



2360

Radio Test Report

3D Sound Labs

3D Sound One Module

3DSLM01

47 CFR Part 15.247 Effective Date 1st October 2015

DTS: Digital Transmission System

Test Date: 23rd June 2016 to 27th June 2016

Report Number: 06-8861-1-16 Issue 01

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Certificate of Test 8861-1

The equipment noted below has been partially tested by R.N. Electronics Limited and, where appropriate, conforms to the relevant subpart of 47 CFR Part 15C. This is a certificate of test only and should not be confused with an equipment authorisation. Other standards may also apply.

Equipment:	3D Sound One Module
Model Number:	3DSLM01
Unique Serial Number:	11199027#2 (radiated unit)
Applicant:	3D Sound Labs 130 Rue de Lourmel Paris France 75015
Proposed FCC ID	2AEBV-3DSLM01
Full measurement results are detailed in Report Number:	06-8861-1-16 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2015 DTS: Digital Transmission System

NOTE:

Only partial tests conducted at request of 3D Sound Labs. For details refer to section 3 of this report. Certain tests were not performed based upon manufacturer's declarations.

DEVIATIONS:

The following tests have not been performed at the request of 3D Sound Labs:- AC power line conducted emissions, Antenna power conducted emissions, Maximum Average conducted output power, Occupied bandwidth, Maximum Peak conducted output power, Maximum Power Spectral Density

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

Date Of Test: 23rd June 2016 to 27th June 2016

Test Engineer:

Approved By:
Technical Manager

Customer
Representative:



2360

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2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	3D Sound Labs 130 Rue de Lourmel Paris France 75015	
Manufacturer of EUT	3D Sound Labs	
Full Name of EUT	3D Sound One Module	
Model Number of EUT	3DSLM01	
Serial Number of EUT	11199027#2 (radiated unit)	
Date Received	10th June 2016	
Date of Test:	23rd June 2016 to 27th June 2016	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	5th July 2016	
Main Function	Motion tracking over Bluetooth Low Energy	
Information Specification	Height	16mm
	Width	32mm
	Depth	43mm
	Weight	0.013kg
	Voltage	3.2 - 4.2V DC, 3.7V nominal Li-Po battery
	Current	8mA

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Mounted on a headphones headband
Choice of model(s) for type tests	Production models (both modified with a battery link and a programming lead for test purposes, one additionally modified with conducted RF lead)
Antenna details	Integral PCB Antenna, 1.7dBi PK gain
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2.48 GHz
Lowest Signal generated in EUT	32.768 kHz
Hardware Version	3.6
Software Version	4
Firmware Version	Is the same as software version
Type of Equipment	Portable
Technology Type	Bluetooth Low Energy
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	2402 - 2480 MHz
EUT Declared Modulation Parameters	GFSK
EUT Declared Power level	+4dBm
EUT Declared Signal Bandwidths	1MHz
EUT Declared Channel Spacing's	2MHz
EUT Declared Duty Cycle	Declared as 50Hz. PC application test software provided by client had a maximum of 69%
Unmodulated carrier available?	Yes
Declared frequency stability	+/-40ppm
RX Parameters	
Alignment range – receiver	2402 - 2480 MHz
EUT Declared RX Signal Bandwidth	1MHz

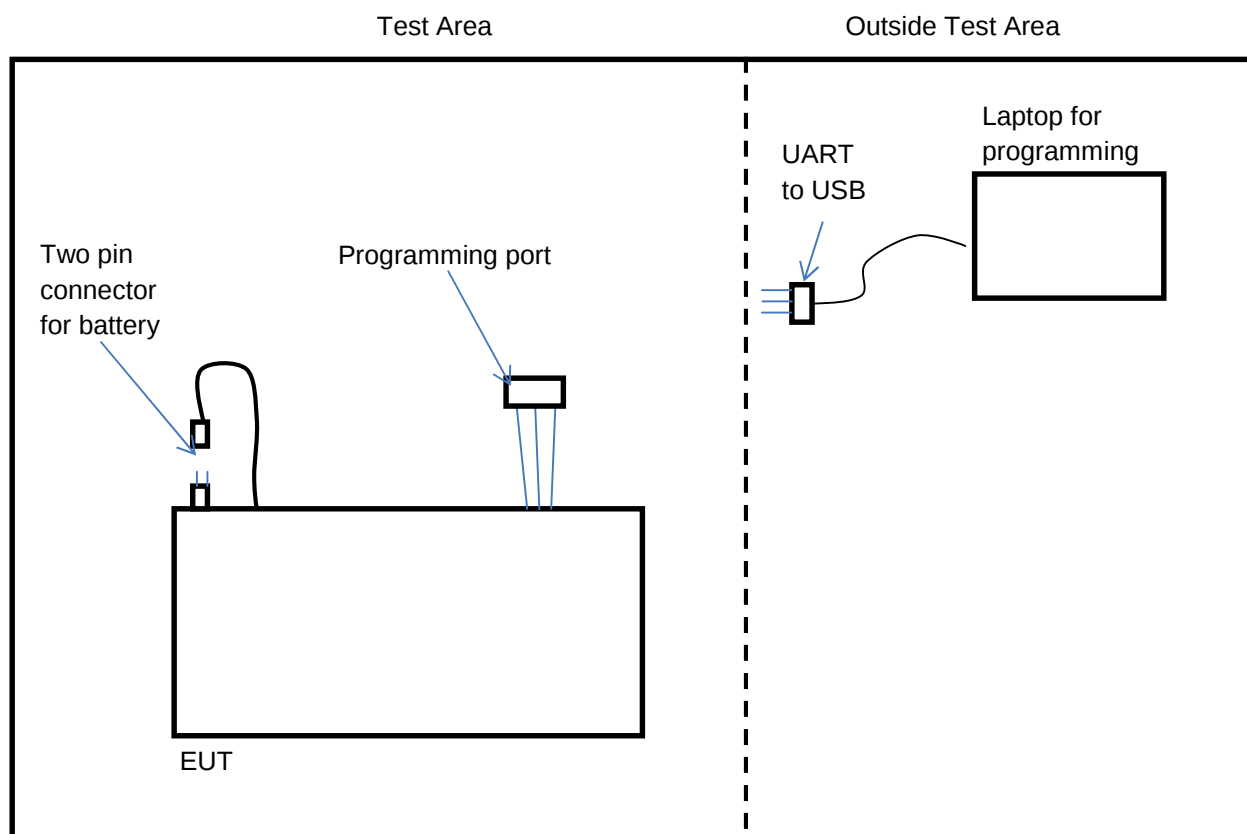
2.3 Functional description

When powered on, the device goes into Bluetooth advertising mode. It can be recognized by another Bluetooth device that can connect to it. When in connected mode, the device automatically sends motion tracking angle information in the form of a quaternion every 50 to 20 ms (20 to 50Hz duty cycle). Connecting a micro-USB cable puts the device into battery charging mode & the device radio is not enabled.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX 1	EUT transmitting at 2402MHz with modulation PRBS at max power and 69% duty cycle	Yes
TX 2	EUT transmitting at 2440MHz with modulation PRBS at max power and 69% duty cycle	Yes
TX 3	EUT transmitting at 2480MHz with modulation PRBS at max power and 69% duty cycle	Yes
TX 4	EUT sweeping across all channels with modulation PRBS at max power and 69% duty cycle	No

2.5 Emissions configuration



Two units were provided for tests, a conducted RF unit (s/n 11199027#1) and a radiated RF unit (s/n 11199027#2). Both units were identical except that the conducted unit had the addition of a temporary RF lead and sma connector port. The units were powered from internal batteries which were fully charged prior to tests. To turn the units on and off an external battery connector was provided on each unit. The unit's were also provided with a programming port to allow configuration of RF test modes via use of the NRFgo PC application software and a separate USB to UART converter board. The units were configured via the PC application and the programming port. After each configuration, the programming port was disconnected from the EUT and tests performed. Continuous 100% duty cycle transmit was not capable through the PC application. A maximum duty cycle of 69% was achieved and used in combination with top, middle and bottom channels as stated within section 2.4 of this report. Hopping mode was also available through the PC application.

A Micro USB port is also available on the units, however this was not connected for tests as it is only used for charging the EUT's, during which the transmitter is not enabled.

All tests were performed on the radiated unit s/n 11199027#2.

2.5.1 Signal leads

Port Name	Cable Type	Connected
Micro USB	Micro USB	No

Micro USB port not connected for tests, transmitter is disabled in charge mode.

3 Summary of test results

The 3D Sound One Module, 3DSLM01 was tested for compliance to the following standard(s) :

47 CFR Part 15.247 Effective Date 1st October 2015
DTS: Digital Transmission System

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions		NOT TESTED ¹
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED ²
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED ²
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 ³
6. Effective radiated power field strength	47 CFR Part 15C Part 15.247(d)	PERFORMED ⁴
7. Band Edge Compliance	47 CFR Part 15C Part 15.215 & 15.247(d)	PASSED
8. Occupied bandwidth		NOT TESTED ¹
9. Maximum Average conducted output power		NOT TESTED ¹
10. Maximum Peak conducted output power		NOT TESTED ¹
11. Maximum Power Spectral Density		NOT TESTED ¹
12. Antenna power conducted emissions		NOT APPLICABLE ⁵
13. Duty cycle	47 CFR Part 15C Part 15.35(c)	PERFORMED ⁶
14. FHSS carrier frequency separation		NOT APPLICABLE ⁷
15. Average time of occupancy		NOT APPLICABLE ⁷
16. Number of Hop Channels		NOT APPLICABLE ⁷

¹ Not tested at applicant's request.

² Spectrum below 30MHz started at a frequency of 32.768 kHz up to a frequency of 30MHz based on the lowest signal generated/used within the equipment as declared by the applicant.

³ Spectrum investigated started at a frequency of 30MHz up to a frequency of 25GHz based on 10 times the highest channel/ signal generated in equipment of 2.48GHz.

⁴ Test performed to obtain maximised field strength position for restricted band edge measurements.

⁵ EUT is integral Antenna equipment. Radiated emissions performed with antenna in place.

⁶ No limits apply, however duty cycle measurement performed to verify correction factors for average emissions and 69% duty cycle test modes.

⁷ EUT does not employ FHSS technology.

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
4.1.4	DA 00-705	2000	PUBLIC NOTICE Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
4.1.5	KDB 558074 D01 v03r03	2013	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

4.2 Deviations

The following tests have not been performed at the request of 3D Sound Labs: -
AC power line conducted emissions: Not tested at applicant's request.
Antenna power conducted emissions: Not tested at applicant's request.
Maximum Average conducted output power: Not tested at applicant's request.
Occupied bandwidth: Not tested at applicant's request.
Maximum Peak conducted output power: Not tested at applicant's request.
Maximum Power Spectral Density: Not tested at applicant's request.

5 Tests, methods and results

5.1 AC power line conducted emissions

NOT TESTED: Not tested at applicant's request.

5.2 Radiated emissions 9 - 150 kHz

5.2.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery. The EUT was operated in TX 1 and TX 2 and TX 3 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 (if required) made 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 H.

5.2.4 Test equipment

TMS81, TMS45, ZSW1, E534, E535

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	20°C
Humidity of test environment	61%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Mid channel	2440 MHz

Plot refs
8861-1 Rad 1 9-150kHz Para
8861-1 Rad 1 9-150kHz Perp

No signals observed on any channel during pre-scans in the chamber, therefore final measurements on an OATS were not required and only Mid channel plots are shown in this report.

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

LIMITS:

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

15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.

The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
9kHz - 30MHz ± 3.9 dB

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX 1 and TX 2 and TX 3 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 (if required) made 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 H.

5.3.4 Test equipment

TMS81, TMS45, ZSW1, E534, E535

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	20°C
Humidity of test environment	61%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Mid channel	2440 MHz

Plot refs
8861-1 Rad 1 150k-30MHz Para
8861-1 Rad 1 150k-30MHz Perp

No signals observed on any channel during pre-scans in the chamber, therefore final measurements on an OATS were not required and only Mid channel plots are shown in this report.

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

LIMITS:

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

15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.

The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
9kHz - 30MHz ± 3.9 dB

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.247(d) [Reference 4.1.1 of this report]

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX 1 and TX 2 and TX 3 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° 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 H.

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	20°C
Humidity of test environment	61%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Mid channel	2440 MHz

Plot refs
8861-1 Rad 1 VHF Horiz
8861-1 Rad 1 VHF Vert
8861-1 Rad 1 UHF Horiz
8861-1 Rad 1 UHF Vert

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

No discernible difference was noted in emissions between channel settings Low, Mid and High (exploratory measurements), therefore final measurements are presented for TX mid channel mode only for these test ranges and only Mid channel plots are shown in this report. No signals were observed within 20dB of limits.

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:

File Name: 3D Sound Labs.8861-1 Issue 01

30MHz - 1000MHz ± 5.1 dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(d) & 15.209 [Reference 4.1.1 of this report]

5.5.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX 1 and TX 2 and TX 3 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° to record the worst case emissions. A measurement distance of 3m was used between the test range 1 - 6GHz, 1.2m was used in the test range 6 - 25GHz. At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site H.

5.5.4 Test equipment

E533, E534, LPE261, LPE333, TMS78, TMS79, ZSW1

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	19-22°C
Humidity of test environment	41-56%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Low channel	2402 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
2329	54.5	-19.5	37.0	-17.0	Flat	Horizontal
2384	55.0	-19.0	39.0	-15.0	Flat	Horizontal

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Mid channel	2440 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
7320	53.8	-20.2	46.6	-7.4	Flat	Vertical
7320	52.5	-21.5	45.1	-8.9	Flat	Horizontal

Plots	
8861-1 Horiz 1-2GHz Mid channel TX	
8861-1 Vert 1-2GHz Mid channel TX	
8861-1 Horiz 2-2.7GHz Mid channel TX	
8861-1 Vert 2-2.7GHz Mid channel TX	
8861-1 Horiz 2.7-6GHz Mid channel TX	
8861-1 Vert 2.7-6GHz Mid channel TX	
8861-1 Horiz 6-9GHz Mid channel TX	
8861-1 Vert 6-9GHz Mid channel TX	
8861-1 Horiz 9-12GHz Mid channel TX	
8861-1 Vert 9-12GHz Mid channel TX	
8861-1 Horiz 12-15GHz Mid channel TX	
8861-1 Vert 12-15GHz Mid channel TX	
8861-1 Horiz 15-18GHz Mid channel TX	
8861-1 Vert 15-18GHz Mid channel TX	
8861-1 Horiz 18-21.5GHz Mid channel TX	
8861-1 Vert 18-21.5GHz Mid channel TX	
8861-1 Horiz 21.5-25GHz Mid channel TX	
8861-1 Vert 21.5-25GHz Mid channel TX	

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
High channel	2480 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
7440	51.7	-22.3	44.0	-10.0	Flat	Vertical
7440	51.6	-22.4	45.5	-8.5	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. Only emissions measured within 20dB of limits have been shown in this report.

LIMITS:

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

15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209. The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

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

1 – 18 GHz $\pm 3.5\text{dB}$, 18 – 26.5 GHz $\pm 3.9\text{dB}$

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 6.6 [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 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was rotated in all three orthogonal planes to maximise emissions. Final measurements were taken at 3m. The EUT was operated in TX 1, TX 2 and TX 3 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 EUT was rotated through 360° to capture maximum field strength.

Tests were performed in test site H.

5.6.4 Test equipment

E533, E534, E535, LPE333, LPE261

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	21°C
Humidity of test environment	54%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Low channel	2402 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low	Mid	High
Peak Level (dBµV/m) @ 3m	95.70	91.80	86.30
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Flat	Flat	Flat

Highest radiated power was found to be with the EUT in a flat position and the measuring antenna in a horizontal polarisation.

LIMITS:

Not required, test performed to obtain maximised EUT position and polarisation for radiated restricted band edge measurements.

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 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 operated in TX 1 and TX 3 modes.

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. Due to the EUT only having a 69% duty cycle, Average (RMS) band edge measurements were made using the procedure stated in ANSI C63.10 clause 11.13.3.4. This included a Duty cycle correction factor that was applied to the plots/results.
Tests were performed using Test Site H.

5.7.4 Test equipment

E533, E534, E535, LPE261, LPE333

See Section 9 for more details

5.7.5 Test results

Temperature of test environment 21°C
Humidity of test environment 58%
Pressure of test environment 102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Low channel	2402 MHz
High channel	2480 MHz

	Low Channel	High Channel
Peak Level (dBuV/m)	55.6	44
Peak Plot reference	J8861-1 Low channel PK restricted band edge	J8861-1 High channel PK restricted band edge
Average Level (dBuV/m)	41.4	33.8
Average Plot reference	J8861-1 Low channel AV restricted band edge	J8861-1 High channel AV restricted band edge

	Low Channel	High Channel
Band Edge Plot reference	J8861-1 Low channel PK authorised band edge 20dBc	J8861-1 High channel PK authorised band edge 20dBc

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. These show the 20dBc requirement of 15.247(d) are met at the band edges of 2400 and 2483.5 MHz. Restricted band edge plots are also shown in section 6. The tables list the field strengths observed in the adjacent restricted bands, which are required to meet the tighter 15.209 limits. Average results shown have been corrected by $20\log(1/0.69) = 3.2\text{dB}$, due to only a 69% duty cycle being available for test.

LIMITS:

AV = 54dBuV/m at band edges

PK = 74dBuV/m at band edges

The restricted band edges closest to the EUT frequency of 2400-2483.5MHz are 2390 & 2483.5MHz.

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

NOT TESTED: Not tested at applicant's request.

5.9 Maximum Average conducted output power

NOT TESTED: Not tested at applicant's request.

5.10 Maximum Peak conducted output power

NOT TESTED: Not tested at applicant's request.

5.11 Maximum Power Spectral Density

NOT TESTED: Not tested at applicant's request.

5.12 Antenna power conducted emissions

NOT TESTED: Not tested at applicant's request.

5.13 Duty cycle

5.13.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.35(c) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 7.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.35c [Reference 4.1.1 of this report]

5.13.2 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 operated in TX 1 mode.

5.13.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The centre frequency of the analyser was set to that of the transmitter, and the span set to zero. The sweep time was adjusted so that the pulse width and the periodic operation could be observed. Measurements were performed test in site H.

5.13.4 Test equipment

E533, E534, LPE261, LPE333

See Section 9 for more details

5.13.5 Test results

Temperature of test environment	19-22°C
Humidity of test environment	41-56%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level declared	4 dBm
Channel Spacing	2 MHz
Mod Scheme	GFSK
Single channel	2440 MHz

	Single
TX on time (uS)	431.205
TX on Plot filename	J8861-1 Duty cycle
TX repetition time (uS)	625.320
Calculated TX Duty cycle (%)	68.96

These results show that the duty cycle correction factor from 69% up to 100% for average emissions is therefore $20\log(1/0.69) = 3.22$ dB.

Analyser plots for the duty cycle can be found in Section 6 of this report.

LIMITS:

Limits not specified, measurement performed in line with ANSI C63.10 Clause 11.13.3.4 to determine correction factor for average restricted band edge emissions.

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

5.14 FHSS carrier frequency separation

NOT APPLICABLE: EUT does not employ FHSS technology

5.15 Average time of occupancy

NOT APPLICABLE: EUT does not employ FHSS technology

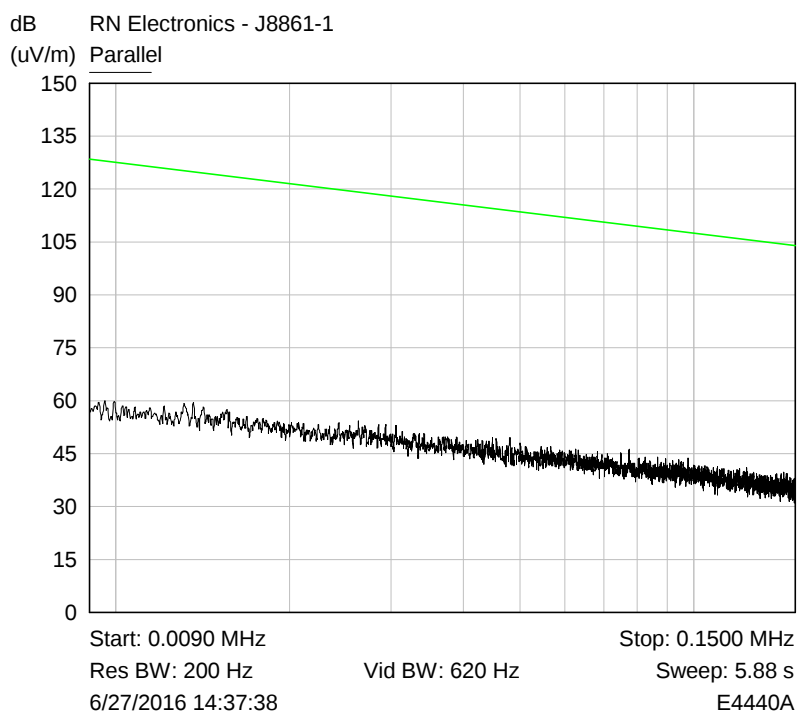
5.16 Number of Hop Channels

NOT APPLICABLE: EUT does not employ FHSS technology

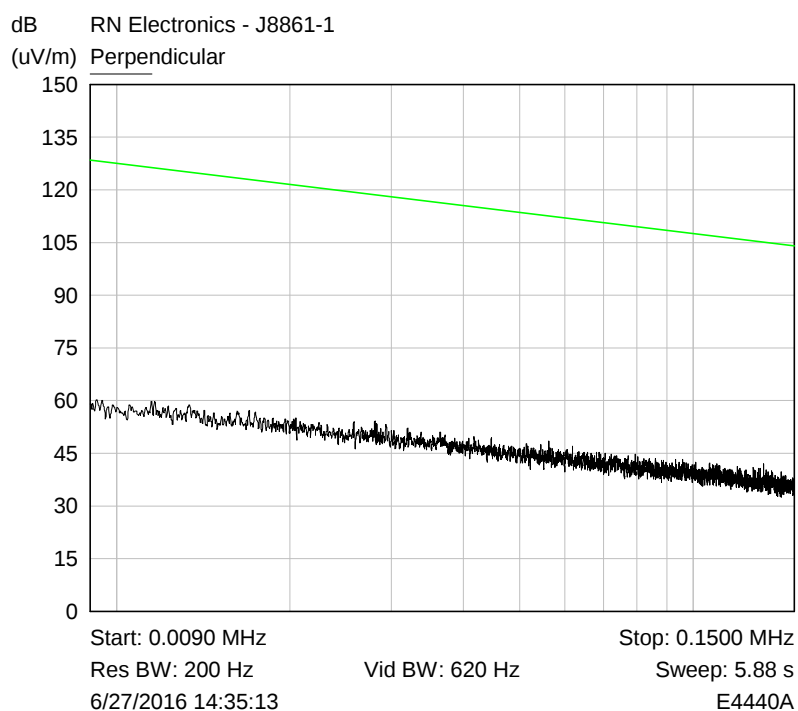
6 Plots/Graphical results

6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2440 MHz



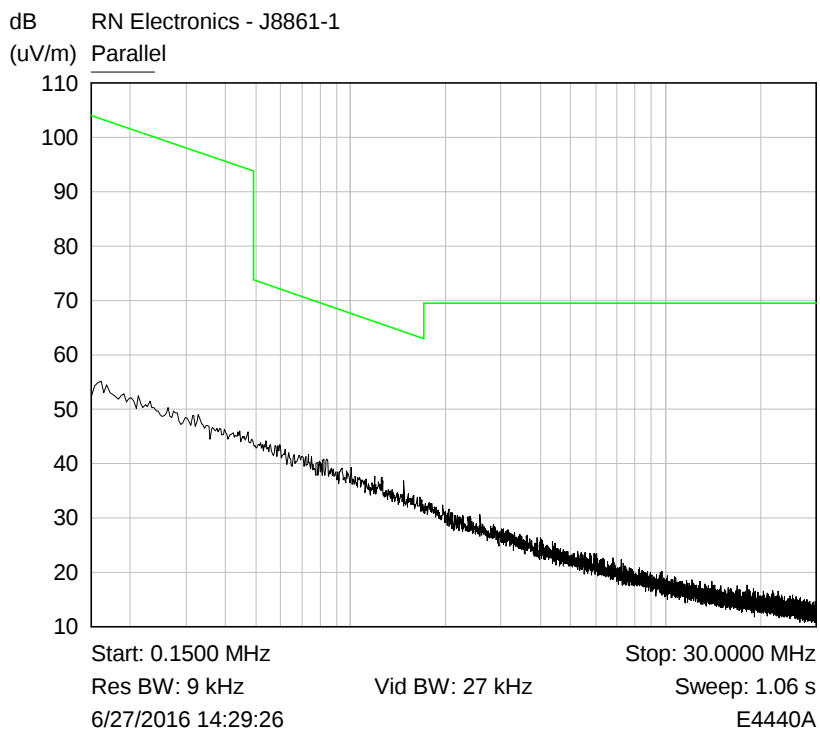
Plot of 9 – 150 kHz Parallel



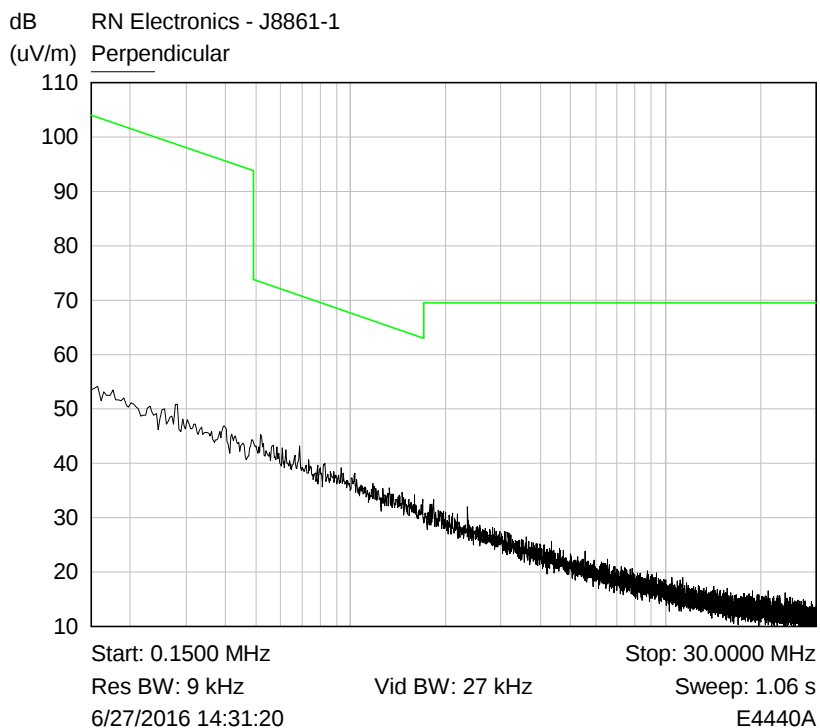
Plot of 9 – 150 kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2440 MHz



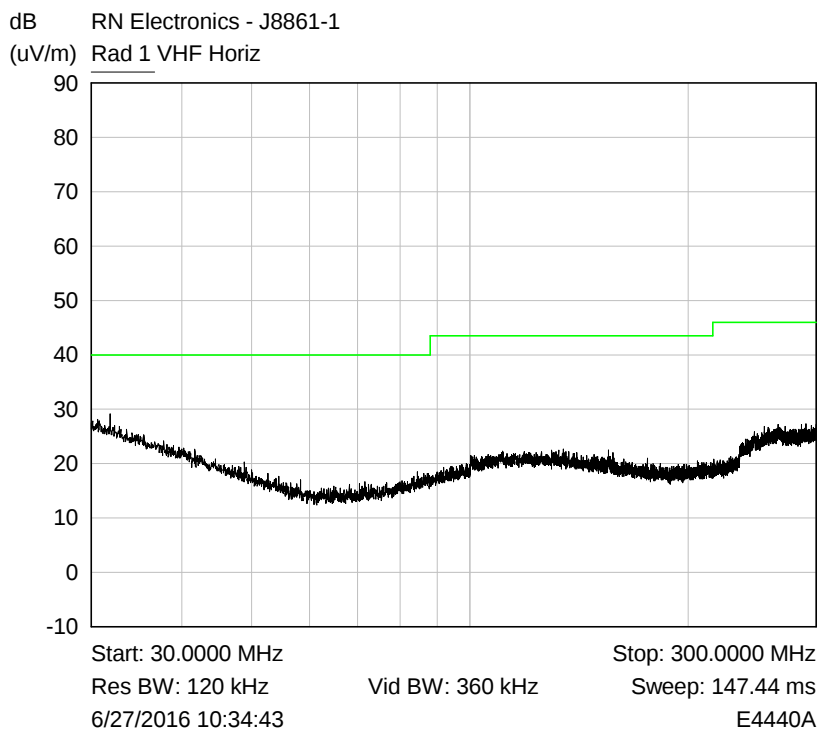
Plot of 150kHz-30MHz Parallel



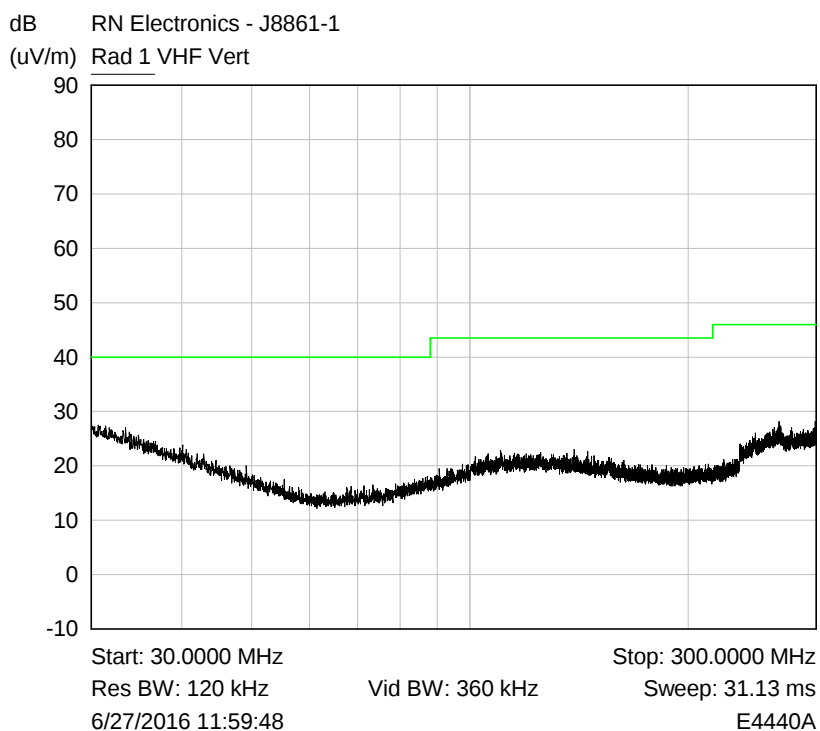
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

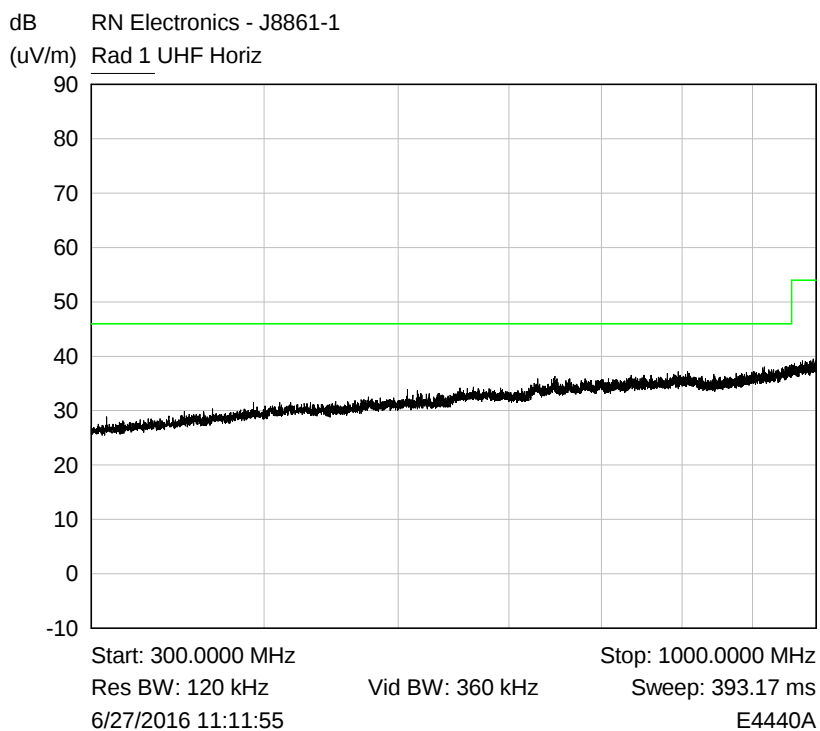
RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2440 MHz



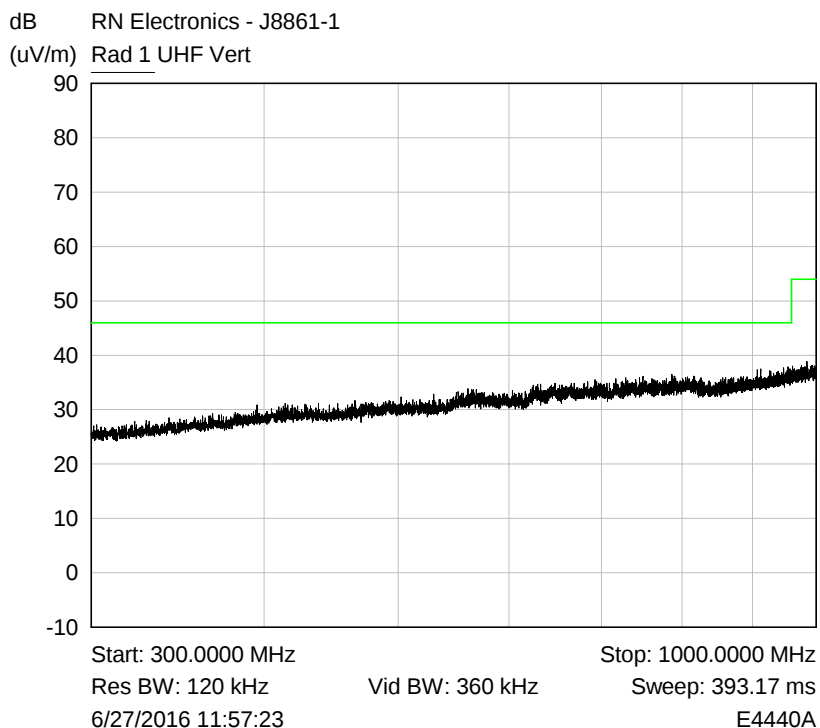
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



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

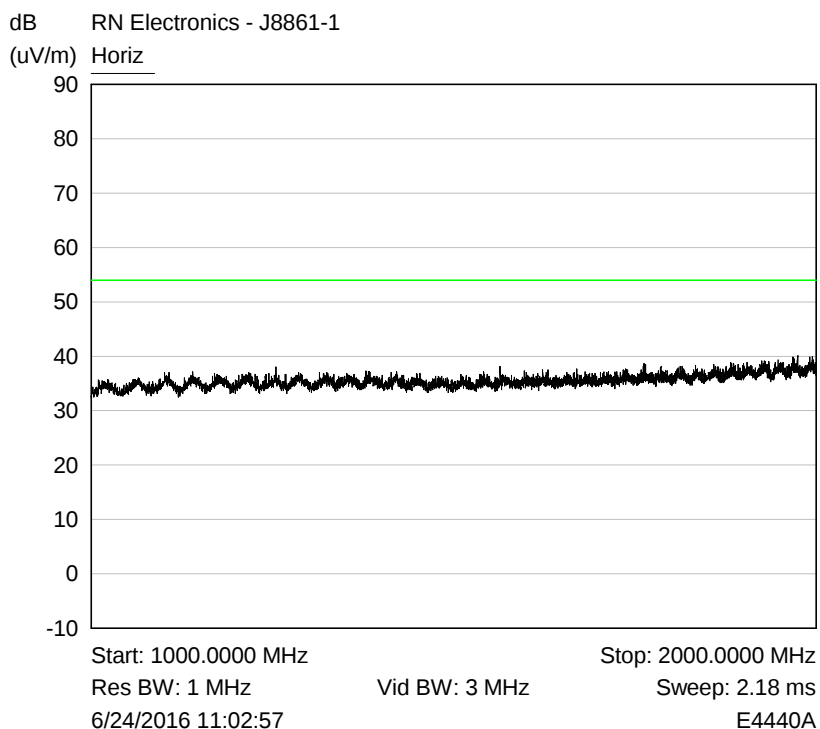


Plot of Peak emissions for UHF Vertical against the QP limit line.

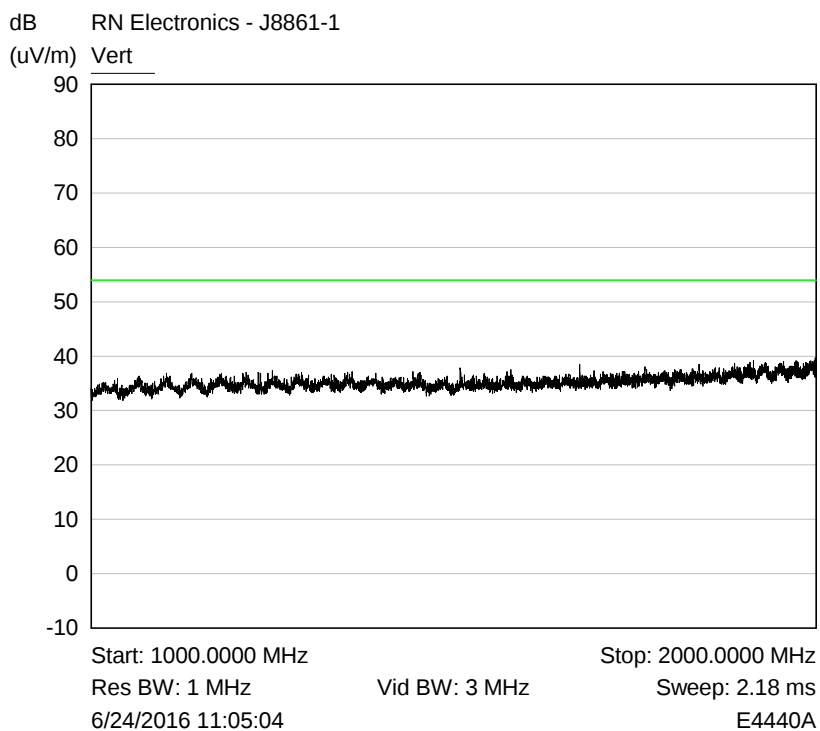
6.4 Radiated emissions above 1 GHz

Note: Whilst Low, Middle and High channels have been tested, to minimise report size, only middle channel plots are shown. Plots are PK detector max held against Average limit line.

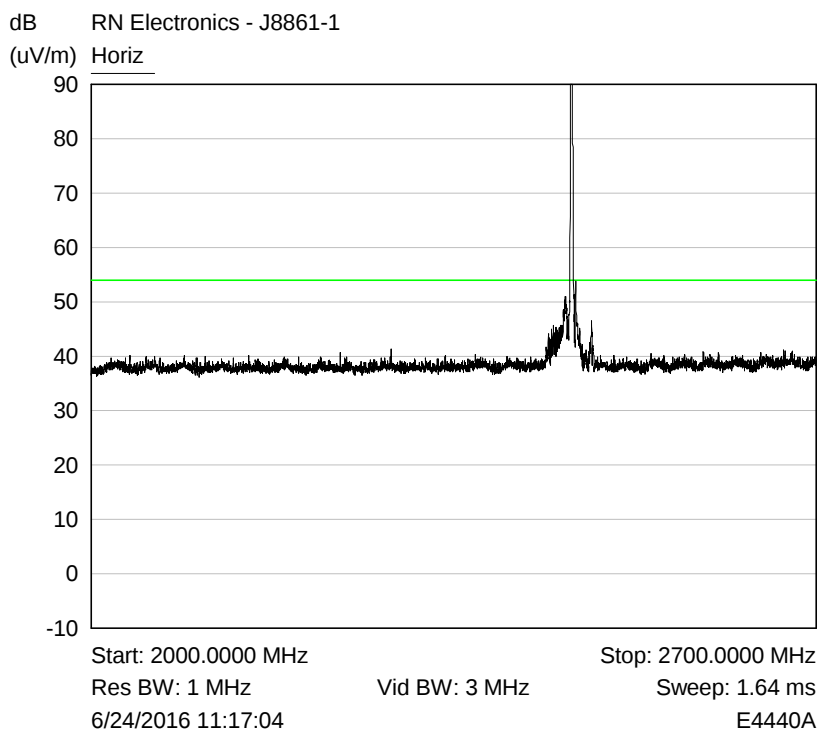
RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2440 MHz



Plot of Horizontal 1 – 2 GHz emissions

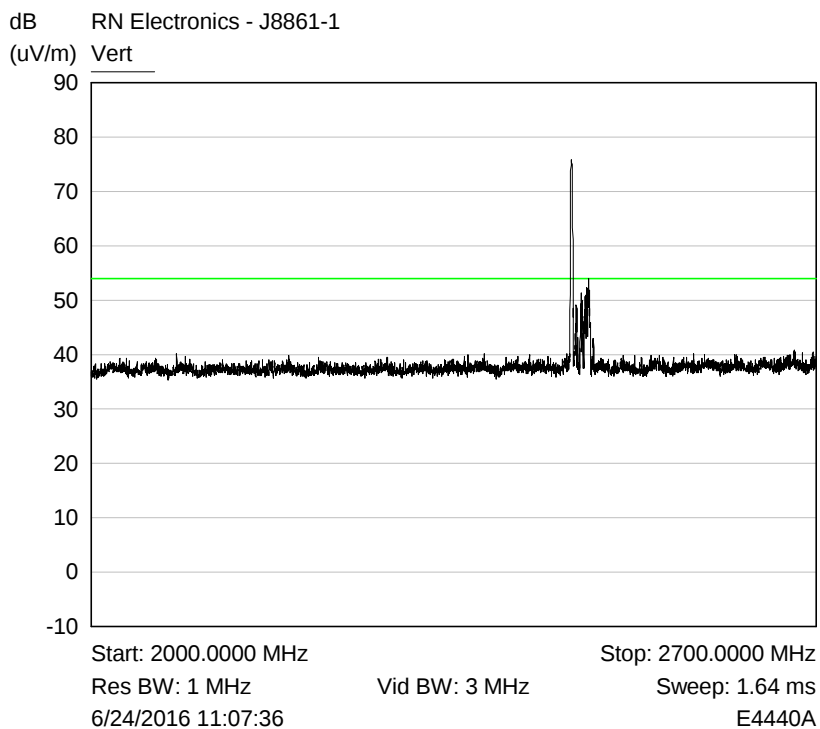


Plot of Vertical 1 – 2 GHz emissions



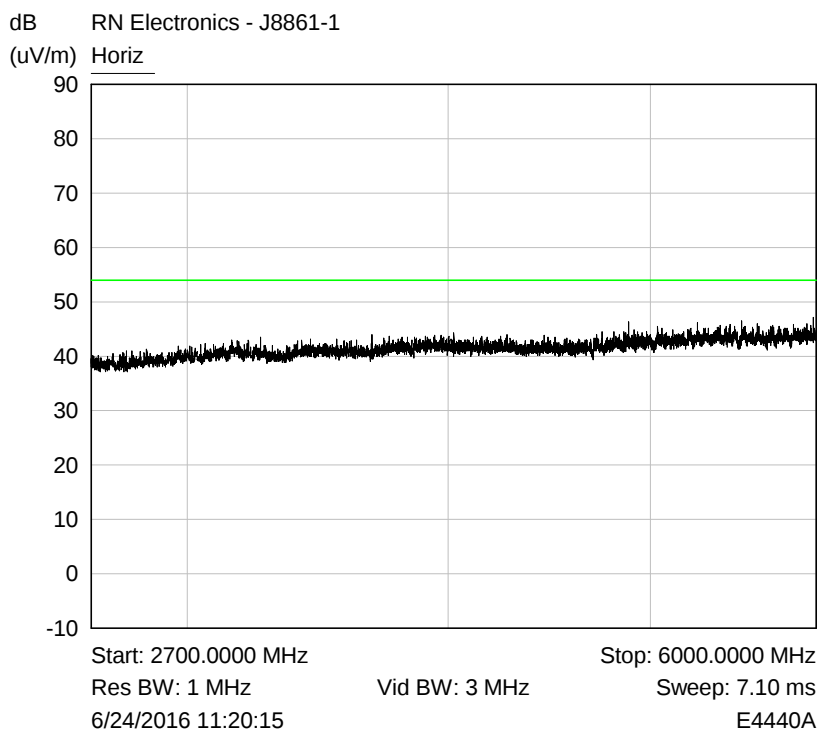
Plot of Horizontal 2 – 2.7 GHz emissions

Note: Plot shows fundamental frequency.

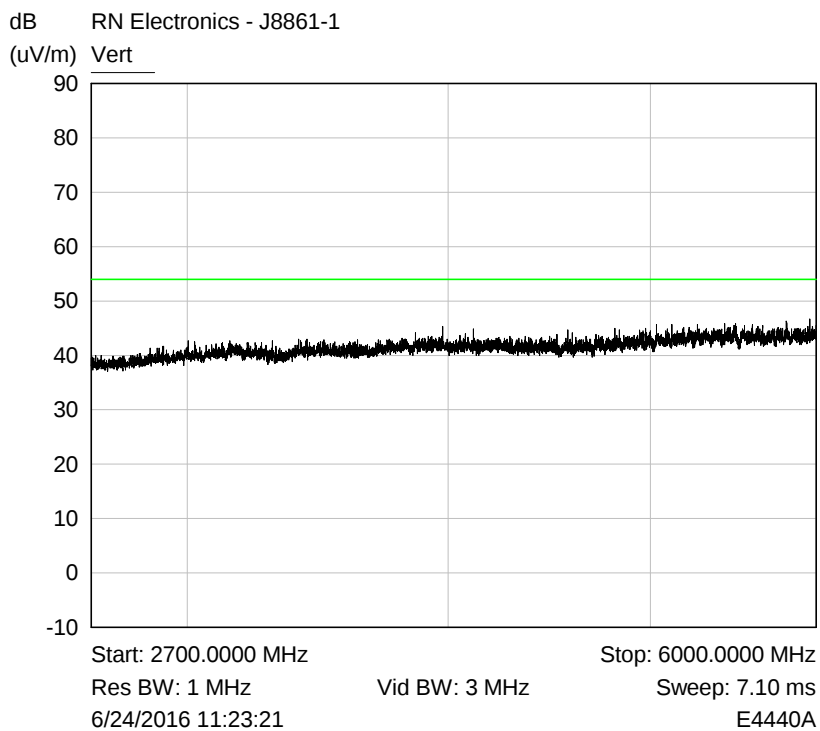


Plot of Vertical 2 – 2.7 GHz emissions

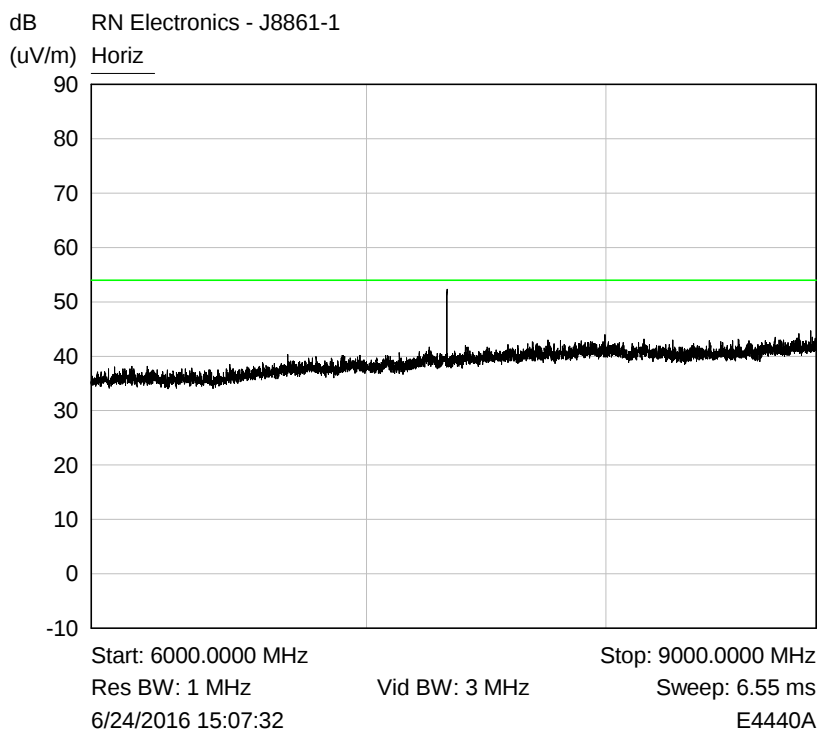
Note: Plot shows fundamental frequency.



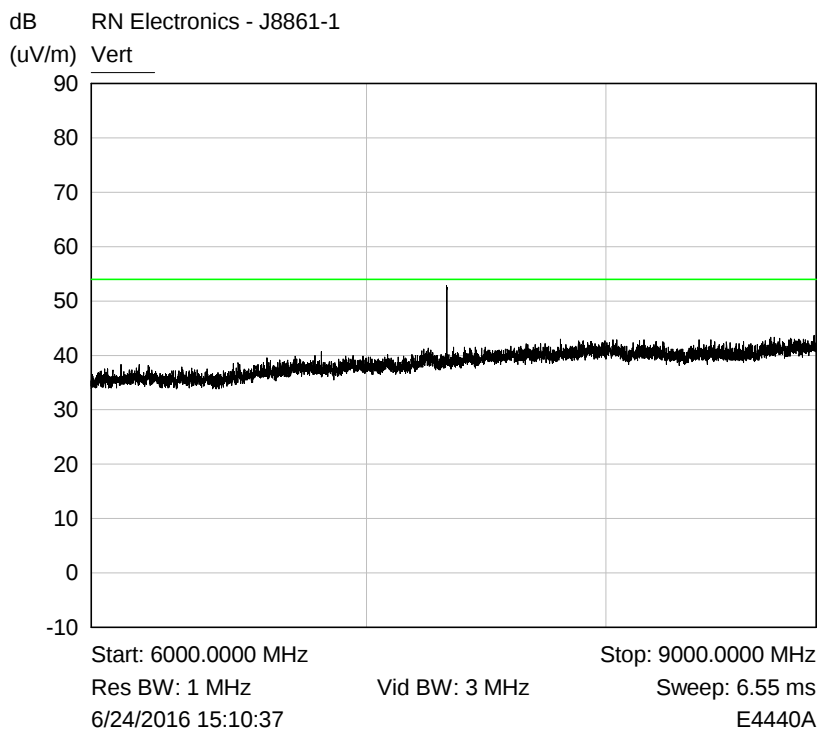
Plot of Horizontal 2.7 – 6 GHz emissions



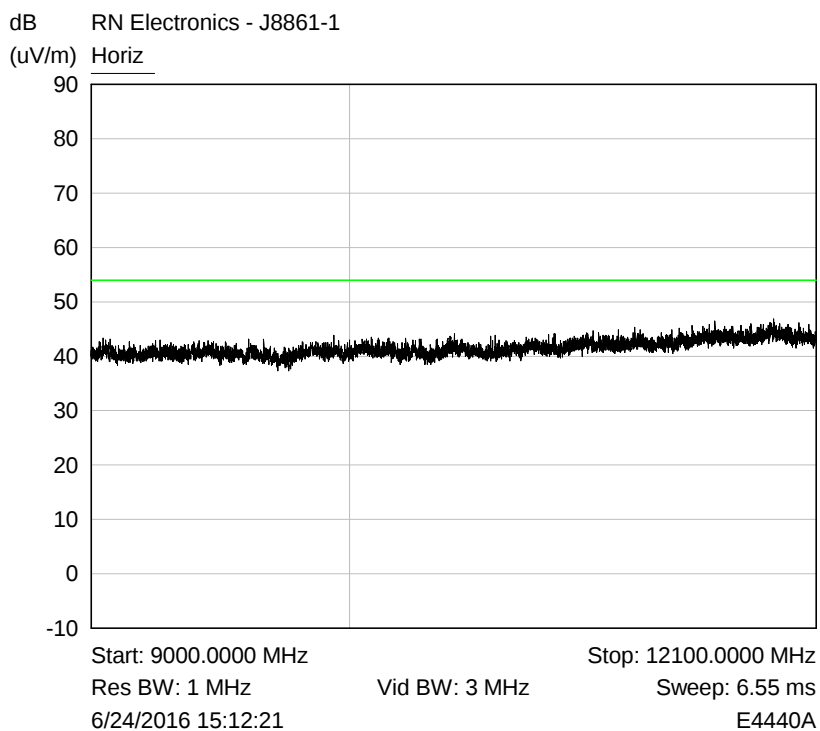
Plot of Vertical 2.7 – 6 GHz emissions



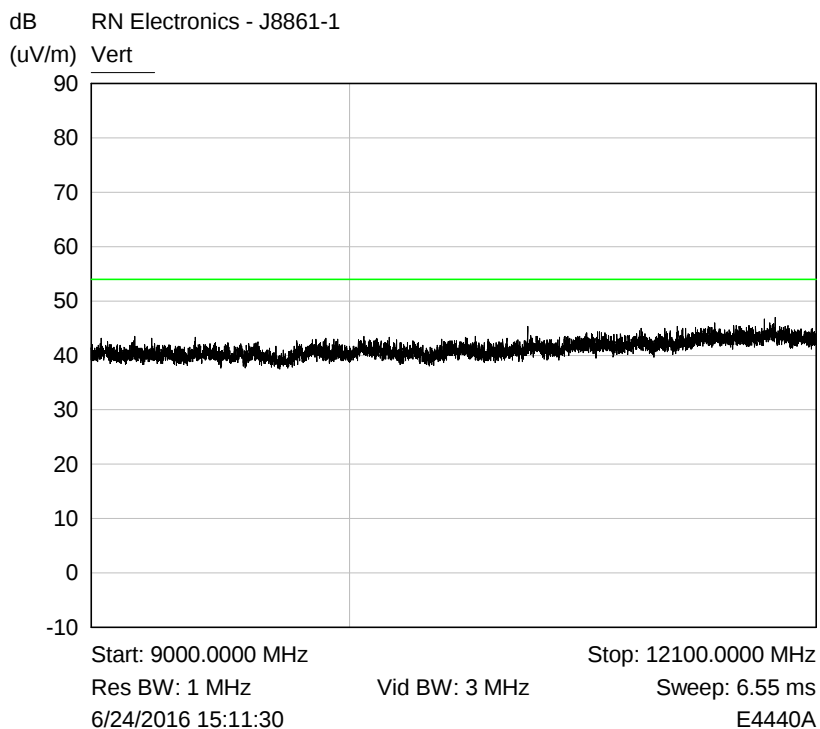
Plot of Horizontal 6 – 9 GHz emissions



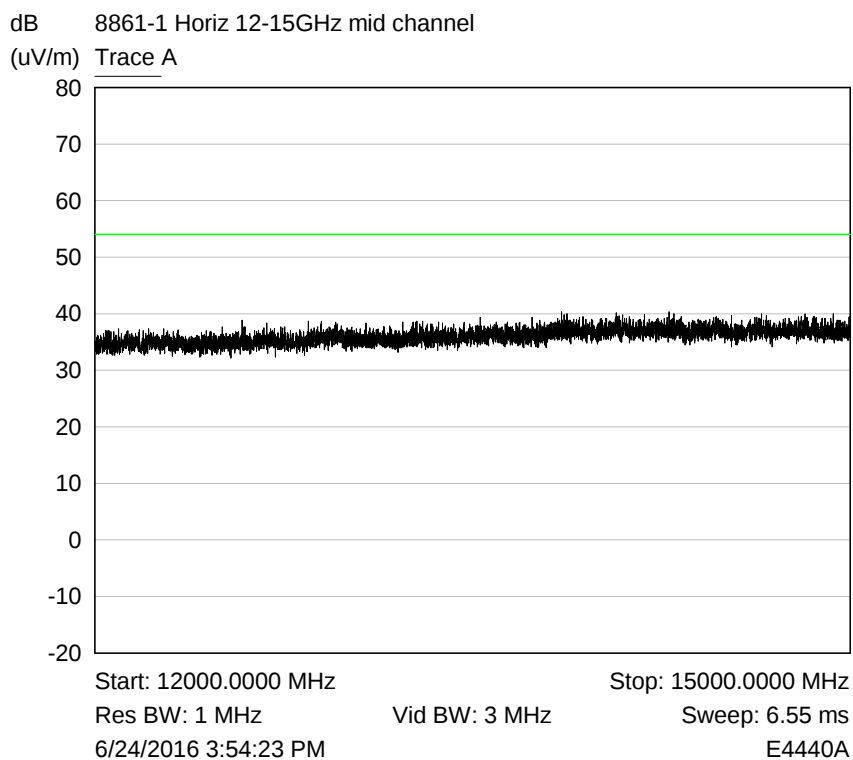
Plot of Vertical 6 – 9 GHz emissions



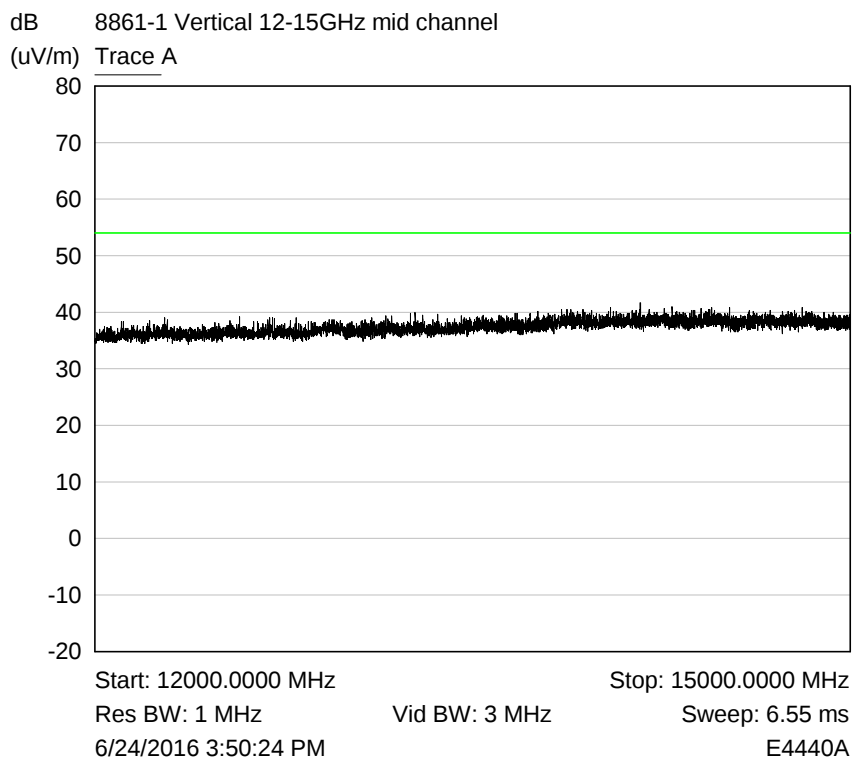
Plot of Horizontal 9 – 12 GHz emissions



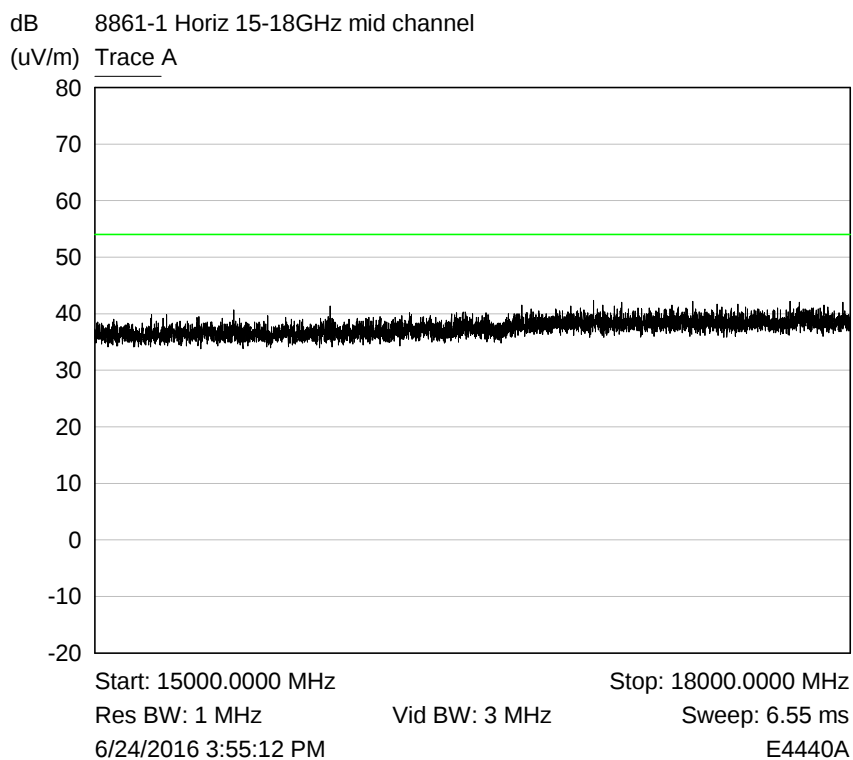
Plot of Vertical 9 – 12 GHz emissions



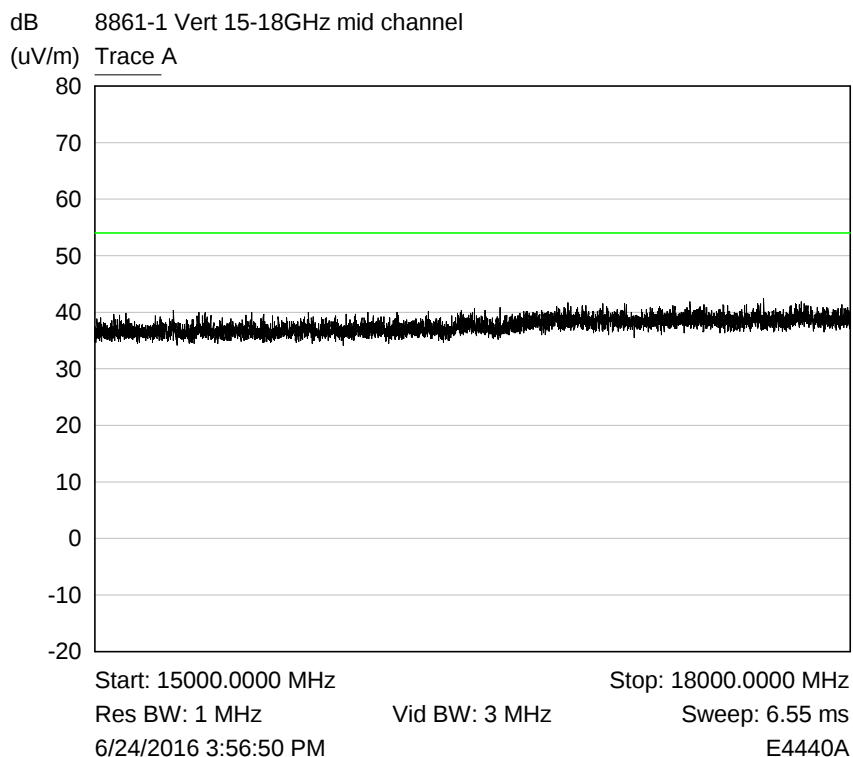
Plot of Horizontal 12 – 15 GHz emissions



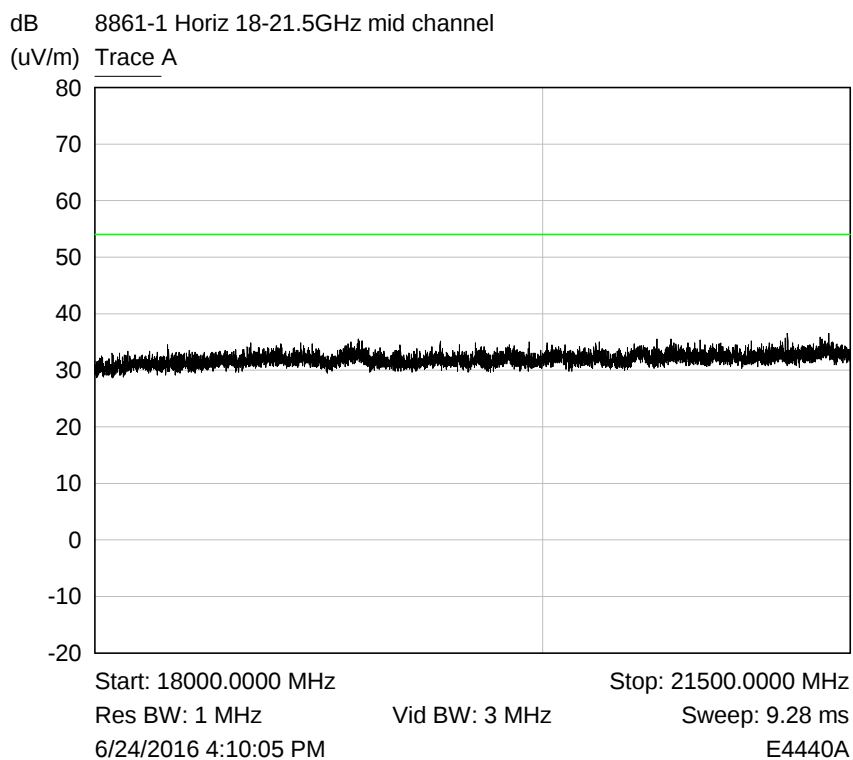
Plot of Vertical 12 – 15 GHz emissions



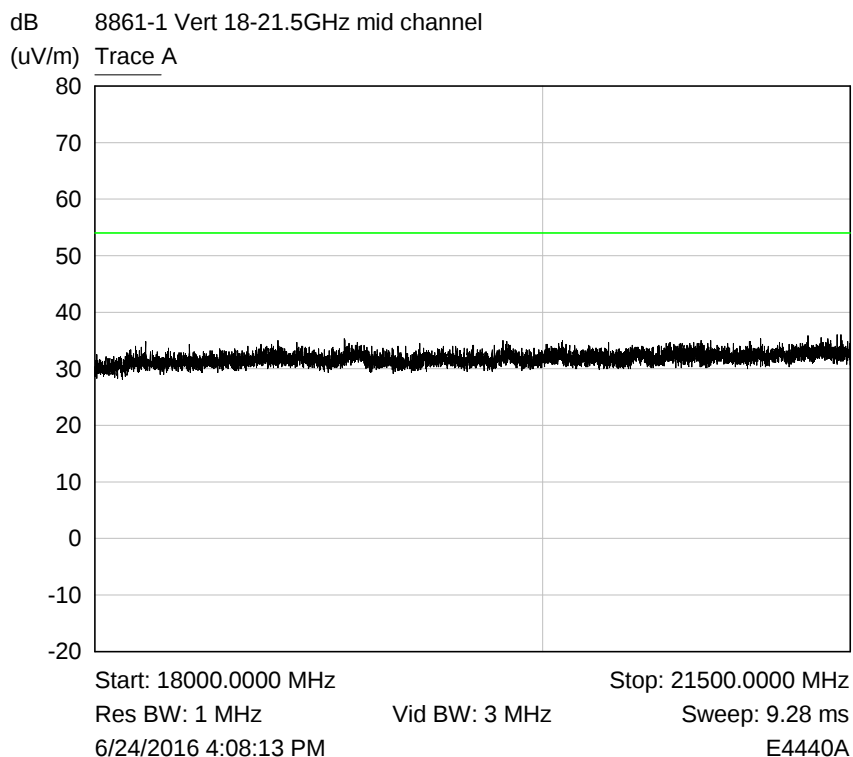
Plot of Horizontal 15 – 18 GHz emissions



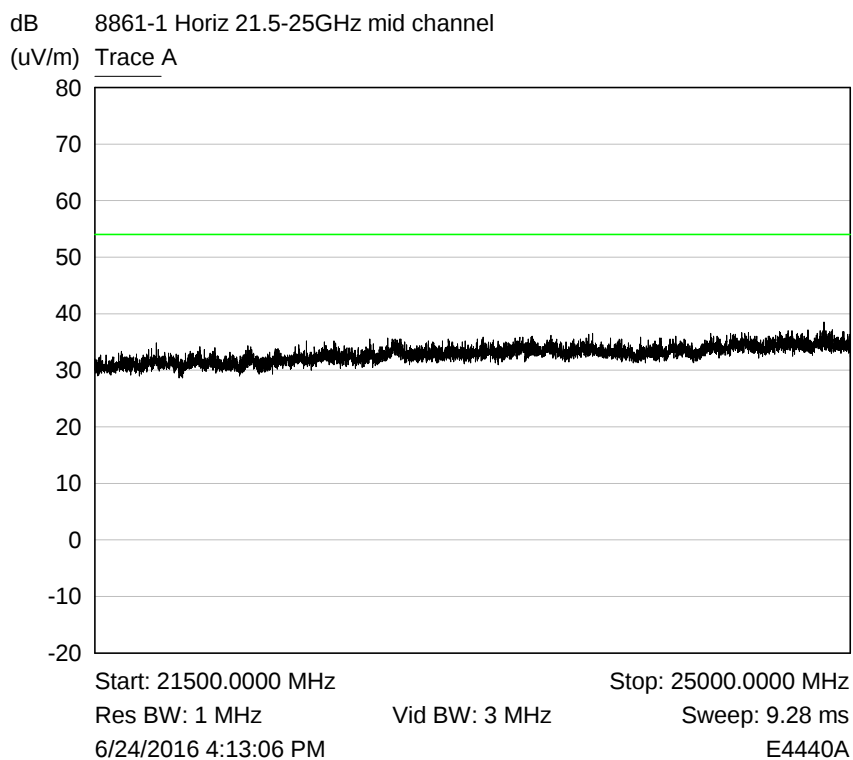
Plot of Vertical 15 – 18 GHz emissions



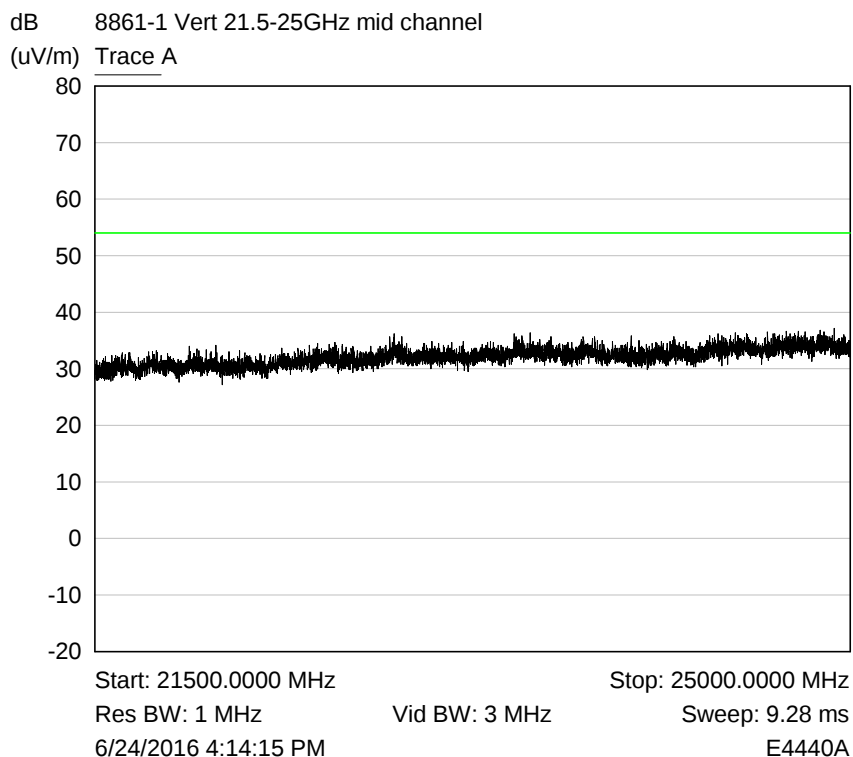
Plot of Horizontal 18 – 21.5 GHz emissions



Plot of Vertical 18 – 21.5 GHz emissions



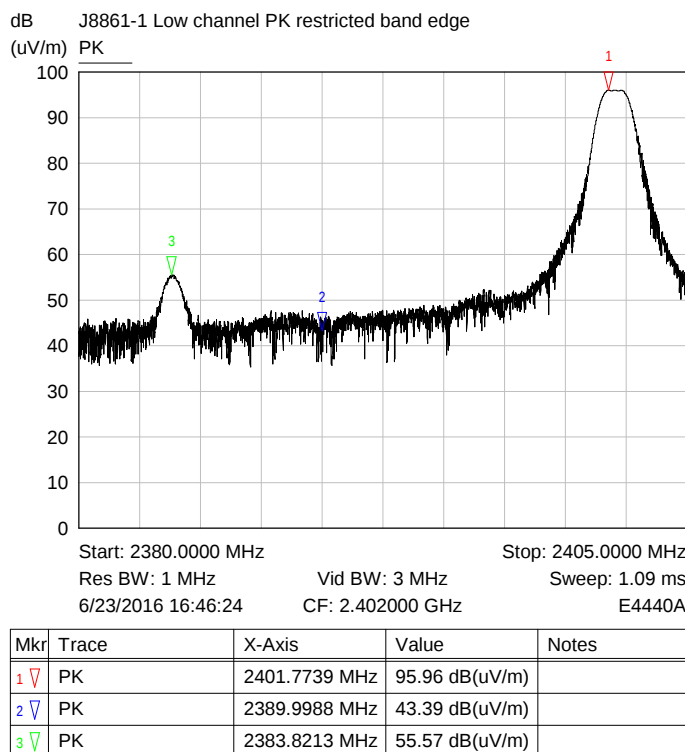
Plot of Horizontal 21.5 – 25 GHz emissions



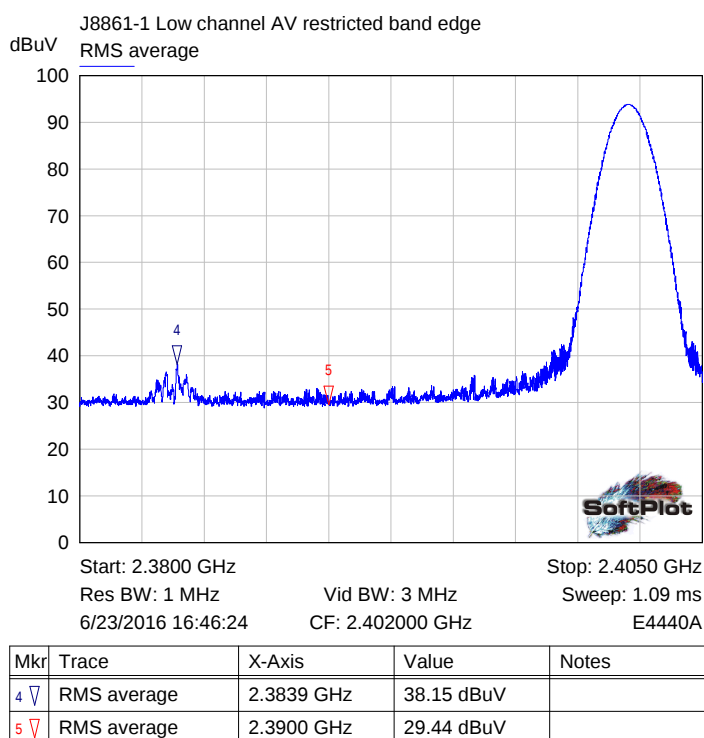
Plot of Vertical 21.5 – 25 GHz emissions

6.4 Band Edge Compliance

RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2402 MHz

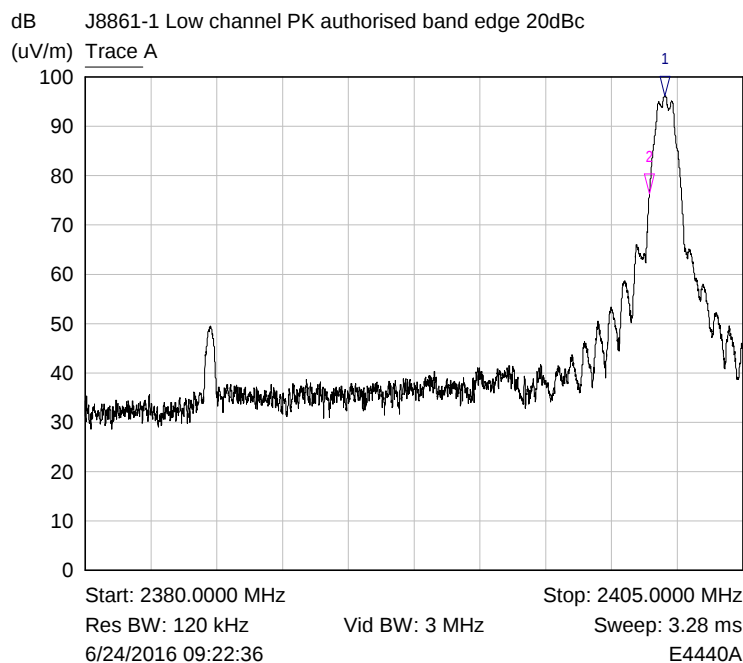


Peak Plot



Average Plot

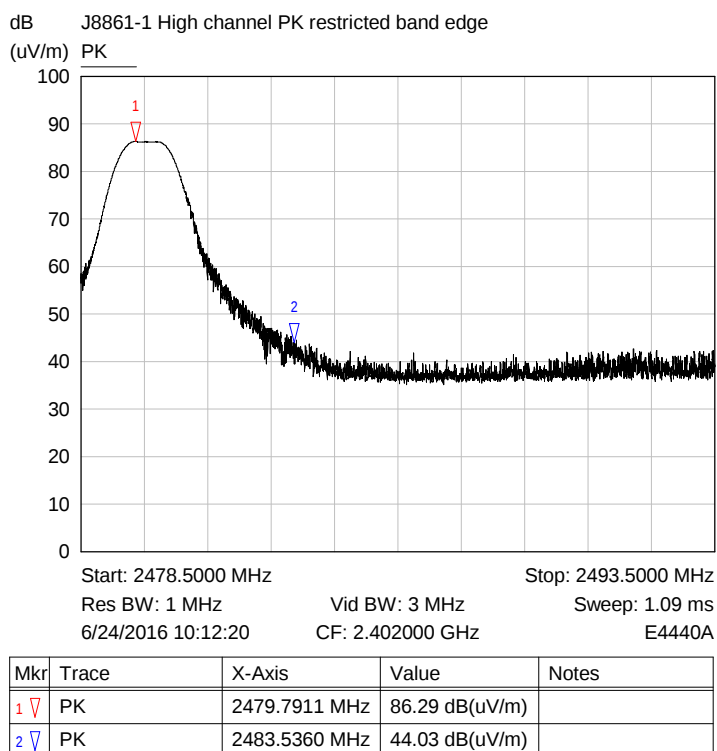
Note: Correction factor to be applied to AV plot result per section 5.7.



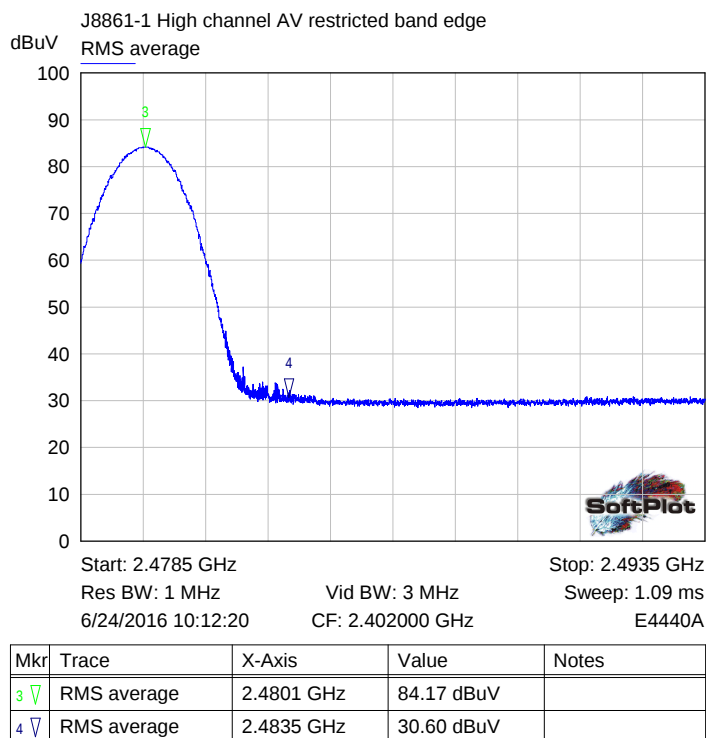
Mkr	Trace	X-Axis	Value	Notes
1 ▾	Trace A	2402.0394 MHz	96.20 dB(uV/m)	
2 ▾	Trace A	2401.4290 MHz	76.32 dB(uV/m)	

Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK, Channel 2480 MHz



Peak Plot

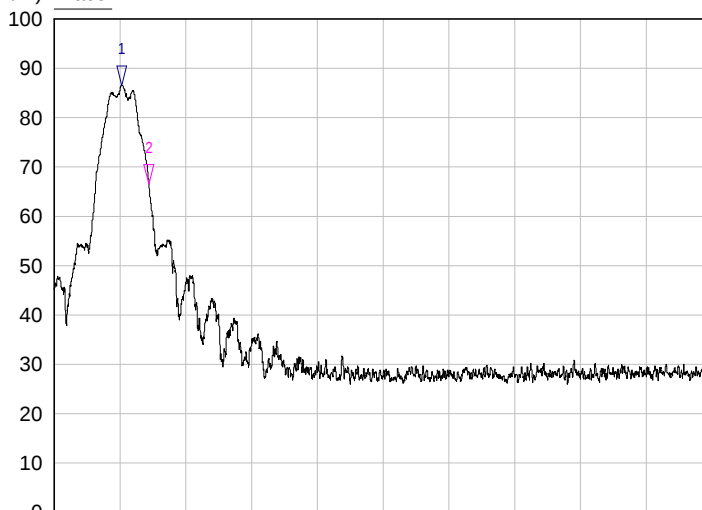


Average Plot

Note: Correction factor to be applied to AV plot result per section 5.7.

dB J8861-1 High channel PK authorised band edge 20dBc

(uV/m) Trace A



Start: 2478.5000 MHz

Stop: 2493.5000 MHz

Res BW: 120 kHz

Vid BW: 360 kHz

Sweep: 2.18 ms

6/24/2016 10:00:06

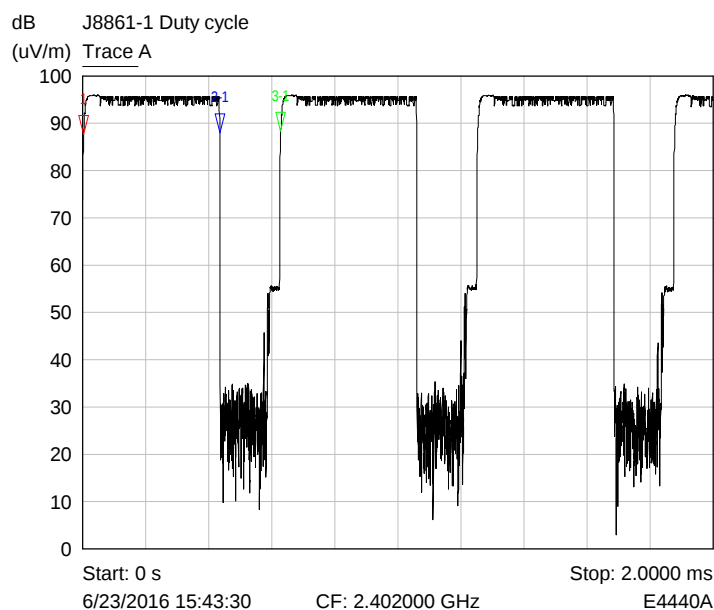
E4440A

Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2480.0364 MHz	86.58 dB(uV/m)	
2 ▽	Trace A	2480.6572 MHz	66.56 dB(uV/m)	

Band Edge Plot

6.5 Duty cycle

RF Parameters: Band 2400-2483.5 MHz, Power 4 dBm, Channel Spacing 2 MHz, Modulation GFSK



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.9300 us	87.74 dB(uV/m)	
2 ▽	Trace A	431.2050 us	0.29 dB	
3 ▽	Trace A	625.3205 us	0.52 dB	

TX on time (uS) and TX repetition time

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

Measurements are made as required by the standard. These measurements are made and recorded using detectors, either peak, quasi peak or average dependant on the test. A table of results has been given following the relevant plots. This table looks similar to the one illustrated below dependant on the measurements required by the test: -

Signal No.	Freq (MHz)	Peak Amp (dBμV)	Pk – Lim 1 (dB)	QP Amp (dBμV)	QP - Lim1 (dB)	Av Amp (dBμV)	Av - Lim1 (dB)
1	12345	54.9	-10.5	48	-12.6	37.6	-14.4

Column One - Labelled Signal No. is an incremental number that the receiver has given to each signal that has been measured.

Column Two - Labelled Freq (MHz) is the approximate frequency of the signal received.

Column Three - Labelled Peak Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the peak detector.

Column Four - Labelled Pk - Lim1 (dB) is the difference in level from the peak signal given to the active limit line. If this column appears in the table the peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Five - Labelled QP Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the quasi-peak detector.

Column Six - Labelled QP - Lim1 (dB) is the difference in level from the quasi-peak signal given to the active limit line. If this column appears in the table the quasi-peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Seven - Labelled Av Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the average detector.

Column Eight - Labelled Av - Lim1 (dB) is the difference in level from the average signal given to the active limit line. If this column appears in the table the average detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Only signals highlighted in red are deemed to exceed the limit of the detector required.

7.2 Explanation of limit line calculations for radiated measurements

The limits given in the test standard are normally expressed as absolute values (e.g. in μV/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dBμV/m referenced to the measuring instrument inputs. RN Electronics calibrate the test set-up to account for any path losses, antenna gains, etc. so that the value read at the receiver relates directly to the absolute value required, except that it is expressed in dB relative to one microVolt and may need to take account of any alternative measuring distance used. Examples:

(a) limit of 500 μV/m equates to $20 \cdot \log(500) = 54 \text{ dB } \mu\text{V/m}$.

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

(c) limit of 30 $\mu\text{V/m}$ at 30m, but below 30MHz, equates to $20.\log(30) + 40.\log(30/3) = 69.5 \text{ dB}\mu\text{V/m}$ at 3m, as extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

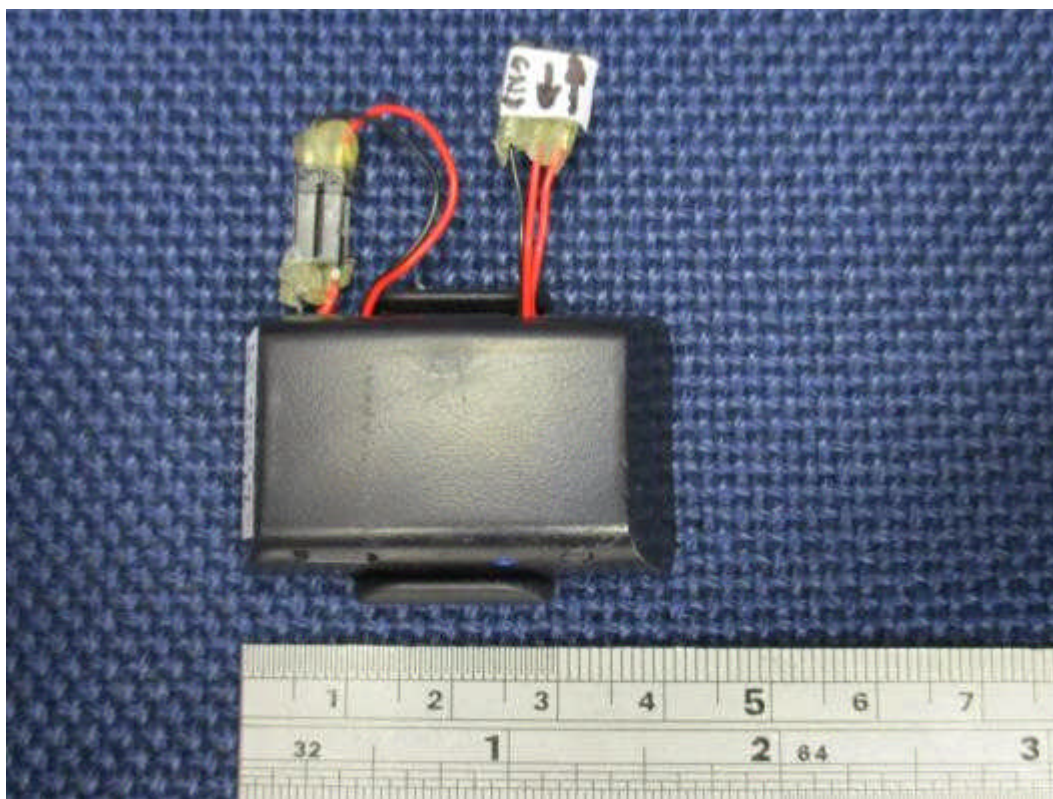
The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

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

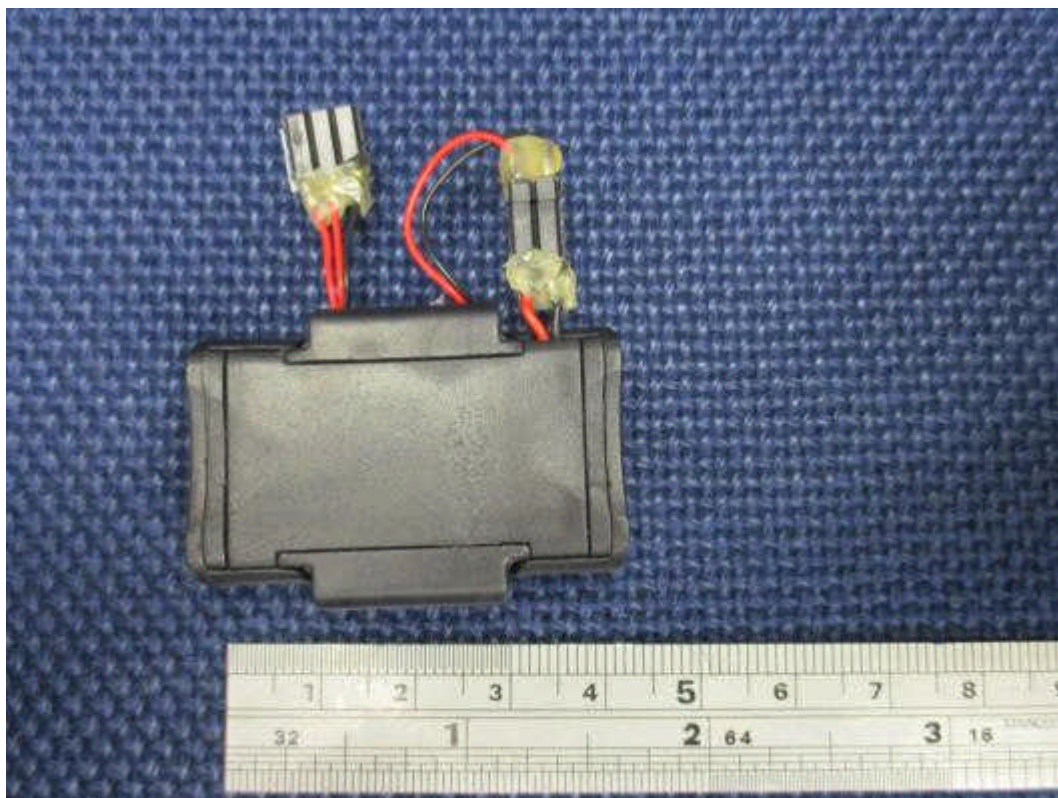
Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

8 Photographs

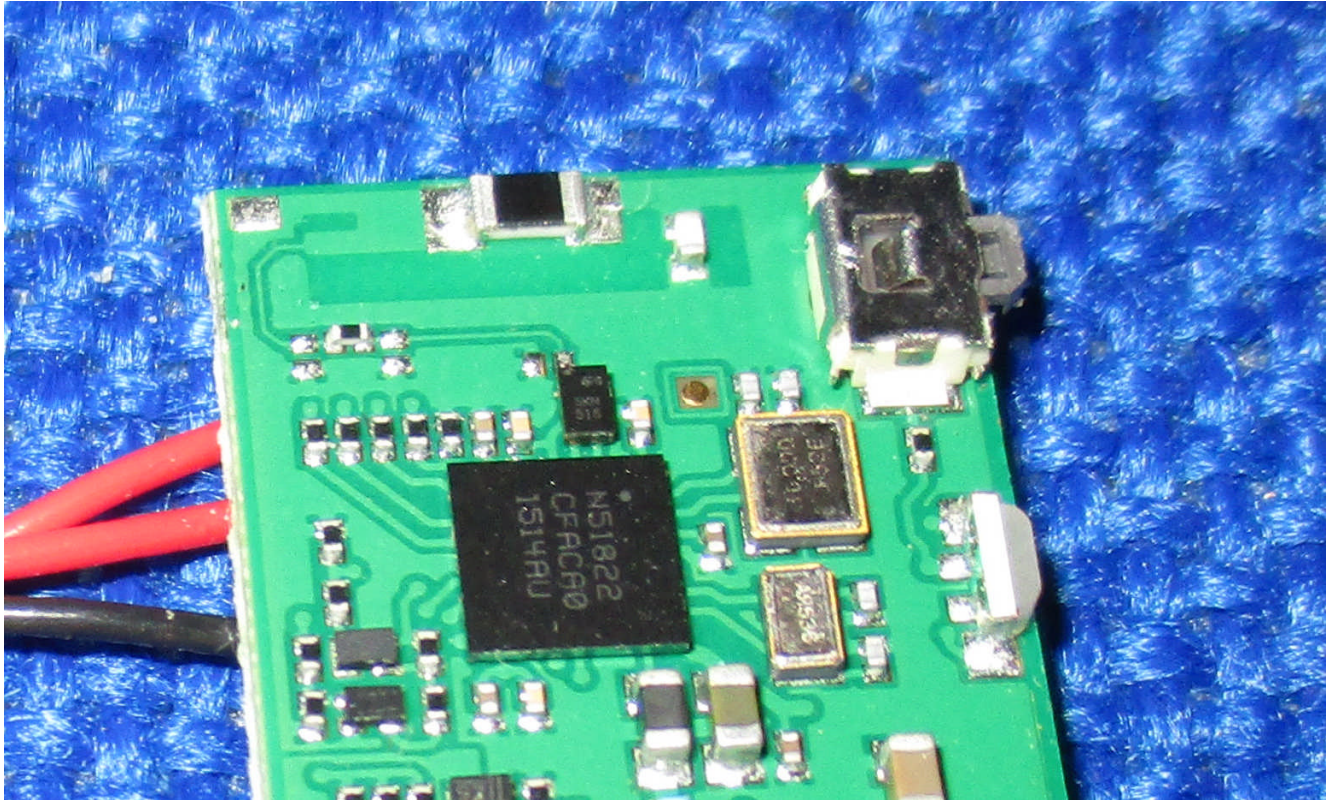
8.1 EUT Front View



8.2 EUT Reverse Angle



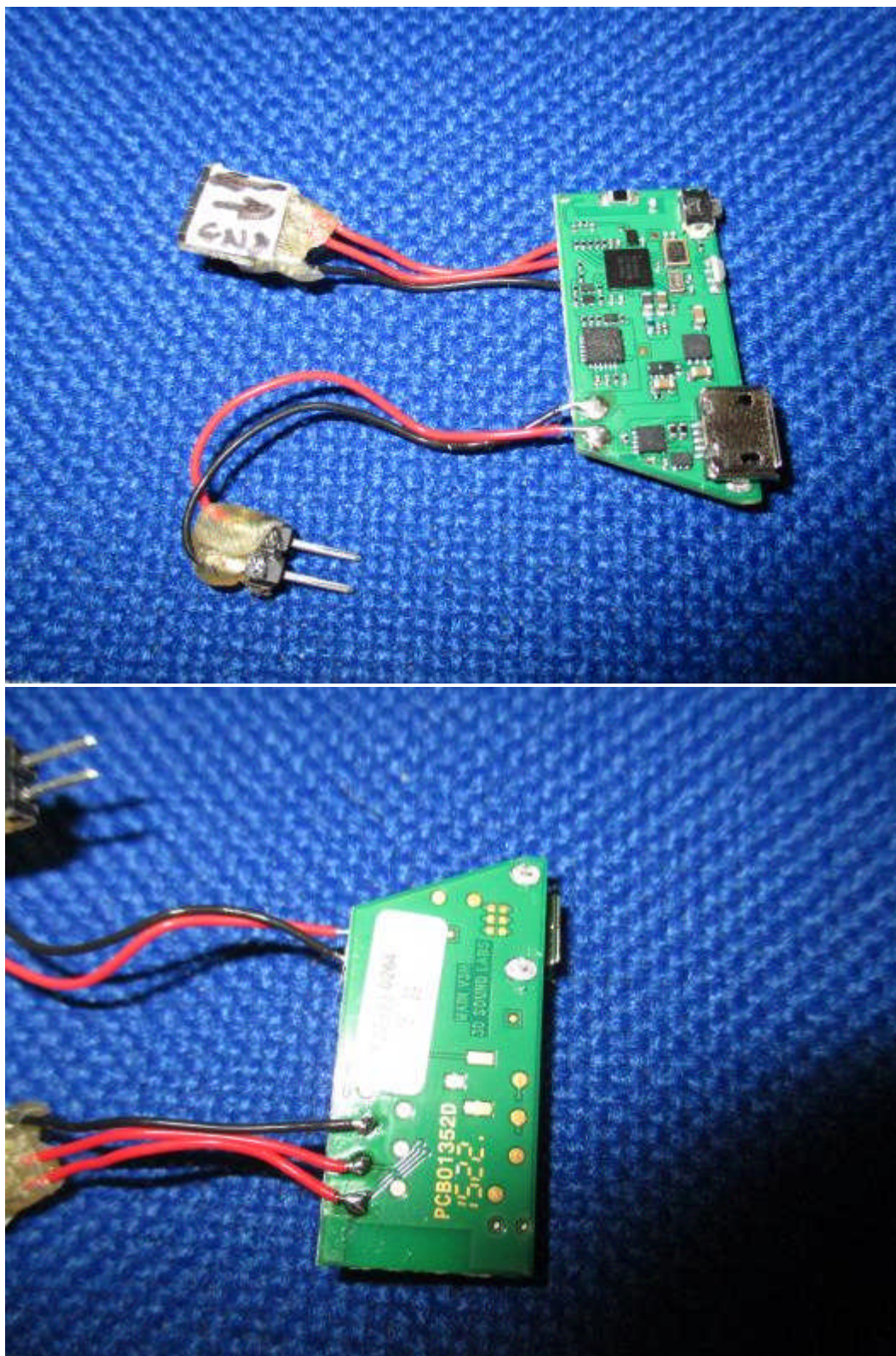
8.3 EUT Antenna

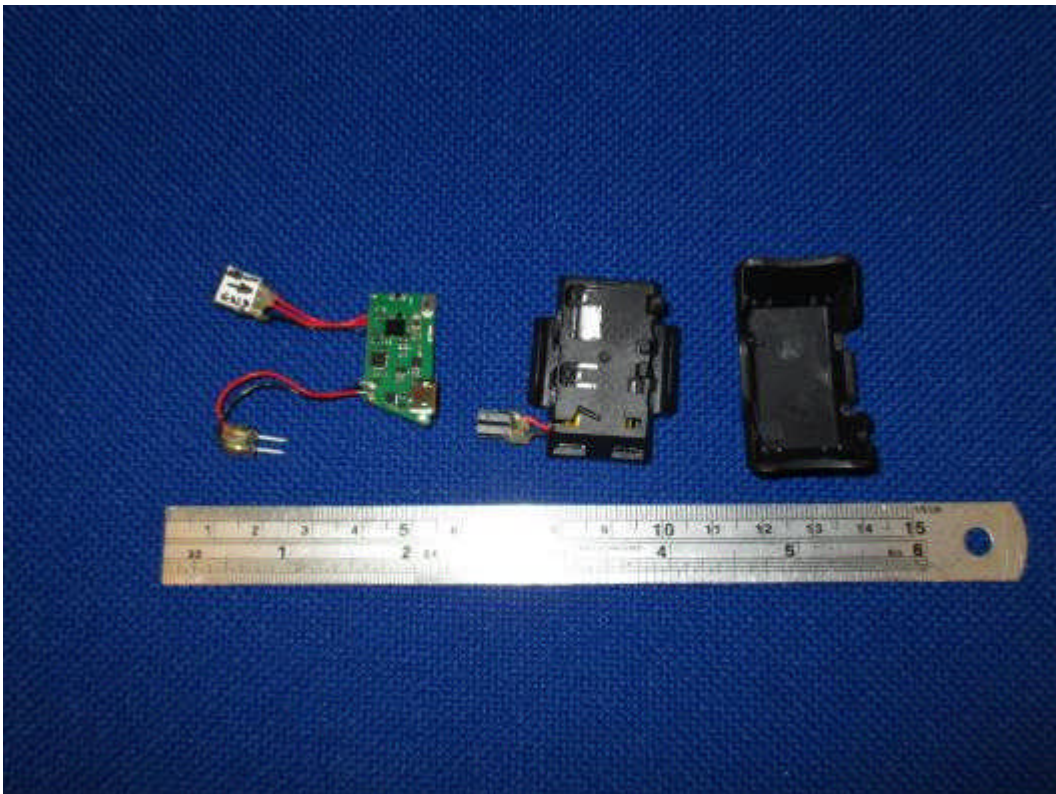
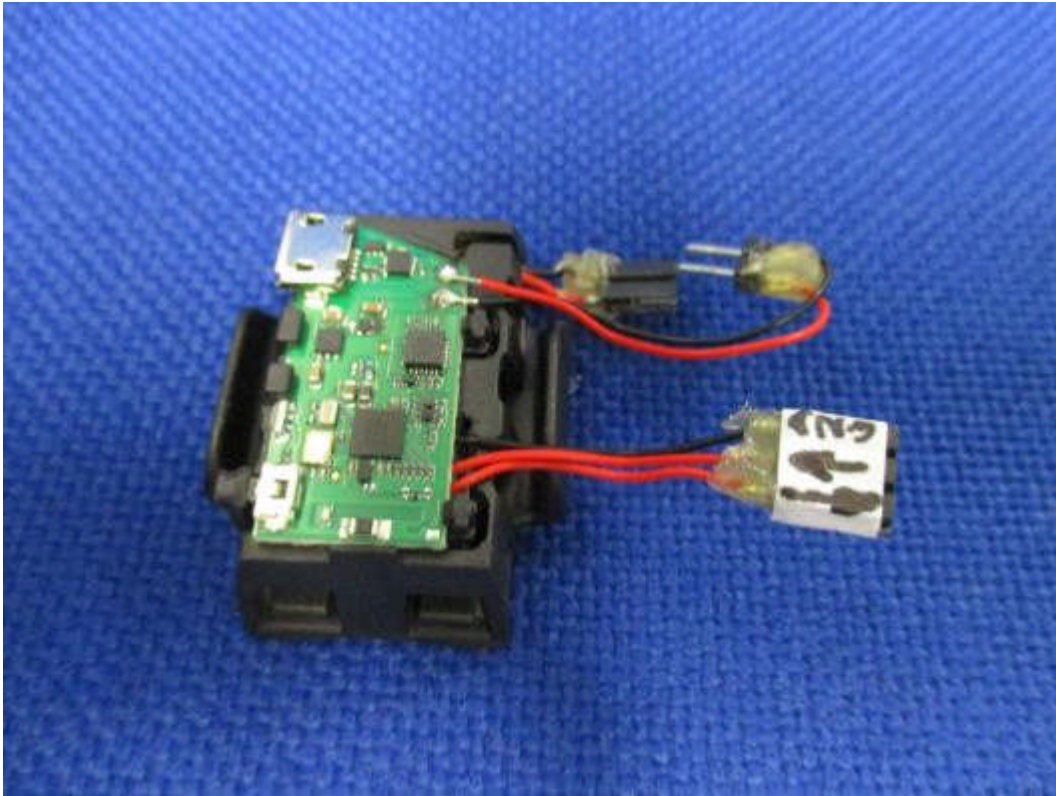


8.4 EUT Display & Controls

EUT had no display or controls.

8.5 EUT Internal photos

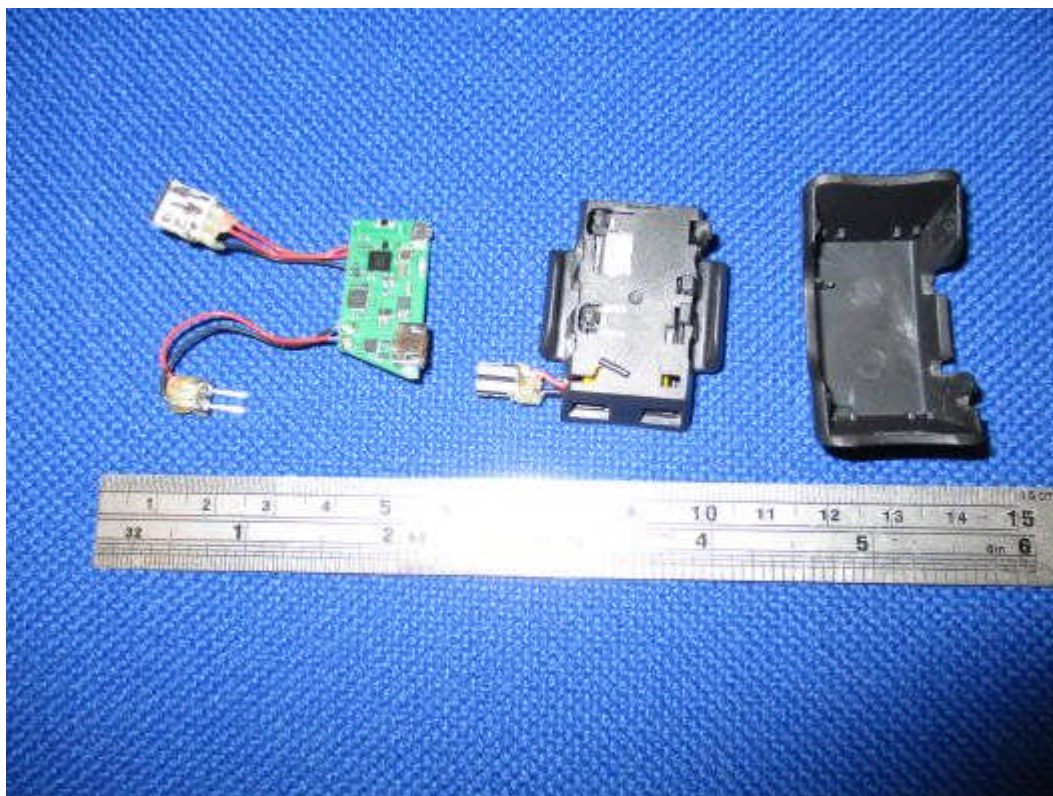




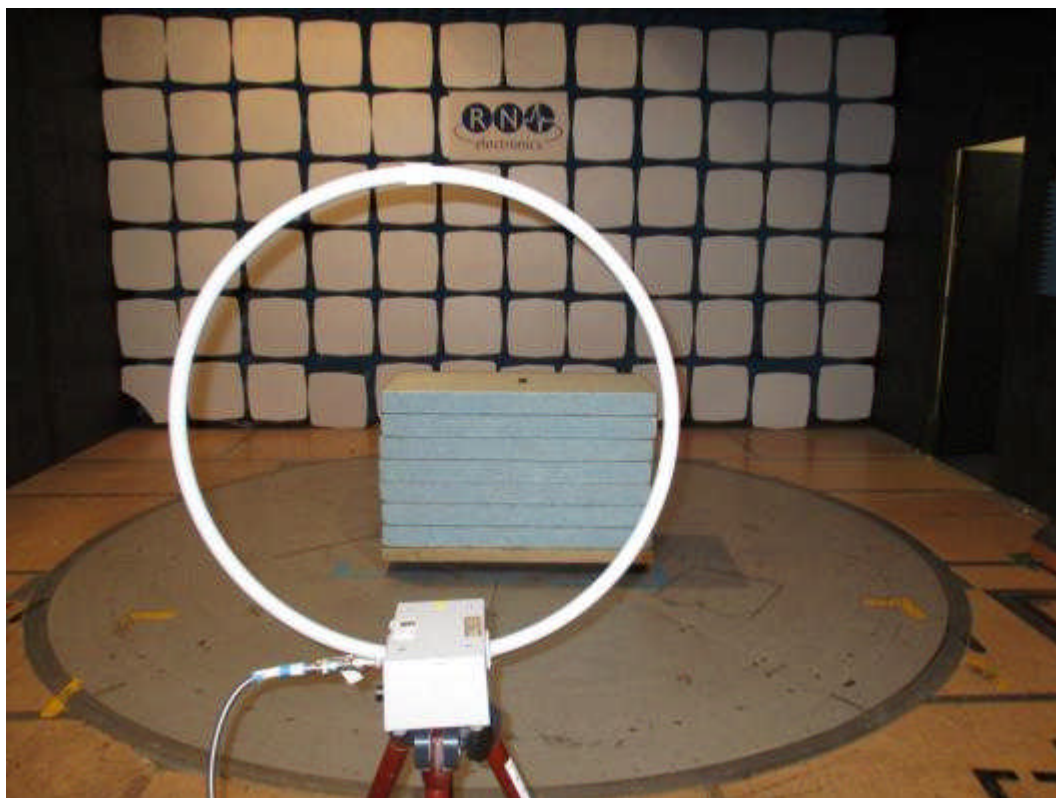
8.6 EUT ID Label

EUT had no FCC ID production label supplied

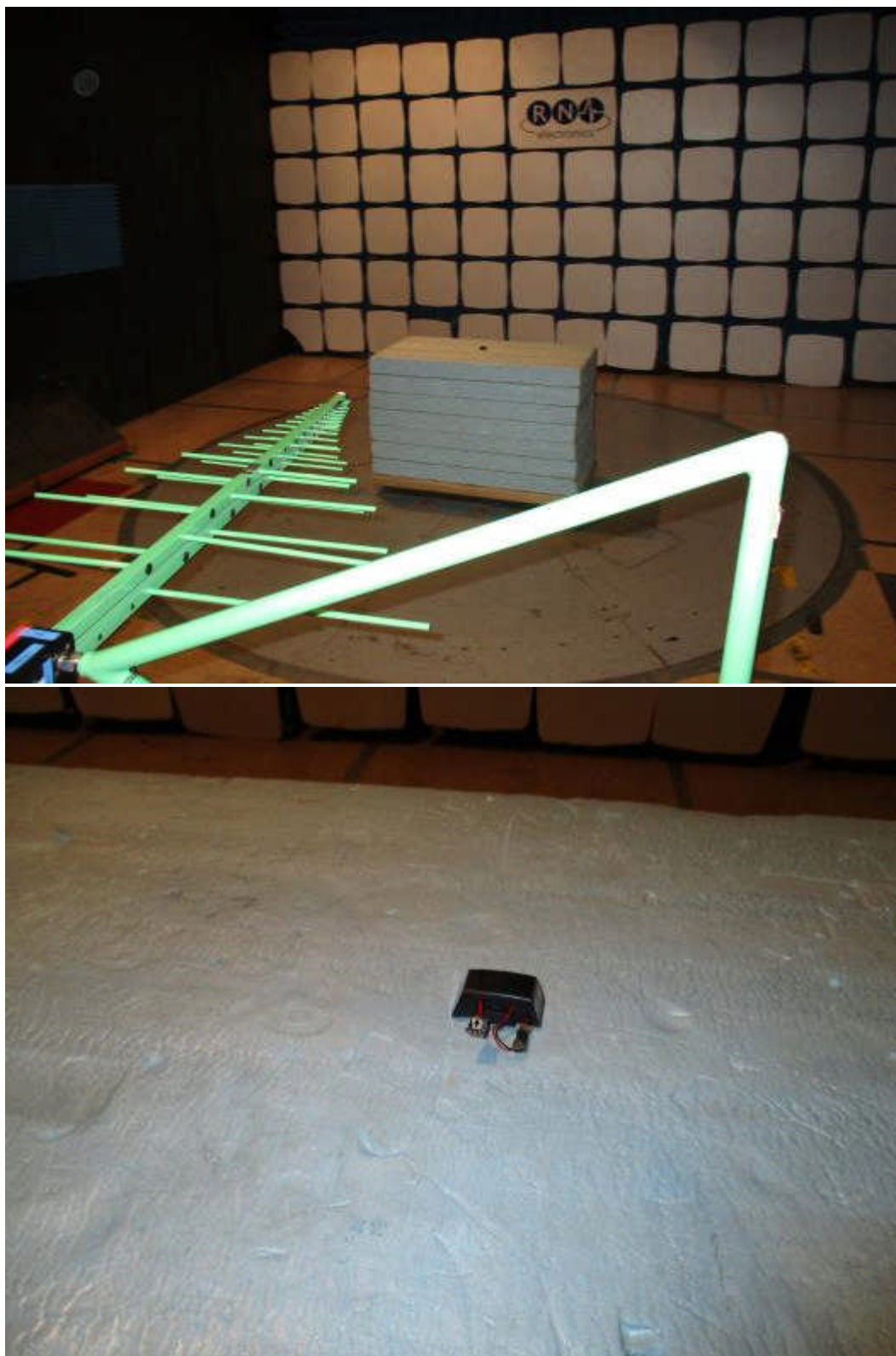
8.7 EUT Chassis



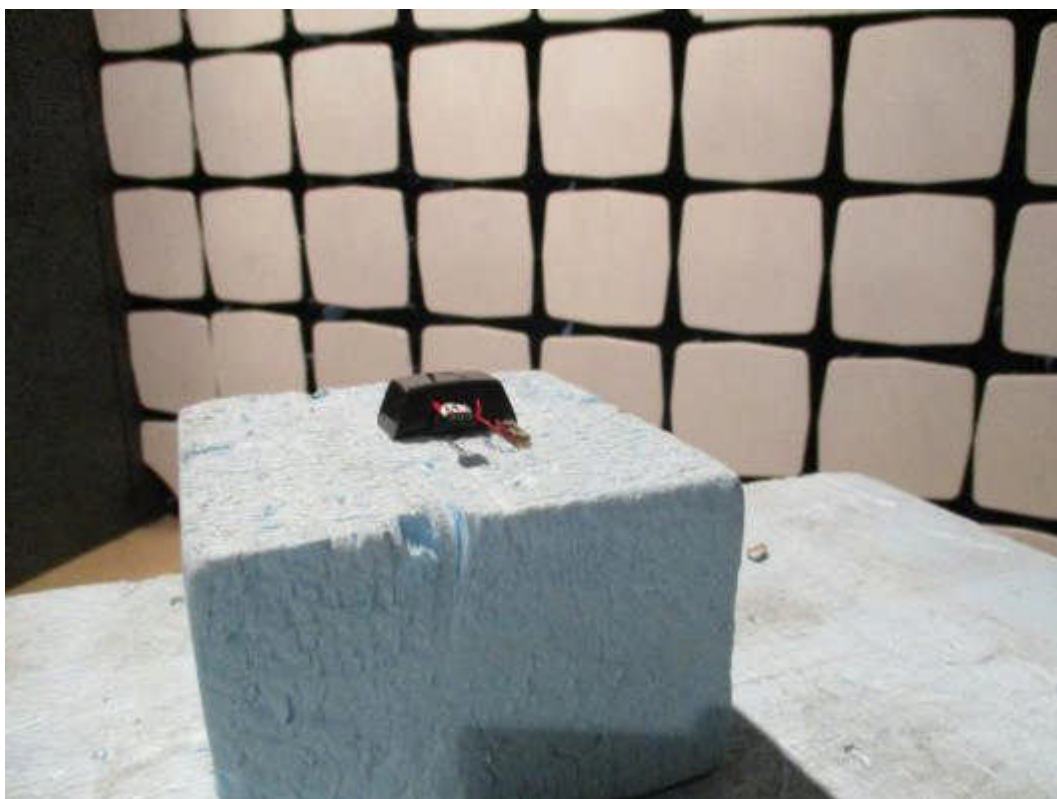
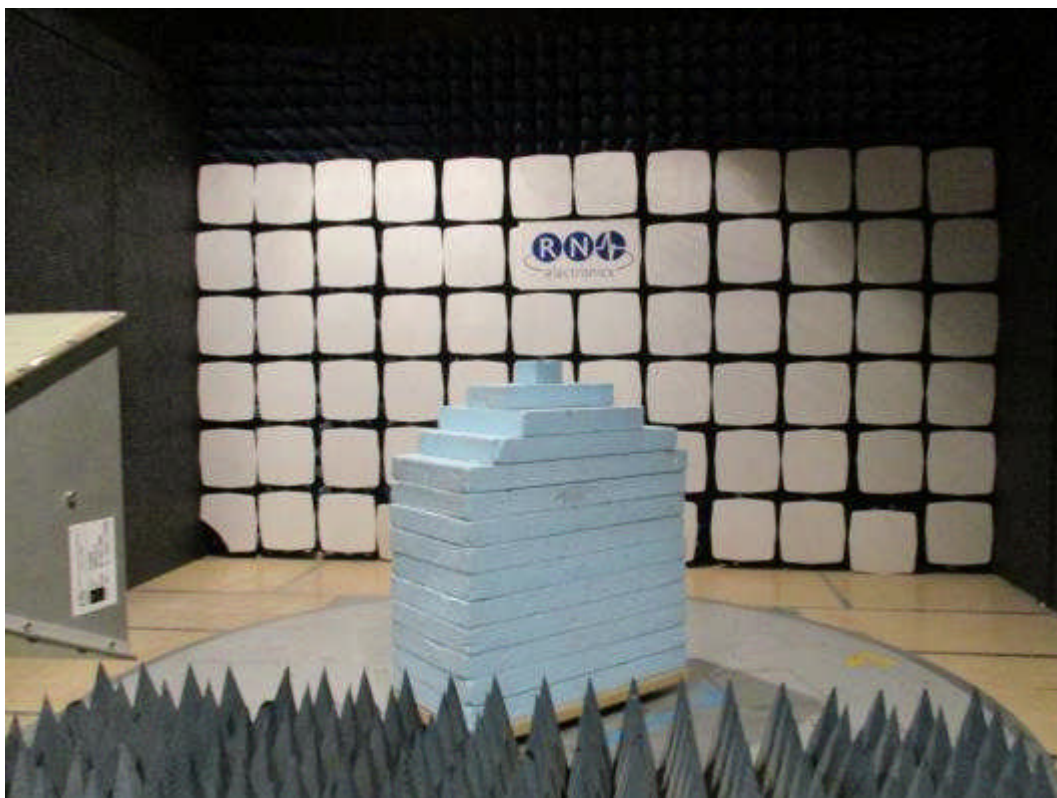
8.8 Radiated emissions 9 kHz – 30 MHz

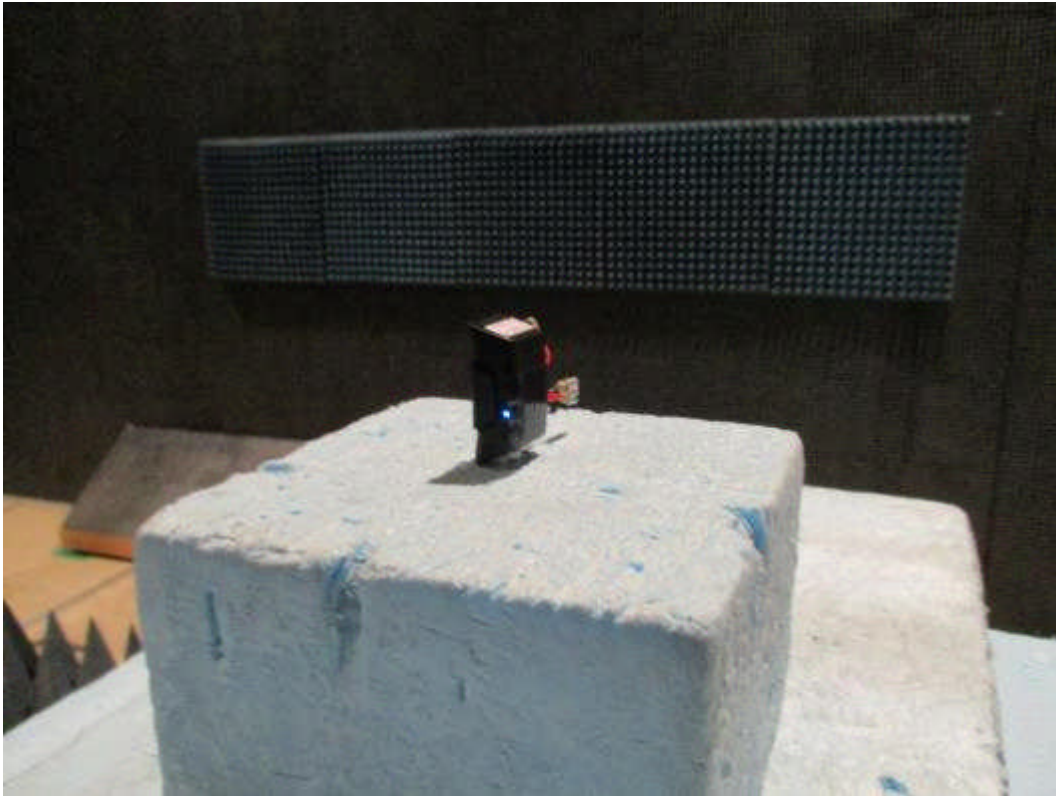


8.9 Radiated emissions 30 MHz -1 GHz



8.10 Radiated emissions above 1 GHz





8.11 Radiated emission diagram

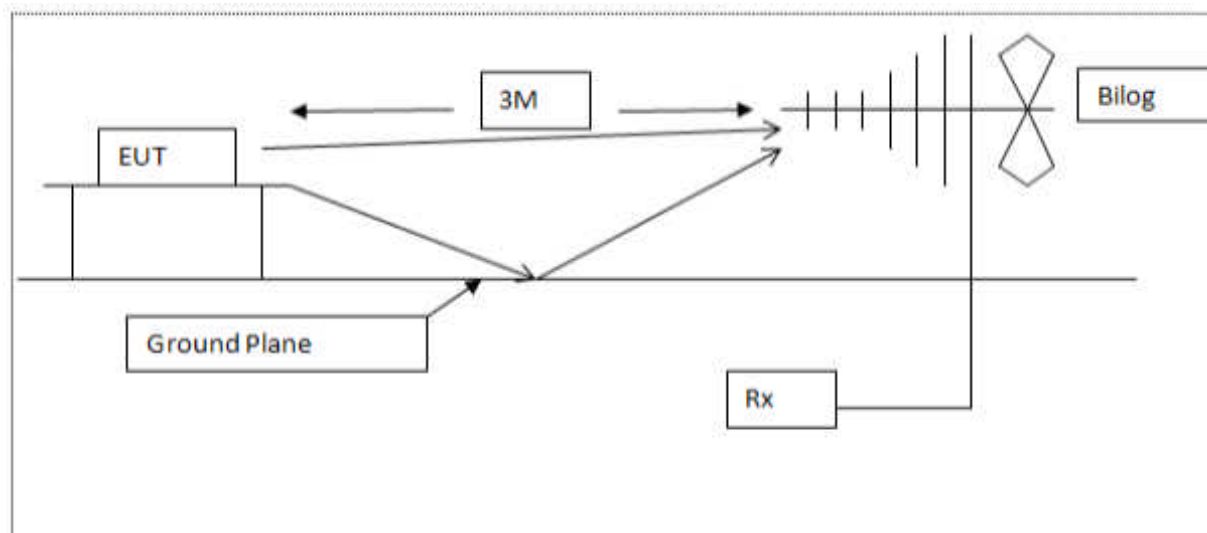


Diagram of the radiated emissions test setup 30 - 1000 MHz

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
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
LPE261	3115	1-18GHz Horn	EMCO	04-Apr-2016	24 months
LPE333	8449B	Pre-amplifier 1GHz - 26.5GHz	Hewlett Packard	18-Apr-2016	24 months
LPE364	CBL6112A	30MHz - 2GHz Bilog Antenna	Chase Electronics Ltd	22-Jan-2016	24 months
TMS45	Model1	Attenuator	Weinschel	07-Jul-2015	12 months
TMS78	3160-08	Std Gain Horn Antenna 12.4-18 GHz	ETS Systems	03-Jun-2016	12 months
TMS79	3160-09	Std Gain Horn Antenna 18-26.5 GHz	ETS Systems	03-Jun-2016	12 months
TMS81	6502	Active Loop Antenna	EMCO	27-Apr-2015	24 months
ZSW1	V2.0	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	-	UART to USB bridge	Nordic Semiconductors	11179027

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
µA/m	microAmps per metre	LO	Local Oscillator
µV	microVolts	mA	milliAmps
µW	microWatts	max	maximum
AC	Alternating Current	kPa	Kilopascal
ALSE	Absorber Lined Screened Enclosure	Mbit/s	MegaBits per second
AM	Amplitude Modulation	MHz	MegaHertz
Amb	Ambient	mic	Microphone
ATPC	Automatic Transmit Power Control	min	minimum
BER	Bit Error Rate	mm	milliMetres
°C	Degrees Celsius	ms	milliSeconds
C/I	Carrier / Interferer	mW	milliWatts
CEPT	European Conference of Postal and Telecommunications Administrations	NA	Not Applicable
COFDM	Coherent OFDM	nom	Nominal
CS	Channel Spacing	nW	nanoWatt
CW	Continuous Wave	OATS	Open Area Test Site
dB	decibel	OFDM	Orthogonal Frequency Division Multiplexing
dBµA/m	decibel relative to 1µA/m	ppm	Parts per million
dBµV	decibel relative to 1µV	PRBS	Pseudo Random Bit Sequence
dBc	decibel relative to Carrier	QAM	Quadrature Amplitude Modulation
dBm	decibel 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		