QAI Laboratories
3980 North Fraser Way
Burnaby, BC, V5J 5K5 Canada

TEST REPORT

Report Reference Number:	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev1.1
Total Number of Pages:	67
Date of Issue:	December 18, 2023

EMC Test Laboratory:	**QAI Laboratories Ltd.**
Address:	3980 North Fraser Way, Burnaby, BC, V5J 5K5 Canada
Phone:	(604) 527-8378
Fax:	(604) 527-8368

Laboratory Accreditations (per ISO/IEC 17025:2017)

ACCREDITED
CERT #3657.02

This report has been completed in accordance with the requirements of ISO/IEC 17025. Test results contained in this report are within QAI Laboratories ISO/IEC 17025 accreditations. QAI Laboratories authorizes the applicant to reproduce this report, provided it is reproduced in its entirety and for the use by the company's employees only.

Manufacturer:	**JSF Technologies Inc.**
Address:	6582 Bryn Rd. Victoria BC, Canada V8M 1X6
Equipment Tested:	**WP6 - Wireless Platform 6**
Model Number(s):	WP6
FCC ID:	SFIWP6
ISED ID:	5301A-WP6

REVISION HISTORY

Date	Report Number	Details	Author's Initials
September 19, 2023	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev0.0	Initial draft	JS
September 29, 2023	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev0.1	Draft	AH
November 1, 2023	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev0.2	Draft	AH
November 9, 2023	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev1.0	Final	AH
December 18, 2023	E11168-2301_JSF_Technologies_WP6(LoRa)_FCC-ISED_Rev1.1	Revision	AH
All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.			

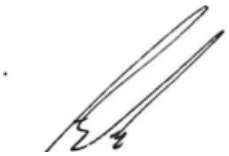
REPORT AUTHORIZATION

The data documented in this report is for the test equipment provided by the manufacturer and the results relate only to the item tested. The tests were conducted on the sample equipment as requested by the manufacturer for the purpose of demonstrating compliance with the standards outlined in Section I of this report as agreed upon by the Manufacturer under the quote 23TW08161R1.

The Manufacturer is responsible for the tested product configurations, continued product compliance, and for the appropriate auditing of subsequent products as required.

This report may comprise a partial list of tests that are required for FCC and ISED. A Declaration of Conformity can only be produced by the manufacturer. This is to certify that the following report is true and correct to the best of our knowledge.

This report is the confidential property of the client addressed. The report may only be reproduced in full. Publication of extracts from this report is not permitted without written approval from QAI. Any liability attached thereto is limited to the fee charged for the individual project file referenced. The results of this report pertain only to the specific items tested, calibrated, or sampled. Unless specifically stated or identified otherwise, QAI has utilized a simple acceptance rule to make conformity decisions on testing results contained in this report as applicable.



Testing Performed by
Alec Hope
Senior RF/EMC Engineer

Report Prepared by
Jeffrey Simon
RF/EMC Technologist

Report Reviewed by
Parminder Singh
Vice president of EMC

QAI FACILITIES

British Columbia

QAI Laboratories Inc.
Main Laboratory/Headquarters
3980 North Fraser Way,
Burnaby, BC V5J Canada

Ontario

QAI Laboratories Inc.
25 Royal Group Crescent #3,
Vaughan,
ON L4H 1X9 Canada

Virginia

QAI Laboratories Ltd.
1047 Zachary Taylor Hwy,
Suite A Huntly,
VA 22640 USA

China

QAI Laboratories Ltd
Room 408, No. 228, Jiangchang 3rd Road Jing'An District,
Shanghai, China 200436

California

QAI Laboratories Ltd.
8385 White Oak Avenue Rancho
Cucamonga, CA 91730 USA

Oklahoma

QAI Laboratories Ltd.
5110 North Mingo Road
Tulsa, OK 74117, USA

Miami

QAI Laboratories Ltd.
8148 NW 74th Ave,
Medley, FL 33166 USA

South Korea

QAI Laboratories Ltd
#502, 8, Sanbon-ro 324beon-gil
Gunpo-si, Gyeonggi-do, 15829,
South Korea

QAI EMC ACCREDITATION

QAI EMC is your one-stop regulatory compliance partner for electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Products are tested to the latest and applicable EMC/EMI requirements for domestic and international markets. QAI EMC goes above and beyond being a testing facility—we are your regulatory compliance partner. QAI EMC has the capability to perform RF Emissions and Immunity for all types of electronics manufacturing including Industrial, Scientific, Medical, Information Technology, Telecom, Wireless, Automotive, Marine and Avionics.

EMC Laboratory Location	FCC Designation (3m SAC)	IC Registration (3m SAC)	A2LA Certificate
Burnaby, BC, Canada	CA9543	9543A	3657.02

EMC Facility Burnaby BC, Canada

TABLE OF CONTENTS

REVISION HISTORY 2
REPORT AUTHORIZATION 2
QAI FACILITIES 3
QAI EMC ACCREDITATION 3

1 EXECUTIVE SUMMARY 8

1.1 PURPOSE 8
1.2 SCOPE 8
1.3 SUMMARY OF RESULTS 9

2 GENERAL INFORMATION 10

2.1 PRODUCT DESCRIPTION 10
2.2 ENVIRONMENTAL CONDITIONS 12
2.3 MEASUREMENT UNCERTAINTY 12
2.4 WORST TEST CASE 13
2.5 SAMPLE CALCULATIONS OF EMISSIONS DATA 13

3 DATA & TEST RESULTS 14

3.1 ANTENNA REQUIREMENTS 14
3.2 RF PEAK OUTPUT POWER (CONDUCTED & RADIATED) 15
3.3 POWER SPECTRAL DENSITY 19
3.4 6 DB BANDWIDTH 23
3.5 OUT-OF-BAND EMISSIONS (BAND EDGE) 27
3.6 FREQUENCY STABILITY 30
3.7 UNINTENTIONAL RADIATED EMISSIONS 37
3.7.1 150kHz to 30 MHz 39
3.7.2 30 MHz to 1 GHz 45
3.7.3 1 GHz to 6 GHz 51
3.7.4 30 MHz to 1 GHz 57

APPENDIX A: TEST SETUP PHOTOS 63

APPENDIX B: ABBREVIATIONS 67

LIST OF FIGURES

Figure 1: EUT 10
Figure 2: Peak Output Power – LoRa SF7, Low channel 902.5MHz 16
Figure 3: Peak Output Power – LoRa SF7, Mid channel 915.25MHz 16
Figure 4: Peak Output Power – LoRa SF7, High channel 925.75MHz 17
Figure 5: Peak Output Power – LoRa SF12, Low channel 902.5MHz 17
Figure 6: Peak Output Power – LoRa SF12, Mid channel 915.25MHz 18
Figure 7: Peak Output Power – LoRa SF12, High channel 925.75MHz 18
Figure 8: Power spectral density – LoRa SF7, Low channel 902.5MHz 20
Figure 9: Power spectral density – LoRa SF7, Mid channel 915.25MHz 20
Figure 10: Power spectral density – LoRa SF7, High channel 925.75MHz 21
Figure 11: Power spectral density – LoRa SF12, Low channel 902.5MHz 21
Figure 12: Power spectral density – LoRa SF12, Mid channel 915.25MHz 22
Figure 13: Power spectral density – LoRa SF12, High channel 925.75MHz 22
Figure 14: 6 dB Bandwidth – LoRa SF7, Low channel, 902.5 MHz 24
Figure 15: 6 dB Bandwidth – LoRa SF7, Mid channel, 915.25 MHz 24
Figure 16: 6 dB Bandwidth – LoRa SF7, High channel, 925.75 MHz 25
Figure 17: 6 dB Bandwidth – LoRa SF12, Low channel, 902.5 MHz 25
Figure 18: 6 dB Bandwidth – LoRa SF12, Mid channel, 915.25 MHz 26
Figure 19: 6 dB Bandwidth – LoRa SF12, High channel, 925.75 MHz 26
Figure 20: Band Edge – LoRa SF7, Low channel, 902.5 MHz 28
Figure 21: Band Edge – LoRa SF7, High channel, 925.75 MHz 28
Figure 22: Band Edge – LoRa SF12, Low channel, 902.5 MHz 29
Figure 23: Band Edge – LoRa SF12, High channel, 925.75 MHz 29
Figure 24: Frequency stability at -40 °C – LoRa SF7, Low channel, 902.5 MHz 31
Figure 25: Frequency stability at -40 °C – LoRa SF12, Low channel, 902.5 MHz 31
Figure 26: Frequency stability at -40 °C – LoRa SF7, High channel, 925.75 MHz 32
Figure 27: Frequency stability at -40 °C – LoRa SF12, High channel, 925.75 MHz 32
Figure 28: Frequency stability at 80 °C – LoRa SF7, Low channel, 902.5 MHz 33
Figure 29: Frequency stability at 80 °C – LoRa SF12, Low channel, 902.5 MHz 33
Figure 30: Frequency stability at 80 °C – LoRa SF7, High channel, 925.75 MHz 34
Figure 31: Frequency stability at 80 °C – LoRa SF12, High channel, 925.75 MHz 34
Figure 32: Frequency stability at 10.4V – LoRa SF7, Low channel, 902.5 MHz 35
Figure 33: Frequency stability at 10.4V – LoRa SF12, Low channel, 902.5 MHz 35
Figure 34: Frequency stability at 10.4V – LoRa SF7, High channel, 925.75 MHz 36
Figure 35: Frequency stability at 10.4V – LoRa SF12, High channel, 925.75 MHz 36
Figure 36: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 Low channel. 39
Figure 37: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 Low channel. 39
Figure 38: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 Mid channel. 40
Figure 39: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 Mid channel. 40
Figure 40: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 High channel. 41
Figure 41: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 High channel. 41
Figure 42: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 Low channel. 42
Figure 43: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 Low channel. 42
Figure 44: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 Mid channel. 43
Figure 45: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 Mid channel. 43
Figure 46: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 High channel. 44
Figure 47: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 High channel. 44
Figure 48: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel. 45
Figure 49: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel. 46
Figure 50: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 High channel. 47
Figure 51: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel. 48
Figure 52: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel. 49
Figure 53: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 High channel. 50
Figure 54: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel. 51
Figure 55: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel. 52
Figure 56: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 High channel. 53
Figure 57: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel. 54
Figure 58: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel. 55
Figure 59: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 High channel. 56

Figure 60: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel. 57
Figure 61: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel. 58
Figure 62: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 High channel. 59
Figure 63: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel. 60
Figure 64: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel. 61
Figure 65: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 High channel. 62
Figure 66: Conducted RF Measurement Setup 63
Figure 67: Radiated Measurement Setup, < 30 MHz, Antenna 1 63
Figure 68: Radiated Measurement Setup, < 30 MHz, Antenna 2 64
Figure 69: Radiated Measurement Setup, 30 MHz to 1 GHz, Antenna 1 64
Figure 70: Radiated Measurement Setup, 30 MHz to 1 GHz, Antenna 2 65
Figure 71: Radiated Measurement Setup, > 1 GHz, Antenna 1 65
Figure 72: Radiated Measurement Setup, > 1 GHz, Antenna 2 66
Figure 73: Frequency stability test with respect to temperature. 66

LIST OF TABLES

Table 1: Applicable test standards and descriptions 9
Table 2: Sample Quasi-Peak Correction Data – Radiated 13
Table 3: Sample Quasi-Peak Correction Data - Conducted Emissions 13
Table 4: Sample Average Correction Data- Conducted Emissions 13
Table 5: RF Peak Output Power 15
Table 6: 6 dB Bandwidth Results 23
Table 7: Band Edge Results....27
Table 8: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 1, LoRa SF12 Low channel. 45
Table 9: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 1, LoRa SF12 Mid channel. 46
Table 10: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 1, LoRa SF12 channel High channel....47
Table 11: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 Low channel....48
Table 12: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 Mid channel. 49
Table 13: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 High channel. 50
Table 14: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 Low channel. 51
Table 15: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 Mid channel. 52
Table 16: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 High channel. 53
Table 17: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 Low channel. 54
Table 18: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 Mid channel. 55
Table 19: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 High channel. 56
Table 20: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 Low channel. 57
Table 21: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 Mid channel. 58
Table 22: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 High channel. 59
Table 23: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 Low channel. 60
Table 24: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 Mid channel. 61
Table 25: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 High channel. 62

1 EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to demonstrate and document the compliance of WP6 - Wireless Platform 6 as per Sections 1.2 and 1.3.

1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 23TW08161R1:

- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart B – Unintentional Radiators
- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators
- **RSS-Gen Issue 5 –** General Requirements for Compliance of Radio Apparatus.
- **RSS-102 Issue 5** – Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands).
- **RSS-210 Issue 10 –** License-Exempt Radio Apparatus: Category I Equipment.
- **RSS-247 Issue 3 –** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices.
- **ICES-003 Issue 7 –** Information Technology Equipment (including Digital Apparatus)

1.3 Summary of Results

The following testing was performed pursuant to FCC Title 47 Part 15 and Industry Canada ICES-003 to demonstrate the testimony to "FCC, IC, & CE" mark Electromagnetic Compatibility testing for the product.

No.	Test	Applicable Standard	Test Method	Result
1	Antenna Requirement	RSS-Gen Issue FCC CFR 15.	KDB 558074 D01	Complies
2	RF Peak Output Power	RSS-247 Issue 3 FCC CFR 15.247	KDB 558074 D01 ANSI C63.10	Complies
3	Power Spectral Density (PSD)	RSS-247 Issue 3 FCC CFR 15.247	KDB 558074 D01 ANSI C63.10	Complies
4	6 dB Bandwidth	RSS-247 Issue 3 FCC CFR 15.247	KDB 558074 D01 ANSI C63.10	Complies
5	Out of Band Emissions	RSS-247 Issue 3 FCC CFR 15.247	KDB 558074 D01 ANSI C63.10	Complies
6	Frequency Stability	RSS-Gen FCC CFR 15.215	KDB 558074 D01 ANSI C63.10	Complies
7	Unintentional Radiated Emissions	ICES-003 Issue FCC CFR 15.33 FCC CFR 15.109 FCC CFR 15.209	KDB 558074 D01 ANSI C63.10	Complies

Table 1: Applicable test standards and descriptions

Note: The gain of the antenna(s) is provided by the client to measure or calculate test results and is not independently measured by QAI.

2 GENERAL INFORMATION

2.1 Product Description

The information provided in this section is for the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment needed to perform the tests as a complete system.

Figure 1: EUT

Equipment Under Test (EUT)

Equipment	WP6 - Wireless Platform 6
Description	The WP6 is a radio for push button activated solar powered LED assembly flasher to use primarily in crosswalk and related traffic warning applications.
Manufacturer	JSF Technologies Inc.
Model No.	WP6
Serial No.	Sample 1
Clock frequencies tuned upon within the EUT: Highest frequency generated within the EUT:	32 kHz, 32MHz 928 MHz

Equipment Under Test (EUT) – RF Information

RF device type	**Digital Transmission System (DTS)**
Model No. (HVIN)	WP6
Operating frequency	902MHz to 927.25 MHz
Number of available channels/Transmitter	16 Channels, 500 kHz bandwidth (LoRa).
Output Power/Transmitter	LoRa: 18.5dBm
Modulation type	LoRa
Test Channels (L, M, H)	LoRa: 902.5 MHz, 915.25 MHz, 925.75 MHz
Data Rate	21875 bps SF7, 1171.88 bps SF12
Adaptive	No
Geo-location-capable	No
Number of antennas	2
Antenna 1 type & gain	1/4 Wave, Chrome, Mobile Ant, 0dBi, LM Hole Mount.
Antenna 2 type & gain	Larson Q cone, 3.5"- Hinged-whip antenna, 2.5dBi

Notes: None.

Equipment Under Test (EUT) – General Information

Tested as	Table-top
Dimensions	WP6 Module case: 22 x 9.6 x 4 cm, Solar Enclosure: 78.4 x 33.7 x 11.5 cm
Declared operating temperature range:	-40C to +60C
Input power	20V Solar Input, 12-15V SLA Battery Input, 4A Battery load output maximum.
Grounded	No
Device use	Fixed Location – Physically secured and not easily moved.

Notes: None.

Test Modes

Test	Transmitter State	Power
1	On – LoRa Modulated, SF7	12V, battery supplied
2	On – LoRa Modulated, SF12	12V, battery supplied
3	Off – Receive Mode	12V, battery supplied

Auxiliary Manufacturer Supplied Equipment

Equipment	Manufacturer	Product Description	Model No.
Aux 1	Interstate Batteries	12V Battery	HSL1125

2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	QAI Burnaby – Indoors
Temperature	25 °C
Relative Humidity	53% RH

2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1.5 x 10-5 MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1ºC
Humidity	±5 %
DC and low frequency voltages	±3 %

2.4 Worst Test Case

Worst-case orientation was determined during the preliminary testing. The final radiated emissions were performed in the worst-case orientation.

2.5 Sample Calculations of Emissions Data

Radiated and conducted emissions were performed using EMC32 software developed by Rohde & Schwarz. Transducer factors such as antenna factors, cable losses and amplifier gains were stored in the test templates which are used to perform the emissions measurements. After the test is finished, data is generated from the EMC32 consisting of product details, emission plots and final data tables as shown below.

Frequency (MHz)	Q-Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. Ht. (cm)	Pol	Turntable Position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
42.663900	33.0	1000.000	120.000	100.0	H	70.0	13.2	7.5	40.5

Table 2: Sample Quasi-Peak Correction Data – Radiated

Quasi-Peak reading shown in the table above is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

Or

Corr.(dB) = Antenna factor + Cable Loss - Amp gain (if pre-amplifier was used)

The final Quasi peak reading shown in the data is calculated by the software using following equation:

Corrected Quasi-Peak (dBµV/m) = Raw Quasi-Peak Reading + Antenna factor + Cable loss

To obtain the final Quasi-Peak or Average reading during power line conducted emissions, transducer factors are included in the final measurement as shown below.

Frequency (MHz)	Q-Peak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	44.3	1000.000	9.000	GND	0.6	21.7	66.0

Table 3: Sample Quasi-Peak Correction Data - Conducted Emissions

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	27.2	1000.000	9.000	GND	0.6	28.8	56.0

Table 4: Sample Average Correction Data- Conducted Emissions

Quasi Peak or Average reading shown in the preceding table is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

The final Quasi-peak or Average reading shown in the data is calculated by the software using following equation:

Corr. Quasi-Peak/Average Reading (dBµV) = Raw Quasi-Peak/Average Reading + Antenna factor + Cable loss

The allowable margin from the limits, as per the standards, were calculated for both radiated and conducted emissions:

Margin(dB) = Limit – Quasi-Peak or Average reading

3 DATA & TEST RESULTS

3.1 Antenna Requirements

Date Performed: August 24, 2023

Test Standard: FCC CFR 47 Part 15.203
IC RSS-Gen Issue 7 Section 7.1.2

Test Method: ANSI C63.10:2013

Modifications: None

Final Result: Complies

Applicable Regulations:

The purpose of this requirement is to make certain that no other antenna, except for that provided by the responsible party, shall be used with the Equipment-Under-Test (EUT) as defined in Section 1.1.

"An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited." … "the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in the Part are not exceeded."

Data:

Ant.	Manufacturer	Part Number	Type	Connection	Max Gain (dBi)
1	Linx	ANT-916-CW-HWR-ccc	Hinged Whip	SMA	1.2
2	Larsen	Q800	Whip	SMA	2

Note 1: Antenna gain provided by manufacturer.
Note 2: Product will be professionally installed with no user access after installation.

3.2 RF Peak Output Power (Conducted)

Date Performed: September 7, 2023

Test Standard: FCC CFR 47 Part 15.247 (b)(3)
IC RSS-247 Issue 3

Test Method: FCC KDB 558074 D01 DTS Measurement Guidance V04 & ANSI C63.10:2013
Span = 5 MHz, RBW = 1 MHz, VBW = 2 MHz
Trace stabilization time: 3.5 minutes

Modifications: None.

Final Result: Complies

Applicable Regulation:

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one-Watt limit can be based on a measurement of the maximum conducted output power.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per FCC KDB 558074 D01 & ANSI C63.10:2013 DTS Measurement Guidance V04. The spectrum analyser was set as follows:

Measurement Data and Plots:

Modulation scheme	Carrier Frequency (MHz)	Raw Peak (dBm)	Correction Factor[1] (dB)	Corrected Peak Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)	Results
LoRa SF7	902.5	3.42	10.07	13.49	30	16.51	Complies
LoRa SF7	915.25	2.93	10.08	13.01	30	16.99	Complies
LoRa SF7	925.75	2.49	10.09	12.58	30	17.42	Complies
LoRa SF12	902.5	3.45	10.07	13.52	30	16.48	Complies
LoRa SF12	915.25	2.95	10.08	13.03	30	16.97	Complies
LoRa SF12	925.75	2.48	10.09	12.57	30	17.43	Complies

[1] Correction factor consists of cable loss, external attenuator, and adapter(s)

Table 5: RF Peak Output Power – Conducted

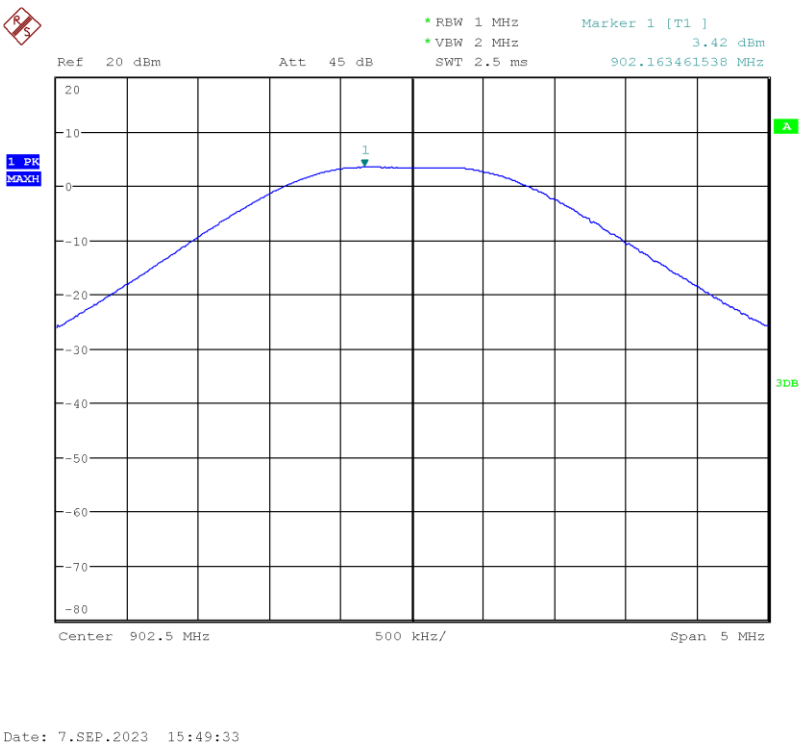


Figure 2: Peak Output Power – LoRa SF7, Low channel 902.5MHz

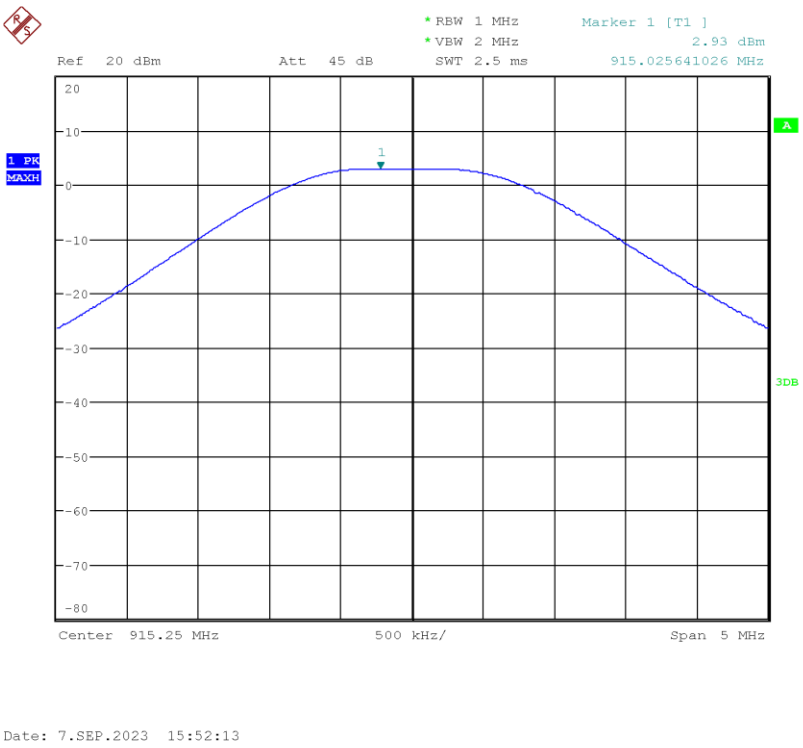


Figure 3: Peak Output Power – LoRa SF7, Mid channel 915.25MHz

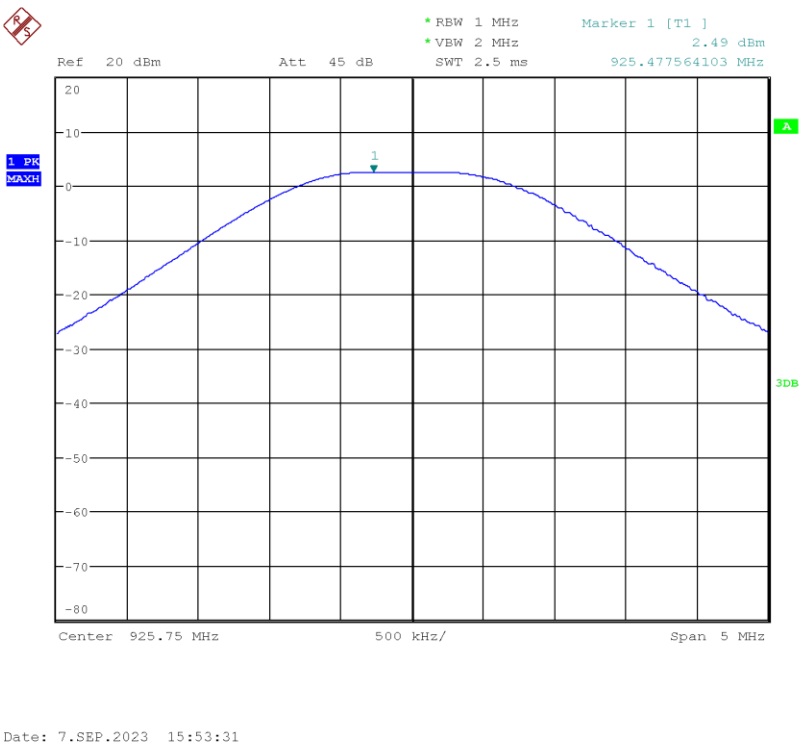


Figure 4: Peak Output Power – LoRa SF7, High channel 925.75MHz

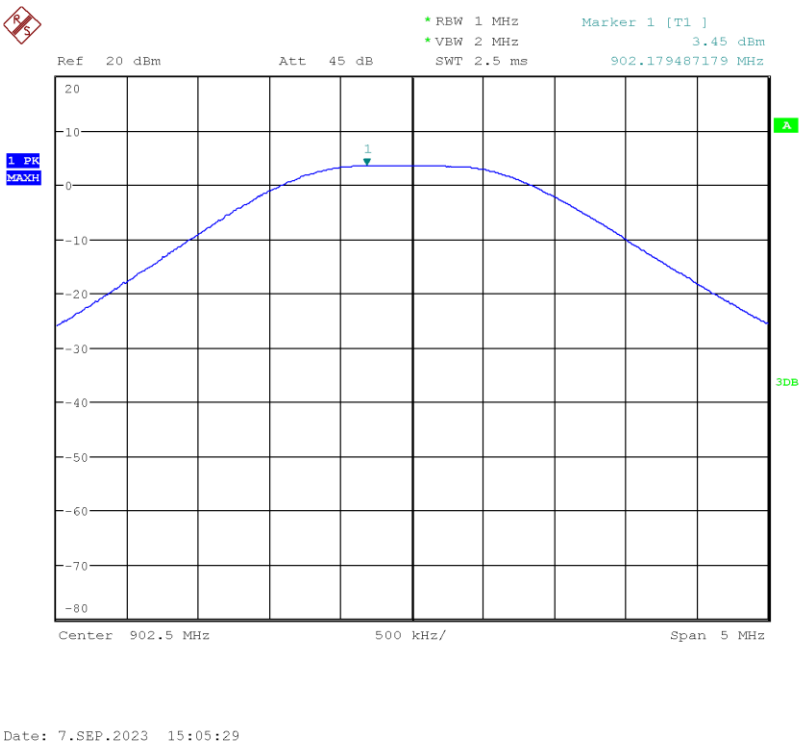


Figure 5: Peak Output Power – LoRa SF12, Low channel 902.5MHz

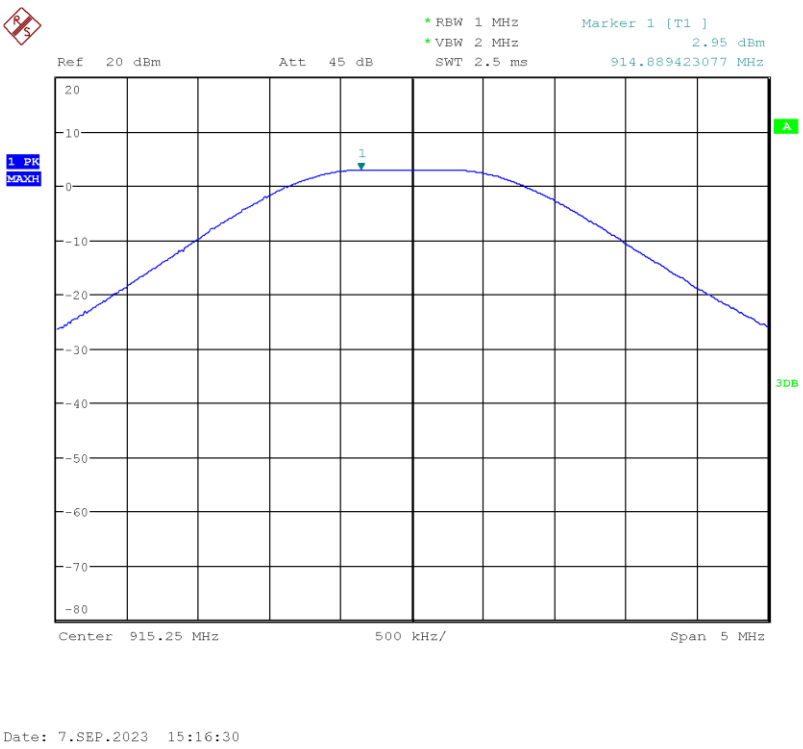


Figure 6: Peak Output Power – LoRa SF12, Mid channel 915.25MHz

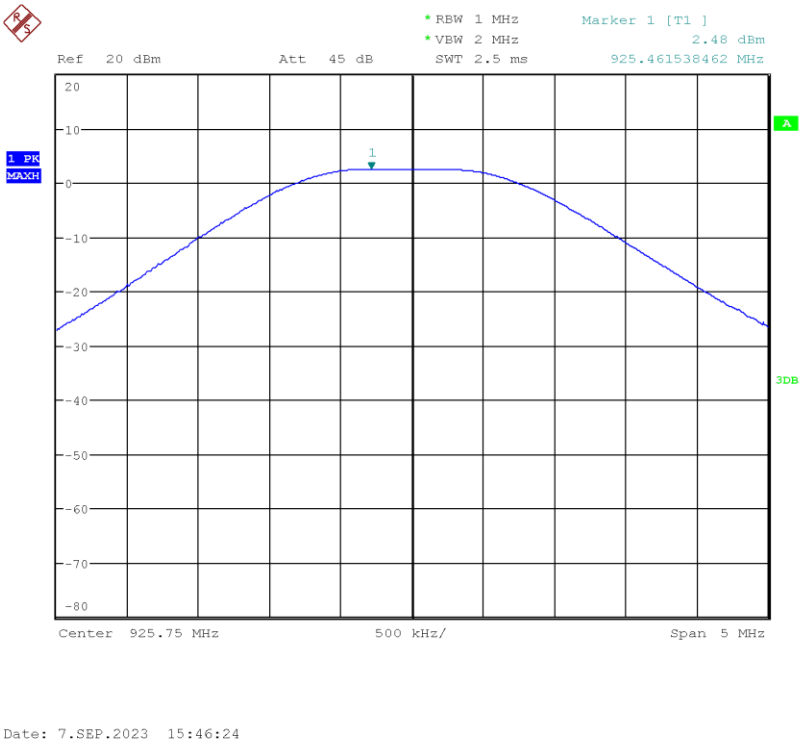


Figure 7: Peak Output Power – LoRa SF12, High channel 925.75MHz

3.3 Power spectral density

Date Performed: September 7, 2023 - September 8, 2023

Test Standard: FCC CFR 47 Part 15.247 (e)
IC RSS-247 Issue 3 (5.2) (b)

Test Method: ANSI C63.10:2013
Span = 1 MHz, RBW = 120 kHz, VBW = 300 kHz

Modifications: None.

Final Result: Complies

Applicable Regulation:

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

Measurement Data and Plots:

Modulation scheme	Carrier Frequency (MHz)	Raw Peak (dBm)	Correction Factor[1] (dB)	Corrected Peak Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)	Results
LoRa SF7	902.5	-9.56	10.07	0.51	8	7.49	Complies
LoRa SF7	915.25	-10.04	10.08	0.04	8	7.96	Complies
LoRa SF7	925.75	-10.44	10.09	-0.35	8	8.35	Complies
LoRa SF12	902.5	-10.49	10.07	-0.42	8	8.42	Complies
LoRa SF12	915.25	-10.30	10.08	-0.22	8	8.22	Complies
LoRa SF12	925.75	-11.62	10.09	-1.53	8	9.53	Complies

[1] Correction factor consists of cable loss, external attenuator, and adapter(s)

Table 6: Power Spectral Density (PSD)

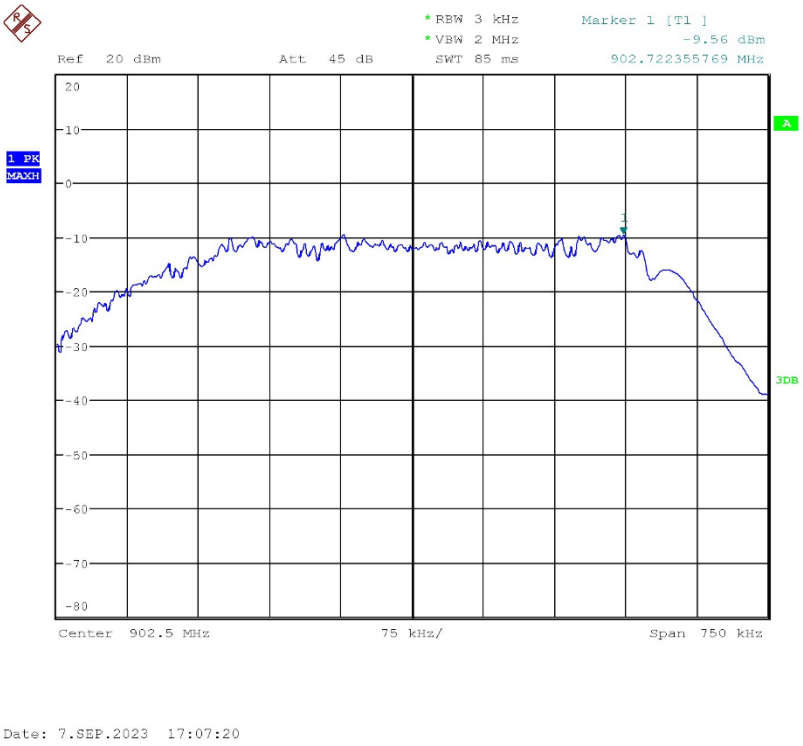


Figure 8: Power spectral density – LoRa SF7, Low channel 902.5MHz

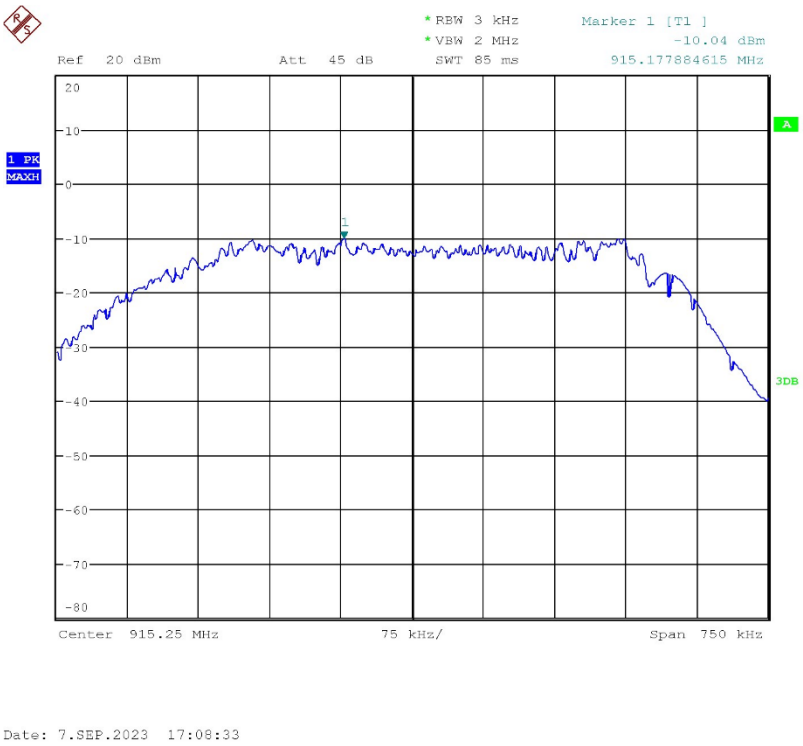


Figure 9: Power spectral density – LoRa SF7, Mid channel 915.25MHz

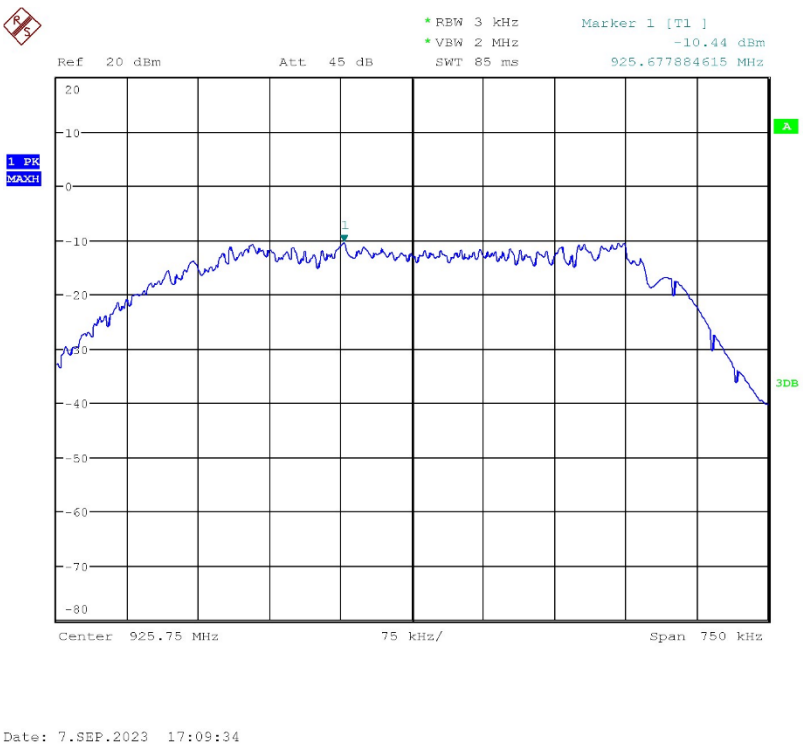


Figure 10: Power spectral density – LoRa SF7, High channel 925.75MHz

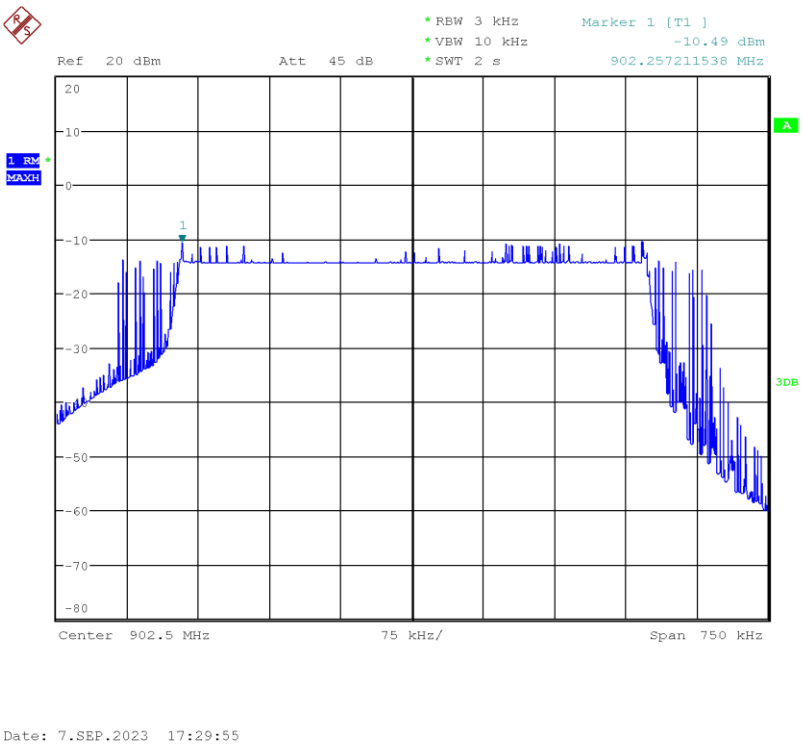


Figure 11: Power spectral density – LoRa SF12, Low channel 902.5MHz

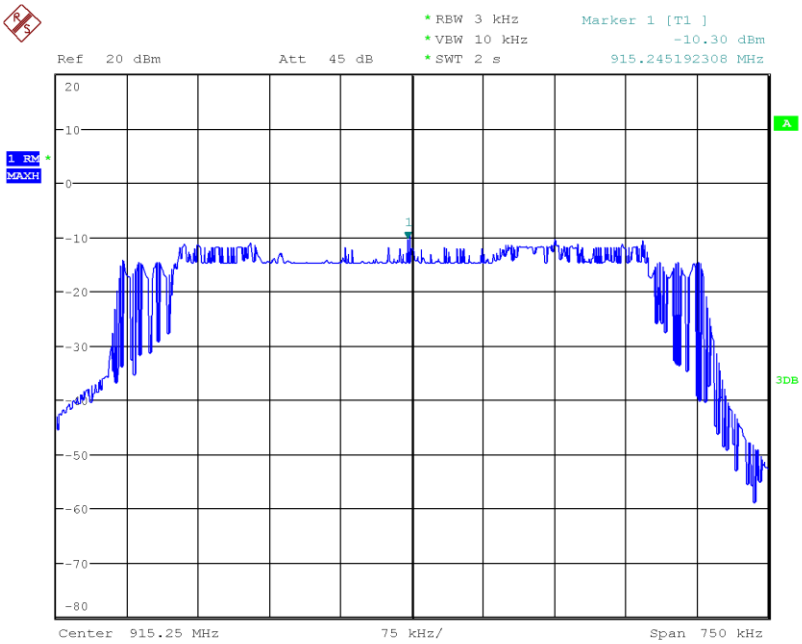


Figure 12: Power spectral density – LoRa SF12, Mid channel 915.25MHz

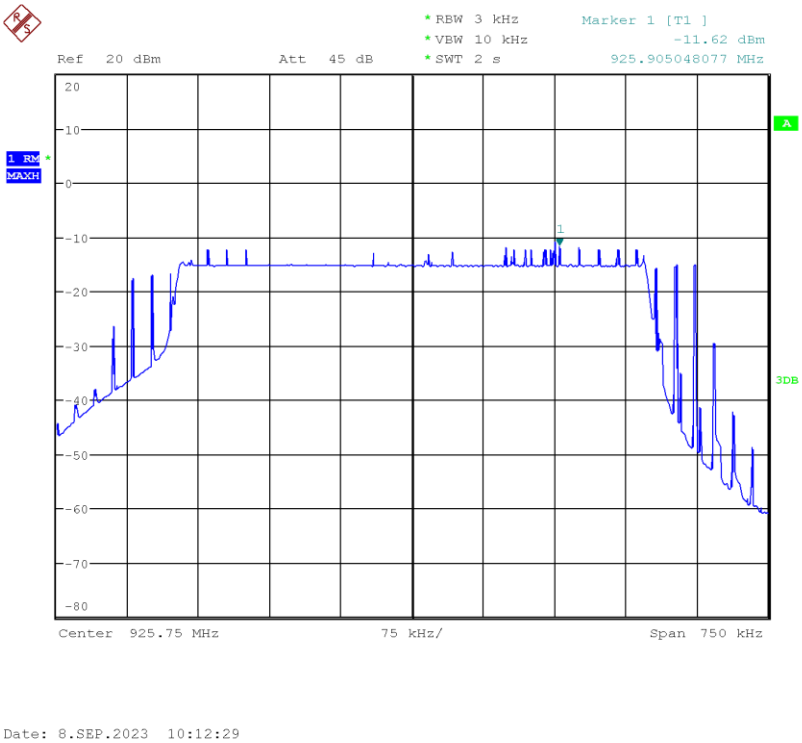


Figure 13: Power spectral density – LoRa SF12, High channel 925.75MHz

3.4 6 dB Bandwidth

Date Performed: September 8, 2023

Test Standard: FCC 47 CFR Part 15.247 (a)(1)(i)
RSS-247 Issue 3 (5.1) (c)

Test Method: ANSI C63.10:2013
Span = 2 to 5 x OBW, RBW = 1 to 5% of OBW, VBW = 3 x RBW
Ref Level > 10log(OBW/RBW) above signal peak.

Modifications: None

Final Result: Complies

Applicable Regulations:

DTSs include systems that employ digital modulation techniques resulting in spread characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

a) The minimum 6 dB bandwidth shall be 500 kHz.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10: 2013, 7.4.

A spectrum analyzer or other instrument providing a spectral display is recommended for these measurements. When using a spectrum analyzer or other instrument providing a spectral display, the video bandwidth shall be set to a value at least three times greater than the IF bandwidth of the measuring instrument to avoid the introduction of unwanted amplitude smoothing. Video filtering is not used during occupied bandwidth tests.

Measurement Data and Plots:

Channels	Modulation scheme	Frequency (MHz)	6 dB Bandwidth (kHz)	Limit (kHz)	Result
Low	LoRa SF7	902.50	769.2	500	Complies
Middle	LoRa SF7	915.25	759.6	500	Complies
High	LoRa SF7	925.75	757.2	500	Complies
Low	LoRa SF12	902.50	805.3	500	Complies
Middle	LoRa SF12	915.25	798.4	500	Complies
High	LoRa SF12	925.75	790.9	500	Complies

Table 7: 6 dB Bandwidth Results

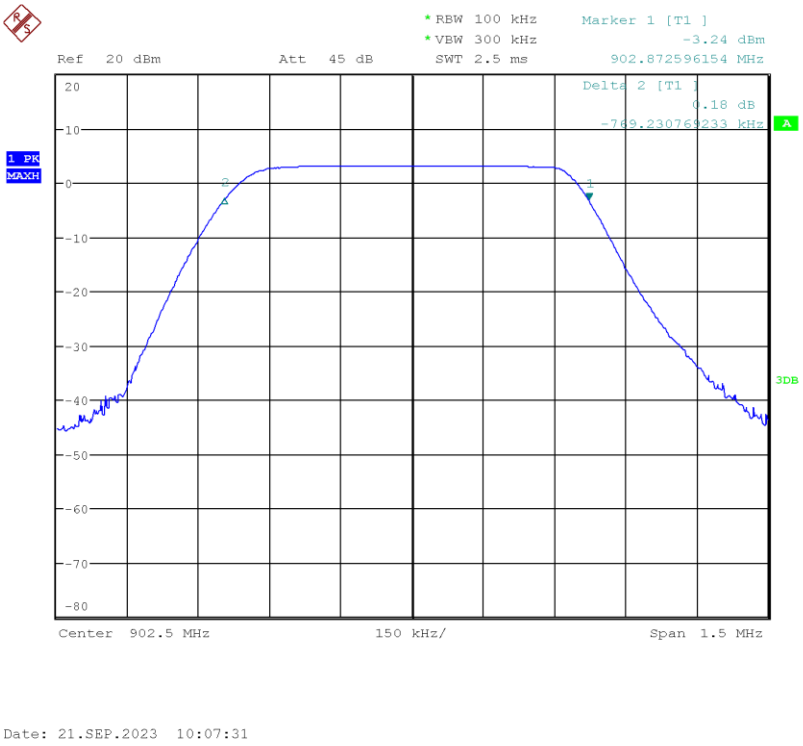


Figure 14: 6 dB Bandwidth – LoRa SF7, Low channel, 902.5 MHz

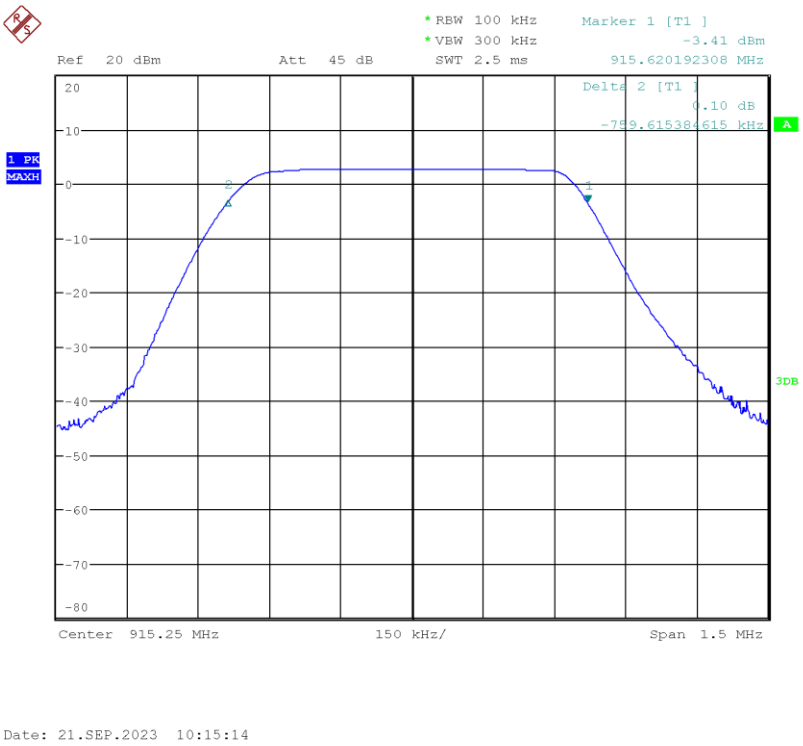


Figure 15: 6 dB Bandwidth – LoRa SF7, Mid channel, 915.25 MHz

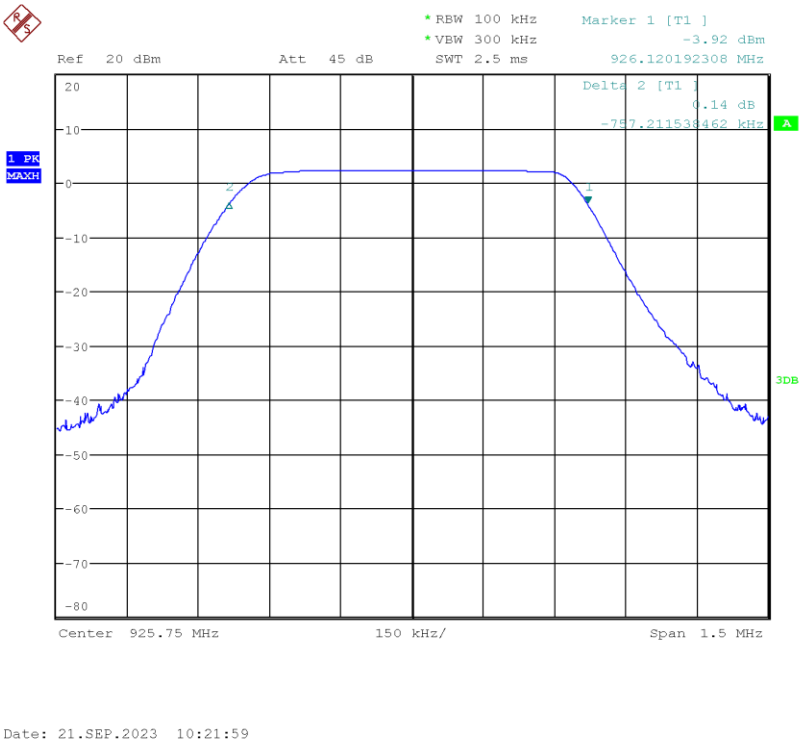


Figure 16: 6 dB Bandwidth – LoRa SF7, High channel, 925.75 MHz

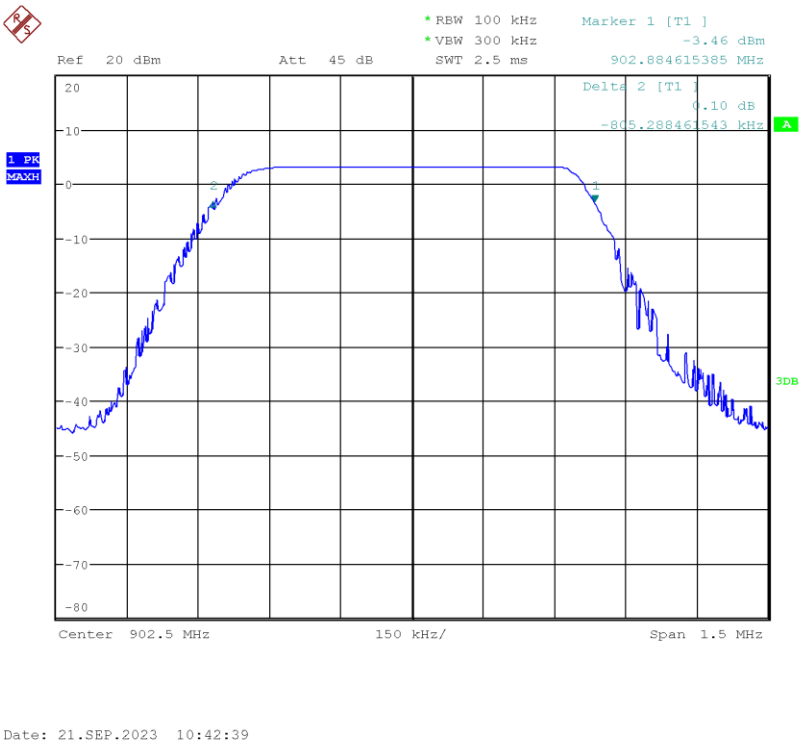


Figure 17: 6 dB Bandwidth – LoRa SF12, Low channel, 902.5 MHz

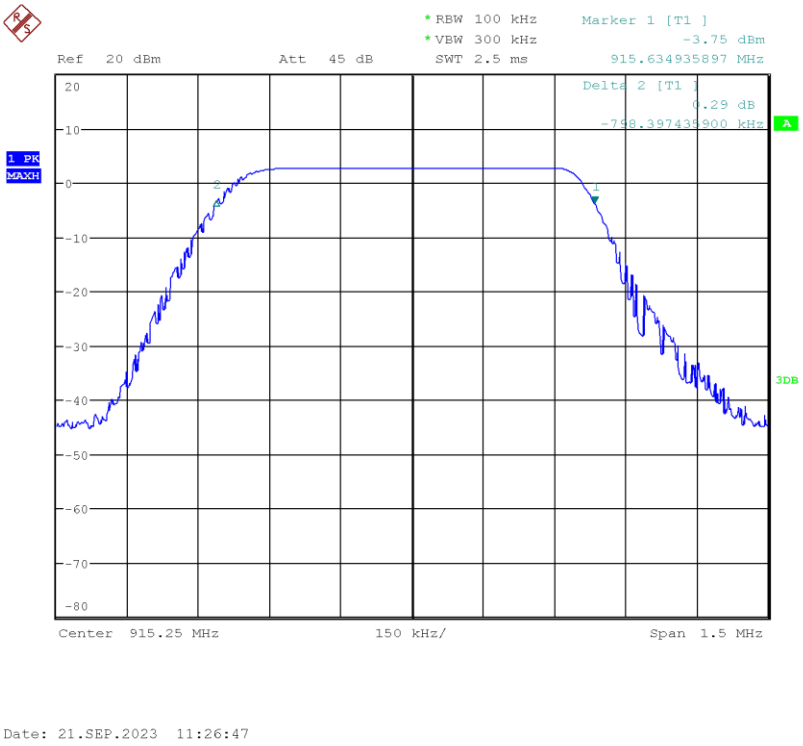


Figure 18: 6 dB Bandwidth – LoRa SF12, Mid channel, 915.25 MHz

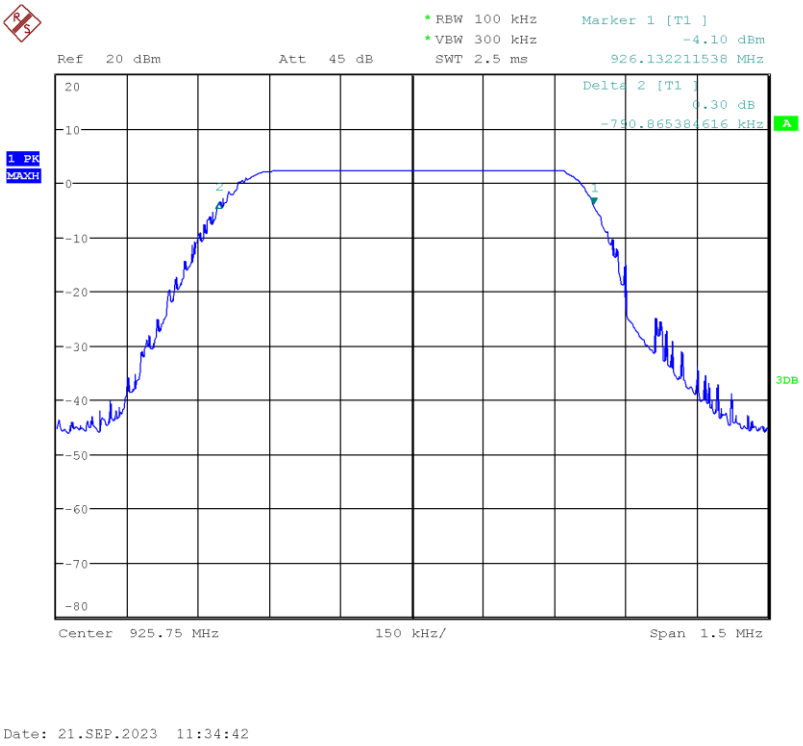


Figure 19: 6 dB Bandwidth – LoRa SF12, High channel, 925.75 MHz

3.5 Out-Of-Band Emissions (Band Edge)

Date Performed: September 8, 2023

Test Standard: FCC CFR 47 Part 15.249 (d)
RSS-247 Issue 3 (5.5)

Test Method: ANSI C63.10:2013
Span = Wide enough to capture the peak level of the emission closest to the band edge, as well as any modulation products that fall outside of the band.
Ref Level = High enough to keep the signal from overdriving the input mixer
RBW = 100 kHz, VBW = 300 kHz
Trace Detector: Peak, Trace: Max Hold

Modifications: None

Final Result: Complies

Applicable Regulation:

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits, whichever is the lesser attenuation.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

For other than frequency-hopping devices, this test sequence shall be performed once. For devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned OFF and then repeated with the hopping function turned ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON. Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods.

Measurement Data and Plots:

Modulation sch.	Channel	Frequency	Limit	Result
LoRa SF7	Low	902.5 MHz	-20 dB	Complies
LoRa SF7	High	925.75 MHz	-20 dB	Complies
LoRa SF12	Low	902.5 MHz	-20 dB	Complies
LoRa SF12	High	925.75 MHz	-20 dB	Complies

Table 8: Band Edge Results

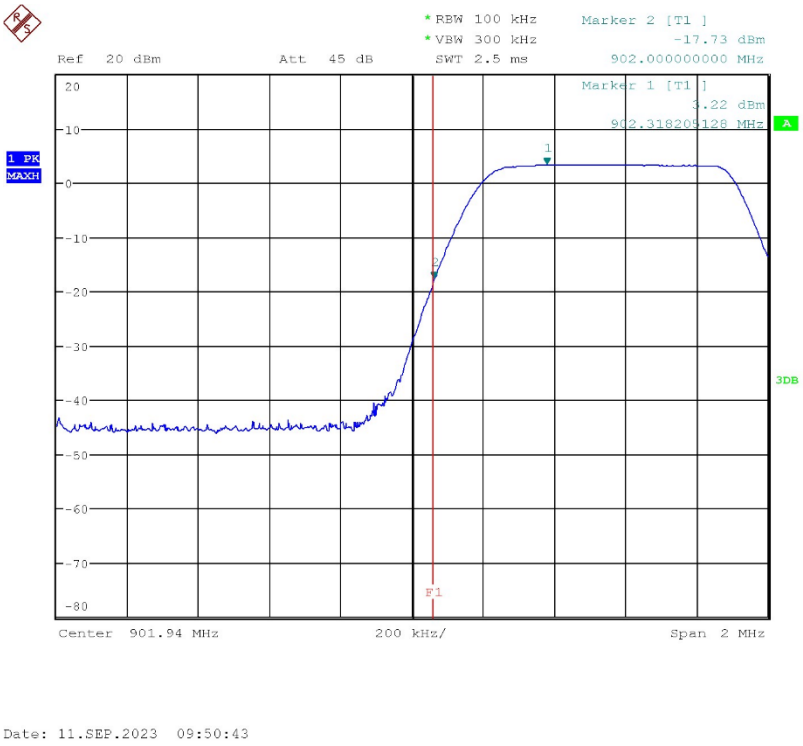


Figure 20: Band Edge – LoRa SF7, Low channel, 902.5 MHz

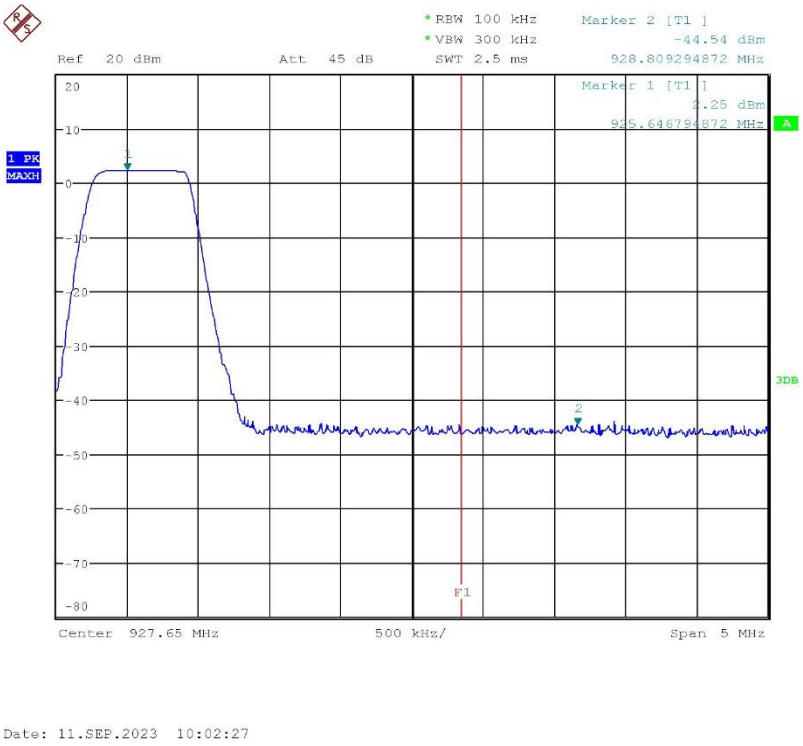


Figure 21: Band Edge – LoRa SF7, High channel, 925.75 MHz

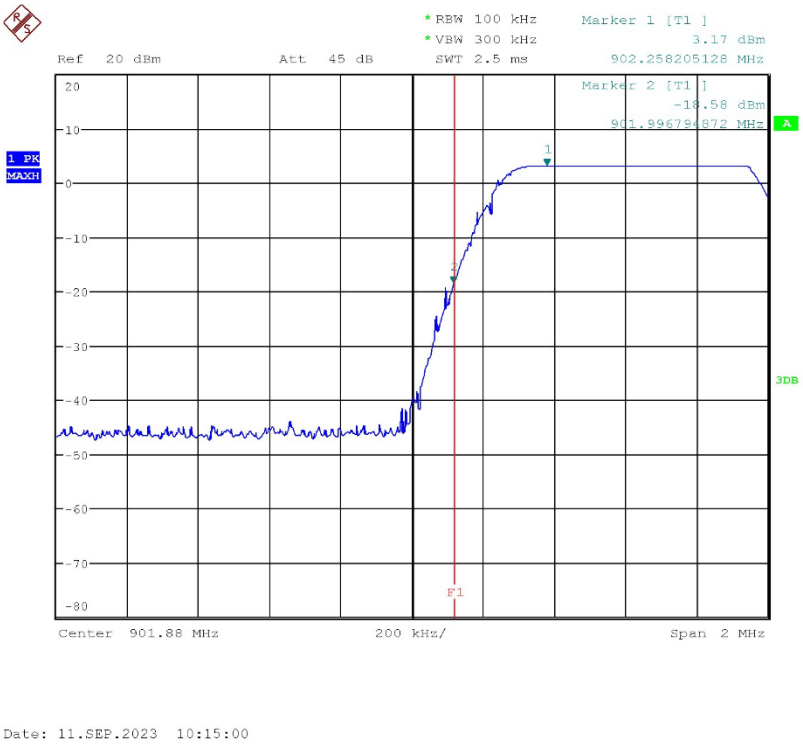


Figure 22: Band Edge – LoRa SF12, Low channel, 902.5 MHz

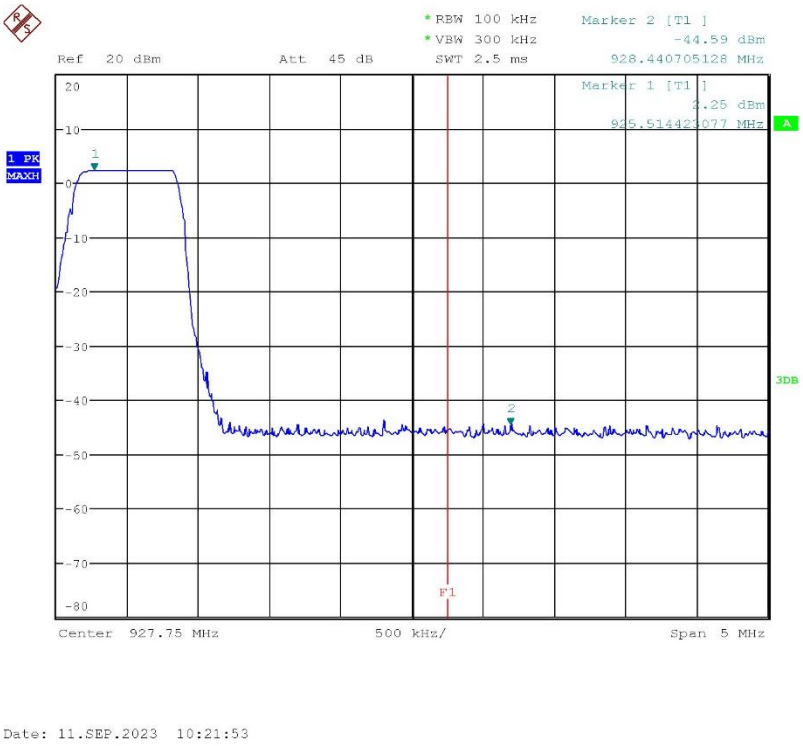


Figure 23: Band Edge – LoRa SF12, High channel, 925.75 MHz

3.6 Frequency stability

Date Performed:	September 11, 2023 – September 18, 2023
Test Standard:	FCC CFR 47 Part 15.215 © RSS-Gen Issue 5 (6.11)
Test Method:	ANSI C63.10:2013 Span = Wide enough to capture the peak of two adjacent channels. Ref Level = High enough to keep the signal from overdriving the input mixer RBW = Approximately 30% of the channel spacing; adjusted as necessary to identify the center of each individual channel. VBW ≥ RBW Trace Detector: Peak, Trace: Max Hold
Modifications:	None.
Final Result:	Complies

Applicable Standard:

The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

The channel separation measurement was made by connecting the spectrum analyzer to the active antenna port using a 20dB attenuator.

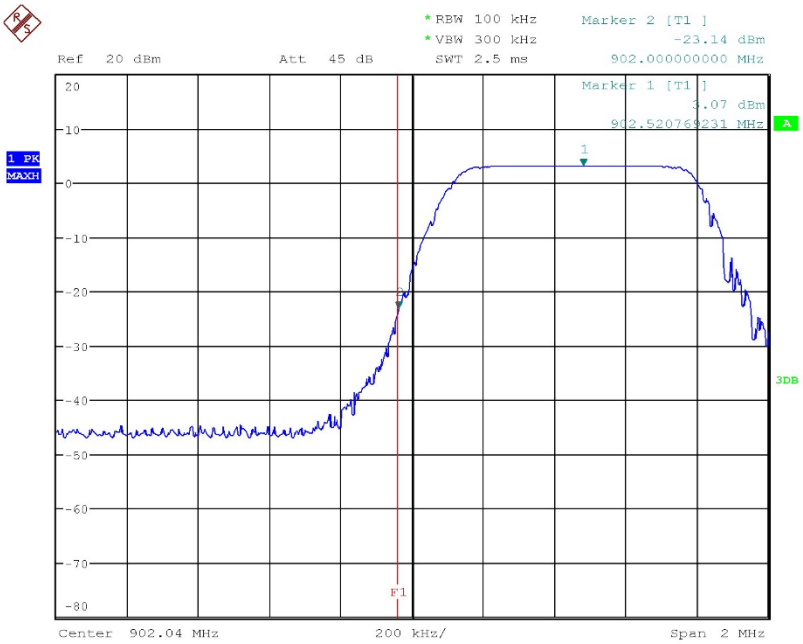


Figure 24: Frequency stability at -40 °C – LoRa SF7, Low channel, 902.5 MHz

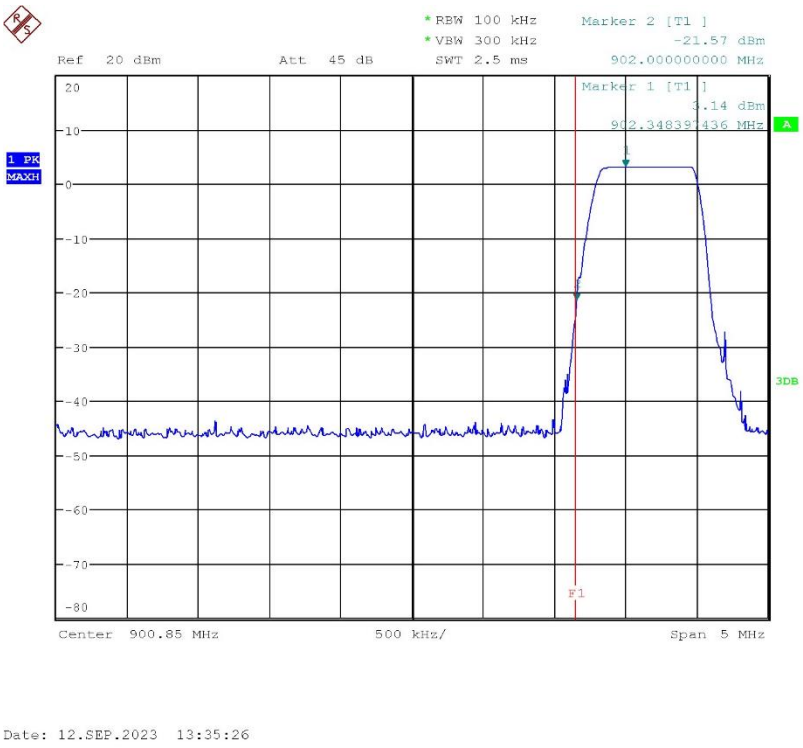


Figure 25: Frequency stability at -40 °C – LoRa SF12, Low channel, 902.5 MHz

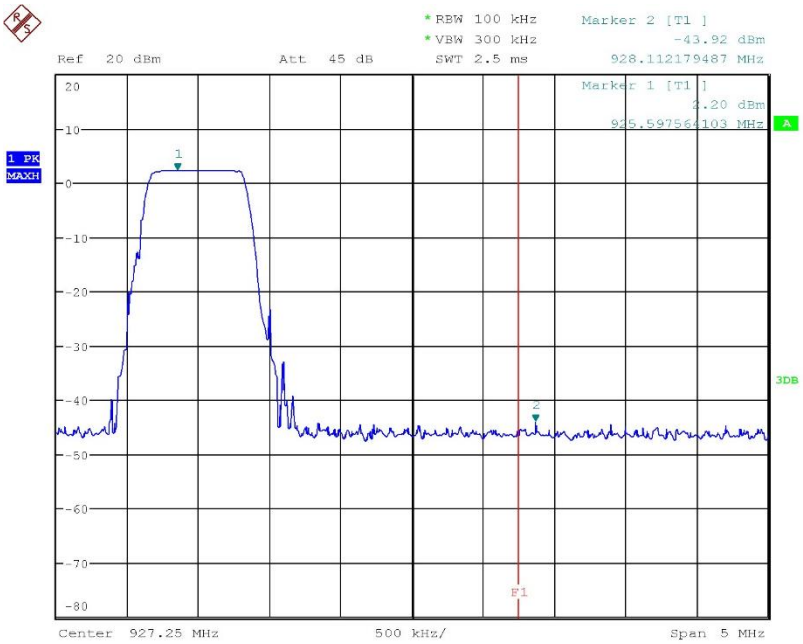


Figure 26: Frequency stability at -40 °C – LoRa SF7, High channel, 925.75 MHz

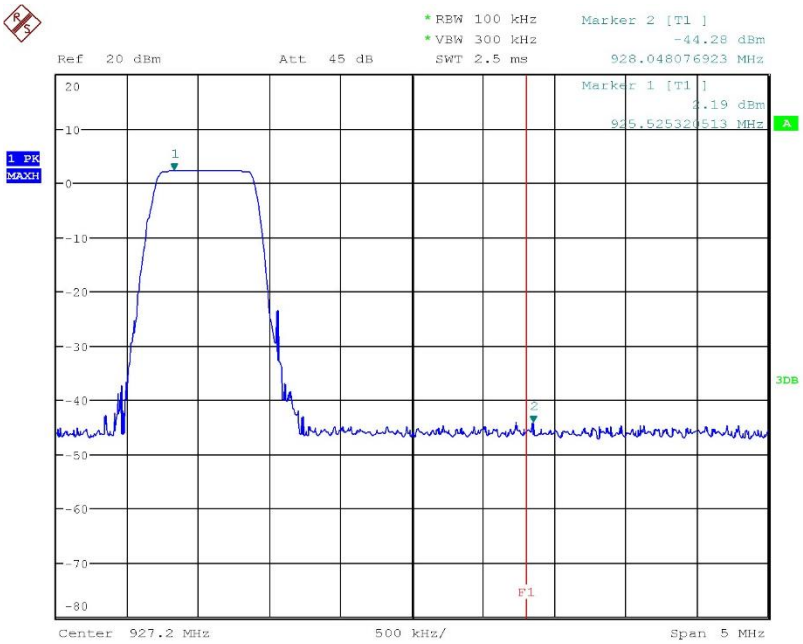


Figure 27: Frequency stability at -40 °C – LoRa SF12, High channel, 925.75 MHz

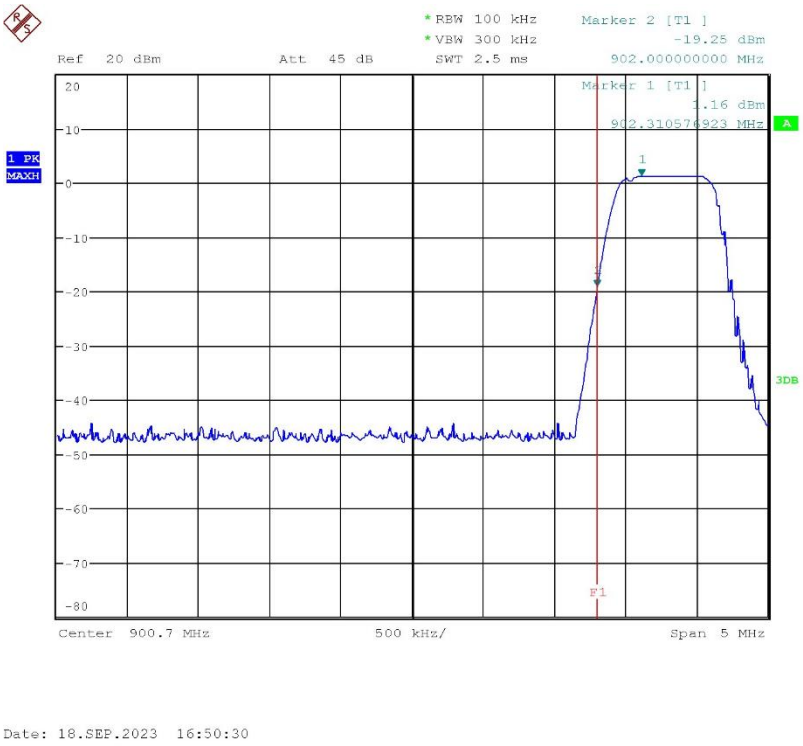


Figure 28: Frequency stability at 80 °C – LoRa SF7, Low channel, 902.5 MHz

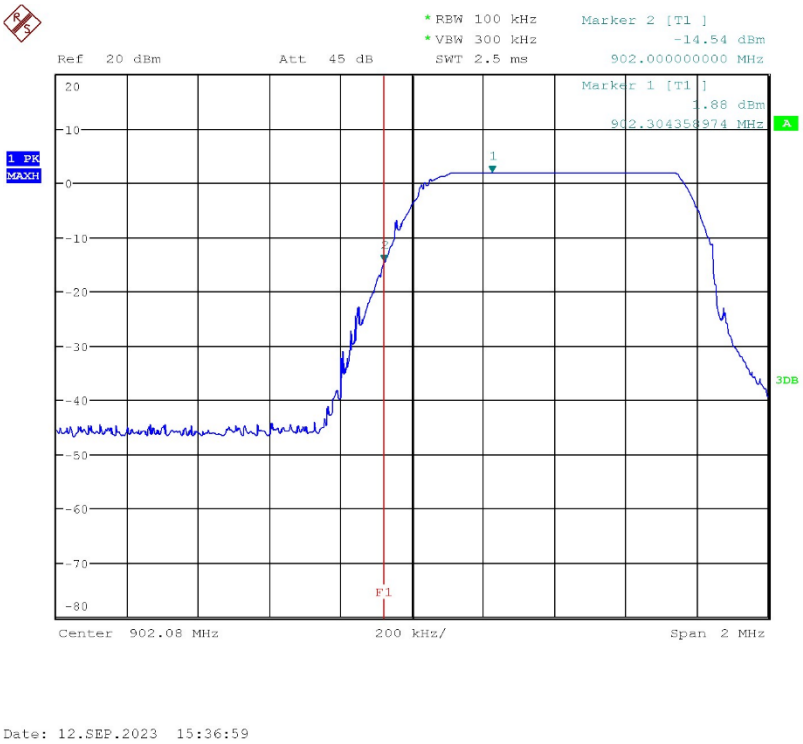


Figure 29: Frequency stability at 80 °C – LoRa SF12, Low channel, 902.5 MHz

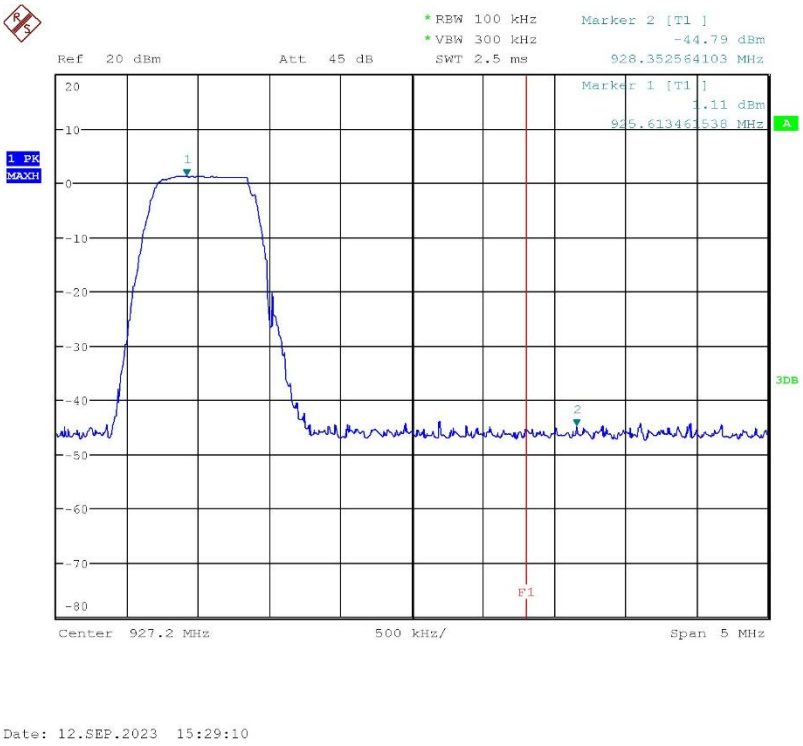


Figure 30: Frequency stability at 80 °C – LoRa SF7, High channel, 925.75 MHz

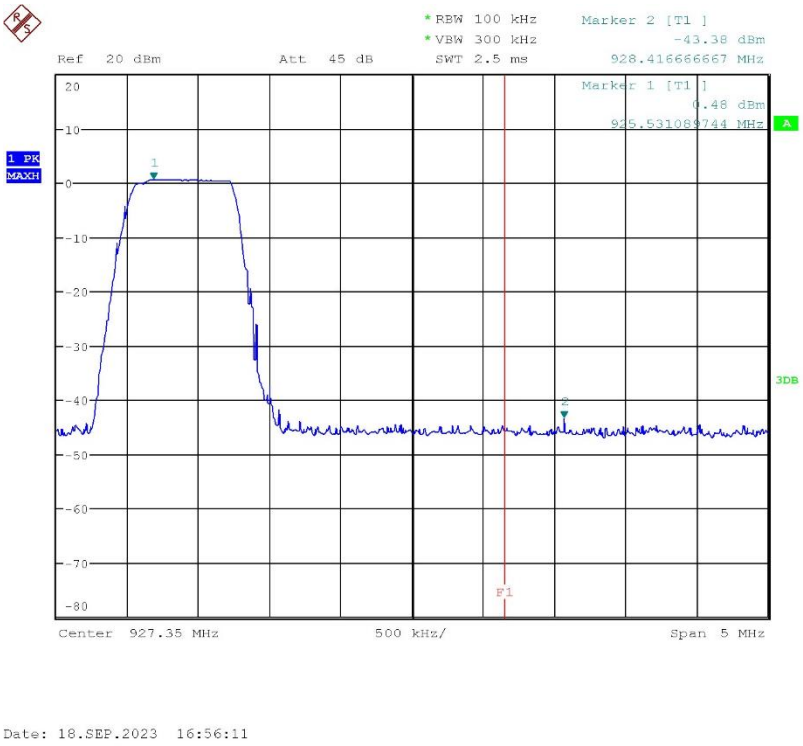


Figure 31: Frequency stability at 80 °C – LoRa SF12, High channel, 925.75 MHz

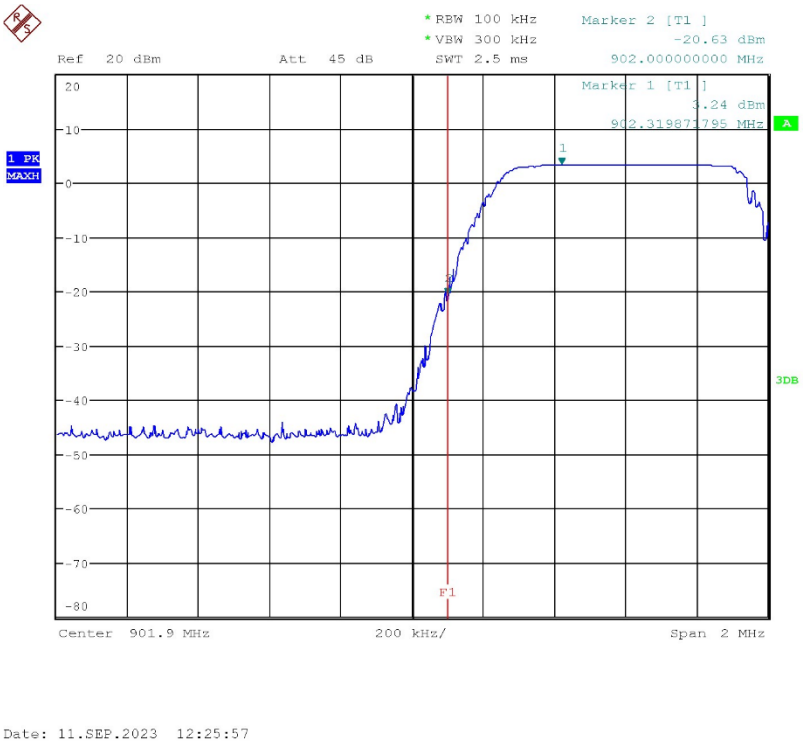


Figure 32: Frequency stability at 10.4V – LoRa SF7, Low channel, 902.5 MHz

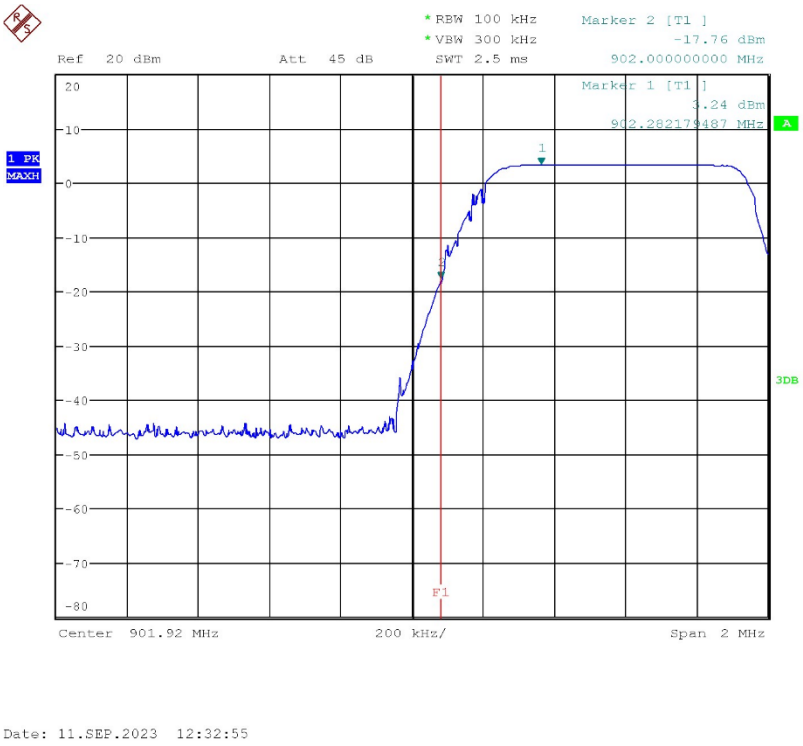


Figure 33: Frequency stability at 10.4V – LoRa SF12, Low channel, 902.5 MHz

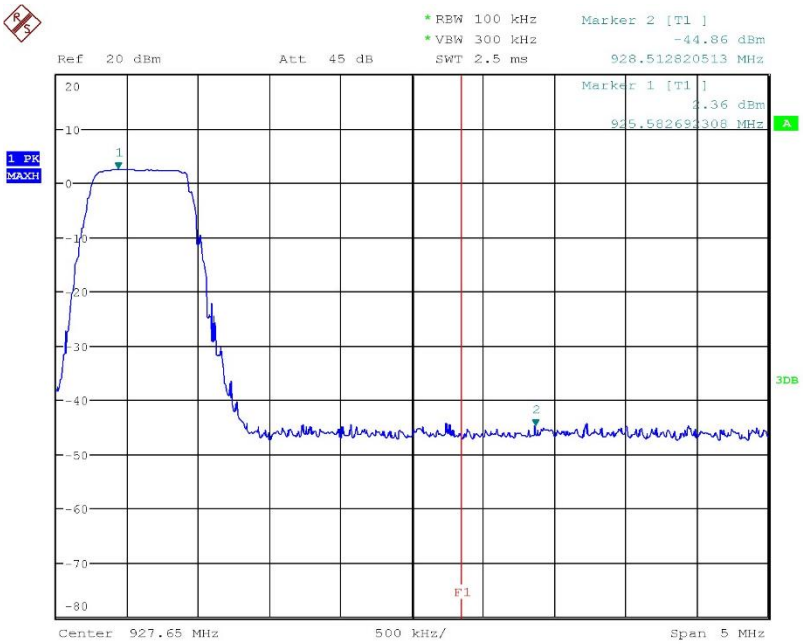


Figure 34: Frequency stability at 10.4V – LoRa SF7, High channel, 925.75 MHz

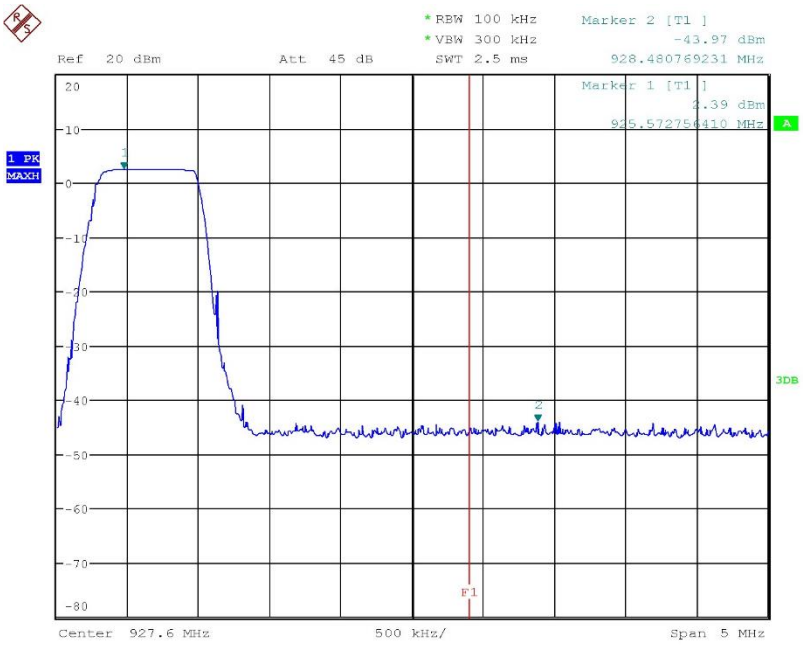


Figure 35: Frequency stability at 10.4V – LoRa SF12, High channel, 925.75 MHz

3.7 Unintentional Radiated Emissions

Date Performed: August 25, 2023 – August 31, 2023

Test Standard: FCC 47 CFR Part 15.33 (a)(1), (5)
FCC 47 CFR Part 15.109
FCC 47 CFR Part 15.209
ICES-003 Issue 7

Test Method: ANSI C63.4:2014

Modifications: None

Final Result: Complies

Applicable Standard:

FCC 47 CFR Part 15.33 (b)(1): Frequency range of radiated measurements

For an unintentional radiator, including a digital device, the spectrum shall be investigated from the lowest radio frequency signal generated or used in the device, without going below the lowest frequency for which a radiated emission limit is specified, up to the frequency shown in the following table:

Highest frequency generated or used in the device or on which the device operates or tunes (MHz)	Upper frequency of measurement range (MHz)
Below 1.075	30
1.075 – 108	1000
108 – 500	2000
500 – 1000	5000
Above 1000	5th harmonic of the highest frequency or 40 GHz, whichever is lower.

FCC 47 CFR Part 15.109: Radiated emission limits

a) Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of emission (MHz)	Field strength (microvolts/meter)
30 – 88	100
88 – 216	150
216 – 960	200
Above 960	500

e) Carrier current systems used as unintentional radiator or other unintentional radiators that are designed to conduct their radio frequency emissions via connecting wires or cables and that operate in the frequency range of 9 kHz to 30 MHz, including devices that deliver the radio frequency energy to transducers, such as ultrasonic devices not covered under Part 18, shall comply with the radiated emission limits for intentional radiators provided in 15.209 for the frequency range of 9 kHz to 30 MHz.

FCC 47 CFR Part 15.209 (a): Radiated emission limits; general requirements

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency, *f* (MHz)	Maximum Field strength Quasi-peak (dBµV/m at 3 m)
0.009 – 0.490	20*log(2400/F(kHz)) + 40 dB
0.490 – 1.705	20*log(24000/F(kHz)) + 20 dB
1.705 – 30.0	49.5
30 – 88	40.0
88 – 216	43.5
216 – 960	46.0
above 960	54.0

Note 1: The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

Note 2: The emissions limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz., 110-490 kHz. And above 1000 MHz.

Radiated emission limits in these three bands are based on measurements employing an average detector

ICES-003 3.2.2 Radiated emission limits

The quasi-peak limits for the electric component of the radiated field strength emitted from ITE or digital apparatus, within 30 MHz to 1 GHz, for a measurement distance of 3 m or 10 m, are:

Frequency Range (MHz)	Class A (3 m) Quasi-peak (dBµV/m)	Class A (10 m) Quasi-peak (dBµV/m)	Class B (3 m) Quasi-peak (dBµV/m)	Class B (10 m) Quasi-peak (dBµV/m)
30 – 88	50.0	40.0	40.0	30.0
88 – 216	54.0	43.5	43.5	33.1
216 – 230	56.9	46.4	46.0	35.6
230 – 960	57.0	47.0	47.0	37.0
960 – 1000	60.0	49.5	54.0	43.5

At and above 1 GHz, except for outdoor units of home satellite receiving systems, the ITE or digital apparatus shall comply with:

Frequency Range (MHz)	Class A Average (dBµV/m)	Class A Peak (dBµV/m)	Class B Average (dBµV/m)	Class B Peak (dBµV/m)
1 – F_M	60	80	54	74

F_M is determined by:

Highest internal frequency (F_X)	Highest measurement frequency (F_M)
$F_X \leq 108$ MHz	1 GHz
108 MHz $\leq F_X \leq$ 500 MHz	2 GHz
500 MHz $\leq F_X \leq$ 1 GHz	5 GHz
$F_X >$ 1 GHz	5 x F_X up to a maximum of 40 GHz

Test Setup:

The EUT was tested in a 3 m SAC and was positioned on the front of the turntable and the radiated output of the device was measured for all emissions up to 18 GHz.

3.7.1 150kHz to 30 MHz

Antenna 1, Tested August 28, 2023:

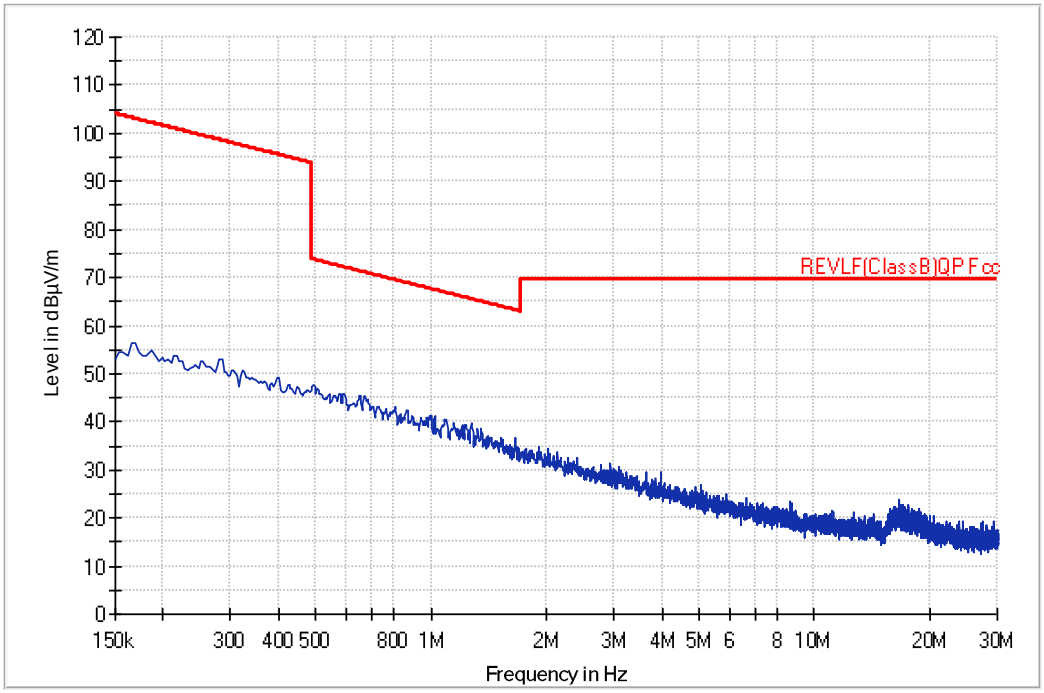


Figure 36: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 Low channel.

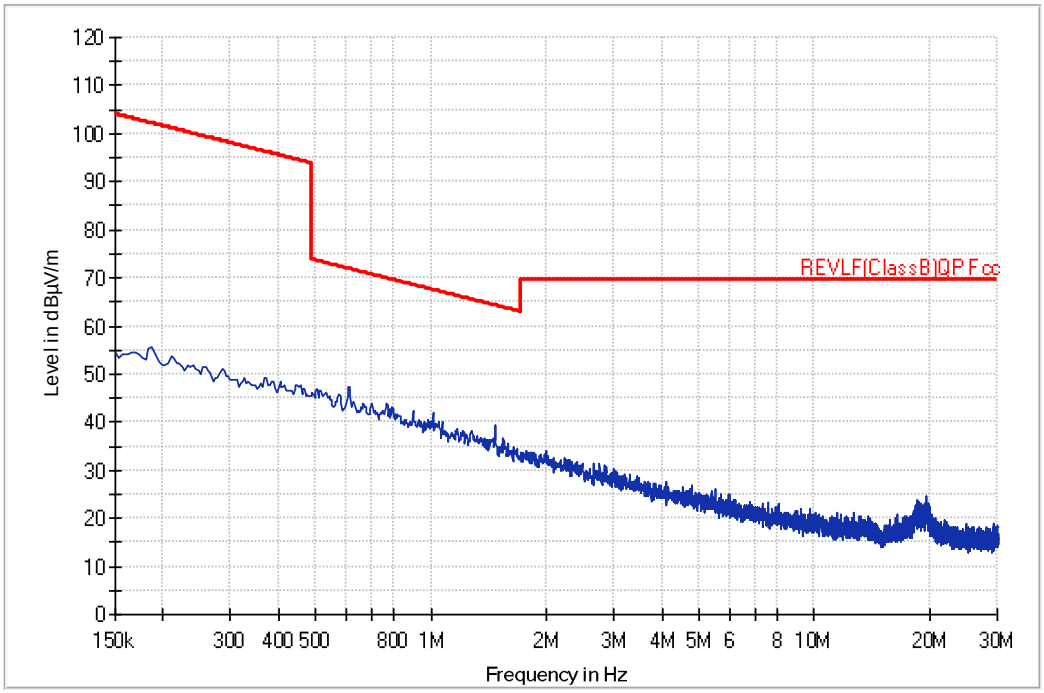


Figure 37: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 Low channel.

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 1, Tested August 28, 2023:

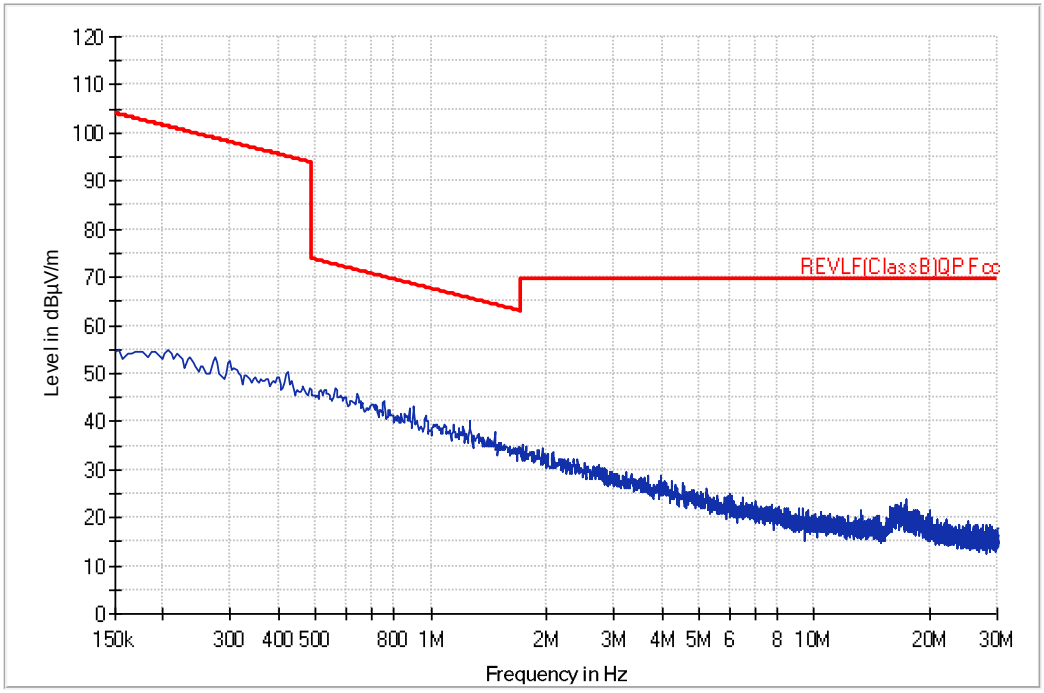


Figure 38: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 Mid channel.

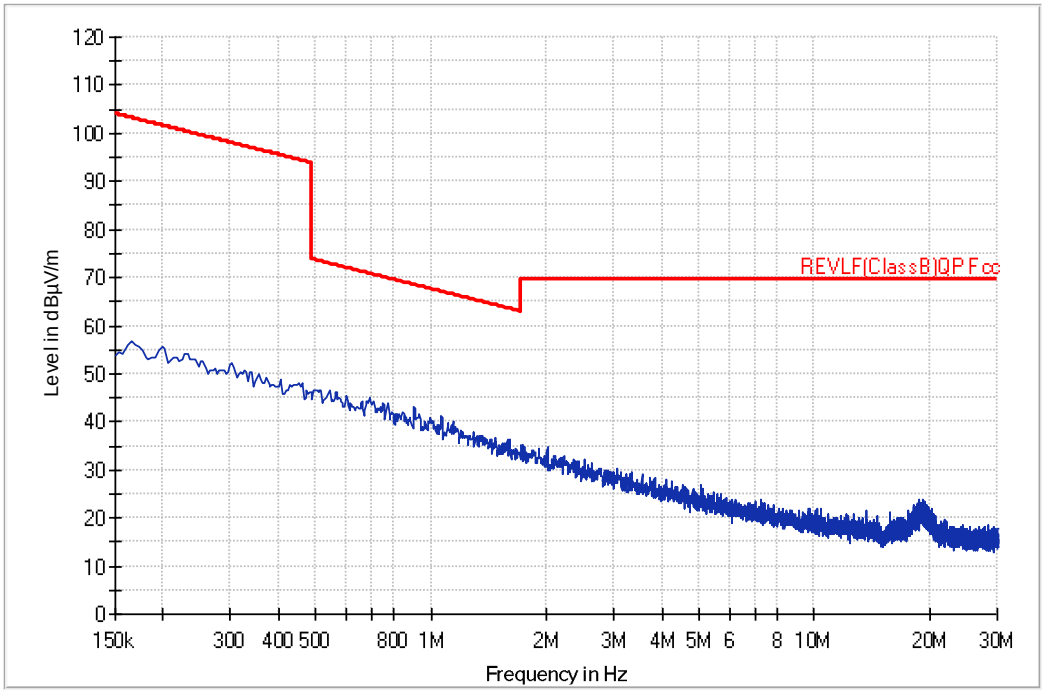


Figure 39: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 Mid channel.

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 1, Tested August 28, 2023:

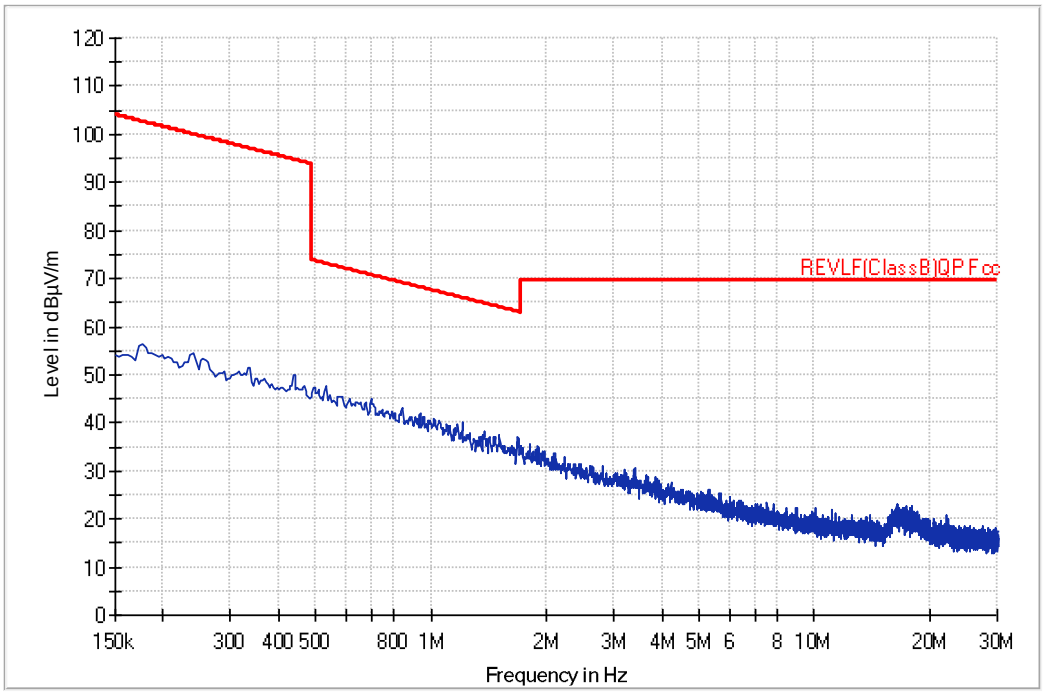


Figure 40: Radiated Emissions Measured at 3m – Antenna 1, Vertically Polarized, LoRa SF12 High channel.

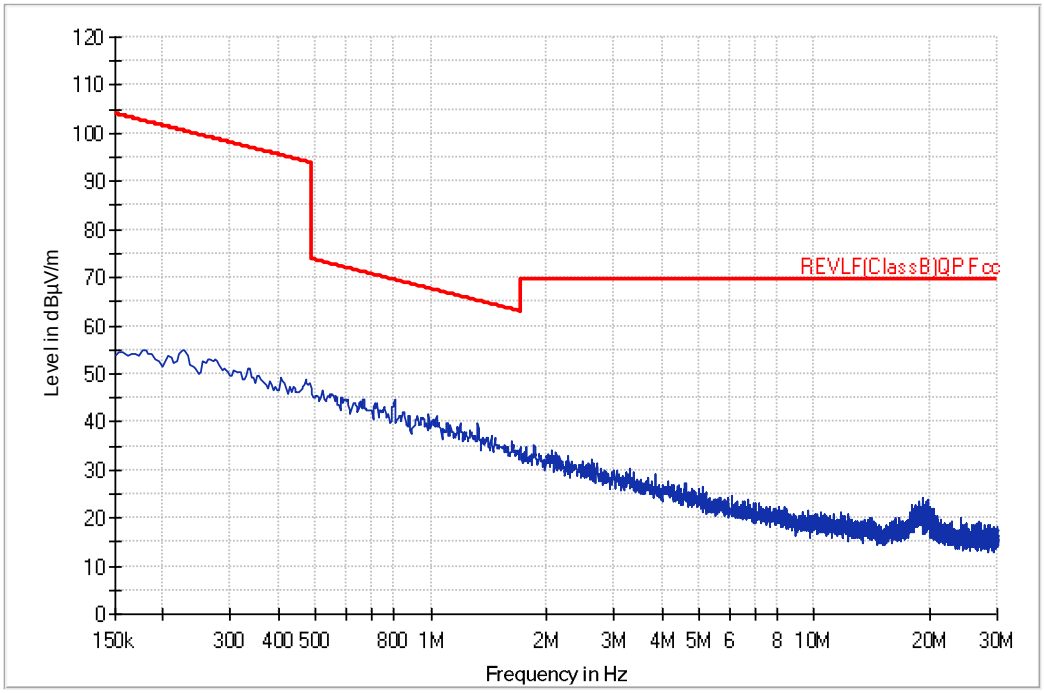


Figure 41: Radiated Emissions Measured at 3m – Antenna 1, Horizontally Polarized, LoRa SF12 High channel.

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 2, Tested August 28, 2023:

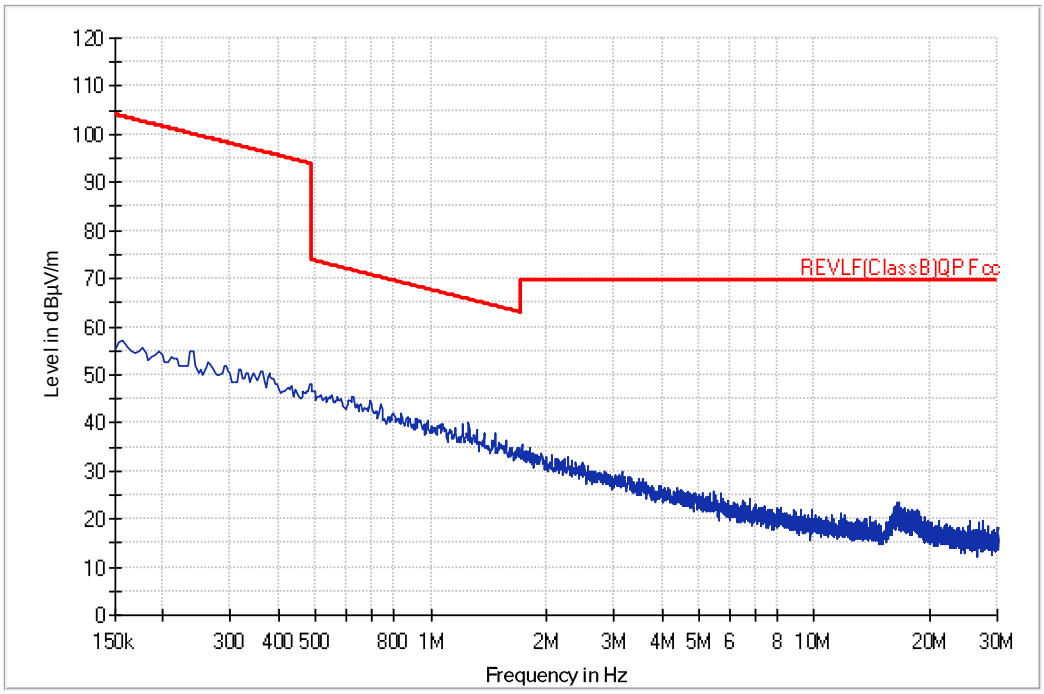


Figure 42: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 Low channel.

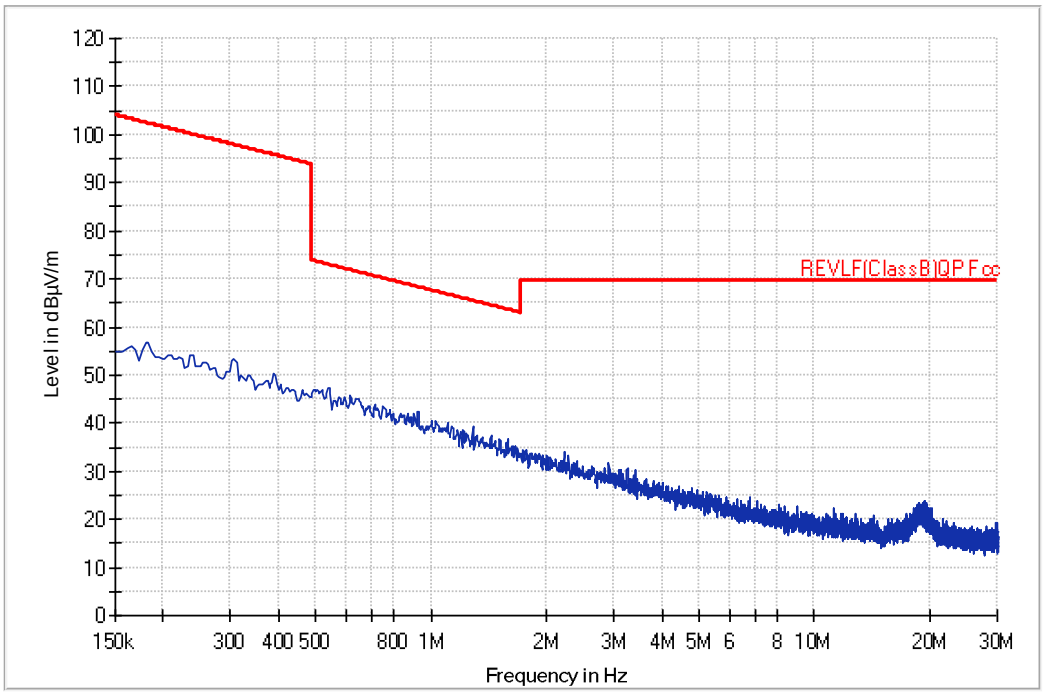


Figure 43: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 Low channel.

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 2, Tested August 28, 2023:

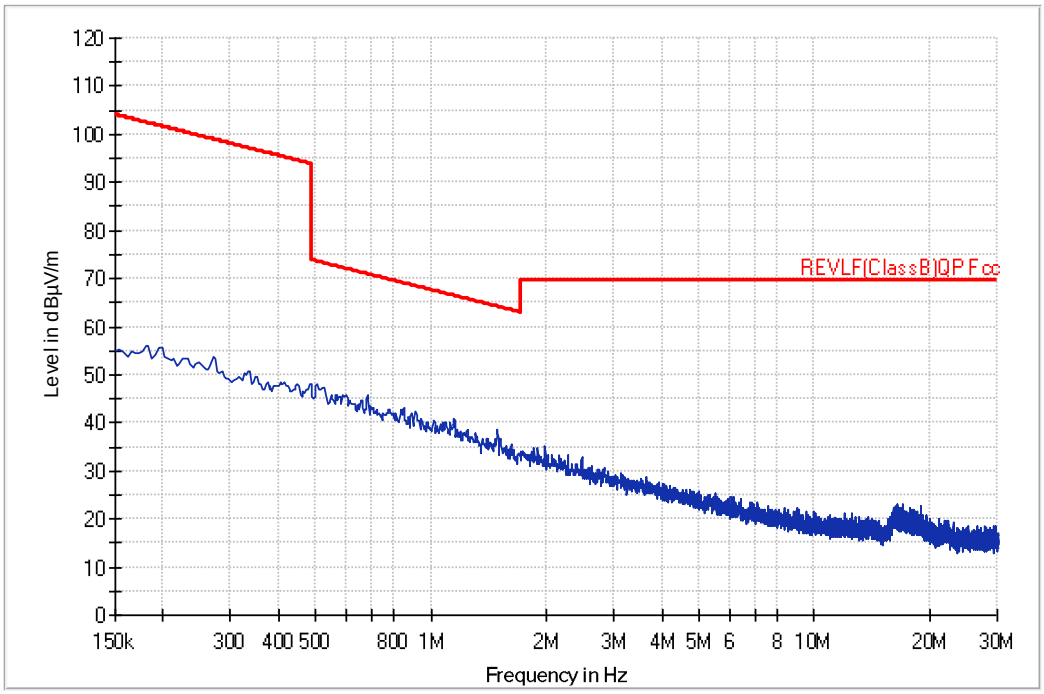


Figure 44: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 Mid channel.

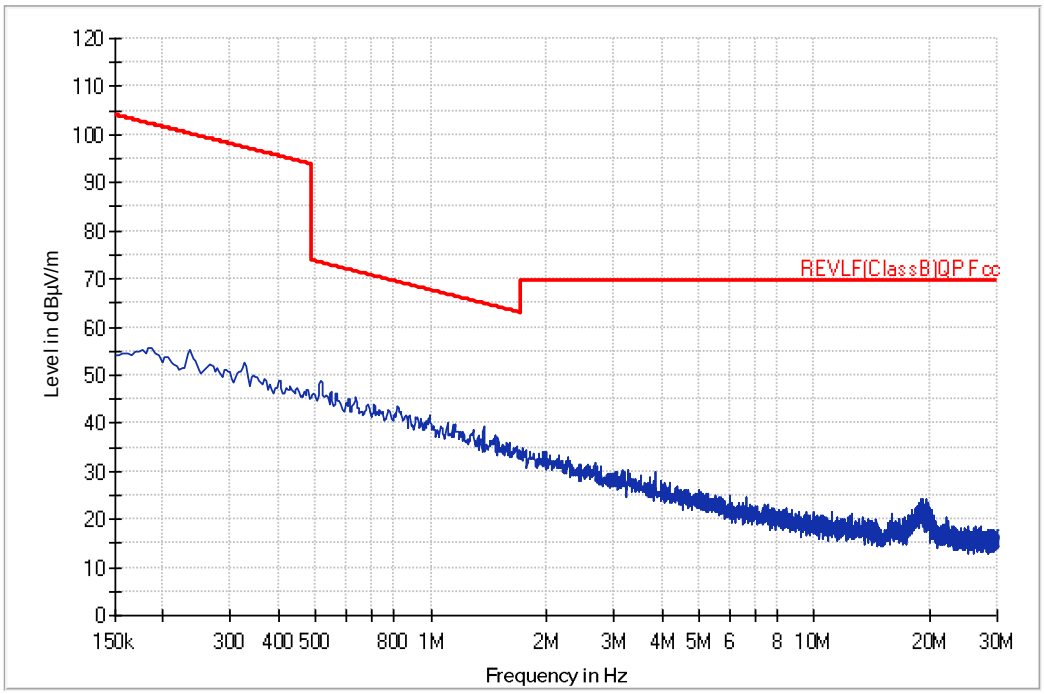


Figure 45: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 Mid channel.

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 2, Tested August 28, 2023:

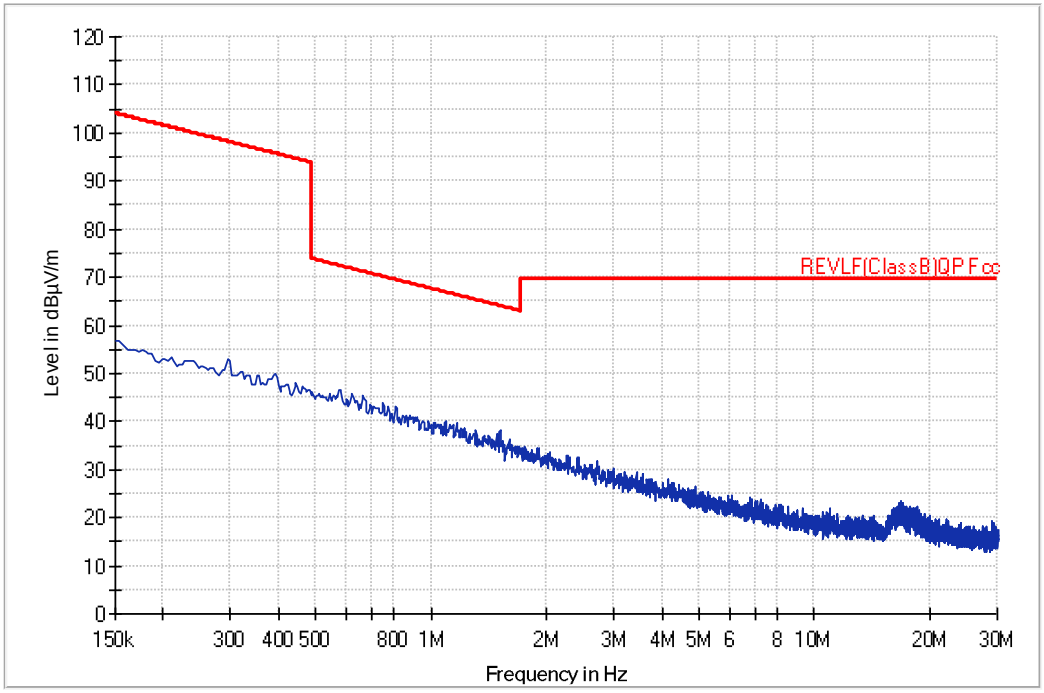


Figure 46: Radiated Emissions Measured at 3m – Antenna 2, Vertically Polarized, LoRa SF12 High channel.

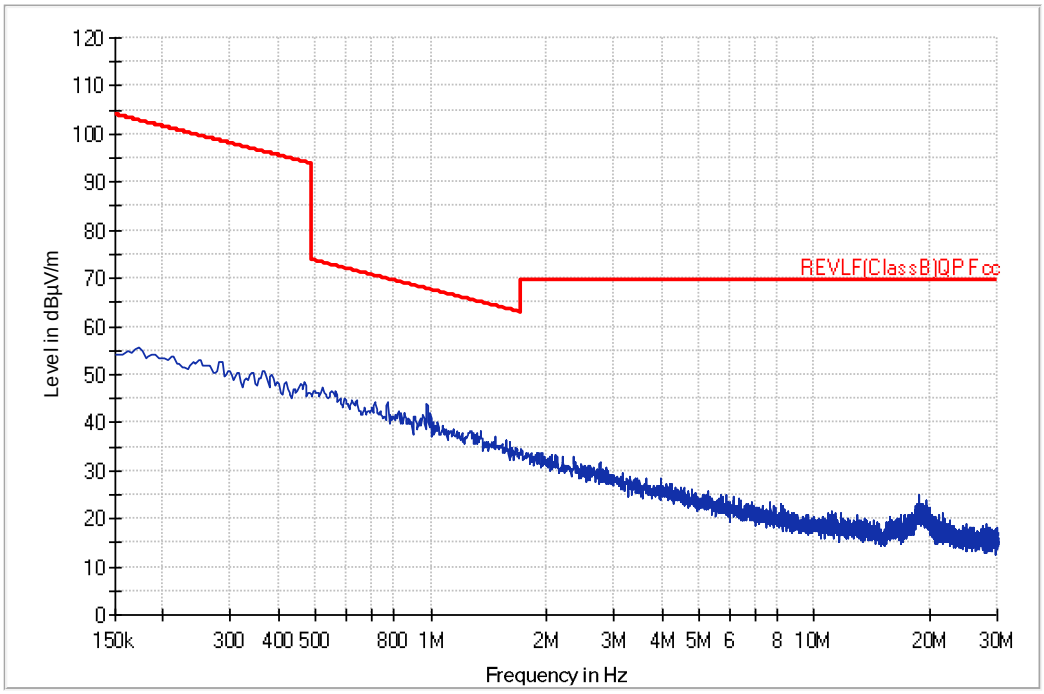


Figure 47: Radiated Emissions Measured at 3m – Antenna 2, Horizontally Polarized, LoRa SF12 High channel.

No significant emissions were seen in either vertical or horizontal polarizations.

3.7.2 30 MHz to 1 GHz

Tested August 23, 2023:

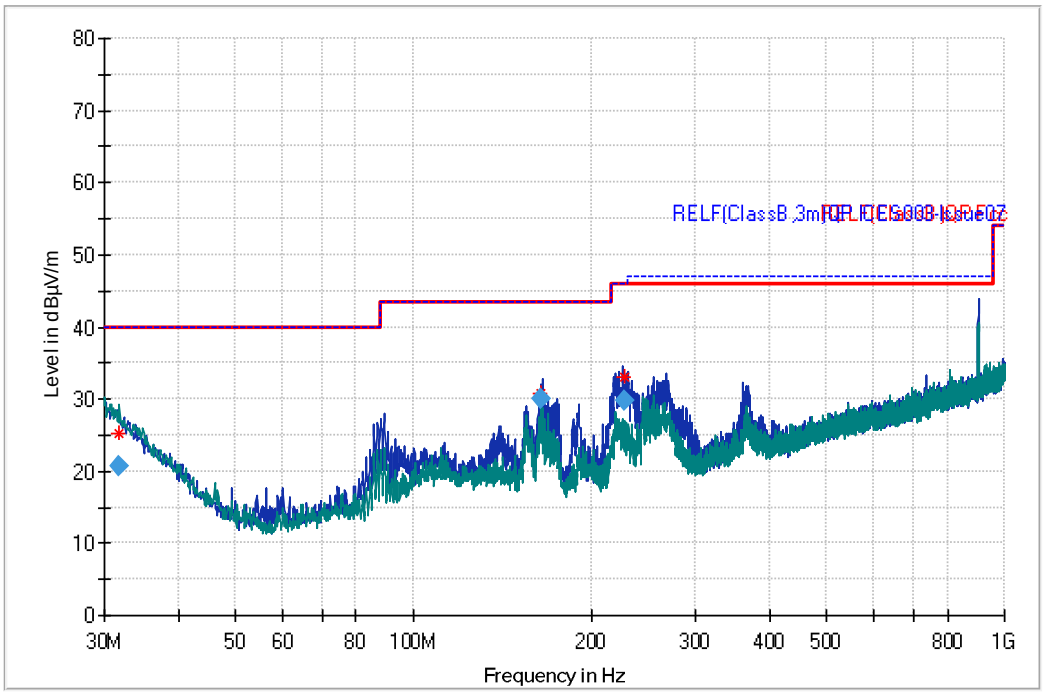


Figure 48: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
31.7811	20.60	40.00	19.40	1000.0	120.0	159.0	V	110	25.2	Complies
164.1476	30.06	43.50	13.44	1000.0	120.0	162.0	H	333	17.5	Complies
226.7622	29.77	46.00	16.23	1000.0	120.0	103.0	H	78	17.1	Complies

Table 9: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel.

Note: Emission at 900 MHz is the intentional transmission

Tested August 23, 2023:

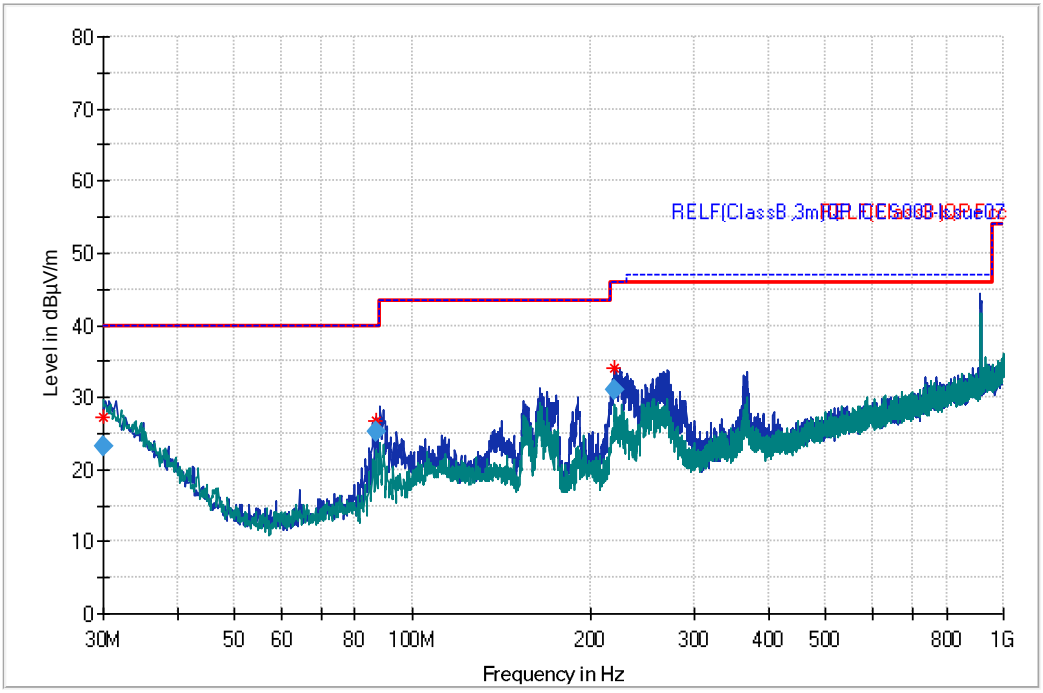


Figure 49: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
30.0533	23.12	40.00	16.88	1000.0	120.0	225.0	V	91	26.5	Complies
86.8616	25.16	40.00	14.84	1000.0	120.0	347.0	H	30	12.5	Complies
220.2039	31.08	46.00	14.92	1000.0	120.0	105.0	H	81	16.8	Complies

Table 10: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 1, LoRa SF12 Mid channel.

Note: Emission at 900 MHz is the intentional transmission

Tested August 23, 2023:

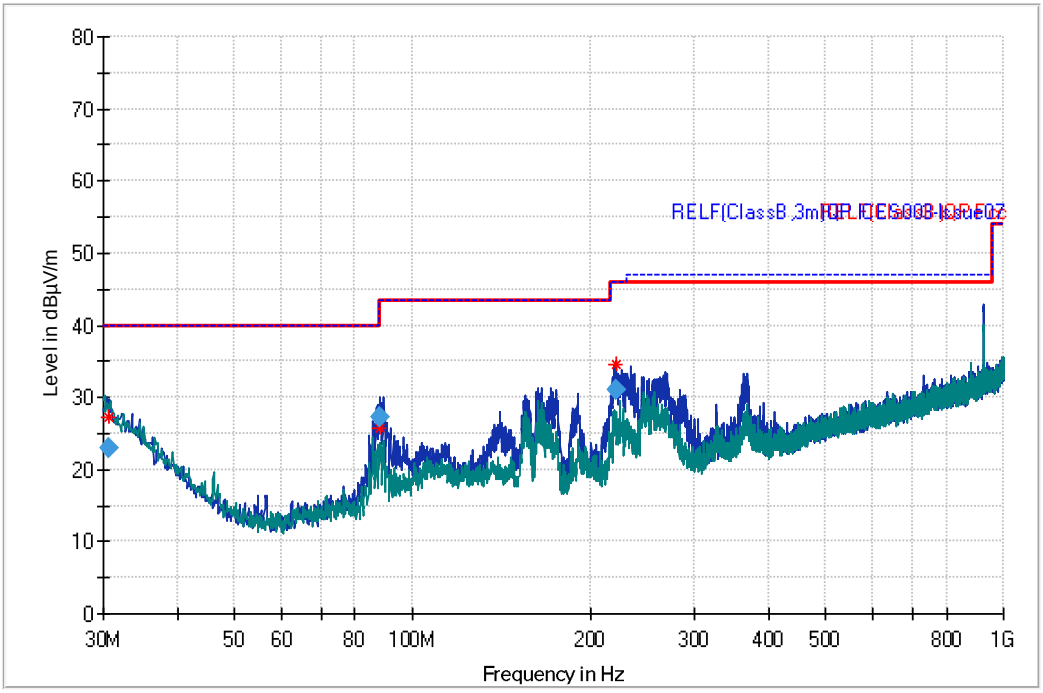


Figure 50: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 1, LoRa SF12 High channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
30.5416	22.95	40.00	17.05	1000.0	120.0	400.0	V	270	26.1	Complies
88.1856	27.32	43.50	16.18	1000.0	120.0	325.0	H	26	12.5	Complies
221.1906	31.16	46.00	14.84	1000.0	120.0	146.0	H	100	16.7	Complies

Table 11: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 1, LoRa SF12 channel High channel.

Note: Emission at 900 MHz is the intentional transmission

Tested August 25, 2023:

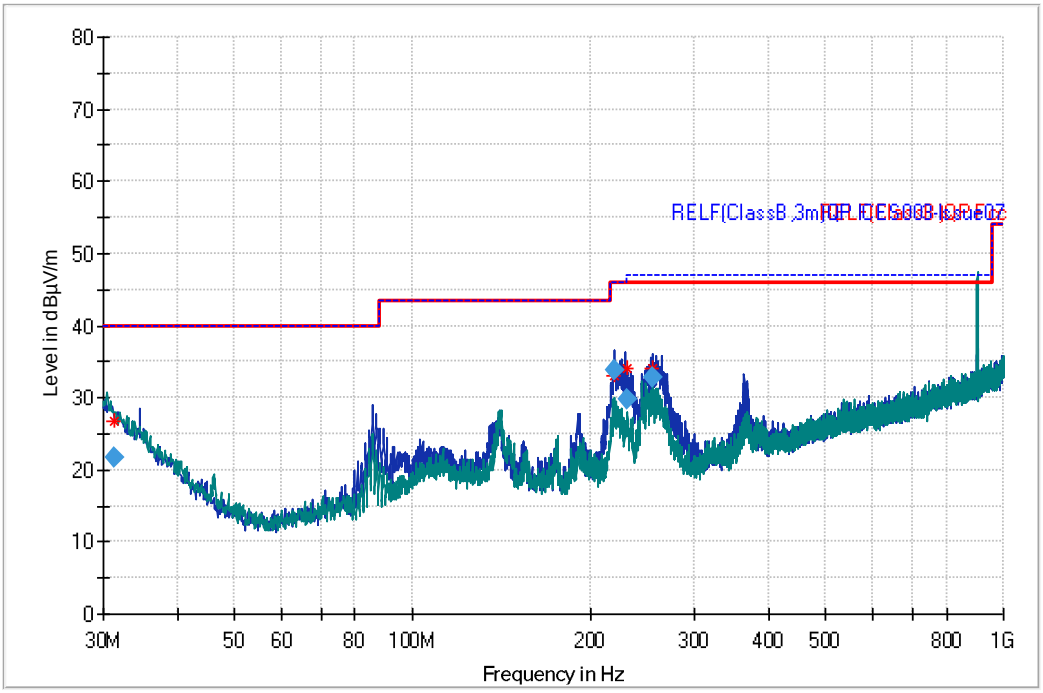


Figure 51: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
30.9100	21.98	40.00	18.02	1000.0	120.0	100.0	H	316	25.9	Complies
218.6100	23.94	40.00	16.06	1000.0	120.0	140.0	H	112	16.6	Complies
999.5626	28.12	47.00	18.88	1000.0	120.0	261.0	V	29	32.2	Complies

Table 12: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 Low channel.

Note: Emission at 900 MHz is the intentional transmission

Tested August 23, 2023:

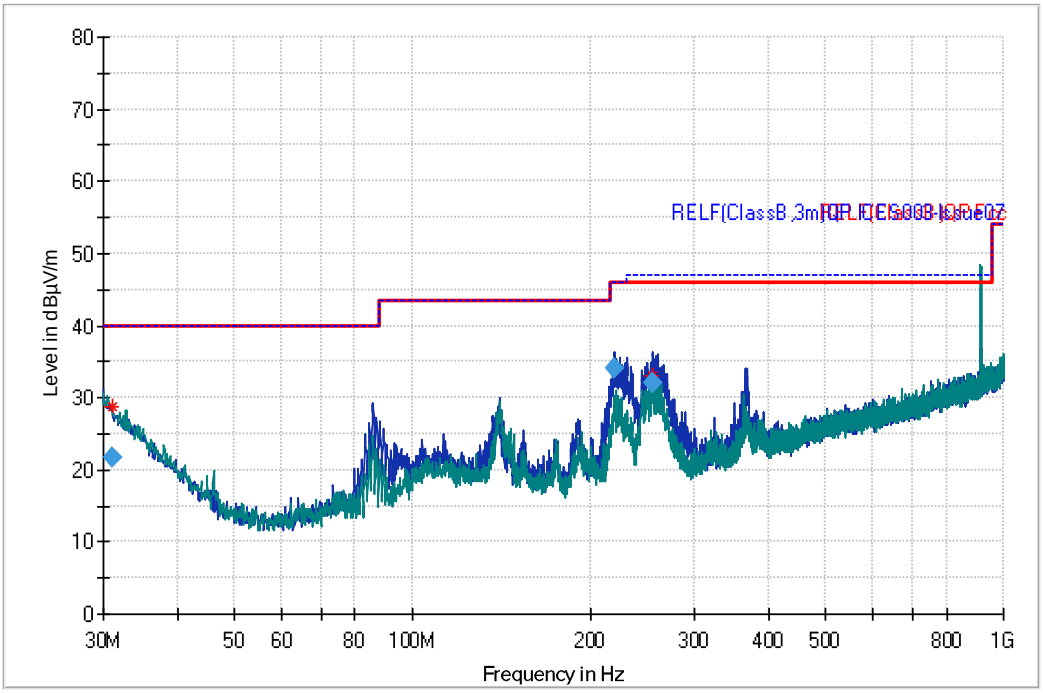


Figure 52: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
31.0298	21.73	40.00	18.27	1000.0	120.0	136.0	H	142	25.8	Complies
219.9499	34.07	46.00	11.93	1000.0	120.0	162.0	H	82	16.8	Complies
254.1894	32.01	46.00	13.99	1000.0	120.0	143.0	H	294	17.7	Complies

Table 13: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 Mid channel.

Note: Emission at 900 MHz is the intentional transmission

Tested August 23, 2023:

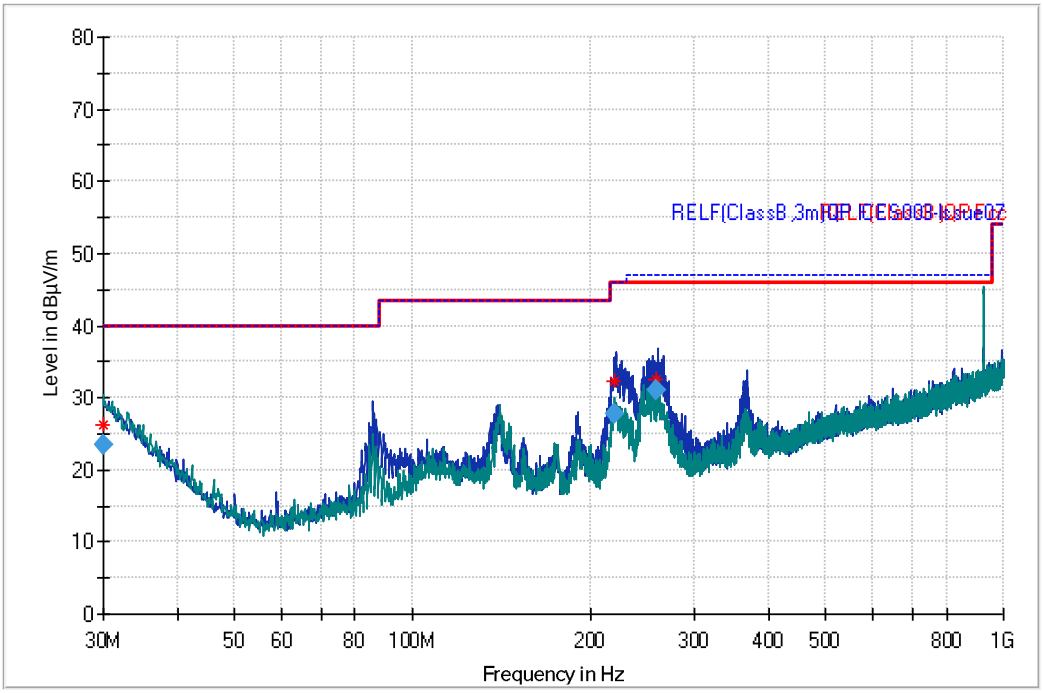


Figure 53: Radiated Emissions (30-1000 MHz) Measured at 3m – Antenna 2, LoRa SF12 High channel.

Frequency (MHz)	Quasi Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
30.0000	23.52	40.00	16.48	1000.0	120.0	297.0	V	334	26.5	Complies
219.2457	27.73	46.00	18.27	1000.0	120.0	124.0	H	81	16.7	Complies
259.0634	31.11	46.00	14.89	1000.0	120.0	159.0	H	68	18.1	Complies

Table 14: Radiated Emissions (30-1000 MHz) Measured at 3m - Antenna 2, LoRa SF12 High channel.

Note: Emission at 900 MHz is the intentional transmission

.

3.7.3 1 GHz to 6 GHz

Tested August 25, 2023:

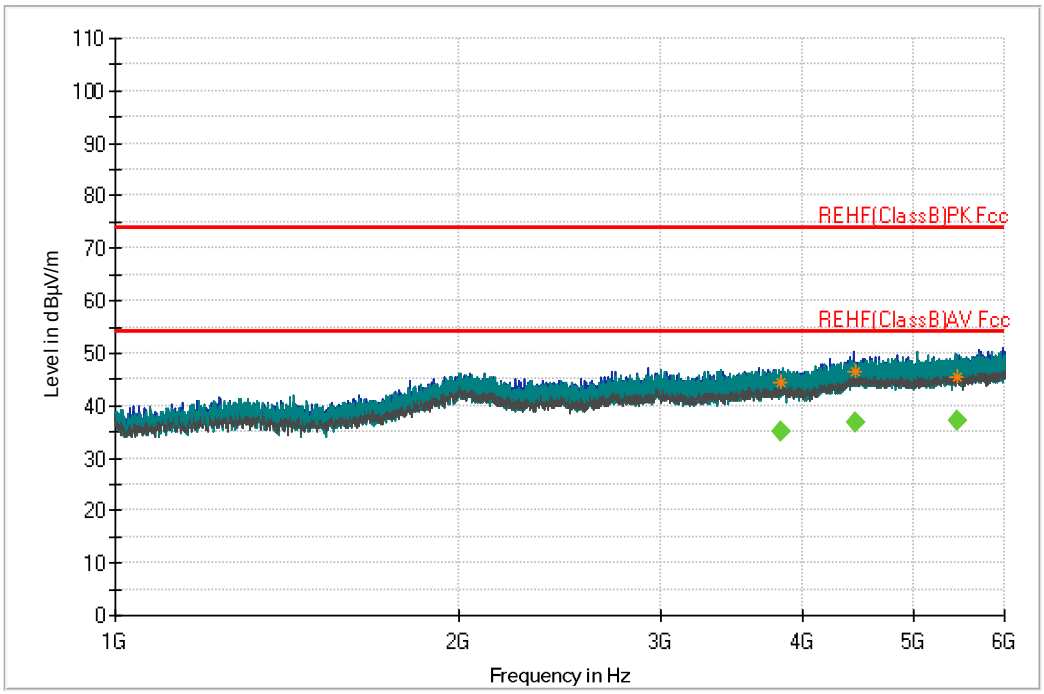


Figure 54: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
3827.4080	34.90	54.00	19.10	1000.0	1000.0	349.0	V	167	4.2	Complies
4436.9280	36.62	54.00	17.38	1000.0	1000.0	149.0	H	0	6.0	Complies
5444.9760	37.15	54.00	16.85	1000.0	1000.0	149.0	V	147	7.4	Complies

Table 15: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 Low channel.

Tested August 25, 2023:

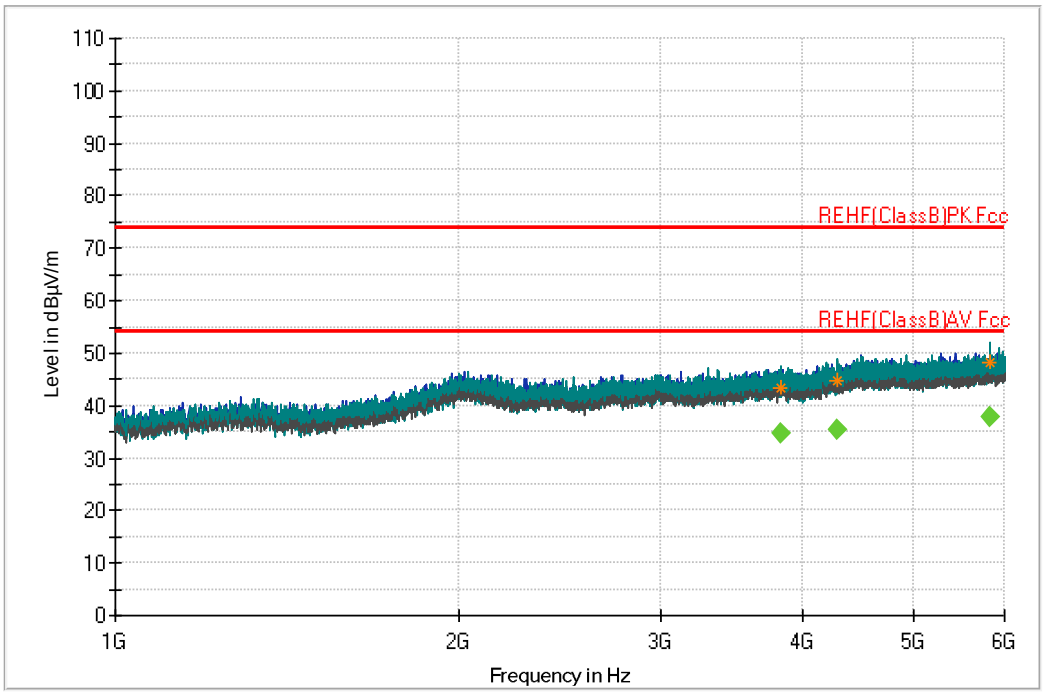


Figure 55: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
3825.1080	34.66	54.00	19.34	1000.0	1000.0	150.0	V	186	4.2	Complies
4279.2040	35.51	54.00	18.49	1000.0	1000.0	150.0	V	258	5.5	Complies
5835.4120	37.67	54.00	16.33	1000.0	1000.0	150.0	V	319	8.3	Complies

Table 16: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 Mid channel.

Tested August 25, 2023:

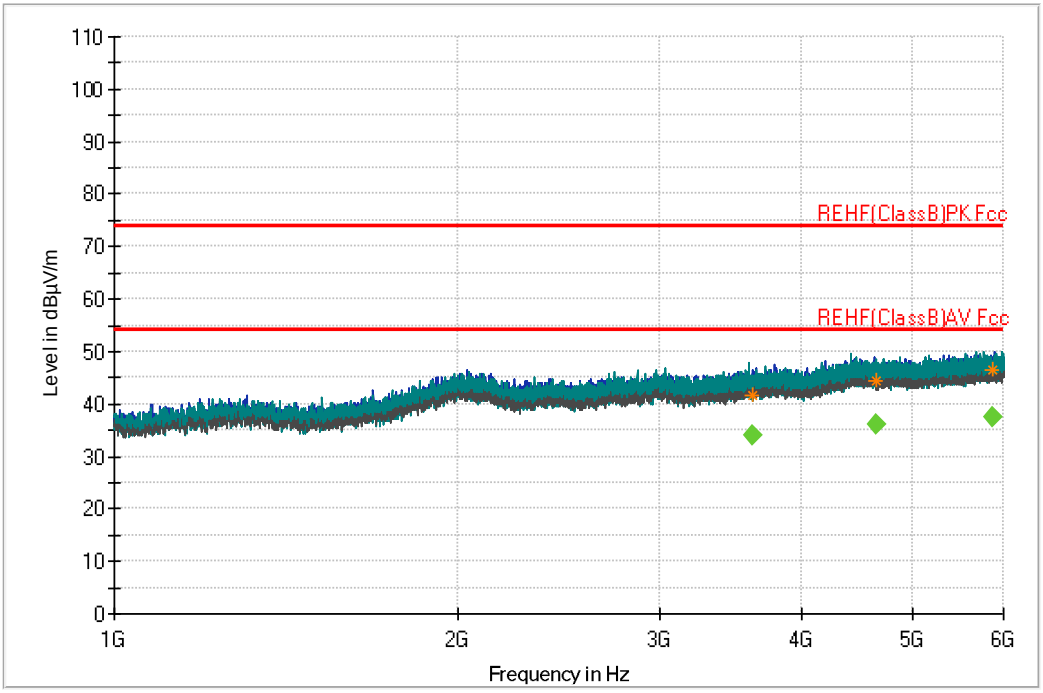


Figure 56: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 1, LoRa SF12 High channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
3614.0960	33.89	54.00	20.11	1000.0	1000.0	349.0	V	135	3.5	Complies
4642.7080	36.00	54.00	18.00	1000.0	1000.0	149.0	H	109	6.7	Complies
5865.2680	37.57	54.00	16.43	1000.0	1000.0	100.0	H	120	8.3	Complies

Table 17: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 1, LoRa SF12 High channel.

Tested August 25, 2023:

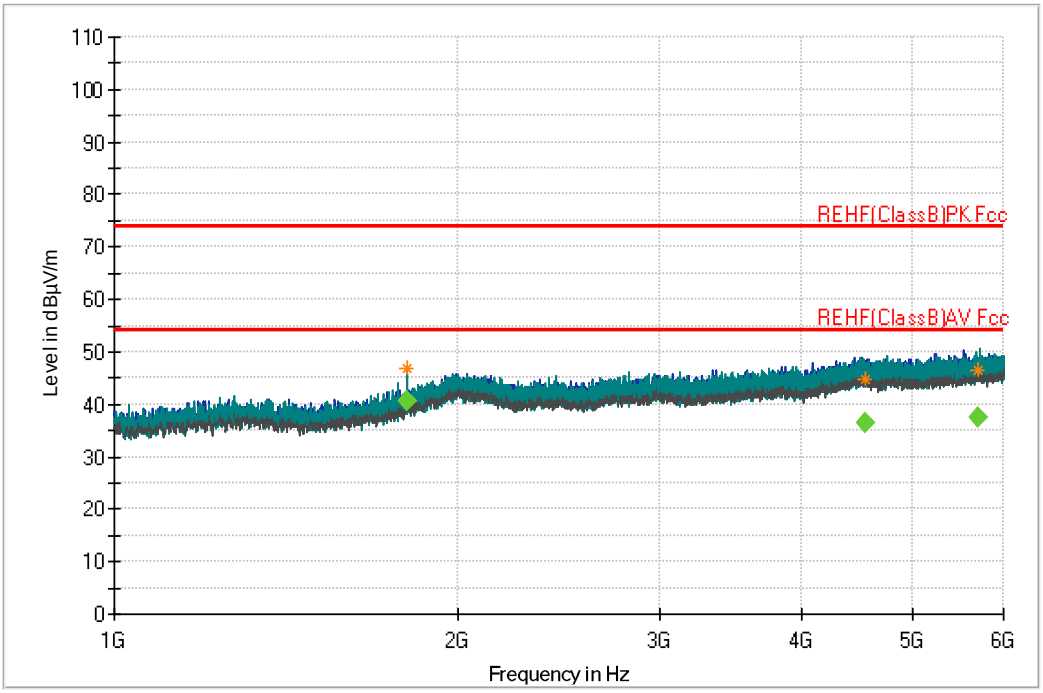


Figure 57: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
1805.2800	40.55	54.00	13.45	1000.0	1000.0	149.0	V	0	-2.0	Complies
4536.4320	36.51	54.00	17.49	1000.0	1000.0	199.0	H	256	6.3	Complies
5693.5800	37.56	54.00	16.44	1000.0	1000.0	299.0	V	239	8.0	Complies

Table 18: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 Low channel.

Tested August 25, 2023:

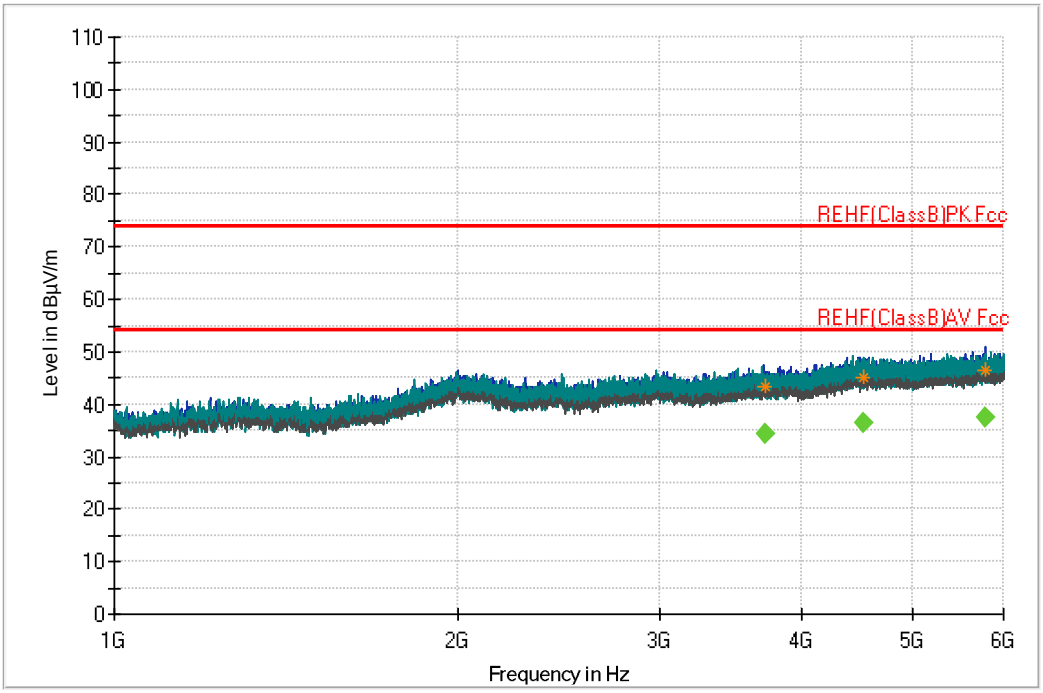


Figure 58: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
3710.2520	34.39	54.00	19.61	1000.0	1000.0	100.0	H	66	3.8	Complies
4525.1080	36.36	54.00	17.64	1000.0	1000.0	349.0	V	353	6.2	Complies
5788.2240	37.55	54.00	16.45	1000.0	1000.0	299.0	H	0	8.2	Complies

Table 19: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 Mid channel.

Tested August 28, 2023:

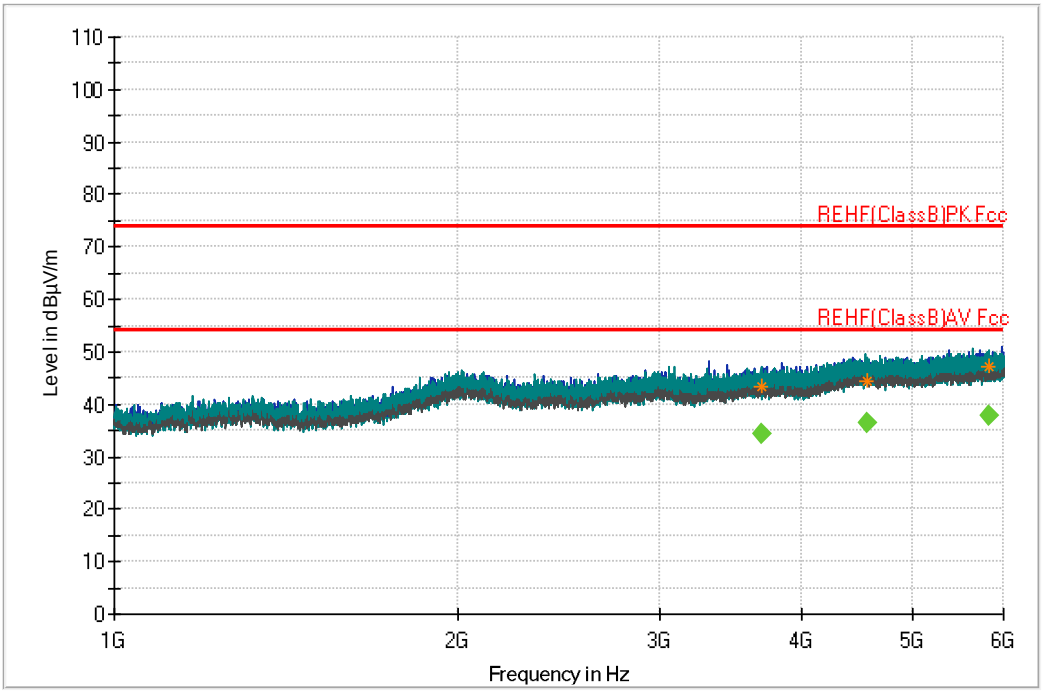


Figure 59: Radiated Emissions (1-6 GHz) Measured at 3m – Antenna 2, LoRa SF12 High channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
3687.7720	34.33	54.00	19.67	1000.0	1000.0	200.0	V	157	3.8	Complies
4557.0200	36.52	54.00	17.48	1000.0	1000.0	149.0	V	157	6.4	Complies
5832.5440	37.73	54.00	16.27	1000.0	1000.0	199.0	V	356	8.3	Complies

Table 20: Radiated Emissions (1-6 GHz) Measured at 3m - Antenna 2, LoRa SF12 High channel.

\

3.7.4 30 MHz to 1 GHz

Tested August 28, 2023

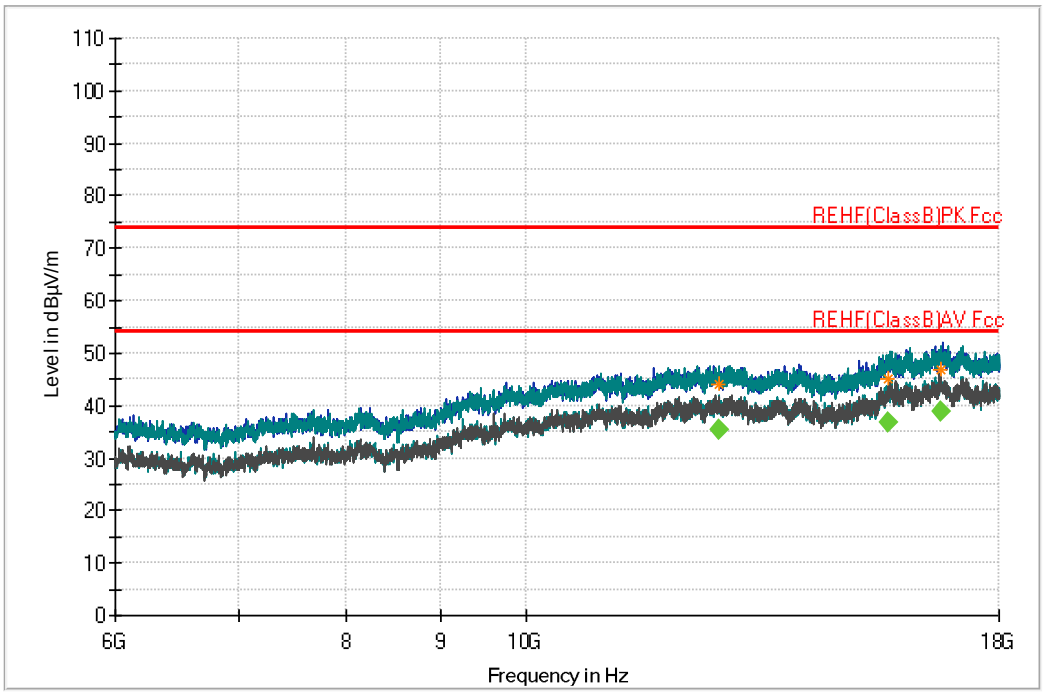


Figure 60: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 Low channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
2092.4360	33.33	50.00	16.67	1000.0	1000.0	100.0	V	16	0.8	Complies
2895.7360	33.22	50.00	16.78	1000.0	1000.0	349.0	H	127	1.4	Complies
5688.3800	37.65	54.00	16.35	1000.0	1000.0	199.0	H	0	8.0	Complies

Table 21: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 Low channel.

Tested August 28, 2023

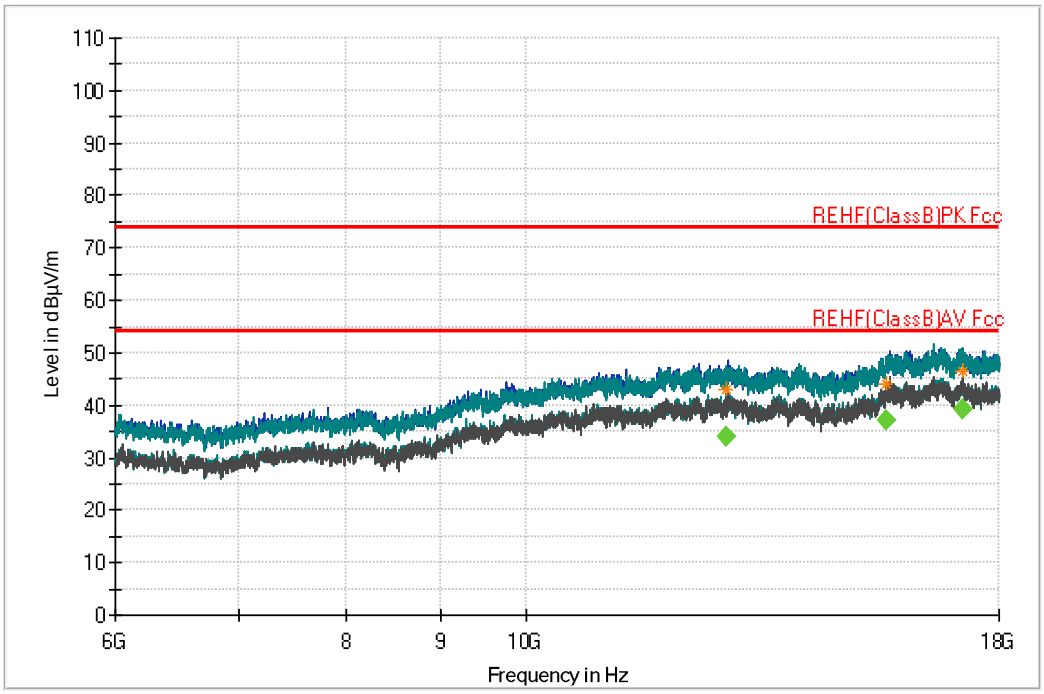


Figure 61: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 Mid channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
12836.3080	34.14	54.00	19.86	1000.0	1000.0	103.0	V	324	7.5	Complies
15660.6680	37.24	54.00	16.76	1000.0	1000.0	103.0	V	0	12.1	Complies
17199.9200	39.30	54.00	14.70	1000.0	1000.0	106.0	V	357	13.4	Complies

Table 22: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 Mid channel.

Tested August 28, 2023

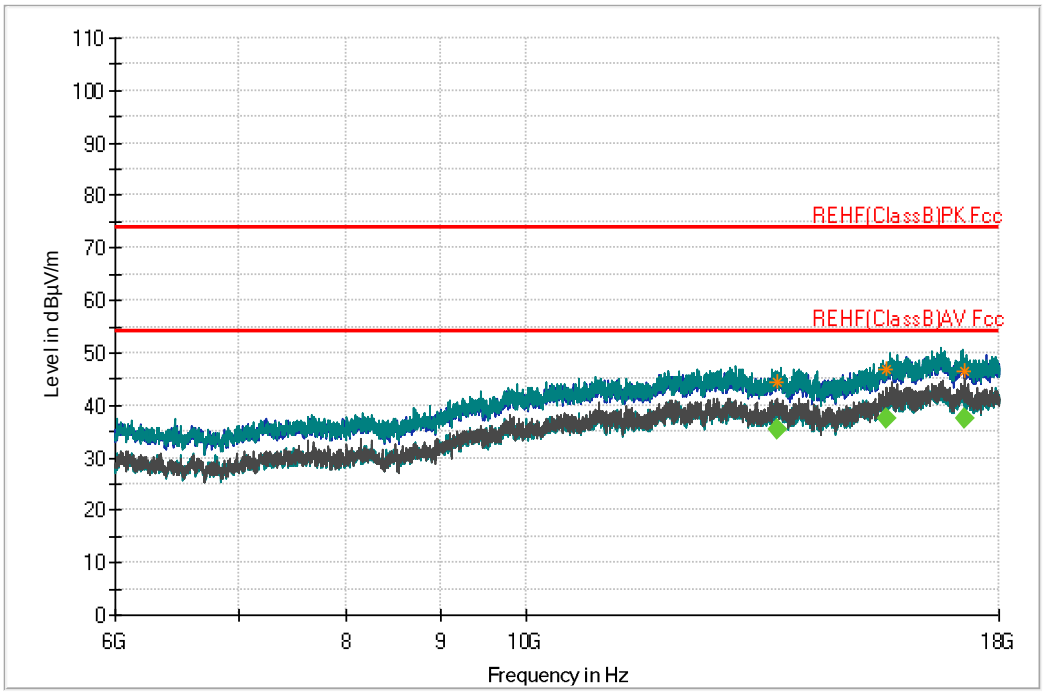


Figure 62: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 1, LoRa SF12 High channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
13663.3080	35.48	54.00	18.52	1000.0	1000.0	103.0	V	250	6.7	Complies
15642.0400	37.30	54.00	16.70	1000.0	1000.0	103.0	V	104	11.9	Complies
17231.0760	37.64	54.00	16.36	1000.0	1000.0	114.0	V	148	13.4	Complies

Table 23: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 1 LoRa SF12 High channel.

Tested August 28, 2023

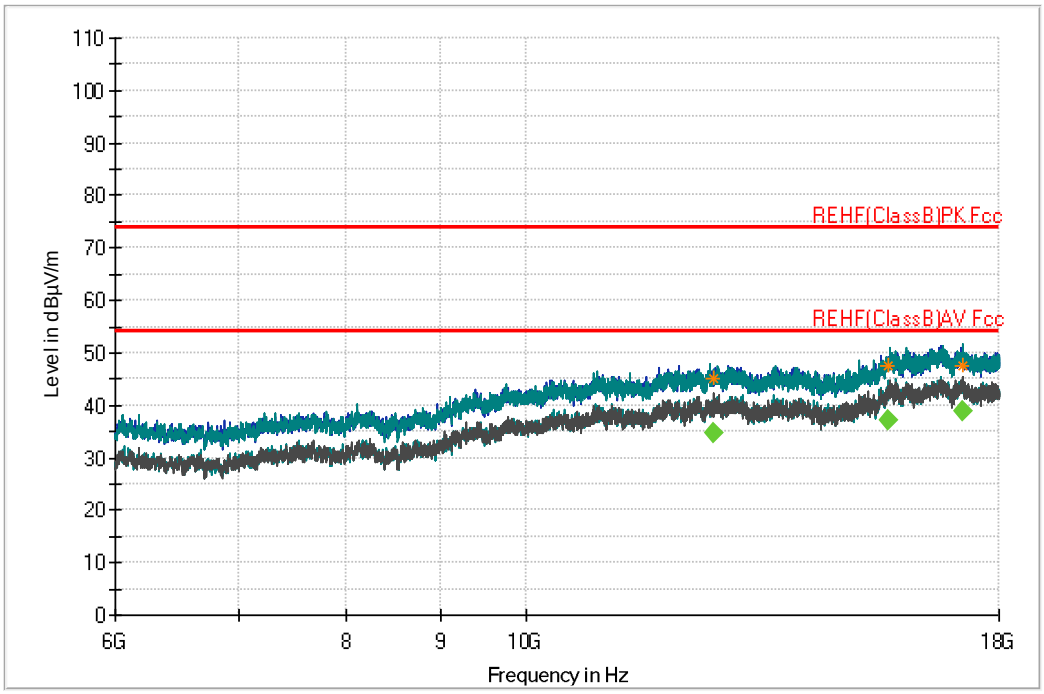


Figure 63: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 Low channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
12633.0680	34.67	54.00	19.33	1000.0	1000.0	326.0	V	209	7.6	Complies
15692.0280	37.25	54.00	16.75	1000.0	1000.0	149.0	H	273	12.3	Complies
17193.2400	38.76	54.00	15.24	1000.0	1000.0	360.0	V	76	13.3	Complies

Table 24: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 Low channel.

Tested August 28, 2023

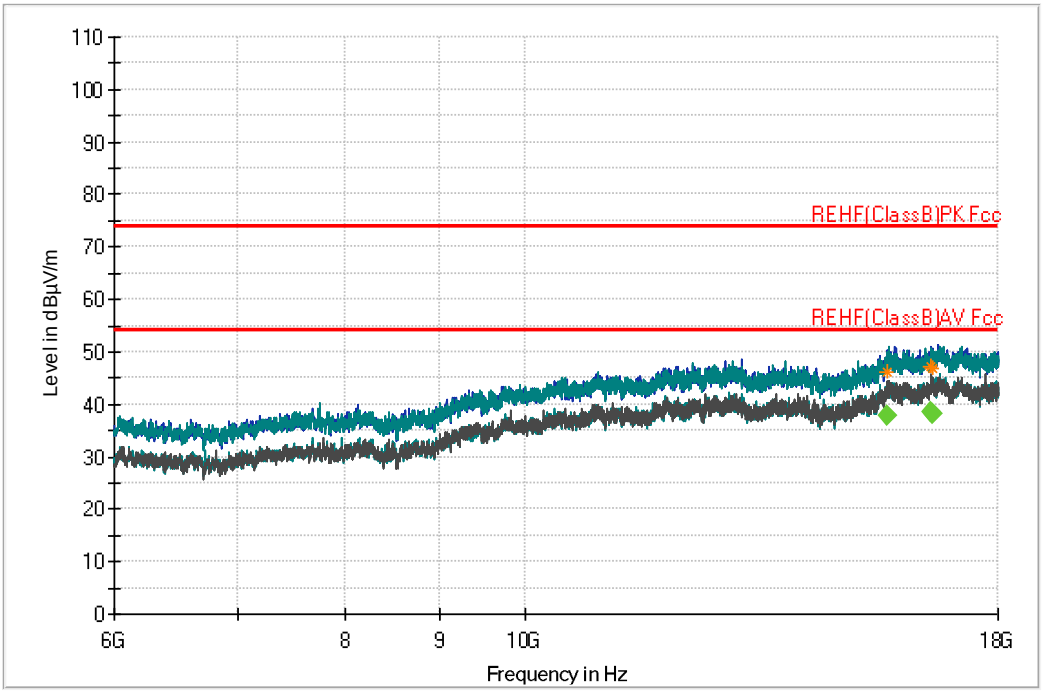


Figure 64: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 Mid channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
15687.4960	37.70	54.00	16.30	1000.0	1000.0	305.0	V	176	12.3	Complies
16571.1360	38.40	54.00	15.60	1000.0	1000.0	246.0	V	15	12.9	Complies
16582.1600	38.09	54.00	15.91	1000.0	1000.0	212.0	V	32	12.9	Complies

Table 25: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 Mid channel.

Tested August 28, 2023

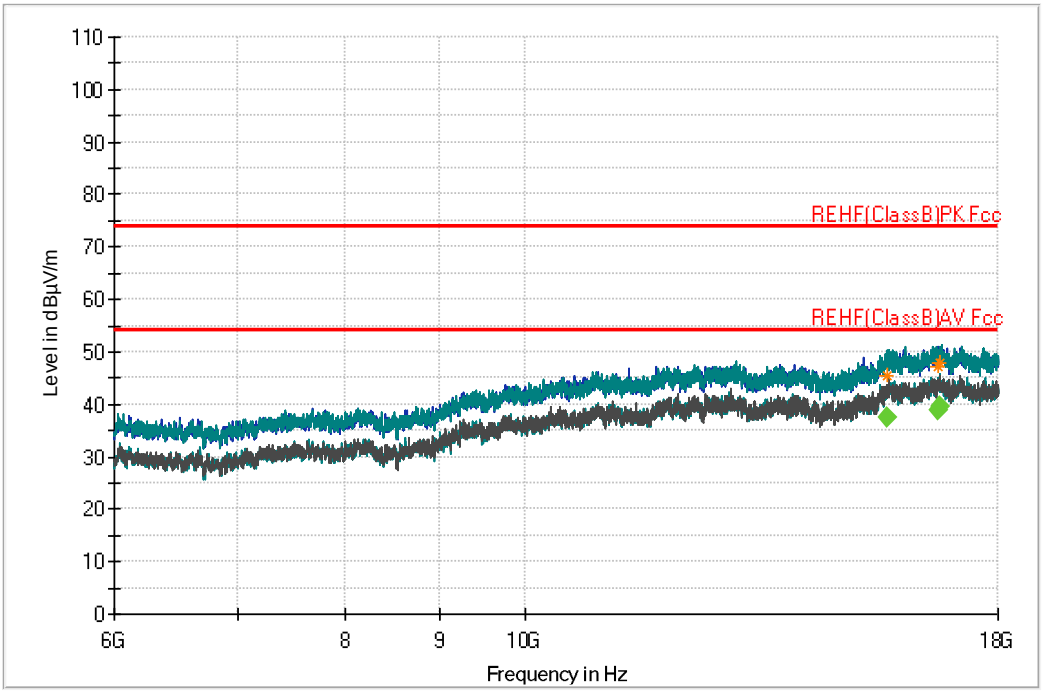


Figure 65: Radiated Emissions (6-18 GHz) Measured at 3m – Antenna 2, LoRa SF12 High channel.

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band Width (kHz)	Height (cm)	Pol.	Azim. (Deg)	Cor. Factor (dB)	Result
15668.8000	37.38	54.00	16.62	1000.0	1000.0	124.0	H	281	12.1	Complies
16718.9760	38.83	54.00	15.17	1000.0	1000.0	367.0	H	112	12.9	Complies
16739.7160	39.50	54.00	14.50	1000.0	1000.0	400.0	H	244	12.9	Complies

Table 26: Radiated Emissions (6-18 GHz) Measured at 3m - Antenna 2 LoRa SF12 High channel.

Appendix A: Test Setup Photos

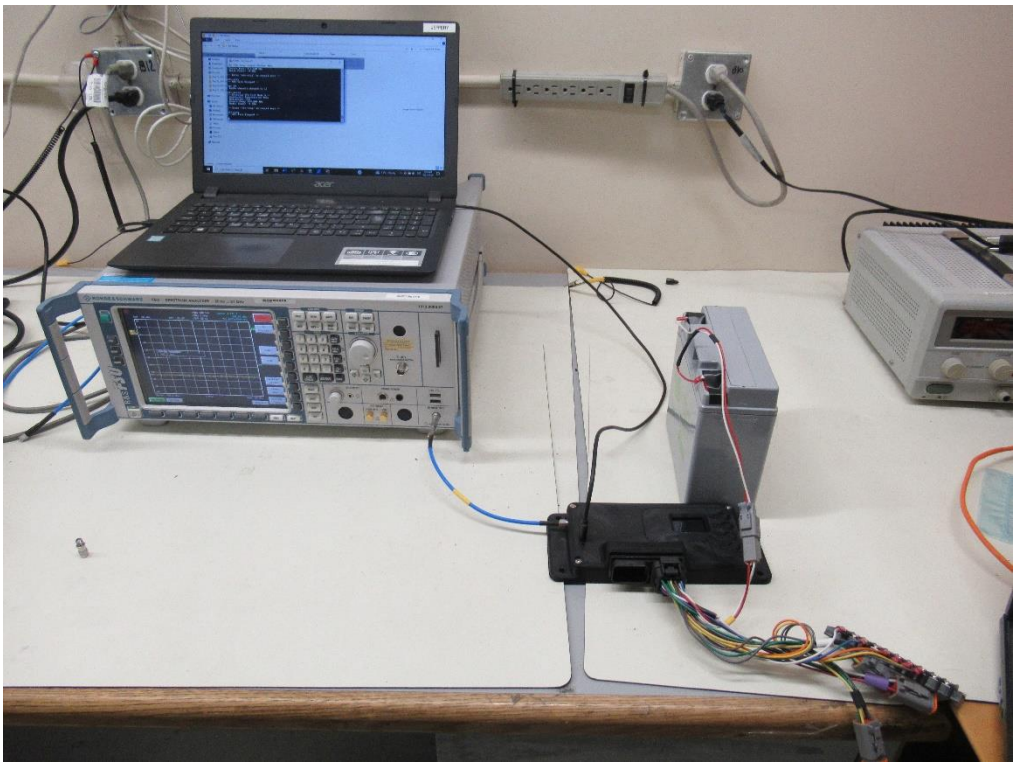


Figure 66: Conducted RF Measurement Setup

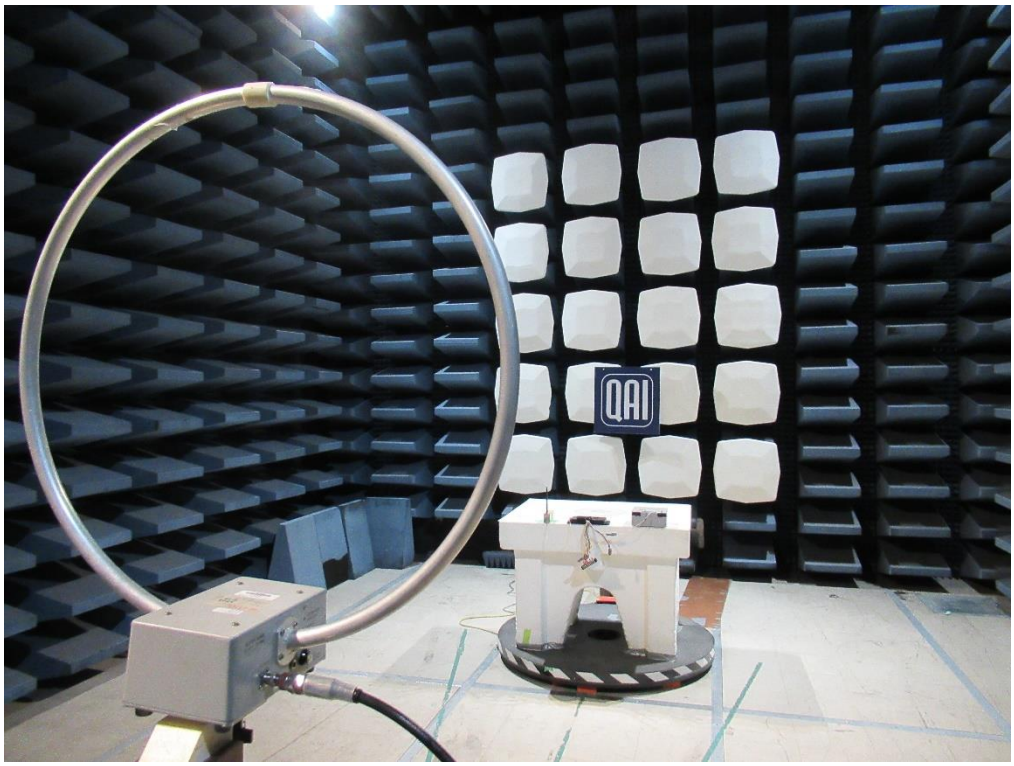


Figure 67: Radiated Measurement Setup, < 30 MHz, Antenna 1

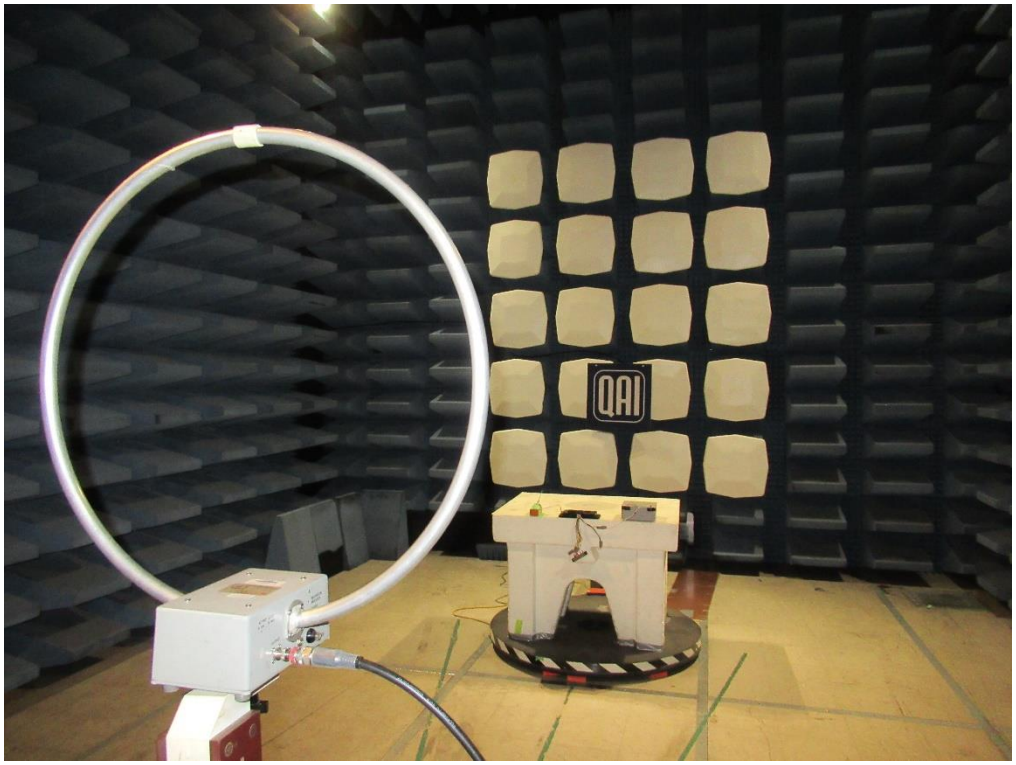


Figure 68: Radiated Measurement Setup, < 30 MHz, Antenna 2

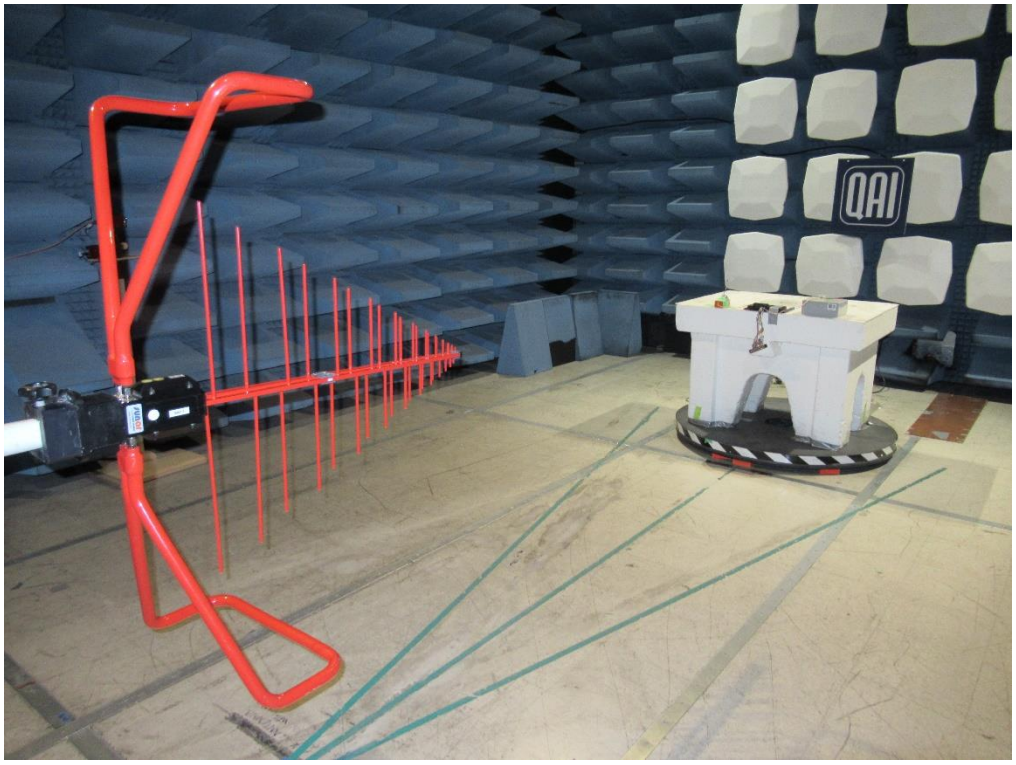


Figure 69: Radiated Measurement Setup, 30 MHz to 1 GHz, Antenna 1

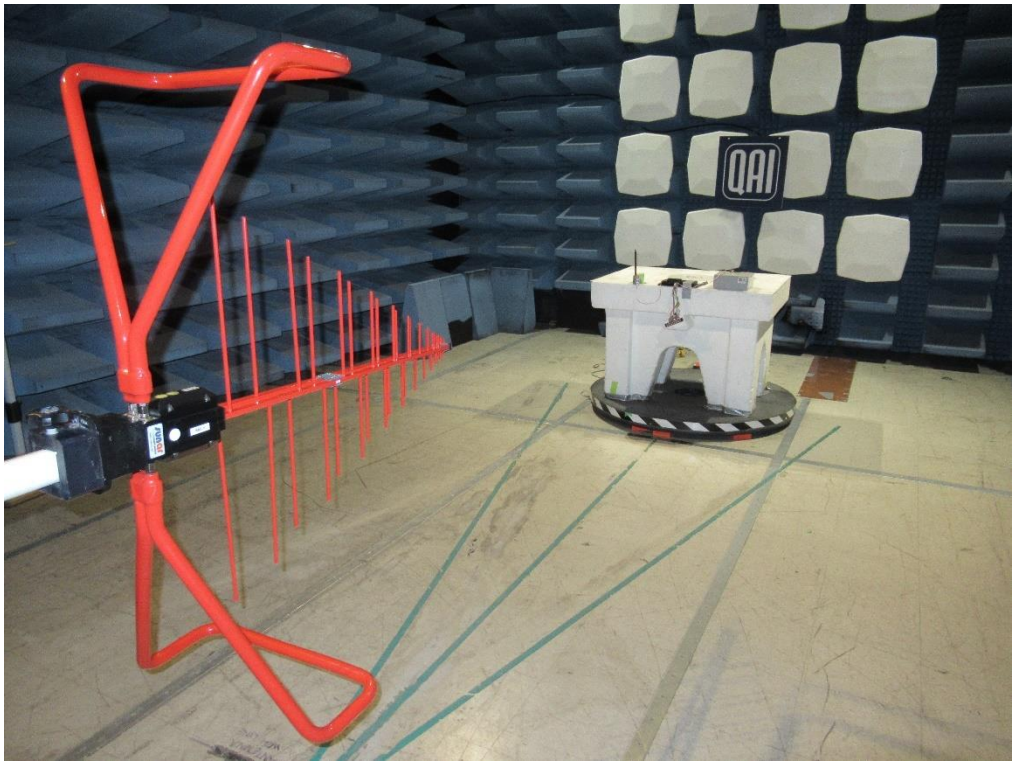


Figure 70: Radiated Measurement Setup, 30 MHz to 1 GHz, Antenna 2

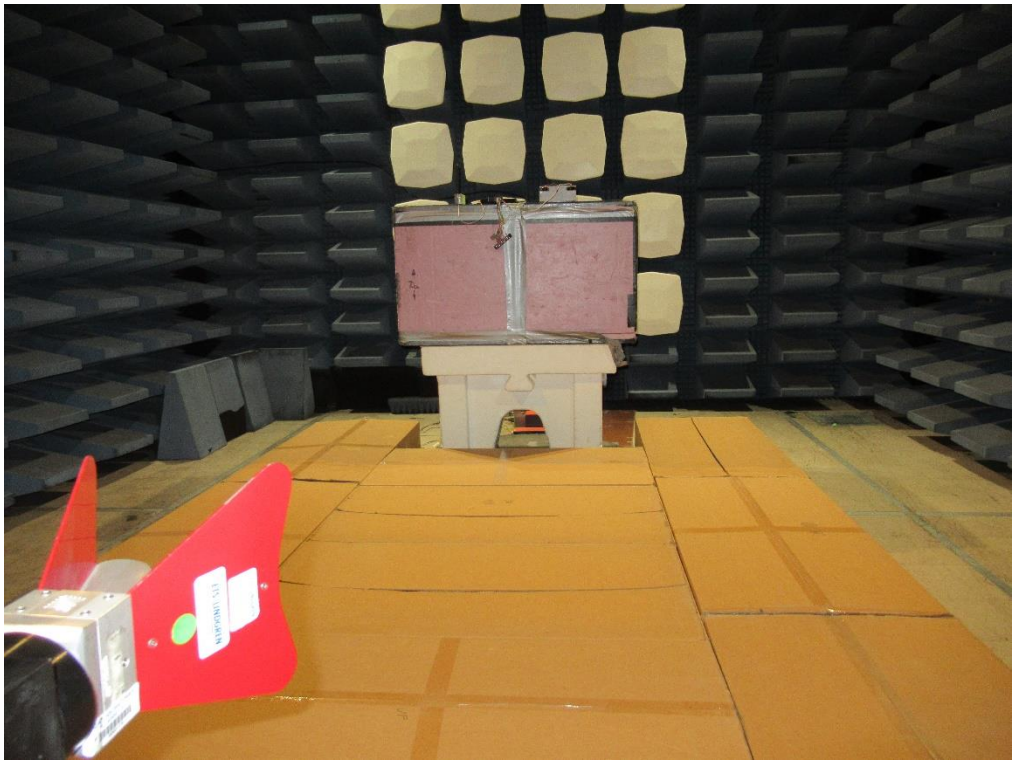


Figure 71: Radiated Measurement Setup, > 1 GHz, Antenna 1

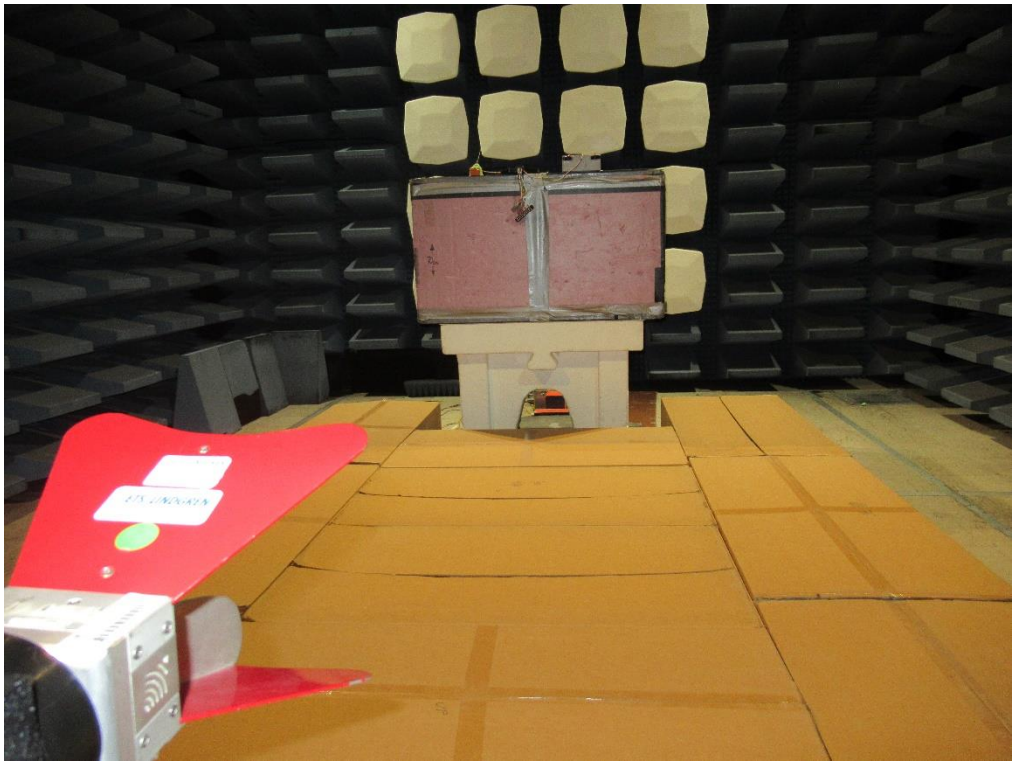


Figure 72: Radiated Measurement Setup, > 1 GHz, Antenna 2

Figure 73: Frequency Stability with Temperature.

Appendix B: Abbreviations

Abbreviation	Definition
AC	Alternating Current
AM	Amplitude Modulation
CE	European Conformity
CISPR	Comité International Spécial des Perturbations Radioélectriques (International Special Committee on Radio Interference)
DC	Direct Current
EFT	Electrical Fast Transient
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electrostatic Discharge
EUT	Equipment Under Test
FCC	Federal Communications Commission
FVIN	Firmware Version Identification Number FVIN
IC	Industry Canada
ICES	Interference Causing Equipment Standard
IEC	International Electrotechnical Commission
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RF	Radio Frequency
RMS	Root-Mean-Square
SAC	Semi-Anechoic Chamber

END OF REPORT