Radio Test Report

Cambridge Communication Systems Ltd

Metnet 60G

G60US050000 & G60US010000

47 CFR Part 15.255 Effective Date 1st October 2018
DXX: Part 15 Low Power Communication Device Transmitter
Test Date: 25th July 2019 to 31st July 2019
Report Number: 07-11429-1-19 Issue 01

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Certificate of Test 11429-1

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:	Metnet 60G
Model Number:	G60US050000 G60US010000
Unique Serial Number:	93
Applicant:	Cambridge Communication Systems Ltd Victory House, Chivers Way Histon, Cambridge CB24 9ZR
Full measurement results are detailed in Report Number:	07-11429-1-19 Issue 01
Test Standards:	47 CFR Part 15.255 Effective Date 1st October 2018 DXX: Part 15 Low Power Communication Device Transmitter

NOTE:
The above list is incomplete as only partial tests conducted at request of the manufacturer, tests performed were in line with requirements for a Class II permissive change request with the FCC. For details refer to section 3 of this report. Certain tests were not performed based upon manufacturer's declarations. Certain other requirements are subject to manufacturer declaration only and have not been tested/verified. For details refer to section 3 of this report.

DEVIATIONS:
The following test has a deviation applied: Radiated emissions above 1GHz. The following tests have not been performed at the request of Cambridge Communication Systems Ltd:- Frequency stability, 20dB Occupied bandwidth, Peak & Average EIRP.

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:	25th July 2019 to 31st July 2019
Test Engineer:	Digitally signed by: Graham Blake DN: CN = Graham Blake C = GB O = RN Electronics Ltd Date: 2019.08.30 13:35:44 +01'00'
Approved By: Radio Approvals Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2019.08.30 12:08:26 Z
Customer Representative:	

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1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Cambridge Communication Systems Ltd Victory House Chivers Way Histon Cambridge CB24 9ZR	
Manufacturer of EUT	Cambridge Communication Systems Ltd	
Full Name of EUT	Metnet 60G	
Model Number of EUT	G60US050000 G60US010000	
Serial Number of EUT	93	
Date Received	3rd June 2019	
Date of Test:	25th July 2019 to 31st July 2019	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	22nd August 2019	
Main Function	60 GHz millimetre-wave backhaul.	
Information Specification	Height	257 mm
	Width	137 mm
	Depth	100 mm
	Weight	3.3 kg
	Voltage	48 V DC power or PoE powered
	Current	Not stated

Note: The model provided for test was a G60US050000 which relates to the PoE powered version with Fibre ports, in normal use the DC input port whilst present, would be blanked off and the unit installed as a PoE powered unit. For the purposes of test, CCS Ltd did not blank of the DC input, so the unit could be tested by RN Electronics as both a PoE with Fibre powered node and a DC input Fibre powered node. Please see below for the related model numbers:-

G60US050000 = PoE + Fibre version node.
G60US010000 = 48 V DC + Fibre version node.
G60US040000 = AC power + Fibre ports. This unit is not covered under this test report, please see RN Electronics report 07-11564-1-19 for details of this model/configuration of node.
G60US000000 = AC Power + Ethernet. This unit is the originally FCC certified node and is not covered under this report, please see RN report for 02-9927-4-19 for details of this model/configuration.

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Mounted on lamppost
Choice of model(s) for type tests	Sample
Antenna details	20 dBi phased array beamforming
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	64.8 GHz
Lowest Signal generated in EUT	25 MHz
Hardware Version	Metnet 60G V1
Software Version	Metnet_node_archemedes_version-0-3-1-c8
Firmware Version	Not applicable
Type of Equipment	millimetre-wave multipoint to multipoint
Technology Type	802.11 ad
Geo-location (yes/no)	Yes
TX Parameters	
Alignment range – transmitter	57-66 GHz
EUT Declared Modulation Parameters	BPSK, QPSK, 16QAM
EUT Declared Power level	+40 dBm EiRP
EUT Declared Signal Bandwidths	2.16 GHz
EUT Declared Channel Spacing's	2.16 GHz
EUT Declared Duty Cycle	Not declared
Unmodulated carrier available?	Yes
Declared frequency stability	+/-2.5 ppm/20 years
RX Parameters	
Alignment range – receiver	57-66 GHz
EUT Declared RX Signal Bandwidth	2.16 GHz
Receiver Signal Level (RSL)	Not declared
Method of Monitoring Receiver BER	PER
FCC Parameters	
FCC Transmitter Class	DXX: Part 15 Low Power Communication Device Transmitter

2.3 Functional description

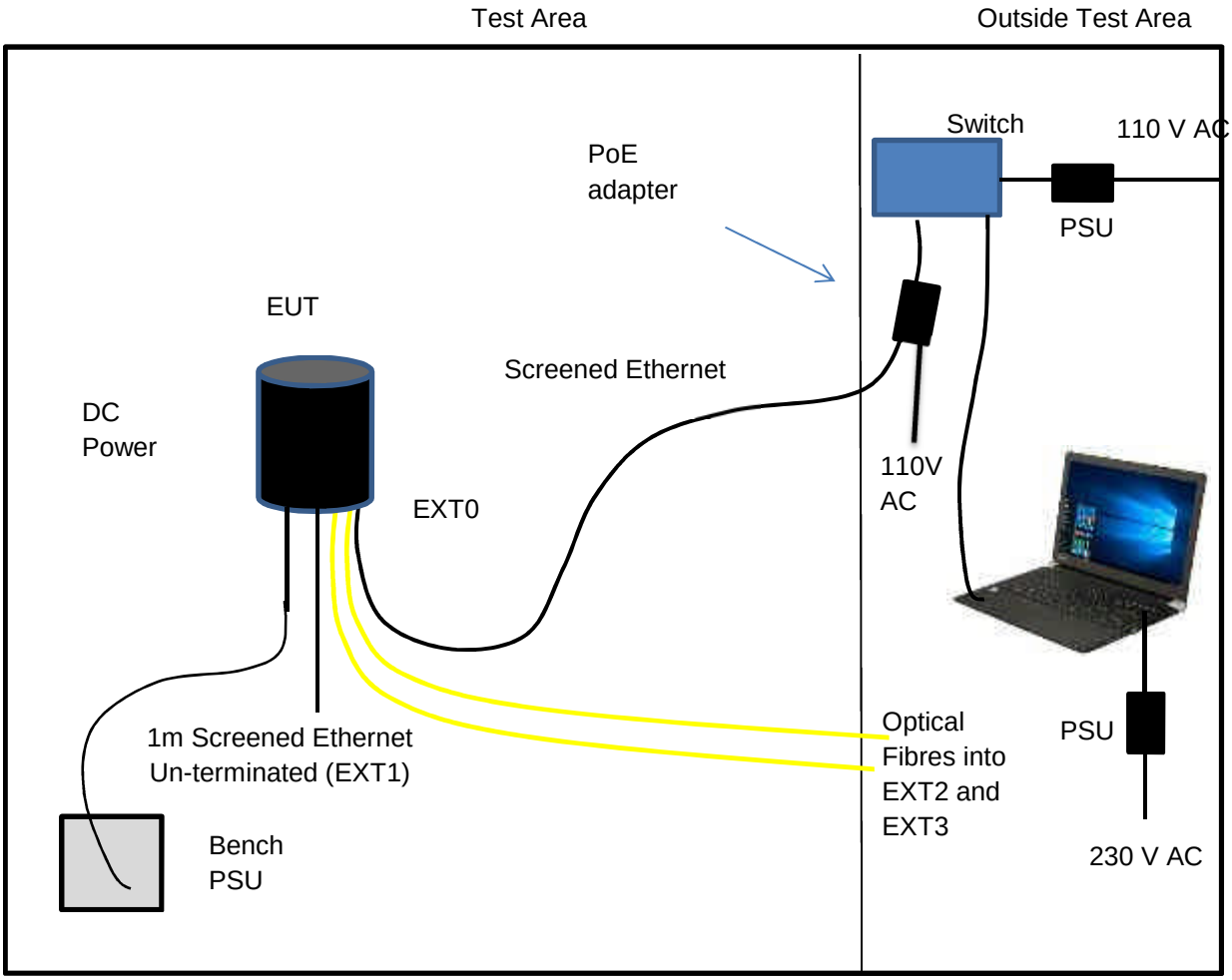
Multipoint to multipoint millimetre-wave backhaul. The equipment contains four 60 GHz transceivers each connected to its own steerable multi element antenna array.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX1	58.32GHz 40dBm MCS0	Yes
TX2	60.48GHz 40dBm MCS0	Yes
TX3	62.64GHz 40dBm MCS0	Yes
TX4	64.8GHz 40dBm MCS0	Yes

Note: Modes above were checked in both PoE powered configuration and 48V DC powered configuration.

2.5 Emissions configuration



Optical fibres were connected to EXT2 and EXT3 ports. In a pre-test the EUT was assessed both whilst powered from a DC bench power supply (set to 48 VDC) and then from a PoE adapter, both powered via 110V AC 60Hz. Worst-case radiated emissions were observed whilst powered from the DC bench power supply and therefore this configuration was used for full radiated tests. The unit was configured using a laptop PC positioned outside of the test area. Using terminal software running on the laptop the EUT was configured to allow permanent transmit modes of the device on the each of 4 radios on the channels as stated within section 2.4 of this report. The settings used for test were as follows:

Radio 1, 58.32 GHz, Power 40 dBm, Modulation scheme DBPSK
Radio 2, 60.48 GHz, Power 40 dBm, Modulation scheme DBPSK
Radio 3, 62.64 GHz, Power 40 dBm, Modulation scheme DBPSK
Radio 4, 64.8 GHz, Power 40 dBm, Modulation scheme DBPSK

The reason for test is to determine the EUT emissions associated with different methods of powering the node and different I/O configurations of the node, in line with applying for class 2 permissive changes on the originally certified device. The four 60GHz radios in the device are identical to the originally certified device.

2.5.1 Signal leads

Port Name	Cable Type	Connected
ETH0	RJ45	Yes
ETH1	RJ45	Yes
ETH2	Optical fibre	Yes
ETH3	Optical fibre	Yes
DC	2-core	Yes

3 Summary of test results

The Metnet 60G, G60US050000 / G60US010000 was tested for compliance to the following standard :

47 CFR Part 15.255 Effective Date 1st October 2018
DXX: Part 15 Low Power Communication Device Transmitter

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	PASSED[1]
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE[4]
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 15.255(d)(2)	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.255(d)(2)/(3)/(4)	PASSED[5]
6. Frequency stability	47 CFR Part 15C Part 15.255(f)	NOT TESTED[3]
7. Peak & Average EIRP	47 CFR Part 15C Part 15.255(c)(1)(i)/(ii)	NOT TESTED[3]
8. Peak Conducted Power	47 CFR Part 15C Part 15.255(c)(3)/(4)	NOT APPLICABLE[2]
9. 20dB Occupied bandwidth	47 CFR Part 15C Part 15. 255(e)1	NOT TESTED[3]

[1] EUT tested in two configurations, via a 110V AC powered PoE injector and via a 110V AC powered DC bench top supply at 48V.

[2] EUT does not have a conducted RF port.

[3] Not tested at request of applicant

[4] Lowest frequency generated within the unit is declared as 25MHz

[5] Spectrum investigated up to a frequency of 40 GHz only, 60GHz radios have not changed since original certification submission.

4 Specifications

The tests were performed and operated in accordance with R.N. Electronics Ltd procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	47 CFR Part 15C	2018	Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES
4.1.2	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
4.1.3	ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

4.2 Deviations

The following test has a deviation applied: Radiated emissions above 1GHz; Tests performed up to 40GHz only.

The following tests have not been performed at the request of Cambridge Communication Systems Ltd:- Frequency stability, 20dB Occupied bandwidth, Peak & Average EIRP

5 Tests, methods and results

5.1 AC power line conducted emissions

5.1.1 Test methods

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

5.1.2 Configuration of EUT

The EUT was placed on a wooden table 0.8m above the ground plane and connected to a LISN via a 1m mains cable. Details of the Peripheral and Ancillary Equipment connected for this test are listed in section 10.

The EUT was assessed both whilst powered from a DC bench power supply connected to 110V AC and then from a PoE adapter connected to 110V AC. The EUT was operated in TX1, TX2, TX3 and TX4 modes.

5.1.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed in the 'Test Equipment' Section. Measurements were made on the live and neutral conductors using both average and quasi-peak detection.

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

Tests were performed in Test Site F.

5.1.4 Test equipment

E150, E035, ZSW1, E624, E411, E465

See Section 9 for more details

5.1.5 Test results

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

Band	57-66 GHz
Power Level	40 dBm
Channel Spacing	2.16 GHz
Mod Scheme	DBPSK
Single channel	Radio 1 58.32 GHz, Radio 2 60.48 GHz, Radio 3 62.64 GHz, Radio 4 64.8 GHz

PoE test

Plot refs
11429-1 Cond 1 AC Live 150k-30M Average
11429-1 Cond 1 AC Live 150k-30M Quasi-Peak
11429-1 Cond 1 AC Neutral 150k-30M Average
11429-1 Cond 1 AC Neutral 150k-30M Quasi-Peak

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.153	57.4	50.7	-15.1	21.3	-34.5
2	0.197	53.7	50.9	-12.8	35.2	-18.5
3	0.199	55.5	50.5	-13.2	34.5	-19.2
4	0.255	49.7	43.9	-17.7	27.5	-24.1
5	0.290	44.5	38.7	-21.8	12.5	-38.0
6	0.371	41.7	35.2	-23.3	16.6	-31.9
7	0.376	42.6	35.8	-22.6	18.9	-29.5

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.161	56.8	51.0	-14.4	22.5	-32.9
2	0.244	49.0	42.4	-19.6	21.1	-30.9
3	0.280	45.3	39.3	-21.5	14.3	-36.5
4	0.281	45.1	39.3	-21.5	14.0	-36.8
5	0.283	44.9	38.9	-21.8	12.7	-38.0
6	0.314	44.3	40.9	-19.0	25.4	-24.5
7	0.423	37.6	31.6	-25.8	8.9	-38.5
8	0.448	37.5	32.7	-24.2	18.4	-28.5
9	0.509	37.3	31.1	-24.9	16.3	-29.7

DC PSU test

Plot refs
11429-1 Cond 2 AC Live 150k-30M Average
11429-1 Cond 2 AC Live 150k-30M Quasi-Peak
11429-1 Cond 2 AC Neutral 150k-30M Average
11429-1 Cond 1 AC Neutral 150k-30M Quasi-Peak

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	6.433	40.8	38.4	-21.6	30.0	-20.0
2	6.921	42.9	38.9	-21.1	29.2	-20.8
3	6.921	42.3	38.8	-21.2	28.5	-21.5
4	7.070	43.4	40.7	-19.3	31.9	-18.1
5	7.400	41.5	38.7	-21.3	29.8	-20.2
6	8.528	45.6	42.6	-17.4	33.6	-16.4
7	18.200	18.5	14.9	-45.1	9.0	-41.0
8	19.144	22.7	19.3	-40.7	12.9	-37.1

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	7.504	44.7	40.1	-19.9	29.7	-20.3
2	7.792	45.6	44.4	-15.6	34.5	-15.5
3	8.350	46.5	43.6	-16.4	34.2	-15.8
4	8.787	43.4	40.2	-19.8	31.7	-18.3
5	17.682	44.3	44.0	-16.0	41.0	-9.0
6	18.003	39.5	39.1	-20.9	35.8	-14.2
7	18.386	20.2	16.1	-43.9	10.0	-40.0
8	19.042	23.0	19.0	-41.0	12.7	-37.3

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

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

These results show that the EUT has PASSED this test.

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

150kHz to 30MHz ±3.6dB.

5.2 Radiated emissions 9 - 150 kHz

NOT APPLICABLE: Lowest frequency generated within the unit is declared as 25MHz.

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 [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 antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was examined in normal use position. Radiated Emissions testing was performed whilst powered from a 110 VAC 60 Hz mains supply. The EUT was operated in TX1, TX2, TX3 and TX4 modes and both 48V DC powered configuration and PoE powered configurations were tested.

5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions. Tests were performed in Test Site M

5.3.4 Test equipment

TMS81, ZSW1, E624, E856, E465

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	20°C
Humidity of test environment	48%
Pressure of test environment	102kPa

Band	57-66 GHz
Power Level	40 dBm
Channel Spacing	2.16 MHz
Mod Scheme	DBPSK
Single channel	Radio 1 58.32 GHz, Radio 2 60.48 GHz, Radio 3 62.64 GHz, Radio 4 64.8 GHz

PoE powered

Plot refs
11429-1 Rad 1 150k-30MHz Para
11429-1 Rad 1 150k-30MHz Perp

No emissions observed within 20dB of limits.

DC powered

Plot refs
11429-1 Rad 2 150k-30MHz Para
11429-1 Rad 2 150k-30MHz Perp

No emissions observed within 20dB of limits.

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

LIMITS:

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

n.b. 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 15.255(d)(2) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.3 & 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.255(d)(2) [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 examined in its normal use position. In a pre-test the EUT was assessed both whilst powered from a DC bench power supply and then from a PoE adapter. Worst-case emissions were observed whilst powered from the DC bench power supply and therefore this configuration was used for full test. The EUT was operated in TX1, TX2, TX3 and TX4 modes.

5.4.3 Test procedure

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

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

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

Tests were performed using Test Site M.

5.4.4 Test equipment

E411, E465, E624, E743, LPE364, NSA-M, ZSW1

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	20°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	57-66 GHz
Power Level	40 dBm
Channel Spacing	2.16 GHz
Mod Scheme	DBPSK
Single channel	Radio 1 58.32 GHz, Radio 2 60.48 GHz, Radio 3 62.64 GHz, Radio 4 64.8 GHz

Plot refs
11429-1 Rad 1 VHF Horiz
11429-1 Rad 1 VHF Vert
11429-1 Rad 1 UHF Horiz
11429-1 Rad 1 UHF Vert

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	442.688	47.9	44.2	-1.8
2	499.691	42.1	36.9	-9.1

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	37.062	36.7	35.3	-4.7
2	90.631	33.5	29.3	-14.2
3	100.466	35.6	32.1	-11.4
4	445.057	44.5	40.8	-5.2
5	451.077	44.3	40.5	-5.5
6	480.625	43.7	39.9	-6.1
7	496.309	44.1	40.4	-5.6
8	510.374	43.4	39.1	-6.9

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.
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 15.255(d)(2)/(3)/(4) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.3 & 6.6 & 9.8 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.255(d)(2)/(3)/(4) [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 examined in its normal use position. In a pre-test the EUT was assessed both whilst powered from the PoE adapter and then from a DC bench power supply. Worst-case emissions were observed whilst powered from the PoE adapter and therefore this configuration was used for full test. The EUT was operated in TX1, TX2, TX3 and TX4 modes.

5.5.3 Test procedure

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

Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. Horn antennas were used at heights where the whole of the EUT was contained within the main beam. The EUT was rotated through 360 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 - 18GHz, 0.3m was used in the test range 18 – 40 GHz.

Above 12.5 GHz, a volumetric measurement was performed over the entire EUT and therefore only a single plot is included for each frequency range as required.

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

Tests were performed using test Site M.

5.5.4 Test equipment

E136, E296-2, E330, E411, E412, E445, E453, E465, E624, E651, E856, E902, E917, E918, E932, TMS78, TMS82, VSWR-M, ZSW1

See Section 9 for more details

5.5.5 Test results

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

Setup Table

Band	57-66 GHz
Power Level	40 dBm
Channel Spacing	2.16 GHz
Mod Scheme	DBPSK
Single channel	Radio 1 58.32 GHz, Radio 2 60.48 GHz, Radio 3 62.64 GHz, Radio 4 64.8 GHz

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
1562.487	43.3	-30.7	36.1	-17.9	Upright	Horizontal
1562.488	44.5	-29.5	38.2	-15.8	Upright	Vertical
2474.992	44.9	-29.1	40.1	-13.9	Upright	Horizontal
2474.992	47.1	-26.9	43.9	-10.1	Upright	Vertical
2499.992	46.6	-27.4	41.8	-12.2	Upright	Horizontal
2499.992	45.7	-28.3	40.4	-13.6	Upright	Vertical
4999.982	45.7	-28.3	38.0	-16.0	Upright	Vertical
4999.983	47.3	-26.7	40.7	-13.3	Upright	Horizontal
5624.959	46.1	-27.9	37.0	-17.0	Upright	Vertical
10312.466	43.3	-30.7	37.1	-16.9	Upright	Horizontal
10312.466	42.4	-31.6	35.2	-18.8	Upright	Vertical
20625	46.8	-27.2	44.4	-9.6	Side	Horizontal
20625	46.8	-27.2	44.4	-9.6	Side	Vertical

Plots
11429-1 Rad 1 1-2GHz Horiz
11429-1 Rad 1 1-2GHz Vert
11429-1 Rad 1 2-5GHz Horiz
11429-1 Rad 1 2-5GHz Vert
11429-1 Rad 1 5-6GHz Horiz
11429-1 Rad 1 5-6GHz Vert
11429-1 Rad 1 6upto10GHz Horiz
11429-1 Rad 1 6upto10GHz Vert
11429-1 Rad 1 10upto12_5GHz Horiz
11429-1 Rad 1 10upto12_5GHz Vert
11429-1 12.5 - 15 GHz H_V
11429-1 15 - 18 GHz H_V
11429-1 18 - 21 GHz H_V
11429-1 21 - 24 GHz H_V
11429-1 24 - 26.5 GHz H_V
11429-1 26.5 - 30 GHz H_V
11429-1 30 - 34 GHz H_V
11429-1 34 - 38 GHz H_V
11429-1 38 - 40 GHz H_V

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.

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 – 26.5 GHz ±3.9dB, 26.5 – 40 GHz ±3.9dB.

5.6 Frequency stability

NOT TESTED: Not tested at request of applicant.

5.7 Peak & Average EIRP

NOT TESTED: Not tested at request of applicant.

5.8 Peak Conducted Power

NOT APPLICABLE: EUT does not have a conducted RF port.

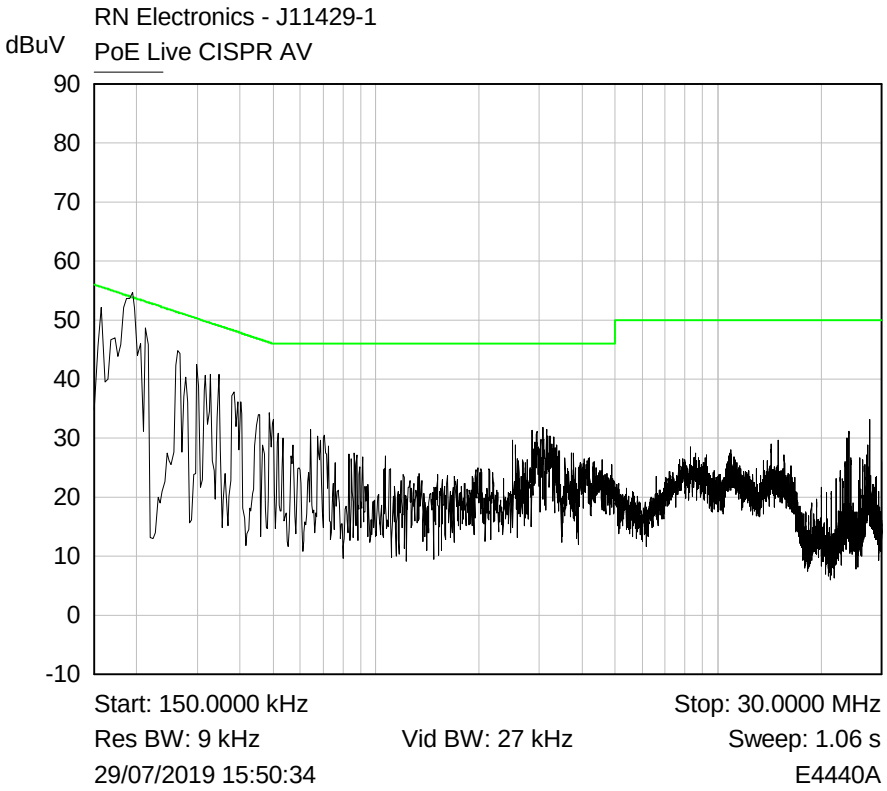
5.9 20dB Occupied bandwidth

NOT TESTED: Not tested at request of applicant.

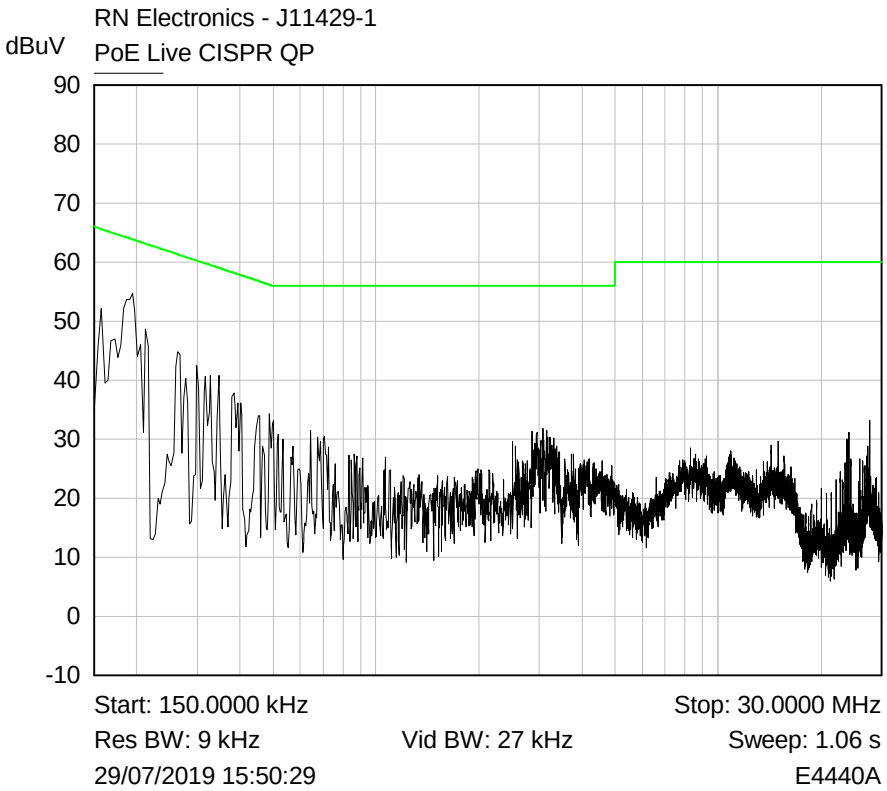
6 Plots/Graphical results

6.1 AC Power line conducted emissions

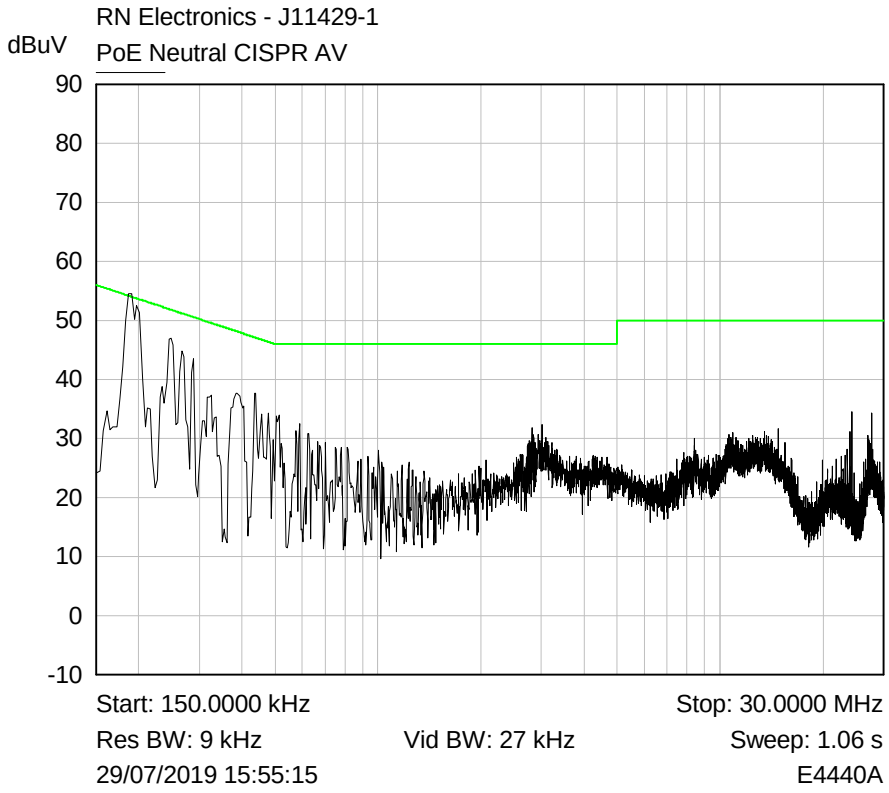
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 GHz, Modulation DBPSK, PoE powered mode



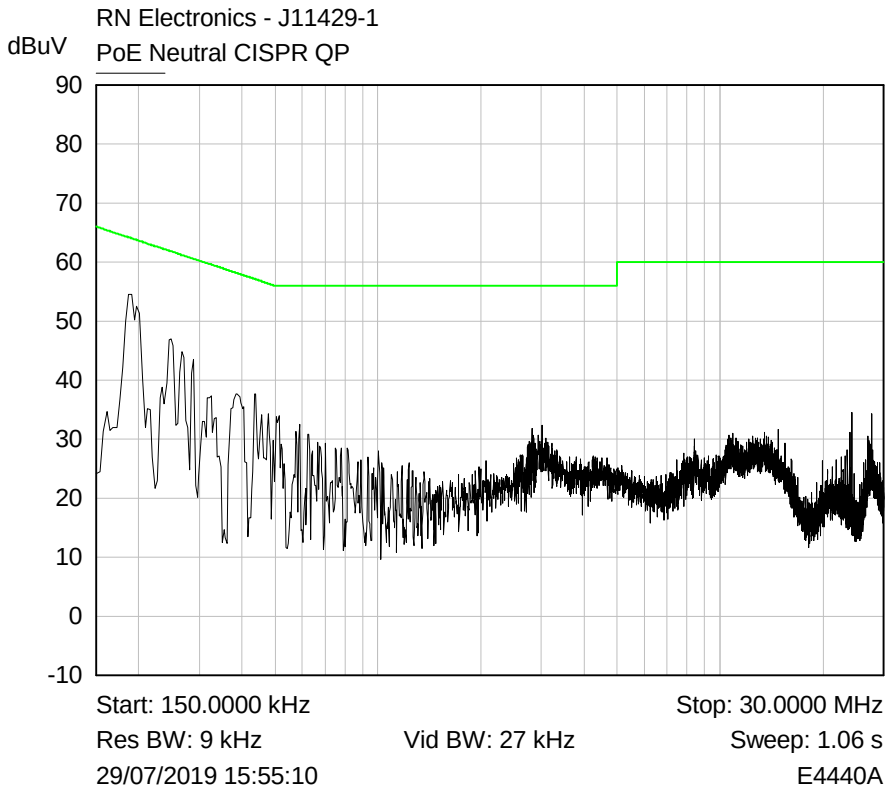
Plot of Peak emissions for Live line 150k – 30MHz against the AV limit line PoE configuration.



Plot of Peak emissions for Live line 150k – 30MHz against the QP limit line PoE configuration.

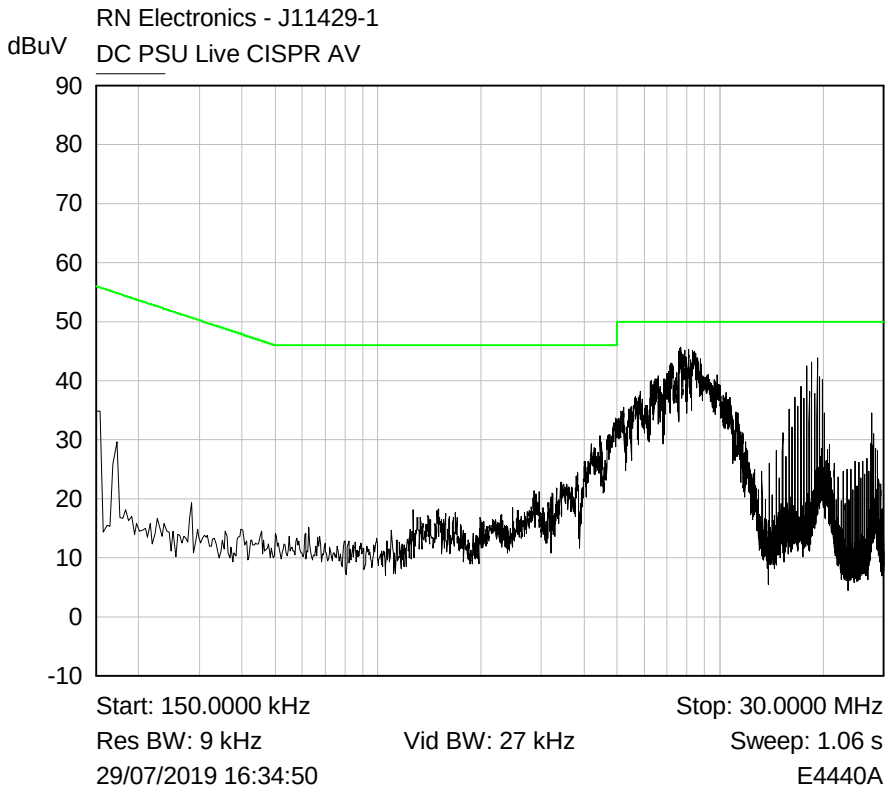


Plot of Peak emissions for Neutral line 150k – 30MHz against the AV limit line PoE configuration.

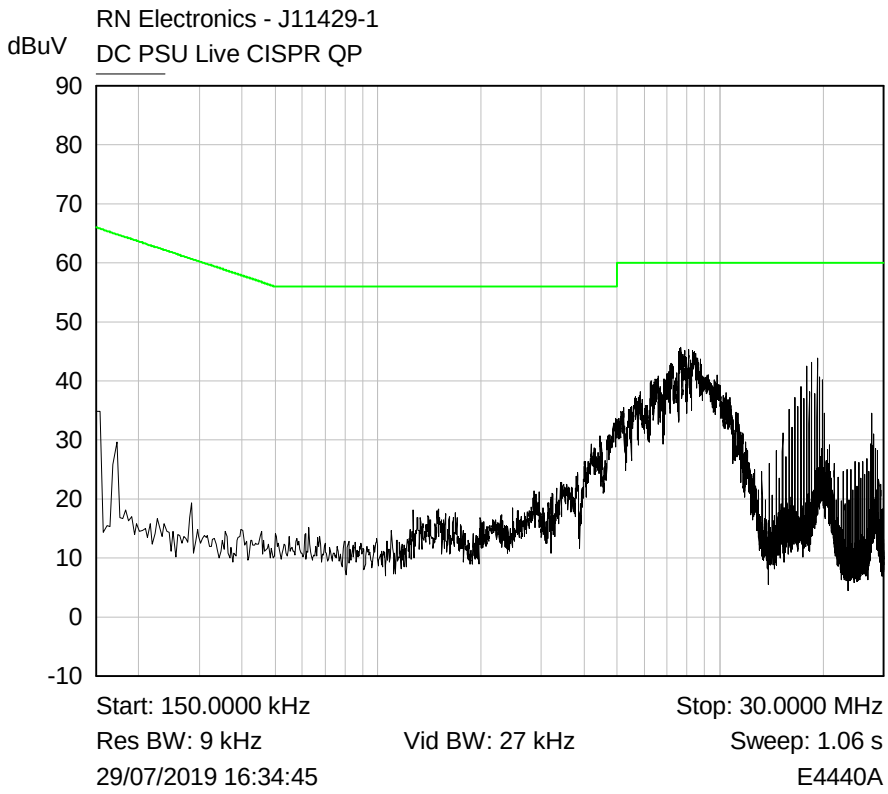


Plot of Peak emissions for Neutral line 150k – 30MHz against the QP limit line PoE configuration.

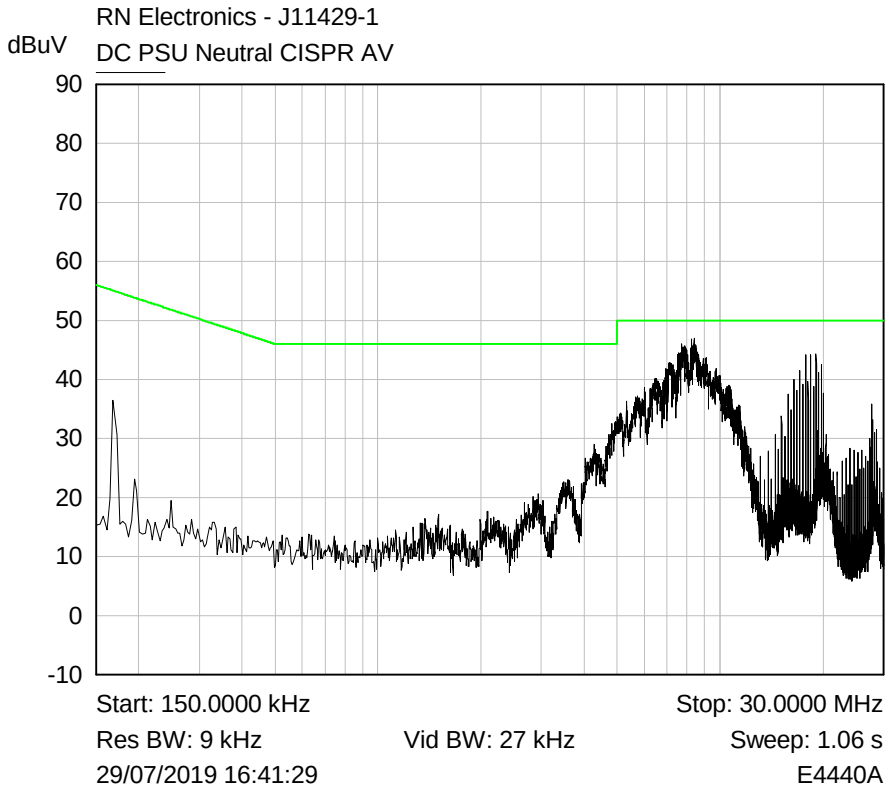
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 GHz, Modulation DBPSK, DC PSU powered mode



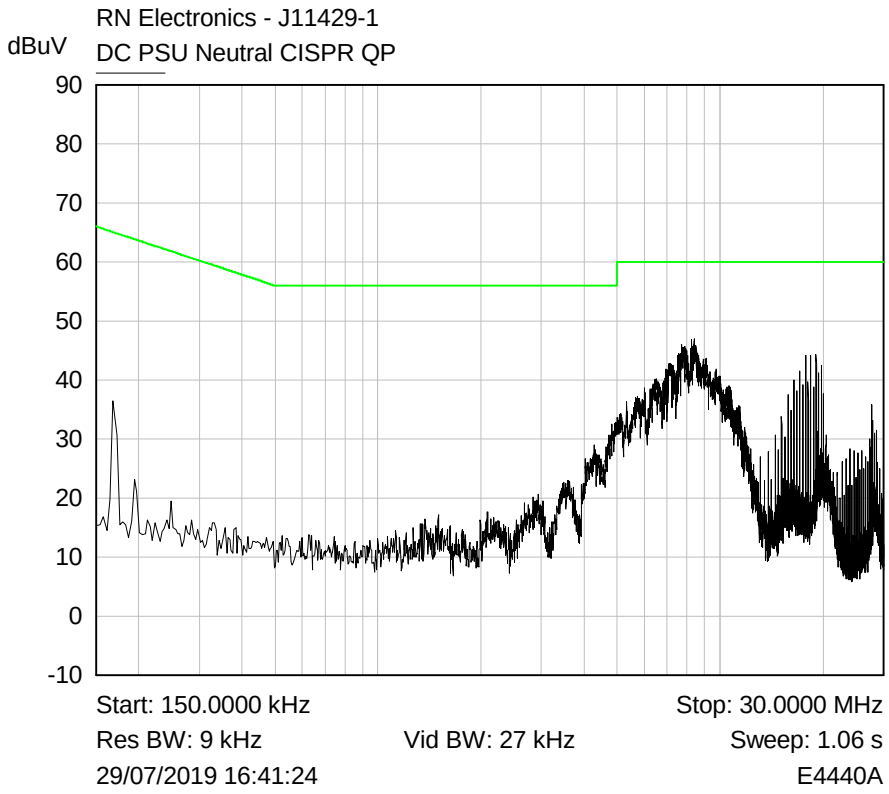
Plot of Peak emissions for Live line 150k – 30MHz against the AV limit line DC PSU configuration.



Plot of Peak emissions for Live line 150k – 30MHz against the QP limit line DC PSU configuration.



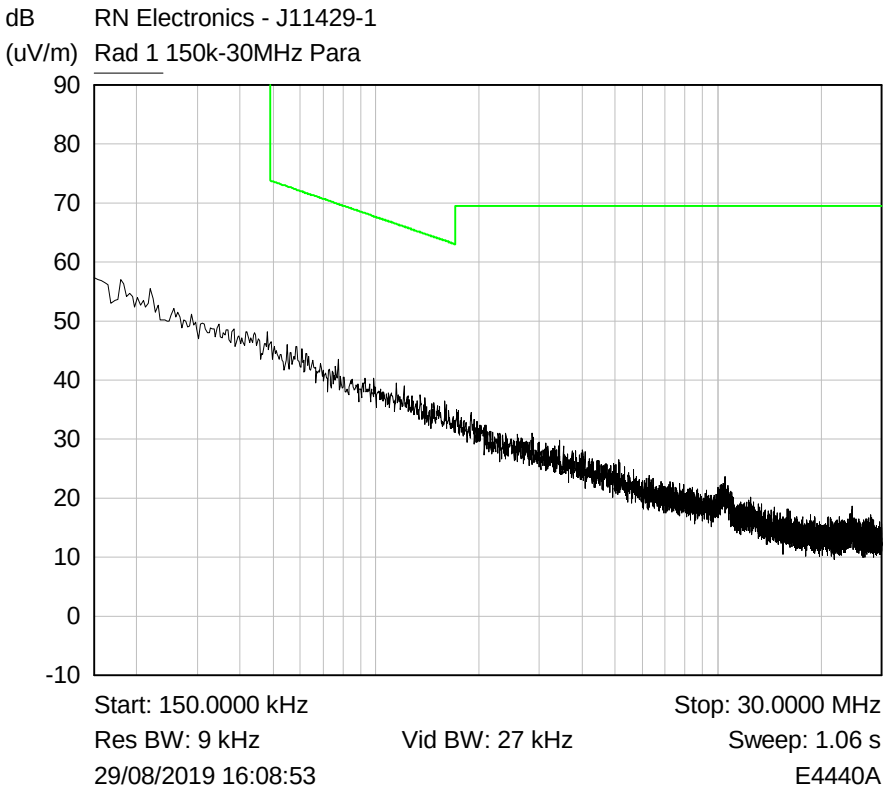
Plot of Peak emissions for Neutral line 150k – 30MHz against the AV limit line DC PSU configuration.



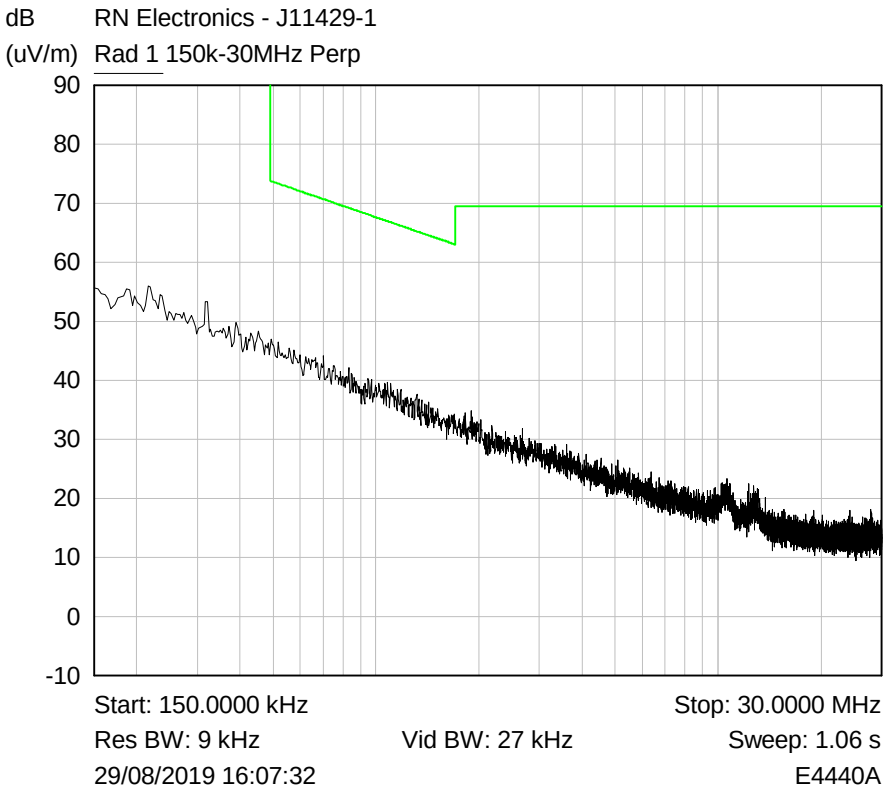
Plot of Peak emissions for Neutral line 150k – 30MHz against the QP limit line DC PSU configuration.

6.2 Radiated emissions 150k - 30 MHz

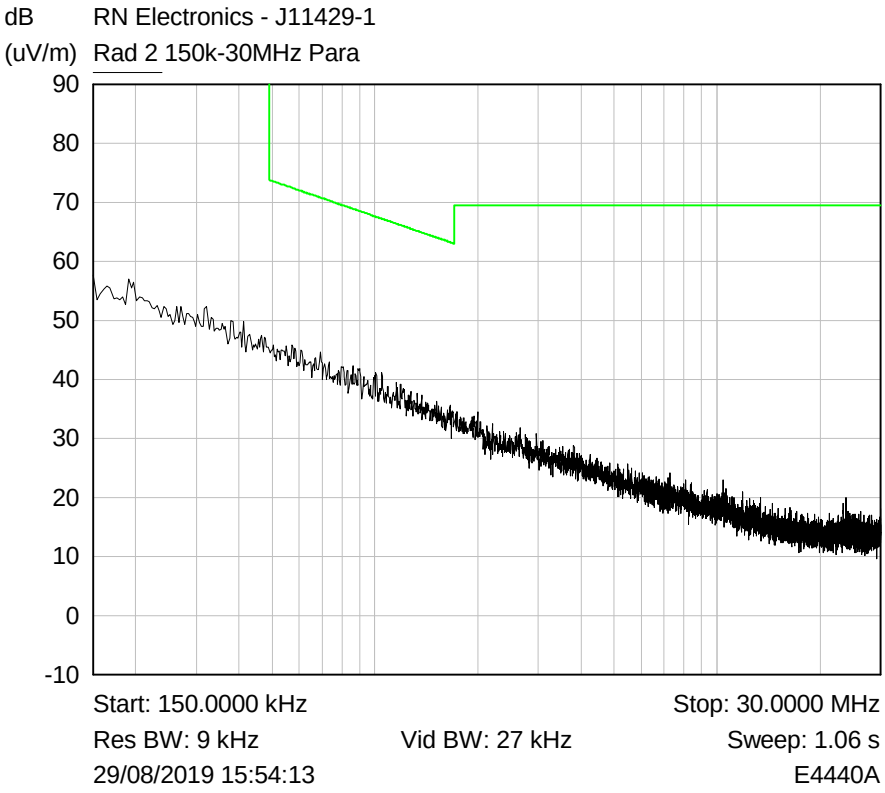
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 GHz, Modulation DBPSK



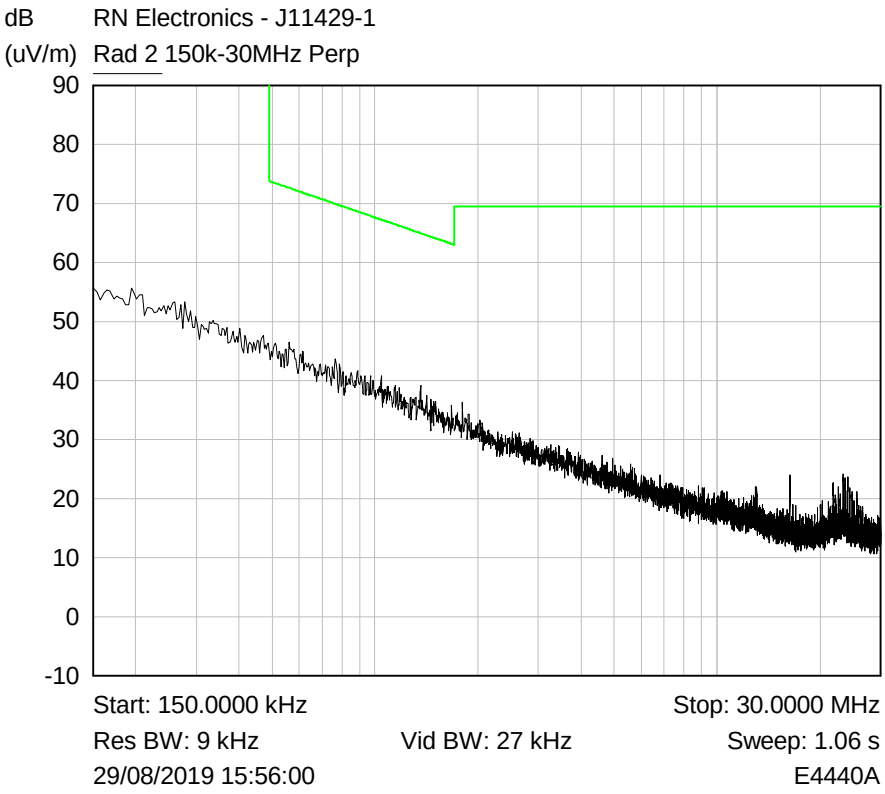
Plot of 150kHz-30MHz Parallel PoE powered



Plot of 150kHz-30MHz Perpendicular PoE powered



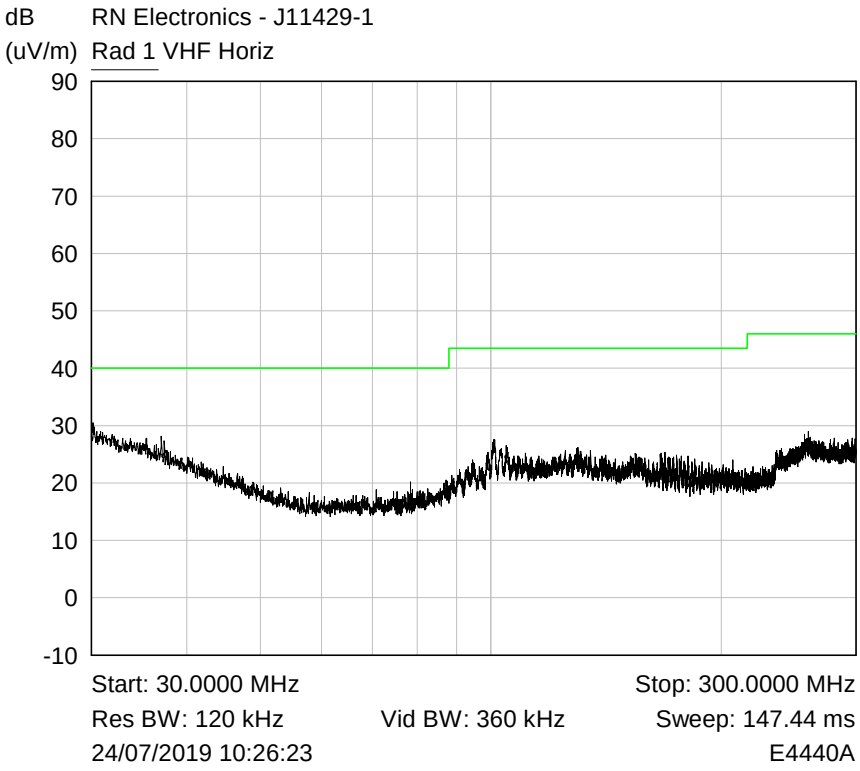
Plot of 150kHz-30MHz Parallel DC powered



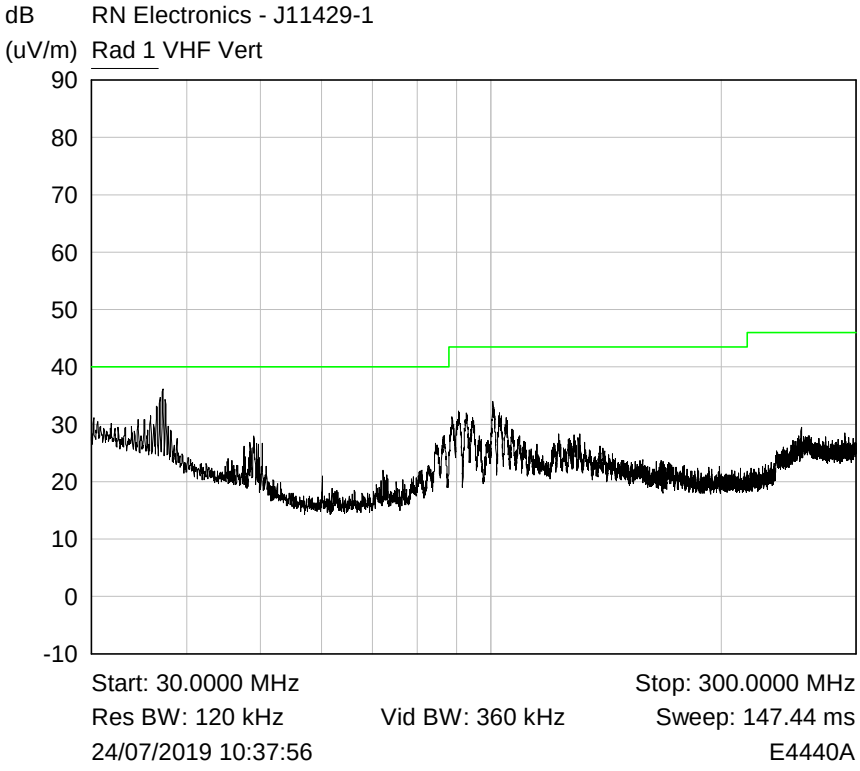
Plot of 150kHz-30MHz Perpendicular DC powered

6.3 Radiated emissions 30 MHz -1 GHz

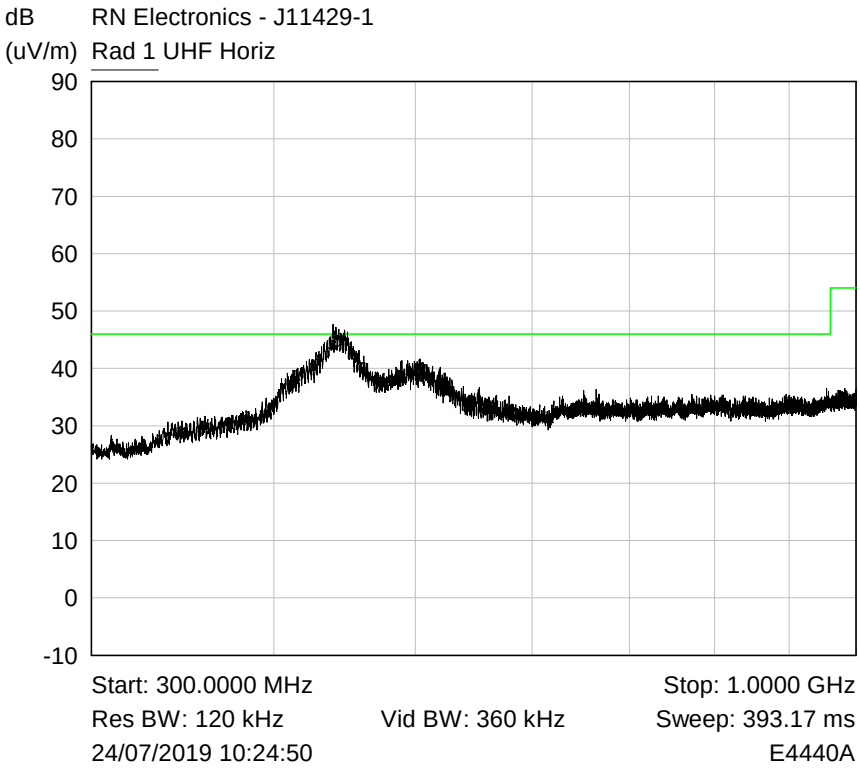
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 GHz, Modulation DBPSK



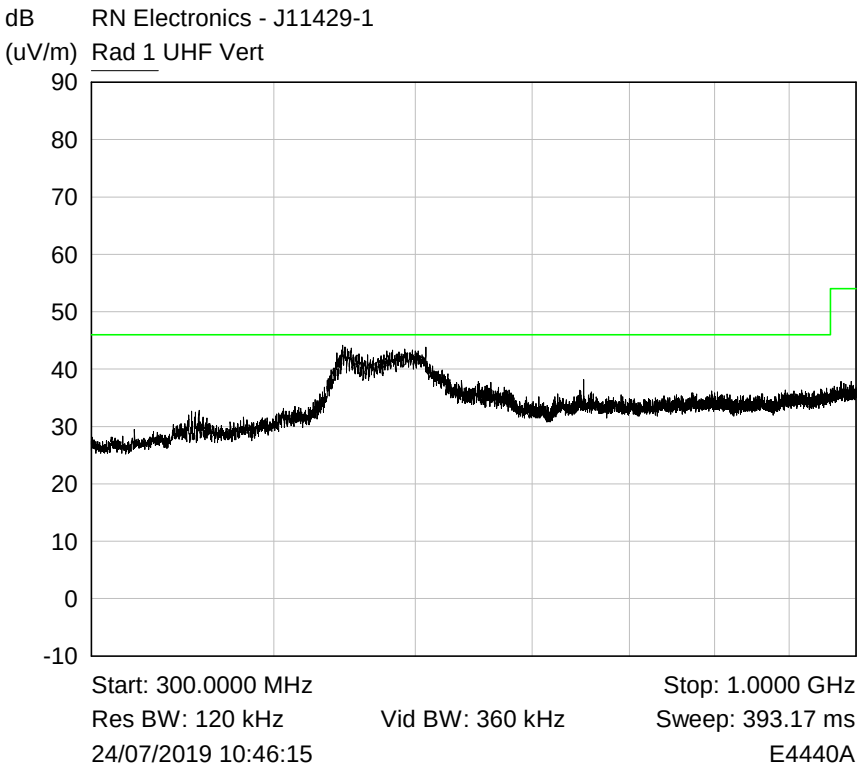
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



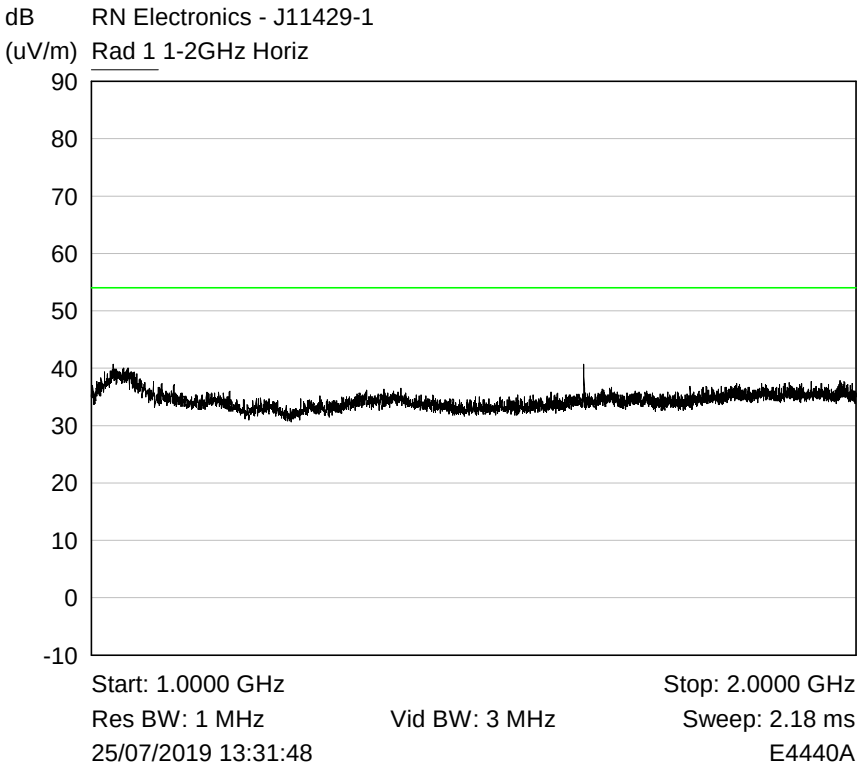
Plot of Peak emissions for UHF Horizontal against the QP limit line.



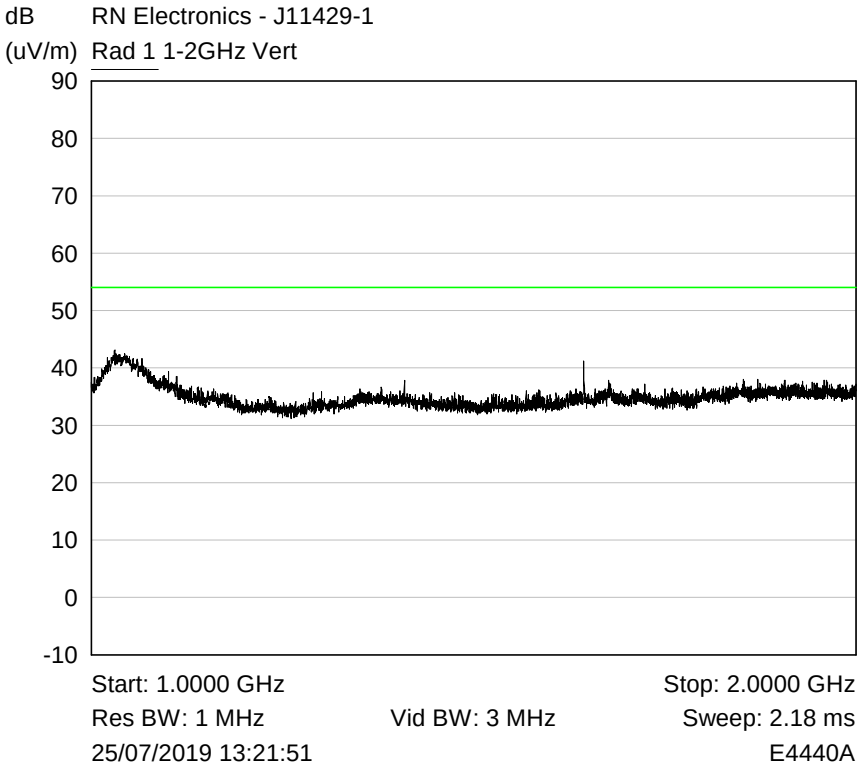
Plot of Peak emissions for UHF Vertical against the QP limit line.

6.4 Radiated emissions above 1 GHz

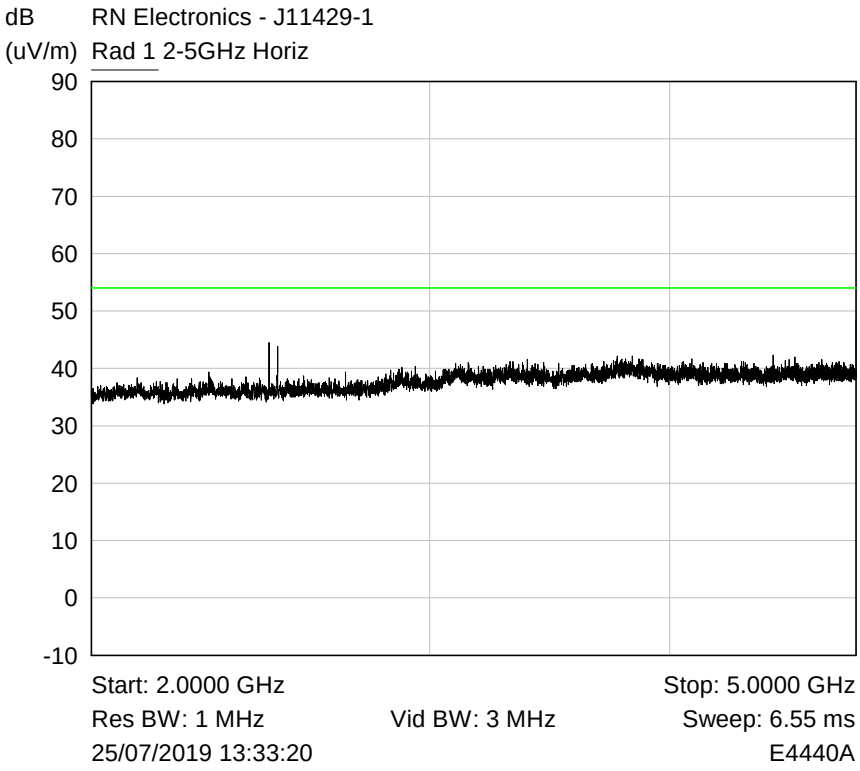
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 GHz, Modulation DBPSK



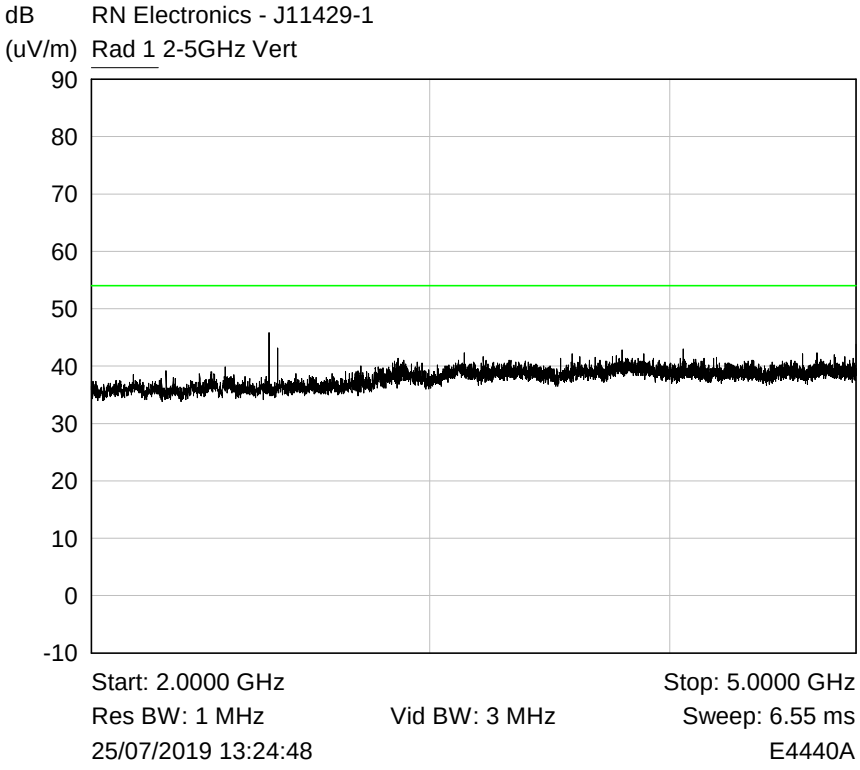
Peak Horizontal emissions 1– 2 GHz against the average limit line



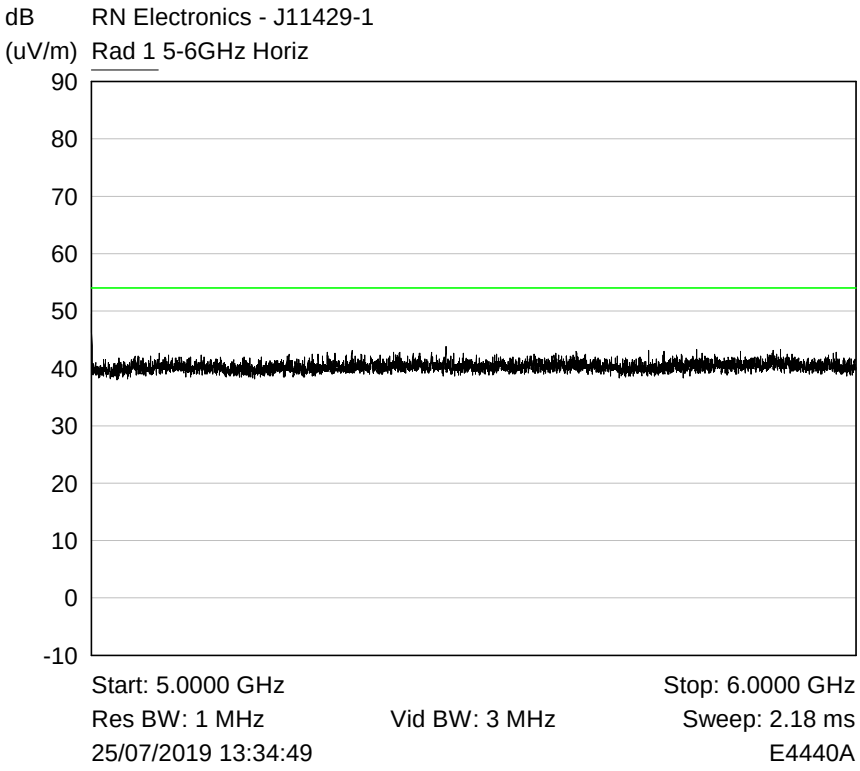
Peak Vertical emissions 1– 2 GHz against the average limit line



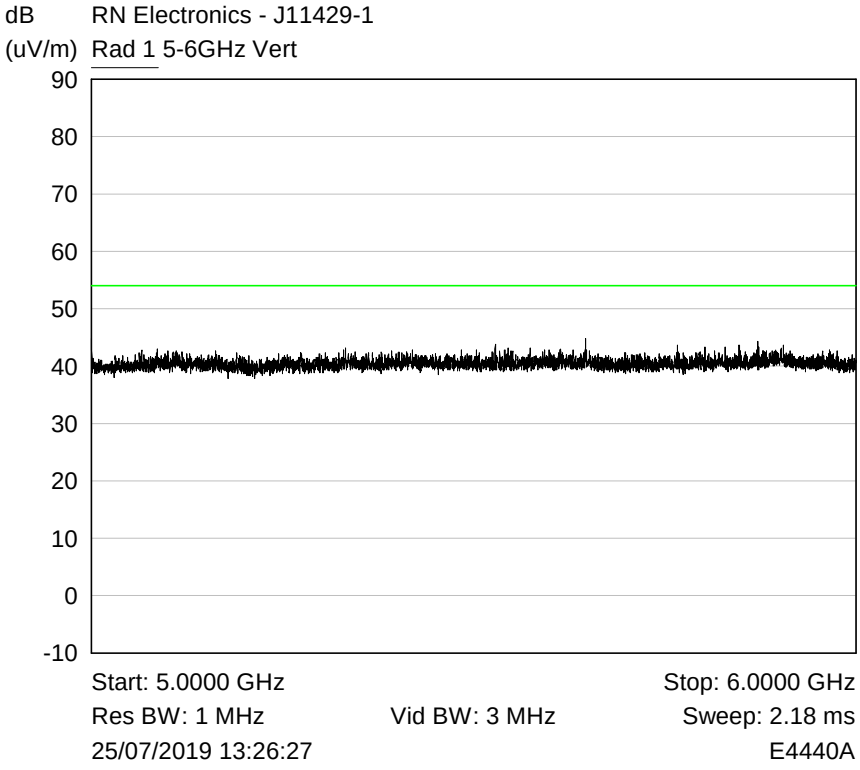
Peak Horizontal emissions 2– 5 GHz against the average limit line



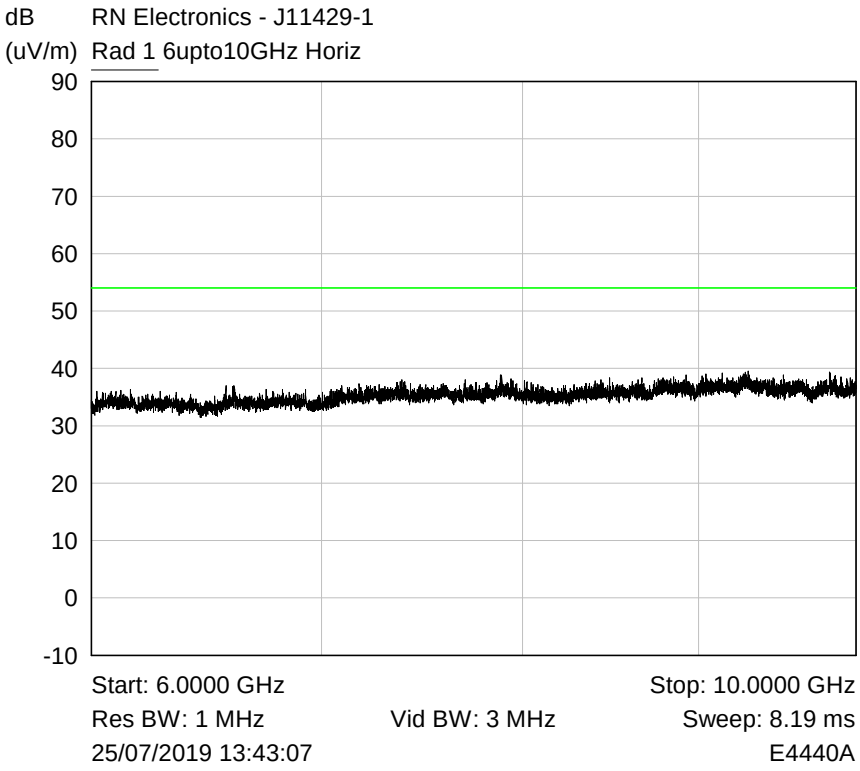
Peak Vertical emissions 2– 5 GHz against the average limit line



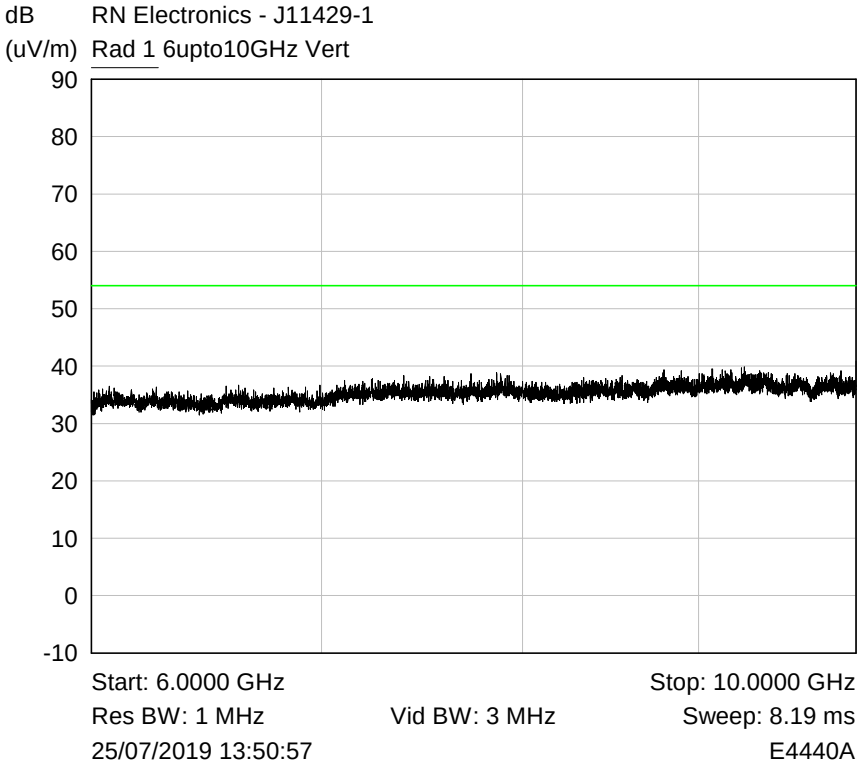
Peak Horizontal emissions 5– 6 GHz against the average limit line



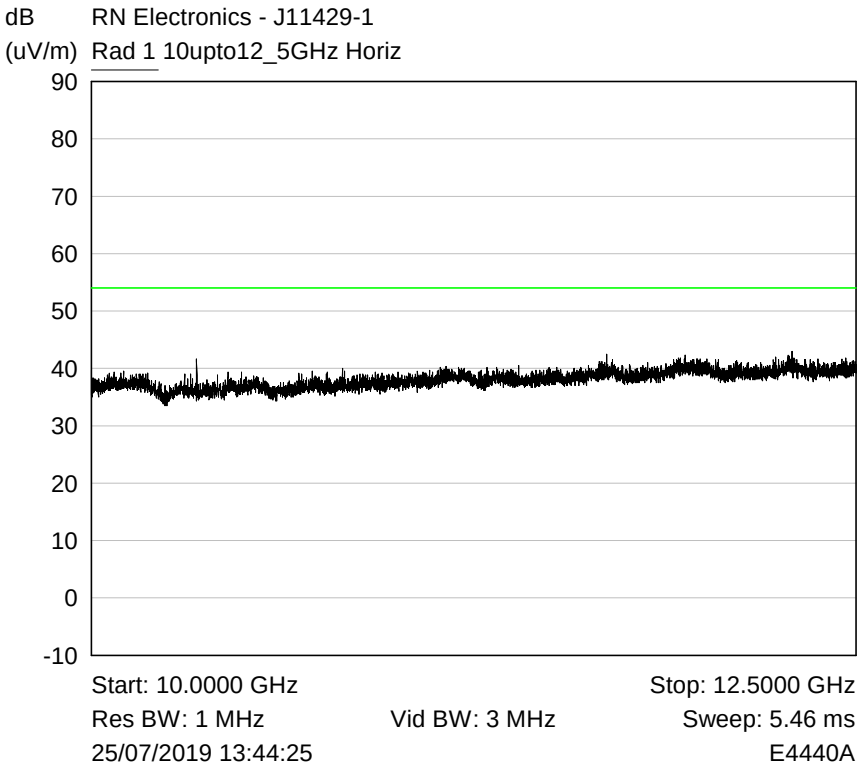
Peak Vertical emissions 5– 6 GHz against the average limit line



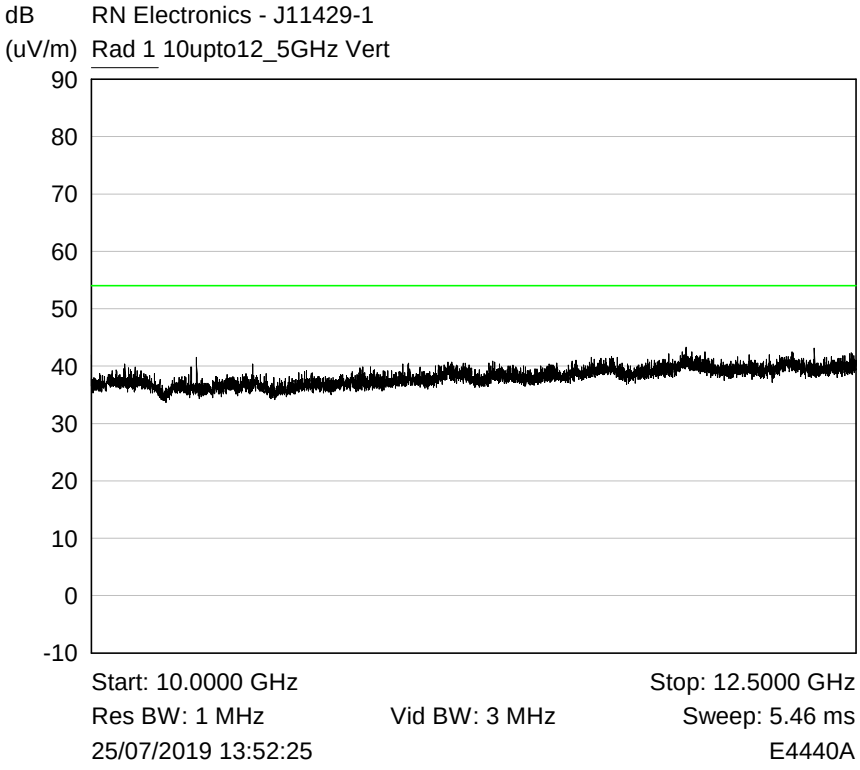
Peak Horizontal emissions 6– 10 GHz against the average limit line



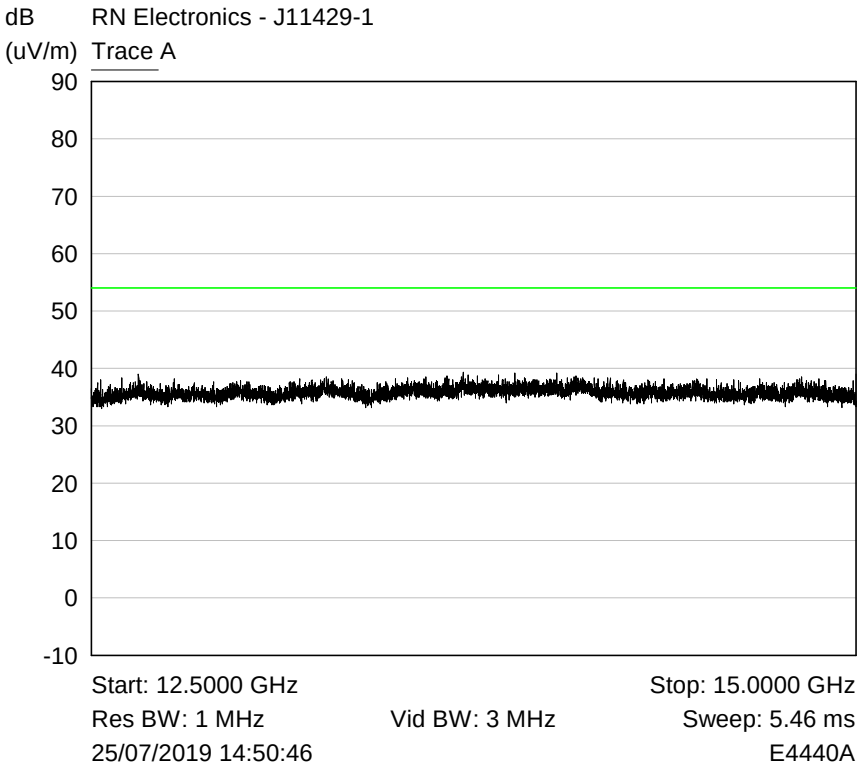
Peak Vertical emissions 6– 10 GHz against the average limit line



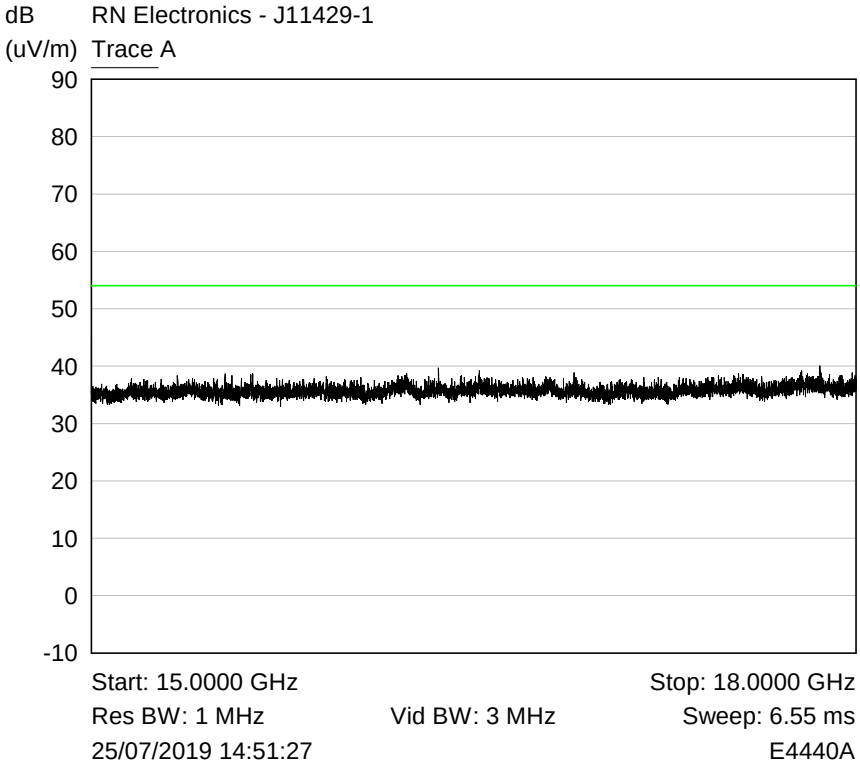
Peak Horizontal emissions 10– 12.5 GHz against the average limit line



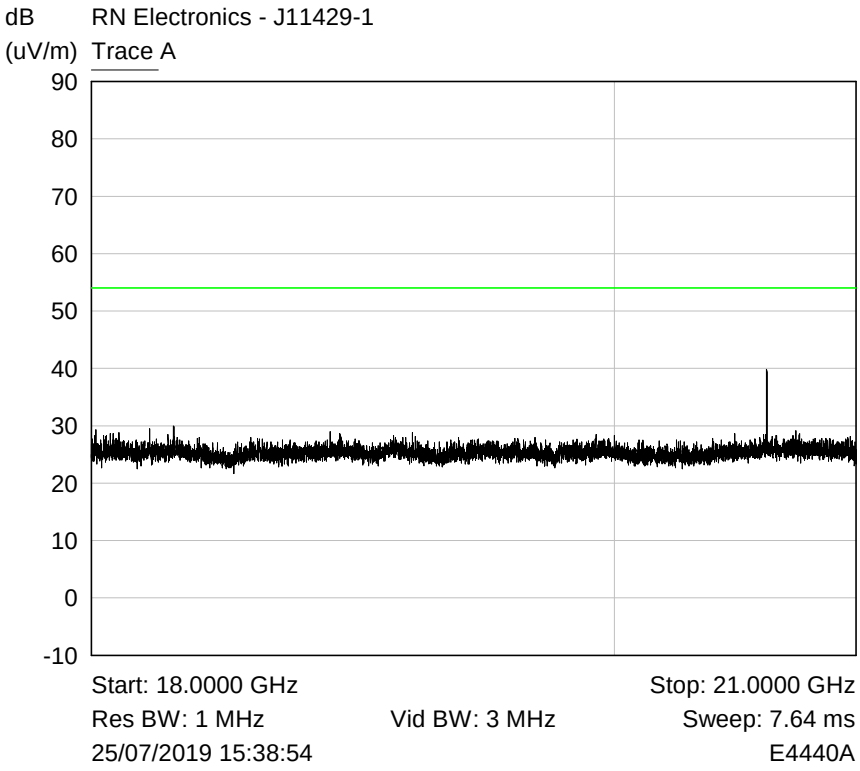
Peak Vertical emissions 10– 12.5 GHz against the average limit line



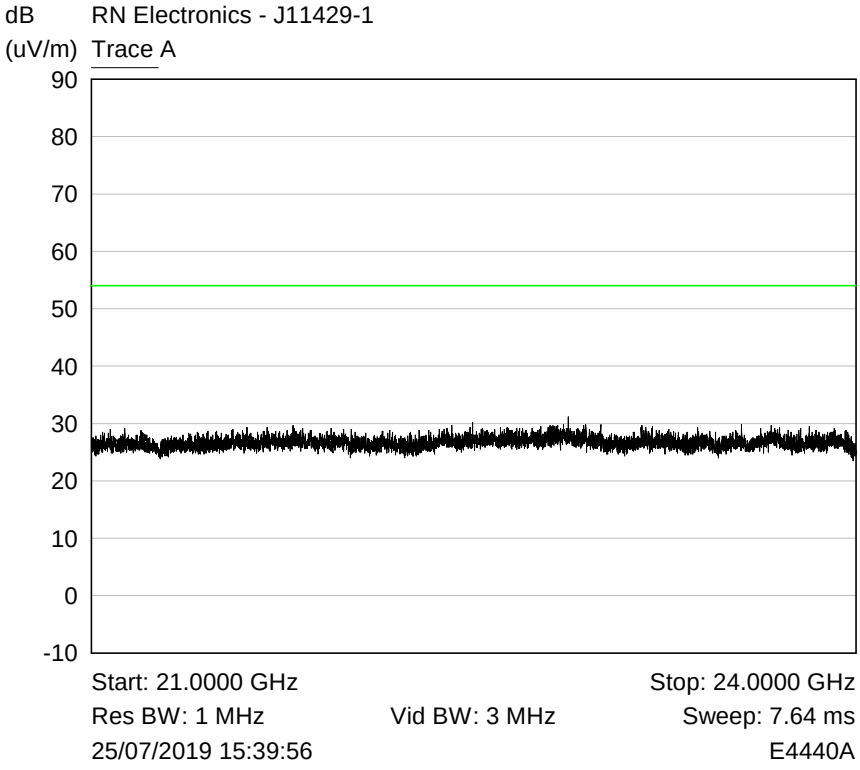
Peak Vertical and Horizontal emissions 12.5– 15 GHz against the average limit line



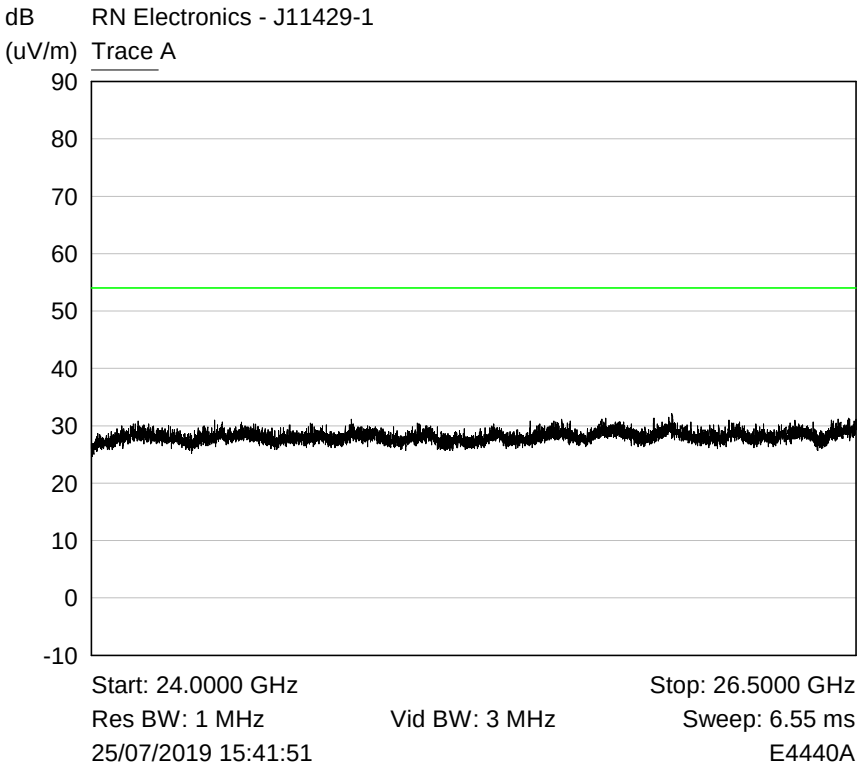
Peak Vertical and Horizontal emissions 15– 18 GHz against the average limit line



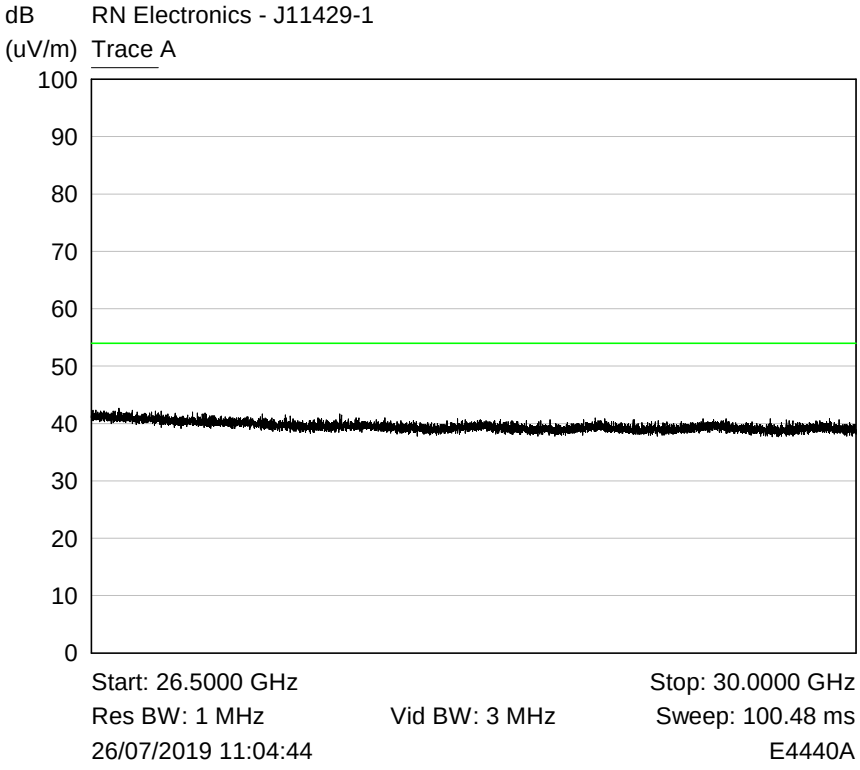
Peak Vertical and Horizontal emissions 18– 21 GHz against the average limit line



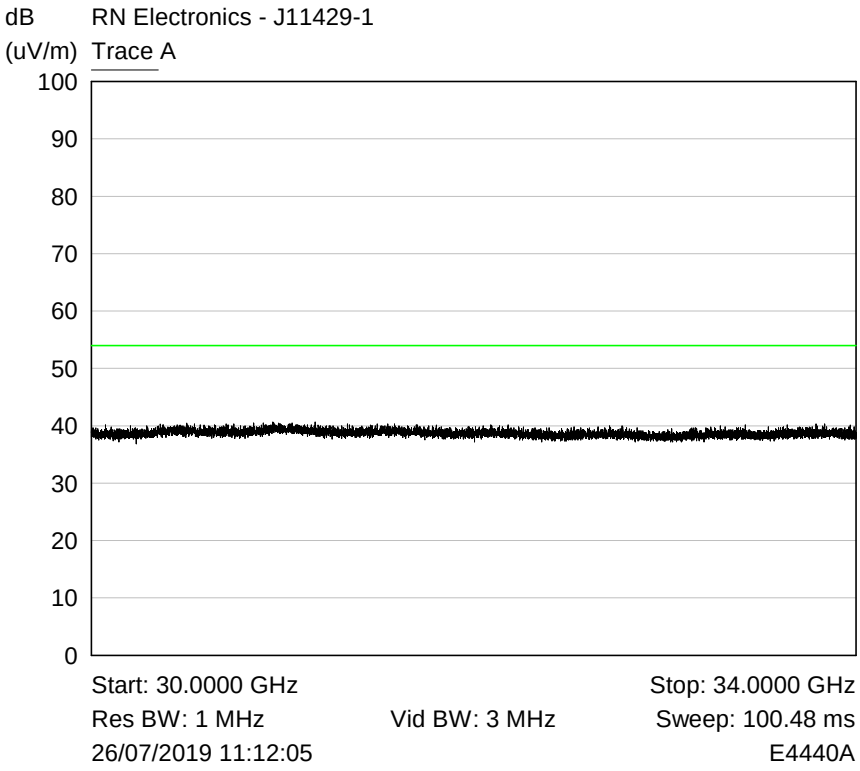
Peak Vertical and Horizontal emissions 21– 24 GHz against the average limit line



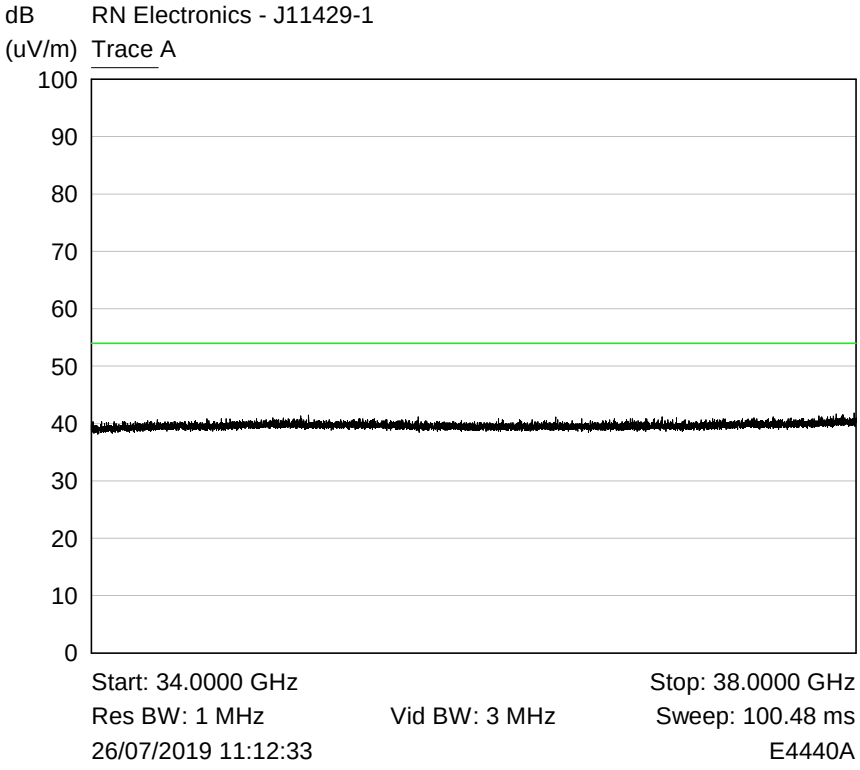
Peak Vertical and Horizontal emissions 24– 26.5 GHz against the average limit line



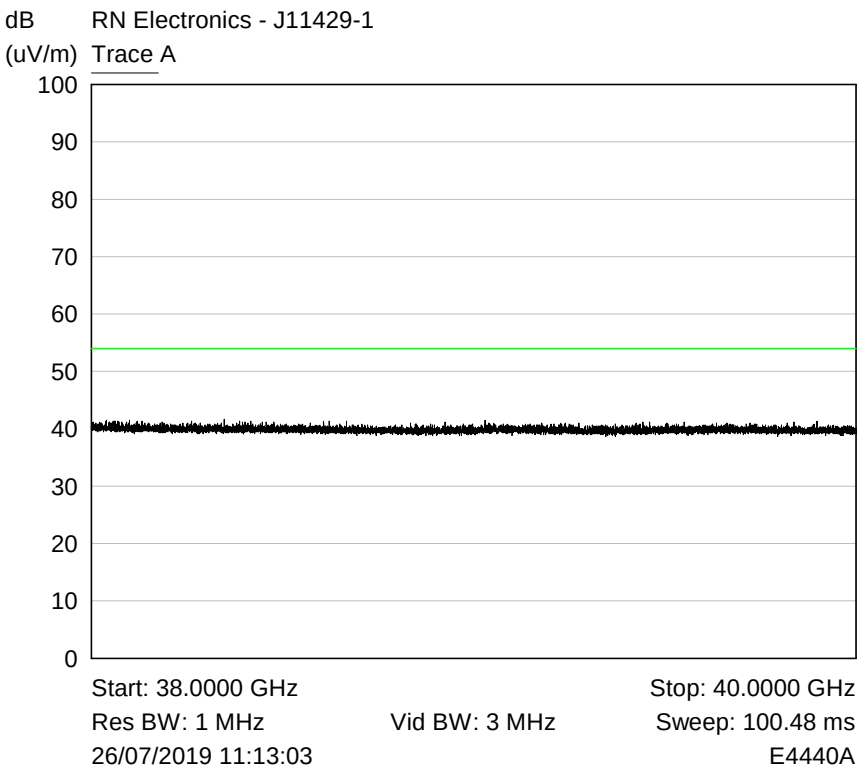
Peak Vertical and Horizontal emissions 26.5– 30 GHz against the average limit line



Peak Vertical and Horizontal emissions 30– 34 GHz against the average limit line



Peak Vertical and Horizontal emissions 34– 38 GHz against the average limit line



Peak Vertical and Horizontal emissions 38– 40 GHz against the average limit line

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

Additional calculation examples per ANSI C63.10 clause 9.4 – 9.6 equations 21, 22, 25 & 26:

Equation 21: $E_{Linear} = 10^{((E_{log}-120)/20)}$

And therefore equation 21 transposed is: $E_{Log} = 20xLog(E_{Linear}) +120$

Where:

E_{Linear} is the field strength of the emission in V/m

E_{Log} is the field strength of the emissions in dBµV/m

Equation 22: $EIRP = E_{Meas} + 20log(d_{Meas}) -104.7$

Where:

EIRP is equivalent isotropically radiated power in dBm

E_{Meas} is the field strength of the emission at the measurement distance in dBµV/m

d_{Meas} is the measurement distance in metres

Equation 25: $PD = EIRP_{Linear} / 4\pi d^2$

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

Where:

PD is the power density at distance specified by the limit, in W/m^2

$EIRP_{Linear}$ is the equivalent isotropically radiated power in Watts

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

Equation 26: PD = $E^2_{Speclimit}$ / 377
And therefore equation 26 transposed is: $E_{Spec\ limit} = \sqrt{(PD \times 377)}$

Where:
PD is the power density at distance specified by the limit, in W/m^2
$E_{spec\ limit}$ is the field strength at the distance specified by the limit in V/m

Example:

Radiated spurious emissions limit at 3metres of $90pW/cm^{2.}$

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

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

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

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

8 Photographs

8.1 EUT Front View

8.2 EUT Reverse Angle

8.3 EUT Left side View

8.4 EUT Right side View

8.5 EUT Antenna Port

Note: Photos are blacked out due to confidentiality of internal photos.

Shows the EUT's 60 GHz antennas

Shows the EUT's 60 GHz antennas

Photograph shows the EUTs GPS antenna.

8.6 EUT Display & Controls

Photograph shows the EUT's status LED's (highlighted)

8.7 EUT Internal photos

Note: Photos are not included/taken due to confidentiality of internal photos.

8.8 EUT ID Label

No EUT label was available at the time of test.

8.9 AC power line conducted emissions

PoE powered

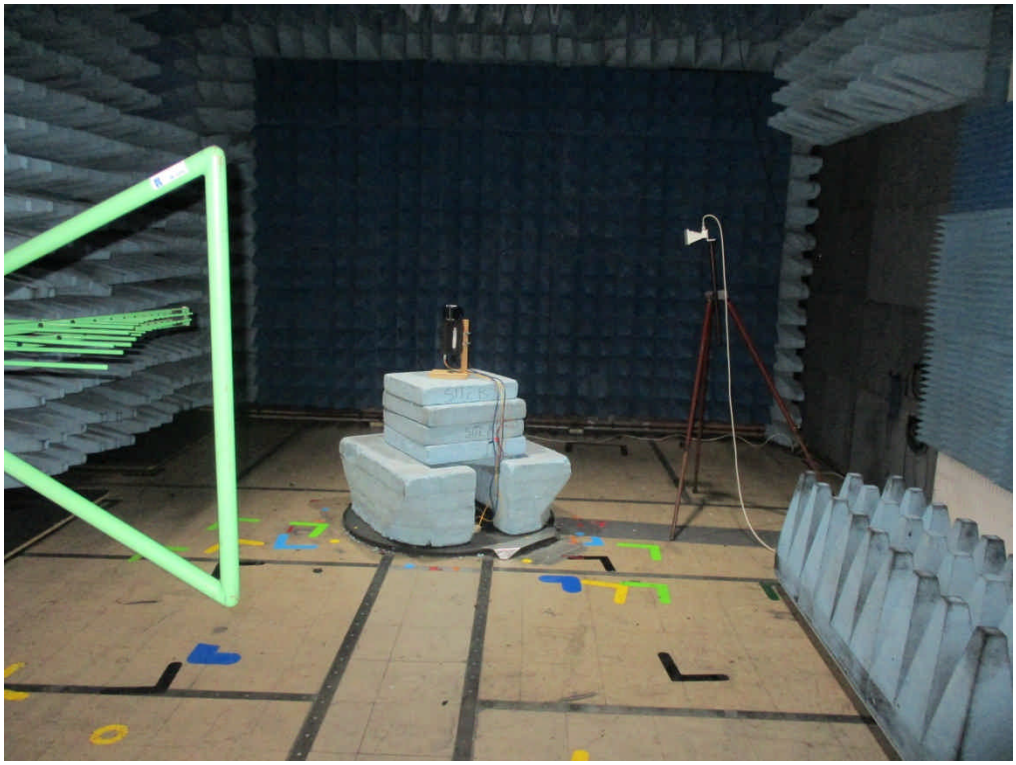
DC PSU powered

8.10 Radiated emissions 150k - 30 MHz

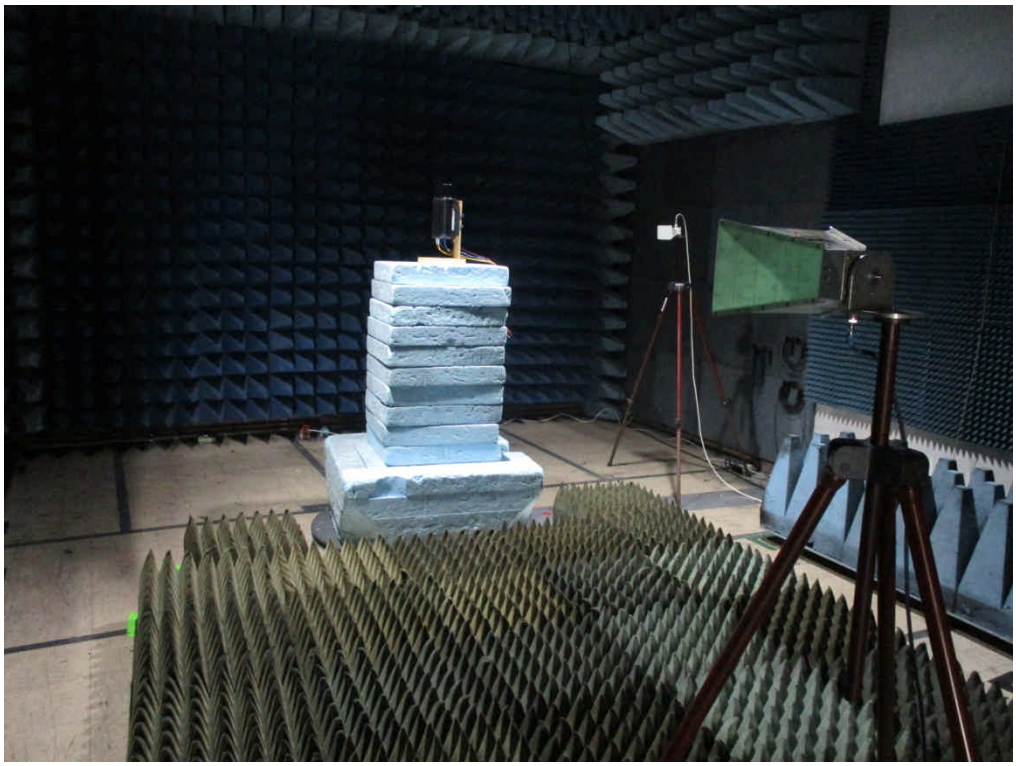
PoE powered

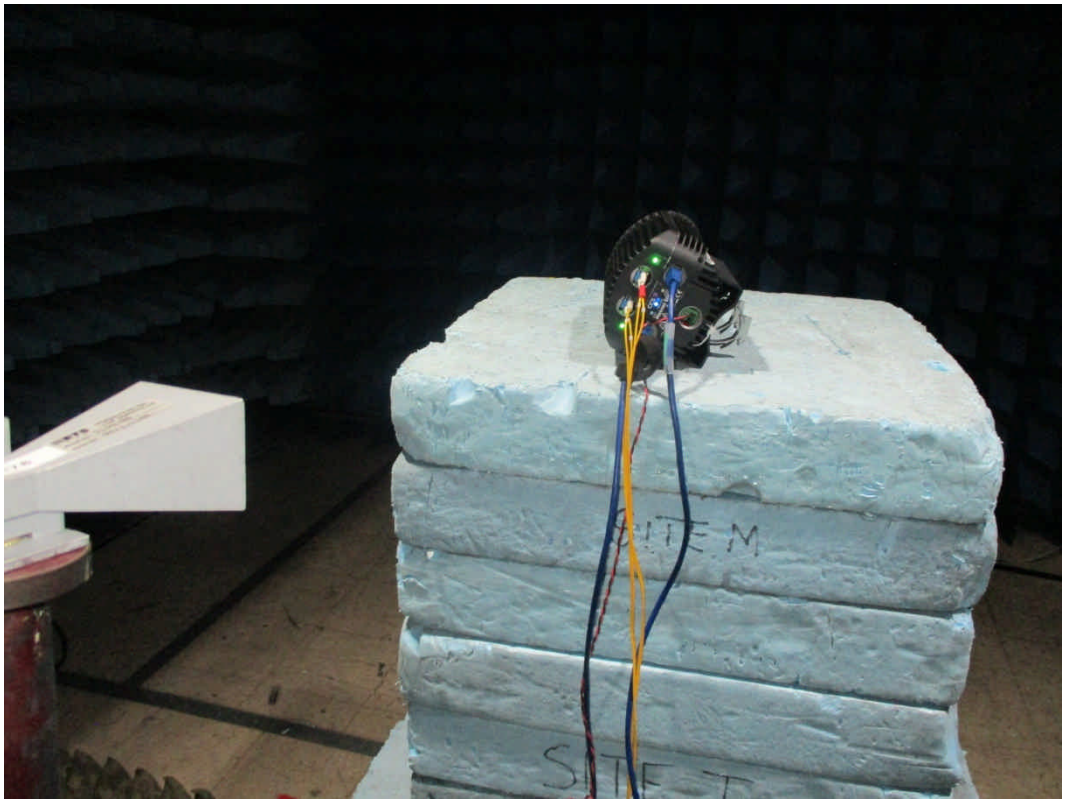
DC PSU powered

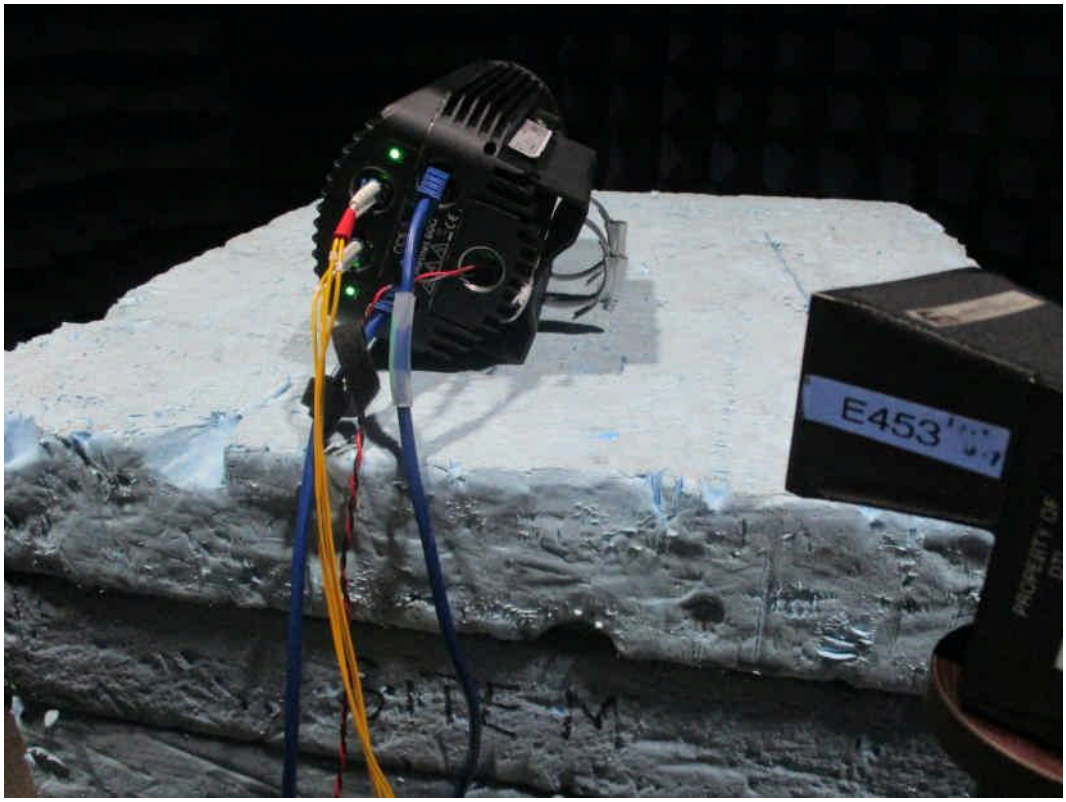
8.11 Radiated emissions 30 MHz -1 GHz



8.12 Radiated emissions above 1 GHz






E453

8.13 Radiated emission diagrams

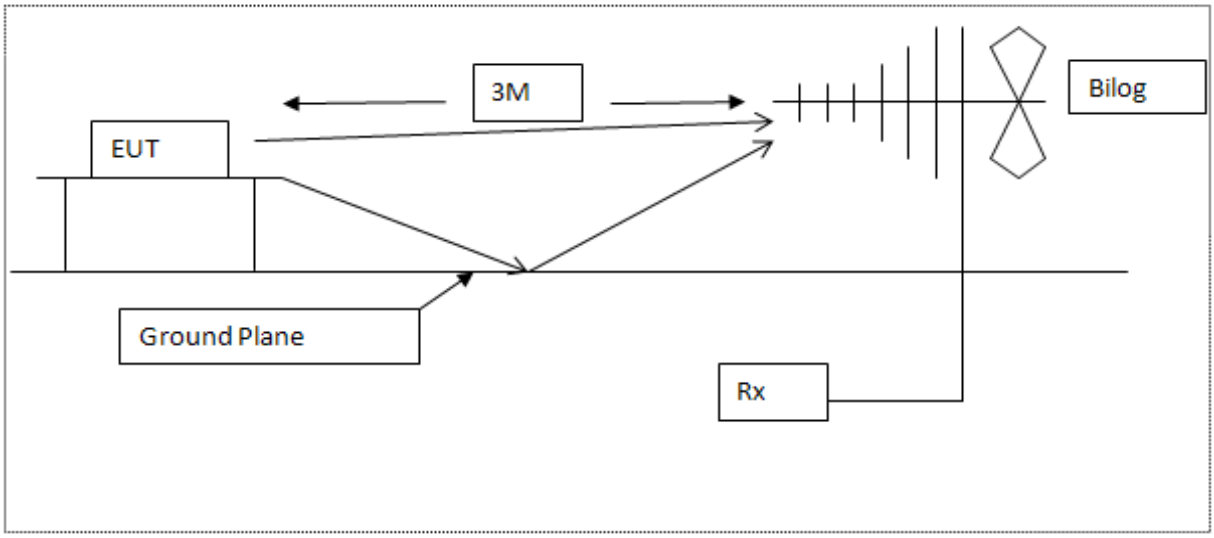


Diagram of the radiated emissions test setup 30 - 1000 MHz

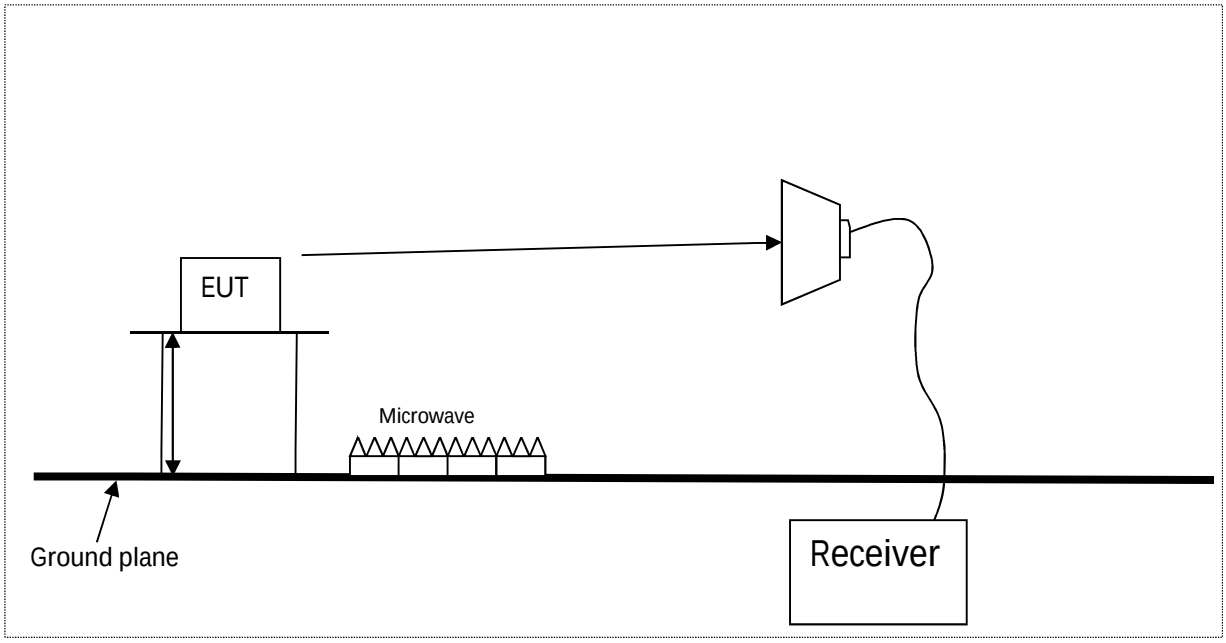


Diagram of the radiated emissions test setup above 1GHz

8.14 AC powerline conducted emission diagram

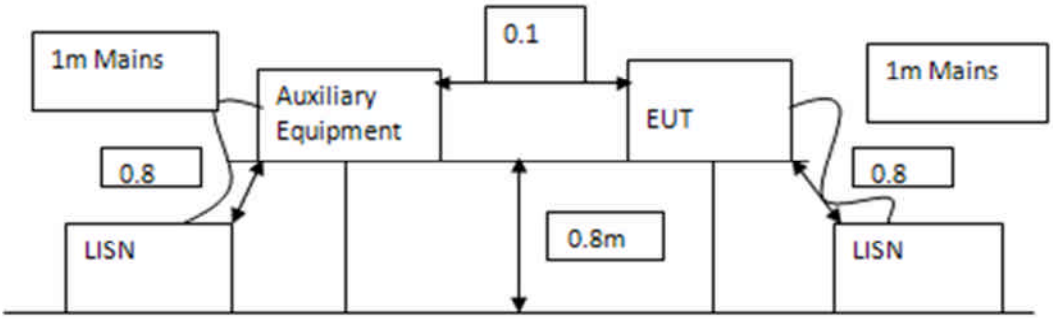


Diagram of the AC conducted emissions test setup

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
E136	3105	Horn Antenna 1-12.5GHz	EMCO	27-Apr-2019	12 months
E296-2	11970A	Harmonic Mixer 26.5-40GHz	Hewlett Packard	03-Jan-2019	12 months
E330	2224-20	Horn Antenna 26.5-40GHz	Flann (FMI)	24-Apr-2019	12 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	11-Jul-2019	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	17-Jul-2018	24 months
E445	MFR64639	Cable SMA - SMA Green Microwave 5.1m	Utiflex Micro Coax	20-Jun-2019	12 months
E453	20240-20-AA	Horn Std Gain 17.6 - 26.7GHz	Flann (FMI)	29-May-2019	12 months
E465	PCR2000LA	AC Power Source 2kVA	Kikusui	15-Jul-2019	12 months
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	09-Jan-2018	24 months
E651	MWX221	Cable N Type to SMA Blue 2m	Junflon	20-Jun-2019	12 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	11-Feb-2019	12 months
E856	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	01-May-2019	12 months
E902	MWX221	Cable SMA (m) to SMA (m) 2m Blue	Junflon	20-Jun-2019	12 months
E917	C-SPSP-1801-1M	Cable SMA SMA 1m Yellow	Intelliconnect	01-Apr-2019	12 months
E918	C-SPSP-1801-1M	Cable SMA SMA 1m Yellow	Intelliconnect	01-Apr-2019	12 months
E932	N5181A	Signal Generator 100kHz to 6GHz	Agilent Technologies	05-Jun-2019	12 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	21-Mar-2018	24 months
NSA-M	NSA - M	NSA - Site M	RN Electronics	09-Jan-2019	36 months
TMS78	3160-08	Horn Std Gain 12.4-18 GHz	ETS Systems	24-Jul-2019	12 months
TMS82	8449B	Pre-Amplifier 1GHz - 26.5GHz	Agilent Technologies	17-Dec-2018	12 months
VSWR-M	VSWR	VSWR 1-18GHz	RN Electronics	09-Jan-2019	36 months
ZSW1	V2.3	Measurement Software Suite	RN Electronics	Not applicable	

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	ThinkPad	Laptop PC	Lenovo	Not stated
2	GS108E	Network switch	Netgear	3UH2565T00841
3	POE60U-1BT	PoE adapter	PHIPONG	P17390053A1

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
E465	PCR2000LA	AC Power Source 2kVA	Kikusui	HJ000995
P168	LT30-2	PSu 30V 2A	Farnell	-

11 Condition of the equipment tested

In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

11.1 Modifications before test

No modifications were made before test by RN Electronics Ltd.

11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 293246
IC Registration No. 5612A-4

Site C Transient Laboratory

Site D Screened Room (Conducted Immunity)

Site E Screened Room (Control Room for Site D)

Site F Screened Room (Conducted Emissions)

Site G Screened Room (Control Room for Site H)

Site H 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246
IC Registration No. 5612A-2

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246
IC Registration No. 5612A-3

Site N Radio Laboratory

Site Q Fully-Anechoic Chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246
IC Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

13 Abbreviations and units

%	Percent
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