



Radio Test Report

FEC Heliports Worldwide Limited

915 MHz Zulu dongle

HP0720

47 CFR Part 15.249 Effective Date 1st October 2015

Test Date: 18th February 2016 to 20th April 2016
Report Number: 04-8587-1-16 Issue 02

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 8587-1

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:	915 MHz Zulu dongle
Model Number:	HP0720
Unique Serial Number:	720-001
Applicant:	FEC Heliports Worldwide Limited 1 Mead Business Centre, 176-178 Berkhamstead Road Chesham, Buckinghamshire HP5 3EE
Proposed FCC ID	2AFNN-HP0720
Full measurement results are detailed in Report Number:	04-8587-1-16 Issue 02
Test Standards:	47 CFR Part 15.249 Effective Date 1st October 2015 DXT: Low power Transceiver, RX verified

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:

Deviations have not been applied.

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

Date Of Test: 18th February 2016 to 20th April 2016

Test Engineer:

Approved By:

Radio Approvals 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
5	Tests, methods and results	10
5.1	AC power line conducted emissions	10
5.2	Radiated emissions 9 - 150 kHz	12
5.3	Radiated emissions 150 kHz - 30 MHz	12
5.4	Radiated emissions 30 MHz -1 GHz	13
5.5	Radiated emissions above 1 GHz	15
5.6	Intentional radiator field strength	17
5.7	Band Edge Compliance	18
5.8	Occupied bandwidth	19
5.9	Duty cycle	20
5.10	Frequency stability	20
6	Plots/Graphical results	21
6.1	AC power line conducted emissions	21
6.2	Radiated emissions 30 MHz -1 GHz	23
6.3	Radiated emissions above 1 GHz	25
6.4	Intentional radiator field strength	29
6.5	Band Edge Compliance	30
6.6	Occupied bandwidth	31
6.7	Duty cycle	32
7	Explanatory Notes	33
7.1	Explanation of Table of Signals Measured	33
7.2	Explanation of limit line calculations for radiated measurements	33
8	Photographs	35
8.1	EUT Front View	35
8.2	EUT Reverse Angle	36
8.3	EUT Antenna Port	37
8.4	EUT Display & Controls	38
8.5	EUT Internal photos	39
8.6	EUT ID Label	40
8.7	AC power line conducted emissions	41
8.8	Radiated emissions 30 MHz -1 GHz	42
8.9	Radiated emissions above 1 GHz	43
8.10	Radiated emission diagram	44
8.11	AC powerline conducted emission diagram	45
9	Test equipment calibration list	46
10	Auxiliary and peripheral equipment	47
10.1	Customer supplied equipment	47
10.2	RN Electronics supplied equipment	47
11	Condition of the equipment tested	48
11.1	Modifications before test	48
11.2	Modifications during test	48
12	Description of test sites	49
13	Abbreviations and units	50

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	FEC Heliports Worldwide Limited 1 Mead Business Centre 176-178 Berkhamstead Road Chesham Buckinghamshire HP5 3EE	
Manufacturer of EUT	RF Solutions Limited	
Full Name of EUT	915 MHz Zulu dongle	
Model Number of EUT	HP0720	
Serial Number of EUT	720-001	
Date Received	18th February 2016	
Date of Test:	18th February 2016 to 20th April 2016	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	28th April 2016	
Test Mode Description	Use terminal program to put unit into continuous transmit whilst hopping by sending "RT" command.	
Main Function	PC wireless interface to "HEMS-Star" portable battery LED helipad lights.	
Information Specification	Height	98 mm (including antenna)
	Width	20 mm
	Depth	58 mm (including antenna)
	Weight	0.02 kg
	Voltage	4.75-5.25 VDC
	Current	0.2A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Inserted directly into a USB port of a (portable) PC.
Choice of model(s) for type tests	Production sample
Antenna details	ANT-GHEL2R-SMARP
Antenna port	Reverse SMA
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	915.27 MHz
Lowest Signal generated in EUT	30 MHz
Hardware Version	Zulu-M-USB rev 2
Type of Equipment	Standalone, single radio
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	915-915.27MHz
EUT Declared Modulation Parameters	FSK (max 115.2 kbps)
EUT Declared Power level	-1.3dBm
EUT Declared Signal Bandwidths	90 kHz
EUT Declared Channel Spacings	90 kHz
EUT Declared Duty Cycle	Maximum of 25 characters sent at 1920 characters/sec giving a maximum transmission time of 14 ms. Transmission cannot be repeated more than once every several hundred milliseconds.
Declared frequency stability	10 ppm
RX Parameters	
Alignment range – receiver	915-915.27MHz
EUT Declared RX Signal Bandwidth	100 kHz

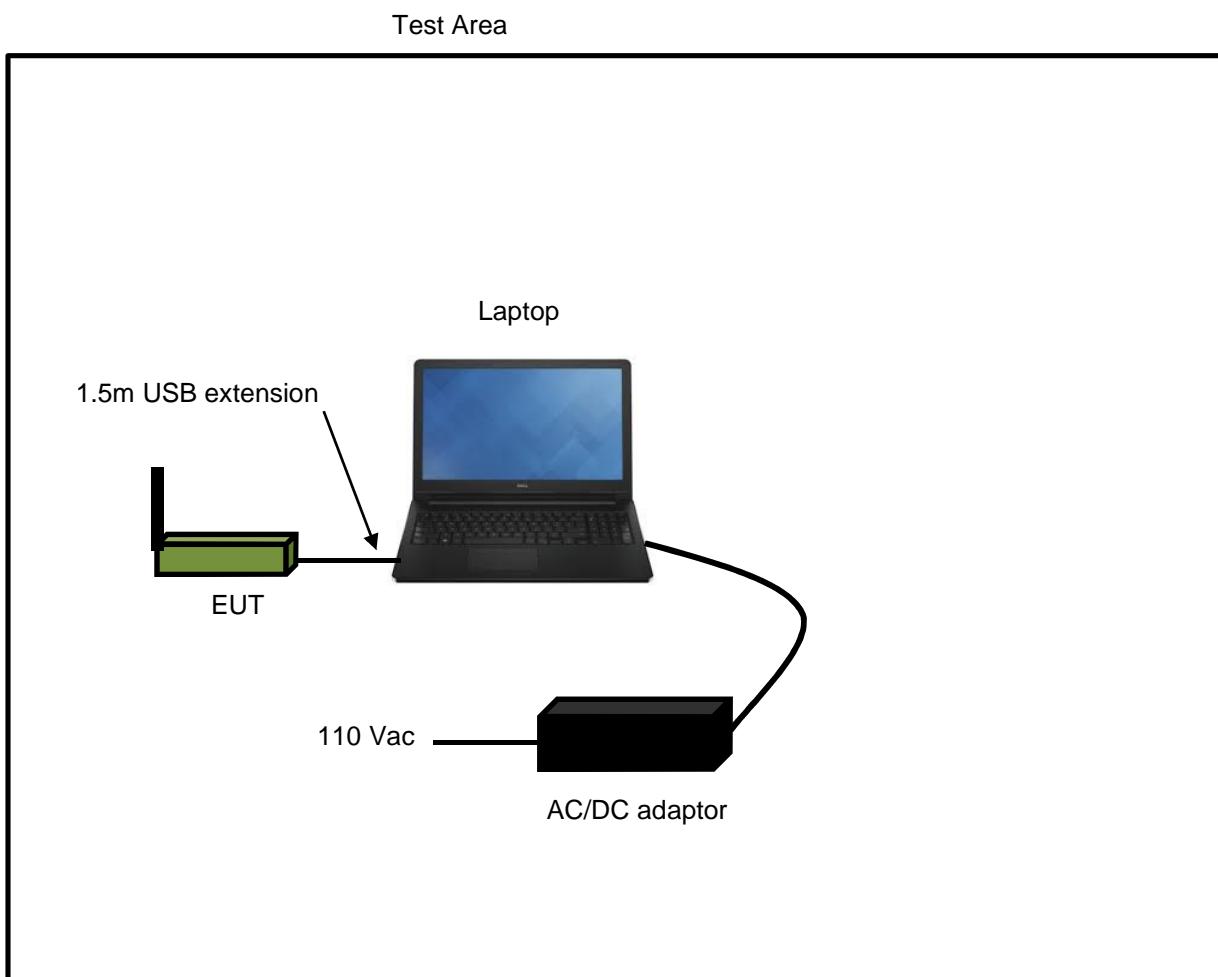
2.3 Functional description

The Zulu dongle is a UHF transceiver integrated with a USB plug and fitted with a small stub antenna. The dongle appears to the host PC as a modem, the wireless link layer being transparent to the PC.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX1	Hopping, continuous transmit, power level 01	Yes
TX2	915.27 MHz, continuous transmit, power level 01	Yes

2.5 Emissions configuration



The unit was powered from the USB port of a laptop via a 1.5m extension. The laptop in turn was powered from the dedicated AC/DC adapter. Two units were used for testing. One to allow transmit on four channels in succession and one to allow permanent transmission on a single channel only as stated within section 2.4 of this report. Power levels were set using the engineering mode provided within the unit to level 01 (this is the setting for -1.3dBm ERP). No other power settings were used for testing.

2.5.1 Signal leads

Port Name	Cable Type	Connected
PC	USB-B	Yes
Aerial	Reverse SMA	Yes

3 Summary of test results

The 915 MHz Zulu dongle, HP0720 was tested for compliance to the following standard(s) :

47 CFR Part 15.249 Effective Date 1st October 2015
DXT: Low power Transceiver, RX verified

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	NOT APPLICABLE ¹
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE ¹
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209	PASSED ²
6. Intentional radiator field strength	47 CFR Part 15C Part 15.249a	PASSED
7. Band Edge Compliance	47 CFR Part 15C Part (15.215 and 15.249)	PASSED
8. Occupied bandwidth	47 CFR Part 15C Part 15.215	PASSED
9. Duty cycle	47 CFR Part 15C Part 15.35 & 15.249(e)	NOT APPLICABLE ³
10. Frequency stability	47 CFR Part 15C Part 15.249(b)(2)	NOT APPLICABLE ⁴

¹ Manufacturer declares lowest generated frequency to be 30 MHz.

² Spectrum investigated up to a frequency of 10 GHz based on 10 times the highest channel/signal generated in equipment of 915.27 MHz.

³ Test performed to confirm manufacturer declaration.

⁴ Test only applies to equipment intended for fixed, point-to-point operation.

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	2015	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

4.2 Deviations

No deviations to the standards have been applied.

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 0.8 m above the ground plane and connected to the USB port of a laptop which was powered from an AC/DC adaptor connected to a LISN via a 1m mains cable.

Details of the Peripheral and Ancillary Equipment connected for this test are listed in section 10.

For final test the EUT was operated in mode TX1.

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

E150, E035, ZSW1, E412, E411, E410, E624, E465

See Section 9 for more details

5.1.5 Test results

Temperature of test environment 20 - 22°C

Humidity of test environment 24 - 34%

Pressure of test environment 102kPa

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	4 channels
Mod Scheme	FSK
Channels	Cycling through each channel (normal operation)

Plot refs
8587-1 Cond 2 AC Live 150k-30M Average
8587-1 Cond 2 AC Live 150k-30M Quasi-Peak
8587-1 Cond 2 AC Neutral 150k-30M Average
8587-1 Cond 2 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	0.169	61.5	55.8	-9.2	24.8	-30.2
2	0.185	59.3	53.5	-10.8	23.0	-31.3
3	0.226	55.3	49.2	-13.4	20.8	-31.8
4	0.276	52.9	46.5	-14.4	32.7	-18.2
5	0.321	47.4	41.6	-18.1	14.6	-35.1
6	0.345	47.3	41.1	-18.0	28.0	-21.1
7	0.480	40.2	34.3	-22.0	23.9	-22.4
8	1.379	33.3	32.6	-23.4	31.1	-14.9
9	1.448	33.6	32.9	-23.1	31.3	-14.7
10	1.517	33.5	32.6	-23.4	31.3	-14.7

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	64.1	57.7	-8.2	26.5	-29.4
2	0.178	59.9	54.0	-10.6	23.1	-31.5
3	0.276	52.2	44.9	-16.0	28.3	-22.6
4	0.345	46.8	40.5	-18.6	25.3	-23.8
5	0.500	37.2	31.3	-24.7	7.4	-38.6
6	0.554	37.3	31.5	-24.5	20.0	-26.0
7	0.963	27.6	24.7	-31.3	20.5	-25.5
8	1.447	32.2	29.5	-26.5	24.5	-21.5
9	1.587	31.8	29.9	-26.1	28.7	-17.3
10	1.862	31.5	29.1	-26.9	23.2	-22.8

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 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:

150 kHz to 30 MHz ± 3.6 dB

5.2 Radiated emissions 9 - 150 kHz

NOT APPLICABLE: Manufacturer declares lowest frequency generated to be 30 MHz.

5.3 Radiated emissions 150 kHz - 30 MHz

NOT APPLICABLE: Manufacturer declares lowest generated frequency to be 30 MHz.

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.3 & 6.5 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.209/15.249(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. The EUT was operated in TX1 mode.

5.4.3 Test procedure

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

Measurements were made on a site listed with the FCC. The equipment was rotated 360° 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 Sites H and M.

5.4.4 Test equipment

LPE364, TMS45, ZSW1, E534, E535,

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	19°C
Humidity of test environment	38 - 41%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	4 channels
Mod Scheme	FSK
Channel	Cycling through each channel (normal operation)

Plot refs
8587-1 Rad 2 VHF Horiz
8587-1 Rad 2 VHF Vert
8587-1 Rad 2 UHF Horiz
8587-1 Rad 2 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	36.005	37.4	34.4	-5.6
2	37.328	34.4	30.9	-9.1
3	166.039	46.4	32.6	-10.9
4	498.439	31.9	25.5	-20.5
5	664.910	47.1	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	36.011	38.8	36.1	-3.9
2	37.342	35.7	32.2	-7.8
3	57.820	19.4	13.4	-26.6
4	72.025	22.6	18.3	-21.7
5	93.160	27.8	23.3	-20.2
6	99.485	29.0	24.4	-19.1
7	161.628	31.1	26.6	-16.9
8	166.140	47.2	34.0	-9.5
9	166.237	42.9	33.9	-9.6
10	166.496	50.5	35.1	-8.4
11	169.329	34.8	27.6	-15.9
12	170.135	37.2	28.2	-15.3
13	175.101	33.2	29.9	-13.6
14	186.210	30.9	26.9	-16.6
15	187.530	30.7	26.7	-16.8
16	232.001	36.7	32.5	-13.5
17	240.067	34.7	31.2	-14.8
18	664.060	44.2	33.8	-12.2
19	666.539	34.5	28.1	-17.9

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

Test performed with EUT using all available channels in turn.

LIMITS:

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

15.249(d) other emissions, outside the intentional band, must be attenuated by at least 50dB from the level of the fundamental or meet the general limits of 15.209 whichever is the lesser attenuation.

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:

30 MHz – 1000 MHz \pm 5.1 dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.3 & 6.6 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.209/15.249(d) [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. The EUT was operated in TX1 mode.

5.5.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed 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° to record the worst case emissions. A measurement distance of 3m was used between the test range 1 – 6 GHz and 1.2 m was used in the test range 6 – 10 GHz.

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

E268, TMS82, E411, E410, E624

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	22°C
Humidity of test environment	24%
Pressure of test environment	102kPa

Setup Table

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	4 channels
Mod Scheme	FSK
Channel	Cycling through each channel (normal operation)

Spurious Frequency (MHz)	Measured Peak Level (dB μ V/m)	Difference to Peak Limit (dB)	Calculated Average Level (dB μ V/m)	Difference to Average Limit (dB)	Antenna Polarisation	EUT Polarisation
2745	62.3	-11.7	45.8	-8.2	Flat	Vertical
2745	64.0	-10.0	47.5	-6.5	Flat	Horizontal
3660	48.0	-26.0	31.5	-22.5	Flat	Vertical
3660	55.5	-18.5	39.0	-15.0	Flat	Horizontal
4575	46.4	-27.6	29.9	-24.1	Flat	Vertical
4575	49.4	-24.6	32.9	-21.1	Flat	Horizontal
7320	49.8	-24.2	33.3	-20.7	Flat	Horizontal
8235	46.9	-27.1	30.4	-23.6	Flat	Horizontal

Note: Duty cycle correction factor of -16.5 dB applied to peak level measurements in order to obtain Average levels.

Plots
8587-1 Rad 1 1-2GHz Horiz
8587-1 Rad 1 1-2GHz Vert
8587-1 Rad 1 2-5GHz Horiz
8587-1 Rad 1 2-5GHz Vert
8587-1 Rad 1 5-6GHz Horiz
8587-1 Rad 1 5-6GHz Vert
8587-1 Rad 1 6upto10GHz Horiz
8587-1 Rad 1 6upto10GHz Vert

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

Test performed with EUT using all available channels in turn.

LIMITS:

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

15.249(d) other emissions, outside the intentional band, must be attenuated by at least 50dB from the level of the fundamental or meet the general limits of 15.209 whichever is the lesser attenuation.

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 Intentional radiator field strength

5.6.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.249a [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.3/6.5/6.6 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.249a [Reference 4.1.1 of this report]

5.6.2 Configuration of EUT

The EUT was placed on a 0.8 metre 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 antenna was scanned 1-4m in height in both Horizontal and Vertical polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in TX1 mode.

5.6.3 Test procedure

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

Maximum field strength was measured using a spectrum analyser set with the appropriate RBW/span in conjunction with a PK detector.

Measurements were made in a semi-anechoic chamber. This site is listed with the FCC. Measurements were made at Site H.

5.6.4 Test equipment

E533, E534, E535, LPE364, TMS45, LPE351

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	16°C
Humidity of test environment	42%
Pressure of test environment	101.5kPa

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	4 channels
Mod Scheme	FSK
Channel	Cycling through each channel (normal operation)

	Single
PK Level (dB μ V/m)	90.70
Plot reference	8587-1 J8587-1 ERP horiz flat
Antenna Polarisation	Horiz
EUT Polarisation	Flat

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

LIMITS:

15.249(a) 50 mV/m @ 3m (94 dB μ V/m @ 3m).

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:
 ± 5.1 dB (30 - 1000 MHz)

5.7 Band Edge Compliance

5.7.1 Test methods

Test Requirements: 47 CFR Part 15C Part (15.215 and 15.249) [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 [Reference 4.1.1 of this report]

5.7.2 Configuration of EUT

The EUT was placed on a 0.8 metre 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 mode.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed 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, E412, TMS933, E624

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	23°C
Humidity of test environment	34%
Pressure of test environment	102kPa

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	4 channels
Mod Scheme	FSK
Channel	Cycling through each channel (normal)

	All Channels
Peak Level (dB _μ V/m)	90.6
Peak Plot reference	J8587-1 Band Edge (all four channels)

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. These show the 50dBc requirement of 15.249(d) and generic 15.209 limits are met at the band edges of 902 and 928 MHz.

LIMITS:

Emissions radiated outside of the specified frequency bands, shall be attenuated by 50dB below the level of the fundamental field strength or to the general emissions limits of 15.209, whichever is the lesser attenuation. The restricted band edges closest to the EUT frequency of 902-928MHz are 614 & 960MHz and are covered under radiated emissions 30 MHz – 1GHz (refer to section 5.4).

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:
 ± 5.1 dB (30 - 1000 MHz)

5.8 Occupied bandwidth

5.8.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.215 [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) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was connected to the spectrum analyser. The EUT was tested whilst powered via USB from the laptop which in turn was powered from an AC/DC adaptor. The EUT was operated in TX2 mode.

5.8.3 Test procedure

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

Tests were performed using test Site A.

5.8.4 Test equipment

E412

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	22°C
Humidity of test environment	42%
Pressure of test environment	103kPa

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	Single channel
Mod Scheme	FSK
Channel	915.27 MHz

20 dB Bandwidth (kHz)	Mid
	128
Plot reference	8587-1 OBW

Analyser plots for the 20dB 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.

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:
 $\pm 1.9 \%$

5.9 Duty cycle

NOT APPLICABLE: No limits apply, however duty cycle measurement performed to verify any possible correction factors for average emissions.

Band	902-928 MHz
Power Level declared	-1.3 dBm
Channel Spacing	Single channel
Mod Scheme	FSK
Single channel	915.275 MHz

TX on time (mS)	Single 14.95
TX on Plot filename	8587-1 duty cycle correction
TX repetition time (S)	0.1
Calculated TX Duty cycle (%)	14.95

These results show that the duty cycle correction factor for peak to average emissions is therefore $20\log(0.01495/0.1) = -16.5$ dB.

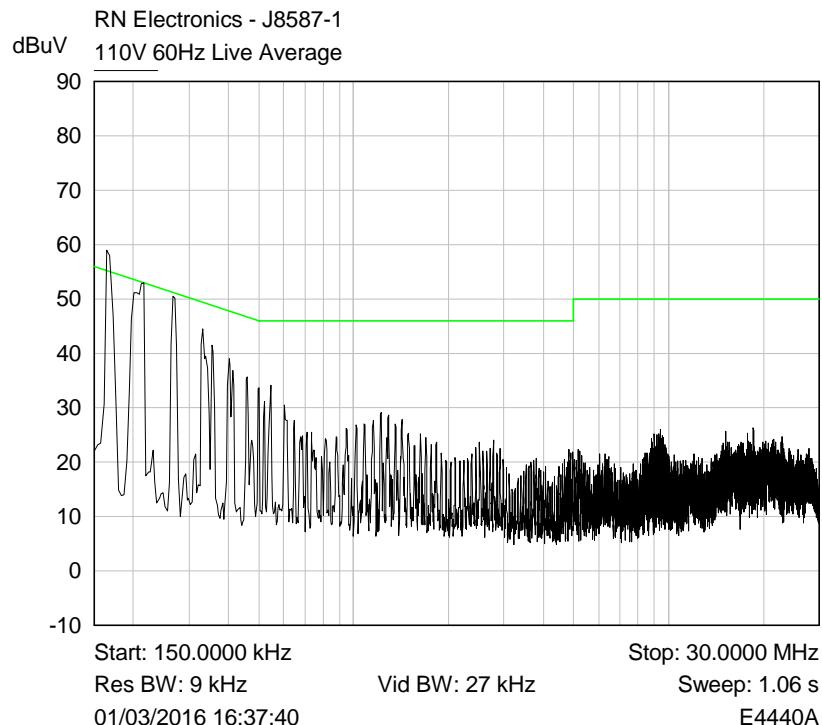
5.10 Frequency stability

NOT APPLICABLE: Test only applies to equipment intended for fixed, point-to-point operation.

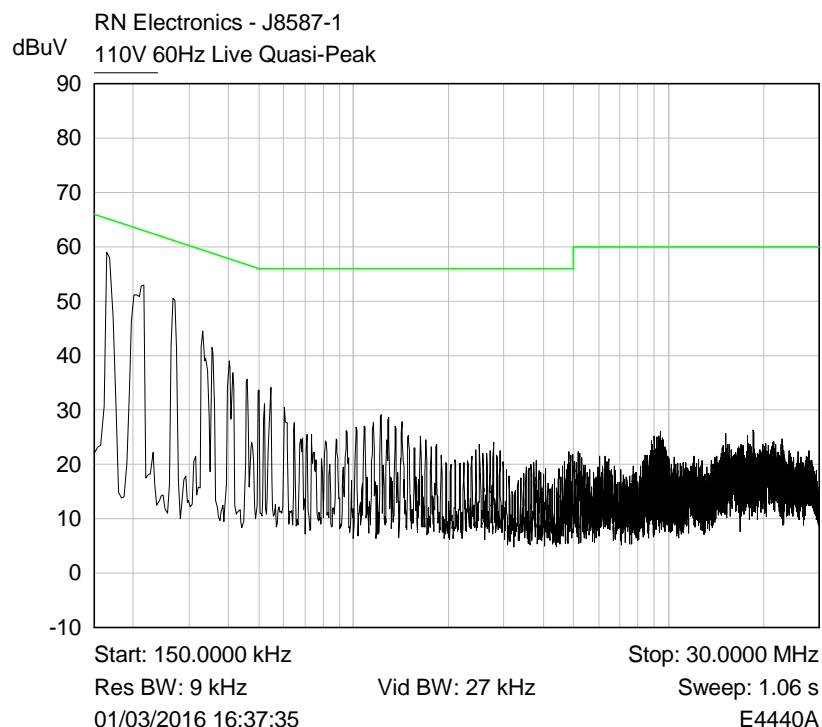
6 Plots/Graphical results

6.1 AC power line conducted emissions

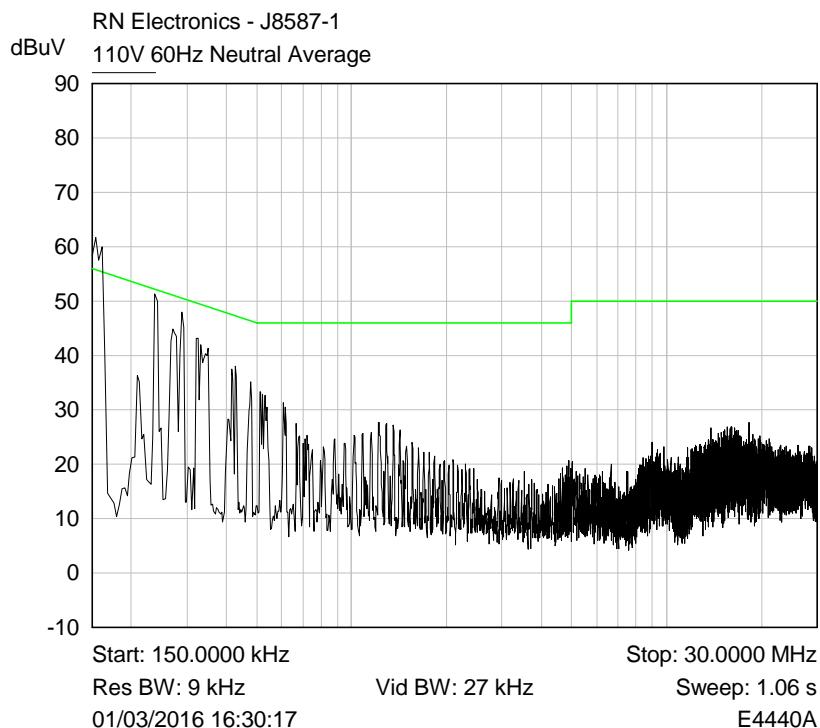
RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels,
Modulation FSK, Normal operation 4 channels cycling



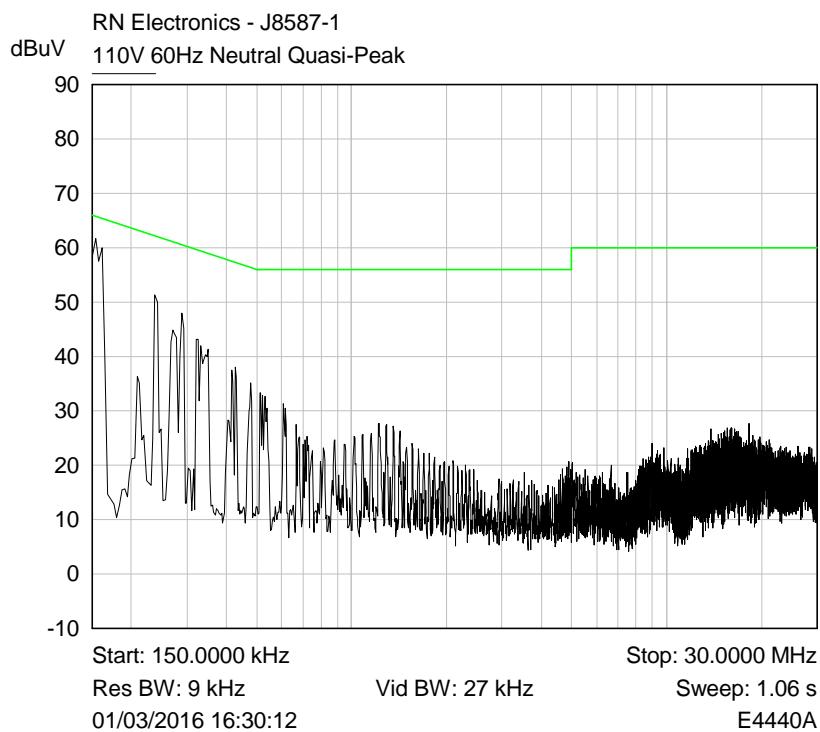
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



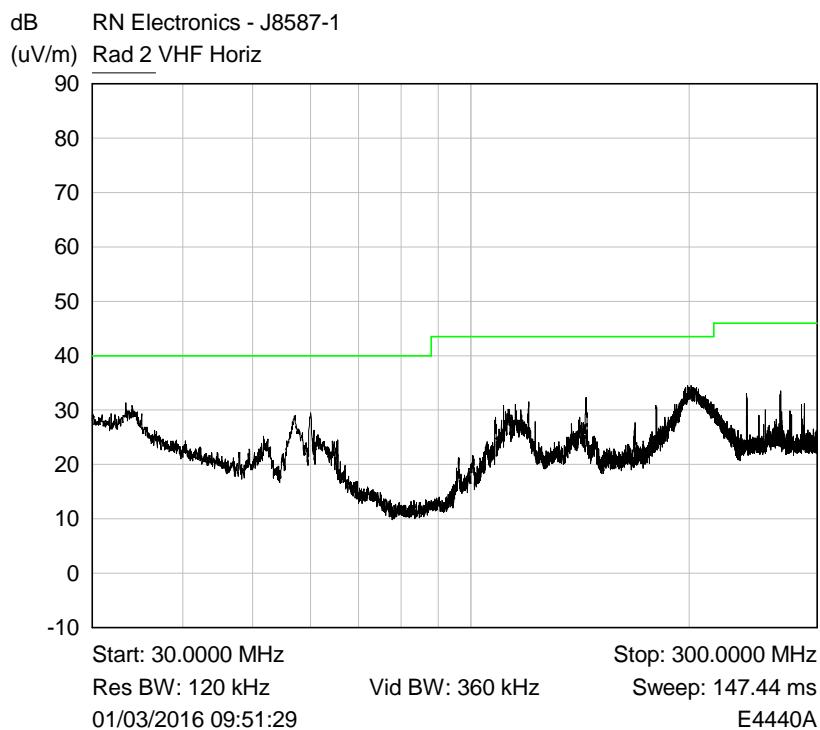
Plot of Neutral150k-30M Average



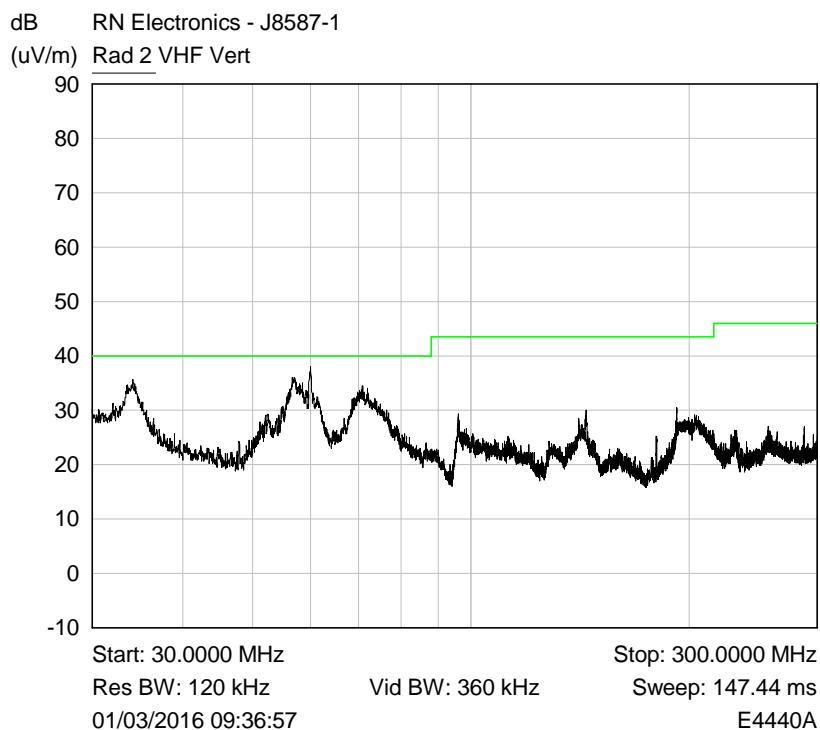
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 30 MHz -1 GHz

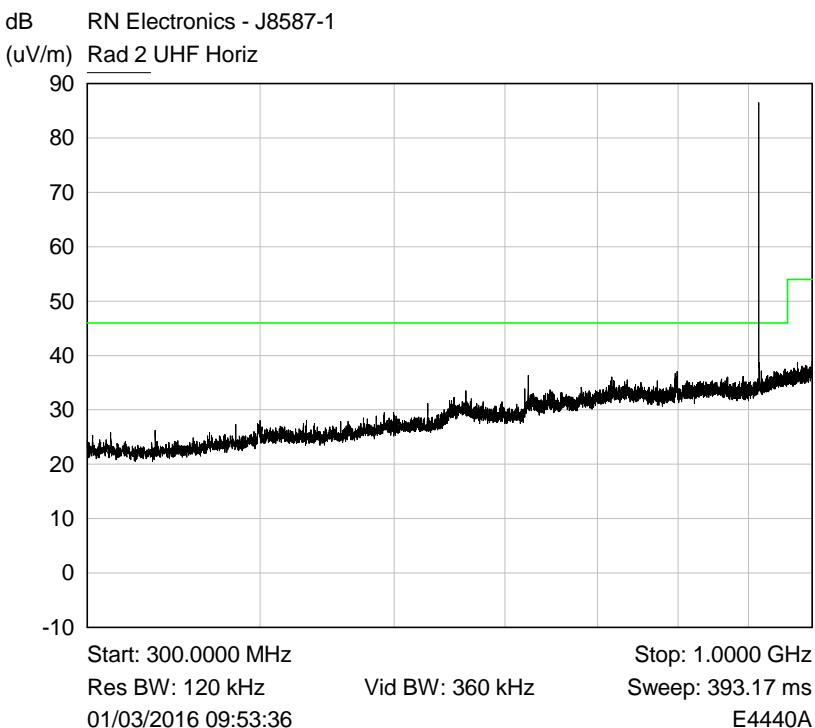
RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels,
Modulation FSK, Normal operation 4 channels cycling



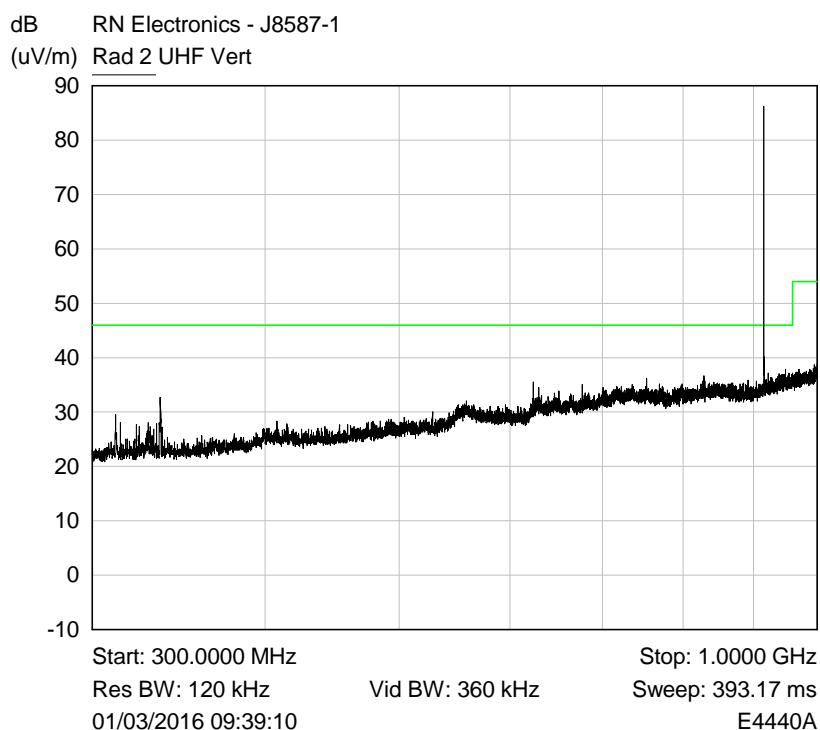
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



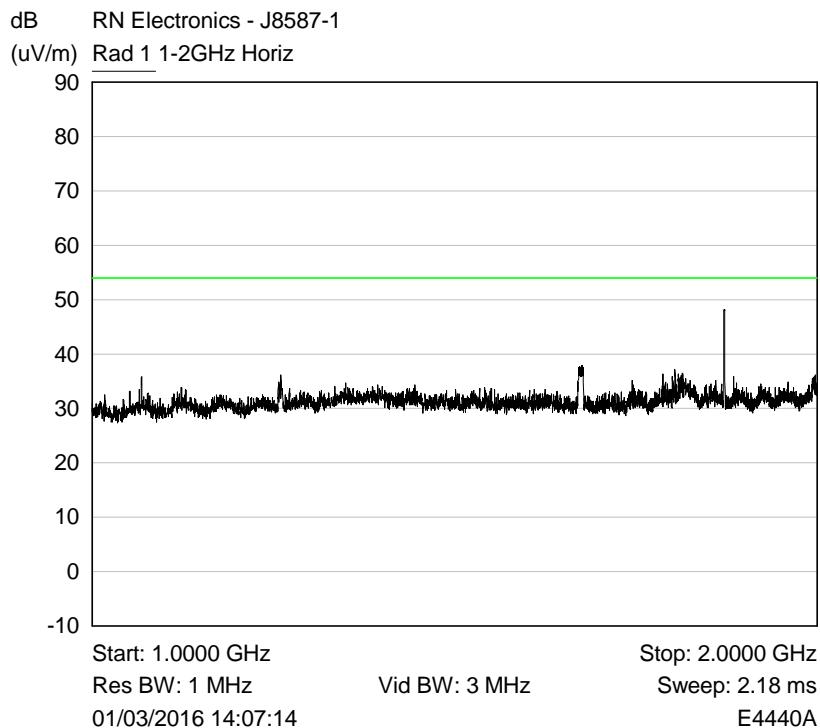
Plot of Peak emissions for UHF Horizontal against the QP limit line.
Note: plot shows fundamental emission.



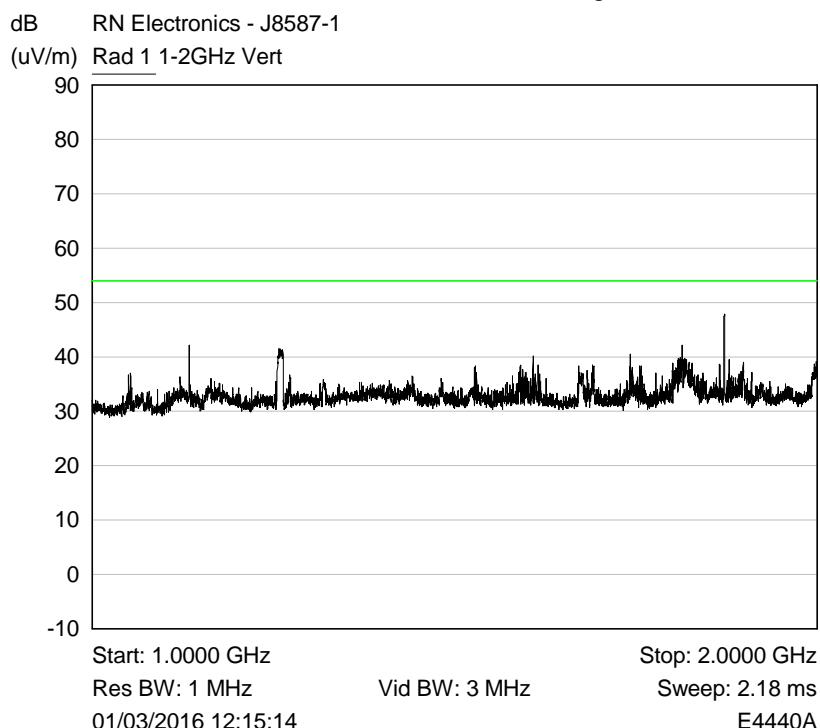
Plot of Peak emissions for UHF Vertical against the QP limit line.
Note: plot shows fundamental emission.

6.3 Radiated emissions above 1 GHz

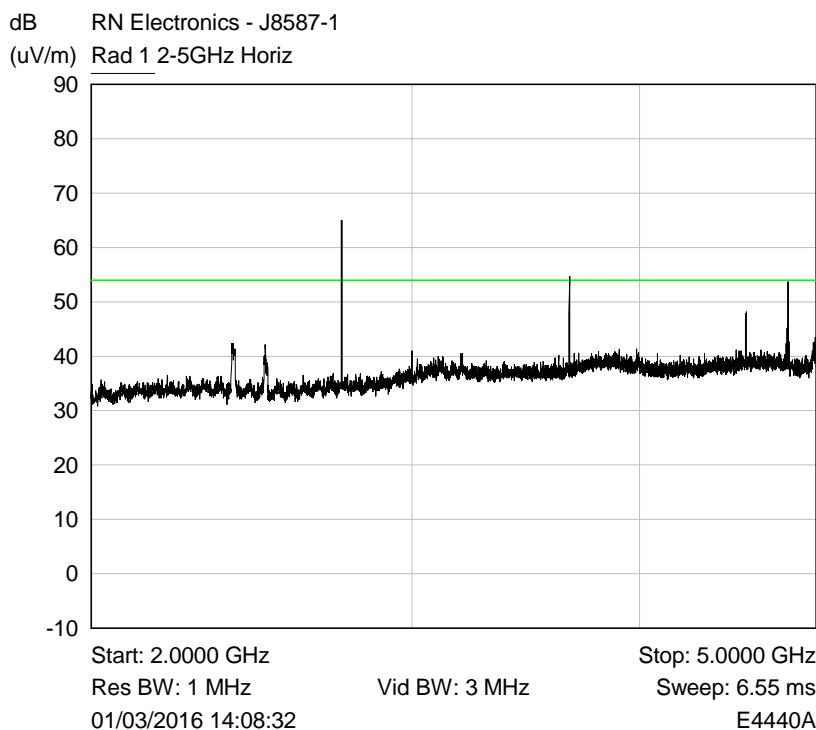
RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels,
Modulation FSK, Normal operation 4 channels cycling



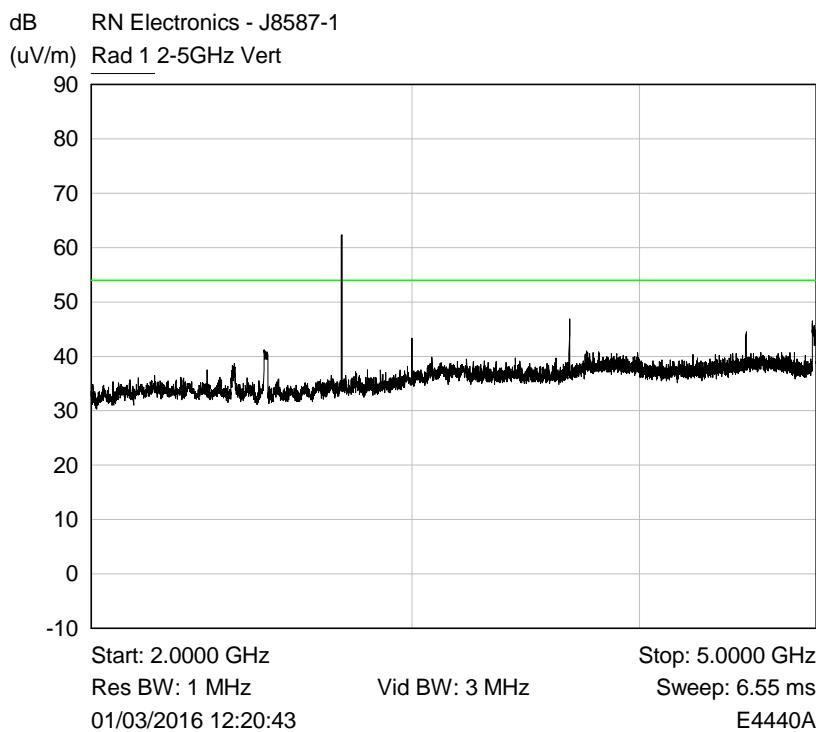
Plot of Peak Horizontal emissions 1 – 2 GHz against the AV limit line



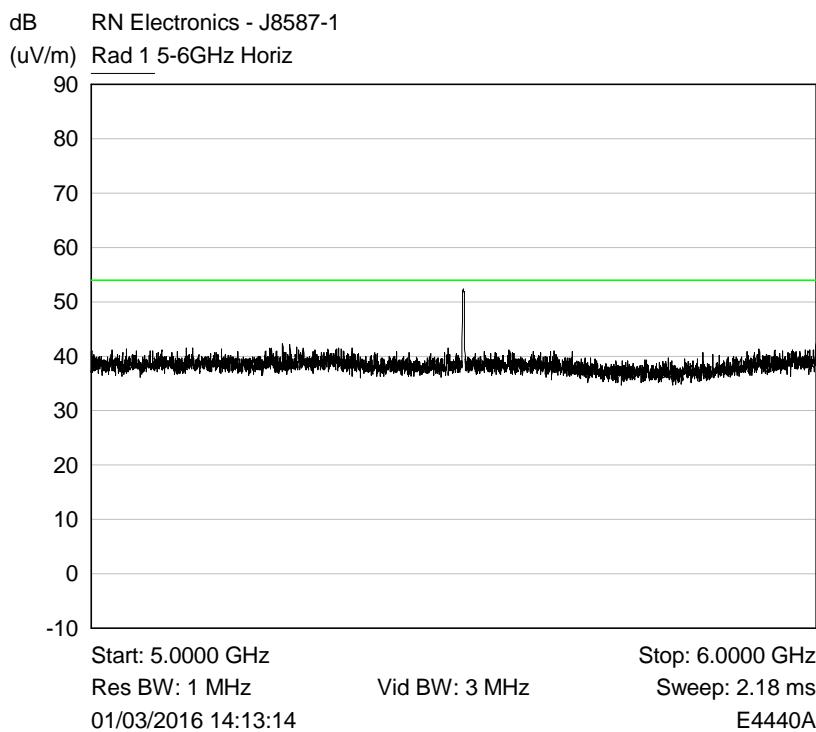
Plot of Peak Vertical emissions 1 – 2 GHz against the AV limit line



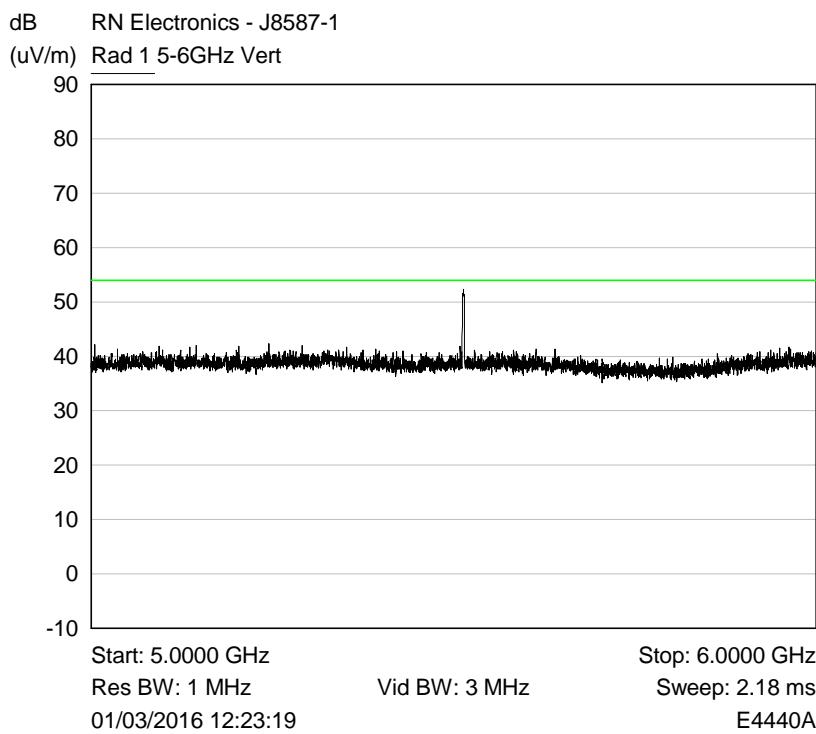
Plot of Peak Horizontal emissions 2 – 5 GHz against the AV limit line



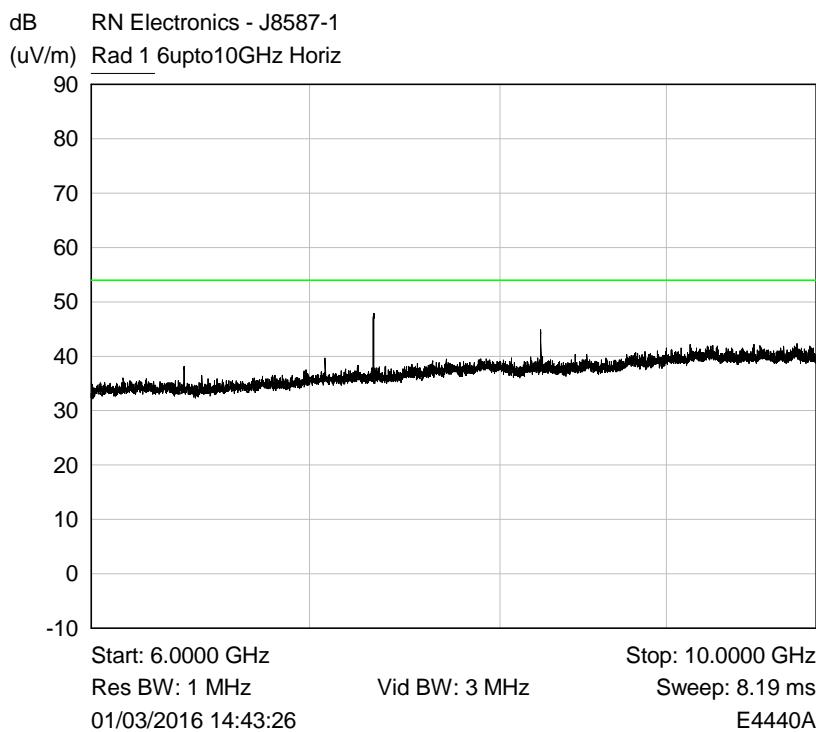
Plot of Peak Vertical emissions 2 – 5 GHz against the AV limit line



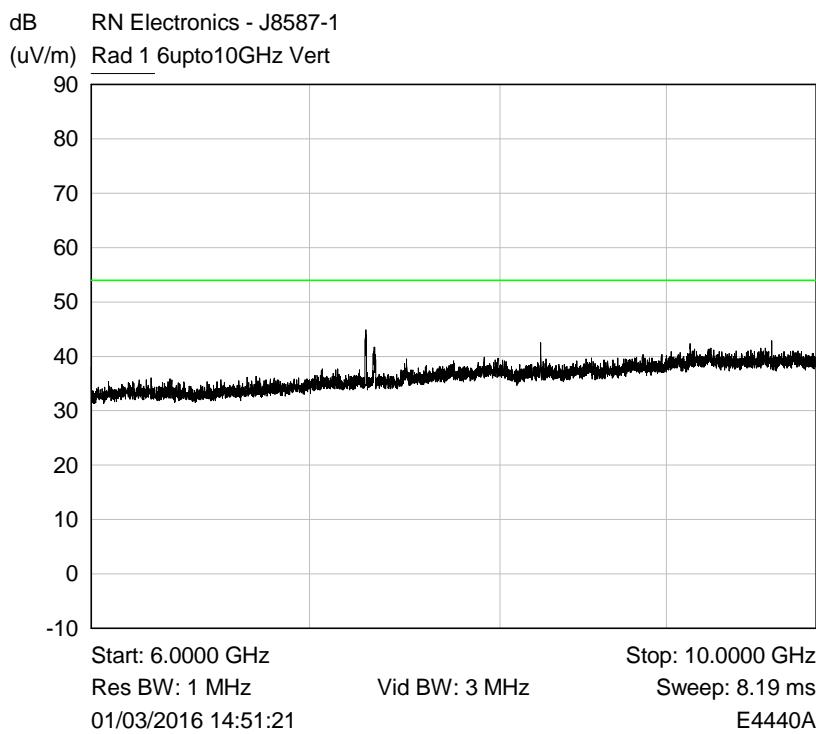
Plot of Peak Horizontal emissions 5 – 6 GHz against the AV limit line



Plot of Peak Vertical emissions 5 – 6 GHz against the AV limit line



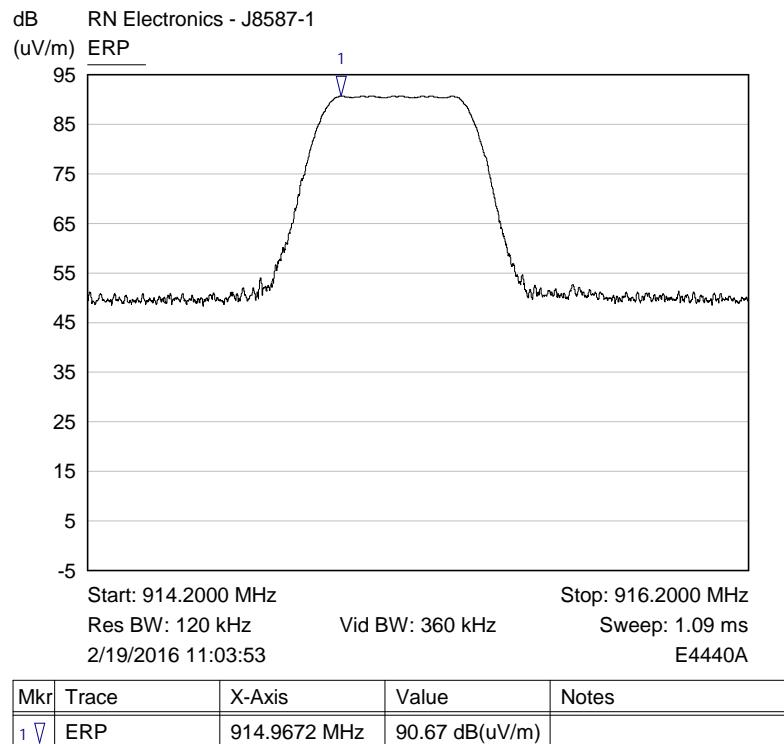
Plot of Peak Horizontal emissions 6 – 10 GHz against the AV limit line



Plot of Peak Vertical emissions 6 – 10 GHz against the AV limit line

6.4 Intentional radiator field strength

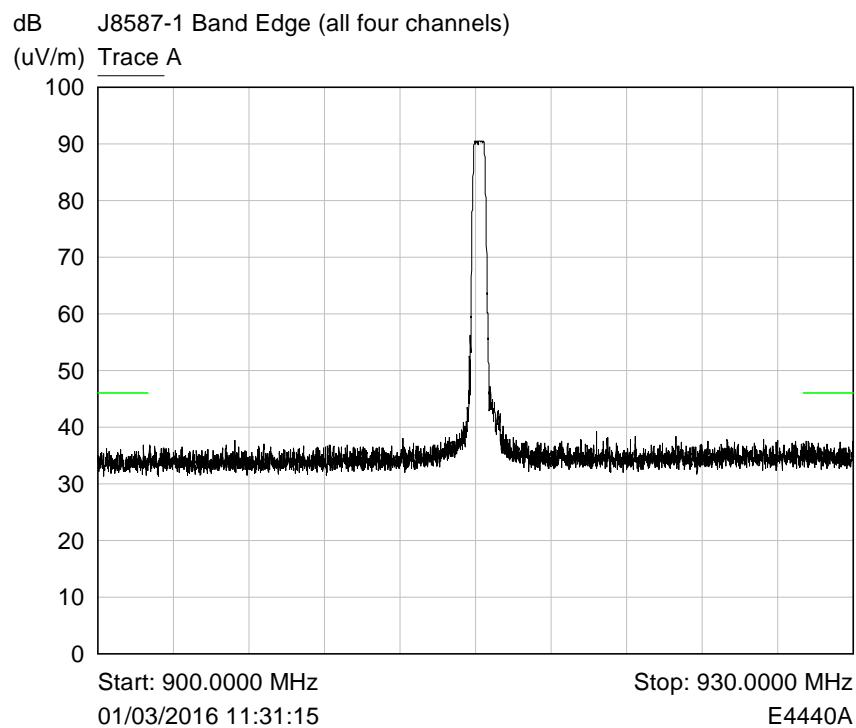
RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels,
Modulation FSK, Normal operation 4 channels cycling



Plot of Horiz polarisation and EUT in Flat position

6.5 Band Edge Compliance

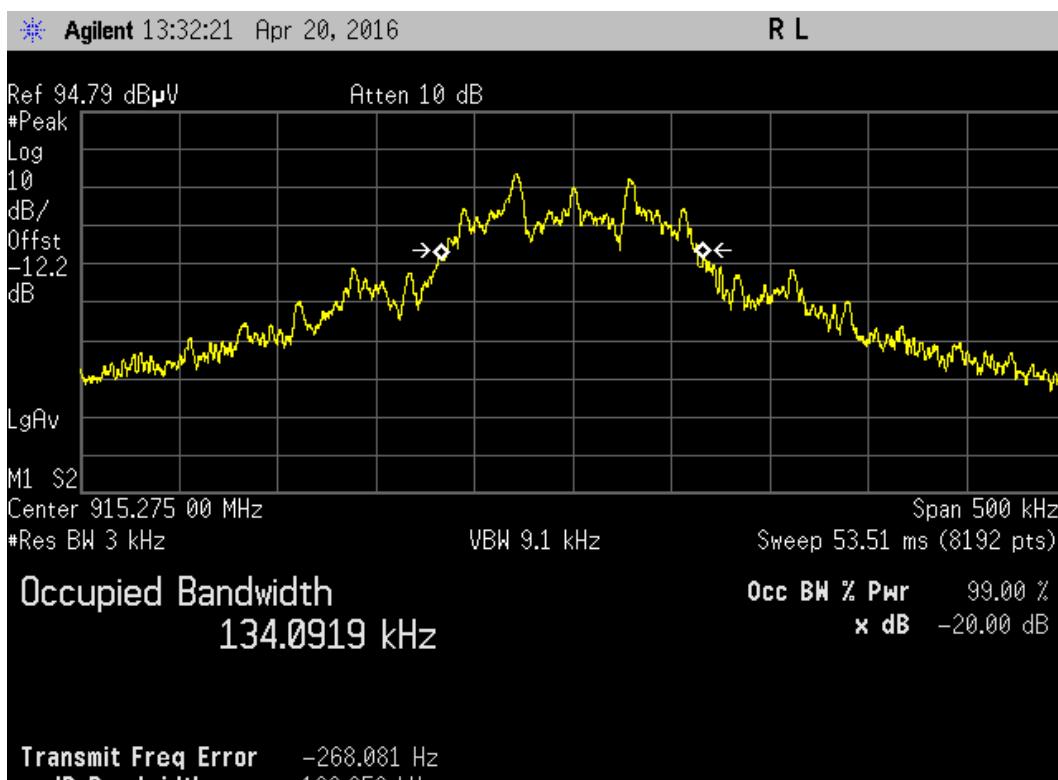
RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels,
Modulation FSK, Normal operation 4 channels cycling



Peak Band edge Plot (shows 902 – 928MHz band edges)

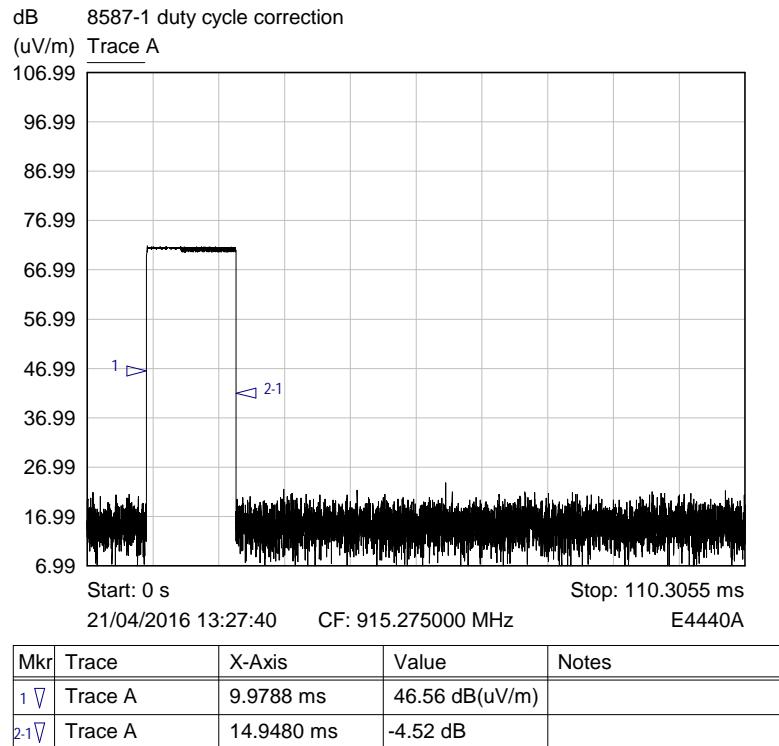
6.6 Occupied bandwidth

RF Parameters: Band 902-928 MHz, Power -1.3 dBm, Channel Spacing 4 channels MHz,
Modulation FSK, Channel 915.275 MHz



6.7 Duty cycle

RF Parameters: Band 902-928 MHz, Power -1.3 dBm, high channel, Modulation FSK



TX on time (mS)

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 (dB μ V)	Pk – Lim 1 (dB)	QP Amp (dB μ V)	QP - Lim1 (dB)	Av Amp (dB μ V)	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 (dB μ V) is the level of received signal that was measured in dB above 1 μ V 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 (dB μ V) is the level of received signal that was measured in dB above 1 μ V 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 (dB μ V) is the level of received signal that was measured in dB above 1 μ V 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 μ V/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dB μ V/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 μ V/m equates to $20 \log(500) = 54$ dB μ V/m.

- (b) limit of 300 $\mu\text{V}/\text{m}$ at 10m equates to $20 \cdot \log(300 \cdot 10/3) = 60 \text{ dB } \mu\text{V}/\text{m}$ at 3m
(c) limit of 30 $\mu\text{V}/\text{m}$ at 30m, but below 30MHz, equates to $20 \cdot \log(30) + 40 \cdot \log(30/3) = 69.5 \text{ dB } \mu\text{V}/\text{m}$ 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



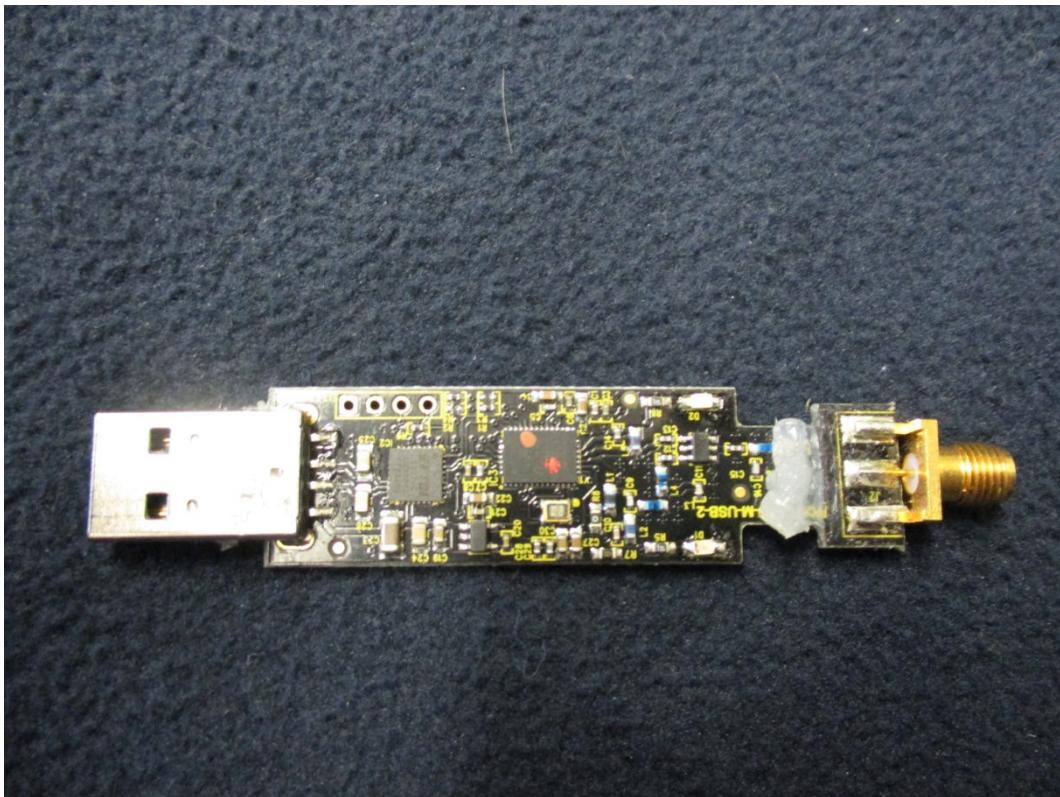
8.3 EUT Antenna Port



8.4 EUT Display & Controls

The EUT has no displays or controls

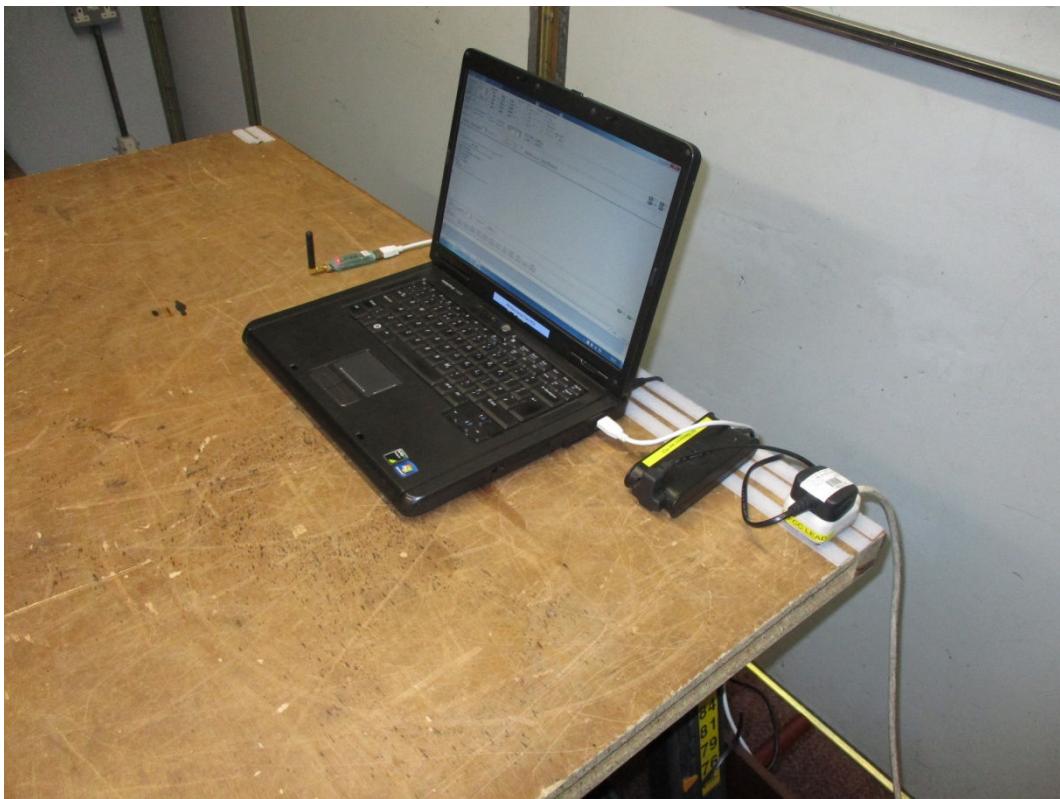
8.5 EUT Internal photos



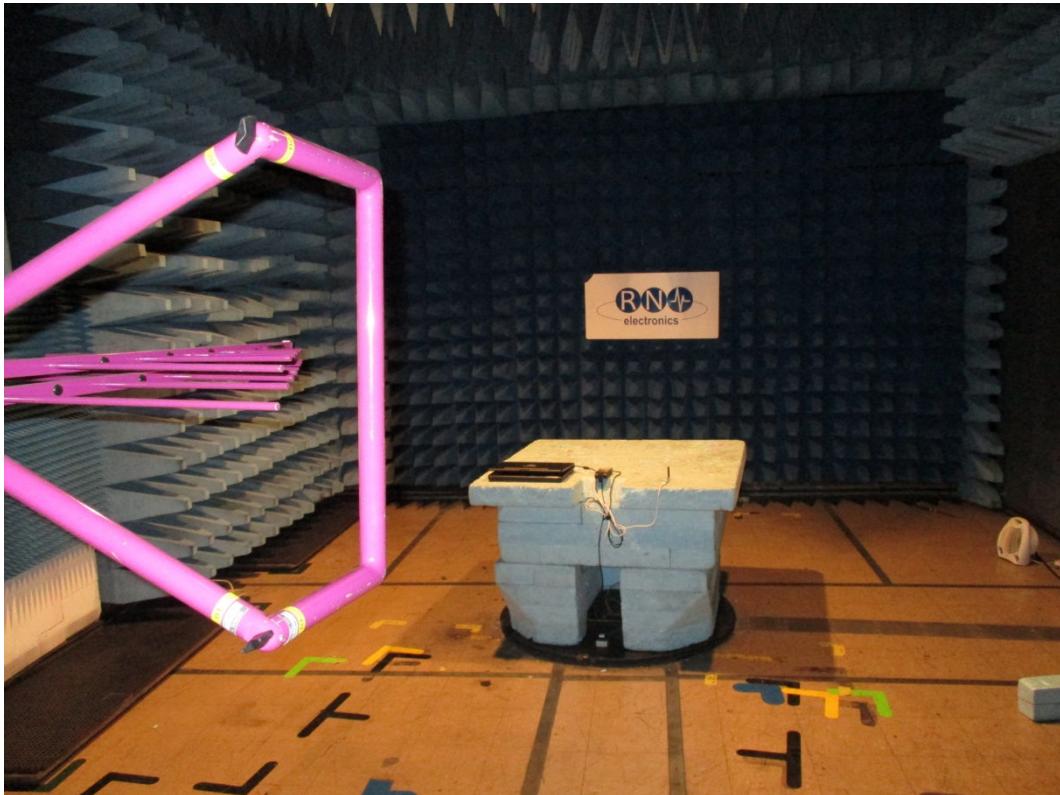
8.6 EUT ID Label



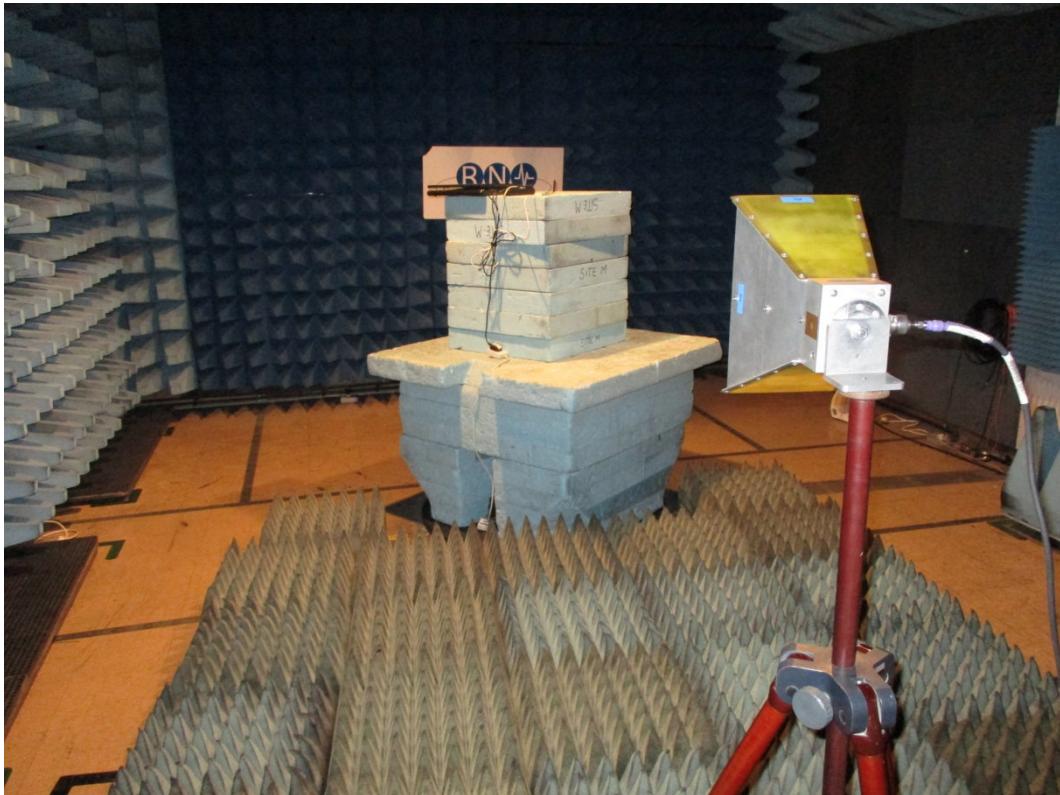
8.7 AC power line conducted emissions



8.8 Radiated emissions 30 MHz -1 GHz



8.9 Radiated emissions above 1 GHz



8.10 Radiated emission diagram

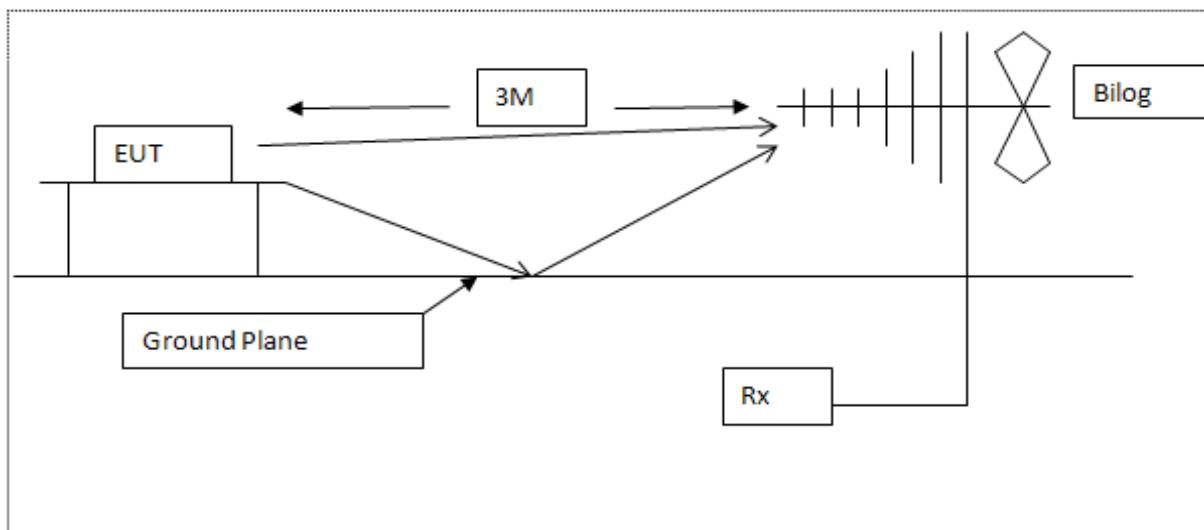


Diagram of the radiated emissions test setup 30 - 1000 MHz

8.11 AC powerline conducted emission diagram

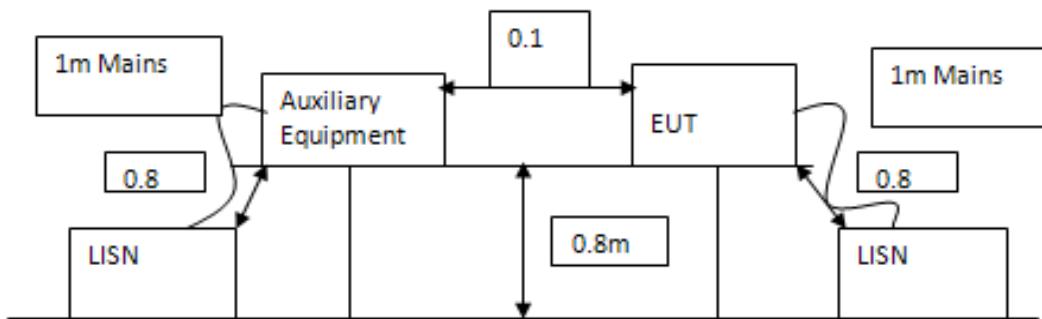


Diagram of the AC conducted emissions test setup

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	14-Dec-2015	6 months
E150	MN2050	LISN 13A	Chase	08-Oct-2015	12 months
E268	BHA 9118	1-18 GHz Horn Antenna	Schaffner	08-Apr-2015	24 months
E301	8493C	Attenuator 20dB 26.5GHz	Hewlett Packard	*17-May-2016	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	29-Apr-2015	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	29-Apr-2015	24 months
E465	PCR2000LA	AC Power Supply	Kikusui	15-May-2015	12 months
E533	N5182A	Signal Generator 6 GHz MXG	Agilent Technologies	*26-Feb-2016	36 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	26-Feb-2015	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	*25-Feb-2016	12 months
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	22-Dec-2015	24 months
LPE351	PAS 5000	5kV Power Source	SPITZENBERGER + SPIES	30-Apr-2015	12 months
LPE364	CBL6112A	30MHz - 2GHz Bilog Antenna	Chase Electronics Ltd	22-Jan-2016	24 months
TMS45	Model1	Attenuator	Weinschel	07-Jul-2015	12 months
TMS82	8449B	Pre Amplifier 1 - 26 GHz	Agilent Technologies	17-Dec-2015	12 months
TMS933	CBL6141A	Bilog Antenna 30MHz - 2GHz	York EMC	29-Sep-2014	24 months
ZSW1	V2.0	Measurement Software Suite	RN Electronics	N/A	N/A

*Equipment was in calibration dates for tests and has since been re-calibrated during/ after tests.

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

No customer supplied equipment.

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
N524	Vostro 1000	DELL Laptop	DELL	J2XPW3J

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
- 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)
VCCI Registration No. C-2823
- 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
- Site Q Fully-anechoic chamber
- Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246
IC Registration No. 5612A-1
VCCI Registration No. R-2580
- Site R Screened Room (Conducted Immunity)
- Site S Safety Laboratory
- Site T Transient Laboratory

13 Abbreviations and units

%	Percent	LBT	Listen Before Talk
$\mu\text{A}/\text{m}$	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
$^{\circ}\text{C}$	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
$\text{dB}\mu\text{A}/\text{m}$	deciBels relative to $1\mu\text{A}/\text{m}$	ppm	Parts per million
$\text{dB}\mu\text{V}$	deciBels relative to $1\mu\text{V}$	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		