2360

Radio Test Report

Centrica Connected Home Ltd

Nano 2 Hub V2

HUB350

47 CFR Part 15.247 Effective Date 1st October 2015
DTS: Digital Transmission System
Test Date: 16th August 2016 to 1st September 2016
Report Number: 09-9015-1-16 Issue 01

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Certificate of Test 9015-1

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:	Nano 2 Hub V2
Model Number:	HUB350
Unique Serial Number:	GGS 157 (Radiated tests) AGS 957 (Conducted tests)
Applicant:	Centrica Connected Home Ltd Millstream, Maidenhead Road Windsor, Berkshire SL4 5GD
Proposed FCC ID	WJHHB35
Full measurement results are detailed in Report Number:	09-9015-1-16 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2015 DTS: Digital Transmission System

NOTE:
Certain 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: 16th August 2016 to 1st September 2016

Test Engineer: Digitally signed by: Graham Blake
DN: CN = Graham Blake C = GB O = RN Electronics Ltd
Date: 2016.09.29 08:34:48 +01'00'

Approved By:
Radio Approvals Manager: Digitally signed by: Daniel Sims
DN: CN = Daniel Sims C = GB O = RN Electronics Ltd
Date: 2016.09.28 15:46:19 Z

Customer Representative:

2360

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2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Centrica Connected Home Ltd Millstream Maidenhead Road Windsor Berkshire SL4 5GD	
Manufacturer of EUT	Centrica Connected Home Ltd	
Full Name of EUT	Nano 2 Hub V2	
Model Number of EUT	HUB350	
Serial Number of EUT	GGS 157 (Radiated tests) AGS 957 (Conducted tests)	
Date Received	7th July 2016	
Date of Test:	16th August 2016 to 1st September 2016	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	1st September 2016	
Main Function	Home automation gateway	
Information Specification	Height	25 mm
	Width	95 mm
	Depth	95 mm
	Weight	0.114 kg
	Voltage	5 VDC Nominal
	Current	250 mA
EUT Supplied PSU	Manufacturer	Phihong
	Model number	PSA05A-050QL6
	Serial number	P162611085A2
	Input voltage	100-240 VAC
	Input current	0.2 Amps
	Output	5 VDC, 1 Amp

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Desktop
Choice of model(s) for type tests	Production sample
Antenna details	Integral pcb trace for Zigbee
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2470 MHz
Lowest Signal generated in EUT	24 MHz
Hardware Version	PCB0048 Rev 2.2
Technology Type	Zigbee (802.15.4)
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	2405 MHz - 2480 MHz (2405 MHz – 2470 MHz for FCC markets)
EUT Declared Modulation Parameters	OQPSK
EUT Declared Power level	20 dBm
EUT Declared Signal Bandwidths	2 MHz
EUT Declared Channel Spacing's	5 MHz
EUT Declared Duty Cycle	27% (maximum transmit time of 27ms per 100ms)
Unmodulated carrier available?	No
Declared frequency stability	40 ppm
RX Parameters	
Alignment range – receiver	2405 MHz - 2480 MHz (2405 MHz – 2470 MHz for FCC markets)
EUT Declared RX Signal Bandwidth	2 MHz
SRD Parameters	
SRD/Receiver Category	DTS: Digital Transmission System

2.3 Functional description

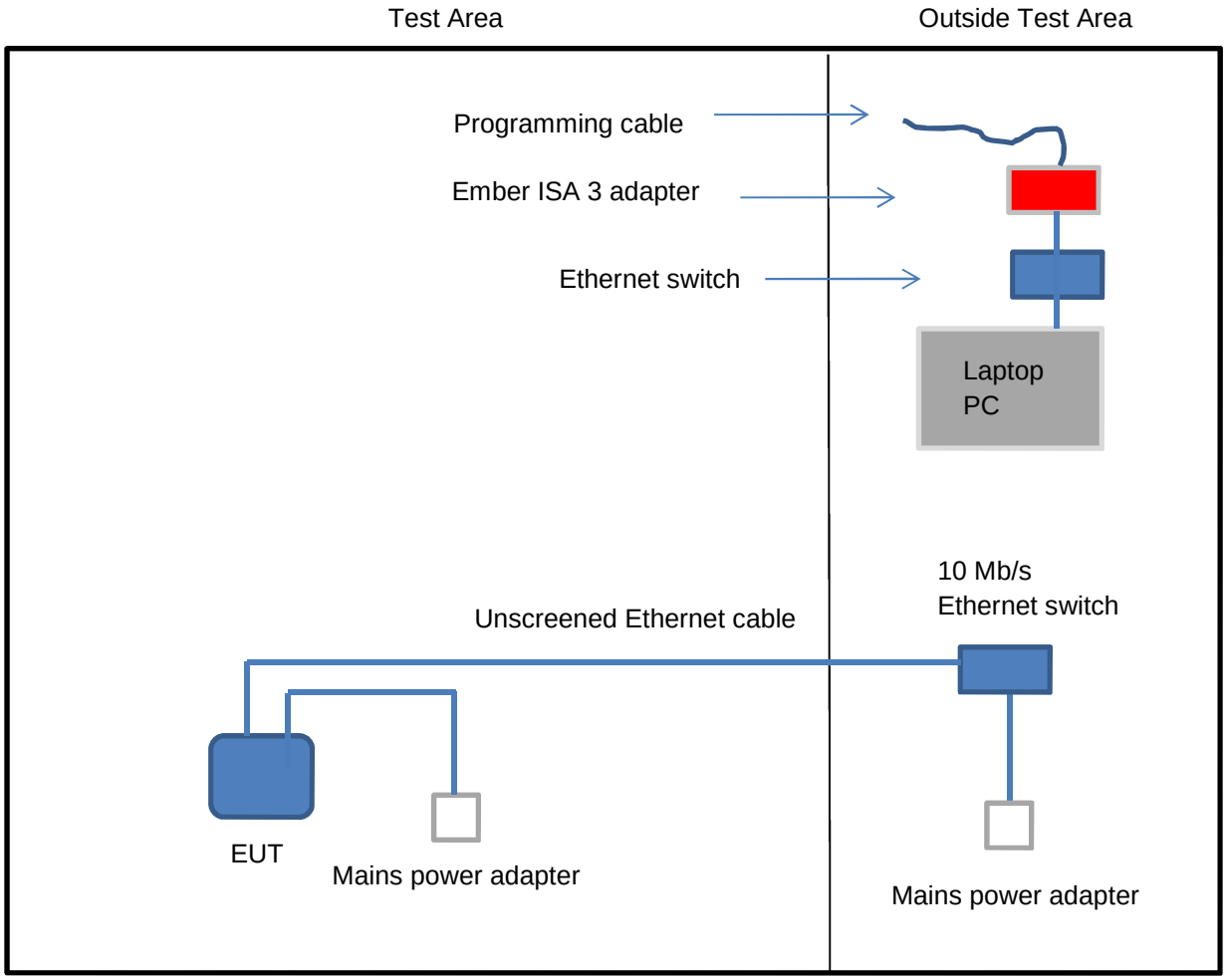
The Nano2 hub is a 5VDC powered home gateway, connecting to the wide area by 10Mbps Ethernet link to a home router, and communicating within the home by low power RF to a range of home automation devices. The EUT uses a proprietary ZigBee radio operating over the frequency range 2405 MHz - 2480 MHz (2405 MHz – 2470 MHz for FCC markets) and a Z-Wave module operating on a fixed frequency of 908.42 MHz.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX2405	Transmitting continuously at 2405 MHz with normal modulation.	Yes
TX2445	Transmitting continuously at 2445 MHz with normal modulation.	Yes
TX2470	Transmitting continuously at 2470 MHz with normal modulation.	Yes
RX2405	Receiving at 2405 MHz.	No
RX2445	Receiving at 2445 MHz.	No
RX2470	Receiving at 2470 MHz.	No

Note: The EUT incorporates a second radio module operating at a fixed frequency of 908.42 MHz. This radio was configured by the manufacturer to continuously transmit packets of data at the same time and in conjunction with the above TX modes. This report covers only the Zigbee (2.4 – 2.47 GHz) operation of the device.

2.5 Emissions configuration



The EUT was powered using the manufacturer supplied AC/DC adapter. Mains power was provided using a 110 V / 60 Hz power source. The EUT was connected to a 10 Mb/s Ethernet switch positioned outside of the test area using the supplied unscreened Ethernet cable. The EUT was configured into the test modes as stated in section 2.4 using a laptop PC connected to an Ember ISA3 adapter. Terminal software (Putty) was used. The laptop and Ember adapter were removed from the test area prior to tests. For conducted tests, a second test unit was supplied where the integral antenna had been disconnected and a coax cable assembly fitted to the RF port of the radio. The transmit modes were 100% continuous, using normal system modulation and the power settings for each channel was set to 'Level -2' at the request of the manufacturer for all tests.

The Ethernet port on the supplied test units were capable of operating at both 10 Mbps and 100 Mbps, however the manufacturer states that the Ethernet port on the final version of EUT will be restricted in firmware to operate at 10 Mbps only. For this reason the EUT was tested whilst connected to a 10 Mb/s Ethernet switch as it was not possible to implement this firmware to restrict the operation of the Ethernet port and still have full control of the EUT engineering modes for tests.

The EUT incorporates a second radio module operating at a fixed frequency of 908.42 MHz. This transmitter could operate at the same time as the ZigBee transmitter; therefore, for tests within this report, this radio was configured by the manufacturer to continuously transmit packets of data during the zigbee test modes. This was maintained during the tests covered in this report.

2.5.1 Signal leads

Port Name	Cable Type	Connected
Ethernet	Supplied unscreened CAT-5 cable	Yes
DC Power	2.5 mm connector 2-core cable	Yes
USB	USB Type A connector	No

The EUT is supplied with the USB socket intentionally blanked off and cannot be accessed by the end-user.

3 Summary of test results

The Nano 2 Hub V2, HUB350 was tested for compliance to the following standards :

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	47 CFR Part 15C Part 15.207	PASSED
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED[1]
6. Effective radiated power field strength	47 CFR Part 15C Part 15.247(d)	PASSED
7. Band Edge Compliance	47 CFR Part 15C Part 15.215 & 15.247(d)	PASSED
8. Occupied bandwidth	47 CFR Part 15C Part 15.247(a)(2)	PASSED
9. Maximum Average conducted output power		NOT APPLICABLE[2]
10. Maximum Peak conducted output power	47 CFR Part 15C Part 15.247(b)(3)	PASSED
11. Maximum Power Spectral Density	47 CFR Part 15C Part 15.247(e)	PASSED
12. Antenna power conducted emissions		NOT APPLICABLE[3]
13. Duty cycle		NOT APPLICABLE[4]
14. FHSS carrier frequency separation		NOT APPLICABLE[5]
15. Average time of occupancy		NOT APPLICABLE[5]
16. Number of Hop Channels		NOT APPLICABLE[5]

[1] Spectrum investigated up to a frequency of 25GHz based on 10 times the highest channel generated in equipment of 2470MHz.
[2] Not required. Peak Conducted power has been measured instead.
[3] Applies to EUT's with an antenna port. The EUT has an integral antenna only. Radiated emissions have been performed with integral antenna in place.
[4] No limits apply, however the manufacturer has declared a maximum duty cycle of 27%. This figure has been used to provide correction factors for average emissions.
[5] 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

Deviations have not 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 0.8m above the ground plane and connected to the manufacturer supplied AC/DC power supply, which in turn was connected to a LISN via a 1m mains cable.

Details of the Peripheral and Ancillary Equipment connected for this test is listed in section 11.

The EUT was operated in all the modes listed in 2.4 and no discernible difference in emissions was observed, therefore for full test **TX2445** mode was used.

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

E035, E150, E410, E411, E412

See Section 9 for more details

5.1.5 Test results

Temperature of test environment	25°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2445 MHz

Plot refs
9015-1 Cond 1 AC Live 150k-30M Quasi-Peak
9015-1 Cond 1 AC Live 150k-30M Average
9015-1 Cond 1 AC Neutral 150k-30M Quasi-Peak
9015-1 Cond 1 AC Neutral 150k-30M Average

Table of signals measured for Cond 1 AC Live 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)	AV Amp (dBuV)	AV Lim (dB)
1	0.262	34.7	30.0	-31.4	16.0	-35.4
2	0.471	45.5	44.4	-12.1	36.2	-10.3
3	0.557	38.6	37.0	-19.0	30.0	-16.0
4	0.602	36.2	34.5	-21.5	27.2	-18.8
5	9.308	40.8	35.2	-24.8	25.5	-24.5
6	9.476	40.8	36.8	-23.2	26.2	-23.8
7	9.519	42.0	36.6	-23.4	26.2	-23.8

Table of signals measured for Cond 1 AC Neutral 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)	AV Amp (dBuV)	AV Lim (dB)
1	0.473	47.6	45.9	-10.6	43.6	-2.9
2	0.516	40.6	39.7	-16.3	34.3	-11.7
3	8.710	39.5	35.2	-24.8	24.9	-25.1
4	8.852	41.3	37.4	-22.6	25.9	-24.1
5	9.016	41.8	37.8	-22.2	27.2	-22.8
6	9.078	41.0	37.2	-22.8	27.1	-22.9
7	9.217	40.6	36.9	-23.1	27.6	-22.4
8	9.257	41.3	37.0	-23.0	27.3	-22.7
9	9.301	41.7	37.5	-22.5	27.1	-22.9
10	9.363	43.0	37.5	-22.5	26.9	-23.1
11	9.461	41.5	36.0	-24.0	27.5	-22.5
12	9.483	42.2	38.3	-21.7	27.5	-22.5
13	9.508	41.3	38.4	-21.6	27.4	-22.6
14	9.607	42.3	36.6	-23.4	26.8	-23.2
15	9.643	41.8	36.9	-23.1	27.2	-22.8
16	9.760	41.8	37.2	-22.8	27.2	-22.8
17	9.811	41.9	37.5	-22.5	26.9	-23.1
18	9.858	41.0	37.7	-22.3	26.3	-23.7
19	10.033	42.2	36.1	-23.9	26.7	-23.3
20	10.153	40.5	35.8	-24.2	26.6	-23.4

No discernible difference was noted in emissions between channels (exploratory measurements); therefore the final measurements are presented for TX mid channel mode only.
Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

LIMITS:
15.207: as given in the above tables / drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
(For LISN) 150kHz to 30MHz ±3.6dB

5.2 Radiated emissions 9 - 150 kHz

5.2.1 Test methods

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

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed whilst powered using the manufacturer supplied power supply.

The EUT was operated in all the modes listed in 2.4 and no discernible difference in emissions was observed, therefore for full test **TX2445** mode was used.

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 final measurements 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 and OATS.

5.2.4 Test equipment

E533, E534, E535, TMS81, ZSW1

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	22°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2445 MHz

Plot refs
9015-1 9-150k Parallel
9015-1 9-150k Perpendicular

No emissions were observed within 20 dB of the limit.

The EUT was tested in constant 100 % transmit state.

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 20dB from the level of the fundamental or meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

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

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

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

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed whilst powered using the manufacturer supplied power supply.

The EUT was operated in all the modes listed in 2.4 and no discernible difference in emissions was observed, therefore for full test **TX2445** mode was used.

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 final measurements 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 and OATS.

5.3.4 Test equipment

E533, E534, E535, TMS81, ZSW1

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	22°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2445 MHz

Plot refs
9015-1 150k-30M Parallel
9015-1 150k-30M Perpendicular

No emissions were observed within 20 dB of the limit.

The EUT was tested in constant 100 % transmit state.

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 20dB from the level of the fundamental or meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

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

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

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

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed whilst powered using the manufacturer supplied power supply.

The EUT was operated in all the modes listed in 2.4 and no discernible difference in emissions was observed, therefore for full test **TX2445** mode was used.

5.4.3 Test procedure

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

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

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

Tests were performed using Test Site H.

5.4.4 Test equipment

E533, E534, E535, LPE364, ZSW1, TMS45

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	25°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2405 MHz

Horizontal Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	422.509	29.9	24.0	-22.0
2	432.023	34.7	30.2	-15.8

Vertical Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	624.055	36.6	32.6	-13.4
2	816.014	39.0	34.4	-11.6

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2445 MHz

Plot refs
9015-1 Rad 1 VHF Horiz
9015-1 Rad 1 VHF Vert
9015-1 Rad 1 UHF Horiz
9015-1 Rad 1 UHF Vert

Horizontal Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	422.800	30.1	23.9	-22.1
2	434.905	30.4	23.8	-22.2
3	579.799	33.6	26.6	-19.4

Vertical Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	436.018	29.6	23.8	-22.2
2	624.016	37.9	33.8	-12.2

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2470 MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	336.034	31.8	27.4	-18.6
2	431.957	35.2	27.6	-18.4
3	816.013	39.0	34.7	-11.3

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)
1	432.048	29.9	24.1	-21.9
2	587.160	32.2	26.4	-19.6
3	624.017	36.6	32.4	-13.6

The EUT was tested in constant 100 % transmit state.

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

LIMITS:

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20/30dB from the level of the fundamental / meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
30MHz - 1000MHz ±6.1dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

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

5.5.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed whilst powered using the manufacturer supplied power supply.

The EUT was operated in **TX2405, TX2445** and **TX2470** modes.

5.5.3 Test procedure

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

Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. Horn antennas were used at heights where the whole of the EUT was contained within the main beam. The EUT was rotated through 360 degrees to record the worst case emissions. A measurement distance of 3m was used between the test range 1 - 6GHz, 1.2m was used in the test range 6 – 18 GHz and 0.3m was used in the test range 18 - 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

E429, E533, E534, E535, LPE261, LPE333, TMS78, TMS79

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	25°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Setup Table

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Calculated Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2801	45.1	-28.9	33.7	-20.3	side	Vertical
2801	46.7	-27.3	35.3	-18.7	side	Horizontal
4810	63.6	-10.4	52.2	-1.8	side	Vertical
4810	58.1	-15.9	46.7	-7.3	side	Horizontal
7215	56.3	-17.7	44.9	-9.1	side	Vertical
7215	59	-15	47.6	-6.4	side	Horizontal
8175	53.6	-20.4	42.2	-11.8	side	Vertical
8175	56.5	-17.5	45.1	-8.9	side	Horizontal
9620	57.6	-16.4	46.2	-7.8	side	Vertical
9620	60.5	-13.5	49.1	-4.9	side	Horizontal
12025	65.2	-8.8	53.8	-0.2	side	Vertical
12025	59.1	-14.9	47.7	-6.3	flat	Horizontal
14430	50.7	-23.3	39.3	-14.7	flat	Vertical
14430	54.9	-19.1	43.5	-10.5	flat	Horizontal

Setup Table

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2445 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Calculated Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2842	47.9	-26.1	36.5	-17.5	side	Horizontal
2842	47.6	-26.4	36.2	-17.8	side	Vertical
4890	63.3	-10.7	51.9	-2.1	side	Vertical
4890	64.6	-9.4	53.2	-0.8	side	Horizontal
7335	57.2	-16.8	45.8	-8.2	upright	Vertical
7335	55.8	-18.2	44.4	-9.6	side	Horizontal
8175	54.6	-19.4	43.2	-10.8	side	Horizontal
8175	57.1	-16.9	45.7	-8.3	side	Vertical
9780	58.3	-15.7	46.9	-7.1	side	Vertical
9780	57	-17	45.6	-8.4	side	Horizontal
12225	59.4	-14.6	48	-6	side	Vertical
12225	58.1	-15.9	46.7	-7.3	upright	Horizontal
14670	54.1	-19.9	42.7	-11.3	side	Vertical
14670	54.7	-19.3	43.3	-10.7	side	Horizontal

Setup Table

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
High channel	2470 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Calculated Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
2085	45.9	-28.1	34.5	-19.5	side	Vertical
4940	63.1	-10.9	51.7	-2.3	side	Vertical
4940	65	-9	53.6	-0.4	side	Horizontal
7410	56.7	-17.3	45.3	-8.7	flat	Vertical
7410	56.9	-17.1	45.5	-8.5	side	Horizontal
8175	54.2	-19.8	42.8	-11.2	side	Horizontal
8175	55.3	-18.7	43.9	-10.1	side	Vertical
9880	59.1	-14.9	47.7	-6.3	flat	Vertical
9880	58.8	-15.2	47.4	-6.6	side	Horizontal
12350	56.5	-17.5	45.1	-8.9	side	Vertical
12350	54.9	-19.1	43.5	-10.5	side	Horizontal
14820	54.4	-19.6	43	-11	flat	Vertical
14820	56.4	-17.6	45	-9	side	Horizontal

NOTE: Only middle channel plots are shown in this report to reduce report size, however, Low, middle and high channels have been fully tested and results tabulated. Only results observed within 20dB of limits have been included in results tables. Average results have been calculated from Peak measurements and corrected with duty cycle correction factor per FCC 15.35/ANSI C63.10:2013 in a 0.1second period. Correction used is -11.4dB. See section 5.13 within this report.

Spectrum investigated up to a frequency of 25GHz based on 10 times the highest channel generated in equipment of 2470MHz.

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

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 20dB from the level of the fundamental or meet the general limits of 15.209.
The general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
1 – 18 GHz ±3.5dB, 18 – 25 GHz ±3.9dB

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 **TX2405**, **TX2445** and **TX2470** 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. Tests were performed in test site H.

5.6.4 Test equipment

E252, E533, E534, E535, LPE333

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	22°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2445 MHz
High channel	2470 MHz

	Low	Mid	High
Peak Level (dBµV/m) @ 3m	117.3	117.5	117.2
Plot reference	Field Strength 2405	Field Strength 2445	Field Strength 2470
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Side	Side	Side

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

LIMITS:
The maximum output power in all cases is 30dBm/ 1watt (125 dBuV/m @ 3 metres).

These results show that the EUT has PASSED this test.

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

5.7 Band Edge Compliance

5.7.1 Test methods

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

5.7.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was rotated through 360° in 3 orthogonal positions to find the maximum field strength per channel required. The EUT was measured at a distance of 3 metres.

The EUT was operated in **TX2405** and **TX2470** mode.

5.7.3 Test procedure

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

Tests were performed using Test Site H.

5.7.4 Test equipment

E252, E533, E534, E535, LPE261, LPE333

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
High channel	2470 MHz

	Low Channel	High Channel
Peak Level (dBµV/m)	59.8	62.5
Peak Plot reference	Restricted Band edge Low PK	Restricted Band Edge High PK
Calculated Average Level (dBµV/m)	48.4	51.1
Average Plot reference	N/A	N/A

Note: AV results are calculated from PK results corrected for Duty cycle of 27% providing a correction of -11.4dB.

	Low Channel	High Channel
Band Edge Plot reference	Band edge Low PK	Band Edge High PK

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.

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

The limit is 54dBuV/m for Average emissions. According to 15.35(c): when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

The manufacturer states a 27ms tx time every 100ms (27% duty cycle), and therefore the power measured is reduced by 20 log (0.27) = -11.4dB. According to the declared duty cycle, therefore, the emissions observed are below the limit after averaging for pulse rate.

The restricted band edges closest to the EUT frequency of 2400-2470MHz 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

5.8.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(a)(2) [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 15.247(a)(2) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was tested on a bench using an analyser connected to the temporary RF port. The EUT was operated in **TX2405, TX2445** and **TX2470** modes.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 100kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 6dB bandwidth. Tests were performed using Test Site H.

5.8.4 Test equipment

E252, E533, E534, E535

See Section 9 for more details

5.8.5 Test results

Temperature of test environment 22°C
Humidity of test environment 50%
Pressure of test environment 102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2445 MHz
High channel	2470 MHz

	Low	Mid	High
6dB Bandwidth (MHz)	1.58	1.59	1.60
Plot reference	9015-1 OBW 2405	9015-1 OBW 2445	9015-1 OBW 2470

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

LIMITS:
15.247(a)(2) The minimum 6dB bandwidth shall be at least 500kHz.

These results show that the EUT has PASSED this test.

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

5.9 Maximum Average conducted output power

Not required. Peak Conducted power has been measured instead.

5.10 Maximum Peak conducted output power

5.10.1 Test methods

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

5.10.2 Configuration of EUT

The EUT was measured on a bench using a PK power meter connected to the temporary RF port. The EUT was set to each transmit mode (see section 2.4) and highest power levels recorded.

The EUT was operated in **TX2405, TX2445** and **TX2470** modes for this test.

5.10.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Power meter reading stated is maximum power observed using a peak power head. Measurements were made on a test bench in site H.

5.10.4 Test equipment

E313, E611

See Section 9 for more details

5.10.5 Test results

Temperature of test environment 25°C
Humidity of test environment 60%
Pressure of test environment 102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2445 MHz
High channel	2470 MHz

Test conditions Nominal Temperature Nominal Volts	Peak Power Low Channel	Peak Power Mid Channel	Peak Power High Channel
Maximum TX Power observed (dBm)	18.20	18.80	18.50
Maximum TX Power observed (Watts)	0.07	0.08	0.07

LIMITS:
15.247(b)(3)
For systems using digital modulation in the 902-928, 2400-2483.5 or 5725-5850 MHz bands 1 Watt.

These results show that the EUT has PASSED this test.

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

5.11 Maximum Power Spectral Density

5.11.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 10.10 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]

5.11.2 Configuration of EUT

The EUT was measured on a bench using a spectrum analyser connected to the temporary RF port. The EUT was operated in **TX2405, TX2445** and **TX2470** modes for this test.

5.11.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The measurements & plots were taken with the spectrum analyser span set to 1.5 times the measured DTS bandwidth using the required bandwidth. Tests were performed using Test Site H.

5.11.4 Test equipment

E252, E533, E534, E535

See Section 9 for more details

5.11.5 Test results

Temperature of test environment	22°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	Setting -2
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2445 MHz
High channel	2470 MHz

	Low	Mid	High
Duty Cycle (%)	100	100	100
dBm per 3 kHz	2.57	2.47	3.07
Plot reference	PSD 2405	PSD 2445	PSD 2470

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

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

These results show that the EUT has PASSED this test.

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

5.12 Antenna power conducted emissions

NOT APPLICABLE: Applies to EUT's with an antenna port. The EUT has an integral antenna only. Radiated emissions have been performed with integral antenna in place.

5.13 Duty cycle

NOT APPLICABLE: No limits apply, however the manufacturer has declared a maximum transmit time of 27ms per 100ms (duty cycle of 27%). This figure has been used to provide correction factors for average emissions.

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.

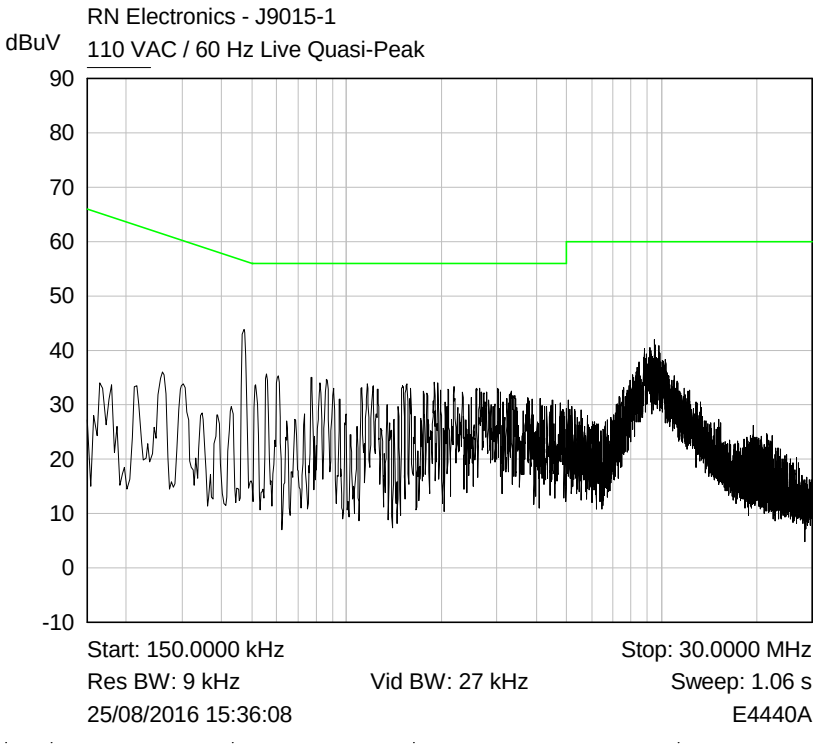
5.16 Number of Hop Channels

NOT APPLICABLE: EUT does not employ FHSS technology

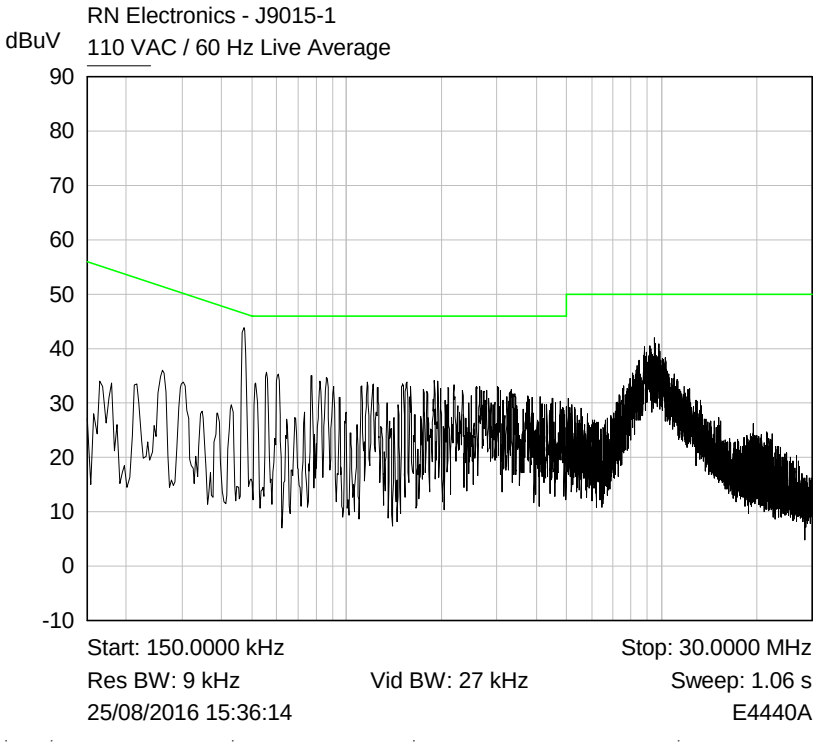
6 Plots/Graphical results

6.1 AC power line conducted emissions

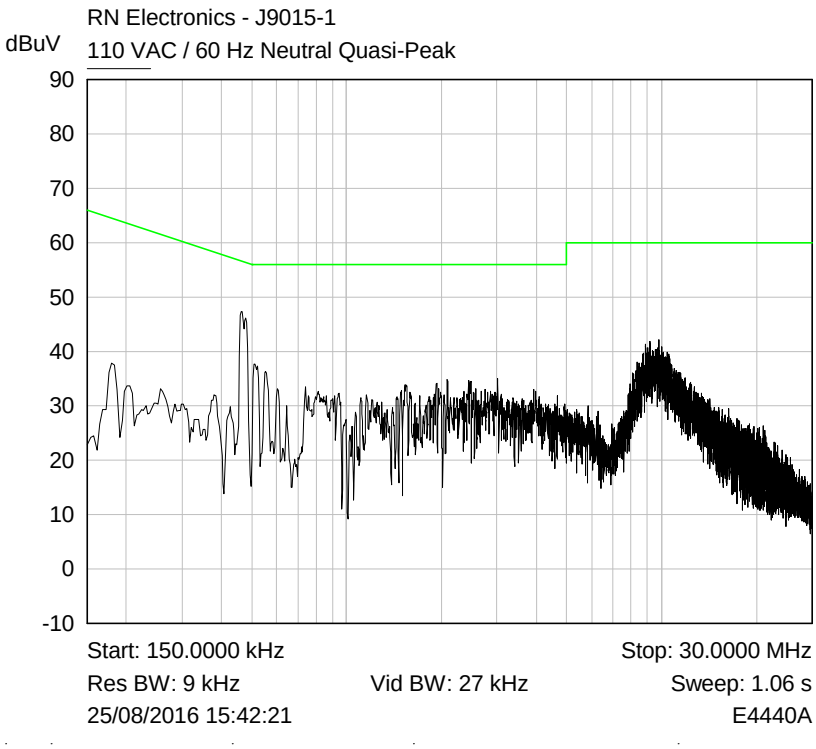
RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



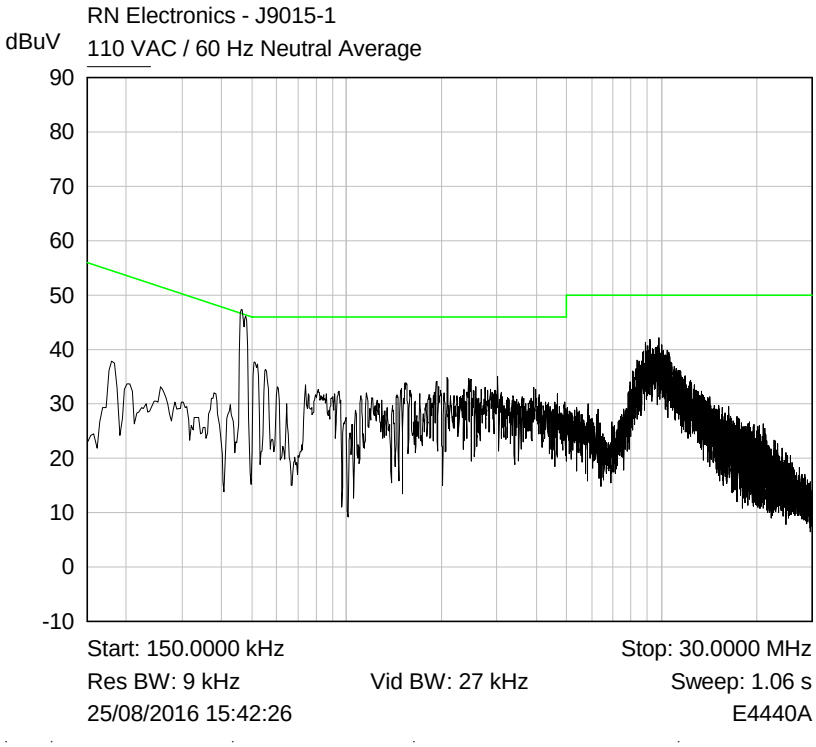
Plot of Live150k-30M Quasi-Peak



Plot of Live150k-30M Average



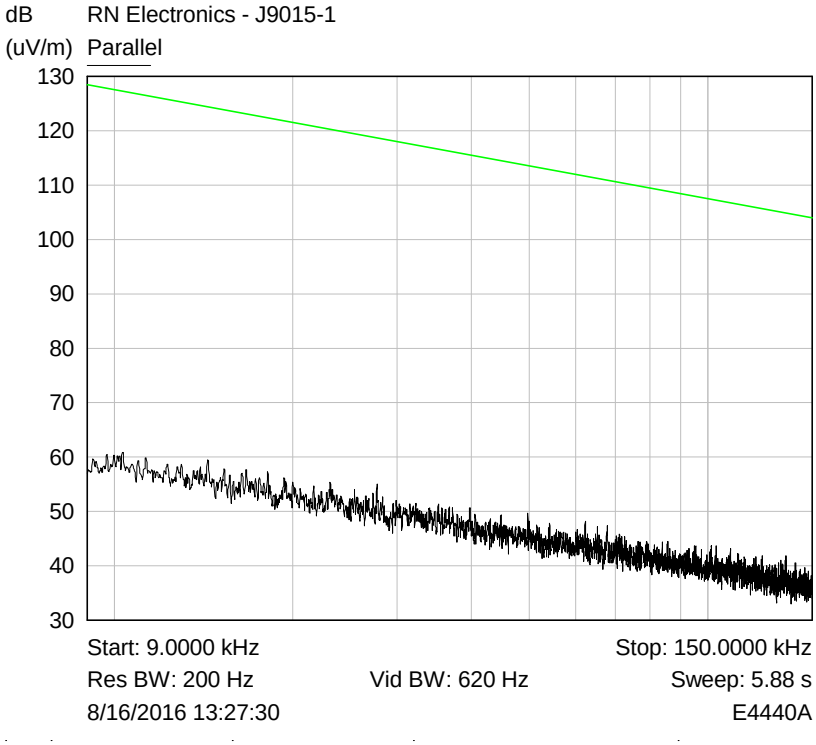
Plot of Neutral150k-30M Quasi-Peak



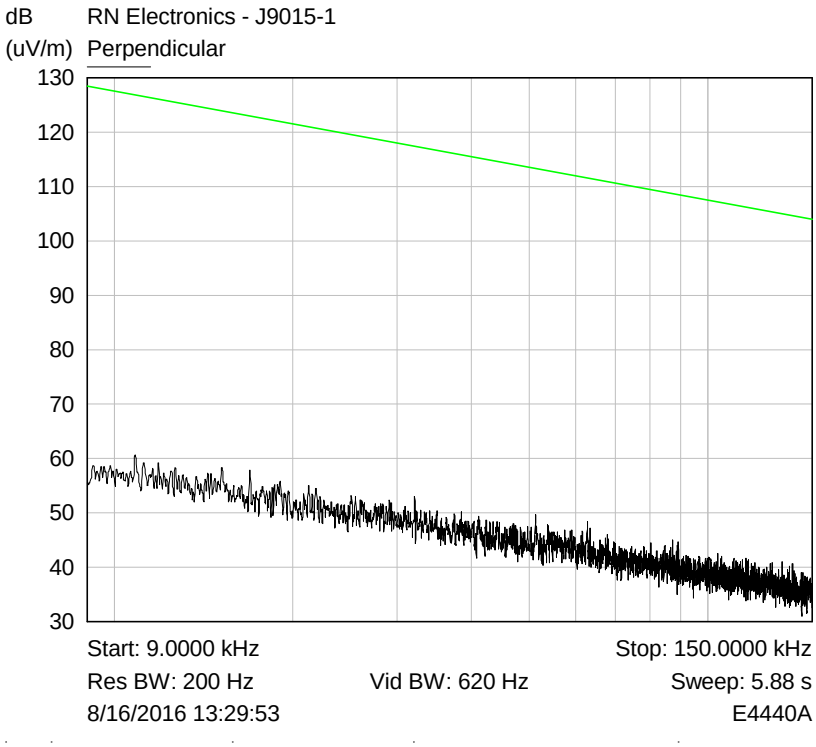
Plot of Neutral150k-30M Average

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 2400-2483.5 MHz, Power -2 dBm, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



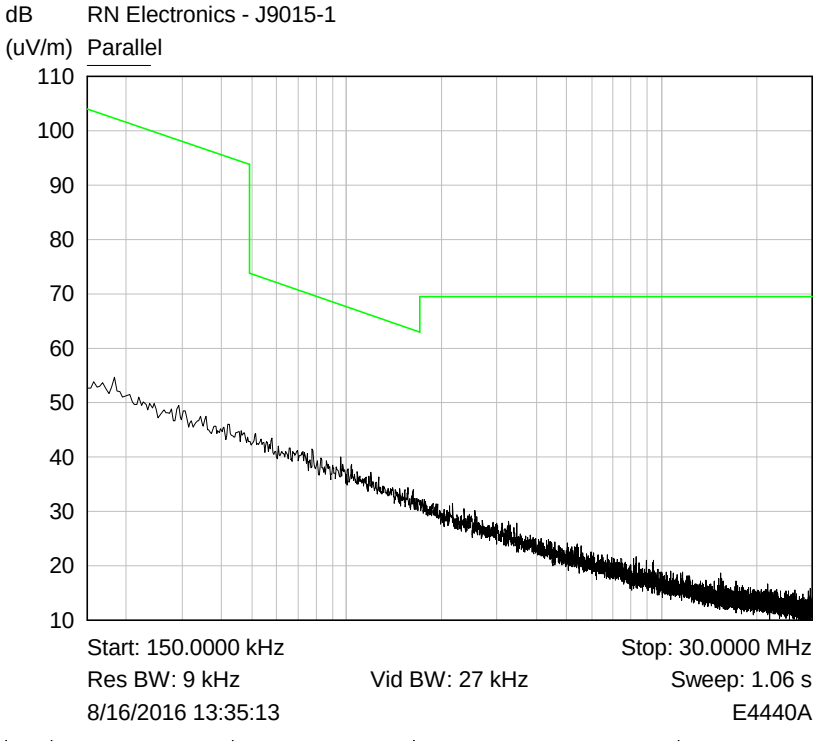
Plot of 9-150kHz Parallel



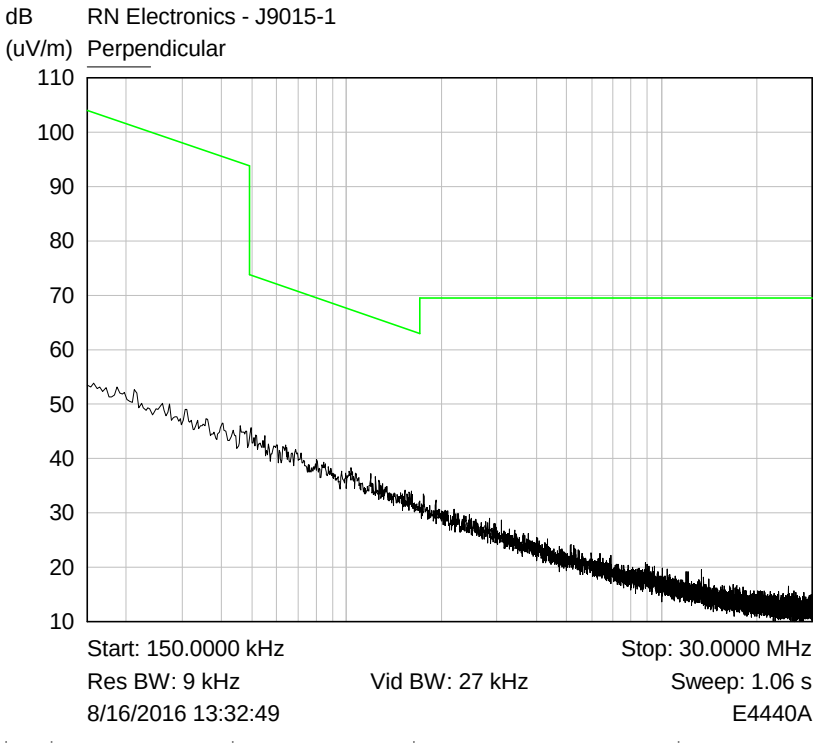
Plot of 9-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 2400-2483.5 MHz, Power -2 dBm, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



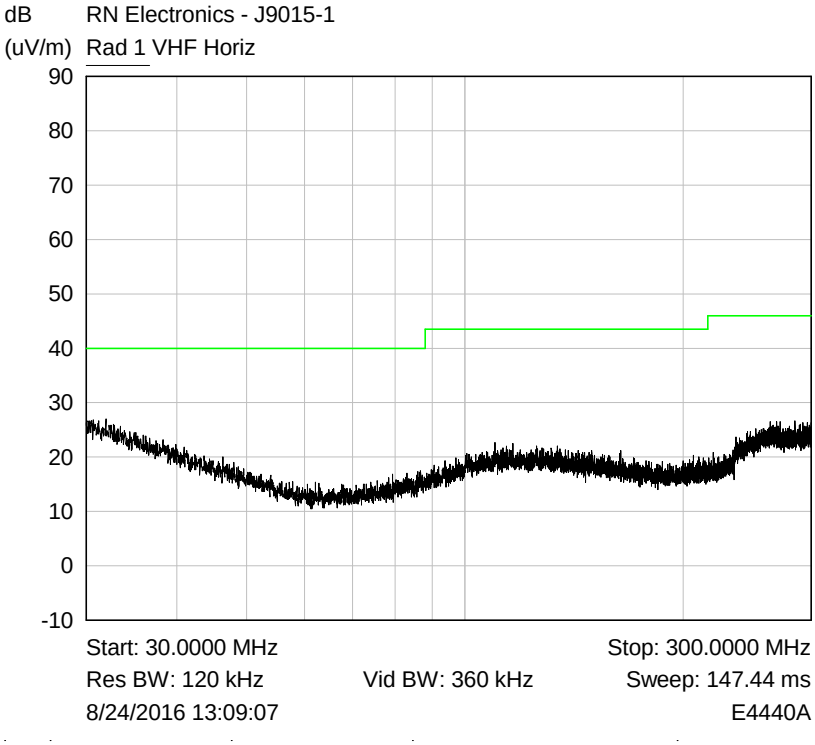
Plot of 150kHz-30MHz Parallel



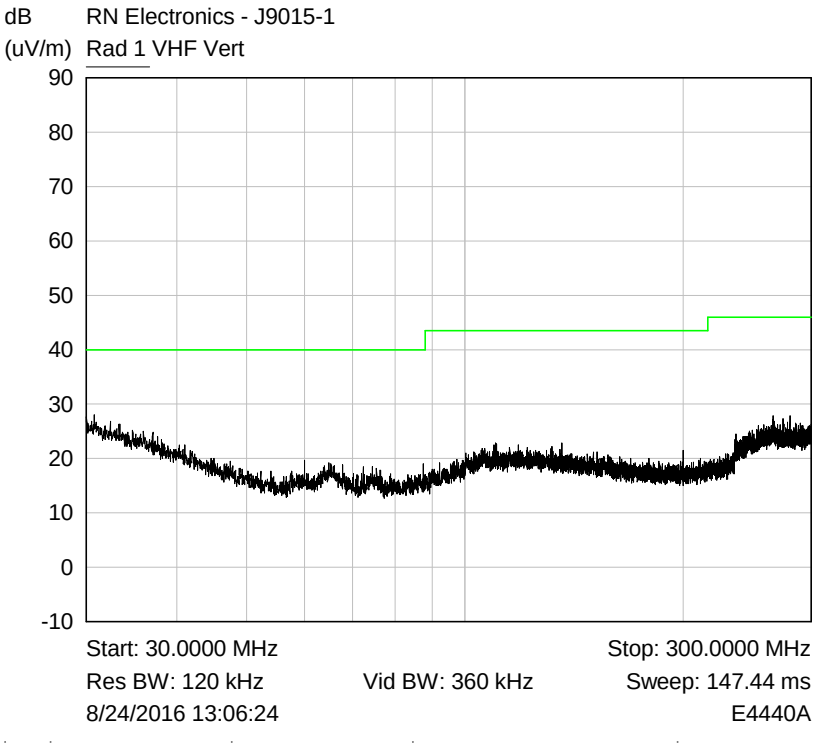
Plot of 150kHz-30MHz Perpendicular

6.4 Radiated emissions 30 MHz -1 GHz

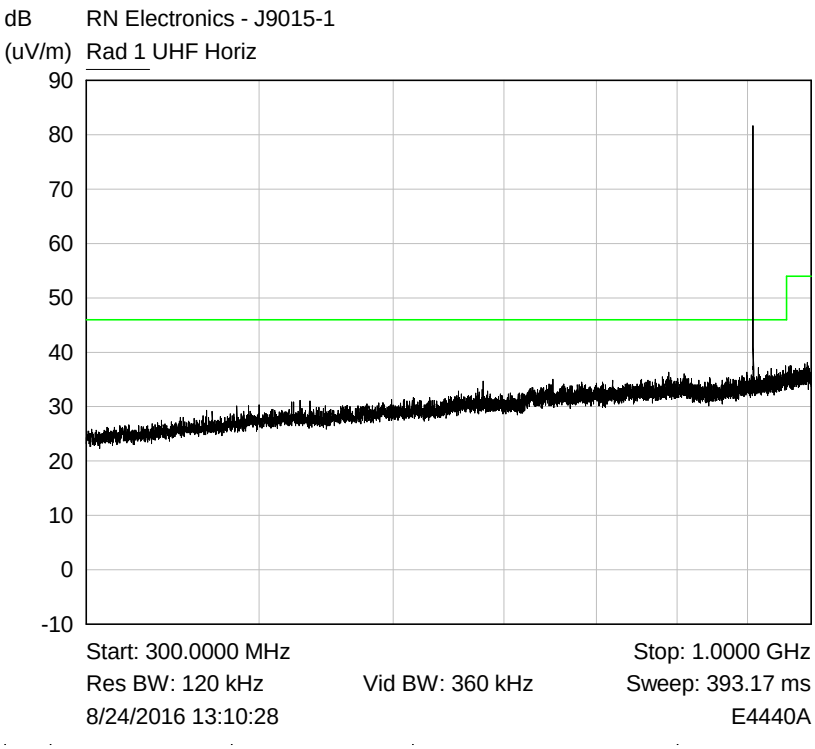
RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



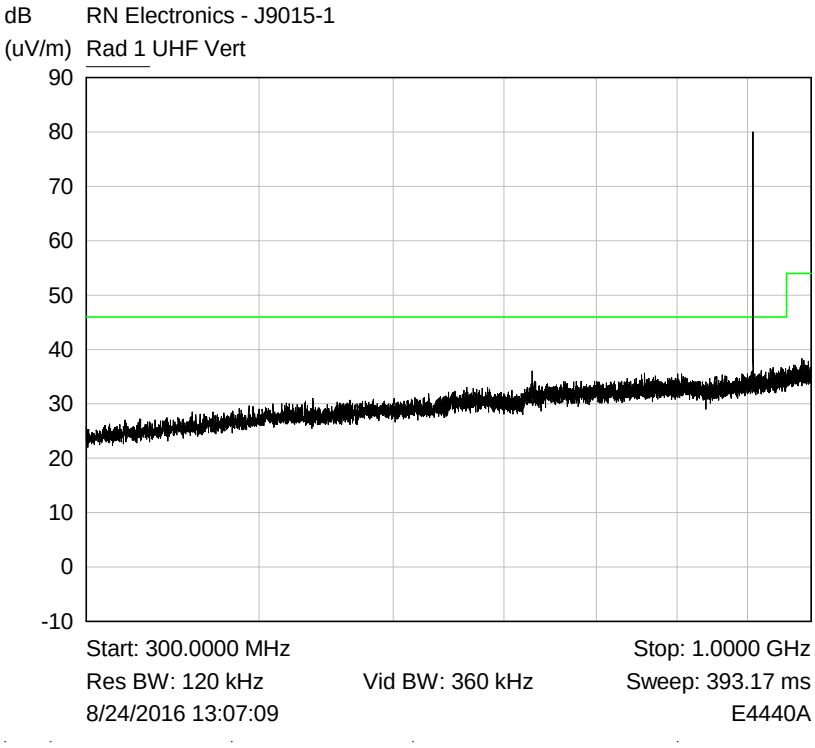
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



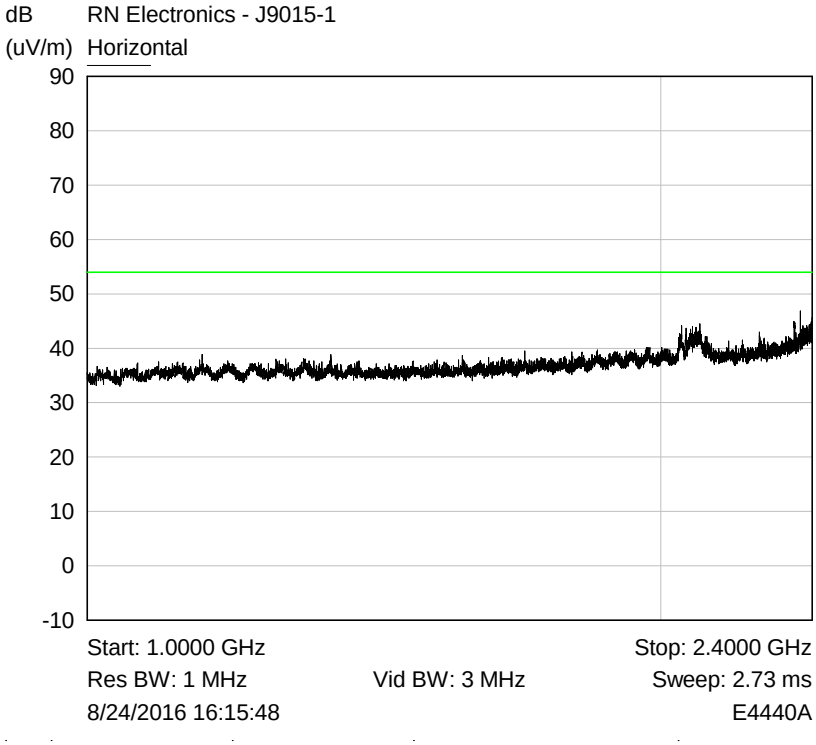
Plot of Peak emissions for UHF Horizontal against the QP limit line.
Plot shows the fundamental carrier frequency of the 908.42 MHz Z-wave module.



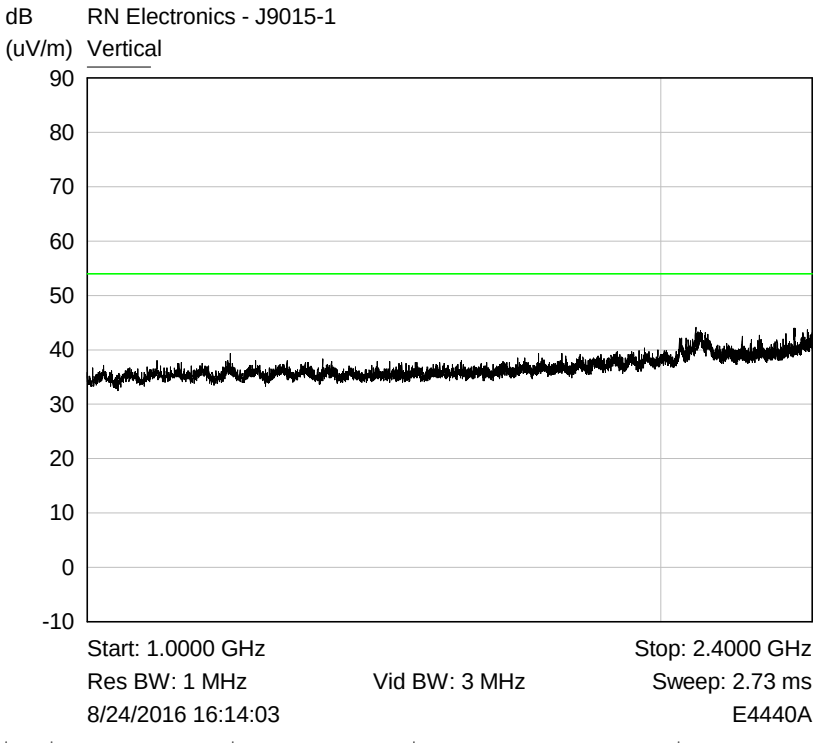
Plot of Peak emissions for UHF Vertical against the QP limit line.
Plot shows the fundamental carrier frequency of the 908.42 MHz Z-wave module.

6.5 Radiated emissions above 1 GHz

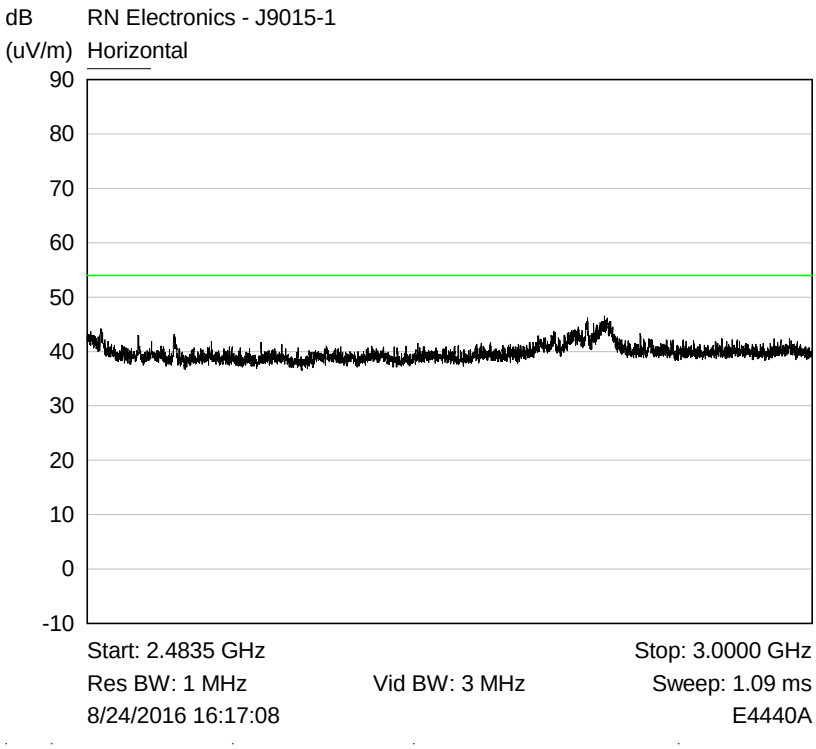
RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



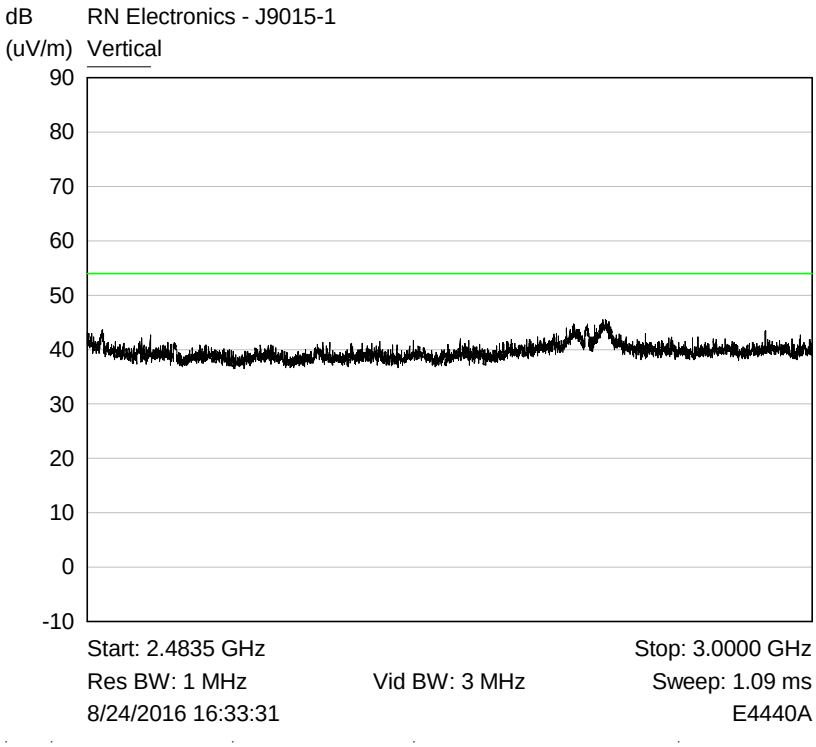
Plot of Peak horizontal (max held) emissions 1 – 2.4 GHz against the AV limit line.



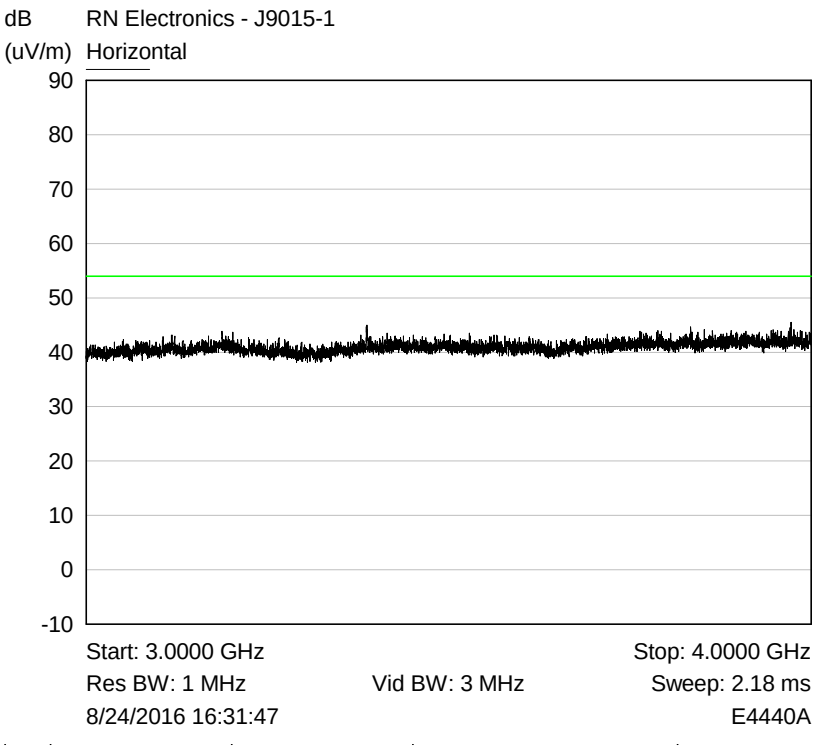
Plot of Peak Vertial (max held) emissions 1 – 2.4 GHz against the AV limit line.



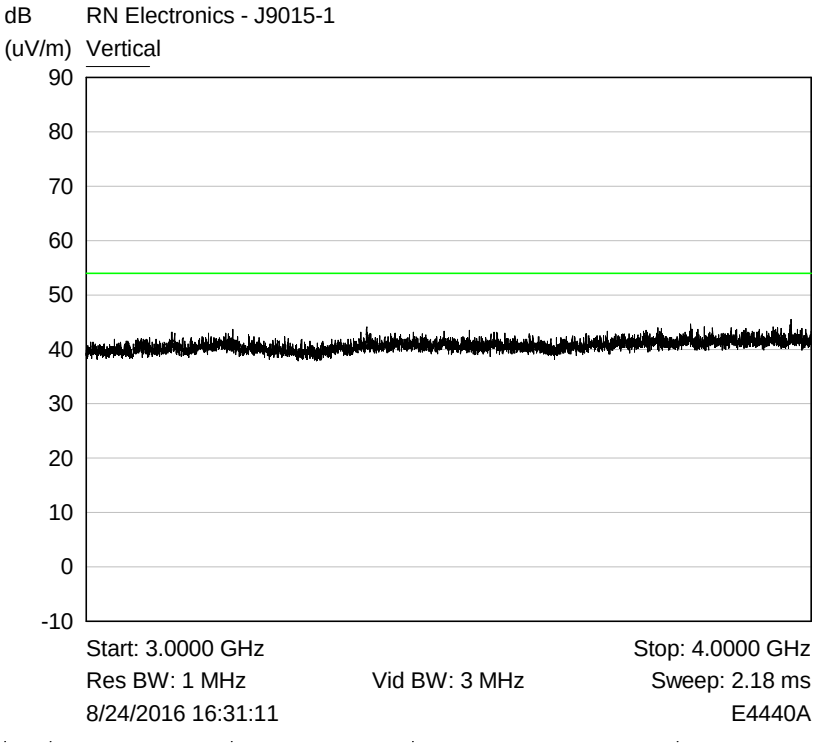
Plot of Peak horizontal (max held) emissions 2.4385 – 3 GHz against the AV limit line.



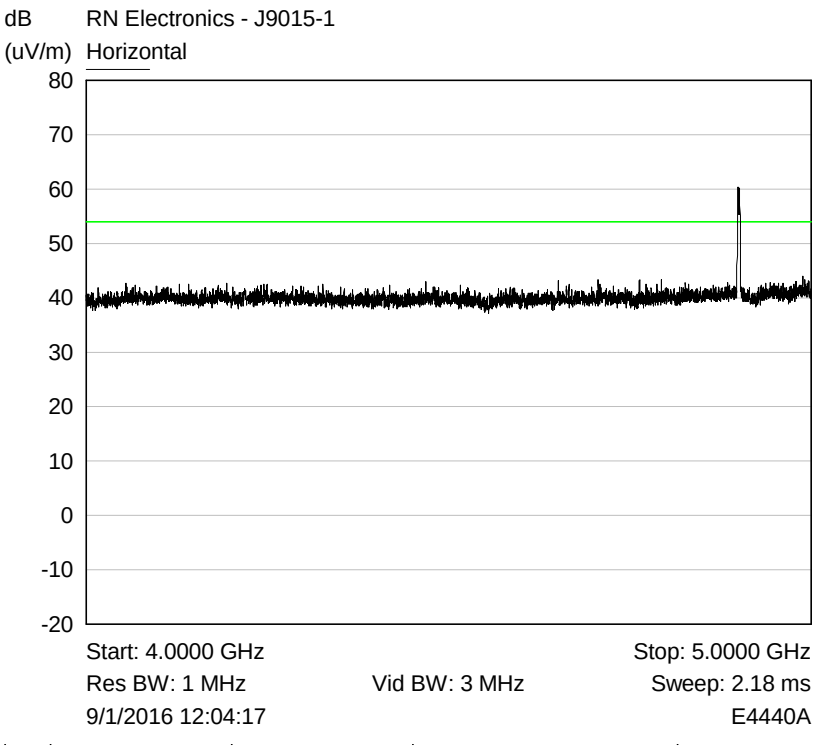
Plot of Peak Vertical (max held) emissions 2.4385 – 3 GHz against the AV limit line.



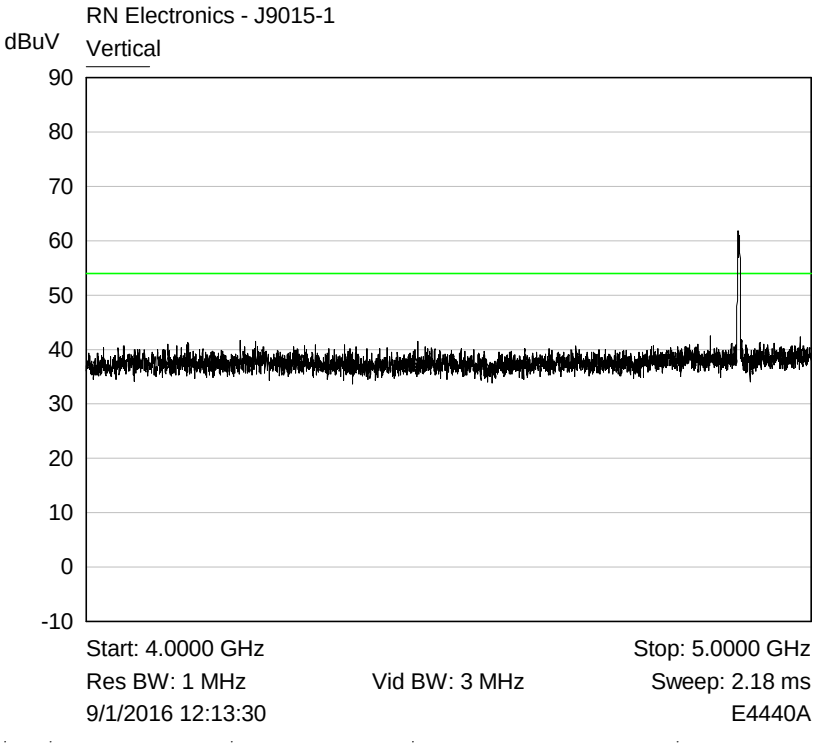
Plot of Peak horizontal (max held) emissions 3 – 4 GHz against the AV limit line.



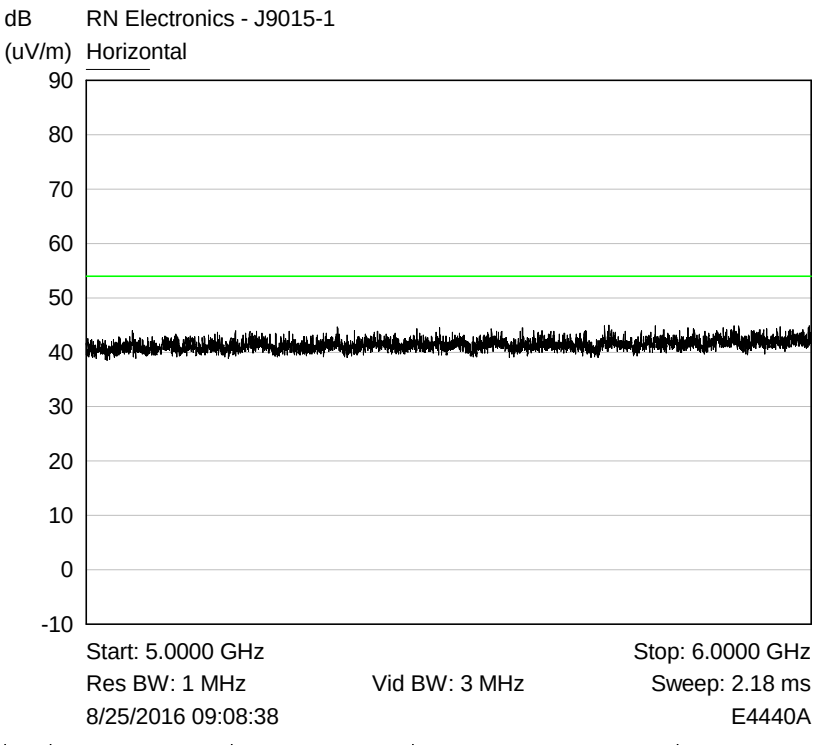
Plot of Peak vertical (max held) emissions 3 – 4 GHz against the AV limit line.



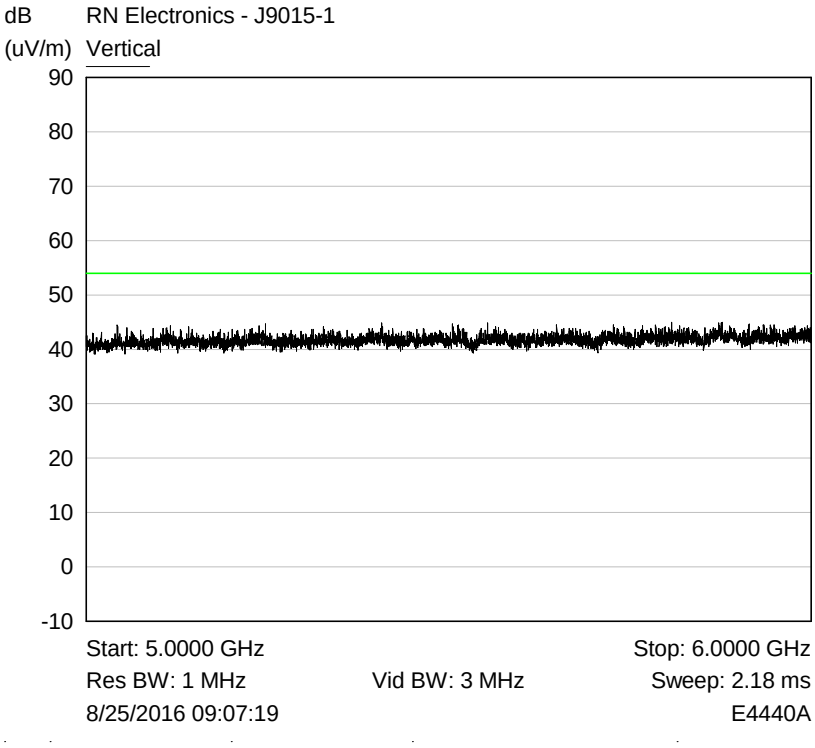
Plot of Peak horizontal (max held) emissions 4 – 5 GHz against the AV limit line.



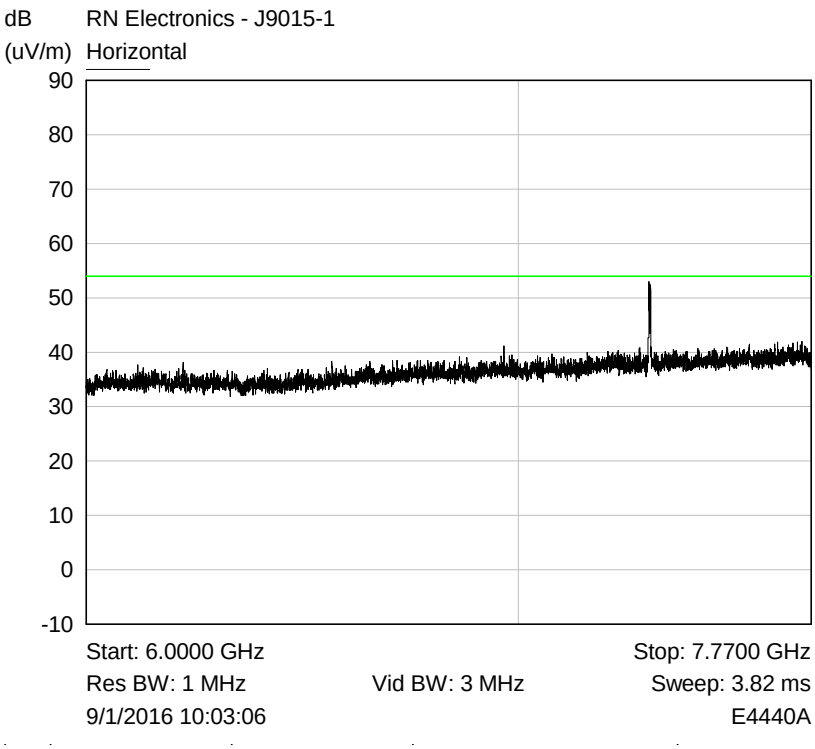
Plot of Peak vertical (max held) emissions 4 – 5 GHz against the AV limit line.



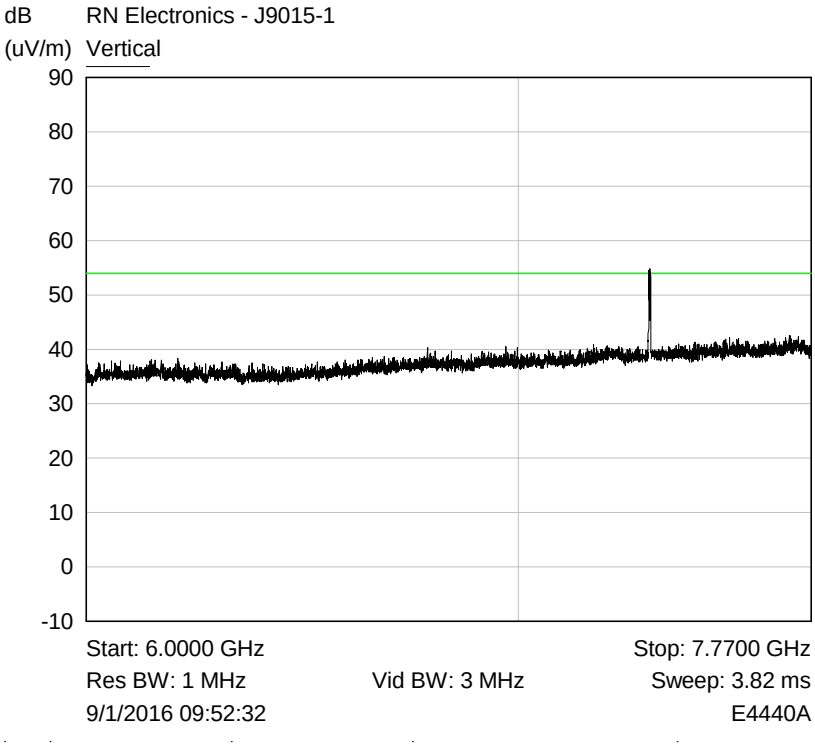
Plot of Peak horizontal (max held) emissions 5 – 6 GHz against the AV limit line.



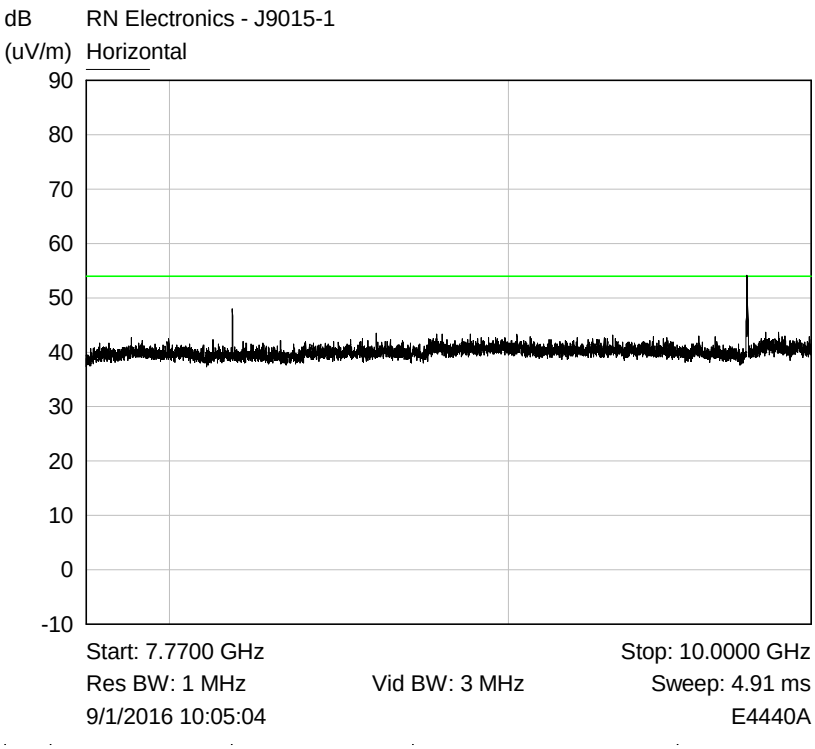
Plot of Peak vertical (max held) emissions 5 – 6 GHz against the AV limit line.



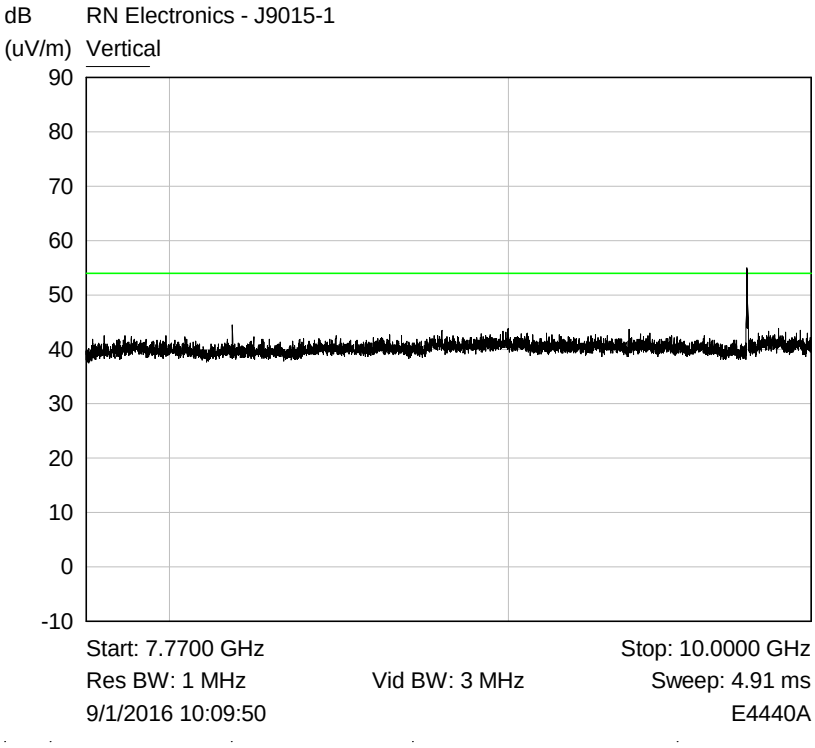
Plot of Peak horizontal (max held) emissions 6 – 7.77 GHz against the AV limit line.



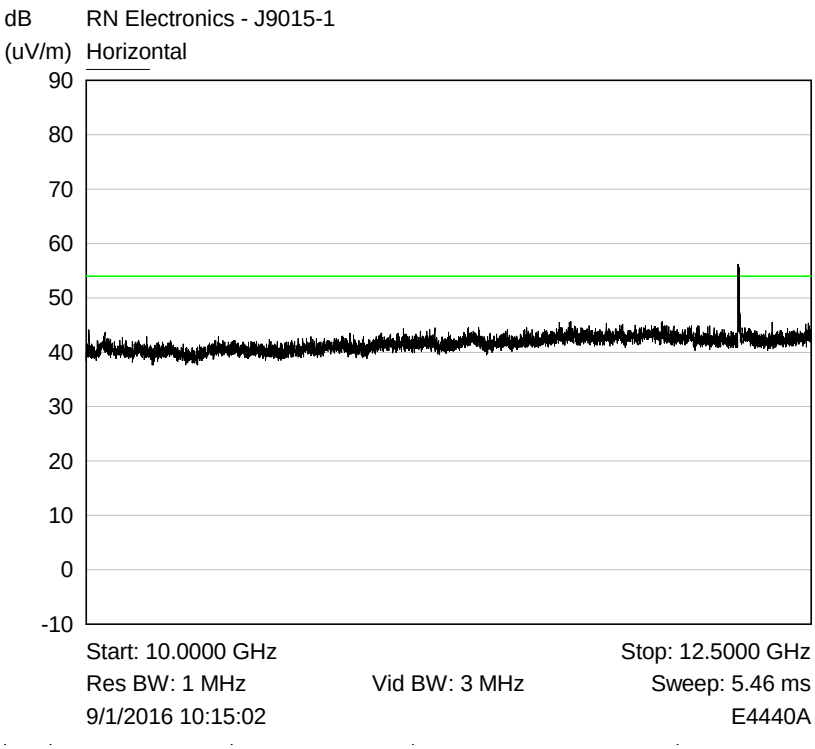
Plot of Peak vertical (max held) emissions 6 – 7.77 GHz against the AV limit line.



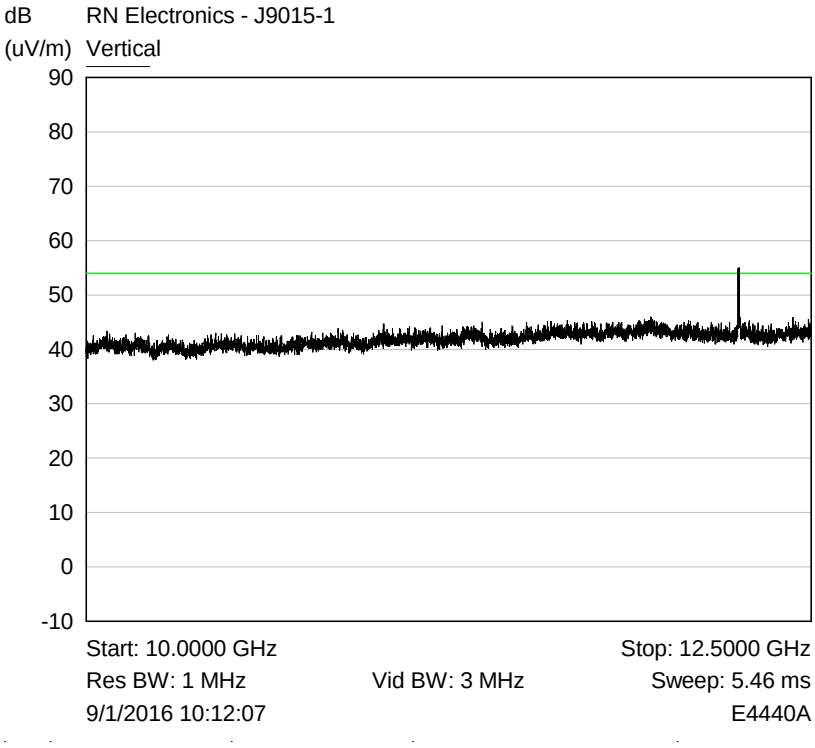
Plot of Peak horizontal (max held) emissions 7.77 – 10 GHz against the AV limit line.



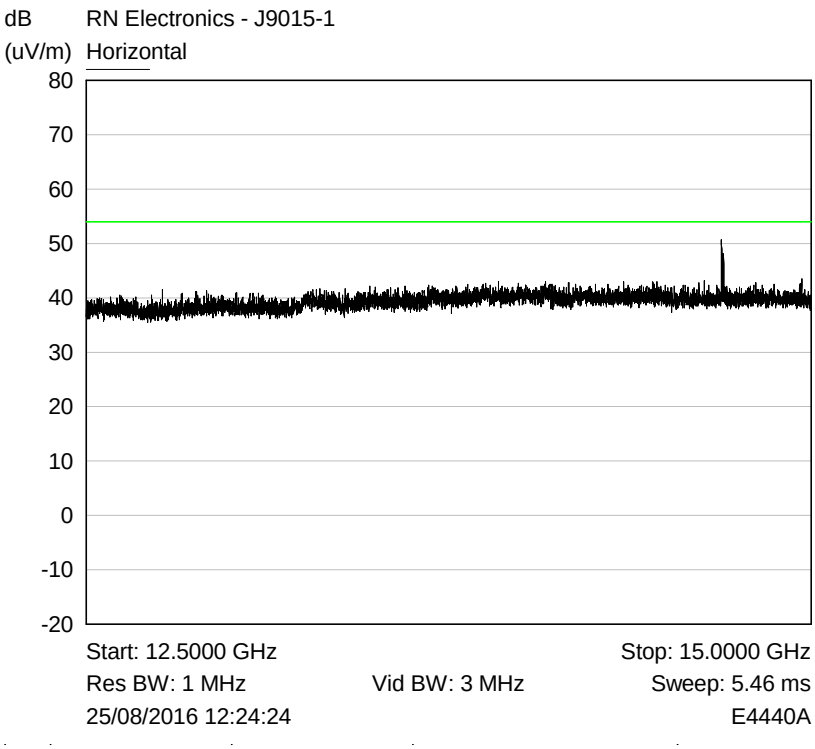
Plot of Peak vertical (max held) emissions 7.77 – 10 GHz against the AV limit line.



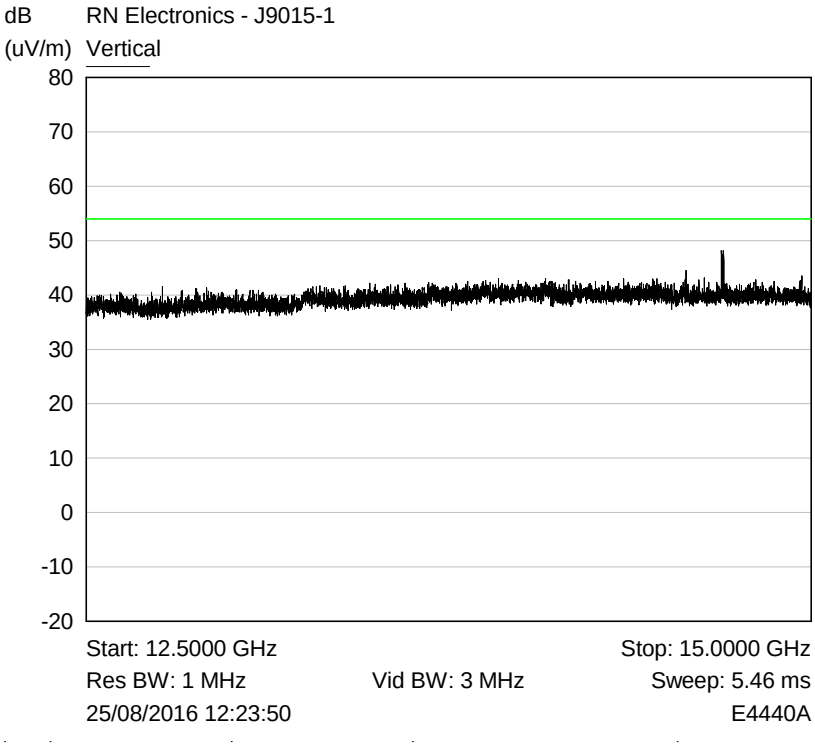
Plot of Peak horizontal (max held) emissions 10 – 12.5 GHz against the AV limit line.



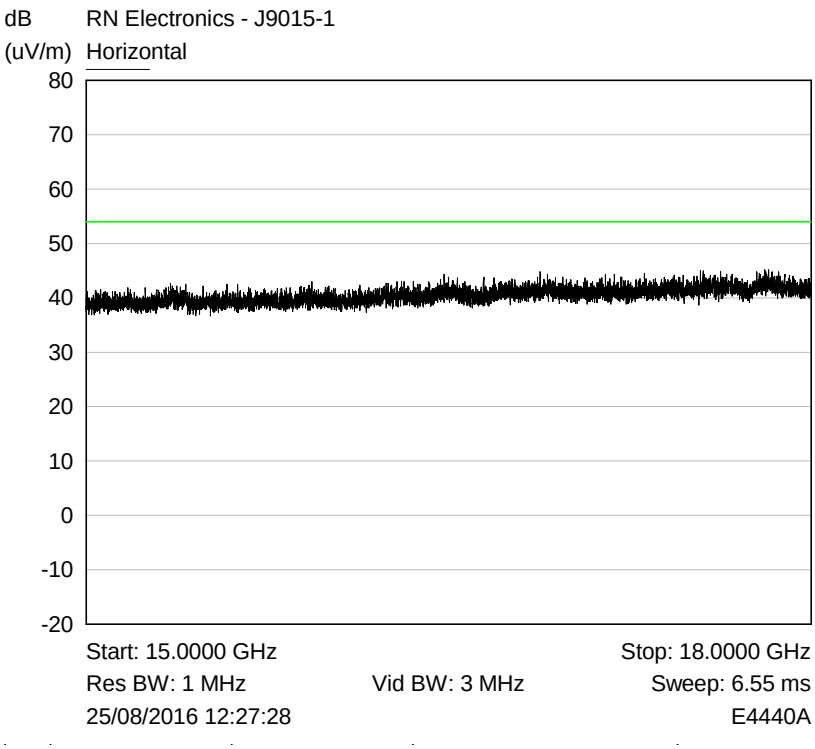
Plot of Peak vertical (max held) emissions 10 – 12.5 GHz against the AV limit line.



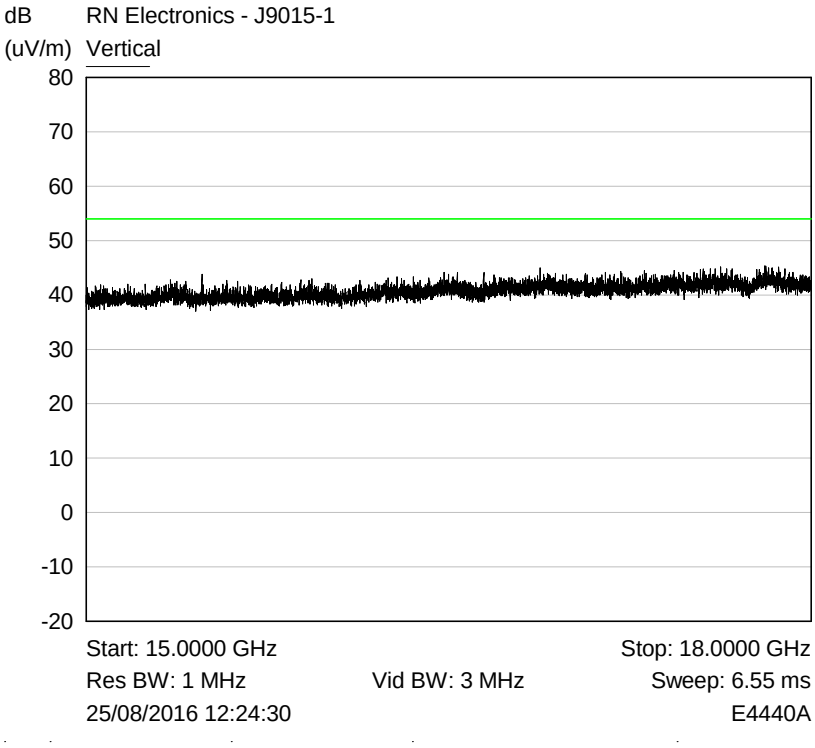
Plot of Peak horizontal (max held) emissions 12.5 – 15 GHz against the AV limit line.



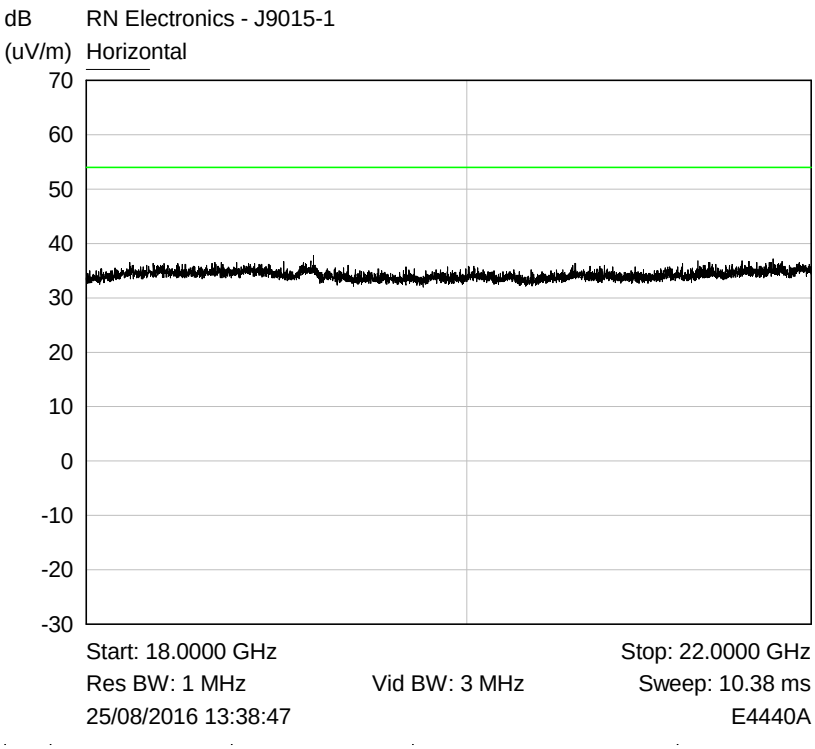
Plot of Peak horizontal (max held) emissions 12.5 – 15 GHz against the AV limit line.



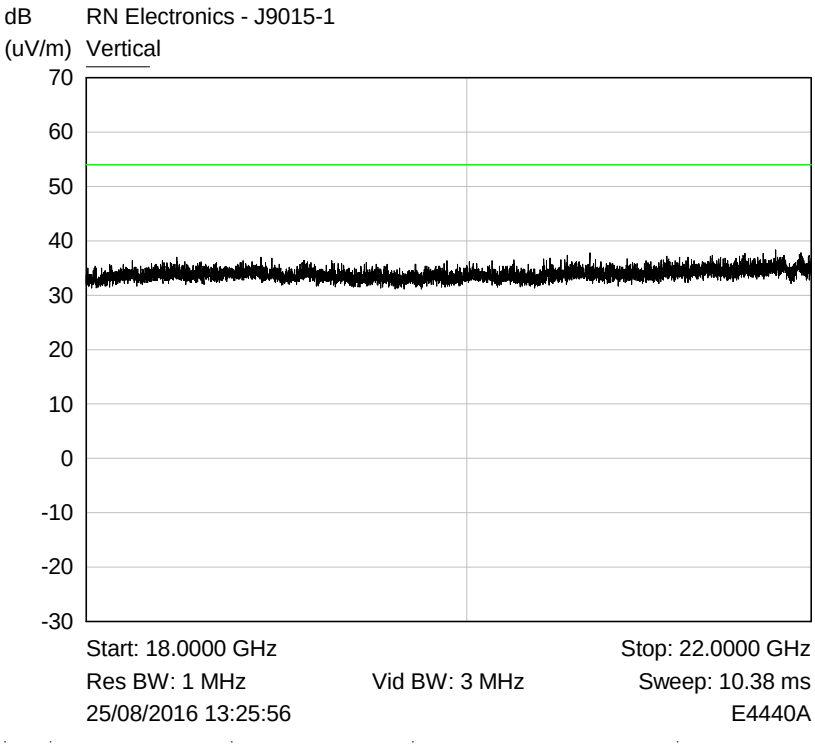
Plot of Peak horizontal (max held) emissions 15 – 18 GHz against the AV limit line.



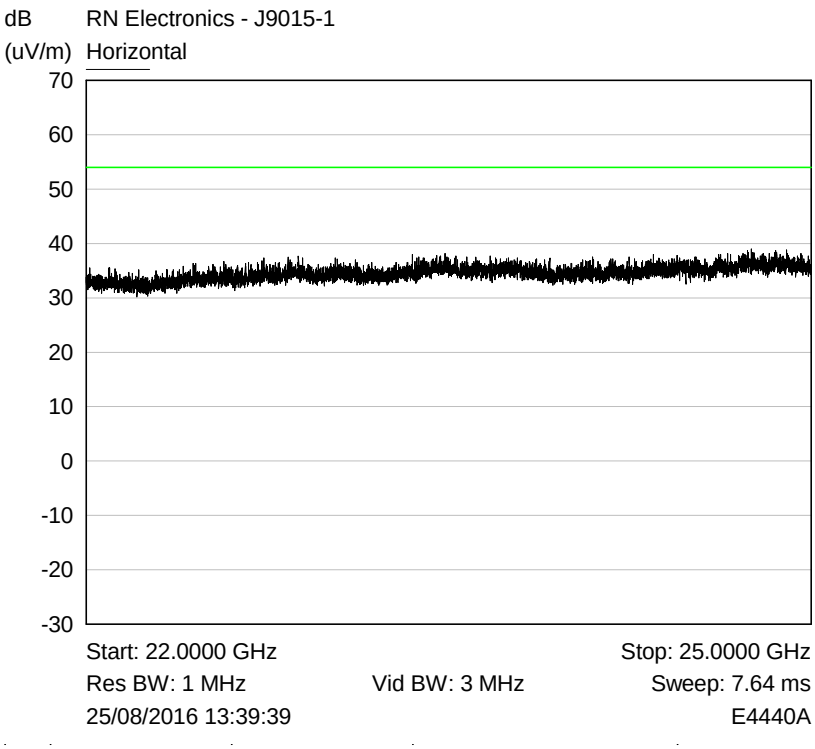
Plot of Peak vertical (max held) emissions 15 – 18 GHz against the AV limit line.



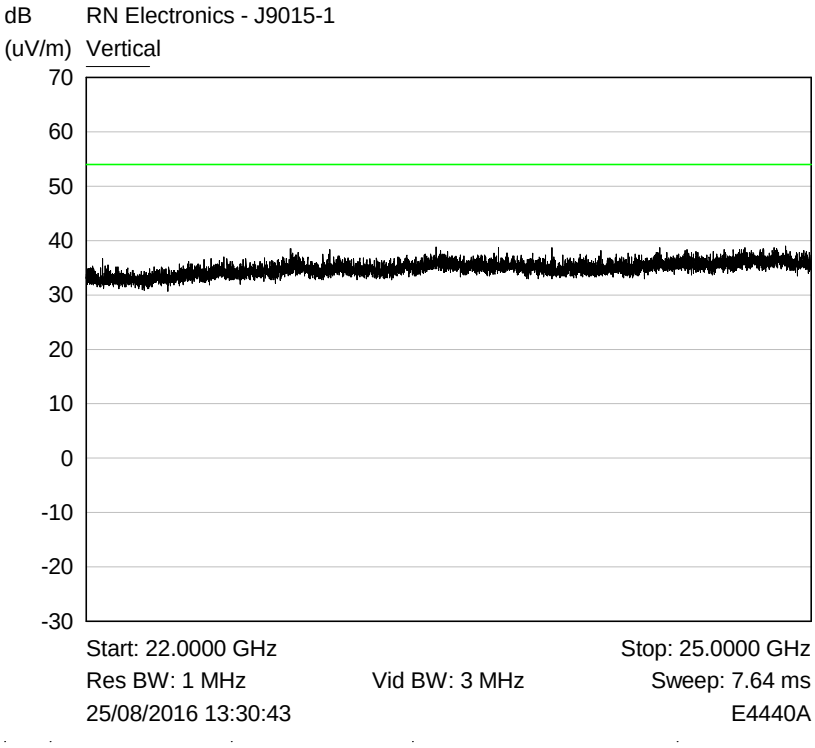
Plot of Peak horizontal (max held) emissions 18 – 22 GHz against the AV limit line.



Plot of Peak vertical (max held) emissions 18 – 22 GHz against the AV limit line.



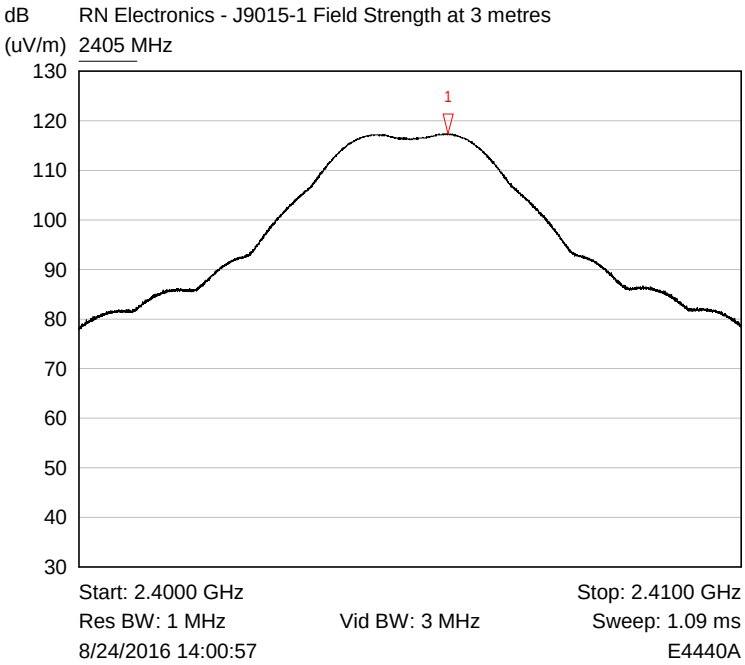
Plot of Peak horizontal (max held) emissions 22 – 25 GHz against the AV limit line.



Plot of Peak vertical (max held) emissions 22 – 25 GHz against the AV limit line.

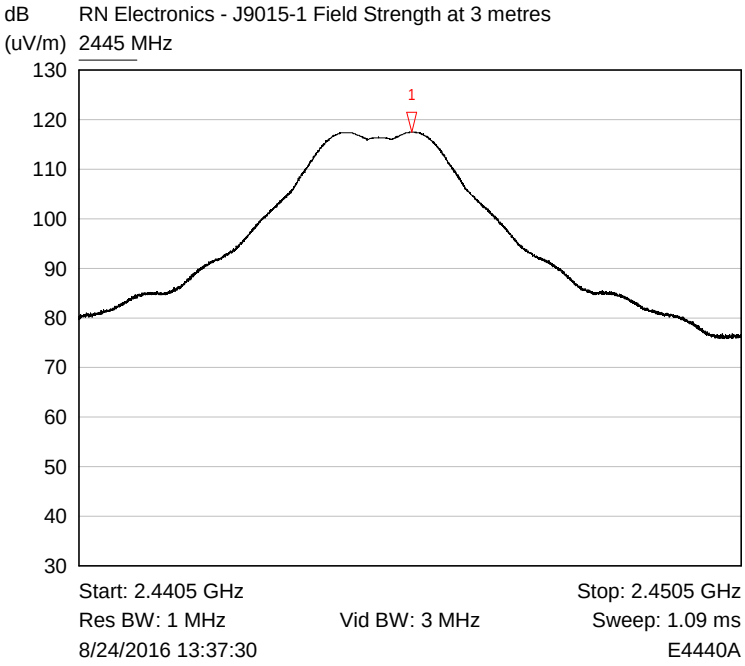
6.6 Effective radiated power field strength

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



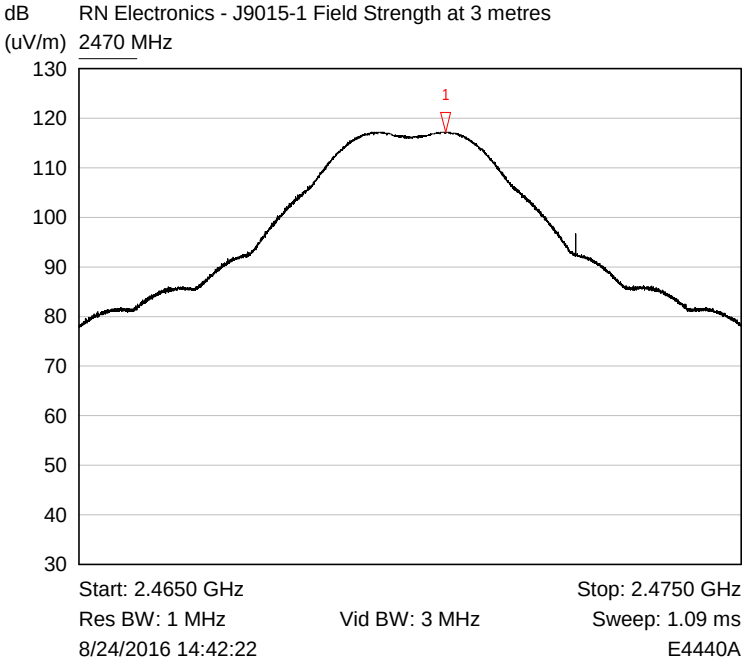
Mkr	Trace	X-Axis	Value	Notes
1 ▽	2405 MHz	2.4056 GHz	117.32 dB(uV/m)	

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	2445 MHz	2.4455 GHz	117.45 dB(uV/m)	

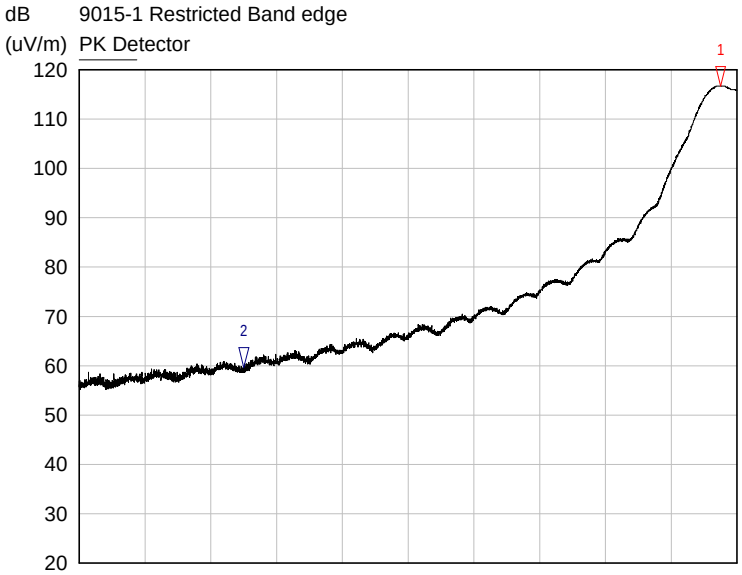
RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2470 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	2470 MHz	2.4705 GHz	117.19 dB(uV/m)	

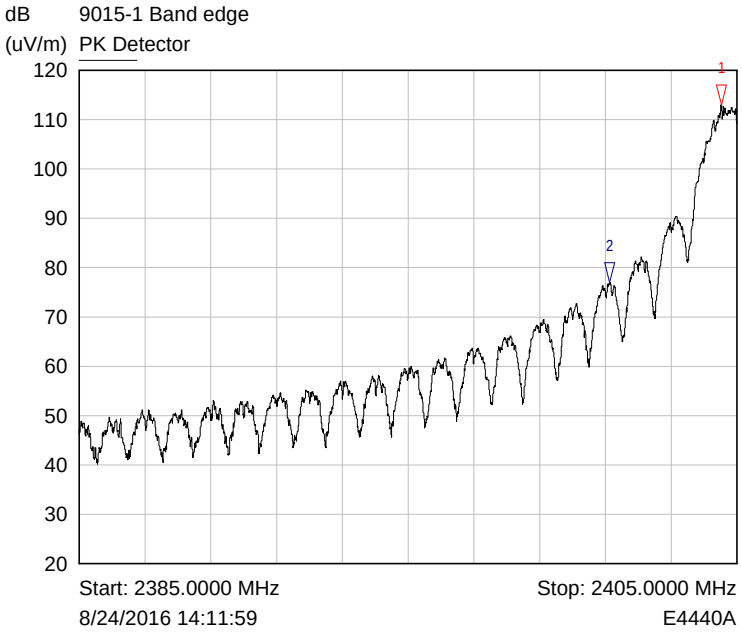
6.7 Band Edge Compliance

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



Mkr	Trace	X-Axis	Value	Notes
1	PK Detector	2404.4970 MHz	116.74 dB(uV/m)	
2	PK Detector	2390.0006 MHz	59.75 dB(uV/m)	

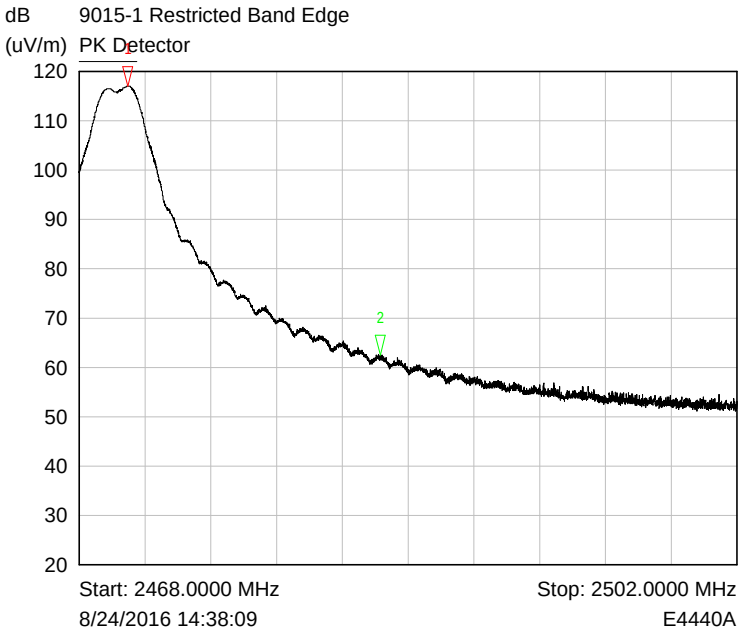
Restricted Band Edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1	PK Detector	2404.5165 MHz	113.04 dB(uV/m)	
2	PK Detector	2401.1372 MHz	76.93 dB(uV/m)	

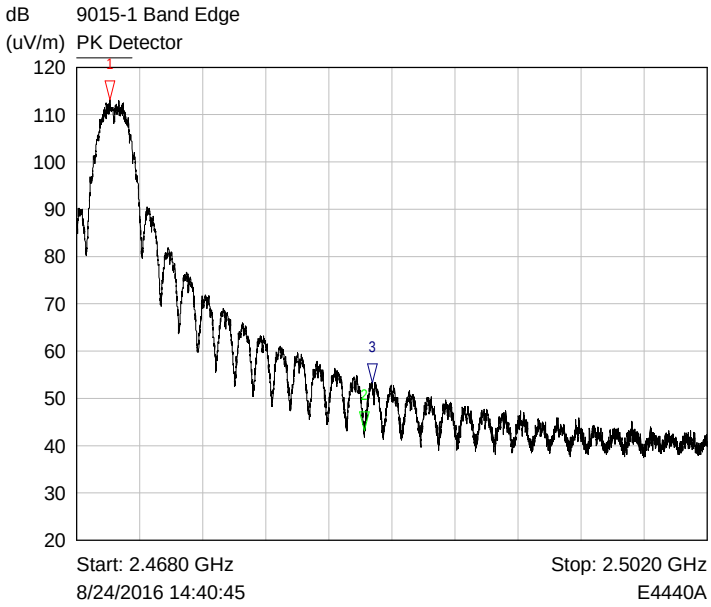
Band Edge Peak Plot

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2470 MHz



Mkr	Trace	X-Axis	Value	Notes
1	PK Detector	2470.4905 MHz	117.06 dB(uV/m)	
2	PK Detector	2483.5675 MHz	62.51 dB(uV/m)	

Restricted Band Edge Peak Plot

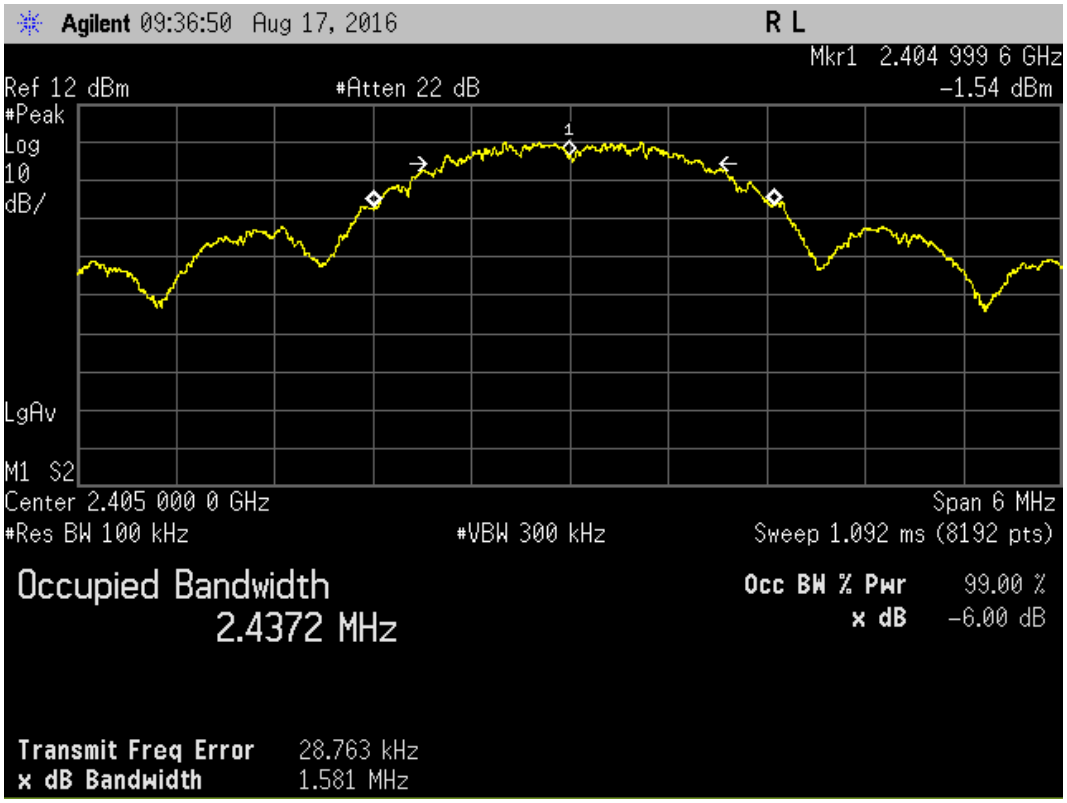


Mkr	Trace	X-Axis	Value	Notes
1	PK Detector	2.4698 GHz	113.12 dB(uV/m)	
2	PK Detector	2.4835 GHz	43.13 dB(uV/m)	
3	PK Detector	2.4839 GHz	53.31 dB(uV/m)	

Band Edge Peak Plot

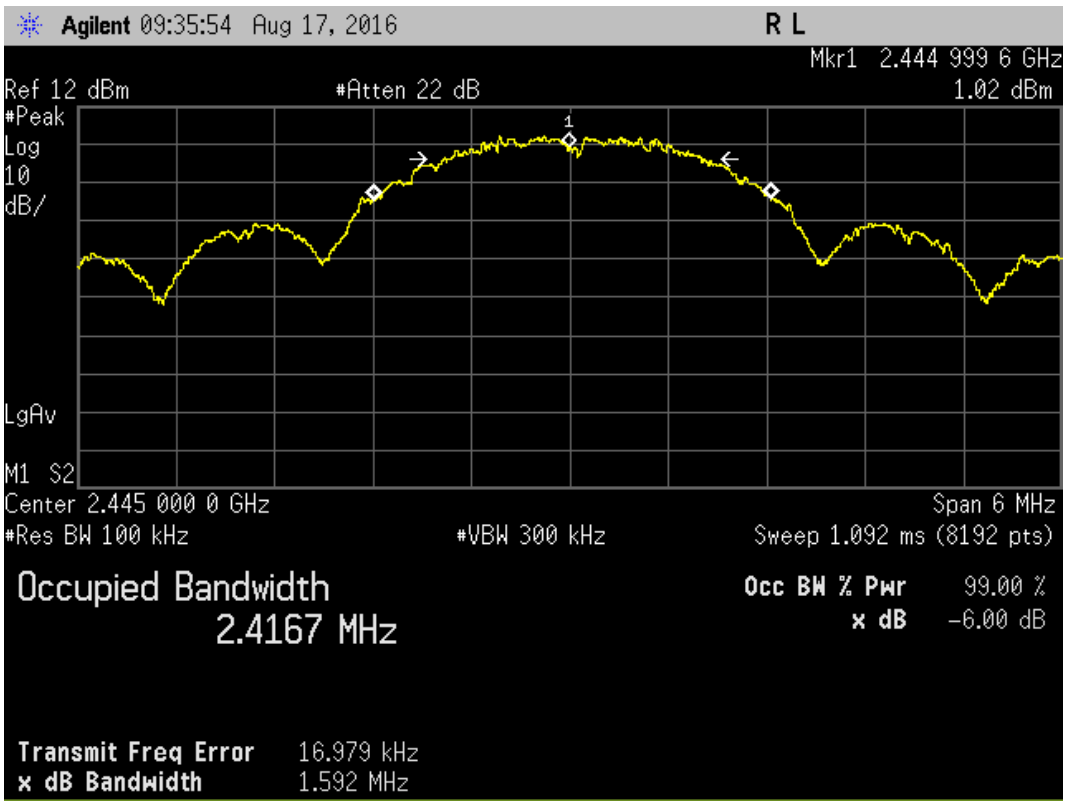
6.8 Occupied bandwidth

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



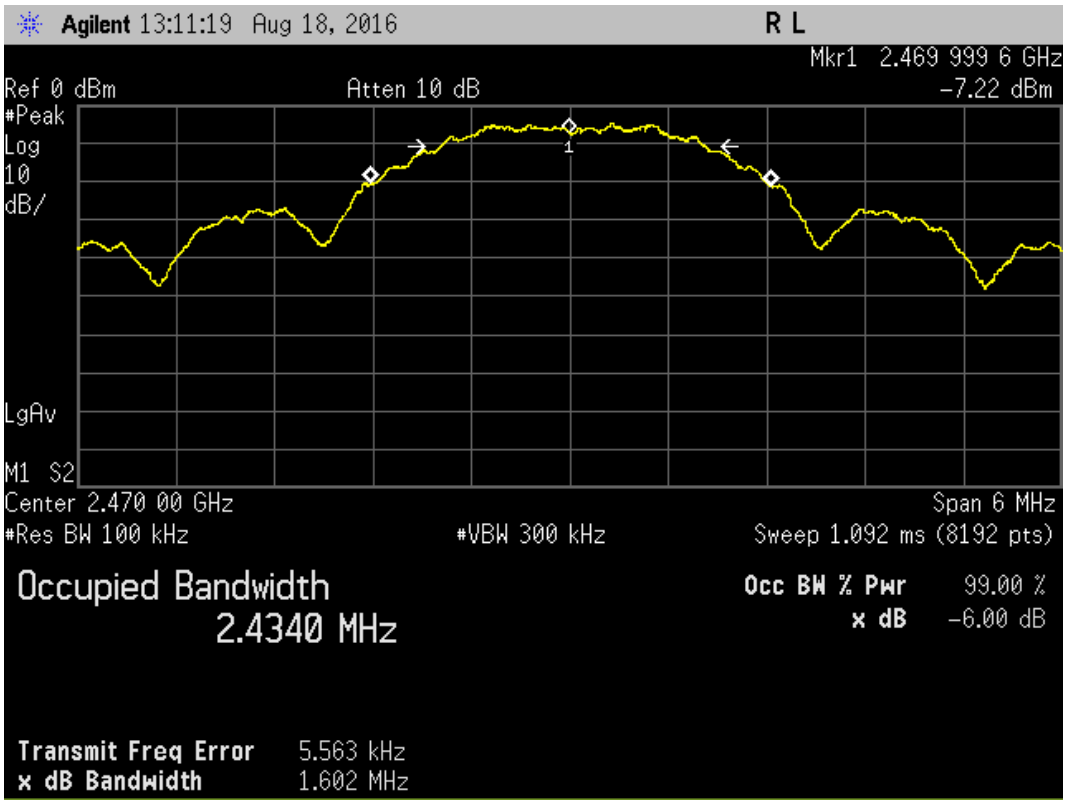
Plot for 6dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



Plot for 6dB Bandwidth (MHz)

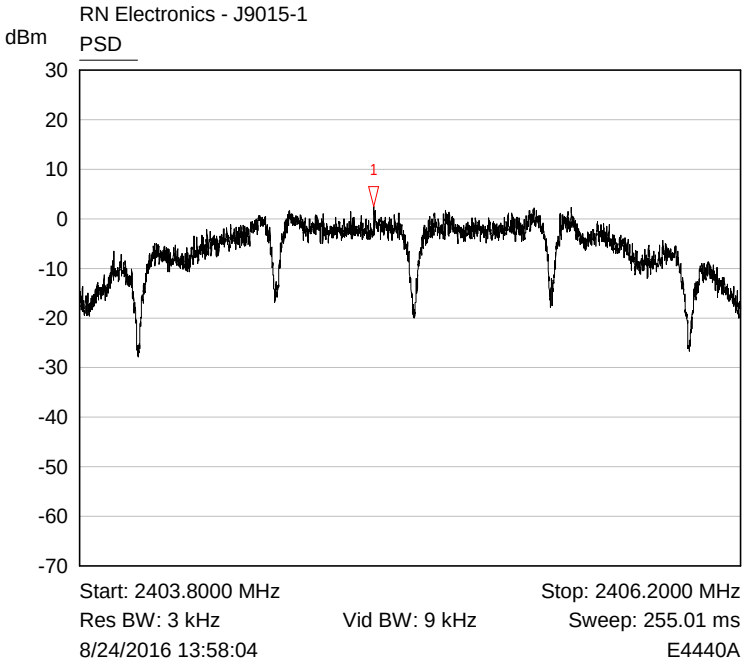
RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2470 MHz



Plot for 6dB Bandwidth (MHz)

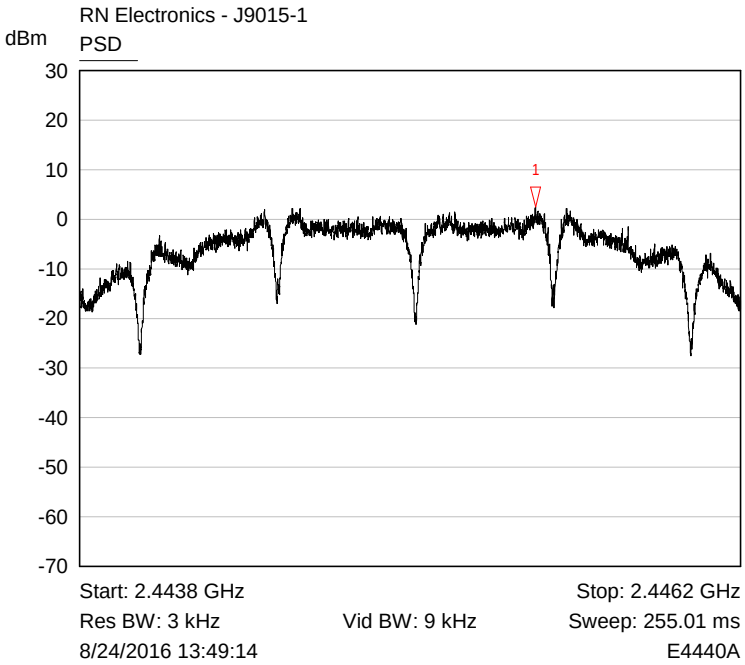
6.9 Maximum Power Spectral Density

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



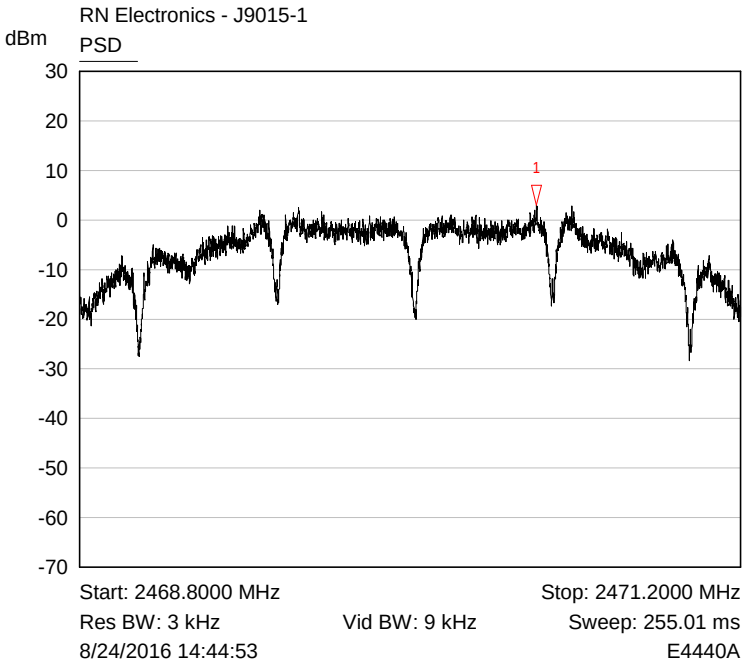
Mkr	Trace	X-Axis	Value	Notes
1 ▽	PSD	2404.8686 MHz	2.57 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2445 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	PSD	2.4455 GHz	2.47 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power Setting -2, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2470 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	PSD	2470.4596 MHz	3.07 dBm	

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

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

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

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

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

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

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

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

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

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

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

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

7.2 Explanation of limit line calculations for radiated measurements

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

(a) limit of 500 µV/m equates to 20.log (500) = 54 dB µV/m.

(b) limit of 300 µV/m at 10m equates to 20.log (300 . 10/3) = 60 dB µV/m at 3m

(c) limit of 30 µV/m at 30m, but below 30MHz, equates to 20.log(30) + 40.log(30/3) = 69.5 dBµV/m at 3m, as extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

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

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

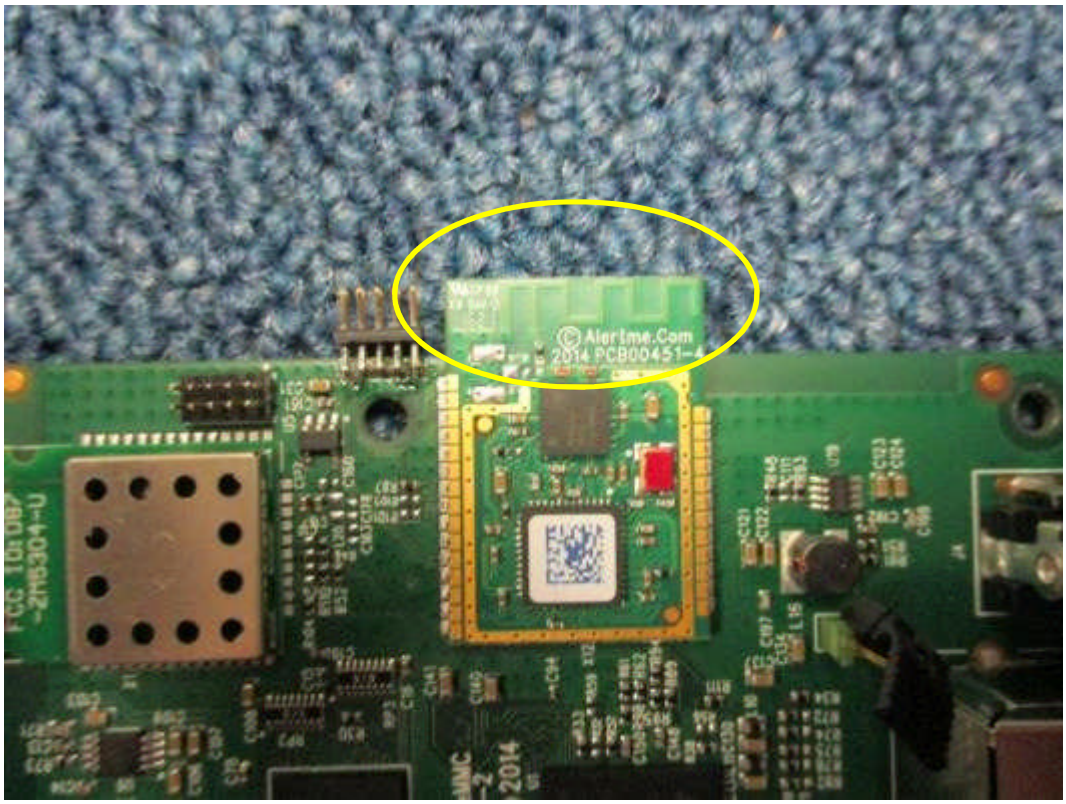
Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

8 Photographs

8.1 EUT Front View

8.2 EUT Reverse Angle

8.3 EUT Antenna

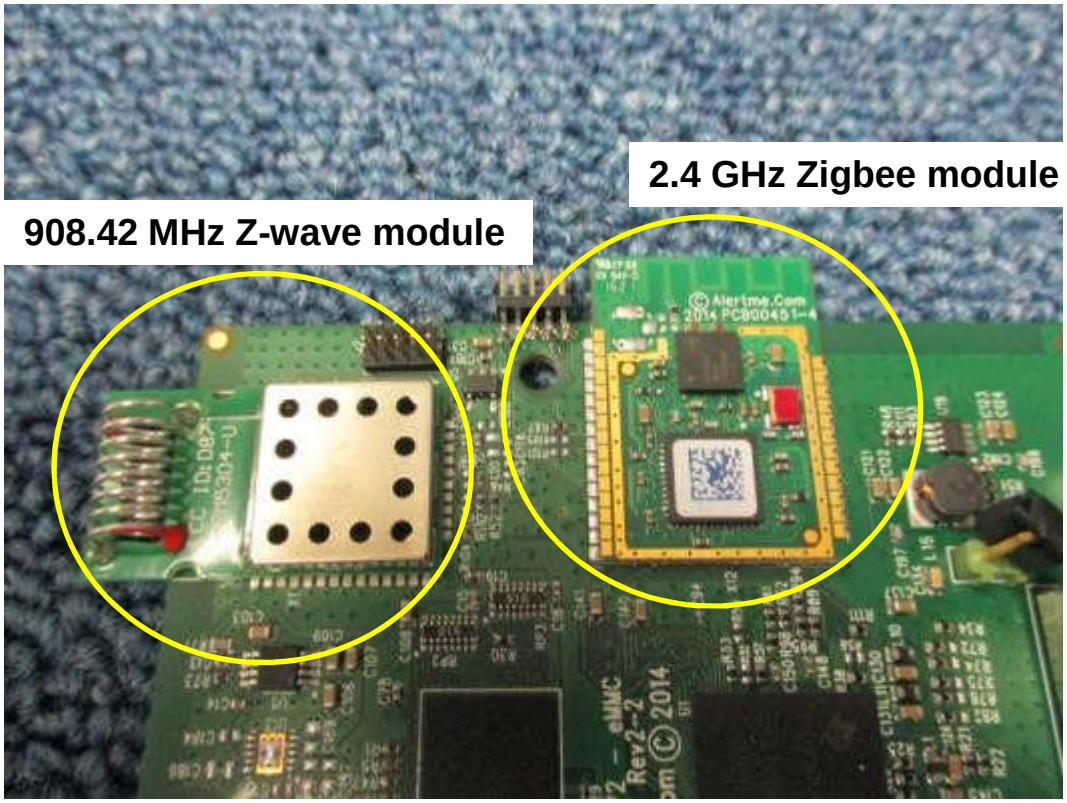


Photograph shows the antenna of the 2.4GHz Zigbee radio (circled)

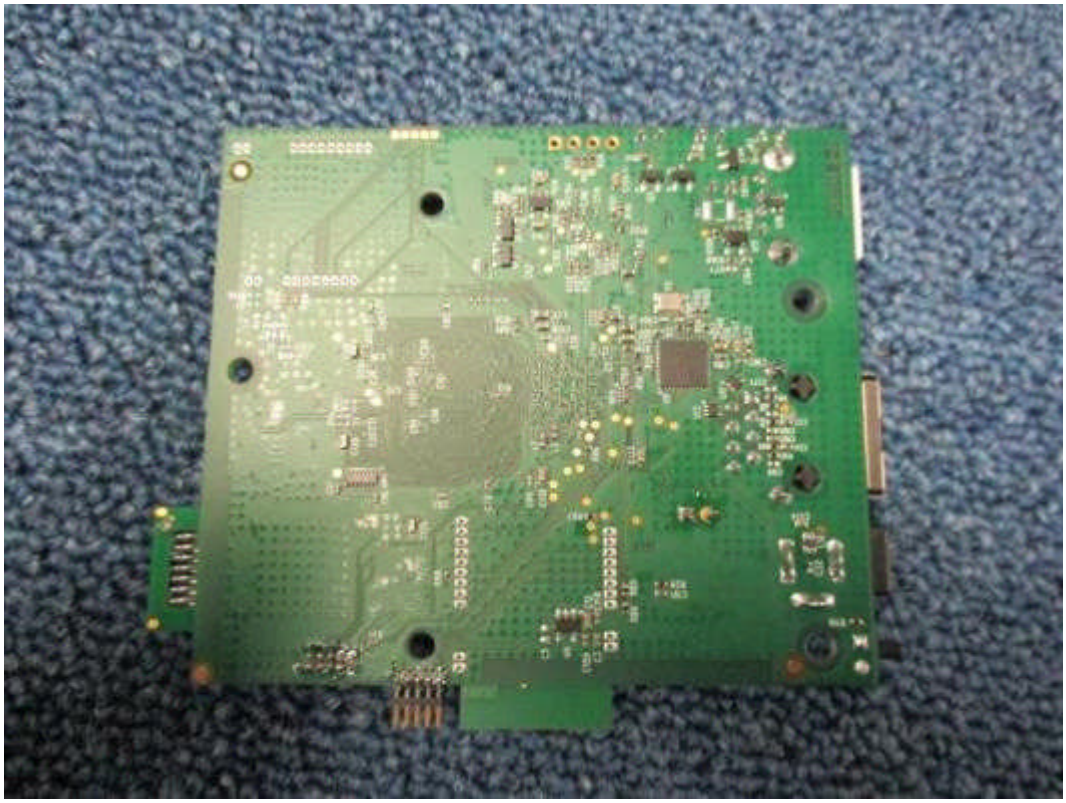
8.4 EUT Display & Controls

Photograph shows the location of the status LEDs (circled)

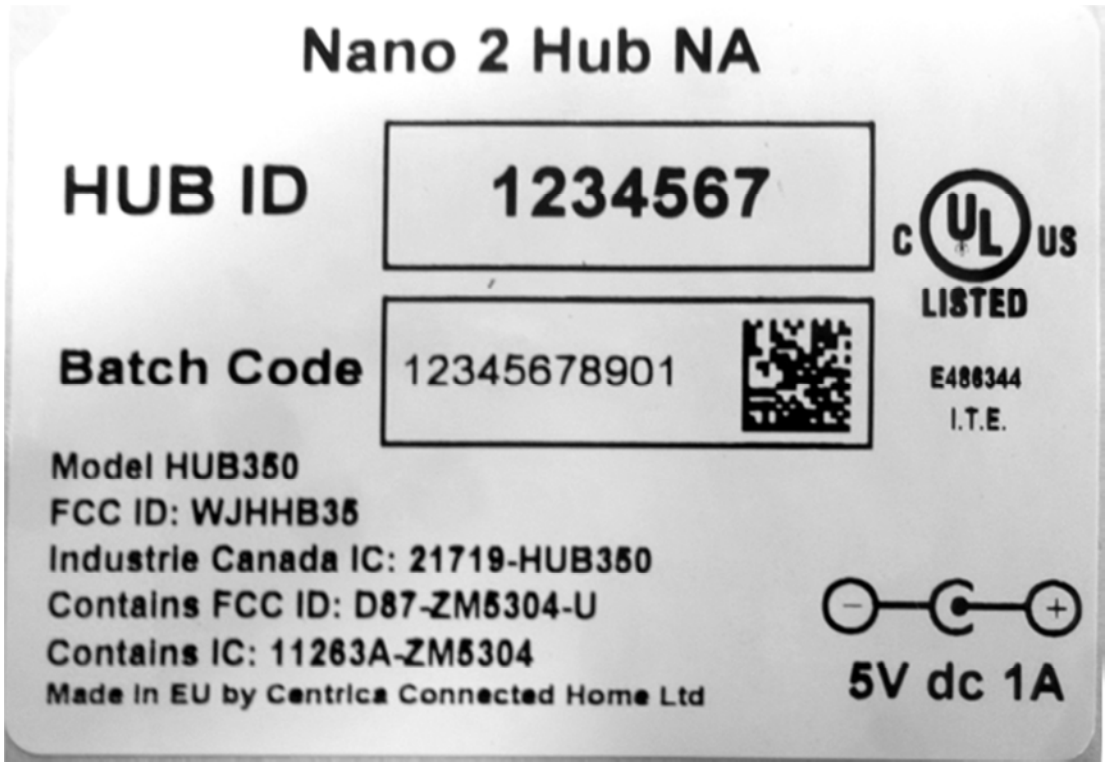
8.5 EUT Internal photos

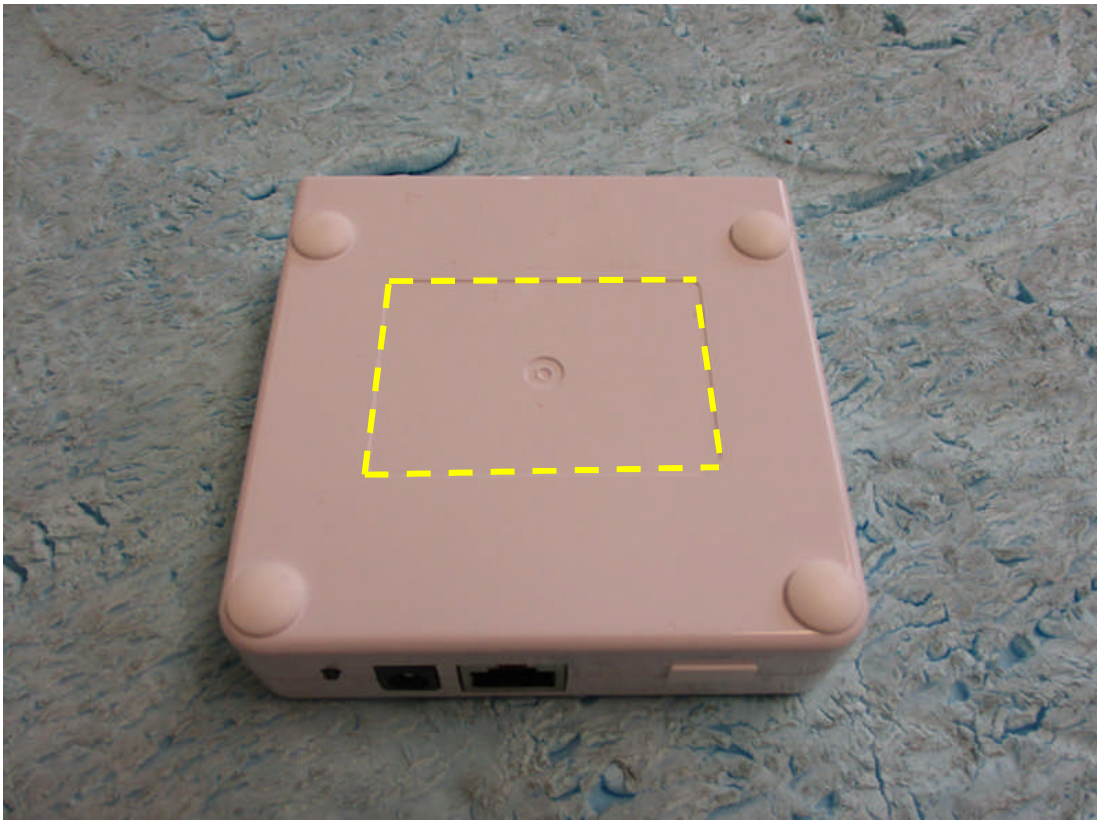


Photograph shows the location of both internal radio modules.



8.6 EUT ID Label





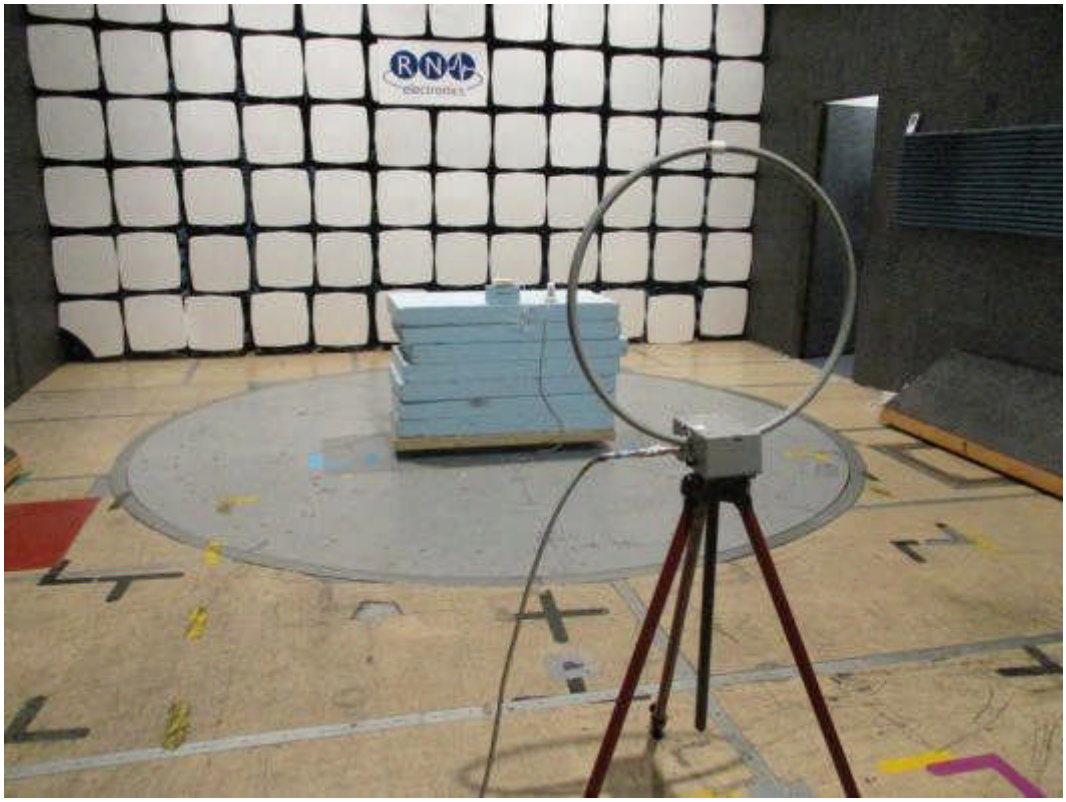
Photograph shows the location of the label

8.7 EUT Chassis

The EUT has no chassis

8.8 AC power line conducted emissions

8.9 TX Unwanted radiated emissions 9 kHz – 30 MHz

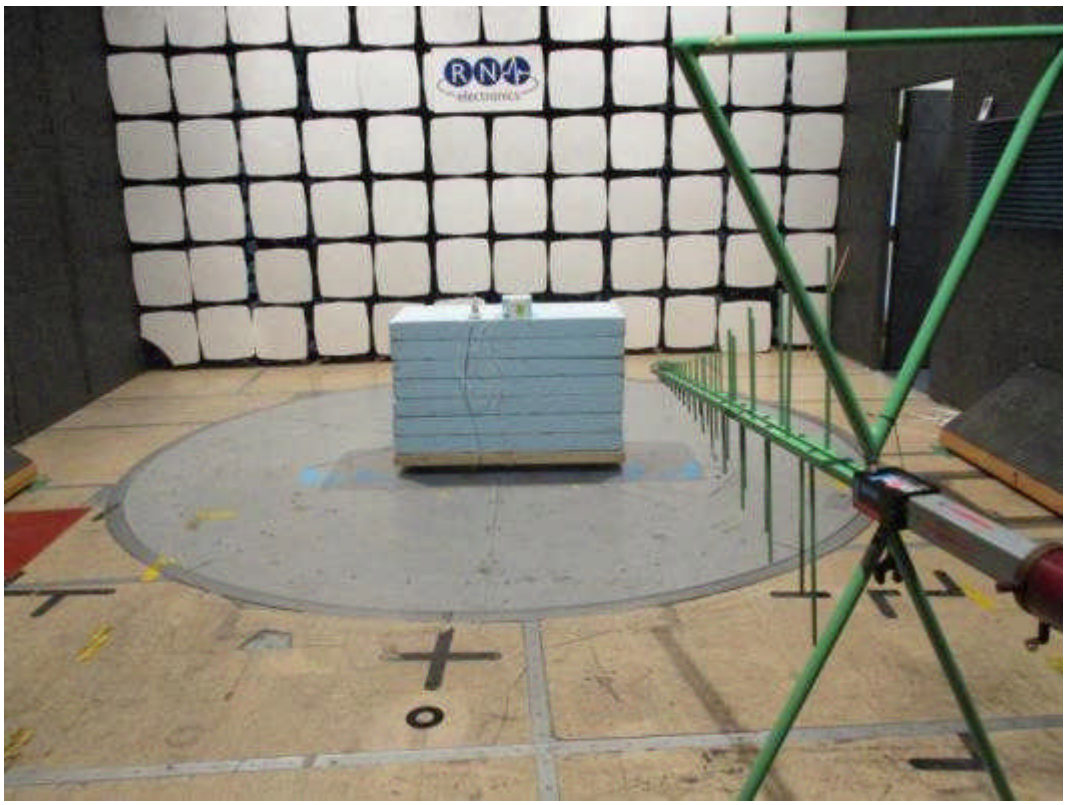


Site H

Site OATS

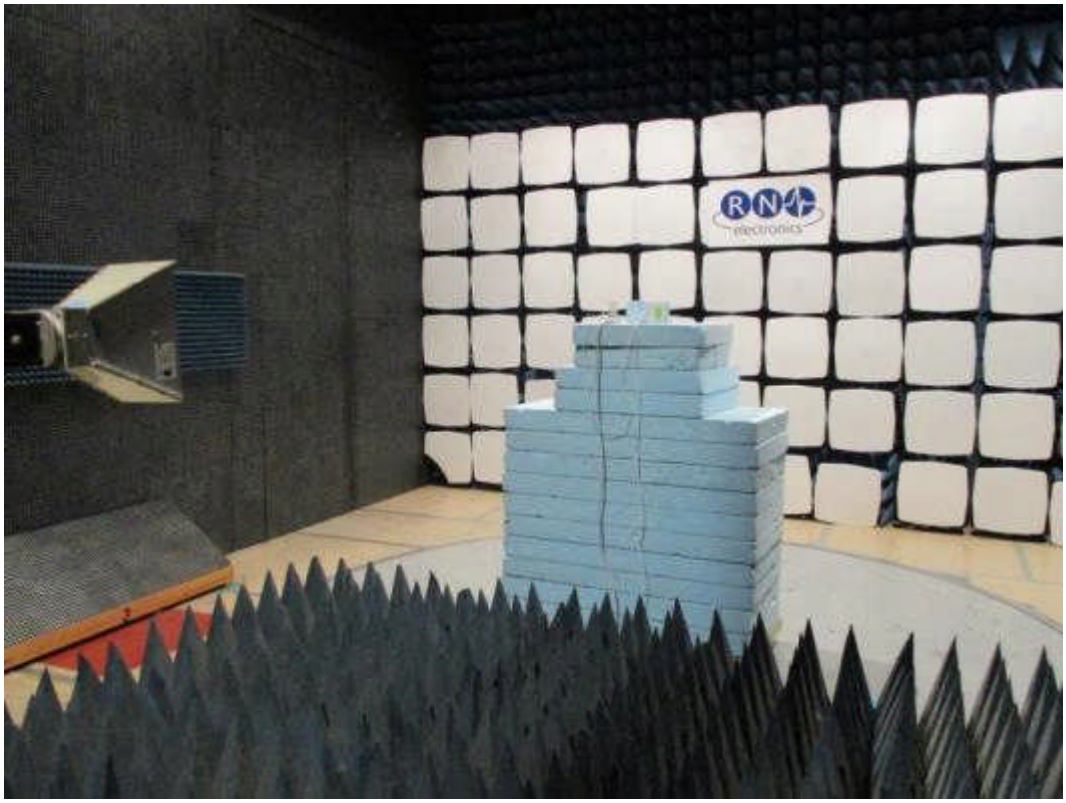
Site OATS

8.10 Radiated emissions 30 MHz -1 GHz



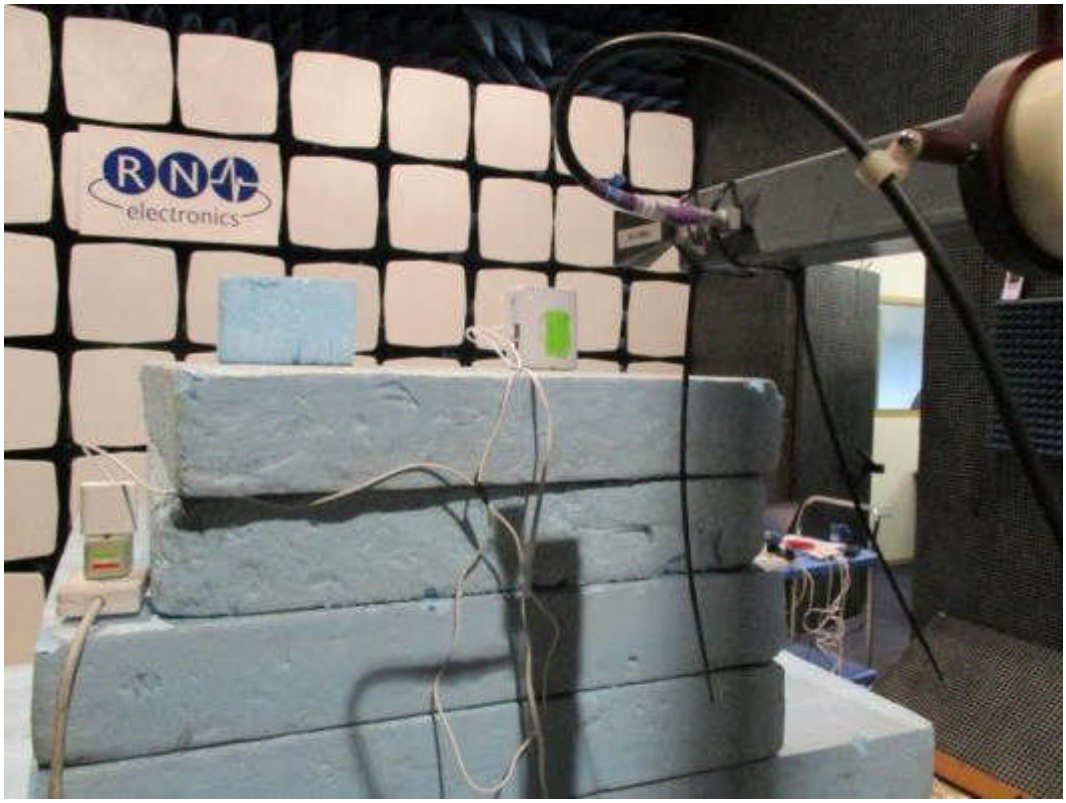
Site H

8.11 Radiated emissions above 1 GHz



Site H

Site H



Site H

8.12 Radiated emission diagram

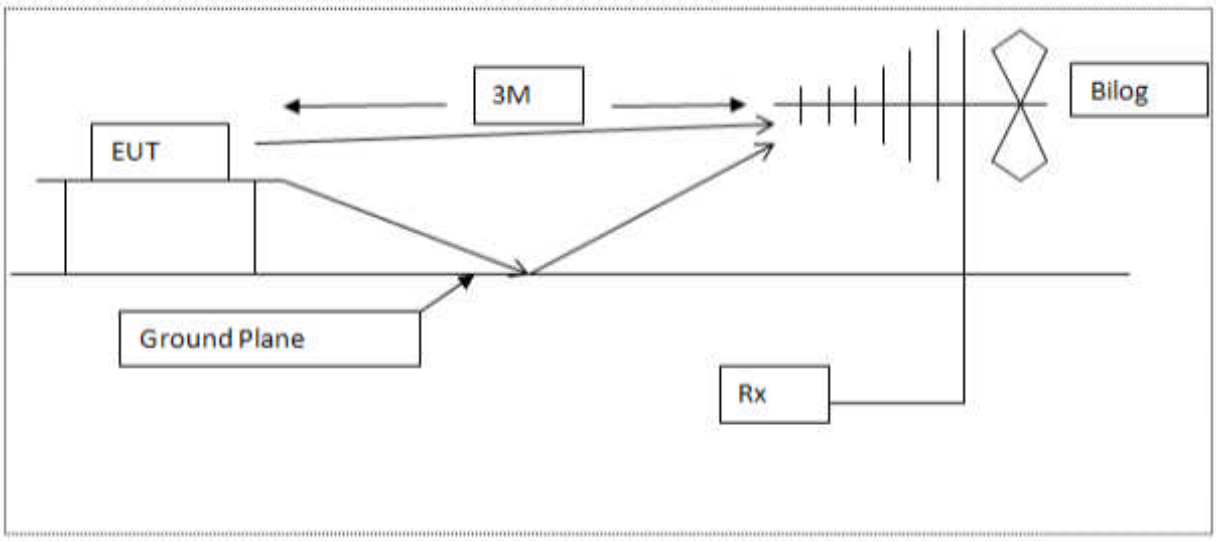


Diagram of the radiated emissions test setup 30 - 1000 MHz

8.13 AC powerline conducted emission diagram

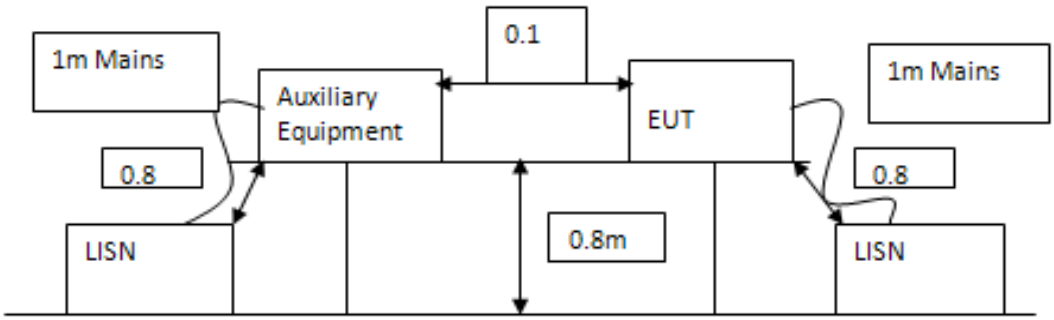


Diagram of the AC conducted emissions test setup

9 Test equipment calibration list

The following is a list of the test equipment used by R.N. Electronics Ltd to test the unit detailed within this report. In line with our procedures, the equipment was within calibration for the period during which testing was carried out.

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
E035	11947A	Transient Limiter + 10dB Atten.	Hewlett Packard	01-Jun-2016	6 months
E150	MN2050	LISN 13A	Chase	08-Oct-2015	12 months
E252	6810.19.A	Attenuator 10 dB	Suhner	11-Aug-2016	12 months
E313	777C	Attenuator 30dB	Narda	17-Jun-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	06-Jul-2016	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	06-Jul-2016	24 months
E429	-	5 Switch Filter Box 0.91 GHz - 16.3 GHz	RN Electronics	18-Jul-2016	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
E611	RPR3006W	USB RF Power Sensor 10MHz - 6GHz	DARE Instruments	21-Apr-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 3dB 12.4GHz	Weinschel	*02-Sep-2016	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

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

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Latitude E6440	Laptop PC	Dell	198
2	BR-6314UK	Router	Edimax	BR6314UK05MD0053
3	ISA3	De-bug adaptor	Ember	EM-ISA-01
4	PSAA05K-050G	Mains power supply	Phihong	P162611085A2

10.2 RN Electronics supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	EN106	10-BASE-T Ethernet Hub	Netgear	ENT6006298

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