has been given following the relevant plots. This table looks similar to the one illustrated below dependant on the measurements required by the test: -

Signal No.	Freq (MHz)	Peak Amp (dBuV)	Pk – Lim 1 (dB)	QP Amp (dBuV)	QP - Lim1 (dB)	Av Amp (dBuV)	Av - Lim1 (dB)
1	12345	54.9	-10.5	48	-12.6	37.6	-14.4

Column One - Labelled Signal No. is an incremental number that the receiver has given to each signal that has been measured.

Column Two - Labelled Freq (MHz) is the approximate frequency of the signal received.

Column Three - Labelled Peak Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the peak detector.

Column Four - Labelled Pk - Lim1 (dB) is the difference in level from the peak signal given to the active limit line. If this column appears in the table the peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Five - Labelled QP Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the quasi-peak detector.

Column Six - Labelled QP - Lim1 (dB) is the difference in level from the quasi-peak signal given to the active limit line. If this column appears in the table the quasi-peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Seven - Labelled Av Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the average detector.

Column Eight - Labelled Av - Lim1 (dB) is the difference in level from the average signal given to the active limit line. If this column appears in the table the average detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Only signals highlighted in red are deemed to exceed the limit of the detector required.

7.2 Explanation of limit line calculations for radiated measurements

The limits given in the test standard are normally expressed as absolute values (e.g. in μV/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dBμV/m referenced to the measuring instrument inputs. Kiwa Electrical Compliance calibrate the test set-up to account for any path losses, antenna gains, etc. so that the value read at the receiver relates directly to the absolute value required, except that it is expressed in dB relative to one microVolt and may need to take account of any alternative measuring distance used. Examples:

(a) limit of 500 μV/m equates to 20.log (500) = 54 dB μV/m.

(b) limit of 300 μV/m at 10m equates to 20.log (300 . 10/3) = 60 dB μV/m at 3m

(c) limit of 30 μV/m at 30m, but below 30MHz, equates to 20.log(30) + 40.log(30/3) = 69.5 dBμV/m at 3m, as extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

Example calculation: - FS = RA + AF + CL.

Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

Additional calculation examples per ANSI C63.10 clause 9.4 – 9.6 equations 21, 22, 25 & 26:

Equation 21: $E_{Linear} = 10^{((E_{log}-120)/20)}$

And therefore equation 21 transposed is: $E_{Log} = 20xLog(E_{Linear}) +120$

Where:

E_{Linear} is the field strength of the emission in V/m

E_{Log} is the field strength of the emissions in dBµV/m

Equation 22: $EIRP = E_{Meas} + 20log(d_{Meas}) -104.7$

Where:

EIRP is equivalent isotropically radiated power in dBm

E_{Meas} is the field strength of the emission at the measurement distance in dBµV/m

d_{Meas} is the measurement distance in metres

Equation 25: $PD = EIRP_{Linear} / 4\pi d^2$

And therefore equation 25 transposed is: $EIRP_{Linear} = PD \times 4\pi d^2$

Where:

PD is the power density at distance specified by the limit, in W/m^2

$EIRP_{Linear}$ is the equivalent isotropically radiated power in Watts

d is the distance at which the power density limit is specified in metres

Equation 26: $PD = E^2_{Speclimit} / 377$

And therefore equation 26 transposed is: $E_{Spec\ limit} = \sqrt{(PD \times 377)}$

Where:

PD is the power density at distance specified by the limit, in W/m^2

$E_{spec\ limit}$ is the field strength at the distance specified by the limit in V/m

Example:

Radiated spurious emissions limit at 3metres of $90pW/cm^2$.

$90pW/cm^2 \times 100^2 = 0.9\ \mu W/m^2$ = (EIRP Linear)

Equation 25 transposed: $0.9 \times 10^{-6} \times 4 \times \pi \times 3^2 = 0.0001017876$ W

And

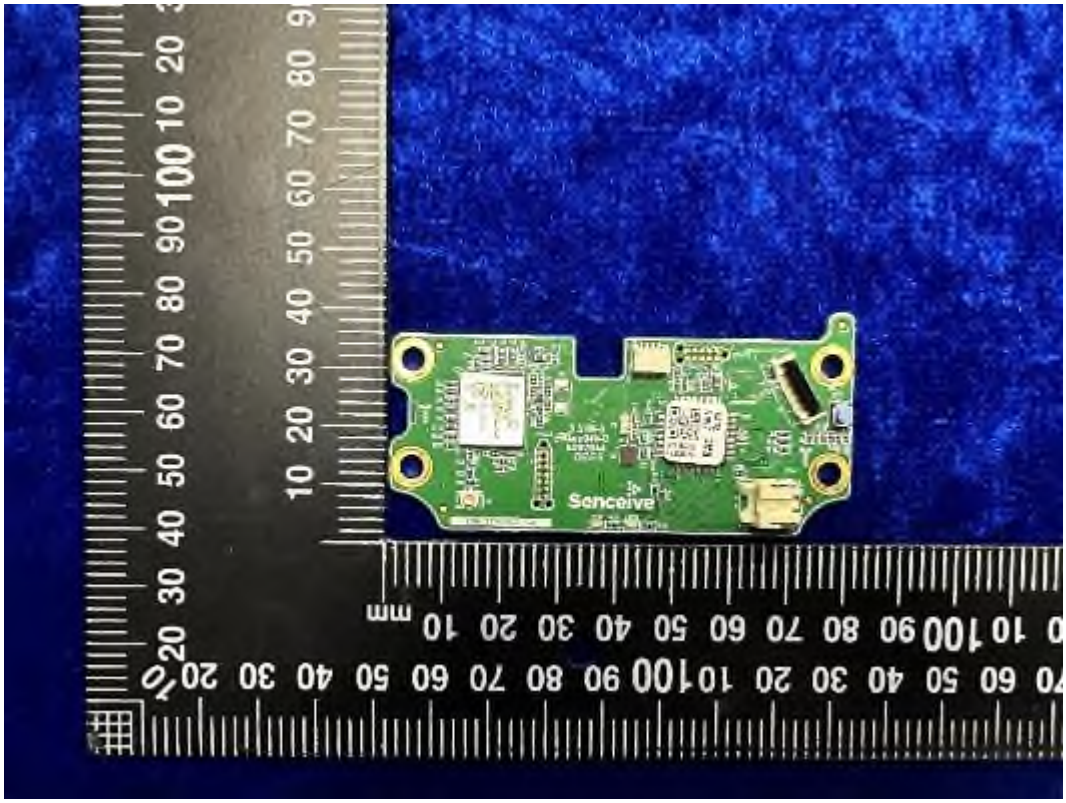
Equation 26 transposed: $E_{Spec\ limit} = \sqrt{(0.9x10^{-6} \times 377)} = 0.01842$ V/m.

And

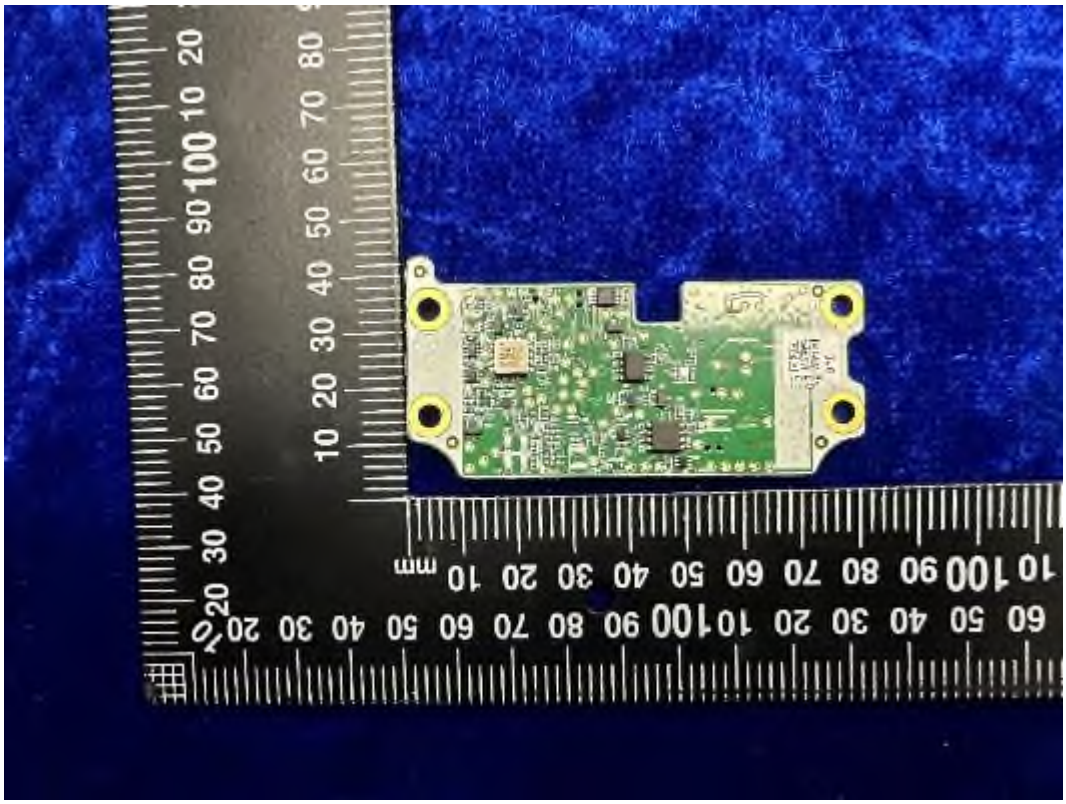
Equation 21 transposed: $E_{Log} = 20Log(0.01842) +120 = 85.3$dBµV/m @ 3m.

8 Photographs

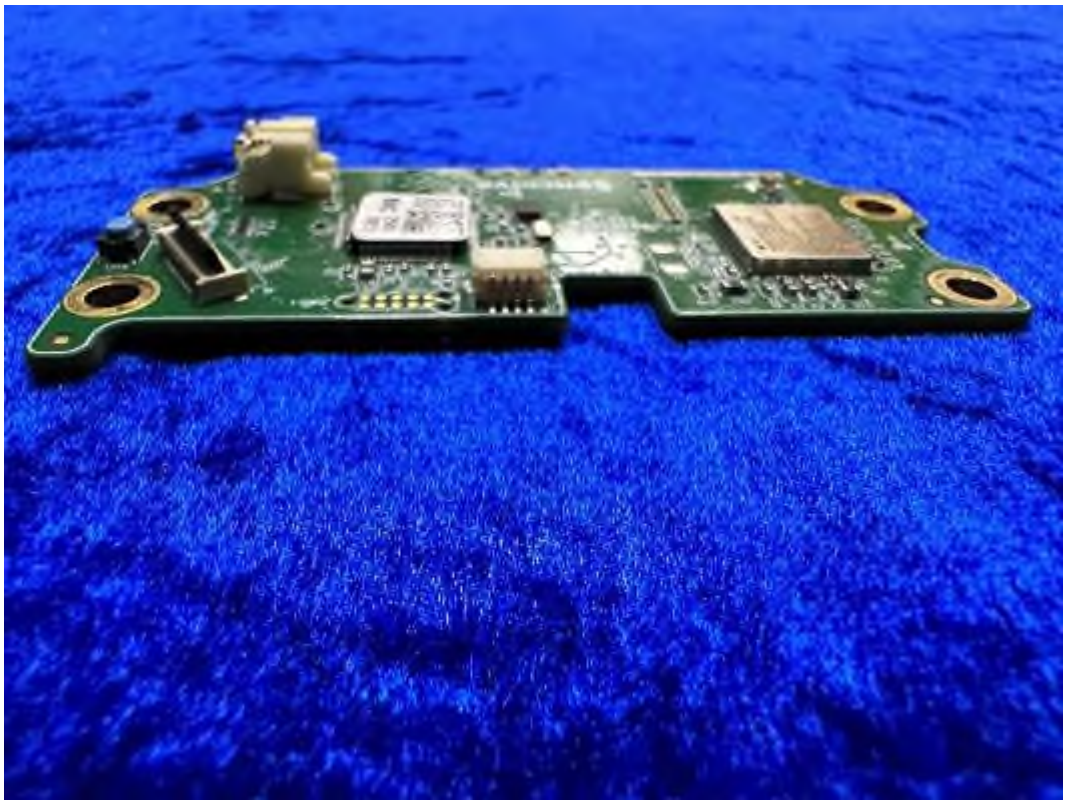
8.1 EUT Front View



8.2 EUT Reverse Angle

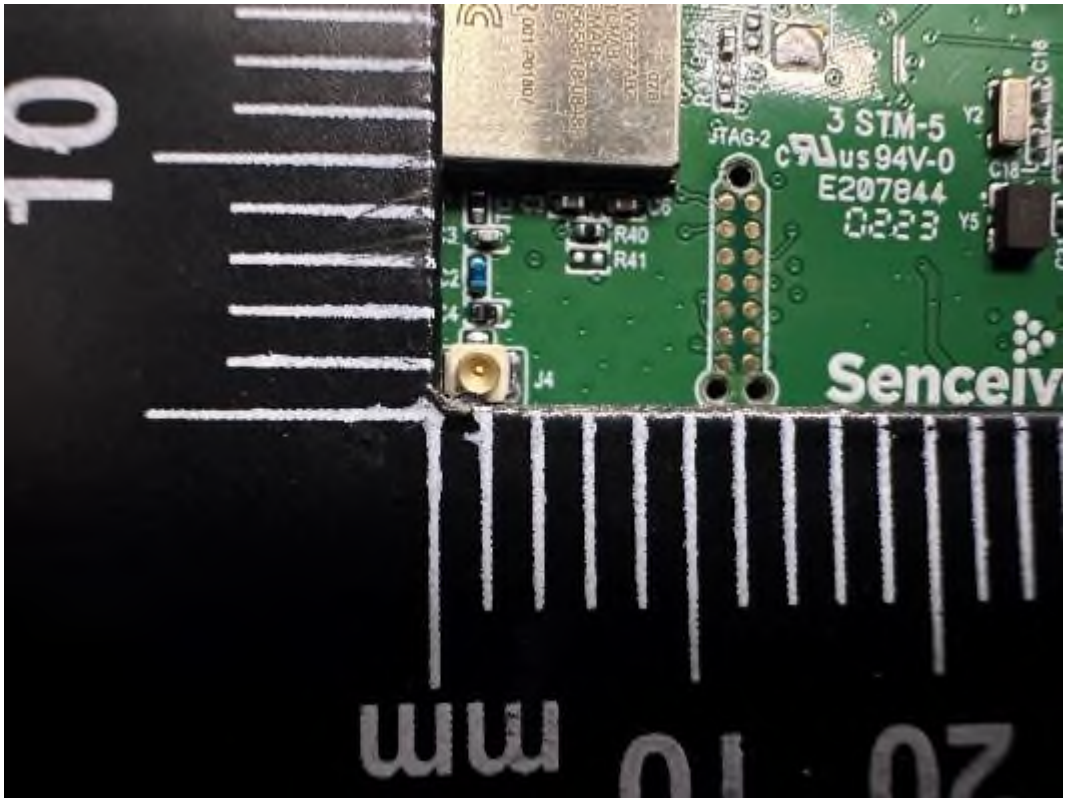


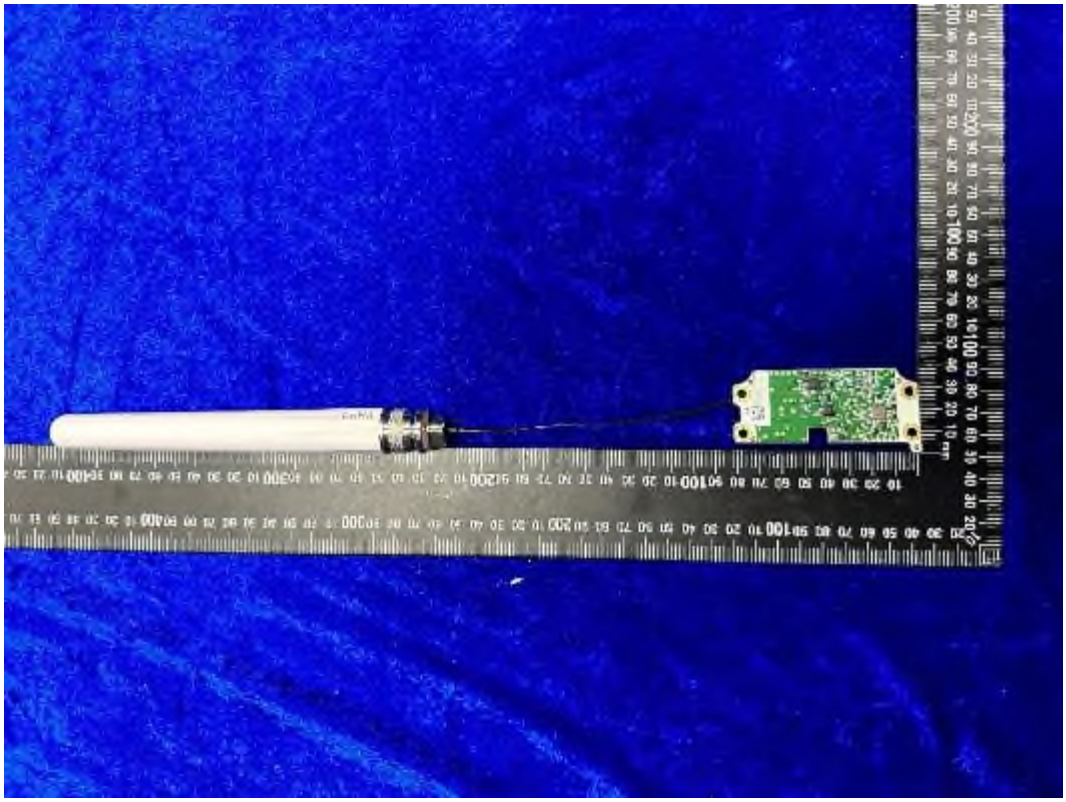
8.3 EUT Left side View

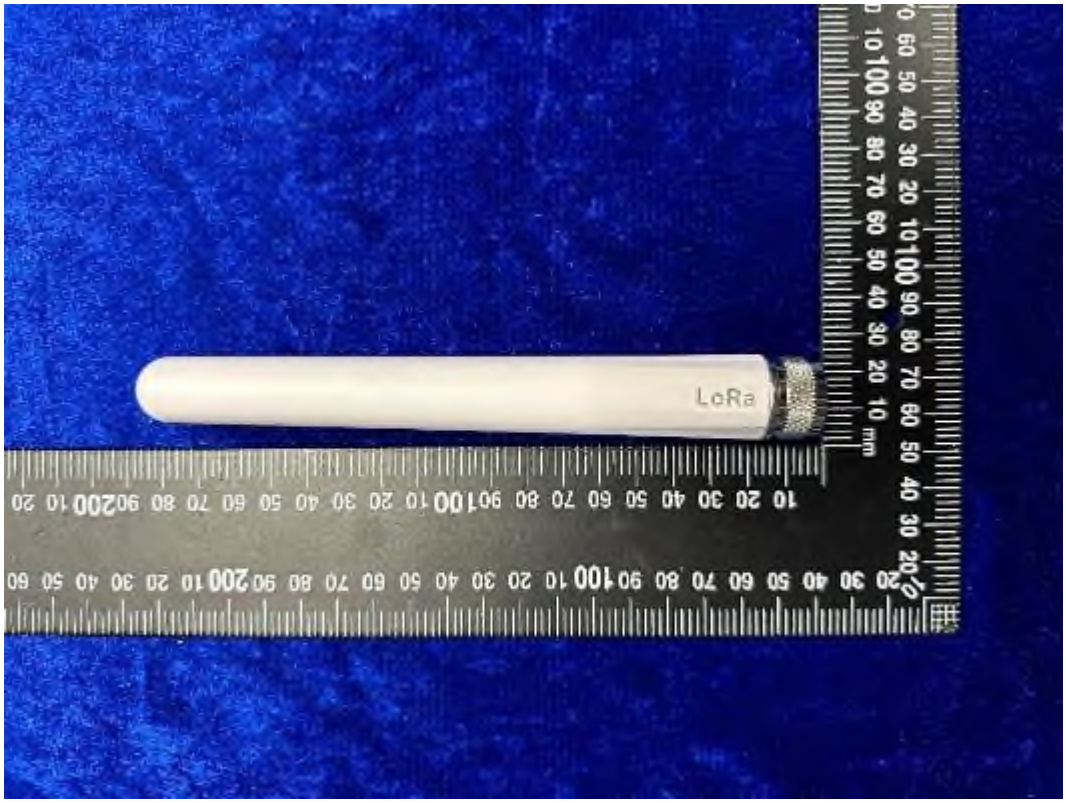


8.4 EUT Right side View

8.5 EUT Antenna Port





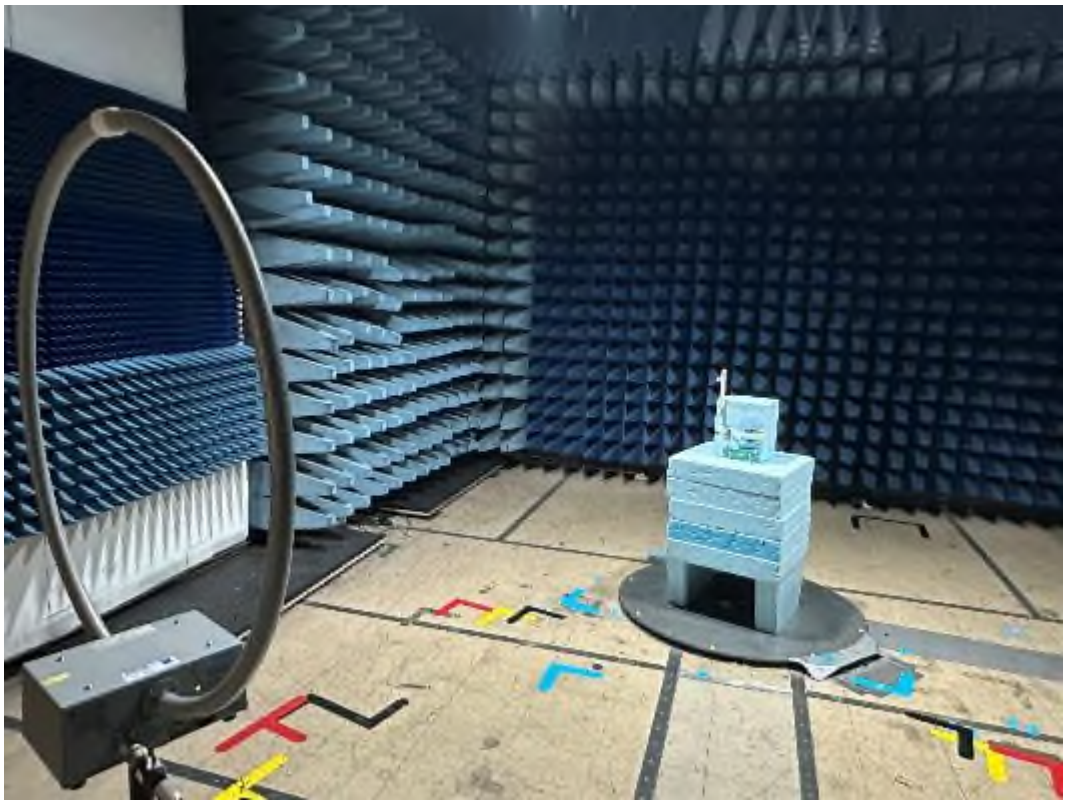

LoRa

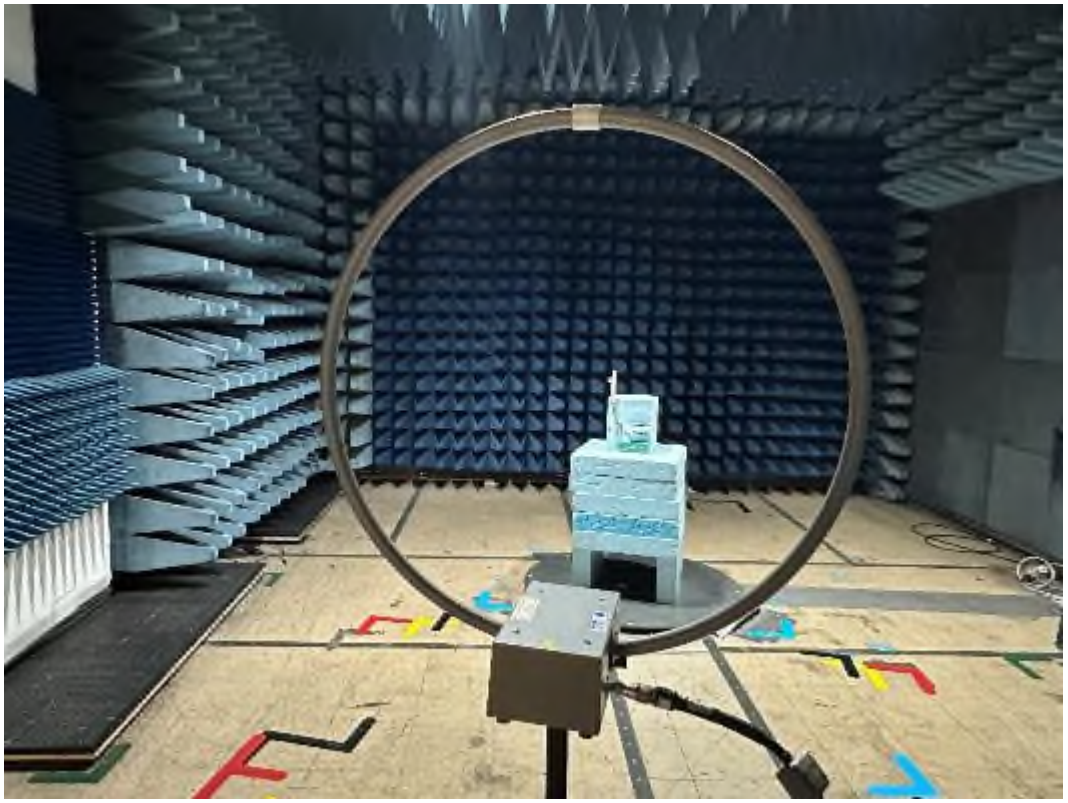

LoRa

8.6 EUT Internal photos

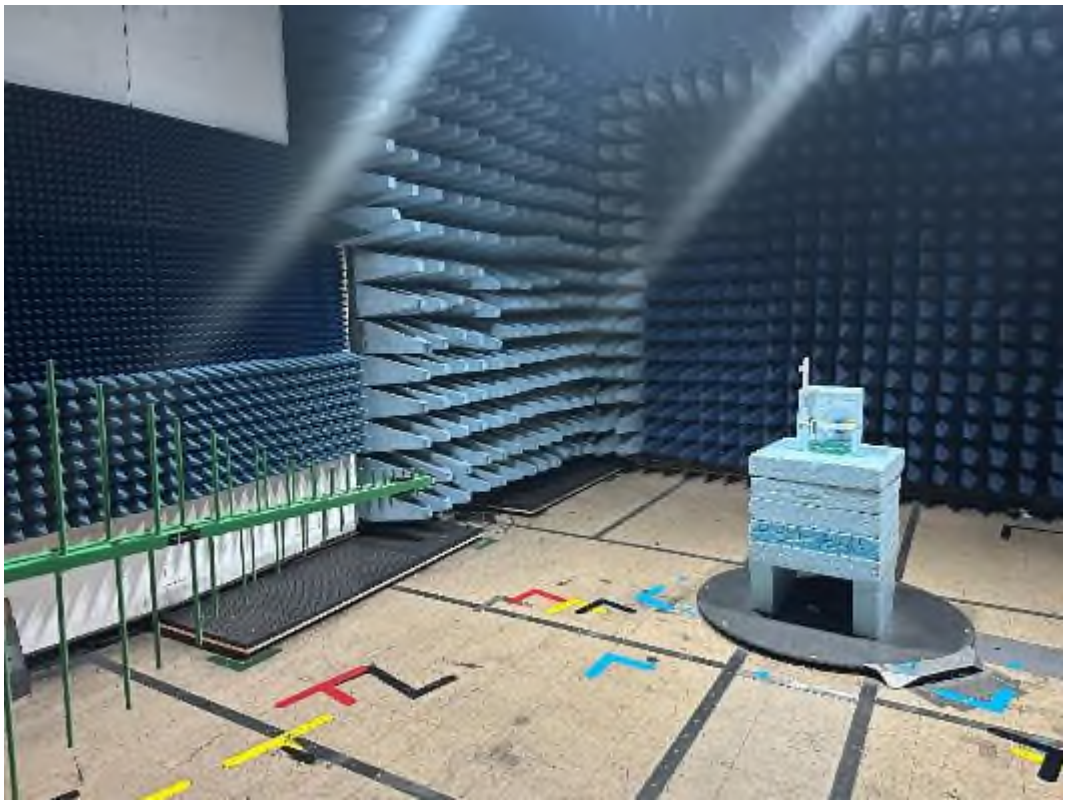
8.7 EUT ID Label

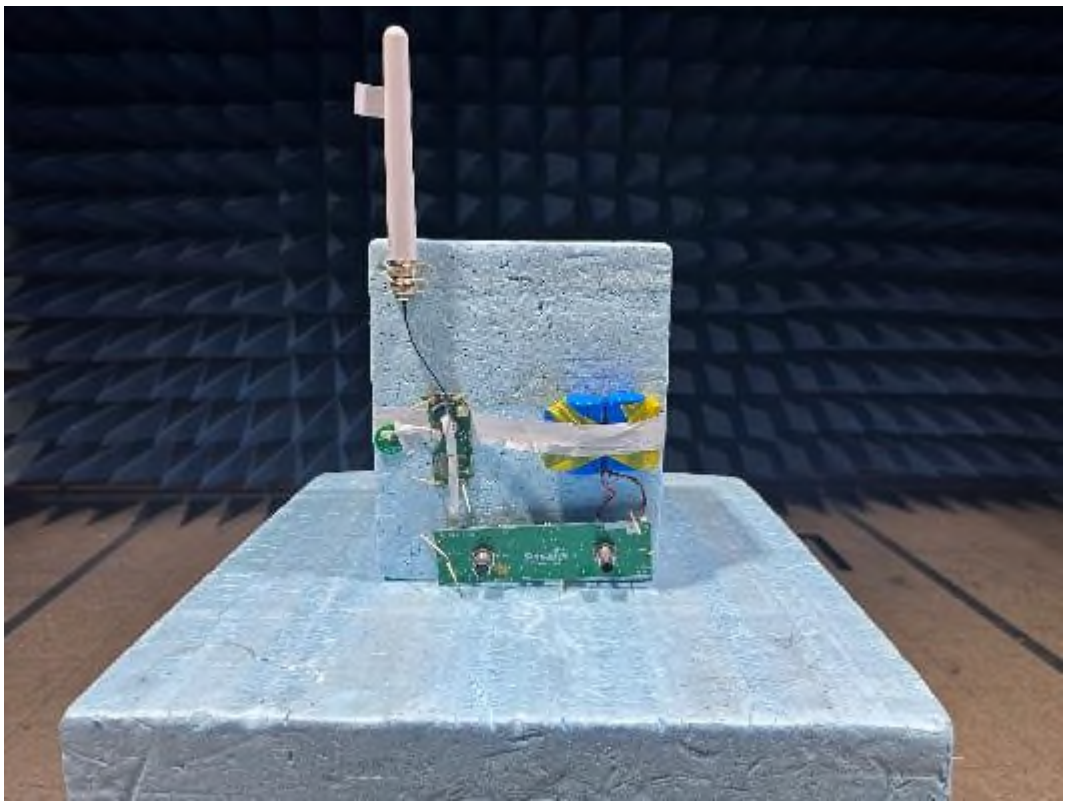
8.8 Radiated emissions 9 kHz - 30 MHz



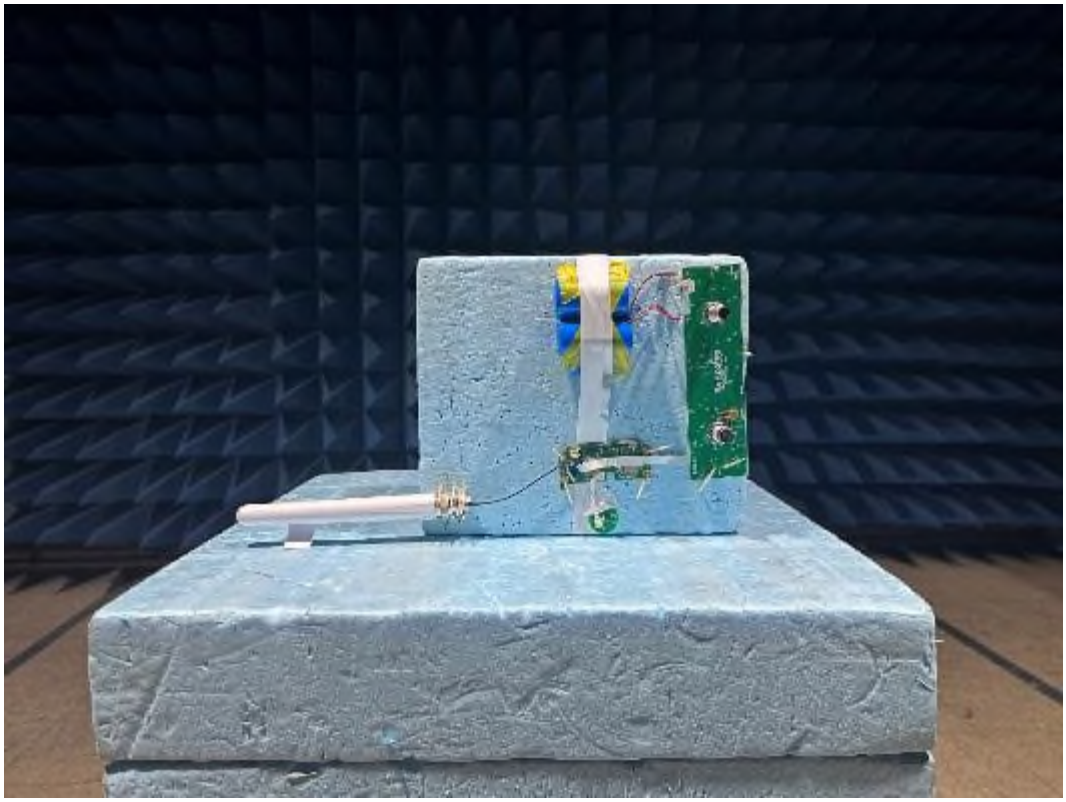


8.9 Radiated emissions 30 MHz -1 GHz

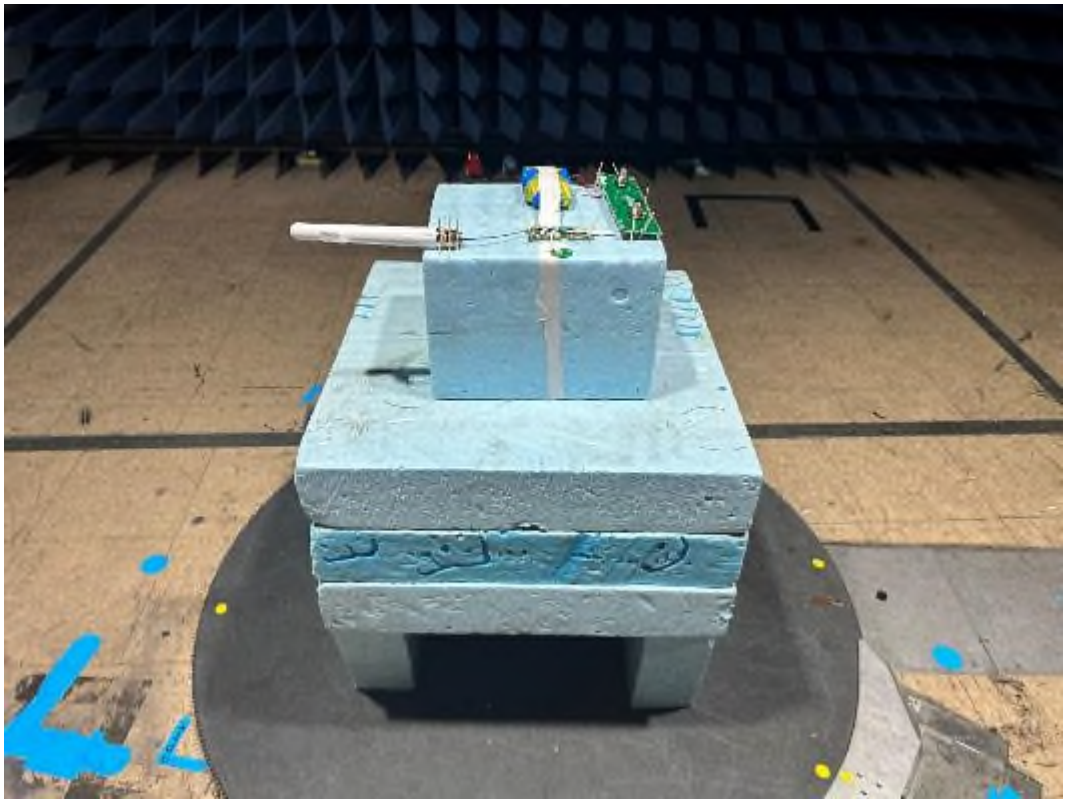




EUT Upright

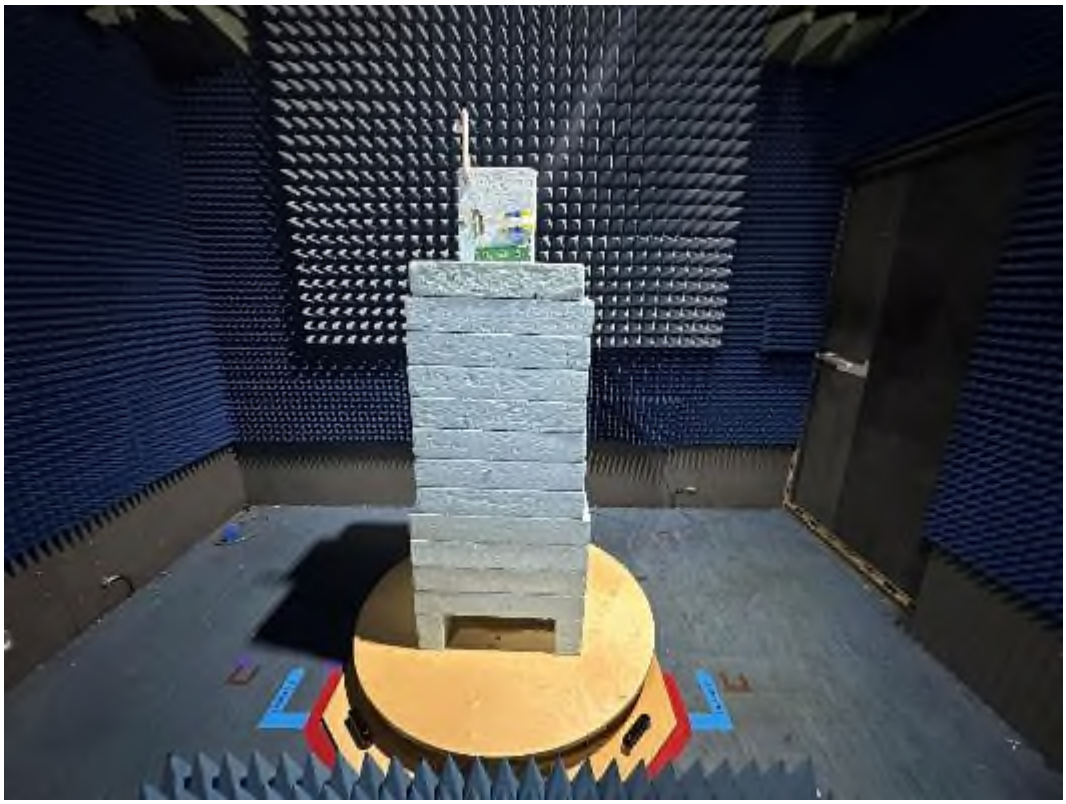


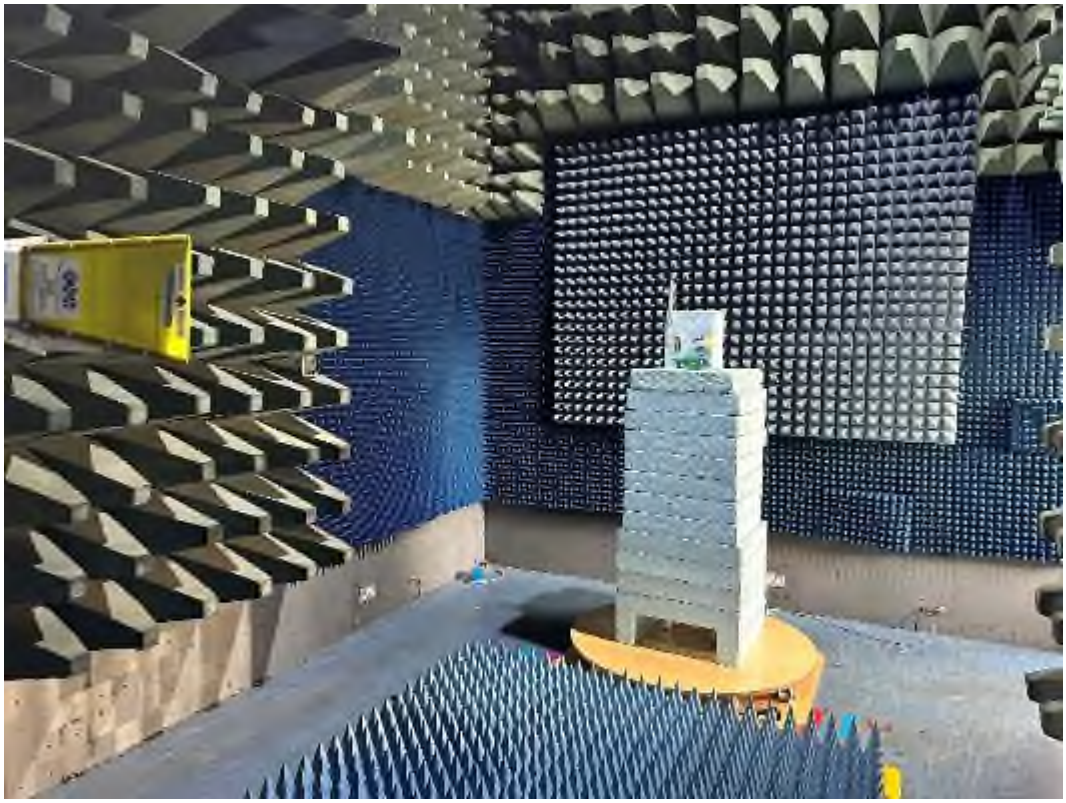
EUT Side

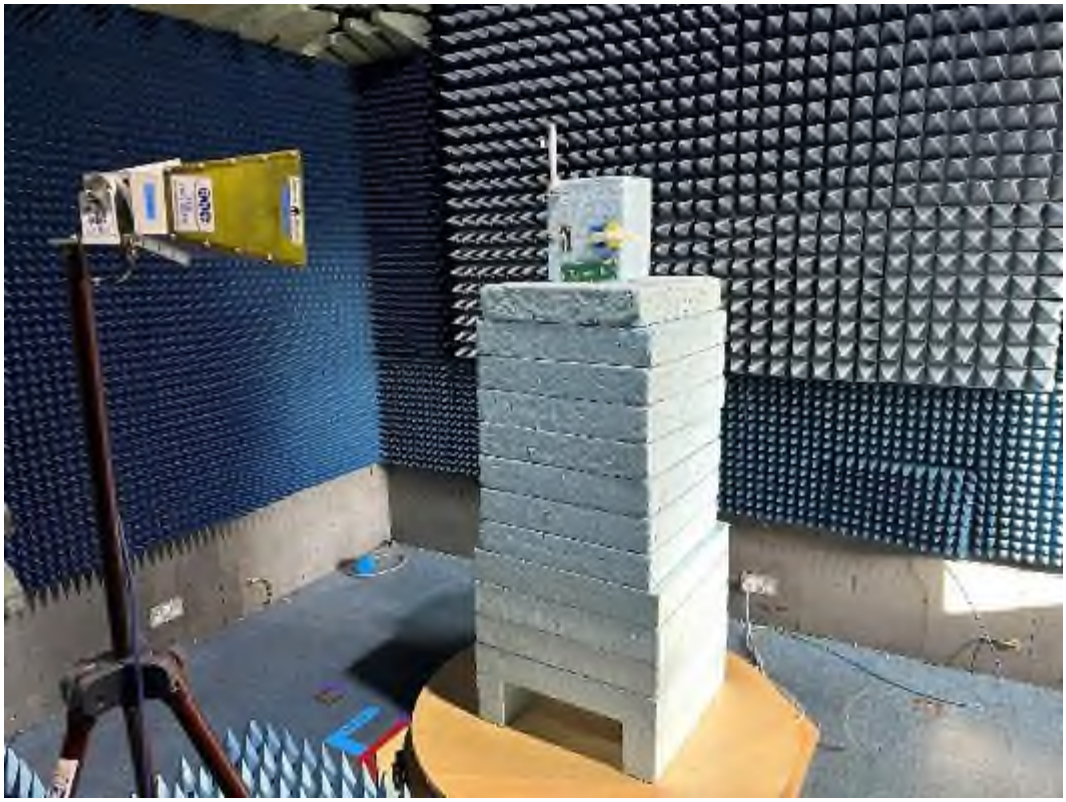


EUT Flat

8.10 Radiated emissions above 1 GHz







8.11 Radiated emission diagrams

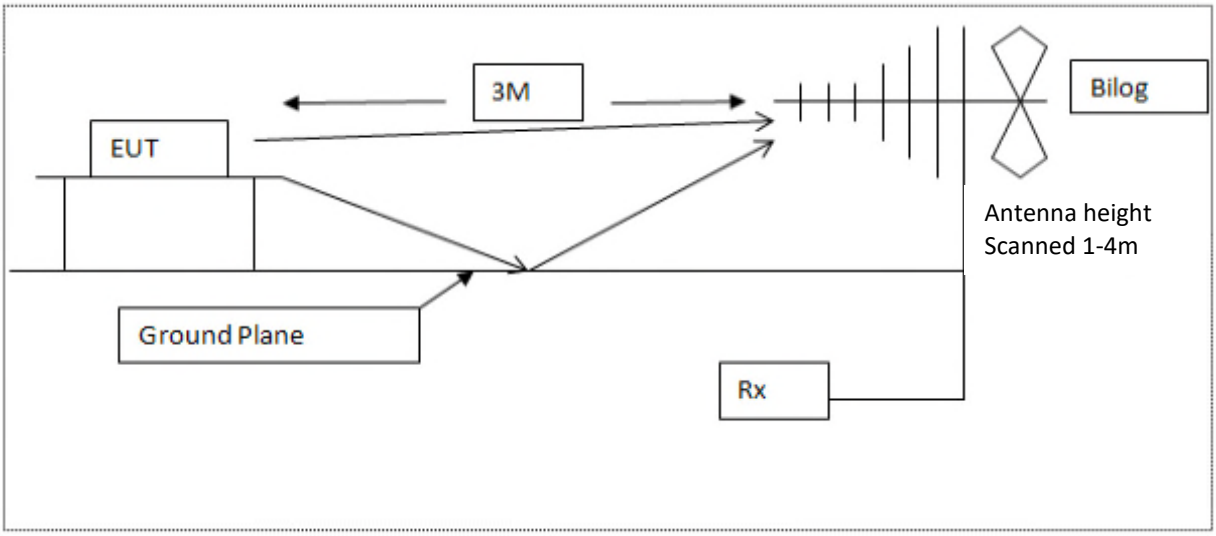


Diagram of the radiated emissions test setup 30 - 1000 MHz

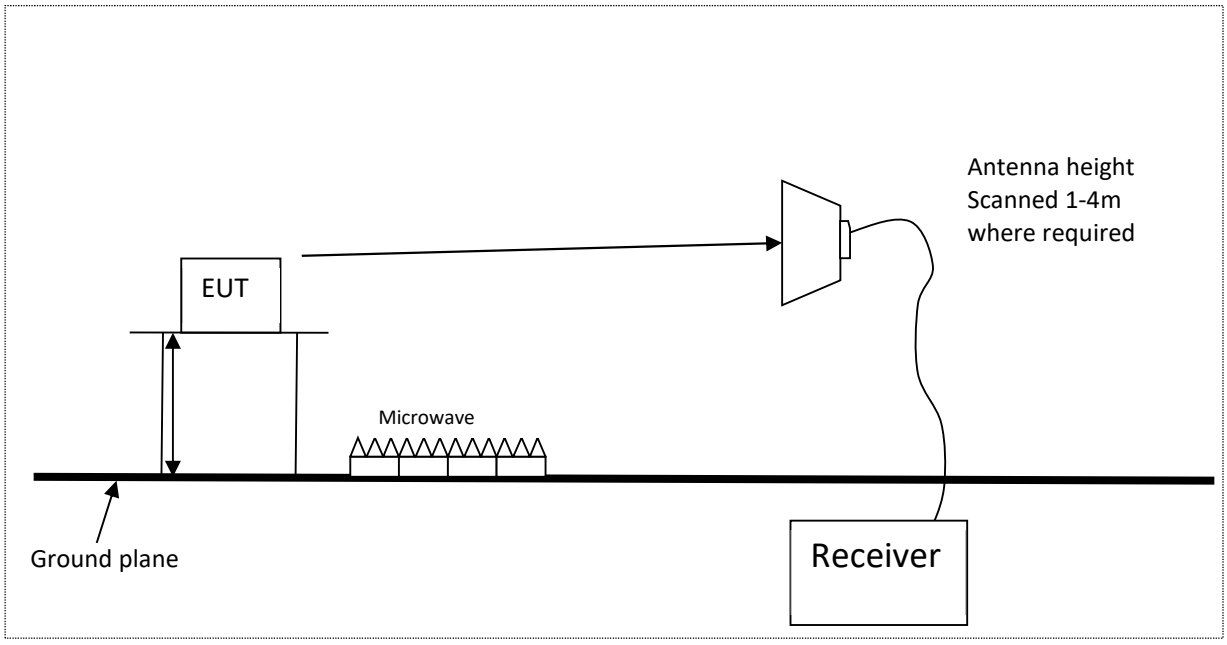


Diagram of the radiated emissions test setup above 1GHz

9 Test equipment calibration list

The following is a list of the test equipment used by Kiwa Electrical Compliance to test the unit detailed within this report. In line with our procedures, the equipment was within calibration for the period during which testing was carried out.

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	05-Jul-2023	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	21-Jun-2022	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	21-Aug-2023	12 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	15-Mar-2023	12 months
E755	N9030B	PXA Signal Analyser 3 Hz to 50 GHz	Keysight Technologies	14-Aug-2023	12 months
E834	MWX221	Cable N-Type-SMA Blue 2m	Junflon	24-Aug-2023	12 months
E904	5086-7805	Pre-Amplifier 1GHz - 26.5GHz	Hewlett Packard	03-May-2023	12 months
F307	AA18-10H	Attenuator 10dB 18GHz SMA	Atlantic Microwave	15-Mar-2023	12 months
H071	N9010B	EXA Signal Analyser 10 Hz to 44 GHz	Keysight Technologies	12-Dec-2022	24 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	28-Mar-2022	36 months
NSA-M	NSA - M	NSA - Site M	RN Electronics	29-Nov-2021	36 months
P240	290-10dB	Attenuator 10dB 18GHz	Midwest Microwave	04-Jul-2023	12 months
TMS81	6502	Antenna Active Loop	EMCO	17-Aug-2023	24 months
ZSW1	V2.5.2	Measurement Software Suite	RN Electronics	Not Applicable	

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Latitude 5490	Laptop	Dell	9VS6PQ2
2	02062023 – 2.0	I/O PCB assembly	Senceive Ltd	“12”
3	Not stated	NFC Antenna PCB assembly	Not stated	Not stated
4	ER34615	Battery	Not stated	Not stated

10.2 Kiwa Electrical Compliance supplied equipment

No Kiwa Electrical Compliance supplied equipment was used.

11 Condition of the equipment tested

In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

11.1 Modifications before test

No modifications were made before test by Kiwa Electrical Compliance.

11.2 Modifications during test

No modifications were made during test by Kiwa Electrical Compliance.

12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 654321, ISED Registration No. 5612A-4

Site C Transient Laboratory

Site D Screened Room (Conducted Immunity)

Site E Screened Room (Control Room for Site D)

Site F Screened Room (Conducted Emissions)

Site G Screened Room (Control Room for Site H)

Site H 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 654321, ISED Registration No. 5612A-2, VCCI Registration No. 4065

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 654321, ISED Registration No. 5612A-3

Site N Radio Laboratory

Site Q Fully-Anechoic Chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 654321, ISED Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

CAB identifier as issued by Innovation, Science and Economic Development Canada is UK0002
CAB identifier as issued by FCC is UK2015

13 Abbreviations and units

%	Percent
λ	Wavelength
µA/m	microAmps per metre
µV	microVolts
µW	microWatts
AC	Alternating Current
ACK	ACKnowledgement
ACP	Adjacent Channel Power
AFA	Adaptive Frequency Agility
ALSE	Absorber Lined Screened Enclosure
AM	Amplitude Modulation
Amb	Ambient
ANSI	American National Standards Institute
ATPC	Automatic Transmit Power Control
AVG	Average
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BT	BlueTooth
BLE	BlueTooth Low Energy
BW	Bandwidth
ºC	Degrees Celsius
C/I	Carrier / Interferer
CAC	Channel Availability Check
CCA	Clear Channel Assessment
CEPT	European Conference of Postal and Telecommunications Administrations
CFR	Code of Federal Regulations
CISPR	Comité International Spécial des Perturbations Radioélectriques
cm	centimetre
COFDM	Coherent OFDM
COT	Channel Occupancy Time
CS	Channel Spacing
CW	Continuous Wave
DAA	Detect And Avoid
dB	deciBels
dBµA/m	deciBels relative to 1µA/m
dBµV	deciBels relative to 1µV
dBµV/m	deciBels relative to 1µV/m
dBc	deciBels relative to Carrier
dBd	deciBels relative to dipole gain
dBi	deciBels relative to isotropic gain
dBm	deciBels relative to 1mW
dBr	deciBels relative to a maximum value
dBW	deciBels relative to 1W
DC	Direct Current
DFS	Dynamic Frequency Selection
DMO	Dynamic Modulation Order
DSSS	Direct Sequence Spread Spectrum
DTA	Digital Transmission Analyser
EIRP	Equivalent Isotropic Radiated Power
emf	electromotive force
ERC	European Radiocommunications Committee
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
EU	European Union
EUT	Equipment Under Test
FCC	Federal Communications Commission
FER	Frame Error Rate
FHSS	Frequency Hopping Spread Spectrum
FM	Frequency Modulation
FSK	Frequency Shift Keying
FSS	Fixed Satellite Service
g	Grams
GHz	GigaHertz
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
ISED	Innovation Science and Economic Development
ITU	International Telecommunications Union
KDB	Knowledge DataBase

kg	kilogram
kHz	kiloHertz
kPa	Kilopascal
LBT	Listen Before Talk
LISN	Line Impedance Stabilisation Network
LNA	Low Noise Amplifier
LNB	Low Noise Block
LO	Local Oscillator
m	metre
mA	milliAmps
max	maximum
Mbit/s	MegaBits per second
MCS	Modulation and Coding Scheme
MHz	MegaHertz
mic	Microphone
MIMO	Multiple Input, Multiple Output
min	minimum
mm	millimetres
ms	milliseconds
mW	milliWatts
NA	Not Applicable
NFC	Near Field Communications
nom	Nominal
nW	nanoWatt
OATS	Open Area Test Site
OBW	Occupied Band Width
OCW	Occupied Channel Width
OFDM	Orthogonal Frequency Division Multiplexing
OOB	Out Of Band
ppm	Parts per million
PER	Packet Error Rate
PK	Peak
PMR	Private Mobile Radio
PRBS	Pseudo Random Bit Sequence
PRF	Pulse Repitition Frequency
PSD	Power Spectral Density
PSU	Power Supply Unit
pW	picoWatts
QAM	Quadrature Amplitude Modulation
QP	Quasi Peak
QPSK	Quadrature Phase Shift Keying
RBW	Resolution Band Width
RED	Radio Equipment Directive
R&TTE	Radio and Telecommunication Terminal Equipment
Ref	Reference
RF	Radio Frequency
RFC	Remote Frequency Control
RFID	Radio Frequency IDentification
RLAN	Radio Local Area Network
RMS	Root Mean Square
RNSS	Radio Navigation Satellite Service
RSL	Received Signal Level
RSSI	Received Signal Strength Indicator
RTP	Room Temperature and Pressure
RTPC	Remote Transmit Power Control
Rx	Receiver
s	Seconds
SINAD	Signal to Noise And Distortion
SRD	Short Range Device
Tx	Transmitter
UKAS	United Kingdom Accreditation Service
UKCA	United Kingdom Conformity Assessed
UKRER	United Kingdom Radio Equipment Regulations
UHF	Ultra High Frequency
U-NII	Unlicensed National Information Infrastructure
USB	Universal Serial Bus
UWB	Ultra Wide Band
V	Volts
V/m	Volts per metre
VBW	Video Band Width
VHF	Very High Frequency
VSAT	Very Small Aperture Terminal
W	Watts

====== END OF TEST REPORT ======