Radio Test Report

LoRa module installed in GeoWan Node
LR3N - CS2 / CMWX1ZZABZ

47 CFR Part 15.247 Effective Date 1st October 2018
DTS: Digital Transmission System
Test Date: 11th December 2019 to 21st January 2020
Report Number: 01-11799-1-20 Issue 01

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Certificate of Test 11799-1

The equipment noted below has been fully tested by R.N. Electronics Limited 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 GeoWan Node
Model Number:	LR3N - CS2 / CMWX1ZZABZ
Unique Serial Number:	001BC50AA8000007 - hopping mode tests, 001BC50AA800000D - All other tests
Applicant:	Senceive Ltd Imperial Studios, Imperial Road Fulham, London, England SW6 2AG
Proposed FCC ID	2AMFBLR3N
Full measurement results are detailed in Report Number:	01-11799-1-20 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2018 DTS: Digital Transmission System

NOTE:
Certain tests were not performed based upon manufacturer's declarations. Certain other requirements are subject to manufacturer declaration only and have not been tested/verified. For details refer to section 3 of this report.

DEVIATIONS:
No deviations have been applied.

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:	11th December 2019 to 21st January 2020
Test Engineer:	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2020.02.04 09:05:06 Z
Approved By: Technical Manager	Steve Hull Digitally signed by: Steve Hull DN: CN = Steve Hull email = steve@rnelectronics.com C = GB O = RN Electronics Date: 2020.02.04 09:07:47 Z
Customer Representative:	

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1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Senceive Ltd Imperial Studios Imperial Road Fulham, London England SW6 2AG	
Manufacturer of EUT	Senceive Ltd	
Full Name of EUT	LoRa module installed in GeoWan Node	
Model Number of EUT	LR3N - CS2 / CMWX1ZZABZ	
Serial Number of EUT	001BC50AA8000007 - Hopping mode tests, 001BC50AA800000D - All other tests	
Date Received	10th December 2019	
Date of Test:	11th December 2019 to 21st January 2020	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	22nd January 2020	
Main Function	Wireless Data logger operating in 915 - 928 MHz band.	
Information Specification	Height	90 mm
	Width	90 mm
	Depth	60 mm
	Weight	0.5 kg
	Voltage	3.5 VDC (battery)
	Current	0.128 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Fixed
Choice of model(s) for type tests	Production model
Antenna details	External, Linx technologies ANT-916-CW-QW-SMA, 1.8 dBi
Antenna port	Yes
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	927.8 MHz
Lowest Signal generated in EUT	9.6 kHz
Hardware Version	LR3NODE.AAB
Software Version	Not specified
Firmware Version	MODEM-1.0.02
Type of Equipment	Fixed use
Technology Type	Short Range device (SRD)
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	915-928 MHz
EUT Declared Modulation Parameters	LoRa with FHSS
EUT Declared Power level	+20dBm (conducted)
EUT Declared Signal Bandwidths	125 kHz / 500 kHz
EUT Declared Channel Spacing's	125k BW: 200kHz channel spacing, 500k BW: 1.6 MHz channel spacing
EUT Declared Duty Cycle	Not declared
Unmodulated carrier available?	No
Declared frequency stability	Not declared
RX Parameters	
Alignment range – receiver	915-928 MHz
EUT Declared RX Signal Bandwidth	125 kHz
Receiver Signal Level (RSL)	Not declared
Method of Monitoring Receiver BER	Not specified
FCC Parameters	
FCC Transmitter Class	DTS: Digital Transmission System
FHSS Parameters	
Maximum No. Of hop channels	64
Minimum No. Of hop channels	Not declared
Dwell time per hop channel	Not declared
Return time to same channel	Not declared

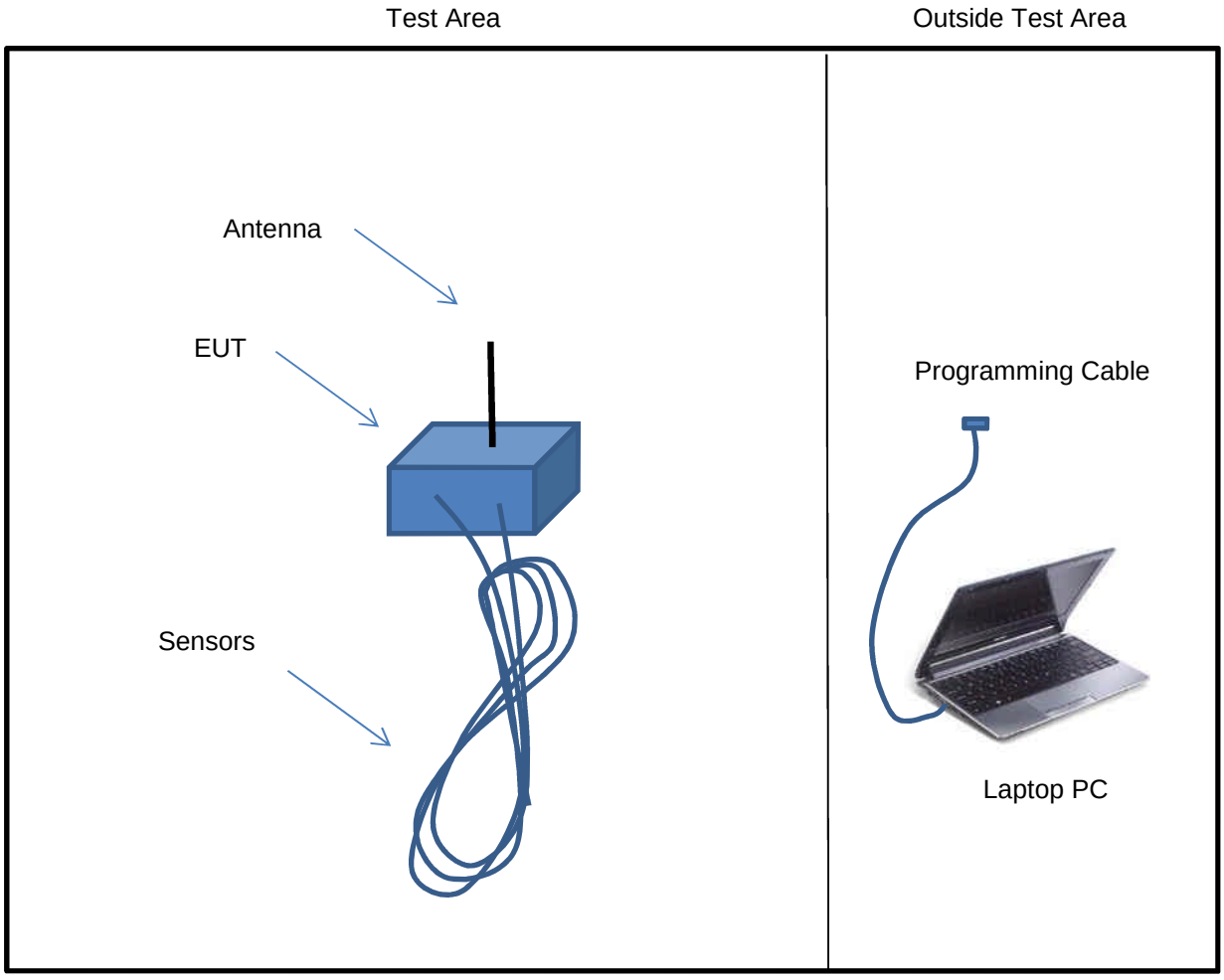
2.3 Functional description

The EUT is a LoRa module installed in a battery powered data logger. Sensors are connected to the EUT and samples are acquired and then transmitted to the gateway. The gateway can send diagnostic commands immediately after a data sample. The EUT operates over a frequency range of 915 - 928 MHz for North American markets. The EUT has a maximum ERP of 20 dBm.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX1	Transmitting on 915.3 MHz 125 kHz BW SF10 20 dBm	Yes
TX2	Transmitting on 922.5 MHz 125 kHz BW SF10 20 dBm	Yes
TX3	Transmitting on 927.7 MHz 125 kHz BW SF10 20 dBm	Yes
TX4	Transmitting on 915.5 MHz 500 kHz BW SF12 20 dBm	Yes
TX5	Transmitting on 922.5 MHz 500 kHz BW SF12 20 dBm	Yes
TX6	Transmitting on 927.5 MHz 500 kHz BW SF12 20 dBm	Yes
TX-Hopping	Transmitting in hopping mode across all 64 channels	Yes

2.5 Emissions configuration



The unit was powered from a new integral battery. Sensors were connected to both of the sensor ports and excess cables were bundled 400mm. For the purposes of testing, the applicant modified the EUT by adding a temporary programming cable to the EUT, which protruded from one side – this programming cable was kept as short as possible to minimise its influence on the results. Prior to test the unit was configured using a laptop PC and programming cable to allow permanent transmit of the device on the top, middle and bottom channels as stated within section 2.4 of this report. The laptop PC was only connected for set up and was removed from the chamber for final measurements. The transmit mode was 100% continuous with modulation and the power settings for each channel stated in section 2.4 above was +20dBm with PA boost. Continuous mode was used as this provided higher power results than packet mode. Spreading factors were set as instructed by Senceive Ltd. For all 125kHz BW channels this was SF10 and all 500kHz BW channels SF12 was used.
In addition to the modes above, a second unit was provided configured for hopping mode tests. In this mode the EUT hopped at random between the 64 available channels, one channel every 30 seconds.

2.5.1 Signal leads

Port Name	Cable Type	Connected
Sensor Port 1	FFC/FPC	Yes
Sensor Port 2	FFC/FPC	Yes
Antenna	SMA connector, whip antenna	Yes

3 Summary of test results

The LoRa module installed in GeoWan Node, LR3N - CS2 / CMWX1ZZABZ was tested for compliance to the following standard(s) :

47 CFR Part 15.247 Effective Date 1st October 2018
DTS: Digital Transmission System

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[2]
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) & 15.247(a)(2)	PASSED
9. Maximum Average conducted output power	47 CFR Part 15C Part 15.247(b3)	PASSED
10. Maximum Peak conducted output power	47 CFR Part 15C Part 15.247(b)(2) & (b)(3)	PASSED
11. Maximum Power Spectral Density	47 CFR Part 15C Part 15.247(e)	PASSED
12. Antenna power conducted emissions	47 CFR Part 15C Part 15.247(d)	NOT APPLICABLE[4]
13. Duty cycle	47 CFR Part 15C Part 15.35(c)	NOT APPLICABLE[5]
14. FHSS carrier frequency separation	47 CFR Part 15C Part 15.247(a1)	PASSED
15. Average time of occupancy	47 CFR Part 15C Part 15.247(a)(1)(i)	PASSED
16. Number of Hop Channels	47 CFR Part 15C Part 15.247(a)(1)(i)	PASSED

[1] EUT does not operate from the AC power lines nor contain provisions for operation while connected to AC power lines.
[2] Spectrum investigated up to a frequency of 10GHz based on 10 times the highest channel/ signal generated in equipment of 927.8MHz.
[3] EUT has been tested for conducted power instead.
[4] Does apply to EUT's with an antenna port, however, the EUT was tested for radiated emissions with its dedicated antenna in position.
[5] No limits apply, however duty cycle measurement performed to verify any possible correction factors for average emissions. EUT Duty was confirmed as operating at 100% constant transmit state for applicable tests.

4 Specifications

The tests were performed and operated in accordance with R.N. Electronics Ltd procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	47 CFR Part 15C	2018	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 v05	2018	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

No deviations were 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 battery.

No discernible difference was observed between channels/modes for emissions, therefore for full test the EUT was operated in TX2 mode.

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 (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site M.

5.2.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	16°C
Humidity of test environment	46%
Pressure of test environment	101kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz
Mod Scheme	LoRa
Single channel	922.5 MHz

Plot refs
11799-1 Rad 1 9k-150kHz Para
11799-1 Rad 1 9k-150kHz Perp

Note: No discernible difference was observed between channels/modes for emissions; therefore plots are shown for mode 2 only. No emissions were observed within 20dB of limits.

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

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 battery.

No discernible difference was observed between channels/modes for emissions, therefore for full test the EUT was operated in TX2 mode.

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 (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site M.

5.3.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	16°C
Humidity of test environment	46%
Pressure of test environment	101kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz
Mod Scheme	LoRa
Single channel	922.5 MHz

Plot refs
11799-1 Rad 1 150k-30MHz Para
11799-1 Rad 1 150k-30MHz Perp

Note: No discernible difference was observed between channels/modes for emissions; therefore plots are shown for mode 2 only. No emissions were observed within 20dB of limits.

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

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 battery.

The EUT was operated in modes TX1 to TX6.

5.4.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made on a site listed with the FCC. The equipment was rotated 360 degrees and the antenna scanned 1 – 4 metres in both horizontal and vertical polarisations to record the worst case emissions.

At least 6 signals within 20dB and all signals within 10dB 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 22 - 23°C
Humidity of test environment 46 - 47%
Pressure of test environment 101kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
Low channel	915.3 MHz

Plot refs
11799-1 Rad 1 VHF Horiz
11799-1 Rad 1 VHF Vert
11799-1 Rad 1 UHF Horiz
11799-1 Rad 1 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
Mid channel	922.5 MHz

Plot refs
11799-1 Rad 2 VHF Horiz
11799-1 Rad 2 VHF Vert
11799-1 Rad 2 UHF Horiz
11799-1 Rad 2 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
High channel	927.7 MHz

Plot refs
11799-1 Rad 3 VHF Horiz
11799-1 Rad 3 VHF Vert
11799-1 Rad 3 UHF Horiz
11799-1 Rad 3 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
Low channel	915.5 MHz

Plot refs
11799-1 Rad 4 VHF Horiz
11799-1 Rad 4 VHF Vert
11799-1 Rad 4 UHF Horiz
11799-1 Rad 4 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
Mid channel	922.5 MHz

Plot refs
11799-1 Rad 5 VHF Horiz
11799-1 Rad 5 VHF Vert
11799-1 Rad 5 UHF Horiz
11799-1 Rad 5 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
High channel	927.5 MHz

Plot refs
11799-1 Rad 6 VHF Horiz
11799-1 Rad 6 VHF Vert
11799-1 Rad 6 UHF Horiz
11799-1 Rad 6 UHF Vert

No emissions observed within 20dB of limits.

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

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 1.5 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 battery.
The EUT was operated in TX1 to TX6 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. At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site M.

5.5.4 Test equipment

E136, E411, E429, E478, E624, TMS82

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	20°C
Humidity of test environment	55%
Pressure of test environment	102kPa

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
Low channel	915.3 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
1830.6	45.7	-28.3	42.5	-11.5	Upright	Vertical
1830.6	47.1	-26.9	44.0	-10.0	Side	Horizontal
2745.9	47.7	-26.3	44.4	-9.6	Upright	Vertical
2745.9	51.1	-22.9	48.9	-5.1	Side	Horizontal
6407.1	47.7	-26.3	39.2	-14.8	Upright	Vertical
6407.1	46.6	-27.4	37.0	-17.0	Upright	Horizontal
7322.4	53.7	-20.3	47.6	-6.4	Upright	Vertical
7322.4	56.8	-17.2	52.1	-1.9	Upright	Horizontal
8237.7	57.9	-16.1	53.5	-0.5	Upright	Vertical
8237.7	57.8	-16.2	52.5	-1.5	Upright	Horizontal
9153	51.1	-22.9	41	-13	Upright	Vertical

Plots
Whilst Low, Middle and High channels were tested, only middle channel plots are shown within this report to minimise report size.

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
Mid channel	922.5 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
1845	46.0	-28	42.7	-11.3	Upright	Vertical
1845	48.2	-25.8	45.6	-8.4	Side	Horizontal
2767.5	48.4	-25.6	43.0	-11.0	Upright	Vertical
2767.5	51.2	-22.8	48.5	-5.5	Side	Horizontal
6457.5	45.8	-28.2	36.1	-17.9	Upright	Vertical
6457.5	46.1	-27.9	36.9	-17.1	Upright	Horizontal
7380	56.1	-17.9	51.4	-2.6	Upright	Vertical
7380	57.2	-16.8	53.1	-0.9	Upright	Horizontal
8302.5	54.7	-19.3	48.7	-5.3	Upright	Vertical
8302.5	56.4	-17.6	50.7	-3.3	Upright	Horizontal
9225	50.5	-23.5	38.7	-15.3	Upright	Vertical

Plots
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 1 - 3 GHz Vert
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 1 - 3 GHz Horiz
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 3 - 5 GHz Vert
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 3 - 5 GHz Horiz
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 5 - 7.77 GHz Vert
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 5 - 7.77 GHz Horiz
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 7.77 - 10 GHz Vert
11799-1 922.5 MHz 125 kHz SF10 Mid Chan 7.77 - 10 GHz Horiz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz (125k BW SF10)
Mod Scheme	LoRa
High channel	927.7 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
1855.4	46.6	-27.4	43.3	-10.7	Upright	Vertical
1855.4	47.8	-26.2	45.1	-8.9	Side	Horizontal
2783.1	45.2	-28.8	40.6	-13.4	Upright	Vertical
2783.1	48.5	-25.5	48.1	-5.9	Side	Horizontal
5566.2	46.1	-27.9	34.6	-19.4	Upright	Vertical
6493.9	48.8	-25.2	41.4	-12.6	Upright	Vertical
6493.9	47.3	-26.7	38.8	-15.2	Upright	Horizontal
7421.6	54.3	-19.7	49.1	-4.9	Upright	Vertical
7421.6	57.0	-17.0	51.9	-2.1	upright	Horizontal
8349.3	55.3	-18.7	49.6	-4.4	Upright	Vertical
8349.3	57.9	-16.1	53.1	-0.9	Upright	Horizontal
9277	51.0	-23.0	39.0	-15.0	Upright	Vertical

Plots
Whilst Low, Middle and High channels were tested, only middle channel plots are shown within this report to minimise report size.

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
Low channel	915.5 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
1831	45.8	-28.2	40.7	-13.3	Upright	Vertical
1831	47.4	-26.6	42.5	-11.5	Side	Horizontal
2746.5	48.2	-25.8	40.9	-13.1	Upright	Vertical
2746.5	51.7	-22.3	45.7	-8.3	Side	Horizontal
6408.5	46.7	-27.3	34.3	-19.7	Upright	Vertical
6408.5	47.1	-26.9	34.4	-19.6	Upright	Horizontal
7324	52.3	-21.7	39.2	-14.8	Upright	Vertical
7324	58.0	-16.0	45.2	-8.8	Upright	Horizontal
8239.5	57.9	-16.1	44.3	-9.7	Upright	Vertical
8239.5	58.9	-15.1	45.7	-8.3	Upright	Horizontal
9155	50.9	-23.1	37.8	-16.2	Upright	Vertical

Plots
Whilst Low, Middle and High channels were tested, only middle channel plots are shown within this report to minimise report size.

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
Mid channel	922.5 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
1845	46.0	-28.0	41.1	-12.9	Upright	Vertical
1845	48.2	-25.8	44.1	-9.9	Side	Horizontal
2767.5	48.0	-26.0	40.3	-13.7	Upright	Vertical
2767.5	51.1	-22.9	44.7	-9.3	Side	Horizontal
7380	56.2	-17.8	43.5	-10.5	Upright	Vertical
7380	57.9	-16.1	45.6	-8.4	Upright	Horizontal
8302.5	55.3	-18.7	42.2	-11.8	Upright	Vertical
8302.5	58.1	-15.9	44.9	-9.1	Upright	Horizontal

Plots
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 1 - 3 GHz Vert
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 1 - 3 GHz Horiz
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 3 - 5 GHz Vert
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 3 - 5 GHz Horiz
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 5 - 7.77 GHz Vert
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 5 - 7.77 GHz Horiz
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 7.77 - 10 GHz Vert
11799-1 922.5 MHz 500 kHz SF12 Mid Chan 7.77 - 10 GHz Horiz

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6 MHz (500k BW SF12)
Mod Scheme	LoRa
High channel	927.5 MHz

Setup Table

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	46.7	-27.3	41.6	-12.4	Upright	Vertical
1855	48.0	-26	43.9	-10.1	Side	Horizontal
2782.5	48.7	-25.3	42.0	-12.0	Upright	Vertical
2782.5	51.4	-22.6	45.5	-8.5	Side	Horizontal
6492.5	48.8	-25.2	35.3	-18.7	Upright	Vertical
6492.5	47.1	-26.9	34.5	-19.5	Upright	Horizontal
7420	55.1	-18.9	42.0	-12.0	Upright	Vertical
7420	58.3	-15.7	45.6	-8.4	Upright	Horizontal
8347.5	55.2	-18.8	41.9	-12.1	Upright	Vertical
8347.5	57.5	-16.5	44.5	-9.5	Upright	Horizontal

Plots
Whilst Low, Middle and High channels were tested, only middle channel plots are shown within this report to minimise report size.

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

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 – 18 GHz ±3.5dB

5.6 Effective radiated power field strength

NOT APPLICABLE: EUT has been tested for conducted power instead.

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

For restricted band edges please see radiated emissions section. For authorised band edges the EUT was tested on a bench connected to an analyser via suitable attenuation.

The EUT was operated in TX1, TX3, TX4, TX6 and TX-Hopping modes.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The EUT was connected to an analyser via suitable attenuation and referenced to maximum power measured. Plots were taken in required bandwidths showing the fundamental emission and the relevant band edges. dBc points at the band edges relevant to maximum power are indicated on the plots.

Tests were performed using Test Site A.

5.7.4 Test equipment

E640, E755, E932

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	19°C
Humidity of test environment	44%
Pressure of test environment	101kPa

NON-Hopping results.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200kHz (125k BW setting)
Mod Scheme	LoRa
Low channel	915.3 MHz
High channel	927.7 MHz

Restricted Band Edge	Low channel	High channel
Peak Level (dBµV/m)	please see radiated emissions results section	please see radiated emissions results section
Peak Plot reference	Not applicable	Not applicable
Average Level (dBµV/m)	please see radiated emissions results section	please see radiated emissions results section
Average Plot reference	Not applicable	Not applicable

Authorised Band Edge	Low channel	High channel
Authorised Band Edge Plot reference	J11799-1 EUT Continuous 915.3MHz channel, 125k BW lower authorised band edge	J11799-1 EUT continuous 927.7MHz channel, 125k BW upper authorised band edge

HOPPING results.

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200kHz (125k BW setting)
Mod Scheme	LoRa
channel	All 64 hopping

Authorised Band Edge	Low channel	High channel
Authorised Band Edge Plot reference	J11799-1 EUT HOPPING all channels, 125k BW lower authorised band edge	J11799-1 EUT HOPPING all channels, 125k BW upper authorised band edge

DTS results

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	1.6MHz (500k BW setting)
Mod Scheme	LoRa
Low channel	915.5 MHz
High channel	927.5 MHz

Restricted Band Edge	Low channel	High channel
Peak Level (dBµV/m)	please see radiated emissions results section	please see radiated emissions results section
Peak Plot reference	Not applicable	Not applicable
Average Level (dBµV/m)	please see radiated emissions results section	please see radiated emissions results section
Average Plot reference	Not applicable	Not applicable

Authorised Band Edge	Low channel	High channel
Authorised Band Edge Plot reference	J11799-1 Low channel 500k BW SF12 lower authorised band edge	J11799-1 High channel 500k BW SF12 upper authorised band edge

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. These show the 20/30dBc 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
The field strengths observed in the adjacent restricted bands are required to meet the tighter 15.209 limits.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
The restricted band edges closest to the EUT frequency of 902-928MHz are 614 & 960MHz.
Further wider span plots have been taken to show the fact that there are no spurious emissions above the restricted limits of 15.209.
20 (PK) / 30 (AV) dBc 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

5.8.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(a)(1)(i) & 15.247(a)(2) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.9 & 11.8 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.215(c) 15.247(a)(1)(i) & 15.247(a)(2) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was measured on a bench using a spectrum analyser connected to the external RF port. The EUT was operated in TX1 to TX6 modes.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. For DTS ANSI C63.10 clause 11.8 requirements were used for the 6dB bandwidth. For FHSS mode the 20dB bandwidth was measured using the requirements from ANSI C63.10 clause 6.9.

Tests were performed using Test Site K.

5.8.4 Test equipment

E558, E642, E932

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	18°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Low channel	915.3 MHz
Mid channel	922.5 MHz
High channel	927.7 MHz

	Low channel	Mid channel	High channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	139.482	140.091	139.998
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	11799-1 915.3 MHz 125 kHz SF10 20dB OBW	11799-1 922.5 MHz 125 kHz SF10 20dB OBW	11799-1 927.7 MHz 125 kHz SF10 20dB OBW

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Low channel	915.5 MHz
Mid channel	922.5 MHz
High channel	927.5 MHz

	Low channel	Mid channel	High channel
6 dB Bandwidth (kHz) Nominal Temp & Volts	772.502	772.138	772.192
Plot for 6 dB Bandwidth (kHz) Nominal Temp & Volts	11799-1 915.5 MHz 500 kHz SF12 6 dB OBW	11799-1 922.5 MHz 500 kHz SF12 6 dB OBW	11799-1 927.5 MHz 500 kHz SF12 6 dB OBW

Analyser plots for the 20dB & 6dB bandwidth can be found in Section 6 of this report.

LIMITS:
15.215(c) The 20dB bandwidth of the emission must be contained within the designated frequency band.
15.247(a)(1)(i) The maximum allowed 20dB bandwidth of the hopping channel is 500kHz.
15.247(a)(2) The minimum 6dB bandwidth shall be at least 500kHz.

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:
<± 1.9 %

5.9 Maximum Average conducted output power

5.9.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(b3) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 11.9.2.2.2 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(b)(3) [Reference 4.1.1 of this report]

5.9.2 Configuration of EUT

EUT was measured on a bench using a spectrum analyser connected to the external RF port.
The EUT was operated in TX4, TX5 and TX6 modes for this test.

5.9.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Stated reading is maximum power observed using a spectrum analyser channel power function over the 6dB bandwidth per ANSI C63.10 Clause 11.9.2.2.2. Measurements were performed test in site K.

5.9.4 Test equipment

E558, E642, E932

See Section 9 for more details

5.9.5 Test results

Temperature of test environment 18°C
Humidity of test environment 60%
Pressure of test environment 102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Low channel	915.5 MHz
Mid channel	922.5 MHz
High channel	927.5 MHz

Test conditions	Carrier Power (dBm)	Carrier Power (dBm)	Carrier Power (dBm)
	Low channel	Mid channel	High channel
Maximum TX Power observed (dBm)	17.63	17.54	17.37

LIMITS:
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

5.10 Maximum Peak conducted output power

5.10.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(b)(2) & (b)(3) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 7.8.5 & 11.9.1.1 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(b)(2) & (b)(3) [Reference 4.1.1 of this report]

5.10.2 Configuration of EUT

EUT was measured on a bench using a spectrum analyser connected to the external RF port.
The EUT was operated in TX1 to TX6 modes for this test.

5.10.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
For DTS: stated reading is maximum Peak power observed using a spectrum analyser RBW > 6dB BW of the EUT per ANSI C63.10 clause 11.9.1.1.
For FHSS: stated reading is maximum peak power observed using a spectrum analyser RBW > 20dB BW of the EUT per ANSI C63.10 clause 7.8.5. Measurements were made on a test bench in site M.

5.10.4 Test equipment

E558, E624, E932

See Section 9 for more details

5.10.5 Test results

Temperature of test environment	18°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Low channel	915.3 MHz
Mid channel	922.5 MHz
High channel	927.7 MHz

Test conditions		Peak Power	Peak Power	Peak Power
Temperature ambient	5 Volts	Low channel	Mid channel	High channel
Maximum TX Power observed (dBm)		17.6	17.5	17.5
Margin from Limit (dB)		-12.4	-12.5	-12.5

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Low channel	915.5 MHz
Mid channel	922.5 MHz
High channel	927.5 MHz

Test conditions		Peak Power	Peak Power	Peak Power
Temperature ambient	5 Volts	Low channel	Mid channel	High channel
Maximum TX Power observed (dBm)		17.5	17.4	17.5
Margin from Limit (dB)		-12.5	-12.6	-12.5

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

5.11.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 11.10 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]

5.11.2 Configuration of EUT

The EUT was configured as for the conducted power test. The EUT was operated in TX4, TX5, and TX6 modes for this test.

5.11.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements & plots were taken on an analyser with the span set to 1.5 times the measured DTS bandwidth using a 3kHz RBW setting, RMS detector and a minimum of 100 trace averages, Per ANSI C63.10 clause 11.10.3.
Tests were performed using Test Site K.

5.11.4 Test equipment

E558, E642, E932

See Section 9 for more details

5.11.5 Test results

Temperature of test environment	19°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Low channel	915.5 MHz
Mid channel	922.5 MHz
High channel	927.5 MHz

	Low channel	Mid channel	High channel
Duty Cycle (%)	100	100	100
dBm per 3 kHz	-2.181	-1.479	-1.266
mW per 3 kHz	0.605	0.711	0.747
Plot reference	11799-1 915.5 MHz 500 kHz SF12 AV PSD	11799-1 922.5 MHz 500 kHz SF12 AV PSD	11799-1 927.5 MHz 500 kHz SF12 AV PSD

Note: Test is only applicable to DTS mode of device.

Analyser plots can be found in Section 6 of this report.

LIMITS:
15.247(e) +8dBm/3kHz.

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:
<± 2 dB

5.12 Antenna power conducted emissions

NOT APPLICABLE: Applies to EUT's with an antenna port. The EUT was tested for radiated emissions with its dedicated antenna in position.

5.13 Duty cycle

NOT APPLICABLE: No limits apply, however duty cycle measurement performed to verify any possible correction factors for average emissions. EUT Duty was confirmed as operating at 100% constant transmit state for applicable tests.

5.14 FHSS carrier frequency separation

5.14.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(a1) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 7.8 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(a1) [Reference 4.1.1 of this report]

5.14.2 Configuration of EUT

The EUT was tested on the bench and ambient conditions were monitored. The EUT was operated in TX-Hopping mode.

5.14.3 Test procedure

Tests were made using the measuring equipment listed in the 'Test Equipment' Section. With the EUT hopping, a span was set on the spectrum analyser to show two adjacent channel peaks. The analyser was set to Peak detector and a max held trace, the trace was allowed enough sweeps to stabilise.
Tests were performed in test site K.

5.14.4 Test equipment

E558, E642, E932

See Section 9 for more details

5.14.5 Test results

Temperature of test environment	18°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz
Mod Scheme	LoRa Hopping
1st channel picked	915.4 MHz
2nd channel picked	915.6 MHz

	Single channel
Separation (kHz)	200.0366
Plot of Separation (kHz)	915.4 MHz 915.6 MHz (Hopping) Carrier Frequency Separation

Analyser plots for the carrier separation can be found in Section 6 of this report

LIMITS:
FHSS shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater.

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:
<± 1.9 %

5.15 Average time of occupancy

5.15.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(a)(1)(i) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 7.8 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(a)(1)(i) [Reference 4.1.1 of this report]

5.15.2 Configuration of EUT

The EUT was tested on the bench and ambient conditions were monitored. The EUT was operated in TX-Hopping mode.

5.15.3 Test procedure

Tests were made using the measuring equipment listed in the 'Test Equipment' Section. With the EUT hopping, a suitable sweep time was set on the spectrum analyser in zero span mode centred on a hopping channel. Both the TX time period and the repetition time were measured and plotted for comparison to the limits.
Tests were performed in test site A.

5.15.4 Test equipment

E640, E755

See Section 9 for more details

5.15.5 Test results

Temperature of test environment	20°C
Humidity of test environment	48%
Pressure of test environment	100kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz
Mod Scheme	LoRa Hopping
Single Channel Selected	917 MHz

Measured Dwell time/pulse width (ms)	246.7
Period time (s)	20
Instances of pulse within period time	1
Average time of occupancy (ms)	246.7
Measured Dwell time/pulse width (plot reference)	J11799-1 Single TX time channel 917 MHz 125k BW setting - hopping mode
Period time (plot reference)	J11799-1 No of Hops in 20seconds channel 917 MHz 125k BW setting - hopping mode

Analyser plots showing pulse width and period /repetition can be found in Section 6 of this report.

LIMITS:
For FHSS in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period.

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:
2.57 ms

5.16 Number of Hop Channels

5.16.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(a)(1)(i) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 7.8 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(a)(1)(i) [Reference 4.1.1 of this report]

5.16.2 Configuration of EUT

The EUT was tested on the bench and ambient conditions were monitored. The EUT was operated in TX-Hopping mode.

5.16.3 Test procedure

Tests were made using the measuring equipment noted in the 'Test Equipment' Section at Site A. With the EUT hopping, a suitable span was set on the spectrum analyser to show clearly over a range of plots the number of channels being used by the EUT. The analyser was set to Peak detector and max held and the trace was allowed to stabilise for each plot.

5.16.4 Test equipment

E640, E755

See Section 9 for more details

5.16.5 Test results

Temperature of test environment	19°C
Humidity of test environment	45%
Pressure of test environment	100kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	200 kHz
Mod Scheme	LoRa
Single channel	All Hopping

No of hopping Channels	64
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-34	Hopping channel number 914 - 922 MHz
Plot of Hopping Channels 34-64	Hopping channel number 922 - 929 MHz

Analyser plots showing the number of hopping channels can be found in Section 6 of this report.

LIMITS:
For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels.

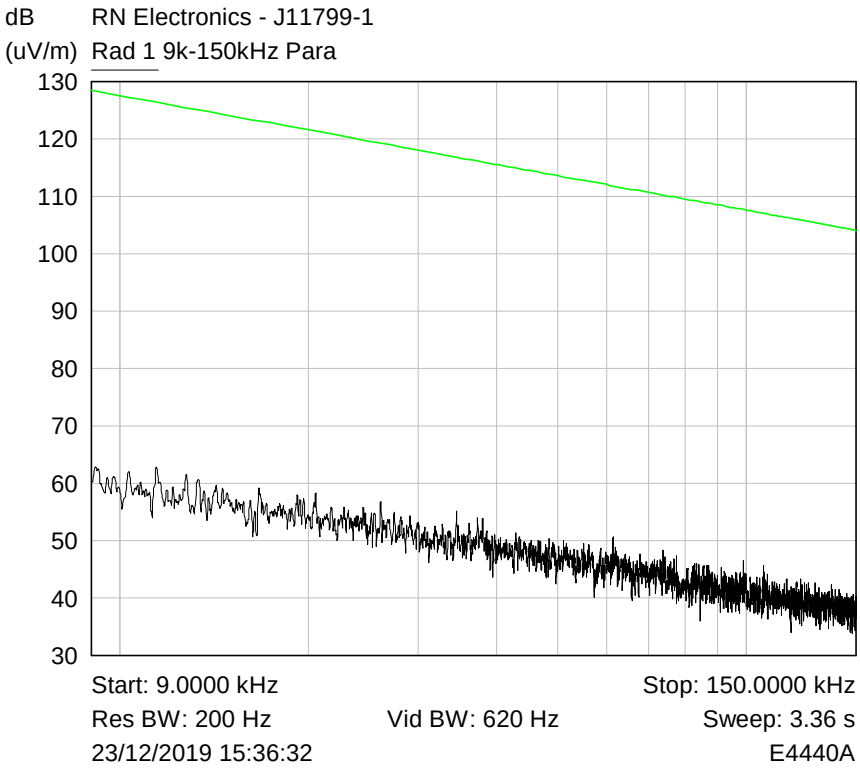
These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 1.9 %

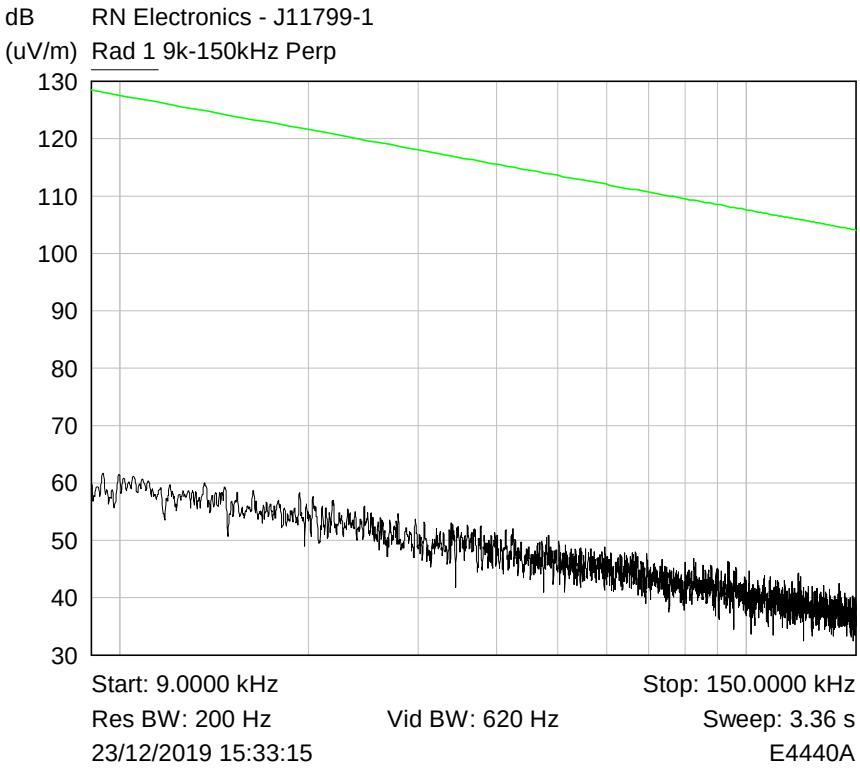
6 Plots/Graphical results

6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 922.5 MHz



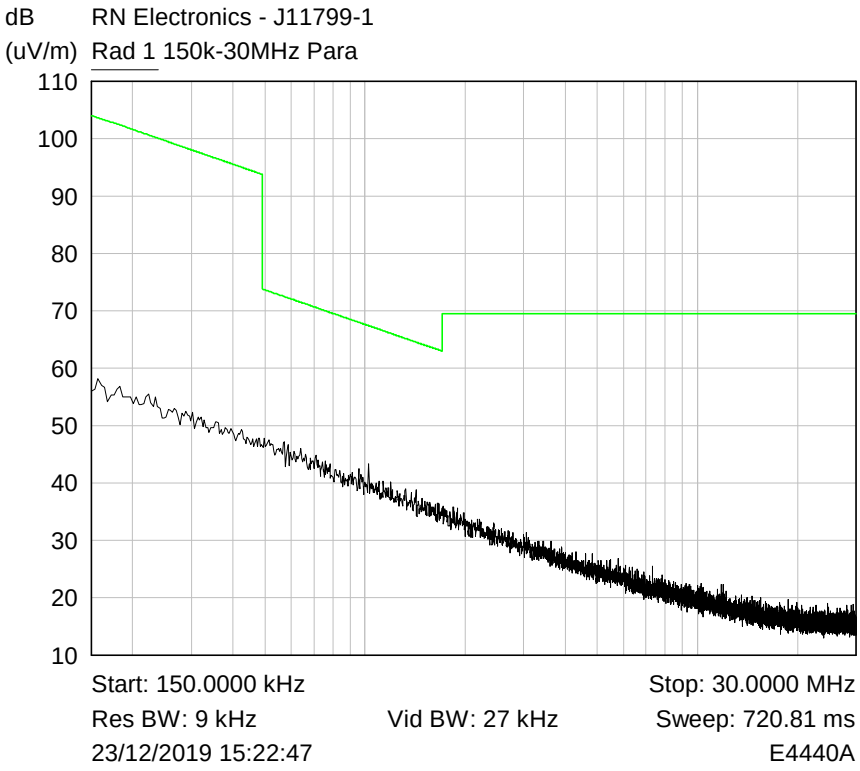
Plot of 9k-150kHz Parallel



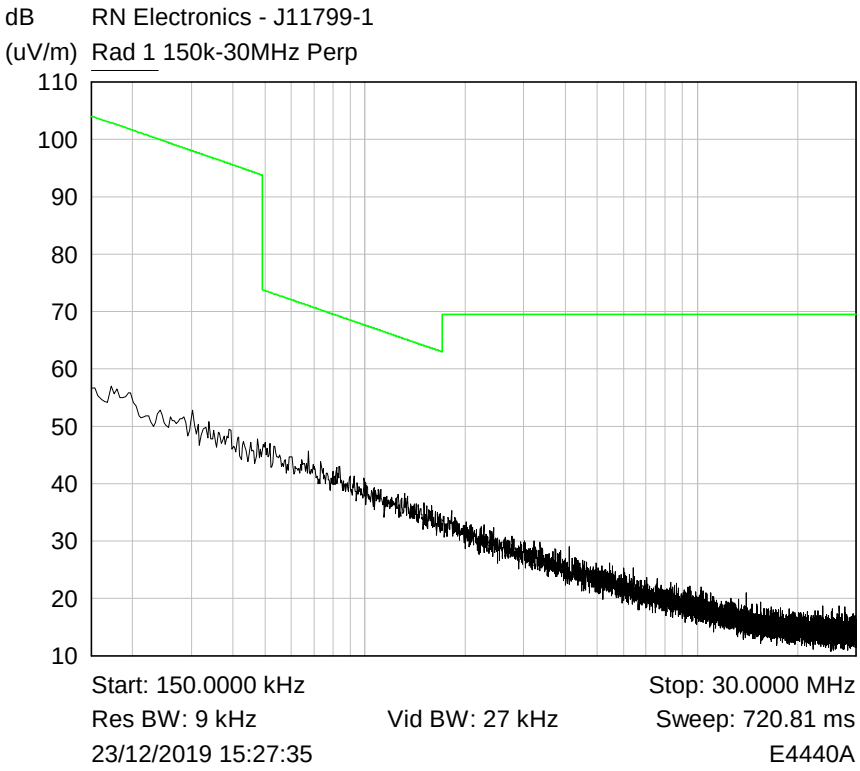
Plot of 9k-150kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 922.5 MHz



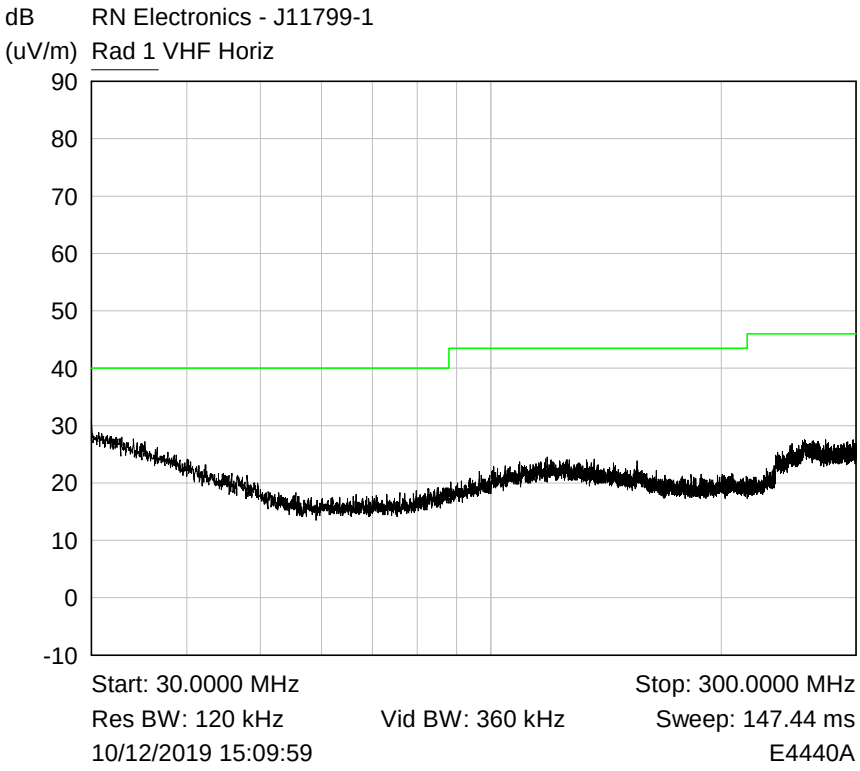
Plot of 150kHz-30MHz Parallel



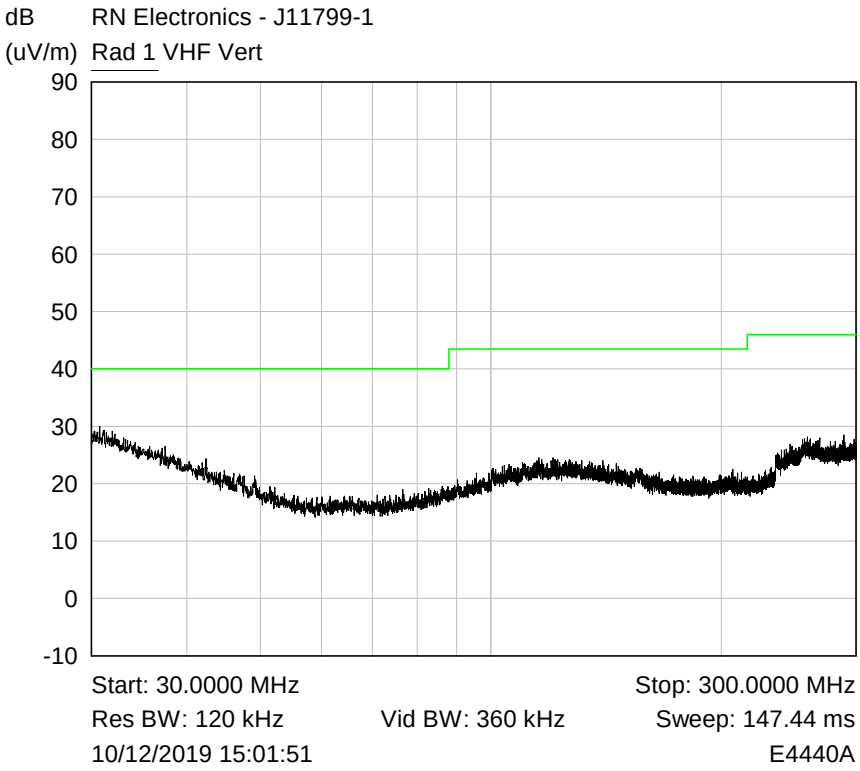
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

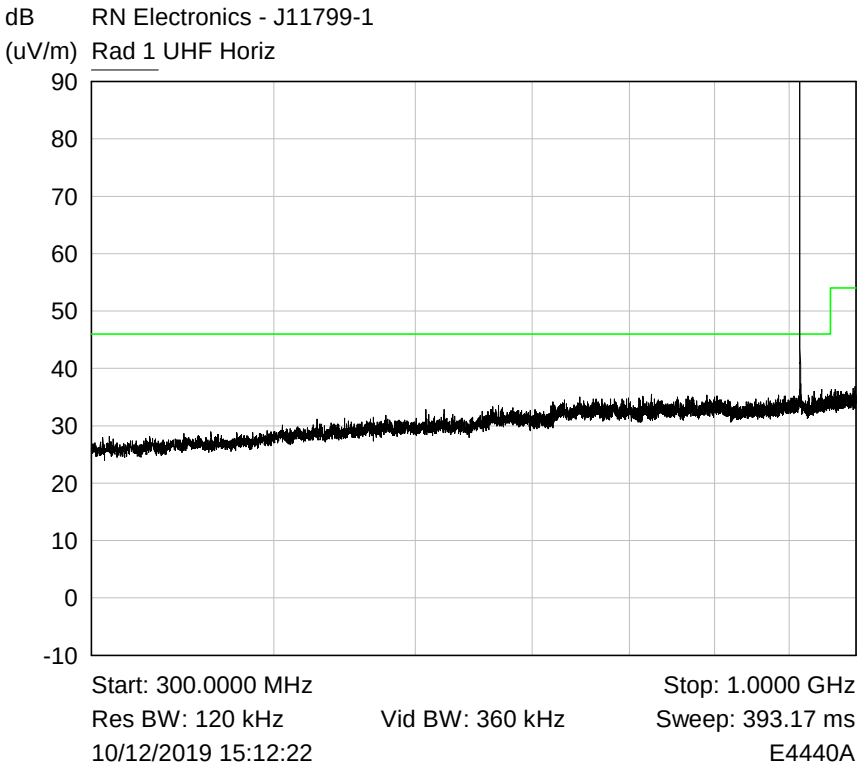
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 915.3 MHz



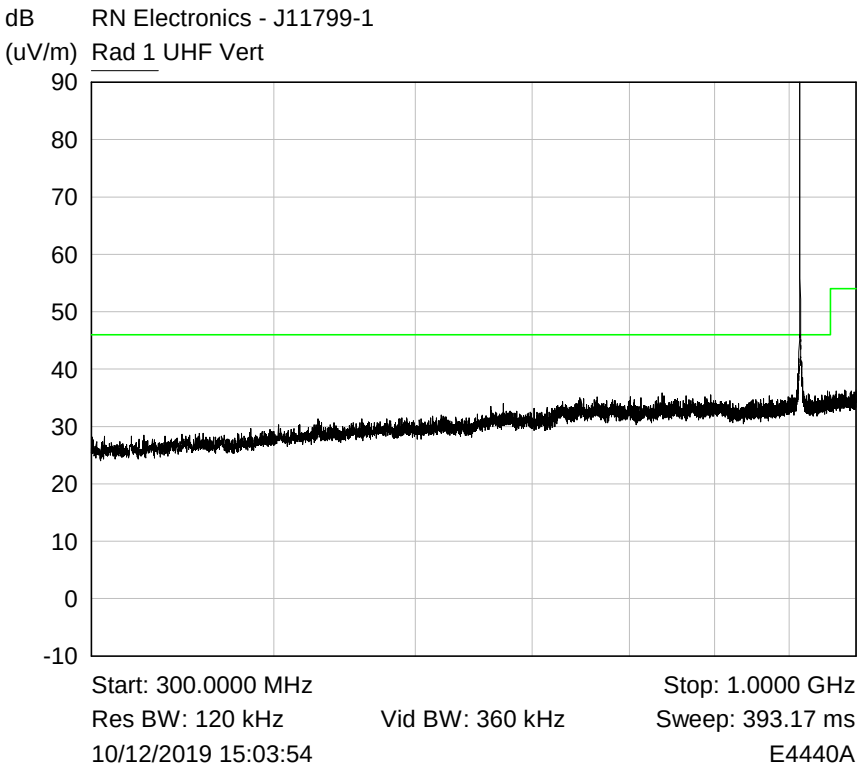
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

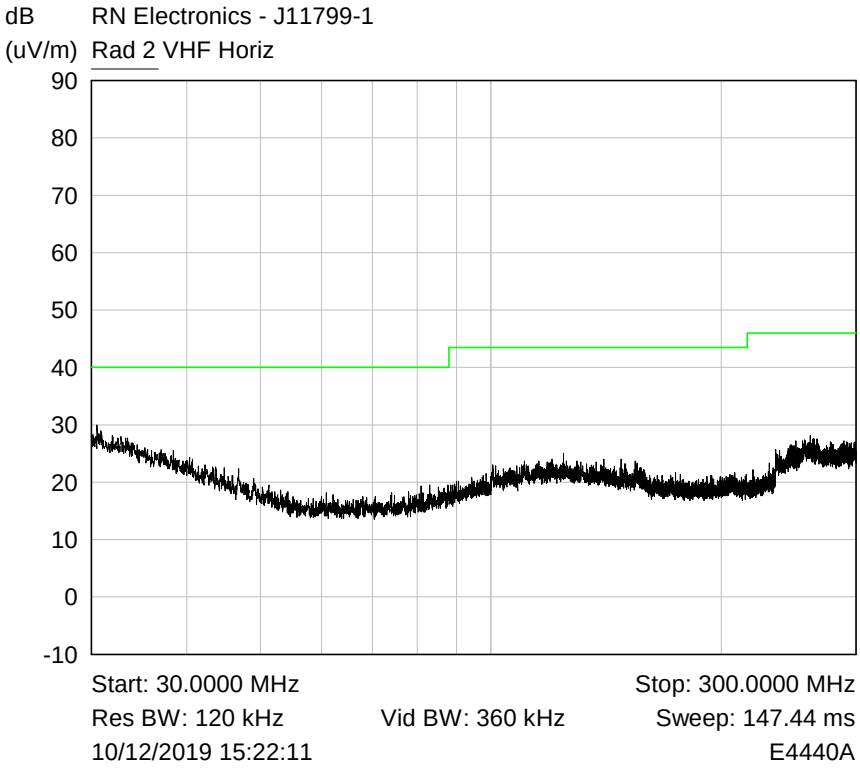


Plot of Peak emissions for UHF Horizontal against the QP limit line.

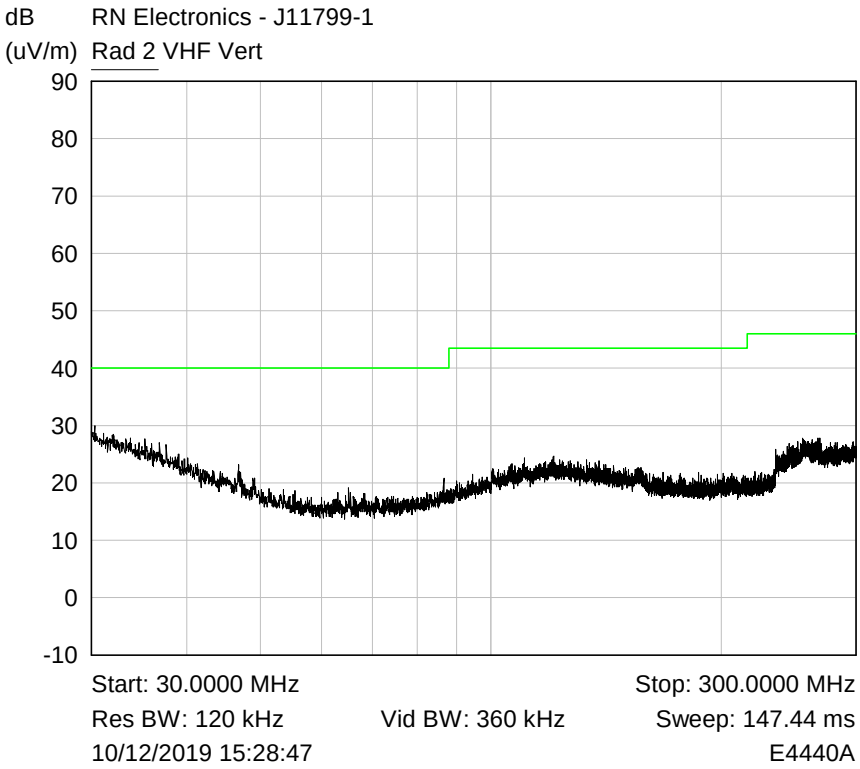


Plot of Peak emissions for UHF Vertical against the QP limit line.

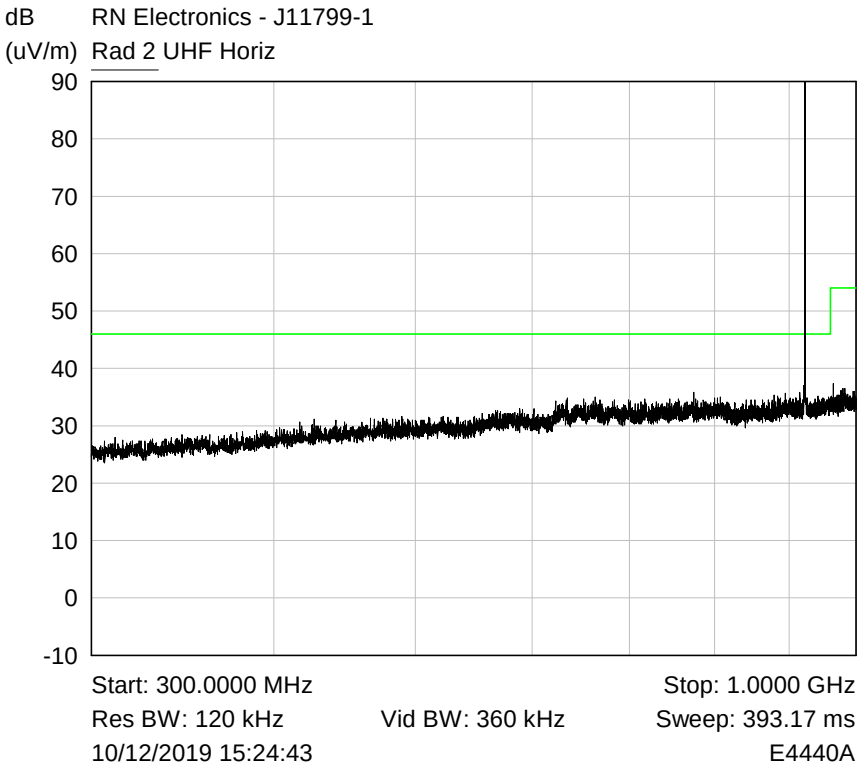
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 922.5 MHz



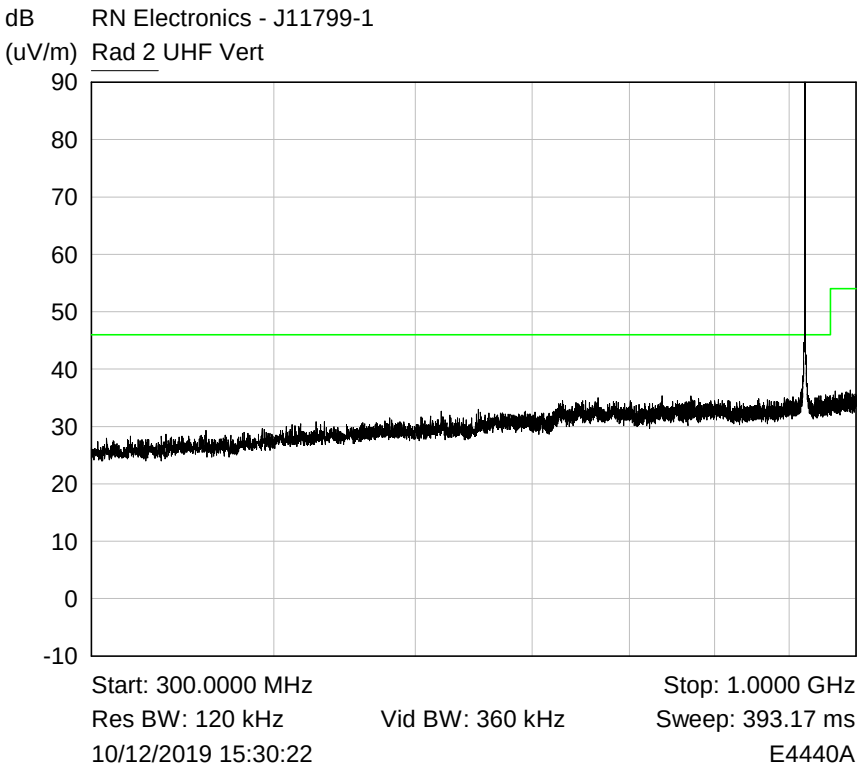
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

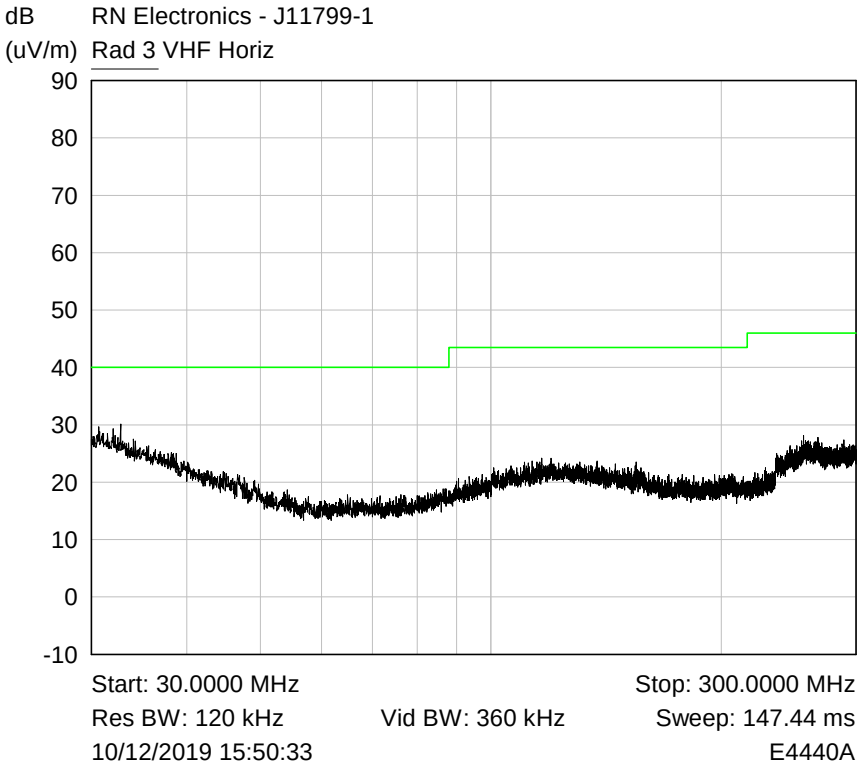


Plot of Peak emissions for UHF Horizontal against the QP limit line.

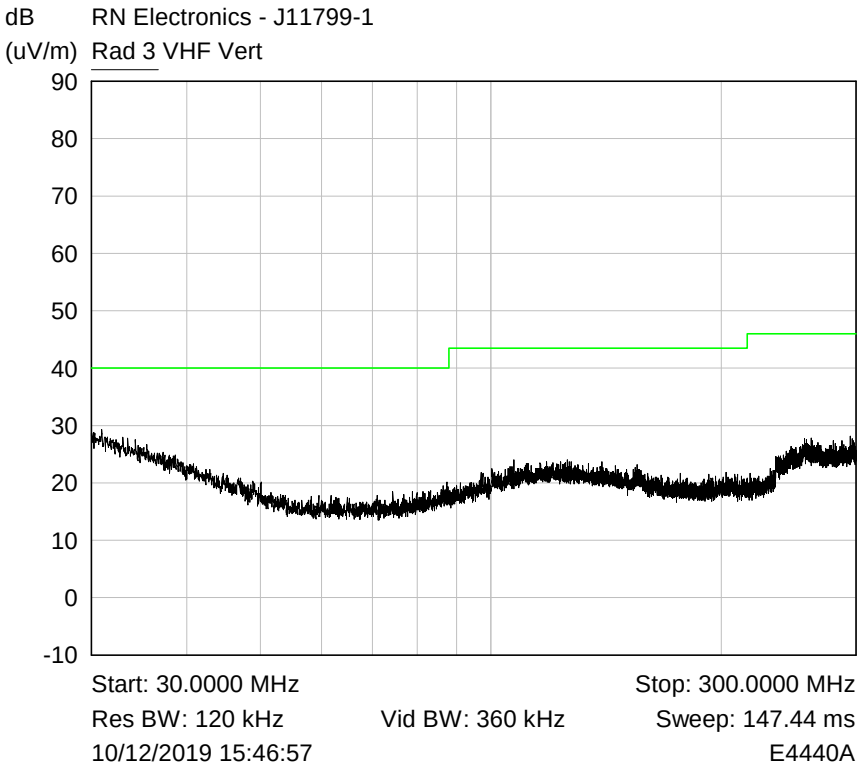


Plot of Peak emissions for UHF Vertical against the QP limit line.

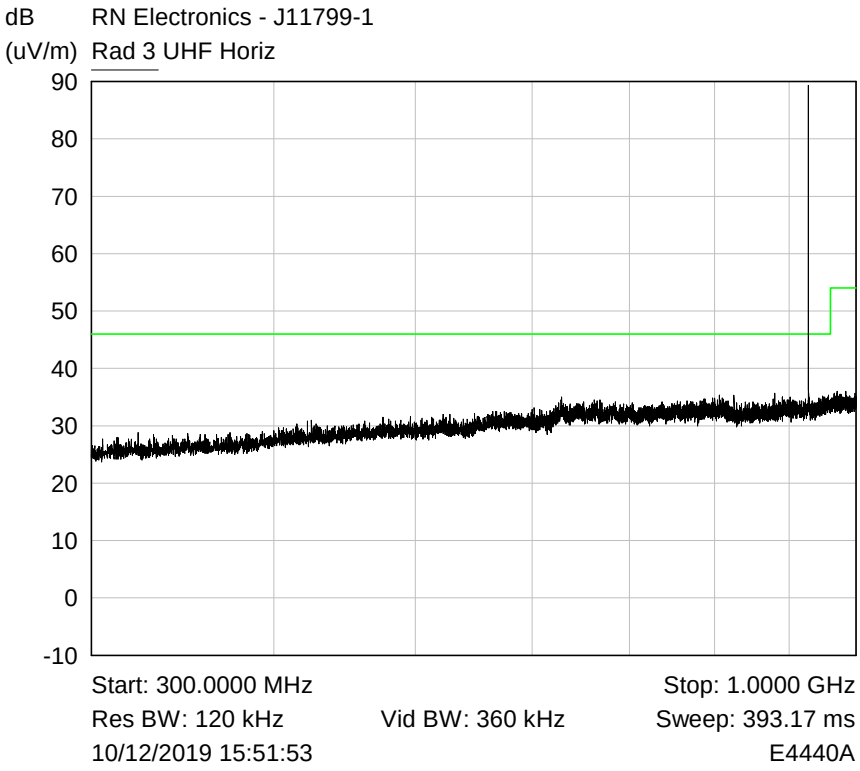
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 927.7 MHz



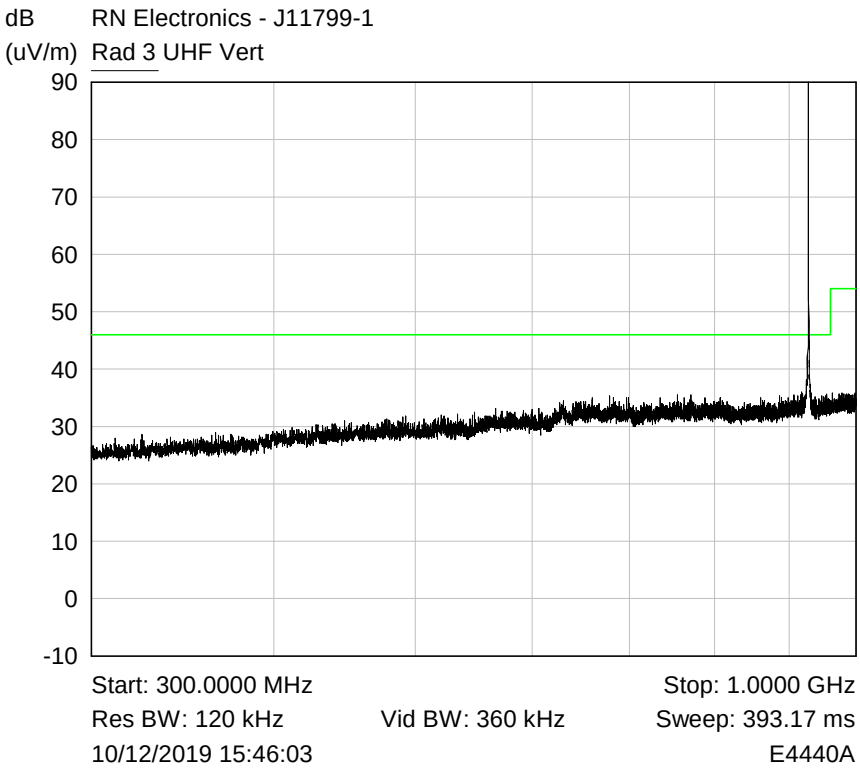
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

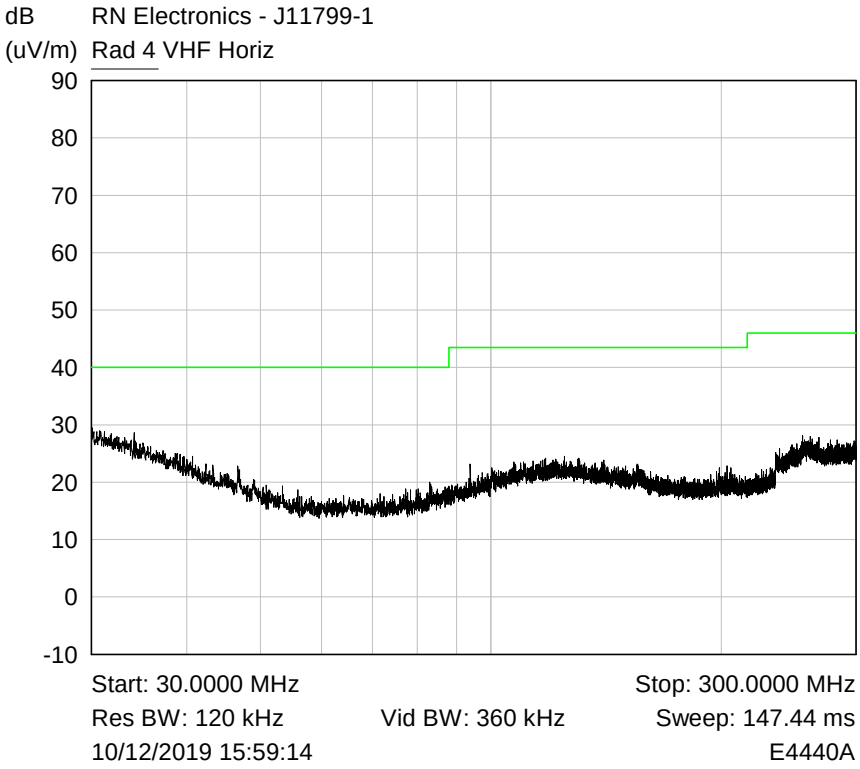


Plot of Peak emissions for UHF Horizontal against the QP limit line.

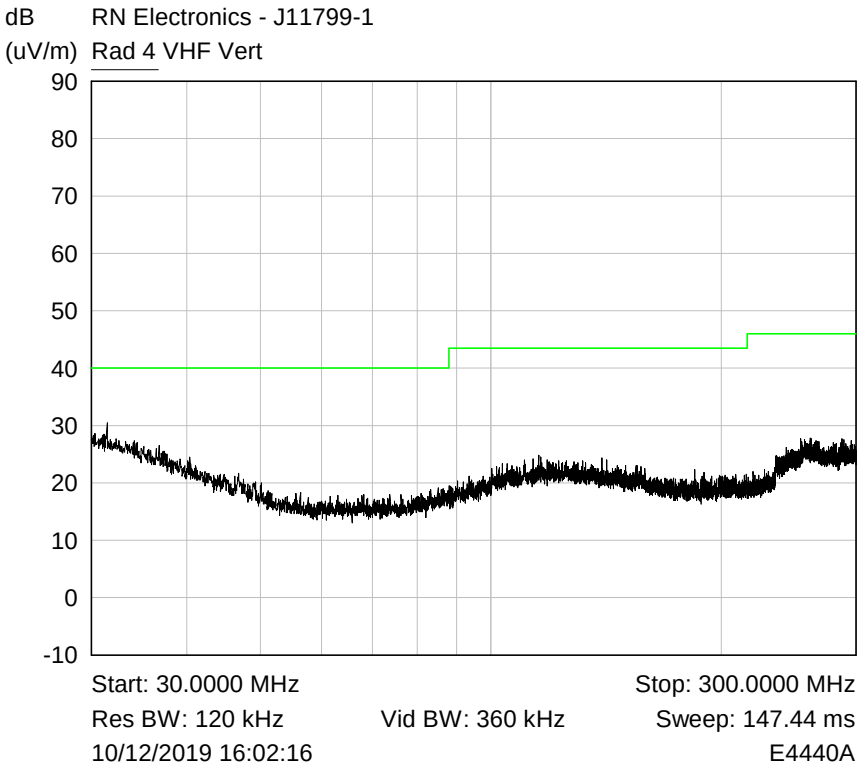


Plot of Peak emissions for UHF Vertical against the QP limit line.

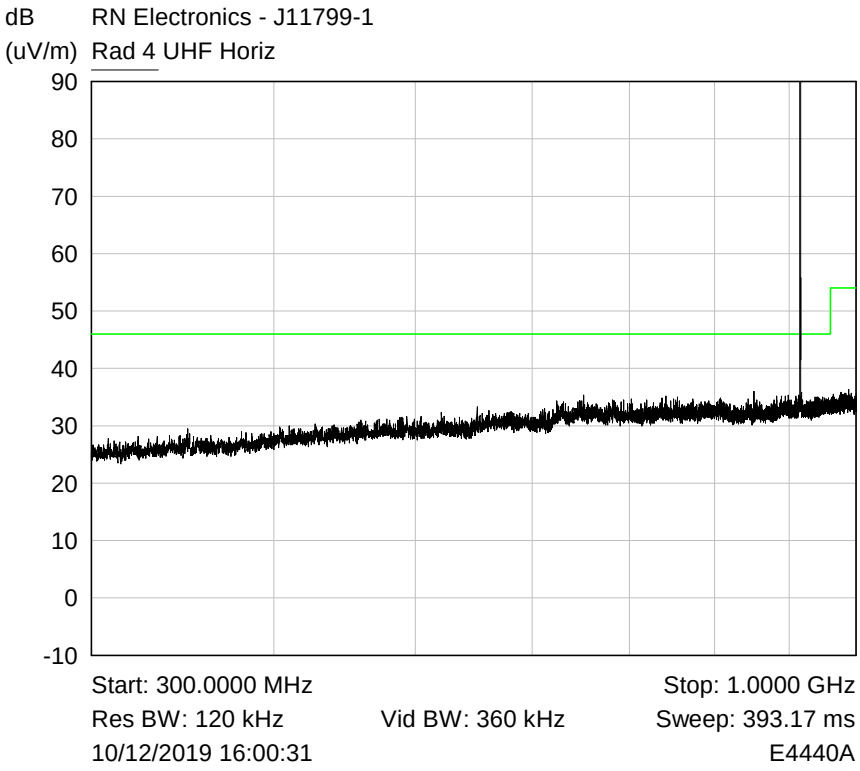
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 1.6 MHz, Modulation LoRa, Channel 915.5 MHz



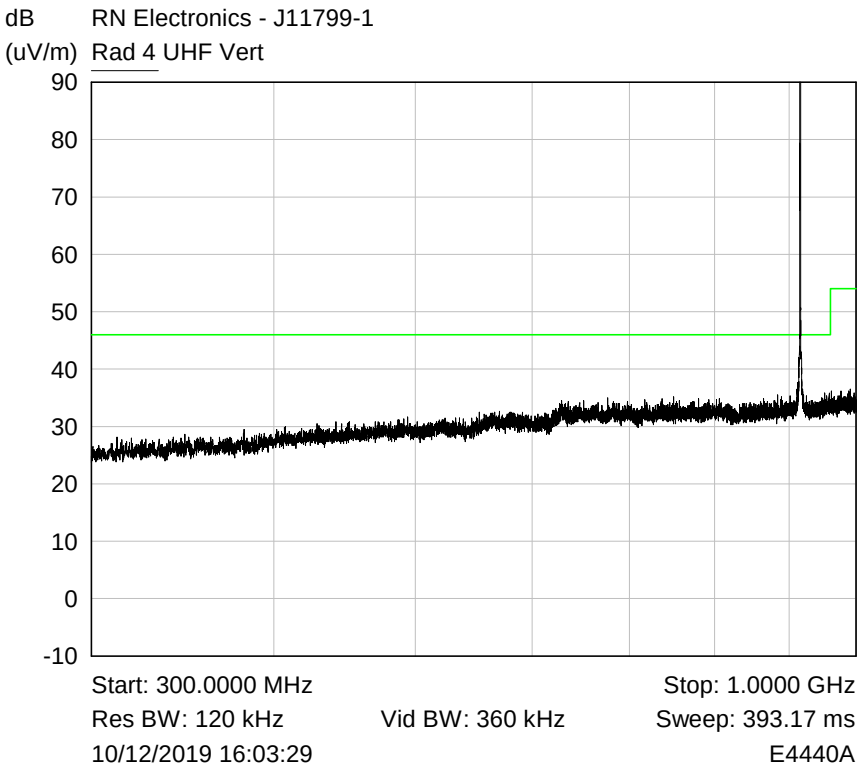
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

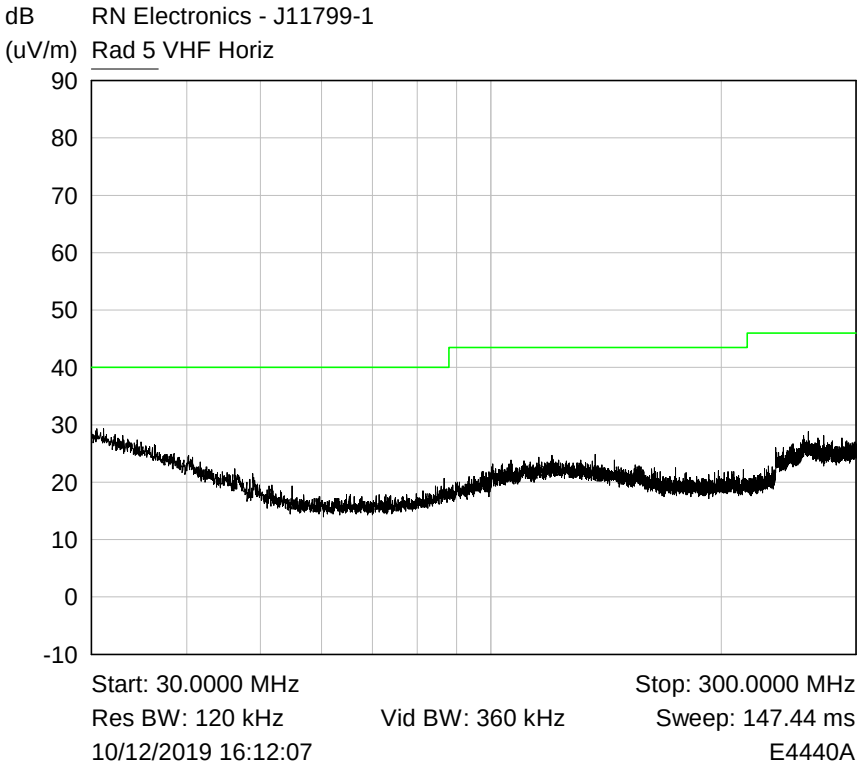


Plot of Peak emissions for UHF Horizontal against the QP limit line.

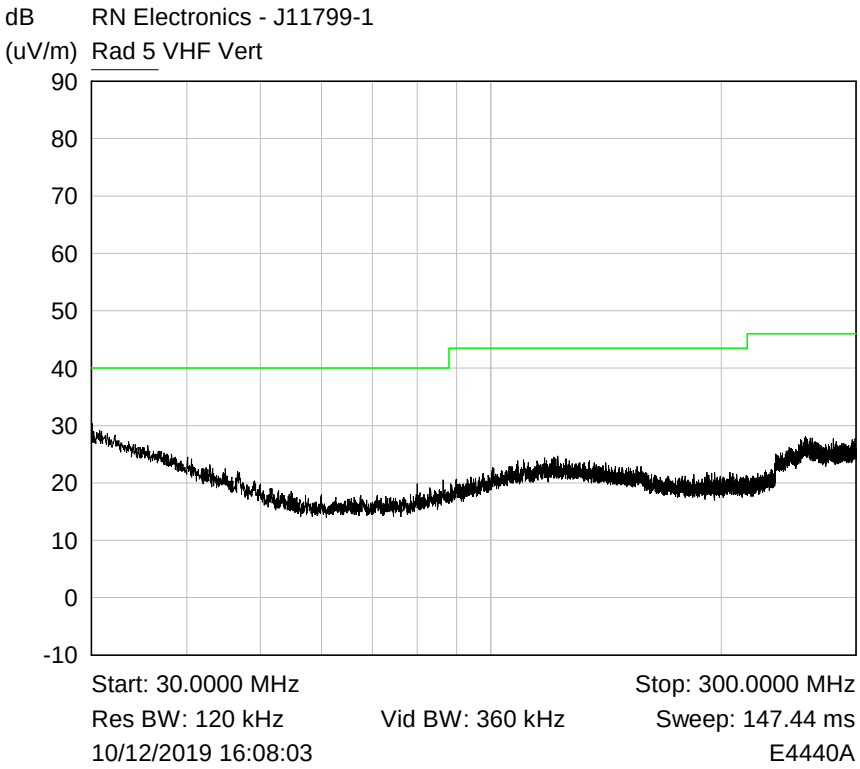


Plot of Peak emissions for UHF Vertical against the QP limit line.

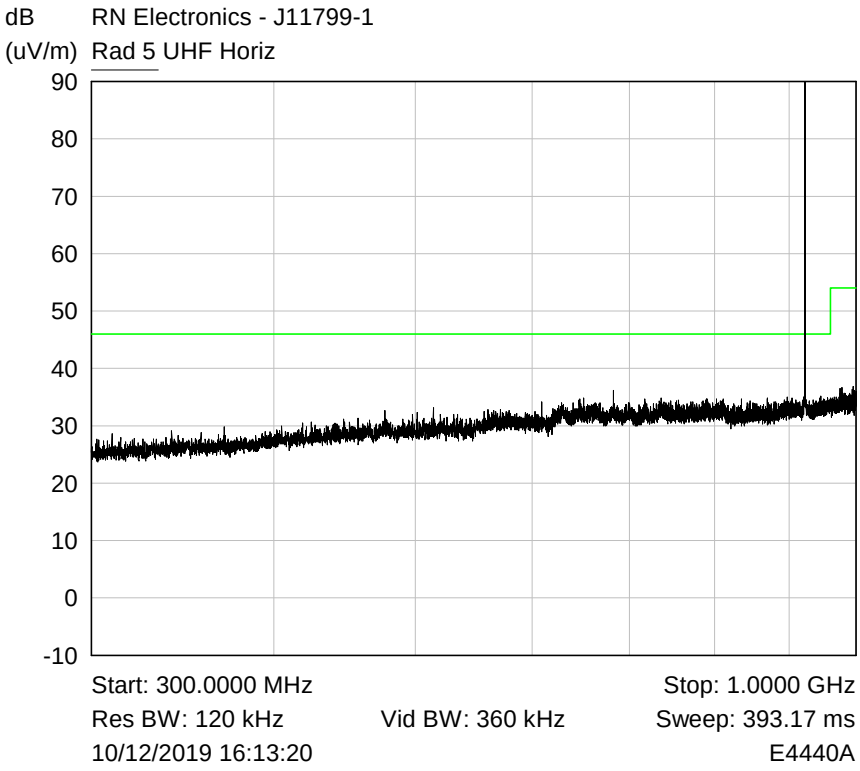
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 1.6 MHz, Modulation LoRa, Channel 922.5 MHz



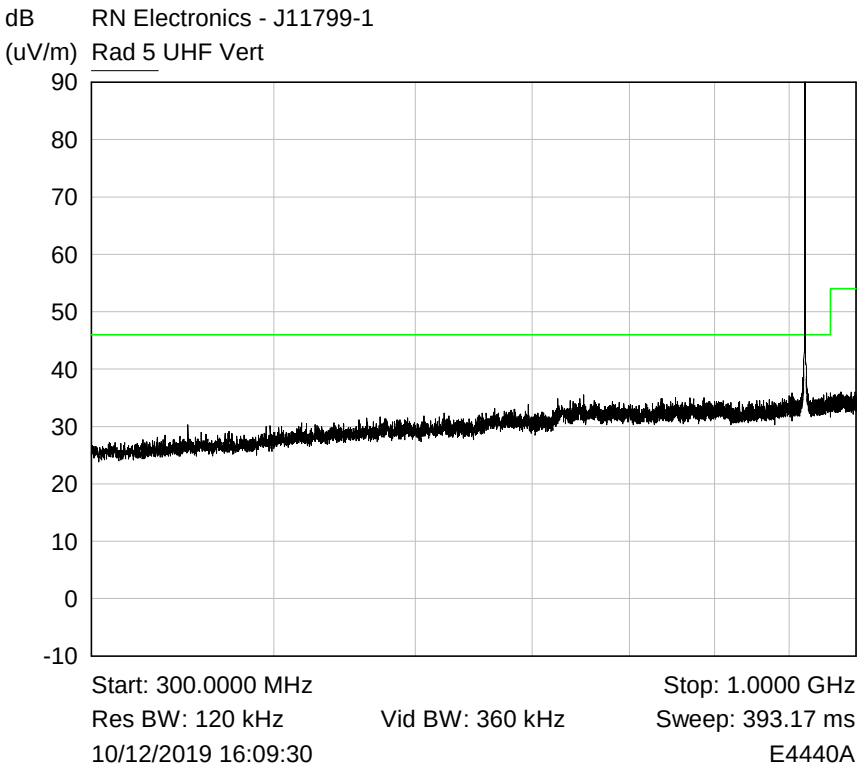
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

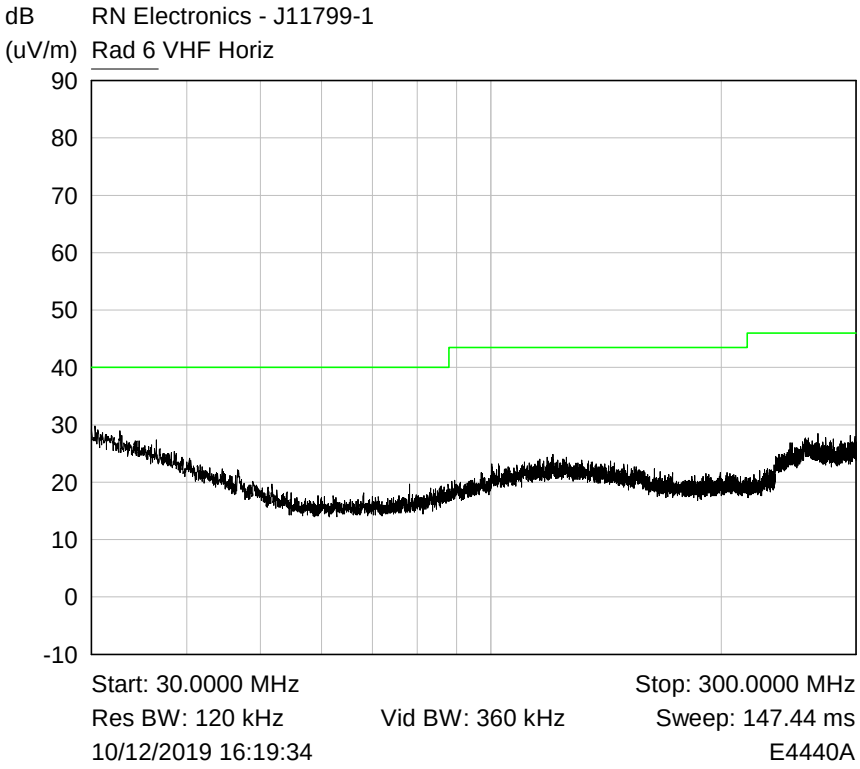


Plot of Peak emissions for UHF Horizontal against the QP limit line.

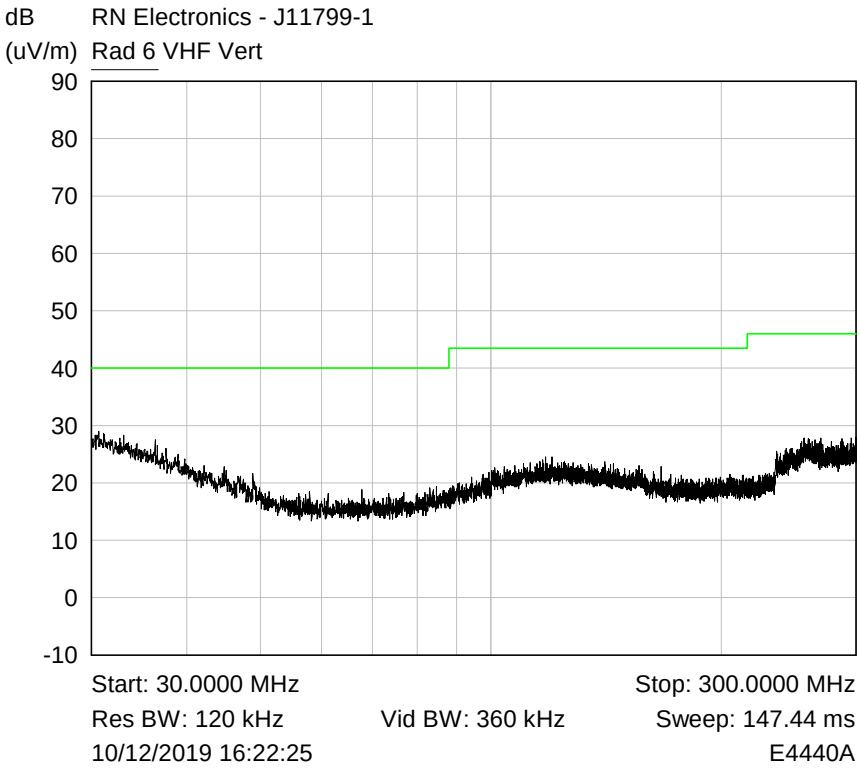


Plot of Peak emissions for UHF Vertical against the QP limit line.

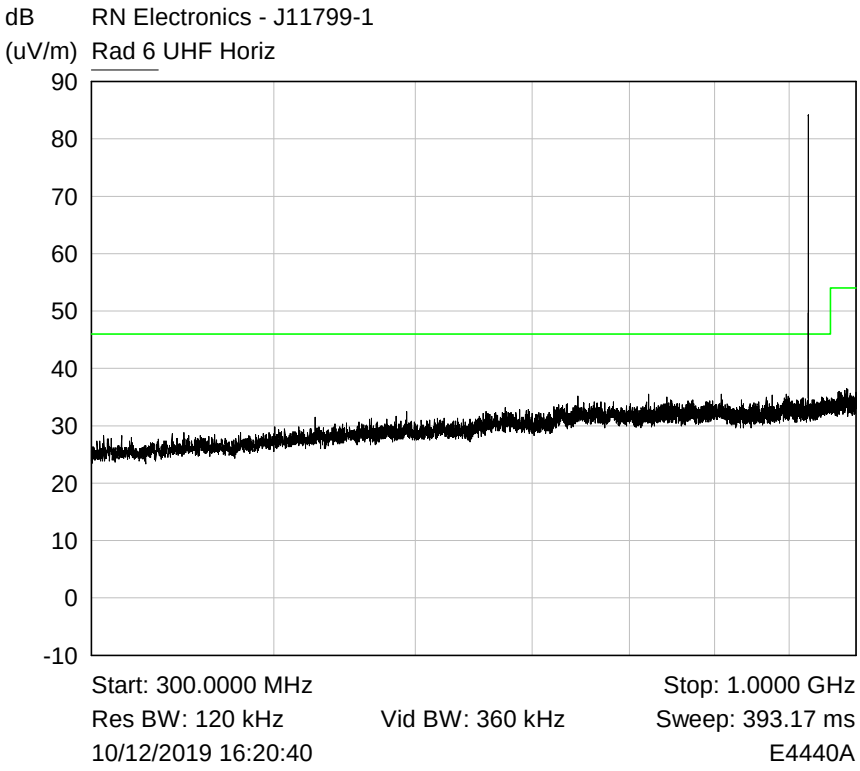
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 1.6 MHz, Modulation LoRa, Channel 927.5 MHz



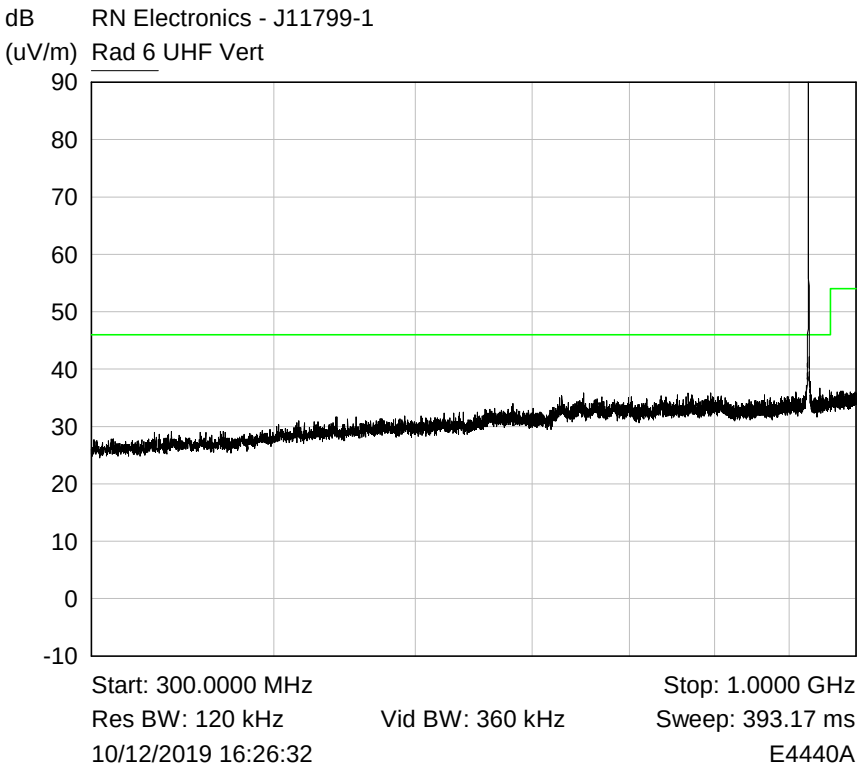
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



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

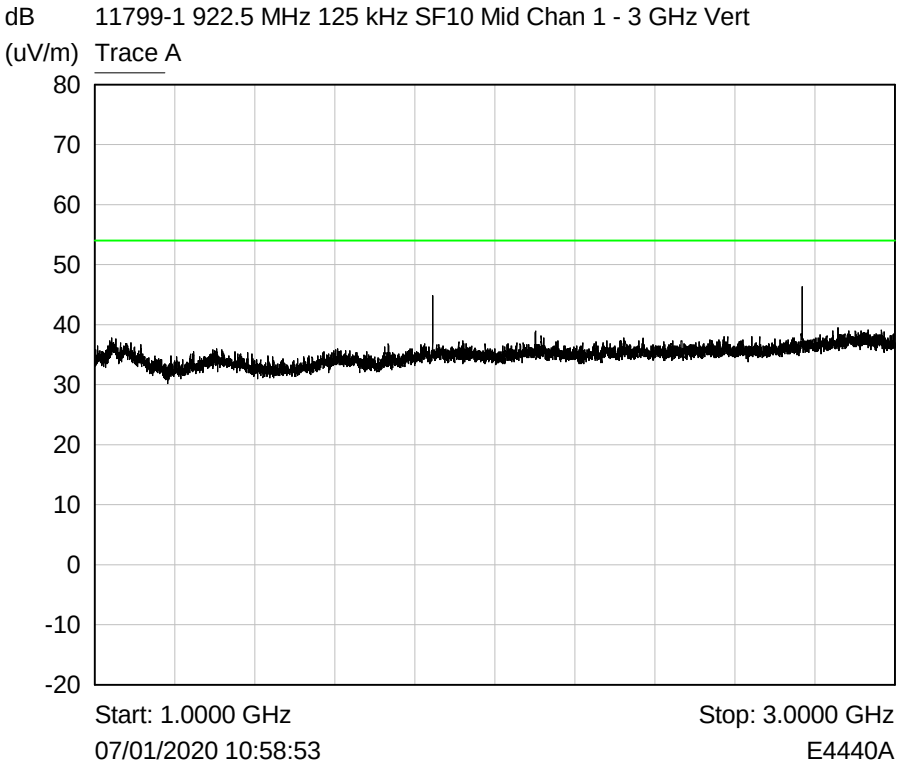


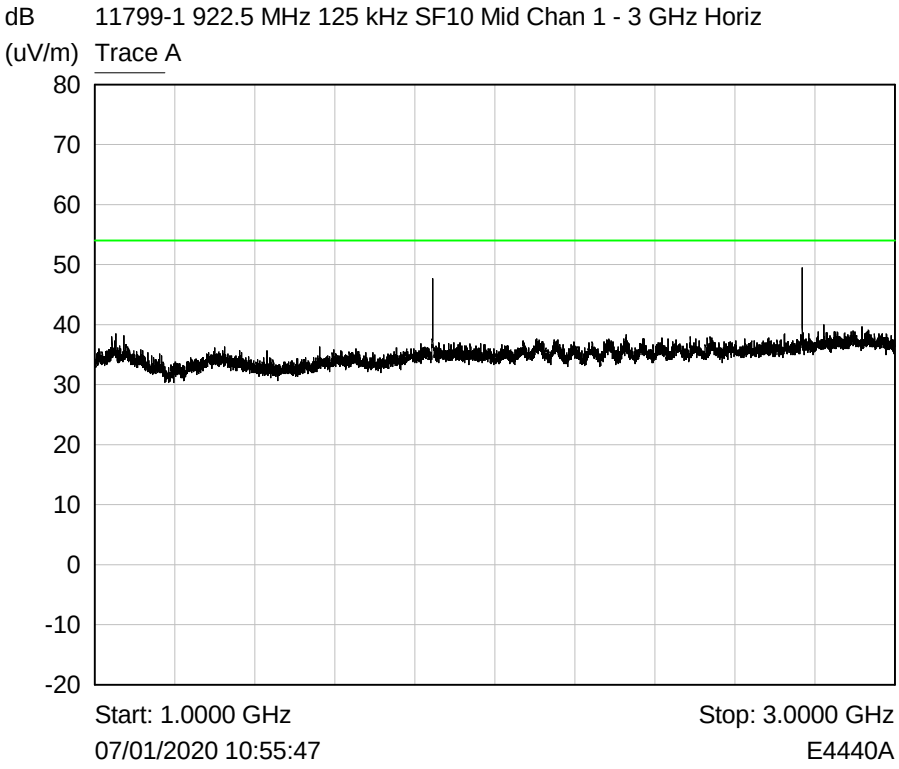
Plot of Peak emissions for UHF Vertical against the QP limit line.

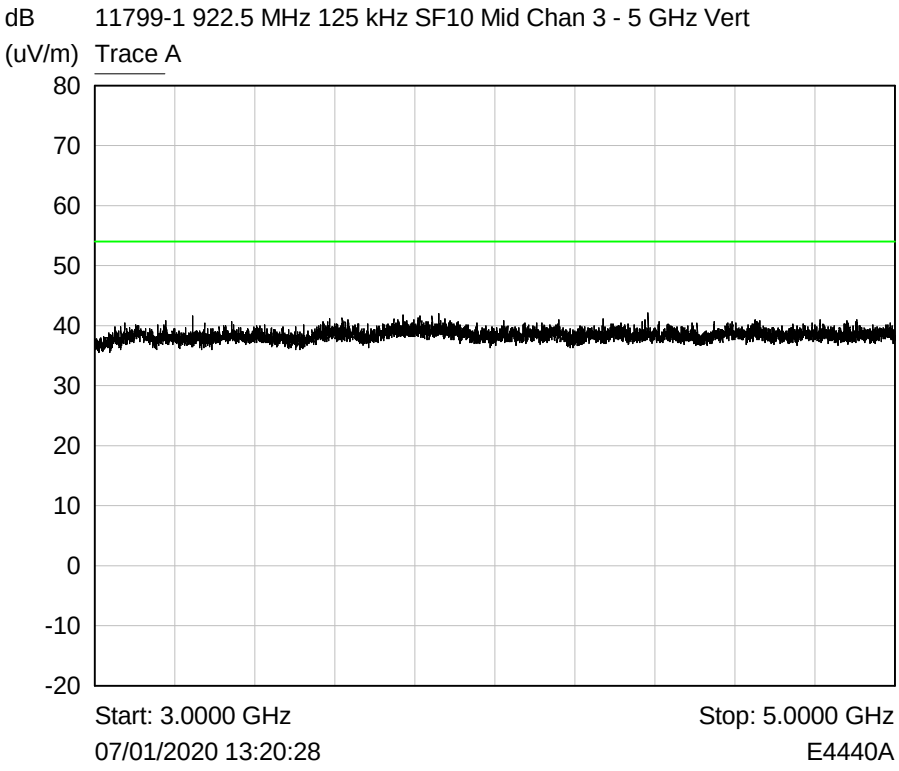
6.4 Radiated emissions above 1 GHz

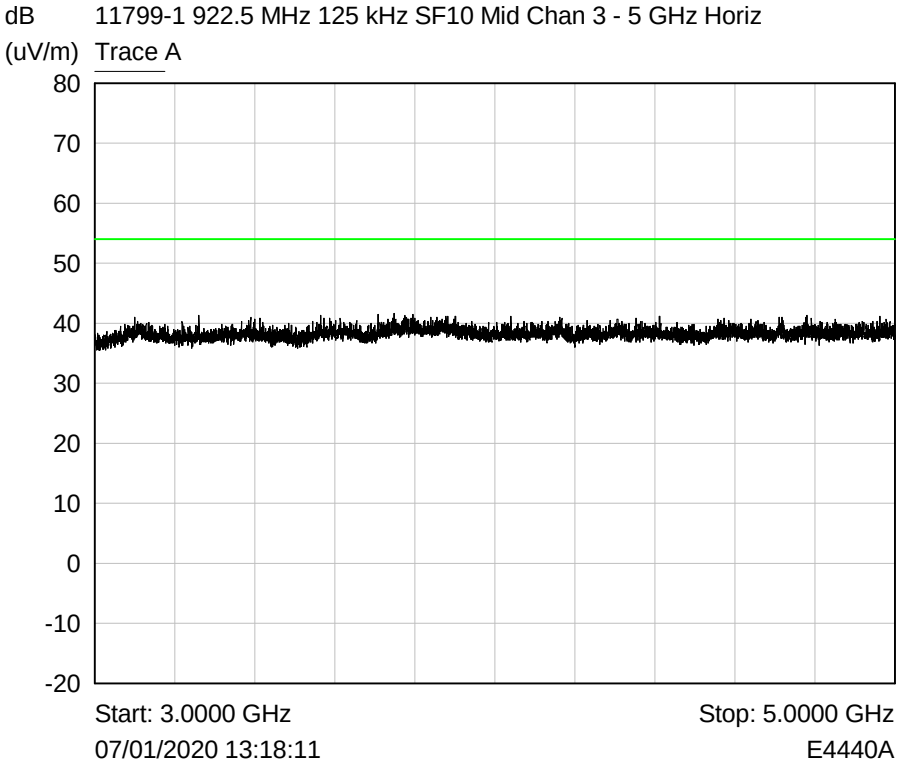
Note: Only middle channel plots are shown here to minimise report size.

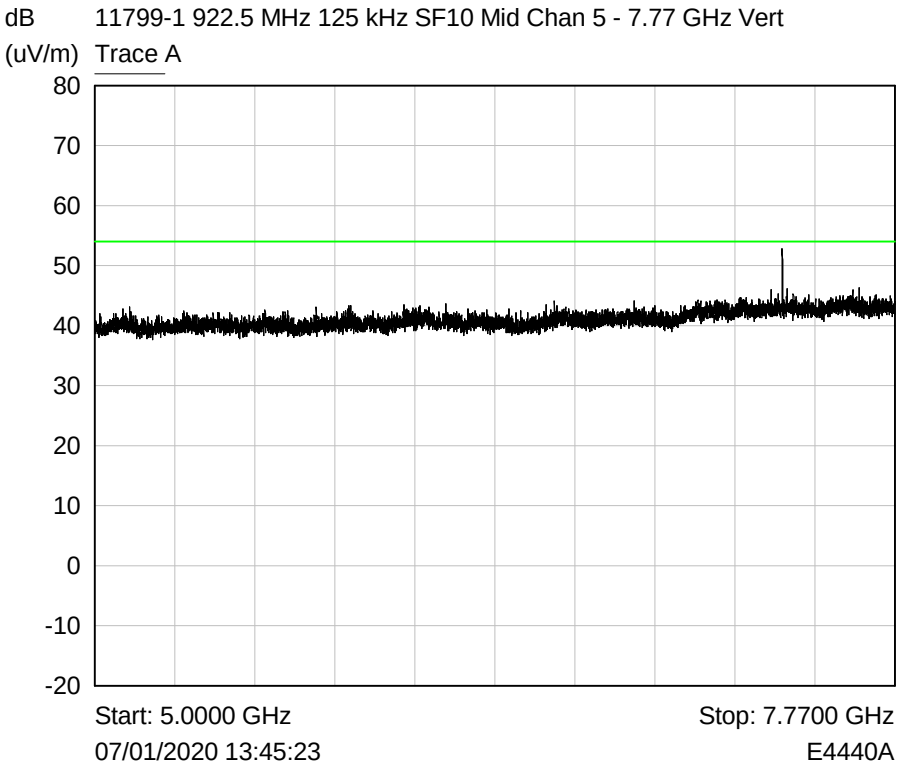
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10, Modulation LoRa, Channel 922.5 MHz

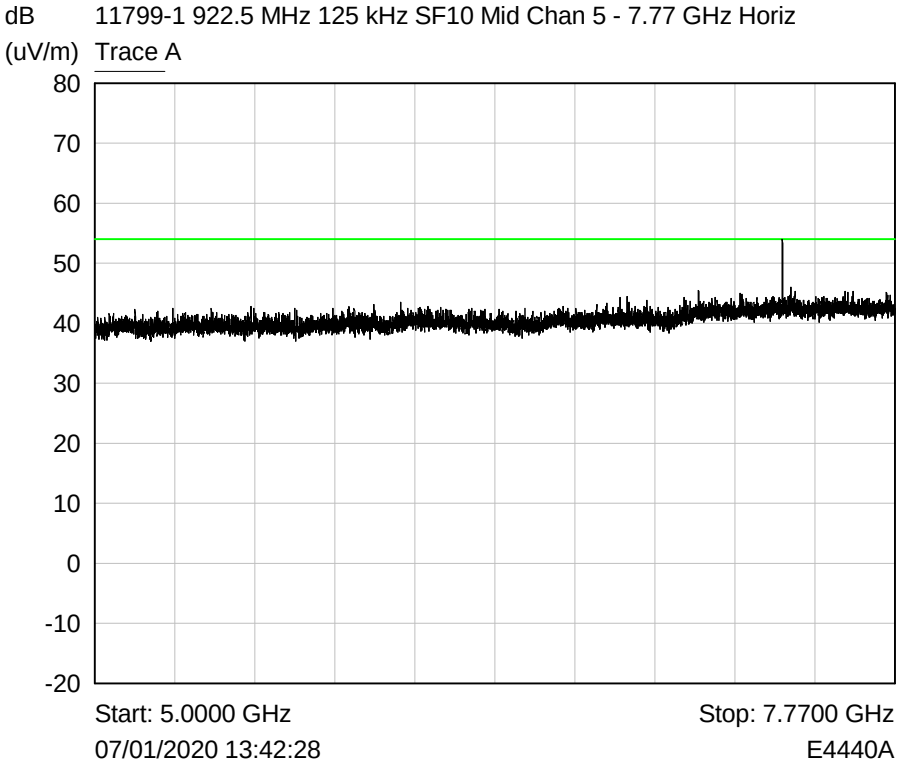


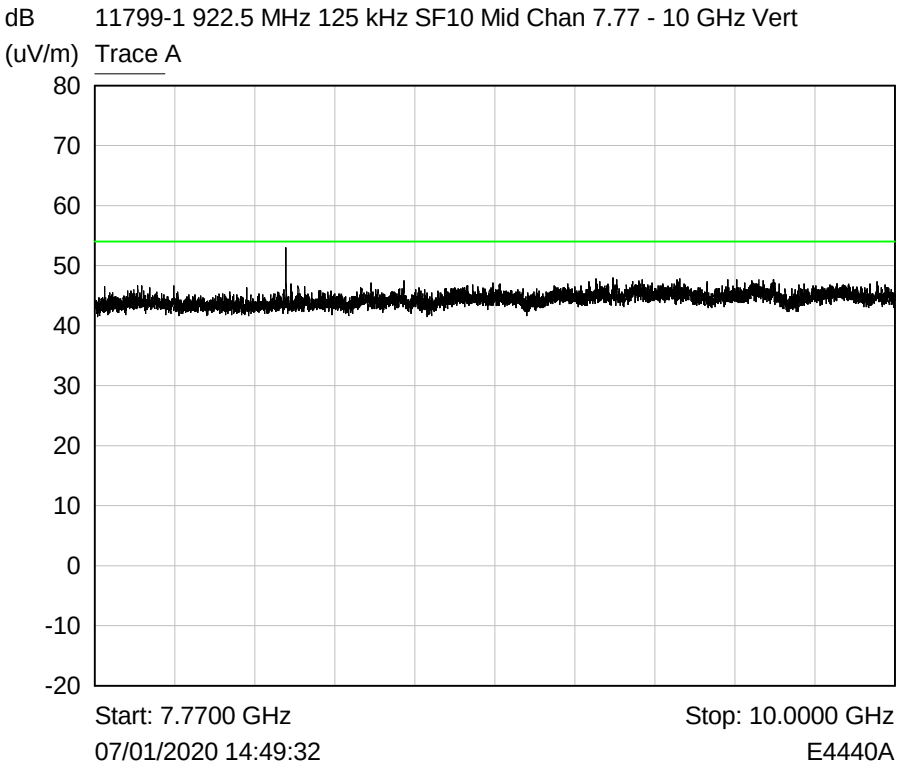


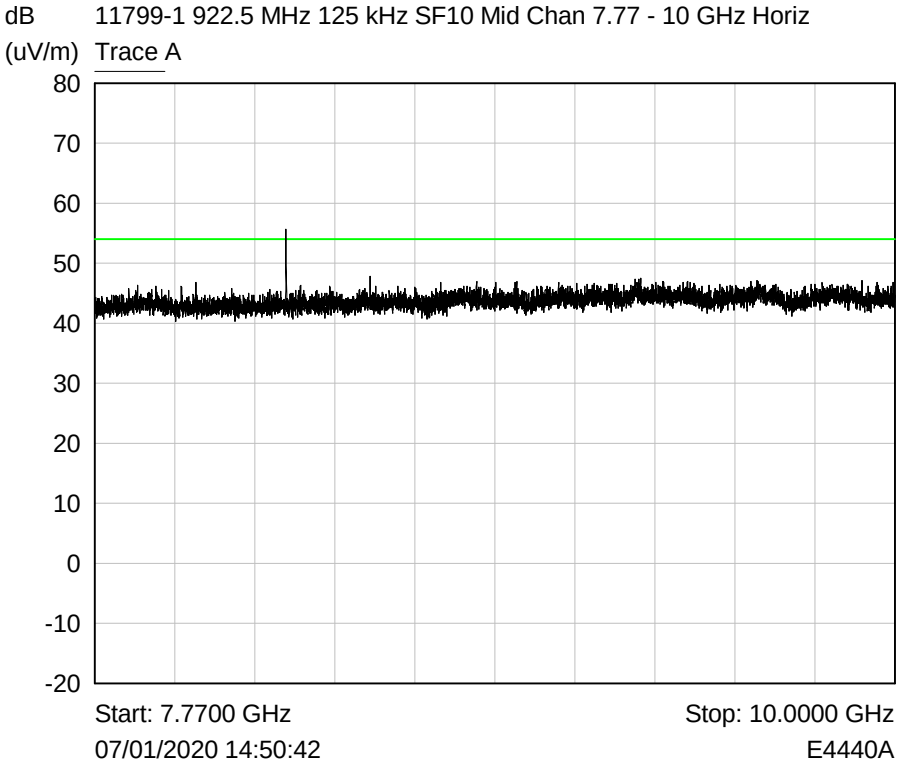




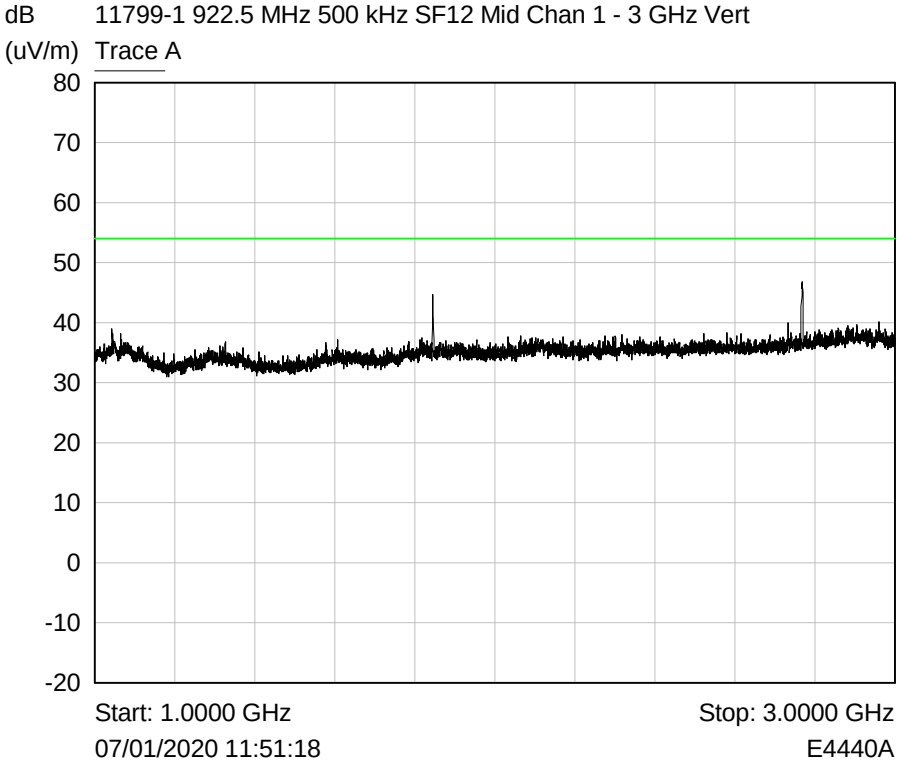


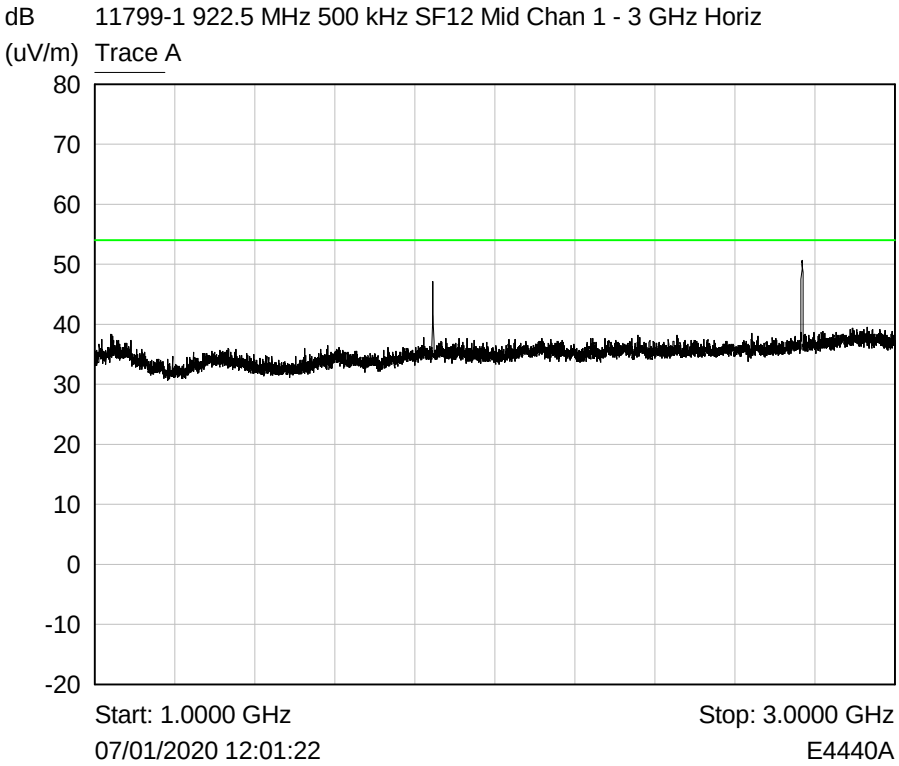


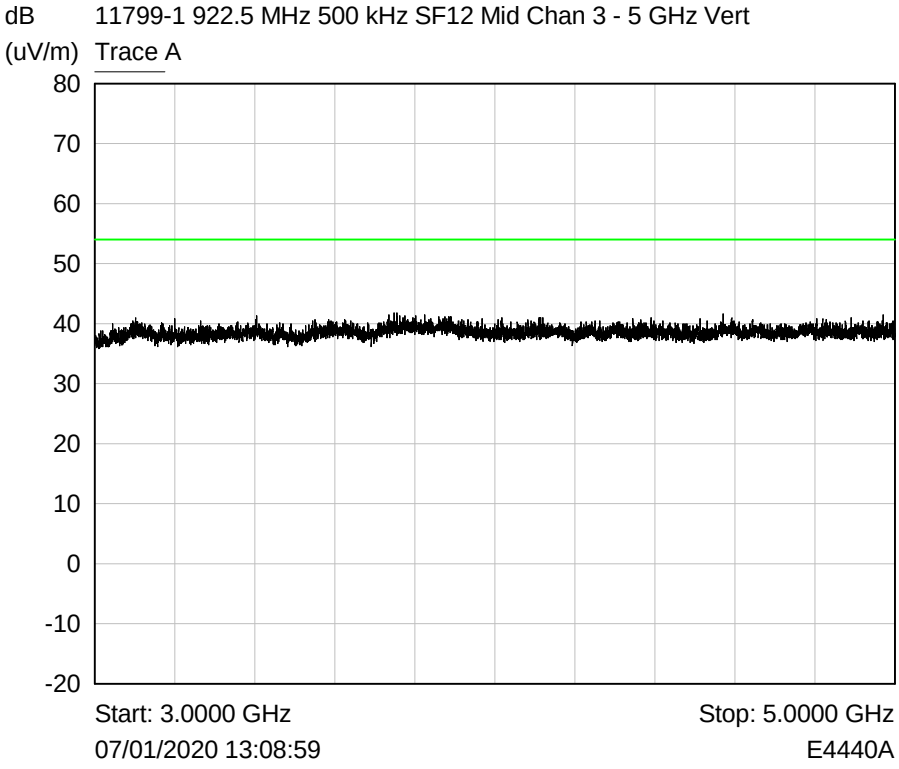


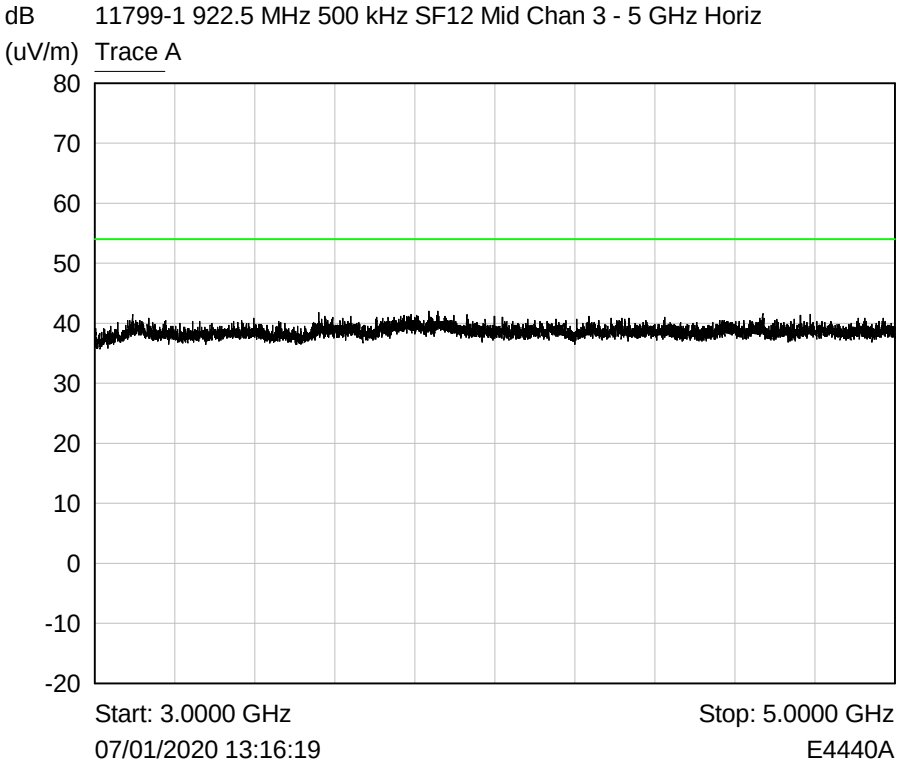


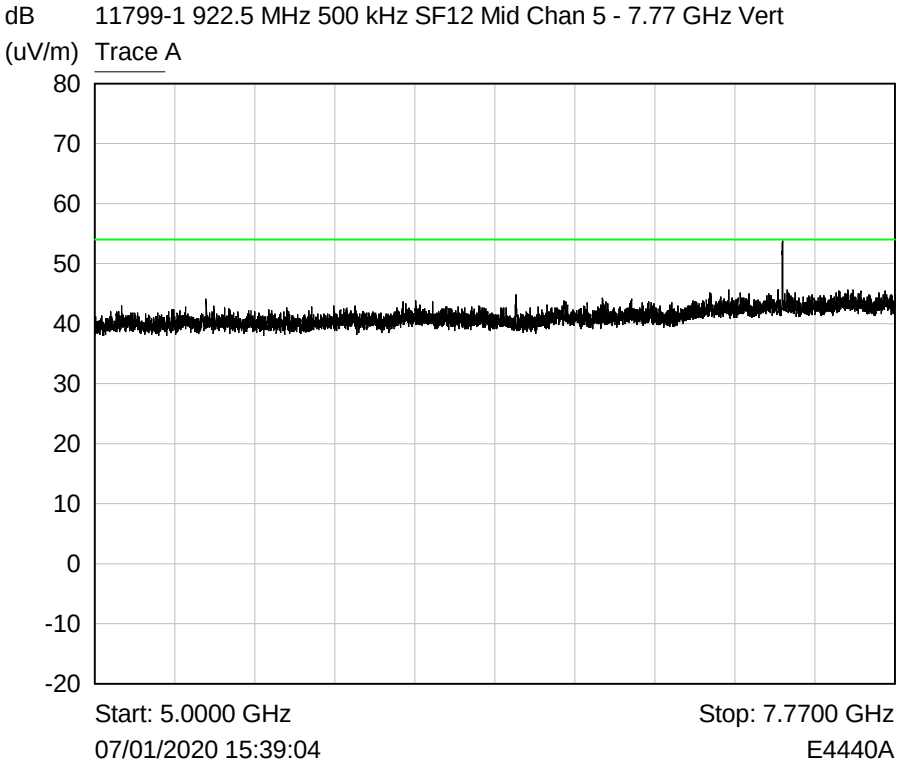
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 922.5 MHz

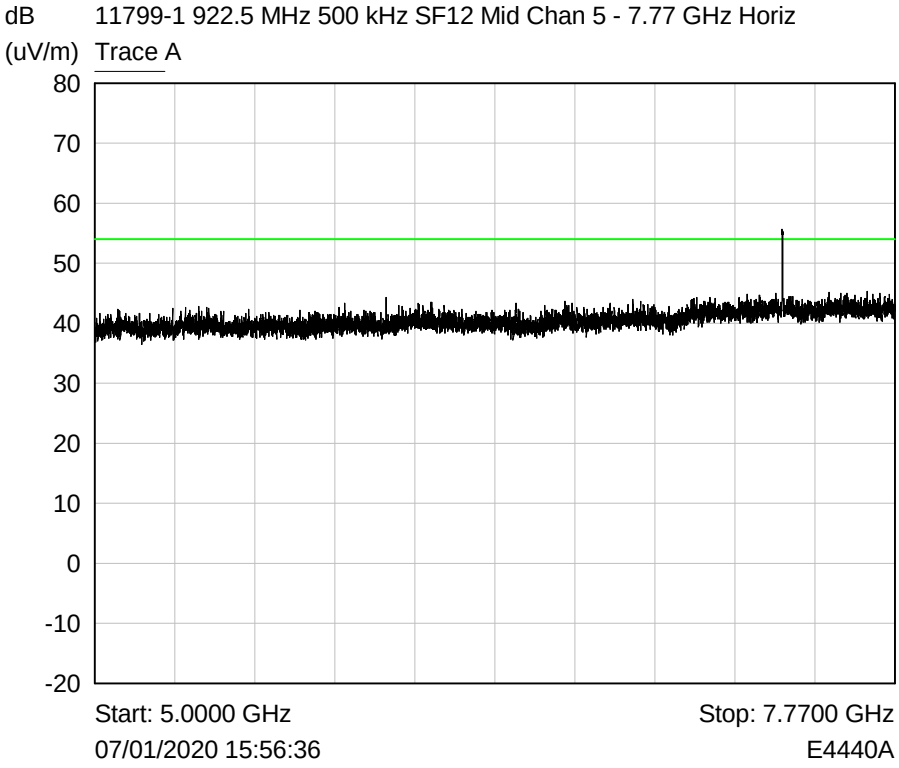


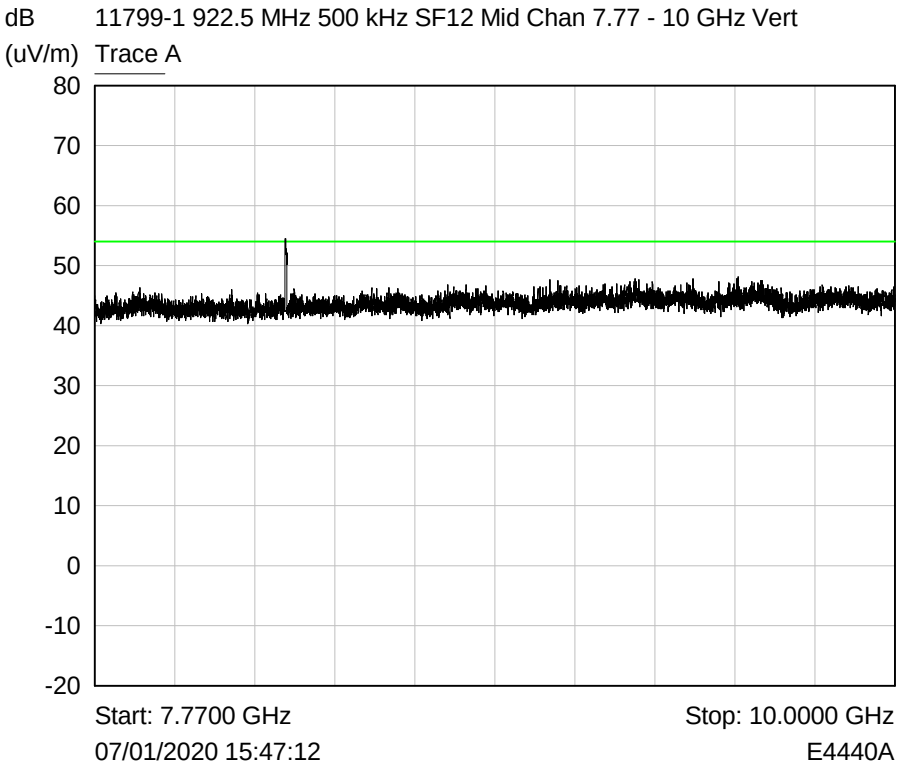


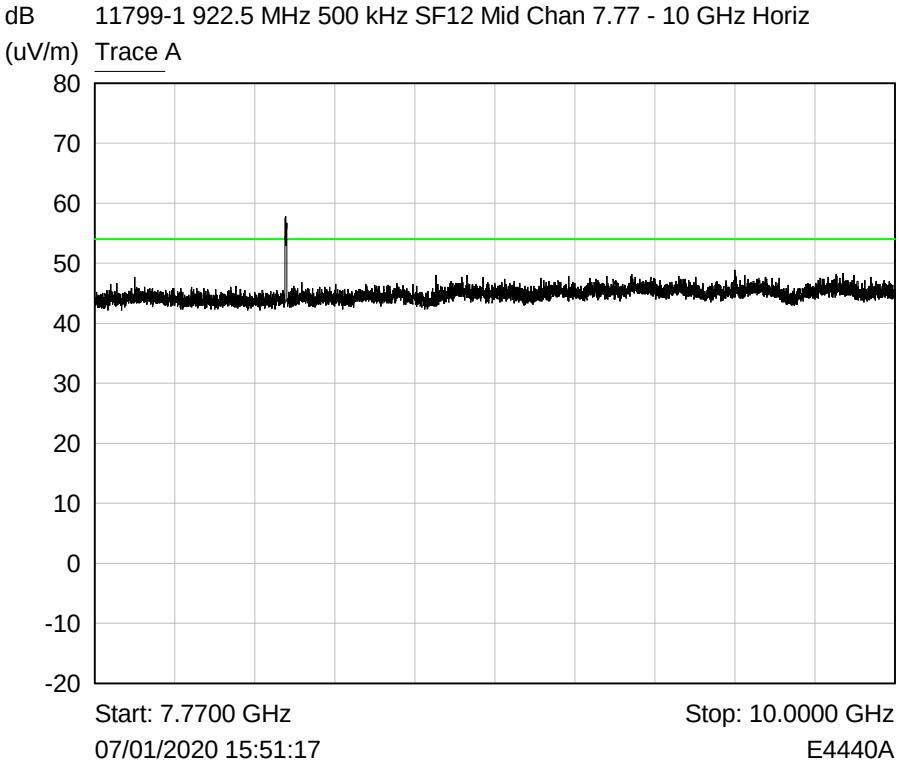






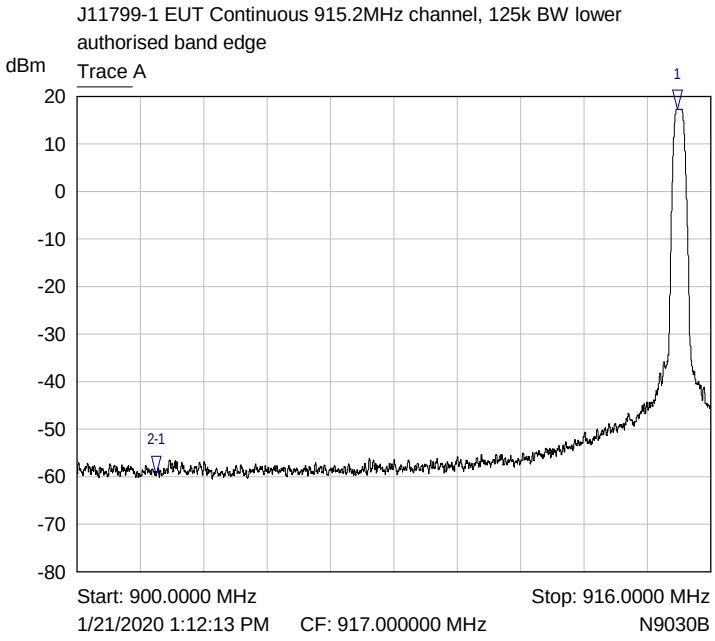






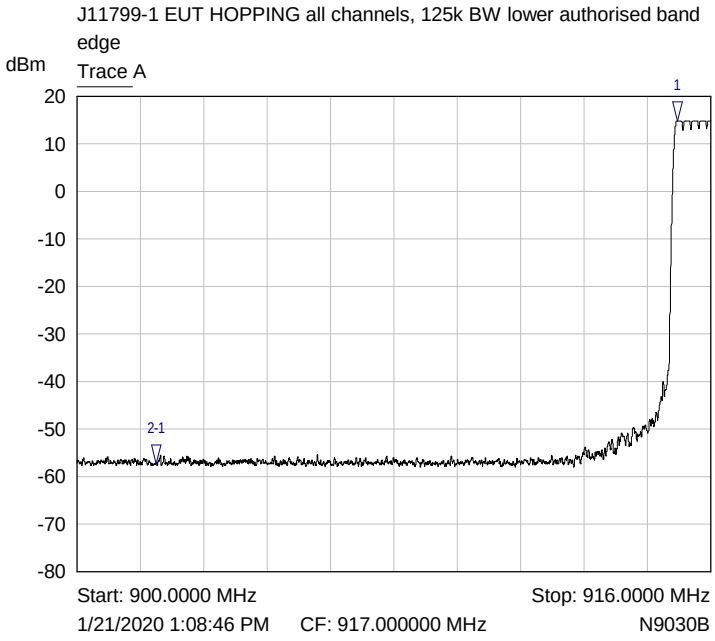
6.5 Band Edge Compliance

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 915.3 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	915.1647 MHz	17.35 dBm	
2-1 ▽	Trace A	-13.1645 MHz	-76.95 dB	

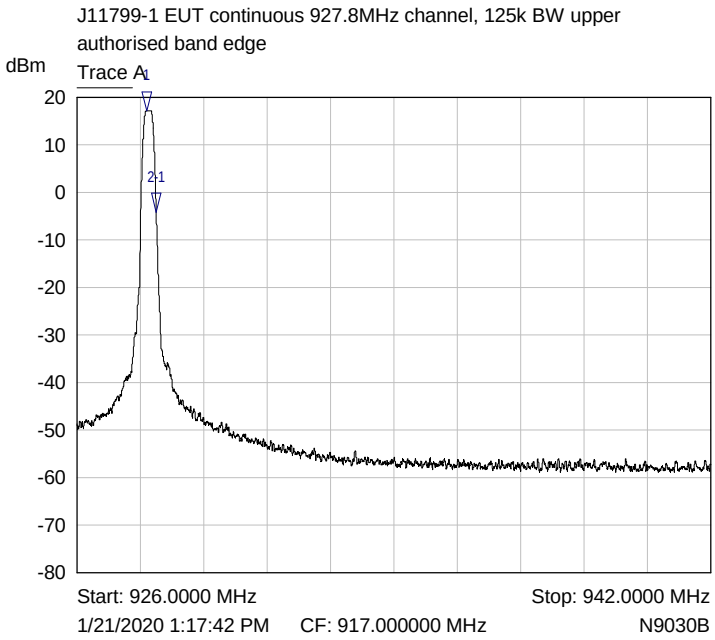
Lower Authorised Band Edge non-hopping Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	915.1647 MHz	14.89 dBm	
2-1 ▽	Trace A	-13.1645 MHz	-72.15 dB	

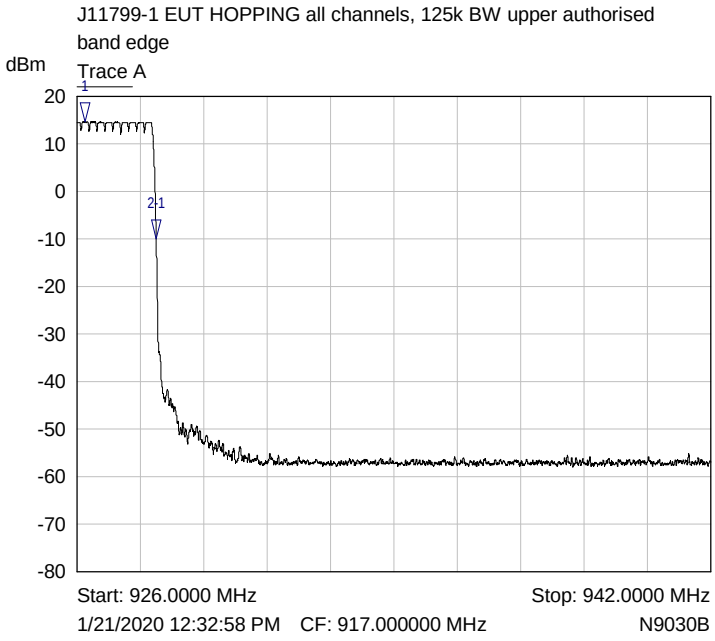
Lower Authorised Band Edge Hopping Plot

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel 927.7 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	927.7506 MHz	17.14 dBm	
2-1	Trace A	249.6250 kHz	-21.23 dB	

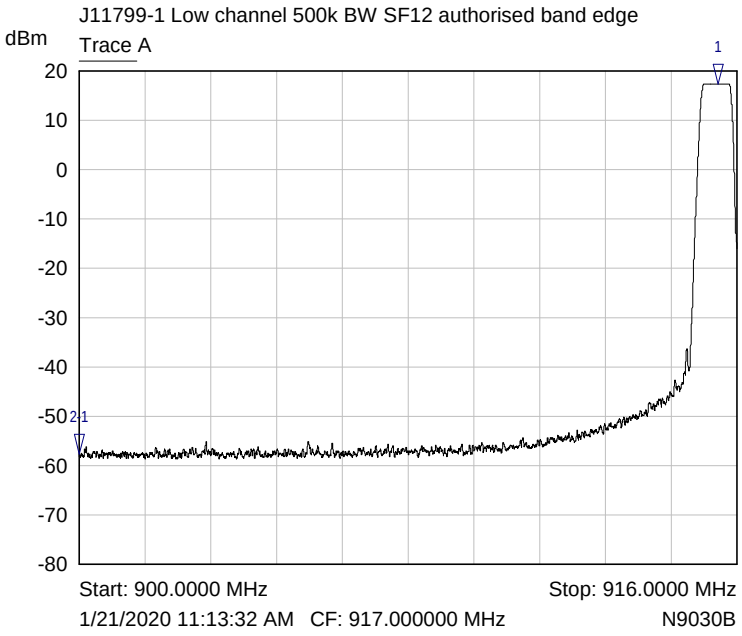
Upper Authorised Band Edge non-hopping Plot



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	926.2096 MHz	14.61 dBm	
2-1	Trace A	1.7906 MHz	-24.58 dB	

Upper Authorised Band Edge Hopping Plot

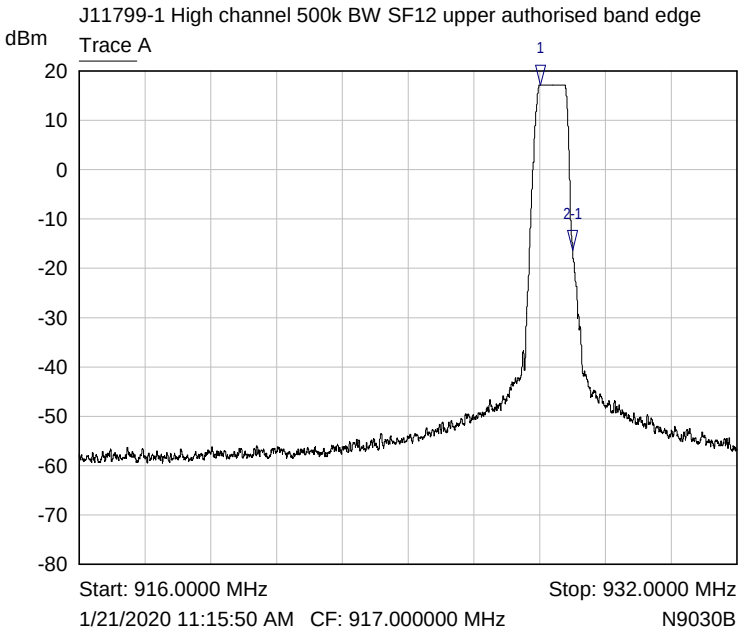
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 1.6 MHz, Modulation LoRa, Channel 915.5 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	915.5488 MHz	17.34 dBm	
2-1 ▽	Trace A	-15.5488 MHz	-74.96 dB	

Lower Authorised Band Edge Plot

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 1.6 MHz, Modulation LoRa, Channel 927.5 MHz

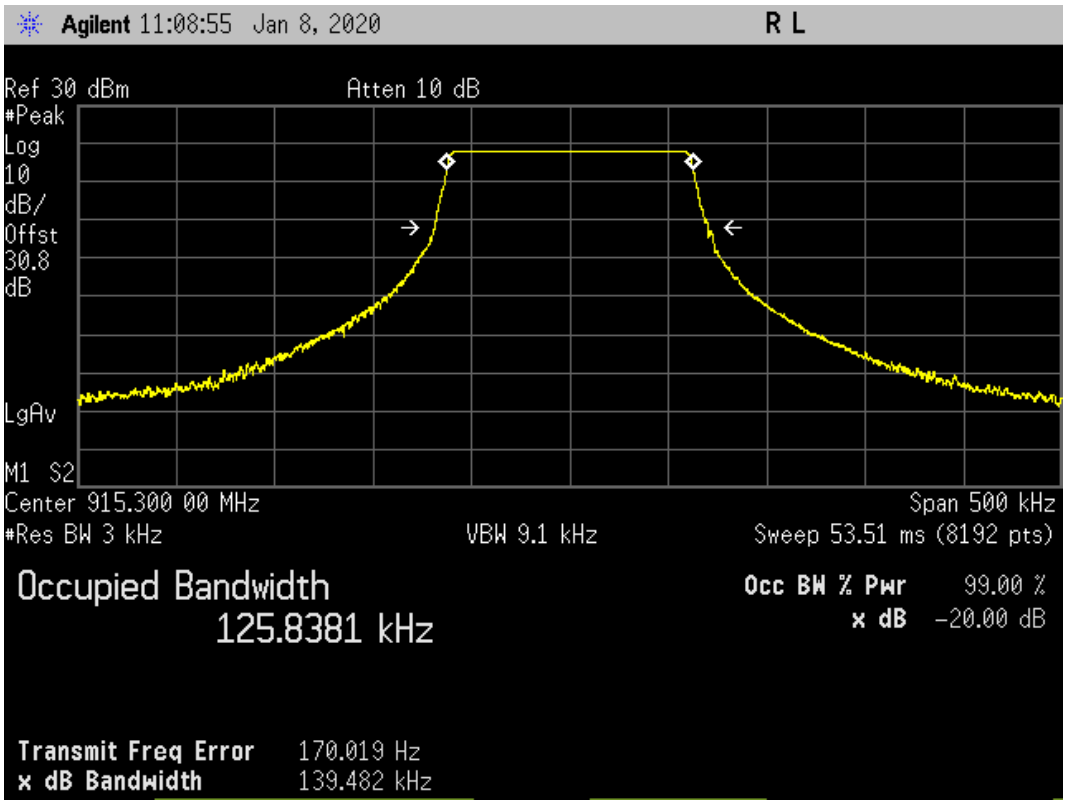


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	927.2139 MHz	17.14 dBm	
2-1 ▽	Trace A	785.6786 kHz	-33.41 dB	

Upper Authorised Band Edge Plot

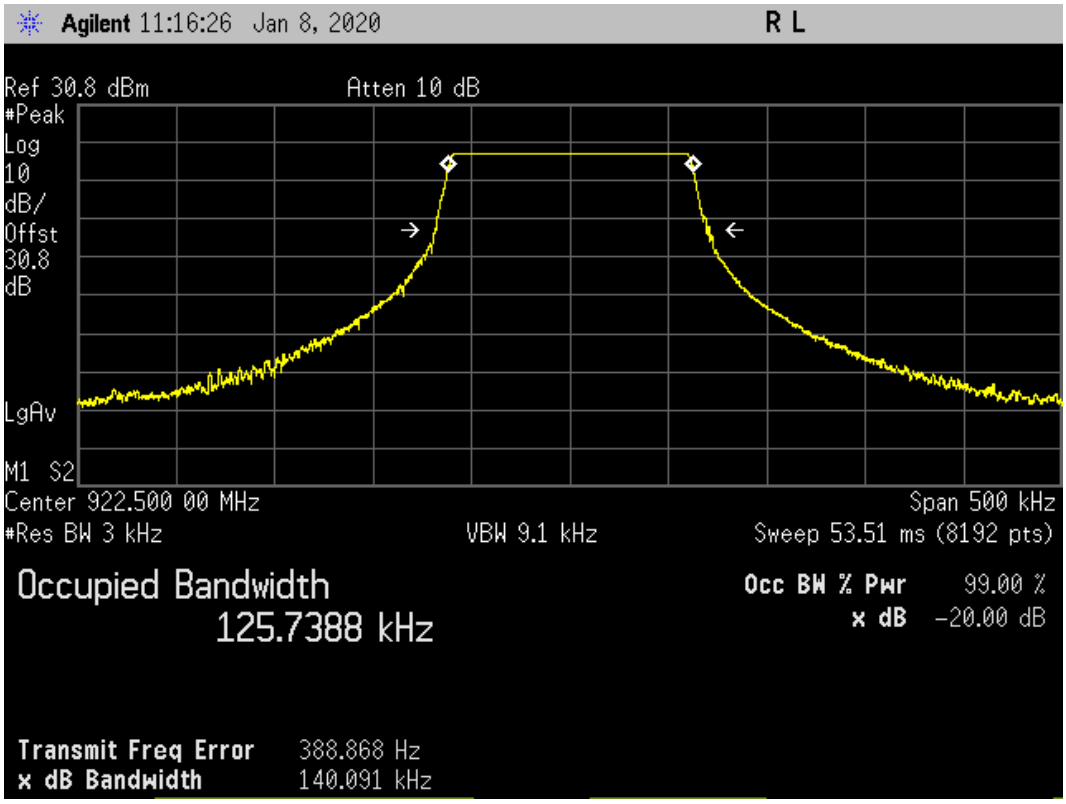
6.6 Occupied bandwidth

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10, Modulation LoRa, Channel 915.3 MHz



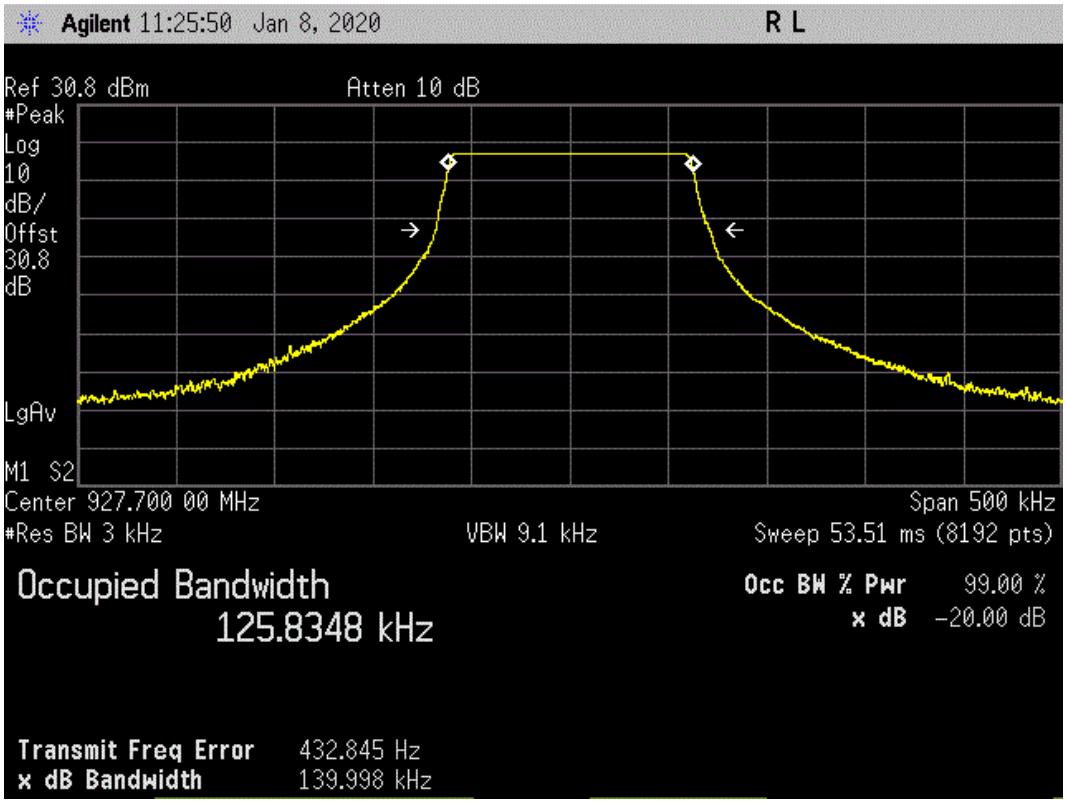
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10, Modulation LoRa, Channel 922.5 MHz



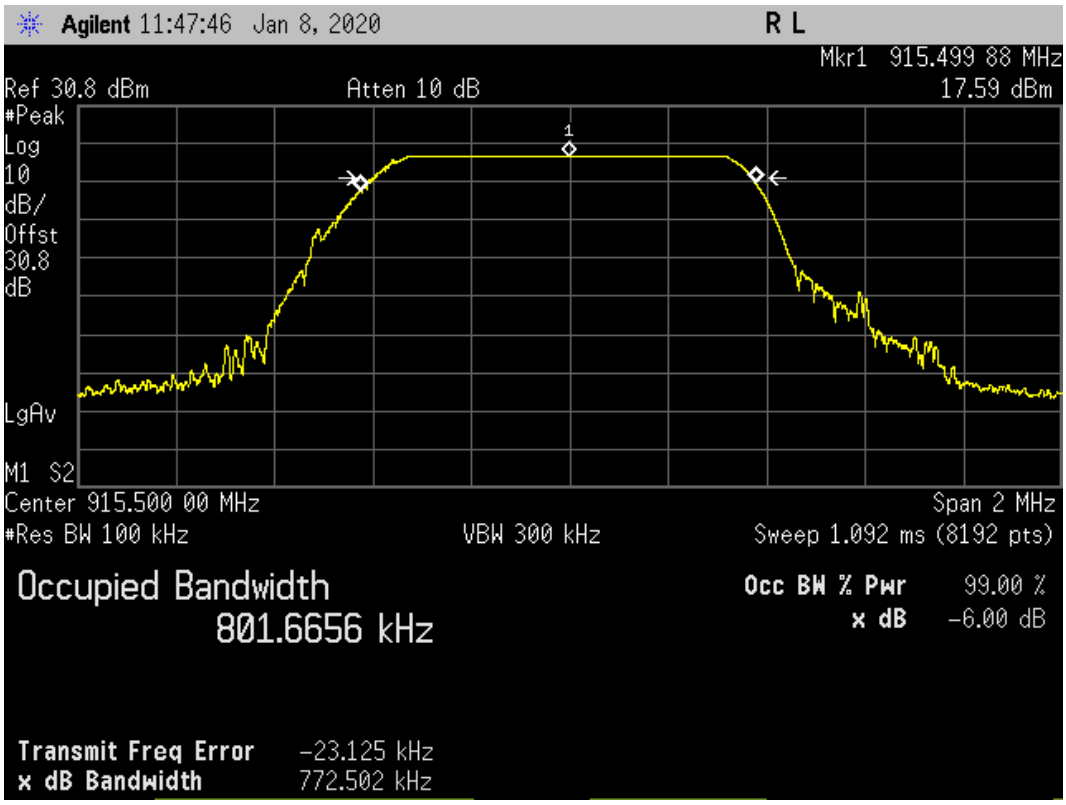
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10, Modulation LoRa, Channel 927.7 MHz



Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 915.5 MHz

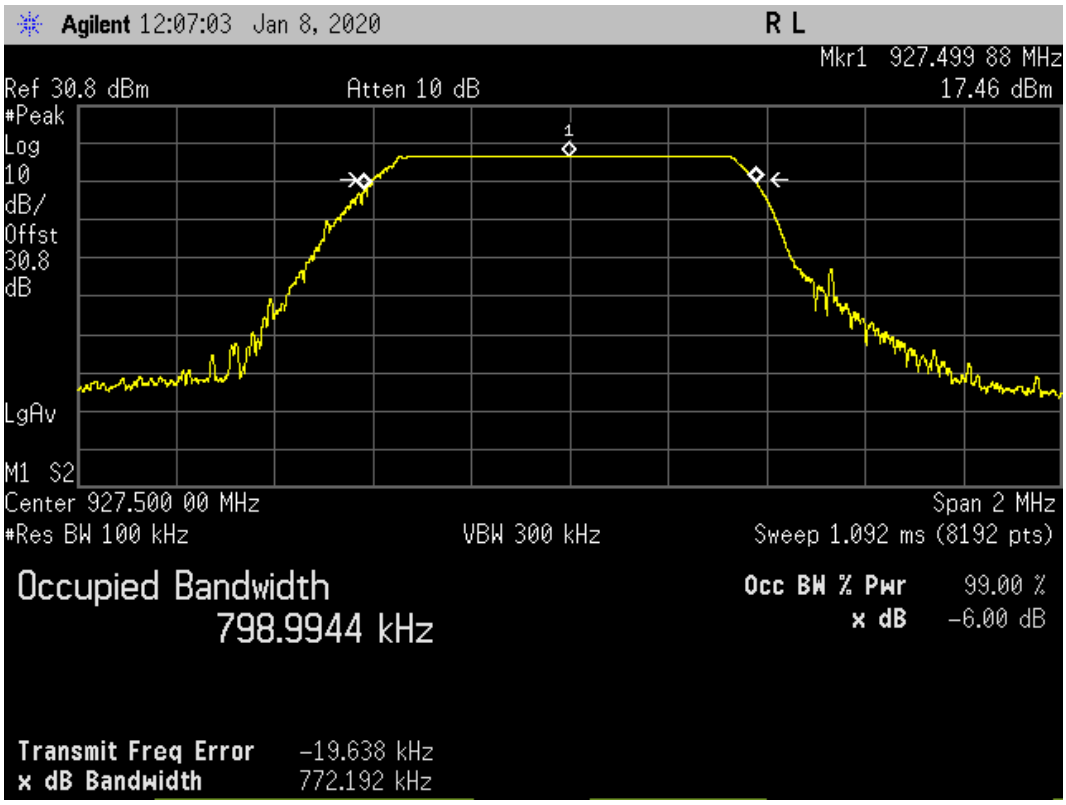


Plot for 6 dB Bandwidth (kHz) Nominal Temp & Volts

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 922.5 MHz

Plot for 6 dB Bandwidth (kHz) Nominal Temp & Volts

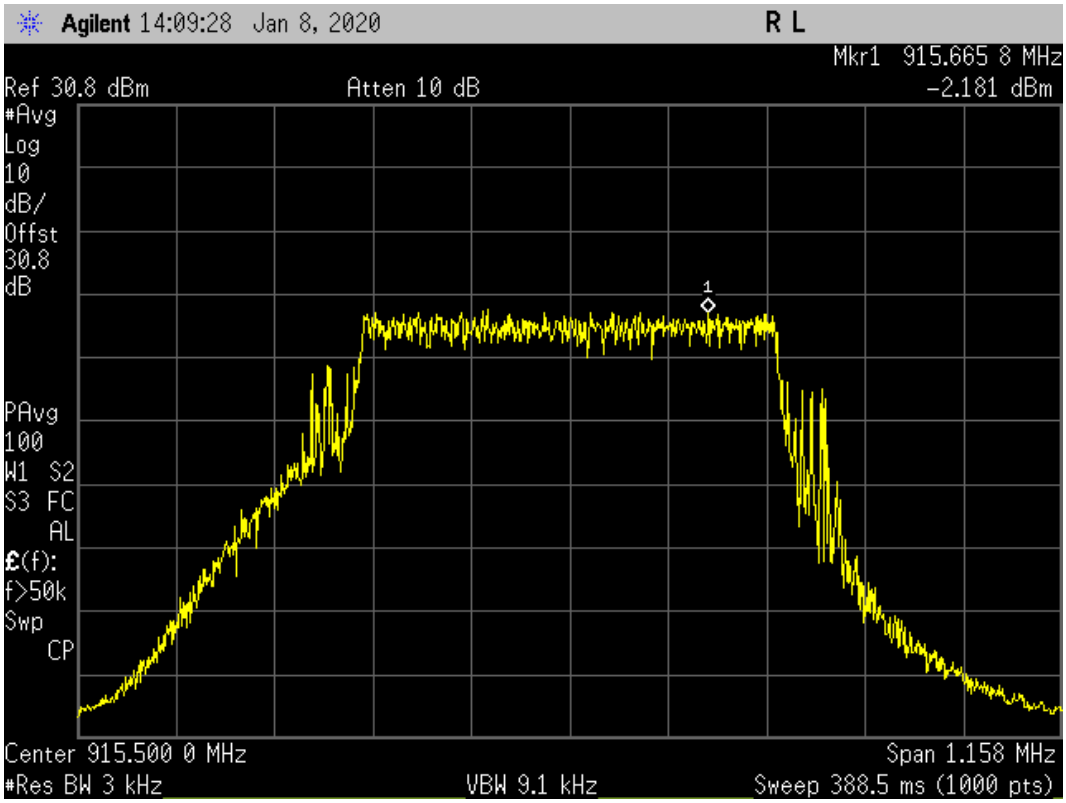
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 927.5 MHz



Plot for 6 dB Bandwidth (kHz) Nominal Temp & Volts

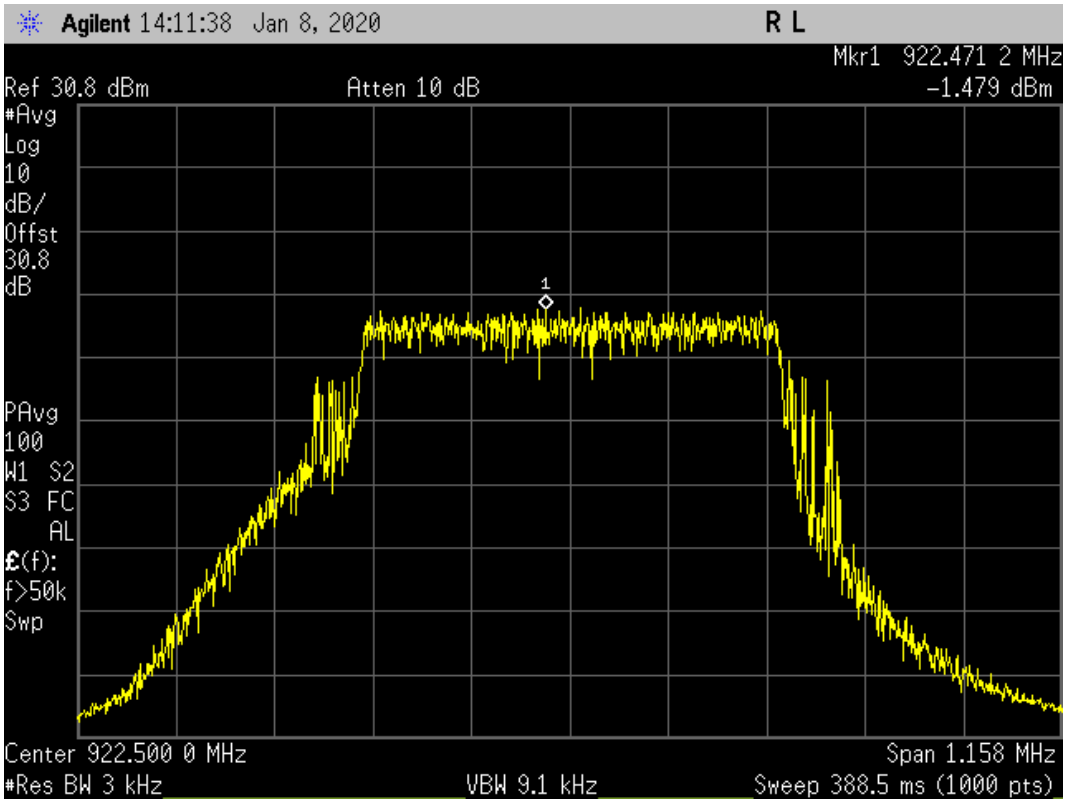
6.7 Maximum Power Spectral Density

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 915.5 MHz



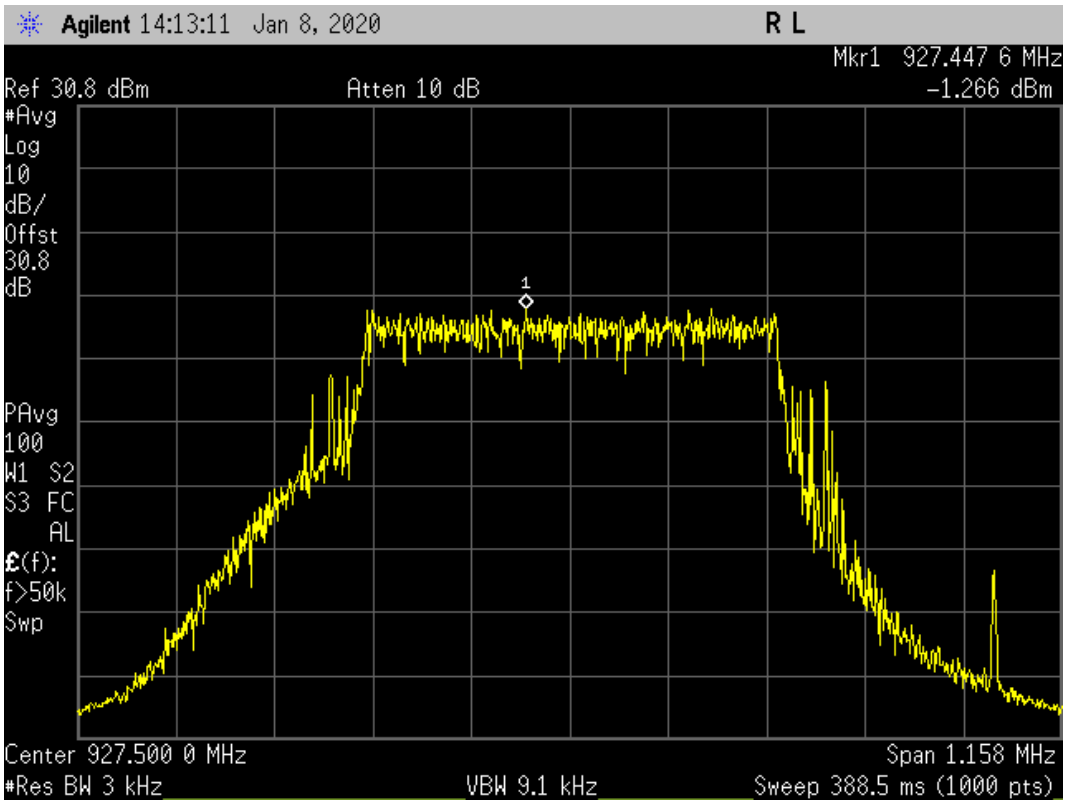
Plot for Power Spectral Density (PSD)

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 922.5 MHz



Plot for Power Spectral Density (PSD)

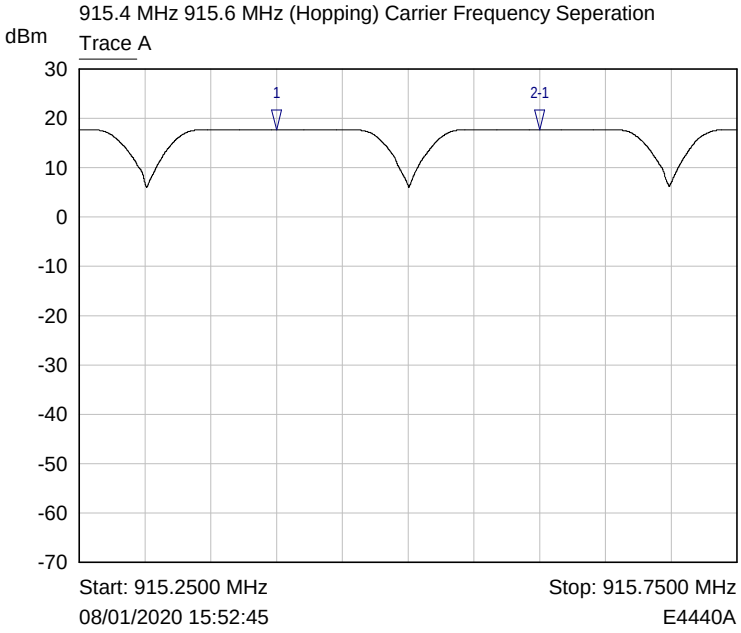
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12, Modulation LoRa, Channel 927.5 MHz



Plot for Power Spectral Density (PSD)

6.8 FHSS carrier frequency separation

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, All hopping

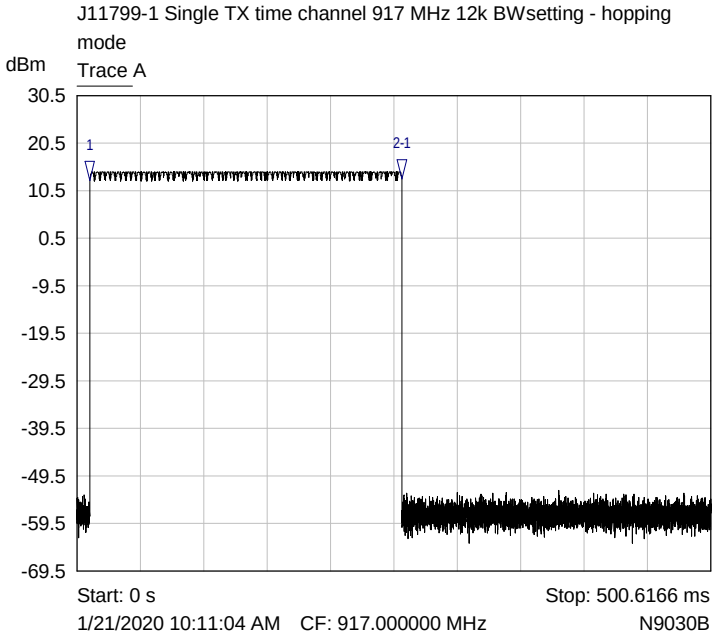


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	915.4000 MHz	17.62 dBm	
2-1 ▽	Trace A	200.0366 kHz	-0.00 dB	

Plot of Separation (kHz)

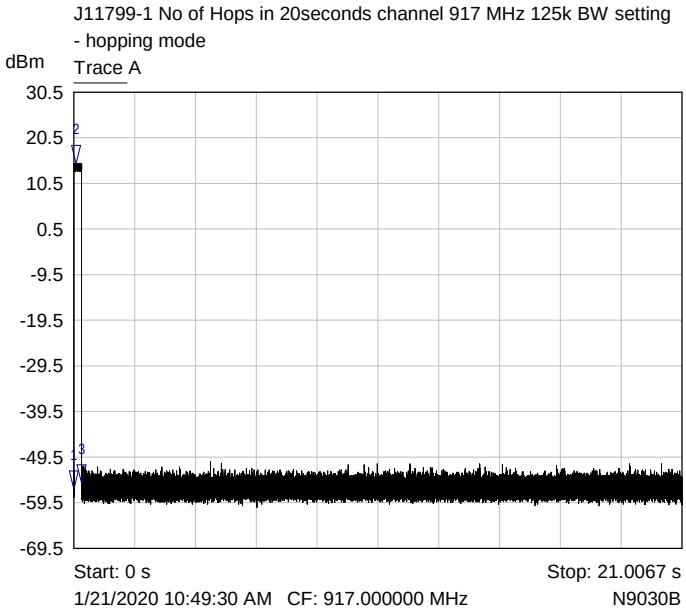
6.9 Average time of occupancy

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa Hopping, Channel 917 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	9.9132 ms	12.66 dBm	
2-1	Trace A	246.7285 ms	0.41 dB	

Measured Dwell time/pulse width (ms)

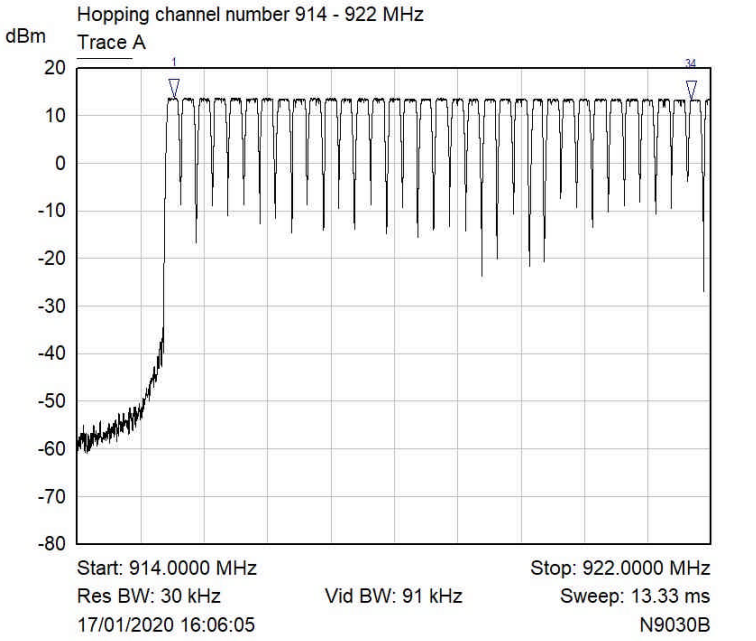


Mkr	Trace	X-Axis	Value	Notes
1	Trace A	9.2429 ms	-56.50 dBm	
2	Trace A	87.3877 ms	14.84 dBm	
3	Trace A	256.4914 ms	-55.22 dBm	

Period time (s)

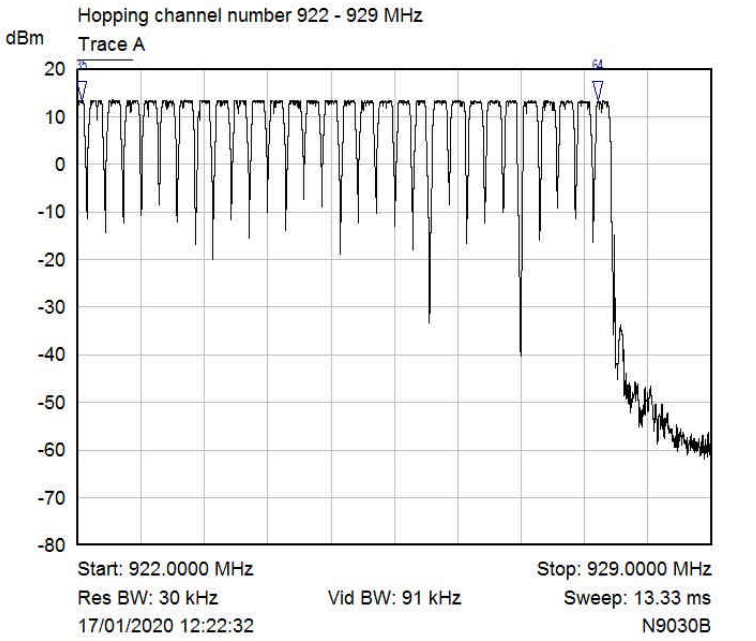
6.10 Number of Hop Channels

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 200 kHz, Modulation LoRa, Channel All Hopping



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	915.2237 MHz	13.73 dBm	
34	Trace A	921.7498 MHz	13.41 dBm	

Plot of Hopping Channels 1-34



Mkr	Trace	X-Axis	Value	Notes
35	Trace A	922.0449 MHz	13.34 dBm	
64	Trace A	927.7478 MHz	13.27 dBm	

Plot of Hopping Channels 34-64

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. RN Electronics 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: $E_{Log} = 20Log(0.01842) +120 = 85.3dB\mu V/m$ @ 3m.

8 Photographs

No photographs included in report at client's request.

8.1 Radiated emission diagrams

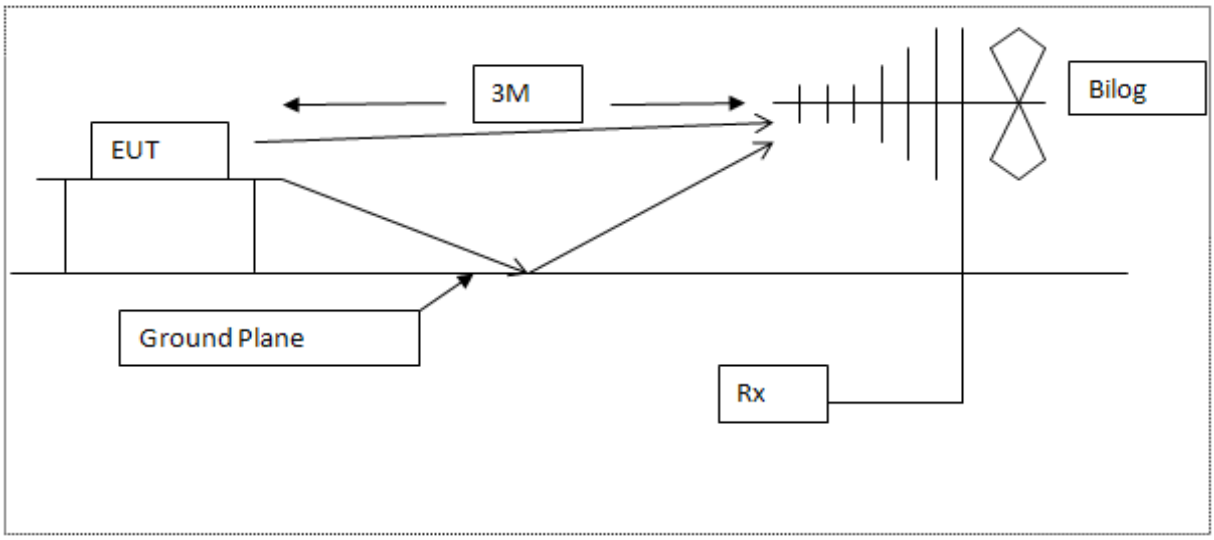


Diagram of the radiated emissions test setup 30 - 1000 MHz

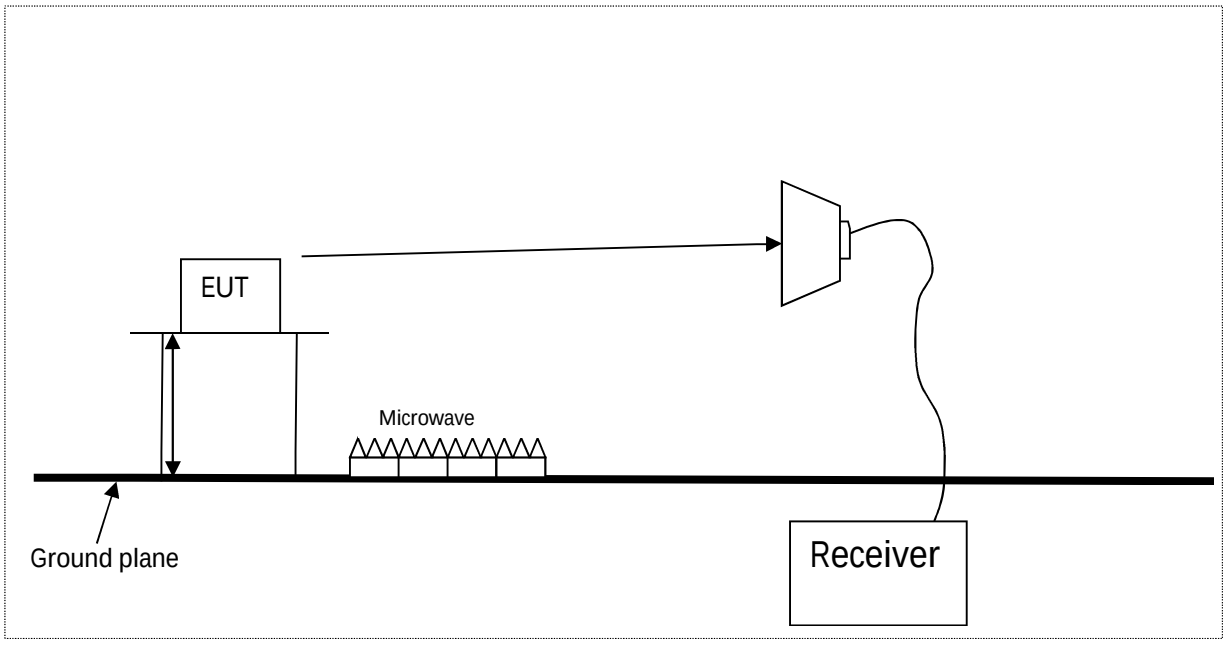


Diagram of the radiated emissions test setup above 1GHz

9 Test equipment calibration list

The following is a list of the test equipment used by R.N. Electronics Ltd 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
E136	3105	Horn Antenna 1-12.5GHz	EMCO	27-Apr-2019	12 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	11-Jul-2019	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	17-Jul-2018	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	27-Aug-2019	12 months
E478	LQ2992/H	Filter Band pass 1-3GHz	RACAL-MESL	29-Mar-2019	12 months
E558	18N20W-30dB	Attenuator 30dB 20W	Inmet	25-Jan-2019	12 months
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	#10-Jan-2020	24 months
E640	6630.19.AA	Attenuator 30dB 18GHz	Suhner	#08-Jan-2020	12 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	11-Dec-2019	24 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	11-Feb-2019	12 months
E755	N9030B	PXA 3Hz to 50GHz	Keysight Technologies	11-May-2019	12 months
E932	N5181A	Signal Generator 100kHz to 6GHz	Agilent Technologies	05-Jun-2019	12 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	21-Mar-2018	24 months
NSA-M	NSA - M	NSA - Site M	RN Electronics	09-Jan-2019	36 months
TMS81	6502	Antenna Active Loop	EMCO	24-Jun-2019	24 months
TMS82	8449B	Pre-Amplifier 1GHz - 26.5GHz	Agilent Technologies	18-Dec-2019	12 months
ZSW1	V2.4	Measurement Software Suite	RN Electronics	N/A	N/A

Equipment was within calibration dates for tests and has been re-calibrated since date of tests.

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	S205 Ideapad	Laptop PC	Lenovo	WB03057452
2	Not stated	USB to serial cable	Generic	Not stated

10.2 RN Electronics supplied equipment

No RN Electronics Ltd 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 RN Electronics Ltd.

11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 293246
IC 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. 293246
IC Registration No. 5612A-2

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246
IC 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. 293246
IC Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

13 Abbreviations and units

%	Percent
µA/m	microAmps per metre
µV	microVolts
µW	microWatts
AC	Alternating Current
ALSE	Absorber Lined Screened Enclosure
AM	Amplitude Modulation
Amb	Ambient
ATPC	Automatic Transmit Power Control
BER	Bit Error Rate
ºC	Degrees Celsius
C/I	Carrier / Interferer
CEPT	European Conference of Postal and Telecommunications Administrations
COFDM	Coherent OFDM
CS	Channel Spacing
CW	Continuous Wave
dB	deciBels
dBµA/m	deciBels relative to 1µA/m
dBµV	deciBels relative to 1µV
dBc	deciBels relative to Carrier
dBm	deciBels relative to 1mW
DC	Direct Current
DTA	Digital Transmission Analyser
EIRP	Equivalent Isotropic Radiated Power
ERP	Effective Radiated Power
EU	European Union
EUT	Equipment Under Test
FM	Frequency Modulation
FSK	Frequency Shift Keying
g	Grams
GHz	GigaHertz
Hz	Hertz
IF	Intermediate Frequency
kHz	kiloHertz
LBT	Listen Before Talk
LO	Local Oscillator
mA	milliAmps
max	maximum
kPa	Kilopascal
Mbit/s	MegaBits per second
MHz	MegaHertz
mic	Microphone
min	minimum
mm	milliMetres
ms	milliSeconds
mW	milliWatts
NA	Not Applicable
nom	Nominal
nW	nanoWatt
OATS	Open Area Test Site
OFDM	Orthogonal Frequency Division Multiplexing
ppm	Parts per million
PRBS	Pseudo Random Bit Sequence
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
R&TTE	Radio and Telecommunication Terminal Equipment
Ref	Reference
RF	Radio Frequency
RFC	Remote Frequency Control
RSL	Received Signal Level
RTP	Room Temperature and Pressure
RTPC	Remote Transmit Power Control
Rx	Receiver
s	Seconds
SINAD	Signal to Noise And Distortion
Tx	Transmitter
V	Volts

Annex A – Chilean power measurements

At the request of the applicant the following extra channels were measured for Peak power using a spectrum analyser and the same method/settings as indicated in section 5.10 within this report.

Band	902 – 928 MHz
Power Level declared	125 kHz: 20 dBm (set in software)
Channel Spacing	200kHz (125 kHz BW)
Mod Scheme	LoRa

Channel frequency (MHz)	Spreading factor used	
	SF10	SF12
916.8	17.3	17.3
917.0	17.2	17.2
917.2	16.9	16.9
917.4	17.3	17.3
917.6	17.4	17.4
917.8	17.2	17.2
918.0	17.1	17.1
918.2	17.2	17.2

Note: There was no discernible difference in power level between SF10 and SF12 settings.