Radio Test Report

Telensa Ltd

480 V Telecell 2

T2A4N

47 CFR Part 15.247 Effective Date 1st October 2017
DSS: Part 15 Spread Spectrum Transmitter
Test Date: 19th December 2017 to 21st December 2017
Report Number: 12-10223-1-17 Issue 01

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Certificate of Test 10223-1

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:	480 V Telecell 2
Model Number:	T2A4N
Unique Serial Number:	2850533
Applicant:	Telensa Ltd Iconix 3, London Road Pampisford, Cambridge CB22 3EG
Full measurement results are detailed in Report Number:	12-10223-1-17 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2017 DSS: Part 15 Spread Spectrum Transmitter

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:
The following tests have had deviations applied: AC power line conducted emissions, Band Edge Compliance, Radiated emissions 30 MHz -1 GHz.

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:	19th December 2017 to 21st December 2017
Test Engineer:	Ian Rose Digitally signed by: Ian Rose DN: CN = Ian Rose email = Ian@rnelectronics.com C = GB O = RN Electronics Date: 2018.05.03 13:04:18 Z
Approved By: Radio Approvals Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2018.05.03 11:48:36 Z
Customer Representative:	

2360

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Telensa Ltd Iconix 3 London Road Pampisford Cambridge CB22 3EG	
Manufacturer of EUT	Telensa Ltd	
Full Name of EUT	480 V Telecell 2	
Model Number of EUT	T2A4N	
Serial Number of EUT	2850533	
Date Received	19th December 2017	
Date of Test:	19th December 2017 to 21st December 2017	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	5th January 2018	
Main Function	Street lighting control and monitoring.	
Information Specification	Height	150 mm
	Width	90 mm
	Depth	90 mm
	Weight	0.5 kg
	Voltage	347-480 V AC
	Current	0.01 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Fixed to a street luminaire, 8 to 10 m above street level
Choice of model(s) for type tests	Production samples
Antenna details	Integral antenna 0 dBi
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	919.9875 MHz
Lowest Signal generated in EUT	32.768 kHz
Hardware Version	6LA30B 02
Software Version	2.13.25
Firmware Version	2.13.25
Type of Equipment	Fixed
Technology Type	Proprietary FHSS
Geo-location (yes/no)	Yes
TX Parameters	
Alignment range – transmitter	910.4875 to 919.9875 MHz split into 6 sub-bands
EUT Declared Modulation Parameters	FSK (1K10F1D)
EUT Declared Power level	100 mW
EUT Declared Signal Bandwidths	1.1 kHz
EUT Declared Channel Spacing's	25 kHz
EUT Declared Duty Cycle	1%
Unmodulated carrier available?	Yes
Declared frequency stability	2 ppm
RX Parameters	
Alignment range – receiver	910.4875 to 919.9875 MHz split into 6 sub-bands
EUT Declared RX Signal Bandwidth	1 kHz
Receiver Signal Level (RSL)	Not applicable
Method of Monitoring Receiver BER	Not applicable
FCC Parameters	
FCC Transmitter Class	DSS: Part 15 Spread Spectrum Transmitter
FHSS Parameters	
Maximum No. Of hop channels	59 per each of 6 sub-bands
Minimum No. Of hop channels	Not applicable
Dwell time per hop channel	0.39 s
Return time to same channel	24 s
Frequency Occupation (statistical)	Not declared

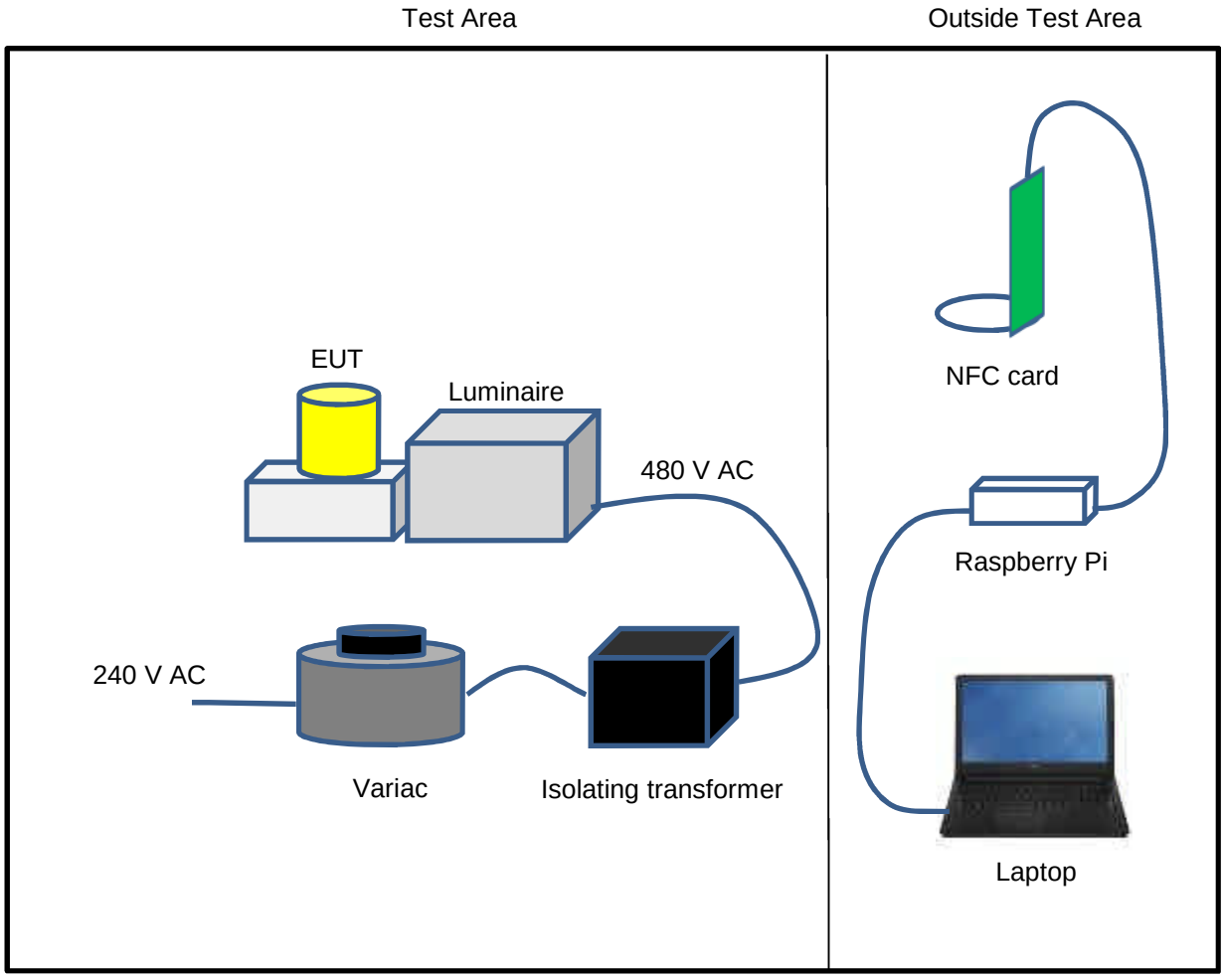
2.3 Functional description

915 MHz transceiver to facilitate On/Off control of street lighting, dimming control of street lights and electricity usage monitoring. Uses GPS receiver to allow location and set up.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX1	Low 20 dBm FSK 62.5 bps	Yes
TX2	Mid 20 dBm FSK 62.5 bps	Yes
TX3	High 20 dBm FSK 62.5 bps	Yes
TX4	Low 20 dBm FSK 500 bps	Yes
TX5	Mid 20 dBm FSK 500 bps	Yes
TX6	High 20 dBm FSK 500 bps	Yes
TX7	Hopping all channels 20 dBm FSK 500 bps	Yes

2.5 Emissions configuration



The unit was installed into a luminaire so that it could receive power as it would during normal installation. The unit was powered at 480 V AC via an isolating transformer fed by a variac from 240 V AC mains. The unit was programmed using Near Field Communications (NFC) and a Raspberry Pi/laptop interface. The NFC card and interface were removed from the chamber prior to measurements being made. The unit was configured with engineering menus in software to allow permanent transmit and receive modes of the unit on the top, middle and bottom channels as stated within section 2.4 of this report. The transmit mode was 100% continuous with modulation and the power settings for each channel were as stated below:-

Low Channel (910.5 MHz) = level 100 mW.
Mid Channel (915 MHz) only = level 100 mW.
High Channel (919.975 MHz) = level 100 mW

2.5.1 Signal leads

Port Name	Cable Type	Connected
Power	Custom 5-pin connector	Yes

3 Summary of test results

The 480 V Telecell 2, T2A4N was tested for compliance to the following standard(s) :

47 CFR Part 15.247 Effective Date 1st October 2017
DSS: Part 15 Spread Spectrum Transmitter

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	PASSED
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
6. Effective radiated power field strength	47 CFR Part 15C Part 15.247(d)	PASSED
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)	PASSED
9. Maximum Average conducted output power	47 CFR Part 15C Part 15.247(b3)	NOT APPLICABLE[1]
10. Maximum Peak conducted output power	47 CFR Part 15C Part 15.247(b)(2)	PASSED
11. Maximum Power Spectral Density	47 CFR Part 15C Part 15.247(e)	NOT APPLICABLE[2]
12. Antenna power conducted emissions	47 CFR Part 15C Part 15.247(d)	NOT APPLICABLE[3]
13. Duty cycle	47 CFR Part 15C Part 15.35(c)	NOT APPLICABLE[2]
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 Peak conducted power measured instead.
[2] EUT uses FHSS technology and is therefore not applicable to this test.
[3] Applies to EUT's with an antenna port. The EUT has an integral antenna only. The EUT was tested for radiated emissions with its dedicated antenna in position.

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	2017	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	DA 00-705	2000	PUBLIC NOTICE Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
4.1.5	KDB 558074 D01 v04	2017	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

4.2 Deviations

Deviations have been applied on the following: - AC power line conducted emissions: EUT supply lead left at 1.4m length for test at manufacturer’s request. Specification requires 1m length.,

5 Tests, methods and results

5.1 AC power line conducted emissions

5.1.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.2 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report]

5.1.2 Configuration of EUT

The EUT was placed on a wooden table 0.8m above the ground plane and connected to a LISN via a 1.4 m mains cable.

During the initial scan, no difference in emissions could be seen with changing data rates and channels. Therefore full tests were performed using mode TX5.

5.1.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed in the 'Test Equipment' Section. Measurements were made on the live and neutral conductors using both average and quasi-peak detection. At least 6 signals within 20dB and/or all signals within 10dB of the limit were investigated.

Tests were performed in Test Site F.

5.1.4 Test equipment

LPE366, E035, ZSW1, E412, E411

See Section 9 for more details

5.1.5 Test results

Temperature of test environment	19°C
Humidity of test environment	55%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Single channel	915 MHz

Plot refs
10223-1 Cond 1 AC Live 150k-30M Average
10223-1 Cond 1 AC Live 150k-30M Quasi-Peak
10223-1 Cond 1 AC Neutral 150k-30M Average
10223-1 Cond 1 AC Neutral 150k-30M Quasi-Peak

Table of signals measured for Cond 1 AC Live 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.167	62.4	54.4	-10.7	22.6	-32.5
2	0.186	60.4	52.1	-12.1	20.3	-33.9
3	0.202	58.3	50.0	-13.5	19.1	-34.4
4	0.215	56.3	48.5	-14.5	21.2	-31.8
5	0.215	56.7	49.1	-13.9	20.7	-32.3
6	0.232	56.2	48.2	-14.2	25.5	-26.9
7	1.227	38.8	36.5	-19.5	21.8	-24.2

8	1.336	41.0	38.8	-17.2	24.6	-21.4
9	1.432	41.2	37.7	-18.3	24.5	-21.5
10	1.471	41.4	39.0	-17.0	24.9	-21.1
11	1.602	39.8	37.3	-18.7	23.7	-22.3
12	2.402	39.8	36.9	-19.1	23.5	-22.5

Table of signals measured for Cond 1 AC Neutral 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.151	64.3	56.1	-9.8	21.8	-34.1
2	0.161	64.3	56.2	-9.2	22.8	-32.6
3	0.184	58.5	50.8	-13.5	21.6	-32.7
4	0.197	59.3	51.4	-12.3	22.3	-31.4
5	0.207	58.8	50.7	-12.6	21.1	-32.2
6	0.216	57.4	49.4	-13.6	20.5	-32.5
7	0.216	54.5	46.7	-16.3	18.7	-34.3
8	1.340	40.1	37.8	-18.2	23.8	-22.2
9	1.358	40.4	38.3	-17.7	24.1	-21.9
10	1.404	39.8	37.1	-18.9	23.3	-22.7
11	1.478	41.2	38.3	-17.7	23.4	-22.6
12	1.627	39.7	37.6	-18.4	23.4	-22.6

No discernible difference was noted in emissions between channels (exploratory measurements); therefore the final measurements are presented for TX mid channel mode only.

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

LIMITS:
15.207: as given in the above tables / 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:
150kHz to 30MHz ±3.6dB.

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 assessed in its normal use position. Radiated Emissions testing was performed whilst powered from a 480 V AC power supply. The EUT was operated in TX4 to TX6 modes.

5.2.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber (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 and OATS.

5.2.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	19°C
Humidity of test environment	55%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz

Plot refs
10223-1 Rad 1 9k-150kHz Para
10223-1 Rad 1 9k-150kHz Perp

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Mid channel	915 MHz

Plot refs
10223-1 Rad 2 9k-150kHz Para
10223-1 Rad 2 9k-150kHz Perp

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
High channel	919.975 MHz

Plot refs
10223-1 Rad 3 9k-150kHz Para
10223-1 Rad 3 9k-150kHz Perp

No signals were found within 20 dB 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 assessed in its normal use position. Radiated Emissions testing was performed whilst powered from a 480 V AC power supply. The EUT was operated in TX4 to TX6 modes.

5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber (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 and OATS.

5.3.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	19°C
Humidity of test environment	55%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz

Plot refs
10223-1 Rad 1 150k-30MHz Para
10223-1 Rad 1 150k-30MHz Perp

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Mid channel	915 MHz

Plot refs
10223-1 Rad 2 150k-30MHz Para
10223-1 Rad 2 150k-30MHz Perp

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
High channel	919.975 MHz

Plot refs
10223-1 Rad 3 150k-30MHz Para
10223-1 Rad 3 150k-30MHz Perp

No signals were found within 20 dB 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 assessed in its normal use position. Radiated Emissions testing was performed whilst powered from a 480 V AC power supply. The EUT was operated in TX4 to TX6 modes.

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, NSA1, ZSW1, E412, E411

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	16 - 20°C
Humidity of test environment	46 - 55%
Pressure of test environment	104kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz

Plot refs
10223-1 Rad 1 VHF Horiz
10223-1 Rad 1 VHF Vert
10223-1 Rad 1 UHF Horiz
10223-1 Rad 1 UHF Vert

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Mid channel	915 MHz

Plot refs
10223-1 Rad 2 VHF Horiz
10223-1 Rad 2 VHF Vert
10223-1 Rad 2 UHF Horiz
10223-1 Rad 2 UHF Vert

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
High channel	919.975 MHz

Plot refs
10223-1 Rad 3 VHF Horiz
10223-1 Rad 3 VHF Vert
10223-1 Rad 3 UHF Horiz
10223-1 Rad 3 UHF Vert

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	79.999	22.9	18.9	-21.1
2	884.500	39.4	36.6	-9.4

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	48.377	22.2	15.5	-24.5
2	79.999	25.4	21.5	-18.5
3	120.001	27.7	23.5	-20.0
4	884.500	40.3	37.7	-8.3
5	936.500	40.1	37.2	-8.8

Table of signals measured for Rad 2 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	79.999	22.2	17.4	-22.6
2	863.594	38.9	34.4	-11.6
3	889.000	39.7	35.7	-10.3

Table of signals measured for Rad 2 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	79.999	25.2	21.8	-18.2
2	120.003	27.3	23.5	-20.0
3	889.000	41.3	38.4	-7.6
4	941.000	40.3	36.8	-9.2

Table of signals measured for Rad 3 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	79.999	22.1	18.0	-22.0
2	864.955	38.2	34.2	-11.8
3	893.975	39.9	36.3	-9.7

Table of signals measured for Rad 3 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	79.999	23.7	20.5	-19.5
2	120.000	27.3	23.1	-20.4
3	893.975	40.7	38.2	-7.8
4	945.975	39.0	35.9	-10.1
5	974.987	36.0	31.8	-22.2

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

Both data rates available were initially tested with no discernible difference in emissions noted.

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 assessed in its normal use position. Radiated Emissions testing was performed whilst powered from a 480 V AC power supply. The EUT was operated in TX1 to TX3 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, and 1.2m was used in the test range 6 - 18GHz.

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, E253, E410, E411, E412, E429, E478, TMS78, TMS82

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	18-21°C
Humidity of test environment	47-50%
Pressure of test environment	104kPa

Setup Table

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 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
1821	68.7	-22.2	56.1	-24.8	flat	Vertical
1821	69.3	-21.6	57.6	-23.3	flat	Horizontal
2731.5	51.0	-23.0	40.5	-13.5	flat	Vertical
2731.5	49.2	-24.8	43.1	-10.9	flat	Horizontal
3642	49.0	-25.0	36.6	-17.4	flat	Vertical
3642	47.6	-26.4	38.8	-15.2	flat	Horizontal
5463	48.5	-42.4	42.2	-38.7	flat	Vertical
5463	52.6	-38.3	49.3	-31.6	flat	Horizontal
7284	41.9	-32.1	32.6	-21.4	flat	Horizontal

Setup Table

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Mid channel	915 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	69.3	-20.8	56.9	-23.2	flat	Vertical
1830	67.8	-22.3	56.2	-23.9	flat	Horizontal
2745	50.4	-23.6	39.3	-14.7	flat	Vertical
2745	49.7	-24.3	43.5	-10.5	flat	Horizontal
3660	49.4	-24.6	36.9	-17.1	flat	Vertical
3660	49.0	-25.0	35.0	-19.0	flat	Horizontal
5490	47.3	-42.8	40.2	-39.9	flat	Vertical
5490	51.5	-38.6	46.9	-33.2	flat	Horizontal
7320	43.9	-30.1	36.6	-17.4	flat	Horizontal

Plots
10223-1 Horizontal 1 - 3 GHz Mid chan TX
10223-1 Horizontal 3 - 5 GHz Mid chan TX
10223-1 Horizontal 5 - 6 GHz Mid chan TX
10223-1 Horizontal 6 - 7.8 GHz Mid chan TX
10223-1 Horizontal 7.8 - 10.0 GHz Mid chan TX
10223-1 Horizontal 10 - 12.4 GHz Mid chan TX
10223-1, Horizontal 12-16GHz Mid chan TX
10223-1 Vertical 1 - 3 GHz Mid chan TX
10223-1 Vertical 3 - 5 GHz Mid chan TX
10223-1 Vertical 5 - 6 GHz Mid chan TX
10223-1 Vertical 6 - 7.8 GHz Mid chan TX
10223-1 Vertical 7.8 - 10 GHz Mid chan TX
10223-1 Vertical 10 - 12.4 GHz Mid chan TX
10223-1, Vertical 12-16GHz Mid chan TX

Setup Table

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
High channel	919.975 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
1839.95	68.2	-20.4	56.4	-22.2	flat	Vertical
1839.95	67.4	-21.2	55.9	-22.7	flat	Horizontal
2759.925	51.6	-22.4	40.5	-13.5	flat	Vertical
2759.925	52.9	-21.1	43.6	-10.4	flat	Horizontal
3679.9	50.1	-23.9	36.9	-17.1	flat	Vertical
3679.9	49.4	-24.6	37.5	-16.5	flat	Horizontal
5519.85	50.3	-38.3	45.3	-33.3	flat	Vertical
5519.85	52.9	-35.7	49.5	-29.1	flat	Horizontal
7359.8	42.9	-31.1	35.4	-18.6	flat	Horizontal
9199.75	42.7	-31.3	30.5	-23.5	flat	Horizontal

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.

Both data rates available were initially tested with no discernible difference in emissions noted.

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

5.6.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(d) [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 15.247(d) & 15.209(a) [Reference 4.1.1 of this report]

5.6.2 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 assessed in its normal use position. Final measurements were taken at 3m. The EUT was operated in TX1 to TX3 modes.

5.6.3 Test procedure

Tests were made in accordance with the Test Method noted above using the measuring equipment listed in the 'Test Equipment used' section. The power stated is Peak field strength. The equipment was rotated 360 degrees and the antenna scanned 1 – 4 metres in both horizontal and vertical polarisations to record the Highest fundamental field strength. Tests were performed in test site M.

5.6.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.6.5 Test results

Temperature of test environment 14°C
Humidity of test environment 49%
Pressure of test environment 103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 62.5 bps
Low channel	910.5 MHz
Mid channel	915 MHz
High channel	919.975 MHz

	Low channel	Mid channel	High channel
Peak Level (dBµV/m)	110.90	110.10	108.60
Plot reference	10223-1 Low vert up 62.5 bps ERP	10223-1 Mid vert up 62.5 bps ERP	10223-1 High vert up 62.5 bps ERP
Antenna Polarisation	Vert	Vert	Vert
EUT Polarisation	Upright	Upright	Upright

Analyser plots can be found in Section 6 of this report.
Note: Both data rates available were initially tested with no discernible difference in output power noted.

LIMITS:
The maximum output power in all cases is 30dBm/ 1watt.

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

5.7 Band Edge Compliance

5.7.1 Test methods

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

5.7.2 Configuration of EUT

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

The EUT was operated in TX4 and TX6 and TX7 mode.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The emission from the EUT was maximised before taking the plots.

Tests were performed using Test Site M.

5.7.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	41%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 dBm
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz
High channel	919.975 MHz

Restricted Band Edge	Low channel	High channel
Restricted Band Edge Plot reference	See TX Unwanted radiated emissions 30 MHz-1 GHz in section 6	

Authorised Band Edge	Low channel	High channel
Authorised Band Edge Plot references	10223-1 Fixed channel lower authorised band edge	10223-1 Fixed channel upper authorised band edge
	10223-1 Hopping lower authorised band edge	10223-1 Hopping upper authorised band edge

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. The restricted band edges are also shown in section 6 under TX Unwanted radiated emissions 30 MHz-1 GHz.

LIMITS:
AV = 54dBuV/m at band edges
PK = 74dBuV/m at band edges

The restricted band edges closest to the EUT frequency of 902-928MHz are 614 & 960MHz.

Further wider span plots have been taken to show the fact that there are no spurious emissions above the restricted limits of 15.209.

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)/ (ii)/(iii)15 [Reference 4.1.1 of this report]

Test Method: ANSI C63.10 Clause 6.9 [Reference 4.1.2 of this report]

Limits: 47 CFR Part 15C Part 15.215(c)/ 15.247(a)(1)(i) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was operated in TX1, TX2, TX3, TX4, TX5 and TX6 modes.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 51 Hz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth.

Tests were performed using Test Site M.

5.8.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	14°C
Humidity of test environment	49%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 62.5 bps
Low channel	910.5 MHz
Mid channel	915 MHz
High channel	919.975 MHz

	Low channel	Mid channel	High channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	0.616397	0.618366	0.618715
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	10223-1 Low 62.5 bps OBW	10223-1 Mid 62.5 bps OBW	10223-1 High 62.5 bps OBW

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz
Mid channel	915 MHz
High channel	919.975 MHz

	Low channel	Mid channel	High channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	1.119	1.107	1.116
Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts	10223-1 Low 500 bps OBW	10223-1 Mid 500 bps OBW	10223-1 High 500 bps OBW

Analyser plots for the 20 dB 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.

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

NOT APPLICABLE: EUT Peak conducted power measured instead.

5.10 Maximum Peak conducted output power

5.10.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(b)(2) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 9.7 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(b)(2) [Reference 4.1.1 of this report]

5.10.2 Configuration of EUT

Please refer to section 5.6 for fundamental field strength.

5.10.3 Test procedure

Tests were made in accordance with the Test Method noted above using the measuring equipment listed in the 'Test Equipment used' section. The power stated is Peak field strength measured in section 5.6 of this report converted to power in dBm minus the antenna gain of 0 dBi as declared by the manufacturer.

5.10.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.10.5 Test results

Temperature of test environment 14°C
Humidity of test environment 49%
Pressure of test environment 103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Low channel	910.5 MHz
Mid channel	915 MHz
High channel	919.975 MHz

Test conditions		Peak Power (dBm)	Peak Power (dBm)	Peak Power (dBm)
Temperature 20 Deg C	480 Volts	Low channel	Mid channel	High channel
Maximum TX Power observed (dBm)		15.74	14.94	13.44
TX Power observed to limit (dB)		-14.30	-15.10	-16.60

Note: Calculations used from ANSI C63.10, clause 9.7: P_{COND} = EIRP ($_{LINEAR}$) / $G_{EUT.}$
and Clause 9.5: EIRP(dBm) = E_{MEAS} + 20Log(d_{MEAS})-104.7. Distance used 3m. E_{MEAS} in dBuV/m.

LIMITS:
15.247(b)(2)
For FHSS operating 902-928 MHz employing at least 50 channels 1 Watt (+30dBm)

These results show that the EUT has PASSED this test.

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

5.11 Maximum Power Spectral Density

NOT APPLICABLE: EUT uses FHSS technology and is therefore not applicable to this test.

5.12 Antenna power conducted emissions

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

5.13 Duty cycle

NOT APPLICABLE: EUT uses FHSS technology and is therefore not applicable to this test.

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 in the chamber and ambient conditions were monitored. The EUT was operated in TX7 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 M.

5.14.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.14.5 Test results

Temperature of test environment	14°C
Humidity of test environment	49%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Single channel	Hopping

	Single channel
Separation (kHz)	25.1892
Plot of Separation (kHz)	10223-1 Hopping 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 placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was assessed in its normal use position. Ambient conditions were monitored. The EUT was operated in TX7 mode for this test.

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. Initial tests showed no difference between 62.5 or 500 bps data rates so results are shown for 500 bps only.

Tests were performed in test site M.

5.15.4 Test equipment

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.15.5 Test results

Temperature of test environment	20°C
Humidity of test environment	41%
Pressure of test environment	103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Single channel	918.5 MHz

Measured Dwell time/pulse width (ms)	399.25
Period time (s)	21
Instances of pulse within period time	1
Average time of occupancy (ms)	399.25
Measured Dwell time/pulse width (ms)	10223-1 Average time of occupancy
Period time (s)	10223-1 Period

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 placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was assessed in its normal use position. Ambient conditions were monitored. The EUT was operated in TX7 mode for this test.

5.16.3 Test procedure

Tests were made using the measuring equipment noted in the 'Test Equipment' Section at Site M. 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

E410, E411, E412, E743, LPE364

See Section 9 for more details

5.16.5 Test results

Temperature of test environment 14°C
Humidity of test environment 49%
Pressure of test environment 103kPa

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	Hopping band 0

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 0

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	Hopping band 1

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 1

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	Hopping band 2

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 2

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	Hopping band 3

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 3

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	Hopping band 4

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 4

Band	910.4875 -919.9875 MHz
Power Level	100 mW
Channel Spacing	25 kHz
Mod Scheme	FSK 500 bps
Channel	hopping band 5

No of hopping Channels	59
Minimum No. Required number by specification	50
Plot of Hopping Channels 1-59	10223-1 Number of channels band 5

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.

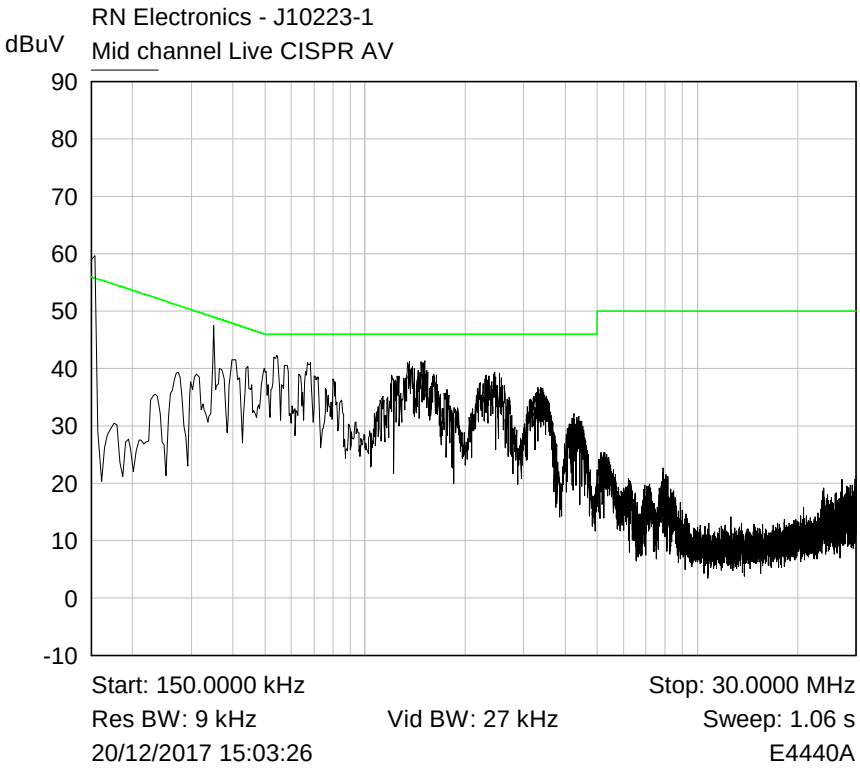
These results show that the EUT has PASSED this test.

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

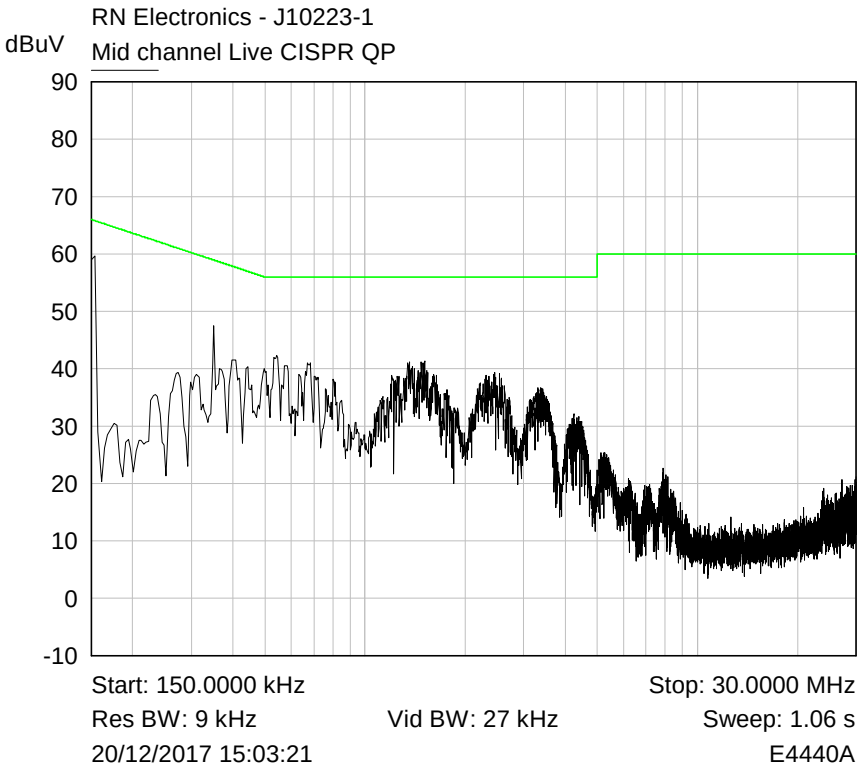
6 Plots/Graphical results

6.1 AC power line conducted emissions

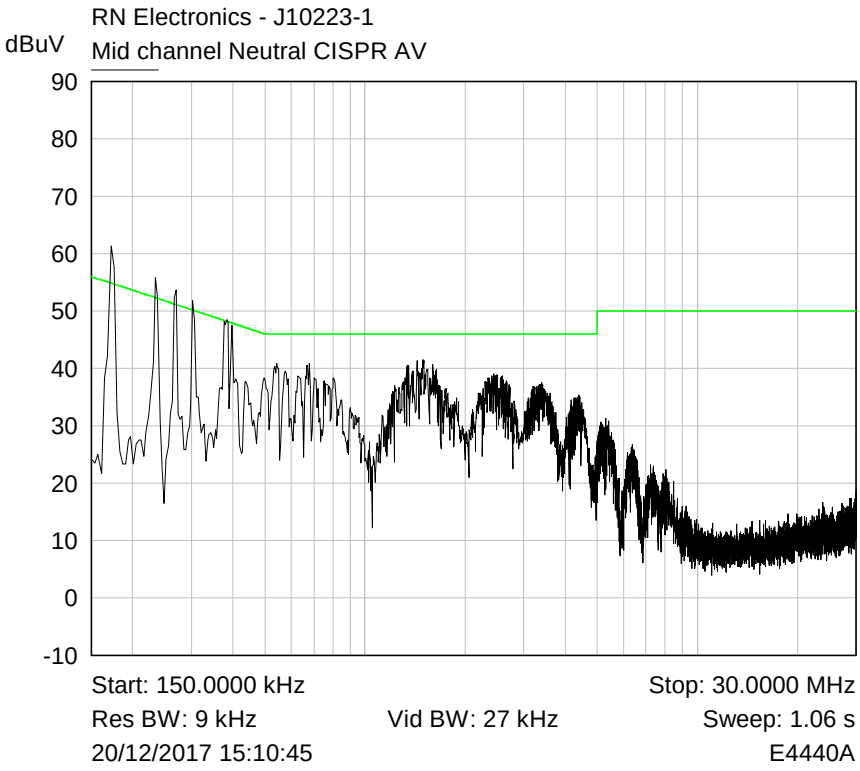
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 915 MHz



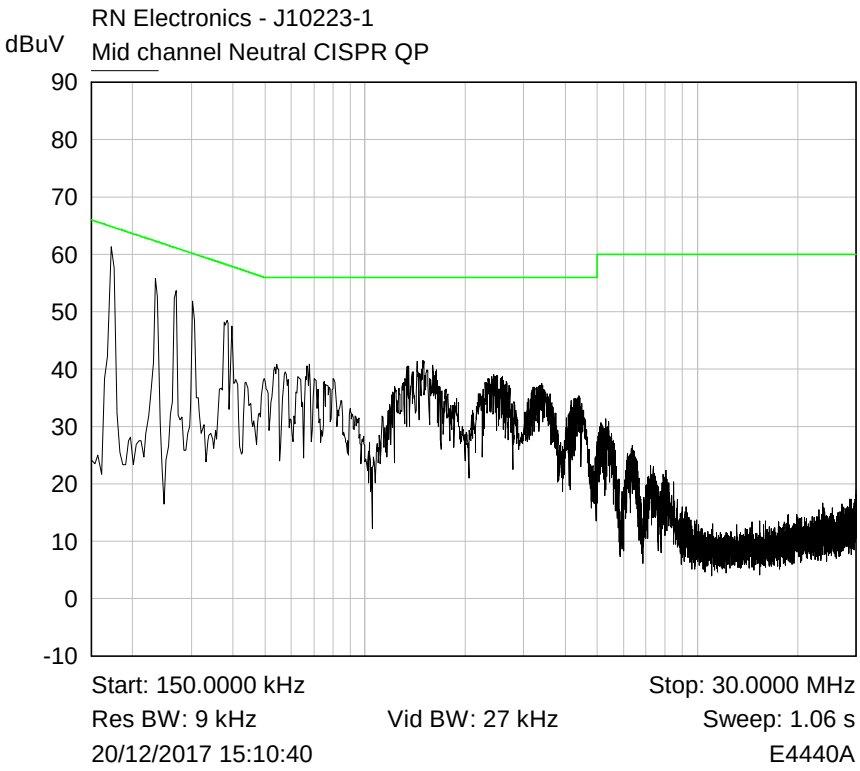
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



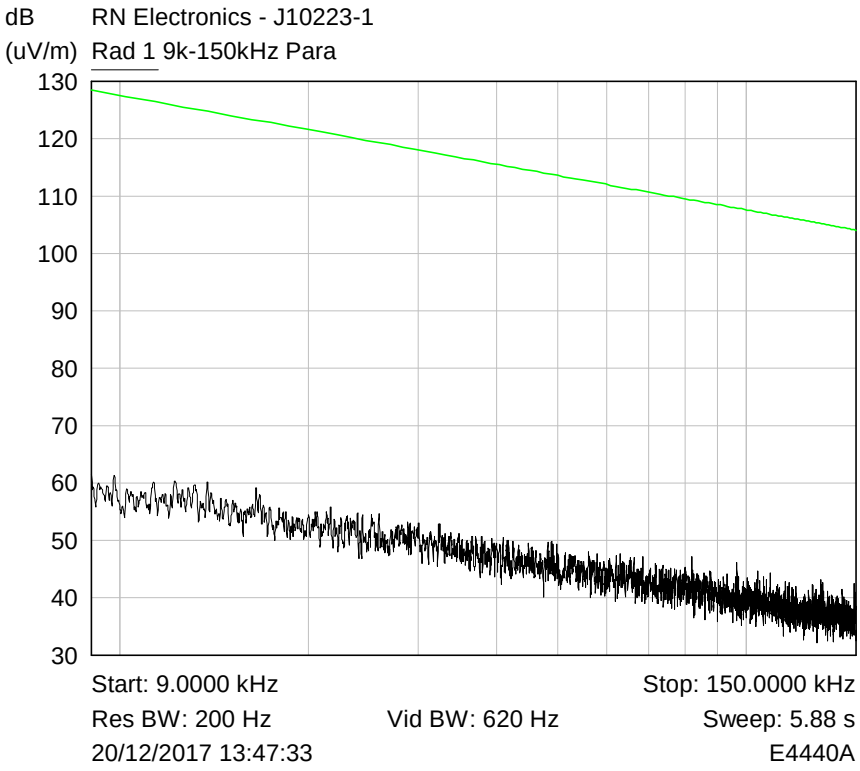
Plot of Neutral150k-30M Average



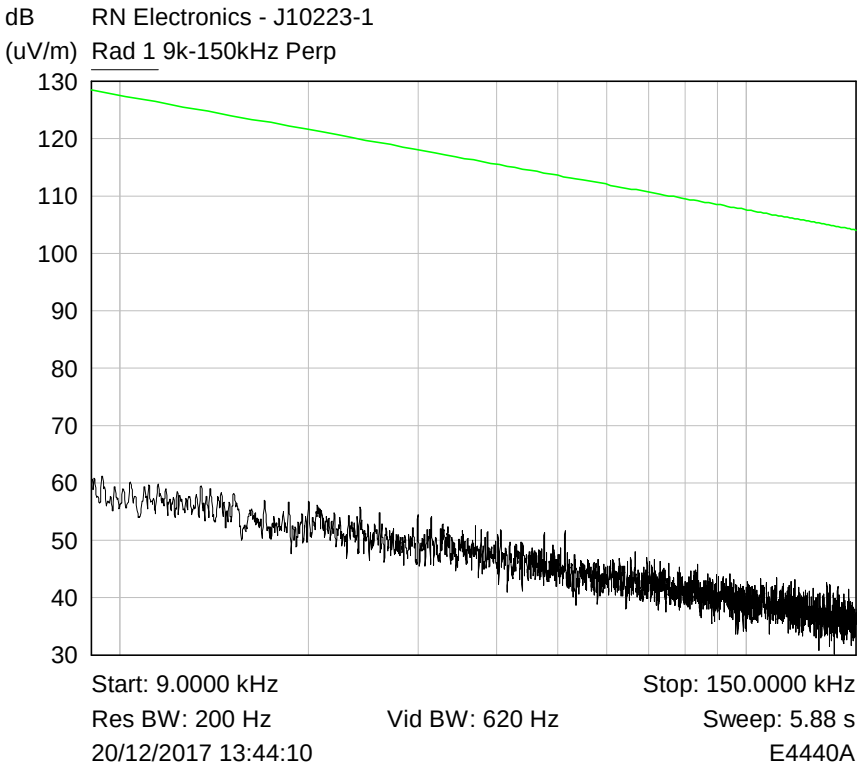
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 910.5 MHz



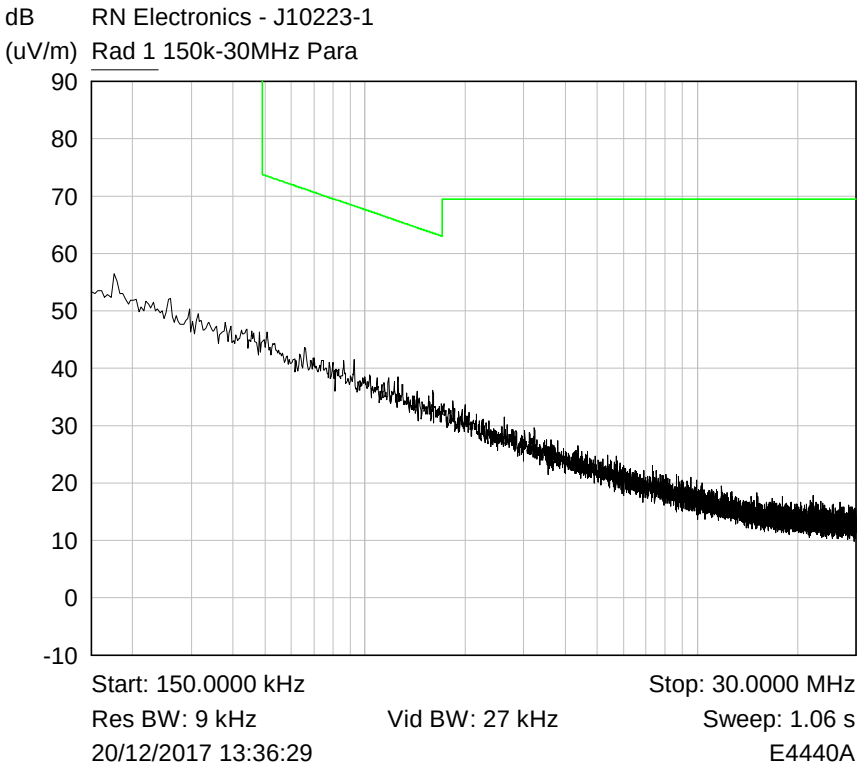
Plot of 9k-150kHz Parallel



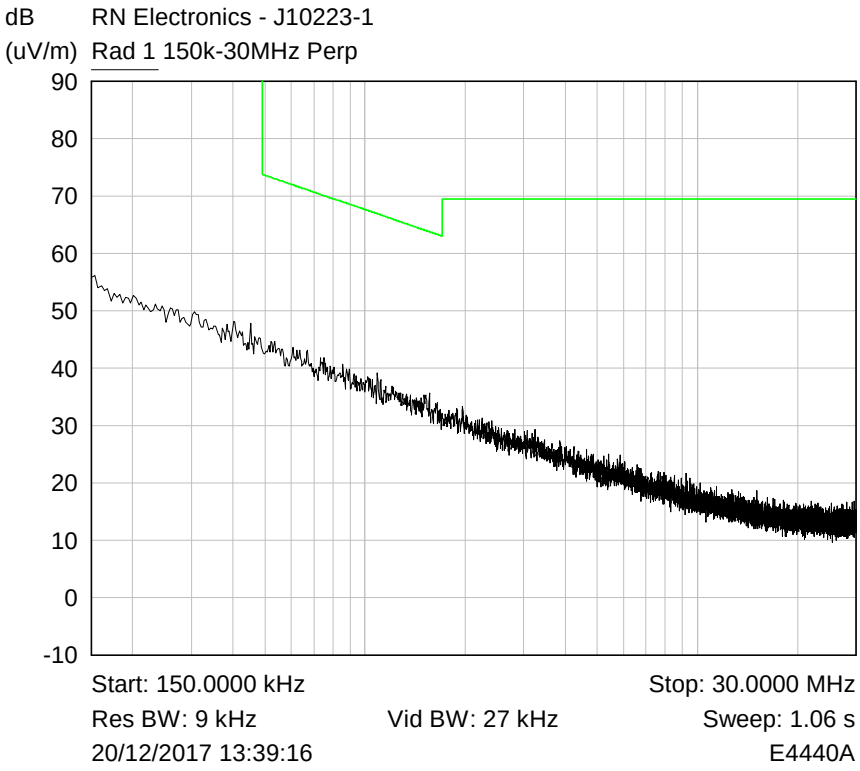
Plot of 9k-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 910.5 MHz



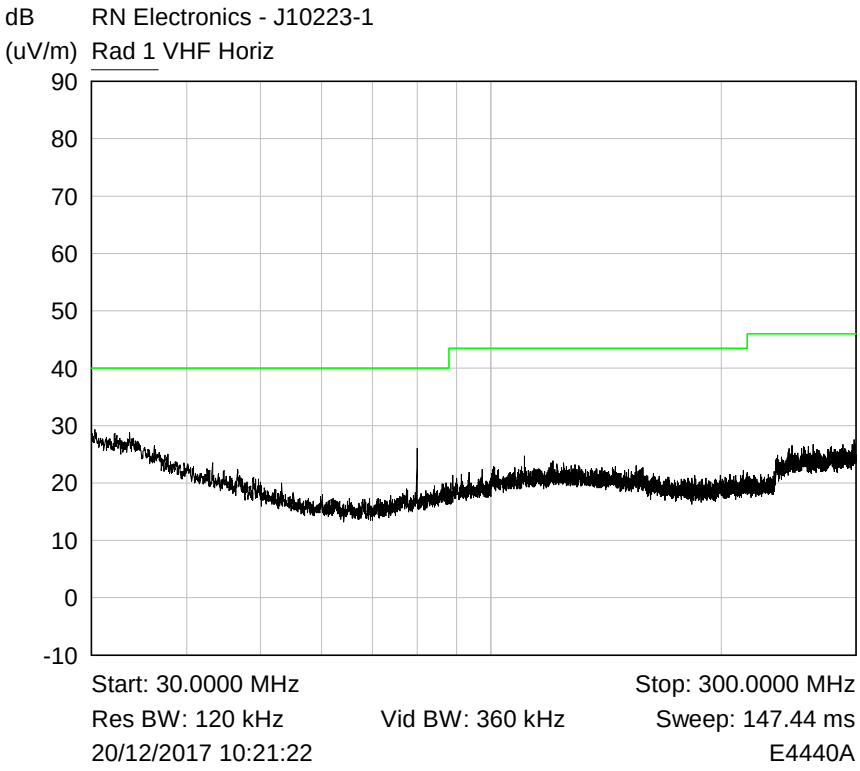
Plot of 150kHz-30MHz Parallel



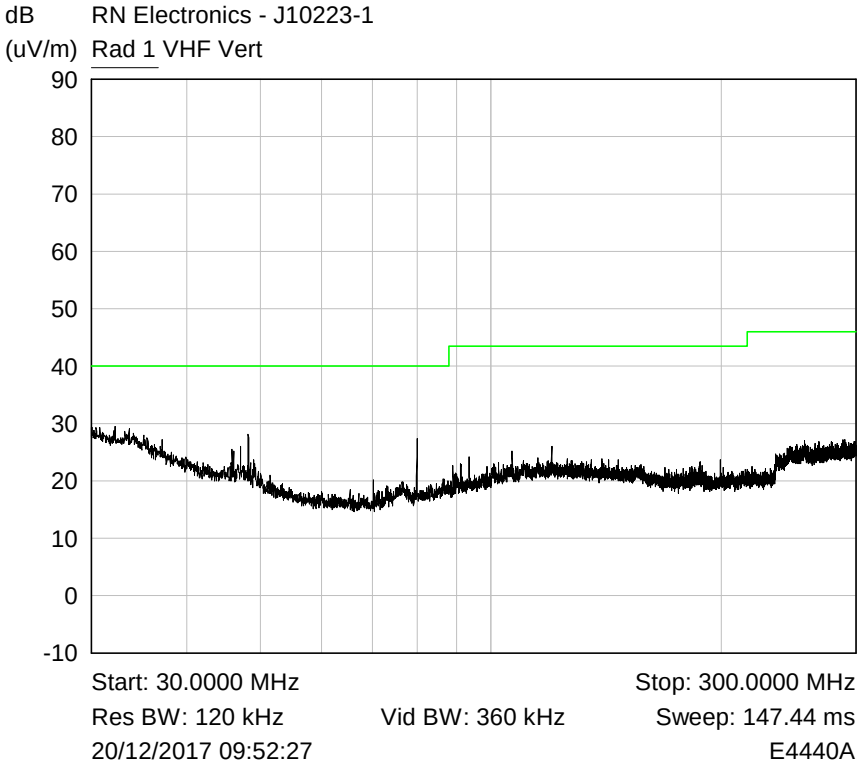
Plot of 150kHz-30MHz Perpendicular

6.4 Radiated emissions 30 MHz -1 GHz

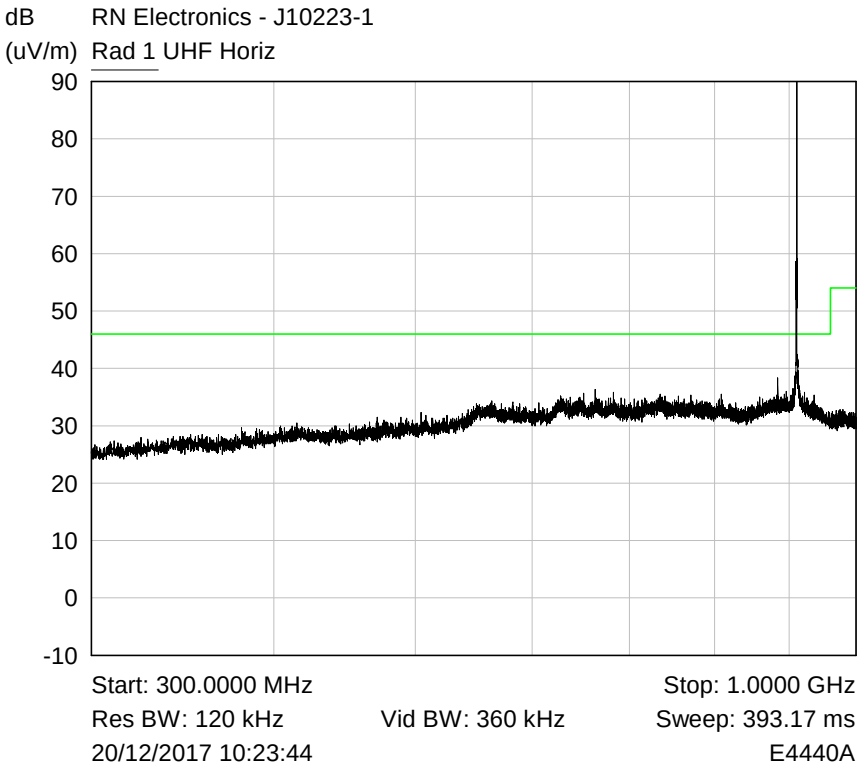
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 910.5 MHz



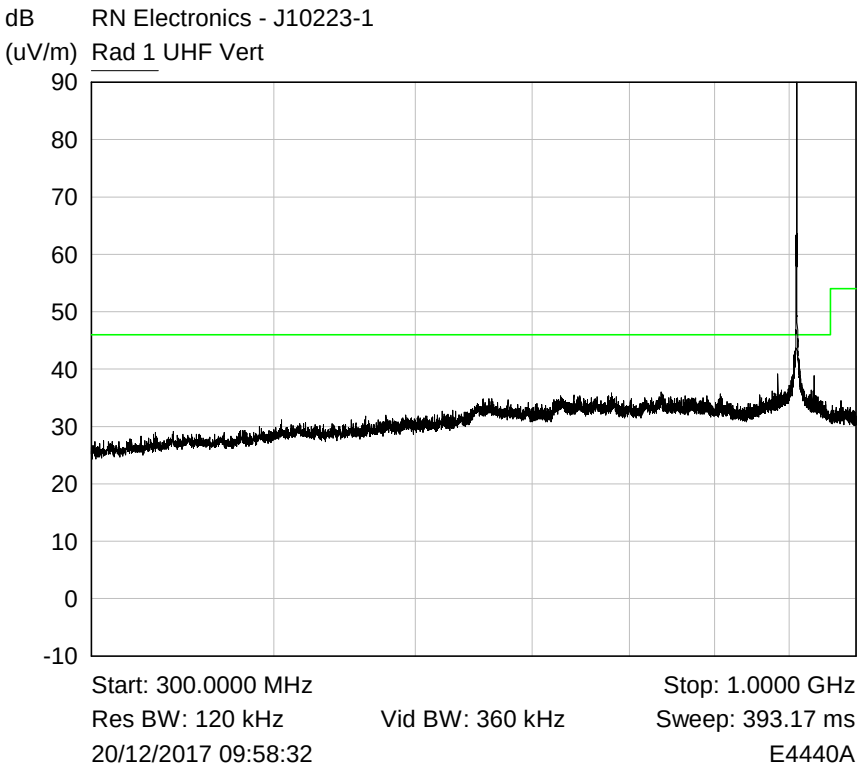
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

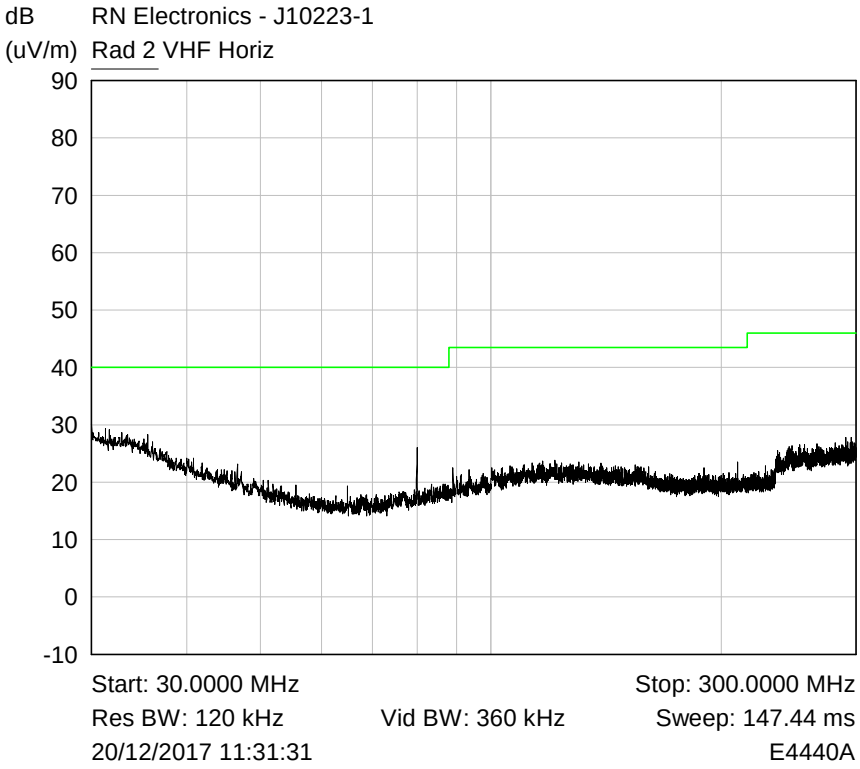


Plot of Peak emissions for UHF Horizontal against the QP limit line.

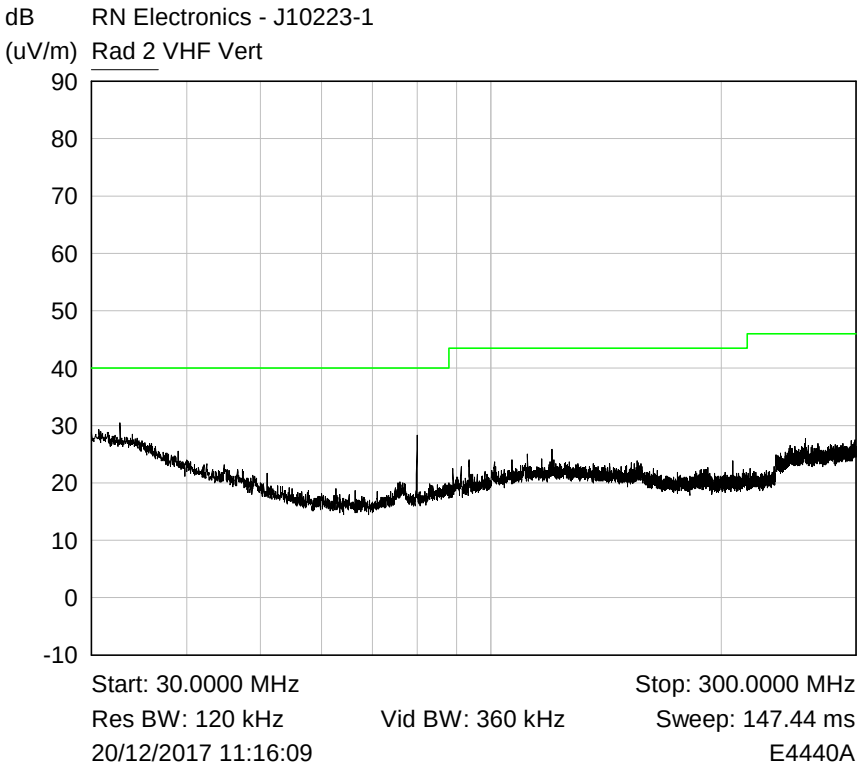


Plot of Peak emissions for UHF Vertical against the QP limit line.

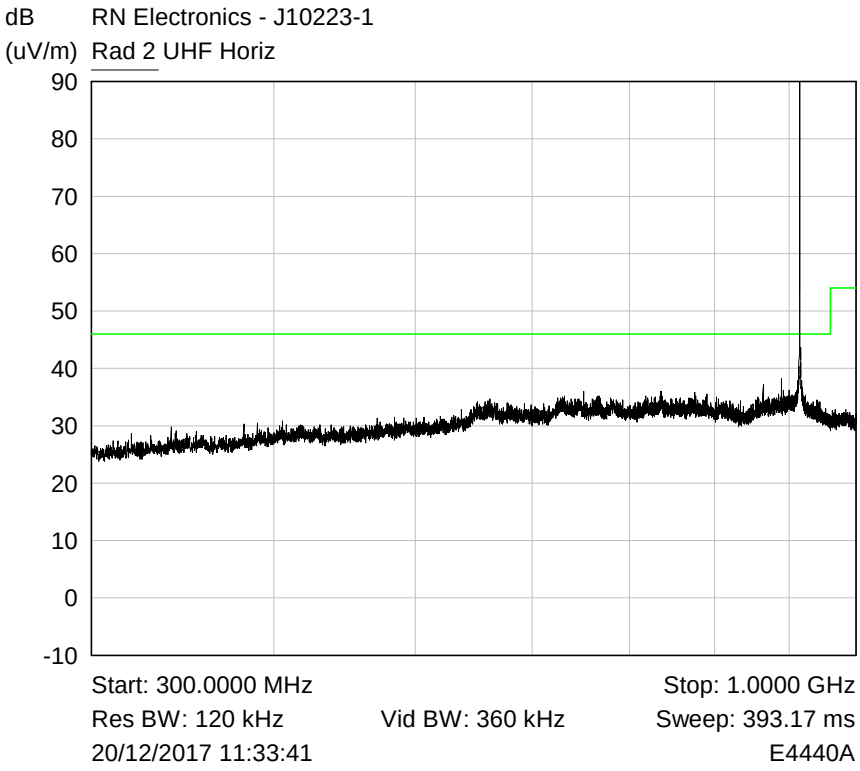
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 915 MHz



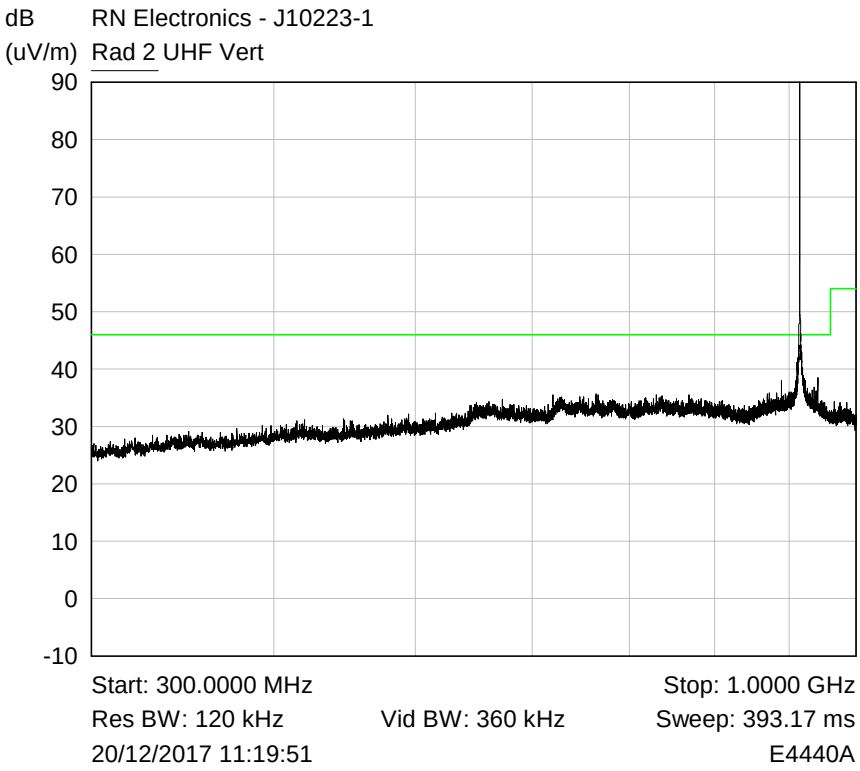
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

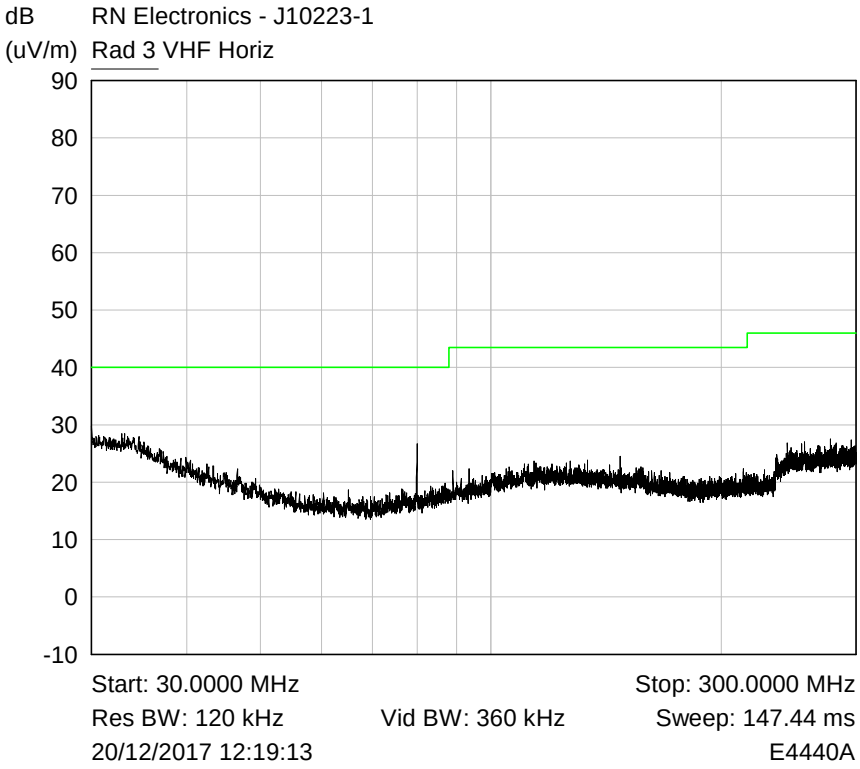


Plot of Peak emissions for UHF Horizontal against the QP limit line.

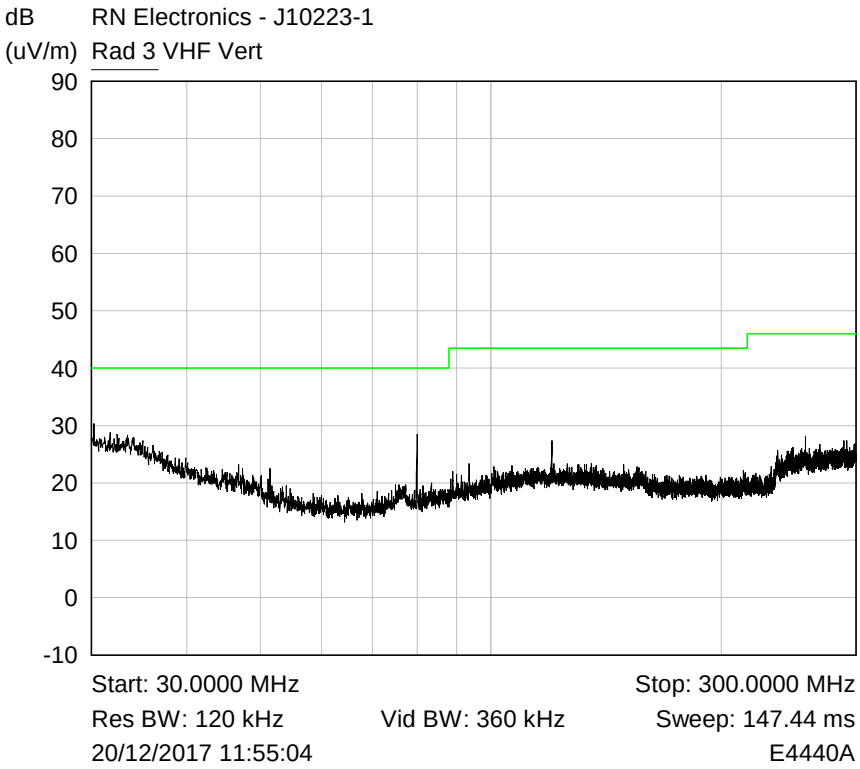


Plot of Peak emissions for UHF Vertical against the QP limit line.

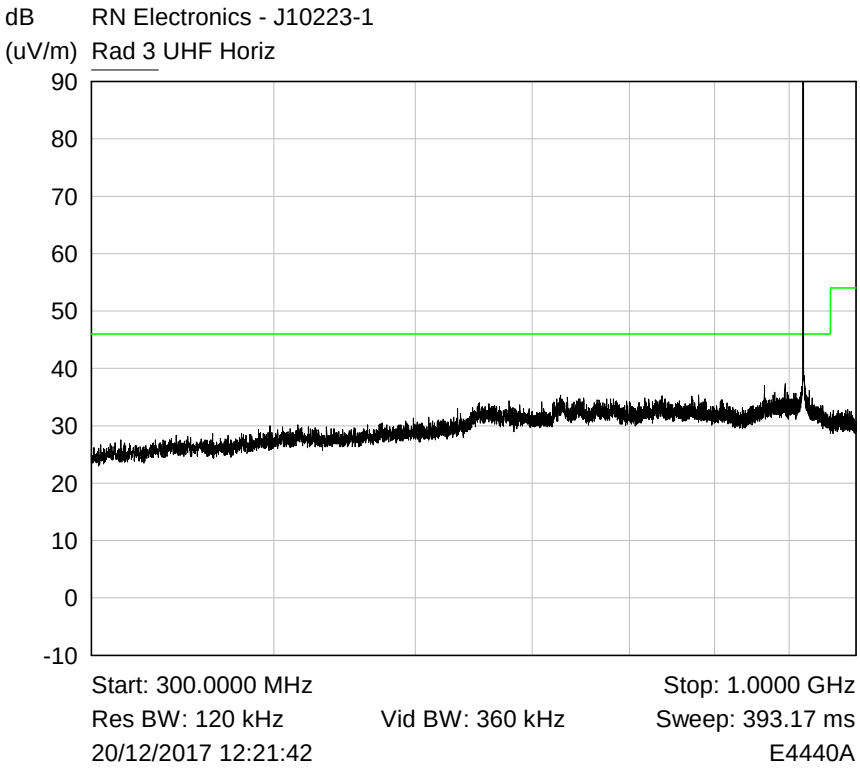
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 919.975 MHz



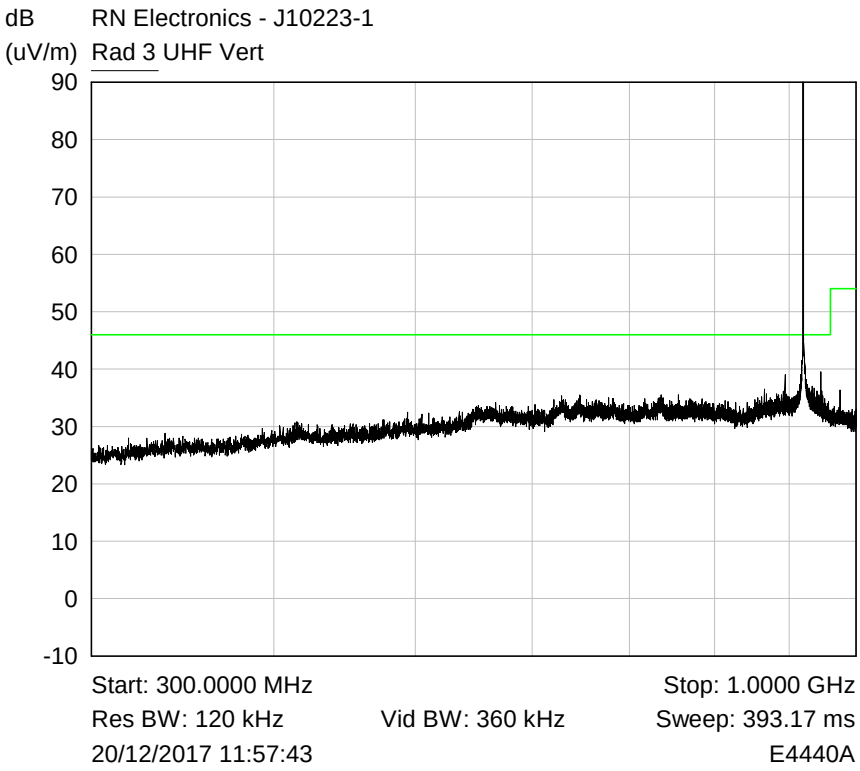
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



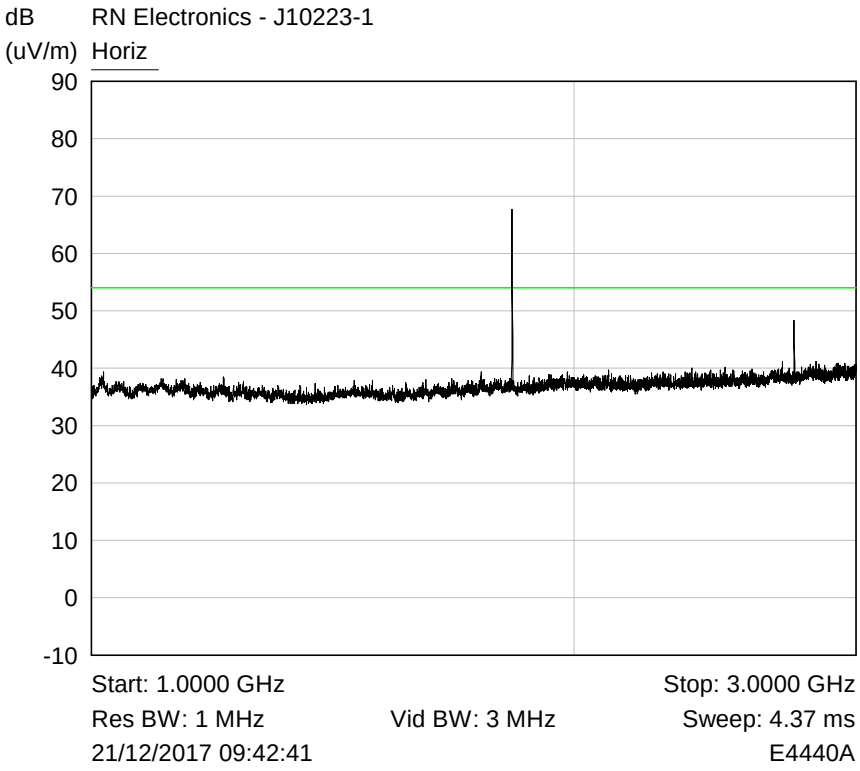
Plot of Peak emissions for UHF Horizontal against the QP limit line.

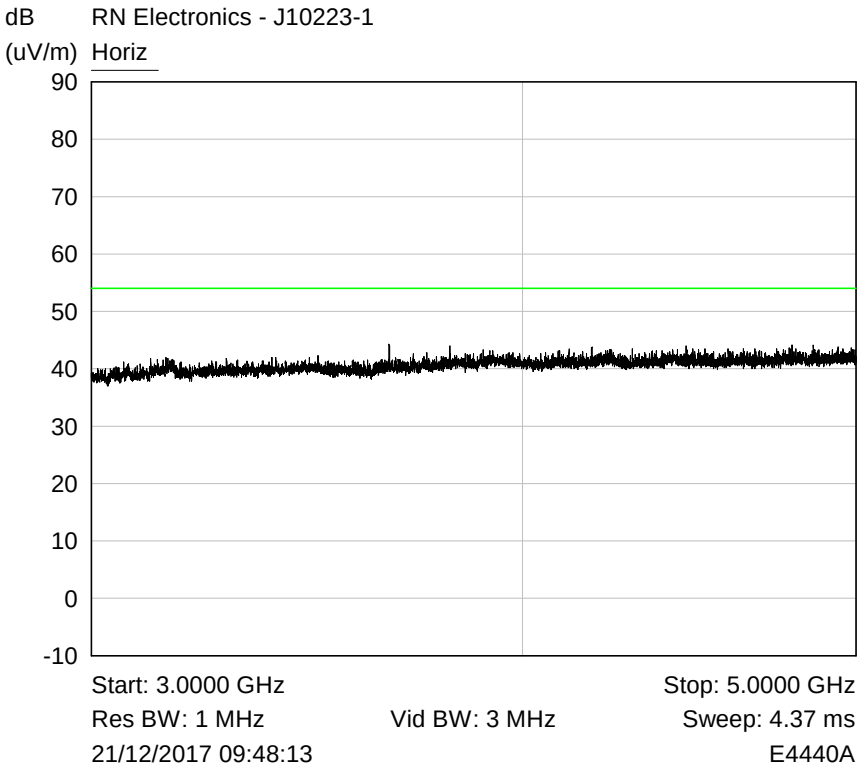


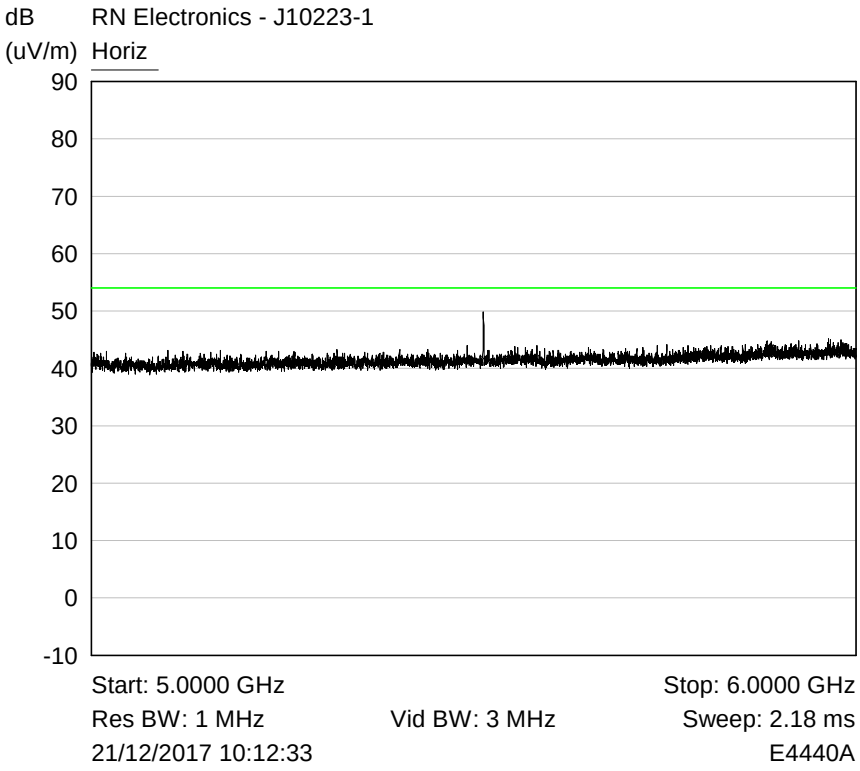
Plot of Peak emissions for UHF Vertical against the QP limit line.

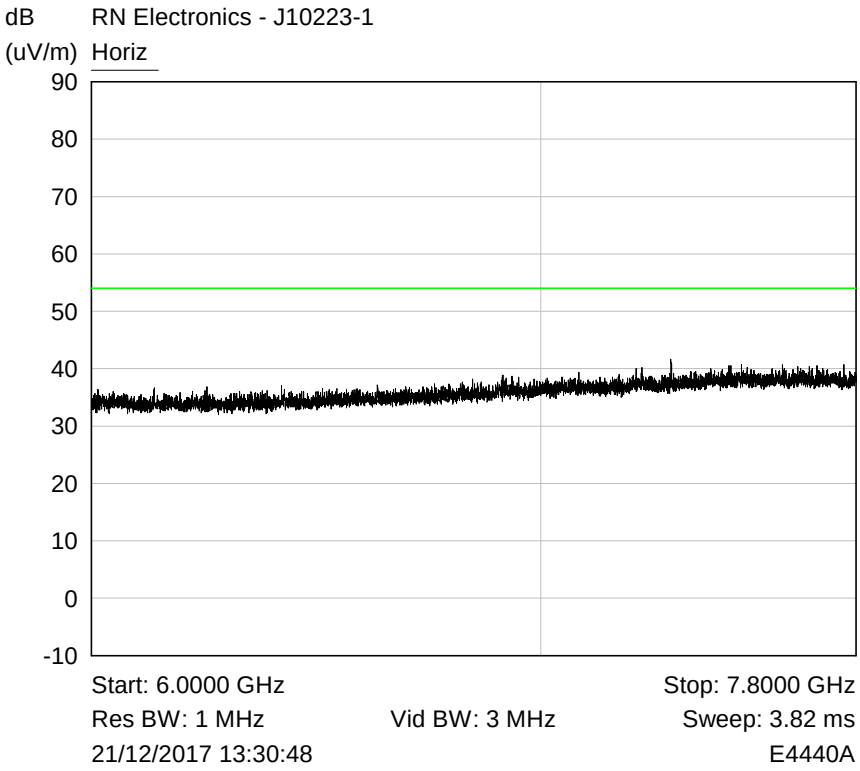
6.5 Radiated emissions above 1 GHz

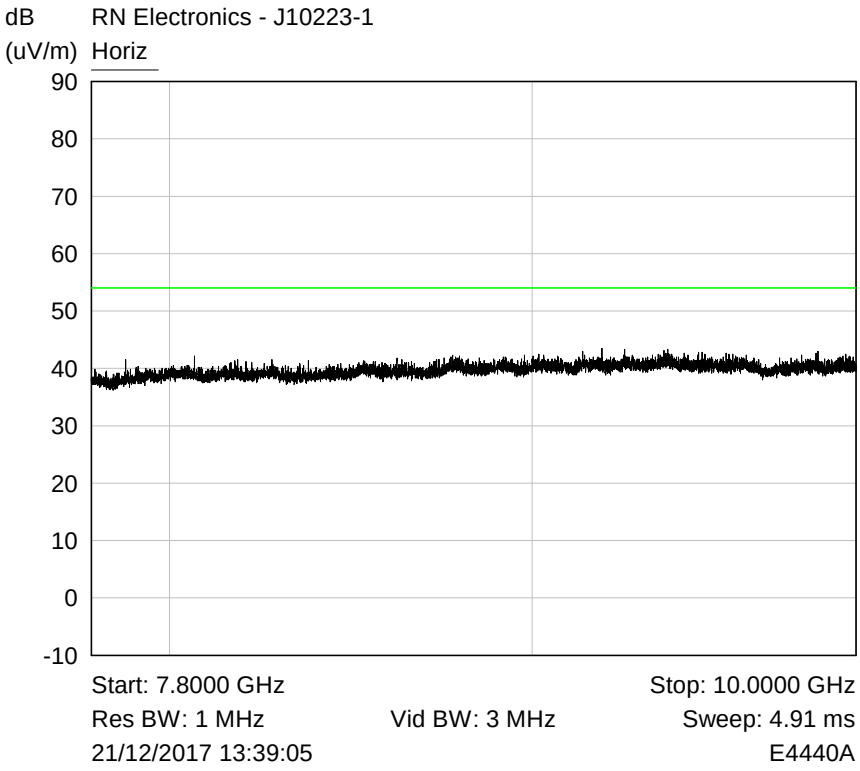
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 915 MHz

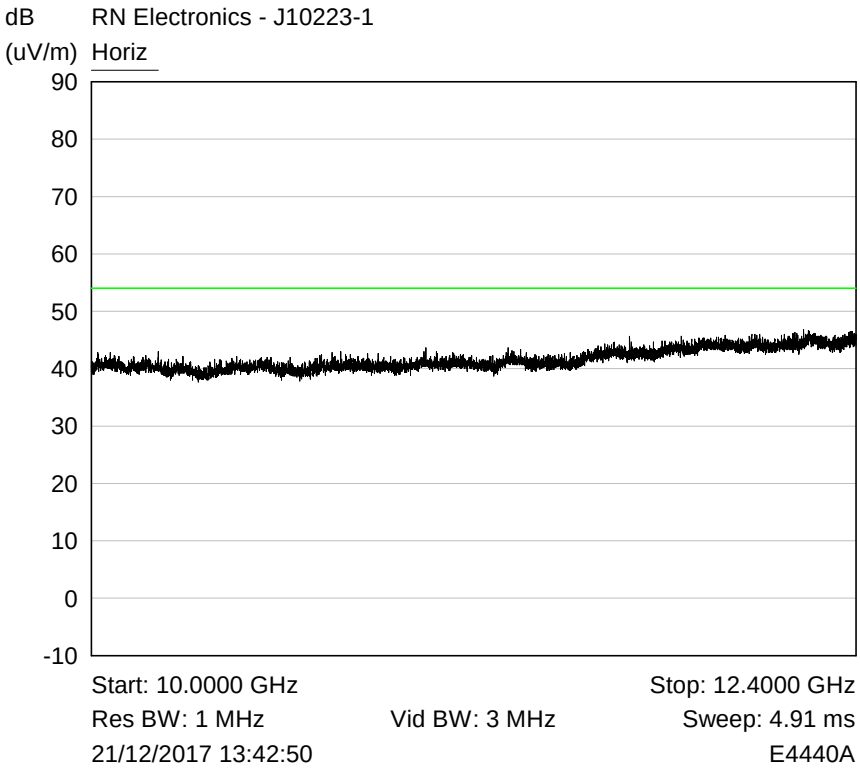


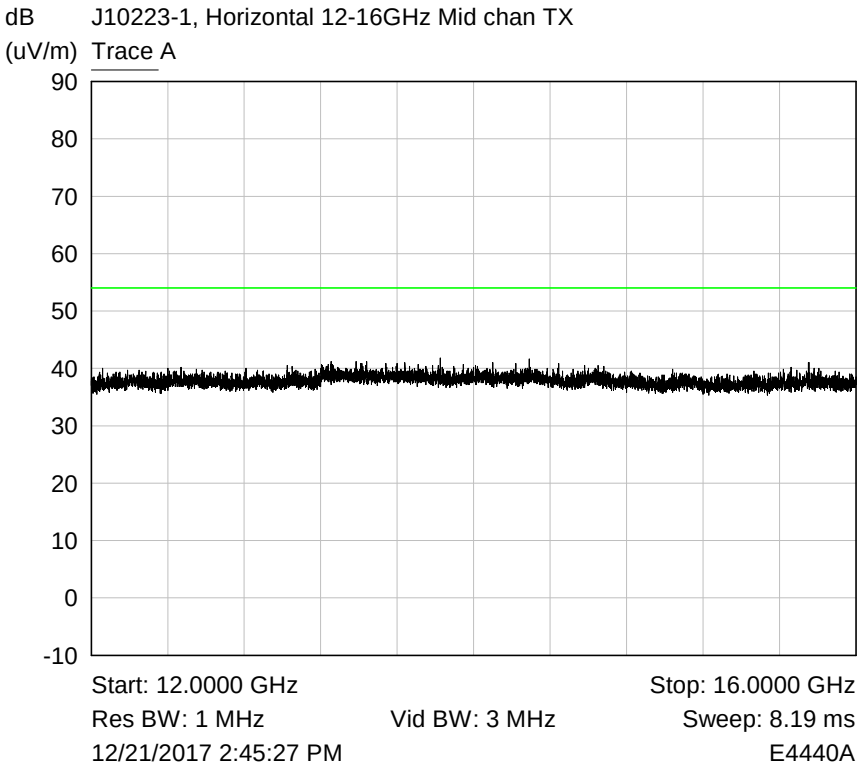


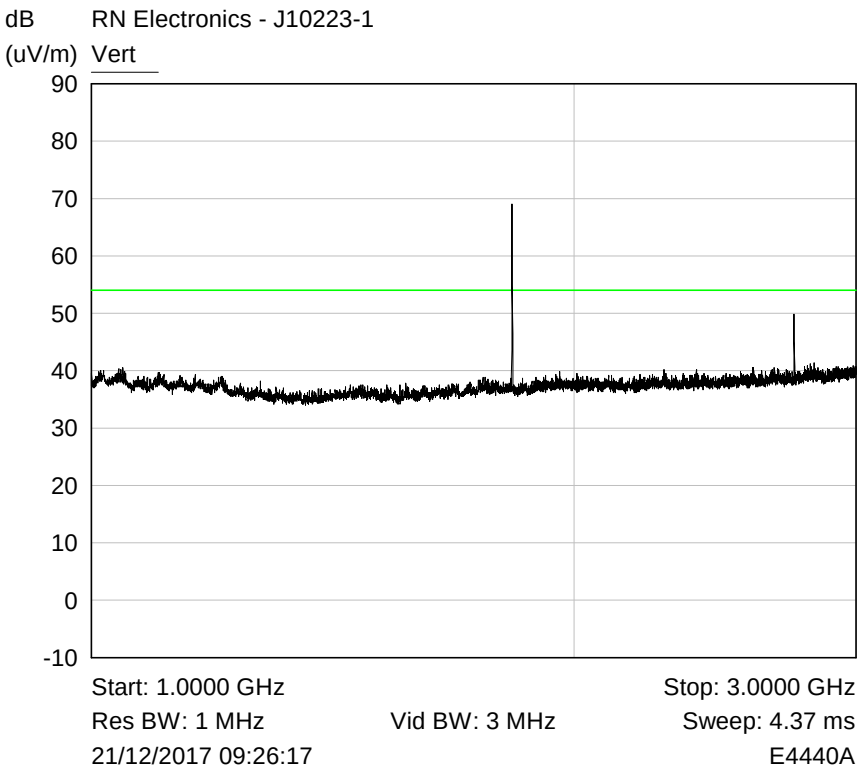


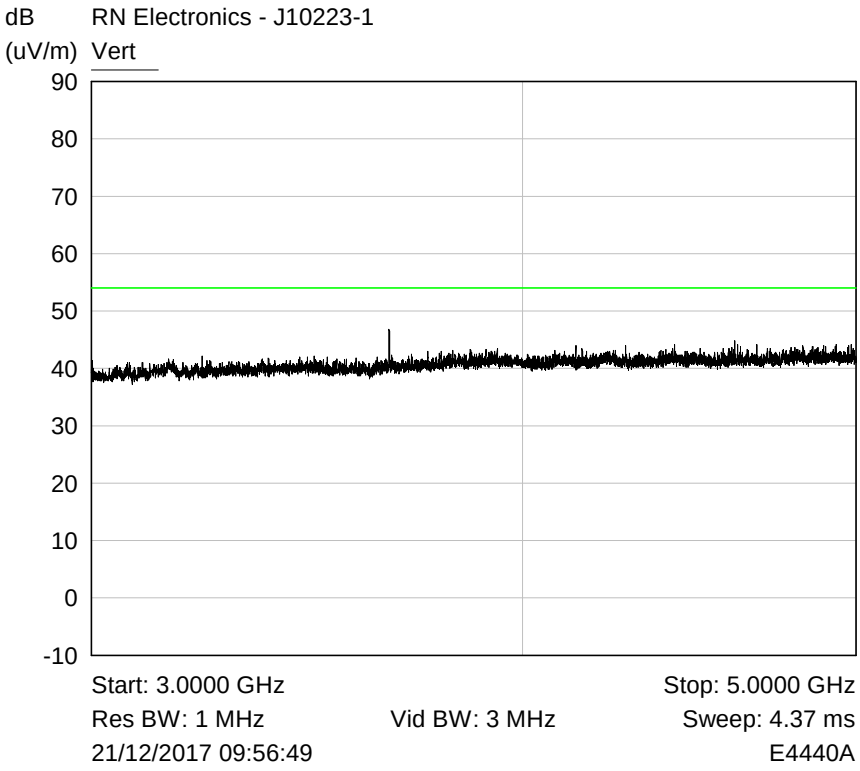


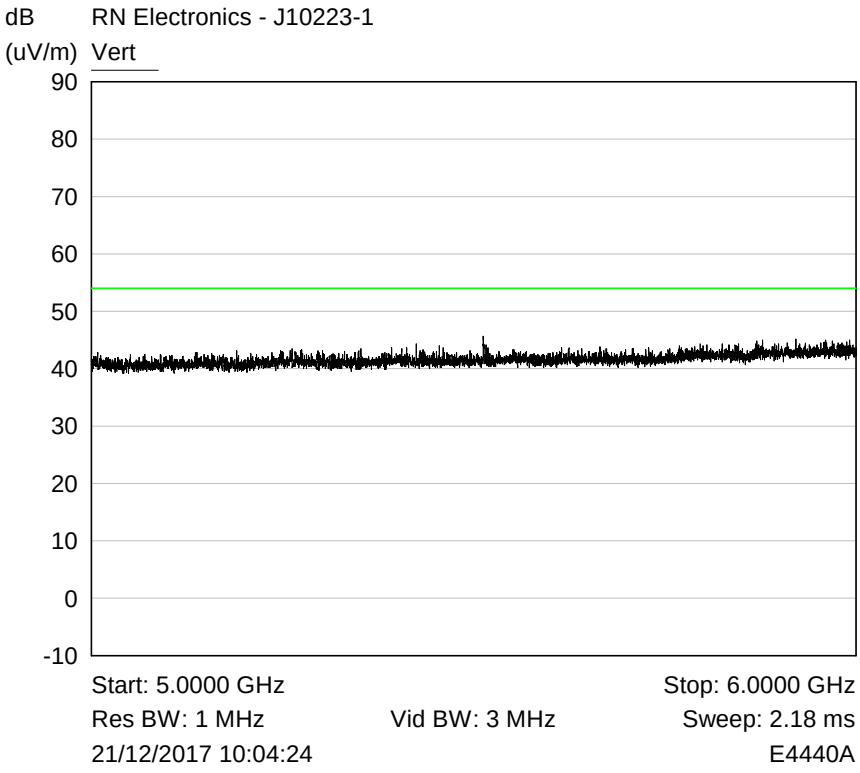


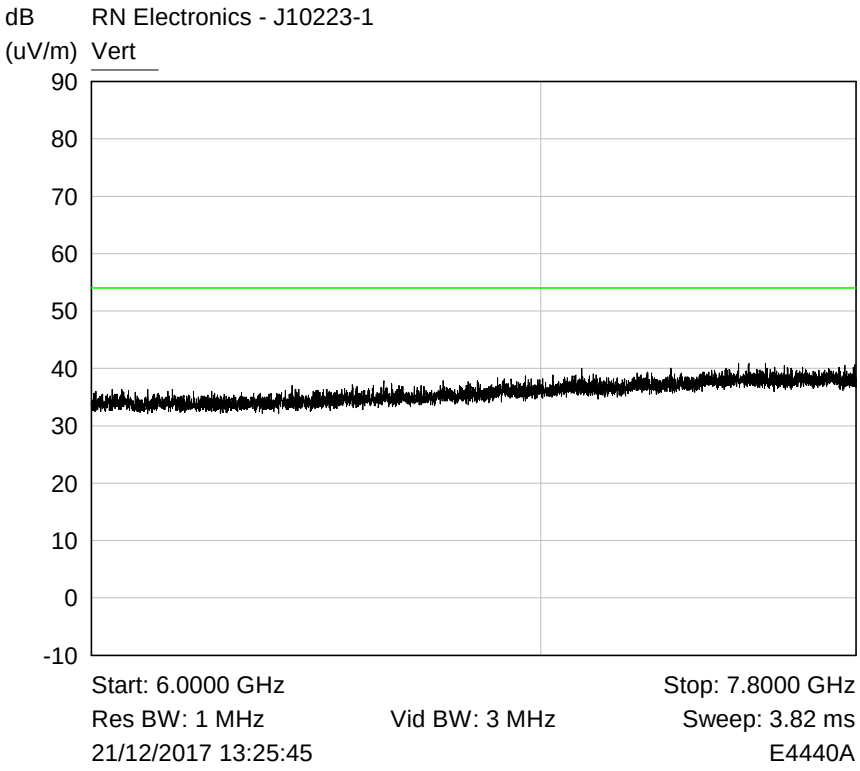


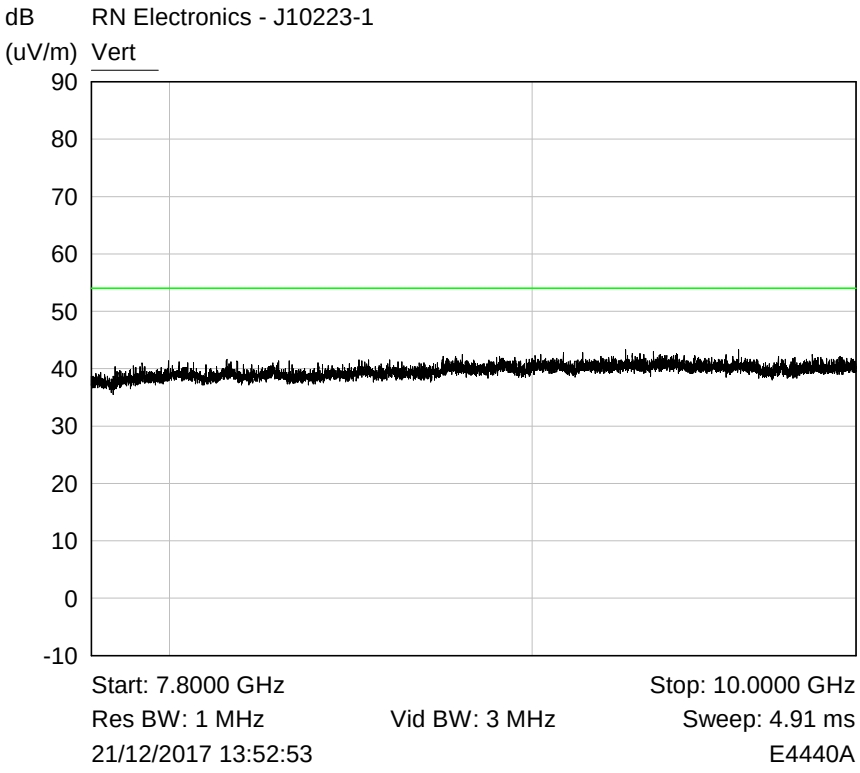


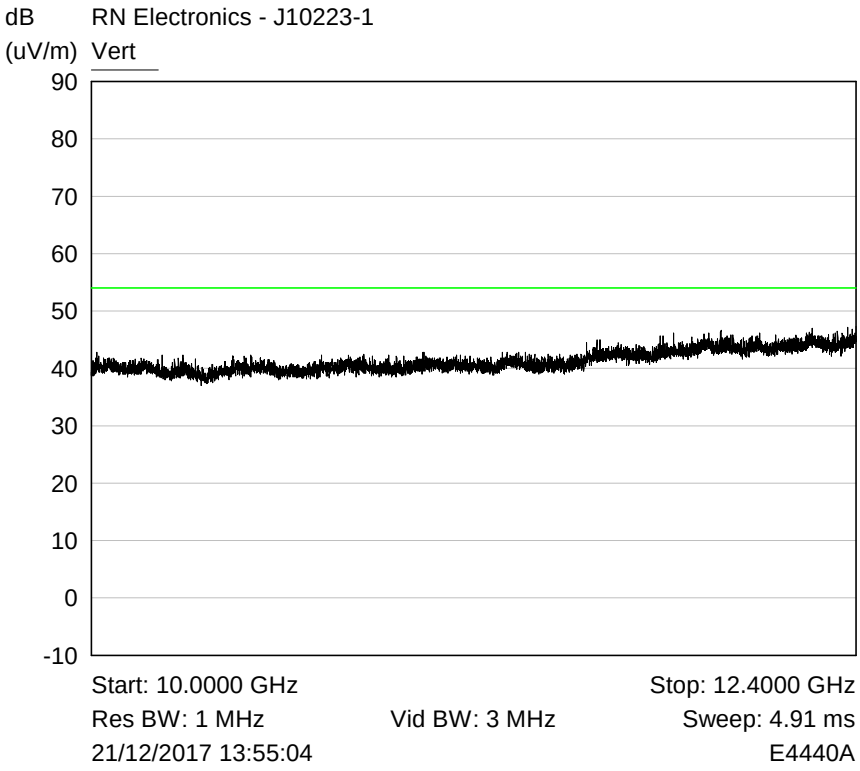


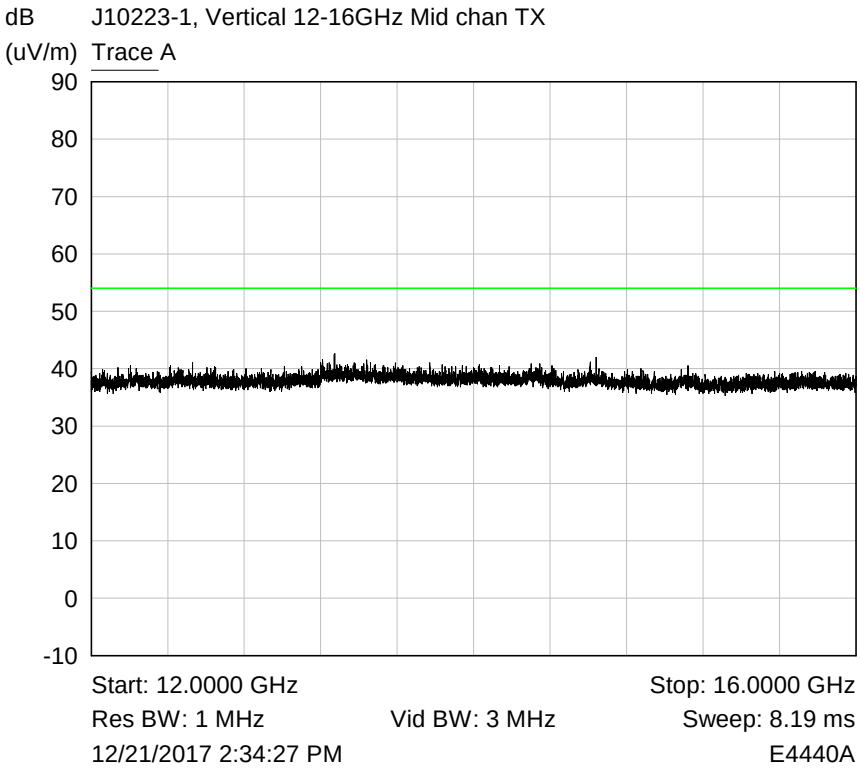




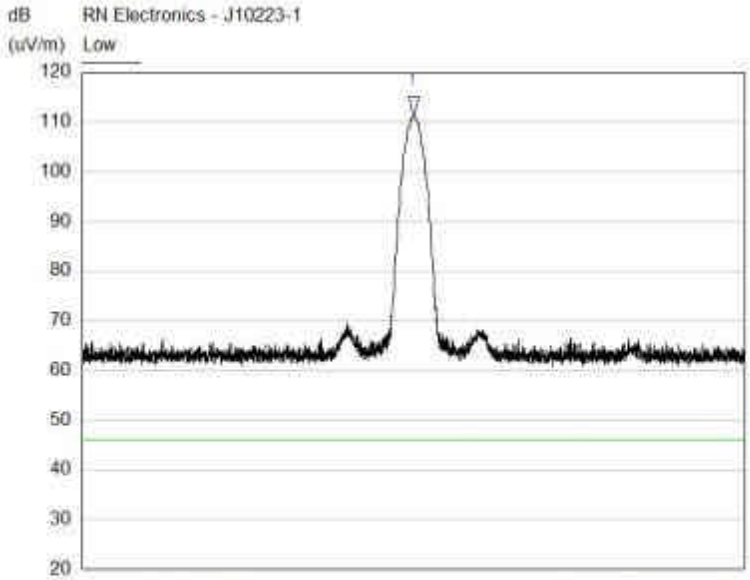




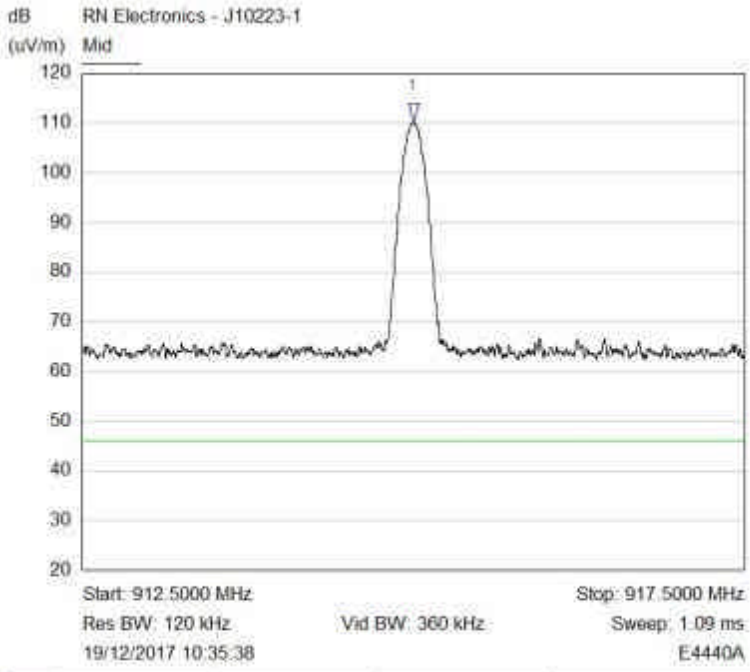




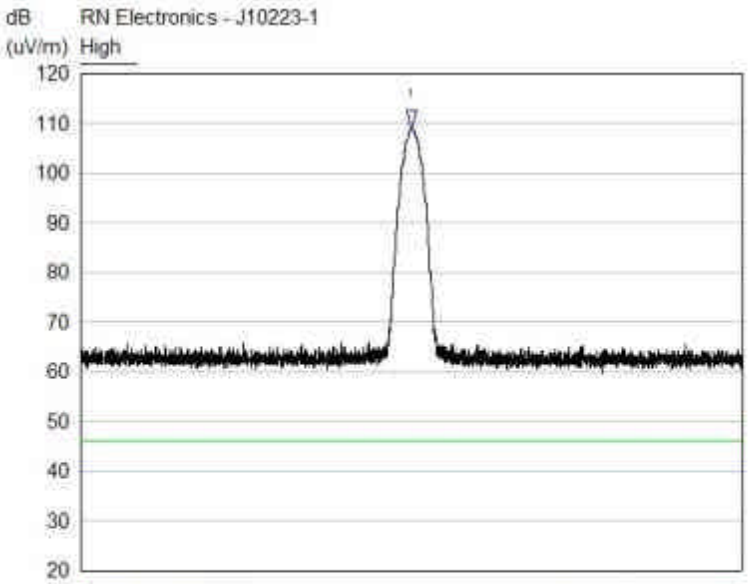
6.6 Effective radiated power field strength



Mkr	Trace	X-Axis	Value	Notes
1	Low	910.4985 MHz	110.98 dB(uV/m)	



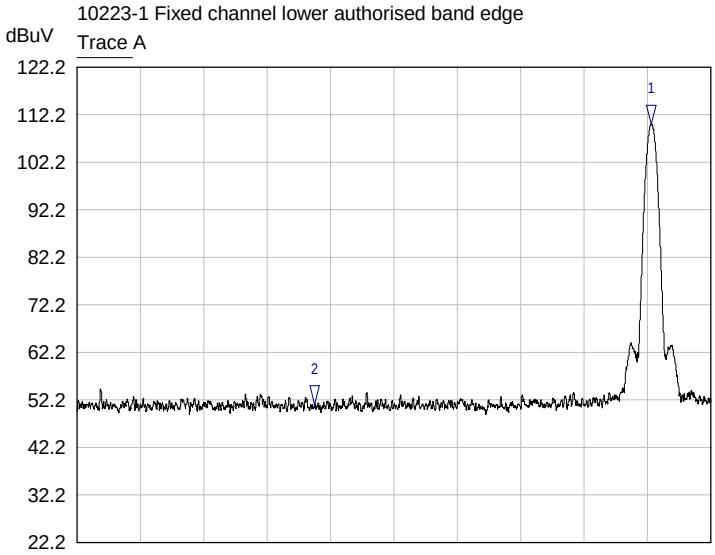
Mkr	Trace	X-Axis	Value	Notes
1	Mid	914.9942 MHz	110.08 dB(uV/m)	



Mkr	Trace	X-Axis	Value	Notes
1	High	919.9704 MHz	108.63 dB(uV/m)	

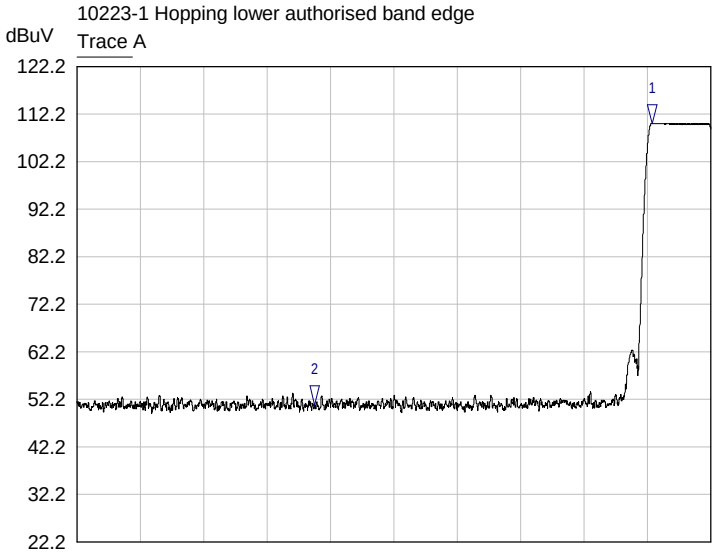
6.7 Band Edge Compliance

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 dBm, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 910.5 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	910.5018 MHz	110.23 dBuV	
2 ▽	Trace A	902.0007 MHz	51.25 dBuV	

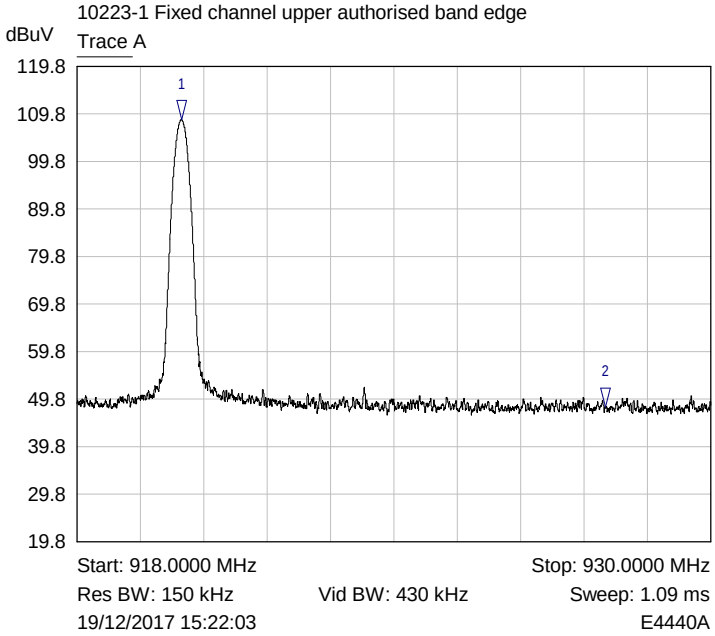
Fixed, lower authorised band edge plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	910.5272 MHz	110.23 dBuV	
2 ▽	Trace A	902.0007 MHz	50.96 dBuV	

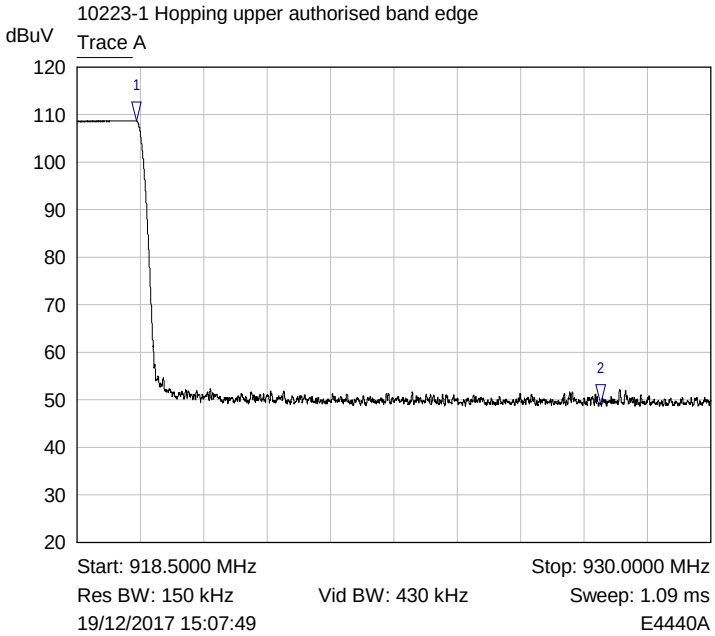
Hopping, lower authorised band edge plot

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 dBm, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 919.975 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	919.9749 MHz	108.55 dBuV	
2	Trace A	928.0002 MHz	48.14 dBuV	

Fixed, upper authorised band edge plot

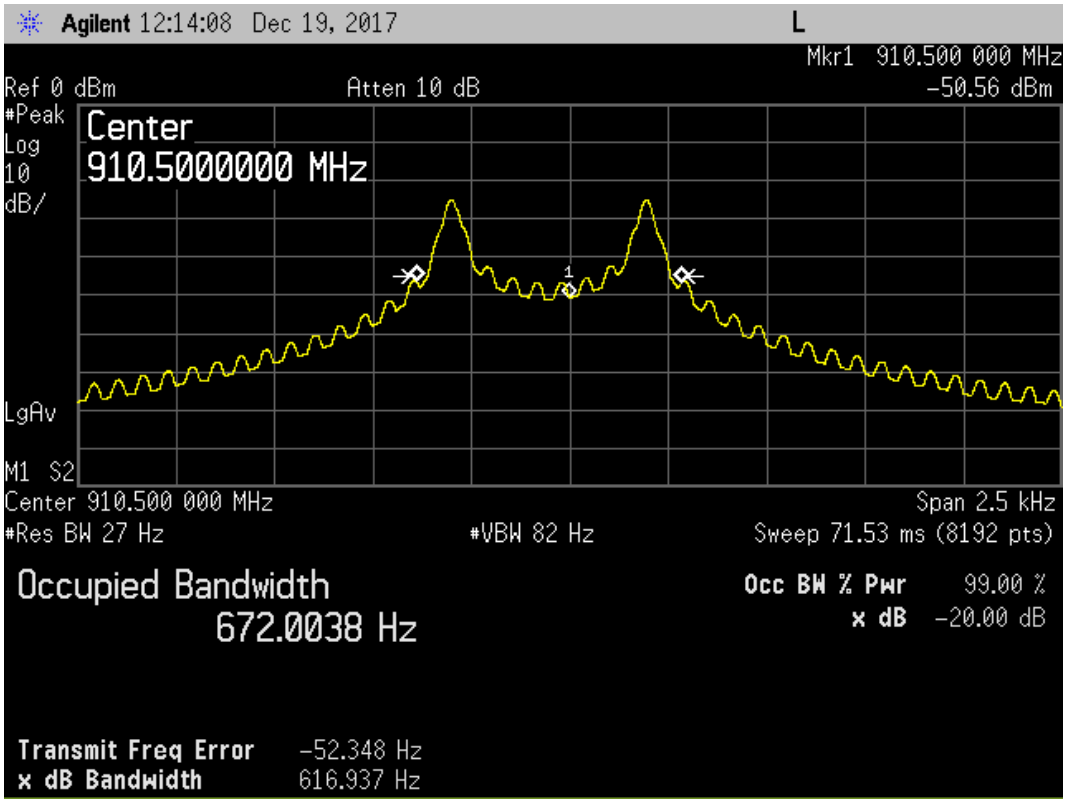


Mkr	Trace	X-Axis	Value	Notes
1	Trace A	919.5754 MHz	108.72 dBuV	
2	Trace A	927.9993 MHz	49.17 dBuV	

Hopping, upper authorised band edge plot

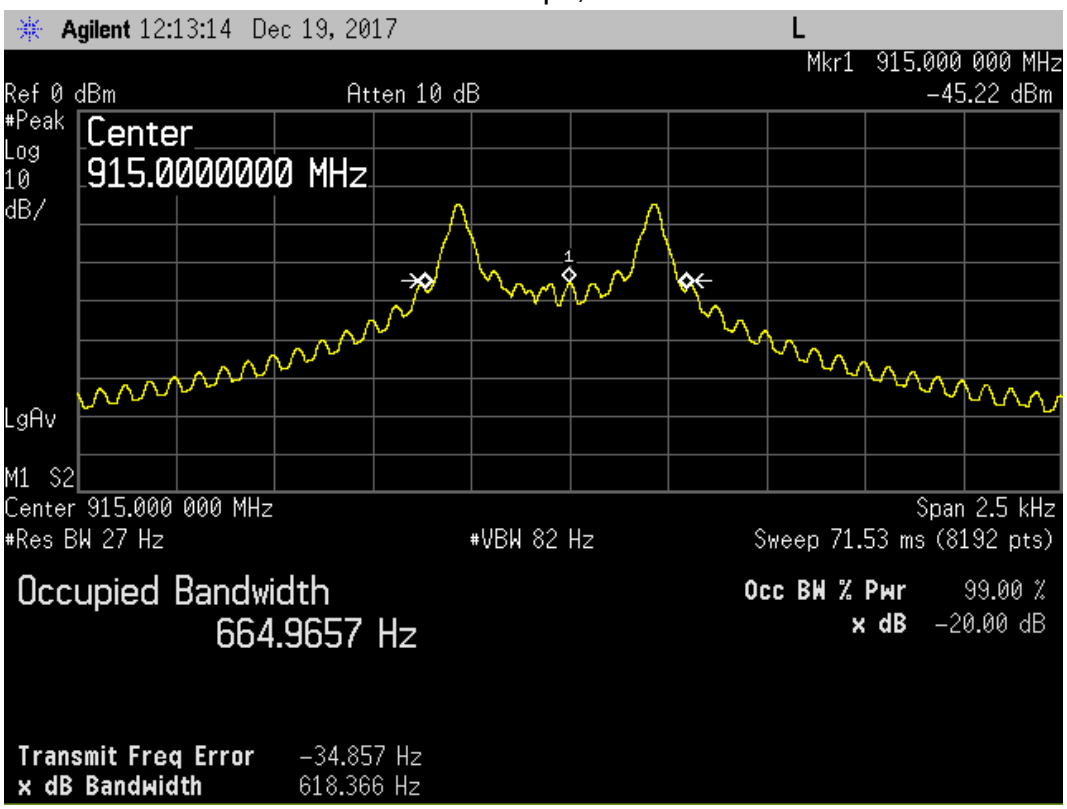
6.8 Occupied bandwidth

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 62.5 bps, Channel 910.5 MHz



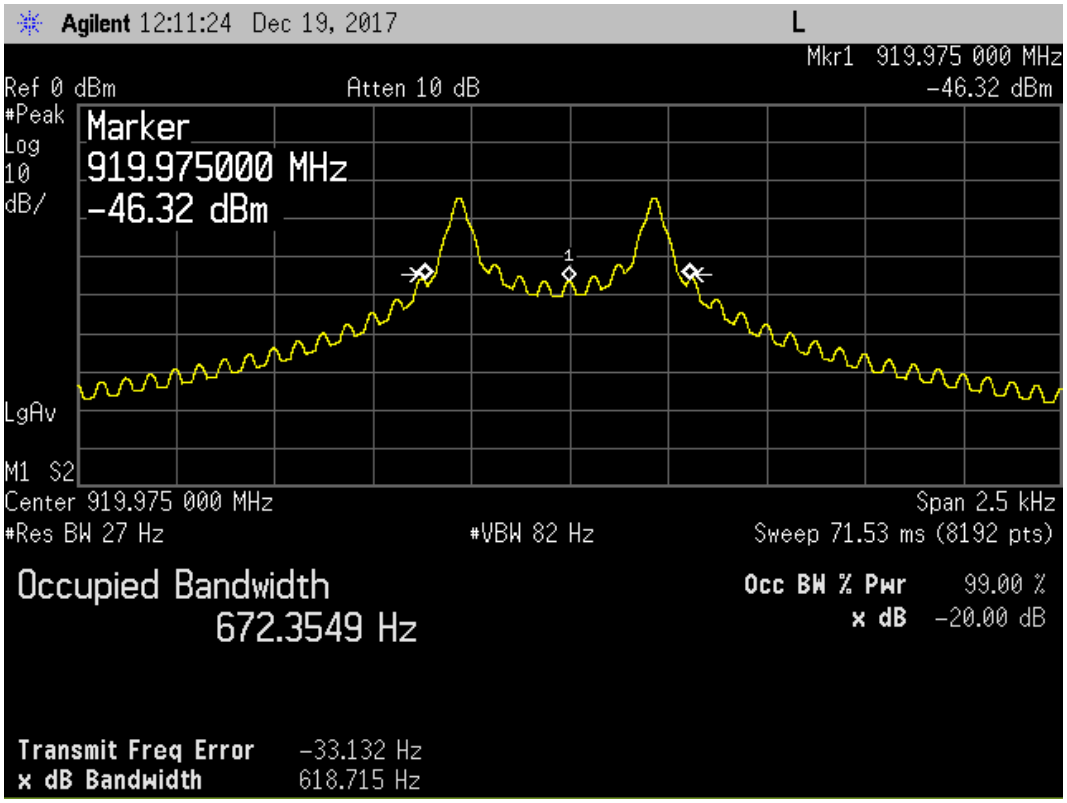
Plot for 20 dB Bandwidth (Hz) Nominal Temp & Volts

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 62.5 bps, Channel 915 MHz



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

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 62.5 bps, Channel 919.975 MHz

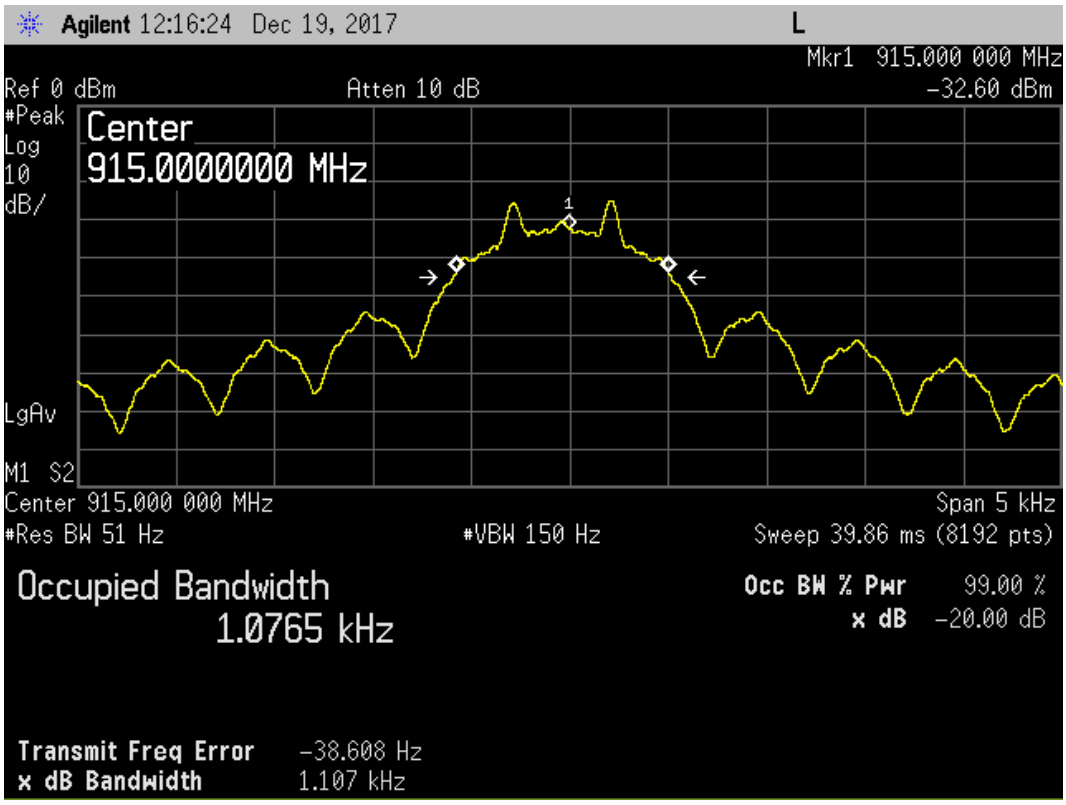


Plot for 20 dB Bandwidth (Hz) Nominal Temp & Volts

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 910.5 MHz

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

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 915 MHz



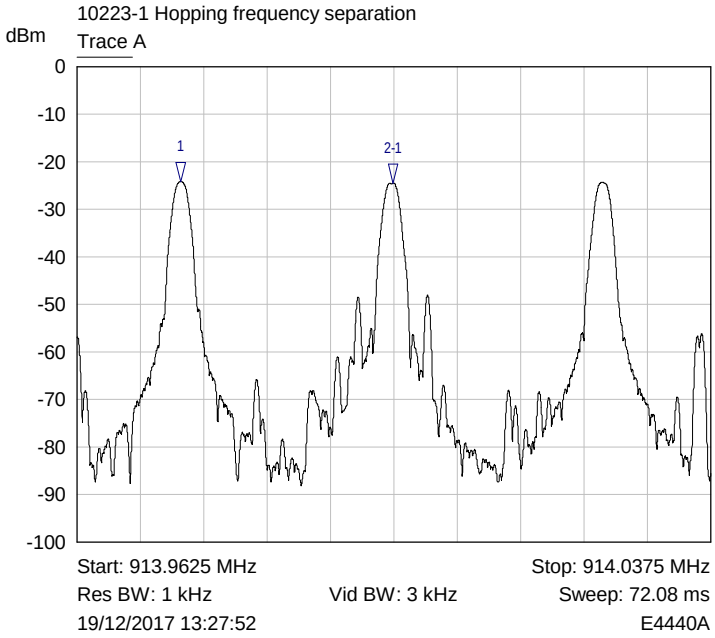
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 919.975 MHz

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

6.9 FHSS carrier frequency separation

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps

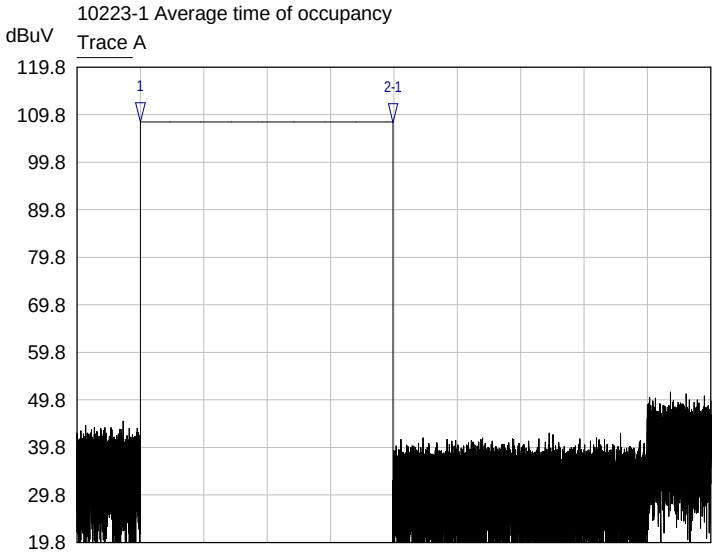


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	913.9747 MHz	-24.16 dBm	
2-1 ▽	Trace A	25.1892 kHz	-0.26 dB	

Plot of Separation (kHz)

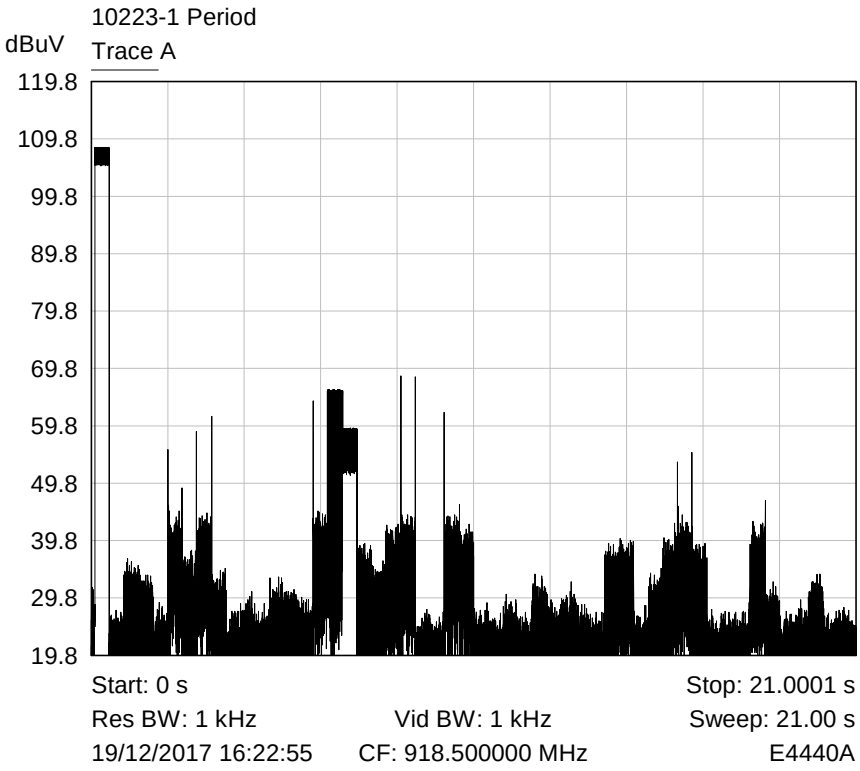
6.10 Average time of occupancy

RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel 918.5 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	99.9051 ms	108.32 dBuV	
2-1	Trace A	399.2539 ms	-0.18 dB	

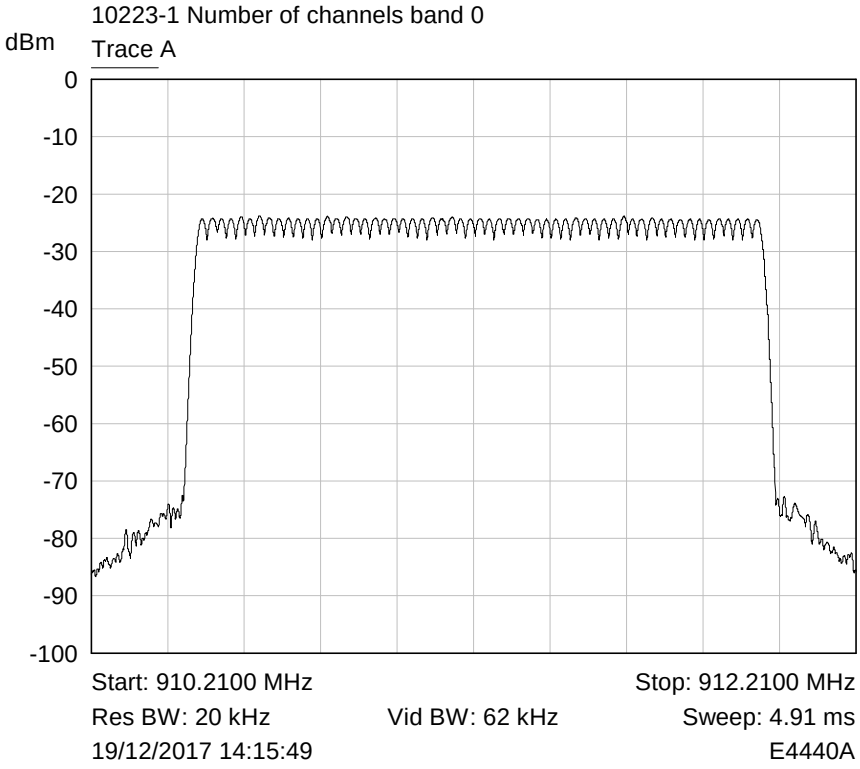
Measured Dwell time/pulse width (ms)



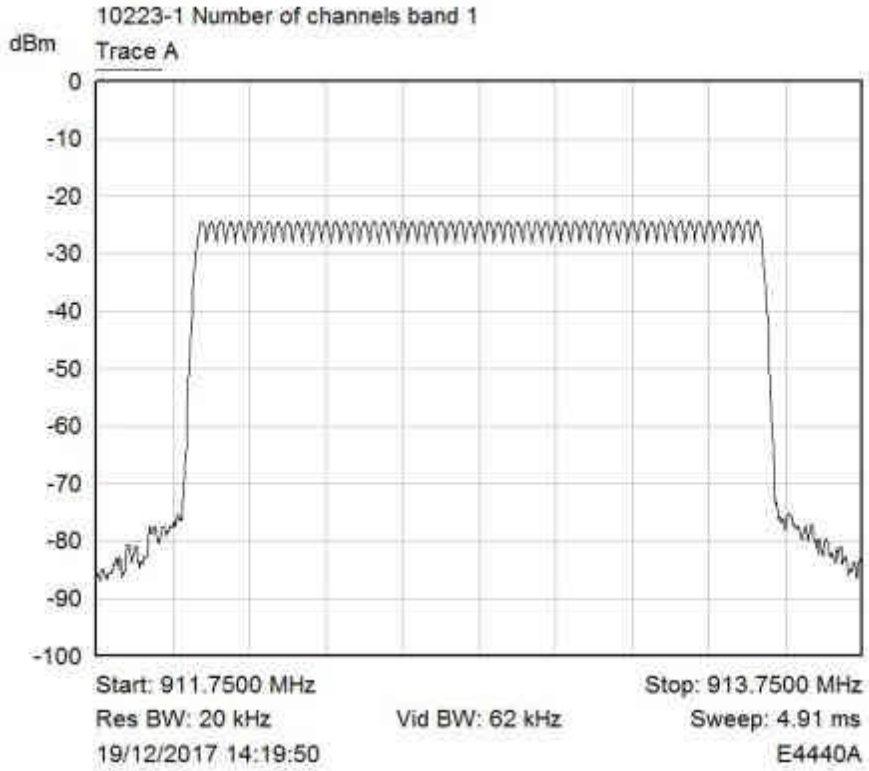
Period time (s)

6.11 Number of Hop Channels

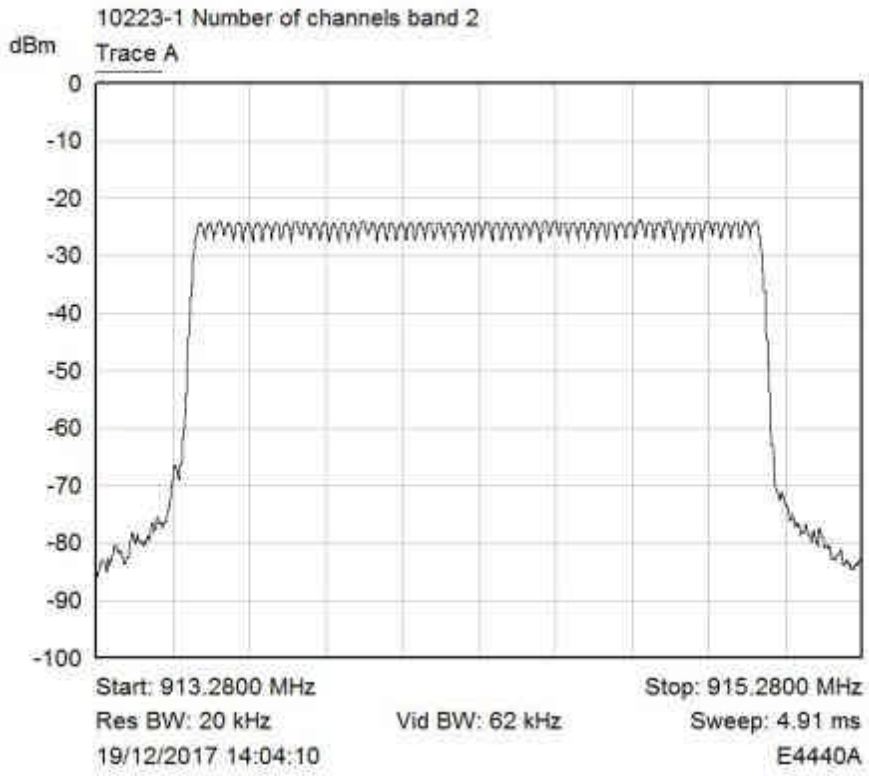
RF Parameters: Band 910.4875 -919.9875 MHz, Power 100 mW, Channel Spacing 25 kHz, Modulation FSK 500 bps, Channel Hopping



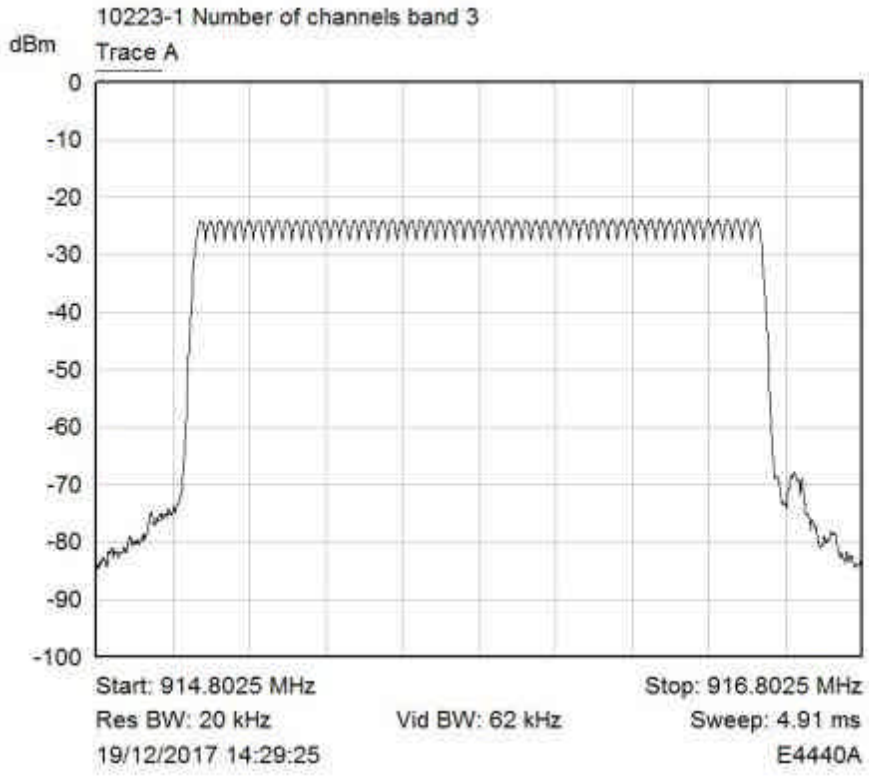
Plot of Hopping Channels band 0



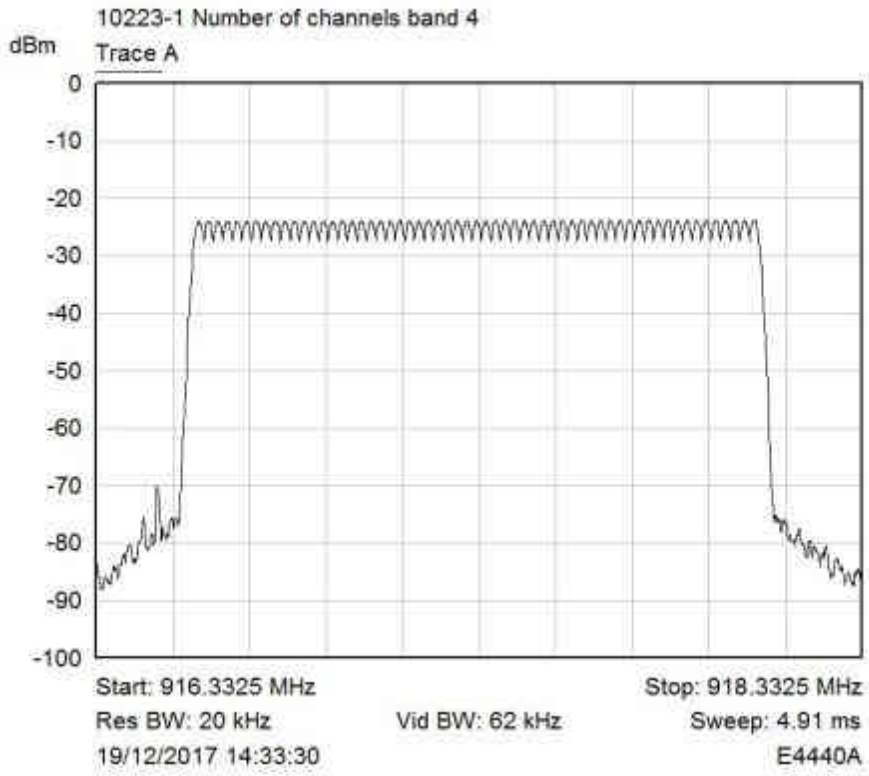
Plot of Hopping Channels band 1



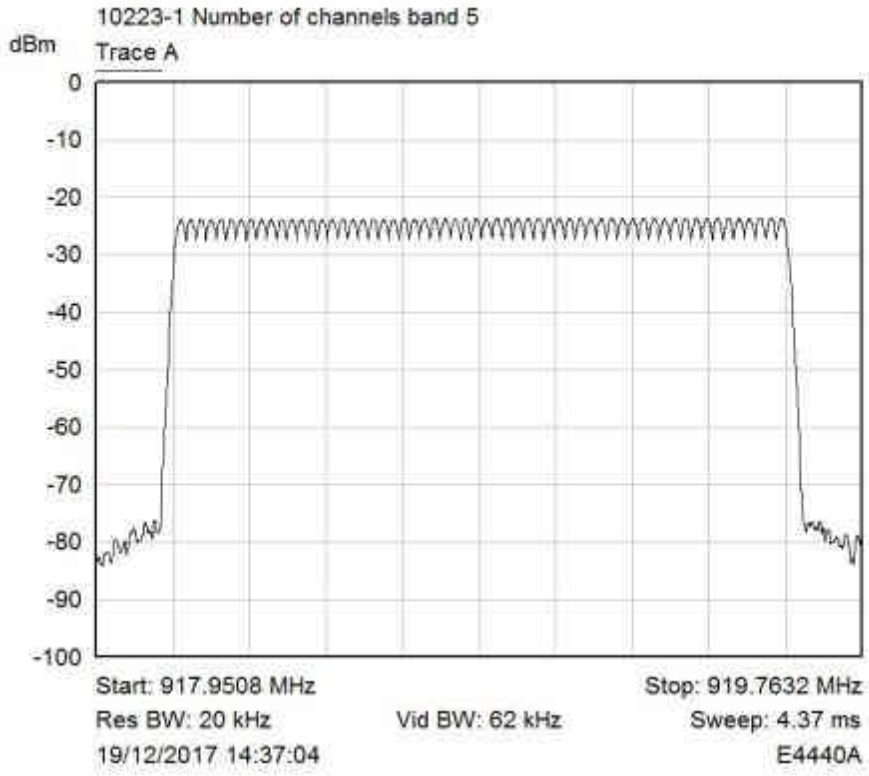
Plot of Hopping Channels band 2



Plot of Hopping Channels band 3



Plot of Hopping Channels band 4



Plot of Hopping Channels band 5

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).

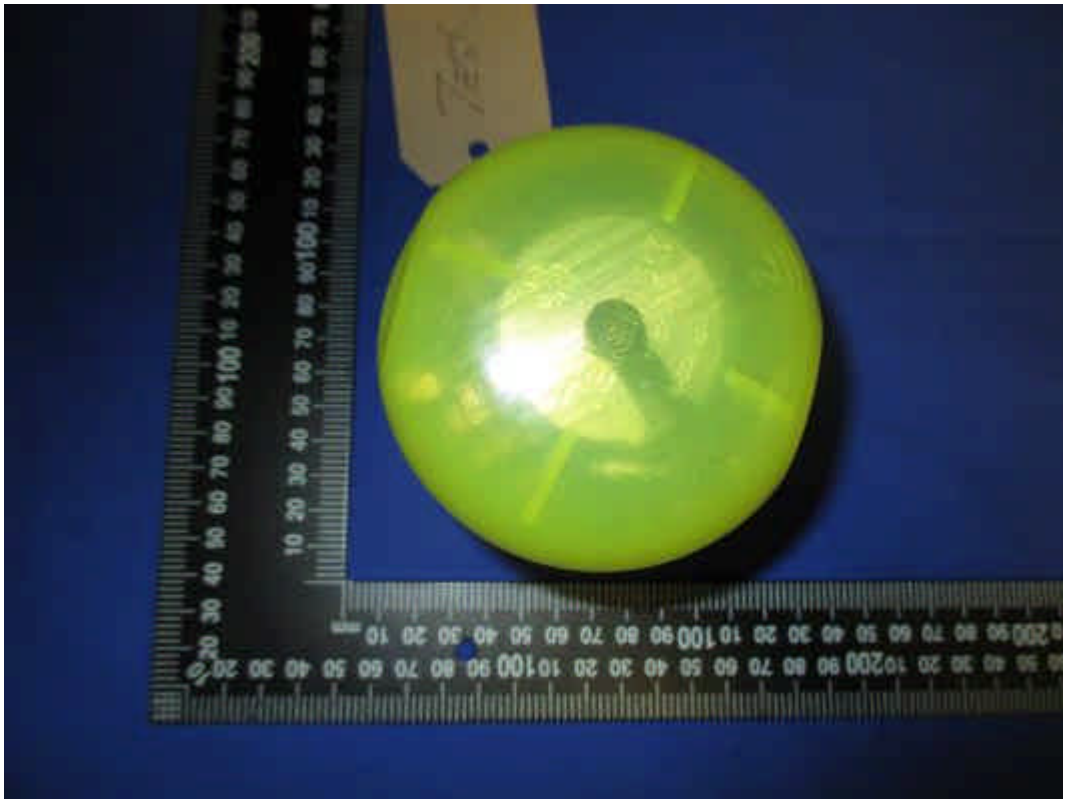
The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

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

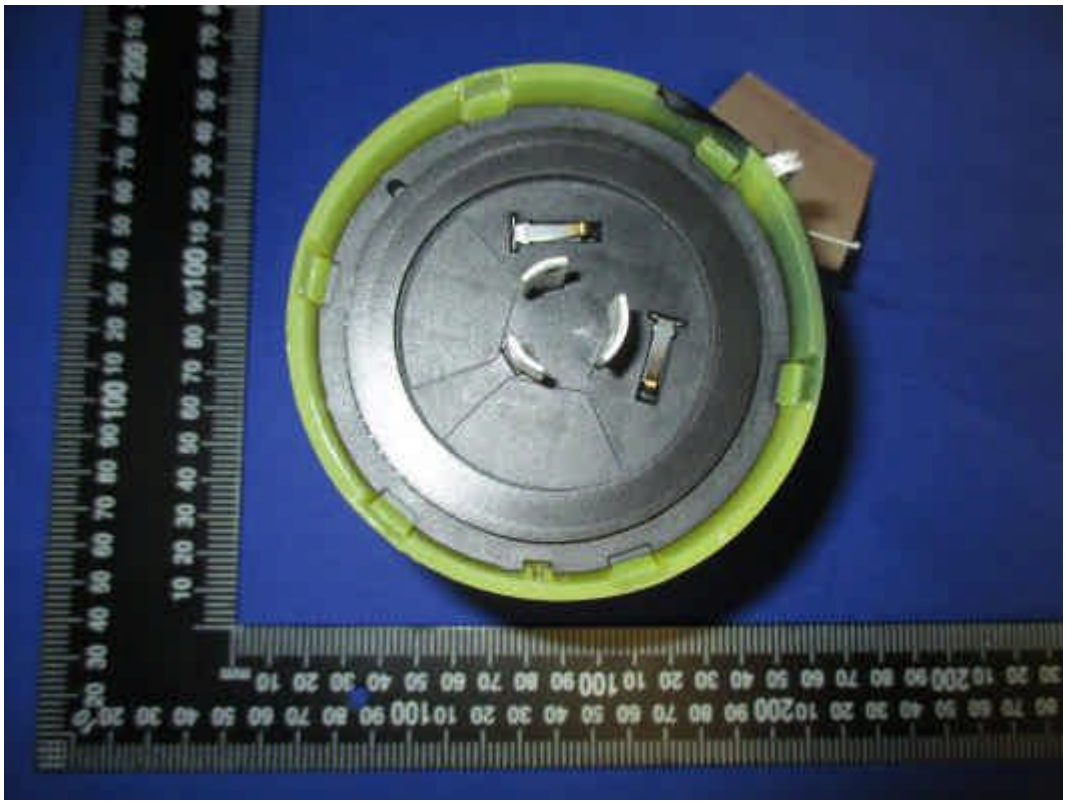
Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

8 Photographs

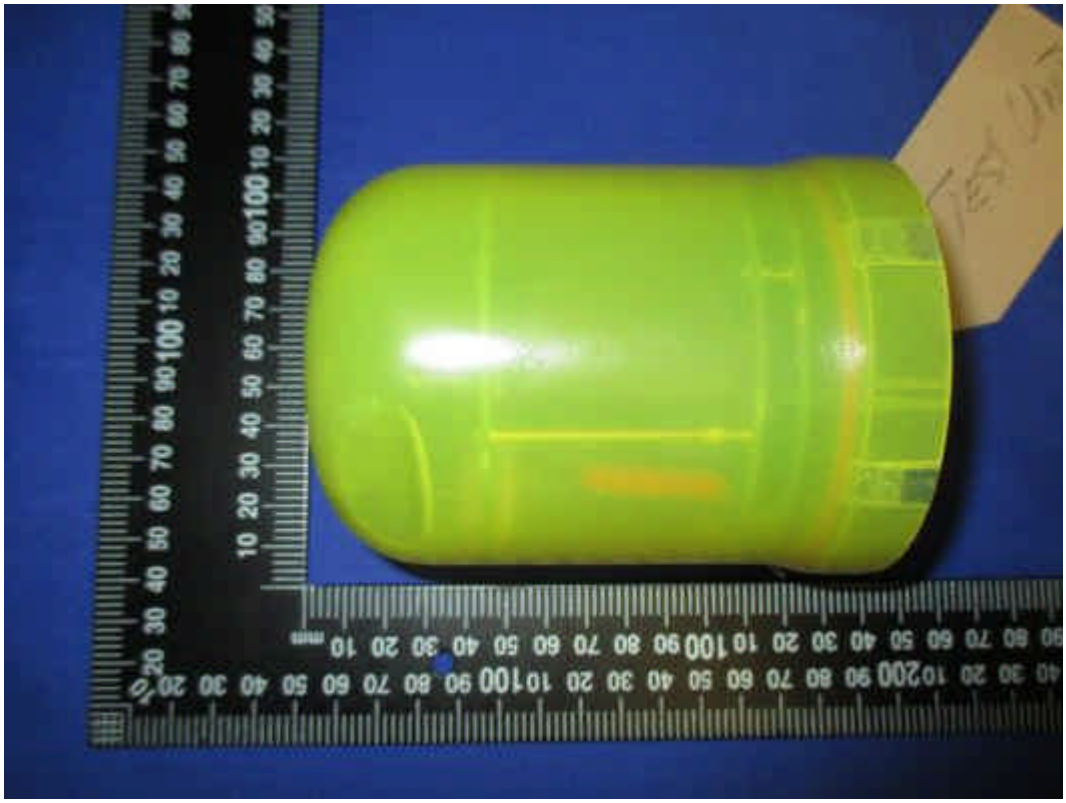
8.1 EUT Front View



8.2 EUT Reverse Angle



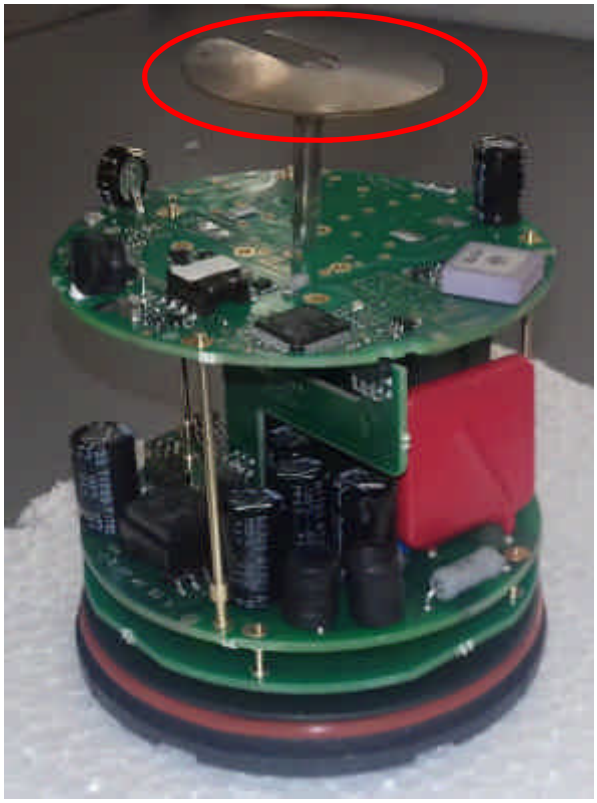
8.3 EUT Left side View



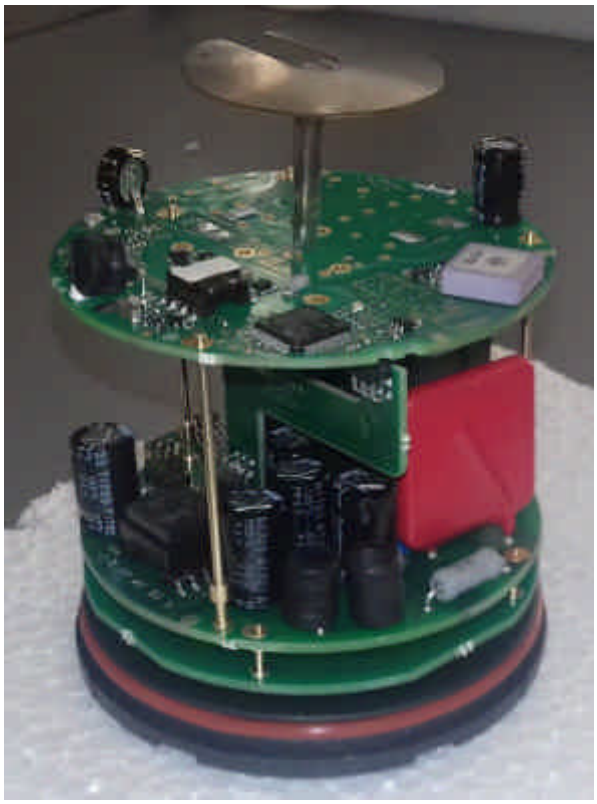
8.4 EUT Right side View

Unit is cylindrical

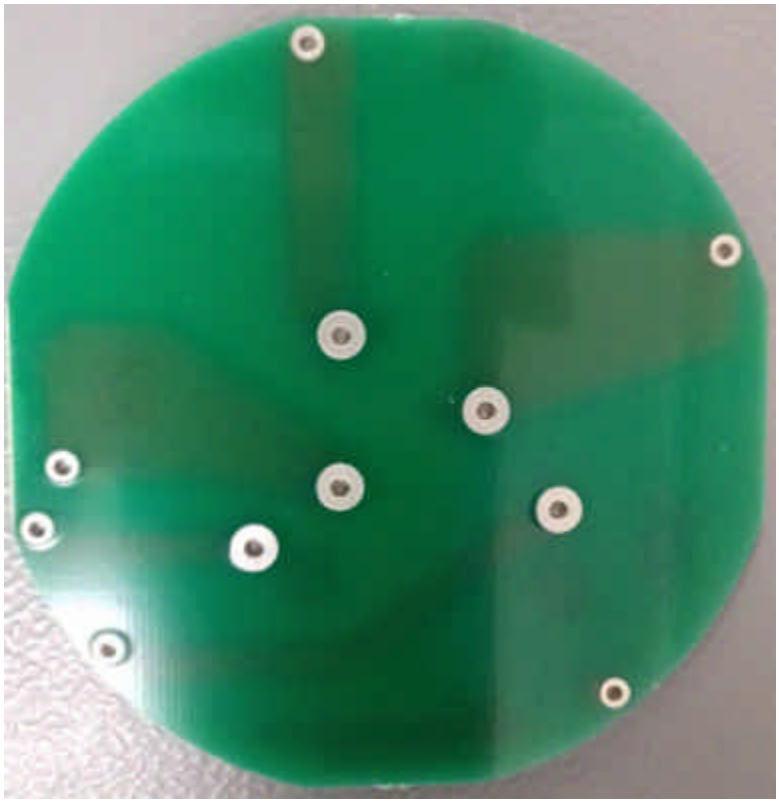
8.5 EUT Antenna Port



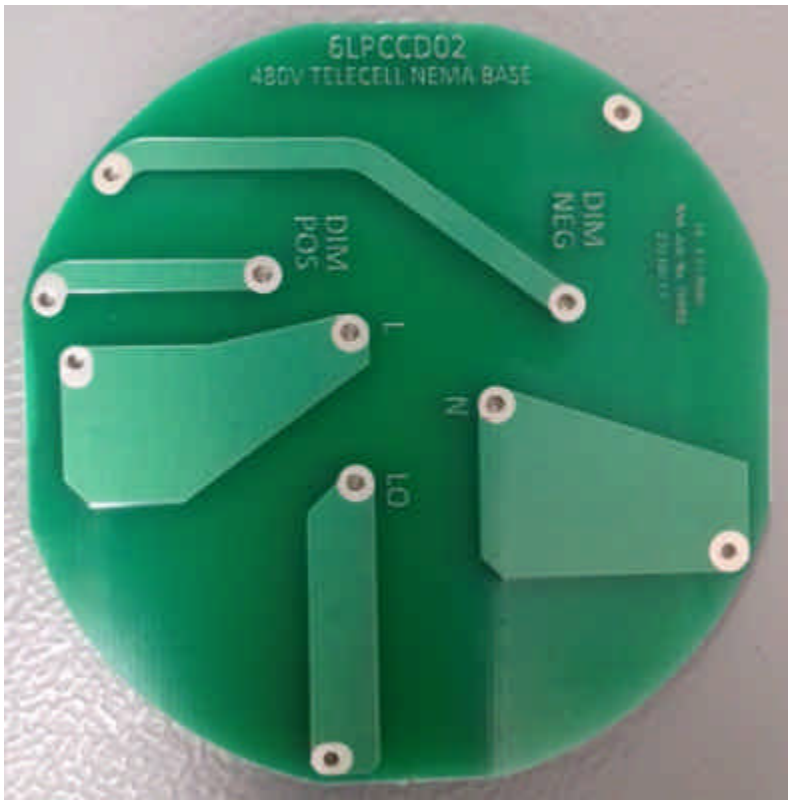
8.6 EUT Internal photos



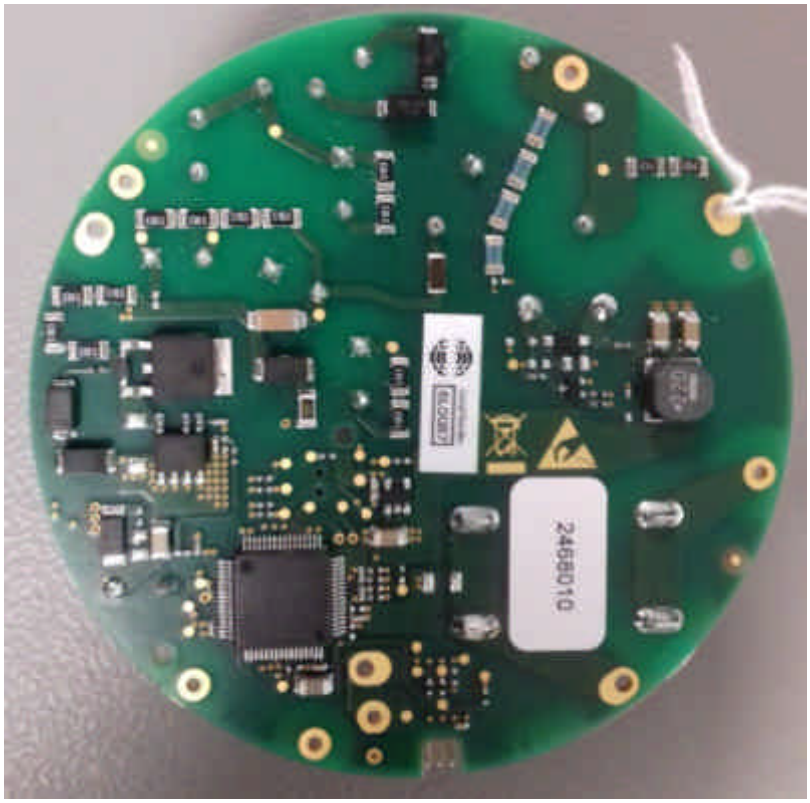
General assembly



Interface board underside



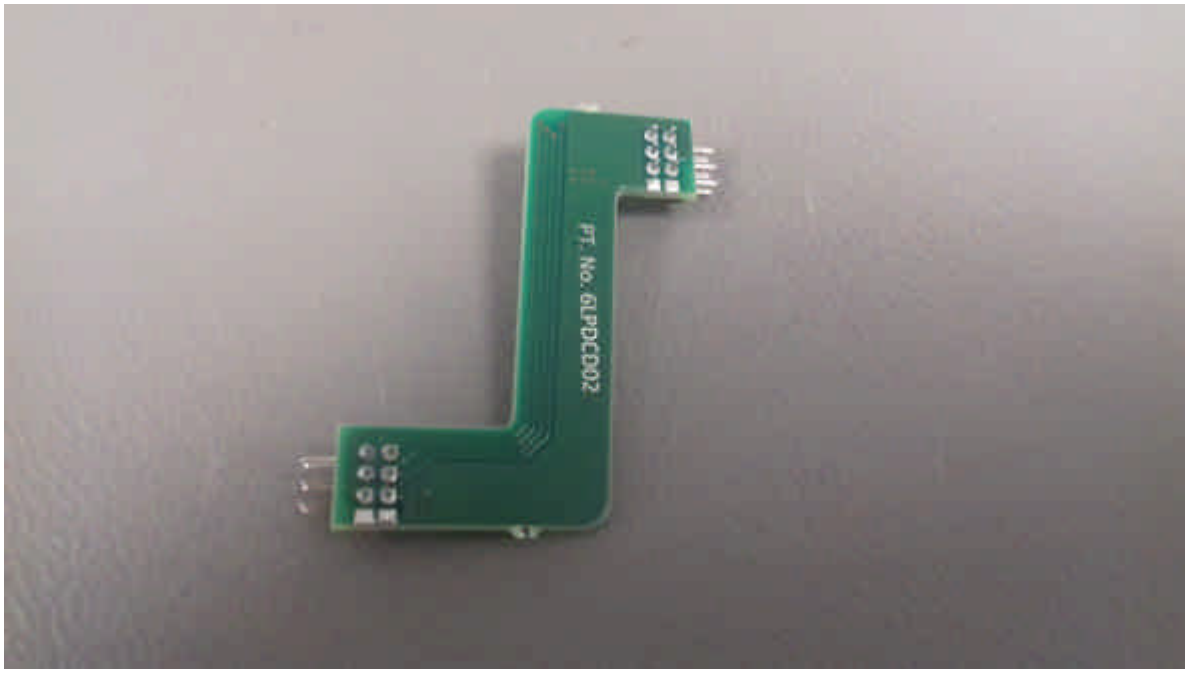
Interface board topside



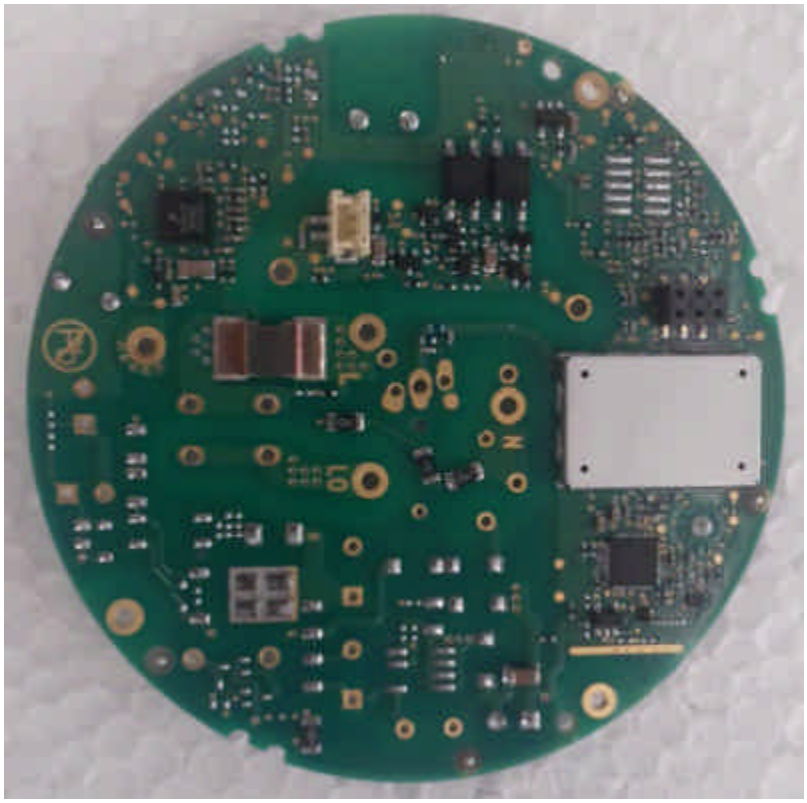
Power board underside

Power board topside

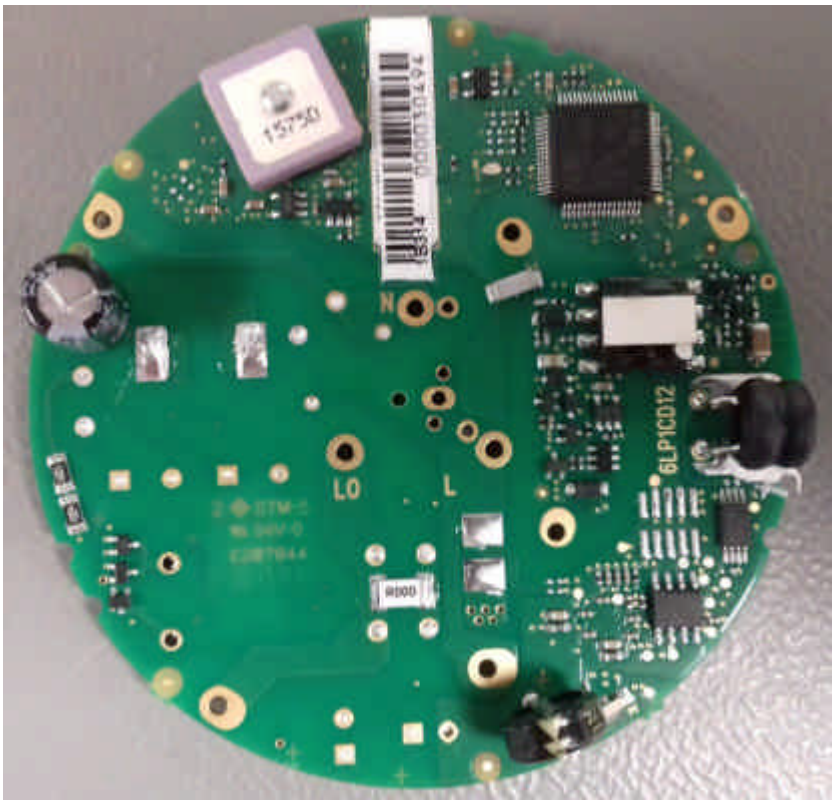
Interboard underside



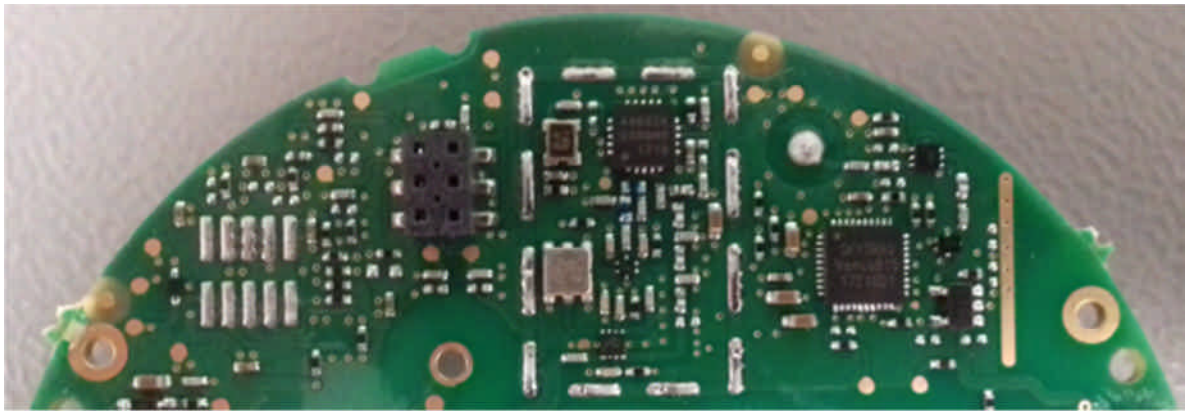
Interboard topside



Radio board underside



Radio board topside

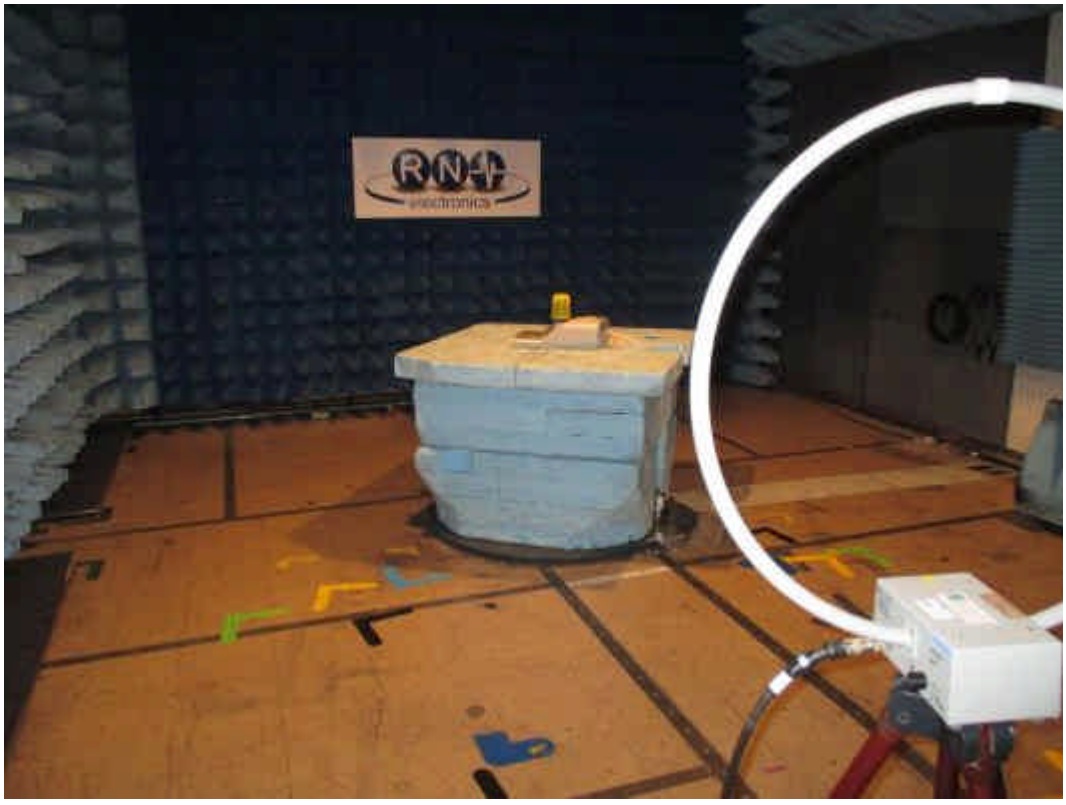


Radio board topside (screening removed)

8.7 EUT ID Label

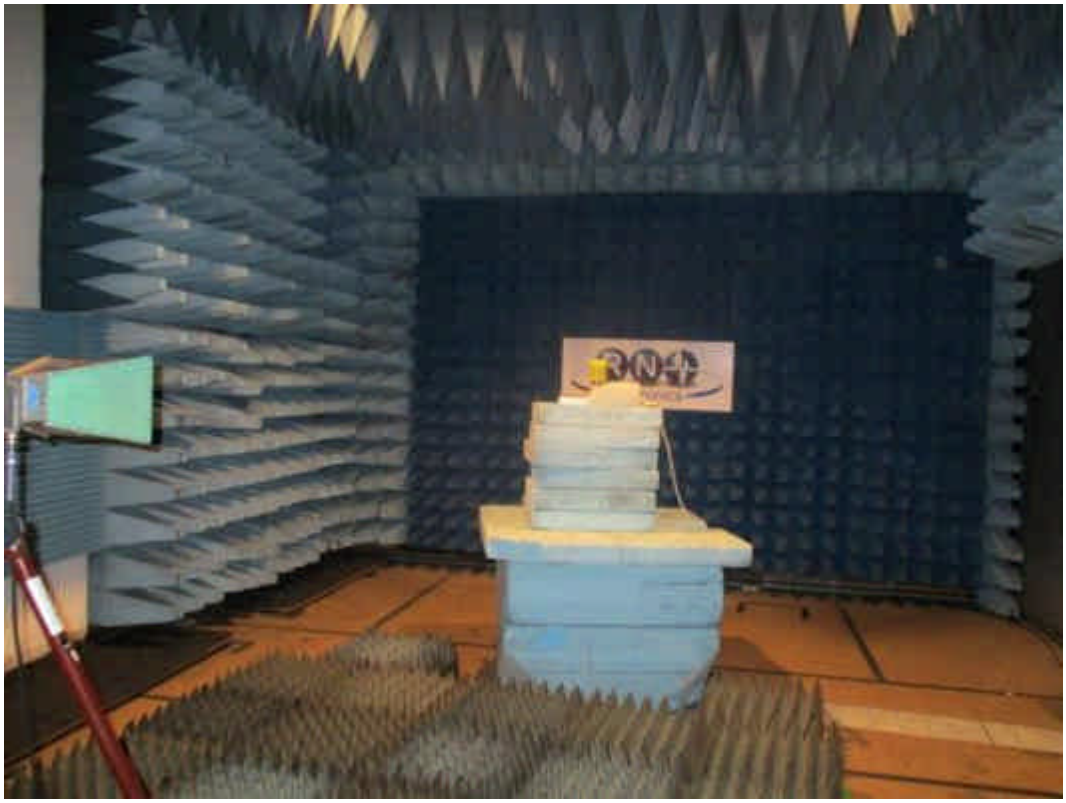
8.8 AC power line conducted emissions

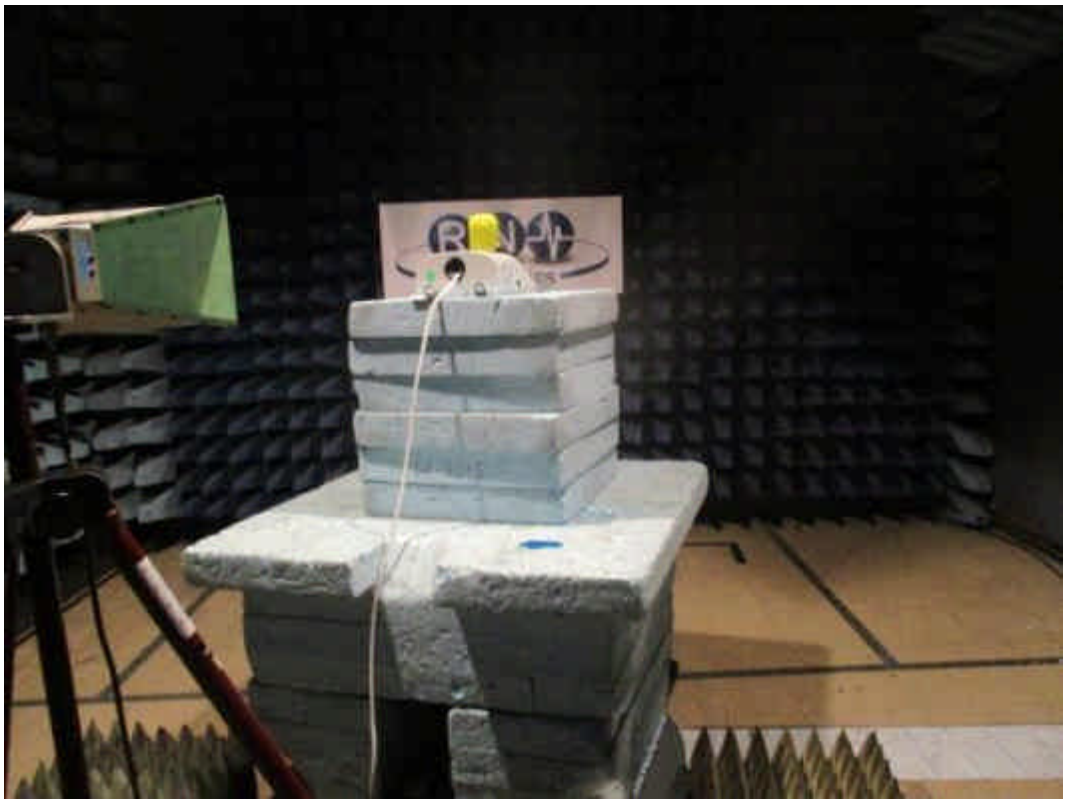
8.9 Radiated emissions 9 kHz - 30 MHz



8.10 Radiated emissions 30 MHz -1 GHz

8.11 Radiated emissions above 1 GHz





8.12 Radiated emission diagram

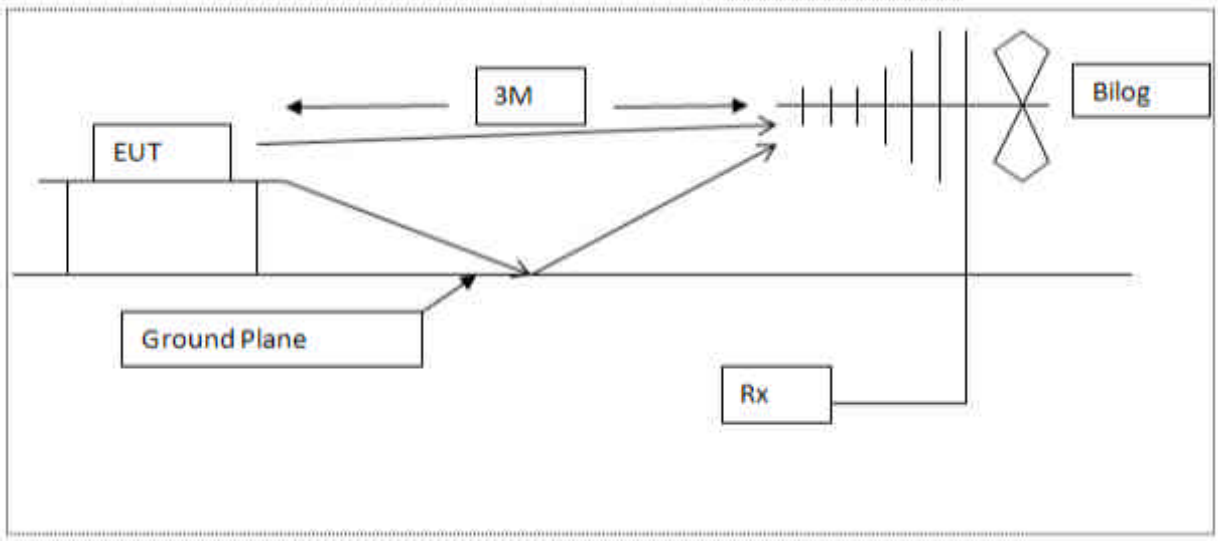


Diagram of the radiated emissions test setup 30 - 1000 MHz

8.13 AC powerline conducted emission diagram

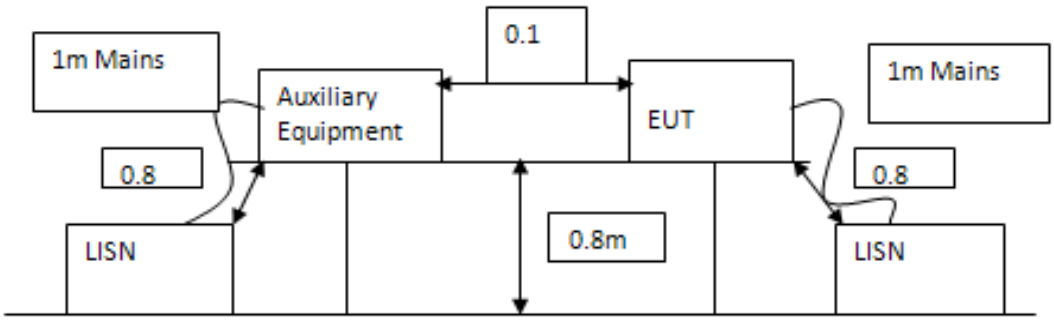


Diagram of the AC conducted emissions test setup

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
E035	11947A	Transient Limiter + 10dB Atten.	Hewlett Packard	27-Nov-2017	6 months
E136	3105	Horn Antenna 12.5GHz	EMCO	03-Apr-2017	12 months
E253	6810.19.A	Attenuator 10 dB	Suhner	22-Mar-2017	12 months
E410	N5181A	Signal Generator 3 GHz MXG	Agilent Technologies	30-Apr-2015	36 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	11-Jul-2017	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	10-Jul-2017	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	29-Aug-2017	12 months
E478	LQ2992/H	Filter - Band pass 1-3GHz	RACAL-MESL	N/A	N/A
E743	RR2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	15-Feb-2017	12 months
LPE364	CBL6112A	Antenna Bilog 30MHz - 2GHz	Chase Electronics Ltd	22-Jan-2016	24 months
LPE366	NNLK 8121	3-Phase LISN 9kHz-30MHz	Schwarzbeck-Mess Elektronik	12-Apr-2017	12 months
NSA1	NSA - M	NSA - Site M	RN Electronics	08-Jan-2015	36 months
TMS78	3160-08	Std Gain Horn Antenna 12.4-18 GHz	ETS Systems	25-Jul-2017	12 months
TMS81	6502	Antenna Active Loop	EMCO	08-Jun-2017	24 months
TMS82	8449B	Pre Amplifier 1 - 26 GHz	Agilent Technologies	19-Dec-2017	12 months
ZSW1	V2.1	Measurement Software Suite	RN Electronics	N/A	N/A

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	ProBook	Laptop and PSU	HP	Telensa asset 1093
2		Raspberry Pi		IP 192.168.1.50
3	MB1054B	NFC card	ST Microelectronics	

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
E187	84534.01	Variac 0-290VAC, 4A, 50Hz	Marconi Instruments	15202

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 / Calibration Laboratory and anechoic chamber
Site B	Semi-anechoic chamber FCC Registration No. 293246 IC Registration No. 5612A-4
Site B1	Control Room for Site B
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	Screened Room
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 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