



2360

Radio Test Report

Cambridge Communication Systems Ltd

Metnet 60G

G60US040000

47 CFR Part 15.255 Effective Date 1st October 2018
DXX: Part 15 Low Power Communication Device Transmitter
Test Date: 23rd July 2019 to 31st July 2019
Report Number: 07-11564-1-19 Issue 01

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Certificate of Test 11564-1

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:	G60US040000
Unique Serial Number:	0000095
Applicant:	Cambridge Communication Systems Ltd Victory House, Chivers Way Histon, Cambridge CB24 9ZR
Full measurement results are detailed in Report Number:	07-11564-1-19 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:	23rd July 2019 to 31st July 2019
Test Engineer:	<input type="text"/>
Approved By: Radio Approvals Manager	<input type="text"/>
Customer Representative:	<input type="text"/>



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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	Jabil Malaysia	
Full Name of EUT	Metnet 60G	
Model Number of EUT	G60US040000	
Serial Number of EUT	0000095	
Date Received	3rd June 2019	
Date of Test:	23rd 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	21st 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	100-240V AC
	Current	1.2 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Mounted on lamppost
Choice of model(s) for type tests	Prototype 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	mmWave 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

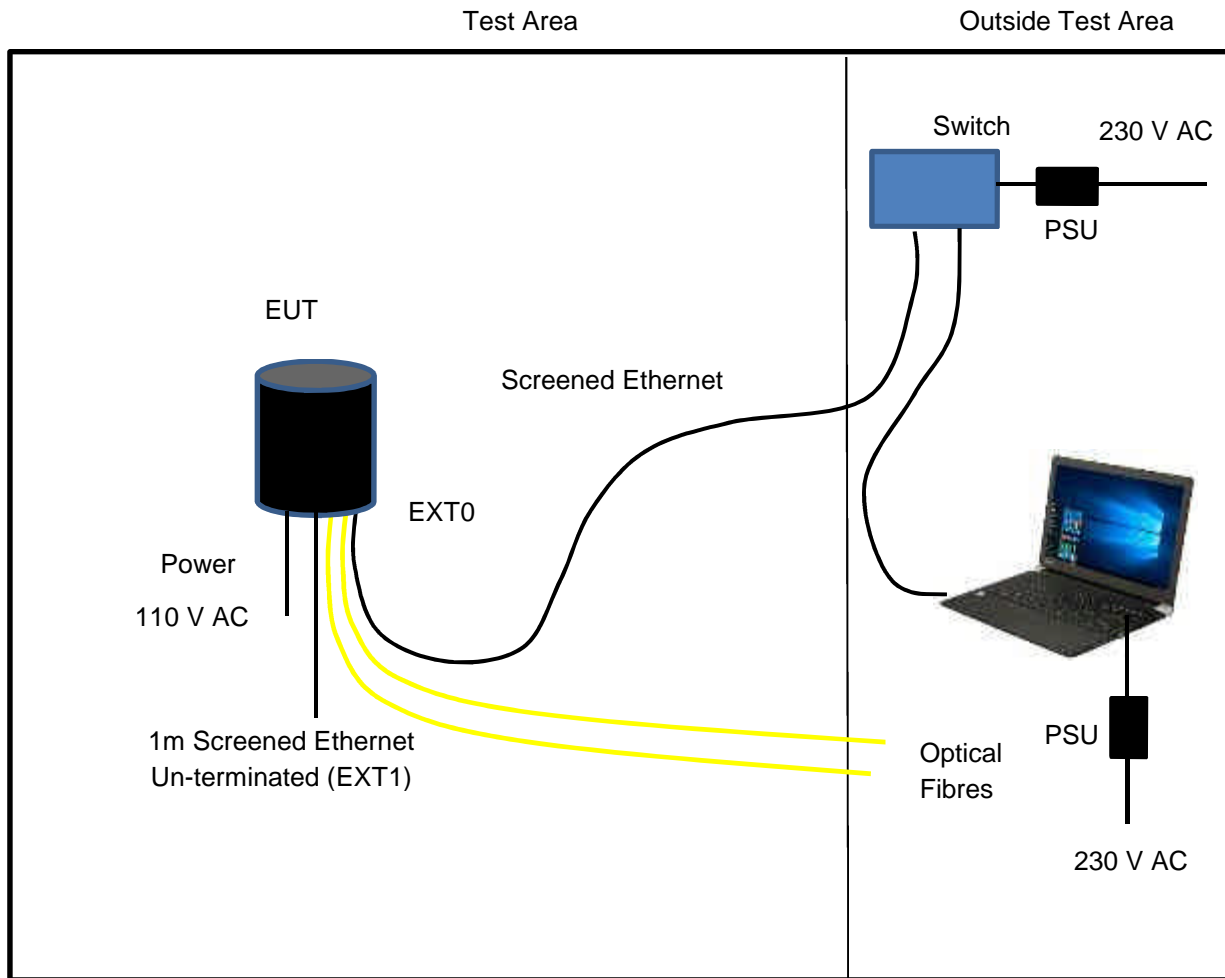
2.3 Functional description

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

2.5 Emissions configuration



The unit was powered from 110 V AC mains. Optical fibres were connected to EXT2 and EXT3 ports. 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 the addition of fibre I/O ports to 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 (have not changed) to the originally certified device.

2.5.1 Signal leads

Port Name	Cable Type	Connected
EXT0	RJ45	Yes
EXT1	RJ45	Yes
EXT2	Optical fibre	Yes
EXT3	Optical fibre	Yes

3 Summary of test results

The Metnet 60G, G60US040000 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
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE ³
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 ⁴
6. Frequency stability	47 CFR Part 15C Part 15.255(f)	NOT TESTED ¹
7. Peak & Average EIRP	47 CFR Part 15C Part 15.255(c)(1)(i)/(ii)	NOT TESTED ¹
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 ¹

¹ Not tested at request of applicant.

² EUT does not have a conducted RF port.

³ Lowest frequency generated within the unit is declared as 25MHz.

⁴ Spectrum investigated up to a frequency of 40 GHz only, 60GHz radios have not changed since original 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 connected to 110V AC 60Hz. 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
11564-1 Cond 1 AC Live 150k-30M Average
11564-1 Cond 1 AC Live 150k-30M Quasi-Peak
11564-1 Cond 1 AC Neutral 150k-30M Average
11564-1 Cond 1 AC Neutral 150k-30M Quasi-Peak

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.205	50.8	47.3	-16.1	32.6	-20.8
2	0.256	51.1	48.4	-13.2	38.3	-13.3
3	0.271	52.8	49.9	-11.2	36.7	-14.4
4	0.310	51.6	47.9	-12.1	34.4	-15.6
5	0.415	52.0	48.8	-8.7	27.8	-19.7
6	0.432	49.5	46.4	-10.8	32.0	-15.2
7	0.494	53.4	49.7	-6.4	39.6	-6.5
8	0.495	53.0	49.3	-6.8	39.7	-6.4
9	0.609	46.1	42.3	-13.7	26.6	-19.4
10	0.623	47.9	45.0	-11.0	31.1	-14.9
11	0.677	46.9	43.6	-12.4	27.8	-18.2
12	0.803	44.1	41.4	-14.6	26.6	-19.4
13	4.230	47.4	44.4	-11.6	37.4	-8.6
14	7.213	40.9	38.3	-21.7	30.0	-20.0
15	7.542	41.8	39.0	-21.0	30.5	-19.5
16	7.796	42.8	40.1	-19.9	32.2	-17.8
17	8.000	41.2	38.2	-21.8	30.8	-19.2
18	8.052	41.8	37.9	-22.1	31.0	-19.0
19	8.528	43.5	39.8	-20.2	32.6	-17.4

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

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.195	50.9	47.8	-16.0	36.3	-17.5
2	0.271	52.5	49.8	-11.3	36.2	-14.9
3	0.414	51.2	48.0	-9.6	27.7	-19.9
4	0.496	52.1	48.2	-7.9	38.0	-8.1
5	0.622	47.0	44.2	-11.8	30.5	-15.5
6	0.745	43.5	39.6	-16.4	25.4	-20.6
7	3.950	47.2	42.2	-13.8	34.4	-11.6
8	4.106	48.3	45.2	-10.8	38.0	-8.0
9	7.741	44.0	41.5	-18.5	33.8	-16.2
10	7.967	43.1	39.7	-20.3	32.4	-17.6
11	8.260	45.4	41.5	-18.5	34.0	-16.0
12	8.482	45.3	42.1	-17.9	34.6	-15.4
13	8.666	43.1	40.2	-19.8	33.1	-16.9
14	8.714	43.9	40.0	-20.0	32.8	-17.2

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.

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

Plot refs	
11564-1 Rad 1 150k-30MHz Para	
11564-1 Rad 1 150k-30MHz Perp	

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 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.

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 50%
 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

Plot refs
11564-1 Rad 1 VHF Horiz
11564-1 Rad 1 VHF Vert
11564-1 Rad 1 UHF Horiz
11564-1 Rad 1 UHF Vert

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	47.277	25.7	16.3	-23.7
2	49.055	24.9	15.5	-24.5
3	52.634	19.6	12.9	-27.1
4	65.383	20.4	12.9	-27.1
5	65.384	20.8	12.8	-27.2
6	73.063	20.5	12.8	-27.2

Note: Horizontal emissions below 1GHz not observed.

Peak detector "Max held" Analyser plots against the Quasi-Peak / Average limit lines 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 ± 6.1 dB

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. 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.

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 - 40GHz.

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, 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 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

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
1562.495	43.1	-30.9	37.8	-16.2	Upright	Vertical
1874.977	43.6	-30.4	35.1	-18.9	Upright	Vertical
1874.994	45.1	-28.9	37.5	-16.5	Upright	Horizontal

2187.485	48.7	-25.3	43.5	-10.5	Upright	Horizontal
2187.485	48.2	-25.8	44.5	-9.5	Upright	Vertical
2474.992	43.4	-30.6	37.8	-16.2	Upright	Vertical
2499.992	46.2	-27.8	40.9	-13.1	Upright	Horizontal
2499.992	47.8	-26.2	43.3	-10.7	Upright	Vertical
2749.991	44.5	-29.5	38.8	-15.2	Upright	Horizontal
2749.991	43.1	-30.9	35.8	-18.2	Upright	Vertical
2812.491	45.4	-28.6	37.3	-16.7	Upright	Vertical
2812.492	45.2	-28.8	39.2	-14.8	Upright	Horizontal
2874.991	46.7	-27.3	42.1	-11.9	Upright	Horizontal
2874.991	49.8	-24.2	45.9	-8.1	Upright	Vertical
2937.49	43.4	-30.6	36.1	-17.9	Upright	Horizontal
2937.491	46.5	-27.5	41.9	-12.1	Upright	Vertical
2999.991	47.2	-26.8	42.4	-11.6	Upright	Vertical
3062.49	45.4	-28.6	39.2	-14.8	Upright	Vertical
3124.996	44.4	-29.6	36	-18	Upright	Vertical
3187.487	43.7	-30.3	35.3	-18.7	Upright	Vertical
3249.99	45.7	-28.3	39.4	-14.6	Upright	Horizontal
3249.99	48.7	-25.3	44.2	-9.8	Upright	Vertical
4999.984	50.6	-23.4	43.7	-10.3	Upright	Horizontal
7343.73	42.0	-32.0	34.4	-19.6	Upright	Vertical
10312.5	43.2	-30.8	37.0	-17.0	Upright	Vertical
20625	45.1	-28.9	41.5	-12.5	Flat	Horizontal
20625	45.1	-28.9	41.5	-12.5	Flat	Vertical

Plots	
11564-1 Rad 1 1-2GHz Horiz	
11564-1 Rad 1 1-2GHz Vert	
11564-1 Rad 1 2-5GHz Horiz	
11564-1 Rad 1 2-5GHz Vert	
11564-1 Rad 1 5-6GHz Horiz	
11564-1 Rad 1 5-6GHz Vert	
11564-1 Rad 1 6upto10GHz Horiz	
11564-1 Rad 1 6upto10GHz Vert	
11564-1 Rad 1 10upto12_5GHz Horiz	
11564-1 Rad 1 10upto12_5GHz Vert	
11564-1 12.5 - 15 GHz H_V	
11564-1 15 - 18 GHz H_V	
11564-1 18 - 21 GHz H_V	
11564-1 21 - 24 GHz H_V	
11564-1 24 - 26.5 GHz H_V	
11564-1 26.5 - 30 GHz H_V	
11564-1 30 - 34 GHz H_V	
11564-1 34 - 38 GHz H_V	
11564-1 38 - 40 GHz H_V	

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.

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

These results show that the EUT has PASSED this test.

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

1 – 18 GHz ± 3.5 dB, 18 – 26.5 GHz ± 3.9 dB, 26.5 – 40 GHz

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.

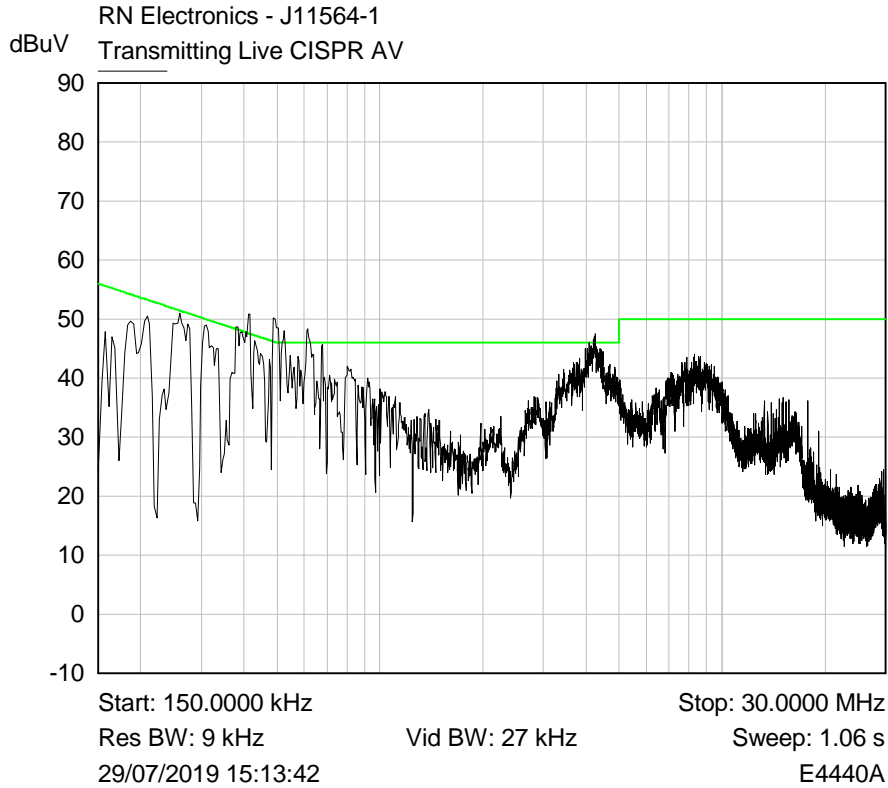
5.9 20dB Occupied bandwidth

NOT TESTED: Not tested at request of applicant.

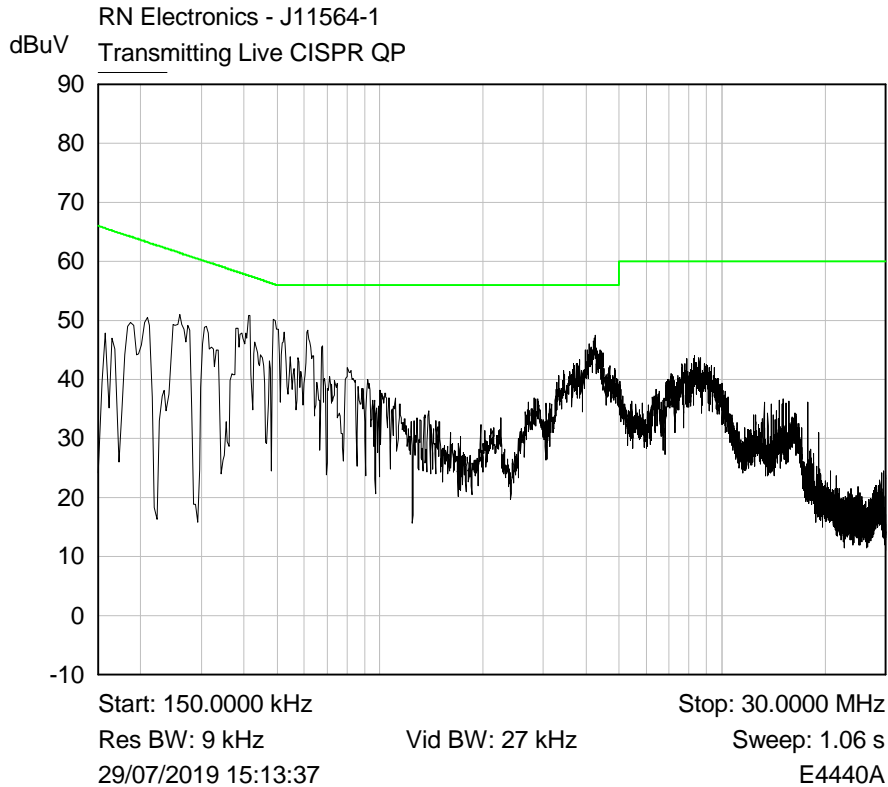
6 Plots/Graphical results

6.1 AC power line conducted emissions

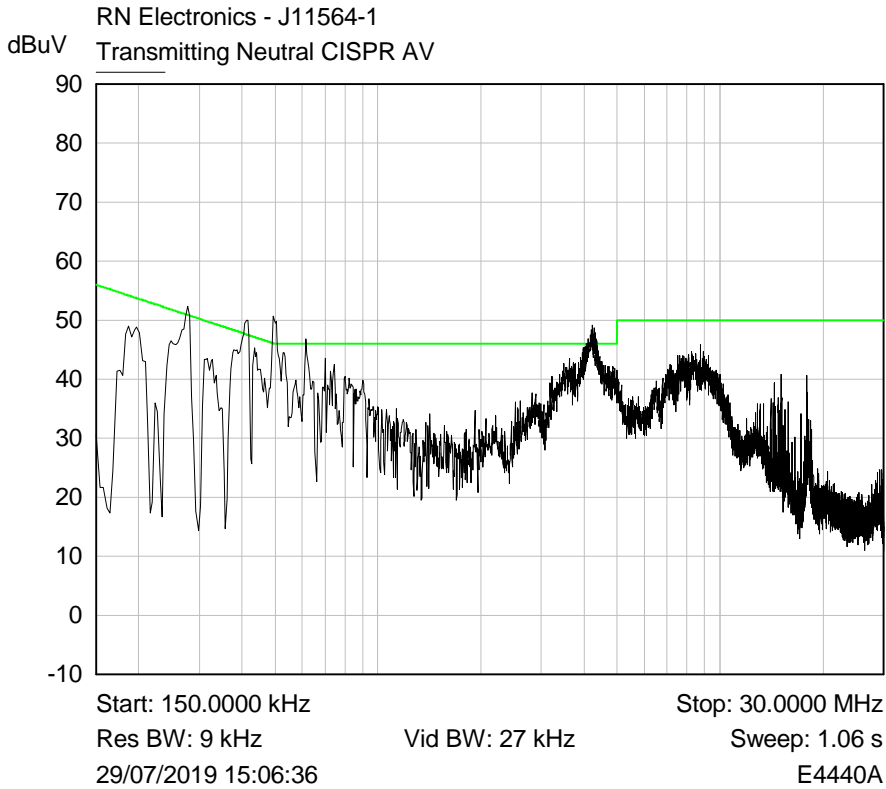
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 MHz, Modulation DBPSK



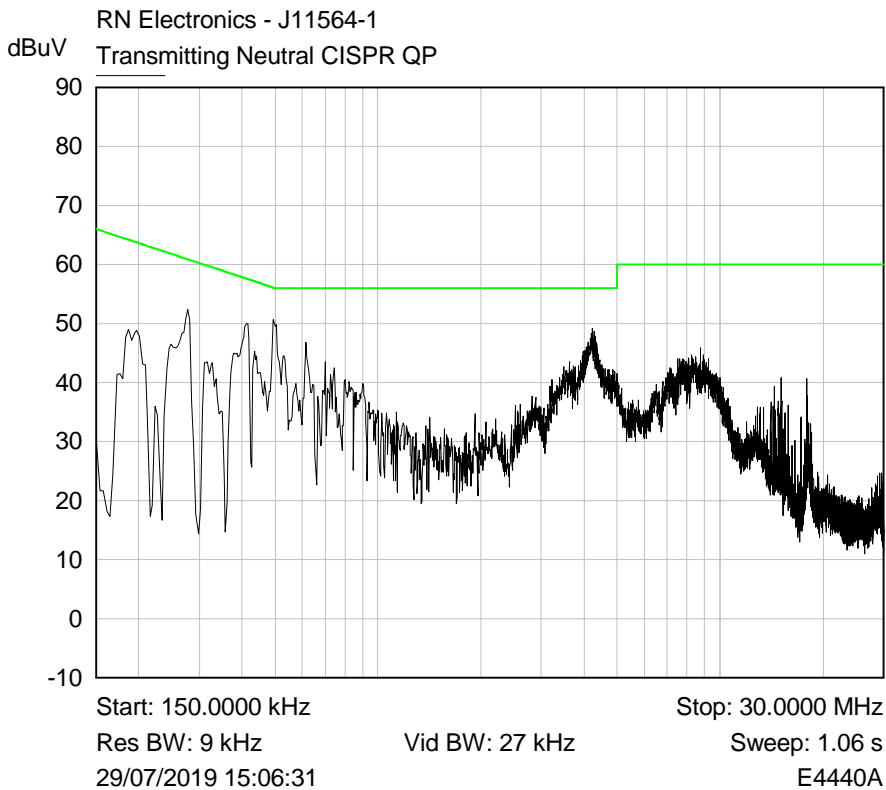
Plot of Peak emissions for Live line 150k – 30MHz against the AV limit line



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



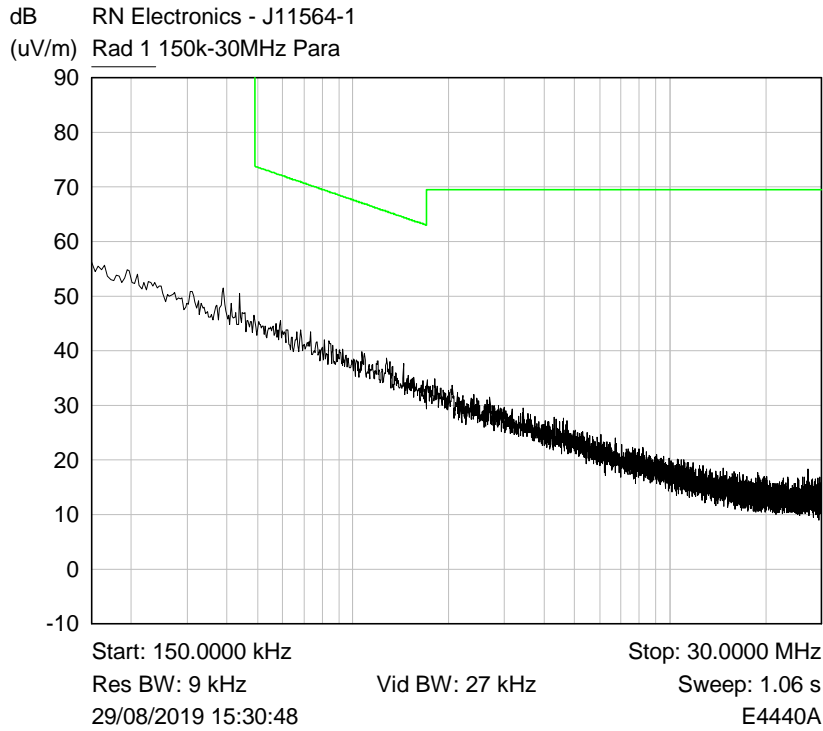
Plot of Peak emissions for Neutral line 150k – 30MHz against the AV limit line



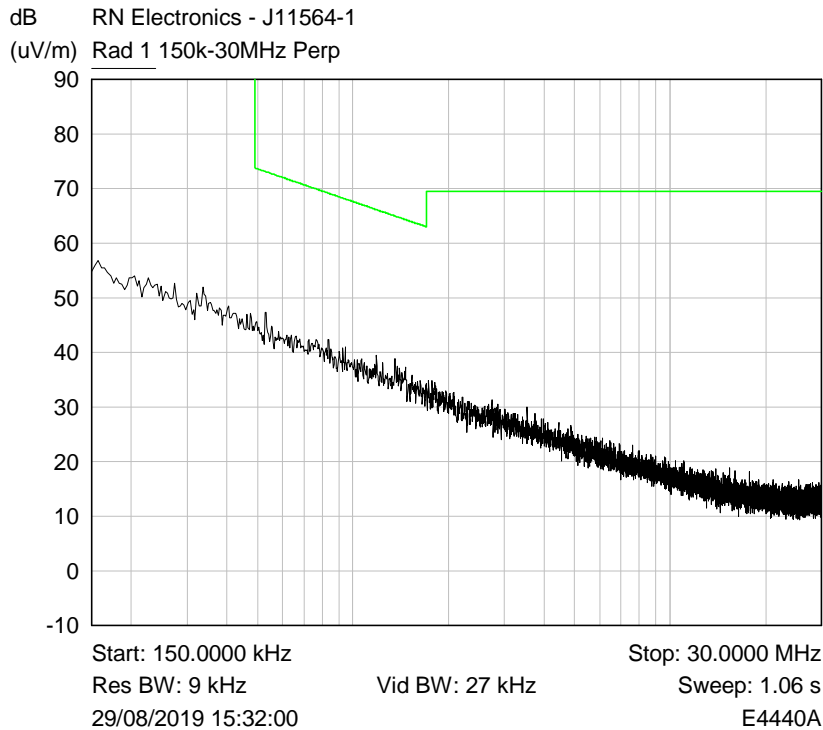
Plot of Peak emissions for Neutral line 150k – 30MHz against the QP limit line

6.2 Radiated emissions 150k - 30 MHz

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



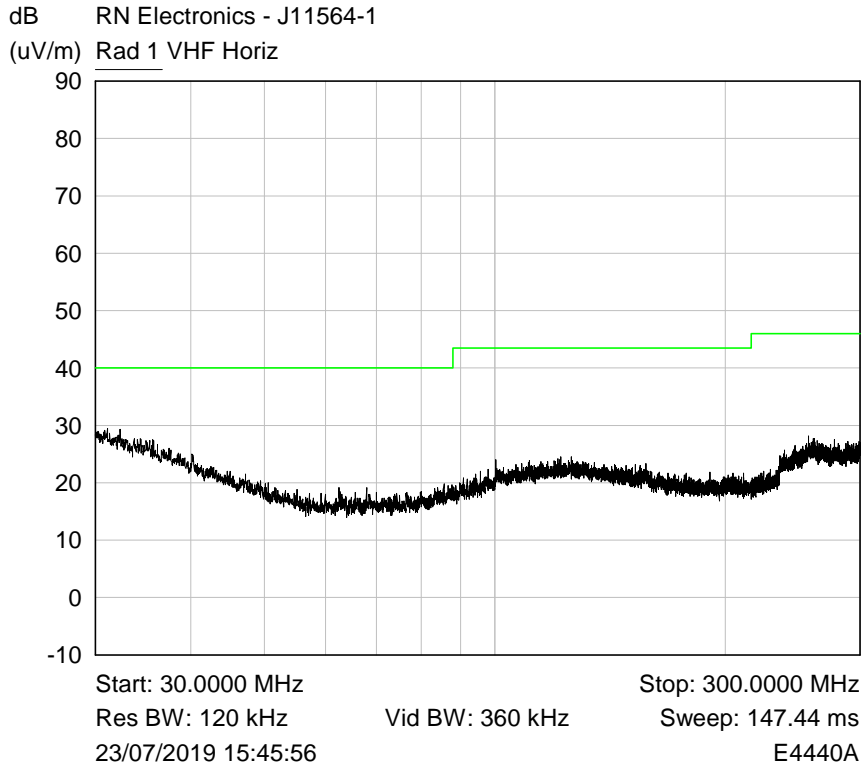
Plot of 150kHz-30MHz Parallel



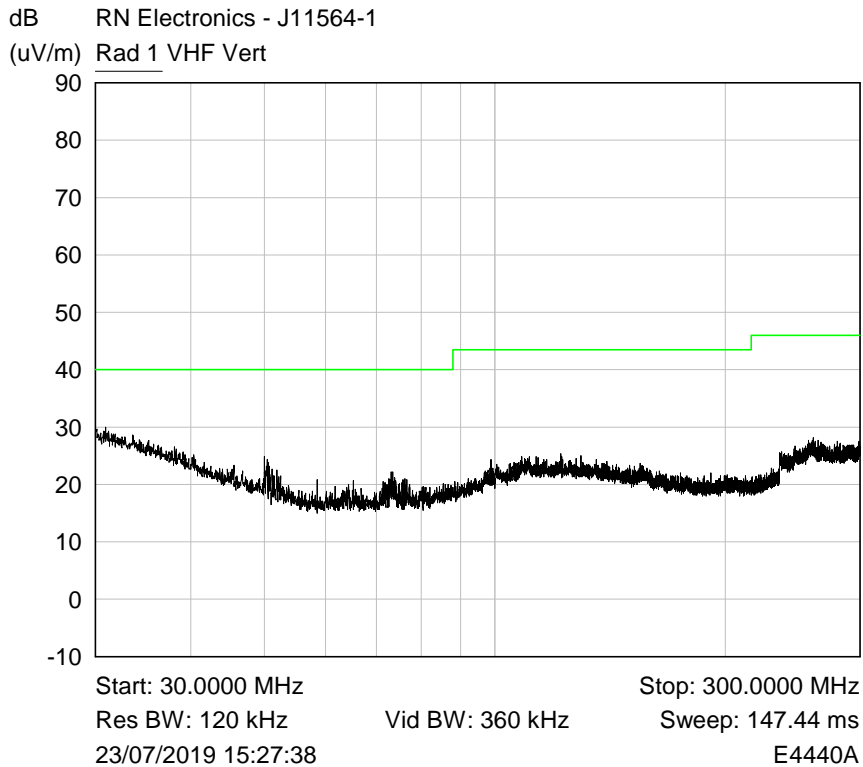
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

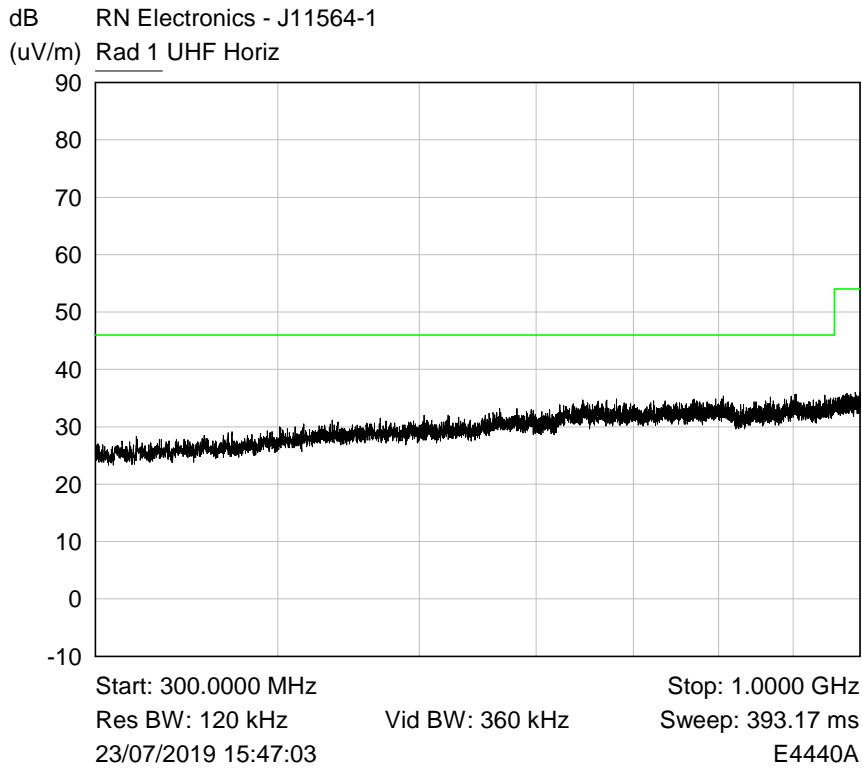
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 MHz, Modulation DBPSK



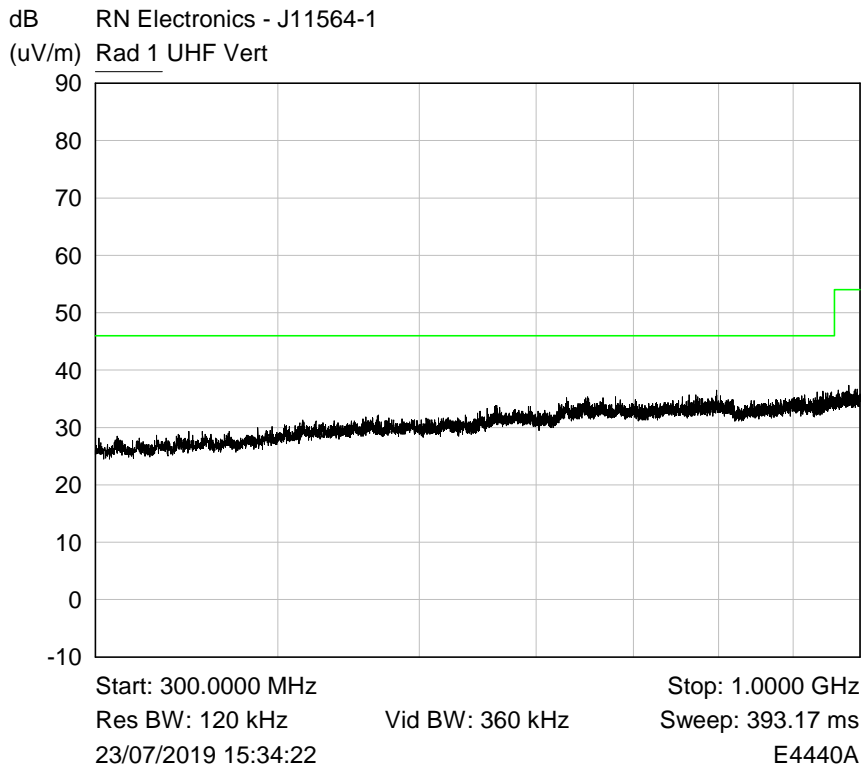
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



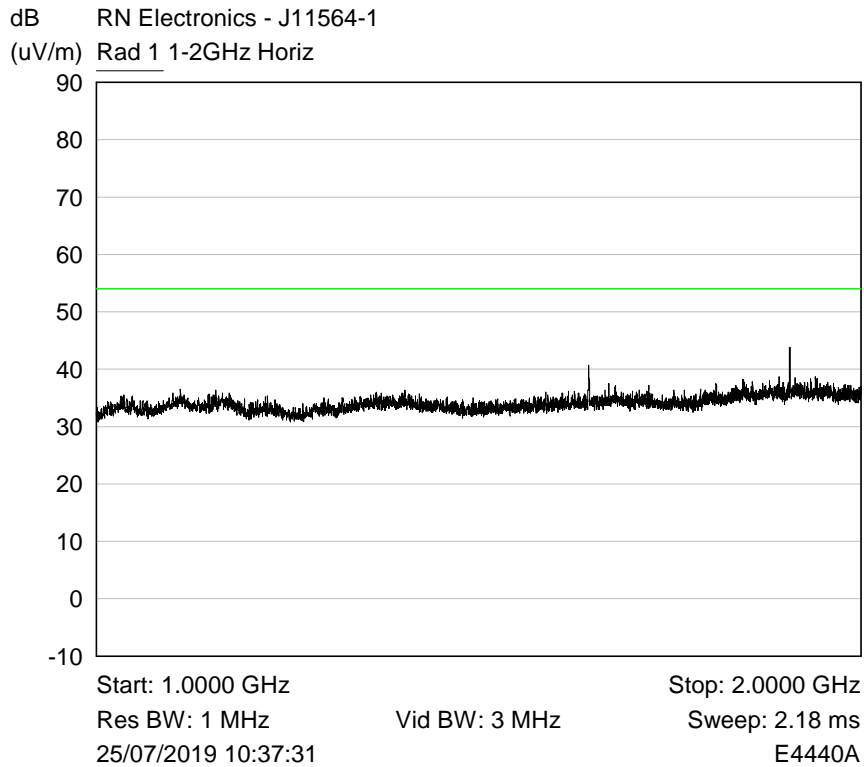
Plot of Peak emissions for UHF Horizontal against the QP limit line.



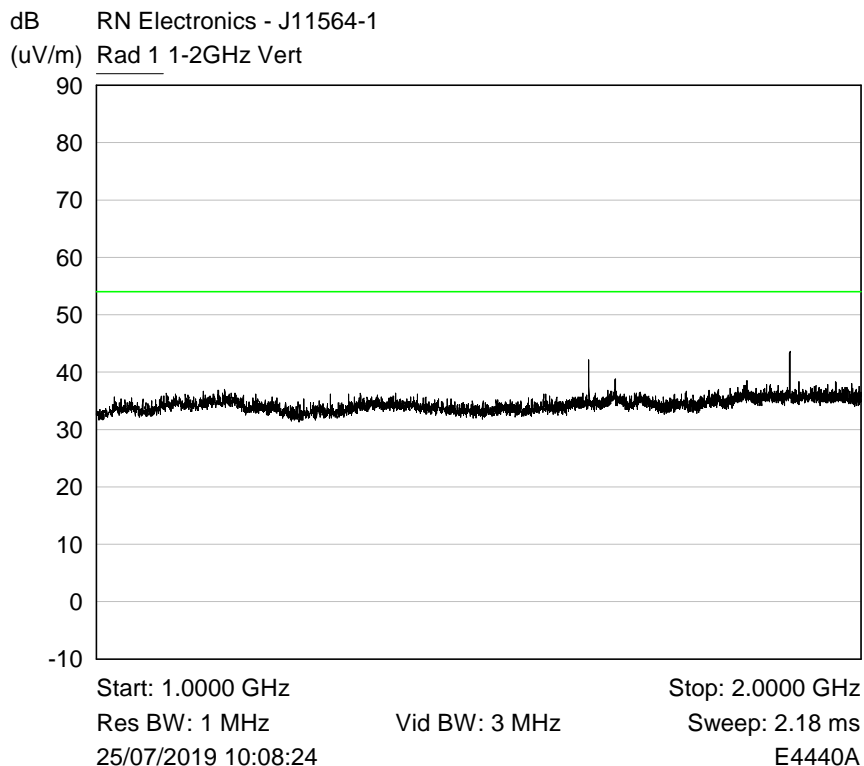
Plot of Peak emissions for UHF Vertical against the QP limit line.

6.4 Radiated emissions above 1 GHz

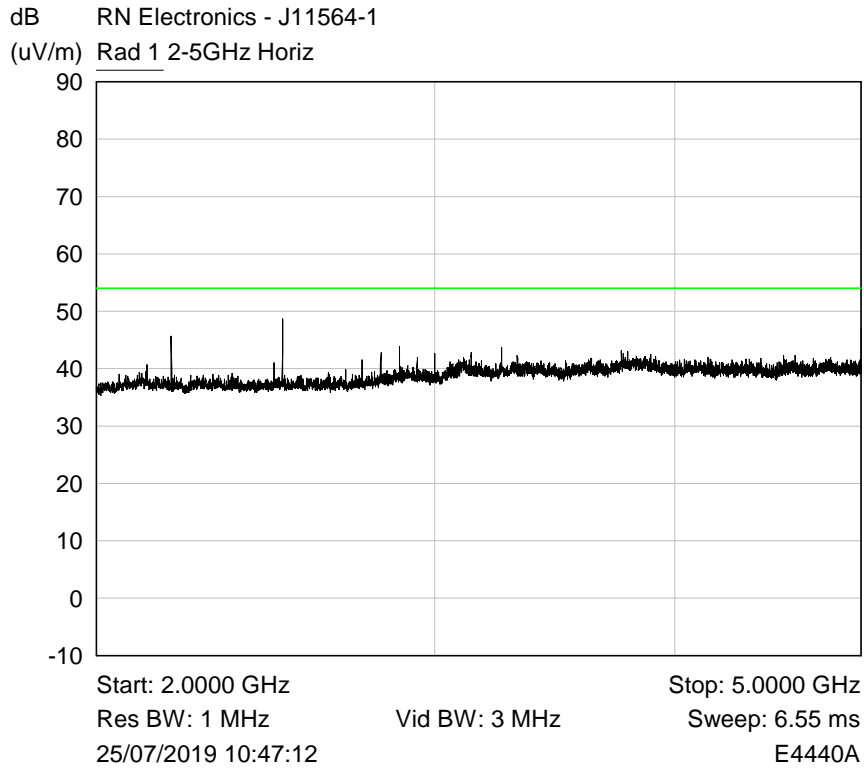
RF Parameters: Band 57-66 GHz, Power 40 dBm, Channel Spacing 2.16 MHz, Modulation DBPSK



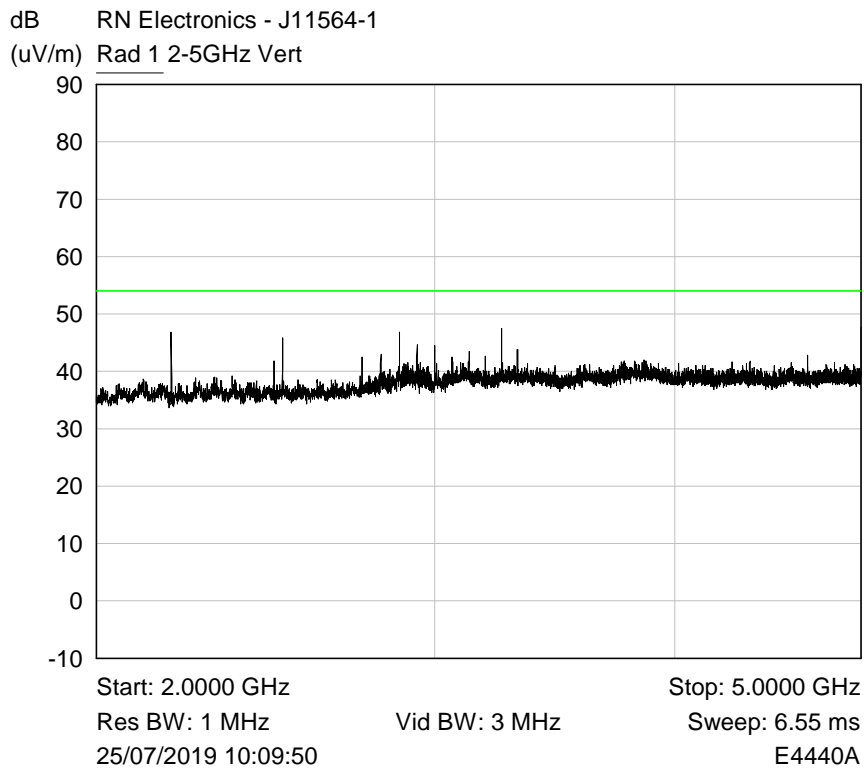
Peak Horizontal emissions 1– 2 GHz against the average limit line



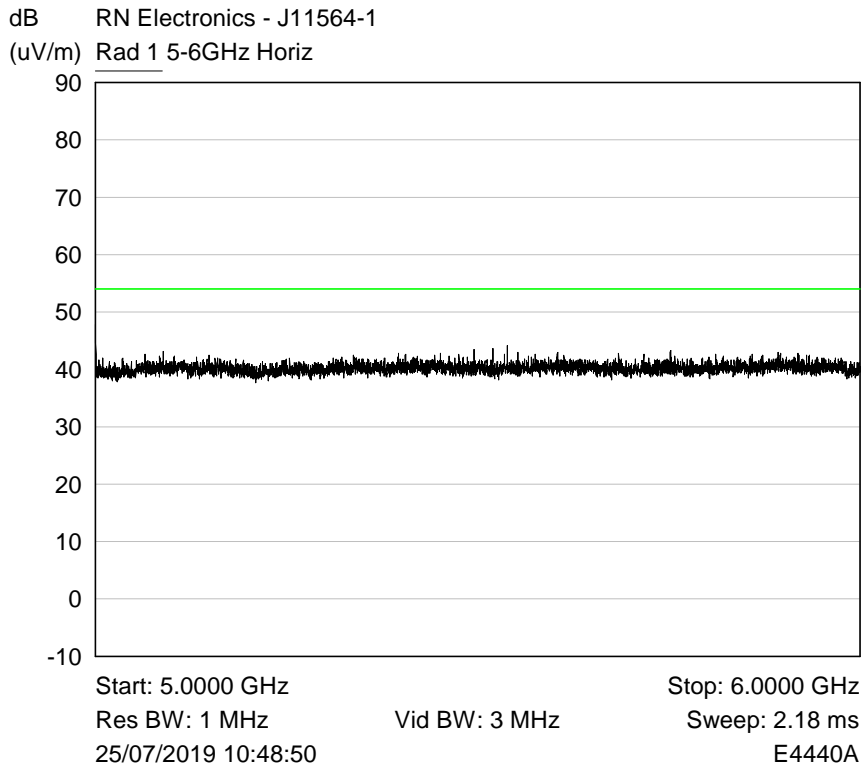
Peak Vertical emissions 1– 2 GHz against the average limit line



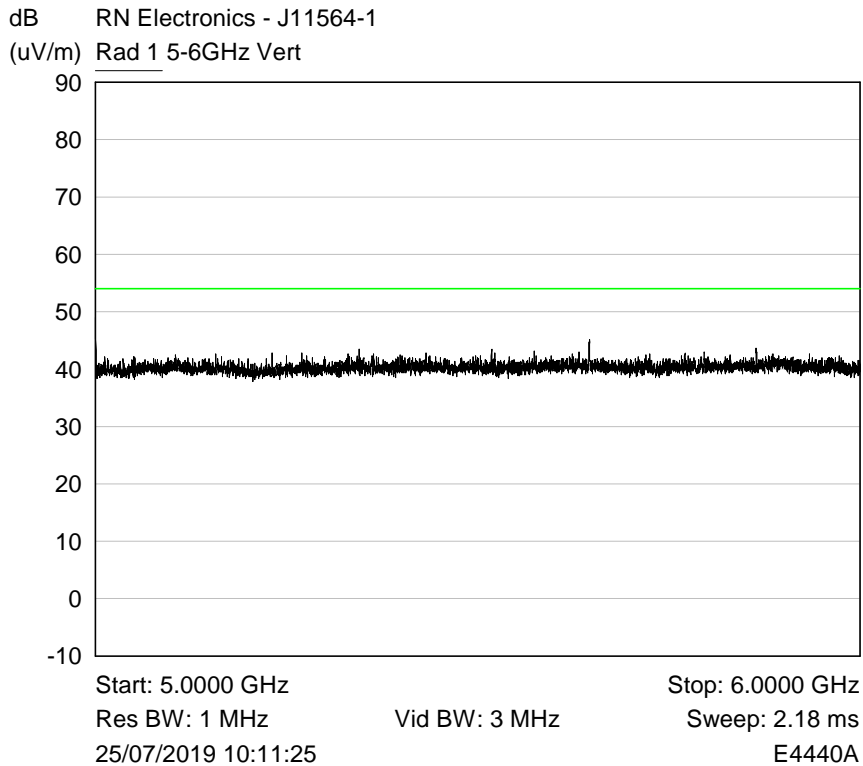
Peak Horizontal emissions 2– 5 GHz against the average limit line



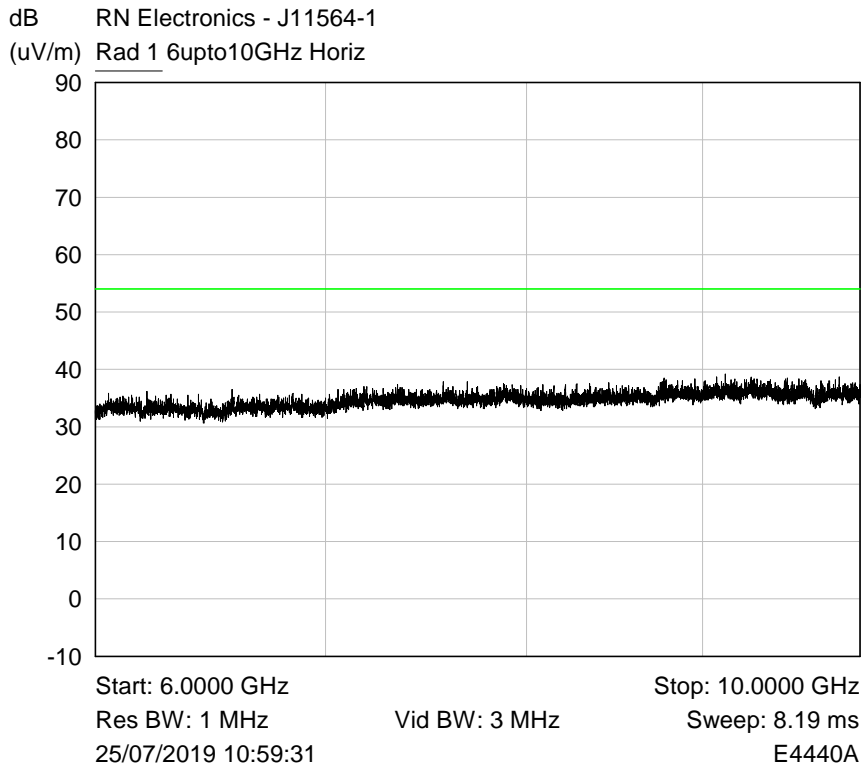
Peak Vertical emissions 2– 5 GHz against the average limit line



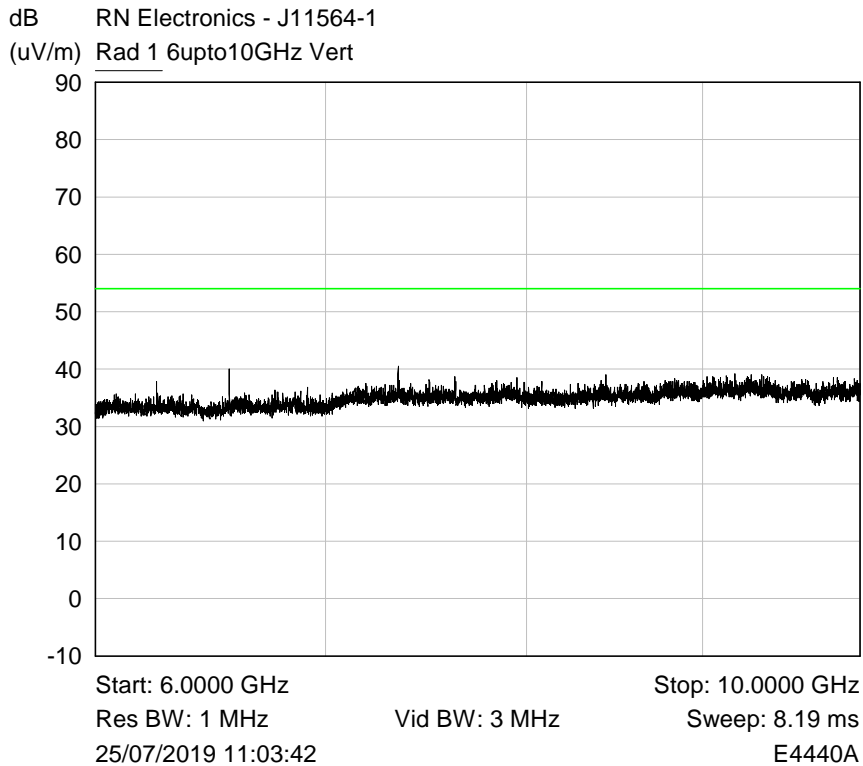
Peak Horizontal emissions 5– 6 GHz against the average limit line



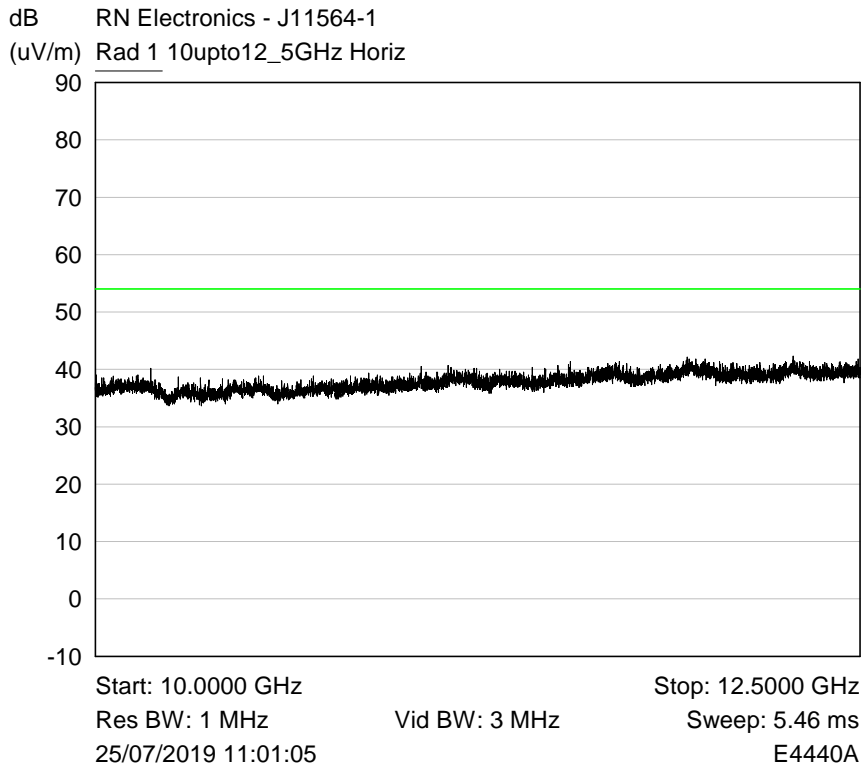
Peak Vertical emissions 5– 6 GHz against the average limit line



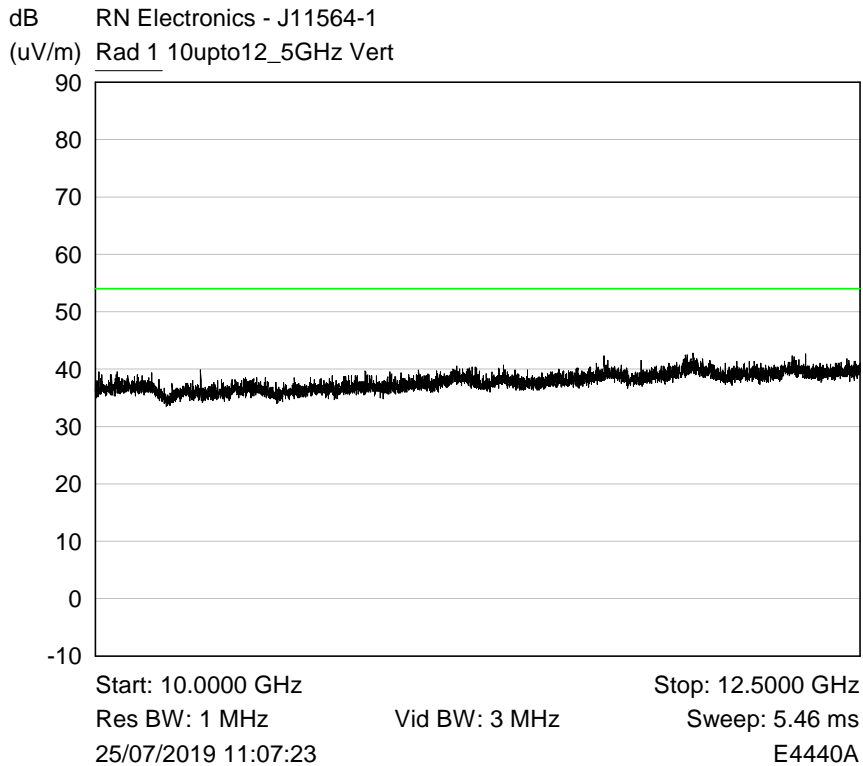
Peak Vertical emissions 6– 10 GHz against the average limit line



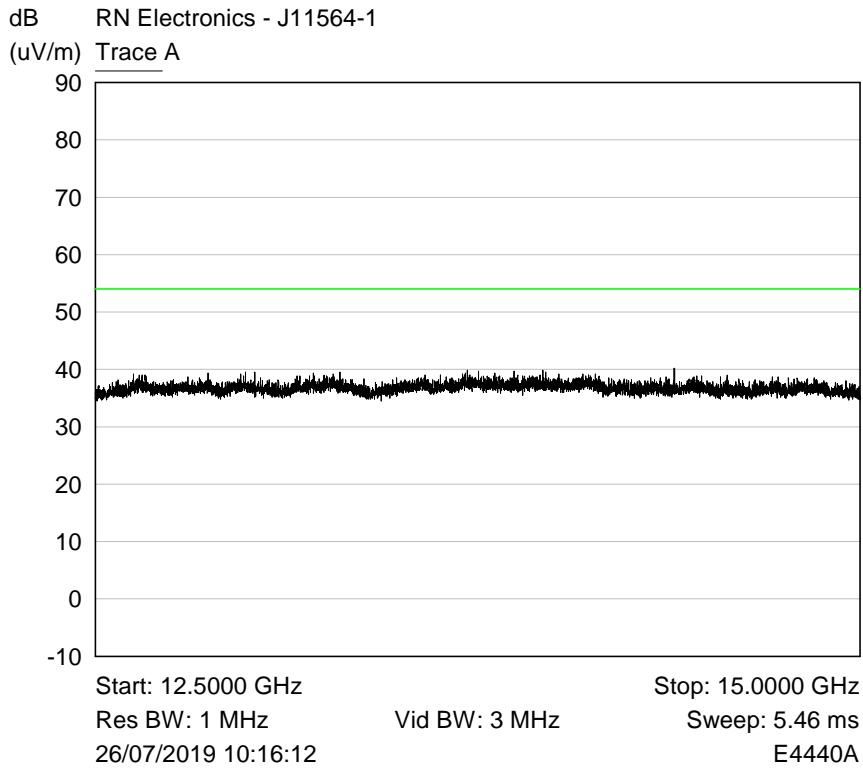
Peak Vertical emissions 6– 10 GHz against the average limit line



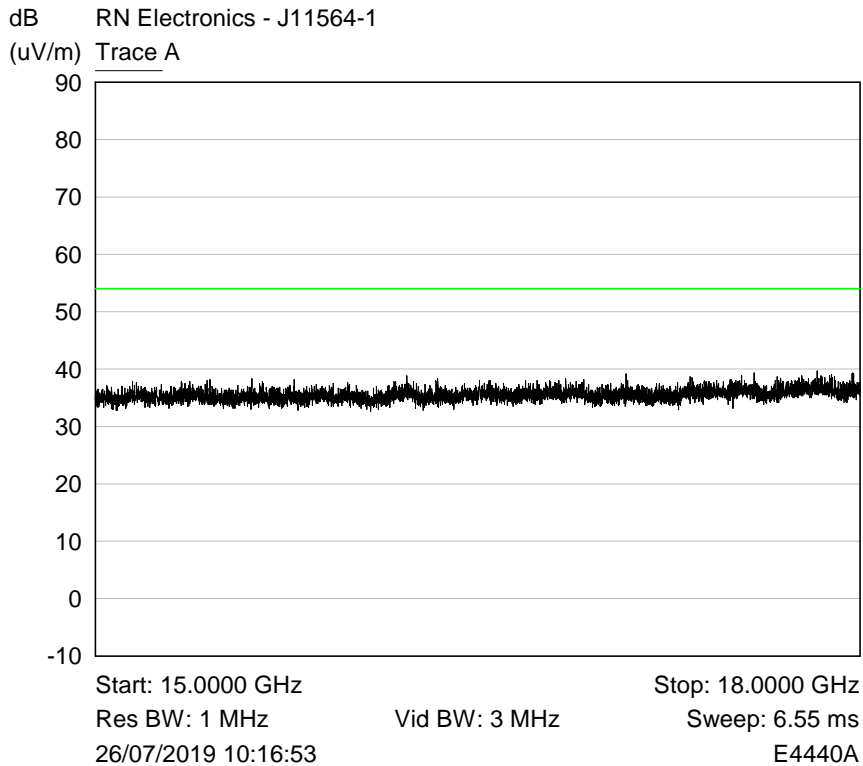
Peak Vertical emissions 10– 12.5 GHz against the average limit line



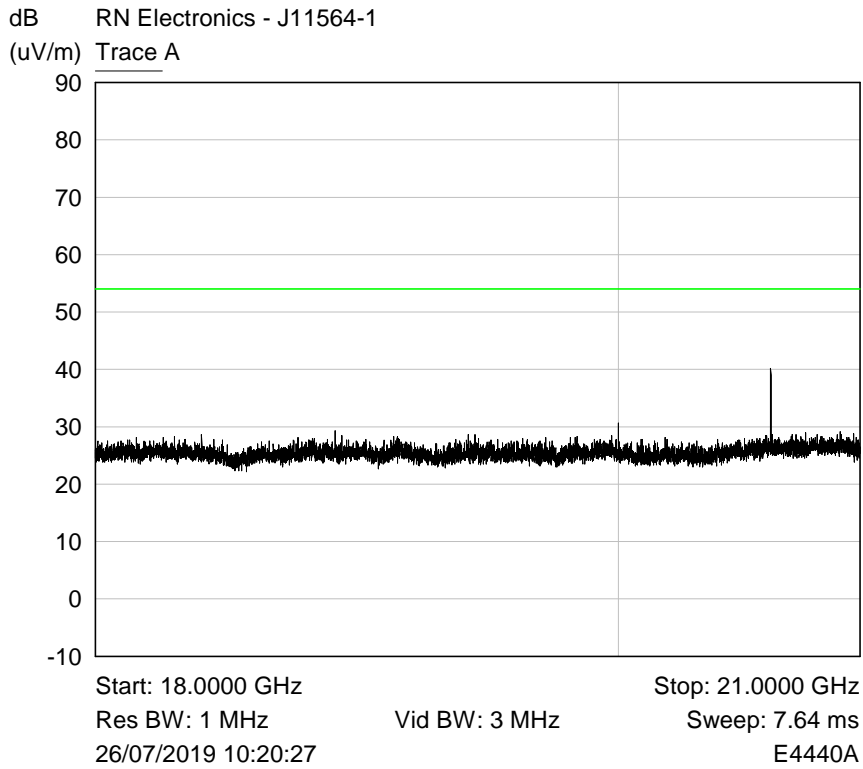
Peak Vertical emissions 10– 12.5 GHz against the average limit line



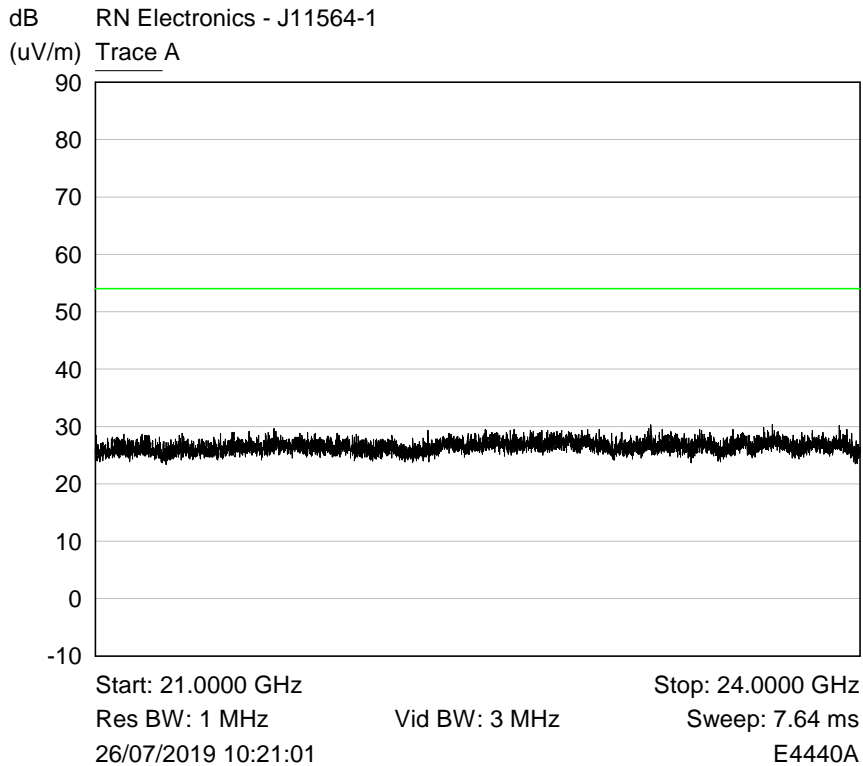
Peak Vertical and Horizontal emissions 12.5– 15 GHz against the average limit line



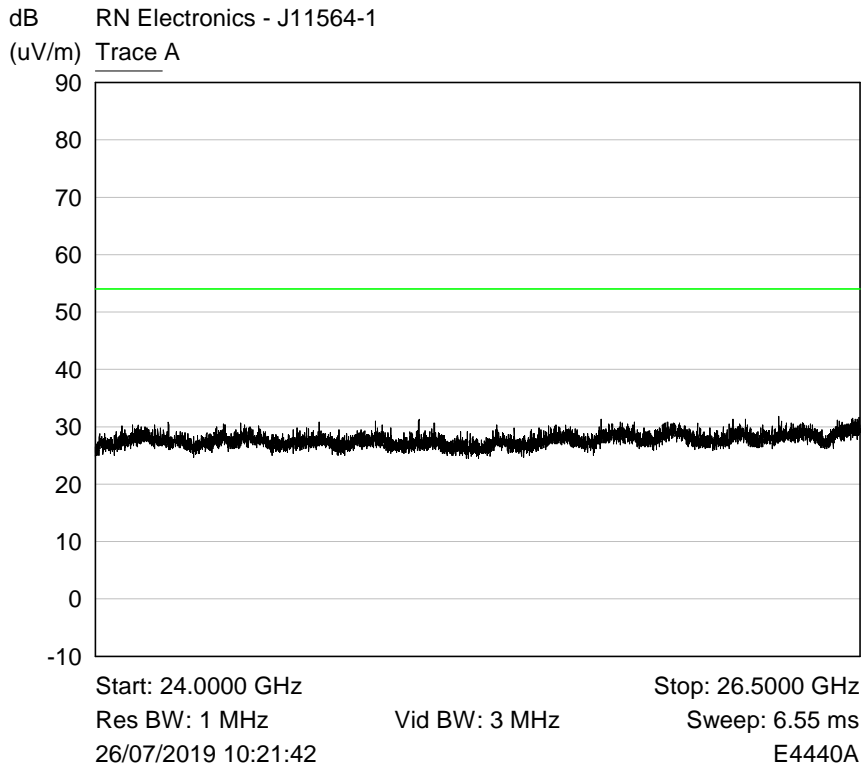
Peak Vertical and Horizontal emissions 15– 18 GHz against the average limit line



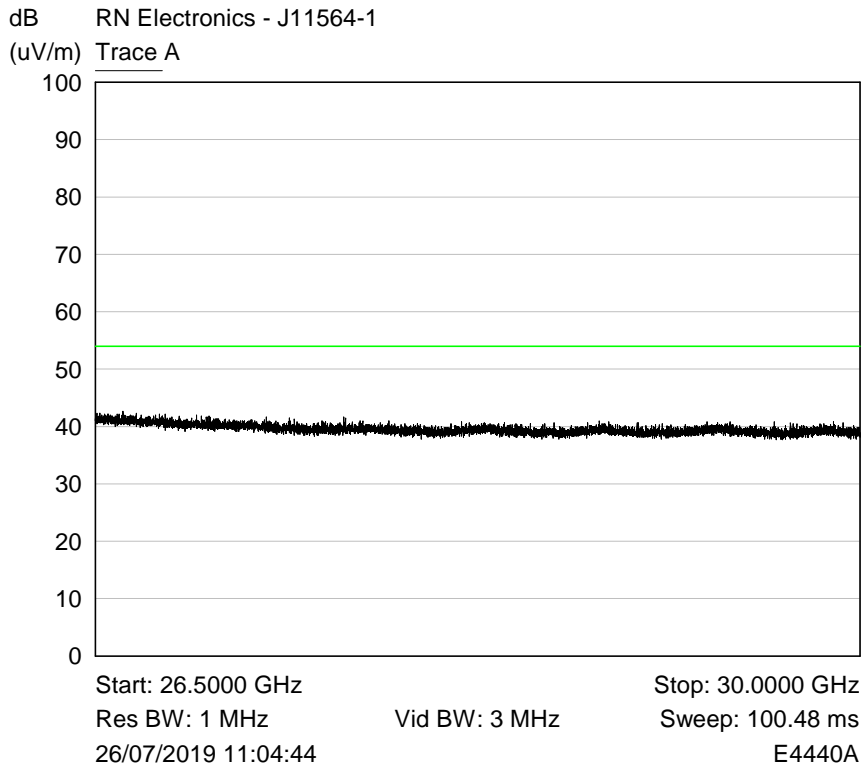
Peak Vertical and Horizontal emissions 18– 21 GHz against the average limit line



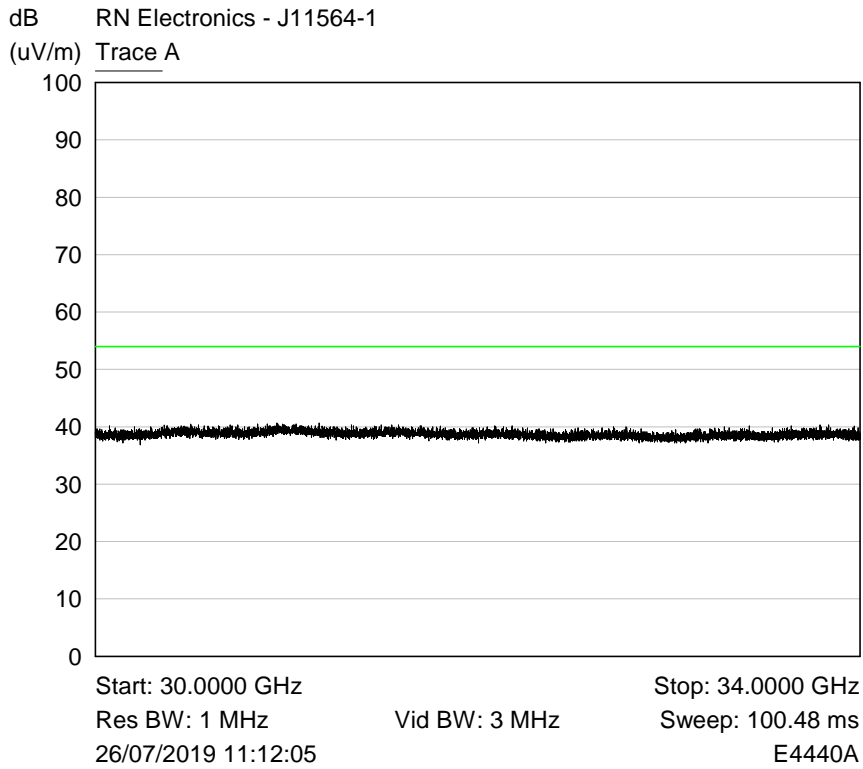
Peak Vertical and Horizontal emissions 21– 24 GHz against the average limit line



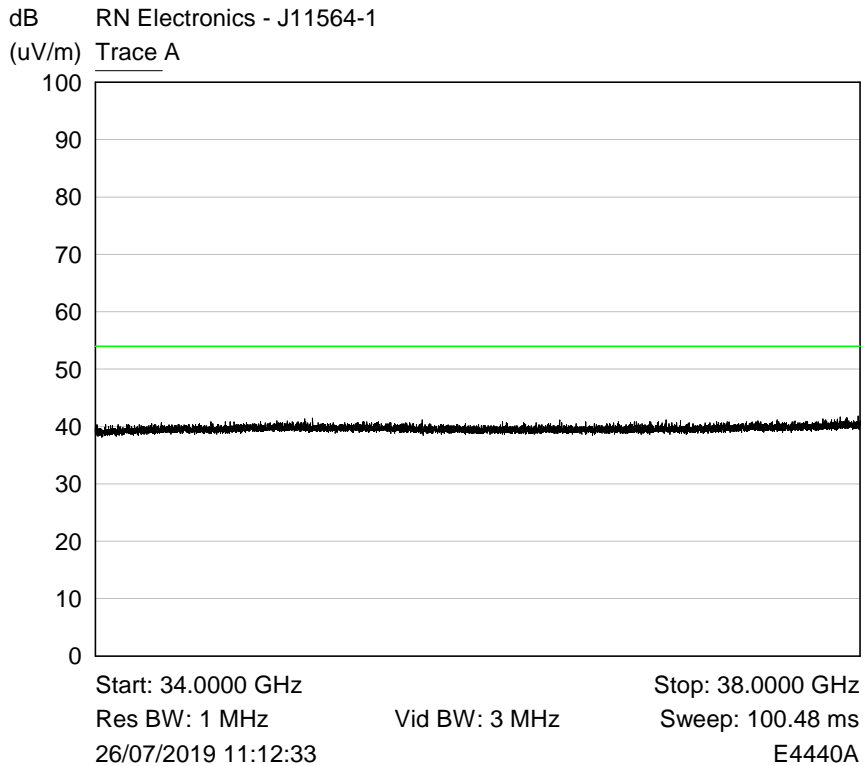
Peak Vertical and Horizontal emissions 24 – 26.5Hz against the average limit line



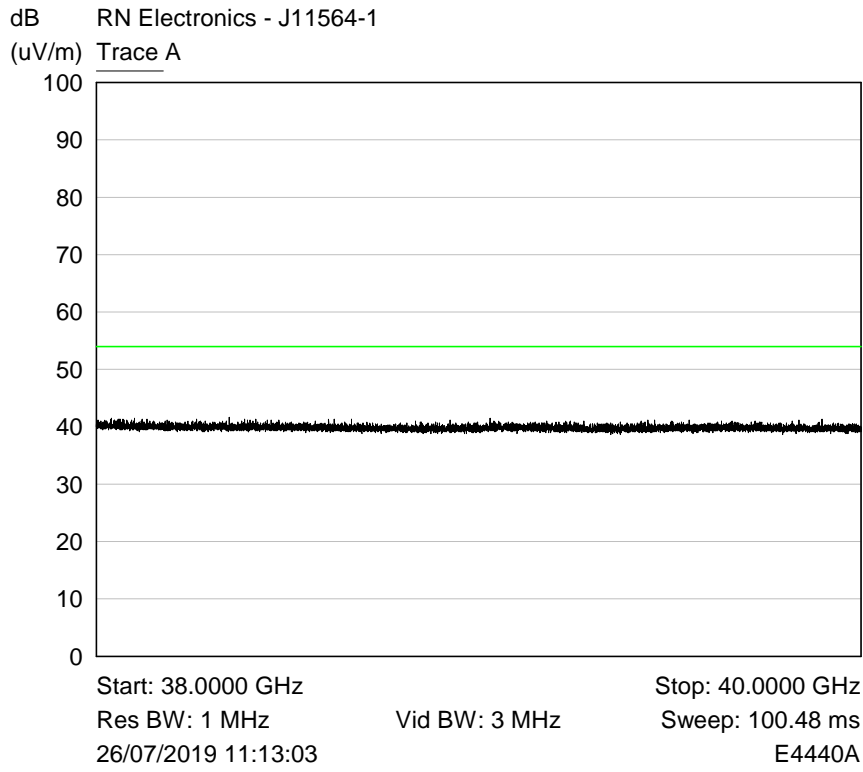
Peak Vertical and Horizontal emissions 26.5– 30 GHz against the average limit line



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 (dB μ V)	Pk – Lim 1 (dB)	QP Amp (dB μ V)	QP - Lim1 (dB)	Av Amp (dB μ V)	Av - Lim1 (dB)
1	12345	54.9	-10.5	48	-12.6	37.6	-14.4

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

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

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

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

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

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

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

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

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

7.2 Explanation of limit line calculations for radiated measurements

The limits given in the test standard are normally expressed as absolute values (e.g. in $\mu\text{V}/\text{m}$ at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in $\text{dB}\mu\text{V}/\text{m}$ 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 $500 \mu\text{V}/\text{m}$ equates to $20.\log(500) = 54 \text{ dB } \mu\text{V}/\text{m}$.
- (b) limit of $300 \mu\text{V}/\text{m}$ at 10m equates to $20.\log(300 \cdot 10/3) = 60 \text{ dB } \mu\text{V}/\text{m}$ at 3m
- (c) limit of $30 \mu\text{V}/\text{m}$ at 30m, but below 30MHz, equates to $20.\log(30) + 40.\log(30/3) = 69.5 \text{ dB}\mu\text{V}/\text{m}$ at 3m, as extrapolation factor below 30MHz is 40dB/decade per $15.31(f)(2)$.

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

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

Receiver	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: $E_{\text{Linear}} = 10^{((E_{\text{Log}} - 120)/20)}$

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

Where:

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

E_{Log} is the field strength of the emissions in $\text{dB}\mu\text{V}/\text{m}$

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

Where:

EIRP is equivalent isotropically radiated power in dBm

E_{Meas} is the field strength of the emission at the measurement distance in $\text{dB}\mu\text{V}/\text{m}$

d_{Meas} is the measurement distance in metres

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

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

Where:

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

$\text{EIRP}_{\text{Linear}}$ is the equivalent isotropically radiated power in Watts

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

Equation 26: $PD = E_{\text{Spec limit}}^2 / 377$

And therefore equation 26 transposed is: $E_{\text{Spec limit}} = \sqrt{(PD \times 377)}$

Where:

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

$E_{\text{Spec limit}}$ is the field strength at the distance specified by the limit in V/m

Example:

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

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

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

And

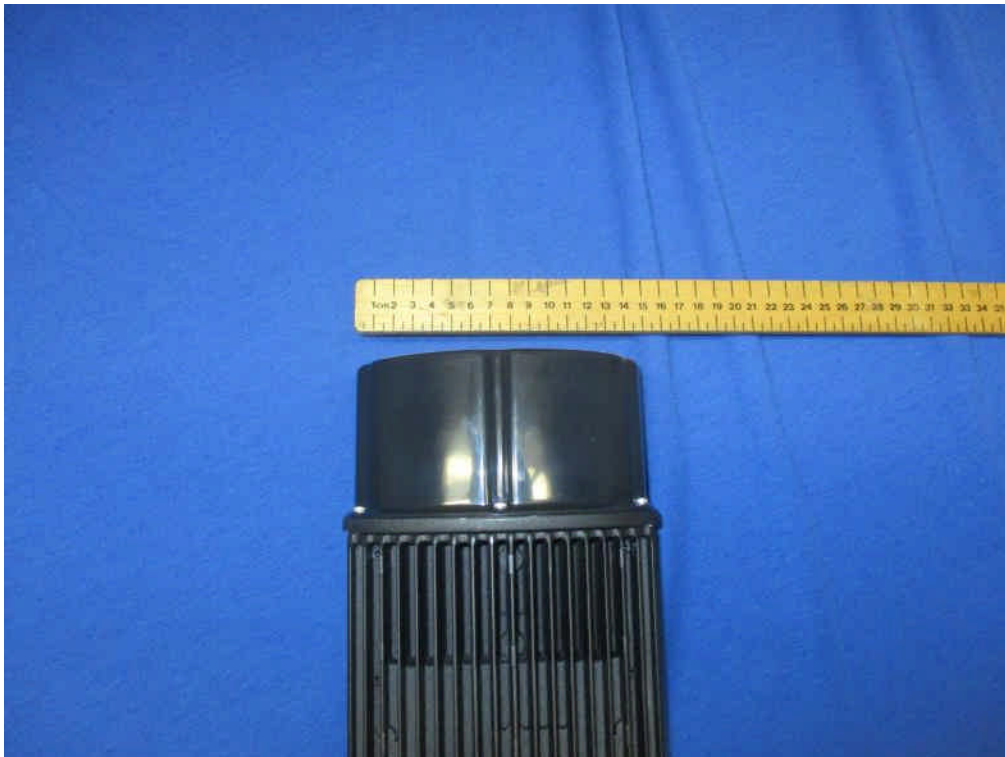
$$\text{Equation 26 transposed: } E_{\text{Spec limit}} = \sqrt{(0.9 \times 10^{-6} \times 377)} = 0.01842 \text{ V/m.}$$

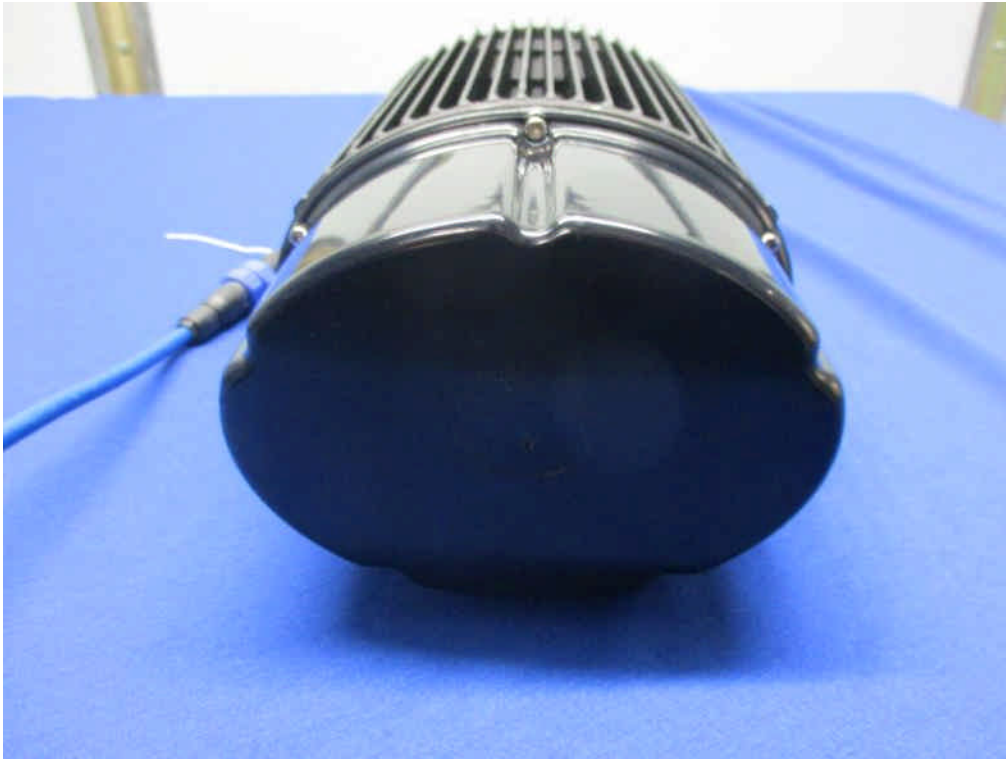
And

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

8 Photographs

8.1 EUT Front View





8.2 EUT Reverse Angle



Photograph shows the optical fibre ports (highlighted yellow) and Ethernet ports (highlighted blue)

8.3 EUT Left side View

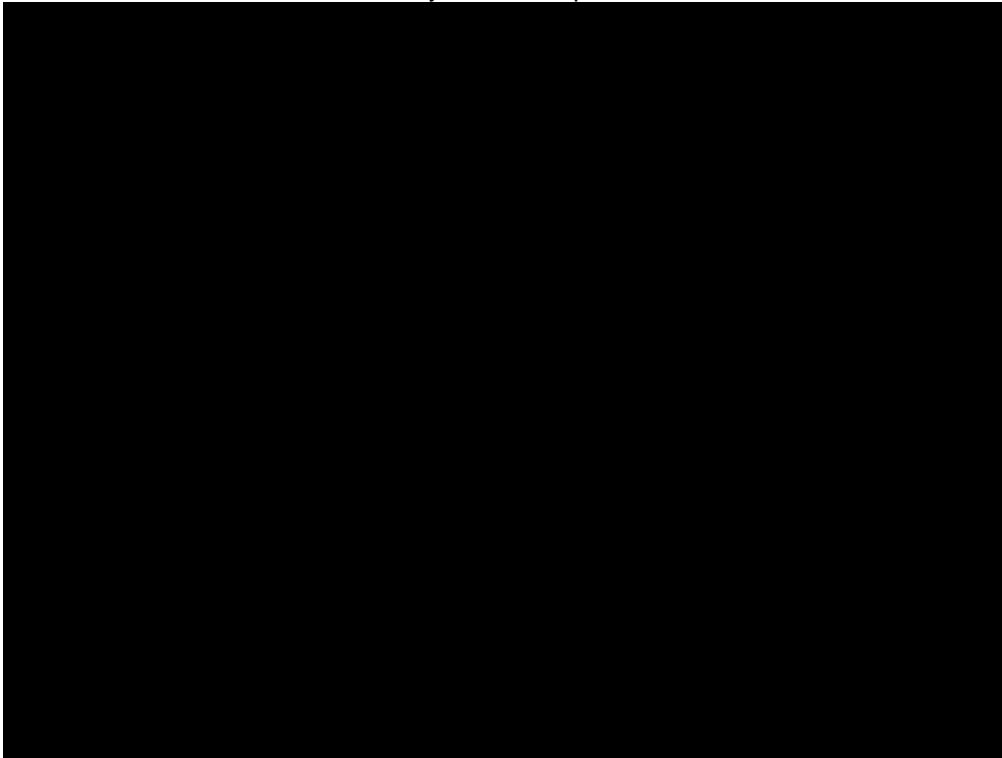


8.4 EUT Right side View

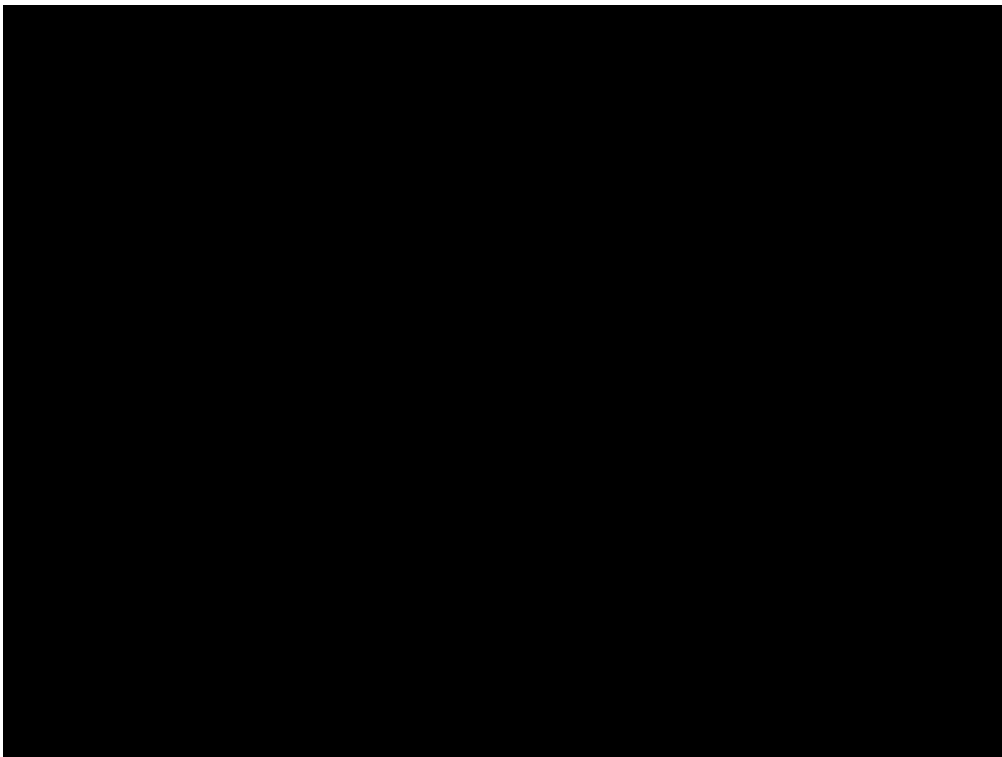


8.5 EUT Antenna

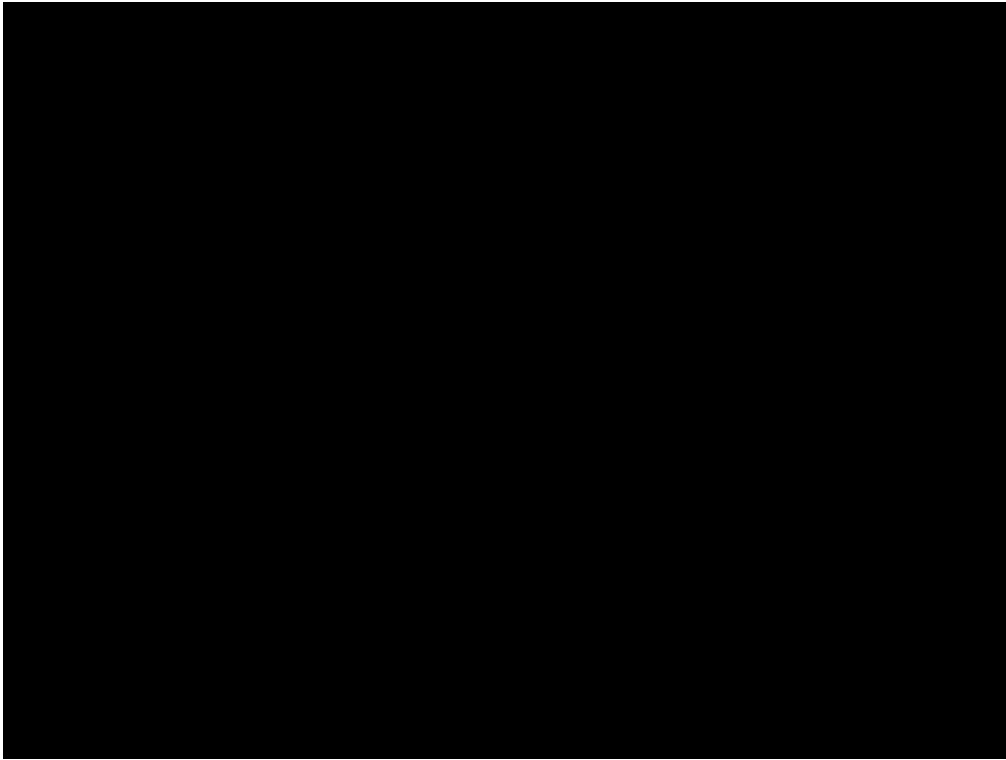
Note: Photos are blacked out due to confidentiality of internal photos.



Shows the EUT's 60 GHz antennas



Shows the EUT's 60 GHz antennas



Shows the EUTs GPS antenna.

8.6 EUT Display & Controls



Photograph shows the EUT's status LEDs (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.

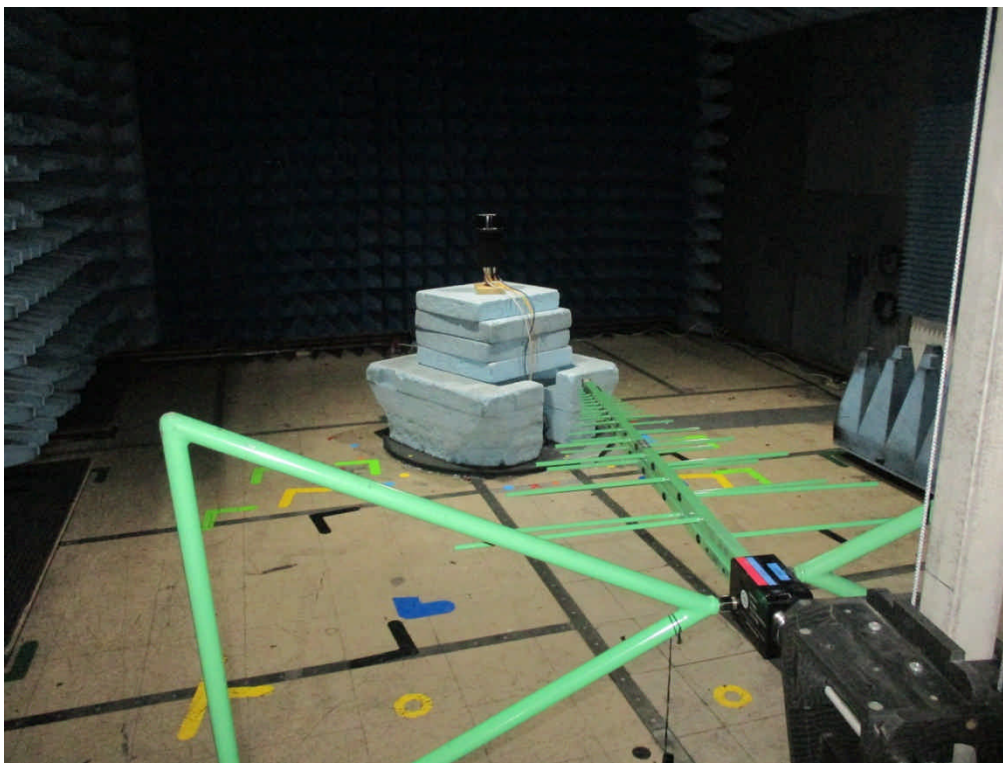
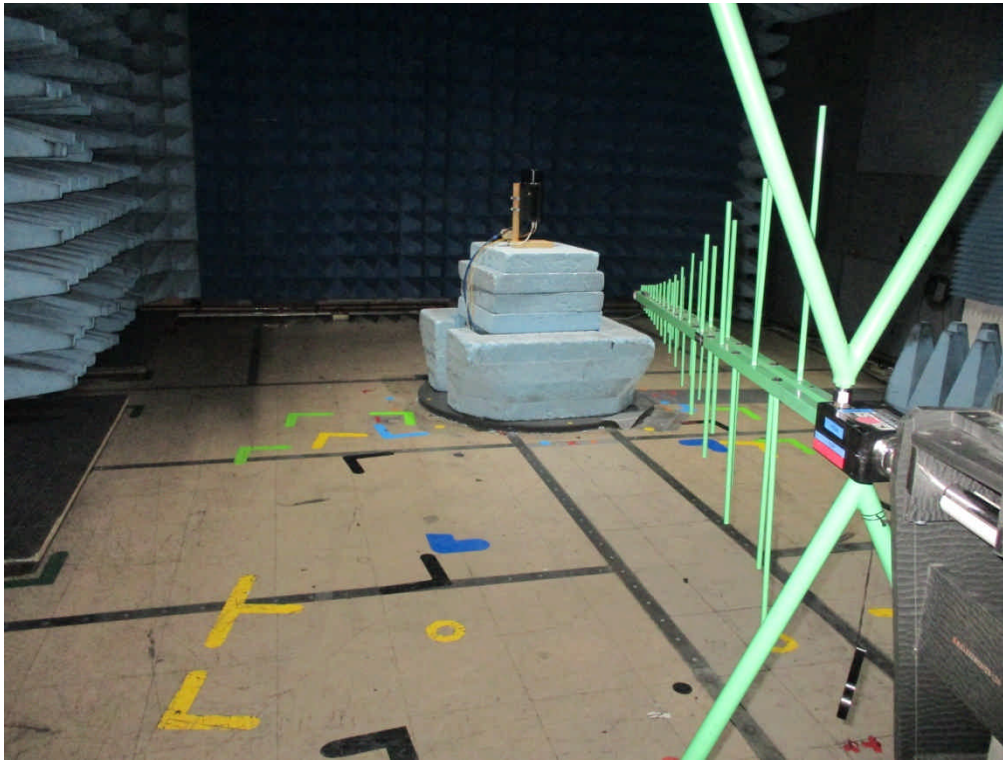
8.9 AC power line conducted emissions



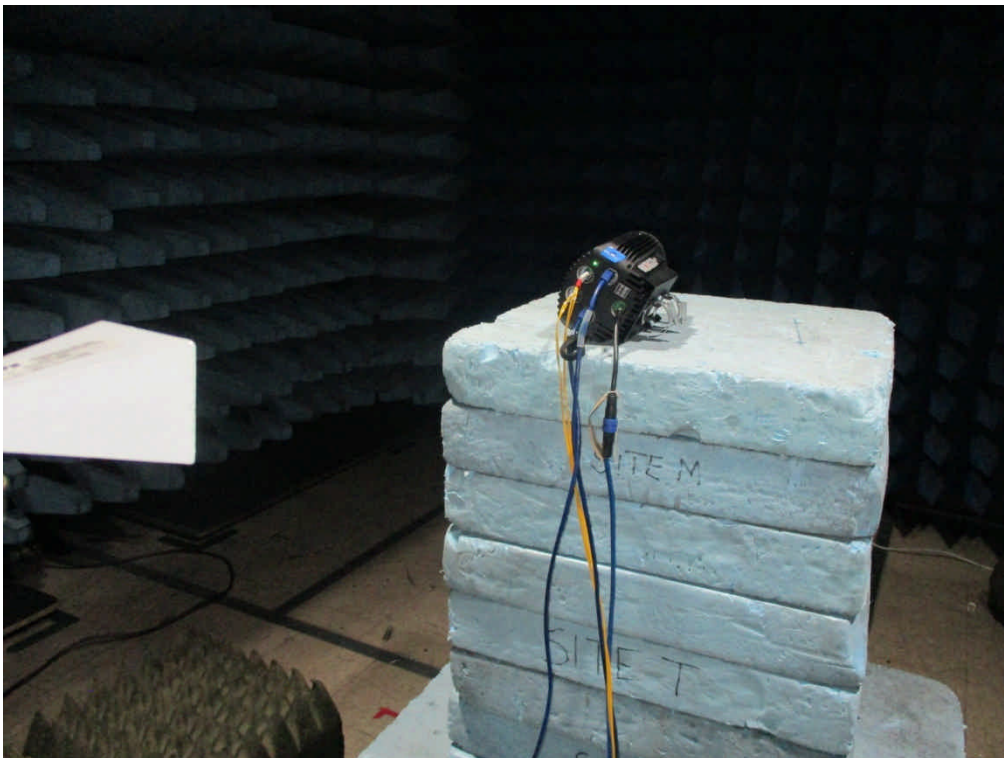
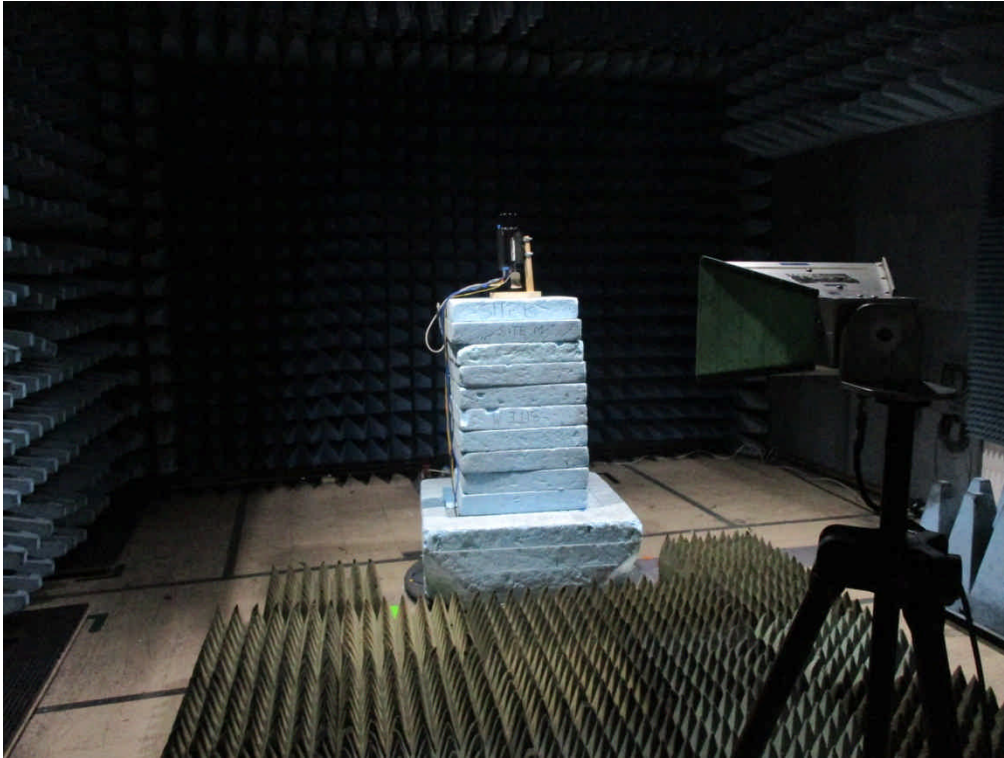
8.10 Radiated emissions 150k – 30 MHz

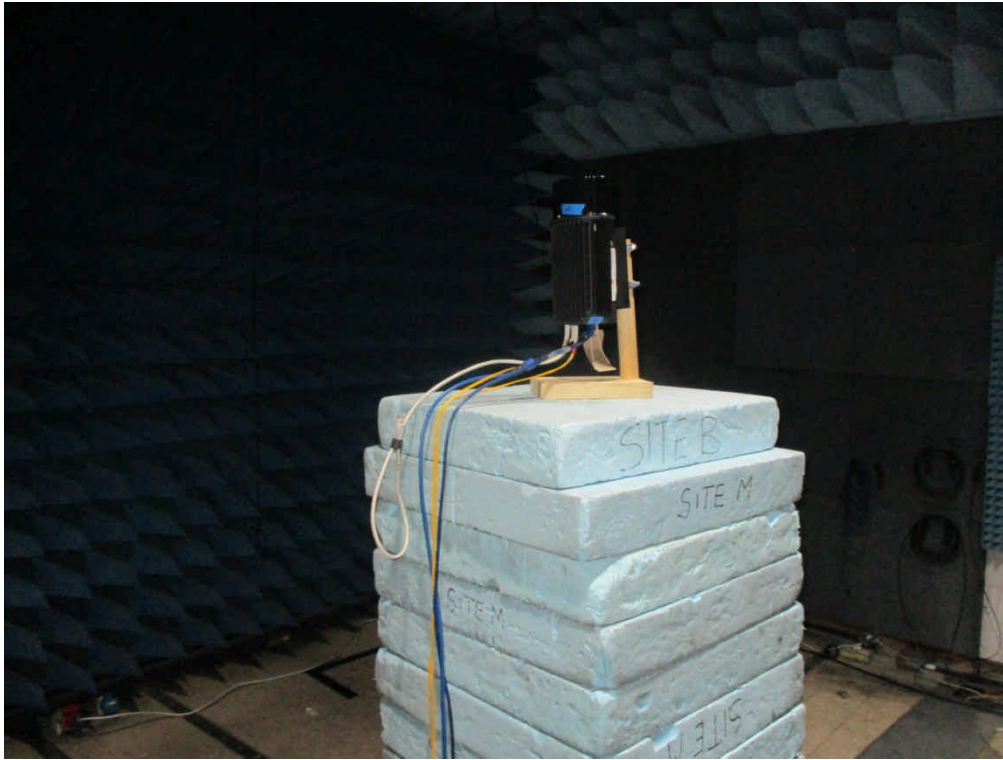


8.11 Radiated emissions 30 – 1000 MHz



8.12 Radiated emissions above 1GHz





8.13 Radiated emission diagrams

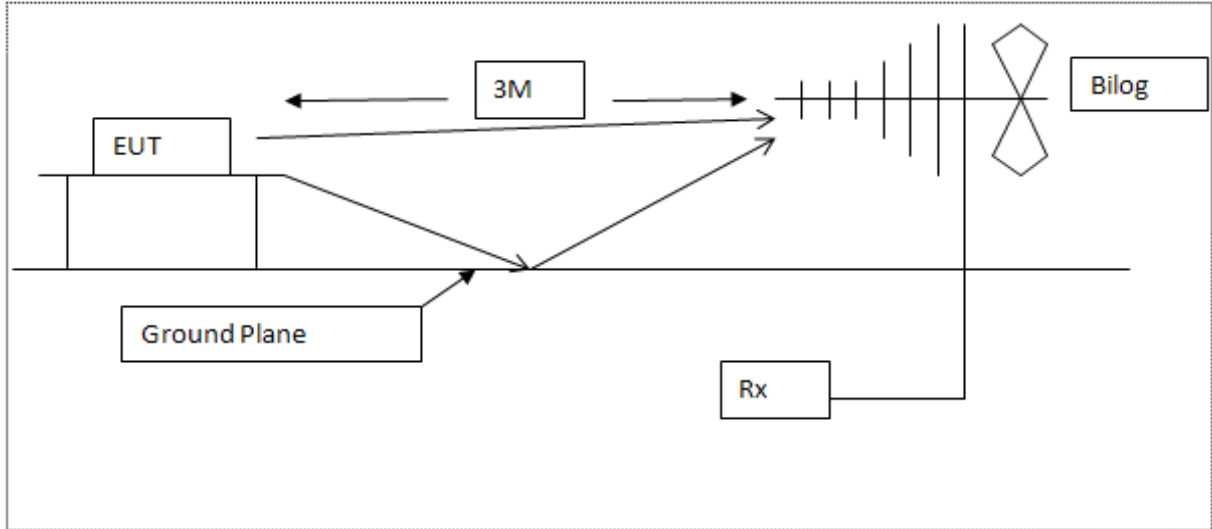


Diagram of the radiated emissions test setup 30 - 1000 MHz

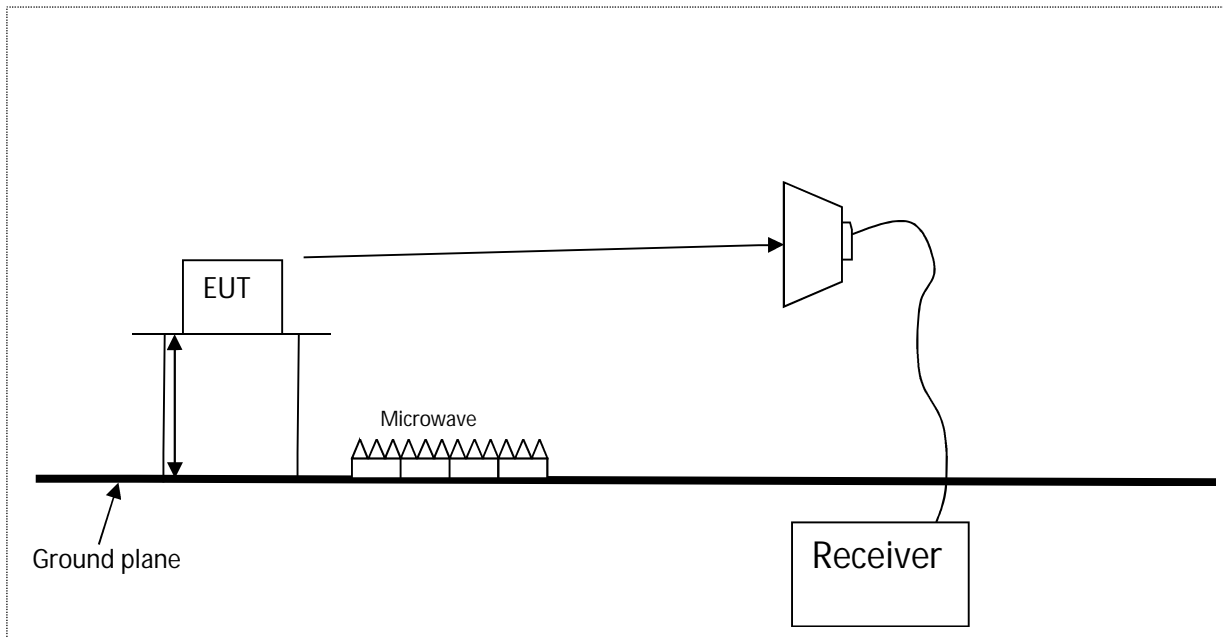


Diagram of the radiated emissions test setup above 1GHz

8.14 AC powerline conducted emission diagram

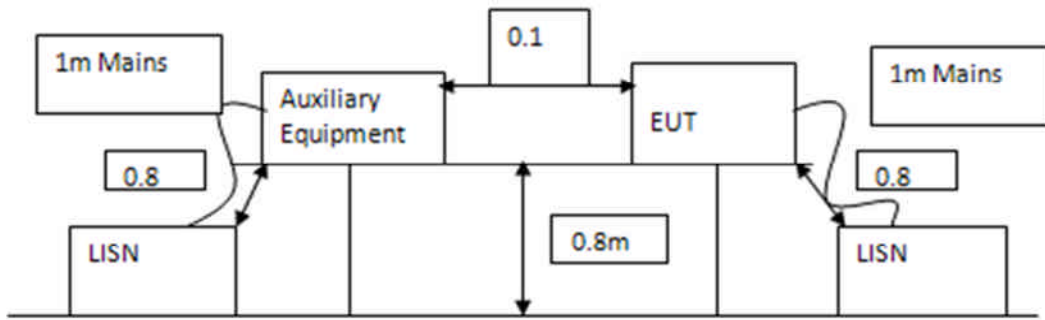


Diagram of the AC conducted emissions test setup

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
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

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
E465	PCR2000LA	AC Power Source 2kVA	Kikusui	HJ000995

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