



Radio Test Report

Senceive Ltd

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: 10th December 2019 to 23rd December 2019

Report Number: 12-11797-1-19 Issue 01

R.N. Electronics Ltd.

Arnolds Court
Arnolds Farm Lane
Mountnessing
Essex
CM13 1UT
U.K.

www.RNelectronics.com

Telephone: +44 (0) 1277 352219

Email: sales@RNelectronics.com

This report is not to be reproduced by any means except in full and in any case not without the written approval of R.N. Electronics Ltd.



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

Certificate of Test 11797-1

The equipment noted below has been partially 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:	001BC50AA800000D
Applicant:	Senceive Ltd Imperial Studios, Imperial Road Fulham, London, England SW6 2AG
Proposed FCC ID	2AMFBLR3N
Full measurement results are detailed in Report Number:	12-11797-1-19 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2018 DTS: Digital Transmission System

NOTE:

The above list is incomplete as only partial tests conducted at request of the manufacturer. For details refer to section 3 of this report. Certain tests were not performed based upon manufacturer's declarations.

DEVIATIONS:

The following tests have not been performed at the request of Senceive Ltd:- Maximum Average conducted output power, Maximum Peak conducted output power, Average time of occupancy, FHSS carrier frequency separation, Antenna power conducted emissions, Duty cycle, Effective radiated power field strength, Number of Hop Channels, Occupied bandwidth, Maximum Power Spectral Density.

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: 10th December 2019 to 23rd December 2019

Test Engineer:

Approved By:
Technical Manager

Customer
Representative:



1 Contents

1	Contents	3
2	Equipment under test (EUT)	4
2.1	Equipment specification.....	4
2.2	Configurations for testing.....	5
2.3	Functional description.....	6
2.4	Modes of operation.....	6
2.5	Emissions configuration.....	7
3	Summary of test results	8
4	Specifications.....	9
4.1	Relevant standards.....	9
4.2	Deviations.....	9
4.3	Tests at extremes of temperature & voltage	Error! Bookmark not defined.
5	Tests, methods and results	10
5.1	AC power line conducted emissions.....	10
5.2	Radiated emissions 9 - 150 kHz.....	11
5.3	Radiated emissions 150 kHz - 30 MHz.....	13
5.4	Radiated emissions 30 MHz -1 GHz.....	15
5.5	Radiated emissions above 1 GHz	18
5.6	Effective radiated power field strength.....	22
5.7	Band Edge Compliance.....	23
5.8	Occupied bandwidth	25
5.9	Maximum Average conducted output power.....	26
5.10	Maximum Peak conducted output power.....	26
5.11	Maximum Power Spectral Density.....	26
5.12	Antenna power conducted emissions	26
5.13	Duty cycle.....	26
5.14	FHSS carrier frequency separation	26
5.15	Average time of occupancy	26
5.16	Number of Hop Channels	26
6	Plots/Graphical results	27
6.1	Radiated emissions 9 - 150 kHz.....	27
6.2	Radiated emissions 150 kHz - 30 MHz.....	28
6.3	Radiated emissions 30 MHz -1 GHz.....	29
6.4	Radiated emissions above 1 GHz	41
6.5	Band Edge Compliance.....	51
7	Explanatory Notes.....	55
7.1	Explanation of Table of Signals Measured	55
7.2	Explanation of limit line calculations for radiated measurements.....	55
8	Photographs	58
8.1	EUT Front View	58
8.2	EUT Reverse Angle.....	58
8.3	EUT Left side View.....	58
8.4	EUT Right side View.....	58
8.5	EUT Antenna & Antenna Port.....	58
8.6	EUT Display & Controls.....	58
8.7	EUT Internal photos.....	58
8.8	EUT ID Label.....	58
8.9	Radiated emissions 9 - 150 kHz.....	58
8.10	Radiated emissions 30 MHz -1 GHz.....	58
8.11	Radiated emissions above 1 GHz	58
8.12	Radiated emission diagrams	59
9	Test equipment calibration list	60
10	Auxiliary and peripheral equipment.....	61
10.1	Customer supplied equipment.....	61
10.2	RN Electronics supplied equipment.....	61
11	Condition of the equipment tested	62
11.1	Modifications before test.....	62
11.2	Modifications during test.....	62
12	Description of test sites.....	63
13	Abbreviations and units.....	64

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	001BC50AA800000D	
Date Received	10th December 2019	
Date of Test:	10th December 2019 to 23rd December 2019	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations using a new antenna type "Linx technologies model:ANT-916-CW-QW-SMA".	
Date Report Issued	14th January 2020	
Main Function	Wireless Data logger operating in 902 - 915 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	914.9 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	902-915 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	902-915 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

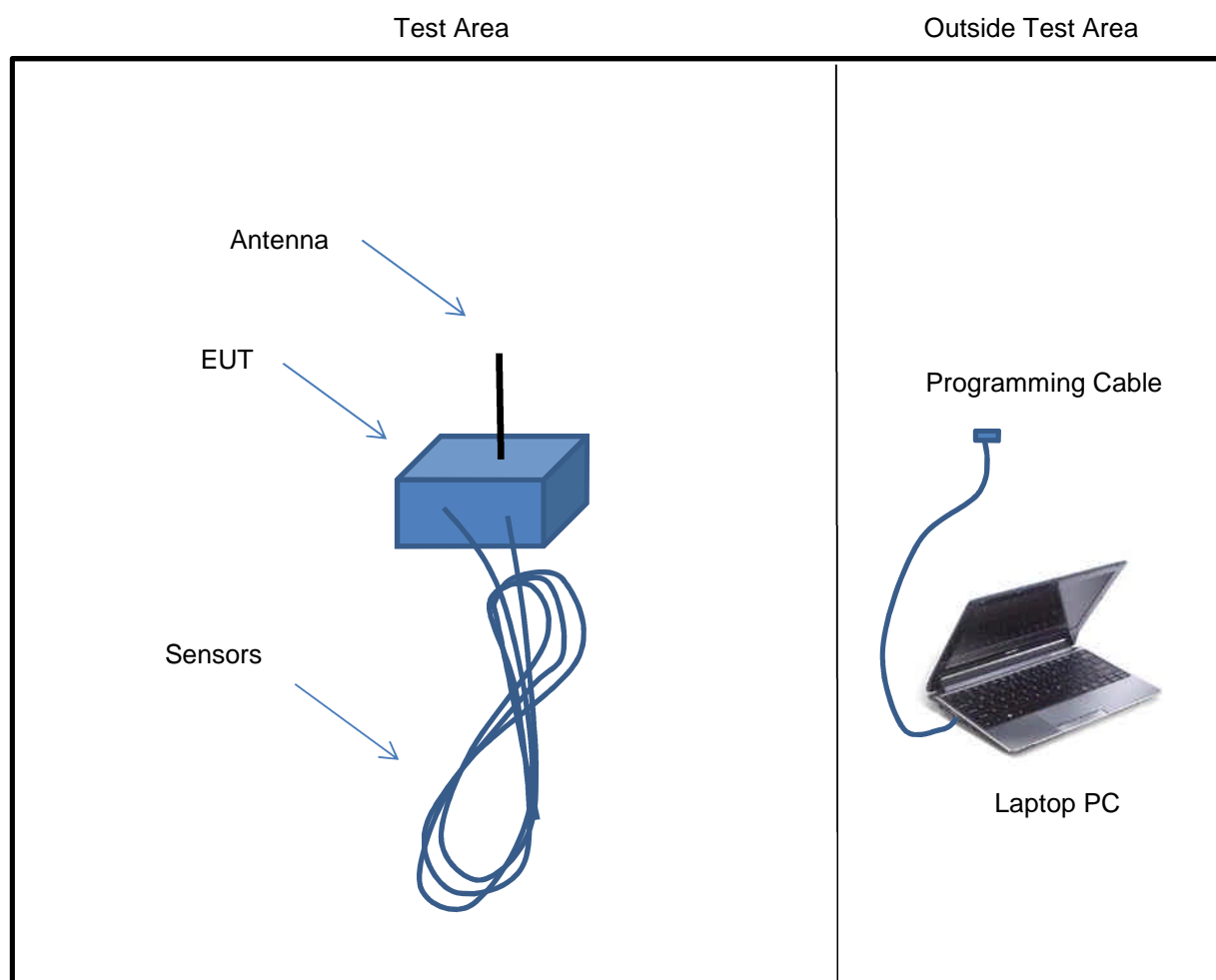
2.3 Functional description

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 902 - 915 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
mode 1	EUT transmitting continuously at 902.3 MHz using SF10, 125k BW	Yes
mode 2	EUT transmitting continuously at 908.5 MHz using SF10, 125k BW	Yes
mode 3	EUT transmitting continuously at 914.9 MHz using SF10, 125k BW	Yes
mode 4	EUT transmitting continuously at 903 MHz using SF12, 500k BW	Yes
mode 5	EUT transmitting continuously at 907.8 MHz using SF12, 500k BW	Yes
mode 6	EUT transmitting continuously at 914.2 MHz using SF12, 500k BW	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 set were as instructed by Senceive Ltd, for all 125kHz BW channels this was SF10, and all 500kHz BW channels SF12 was used.

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

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 914.9 MHz.

³ Not tested at applicant's request.

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

The following tests have not been performed at the request of Senceive Ltd:-

Maximum Average conducted output power , Maximum Peak conducted output power, Average time of occupancy, FHSS carrier frequency separation, Antenna power conducted emissions, Duty cycle, Effective radiated power field strength, Number of Hop Channels, Occupied bandwidth and Power Spectral Density.

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/fully charged battery.

No discernible difference was observed between channels/modes for emissions, therefore for full test the EUT was operated in mode 2.

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	100kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Single channel	908.5 MHz

Plot refs
11797-1 Rad 1 9k-150kHz Para
11797-1 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 ± 3.9 dB

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/fully charged battery.

No discernible difference was observed between channels/modes for emissions, therefore for full test the EUT was operated in mode 2.

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	100kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Single channel	908.5 MHz

Plot refs
11797-1 Rad 1 150k-30MHz Para
11797-1 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 ± 3.9 dB

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/fully charged battery.

The EUT was operated in modes 1 to 6.

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	19-22°C
Humidity of test environment	47-50%
Pressure of test environment	100kPa

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Low channel	902.3 MHz

Plot refs
11797-1 Rad 1 VHF Horiz
11797-1 Rad 1 VHF Vert
11797-1 Rad 1 UHF Horiz
11797-1 Rad 1 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Mid channel	908.5 MHz

Plot refs
11797-1 Rad 2 VHF Horiz
11797-1 Rad 2 VHF Vert
11797-1 Rad 2 UHF Horiz

11797-1 Rad 2 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
High channel	914.9 MHz

Plot refs
11797-1 Rad 3 VHF Horiz
11797-1 Rad 3 VHF Vert
11797-1 Rad 3 UHF Horiz
11797-1 Rad 3 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Low channel	903 MHz

Plot refs
11797-1 Rad 5 VHF Horiz
11797-1 Rad 5 VHF Vert
11797-1 Rad 5 UHF Horiz
11797-1 Rad 5 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
Mid channel	907.8 MHz

Plot refs
11797-1 Rad 6 VHF Horiz
11797-1 Rad 6 VHF Vert
11797-1 Rad 6 UHF Horiz
11797-1 Rad 6 UHF Vert

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
High channel	914.2 MHz

Plot refs
11797-1 Rad 7 VHF Horiz
11797-1 Rad 7 VHF Vert
11797-1 Rad 7 UHF Horiz
11797-1 Rad 7 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 ± 6.1 dB

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/fully charged battery.

The EUT was operated in modes 1 to 6.

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, and 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, E624, E755, TMS82

See Section 9 for more details

5.5.5 Test results

Temperature of test environment 18-21°C
Humidity of test environment 42-50%
Pressure of test environment 99.5kPa

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
Low channel	902.3 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2706.9	44.5	-29.5	37.1	-16.9	Upright	Vertical
6316.1	47.6	-26.4	36.4	-17.6	Upright	Vertical
6316.1	46.9	-27.1	36.3	-17.7	Upright	Horizontal
7218.4	53.8	-20.2	47.9	-6.1	Upright	Vertical
7218.4	54.3	-19.7	48.7	-5.3	Upright	Horizontal
8120.7	56.2	-17.8	51.0	-3.0	Upright	Vertical
8120.7	58.4	-15.6	53.8	-0.2	Upright	Horizontal

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	125 kHz SF10
Mod Scheme	LoRa
Mid channel	908.5 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
7268	54.3	-19.7	48.1	-5.9	Upright	Vertical
7268	56.1	-17.9	51.5	-2.5	Upright	Horizontal
8176.5	53.9	-20.1	47.6	-6.4	Upright	Vertical
8176.5	56.9	-17.1	52.0	-2.0	Upright	Horizontal

Plots

11797-1 908.5 MHz Mid Chan 1 - 3 GHz Vert
11797-1 908.5 MHz Mid Chan 1 - 3 GHz Horiz
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 3 - 5 GHz Vert
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 3 - 5 GHz Horiz
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 5 - 6 GHz Vert
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 5 - 6 GHz Horiz
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 6 - 8 GHz Vert
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 6 - 8 GHz Horiz
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 8 - 10 GHz Vert
11797-1 908.5 MHz 125 kHz SF10 Mid Chan 8 - 10 GHz Horiz

Setup Table

Band	902-928 MHz
Power Level	20 dBm
Channel Spacing	125 kHz SF10
Mod Scheme	LoRa
High channel	914.9 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
7319.2	54.8	-19.2	48.8	-5.2	upright	Vertical
7319.2	55.9	-18.1	51.3	-2.7	side	Horizontal
8234.1	54.8	-19.2	48.8	-5.2	upright	Vertical
8234.1	55.7	-18.3	49.5	-4.5	side	Horizontal

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	500 kHz SF12
Mod Scheme	LoRa
Low channel	903 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
7224	52.9	-21.1	40.6	-13.4	Upright	Vertical
7224	56.1	-17.9	43.7	-10.3	Upright	Horizontal
8127	55.8	-18.2	43.3	-10.7	Upright	Vertical
8127	56.3	-17.7	43.4	-10.6	Upright	Horizontal

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	500 kHz SF12
Mod Scheme	LoRa
Mid channel	907.8 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
7262.4	56.7	-17.3	44.6	-9.4	Upright	Horizontal
8170.2	56.1	-17.9	43.2	-10.8	Upright	Vertical
8170.2	55.7	-18.3	42.4	-11.6	Upright	Horizontal

Plots

11797-1 907.8 MHz 500 kHz SF12 Mid Chan 1 - 3 GHz Vert
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 1 - 3 GHz Horiz
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 3 - 5 GHz Vert
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 3 - 5 GHz Horiz
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 5 - 6 GHz Vert
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 5 - 6 GHz Horiz
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 6 - 8 GHz Vert
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 6 - 8 GHz Horiz
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 8 - 10 GHz Vert
11797-1 907.8 MHz 500 kHz SF12 Mid Chan 8 - 10 GHz Horiz

Setup Table

Band	902-928 MHz
Power Level	20 dBm

Channel Spacing	500 kHz SF12
Mod Scheme	LoRa
High channel	914.2 MHz

Spurious Frequency (MHz)	Measured Peak Level (dB μ V/m)	Difference to Peak Limit (dB)	Measured Average Level (dB μ V/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
7313.6	54.6	-19.4	41.7	-12.3	Upright	Vertical
7313.6	57.1	-16.9	43.9	-10.1	Side	Horizontal
8227.8	55.2	-18.8	41.9	-12.1	Upright	Vertical
8227.8	56.1	-17.9	42.7	-11.3	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.

Note: Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Mid channel plots are shown in 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 ± 3.5 dB

5.6 Effective radiated power field strength

NOT TESTED: Not tested at applicant's request.

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 modes 1, 3, 4 and 6.

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

E517, E640, E755

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	18-21°C
Humidity of test environment	46-50%
Pressure of test environment	100kPa

Band	902-928 MHz
Power Level	20 MHz
Channel Spacing	125 kHz SF10 MHz
Mod Scheme	LoRA MHz
Low channel	902.3 MHz
High channel	914.9 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	J11797-1 902.3 MHz channel lower authorised Band edge - conducted	J11797-1 914.9 MHz channel Upper authorised Band edge - conducted

Band	902-928 MHz
Power Level	20 MHz
Channel Spacing	500 kHz SF12 MHz
Mod Scheme	LoRA MHz
Low channel	903 MHz
High channel	914.2 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	J11797-1 903 MHz channel lower authorised Band edge - conducted	J11797-1 914.2 MHz channel Upper authorised Band edge - conducted

Analyser plots for the Authorised 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

NOT TESTED: Not tested at applicant's request.

5.9 Maximum Average conducted output power

NOT TESTED: Not tested at applicant's request.

5.10 Maximum Peak conducted output power

NOT TESTED: Not tested at applicant's request.

5.11 Maximum Power Spectral Density

NOT TESTED: Not tested at applicant's request.

5.12 Antenna power conducted emissions

NOT TESTED: Not tested at applicant's request.

5.13 Duty cycle

NOT TESTED: Not tested at applicant's request.

5.14 FHSS carrier frequency separation

NOT TESTED: Not tested at applicant's request.

5.15 Average time of occupancy

NOT TESTED: Not tested at applicant's request.

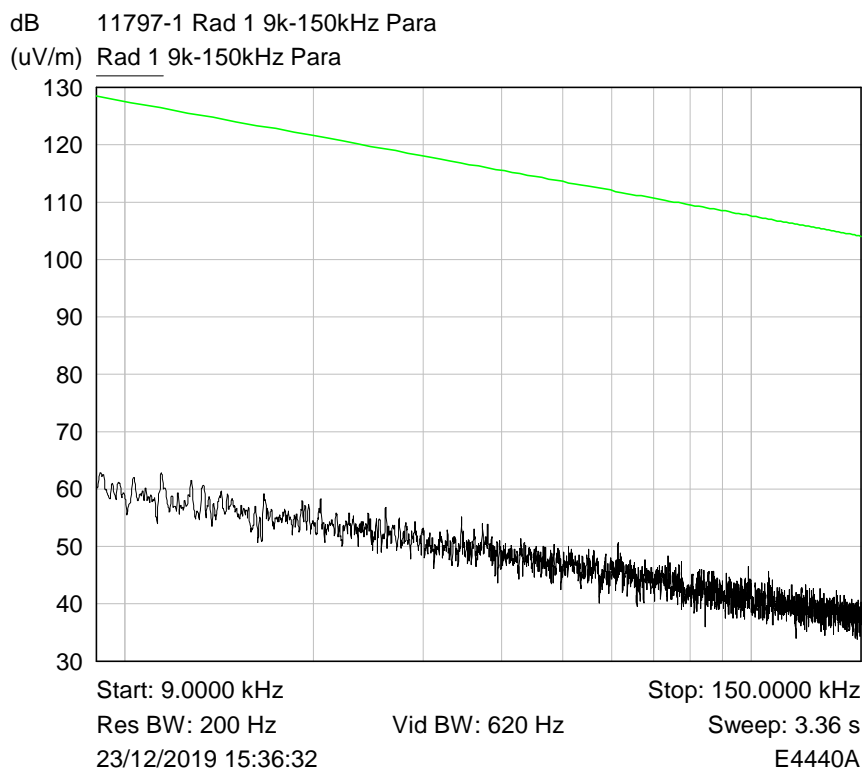
5.16 Number of Hop Channels

NOT TESTED: Not tested at applicant's request.

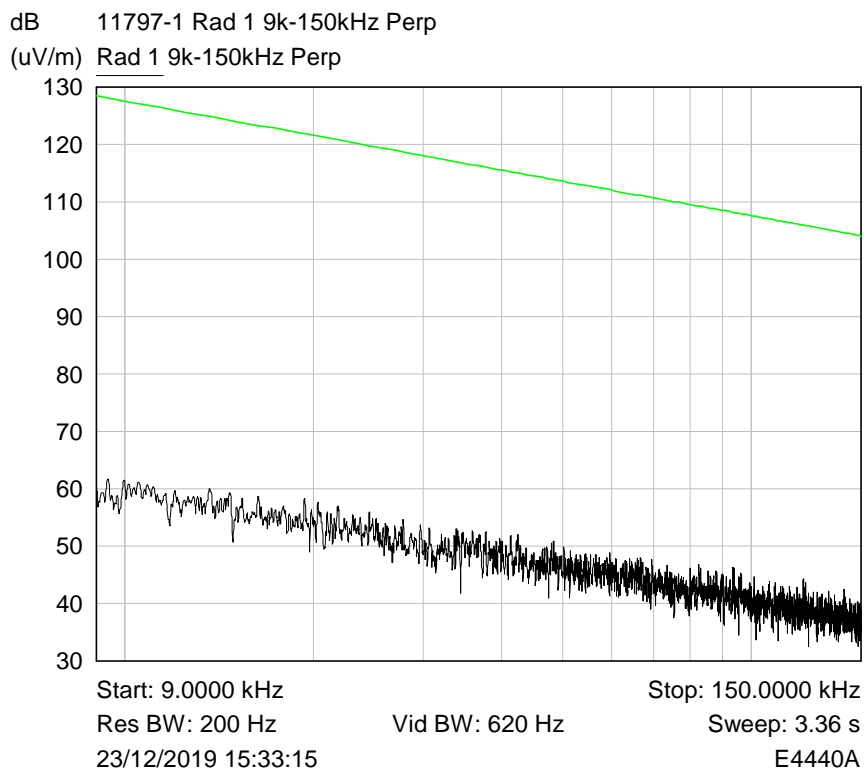
6 Plots/Graphical results

6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 908.5 MHz



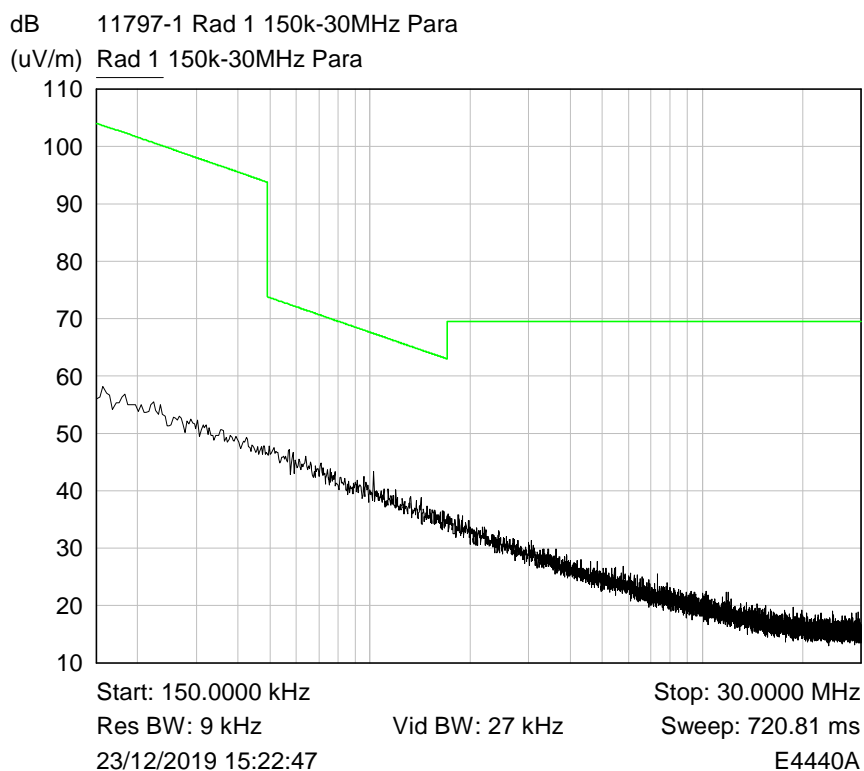
Plot of 9k-150kHz Parallel



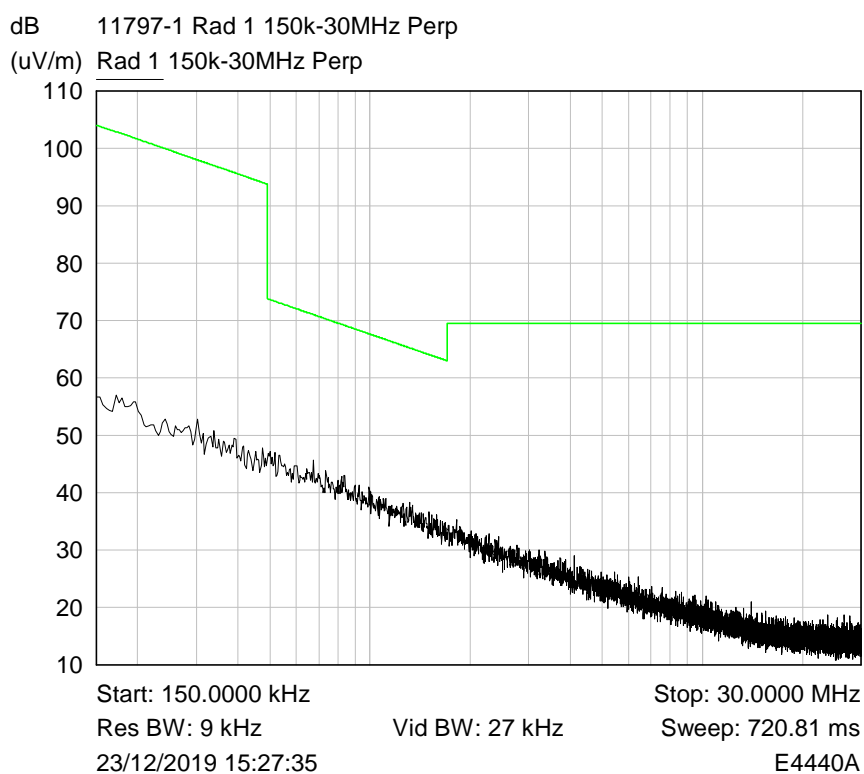
Plot of 9k-150kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 908.5 MHz



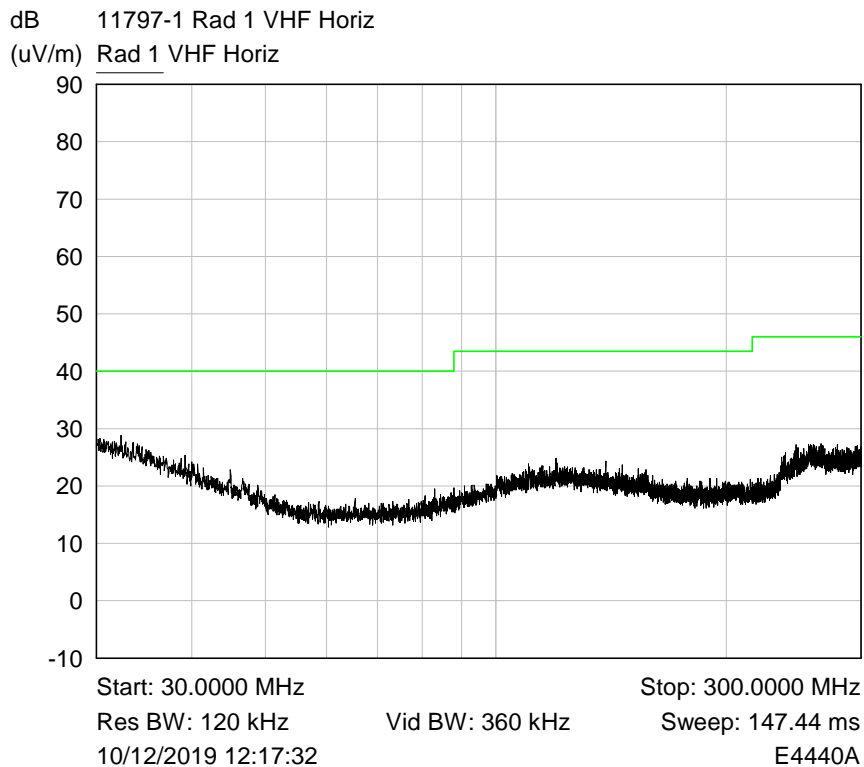
Plot of 150kHz-30MHz Parallel



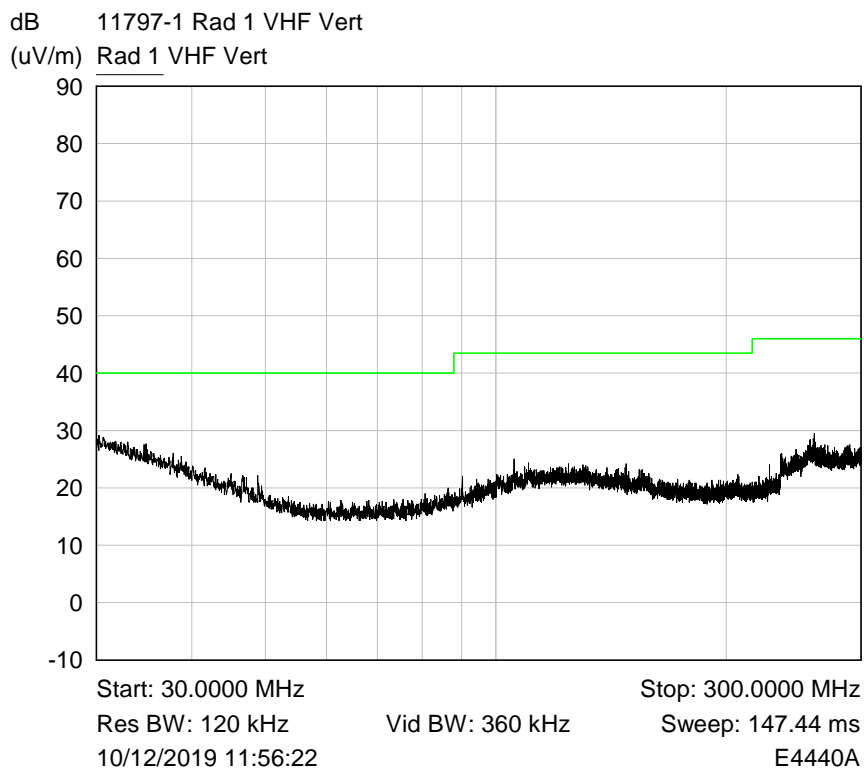
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

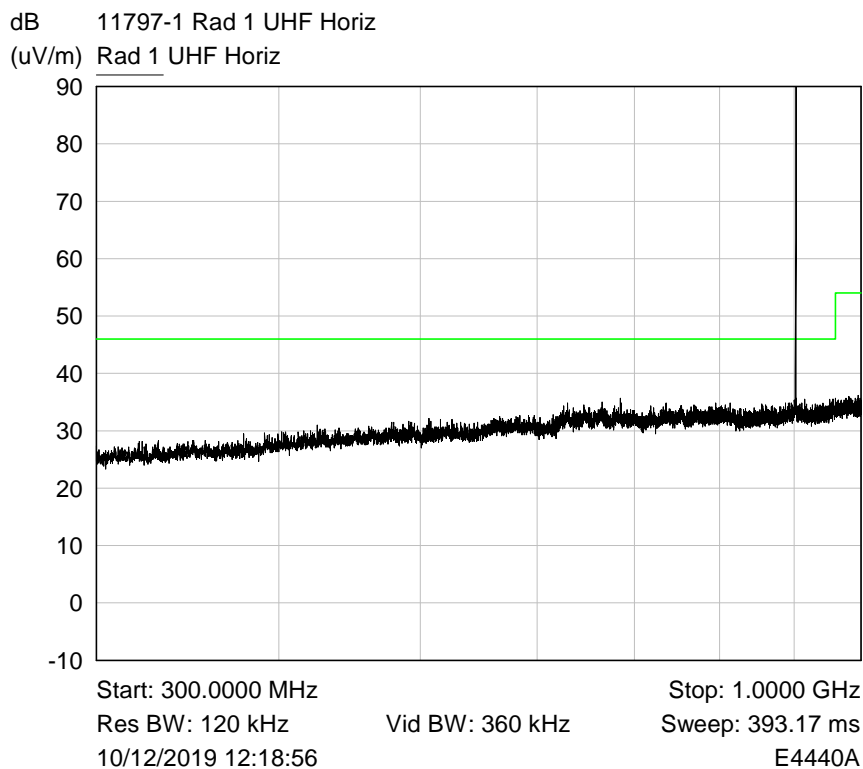
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 902.3 MHz



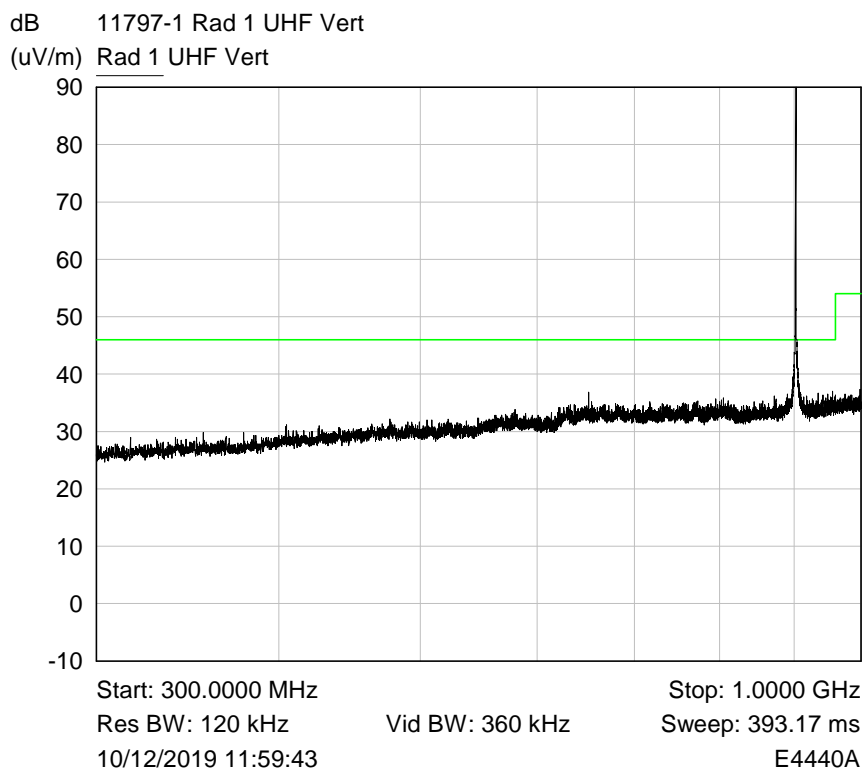
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

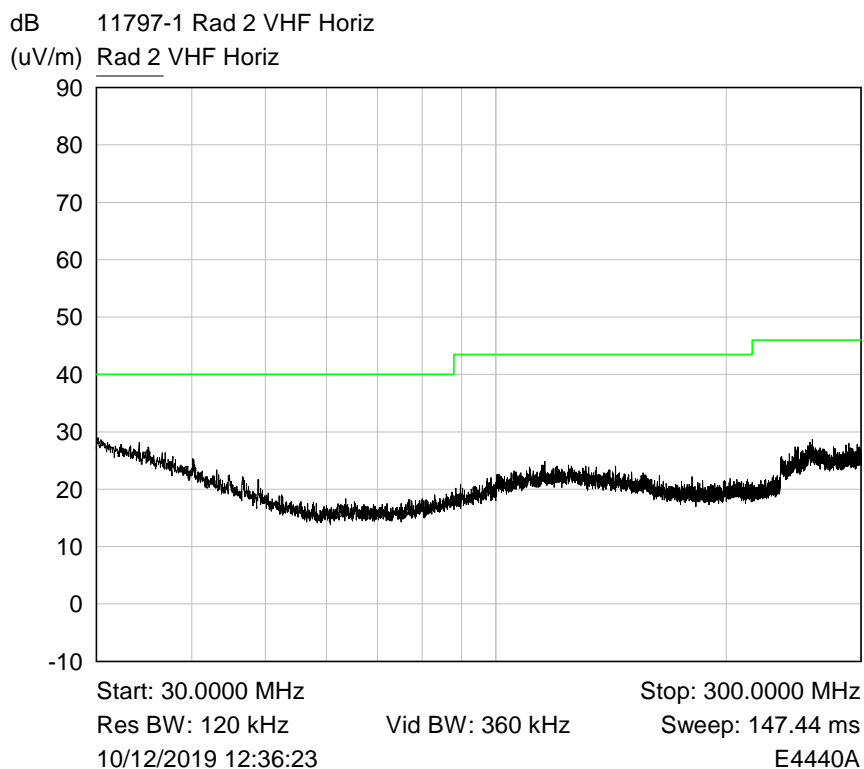


Plot of Peak emissions for UHF Horizontal against the QP limit line.

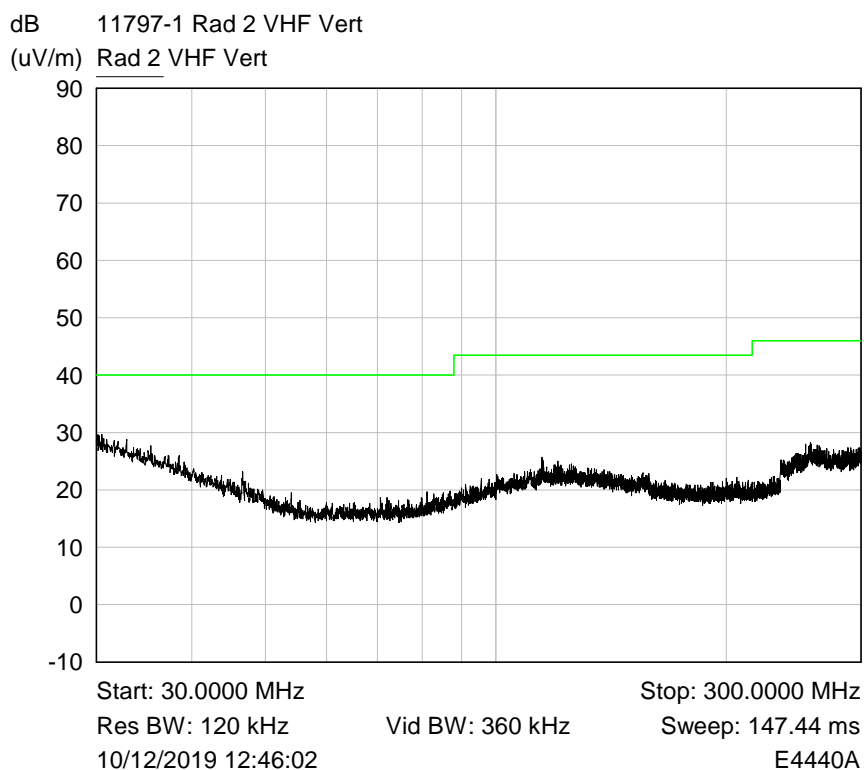


Plot of Peak emissions for UHF Vertical against the QP limit line.

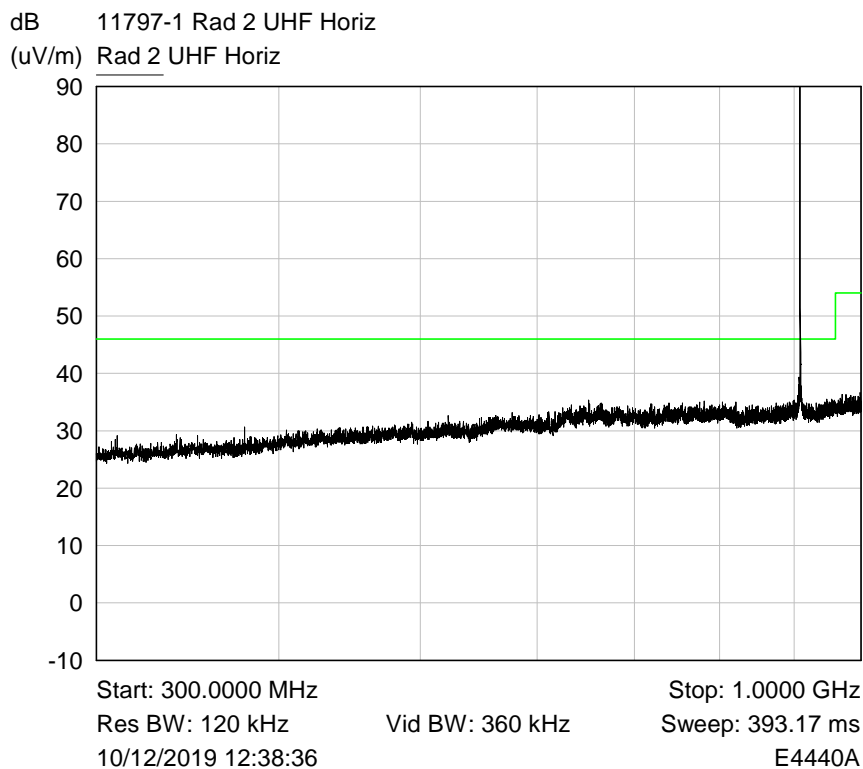
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 908.5 MHz



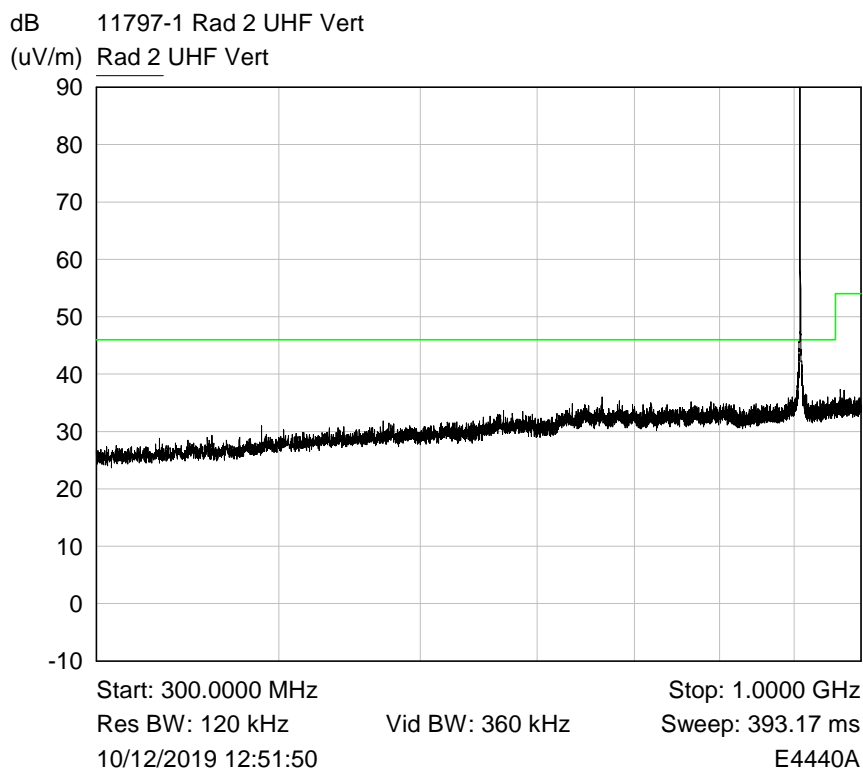
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

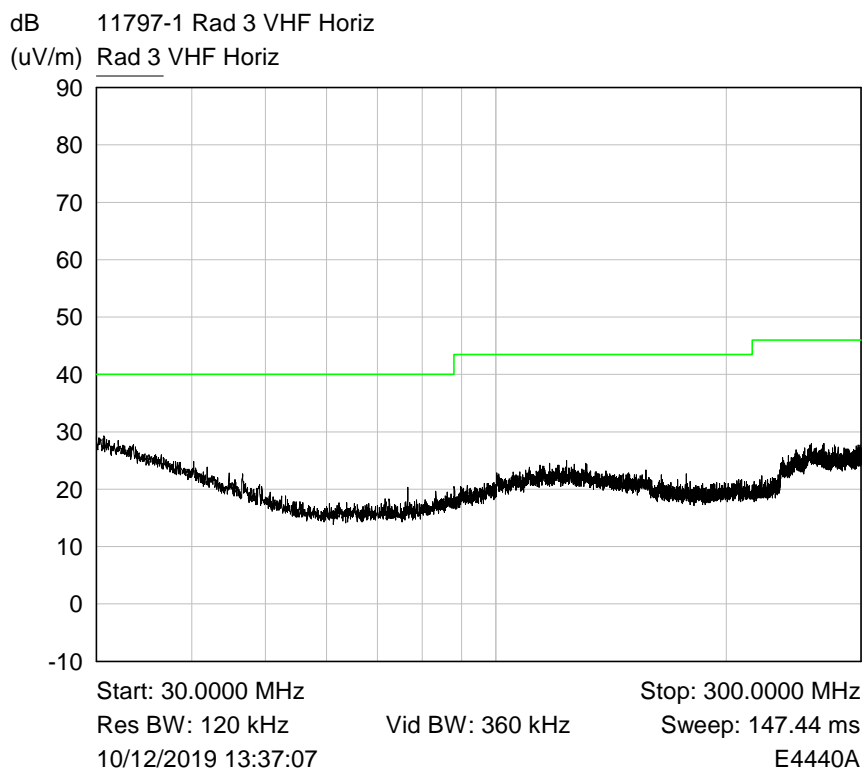


Plot of Peak emissions for UHF Horizontal against the QP limit line.

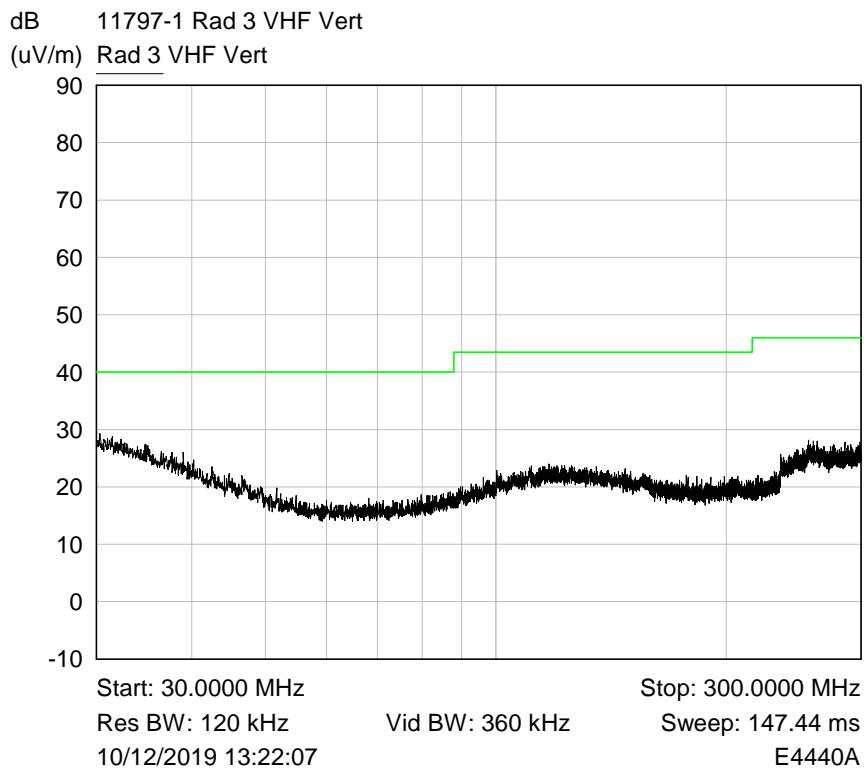


Plot of Peak emissions for UHF Vertical against the QP limit line.

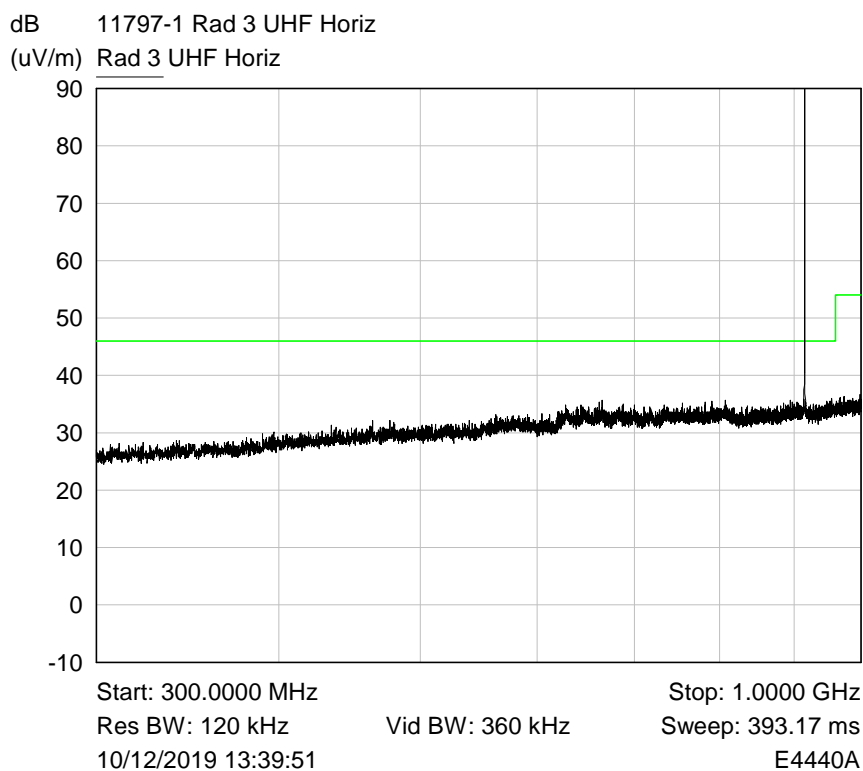
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 914.9 MHz



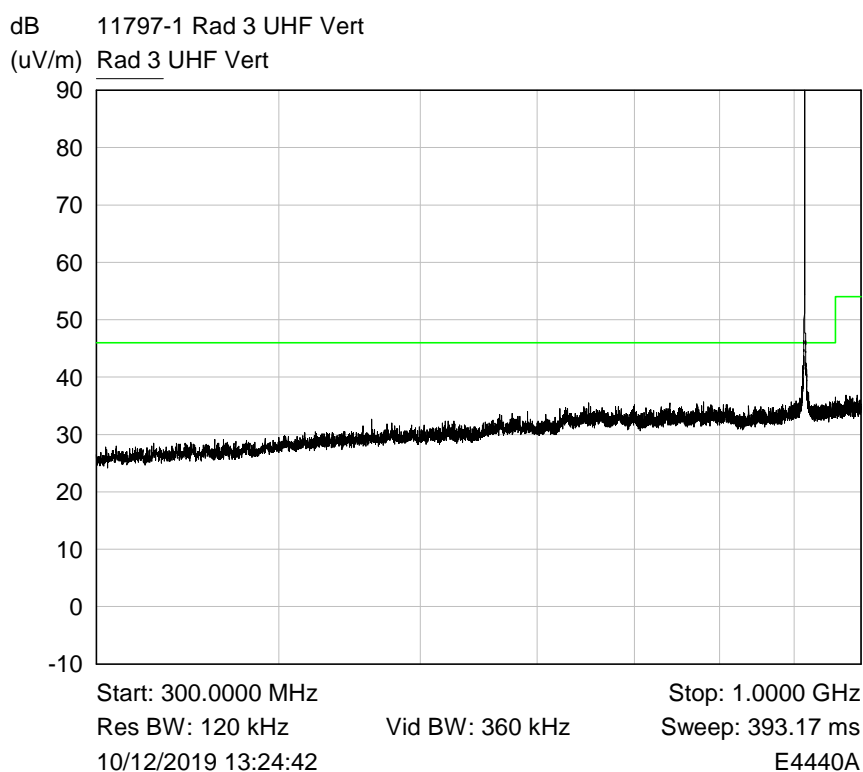
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

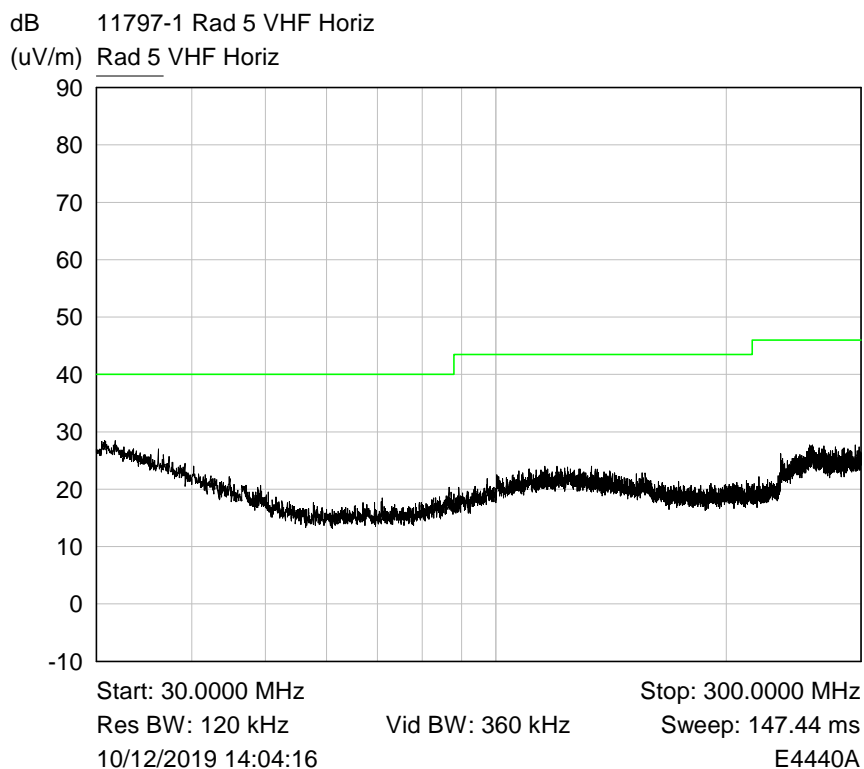


Plot of Peak emissions for UHF Horizontal against the QP limit line.

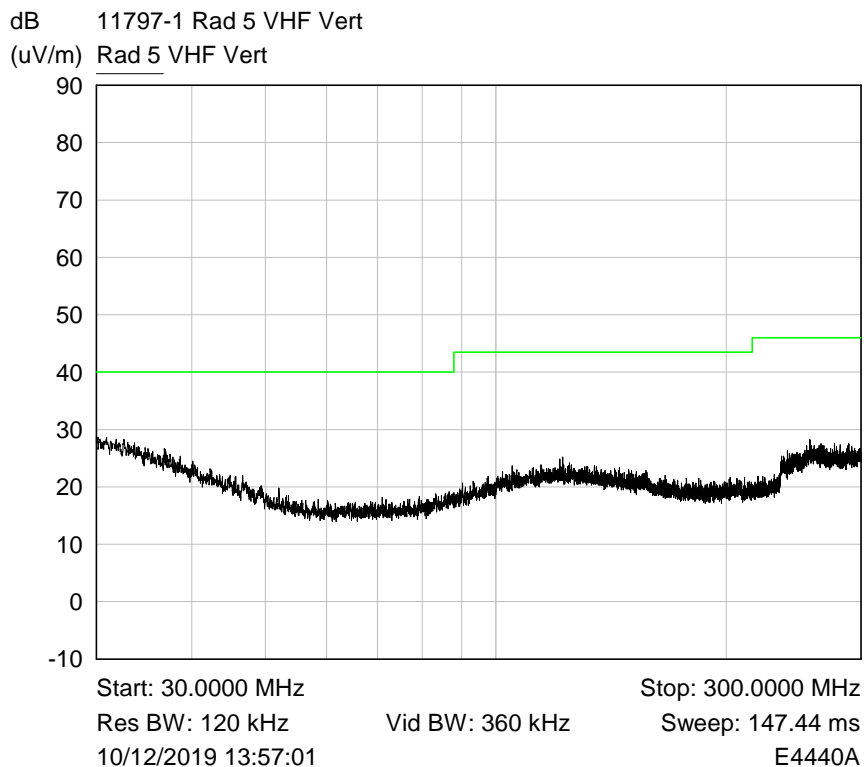


Plot of Peak emissions for UHF Vertical against the QP limit line.

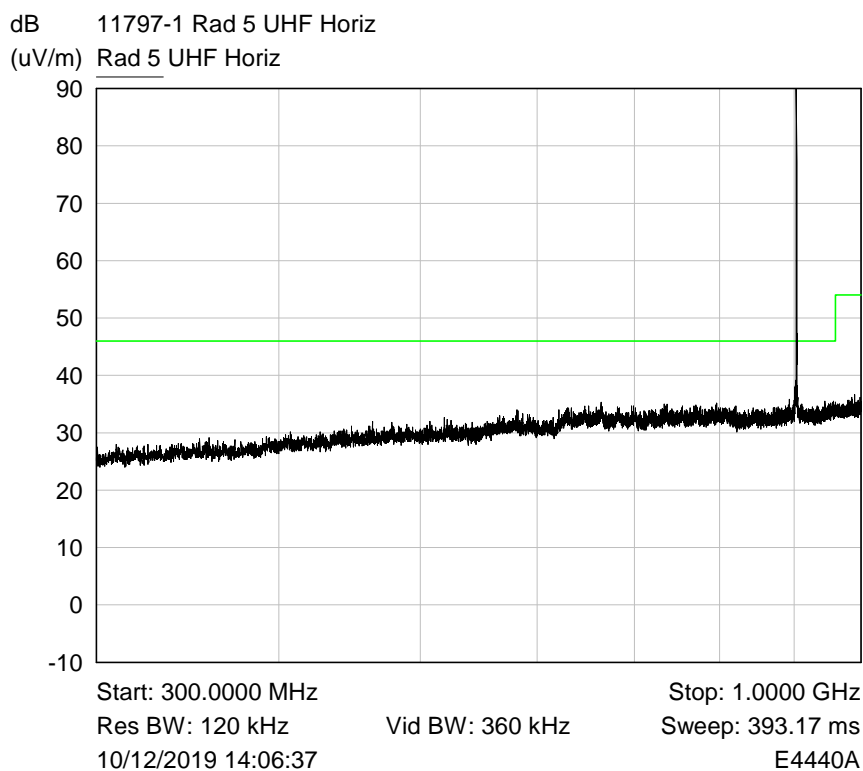
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12,
Modulation LoRa, Channel 903 MHz



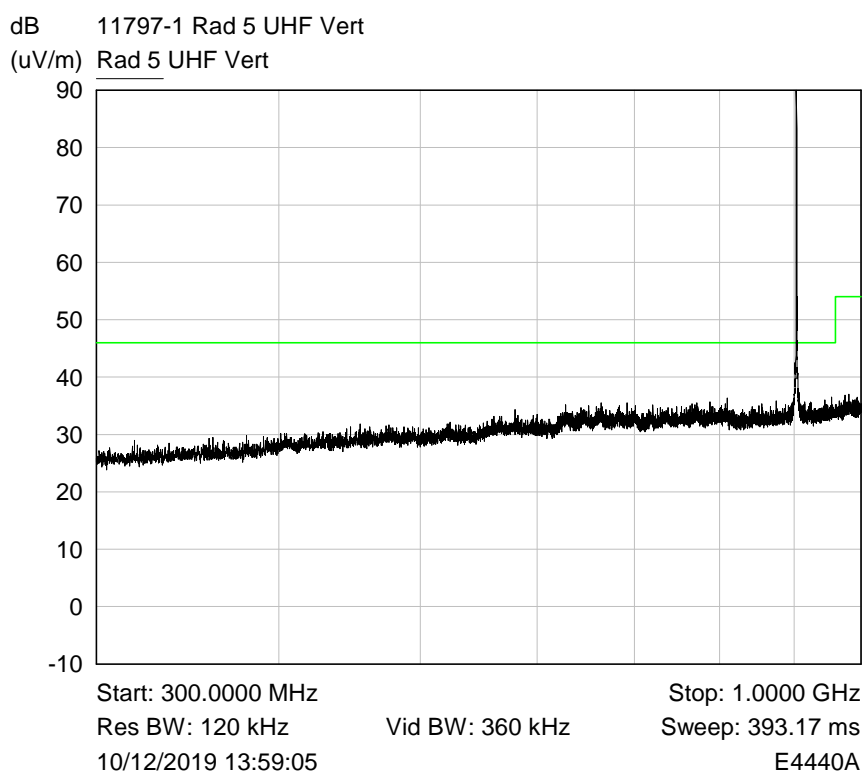
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

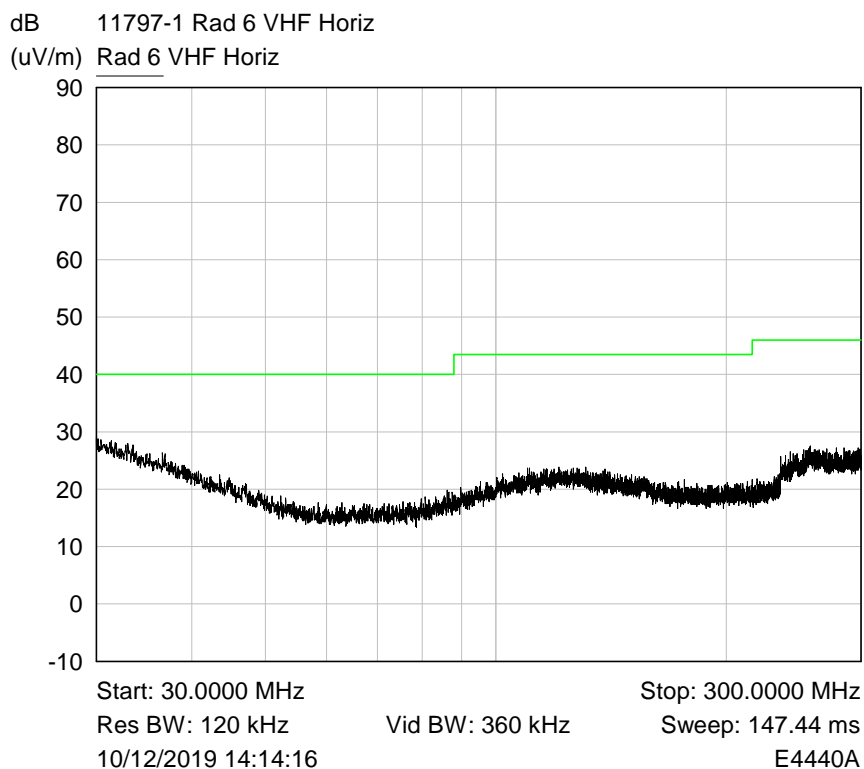


Plot of Peak emissions for UHF Horizontal against the QP limit line.

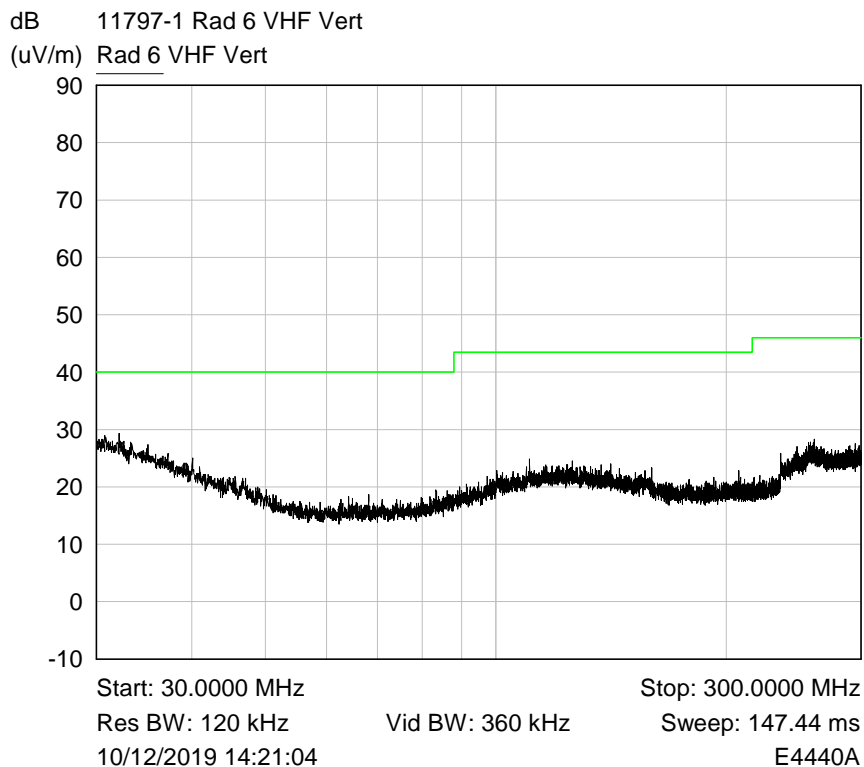


Plot of Peak emissions for UHF Vertical against the QP limit line.

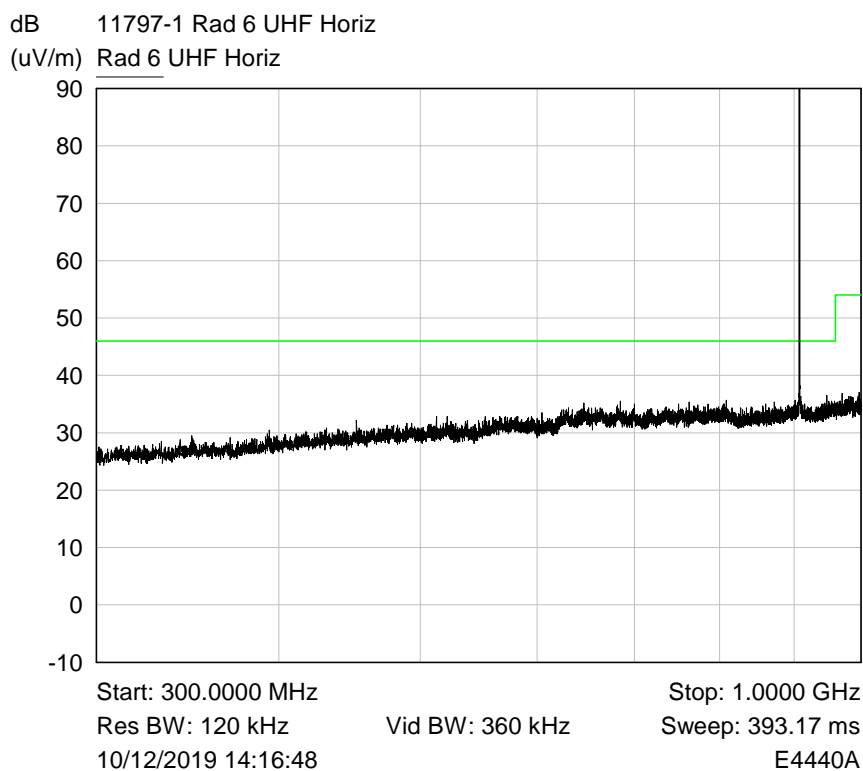
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12,
Modulation LoRa, Channel 907.8 MHz



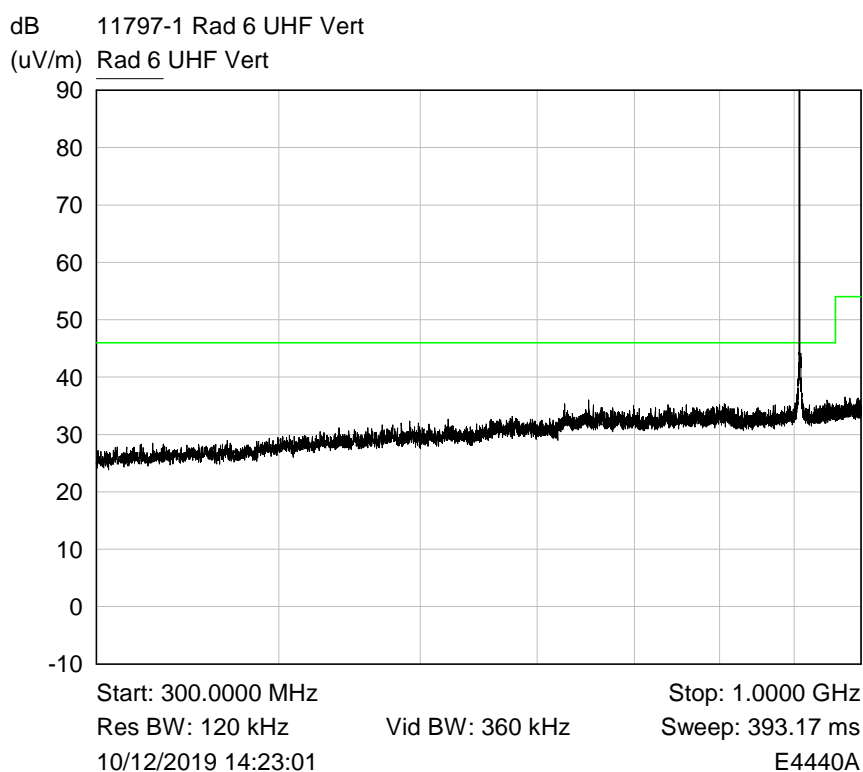
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

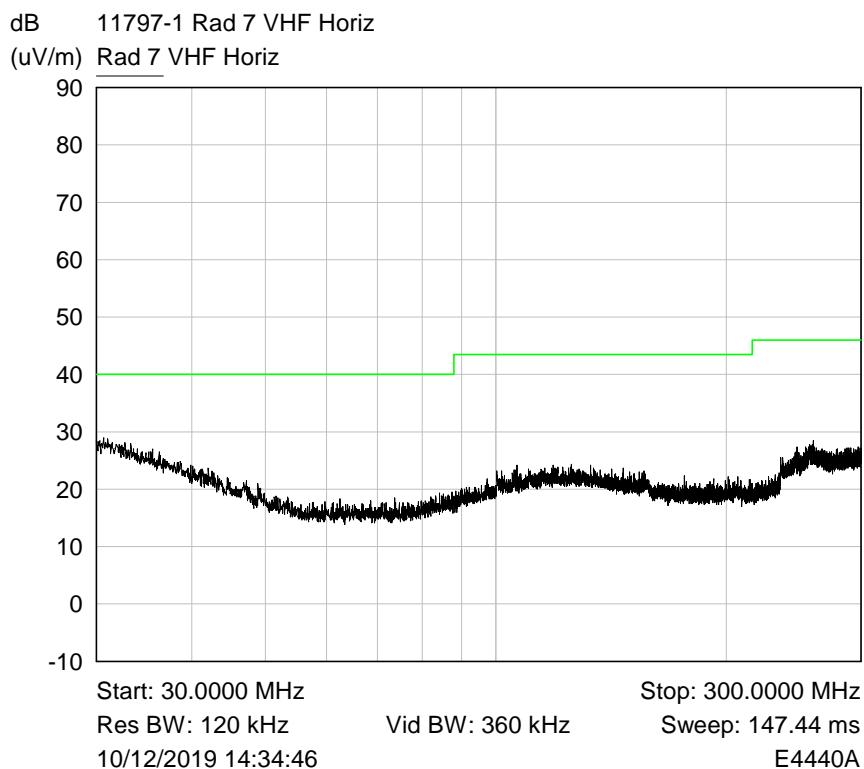


Plot of Peak emissions for UHF Horizontal against the QP limit line.

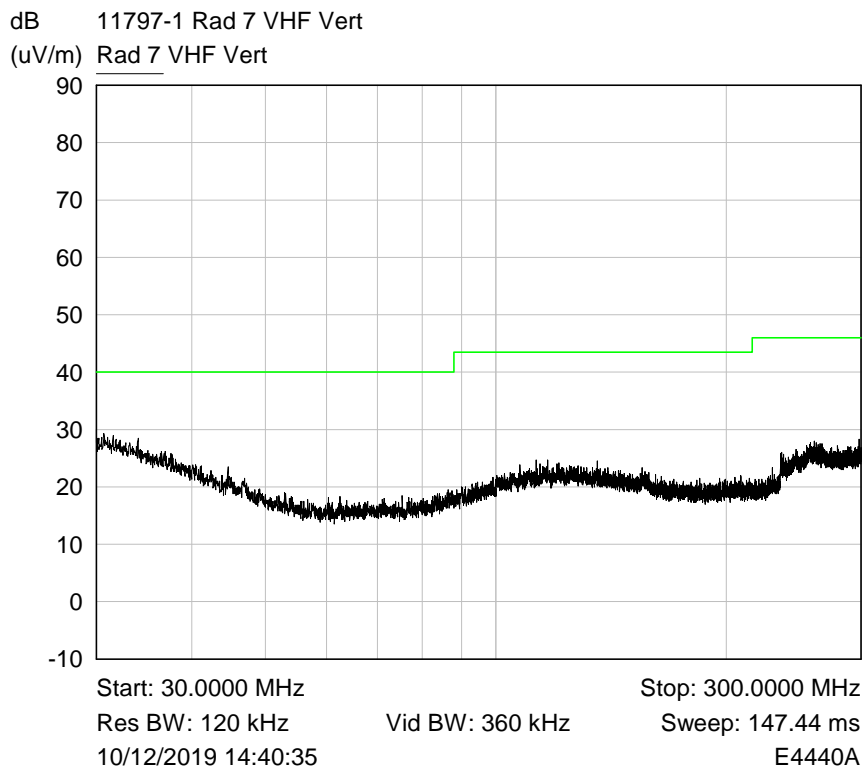


Plot of Peak emissions for UHF Vertical against the QP limit line.

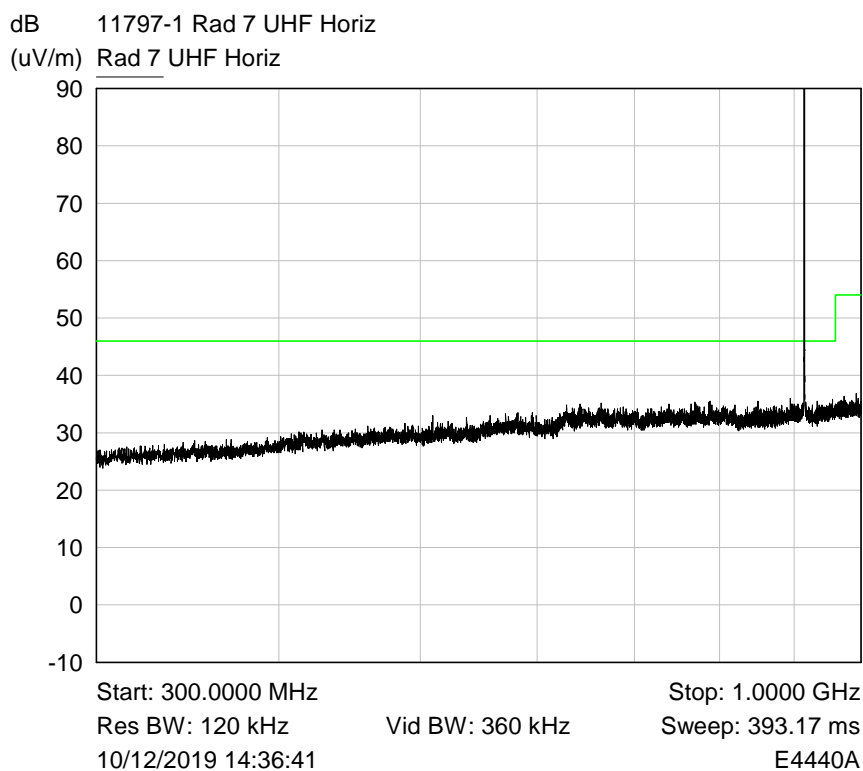
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12,
Modulation LoRa, Channel 914.2 MHz



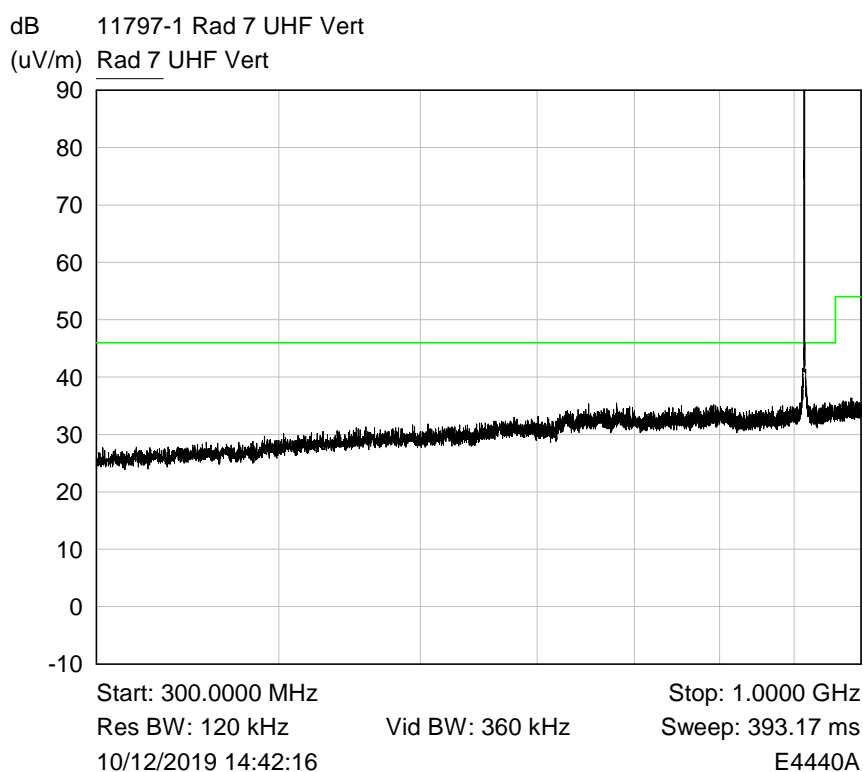
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



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

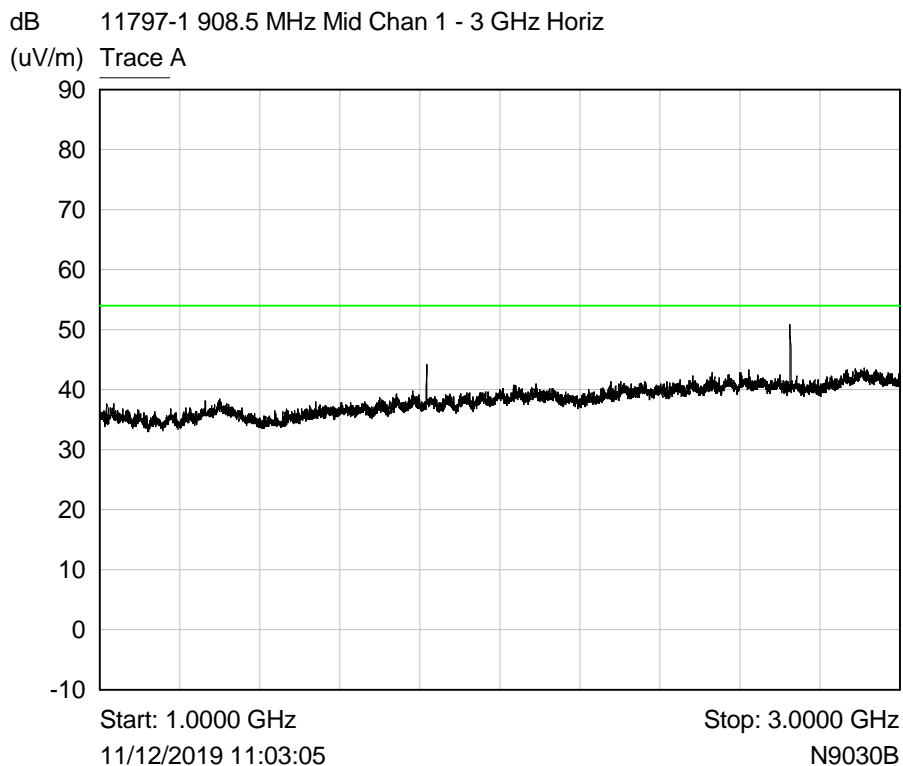
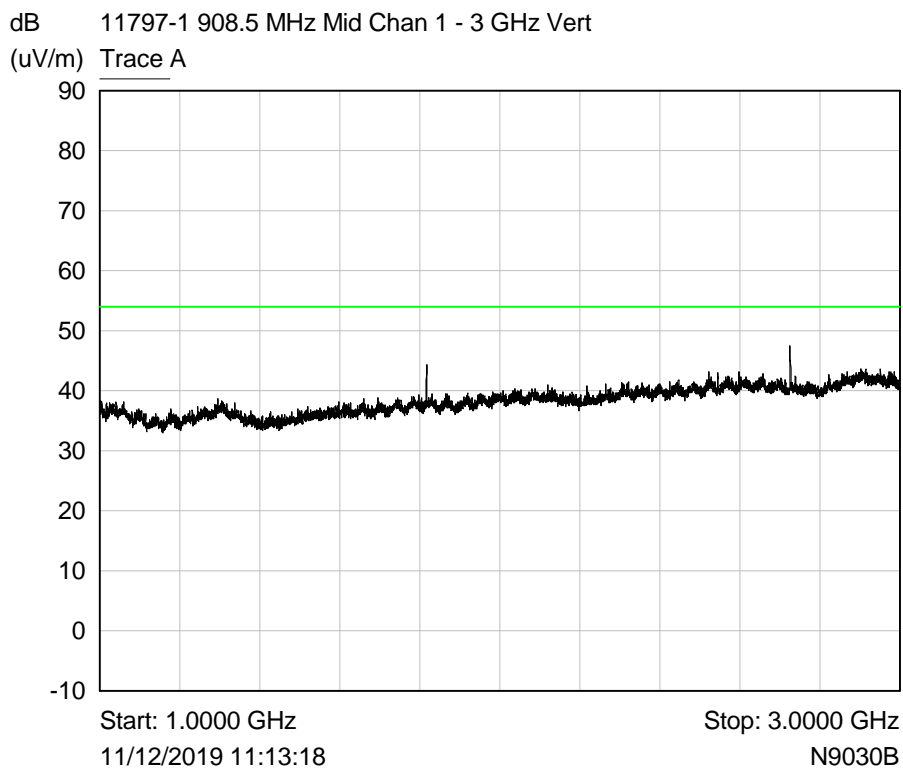


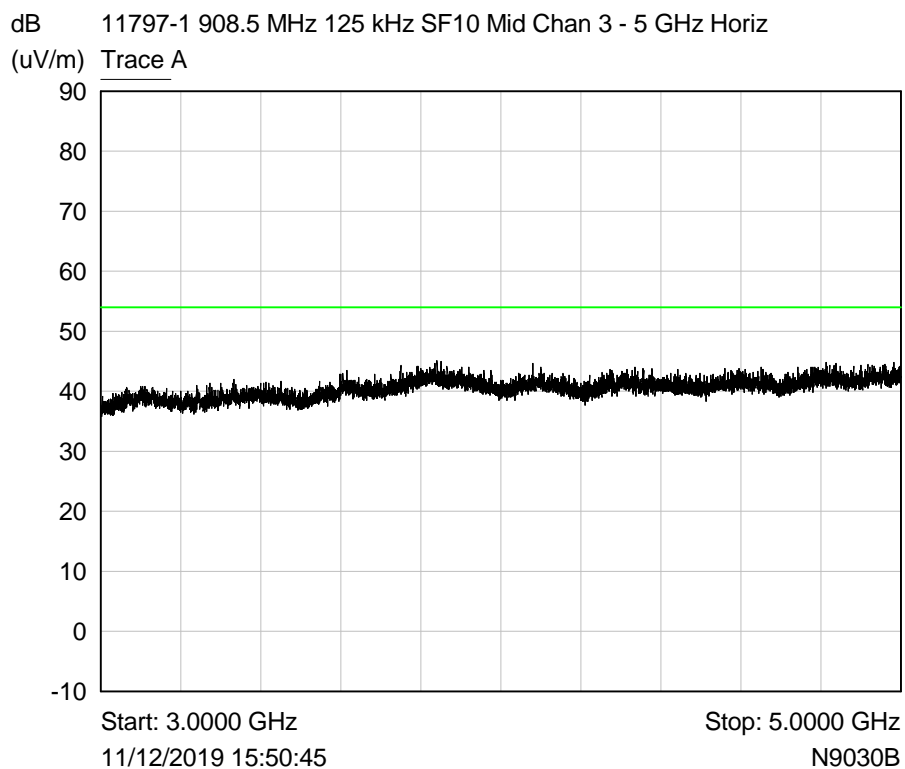
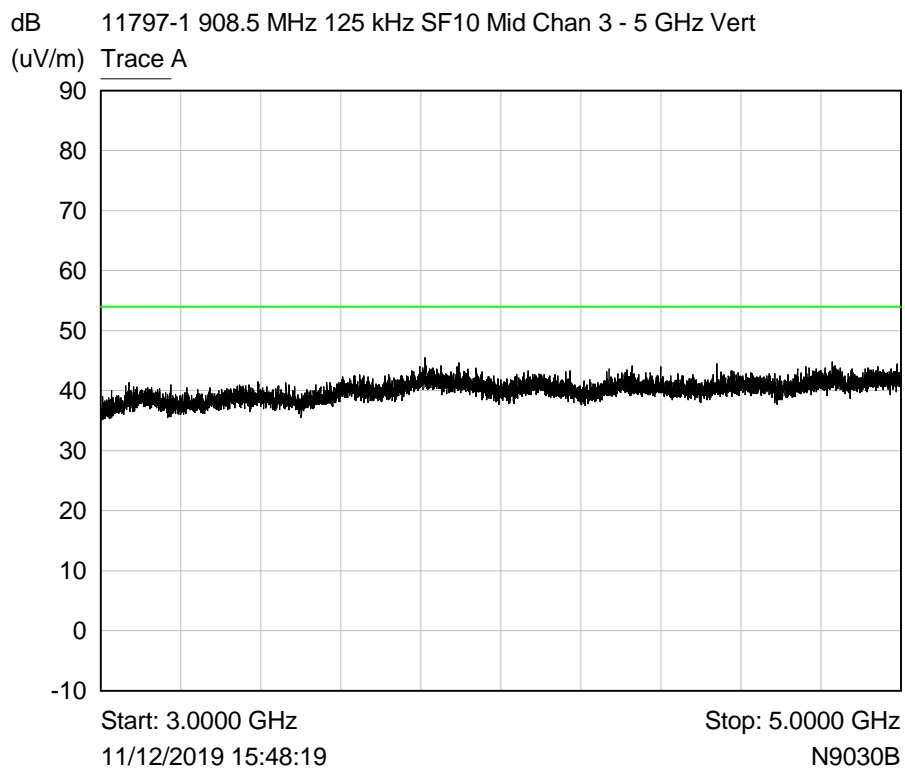
Plot of Peak emissions for UHF Vertical against the QP limit line.

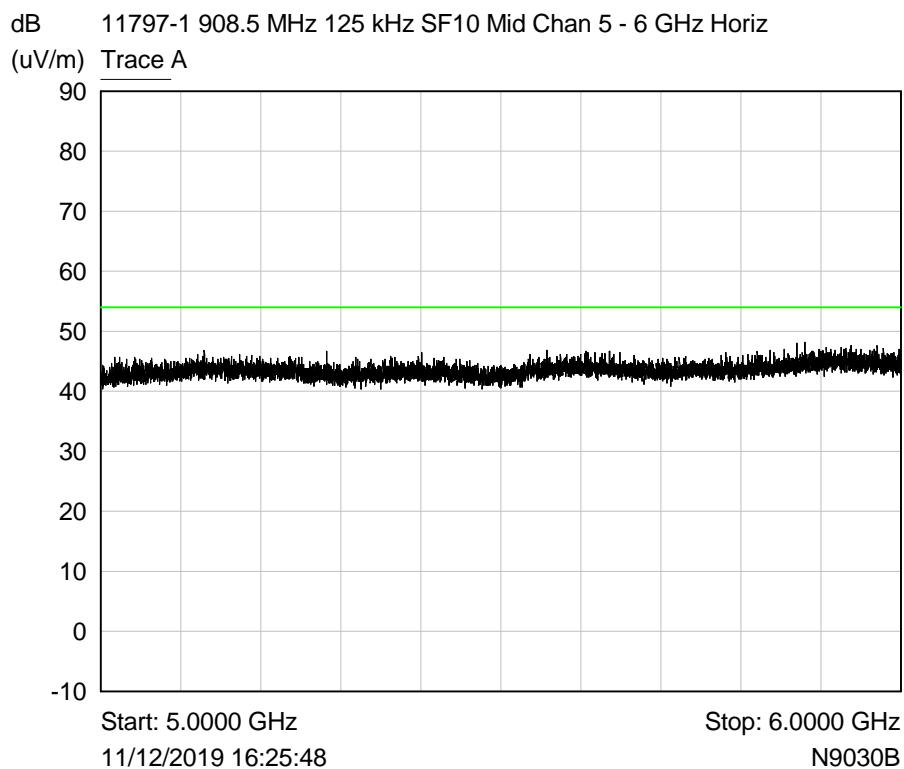
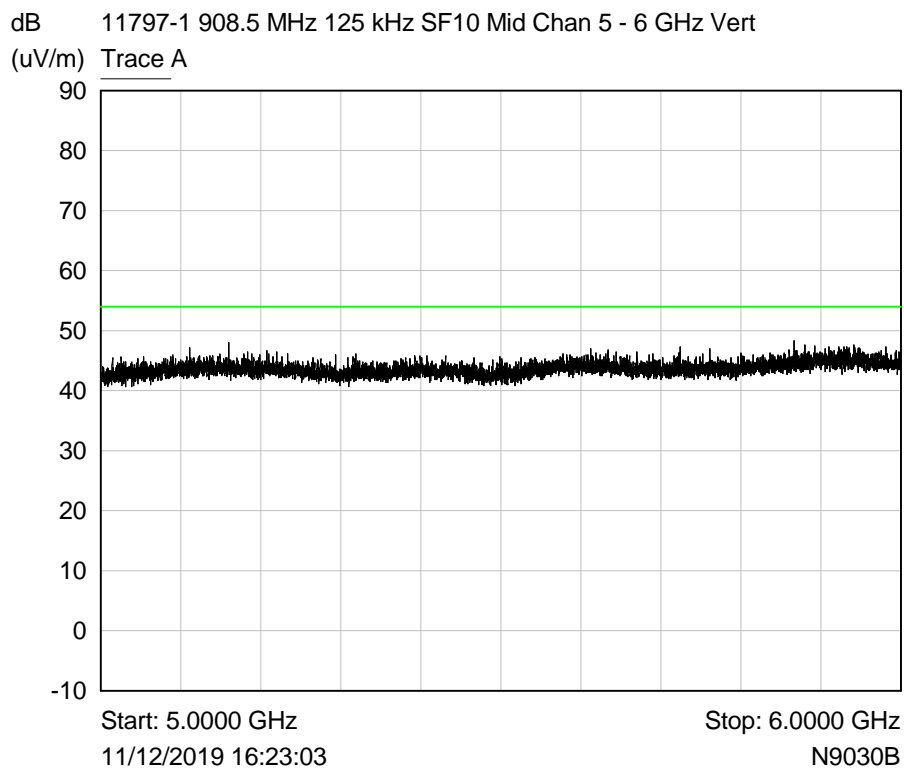
6.4 Radiated emissions above 1 GHz

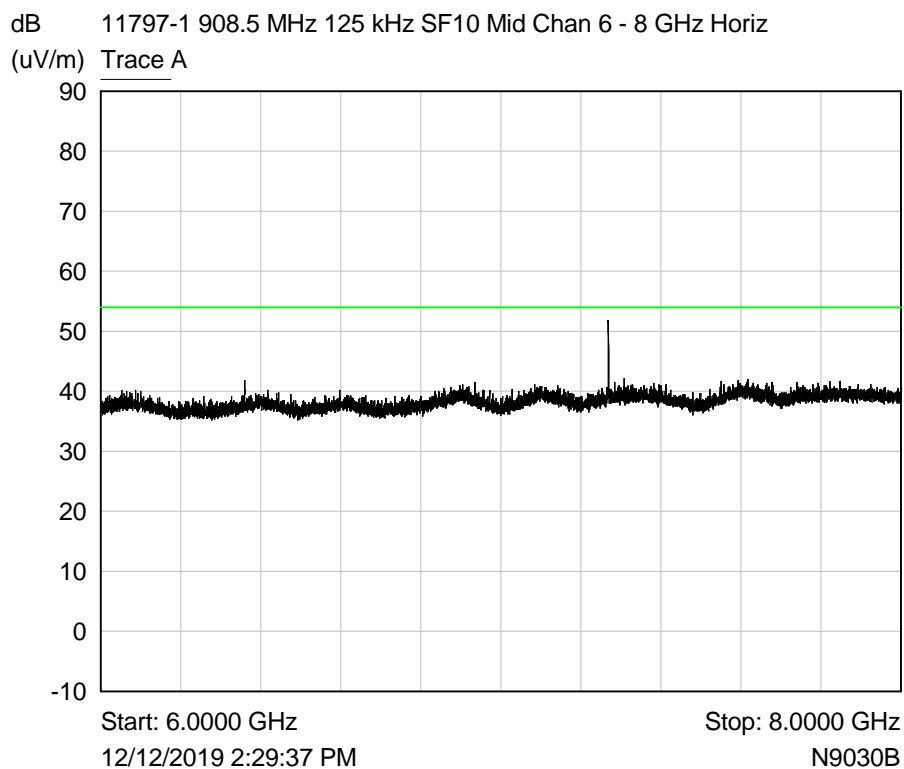
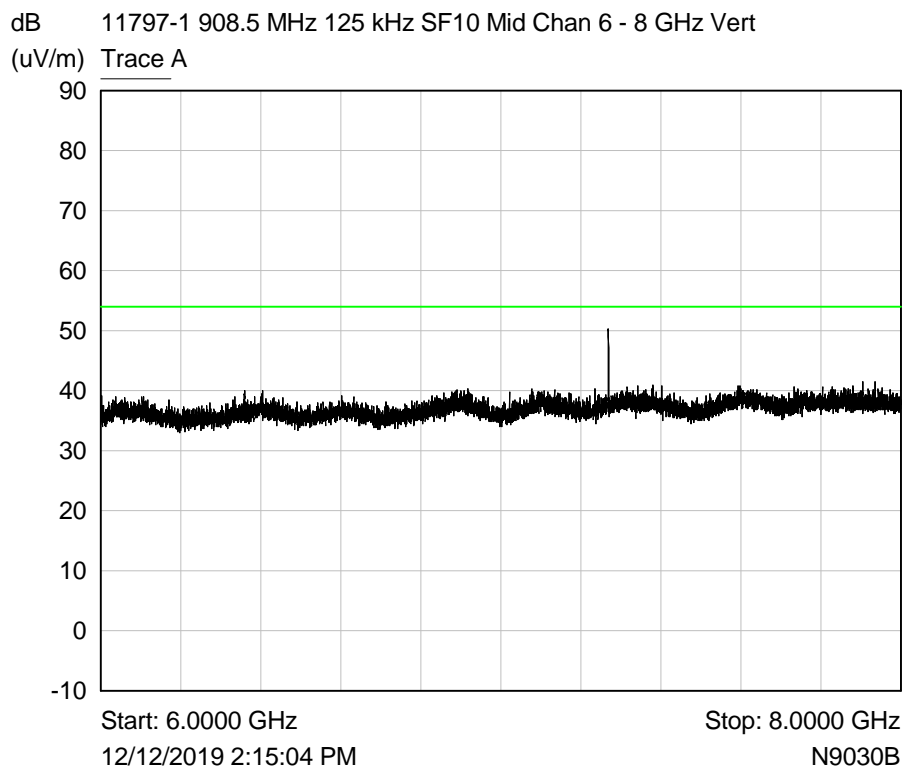
Note: Only middle channel plots are shown here to minimise report size.

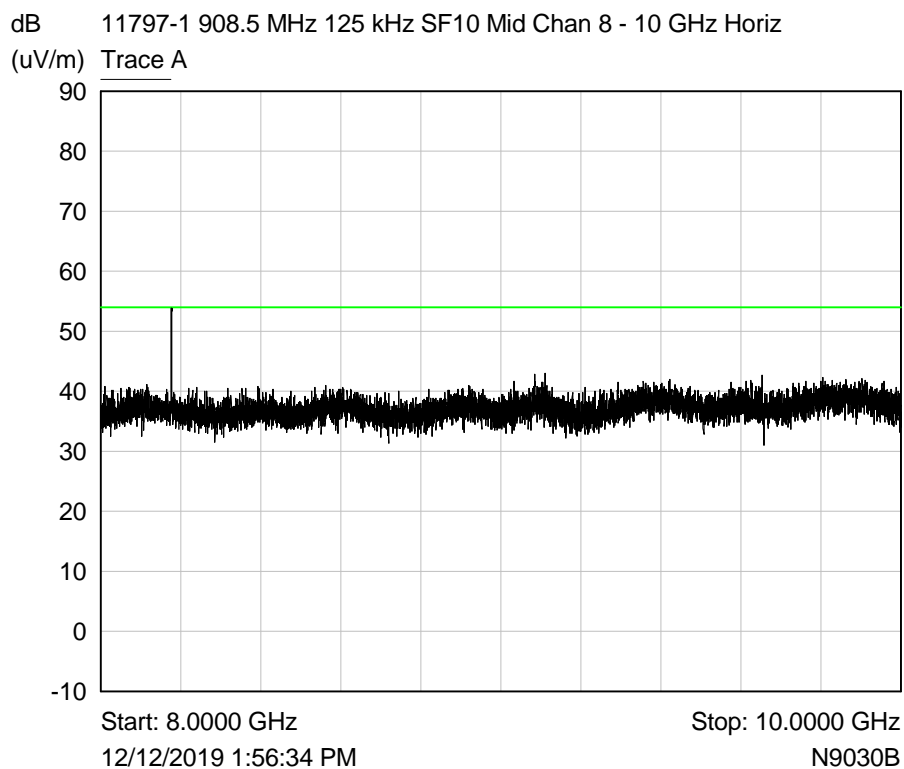
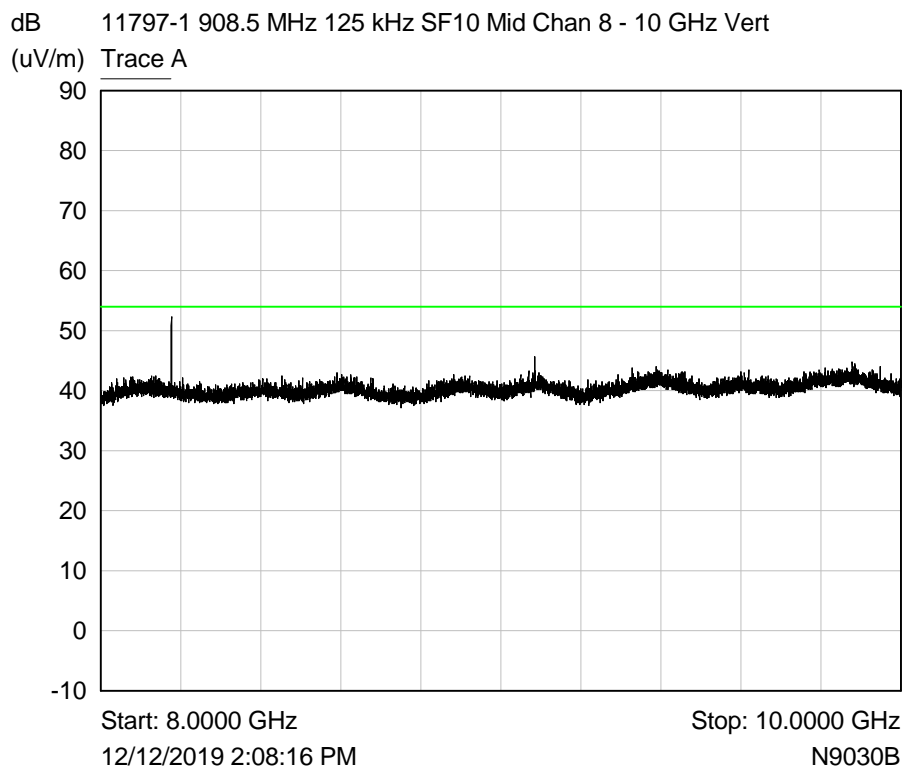
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 125 kHz SF10,
Modulation LoRa, Channel 908.5 MHz



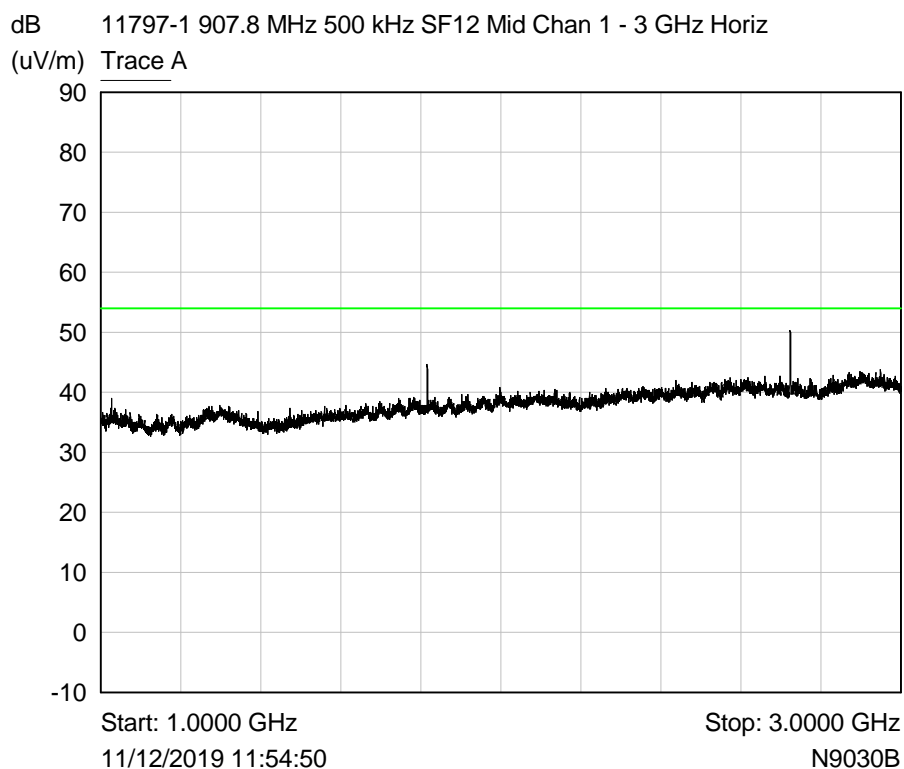
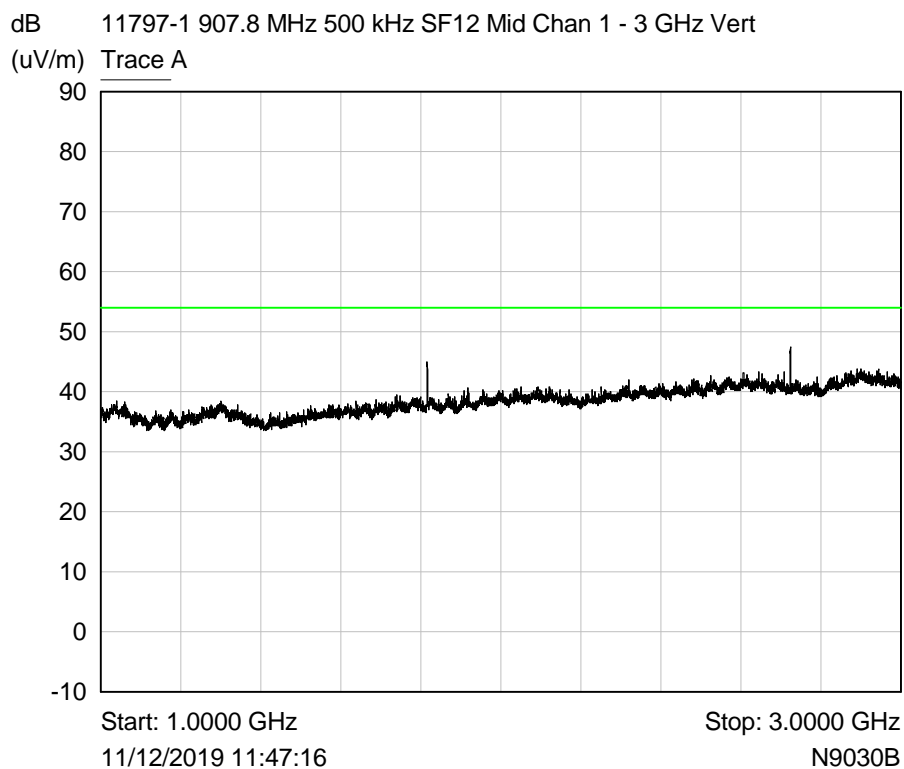


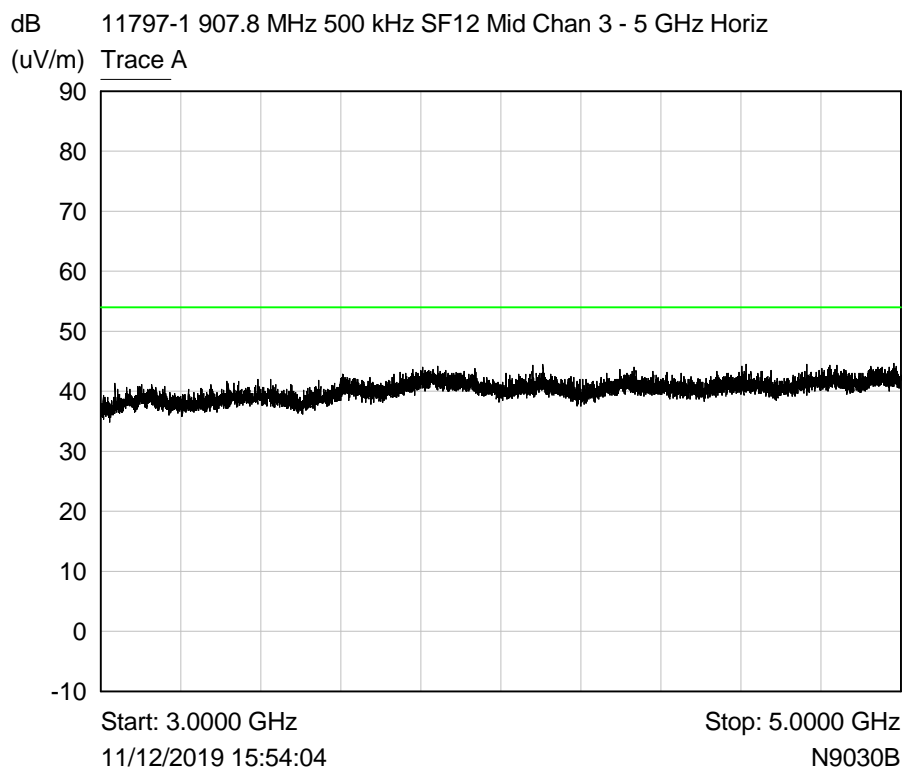
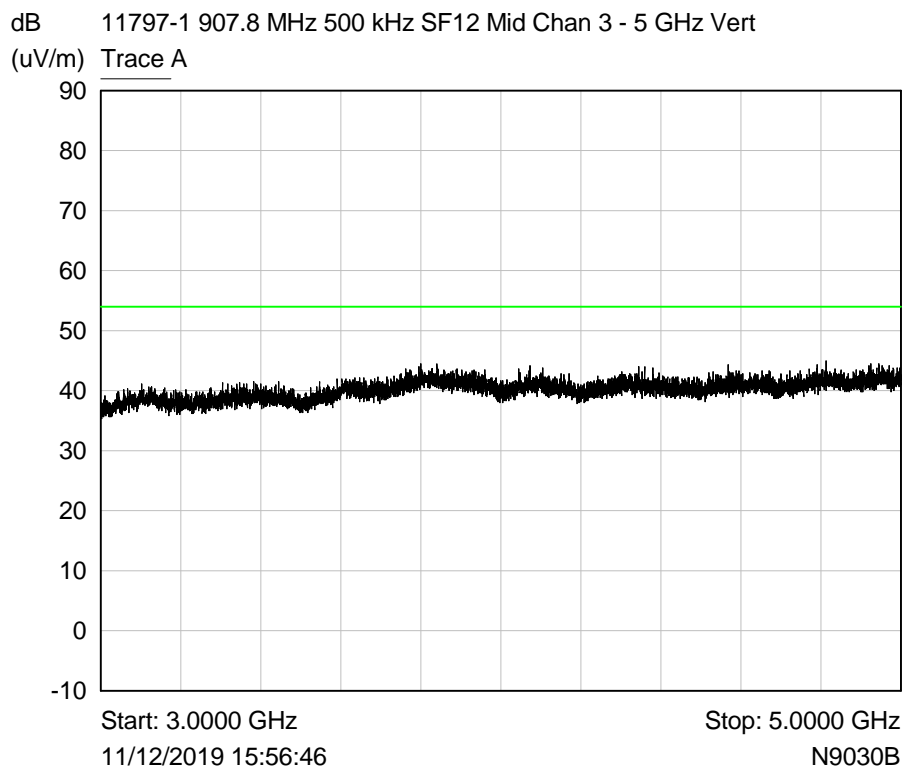


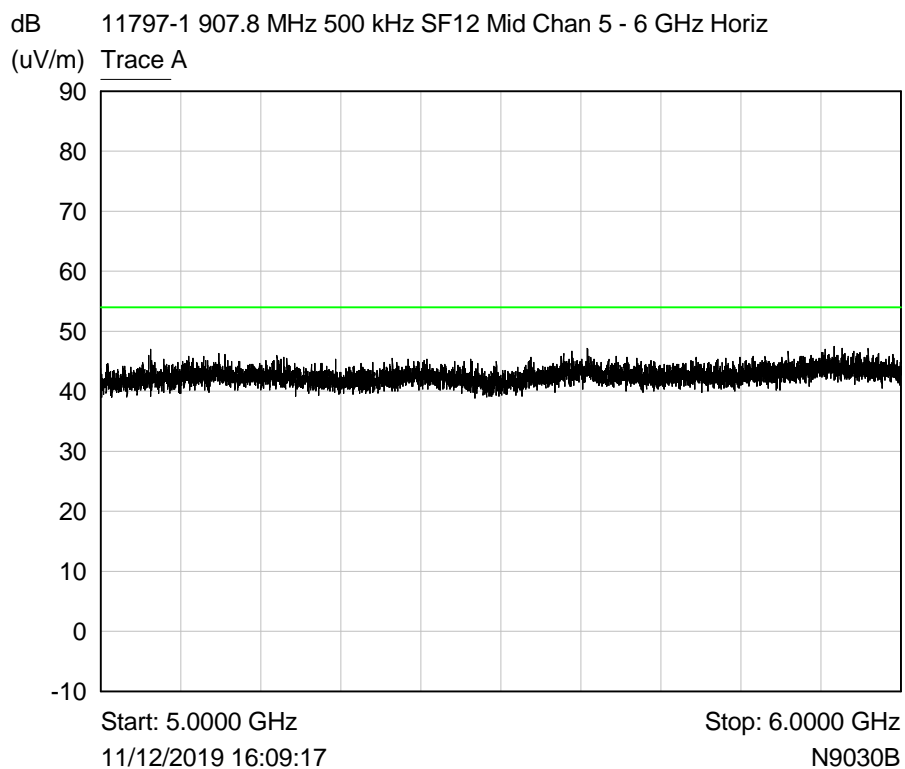
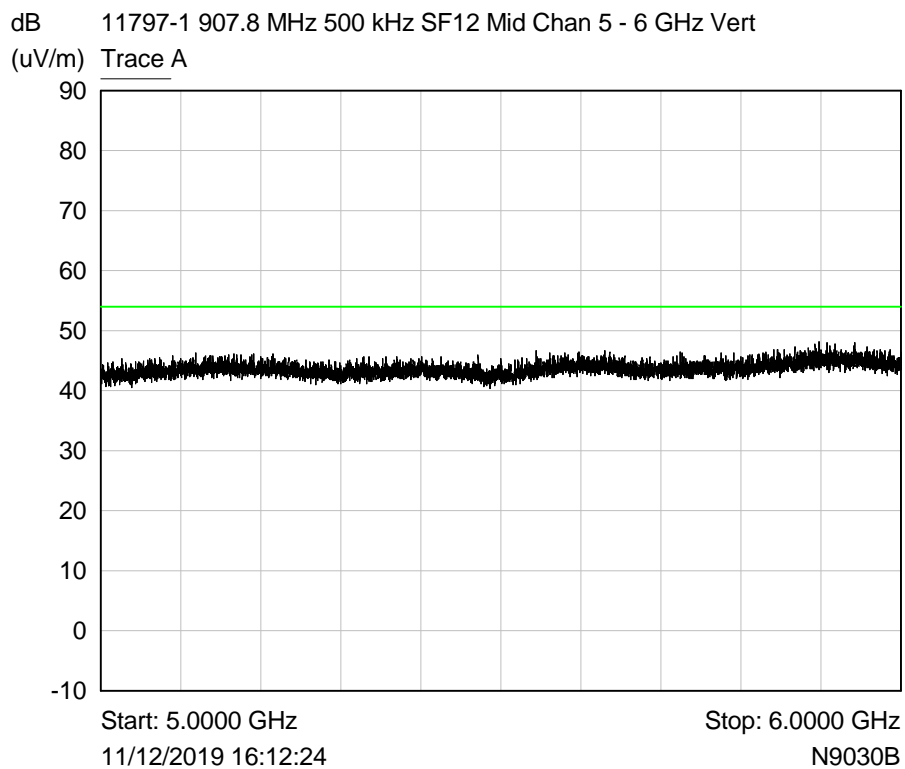


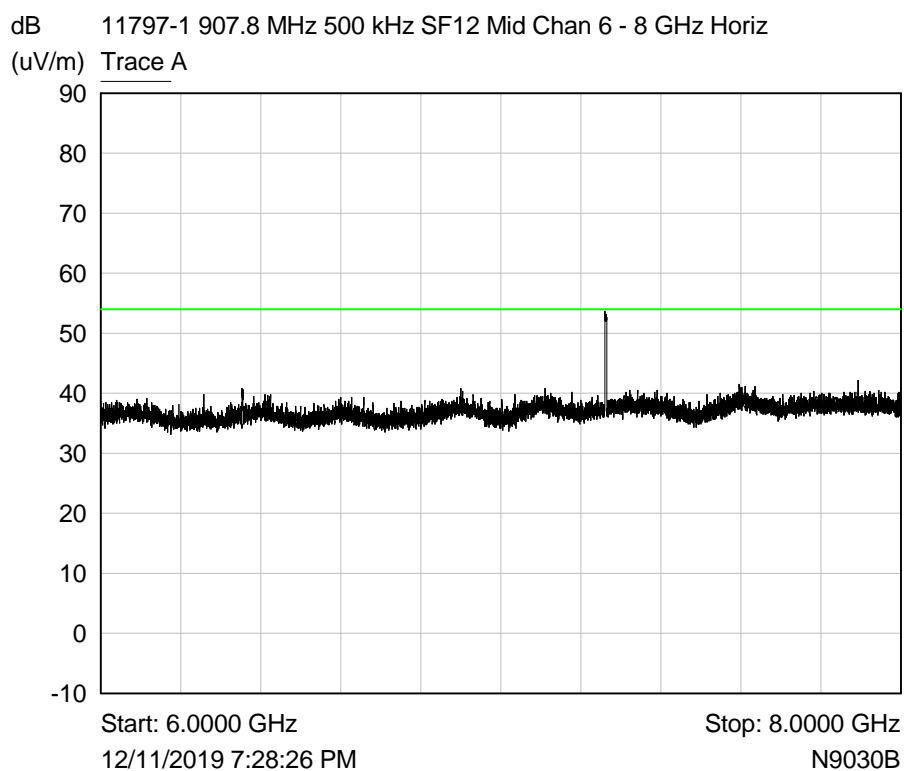
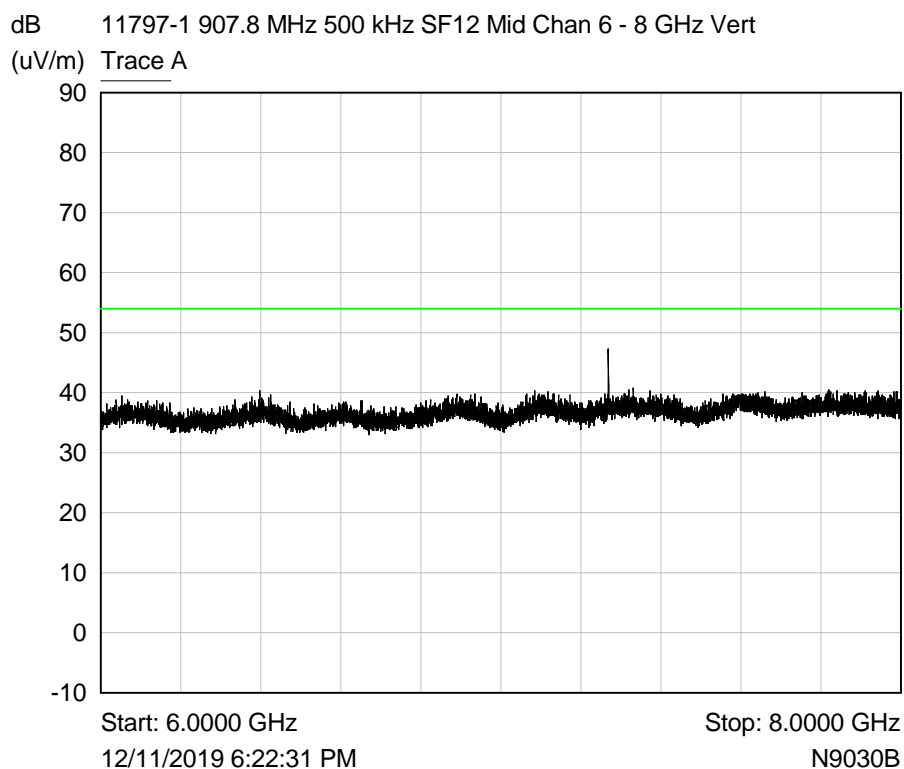


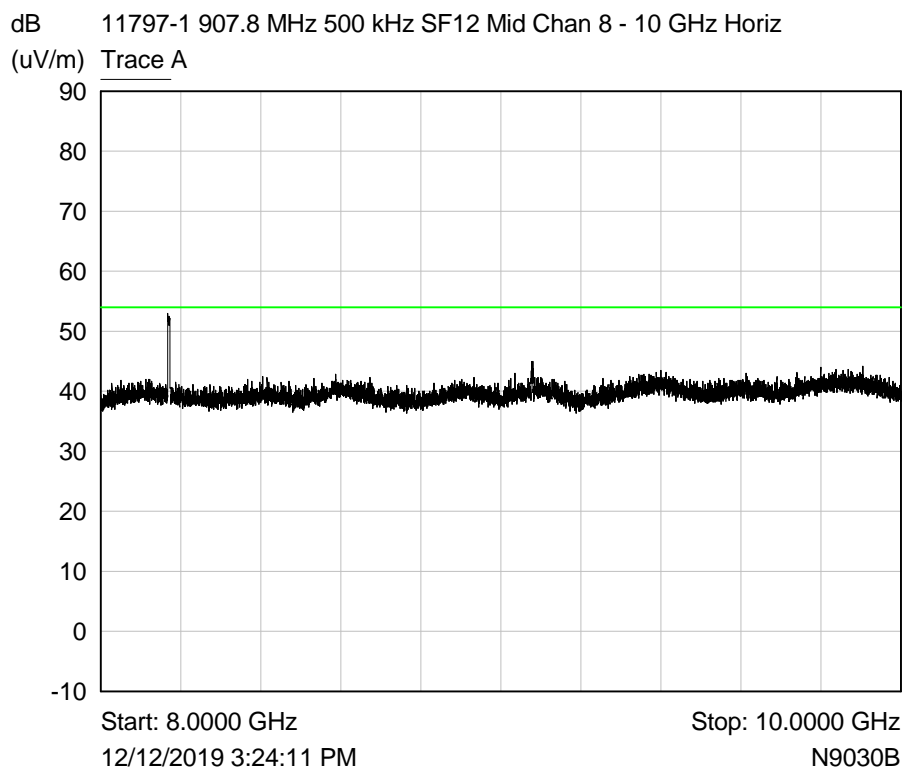
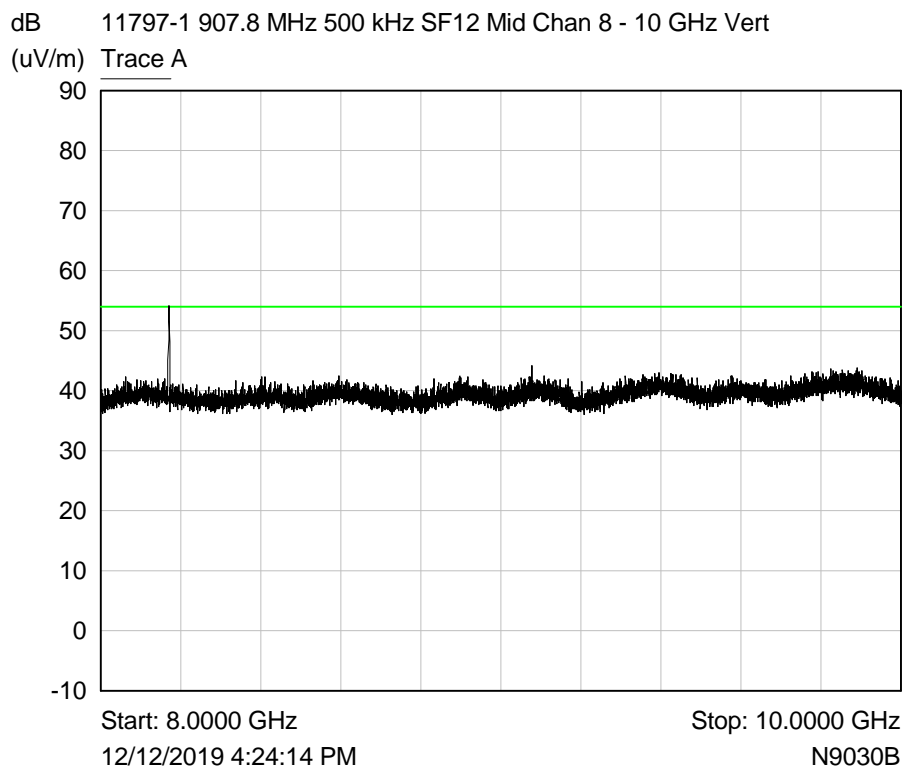
RF Parameters: Band 902-928 MHz, Power 20 dBm, Channel Spacing 500 kHz SF12,
Modulation LoRa, Channel 907.8 MHz





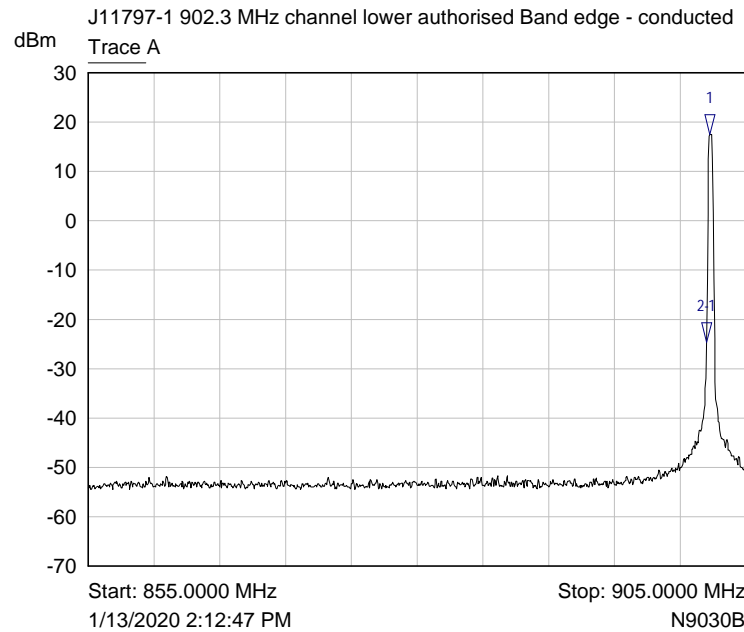






6.5 Band Edge Compliance

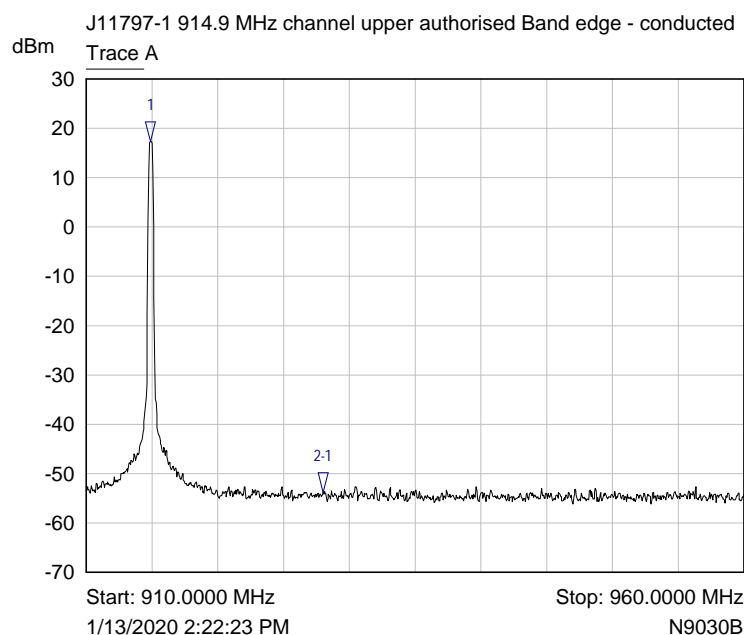
RF Parameters: Band 902-928 MHz, Power 20 MHz, Channel Spacing 125 kHz SF10 MHz,
Modulation LoRA, Channel 902.3 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	902.2500 MHz	17.46 dBm	
2:1 ▽	Trace A	-250.0000 kHz	-42.19 dB	

Lower Authorised Band Edge Plot

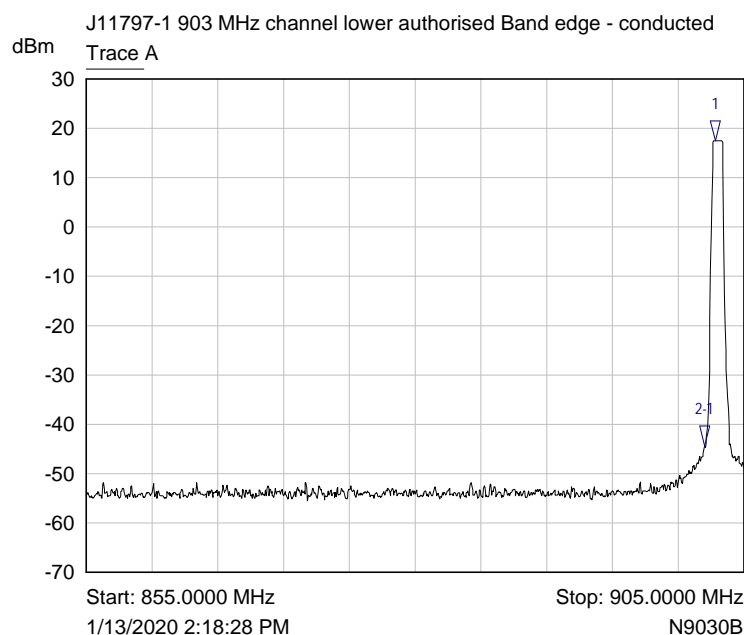
RF Parameters: Band 902-928 MHz, Power 20 MHz, Channel Spacing 125 kHz SF10 MHz,
Modulation LoRA, Channel 914.9 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▾	Trace A	914.8500 MHz	17.38 dBm	
2-1 ▾	Trace A	13.1500 MHz	-71.21 dB	

Upper Authorised Band Edge Plot

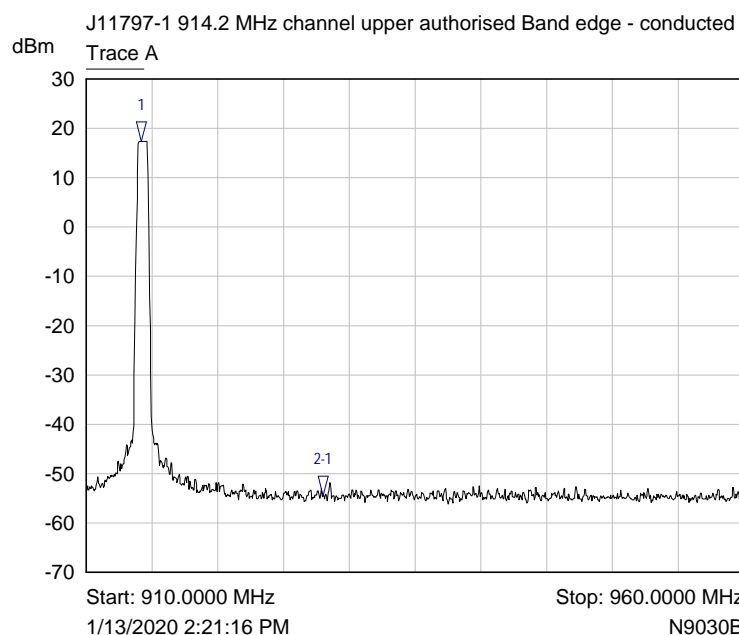
RF Parameters: Band 902-928 MHz, Power 20 MHz, Channel Spacing 500 kHz SF12 MHz,
Modulation LoRA, Channel 903 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	902.8000 MHz	17.55 dBm	
2-1 ▽	Trace A	-800.0000 kHz	-61.89 dB	

Lower Authorised Band Edge Plot

RF Parameters: Band 902-928 MHz, Power 20 MHz, Channel Spacing 500 kHz SF12 MHz,
Modulation LoRA, Channel 914.2 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▾	Trace A	914.2000 MHz	17.39 dBm	
2-1 ▾	Trace A	13.8000 MHz	-71.85 dB	

Authorised Band Edge Plot

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 (dBμV)	Pk – Lim 1 (dB)	QP Amp (dBμV)	QP - Lim1 (dB)	Av Amp (dBμV)	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 $20 \cdot \log(500) = 54 \text{ dB } \mu\text{V/m}$.

(b) limit of 300 μV/m at 10m equates to $20 \cdot \log(300 \cdot 10/3) = 60 \text{ dB } \mu\text{V/m at 3m}$

(c) limit of 30 µV/m at 30m, but below 30MHz, equates to $20 \cdot \log(30) + 40 \cdot \log(30/3) = 69.5$ 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: $E_{\text{Linear}} = 10^{((E_{\text{Log}} - 120)/20)}$

And therefore equation 21 transposed is: $E_{\text{Log}} = 20 \times \log(E_{\text{Linear}}) + 120$

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

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: $\text{PD} = \text{EIRP}_{\text{Linear}} / 4\pi d^2$

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

Where:

PD is the power density at distance specified by the limit, in W/m²

$\text{EIRP}_{\text{Linear}}$ is the equivalent isotropically radiated power in Watts

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

Equation 26: $\text{PD} = E_{\text{Spec limit}}^2 / 377$

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

Where:

PD is the power density at distance specified by the limit, in W/m²

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

Example:

Radiated spurious emissions limit at 3metres of 90pW/cm².

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

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

And

Equation 26 transposed: $E_{\text{Spec limit}} = \sqrt{(0.9 \times 10^{-6} \times 377)} = 0.01842 \text{ V/m.}$

And

Equation 21 transposed: $E_{\text{Log}} = 20\text{Log}(0.01842) + 120 = 85.3\text{dB}\mu\text{V/m @ 3m.}$

8 Photographs

8.1 EUT Front View

Photograph not included in report at applicant's request.

8.2 EUT Reverse Angle

Photograph not included in report at applicant's request.

8.3 EUT Left side View

Photograph not included in report at applicant's request.

8.4 EUT Right side View

Photograph not included in report at applicant's request.

8.5 EUT Antenna & Antenna Port

Photographs not included in report at applicant's request.

8.6 EUT Display & Controls

EUT has no display and controls.

8.7 EUT Internal photos

Photograph not included in report at applicant's request.

8.8 EUT ID Label

Photograph not included in report at applicant's request.

8.9 Radiated emissions 9 - 150 kHz

Photograph not included in report at applicant's request.

8.10 Radiated emissions 30 MHz -1 GHz

Photograph not included in report at applicant's request.

8.11 Radiated emissions above 1 GHz

Photograph not included in report at applicant's request.

8.12 Radiated emission diagrams

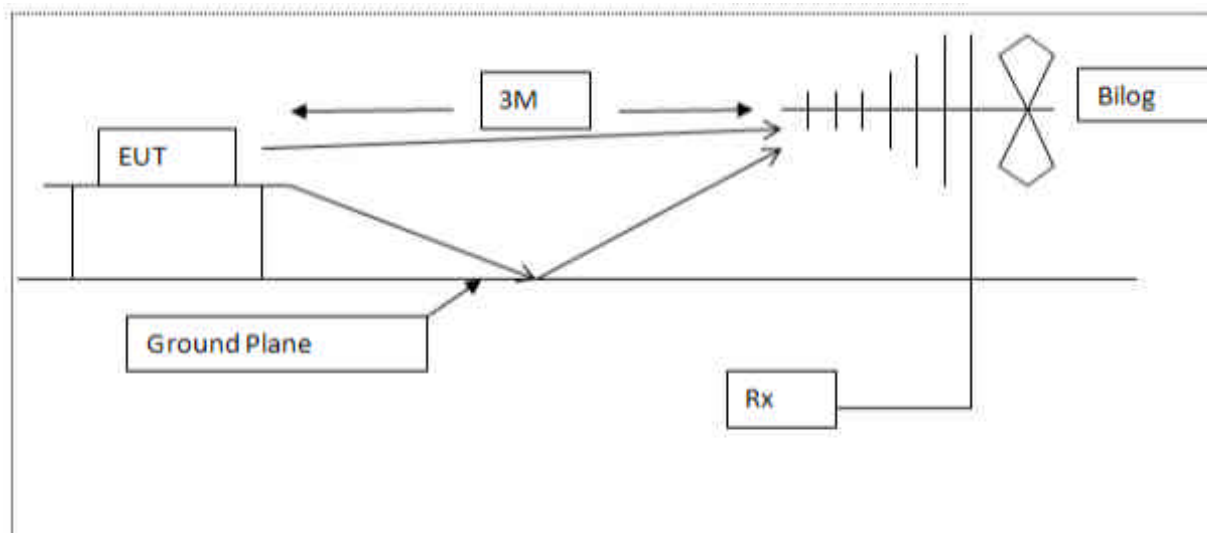


Diagram of the radiated emissions test setup 30 - 1000 MHz

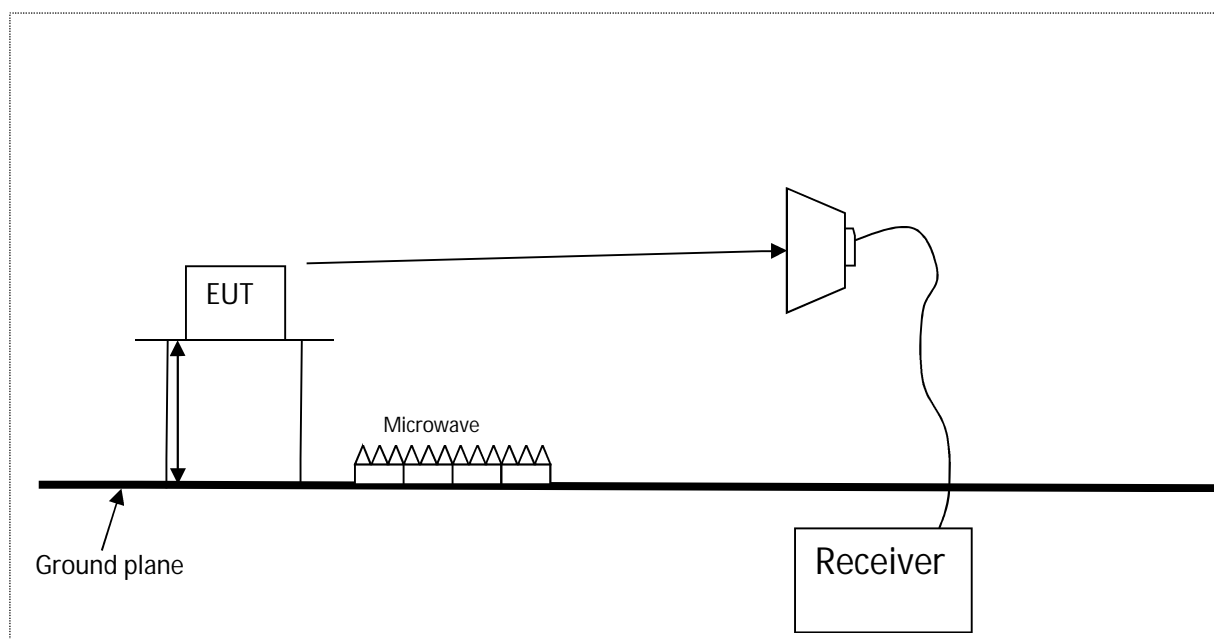


Diagram of the radiated emissions test setup above 1GHz

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
E517	E4421B	Signal Generator 250kHz - 3.0GHz	Hewlett Packard	30-Aug-2019	24 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
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
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	V2.3	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	LBT	Listen Before Talk
µA/m	microAmps per metre	LO	Local Oscillator
µV	microVolts	mA	milliAmps
µW	microWatts	max	maximum
AC	Alternating Current	kPa	Kilopascal
ALSE	Absorber Lined Screened Enclosure	Mbit/s	MegaBits per second
AM	Amplitude Modulation	MHz	MegaHertz
Amb	Ambient	mic	Microphone
ATPC	Automatic Transmit Power Control	min	minimum
BER	Bit Error Rate	mm	milliMetres
°C	Degrees Celsius	ms	milliSeconds
C/I	Carrier / Interferer	mW	milliWatts
CEPT	European Conference of Postal and Telecommunications Administrations	NA	Not Applicable
COFDM	Coherent OFDM	nom	Nominal
CS	Channel Spacing	nW	nanoWatt
CW	Continuous Wave	OATS	Open Area Test Site
dB	decibels	OFDM	Orthogonal Frequency Division Multiplexing
dBµA/m	decibels relative to 1µA/m	ppm	Parts per million
dBµV	decibels relative to 1µV	PRBS	Pseudo Random Bit Sequence
dBc	decibels relative to Carrier	QAM	Quadrature Amplitude Modulation
dBm	decibels relative to 1mW	QPSK	Quadrature Phase Shift Keying
DC	Direct Current	R&TTE	Radio and Telecommunication Terminal Equipment
DTA	Digital Transmission Analyser	Ref	Reference
EIRP	Equivalent Isotropic Radiated Power	RF	Radio Frequency
ERP	Effective Radiated Power	RFC	Remote Frequency Control
EU	European Union	RSL	Received Signal Level
EUT	Equipment Under Test	RTP	Room Temperature and Pressure
FM	Frequency Modulation	RTPC	Remote Transmit Power Control
FSK	Frequency Shift Keying	Rx	Receiver
g	Grams	s	Seconds
GHz	GigaHertz	SINAD	Signal to Noise And Distortion
Hz	Hertz	Tx	Transmitter
IF	Intermediate Frequency	V	Volts
kHz	kiloHertz		