Radio Test Report

Sports and Wellbeing Analytics
Protecht Single Charging Case
SCC001.1

47 CFR Part 15.209 Effective Date 1st October 2021
DCD: Part 15 Low Power Transmitter Below 1705 kHz
Test Date: 17th October 2022 to 4th January 2023
Report Number: 10-13860-1-22 Issue 01

The testing was carried out by RN Electronics Ltd, an independent test house, at their test facility located at:

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This laboratory is accredited in accordance with the recognised International Standard ISO/IEC 17025. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communiqué dated April 2017).

Arnolds Court, Arnolds Farm Lane, Mountnessing, Brentwood Essex, CM13 1UT

Certificate of Test 13860-1

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

Equipment:	Protecht Single Charging Case
Model Number:	SCC001.1
Unique Serial Number:	2620072
Applicant:	Sports and Wellbeing Analytics 3 New Mill Court Llys Felin Newydd Swansea Wales SA7 9FG
Proposed FCC ID	2AT9A-SCC001NA
Full measurement results are detailed in Report Number:	10-13860-1-22 Issue 01
Test Standards:	47 CFR Part 15.209 Effective Date 1st October 2021 DCD: Part 15 Low Power Transmitter Below 1705 kHz

NOTE:
Certain tests were not performed based upon applicant's declarations. Certain other requirements are subject to applicant's declaration only and have not been tested/verified. For details refer to section 3 of this report.

DEVIATIONS:
No deviations have been applied.

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

Date Of Test: 17th October 2022 to 4th January 2023

Test Engineer: Jack Chilvers
Digitally signed by: Jack Chilvers
DN: CN = Jack Chilvers email = Jack.Chilvers@kiwa.com C = GB O = RN Electronics OU = RN Electronics
Date: 2023.01.10 08:50:58 Z

Approved By:
Radio Manager
Digitally signed by: Daniel Sims
DN: CN = Daniel Sims C = GB O = RN Electronics Ltd
Date: 2023.01.10 08:37:18 Z

Customer Representative:

UKAS TESTING 2360

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Sports and Wellbeing Analytics 3 New Mill Court Llys Felin Newydd Swansea Wales SA7 9FG	
Manufacturer of EUT	Sports and Wellbeing Analytics Ltd	
Full Name of EUT	Protecht Single Charging Case	
Model Number of EUT	SCC001.1	
Serial Number of EUT	2620072	
Date Received	26th September 2022	
Date of Test:	17th October 2022 to 4th January 2023	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	6th January 2023	
Main Function	The single charging case main function is to charge instrumented mouth guards that are used in various applications, the main one being contact sport, to measure the accelerations experienced during collision events.	
Information Specification	Height	30 mm
	Width	85 mm
	Depth	120 mm
	Weight	0.12 kg
	Voltage	5 VDC
	Current	1 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Bench Top
Choice of model(s) for type tests	Production Sample
Antenna details	Integral Coil antenna
Antenna port	None
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2480 MHz (Generated by the device it charges, Bluetooth mouthguard)
Lowest Signal generated in EUT	Not Declared
Hardware Version (HVIN)	Not Declared
Software Version	V1.0
Firmware Version (FVIN)	Not Applicable
Type of Equipment	Fixed
Technology Type	WPT (wireless power transfer)
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	128 – 160 kHz
EUT Declared Modulation Parameters	ASK
EUT Declared Power level	1 Watt
EUT Declared Signal Bandwidths	Not Declared
EUT Declared Channel Spacing's	Single Channel
EUT Declared Duty Cycle	100%
Declared frequency stability	Not Declared
RX Parameters	
Alignment range – receiver	Not Declared
EUT Declared RX Signal Bandwidth	Not Declared
Receiver Signal Level (RSL)	Not Declared
Method of Monitoring Receiver BER	Not Declared
FCC/IC Class	
FCC/IC Class - SRD/Receiver Category	DCD: Part 15 Low Power Transmitter Below 1705 kHz

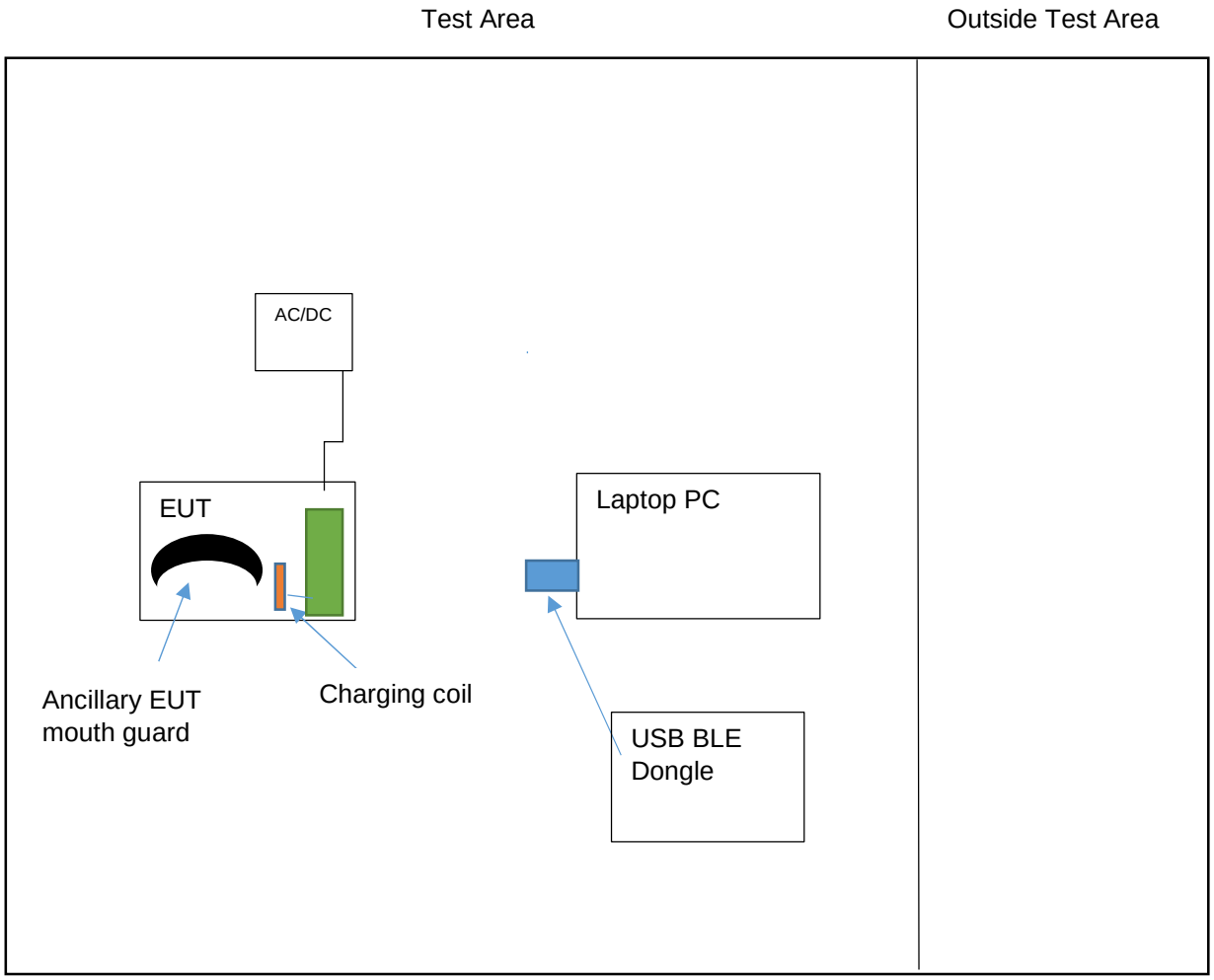
2.3 Functional description

The single charging case uses QI technology between two coils to wirelessly charge the mouth guard. One coil is connected to the charging circuit on the mouth guard PCB, whilst the other is connected to the charging circuit of the case. The coils must be aligned for the mouth guard to charge, and this is achieved by setting the mouth guard in place using adjustable plastic fixings. The two indicators that a guard is charging in the case is a green pulsing LED on the case, and a red LED that stays on located on the mouth guard. Time to full charge from flat is around four hours and there is no indicator when the guard is fully charged.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Charging position 1	Charging the ancillary mouthpiece via WPT, with the mouthpiece in a continuously talking mode to an ancillary laptop over BLE comms link. Charging frequency/Mouthguard position 1 @ 128kHz	Yes
Charging position 2	Charging the ancillary mouthpiece via WPT, with the mouthpiece in a continuously talking mode to an ancillary laptop over BLE comms link. Charging frequency/Mouthguard position 2 @ 145kHz	Yes
Charging position 3	Charging the ancillary mouthpiece via WPT, with the mouthpiece in a continuously talking mode to an ancillary laptop over BLE comms link. Charging frequency/Mouthguard position 3 @ 157kHz	Yes

2.5 Emissions configuration



The unit was powered from the dedicated AC/DC adapter. The EUT initially operated at 144 kHz but can change frequency within the band 128-160 kHz for better match and efficiency as per WTP protocols. The position of the device to be charged (mouthguard) can be slightly different and is dependent on the user placing the device in the WPT charger and aligning it correctly. Alignment of the device to be charged also affected the fundamental TX frequency of charging. Therefore, Pre scans were performed to determine any worst-case position, and the frequency range over which the unit could be charged at. Power level of the RF fundamental appeared to increase slightly as the fundamental frequency reduced. In practice the unit can be easily aligned, and the device incorporates an adjustable plastic fixing arm to pin the mouthguard to the charging coil so frequency is generally 145-155kHz. Alignment of the mouthguard inside the charger was quite critical to achieve WPT. The unit was tested in 3 orthogonal positions to maximise emissions. The AC/DC adapter was provided by the applicant for test as a typical “off-the-shelf” adapter.

The EUT had an ancillary mouth guard placed inside to allow for WPT (charging). The ancillary mouth guard is also a BLE device, and it was connected to an ancillary laptop that had a Bluetooth dongle plugged into it for communications during tests. The laptop had specialist software called Protecht philtronics that was running so data was constantly being transmitted between the laptop and ancillary mouth guard inside the EUT. The ancillary laptop and BLE dongle were located inside the test chamber for testing. Ancillary equipment used within this setup can be found in section 10 of this test report.

The range of fundamental frequencies found dependent on mouthguard position/alignment was 128 – 157 kHz. Pre-scans/Tests were therefore performed 3 times to ensure at each of these charging frequencies any worst-case emissions could be found on the frequencies below:

128 kHz Mouthguard charge position 1
145 kHz Mouthguard charge position 2
157 kHz Mouthguard charge position 3

Please see photos later in report for Mouthguard charging position reference.

2.5.1 Signal leads

Port Name	Cable Type	Connected
USB mini-B	USB	Yes

3 Summary of test results

The Protecht Single Charging Case, SCC001.1 was tested for compliance to the following standard(s):

47 CFR Part 15.209 Effective Date 1st October 2021
DCD: Part 15 Low Power Transmitter Below 1705 kHz

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 & 15.33(a)	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209 & 15.33(a)	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209 & 15.33(a)	PASSED
6. Intentional radiator field strength	47 CFR Part 15C Part 15.209	PASSED
7. Band edge compliance	47 CFR Part 15C Part 15.205	PASSED[1]
8. Occupied bandwidth	47 CFR Part 15C Part 15.215(c)	PASSED
9. Duty Cycle	47 CFR Part 15C Part 15.35	NOT APPLICABLE[2]

[1] The fundamental emission is contained within the range 110-490kHz and has been tested in line with the requirements of 15.205 and 15.209 under the Radiated emissions tests for the applicable frequency range within this report.

[2] EUT Duty cycle was confirmed as operating at 100% constant transmit state for tests.

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	2021	Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES
4.1.2	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
4.1.3	ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

4.2 Deviations

No deviations were applied

5 Tests, methods and results

5.1 AC power line conducted emissions

5.1.1 Test methods

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

5.1.2 Configuration of EUT

The EUT was placed on a wooden table 0.8m above the ground plane and connected to a LISN via a 1m screened extension lead which had an ancillary AC/DC adaptor supplied by the customer connected.

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

No discernible difference in emissions was observed between modes/frequencies, therefore, Mode charging 2 was used for tests.

5.1.3 Test procedure

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

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	110-490 kHz
Power Level declared	1 Watt
Mod Scheme	CW, WPT
Single channel	145 kHz

Plot refs
13860-1 Cond 1 AC Live 150k-30M Average
13860-1 Cond 1 AC Live 150k-30M Quasi-Peak
13860-1 Cond 1 AC Neutral 150k-30M Average
13860-1 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	0.159	40.5	38.8	-26.7	35.3	-20.2
2	0.317	32.9	31.9	-27.9	30.0	-19.8
3	0.477	34.6	32.5	-23.9	26.5	-19.9
4	0.632	37.7	36.8	-19.2	35.7	-10.3
5	0.949	39.3	38.3	-17.7	37.0	-9.0
6	1.265	39.1	38.5	-17.5	37.4	-8.6
7	1.581	39.4	38.0	-18.0	36.3	-9.7
8	1.897	39.1	37.7	-18.3	36.4	-9.6
9	2.213	39.9	37.9	-18.1	36.6	-9.4
10	2.529	40.2	37.8	-18.2	36.5	-9.5
11	2.844	39.7	38.1	-17.9	36.3	-9.7
12	3.161	39.9	38.3	-17.7	36.4	-9.6
13	3.478	39.9	38.7	-17.3	36.8	-9.2
14	3.794	40.8	39.3	-16.7	37.5	-8.5
15	4.110	41.6	40.2	-15.8	37.8	-8.2
16	4.426	42.0	40.3	-15.7	38.9	-7.1
17	4.742	42.1	40.6	-15.4	39.4	-6.6
18	5.057	41.8	40.7	-19.3	39.3	-10.7
19	5.374	41.4	40.6	-19.4	39.7	-10.3
20	5.690	41.0	40.4	-19.6	39.0	-11.0
21	11.541	14.9	10.4	-49.6	34.6	-15.4
22	11.857	40.7	40.4	-19.6	39.3	-10.7
23	12.173	41.0	40.6	-19.4	39.5	-10.5
24	12.491	41.0	40.7	-19.3	39.3	-10.7
25	12.806	40.9	40.7	-19.3	39.4	-10.6
26	13.121	40.8	40.5	-19.5	39.1	-10.9
27	13.441	40.6	40.0	-20.0	36.8	-13.2
28	17.544	33.3	32.3	-27.7	29.3	-20.7
29	18.499	34.3	33.5	-26.5	30.5	-19.5
30	19.129	34.6	33.1	-26.9	31.1	-18.9
31	21.031	35.9	35.0	-25.0	32.4	-17.6
32	21.660	36.6	35.7	-24.3	33.0	-17.0

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	0.150	37.1	31.8	-34.2	23.2	-32.8
2	0.482	38.4	36.5	-19.8	29.9	-16.4
3	0.486	38.5	36.8	-19.4	30.1	-16.1
4	0.821	28.0	24.9	-31.1	17.2	-28.8
5	3.987	32.7	29.9	-26.1	19.9	-26.1
6	3.987	33.3	30.2	-25.8	19.9	-26.1
7	8.752	23.2	20.4	-39.6	16.7	-33.3
8	10.344	24.1	22.3	-37.7	19.9	-30.1

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line can be found in Section 6 of this report. Only results within 20dB of limits are reported.

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:

UE70 9kHz to 150kHz ±3.76dB, UE71 150kHz to 30MHz ±3.4dB

5.2 Radiated emissions 9 - 150 kHz

5.2.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 & 15.33(a) [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]

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. The EUT was operated in Charging mode 1, 2 and 3.

5.2.3 Test procedure

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

Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst-case emissions.

All signals within 20dB of the limit were investigated.

Tests were performed using Test Site M and OATS.

5.2.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

5.2.5 Test results

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

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

Plot refs
13860-1 Rad 1 9k-150kHz Para
13860-1 Rad 1 9k-150kHz Perp

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	128 kHz

Plot refs
13860-1 Rad 2 9k-150kHz Para
13860-1 Rad 2 9k-150kHz Perp

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	157 kHz

Plot refs
13860-1 Rad 3 9k-150kHz Para
13860-1 Rad 3 9k-150kHz Perp

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line can be found in Section 6 of this report. No signals found within 20dB of limits.

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

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 & 15.33(a) [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 EUT was rotated in all three orthogonal planes. The EUT was operated in The EUT was operated in Charging mode 1, 2 and 3.

5.3.3 Test procedure

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

Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst-case emissions.

All signals within 20dB of the limit were investigated.

Tests were performed using Test Site M and OATS.

5.3.4 Test equipment

TMS81, ZSW1, E624, E411, E412

See Section 9 for more details

5.3.5 Test results

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

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

Plot refs
13860-1 Rad 1 150k-30MHz Para
13860-1 Rad 1 150k-30MHz Perp

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	128 kHz

Plot refs
13860-1 Rad 2 150k-30MHz Para
13860-1 Rad 2 150k-30MHz Perp

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	157 kHz

Plot refs
13860-1 Rad 3 150k-30MHz Para
13860-1 Rad 3 150k-30MHz Perp

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line can be found in Section 6 of this report. No signals found within 20dB of limits

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 15.209 [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Clause 15.209 [Reference 4.1.1 of this report]

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. No discernible difference was noted in emissions between modes, therefore the EUT was operated in Charging mode 1 for full test.

5.4.3 Test procedure

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

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.

All signals within 20dB of the limit were investigated.

Tests were performed using Test Site M.

5.4.4 Test equipment

LPE364, E743, NSA-M, ZSW1, E624, E411, E412

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	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

Plot refs
13860-1 Rad 1 VHF Horiz
13860-1 Rad 1 VHF Vert
13860-1 Rad 1 UHF Horiz
13860-1 Rad 1 UHF Vert

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line can be found in Section 6 of this report. No signals found within 20dB of limits.

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:

30MHz - 1000MHz ±6.1dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 & 15.33(a) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.6 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]

5.5.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. No discernible difference was noted in emissions between modes, therefore the EUT was operated in Charging mode 1 for full test.

5.5.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. The EUT was raised, and antenna was placed 1.5m above the ground in line with the EUT, which was rotated through 360 degrees to record the worst-case emissions. A measurement distance of 3m was used between the test range 1GHz - 6GHz, 1.2m was used in the test range 6-18GHz and 0.3m was used in the test range 18-25GHz.

5.5.4 Test equipment

E136, TMS82, VSWR-M, ZSW1, E624, E411, E412, TMS78, TMS79, E429

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	110-490 kHz
Power Level	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

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
No signals within 20dB.						

Plots
13860-1 Rad 1 1-2GHz Vert
13860-1 Rad 1 1-2GHz Horiz
13860-1 Rad 1 2-5GHz Vert
13860-1 Rad 1 2-5GHz Horiz
13860-1 Rad 1 5-6GHz Vert
13860-1 Rad 1 5-6GHz Horiz
13860-1 Vert 6-7.77 G Flat
13860-1 Horiz 6-7.77 G Flat
13860-1 Vert 7.77-11 G Flat
13860-1 Horiz 7.77-11 G Flat
13860-1 Vert 11-12.5 G Flat
13860-1 Horiz 11-12.5 G Flat
13860-1 Rad 1 12-15GHz Vert
13860-1 Rad 1 12-15GHz Horiz
13860-1 Rad 1 15-18GHz Vert

13860-1 Rad 1 15-18GHz Horiz
13860-1 Rad 1 18-22GHz Vert
13860-1 Rad 1 18-22GHz Horiz
13860-1 Rad 1 22-25GHz Vert
13860-1 Rad 1 22-25GHz Horiz

Peak detector “Max held” Analyser plots against the Average limit line can be found in Section 6 of this report. No emissions were observed within 20dB of limits.

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:

1 – 18 GHz ±3.5dB, 18 – 25 GHz ±3.9dB

5.6 Intentional radiator field strength

5.6.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.5/6.6 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.209 & 15.35 [Reference 4.1.1 of this report]

5.6.2 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 scanned 1-4m in height in both Horizontal and Vertical polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in Charging mode 1, 2 and 3.

5.6.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made on an OATS. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees and emissions maximised to record the worst-case emissions.

Measurements were made at Site M and OATS.

5.6.4 Test equipment

E412, E642, E856, TMS81

See Section 9 for more details

5.6.5 Test results

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

Note: Per 15.31 (f)(2) At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations. Results have been extrapolated back to 300m by using the square of an inverse linear distance extrapolation factor (40 dB/decade). Measurement has been performed at 3m distance so two decades to 300m = 80dB.

Band	110-490 kHz
Power Level	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

	Single channel
Measured Peak Level (dBuV/m) @3m	80.6
Extrapolated Peak Level (dBµV/m) @ 300m	0.6
Margin to 300m limit (dB)	-23.8
Plot reference	J13860-1 147kHz OATS field strength 3m
Antenna Polarisation	Perp
EUT Polarisation	Flat

Band	110-490 kHz
Power Level	1 Watt
Mod Scheme	WPT
Single channel	128 kHz

	Single channel
Measured Peak Level (dBuV/m) @3m	83.8

Extrapolated Peak Level (dBµV/m) @ 300m	3.8
Margin to 300m limit (dB)	-21.7
Plot reference	J13860-1 128kHz OATS field strength 3m
Antenna Polarisation	Perp
EUT Polarisation	Flat

Band	110-490 kHz
Power Level	1 Watt
Mod Scheme	WPT
Single channel	157 kHz

	Single channel
Measured Peak Level (dBuV/m) @3m	79.5
Extrapolated Peak Level (dBµV/m) @ 300m	-0.5
Margin to 300m limit (dB)	-24.2
Plot reference	J13860-1 156kHz OATS field strength 3m
Antenna Polarisation	Perp
EUT Polarisation	Flat

Analyser plots can be found in Section 6 of this report. Highest field strength was found in the parallel Measuring antenna position.

LIMITS:
Fc = 145 kHz. 15.209 gives a limit of 2400/fc(kHz) in uV/m @ 300m. This equates to 24.4 dBuV/m @ 300 metres. Fc = 128 kHz. 15.209 gives a limit of 2400/fc(kHz) in uV/m @ 300m. This equates to 25.5 dBuV/m @ 300 metres. Fc = 157 kHz. 15.209 gives a limit of 2400/fc(kHz) in uV/m @ 300m. This equates to 23.7 dBuV/m @ 300 metres.

These results show that the EUT has PASSED this test.

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

5.7 Band edge compliance

The fundamental emission is contained within the range 110-490kHz and has been tested in line with the requirements of 15.205 and 15.209 under the Radiated emissions tests for the applicable frequency range within this report.

5.8 Occupied bandwidth

5.8.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.215(c) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.9 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.215(c) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was 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 operated in Charging mode 1, 2 and 3.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 200Hz RBW, 3x VBW, 2.5kHz span, auto sweep time and max hold settings were used for the 20 dB bandwidth. Tests were performed using Test Site M.

5.8.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

5.8.5 Test results

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

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	145 kHz

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	0.524
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	13860-1 20dB BW @ 147kHz, 2.5k span

FLOW Worst case (kHz)	147.170985
FHIGH Worst case (kHz)	147.695036

Band	110-490 kHz
Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	128 kHz

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	0.464
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	13860-1 20dB BW @ 128kHz, 2.5k span

FLOW Worst case (kHz)	127.858686
FHIGH Worst case (kHz)	128.322916

Band	110-490 kHz

Power Level Declared	1 Watt
Mod Scheme	WPT
Single channel	157 kHz

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	0.494
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	13860-1 20dB BW @ 157kHz, 2.5k span

FLOW Worst case (kHz)	156.841747
FHIGH Worst case (kHz)	157.335887

Analyser plots for the 20 dB bandwidth can be found in Section 6 of this report.

LIMITS:
15.215(c) it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

These results show that the EUT has PASSED this test.

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

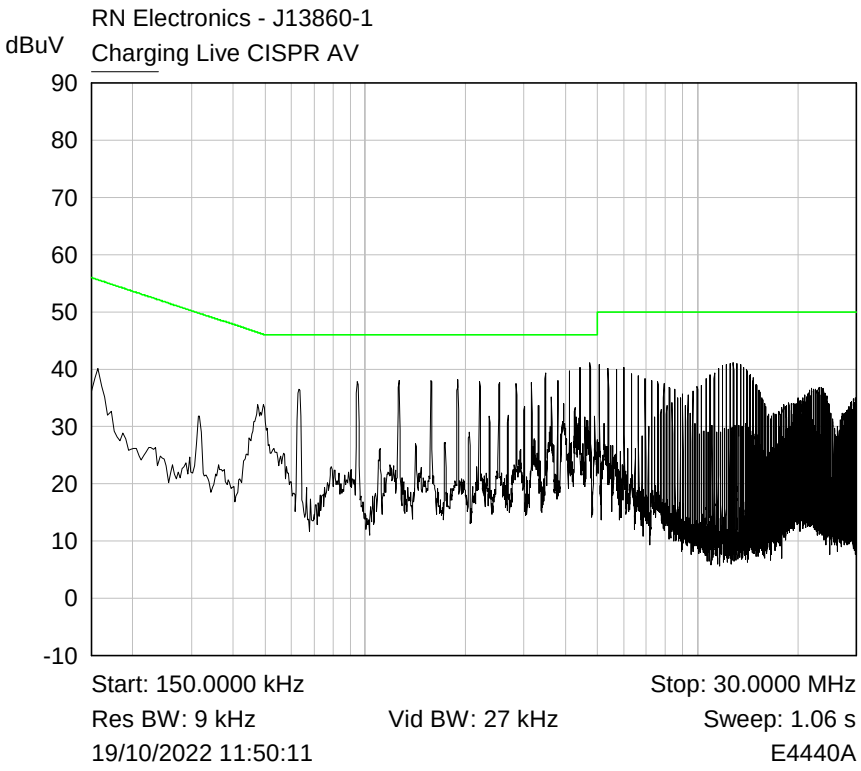
5.9 Duty Cycle

NOT APPLICABLE: EUT Duty was confirmed as operating at 100% constant transmit state for tests.

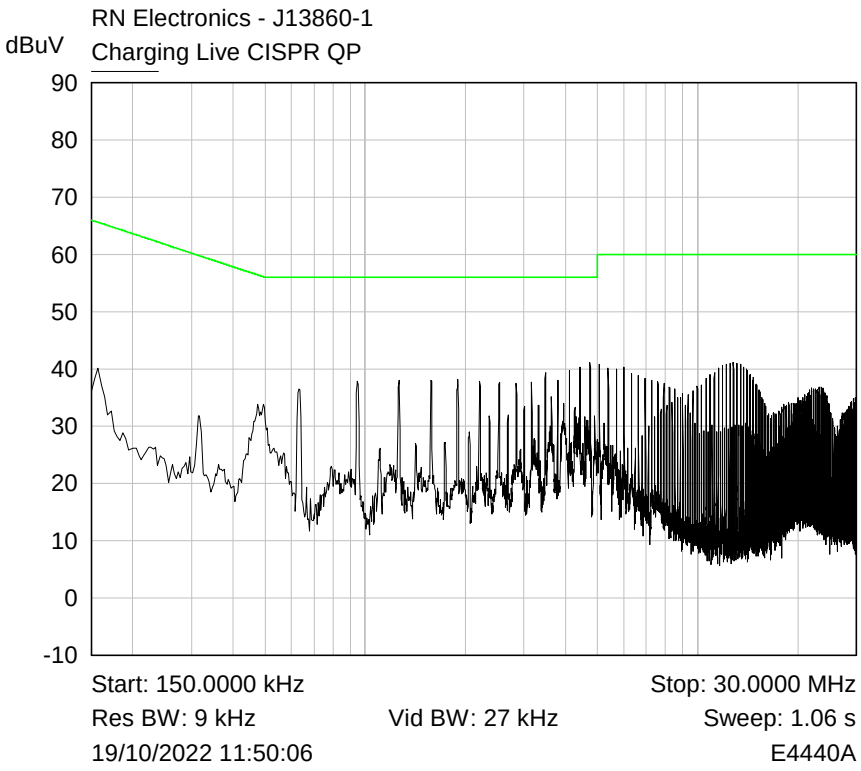
6 Plots/Graphical results

6.1 AC power line conducted emissions

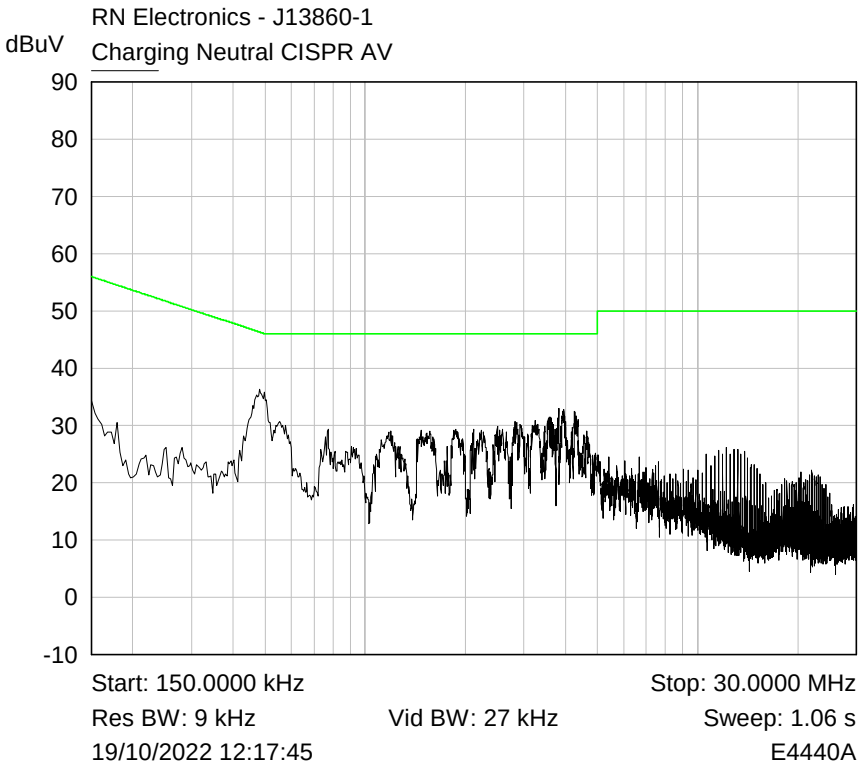
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation CW (WPT), Channel 145 kHz



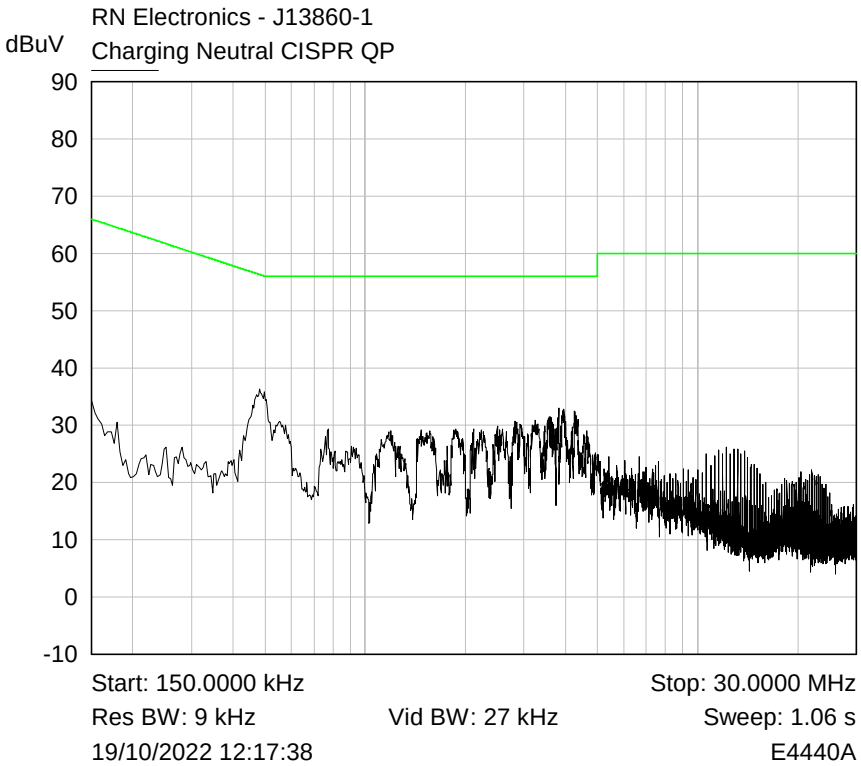
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



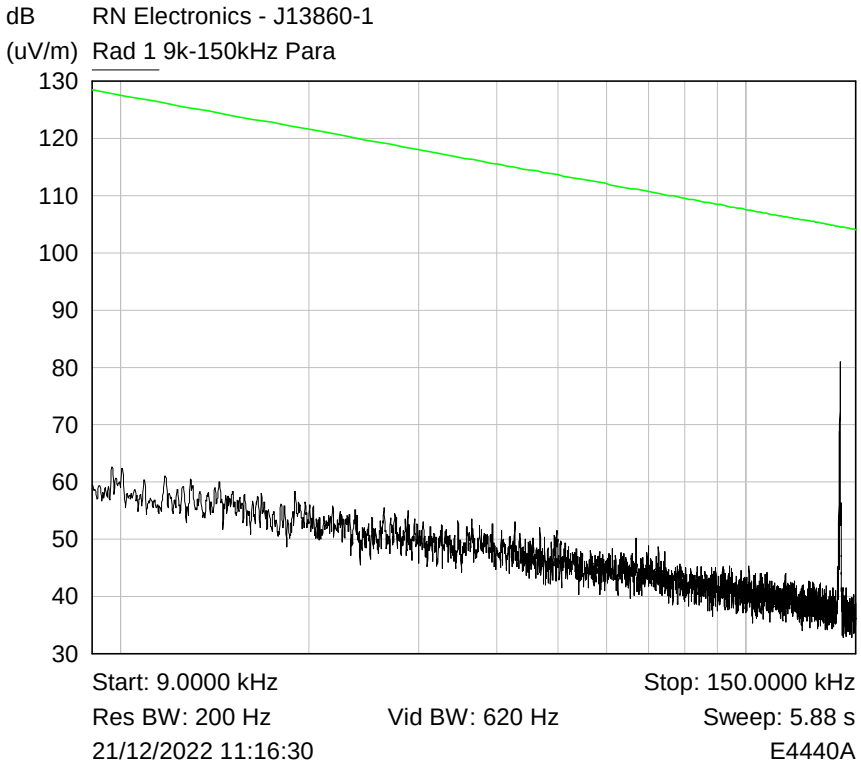
Plot of Neutral150k-30M Average



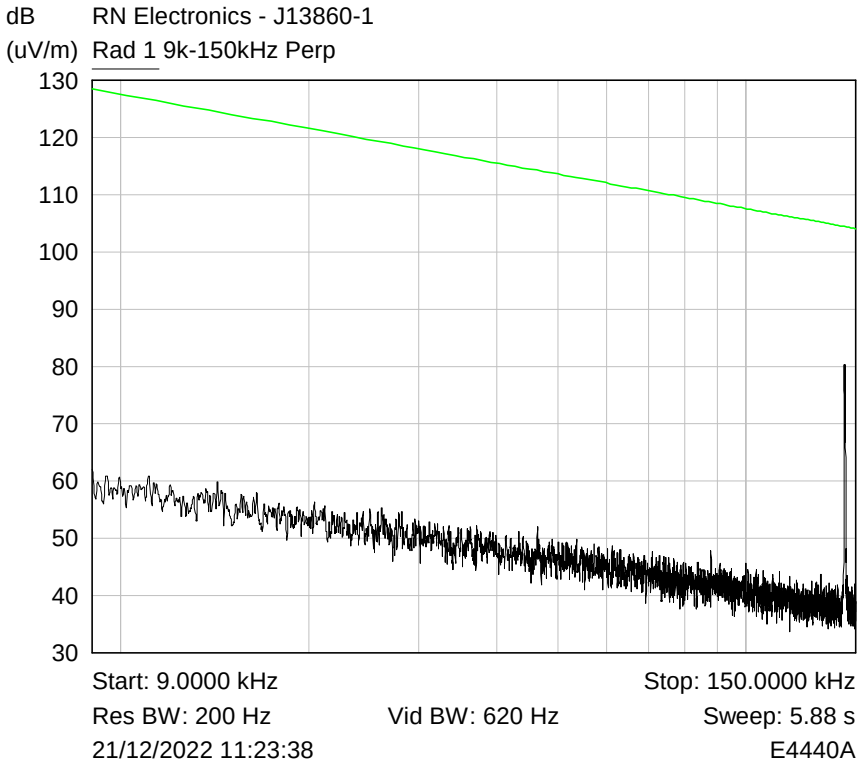
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz

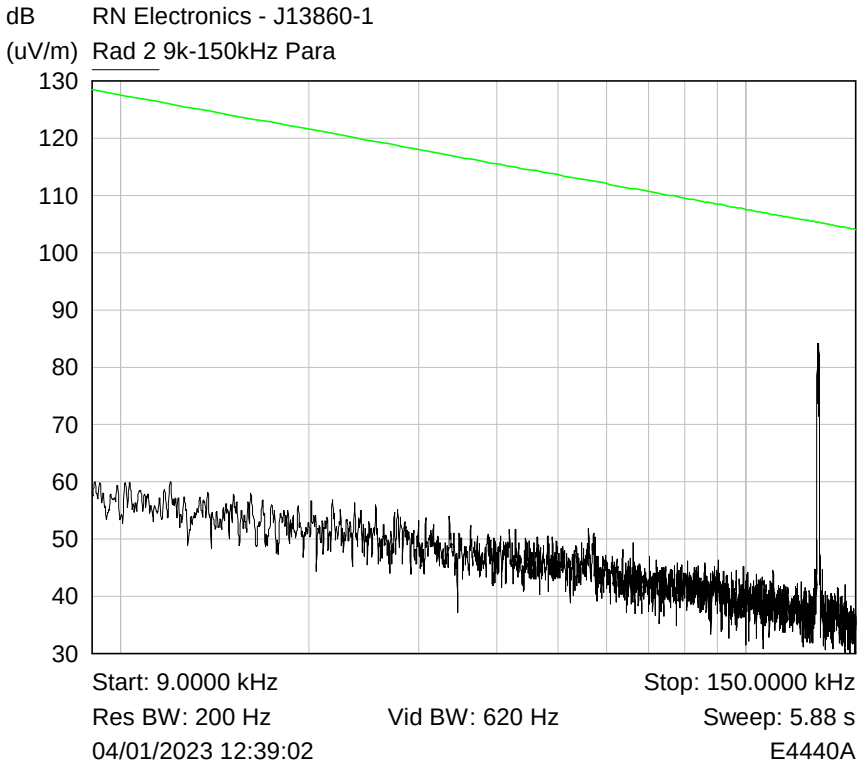


Plot of 9k-150kHz Parallel

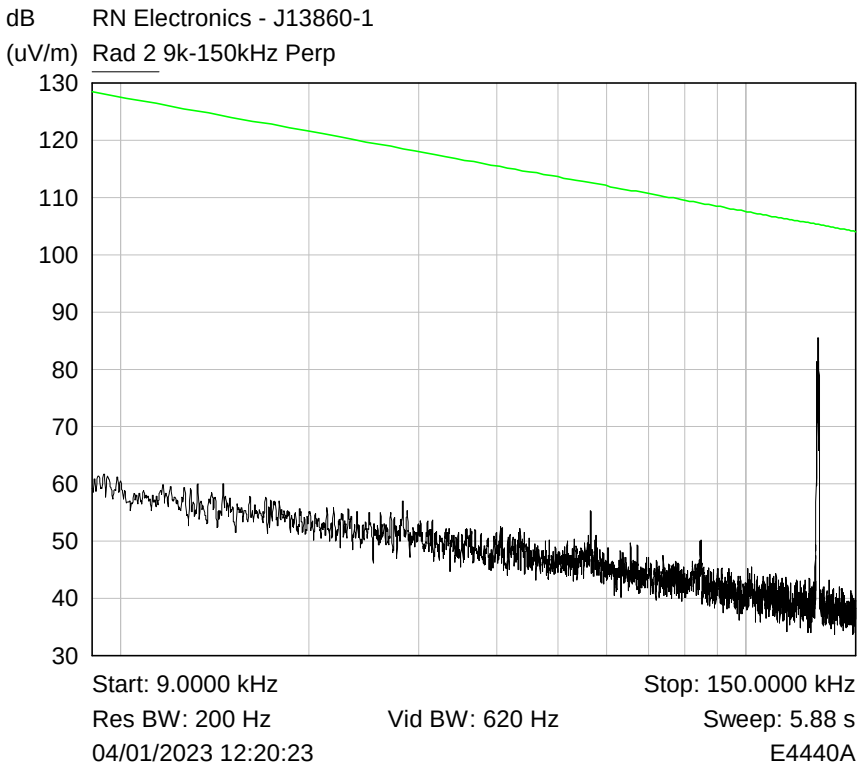


Plot of 9k-150kHz Perpendicular

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 128 kHz

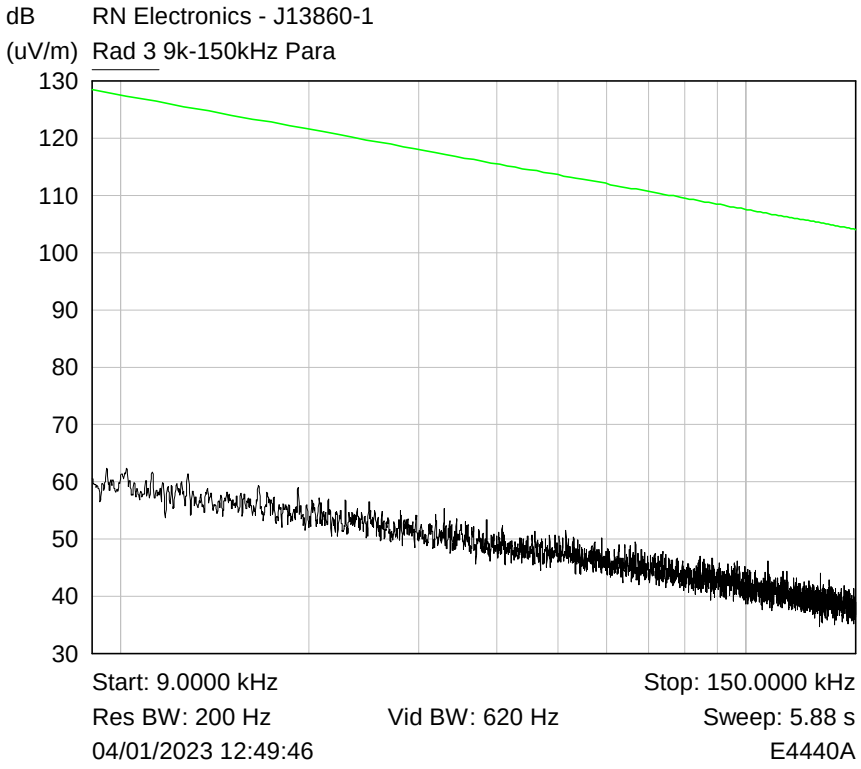


Plot of 9k-150kHz Parallel

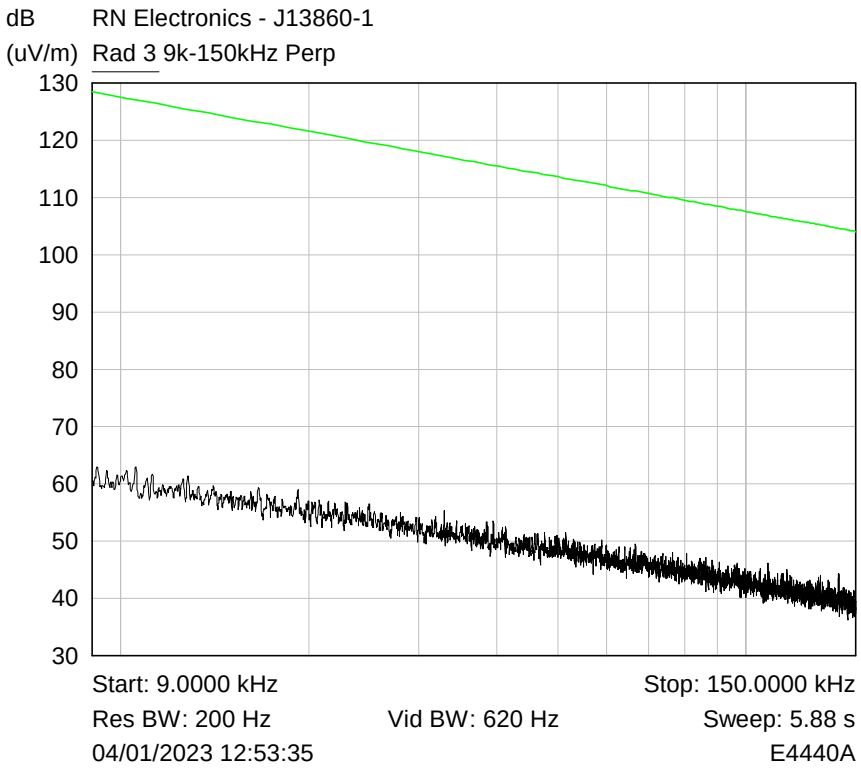


Plot of 9k-150kHz Perpendicular

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 157 kHz



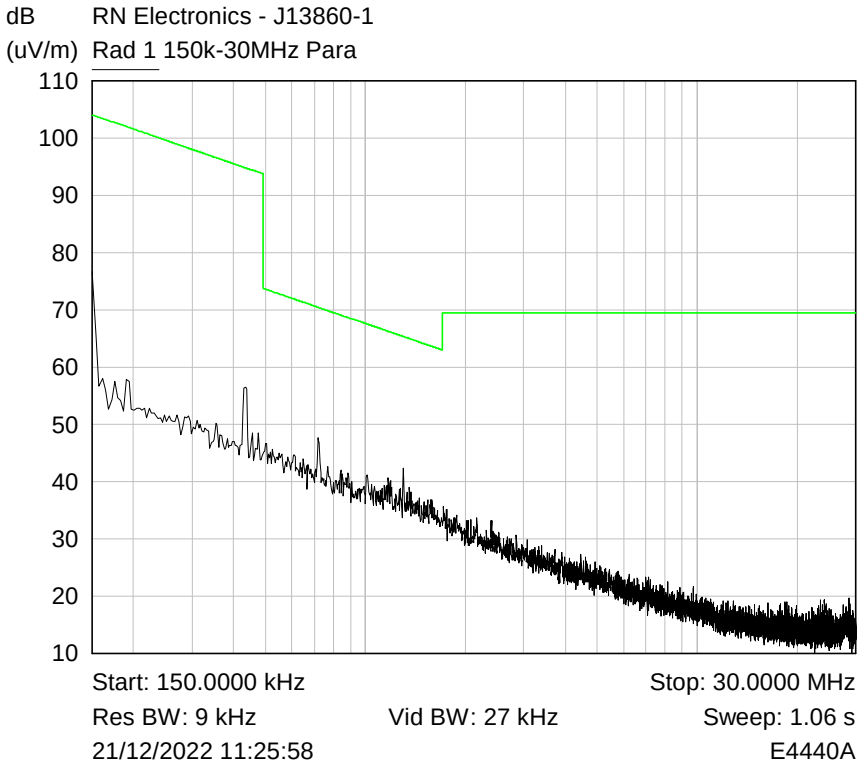
Plot of 9k-150kHz Parallel



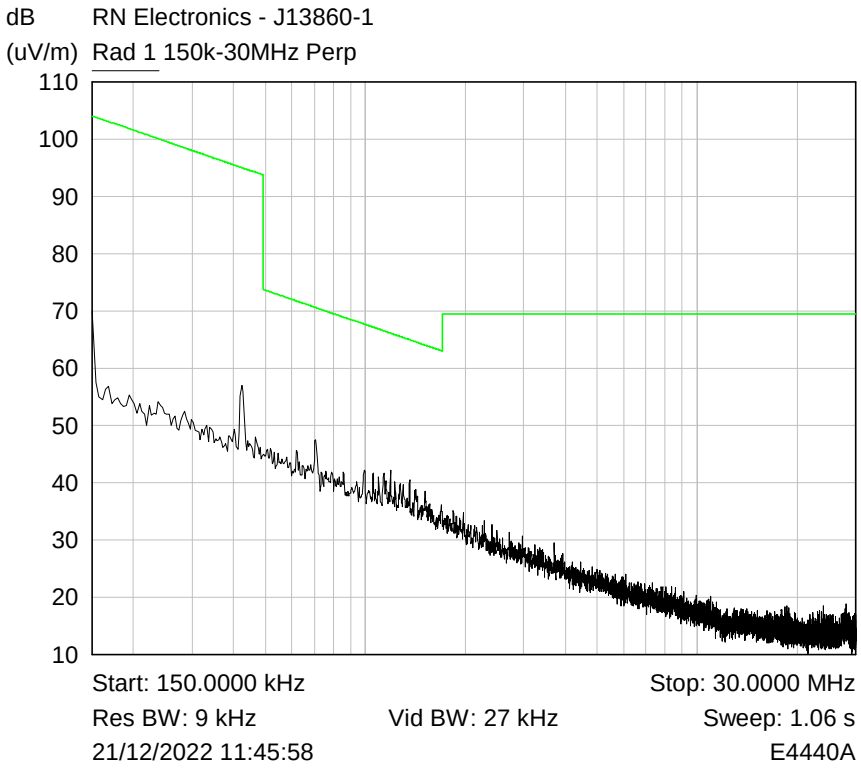
Plot of 9k-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz

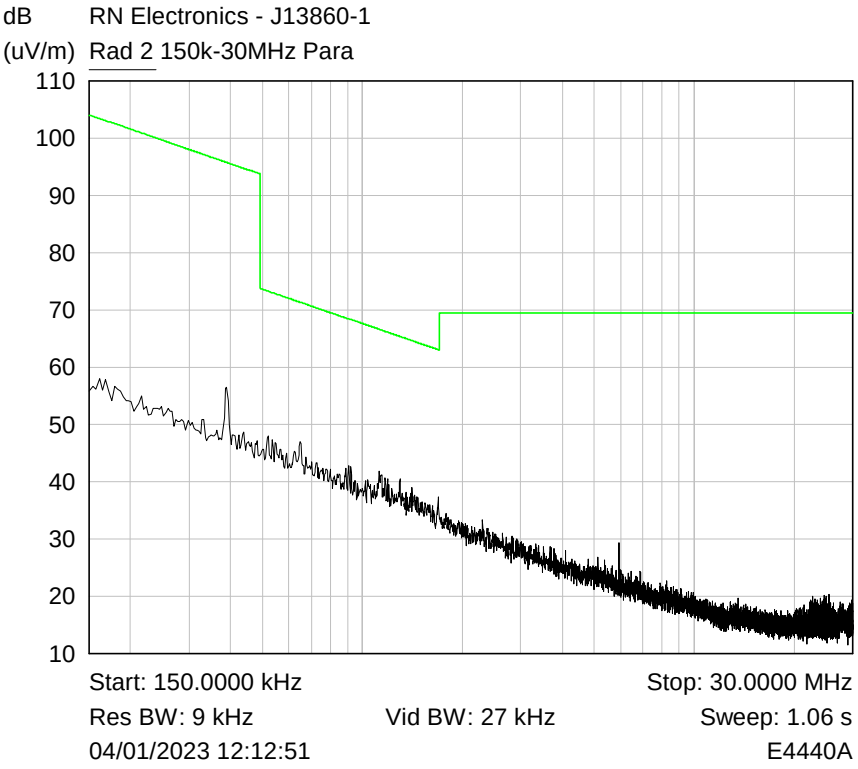


Plot of 150kHz-30MHz Parallel

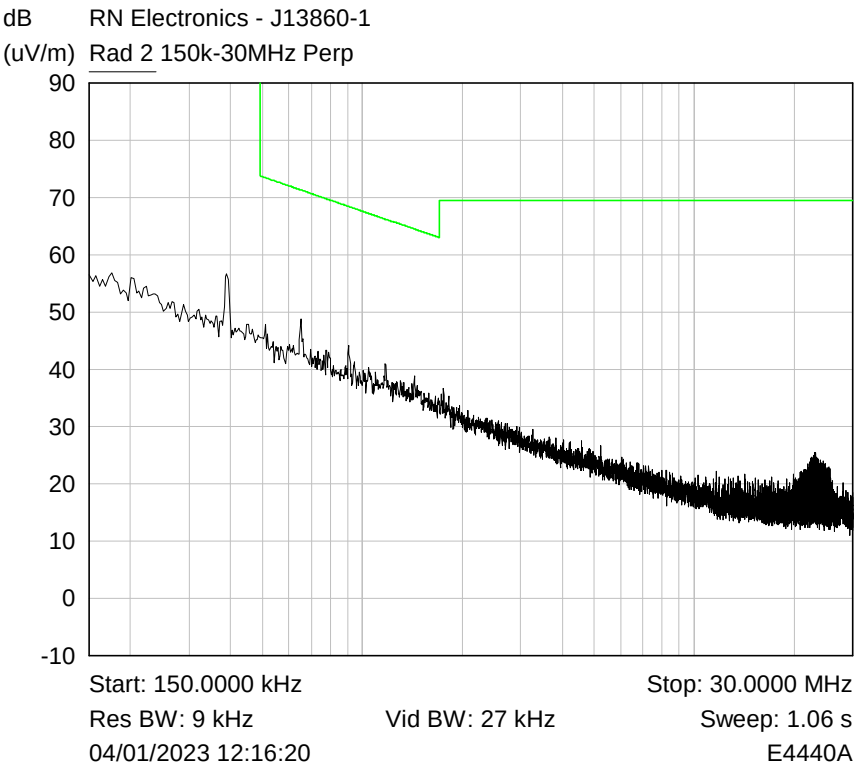


Plot of 150kHz-30MHz Perpendicular

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 128 kHz

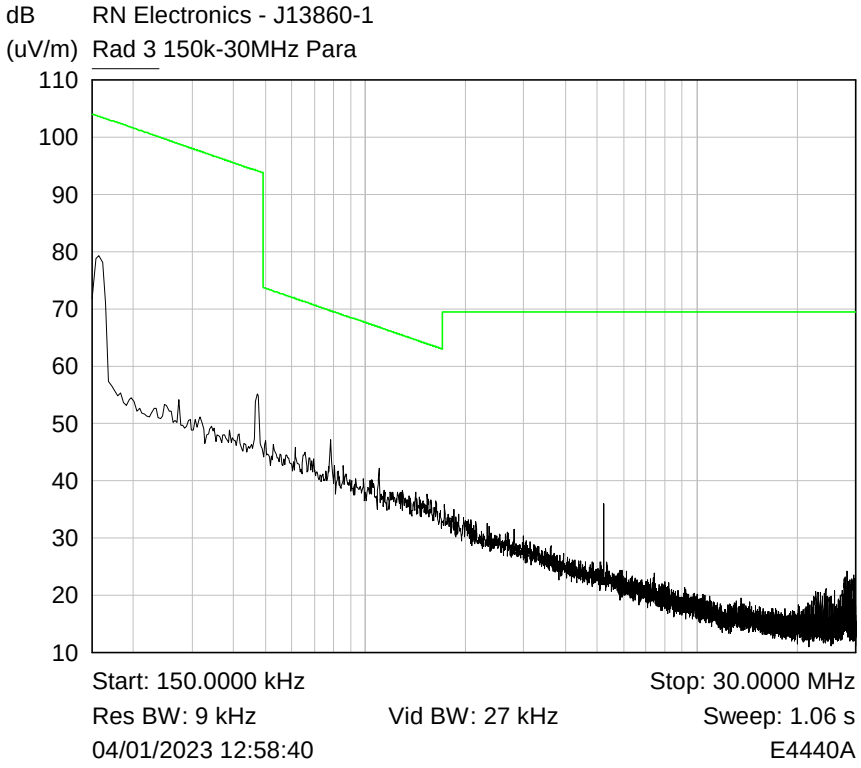


Plot of 150kHz-30MHz Parallel

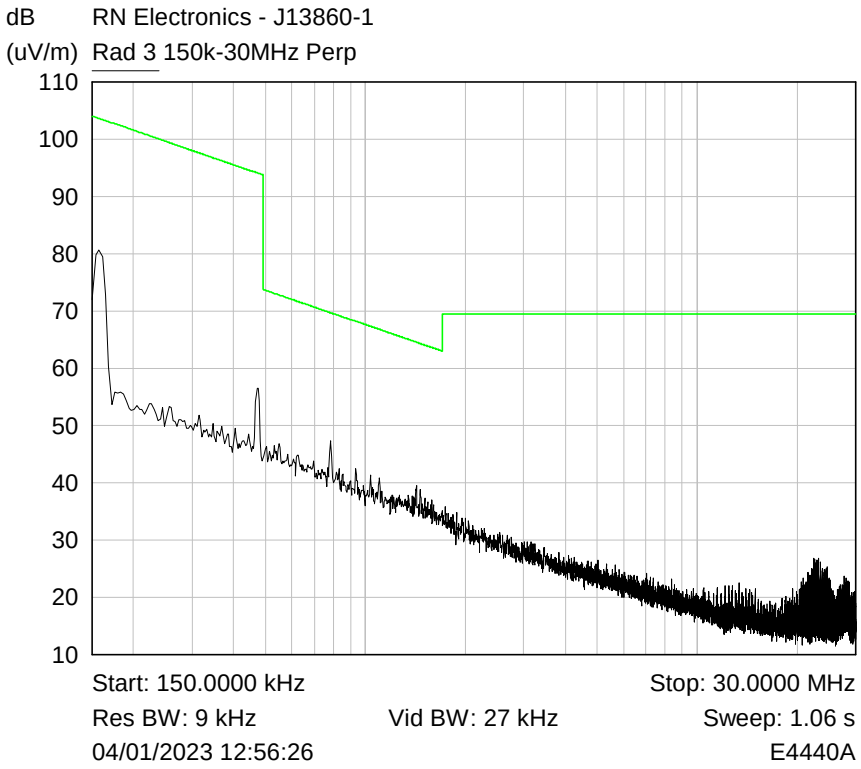


Plot of 150kHz-30MHz Perpendicular

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 157 kHz



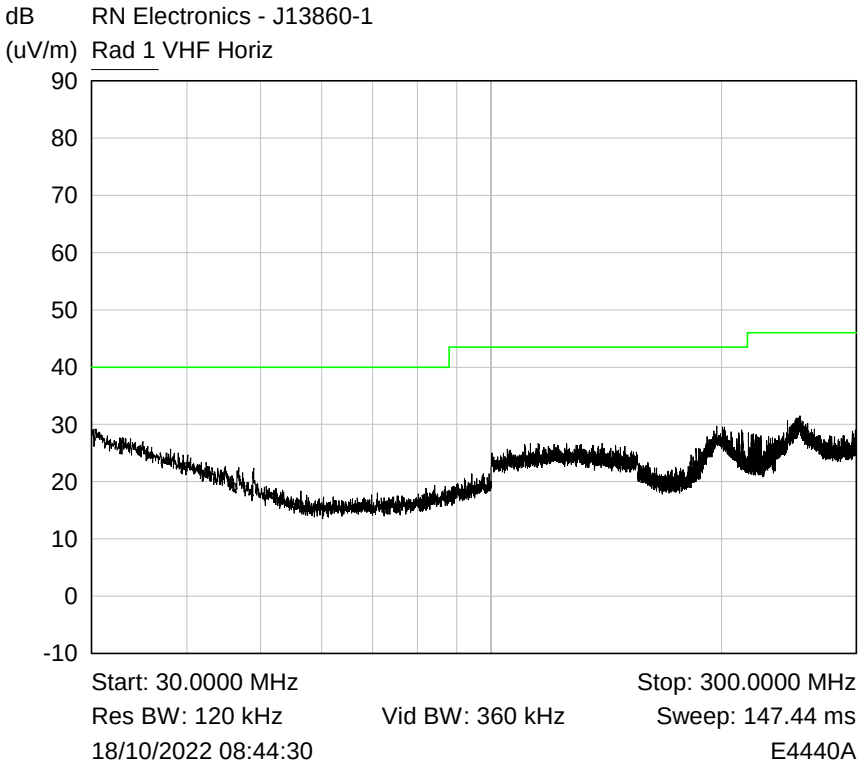
Plot of 150kHz-30MHz Parallel



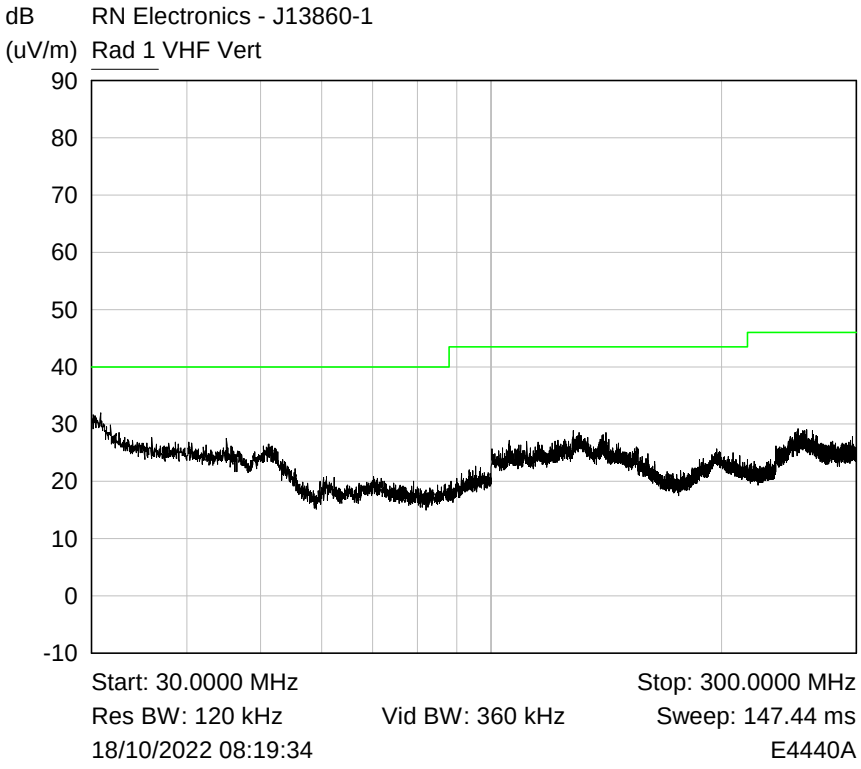
Plot of 150kHz-30MHz Perpendicular

6.4 Radiated emissions 30 MHz -1 GHz

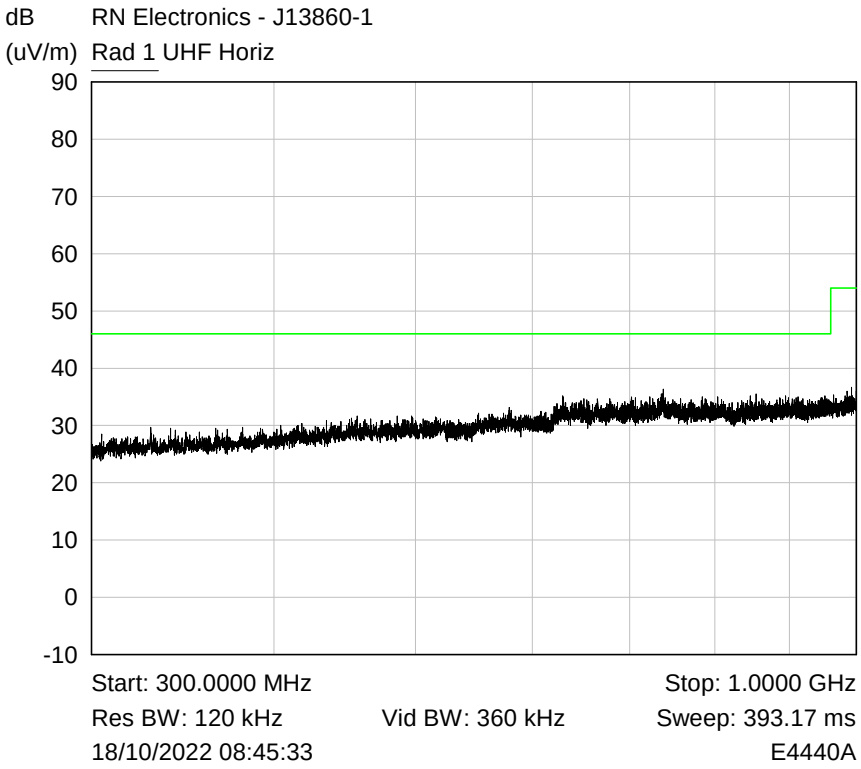
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz



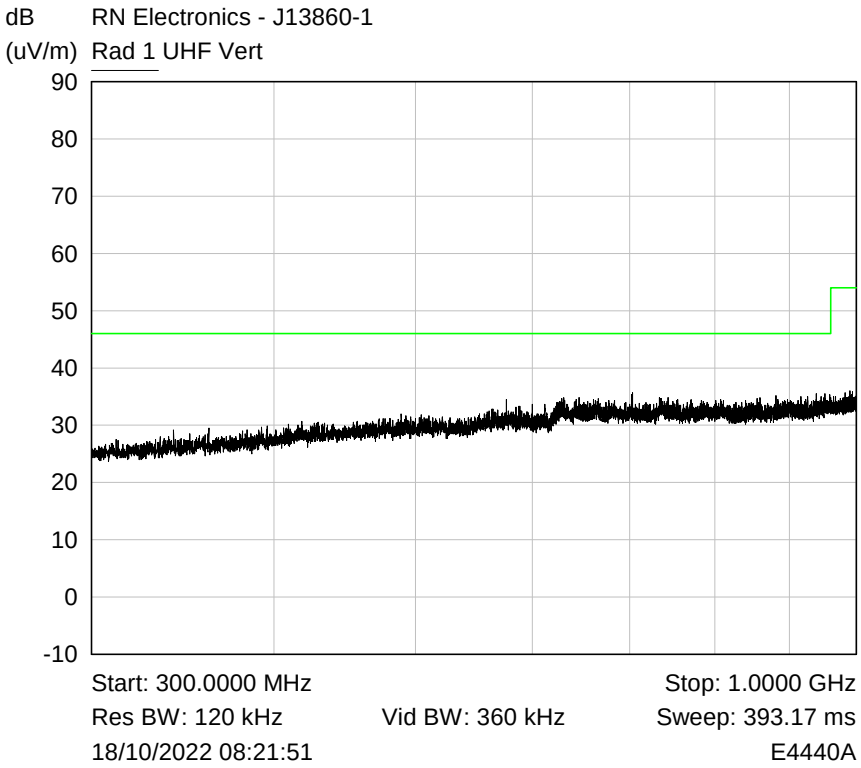
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



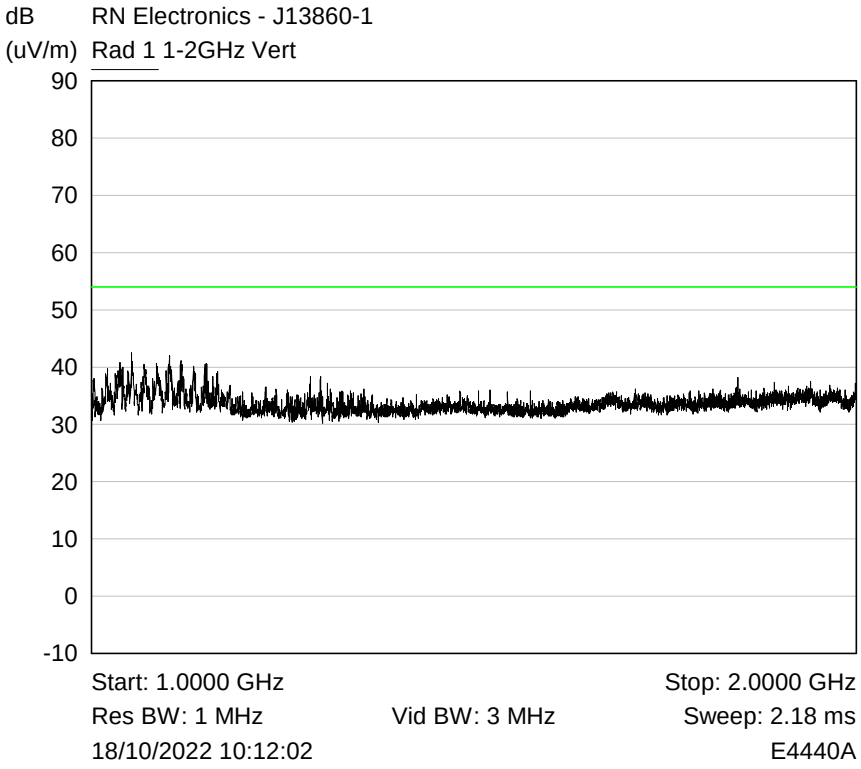
Plot of Peak emissions for UHF Horizontal against the QP limit line.



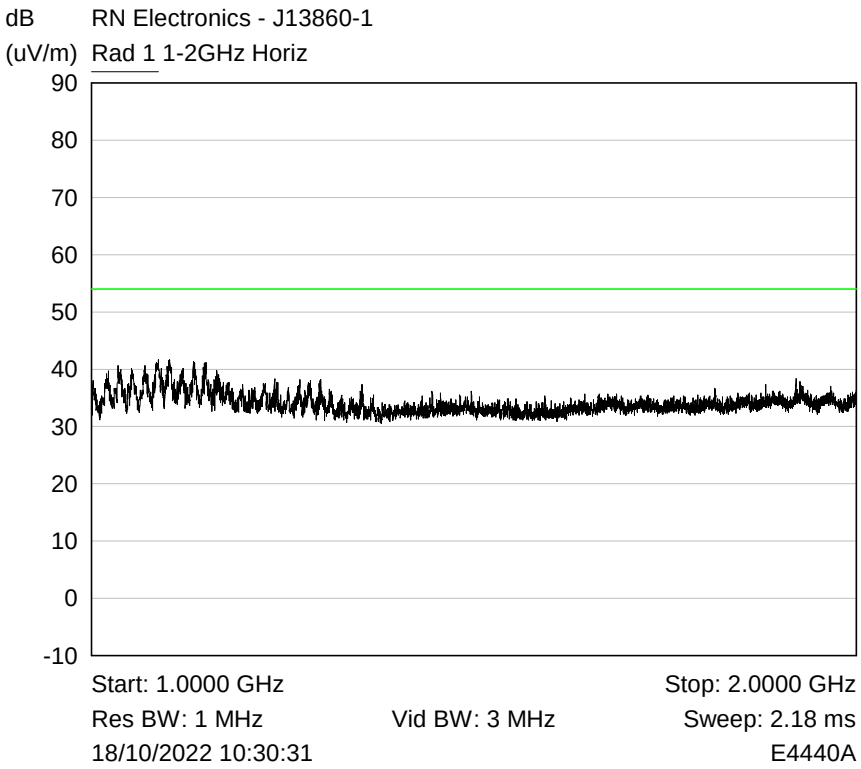
Plot of Peak emissions for UHF Vertical against the QP limit line.

6.5 Radiated emissions above 1 GHz

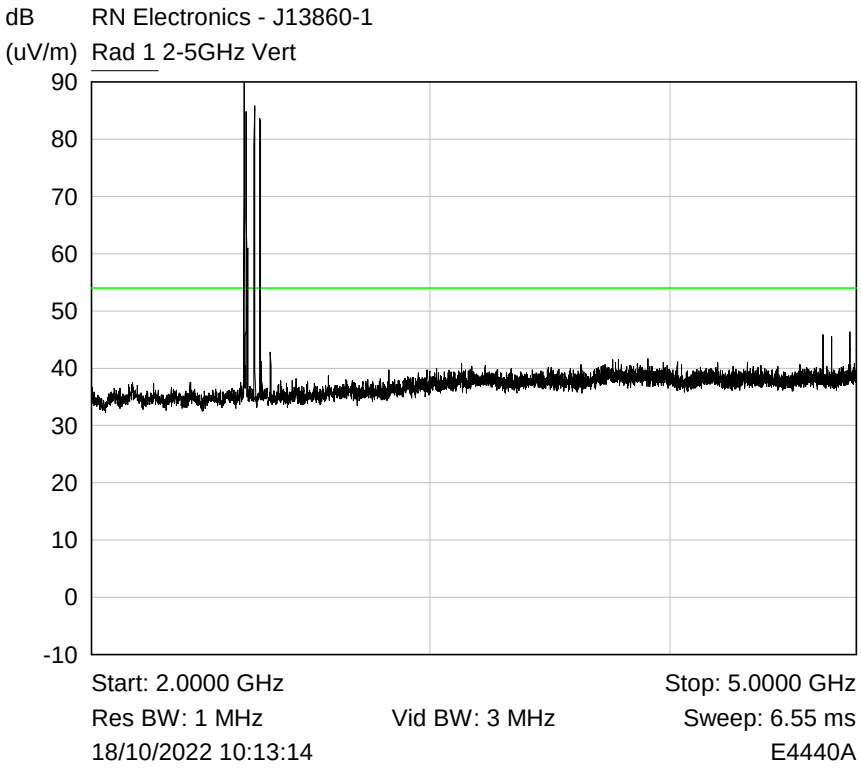
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz



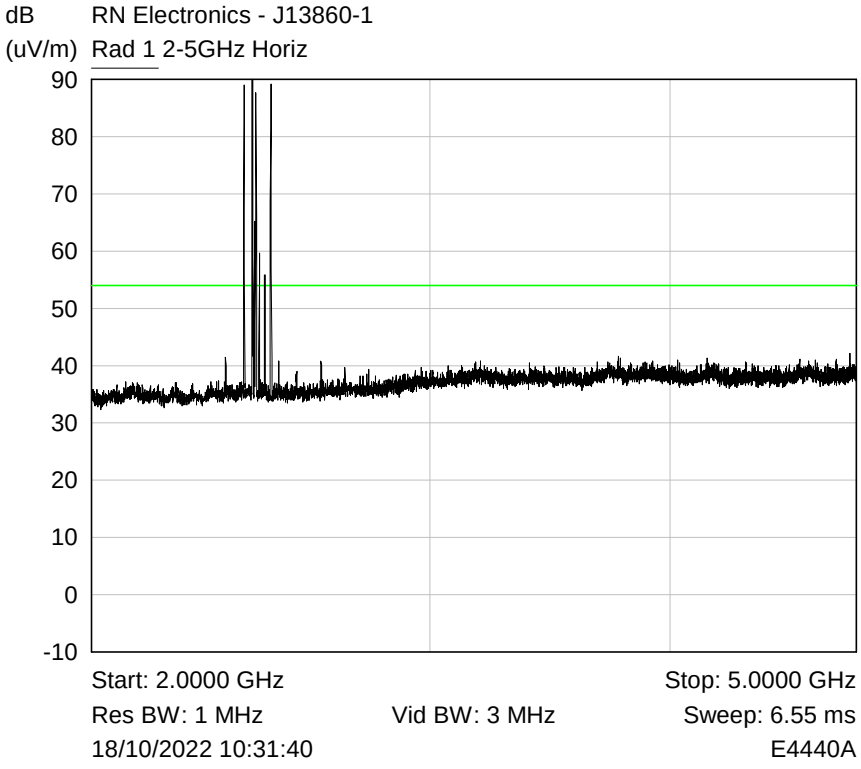
Plot of Peak emissions for 1-2 GHz Vertical against the average limit line



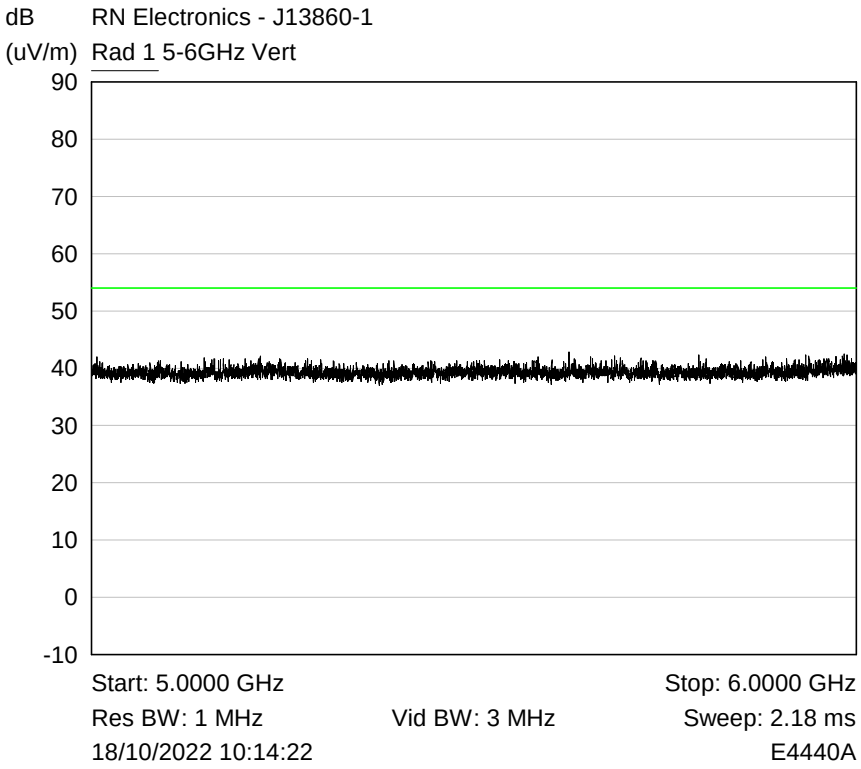
Plot of Peak emissions for 1-2 GHz Horizontal against the average limit line



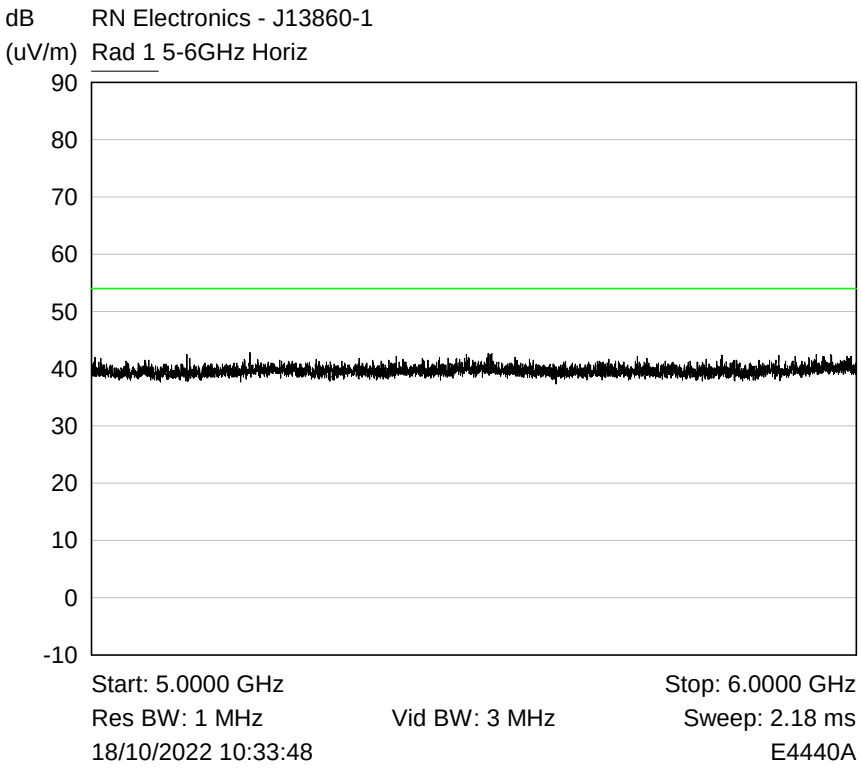
Plot of Peak emissions for 2-5 GHz Vertical against the average limit line
Signals between 2400-2480 MHz are intentional transmissions from BLE in the ancillary mouth guard



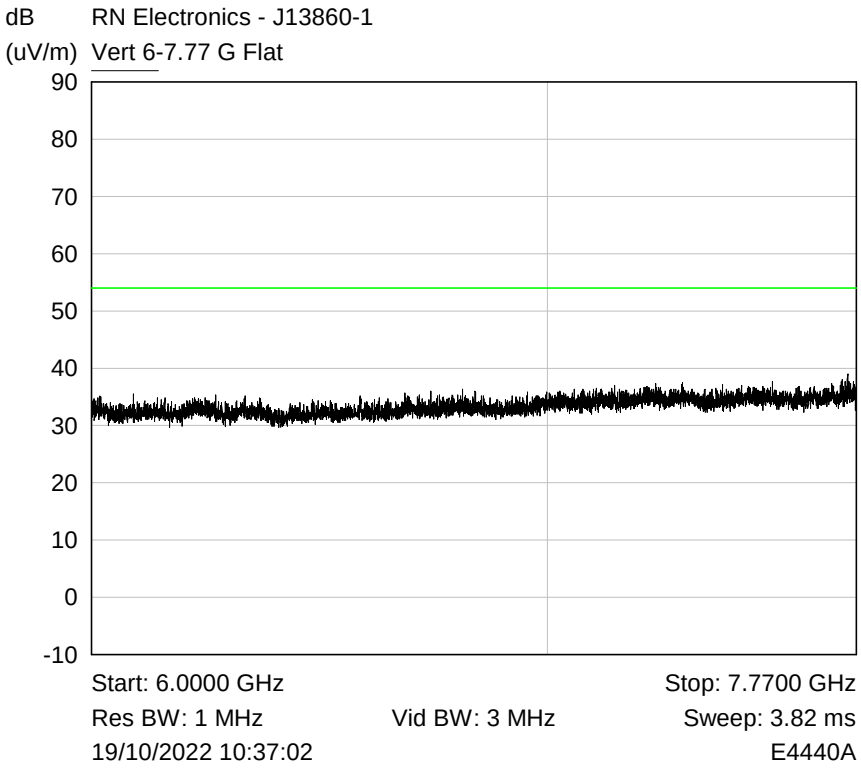
Plot of Peak emissions for 2-5 GHz Horizontal against the average limit line
Signals between 2400-2480 MHz are intentional transmissions from BLE in the ancillary mouth guard



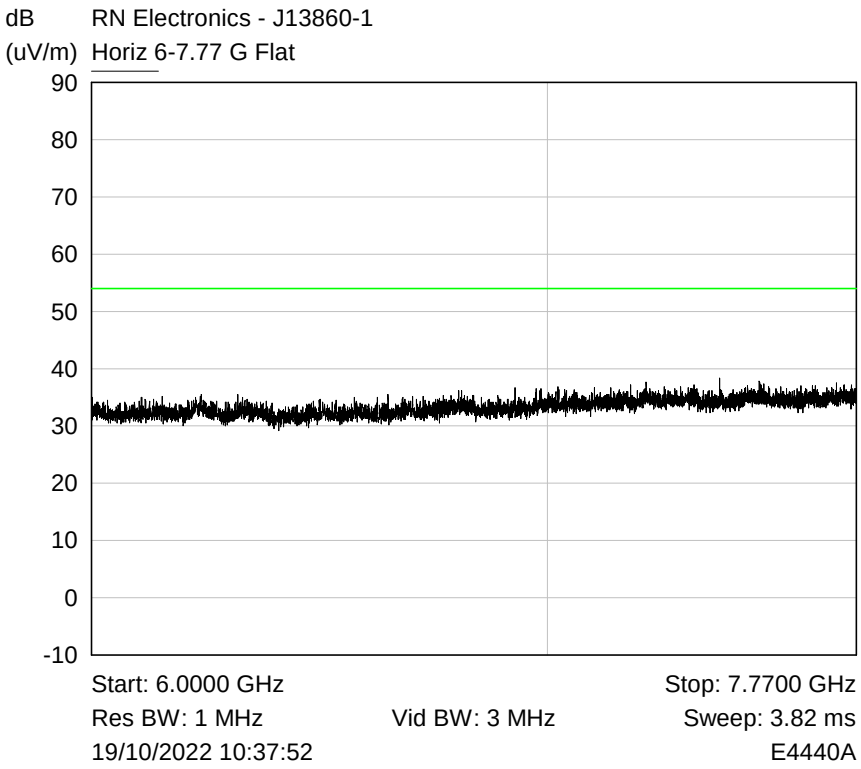
Plot of Peak emissions for 5-6 GHz Horizontal against the average limit line



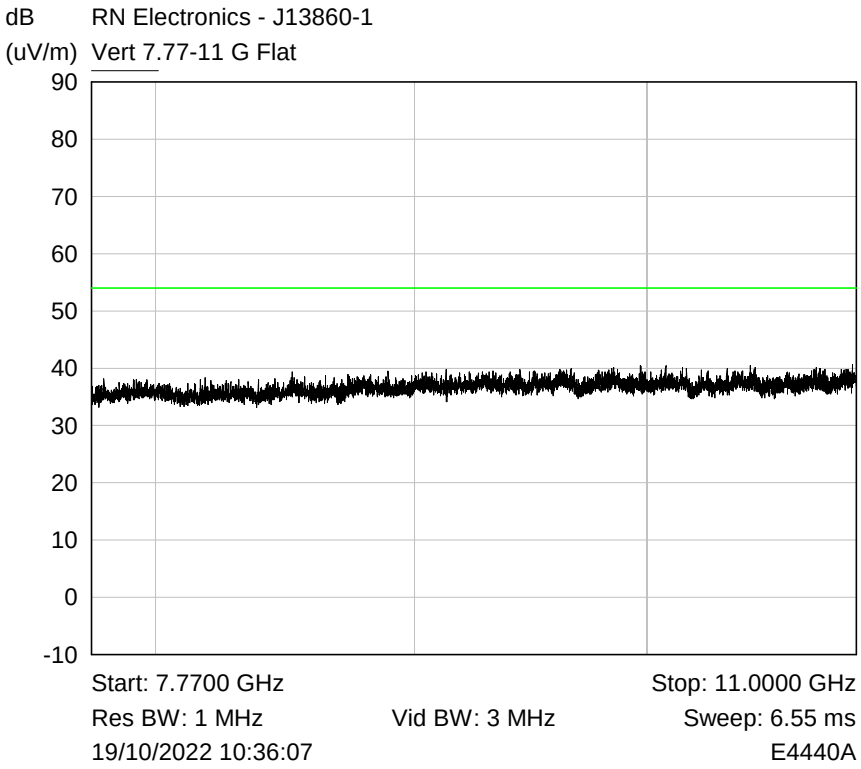
Plot of Peak emissions for 5-6 GHz Vertical against the average limit line



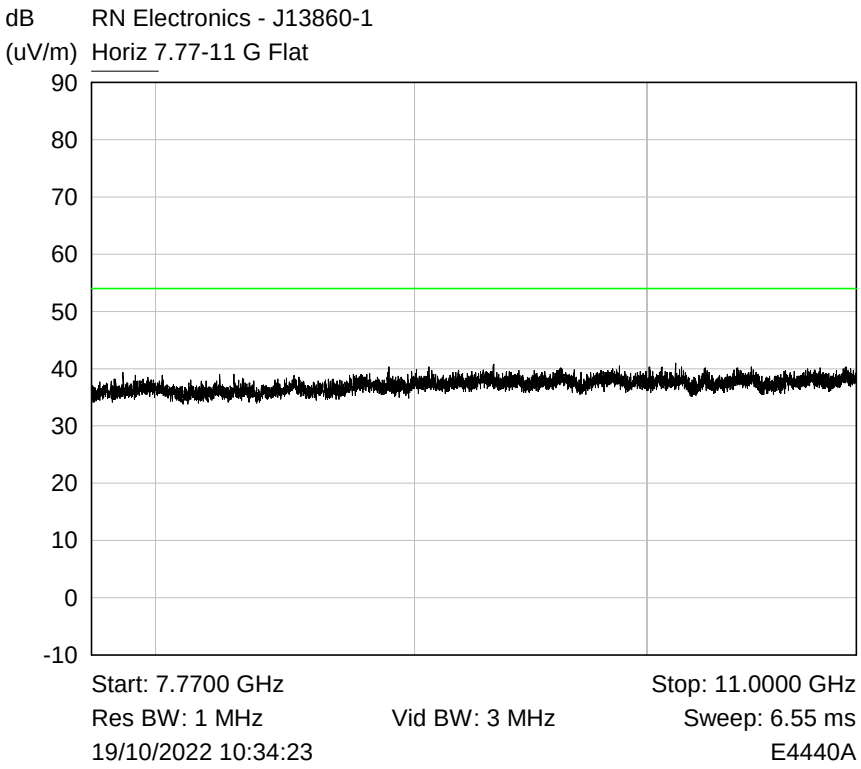
Plot of Peak emissions for 6-7.77 GHz Horizontal against the average limit line



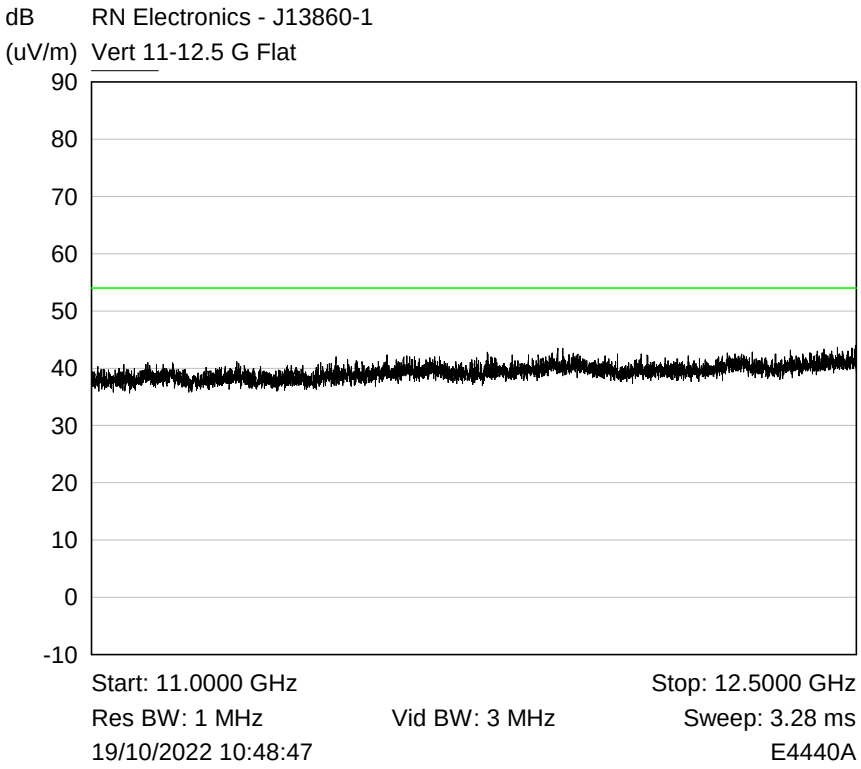
Plot of Peak emissions for 6-7.77 GHz Vertical against the average limit line



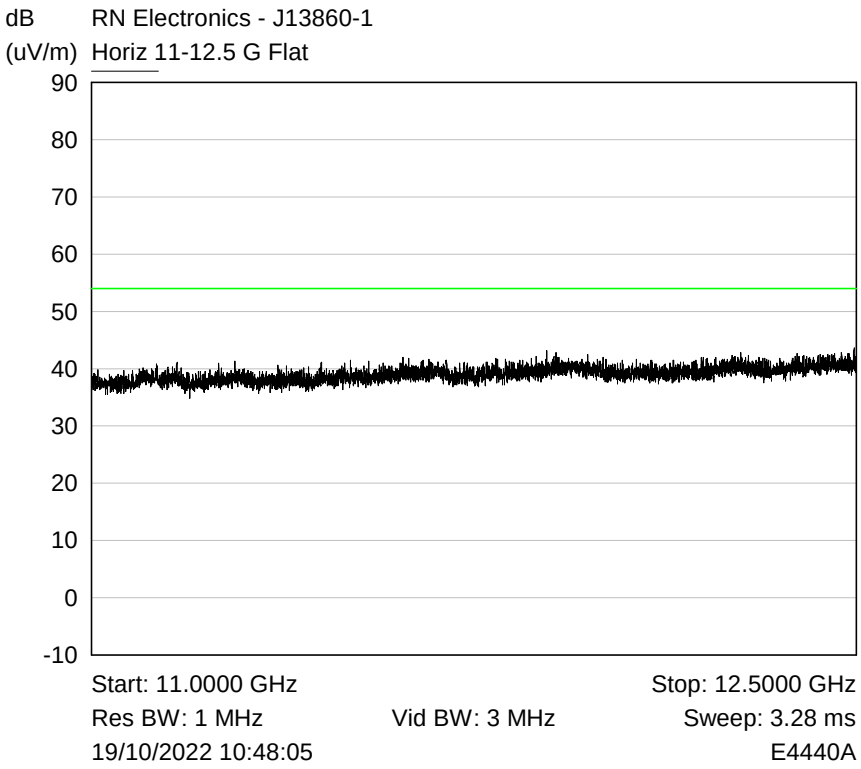
Plot of Peak emissions for 7.77-11 GHz Horizontal against the average limit line



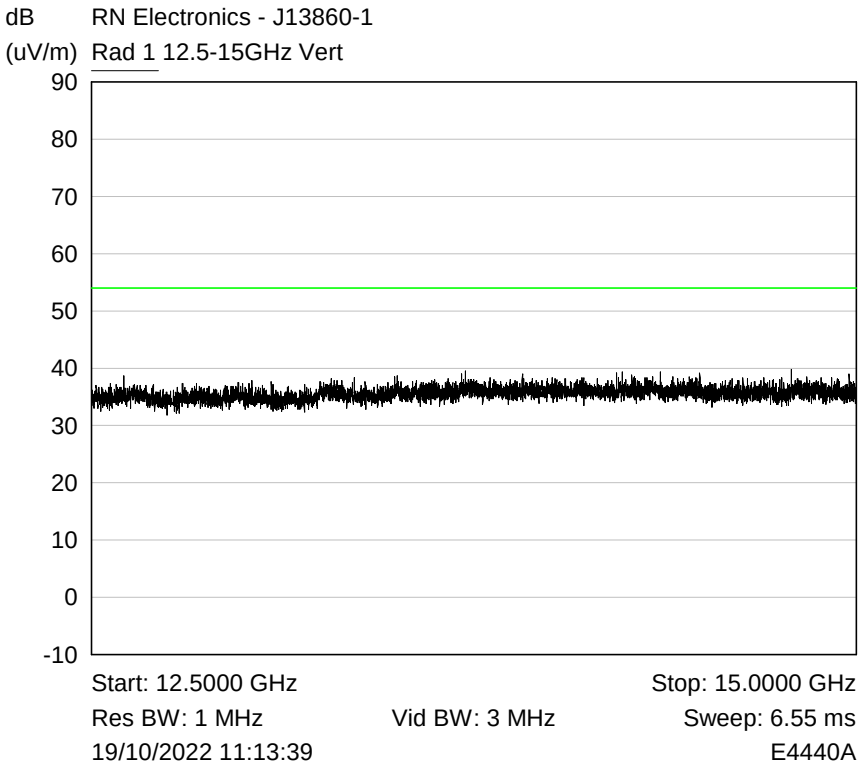
Plot of Peak emissions for 7.77-11 GHz Vertical against the average limit line



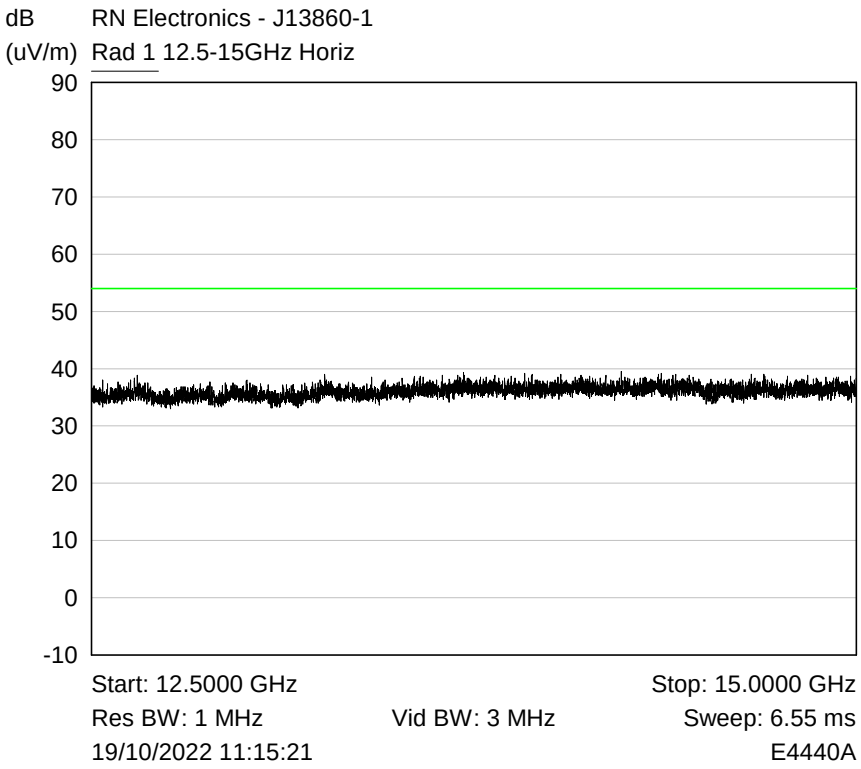
Plot of Peak emissions for 11-12.5 GHz Horizontal against the average limit line



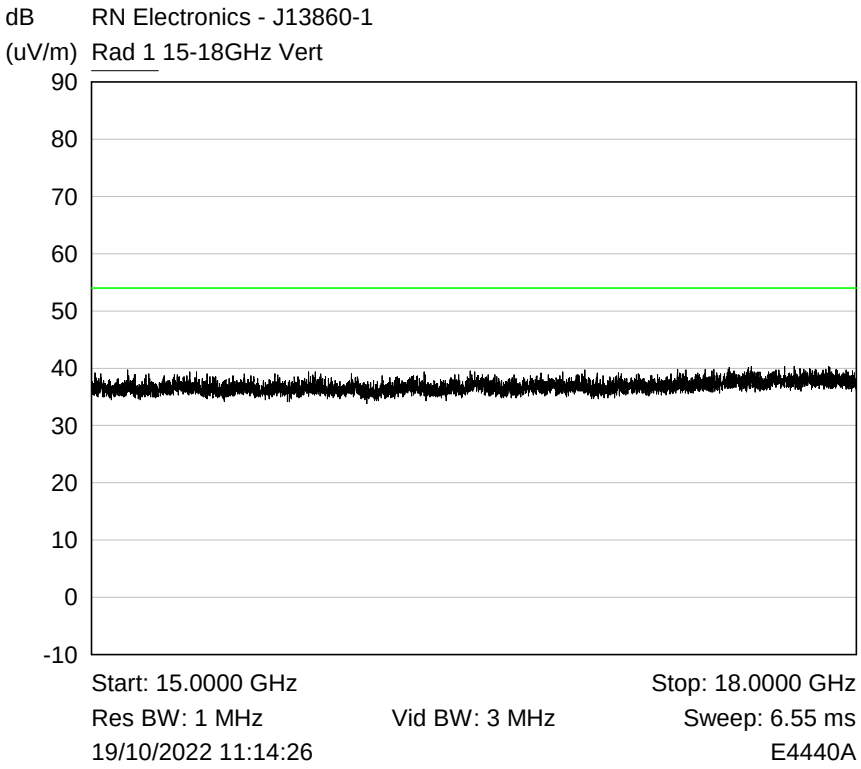
Plot of Peak emissions for 11-12.5 GHz Vertical against the average limit line



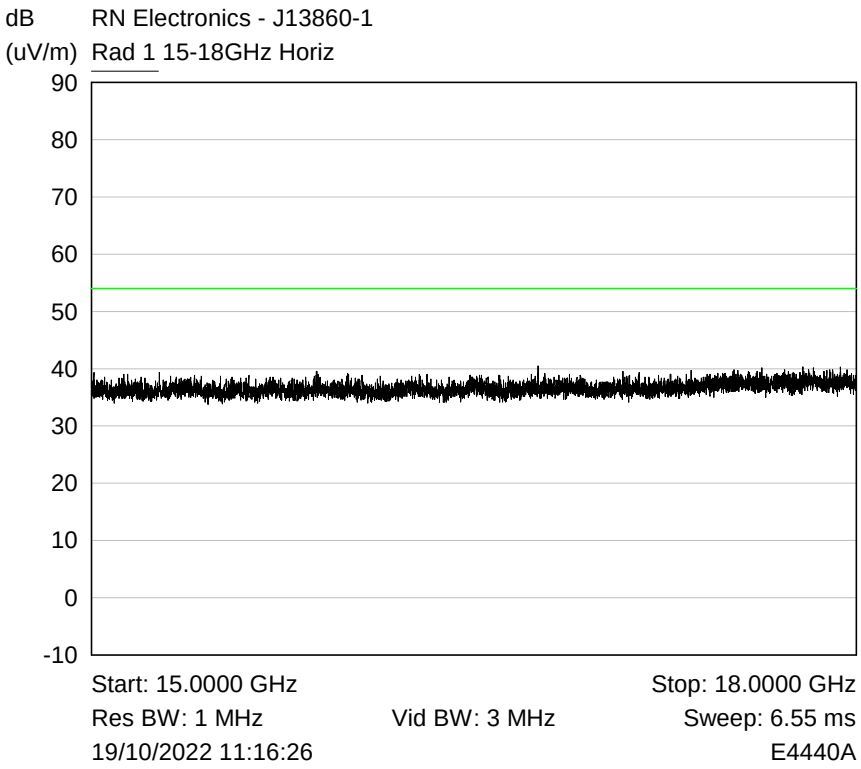
Plot of Peak emissions for 12.5-15 GHz Horizontal against the average limit line



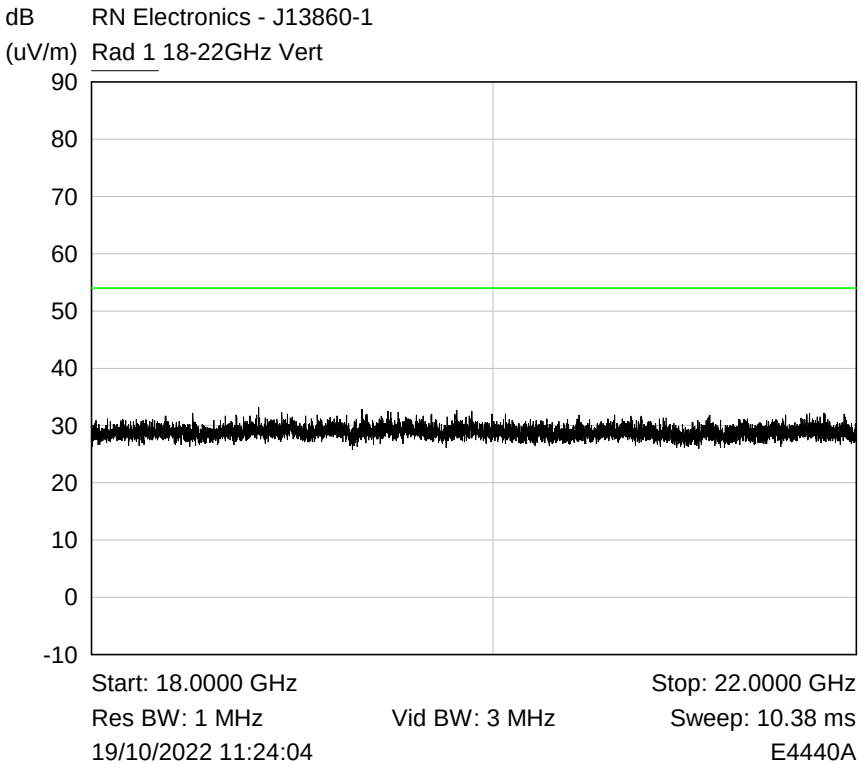
Plot of Peak emissions for 12.5-15 GHz Vertical against the average limit line



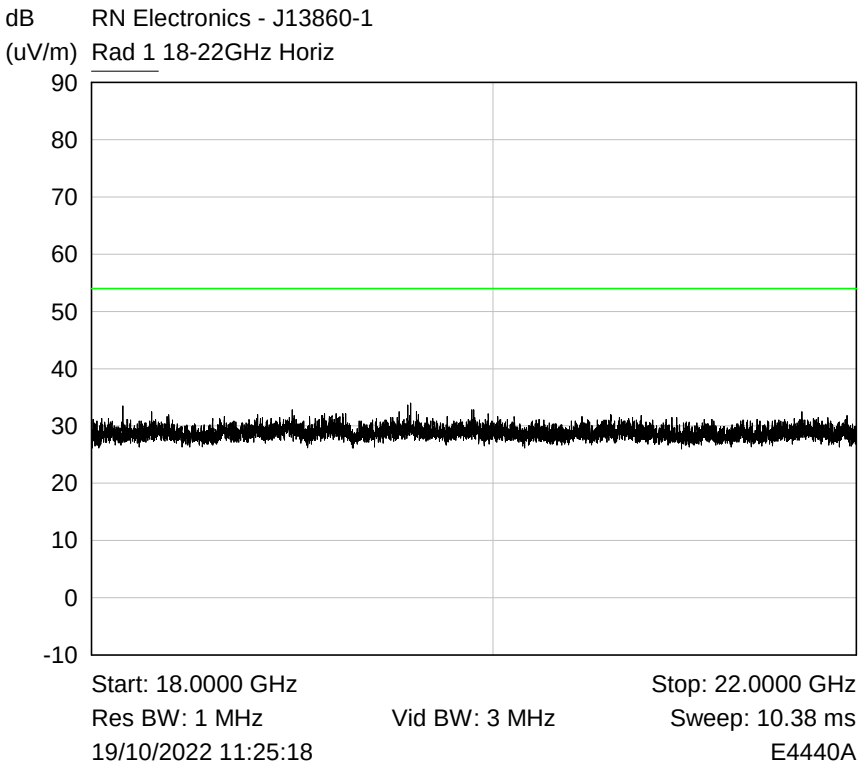
Plot of Peak emissions for 15-18 GHz Horizontal against the average limit line



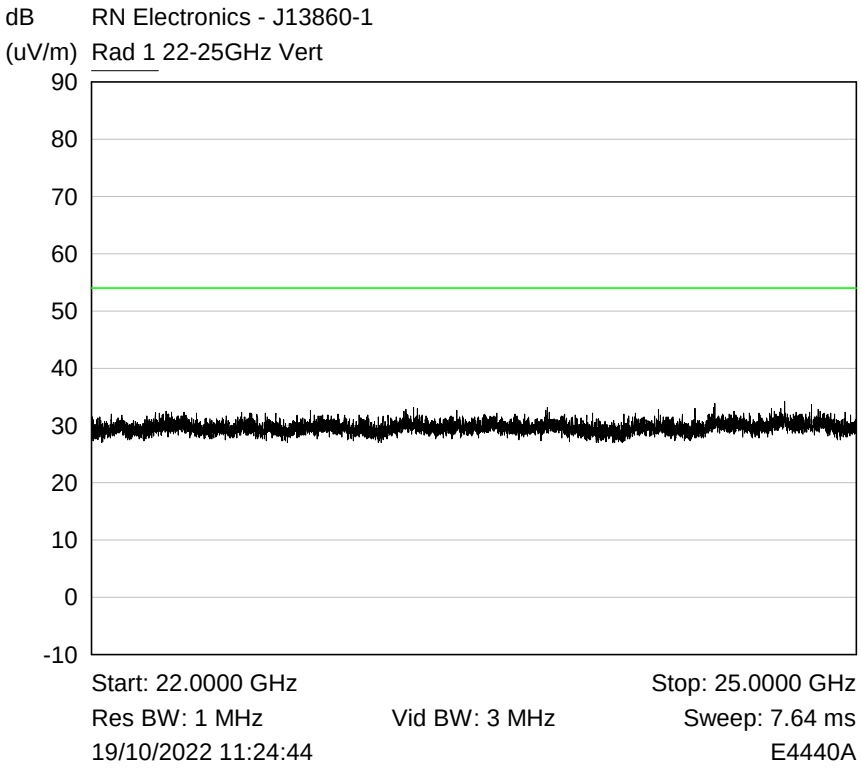
Plot of Peak emissions for 15-18 GHz Vertical against the average limit line



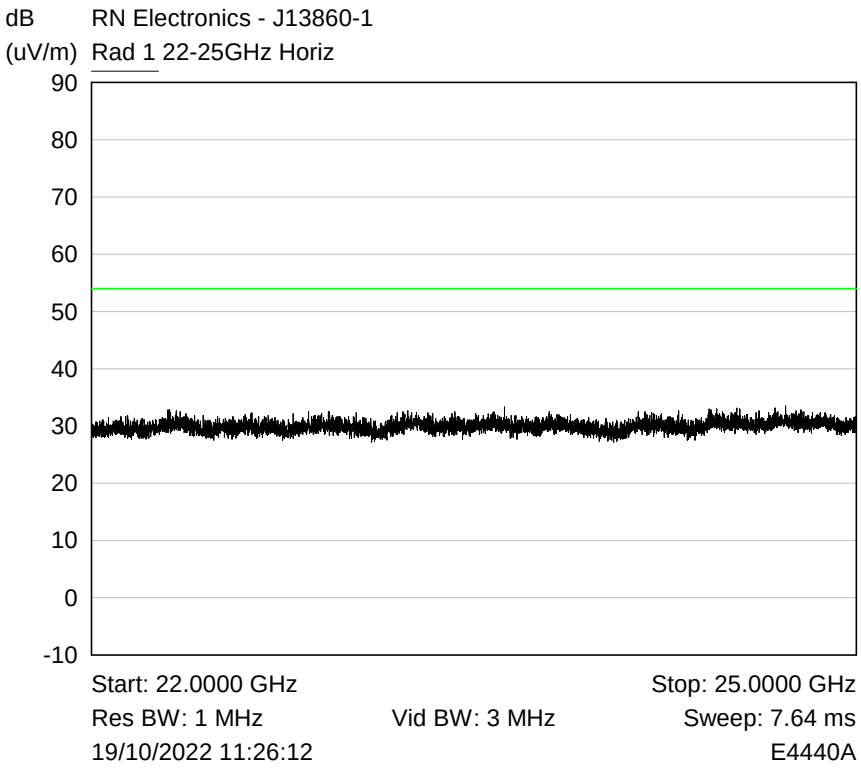
Plot of Peak emissions for 18-22 GHz Vertical against the average limit line



Plot of Peak emissions for 18-22 GHz Vertical against the average limit line



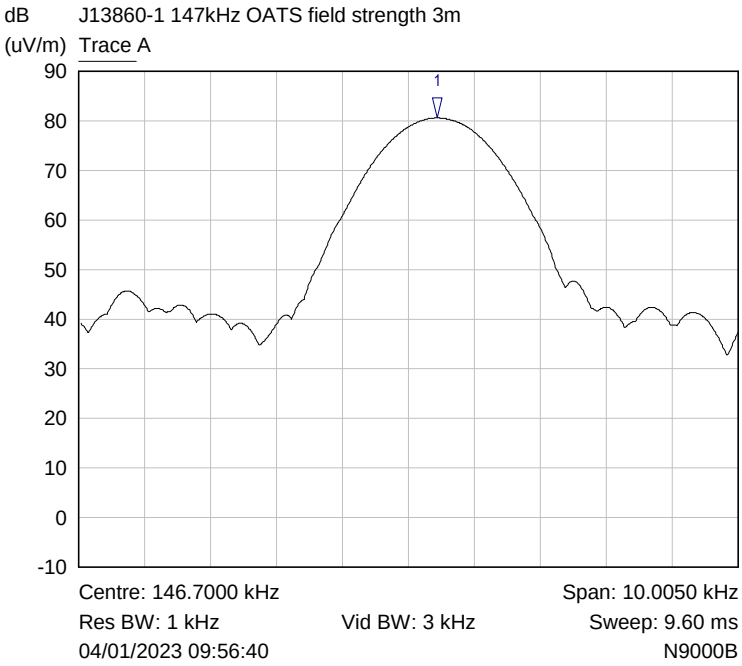
Plot of Peak emissions for 22-25 GHz Vertical against the average limit line



Plot of Peak emissions for 22-25 GHz Vertical against the average limit line

6.6 Intentional radiator field strength

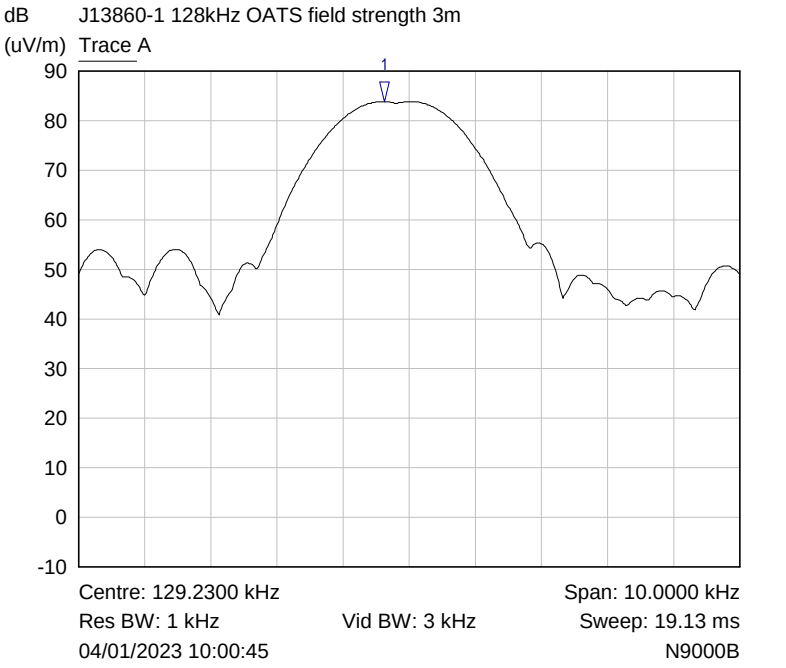
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	147.1400 kHz	80.60 dB(uV/m)	

Plot of Para polarisation and EUT in Flat position

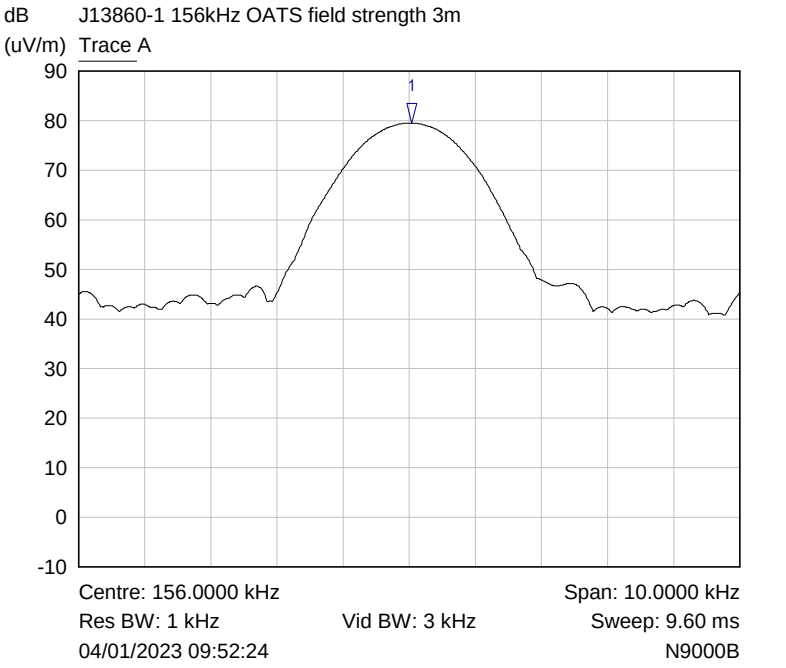
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 128 kHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	128.8500 kHz	83.83 dB(uV/m)	

Plot of Para polarisation and EUT in Flat position

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 157 kHz

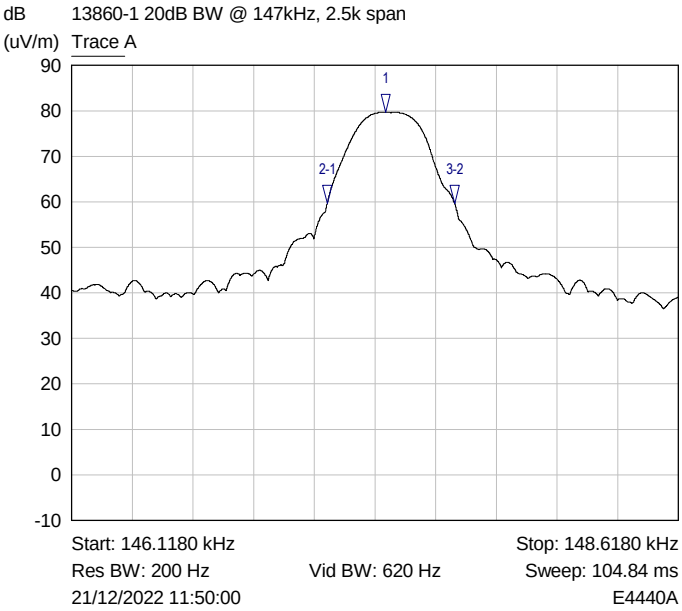


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	156.0400 kHz	79.51 dB(uV/m)	

Plot of Para polarisation and EUT in Flat position

6.7 Occupied bandwidth

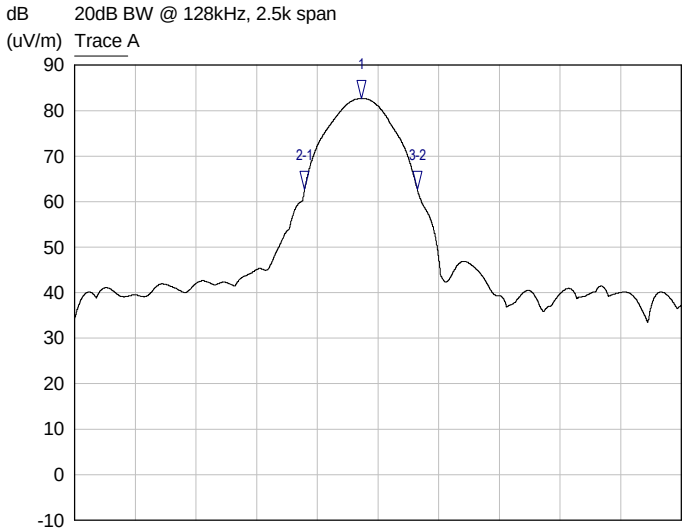
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 145 kHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	147.4112 kHz	79.70 dB(uV/m)	
2-1	Trace A	-240.2027 Hz	-19.99 dB	
3-2	Trace A	524.0508 Hz	0.02 dB	

Plot for 20 dB Bandwidth (Hz) Nominal Temp & Volts

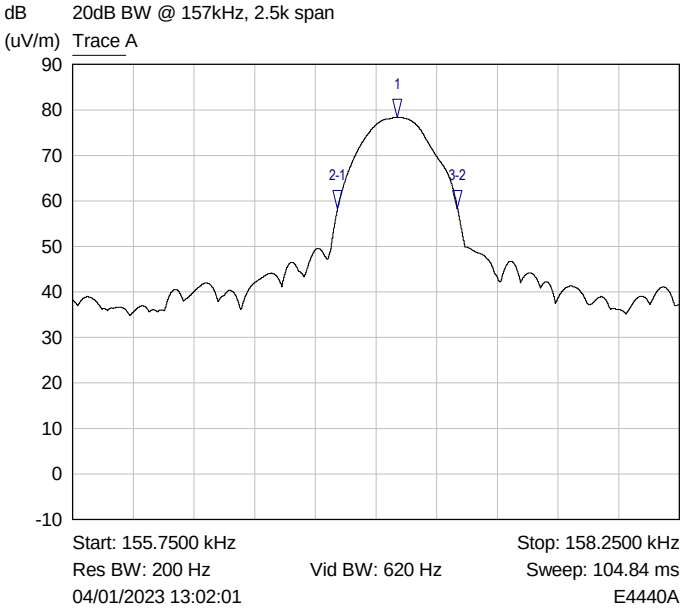
RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 128 kHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	128.0937 kHz	82.71 dB(uV/m)	
2-1	Trace A	-235.0140 Hz	-20.00 dB	
3-2	Trace A	464.2290 Hz	-0.02 dB	

Plot for 20 dB Bandwidth (Hz) Nominal Temp & Volts

RF Parameters: Band 110-490 kHz, Power 1 Watt, Modulation (WPT), Channel 157 kHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	157.0871 kHz	78.34 dB(uV/m)	
2-1 ▽	Trace A	-245.3913 Hz	-20.02 dB	
3-2 ▽	Trace A	494.1399 Hz	0.05 dB	

Plot for 20 dB Bandwidth (Hz) Nominal Temp & Volts

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

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

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

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

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

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

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

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

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

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

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

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

7.2 Explanation of limit line calculations for radiated measurements

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

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

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

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

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

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

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

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: $E_{Spec\ limit} = \sqrt{(PD \times 377)}$

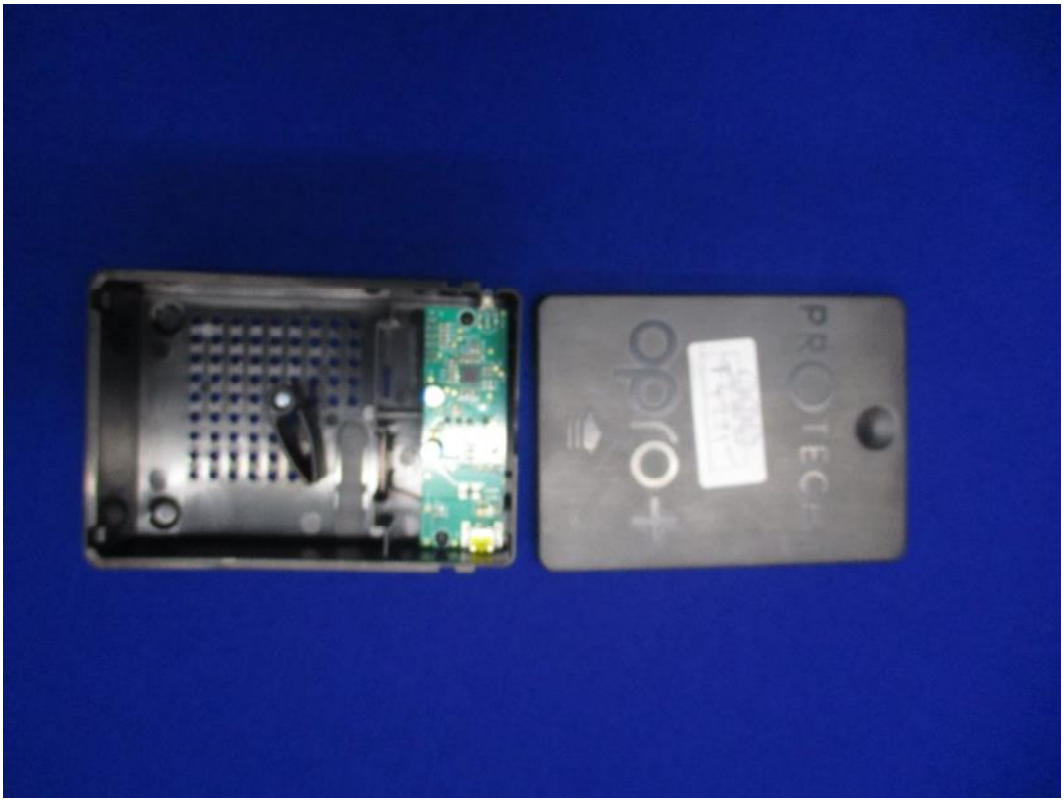
Where:
PD is the power density at distance specified by the limit, in W/m^2
$E_{spec\ limit}$ is the field strength at the distance specified by the limit in V/m

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.

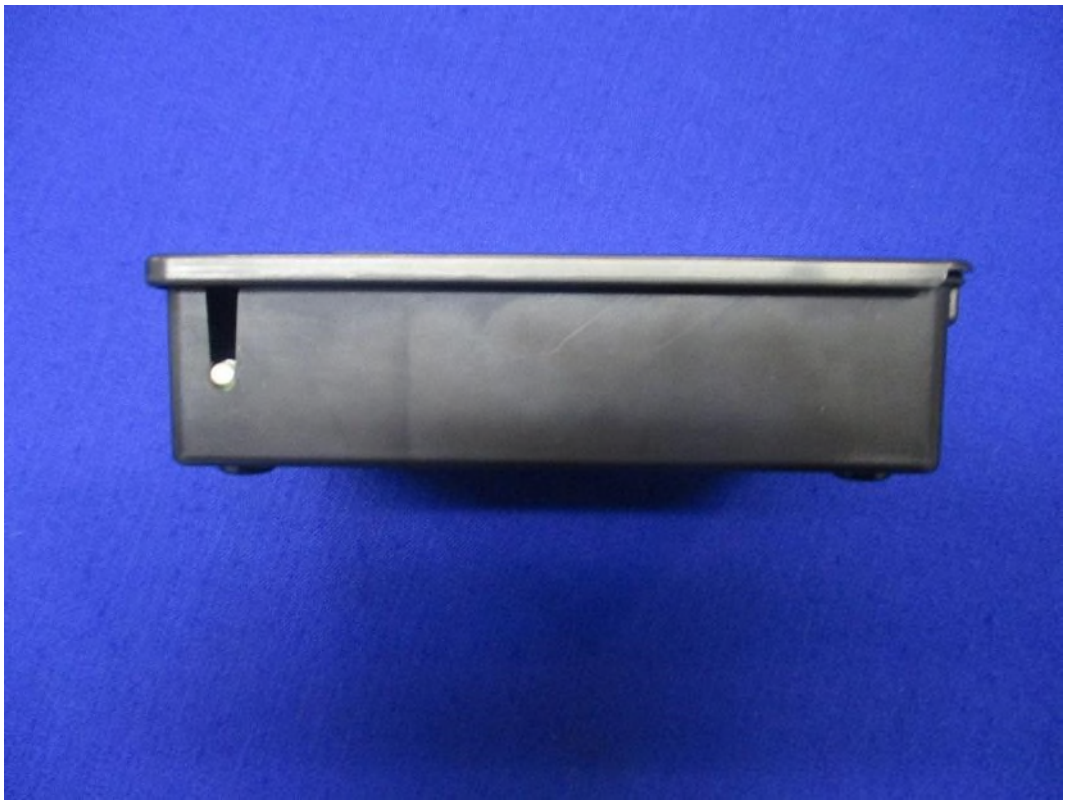
8 Photographs

8.1 EUT Front View



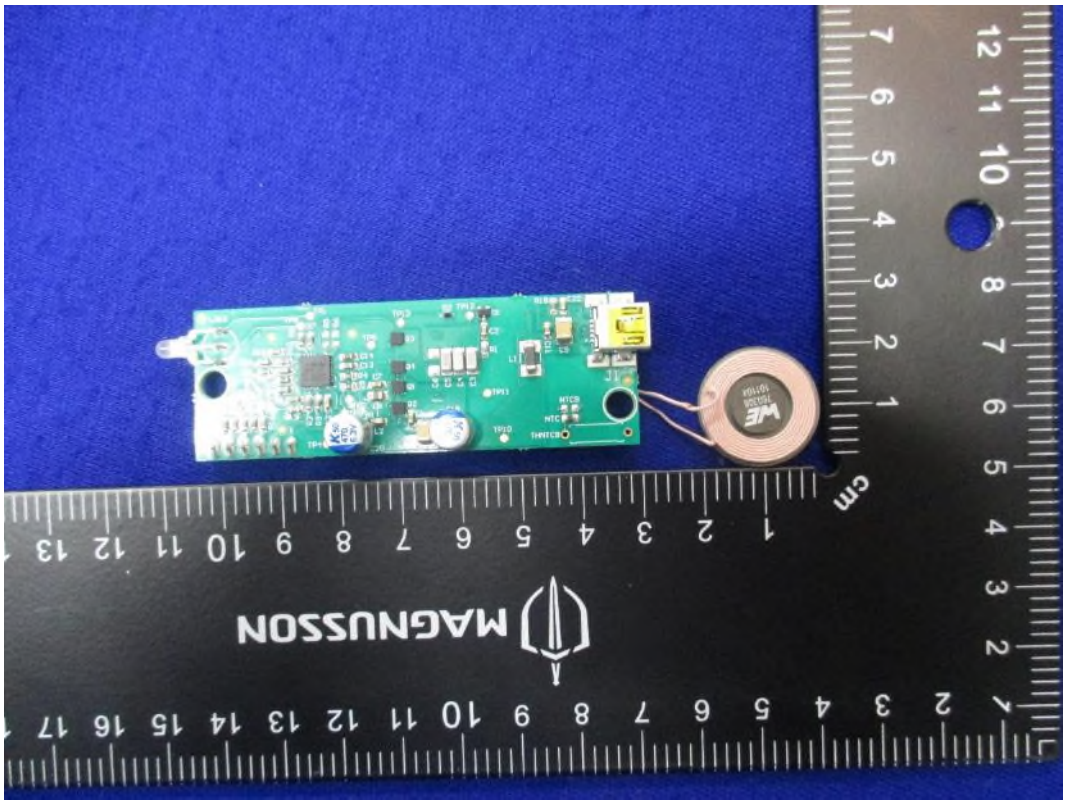
8.2 EUT Reverse Angle

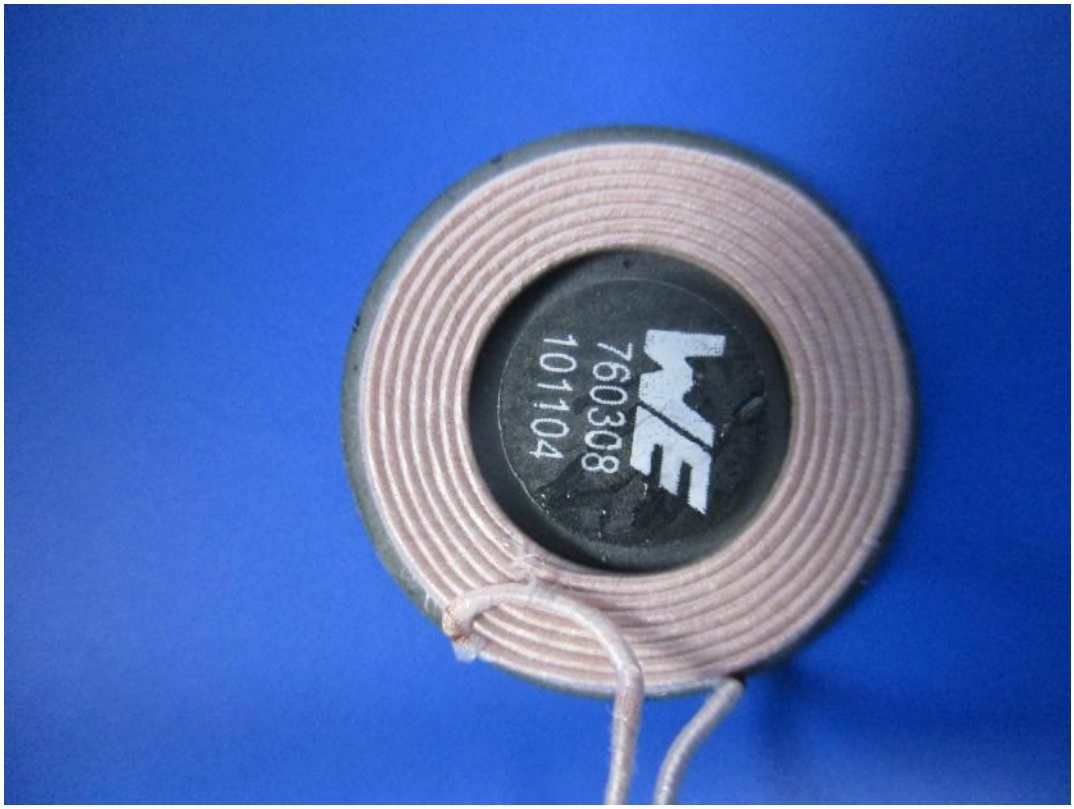
8.3 EUT Left side View



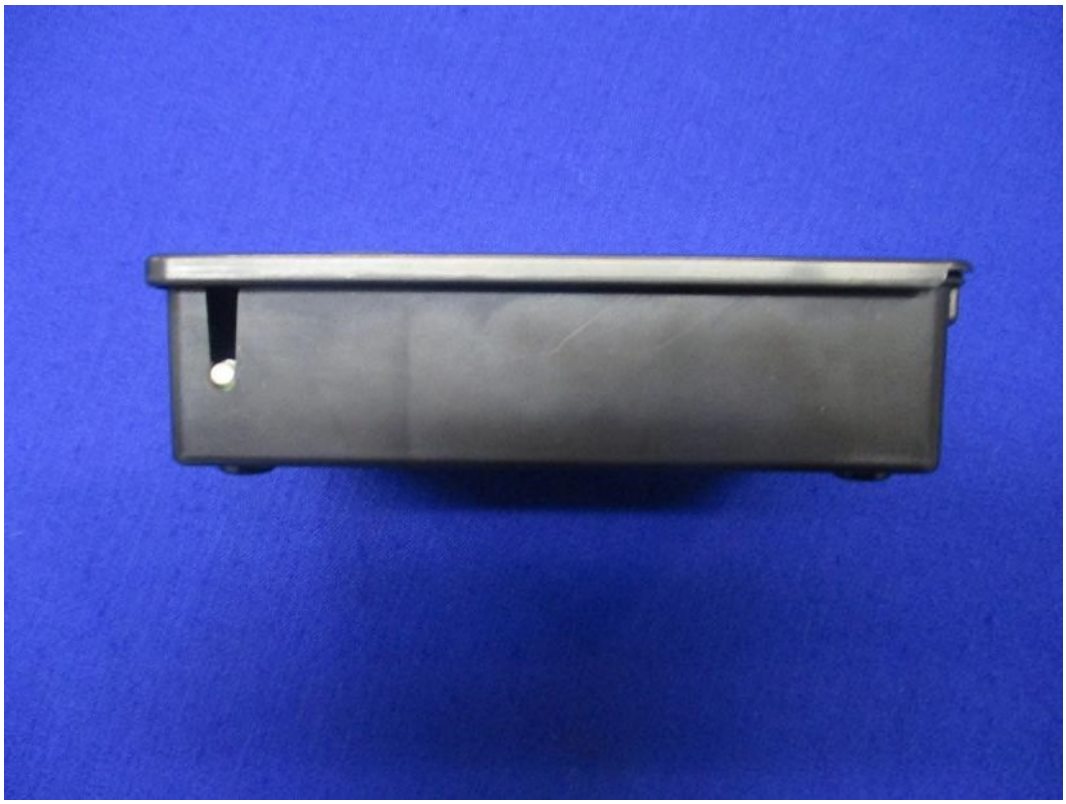
8.4 EUT Right side View

8.5 EUT Antenna Coil

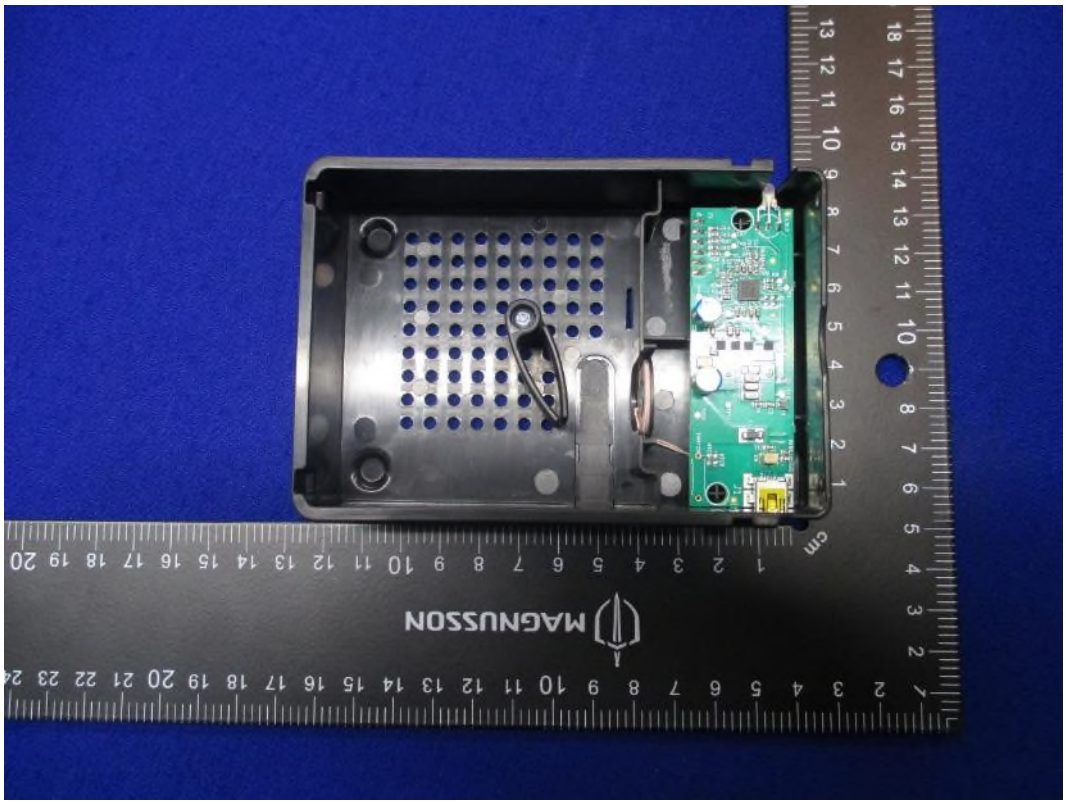


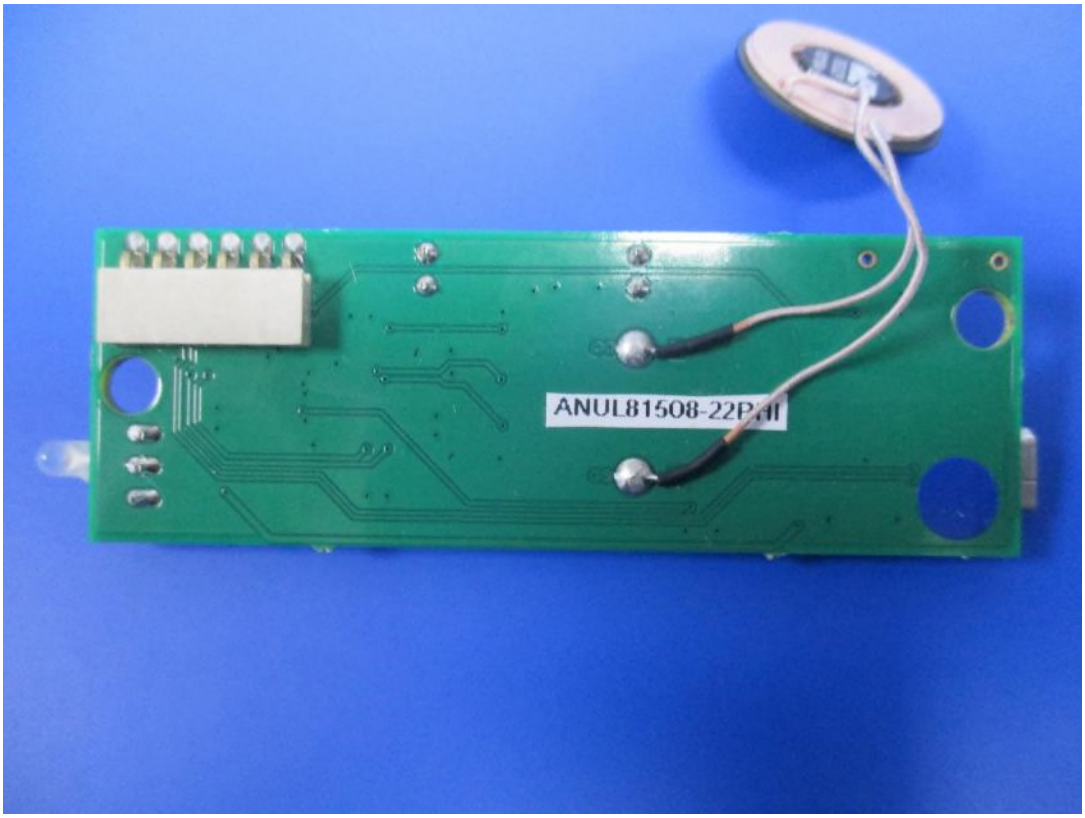


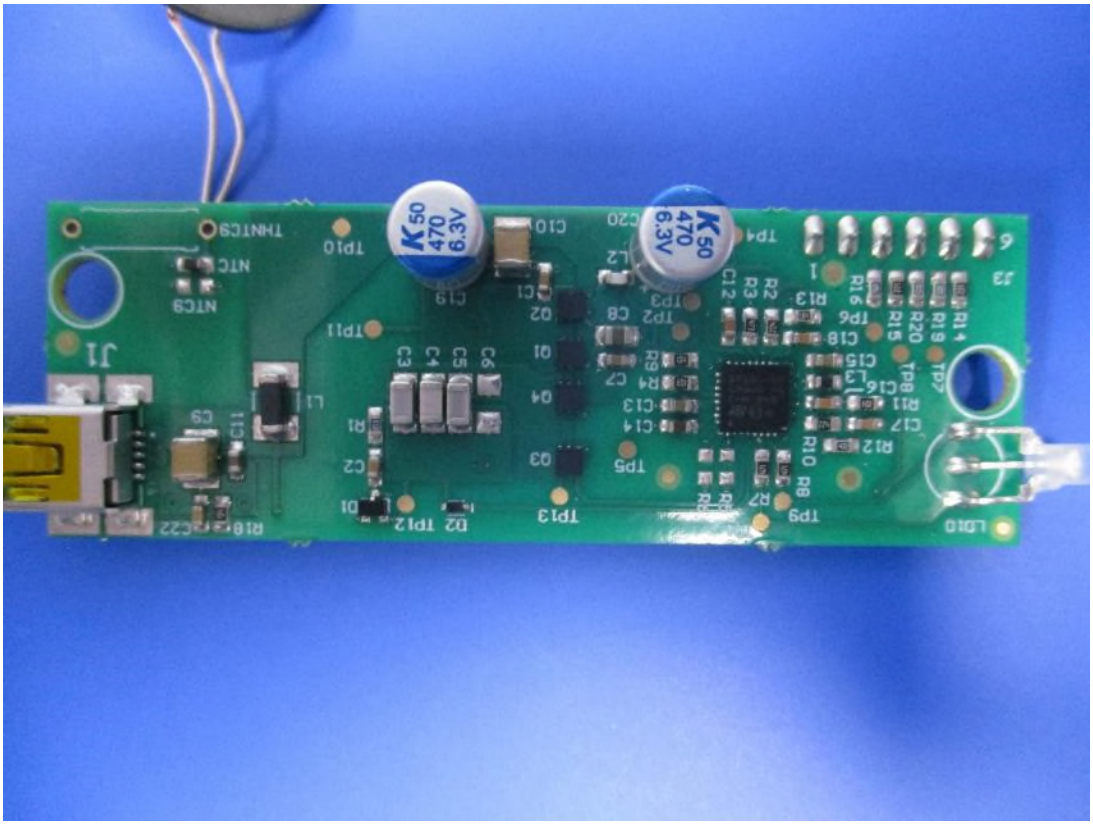
8.6 EUT Display & Controls



8.7 EUT Internal photos

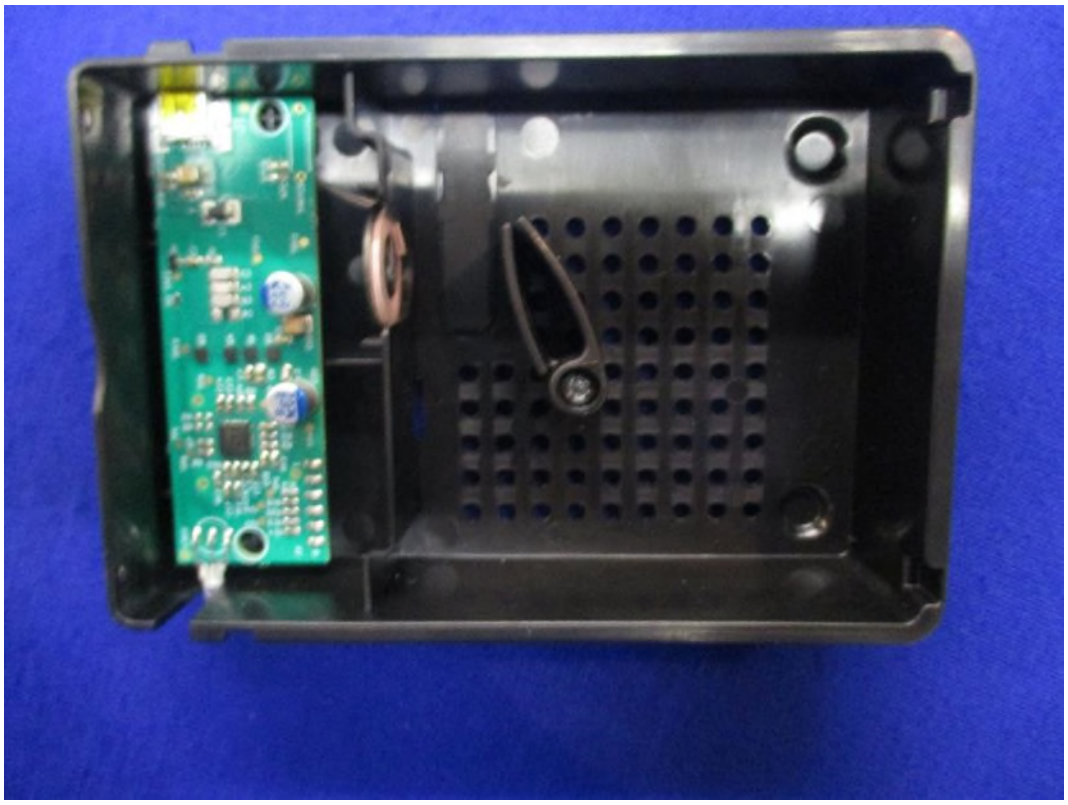

MAGNUSSON


ANUL81508-22P



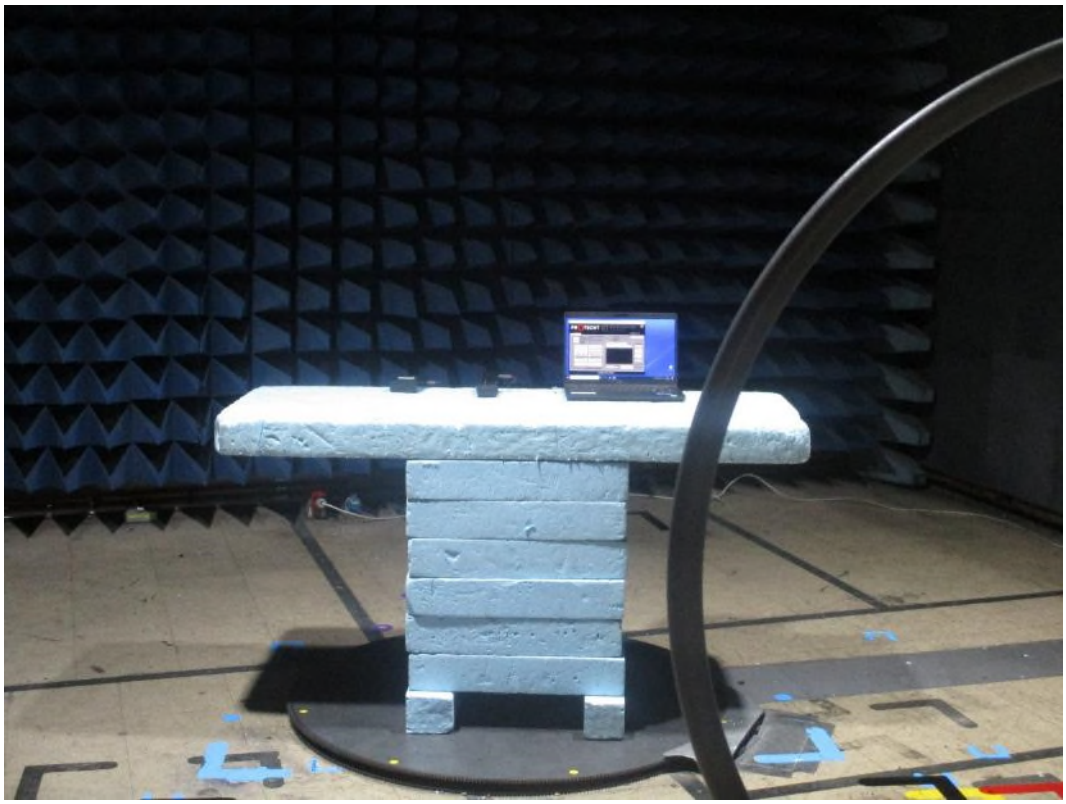
8.8 EUT ID Label

8.9 EUT Chassis

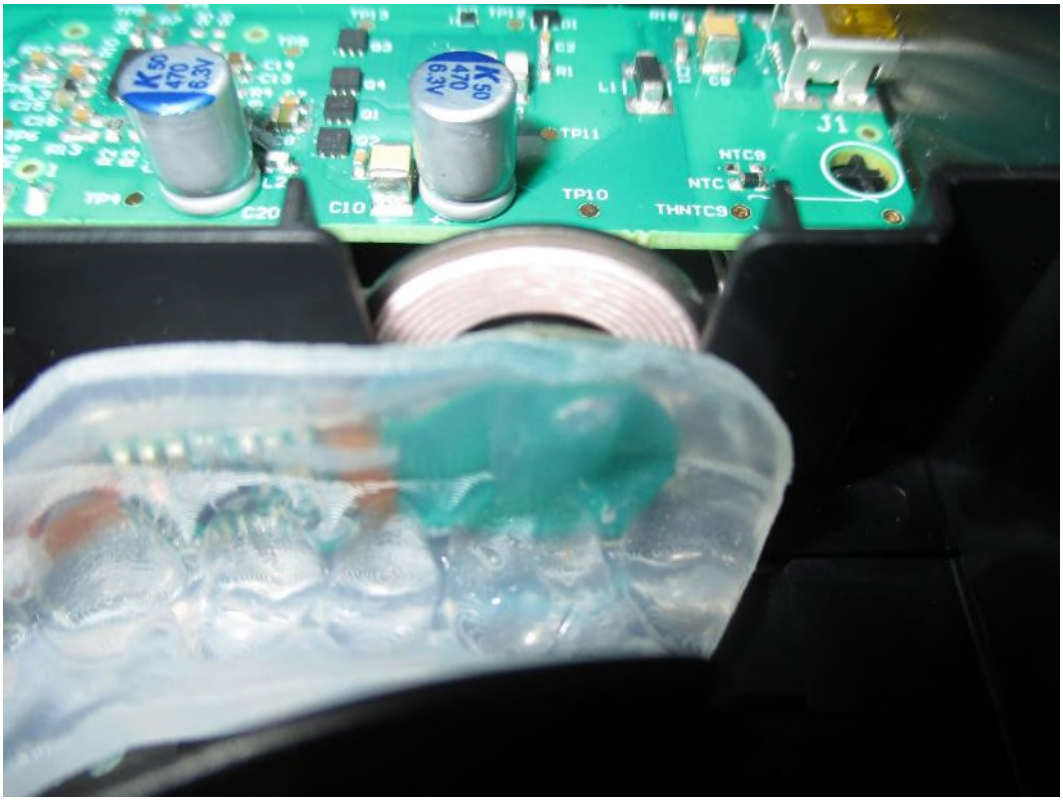


8.10 AC power line conducted emissions

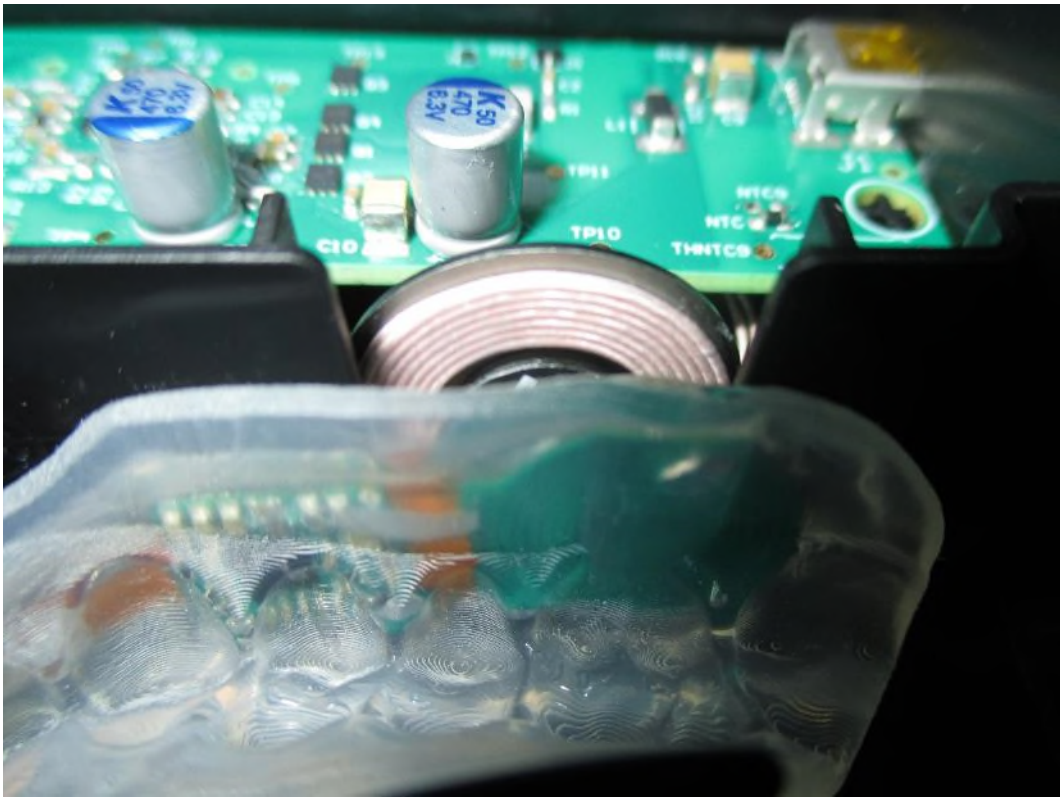
8.11 Radiated emissions 9 - 150 kHz



EUT with mouthguard in position 1

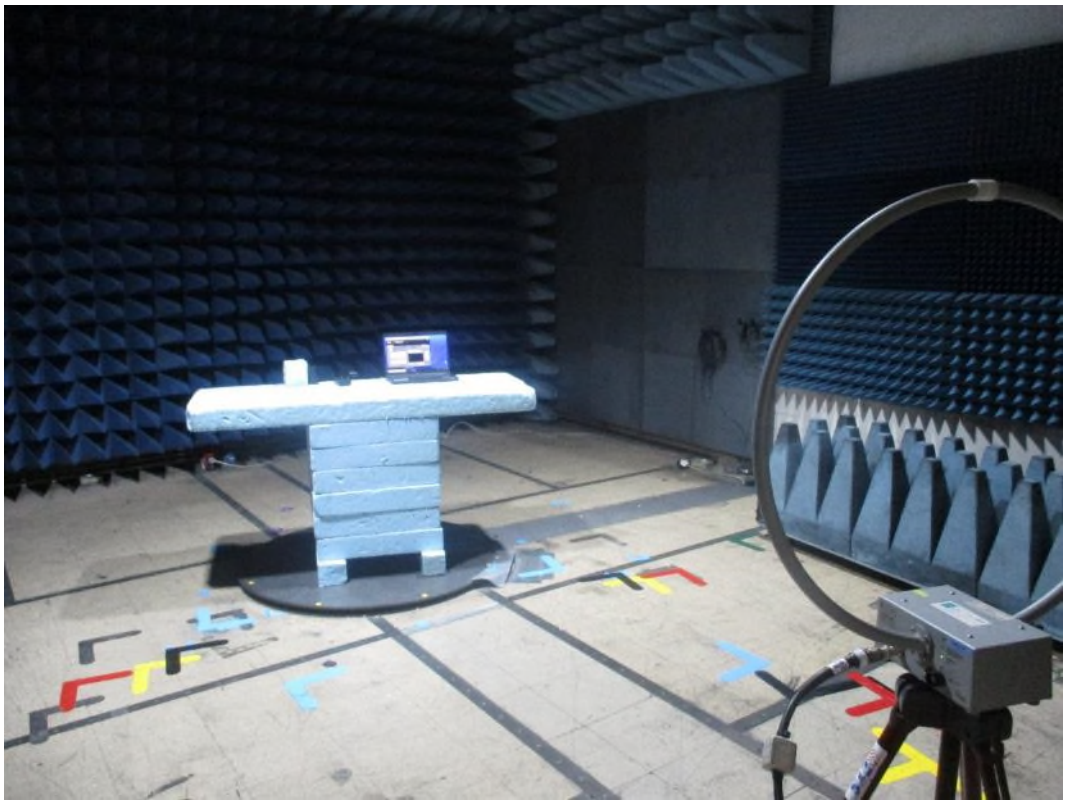


EUT with mouthguard in position 2 (best aligned position)



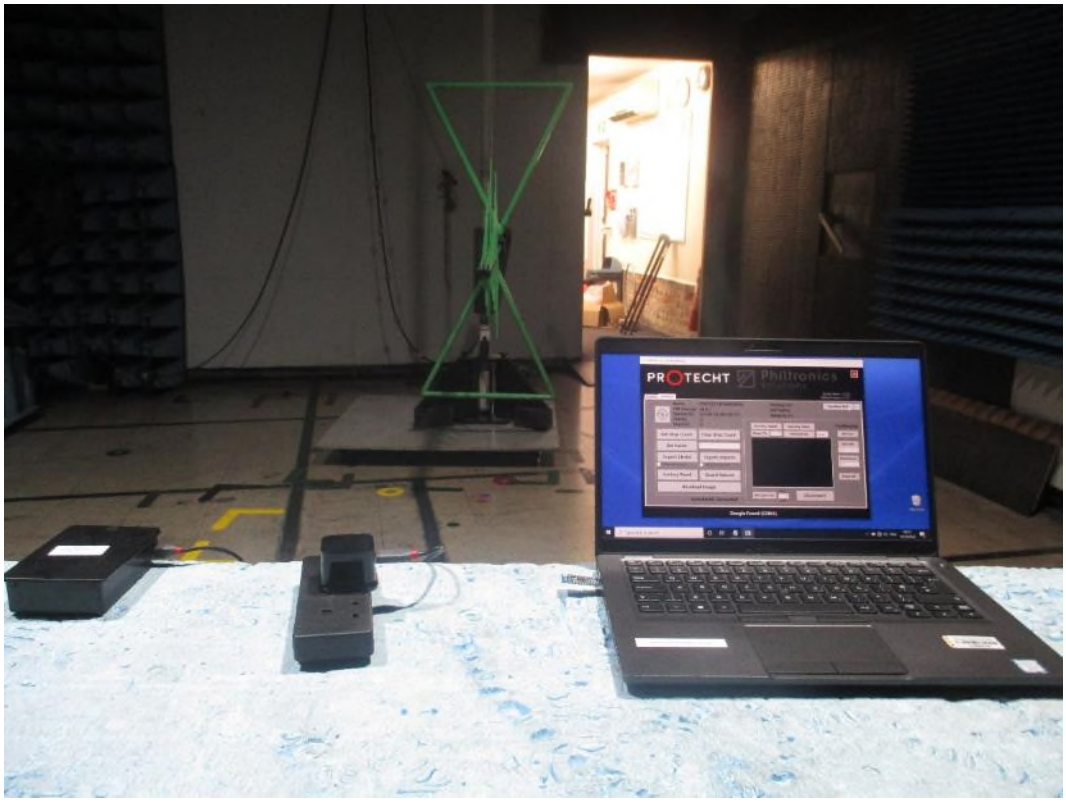
EUT with mouthguard in position 3

8.12 Radiated emissions 150 kHz - 30 MHz

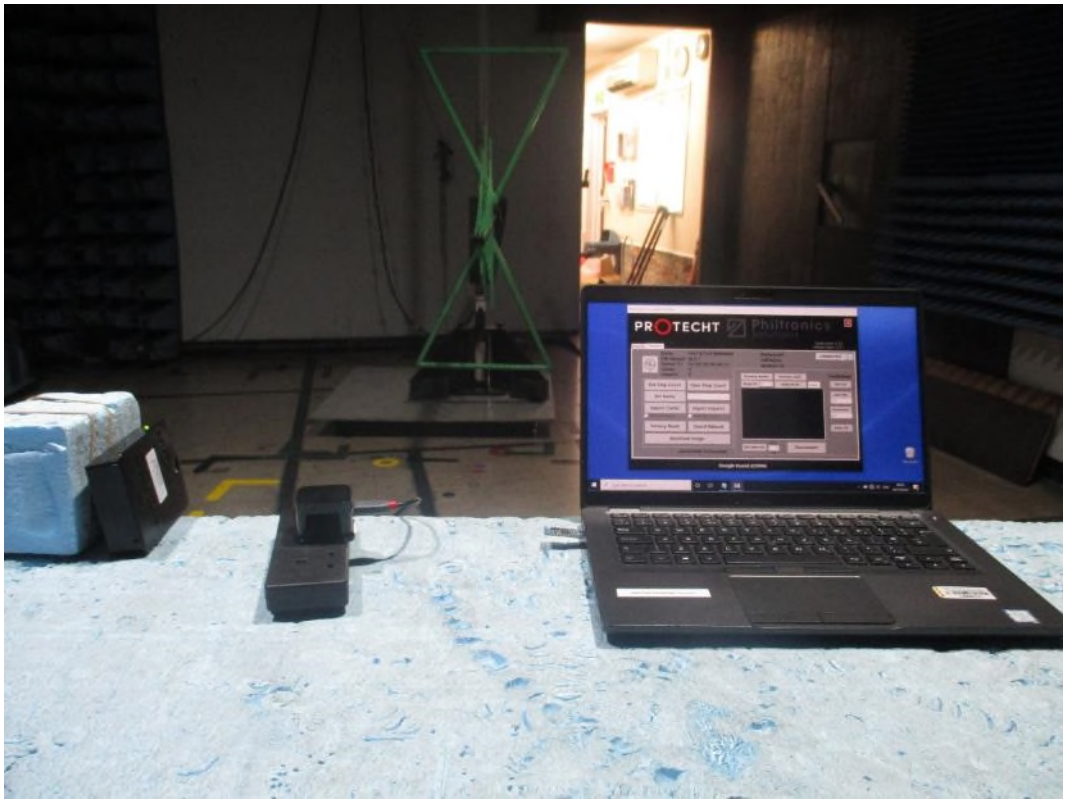


Note: See also mouthguard position photos section 8.11

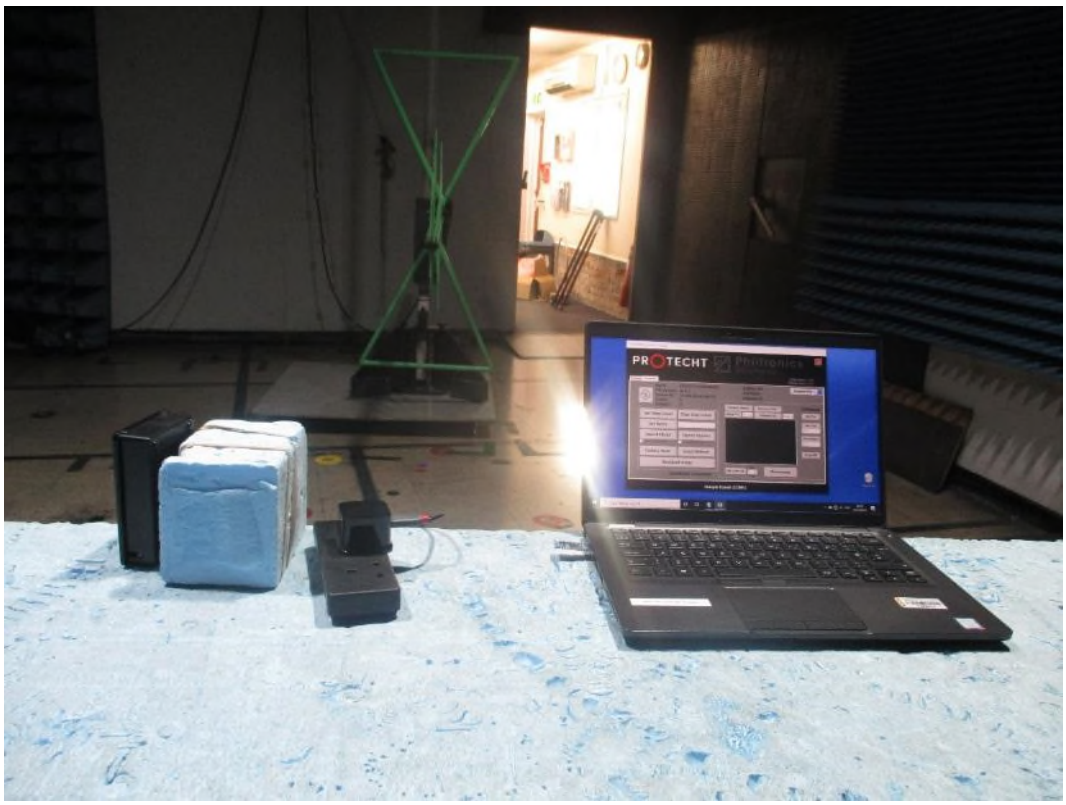
8.13 Radiated emissions 30 MHz -1 GHz



EUT Flat



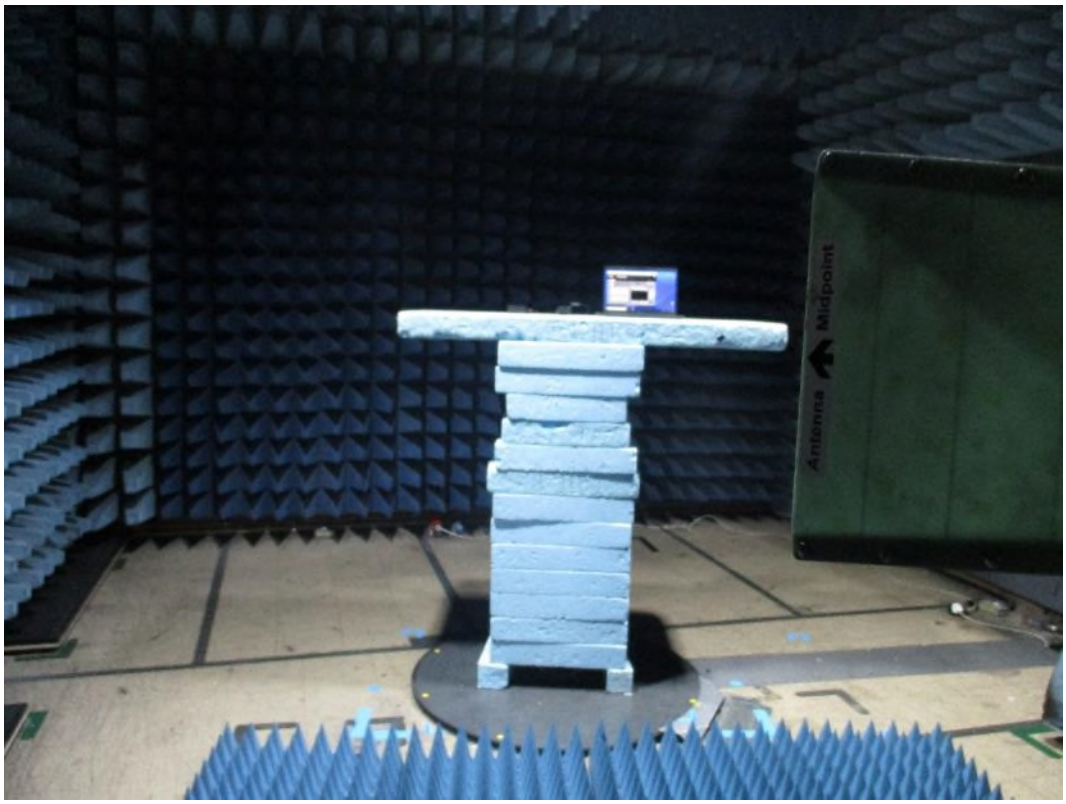
EUT Side

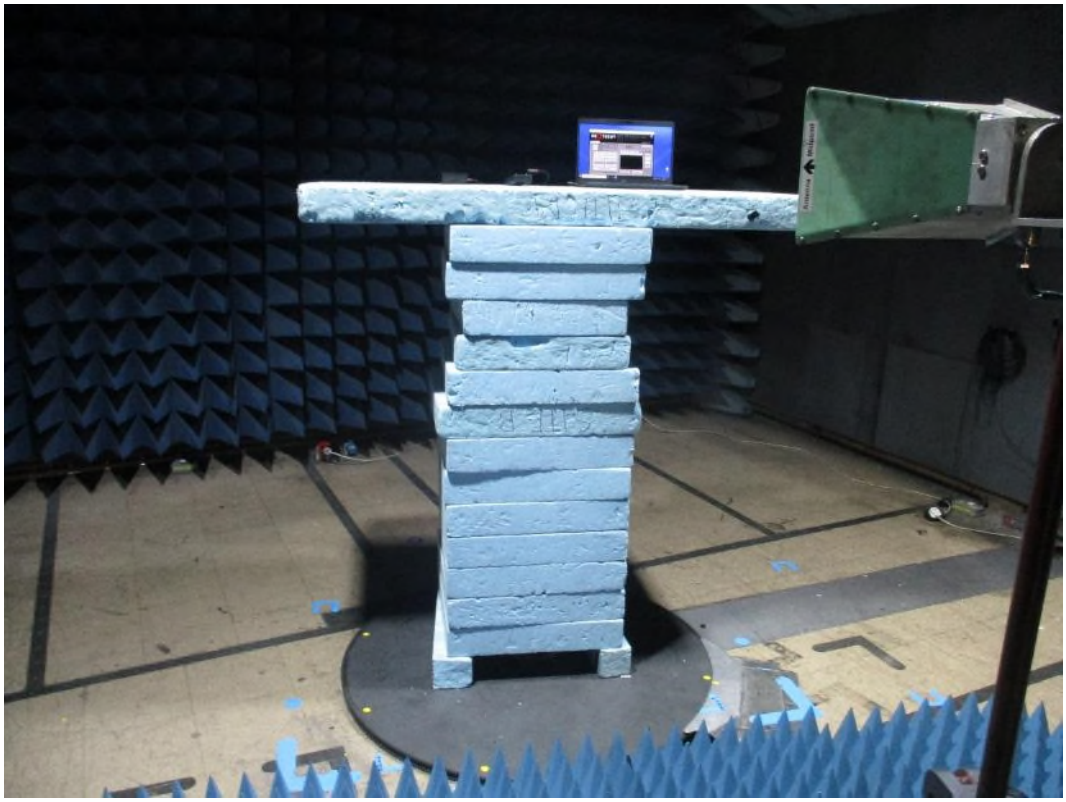


EUT Upright

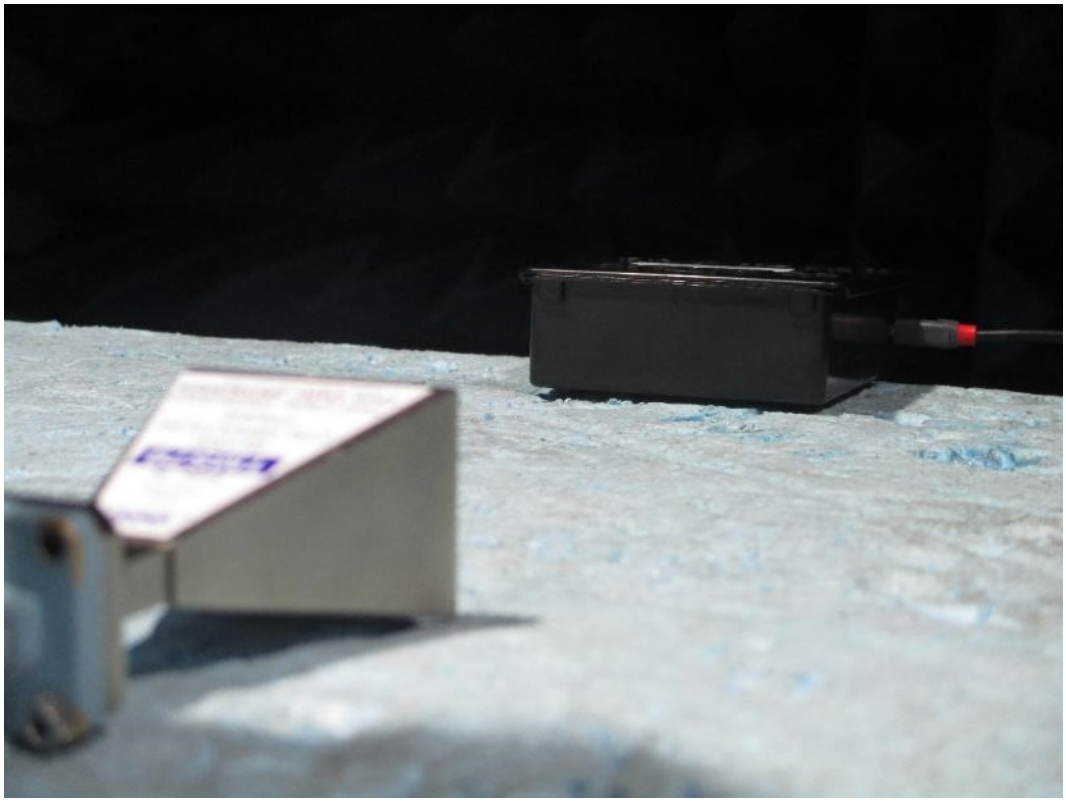
Note: See also mouthguard position photos section 8.11

8.14 Radiated emissions above 1 GHz






PROTECHT
Philtronics



Note: See also mouthguard position photos section 8.11

8.15 Radiated emission diagrams

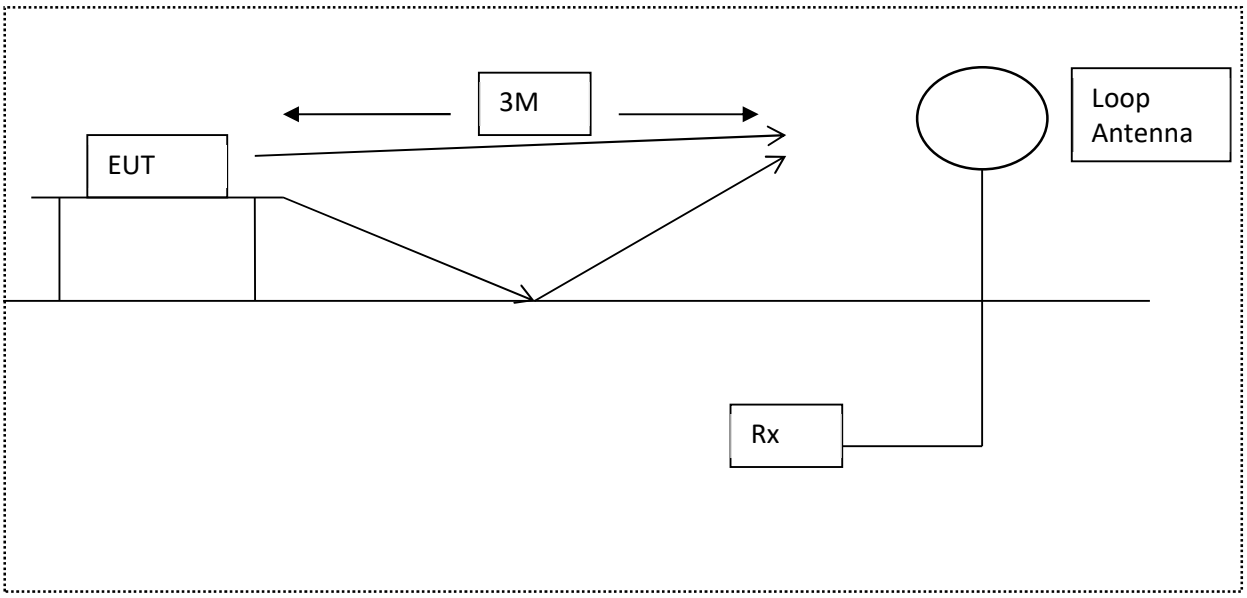


Diagram of the radiated emissions test setup below 30 MHz

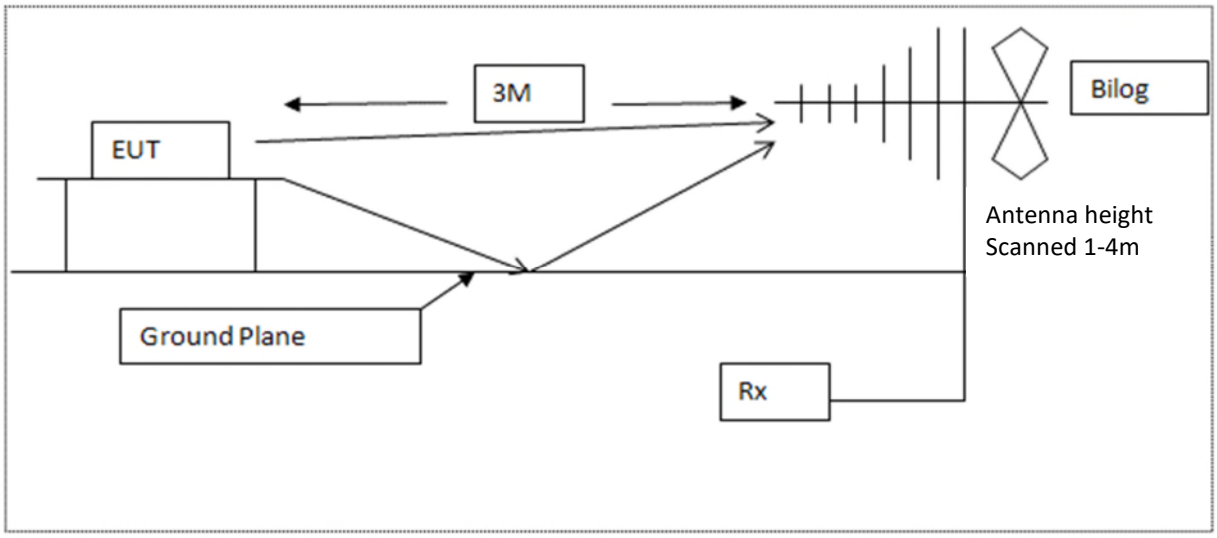


Diagram of the radiated emissions test setup 30 - 1000 MHz

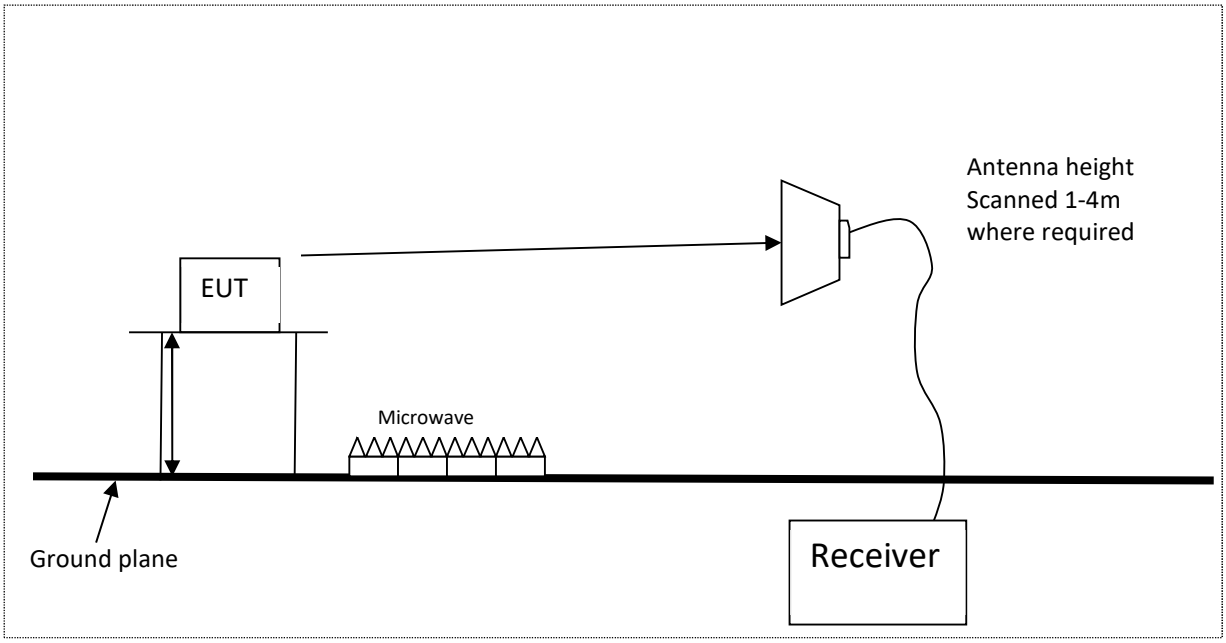


Diagram of the radiated emissions test setup above 1GHz

8.16 AC powerline conducted emission diagram

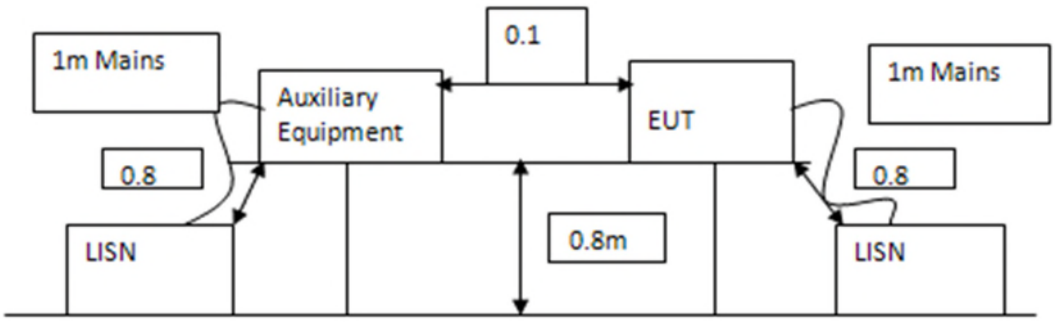


Diagram of the AC conducted emissions test setup

9 Test equipment calibration list

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

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
E035	11947A	Transient Limiter 9kHz - 200MHz	Hewlett Packard	#16-Dec-2022	12 months
E136	3105	Horn Antenna 1 - 12.5 GHz	EMCO	02-Apr-2022	12 months
E150	MN2050	LISN 13A	Chase	25-Apr-2022	12 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	07-Jul-2022	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	21-June-2022	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	23-Aug-2022	12 months
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	06-Jul-2022	24 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	#06-Dec-2022	24 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	10-Mar-2022	12 months
E856	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	#06-Dec-2022	12 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	28-Mar-2022	24 months
NSA-M	NSA - M	NSA - Site M	RN Electronics	29-Nov-2021	36 months
TMS78	3160-08	Horn Std Gain 12.4 - 18 GHz	ETS Systems	#30-Sep-2022	12 months
TMS79	3160-09	Horn Std Gain 18 - 26.5 GHz	ETS Systems	25-May-2022	12 months
TMS81	6502	Antenna Active Loop	EMCO	22-Jul-2021	24 months
TMS82	8449B	Pre-Amplifier 1GHz - 26.5GHz	Agilent Technologies	#16-Dec-2022	12 months
VSWR-M	VSWR	VSWR 1-18GHz	RN Electronics	24-Nov-2021	36 months
ZSW1	V2.5.2	Measurement Software Suite	RN Electronics	Not Applicable	

Equipment was within calibration dates for tests and has been re-calibrated since/during date of tests.

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Not Specified	AC/DC adaptor	Amazon	Not Specified
2	Latitude 5400	Laptop	Dell	3165001706
3	Nrf52840-dongle	BLE USB dongle	Nordic	pca10059
4	Osprey - SWA	Mouth Guard	Morgan Morse	52AB569AEE

10.2 RN Electronics supplied equipment

No RN Electronics Ltd supplied equipment was used.

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, ISED 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, ISED Registration No. 5612A-2, VCCI Registration No. 4065

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, ISED 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, ISED Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

RN Electronics CAB identifier as issued by Innovation, Science and Economic Development Canada is UK0002
RN Electronics CAB identifier as issued by FCC is UK0015

13 Abbreviations and units

%	Percent
λ	Wavelength
µA/m	microAmps per metre
µV	microVolts
µW	microWatts
AC	Alternating Current
ACK	ACKnowledgement
ACP	Adjacent Channel Power
AFA	Adaptive Frequency Agility
ALSE	Absorber Lined Screened Enclosure
AM	Amplitude Modulation
Amb	Ambient
ANSI	American National Standards Institute
ATPC	Automatic Transmit Power Control
AVG	Average
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BT	BlueTooth
BLE	BlueTooth Low Energy
BW	Bandwidth
ºC	Degrees Celsius
C/I	Carrier / Interferer
CAC	Channel Availability Check
CCA	Clear Channel Assessment
CEPT	European Conference of Postal and Telecommunications Administrations
CFR	Code of Federal Regulations
CISPR	Comité International Spécial des Perturbations Radioélectriques
cm	centimetre
COFDM	Coherent OFDM
COT	Channel Occupancy Time
CS	Channel Spacing
CW	Continuous Wave
DAA	Detect And Avoid
dB	deciBels
dBµA/m	deciBels relative to 1µA/m
dBµV	deciBels relative to 1µV
dBµV/m	deciBels relative to 1µV/m
dBc	deciBels relative to Carrier
dBd	deciBels relative to dipole gain
dBi	deciBels relative to isotropic gain
dBm	deciBels relative to 1mW
dBr	deciBels relative to a maximum value
dBW	deciBels relative to 1W
DC	Direct Current
DFS	Dynamic Frequency Selection
DMO	Dynamic Modulation Order
DSSS	Direct Sequence Spread Spectrum
DTA	Digital Transmission Analyser
EIRP	Equivalent Isotropic Radiated Power
emf	electromotive force
ERC	European Radiocommunications Committee
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
EU	European Union
EUT	Equipment Under Test
FCC	Federal Communications Commission
FER	Frame Error Rate
FHSS	Frequency Hopping Spread Spectrum
FM	Frequency Modulation
FSK	Frequency Shift Keying
FSS	Fixed Satellite Service
g	Grams
GHz	GigaHertz
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
ISED	Innovation Science and Economic Development
ITU	International Telecommunications Union
KDB	Knowledge DataBase

kg	kilogram	pW	picoWatts
kHz	kiloHertz	QAM	Quadrature Amplitude Modulation
kPa	Kilopascal	QP	Quasi Peak
LBT	Listen Before Talk	QPSK	Quadrature Phase Shift Keying
LISN	Line Impedance Stabilisation Network	RBW	Resoution Band Width
LNA	Low Noise Amplifier	RED	Radio Equipment Directive
LNB	Low Noise Block	R&TTE	Radio and Telecommunication Terminal Equipment
LO	Local Oscillator	Ref	Reference
m	metre	RF	Radio Frequency
mA	milliAmps	RFC	Remote Frequency Control
max	maximum	RFID	Radio Frequency IDentification
Mbit/s	MegaBits per second	RLAN	Radio Local Area Network
MCS	Modulation and Coding Scheme	RMS	Root Mean Square
MHz	MegaHertz	RNSS	Radio Navigation Satellite Service
mic	Microphone	RSL	Received Signal Level
MIMO	Multiple Input, Multiple Output	RSSI	Received Signal Strength Indicator
min	minimum	RTP	Room Temperature and Pressure
mm	millimetres	RTPC	Remote Transmit Power Control
ms	milliseconds	Rx	Receiver
mW	milliWatts	s	Seconds
NA	Not Applicable	SINAD	Signal to Noise And Distortion
NFC	Near Field Communications	SRD	Short Range Device
nom	Nominal	Tx	Transmitter
nW	nanoWatt	UKAS	United Kingdom Accreditation Service
OATS	Open Area Test Site	UKCA	United Kingdom Conformity Assessed
OBW	Occupied Band Width	UKRER	United Kingdom Radio Equipment Regulations
OCW	Occupied Channel Width	UHF	Ultra High Frequency
OFDM	Orthogonal Frequency Division Multiplexing	U-NII	Unlicensed National Information Infrastructure
OOB	Out Of Band	USB	Universal Serial Bus
ppm	Parts per million	UWB	Ultra Wide Band
PER	Packet Error Rate	V	Volts
PK	Peak	V/m	Volts per metre
PMR	Private Mobile Radio	VBW	Video Band Width
PRBS	Pseudo Random Bit Sequence	VHF	Very High Frequency
PRF	Pulse Repitition Frequency	VSAT	Very Small Aperture Terminal
PSD	Power Spectral Density	W	Watts
PSU	Power Supply Unit		

====== END OF TEST REPORT ======