Radio Test Report

ArjoHuntleigh AB

Caylis

675003

47 CFR Part 15.225 Effective Date 1st October 2021
DXX: Part 15 Low Power Communication Device Transmitter
Test Date: 18th May 2023 to 12th June 2023
Report Number: 06-13758-2-23 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).

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Certificate of Test 13758-2

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:	Caylis
Model Number:	675003
Unique Serial Number:	PE-019 (BT) and PE-005 (Wi-Fi)
Applicant:	ArjoHuntleigh AB Hans Michelsensgatan 10 Malmö, Sweden 211 20
Proposed FCC ID	2BBKF675003
Full measurement results are detailed in Report Number:	06-13758-2-23 Issue 01
Test Standards:	47 CFR Part 15.225 Effective Date 1st October 2021 DXX: Part 15 Low Power Communication Device Transmitter

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: 18th May 2023 to 12th June 2023

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2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	ArjoHuntleigh AB Hans Michelsensgatan 10 Malmö Sweden 211 20	
Manufacturer of EUT	ArjoHuntleigh AB	
Full Name of EUT	Caylis	
Model Number of EUT	675003	
Serial Number of EUT	PE-019 (BT) and PE-005 (WiFi)	
Date Received	18th May 2023	
Date of Test:	18th May 2023 to 12th June 2023	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	19th June 2023	
Main Function	The Caylis (Albatross project name) air mattress system provides low air loss therapy using a multi-section air mattress which is inflated by the pump to be tested. The pump controls which section of the mattress is inflated to provide different therapies and also provides patient turn assist using the air mattress.	
Information Specification	Height	247 mm
	Width	380 mm
	Depth	200 mm
	Weight	4.6 kg
	Voltage	100-230 V AC
	Current	1 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Hooked on to bed - Display facing upwards
Choice of model(s) for type tests	Production sample
Antenna details	Molex 1462362102
Antenna port	N/A
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2480 MHz
Lowest Signal generated in EUT	12 MHz
Hardware Version (HVIN)	Not Specified
Software Version	N/A
Firmware Version (FVIN)	Not Specified
Type of Equipment	Combined
Technology Type	NFC, BTC, BLE & 2.4GHz Wi-Fi
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	NFC: 13.56 MHz Bluetooth Classic & Low Energy: 2400 – 2480 MHz 2.4 GHz Wi-Fi: 2412 – 2480 MHz
EUT Declared Modulation Parameters	NFC: ISO/IEC 15693 Bluetooth Low Energy: LE1M, LE2M & LE coded 2.4 GHz Wi-Fi: 802.11 b/g/n
EUT Declared Power level	NFC: 250 mW Bluetooth Low Energy: Not Specified 2.4 GHz Wi-Fi: Not Specified
EUT Declared Signal Bandwidths	NFC: Not Specified Bluetooth Classic: 1MHz Bluetooth Low Energy: 2 MHz 2.4 GHz Wi-Fi: 20 MHz
EUT Declared Channel Spacing's	NFC: N/A Bluetooth Low Energy: 1MHz 2.4 GHz Wi-Fi: 5 MHz
EUT Declared Duty Cycle	NFC: 99.24% (Tag Present) & 3% (Tag not Present) Bluetooth Low Energy: Not Specified 2.4 GHz Wi-Fi: Not Specified
Unmodulated carrier available?	No
Declared frequency stability	Not Specified
RX Parameters	
Alignment range – receiver	NFC: 13.56 MHz Bluetooth Classic & Low Energy: 2400 – 2483.5 MHz 2.4 GHz Wi-Fi: 2400 – 2483.5 MHz
EUT Declared RX Signal Bandwidth	Not Specified
Receiver Signal Level (RSL)	Not Specified
FCC Parameters	
FCC Transmitter Class	DXX: Part 15 Low Power Communication Device Transmitter

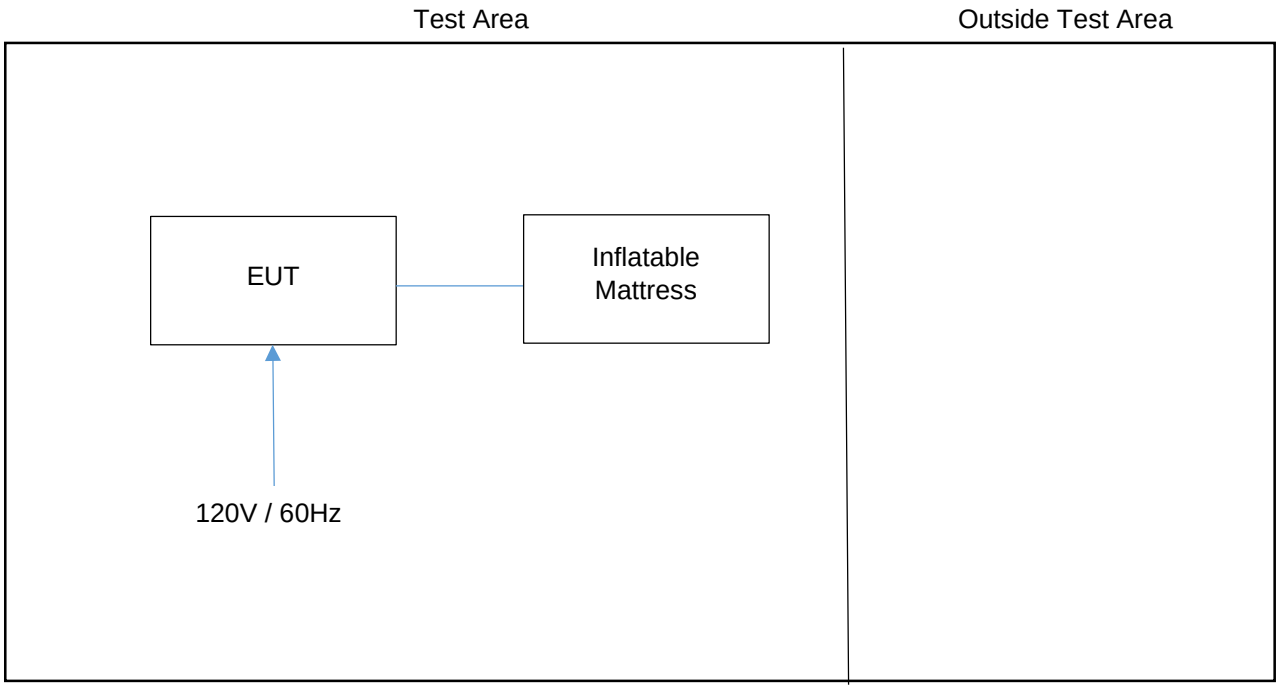
2.3 Functional description

The pump has a touch screen display, uses NFC communications to check the mattress type connected and has CAN bus to communicate with some beds but can operate in standalone mode. It includes the ability for Bluetooth and Wifi capability for remote connection and has a USB interface for servicing. The pump includes a blower which is driven by a BLDC type motor using a suitable controller. It includes butterfly valves controlled by stepper motors to provide fine pressure control for different mattress sections. A rotary valve is used to control the flow of air to the turn assist sections of the mattress. It includes a system to measure the air pressure in a weight sensing bladder under the mattress to provide automatic weight estimation of the patient. It uses 10 pressure sensors to measure the pressures in various parts of the mattress and pump.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Mode 1	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11g 6Mbps Low Channel (2412MHz)	Yes
Mode 2	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11g 6Mbps Mid Channel (2442MHz)	Yes
Mode 3	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11g 6Mbps High Channel (2462MHz)	Yes
Mode 4	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11b 1Mbps High Channel (2462MHz)	Yes
Mode 5	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11b 1Mbps Mid Channel (2442MHz)	Yes
Mode 6	EUT Normal Operation with NFC Communicating with Tag + Wi-Fi 802.11b 1Mbps Low Channel (2412MHz)	Yes
Mode 7	EUT Normal Operation with NFC Communicating with Tag + BLE Low Channel (2402MHz)	Yes
Mode 8	EUT Normal Operation with NFC Communicating with Tag + BLE Mid Channel (2440MHz)	Yes
Mode 9	EUT Normal Operation with NFC Communicating with Tag + BLE High Ch (2480MHz)	Yes
Mode 10	EUT Normal operation with NFC communicating with Tag present	Yes
Mode 11	EUT Normal operation with NFC polling with no Tag present	Yes

2.5 Emissions configuration



The unit was powered from AC mains. The client supplied 2 separate units for testing, one was configured for 2.4 GHz Wi-Fi test modes and the other configured to Bluetooth Low Energy test modes.

For the 2.4 GHz Wi-Fi sample the worst case configuration for radiated emissions below 1GHz was 802.11g modulation scheme with 6Mbps data rate and 802.11b modulation scheme with 1Mbps data rate above 1GHz.

For the Bluetooth Low Energy sample the worst case configuration was LE1M.

The client supplied a support laptop and cable to connect to the EUT ‘CON18’ internal port which allowed the EUT to be programmed/configured, this is not available to any end user. The laptop contained files which were used to configure the EUT into the above worst-case pre-approved module modes on top, middle and bottom channels, in conjunction with the 13.56 MHz RFID function, as stated within section 2.4 of this report.

2.5.1 Signal leads

Port Name	Cable Type	Connected
AC Power	Unscreened, 2 core	Yes, 2 pin plug
CAN bus	-	No

The applicant declares that the CAN bus hardware and connector are present on this unit but the feature is not enabled in software.

3 Summary of test results

The Caylis, 675003 was tested for compliance to the following standard(s):

47 CFR Part 15.225 Effective Date 1st October 2021

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	PASSED
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.225(d)	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209	PASSED
6. Intentional radiator field strength	47 CFR Part 15C Part 15.225(a)	PASSED
7. Occupied bandwidth	47 CFR Part 15C Part 15.215	PASSED
8. Spectrum mask	47 CFR Part 15C Part 15.225	PASSED
9. Frequency stability	47 CFR Part 15C Part 15.225(e)	PASSED

Spectrum below 30MHz started at a frequency of 9 kHz based on the lowest signal generated/used within the equipment as declared by the applicant.

Spectrum investigated up to a frequency of 25GHz based on 10 times the highest channel/ signal generated in equipment of 2480MHz.

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

4.3 Tests at extremes of temperature & voltage

The following test conditions were used to simulate testing at nominal or extremes.

Temperature Test Conditions		Voltage Test Conditions	
T nominal	20 °C	V nominal	120V AC
T minimum	-20 °C	V minimum	100V AC
T maximum	50 °C	V maximum	230V AC

The ambient test conditions of humidity and pressure in the laboratory were as specified in each specific test section within this report

4.4 Test fixtures

In order to measure RF parameters at temperature extremes, the EUT was tested in a temperature controlled chamber as follows:
A permanent internal RF port was used for tests other than Spectrum Mask, Occupied Bandwidth and Frequency stability.
A test fixture was used for testing Spectrum Mask, Occupied Bandwidth and Frequency Stability.

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.

During the initial scan, no difference was noted with either WiFI or BLE active on any channel so Mode 8 was used for this test. The EUT was powered using the mains power supply connected to a 120 VAC 60 Hz power source.

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 of the limit were investigated.

Tests were performed in Test Site F.

5.1.4 Test equipment

E035, E150, E411, E624, ZSW1

See Section 9 for more details

5.1.5 Test results

Temperature of test environment 18°C
Humidity of test environment 52%

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz

Plot refs
13758-2 Cond 1 AC Live 150k-30M Average
13758-2 Cond 1 AC Live 150k-30M Quasi-Peak
13758-2 Cond 1 AC Neutral 150k-30M Average
13758-2 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	0.219	47.7	47.1	-15.8	45.0	-7.9
2	0.362	43.2	41.2	-17.5	35.8	-12.9
3	0.512	36.1	33.2	-22.8	28.1	-17.9
4	0.655	31.6	30.1	-25.9	24.7	-21.3
5	0.809	33.8	29.4	-26.6	22.0	-24.0
6	6.166	33.6	30.2	-29.8	21.8	-28.2
7	8.568	42.0	38.7	-21.3	23.5	-26.5
8	8.573	42.1	38.1	-21.9	22.8	-27.2
9	13.559	55.8	43.2	-16.8	35.5	-14.5
10	17.349	43.3	39.8	-20.2	27.3	-22.7

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	0.219	44.8	43.6	-19.3	42.1	-10.8
2	0.363	42.6	40.7	-18.0	35.8	-12.9
3	0.513	37.3	33.9	-22.1	28.4	-17.6
4	0.808	33.4	29.6	-26.4	21.9	-24.1
5	8.511	40.6	36.4	-23.6	21.6	-28.4
6	13.560	55.2	48.1	-11.9	37.2	-12.8
7	17.661	43.9	39.8	-20.2	27.1	-22.9

No discernible difference was noted in emissions between channels or Wi-Fi and BLE operation with the RFID (exploratory measurements); therefore the final measurements are presented for TX mid channel Wi-Fi mode 8 only.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report. Only results within 20dB of limits have been 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 [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 15.225(d) [Reference 4.1.1 of this report]

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. The EUT was powered using the mains power supply connected to a 120 VAC 60 Hz power source. The EUT was operated in Modes 1, 2, 3, 7, 8 and 9, as no discernible difference was noted in emissions between modes, only middle channel BLE with the RFID and middle channel Wi-Fi with the RFID were plotted.

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.

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

Tests were performed using Test Site H.

5.2.4 Test equipment

E534, E535, TMS81, ZSW1

See Section 9 for more details

5.2.5 Test results

Temperature of test environment 21°C
Humidity of test environment 40%
Pressure of test environment 101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with WiFi: 2442 MHz (Mid Ch) active)

Plot refs
Rad 3 9k-150kHz Para (Side)
Rad 2 9k-150kHz Perp (Side)

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)

Plot refs
Rad 4 9k-150kHz Para (Side)
Rad 4 9k-150kHz Perp (Side)

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

5.3 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 15.225(d) [Reference 4.1.1 of this report]

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes The EUT was powered using the mains power supply connected to a 120 VAC 60 Hz power source.

The EUT was operated in Modes 1, 2, 3, 7, 8 and 9, as no discernible difference was noted in emissions between modes, only middle channel BLE with the RFID and middle channel Wi-Fi with the RFID were plotted.

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.

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

Tests were performed using Test Site H.

5.3.4 Test equipment

TMS81, ZSW1, E534, E535

See Section 9 for more details

5.3.5 Test results

Temperature of test environment 19 - 21°C
Humidity of test environment 40 - 45%
Pressure of test environment 101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with WiFi: 2442 MHz (Mid Ch) active)

Plot refs
Rad 3 150k-30MHz Para (Flat)
Rad 3 150k-30MHz Perp (Side)

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)

Plot refs
Rad 2 150k-30MHz Para (Flat)
Rad 2 150k-30MHz Perp (Side)

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 15.225(d) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. The EUT was powered using the mains power supply connected to a 120 VAC 60 Hz power source. The EUT was operated in Modes 1, 2, 3, 7, 8 and 9.

5.4.3 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. The antenna was height scanned between 1 and 4 metres and the equipment was rotated 360 degrees to record the worst case emissions. Both Horizontal and vertical polarisations of measuring antenna were tested.

Tests were performed in Test Site H

5.4.4 Test equipment

E914, E745, NSA-H, ZSW1, E534, E535

See Section 9 for more details

5.4.5 Test results

Temperature of test environment 20°C
Humidity of test environment 45%
Pressure of test environment 101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with Wi-Fi: 2442 MHz (Mid Ch) active)

Plot refs
13758-2 Rad 1 VHF Horiz
13758-2 Rad 1 VHF Vert
13758-2 Rad 1 UHF Horiz
13758-2 Rad 1 UHF Vert

Table of signals measured for Horizontal Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	45.600	26.6	20.6	-19.4
2	110.531	26.2	19.4	-24.1
3	176.251	32.4	27.0	-16.5
4	189.834	31.1	26.7	-16.8
5	203.403	36.1	31.9	-11.6
6	211.720	31.5	26.3	-17.2
7	216.950	37.0	31.5	-14.5
8	230.517	44.0	39.6	-6.4
9	244.050	33.1	29.6	-16.4
10	254.522	42.2	37.9	-8.1
11	257.620	43.7	40.5	-5.5

12	263.017	31.3	25.1	-20.9
13	272.840	36.7	30.8	-15.2
14	284.740	41.8	37.5	-8.5
15	294.669	45.4	40.4	-5.6
16	311.866	43.3	38.9	-7.1
17	335.467	37.5	31.7	-14.3
18	338.971	44.2	38.4	-7.6
19	366.102	43.5	38.5	-7.5
20	420.319	33.7	28.3	-17.7
21	476.377	31.9	26.3	-19.7
22	582.069	38.6	31.0	-15.0
23	593.911	40.4	33.0	-13.0
24	671.182	35.5	29.5	-16.5
25	871.505	38.4	32.8	-13.2
26	933.469	42.9	36.6	-9.4
27	945.833	38.5	32.3	-13.7
28	956.841	38.4	32.5	-13.5
29	965.220	38.9	32.3	-21.7
30	996.033	39.1	35.2	-18.8

Table of signals measured for Vertical Signal List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	50.310	28.5	22.5	-17.5
2	110.176	36.7	30.9	-12.6
3	172.961	23.7	17.4	-26.1
4	189.835	26.4	23.3	-20.2
5	203.394	25.7	28.8	-14.7
6	209.750	38.0	33.3	-10.2
7	211.001	35.7	30.8	-12.7
8	211.001	34.9	30.7	-12.8
9	216.943	31.8	26.4	-19.6
10	230.512	25.5	31.5	-14.5
11	249.501	33.7	28.7	-17.3
12	257.637	29.2	26.8	-19.2
13	284.748	29.7	27.4	-18.6
14	296.700	42.0	37.1	-8.9
15	311.879	32.1	30.3	-15.7
16	348.110	35.2	29.1	-16.9
17	366.070	39.9	28.8	-17.2
18	382.040	35.0	27.5	-18.5
19	393.233	35.2	33.0	-13.0
20	415.935	40.0	33.7	-12.3
21	424.036	38.8	32.3	-13.7
22	447.422	32.1	29.5	-16.5
23	637.390	34.8	29.0	-17.0
24	680.861	35.6	29.9	-16.1
25	757.720	37.1	30.7	-15.3
26	918.980	46.4	39.3	-6.7
27	922.920	45.7	38.5	-7.5
28	932.969	49.3	42.4	-3.6
29	962.310	43.1	36.8	-17.2
30	997.762	41.2	34.3	-19.7

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)

Plot refs
13758-2 Rad VHF Horiz
13758-2 Rad VHF Vert
13758-2 Rad UHF Horiz
13758-2 Rad UHF Vert

Emissions measured from 30 MHz to 1 GHz were non-radio related and were the same for both WiFi and BLE modes.

Note: No discernible difference was noted in emissions between 13.56 MHz RFID with Wi-Fi on Low, Mid and High channels, and 13.56MHz RFID with BLE on Low, Mid and High channels, therefore results above cover all modes. Plots are shown for Middle channel with Wi-Fi and BLE only.

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

LIMITS:
15.209 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 [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 15.209/15.225(d) [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. The EUT was powered using the mains power supply connected to a 120 VAC 60 Hz power source. The EUT was operated in Modes 4, 5, 6, 7, 8 and 9.

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.

Tests were performed in Test Site M.

5.5.4 Test equipment

E136, E411, E429, E624, E642, E856, E904, E972, TMS78, TMS79, TMS82

See Section 9 for more details

5.5.5 Test results

Temperature of test environment 15°C
Humidity of test environment 68%
Pressure of test environment 103kPa

Setup Table

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with WiFi 802.11 g 6Mbps 20 MHz 2442 MHz (CH7) active)

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
2739.07	43.3	-30.7	35	-19	Side	Vertical
3735.14	44	-30	35.9	-18.1	Side	Horizontal
3984.12	50.4	-23.6	41	-13	Side	Horizontal
7325.07	46.22	-27.78	39.12	-14.88	Side	Vertical
7326.19	48.42	-25.58	38.62	-15.38	Side	Horizontal
7385.64	47.14	-26.86	37.94	-16.06	Side	Vertical
7385.94	48.54	-25.46	37.74	-16.26	Side	Horizontal

Plots
13758-2 Rad 1 1-2GHz Vert WiFi
13758-2 Rad 1 1-2GHz Horiz WiFi
13758-2 Rad 1 2-5GHz Vert WiFi
13758-2 Rad 1 2-5GHz Horiz WiFi

13758-2 Rad 1 5-6GHz Vert WiFi
13758-2 Rad 1 5-6GHz Horiz WiFi
13758-2 Rad 1 6-7.77GHz Vert WiFi
13758-2 Rad 1 6-7.77GHz Horiz WiFi
13758-2 Rad 1 7.77-10GHz Vert WiFi
13758-2 Rad 1 7.77-10GHz Horiz WiFi
13758-2 Rad 1 10-12_5GHz Vert WiFi
13758-2 Rad 1 10-12_5GHz Horiz WiFi
13758-2 Rad 2 12-15GHz Vert WiFi
13758-2 Rad 2 12-15GHz Horiz WiFi
13758-2 Rad 2 15-18GHz Vert WiFi
13758-2 Rad 2 15-18GHz Horiz WiFi
13758-2 Rad 1 18-22GHz Vert WiFi
13758-2 Rad 1 18-22GHz Horiz WiFi
13758-2 Rad 1 22-25GHz Vert WiFi
13758-2 Rad 1 22-25GHz Horiz WiFi

Setup Table

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (with 2440 MHz (CH17) 2 MHz BLE active)

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
1494.023	45.3	-28.7	38.7	-15.3	Upright	Horizontal
1494.043	45.8	-28.2	39.2	-14.8	Flat	Vertical
2490.039	46.1	-27.9	35.3	-18.7	Side	Vertical
4878.788	55.6	-18.4	47.2	-6.8	Upright	Vertical
4878.884	57.6	-16.4	49.8	-4.2	Upright	Horizontal

Plots
13758-2 Rad 1 1-2GHz Vert BLE
13758-2 Rad 1 1-2GHz Horiz BLE
13758-2 Rad 1 2-5GHz Vert BLE
13758-2 Rad 1 2-5GHz Horiz BLE
13758-2 Rad 1 5-6GHz Vert BLE
13758-2 Rad 1 5-6GHz Horiz BLE
13758-2 Rad 1 6-7.77GHz Vert BLE
13758-2 Rad 1 6-7.77GHz Horiz BLE
13758-2 Rad 1 7.77-10GHz Vert BLE
13758-2 Rad 1 7.77-10GHz Horiz BLE
13758-2 Rad 1 10-12_5GHz Vert BLE
13758-2 Rad 1 10-12_5GHz Horiz BLE
13758-2 Rad 2 12-15GHz Vert BLE
13758-2 Rad 2 12-15GHz Horiz BLE
13758-2 Rad 2 15-18GHz Vert BLE
13758-2 Rad 2 15-18GHz Horiz BLE
13758-2 Rad 1 18-22GHz Vert BLE
13758-2 Rad 1 18-22GHz Horiz BLE
13758-2 Rad 1 22-25GHz Vert BLE
13758-2 Rad 1 22-25GHz Horiz BLE

Note: Only signals within 20dB of limits using the applicable detector are reported. Peak detector “Max held” Analyser plots against the Average limit line can be found in Section 6 of this report.

Note: Whilst 13.56 MHz RFID was tested with Low, Middle and High channels of both Wi-Fi and BLE, plots are only shown for Middle channel to minimise report size.

LIMITS:

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

These results show that the EUT has PASSED this test.

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

1 - 6 GHz ±4.7dB,6 – 18 GHz ±4.95dB, 18 – 26.5 GHz ±3.1dB

5.6 Intentional radiator field strength

5.6.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.225(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 15.225(a)/(b)/(c)/(d) [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 orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes.

The EUT was operated in Modes 10 and 11. For full test mode 10 (with Tag) was used for full test as worst case.

5.6.3 Test procedure

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

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

Measurements were made at Site OATS.

5.6.4 Test equipment

E411, E624, TMS81

See Section 9 for more details

5.6.5 Test results

Temperature of test environment 26°C
Humidity of test environment 40%
Pressure of test environment 102kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz

	Single channel
Peak Level (dBµV/m @3m)	47.06
Plot reference	13758-2 ERP 13.56MHz Parallel Side Position
Antenna Polarisation	Parallel
EUT Polarisation	Side

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

The above 3 m worst case measurement is extrapolated to 30 m using ANSI C63.10:2013 clause 6.4.4 as follows: -
Using clause 6.4.4.1 Equation (1)

$d_{near\ field} = 47.77 / f_{MHz}$
$= 47.77 / 13.56$
$= 3.523$ m

Using clause 6.4.4.2 Equation (2)

$FS_{limit} = FS_{max} – 40 \log(d_{near\ field} / d_{measure}) – 20 \log(d_{limit} / d_{near\ field})$
= 47.06 – 40 log(3.523 / 3) – 20 log(30 / 3.523)
= 25.66 dBµV/m @ 30 m.

LIMITS:

15.225(a) QP/Peak = the field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.
15.225(b) QP/Peak = within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 µV/m @ 30m = 50.5 dBµV/m @ 30m.
15.225(c) QP/Peak = within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 µV/m @ 30m = 40.5 dBµV/m @ 30m.
15.225(d) QP/Peak = outside of the 13.110-14.010 MHz band shall not exceed the general radiated emissions limits of 15.209.

These results show that the EUT has PASSED this test.

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

5.7 Occupied bandwidth

5.7.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.215 [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 [Reference 4.1.1 of this report]

5.7.2 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 tested whilst connected to the AC power for maximised emissions. The EUT was operated in Modes 10 and 11.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 10kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth.

Measurements were made via a test fixture referenced to maximum field strength.

Tests were performed using Test Site A.

5.7.4 Test equipment

E412, N610

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	23°C
Humidity of test environment	54%
Pressure of test environment	101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz (Tag Present)

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	41.974
Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts	13758-2 FCC 20dB BW with Tag 10kHzRBW
FLOW Worst case (MHz)	13.539
FHIGH Worst case (MHz)	13.581

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

LIMITS:
No limits apply however, per 15.215, the 20dB bandwidth of the emission is to remain within the band over expected variations in temperature and supply voltage. It is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimise 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 %

5.8 Spectrum mask

5.8.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.225 [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 15.225(a)/(b)/(c)/(d) [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 EUT was measured at a distance of 3 metres. The EUT and antenna were positioned for maximum field strength and referenced to the field strength measured on the OATS. The EUT was operated in Mode 10.

5.8.3 Test procedure

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

Plots were taken and results were referenced to limits at 30m by using the extrapolation factor calculated, per ANSI C63.10 clause 6.4.4 shown below.

Measurements were made at Site A.

5.8.4 Test equipment

E412, E555, L264, TMS38

See Section 9 for more details

5.8.5 Test results

Temperature of test environment 23°C
Humidity of test environment 54%
Pressure of test environment 101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz

	Single channel
Nominal, Maximised RF Output / field strength	47.06 dBµV/m
Nominal plot reference	Mask Nom Temp Nom Voltage

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

The above 3 m worst case measurement is extrapolated to 30 m using ANSI C63.10:2013 clause 6.4.4 as follows: -
Using clause 6.4.4.1 Equation (1)

$d_{near\ field} = 47.77 / f_{MHz}$
$= 47.77 / 13.56$
$= 3.523$ m

Using clause 6.4.4.2 Equation (2)

$FS_{limit} = FS_{max} – 40 \log(d_{near\ field} / d_{measure}) – 20 \log(d_{limit} / d_{near\ field})$
$= 47.06 – 40 \log(3.523 / 3) – 20 \log(30 / 3.523)$
$= 25.66$ dBµV/m @ 30 m.

LIMITS:

15.225(a) QP/Peak = the field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.
15.225(b) QP/Peak = within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 µV/m @ 30m = 50.5 dBµV/m @ 30m.
15.225(c) QP/Peak = within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 µV/m @ 30m = 40.5 dBµV/m @ 30m.
15.225(d) QP/Peak = outside of the 13.110-14.010 MHz band shall not exceed the general radiated emissions limits of 15.209.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows: <± 4.1 dB

5.9 Frequency stability

5.9.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.8 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report]

5.9.2 Configuration of EUT

The EUT's power port was connected to a variable power supply. This allowed the voltage end points to be set as declared by the manufacturer/required by the specification.

The EUT was placed in a temperature controlled chamber. The EUT emissions were observed by means of a test fixture. The EUT was operated in Mode 11.

5.9.3 Test procedure

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

Temperature stability was achieved at each test level before taking measurements. At nominal temperature the EUT supply was varied from -20 to +50˚C. A spectrum analyser was used and connected to an off-air frequency standard. The Analyser's frequency counter function was used to monitor the frequency of the carrier. The analyser was set with a suitable span, RBW and VBW.

Tests were performed using Test Site A.

5.9.4 Test equipment

E412, E434, E555, L264, TMS38, TMS57

See Section 9 for more details

5.9.5 Test results

Temperature of test environment 23°C
Humidity of test environment 54%
Pressure of test environment 101kPa

Band	13.553-13.567 MHz
Power Level	250 mW
Channel Spacing	Single channel
Mod Scheme	ISO/IEC 15693
Single channel	13.56 MHz

Test conditions		Frequency Error (MHz) Single channel
-20°C	Volts Nominal (120)	13.559280
-20°C	Volts Nominal (120)	13.559281
-10°C	Volts Nominal (120)	13.559302
0°C	Volts Nominal (120)	13.559315
10°C	Volts Nominal (120)	13.559258
20°C	Volts Minimum (100)	13.559231
	Volts Nominal (120)	13.559231
	Volts Maximum (230)	13.559231
30°C	Volts Nominal (120)	13.559278
40°C	Volts Nominal (120)	13.559325
50°C	Volts Nominal (120)	13.559336
Max Frequency Error per chan (Hz)		-769
Max Frequency Error observed (MHz)		-0.000769

Note: Error shown is referenced to nominal Channel frequency value.

LIMITS:
+/- 0.01%. (+/- 1.356kHz)

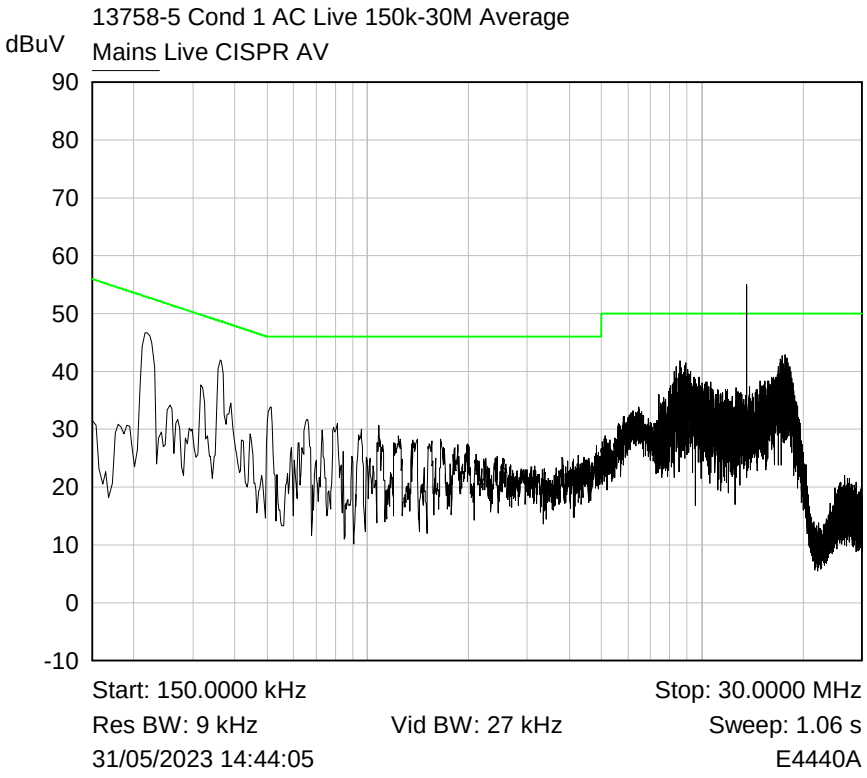
These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 0.0002 ppm (PSA Ext Ref)

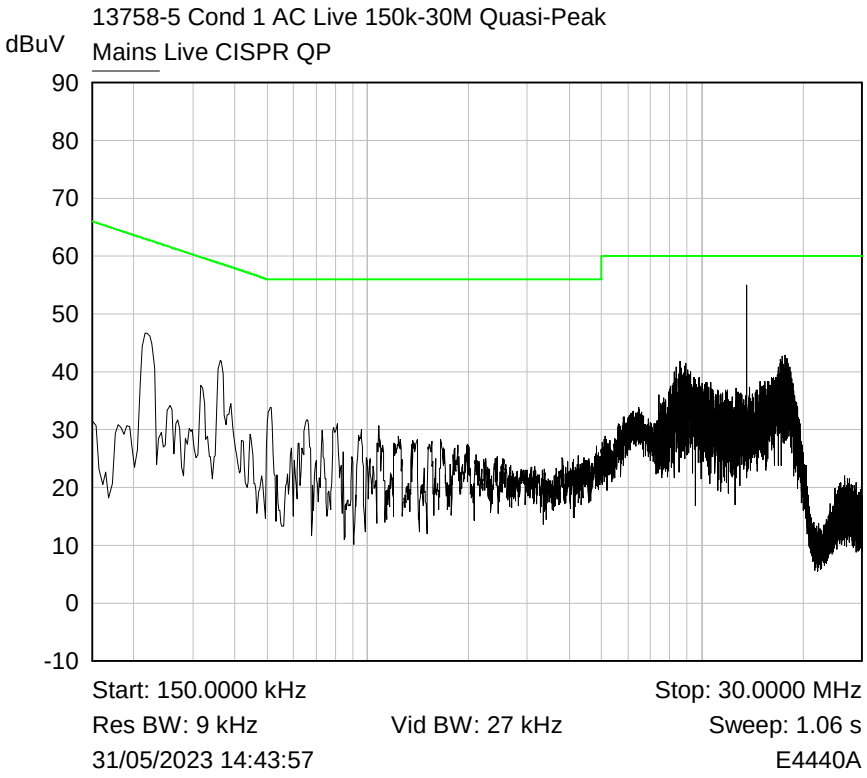
6 Plots/Graphical results

6.1 AC powerline conducted emission

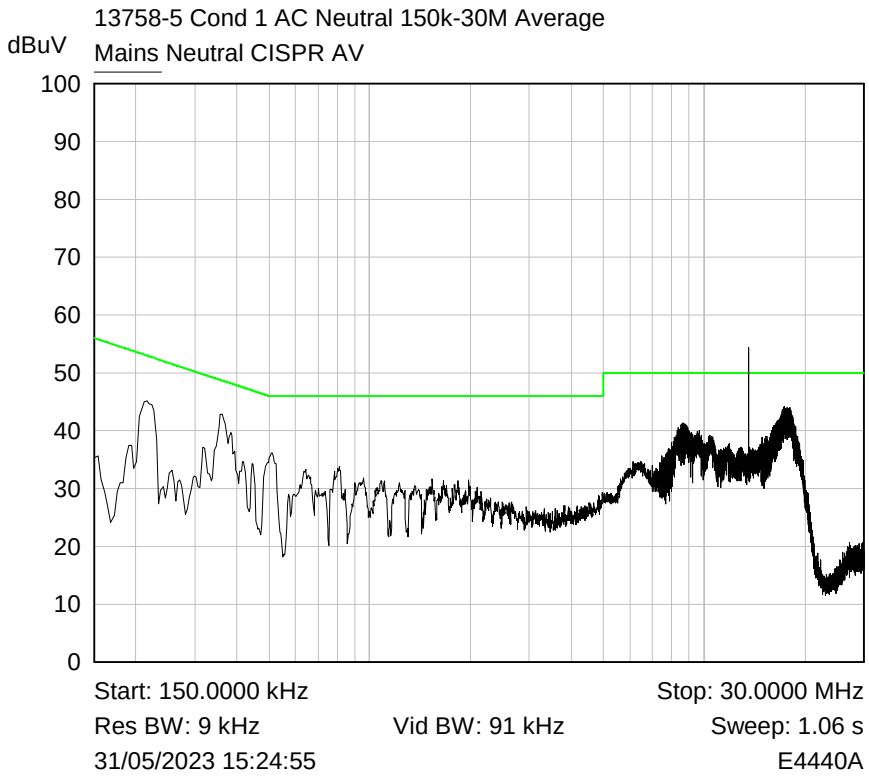
RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz



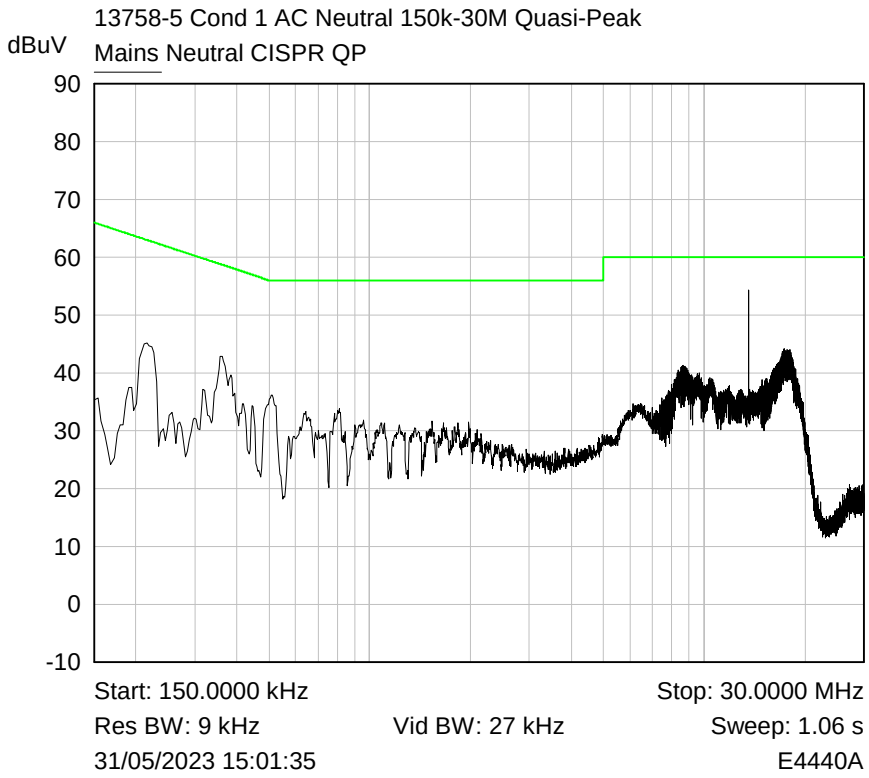
Peak emissions 150 kHz - 30 MHz on the live terminal against the average limit line.



Peak emissions 150 kHz - 30 MHz on the live terminal against the quasi-peak limit line.



Peak emissions 150 kHz - 30 MHz on the neutral terminal against the average limit line.



Peak emissions 150 kHz - 30 MHz on the neutral terminal against the quasi-peak limit line.

Table of signals measured for Live 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.219	47.7	47.1	-15.8	45.0	-7.9
2	0.362	43.2	41.2	-17.5	35.8	-12.9
3	0.512	36.1	33.2	-22.8	28.1	-17.9
4	0.655	31.6	30.1	-25.9	24.7	-21.3
5	0.809	33.8	29.4	-26.6	22.0	-24.0
6	6.166	33.6	30.2	-29.8	21.8	-28.2
7	8.568	42.0	38.7	-21.3	23.5	-26.5
8	8.573	42.1	38.1	-21.9	22.8	-27.2
9	13.559	55.8	43.2	-16.8	35.5	-14.5
10	17.349	43.3	39.8	-20.2	27.3	-22.7

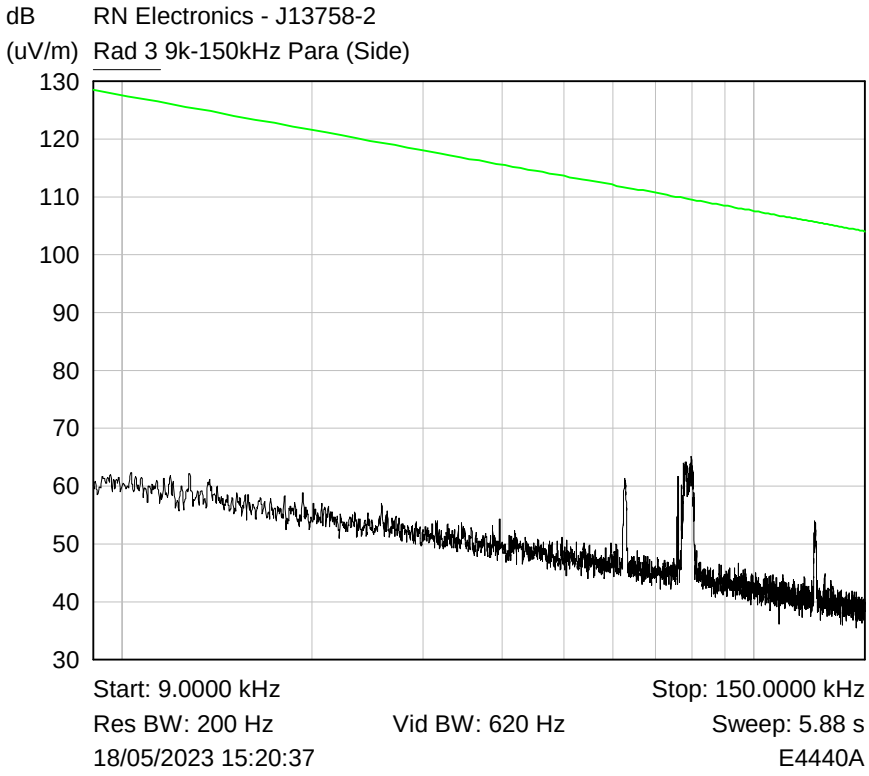
Table of signals measured for Neutral 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.219	44.8	43.6	-19.3	42.1	-10.8
2	0.363	42.6	40.7	-18.0	35.8	-12.9
3	0.513	37.3	33.9	-22.1	28.4	-17.6
4	0.808	33.4	29.6	-26.4	21.9	-24.1
5	8.511	40.6	36.4	-23.6	21.6	-28.4
6	13.560	55.2	48.1	-11.9	37.2	-12.8
7	17.661	43.9	39.8	-20.2	27.1	-22.9

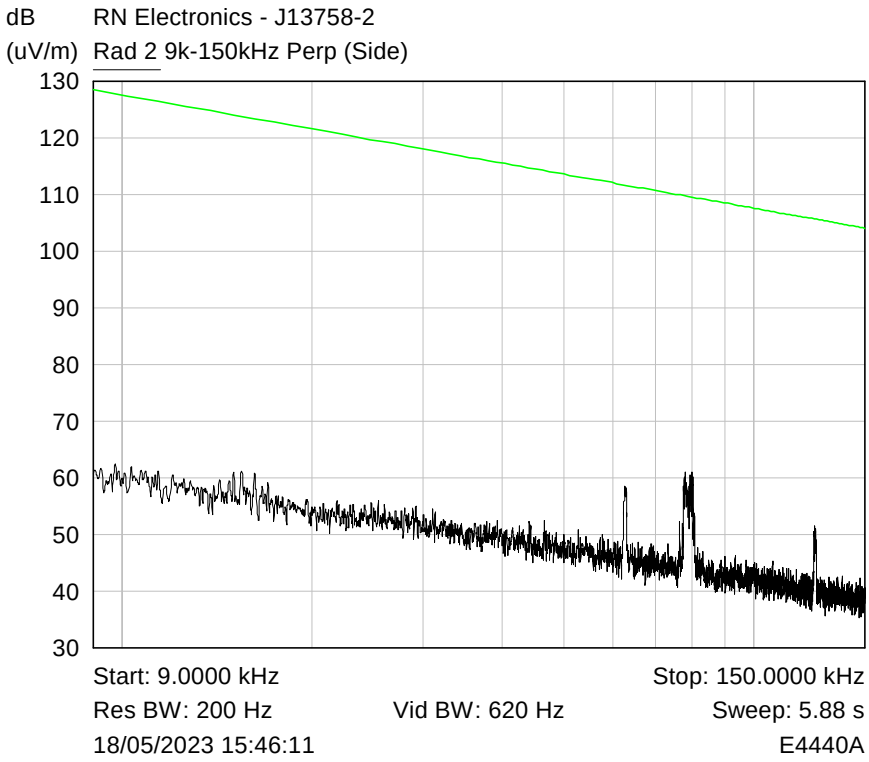
NOTE: The emission at 13.56 MHz is from the EUT RFID. As the emission is low power and does not exceed the limit when measured with an Average/Quasi Peak detector, the RFID Antenna does not need to be further investigated by terminating with a resistive load.

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with WiFi: 2442 MHz (Mid Ch) active)

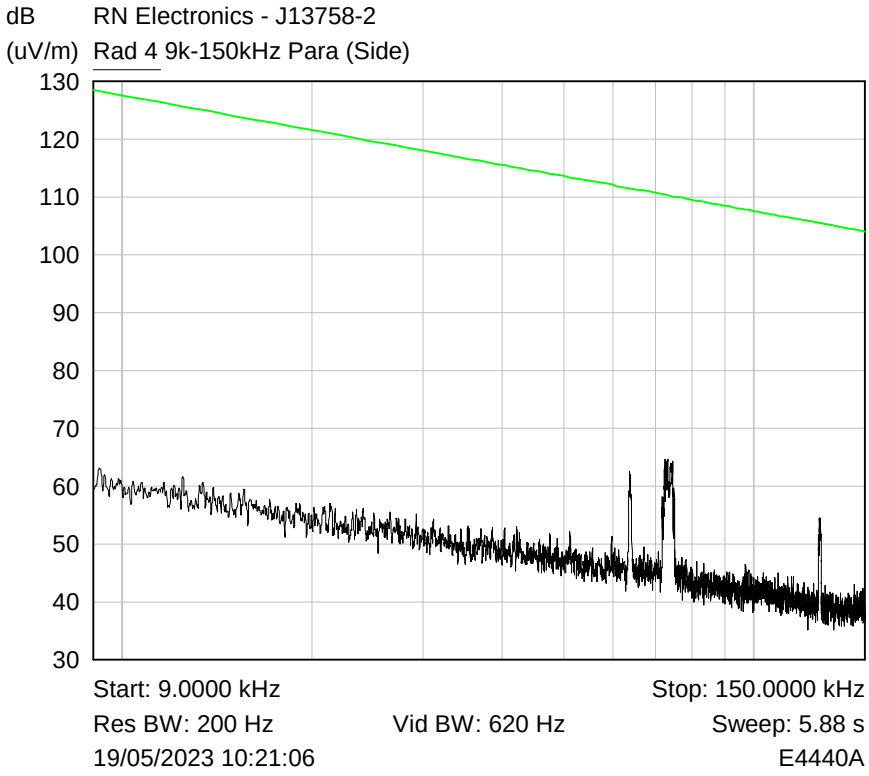


Plot of 9k-150kHz Parallel

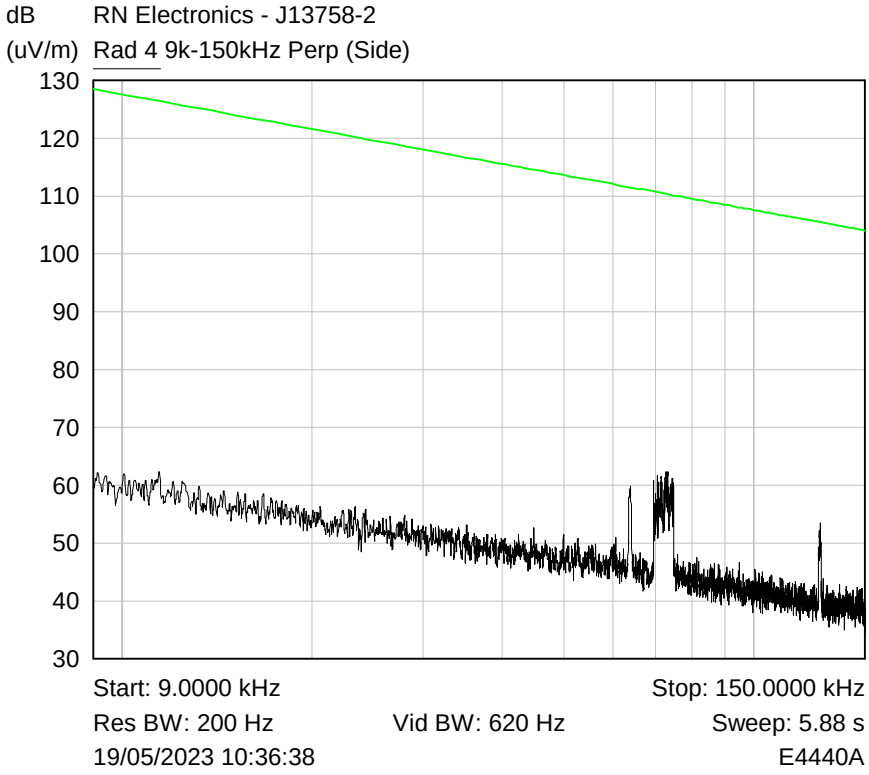


Plot of 9k-150kHz Perpendicular

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)



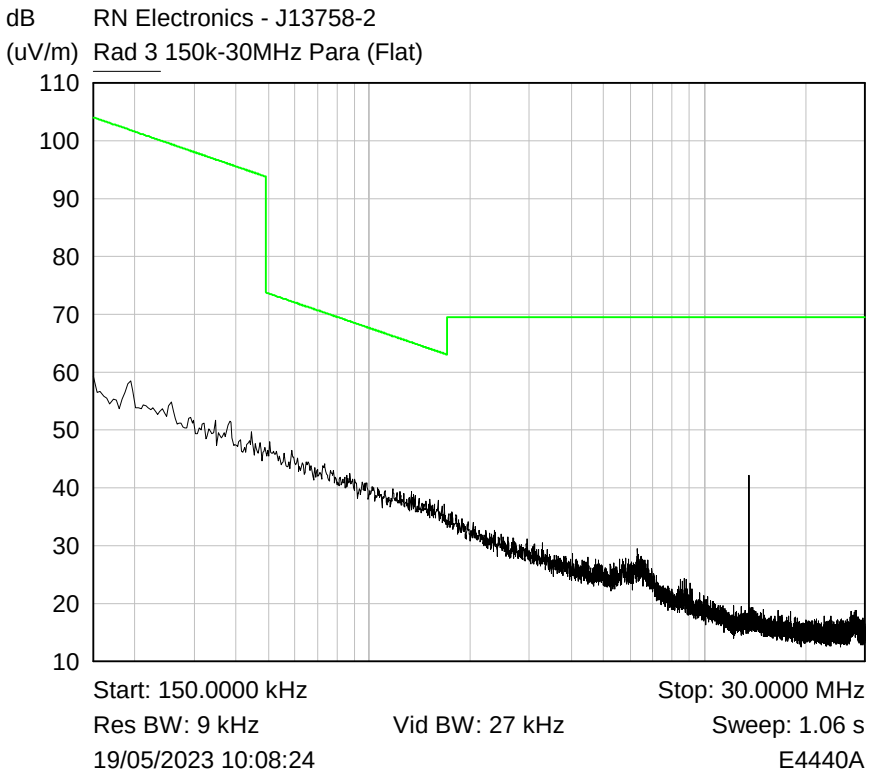
Plot of 9k-150kHz Parallel



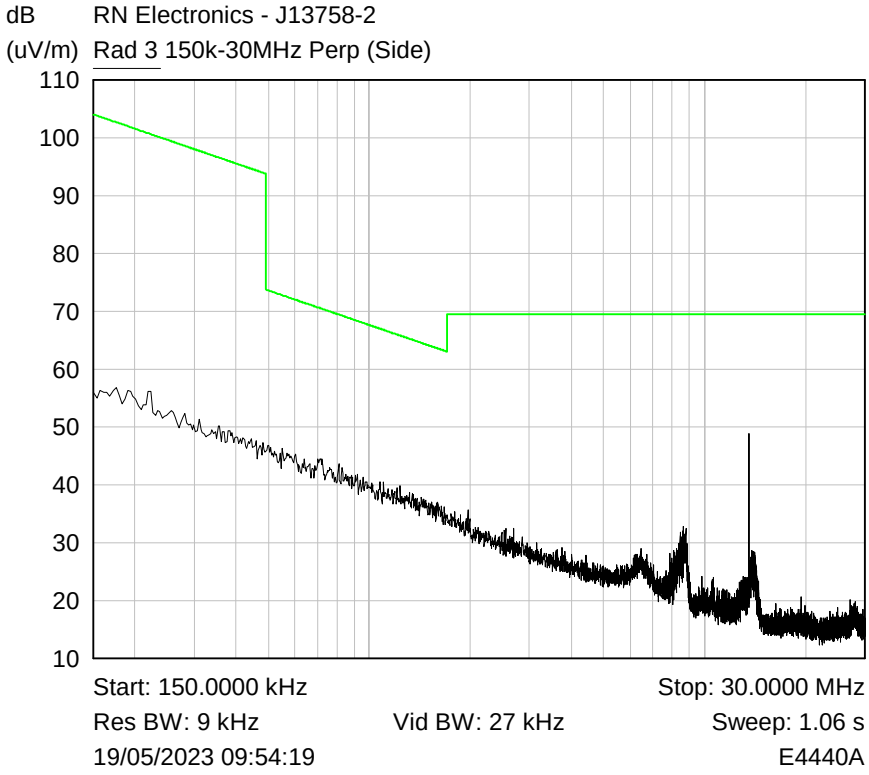
Plot of 9k-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with WiFi: 2442 MHz (Mid Ch) active)

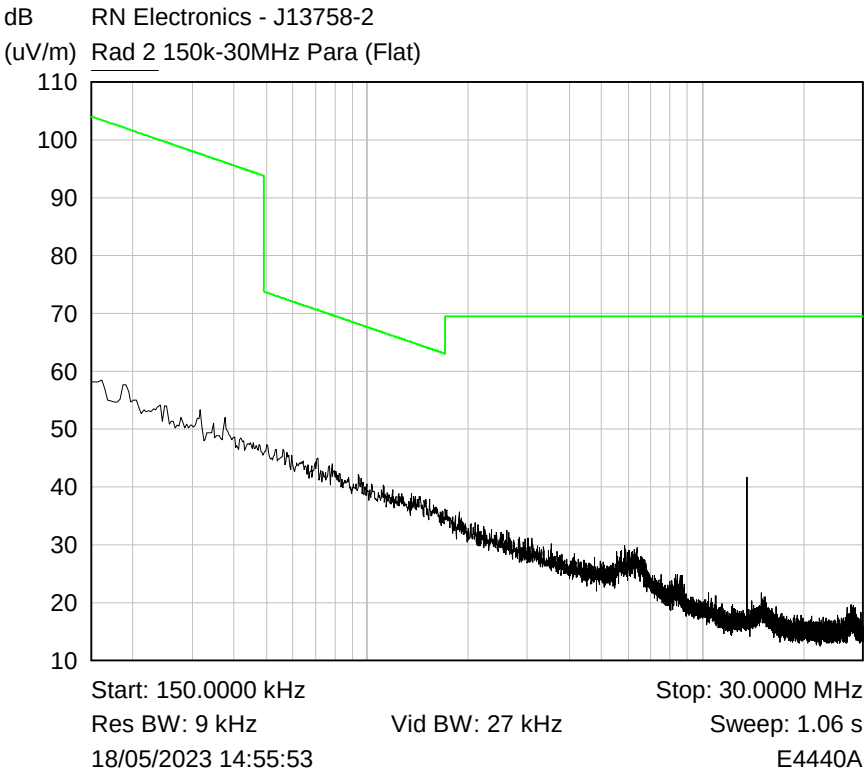


Plot of 150kHz-30MHz Parallel
NOTE: The emission at 13.56 MHz is from the EUT RFID.

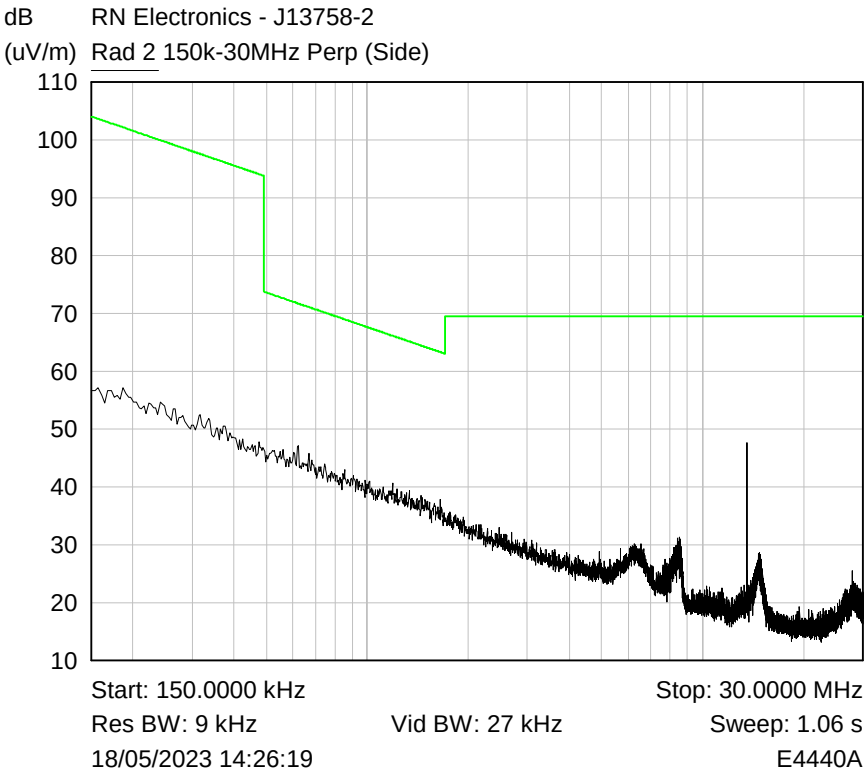


Plot of 150kHz-30MHz Perpendicular
NOTE: The emission at 13.56 MHz is from the EUT RFID.

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)



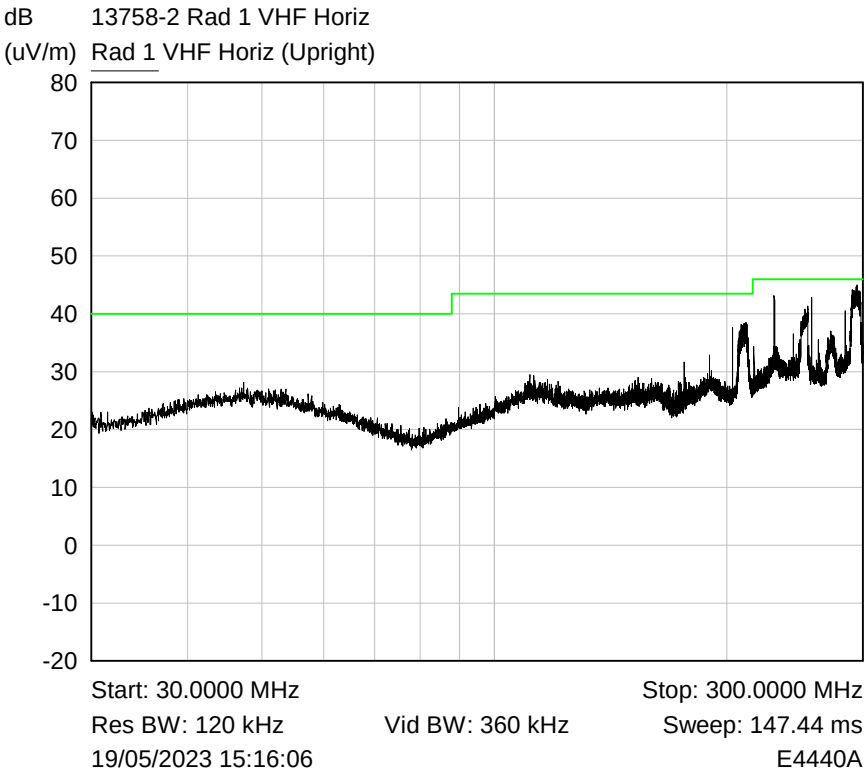
Plot of 150kHz-30MHz Parallel
NOTE: The emission at 13.56 MHz is from the EUT RFID.



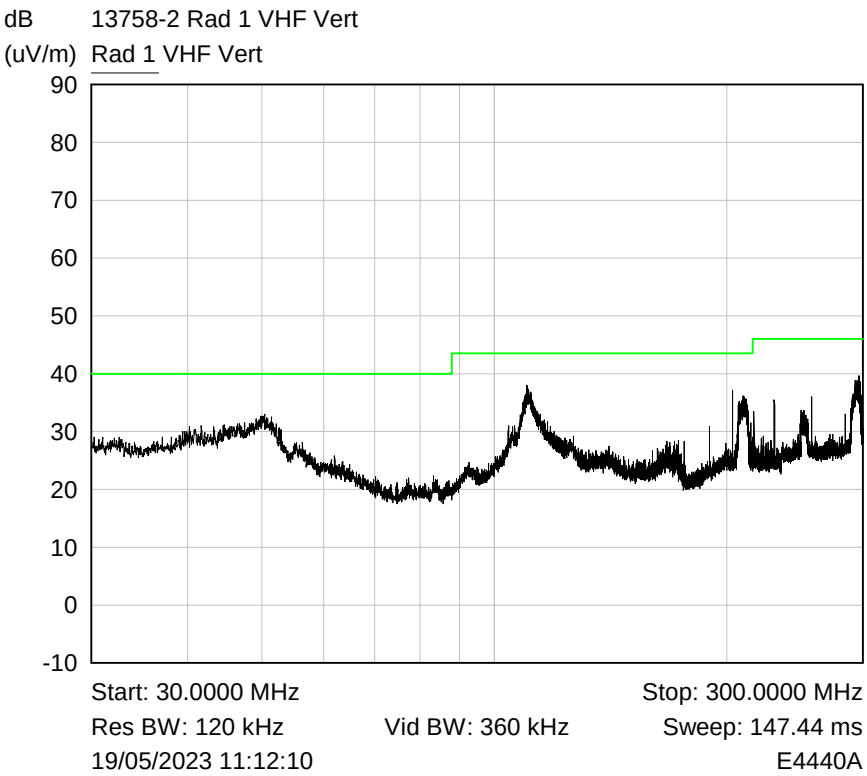
Plot of 150kHz-30MHz Perpendicular
NOTE: The emission at 13.56 MHz is from the EUT RFID.

6.4 Radiated emissions 30 MHz -1 GHz

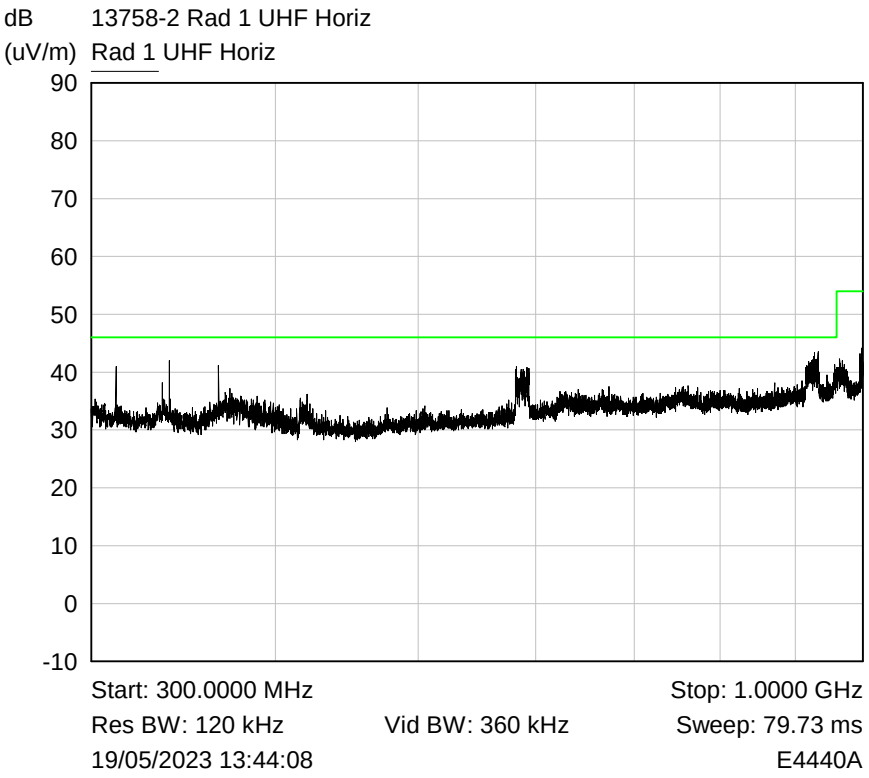
RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with Wi-Fi: 2442 MHz (Mid Ch) active)



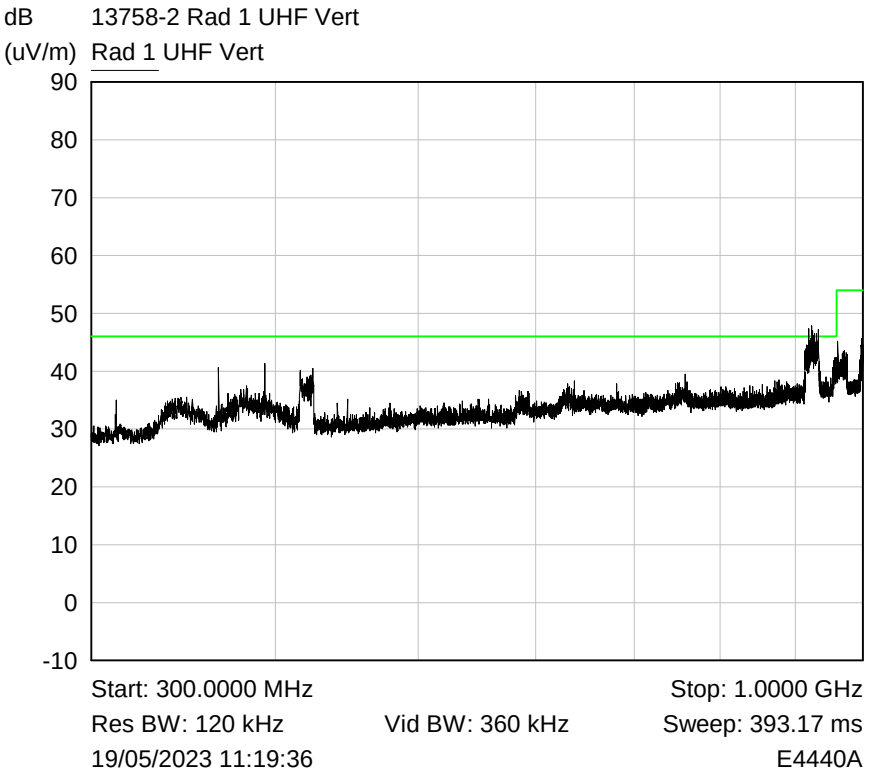
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

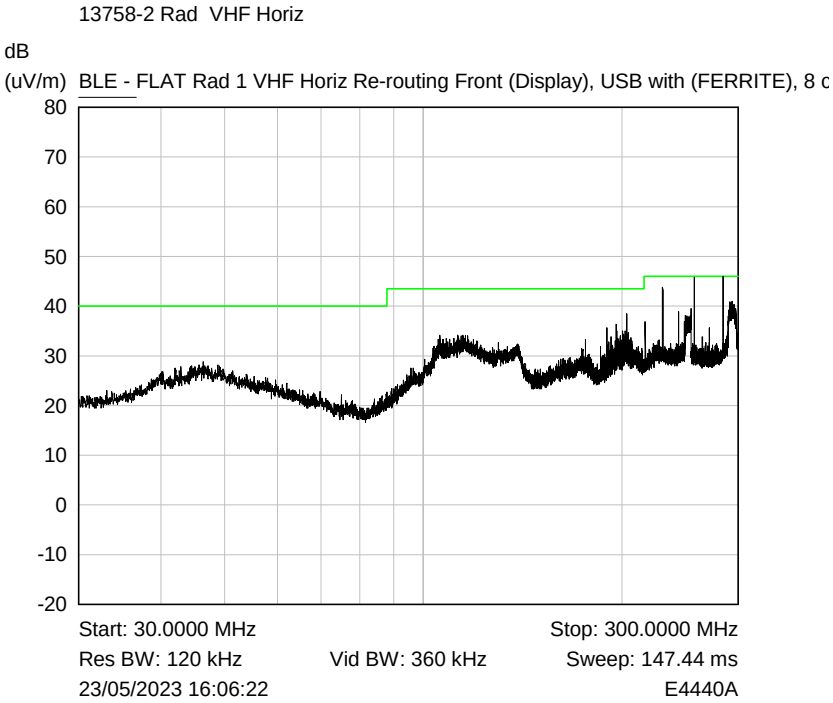


Plot of Peak emissions for UHF Horizontal against the QP limit line.

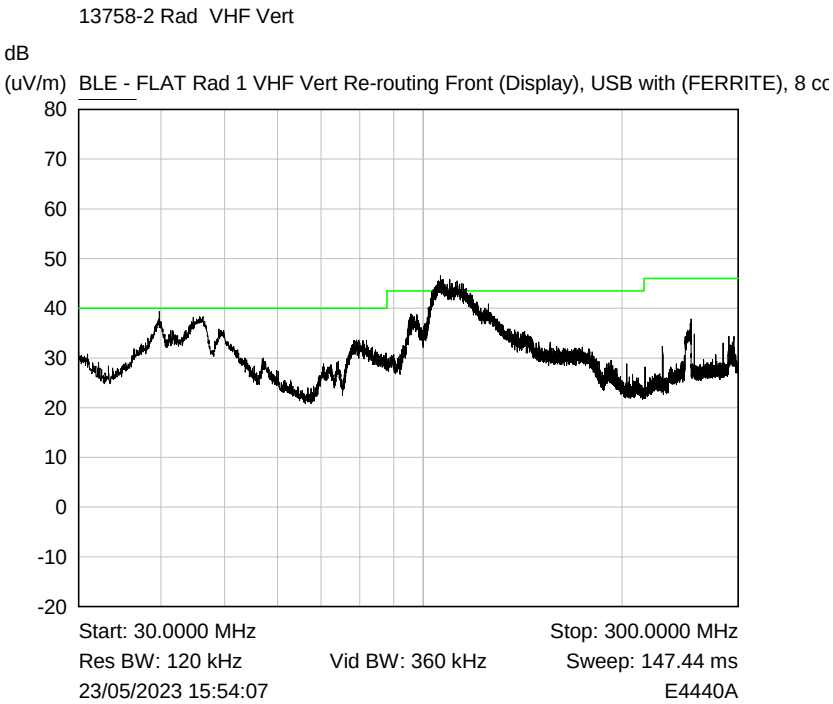


Plot of Peak emissions for UHF Vertical against the QP limit line.

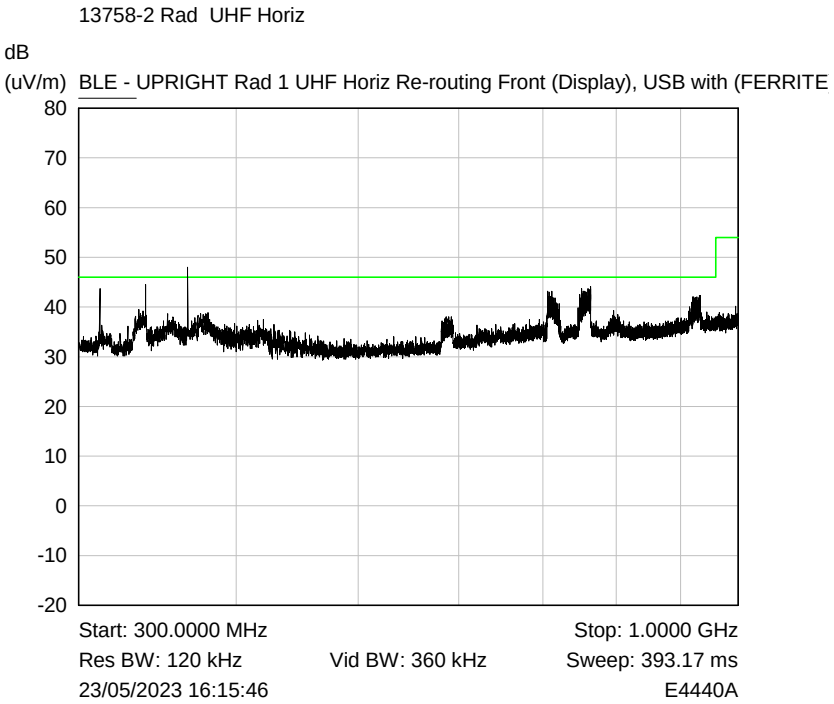
RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with BLE: 2440 MHz (Mid Ch) active)



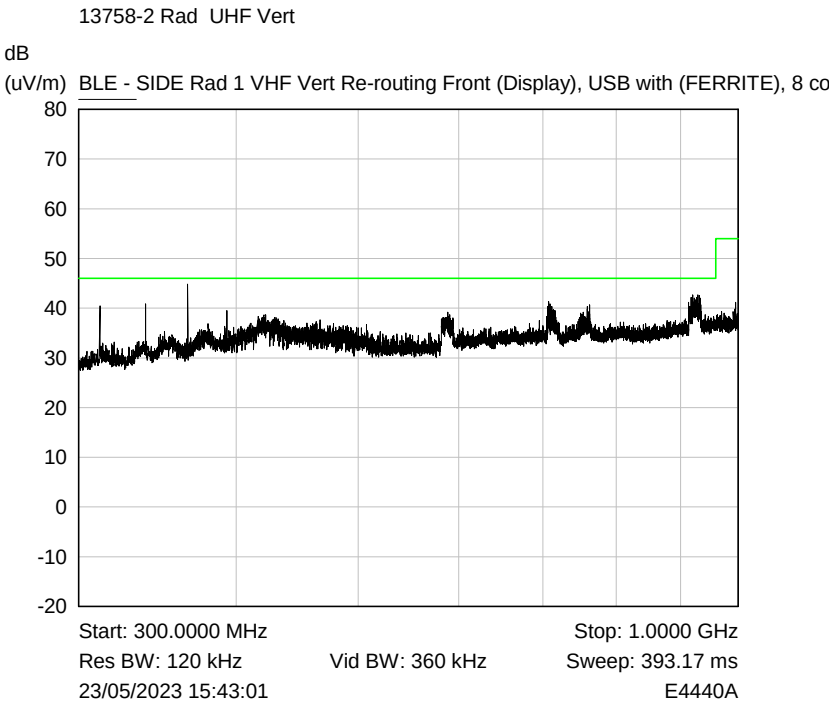
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



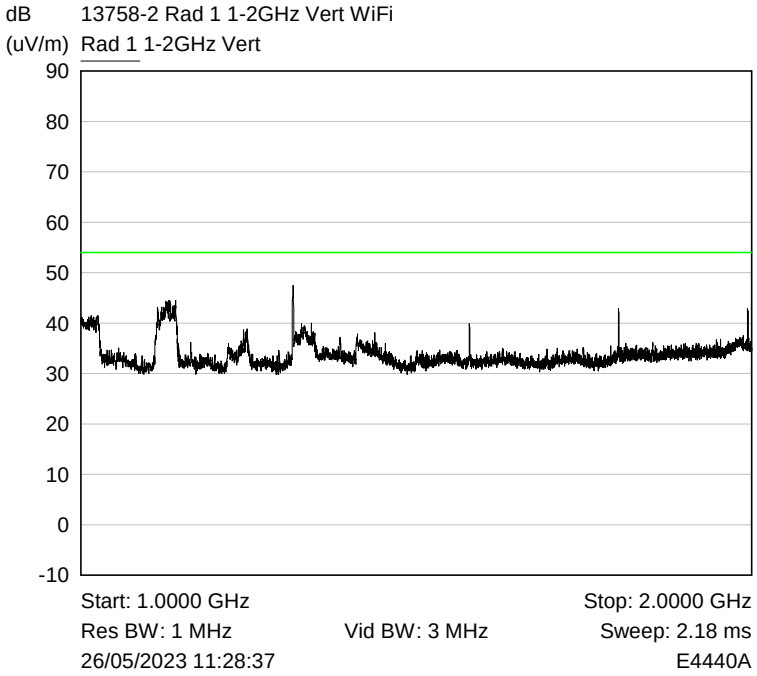
Plot of Peak emissions for UHF Horizontal against the QP limit line.

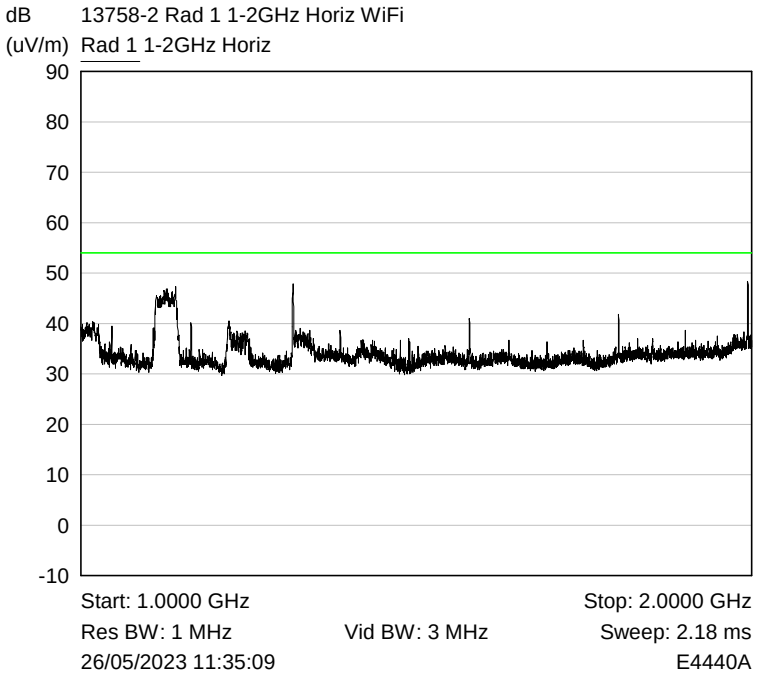


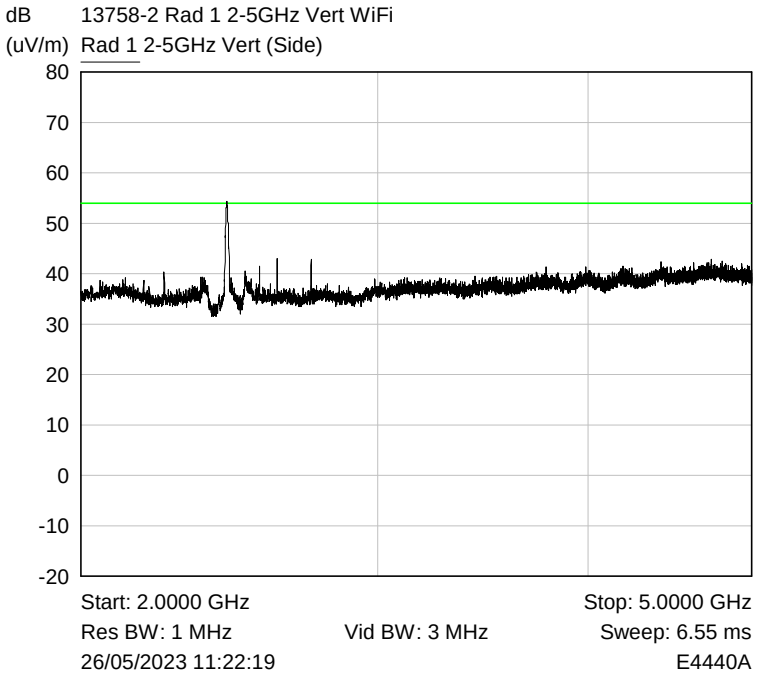
Plot of Peak emissions for UHF Vertical against the QP limit line.

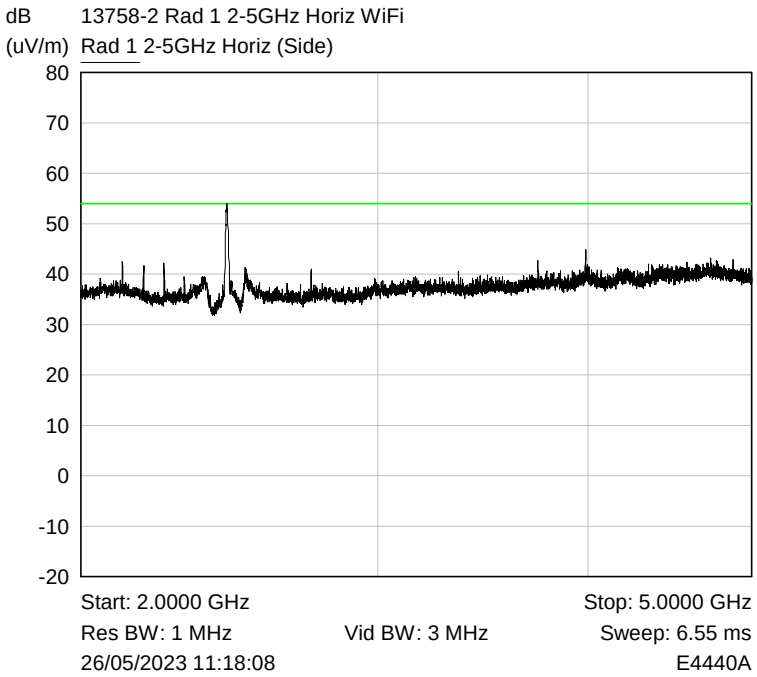
6.5 Radiated emissions above 1 GHz

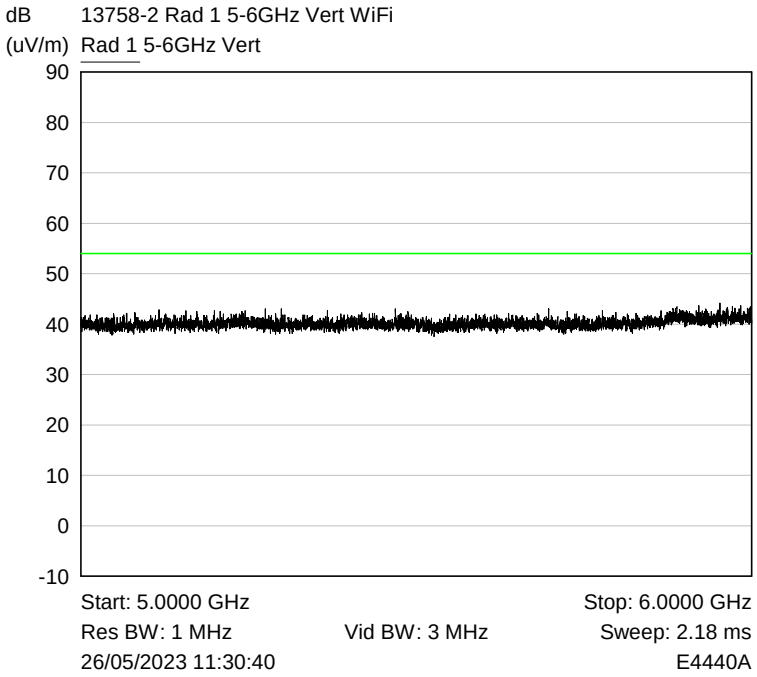
RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with WiFi 802.11 g 6Mbps 20 MHz 2442 MHz (CH7) active)

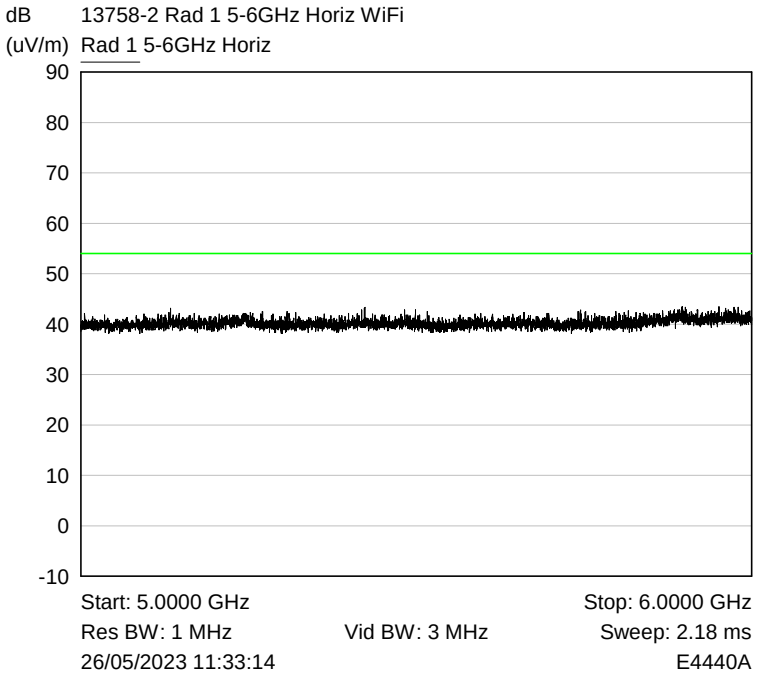


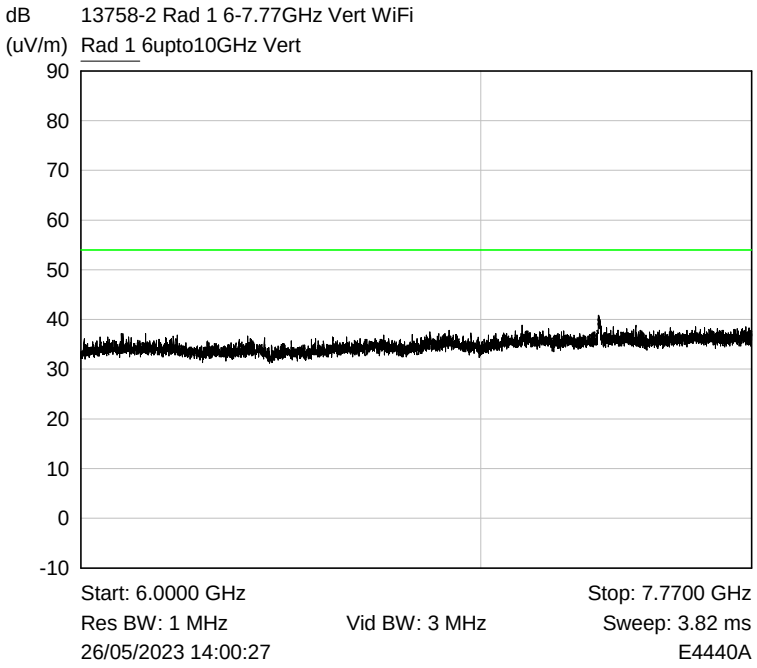


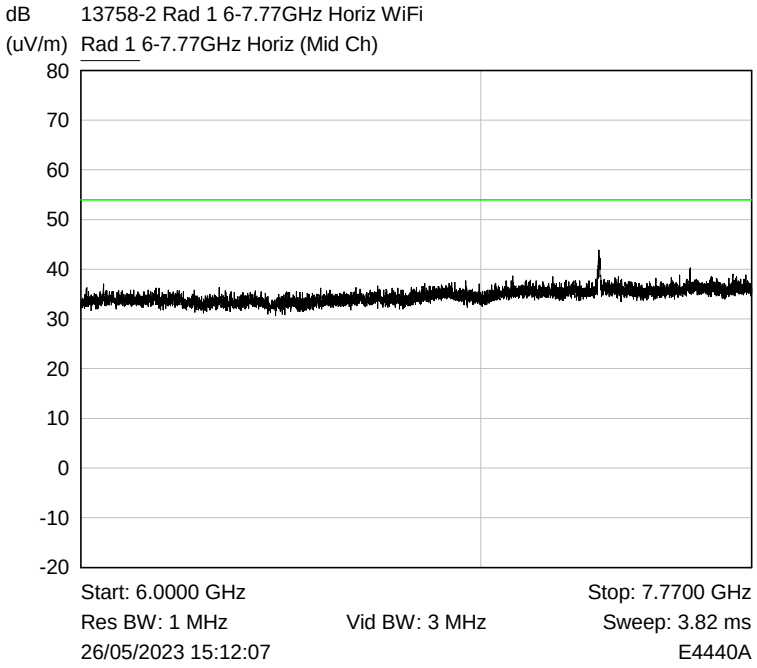


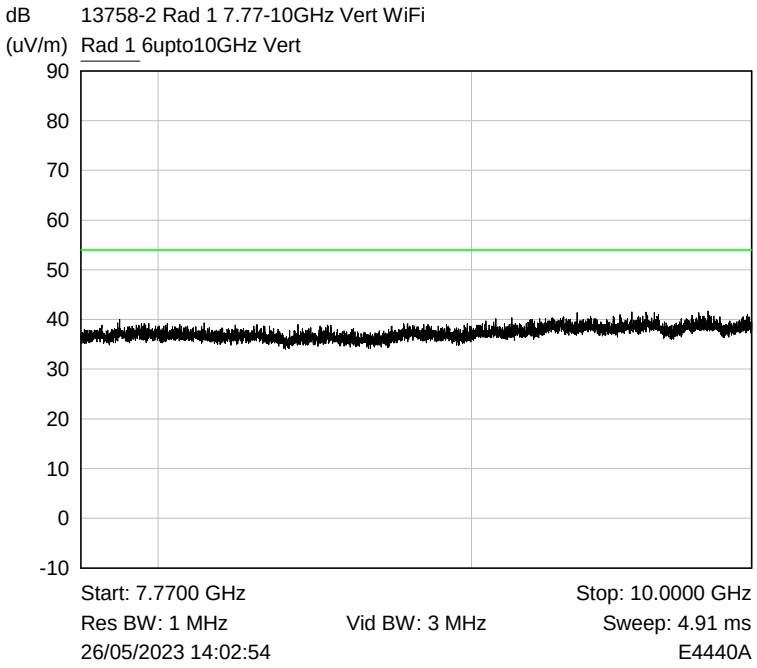


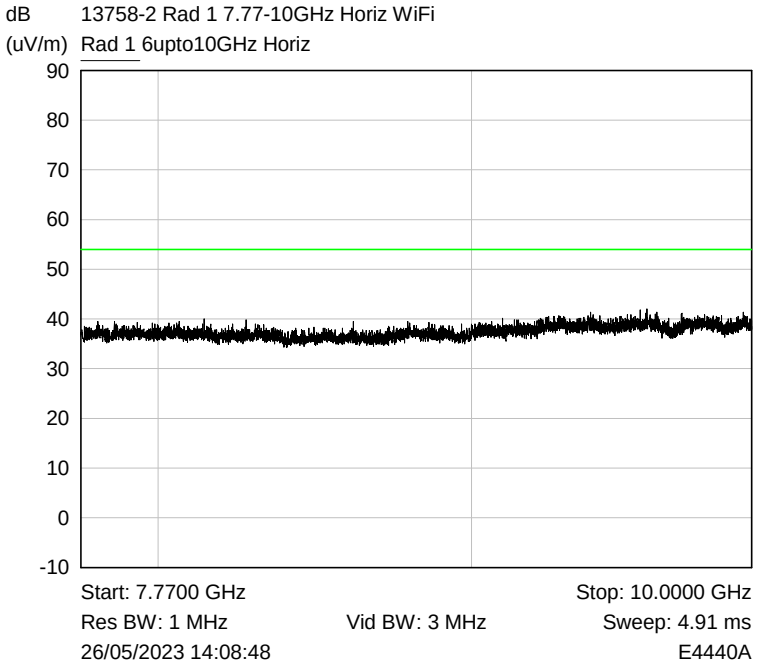


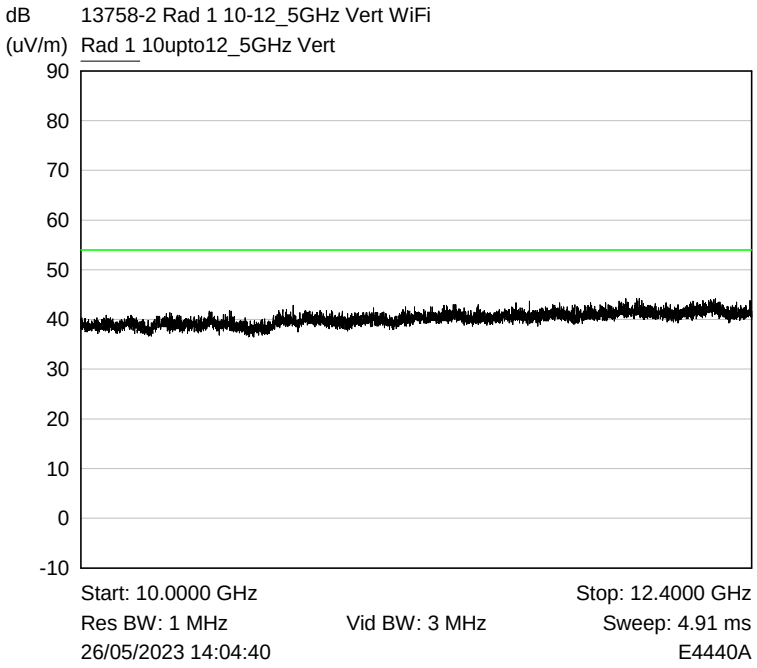


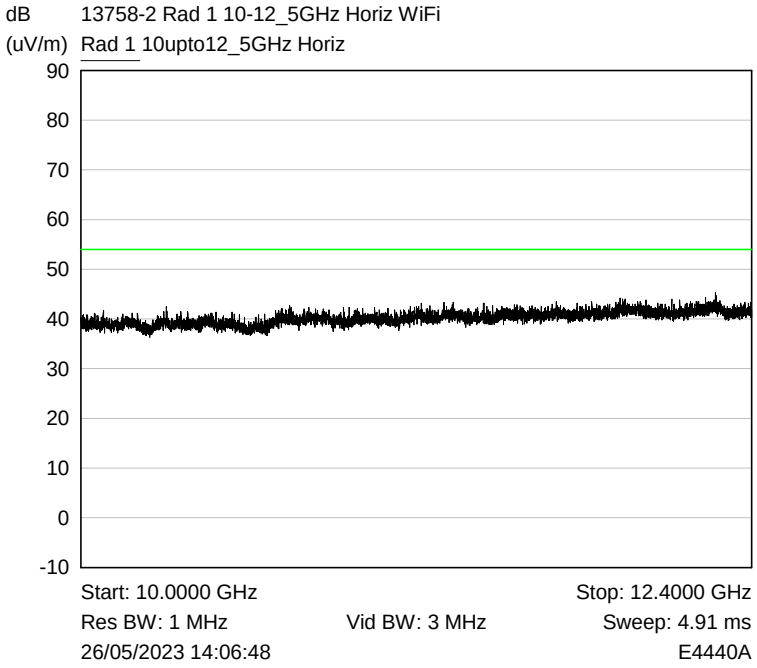


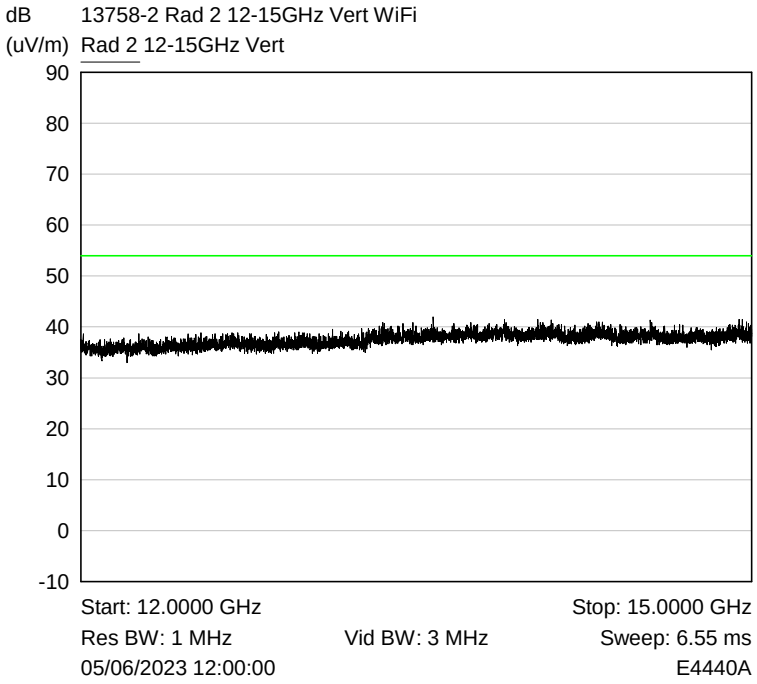


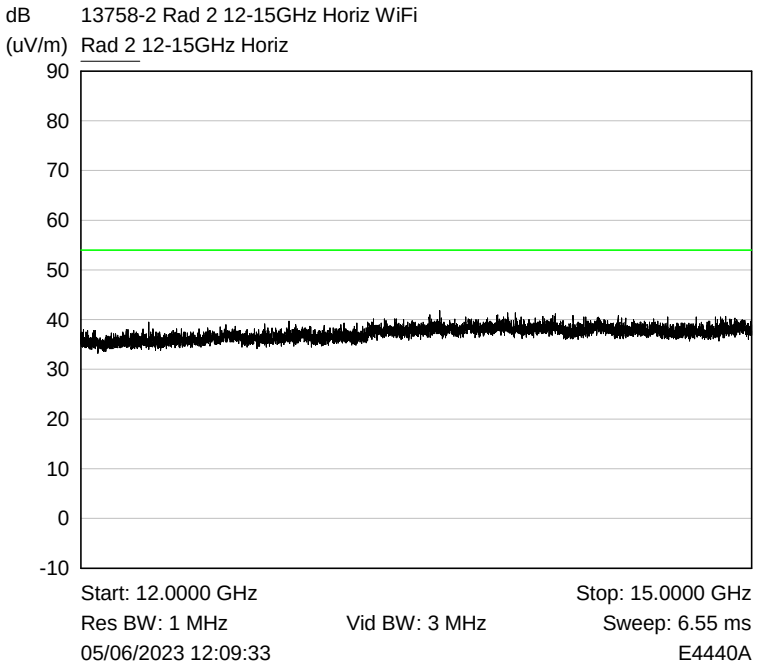


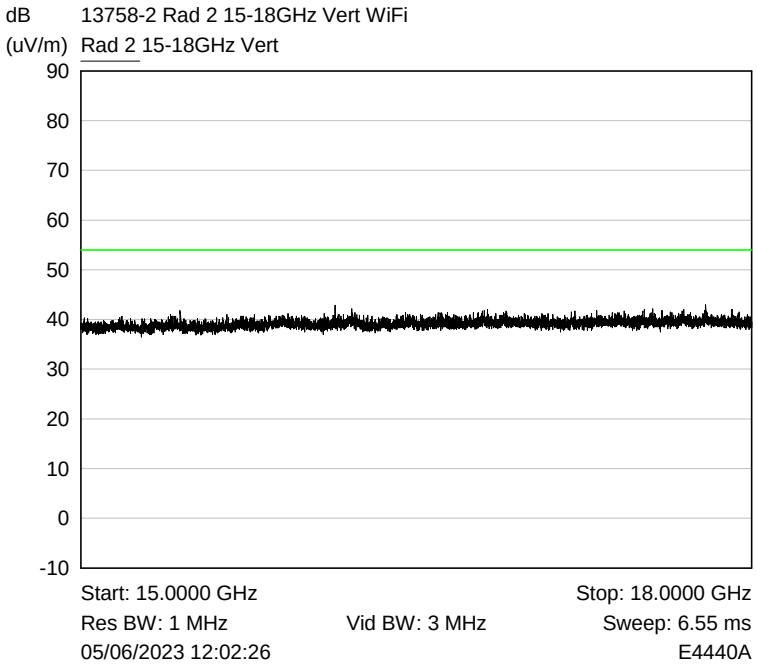


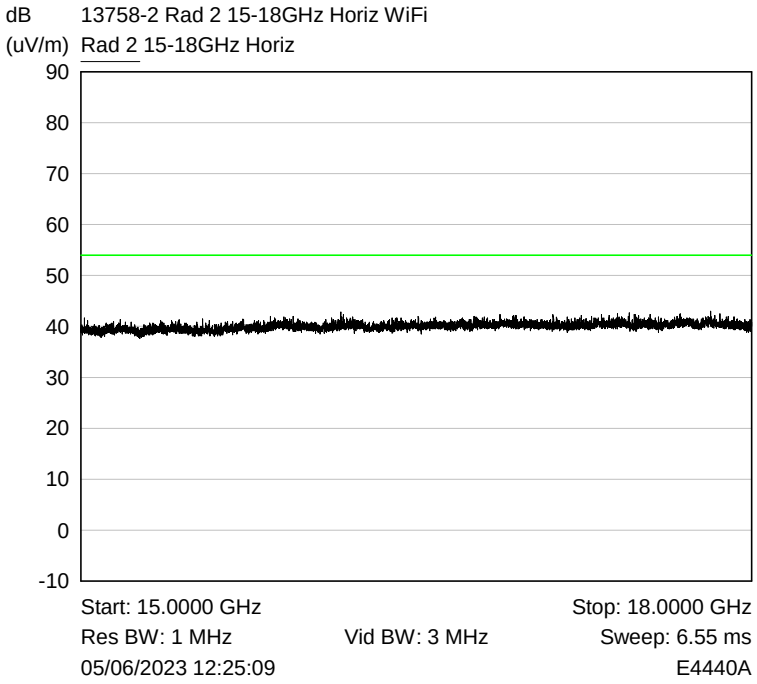


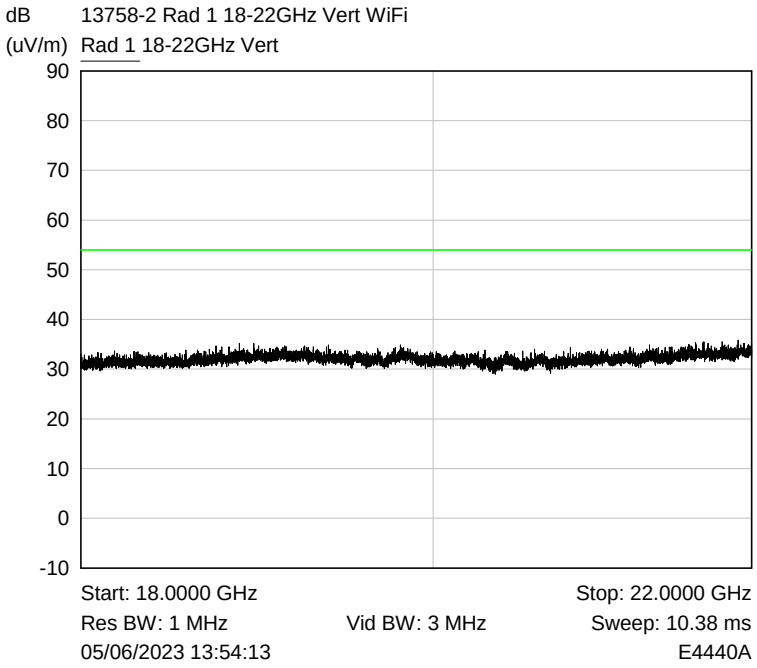


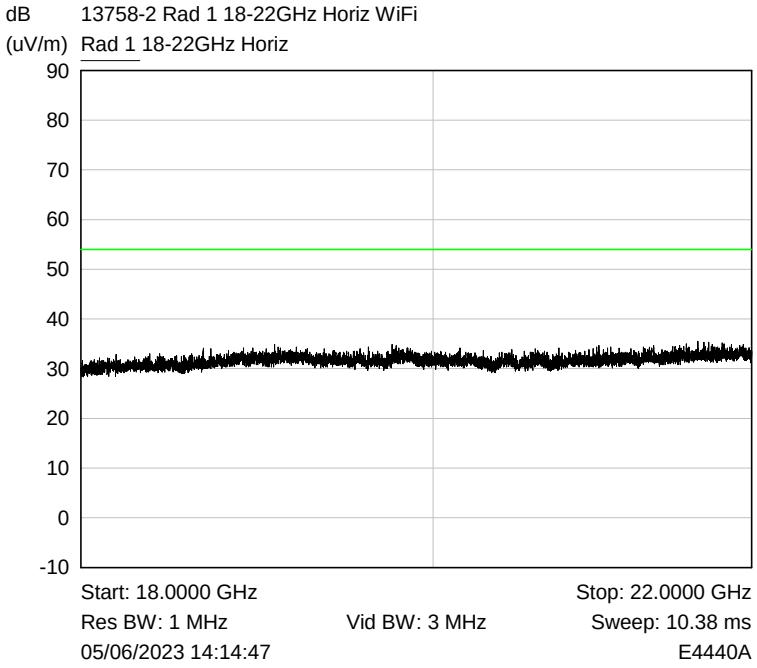


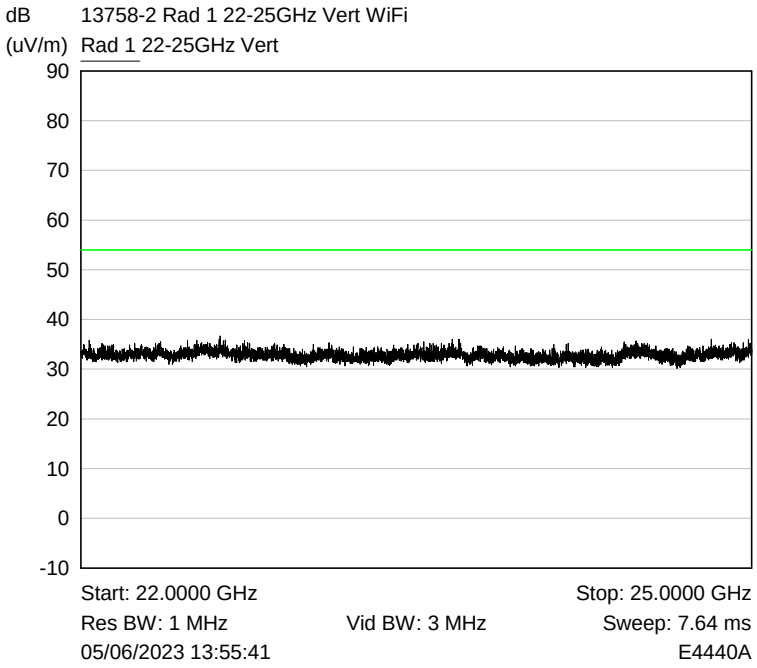


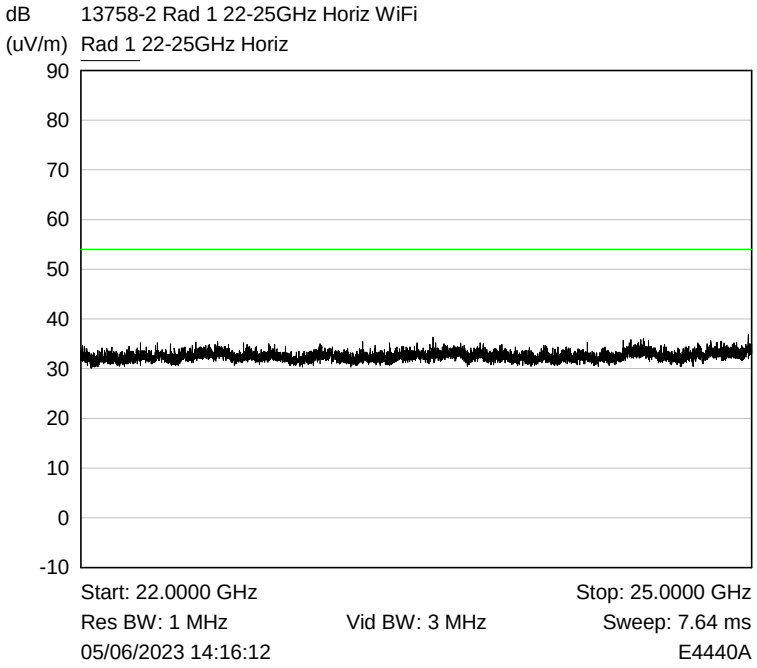




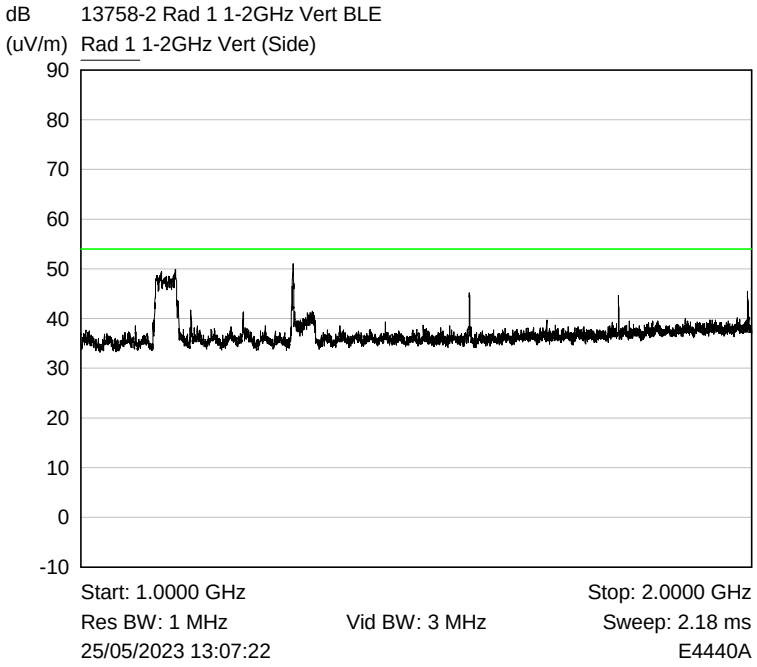


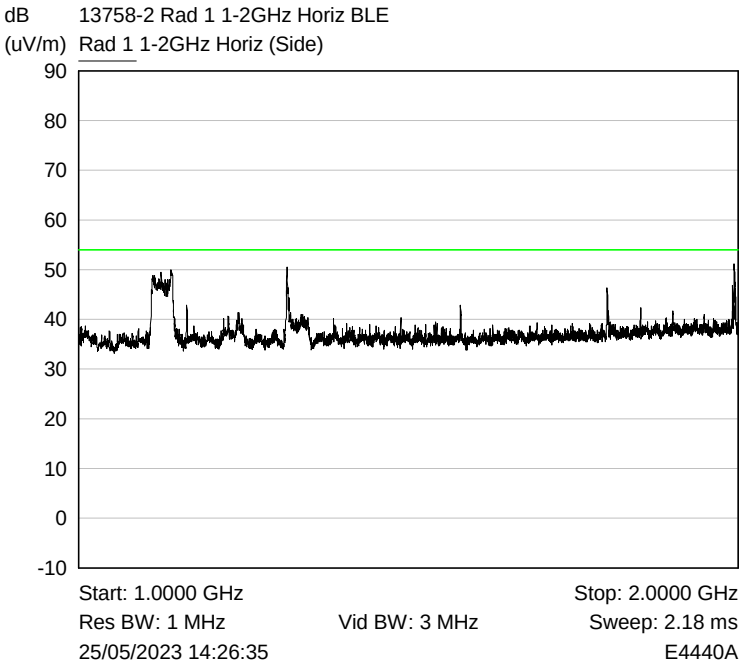


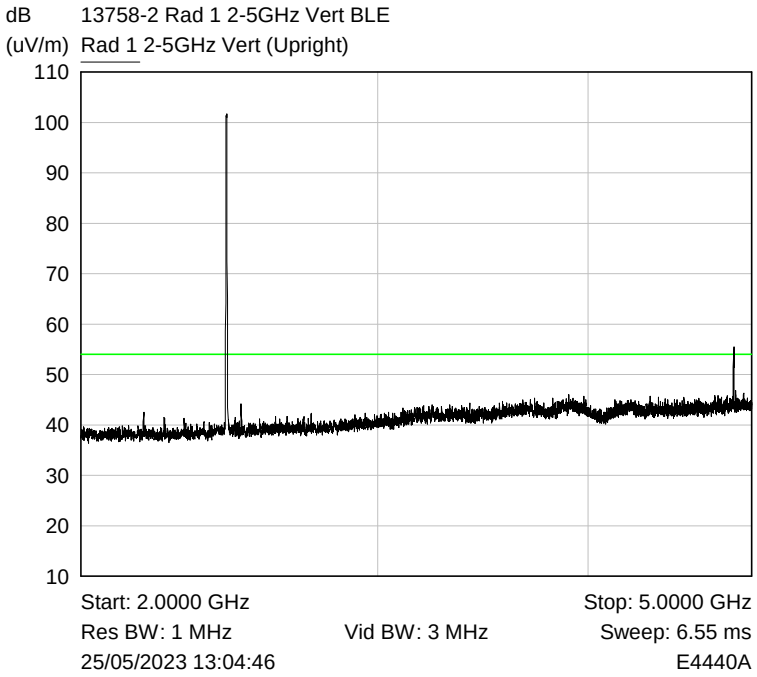




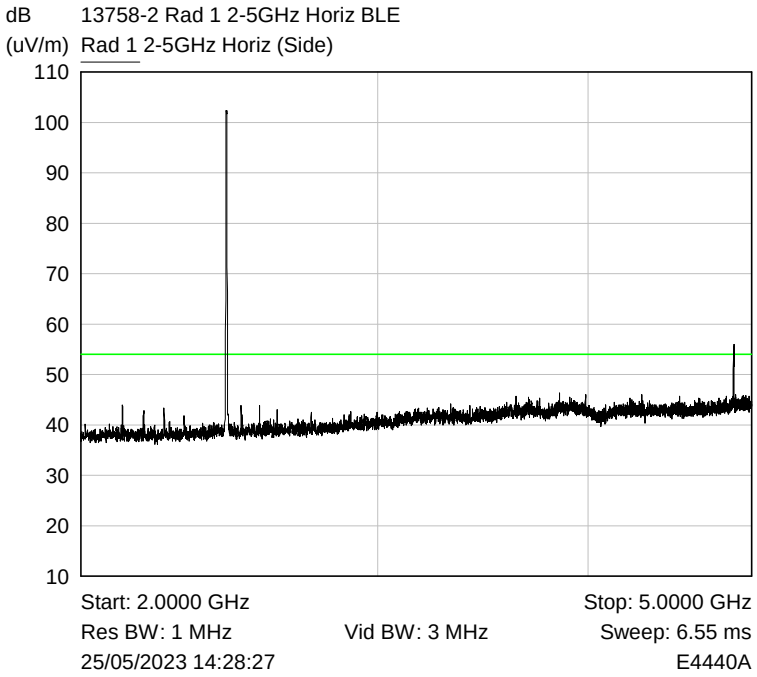
RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz (with 2440 MHz (CH17) 2 MHz BLE active)



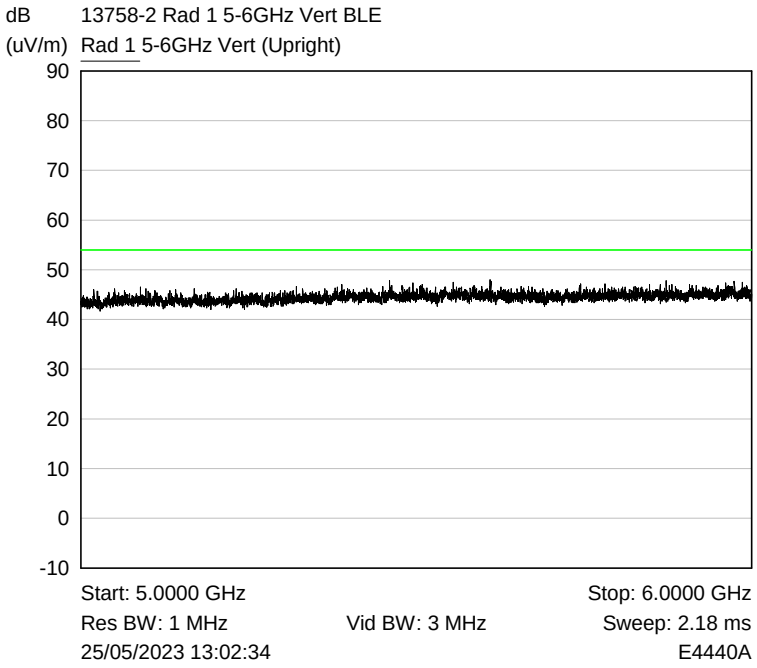


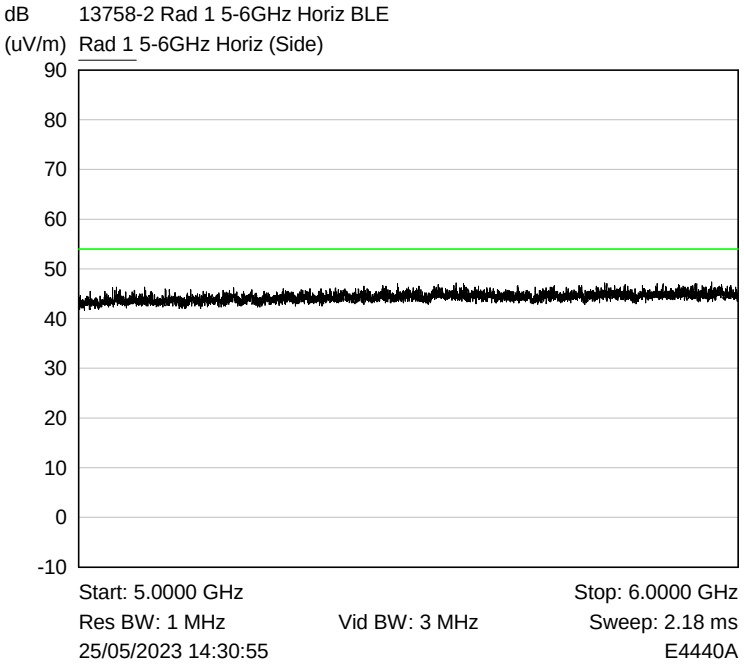


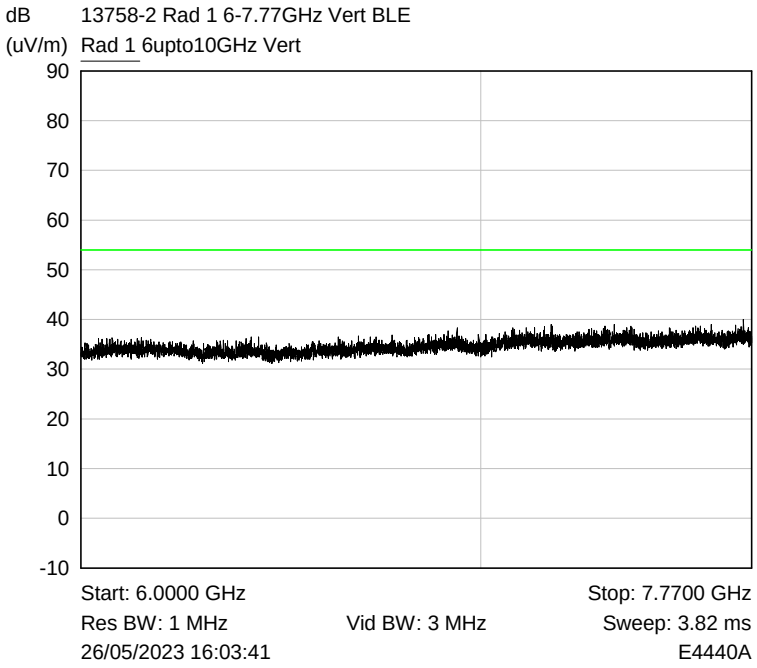
Note: Signals that exceed the limit are from the 2.4 GHz transmission

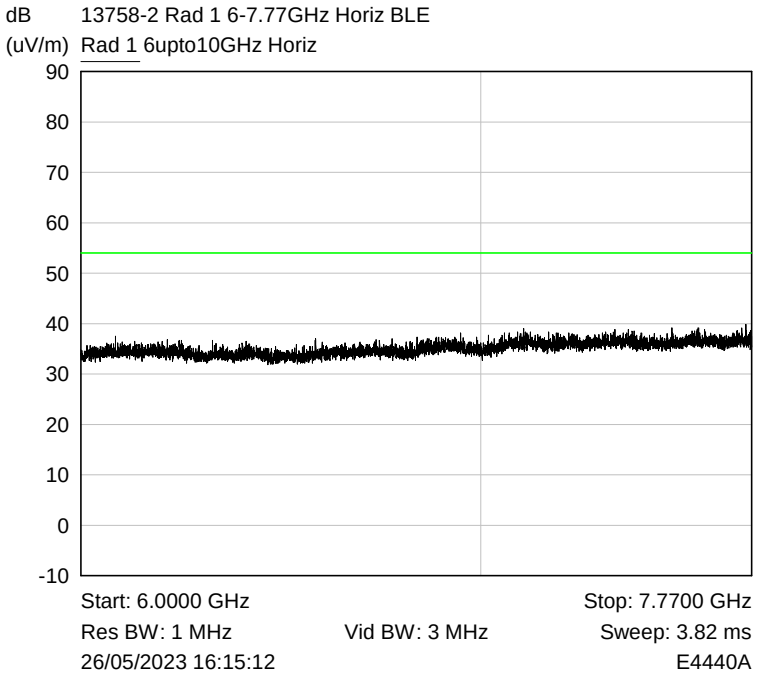


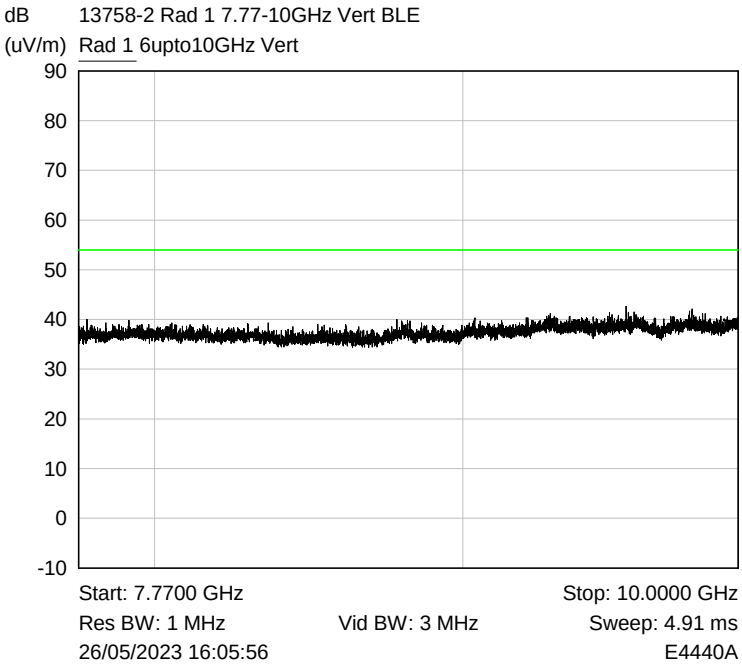
Note: Signals that exceed the limit are from the 2.4 GHz transmission

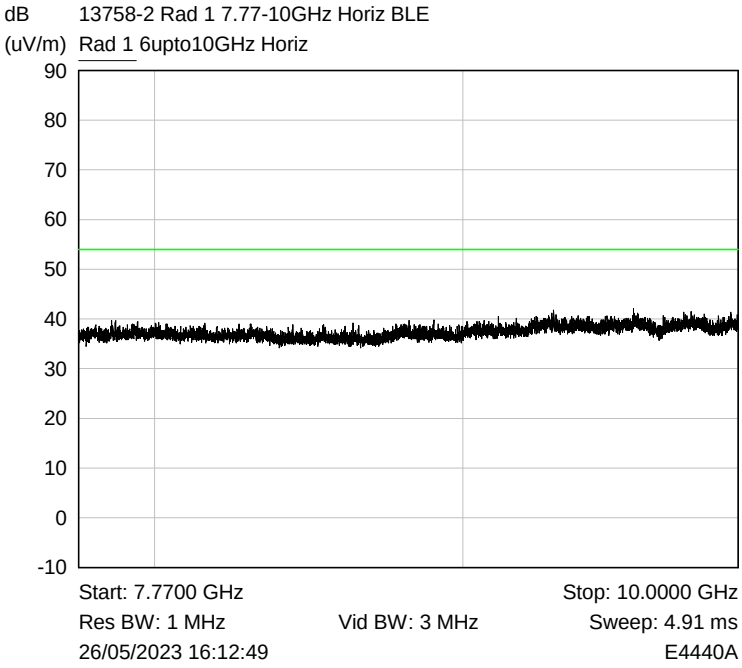


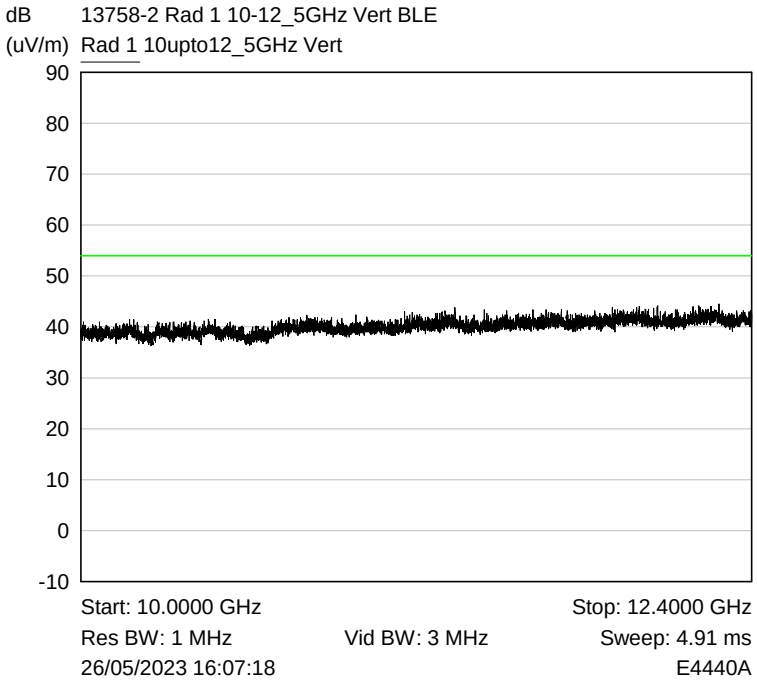


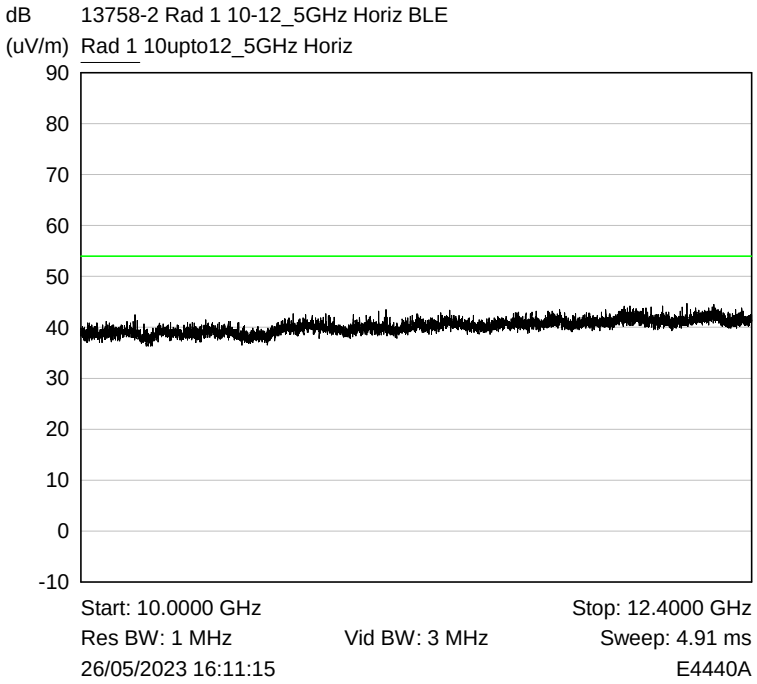


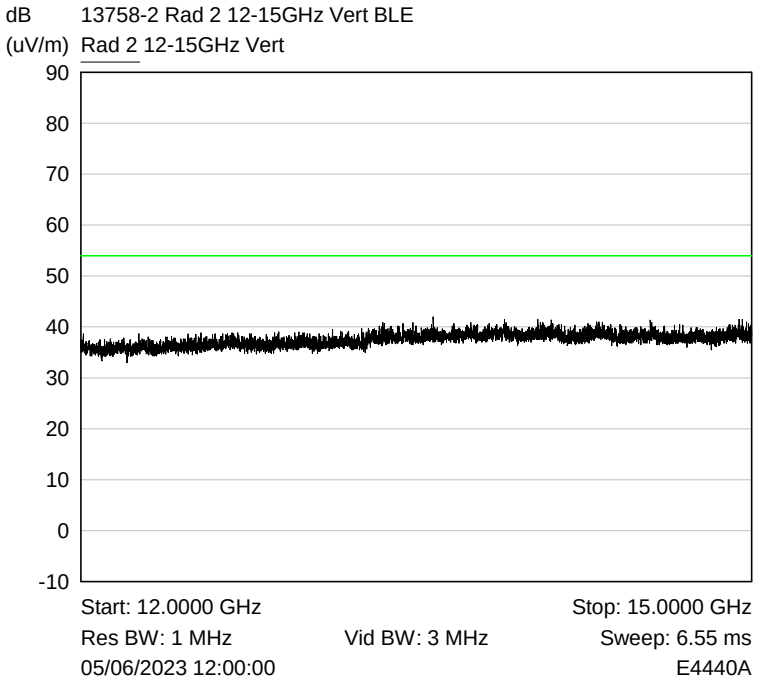


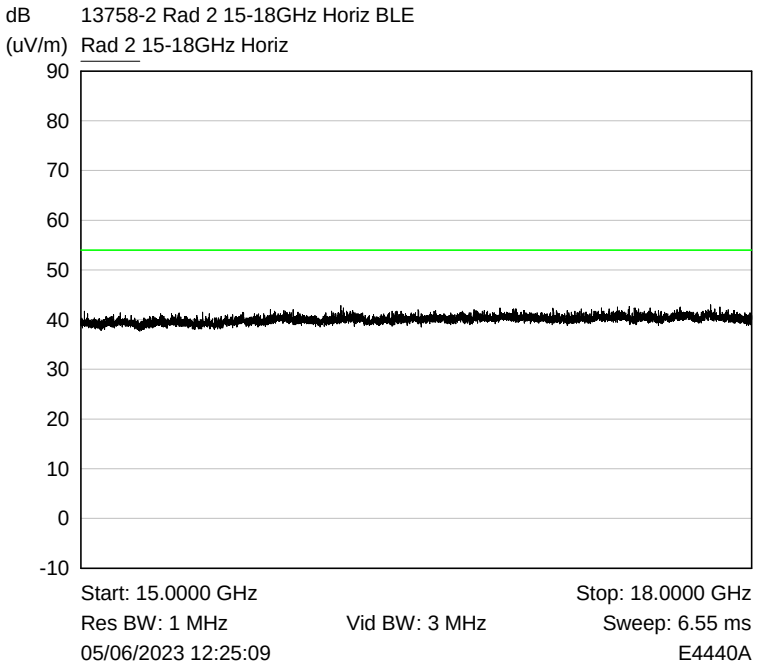


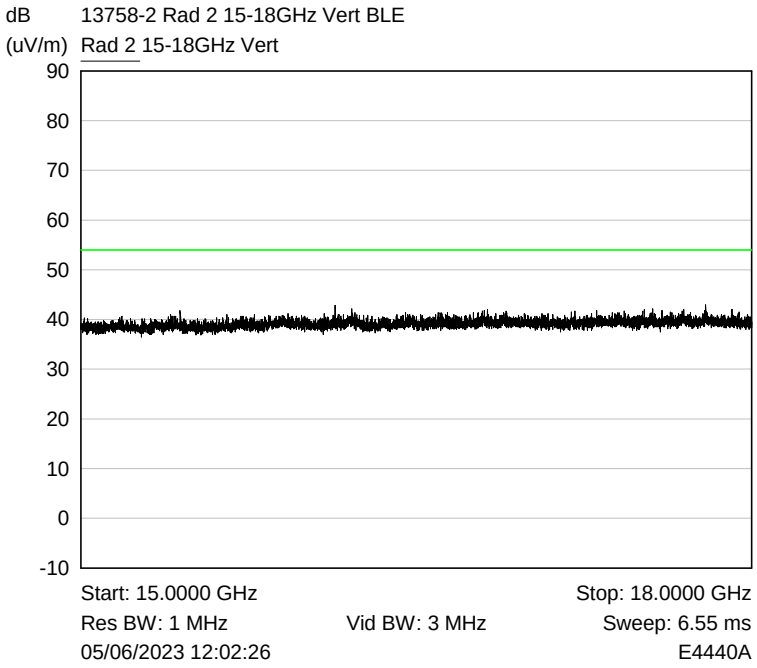


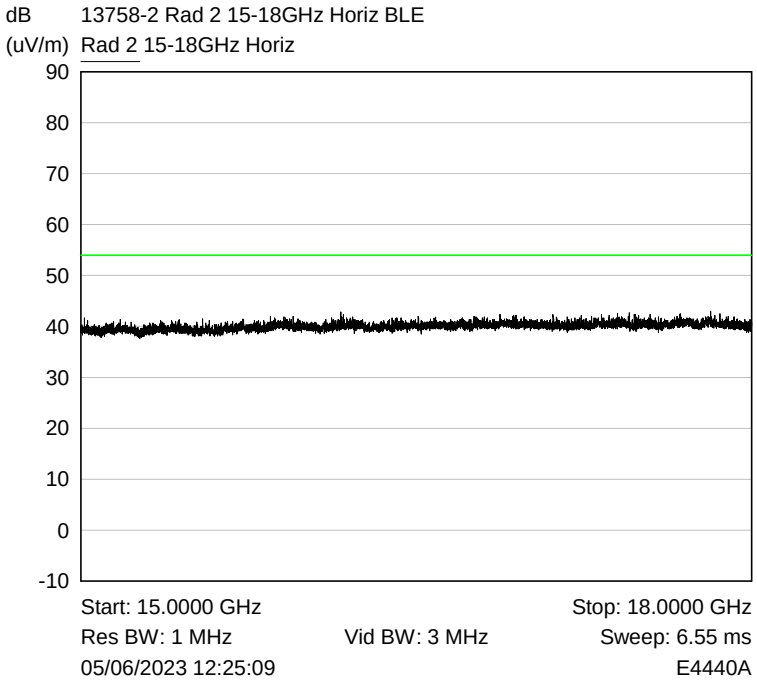


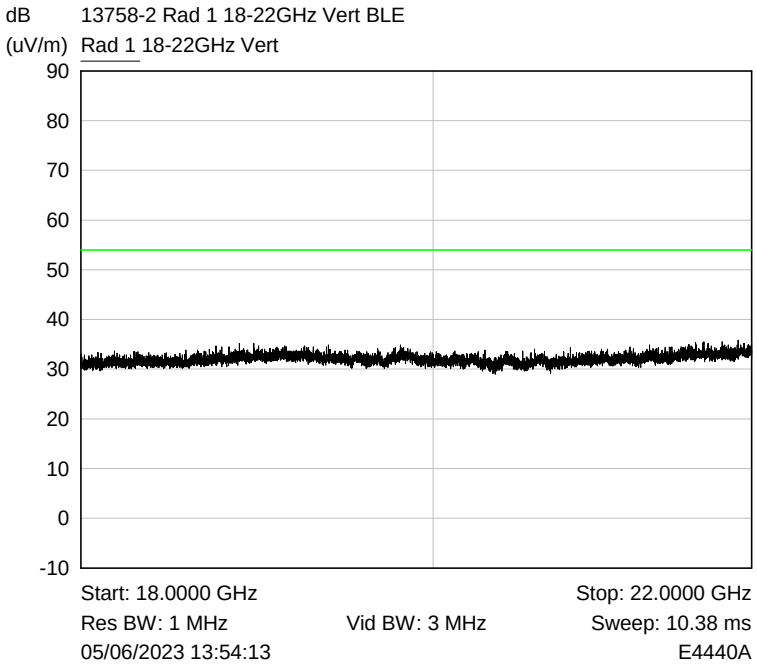


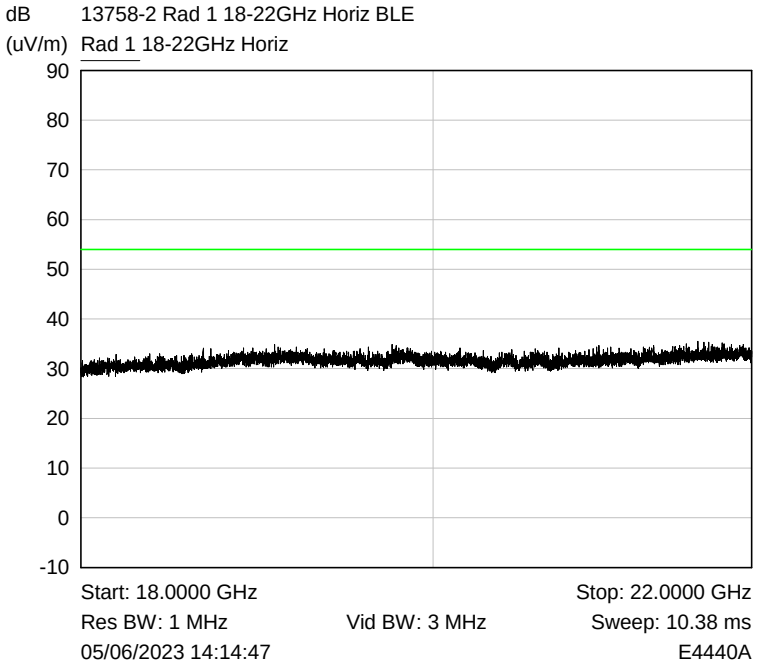


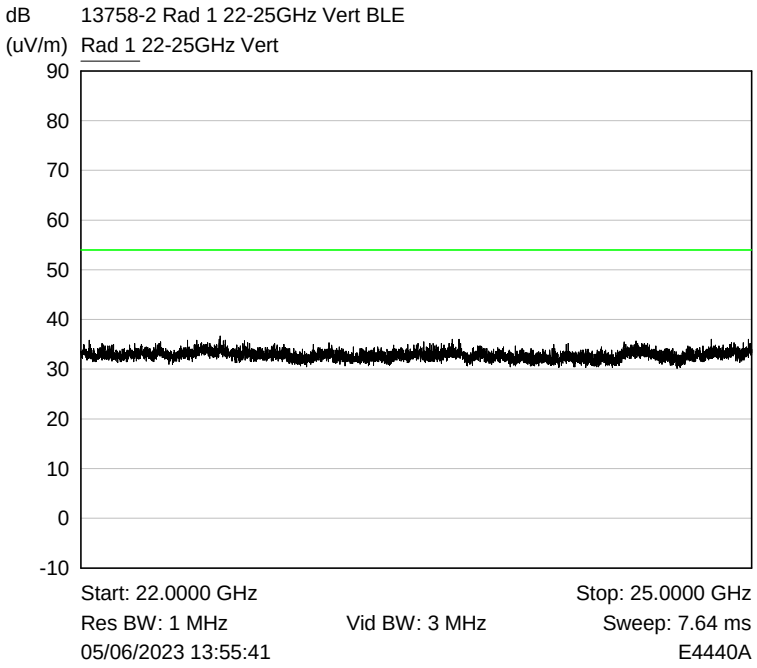


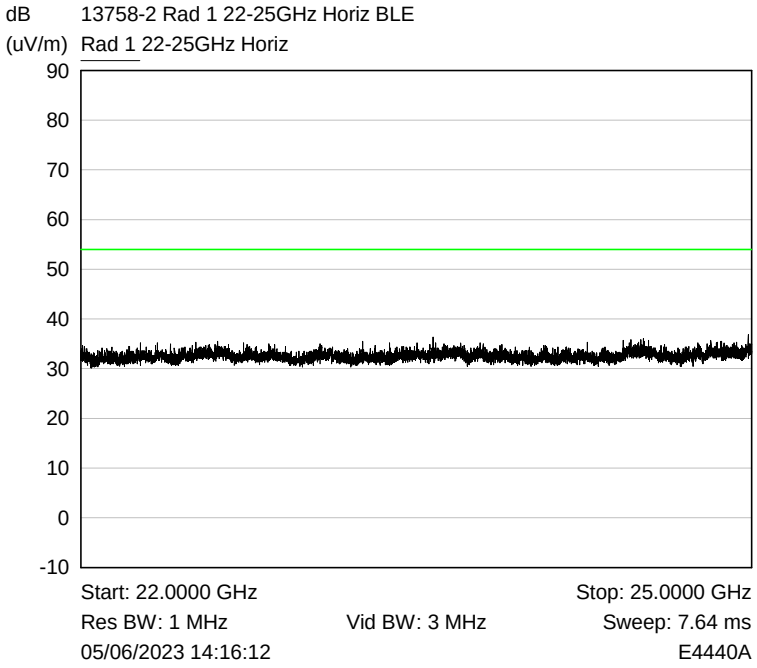






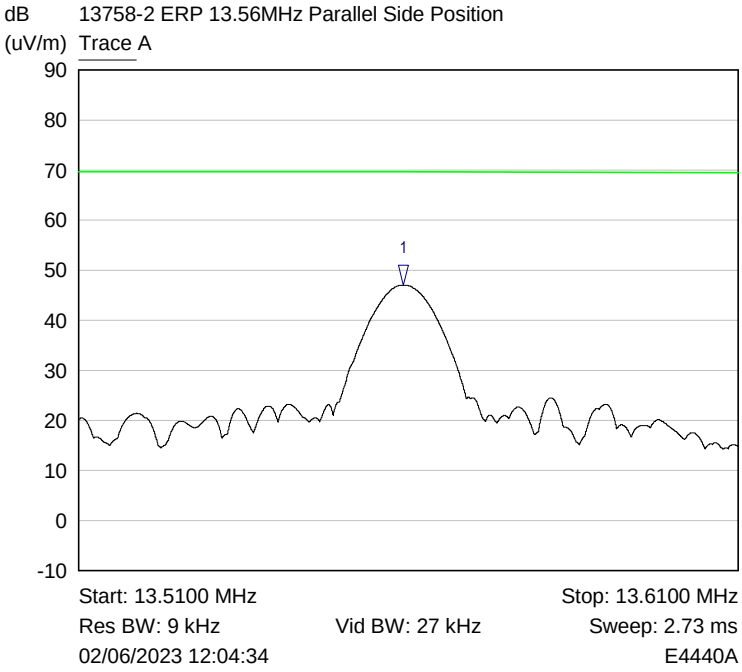






6.6 Intentional radiator field strength

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz

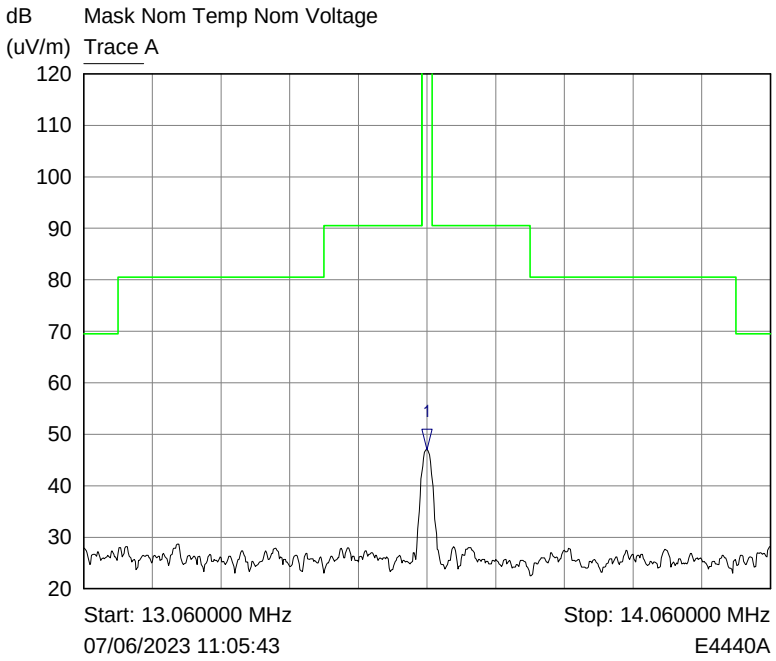


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.5591 MHz	47.06 dB(uV/m)	

Plot of Parallel polarisation and EUT in Side position

6.7 Spectrum mask

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Single Channel, Modulation ISO/IEC 15693, Channel 13.56 MHz

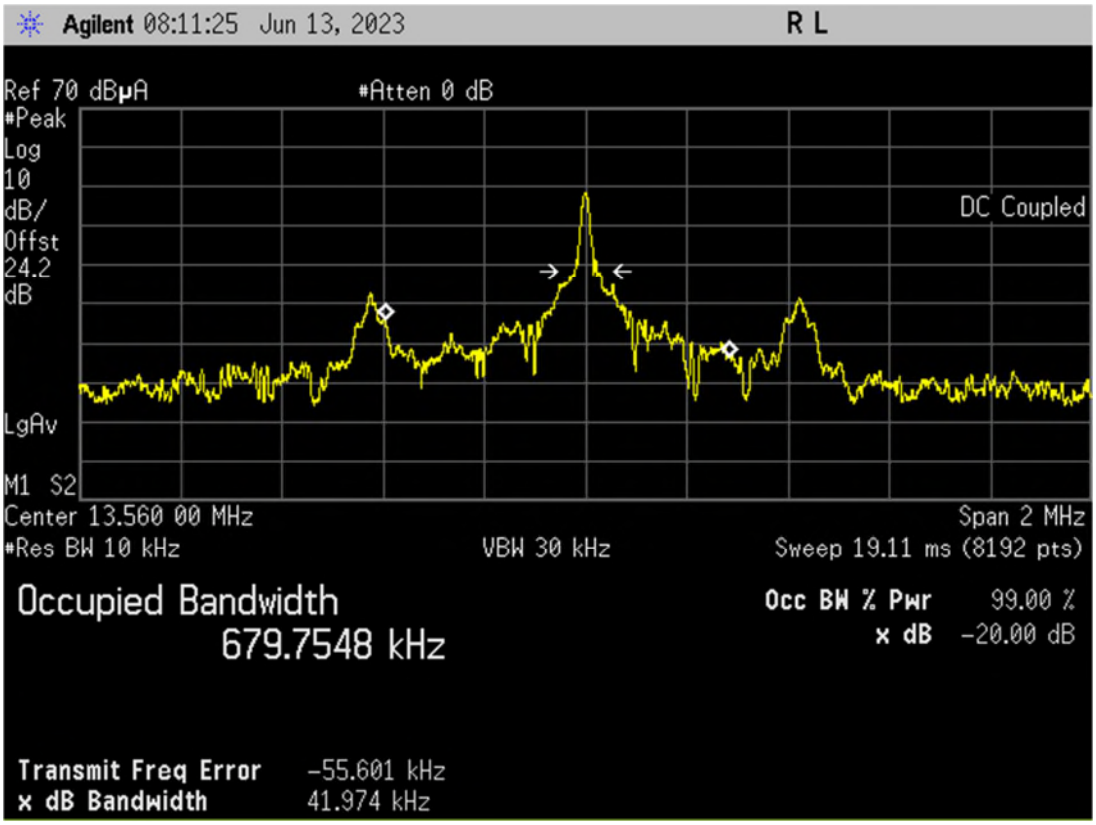


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.560000 MHz	47.0600 dB(uV/m)	

Nominal Temperature, Nominal Voltage

6.8 Occupied bandwidth

RF Parameters: Band 13.553-13.567 MHz, Power 250 mW, Channel Spacing single channel, Modulation ISO/IEC 15693, Channel 13.56 MHz



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: $E_{Spec\ limit} = \sqrt{(0.9x10^{-6} \times 377)} = 0.01842$ V/m.
And
Equation 21 transposed: $E_{Log} = 20Log(0.01842) +120 = 85.3dB\mu V/m$ @ 3m.

8 Photographs

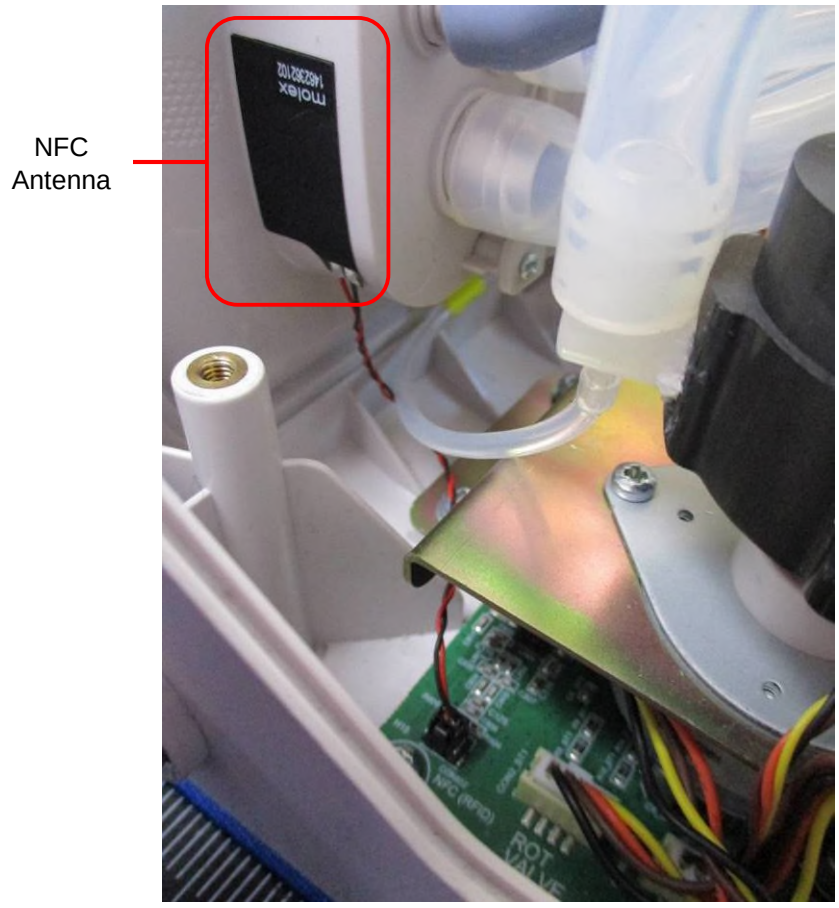
8.1 EUT Front View

8.2 EUT Reverse Angle

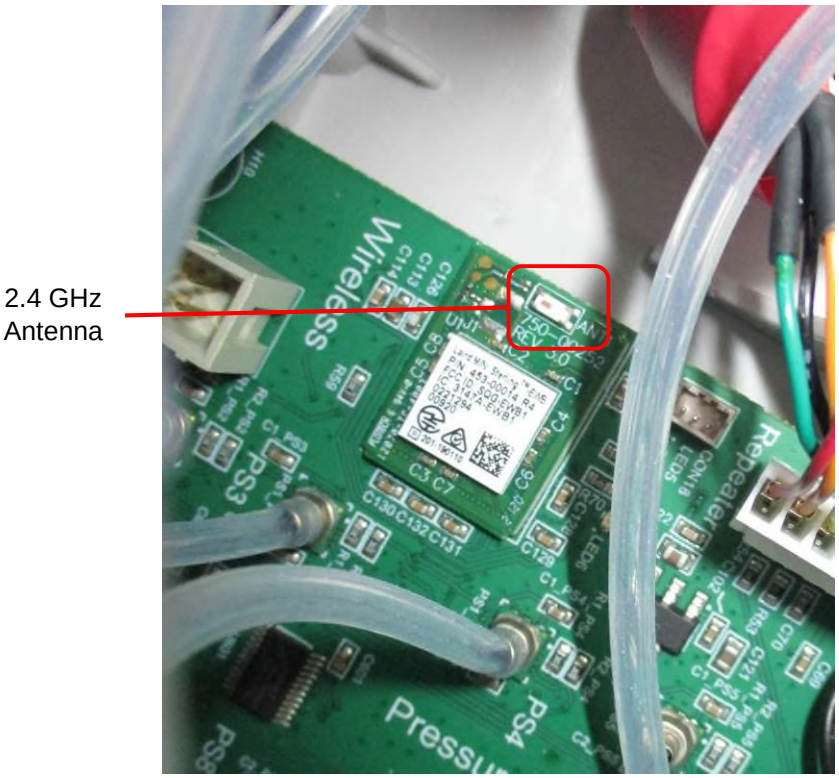
8.3 EUT Left side View

8.4 EUT Right side View

8.5 EUT Antenna Port



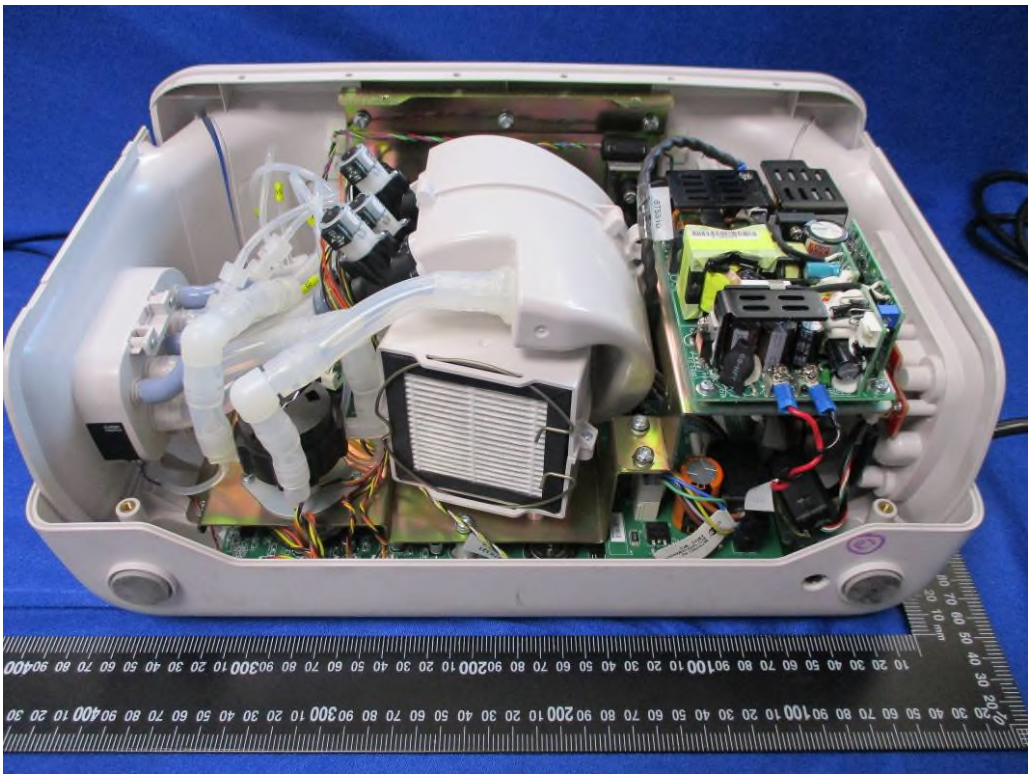
13.56 MHz Antenna

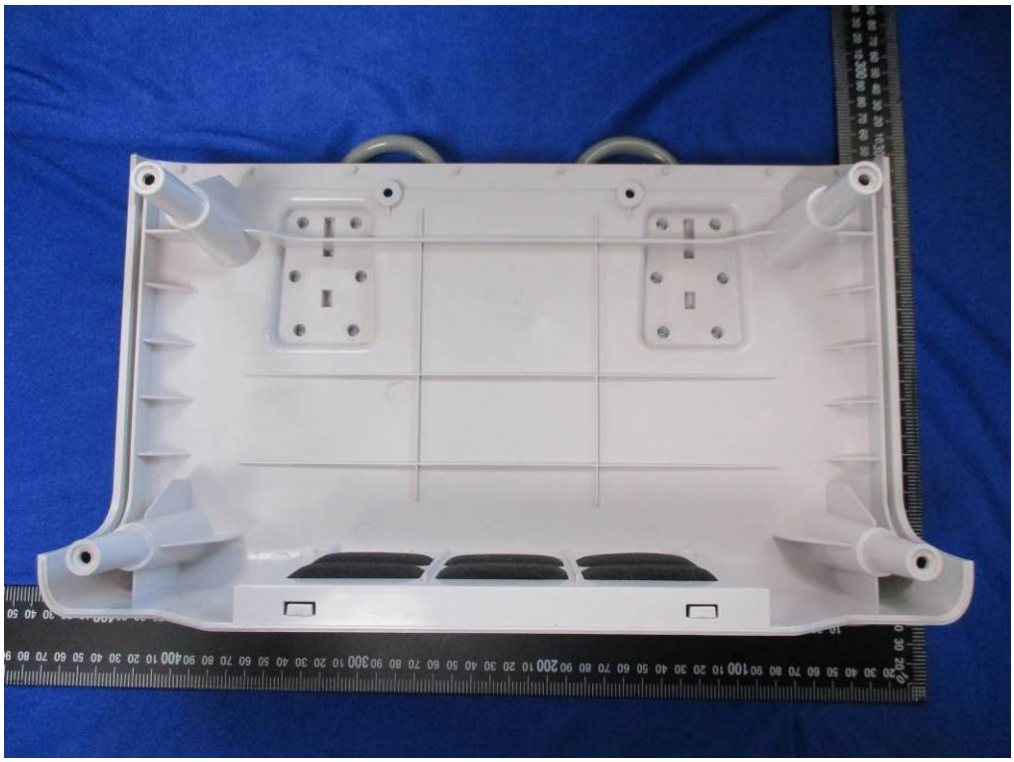


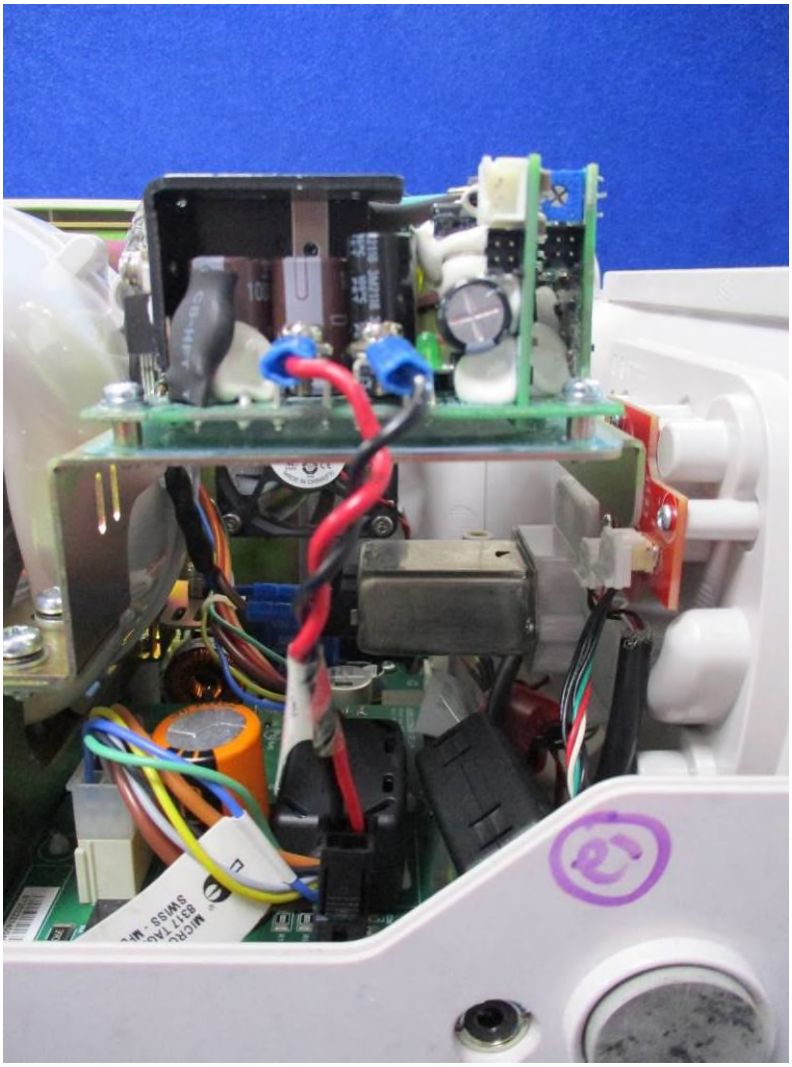
2.4 GHz Antenna

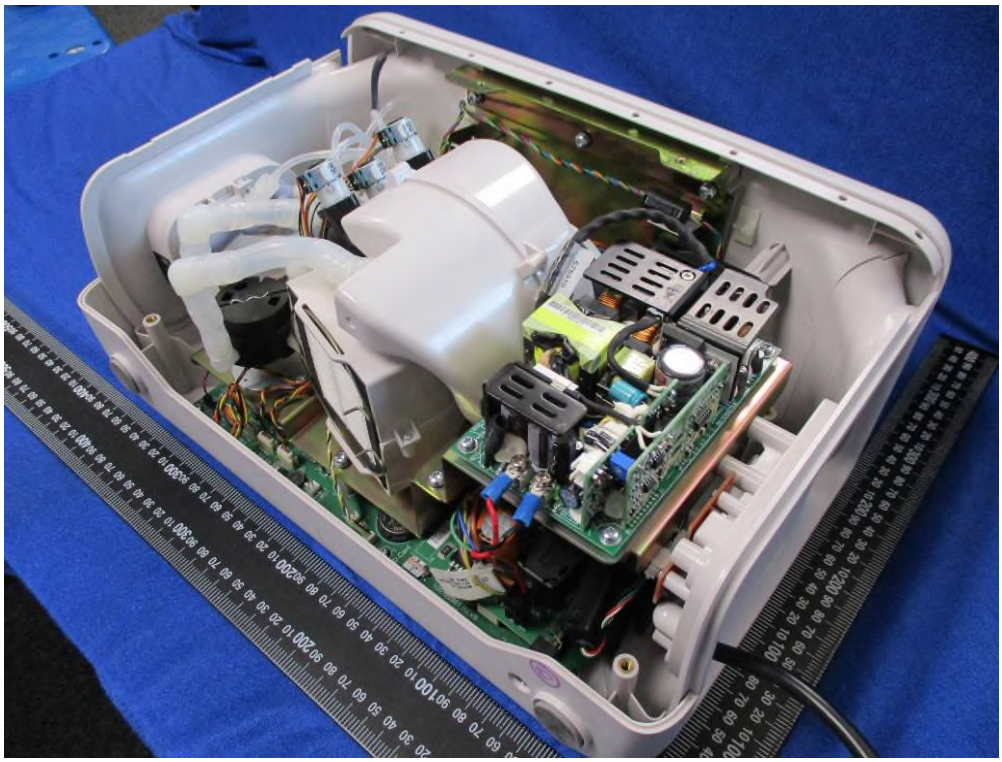
8.6 EUT Display & Controls

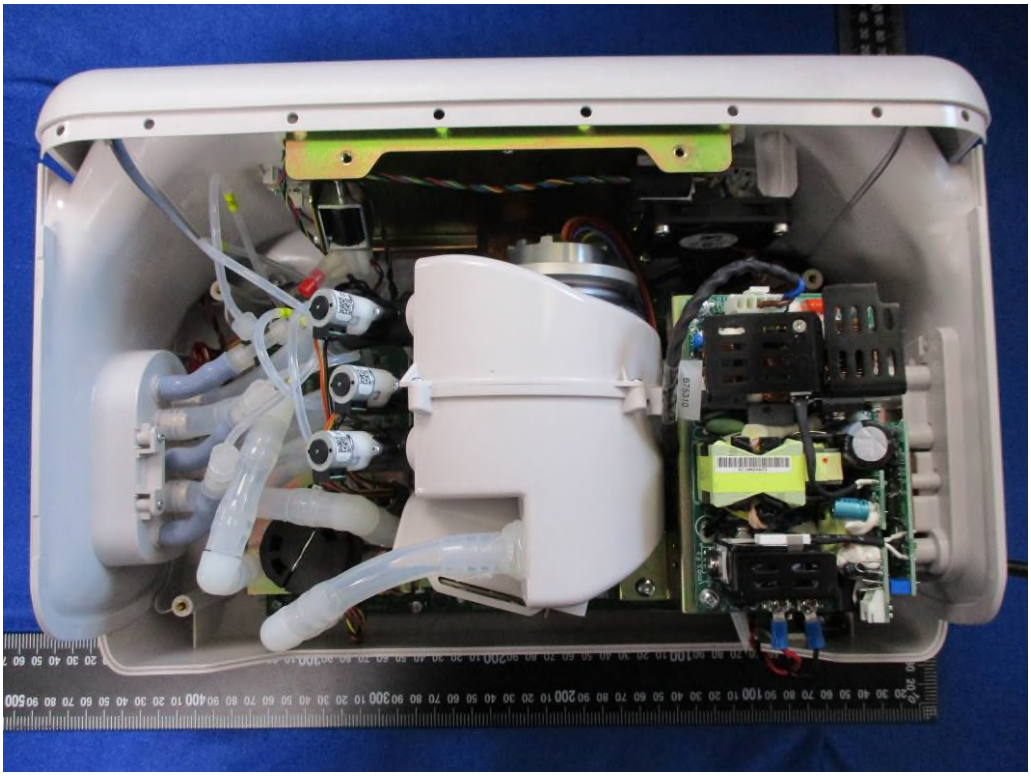
8.7 EUT Internal photos

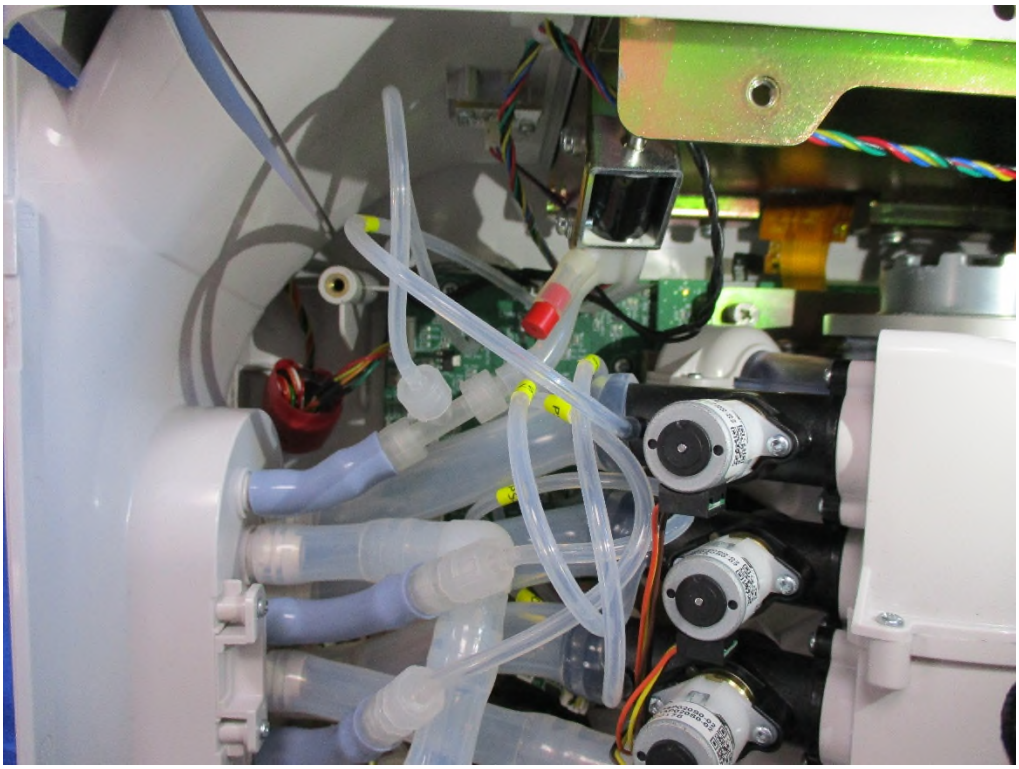


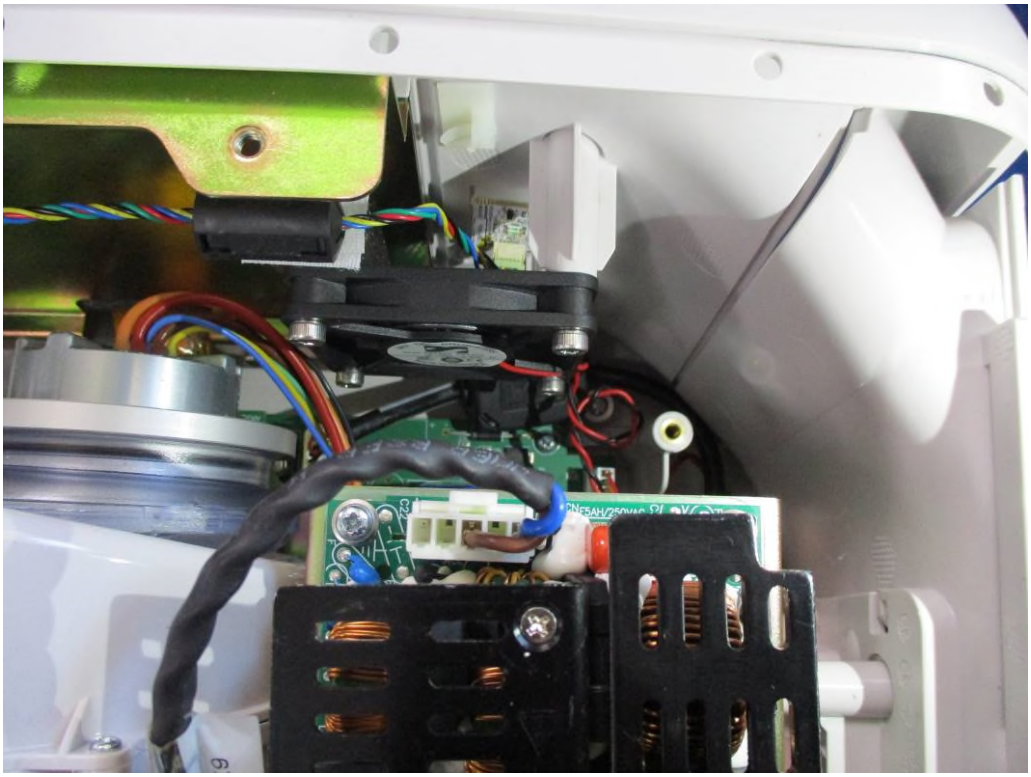


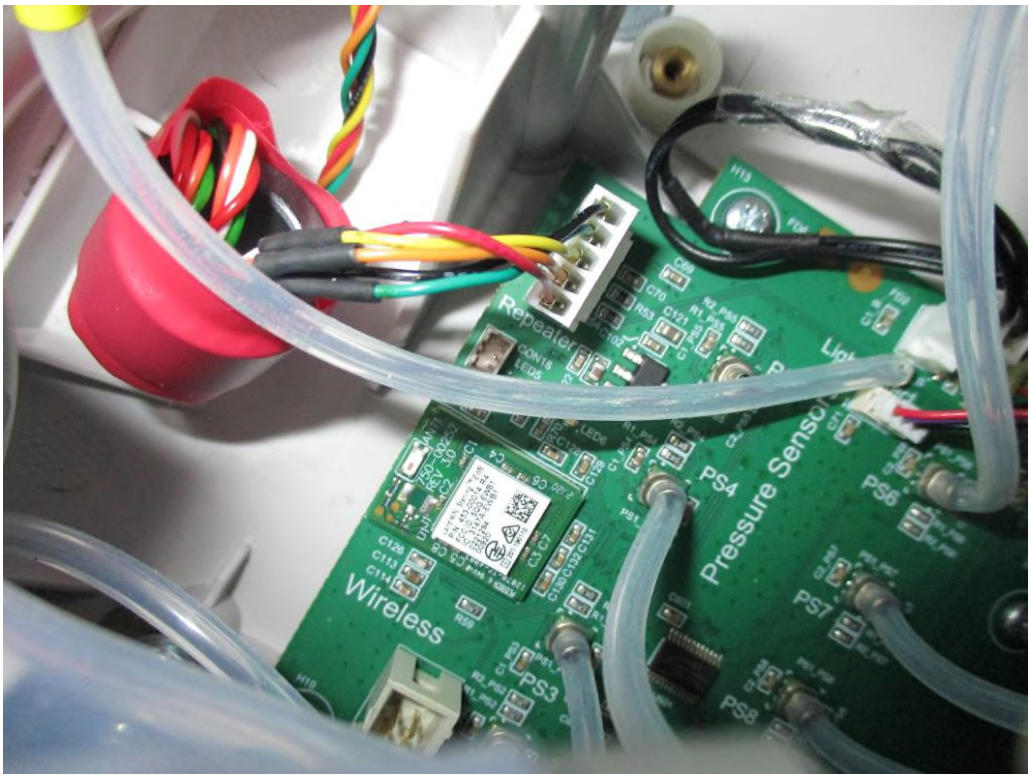




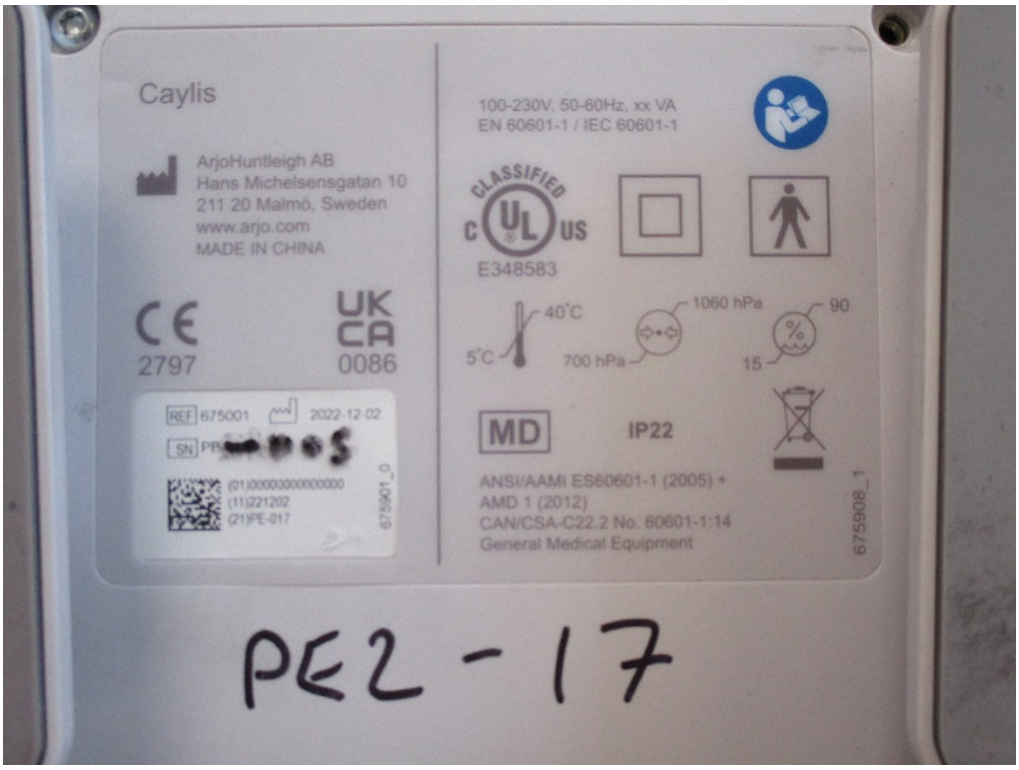




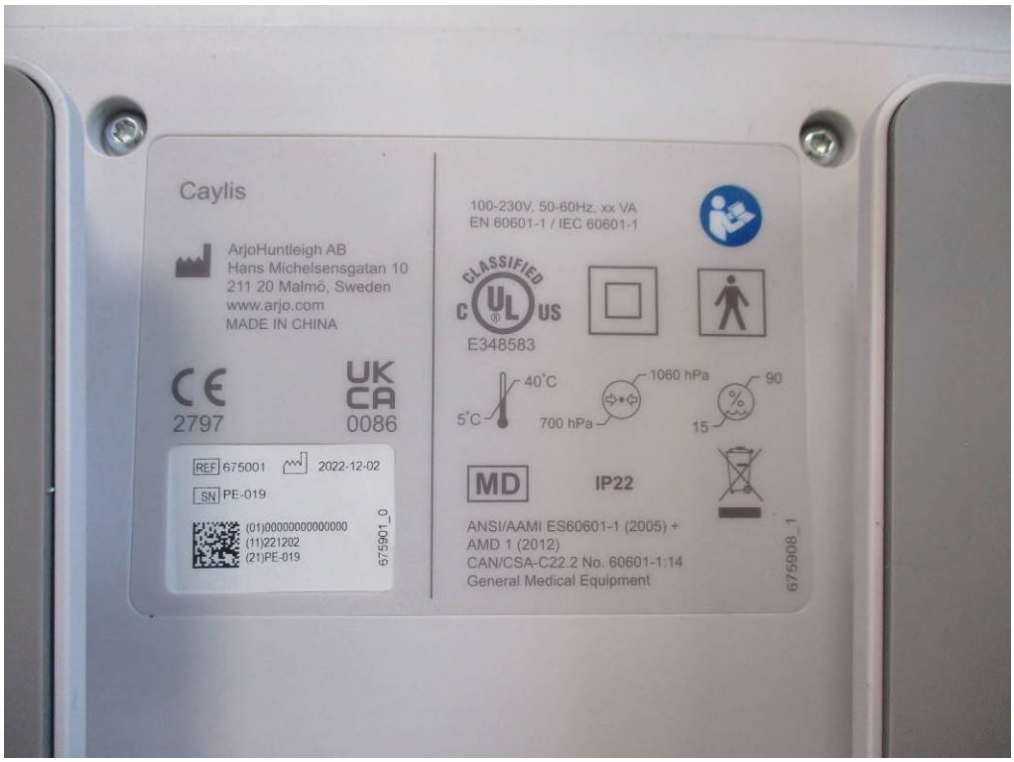



Repeater
Wireless
PS4
PS3
PS7
PS8

8.8 EUT ID Label



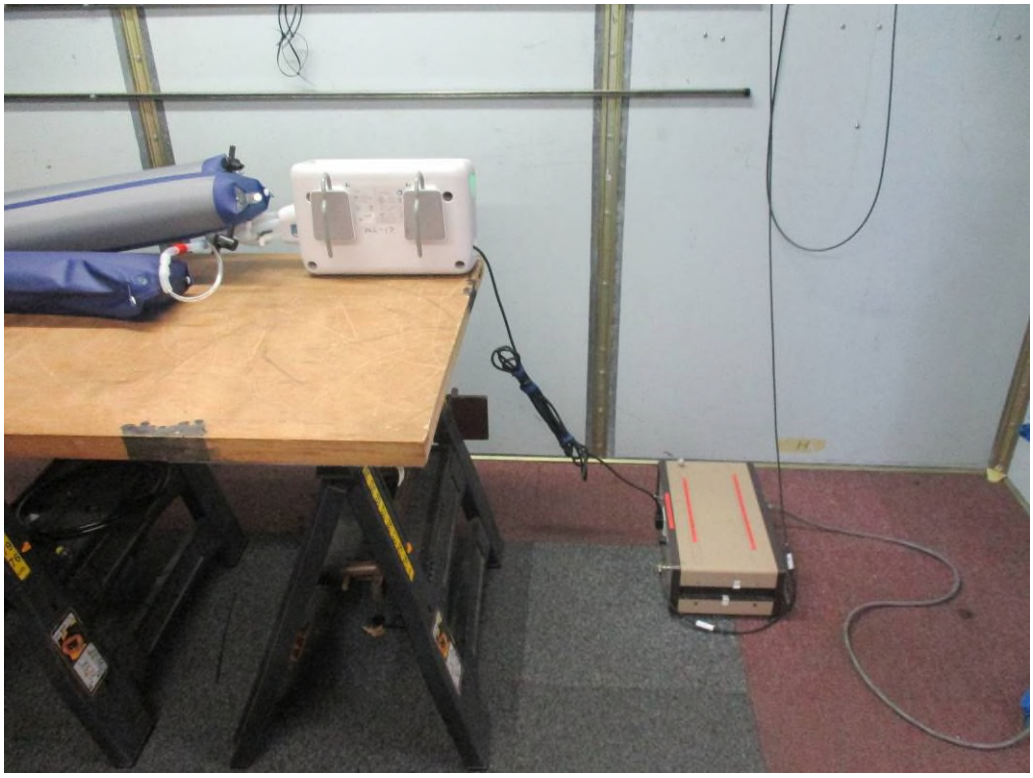
Wi-Fi sample

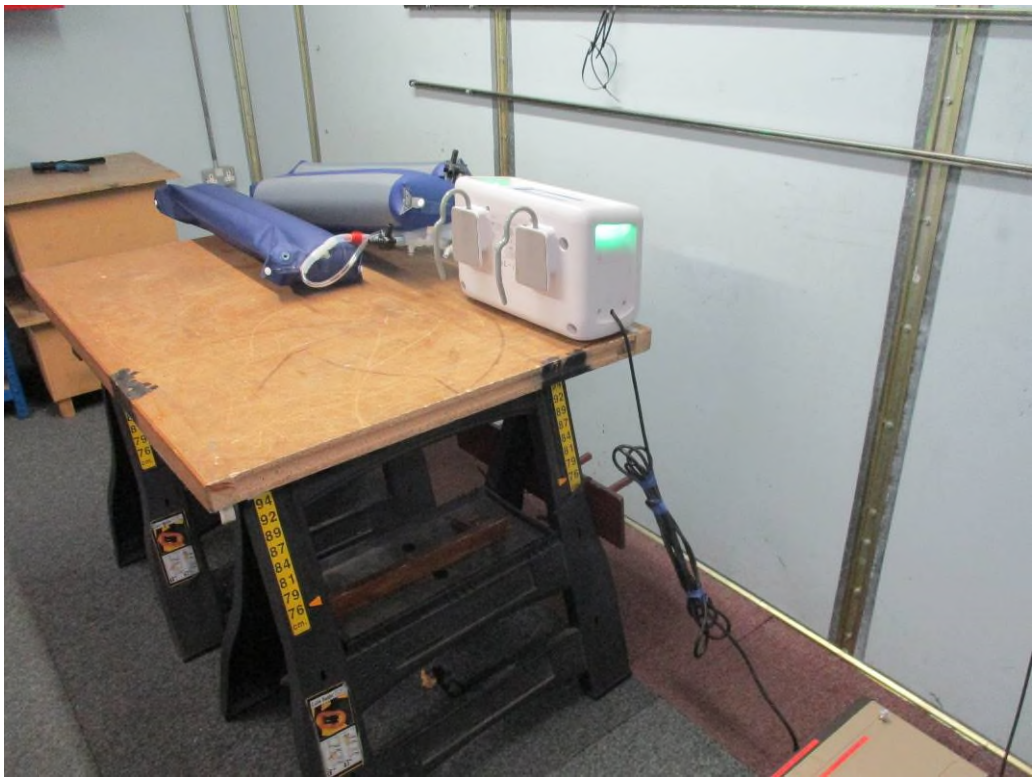


Bluetooth Low Energy sample

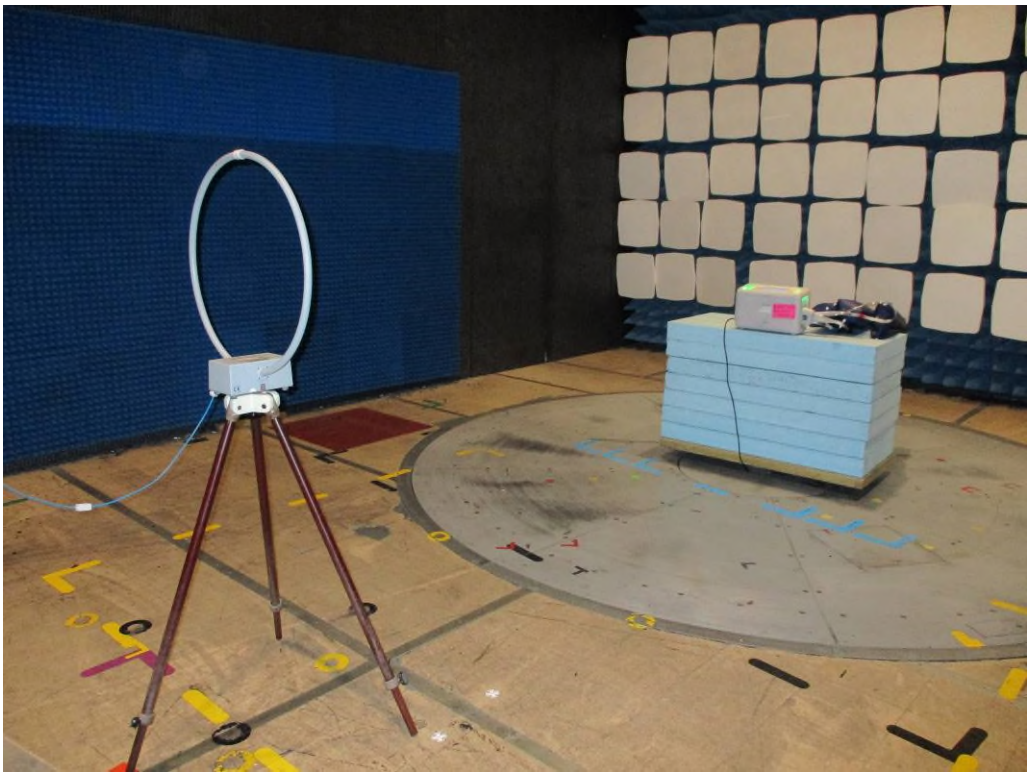
8.9 EUT Chassis

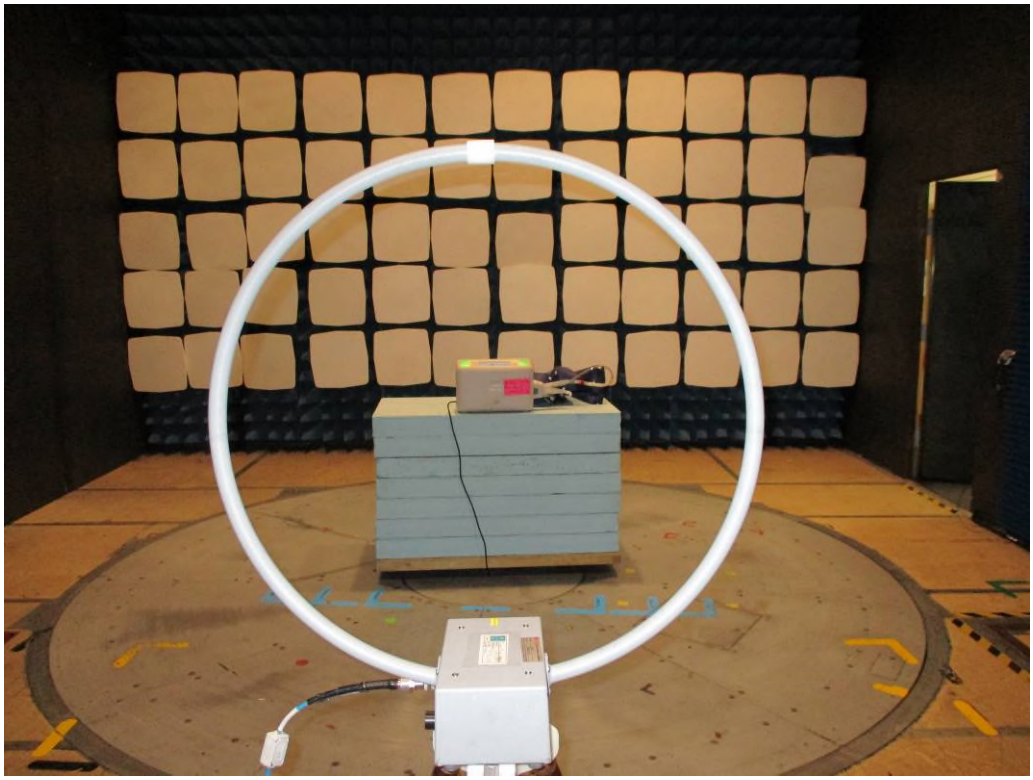
8.10 Conducted Emissions 9 kHz - 30 MHz



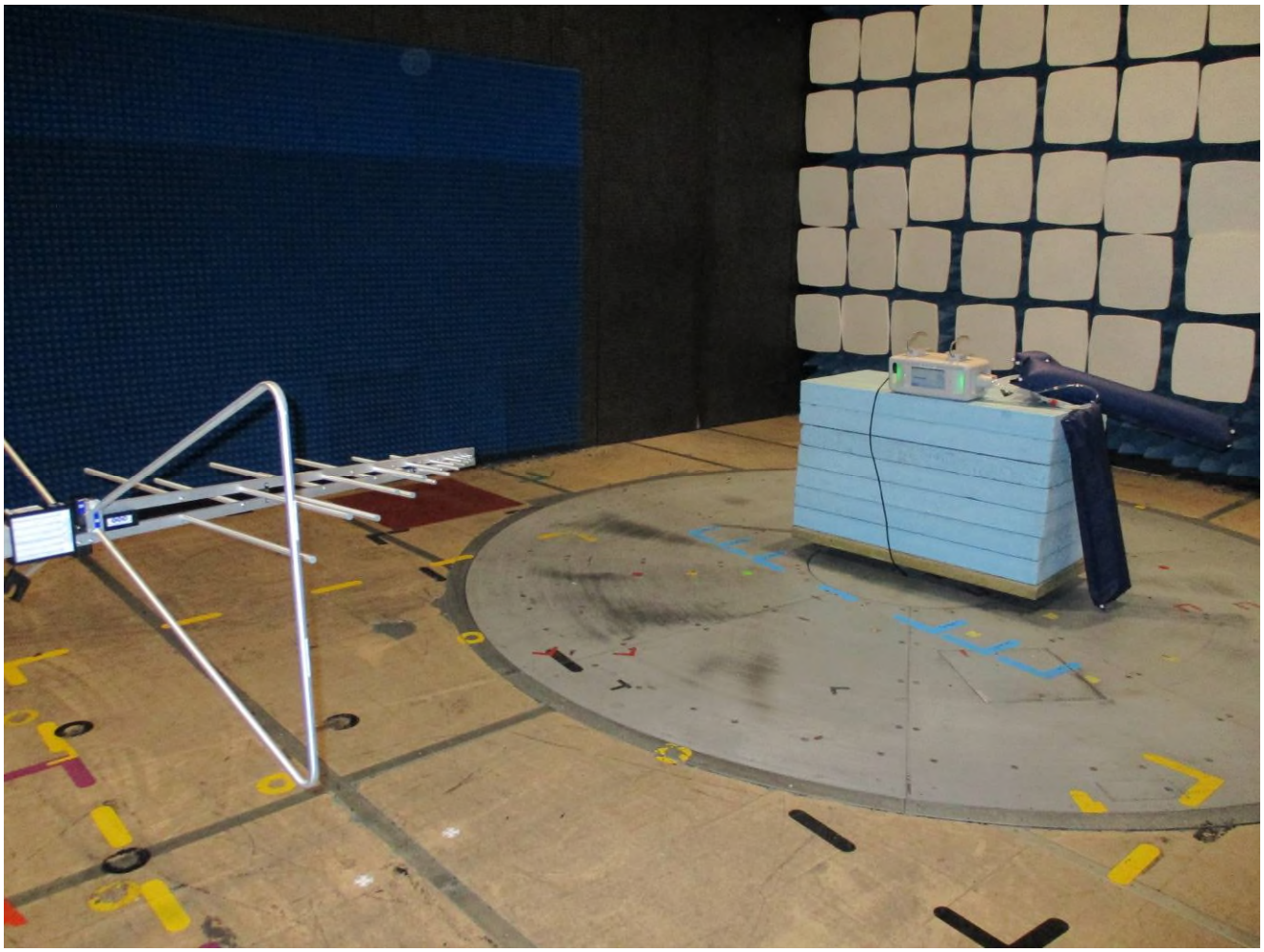


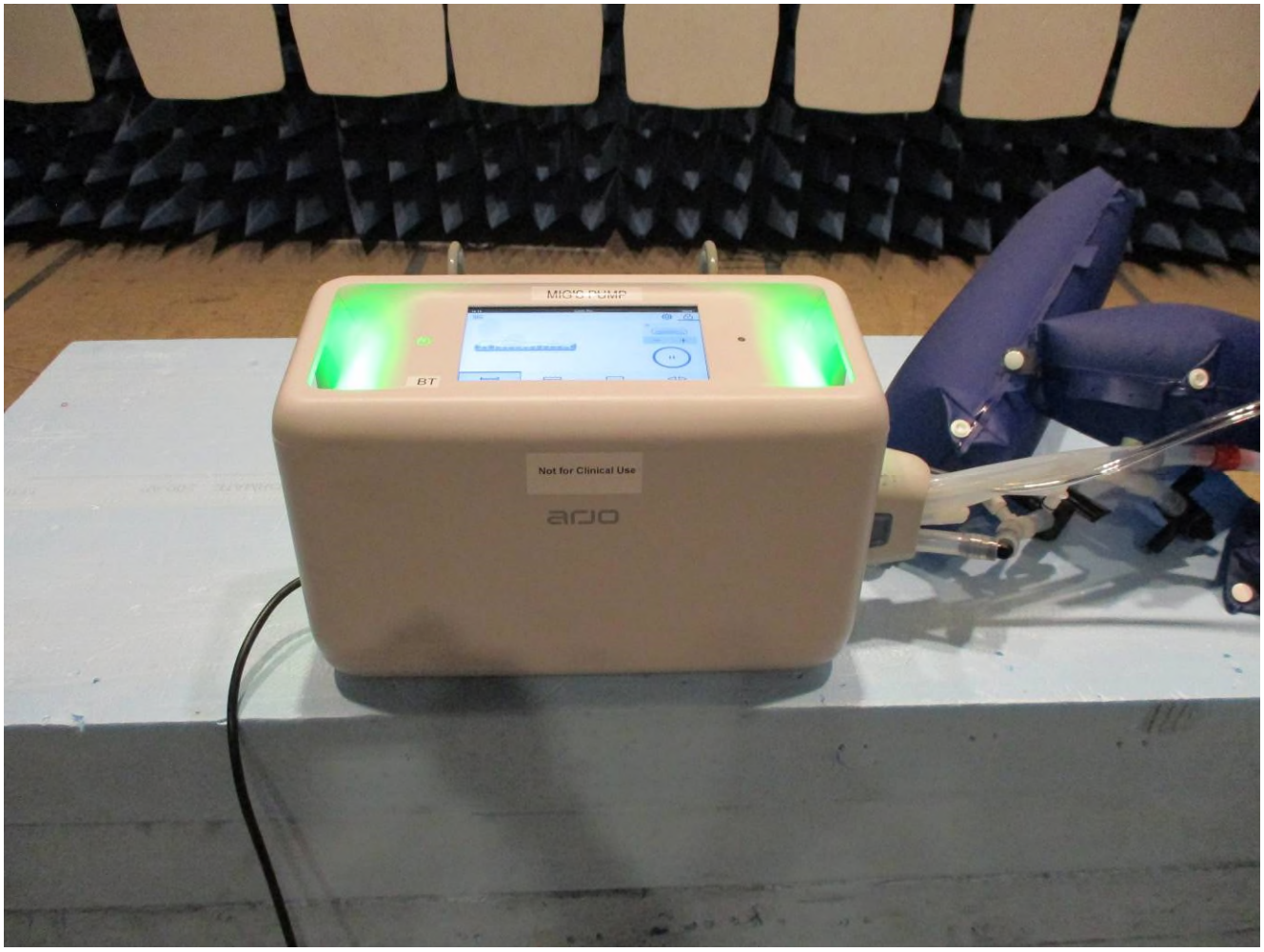
8.11 Radiated Emissions 9 kHz - 30 MHz



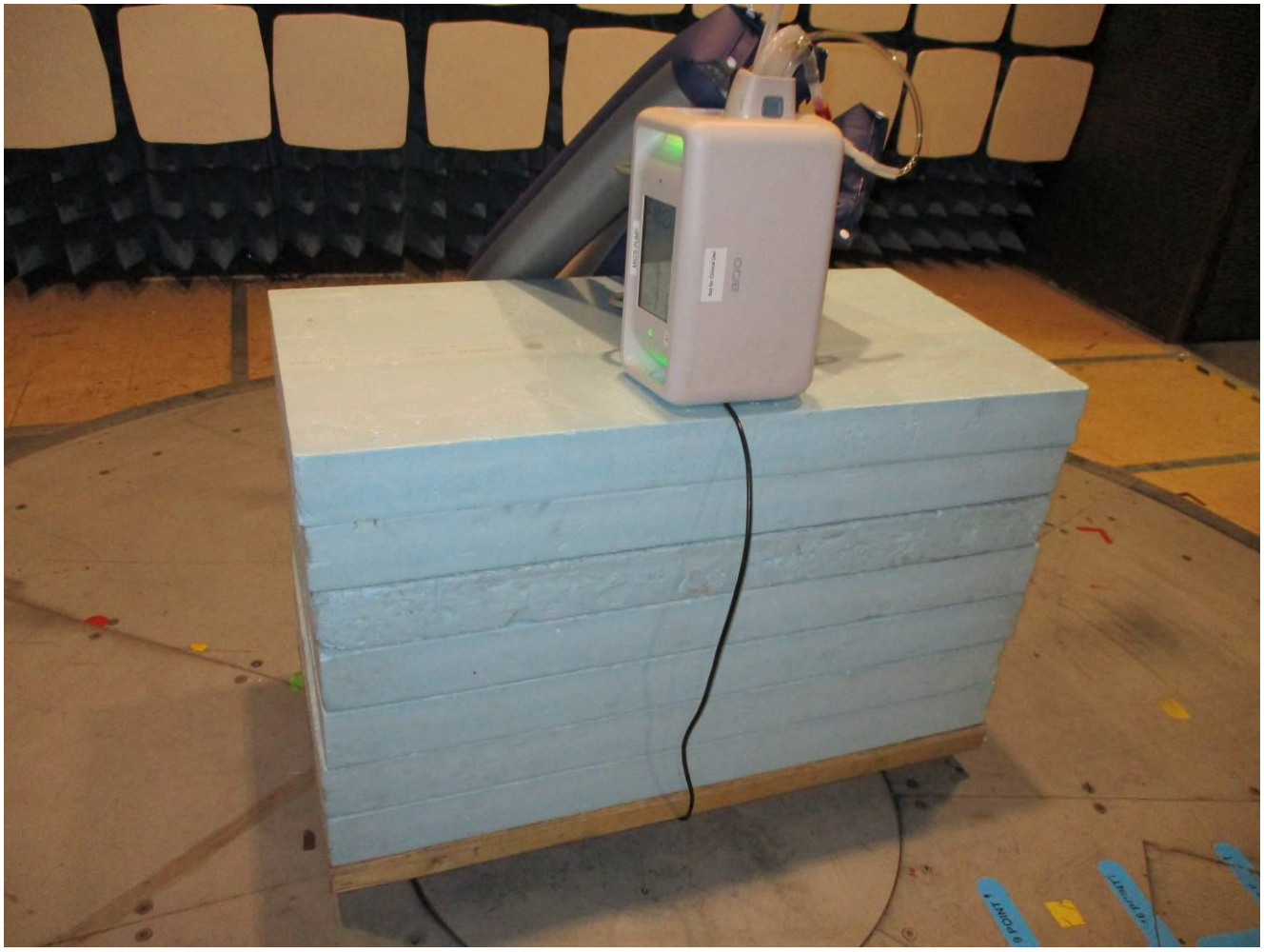


8.12 Radiated Emissions 30 MHz – 1 GHz





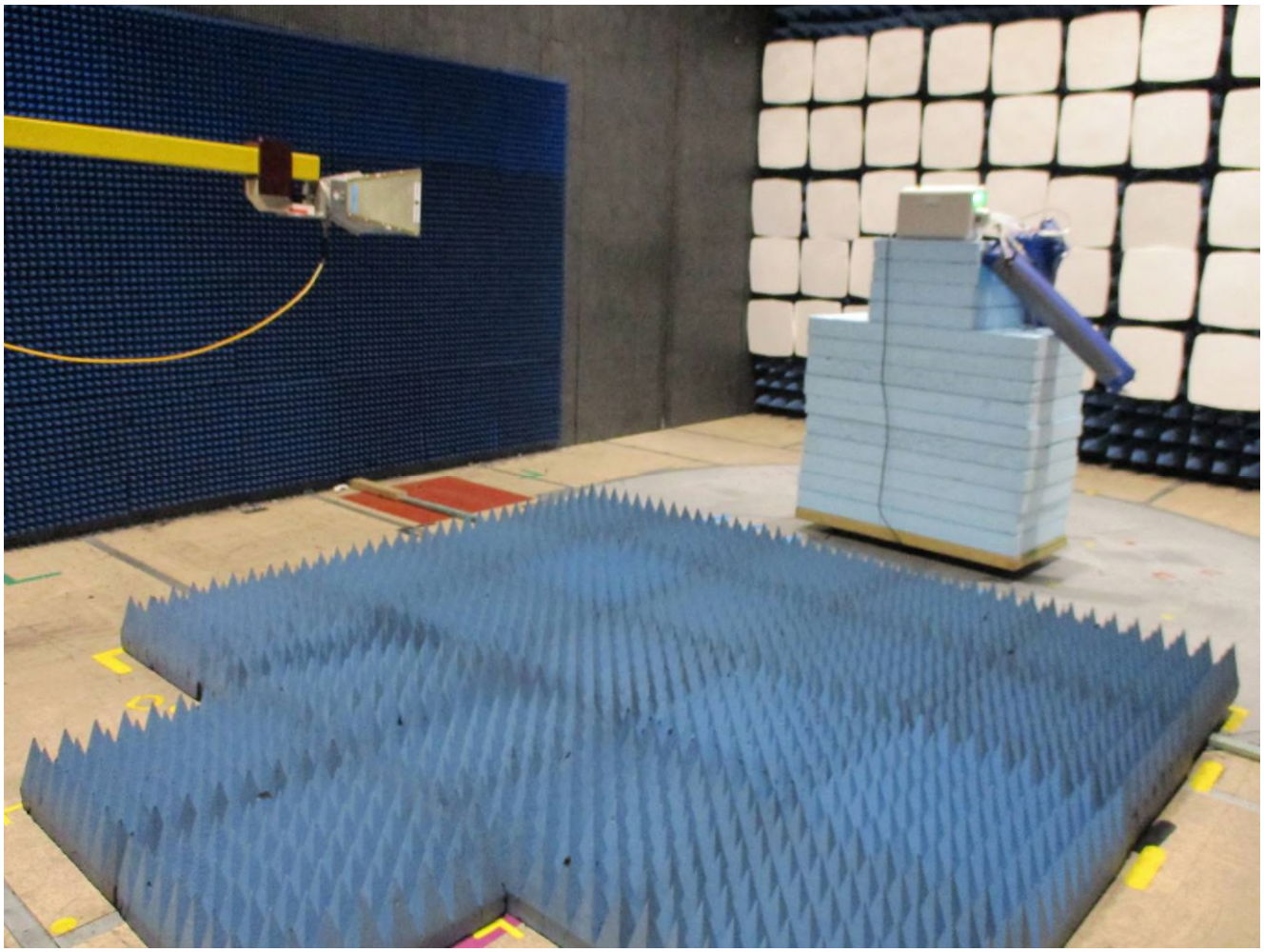
Upright Position

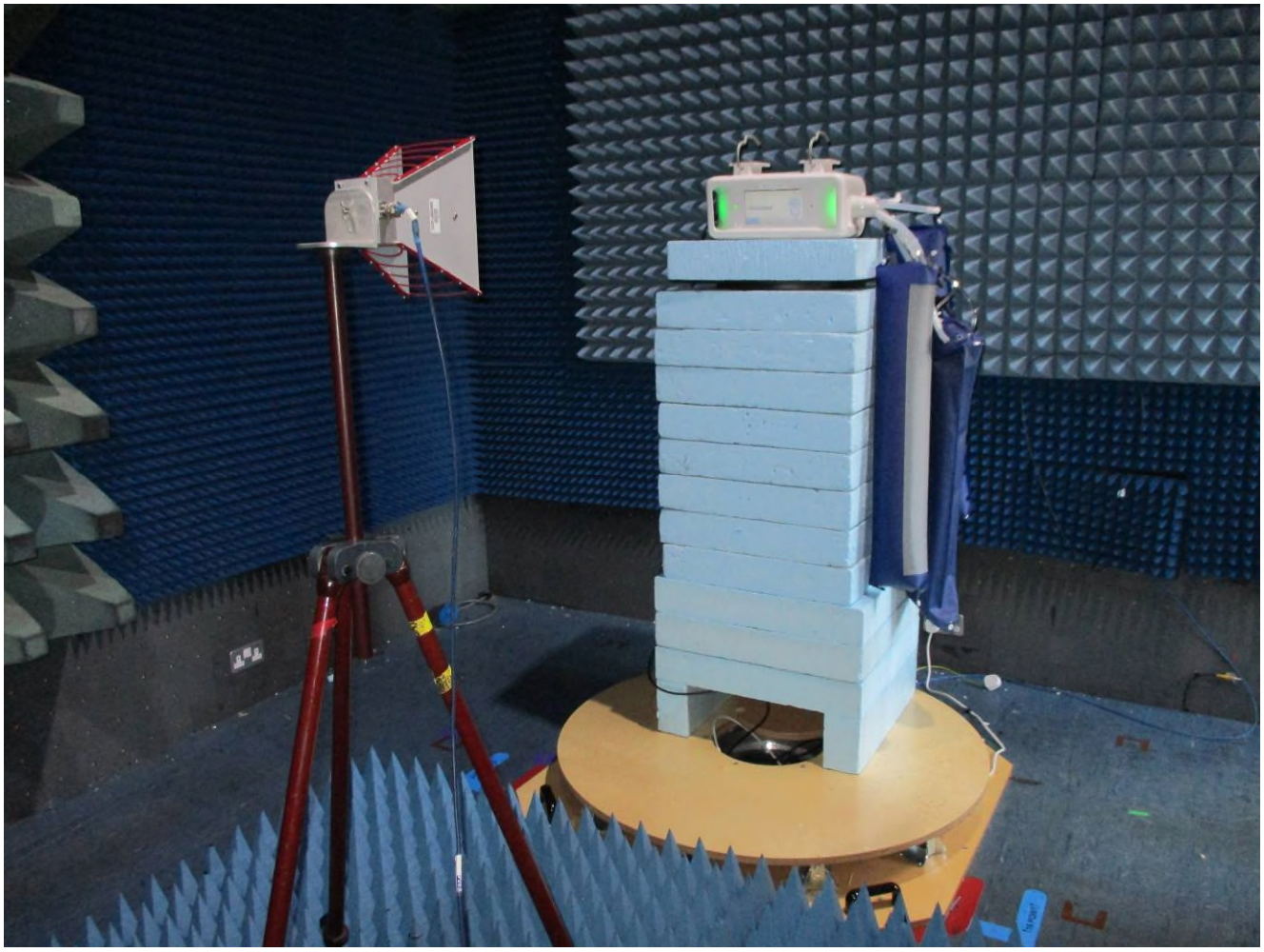


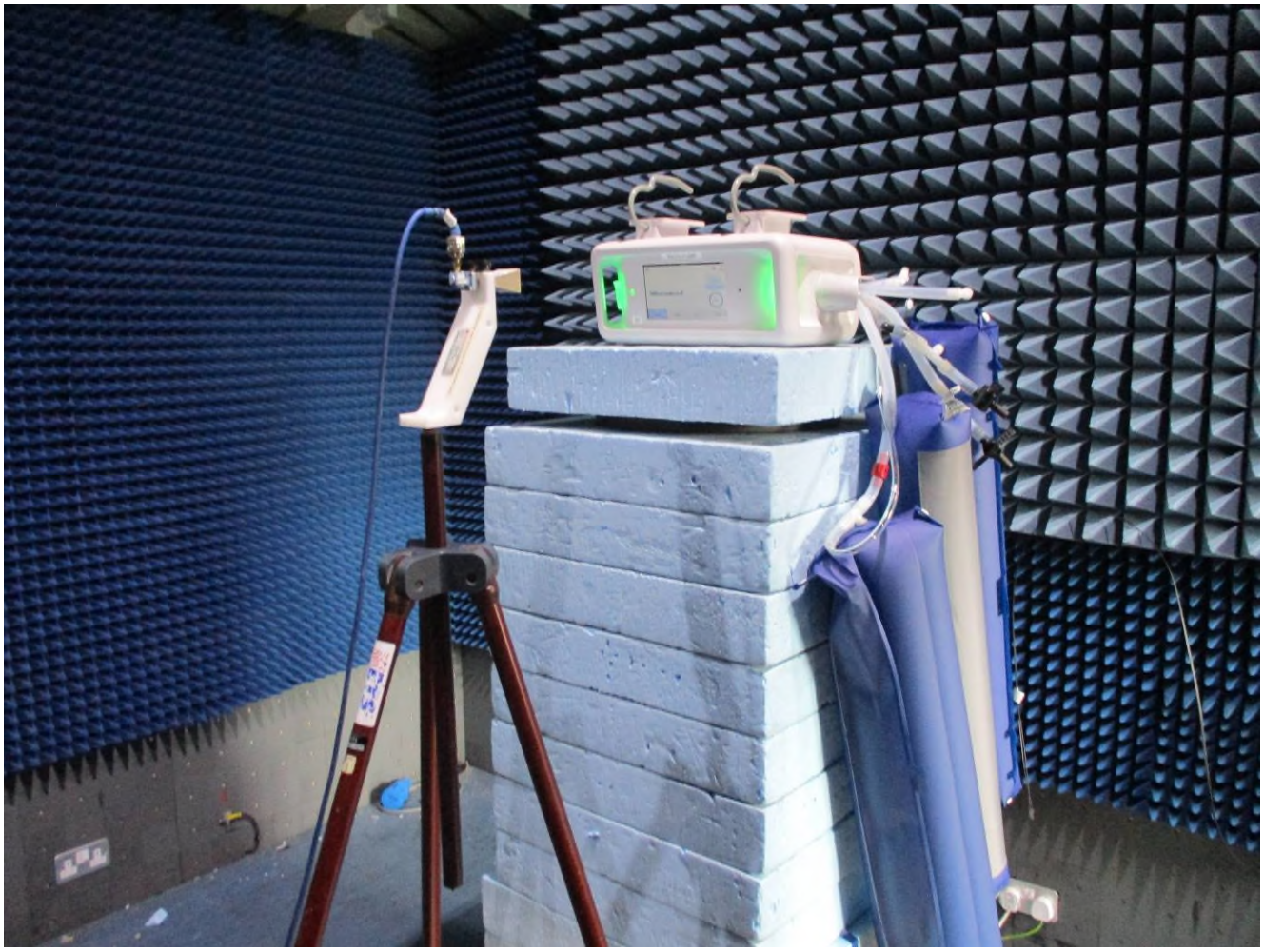
Side Position

Flat Position

8.13 Radiated Emissions 1 - 25 GHz







8.14 Radiated emission diagrams

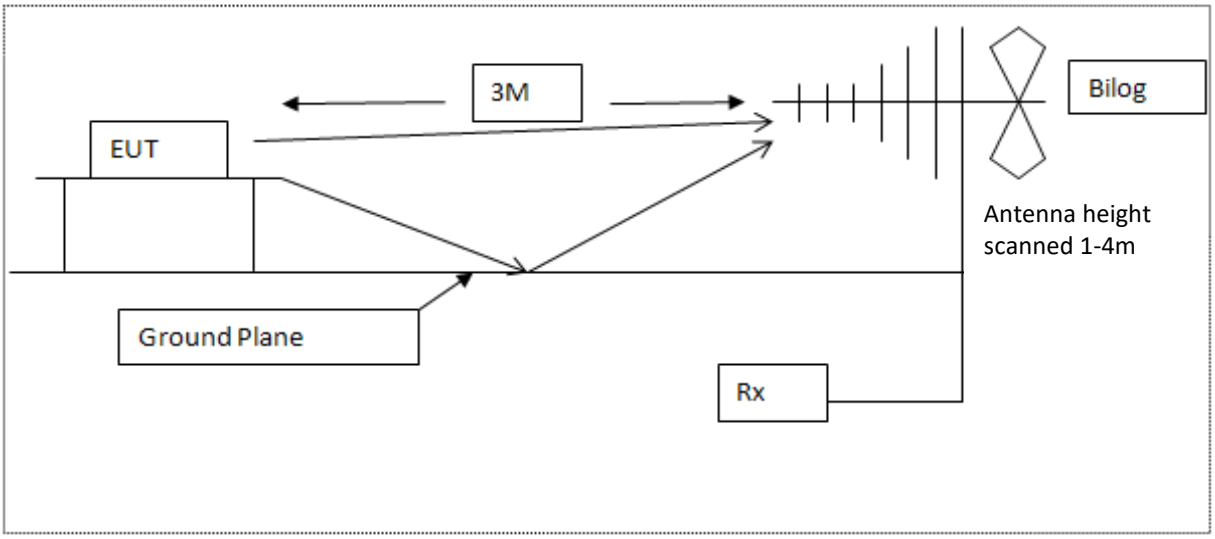


Diagram of the radiated emissions test setup 30 - 1000 MHz

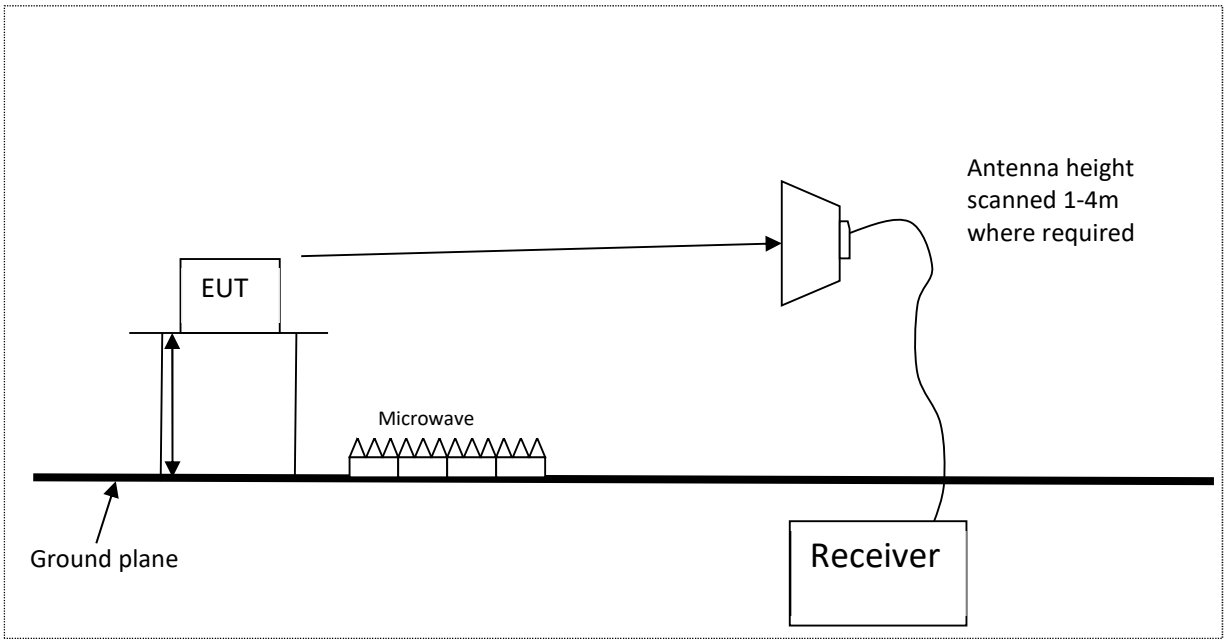


Diagram of the radiated emissions test setup above 1GHz

8.15 AC powerline conducted emission diagram

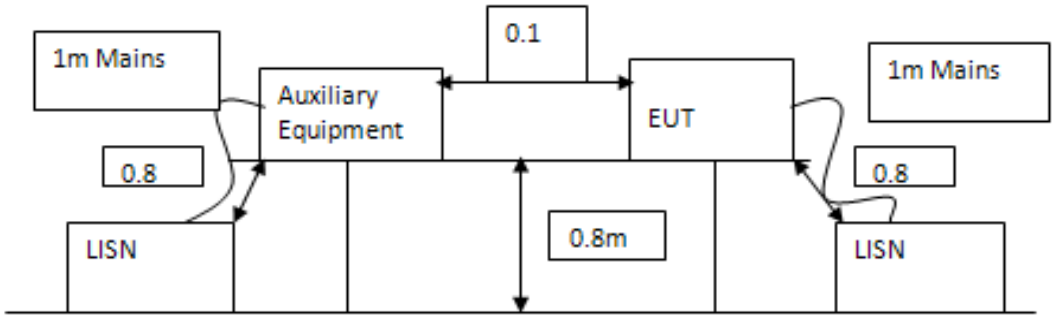


Diagram of the AC conducted emissions test setup

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-2023	12 months
E150	MN2050	LISN 13A	Chase	03-May-2023	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-Jun-2022	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	23-Aug-2022	12 months
E434	G3RUH	10 MHz GPS Disciplined Oscillator	G3RUH - James Miller	06-Mar-2023	12 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	25-Jan-2023	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	25-Feb-2023	12 months
E555	CMV 5E-1	Variac 5A	Carroll & Meynell Ltd	19-Dec-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
E745	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	24-Feb-2023	12 months
E856	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	06-Dec-2022	12 months
E904	5086-7805	Pre-Amplifier 1GHz - 26.5GHz	Hewlett Packard	03-May-2023	12 months
E914	VULB 9163	Antenna BiLog 30MHz to 3GHz	Schwarzbeck	23-Apr-2022	24 months
E972	WRCGV10-2363.5-2400-2483.5-2520-60SS	Filter Band Reject 2400 to 2483.5 MHz	Wainwright Instruments	03-Apr-2023	12 months
L264	DT75	Digital Thermometer	Instrotech Ltd	20-Dec-2021	24 months
N610	-	Loop Antenna	RN Electronics	N/A	N/A
NSA-H	NSA - H	NSA - Site H	RN Electronics	10-Dec-2022	36 months
TMS38	VMT04/140	Environmental Oven	Heraeus Votsch	13-Mar-2023	12 months
TMS57	PM2534	Digital Multimeter	Philips	17-May-2023	12 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
ZSW1	V2.5.2	Measurement Software Suite	RN Electronics	N/A	N/A

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	N22C6	Laptop	Acer	NXK86EK0012360D4B23400

10.2 RN Electronics supplied equipment

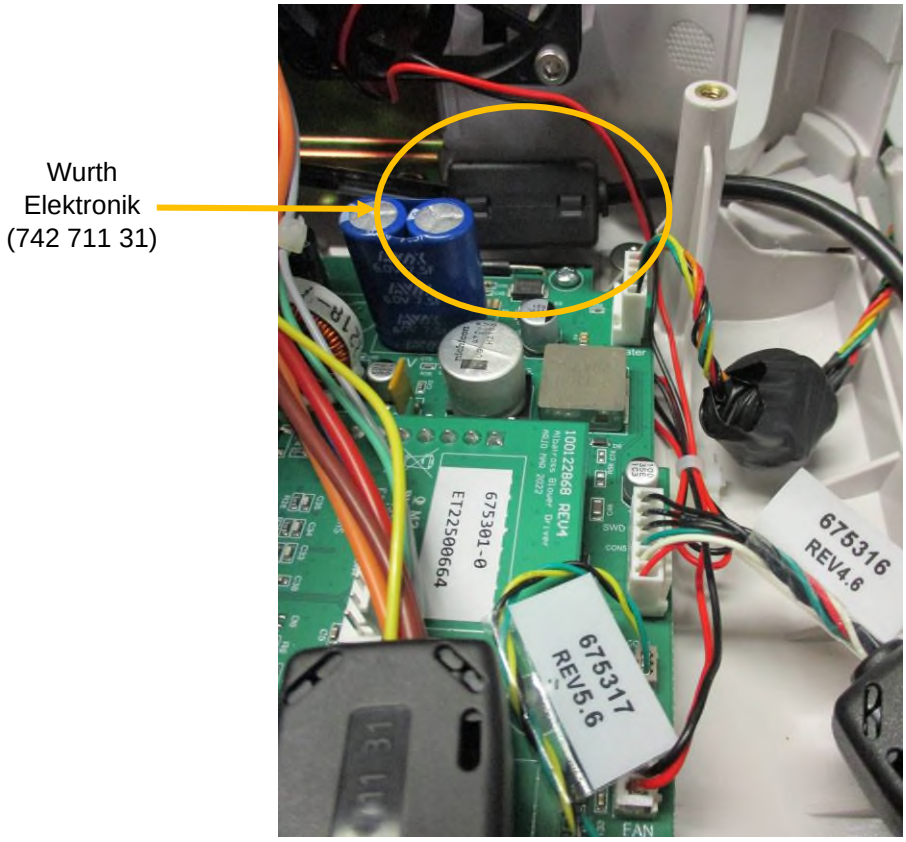
No RN Electronics Ltd supplied equipment was used.

11 Condition of the equipment tested

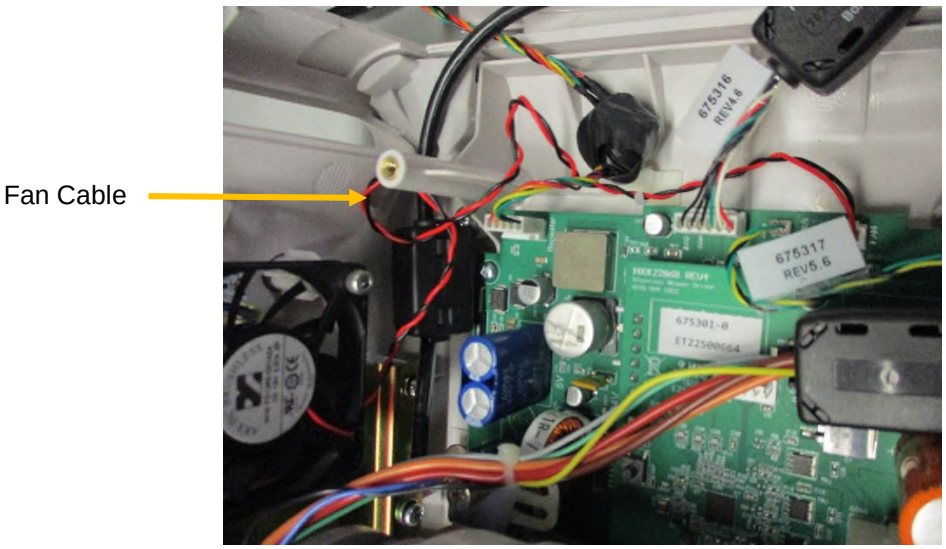
In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

11.1 Modifications before test

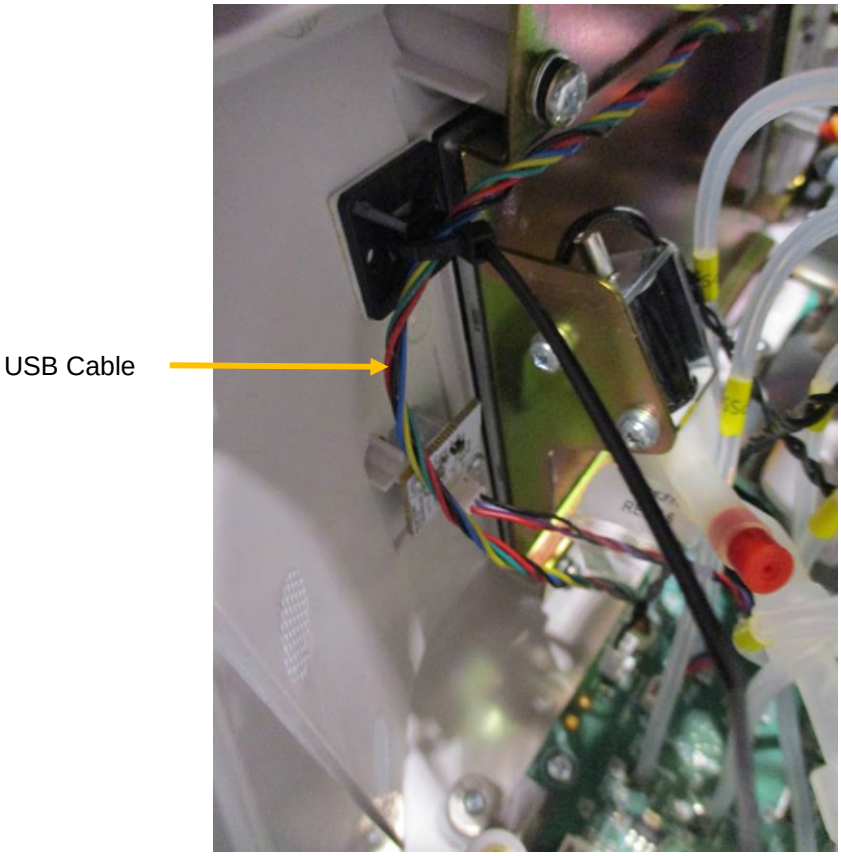
A Wurth Elektronik (742 711 31) ferrite was added to the USB cable at the main PCB/Display end, positioned under the fan next to main display mounting bracket.



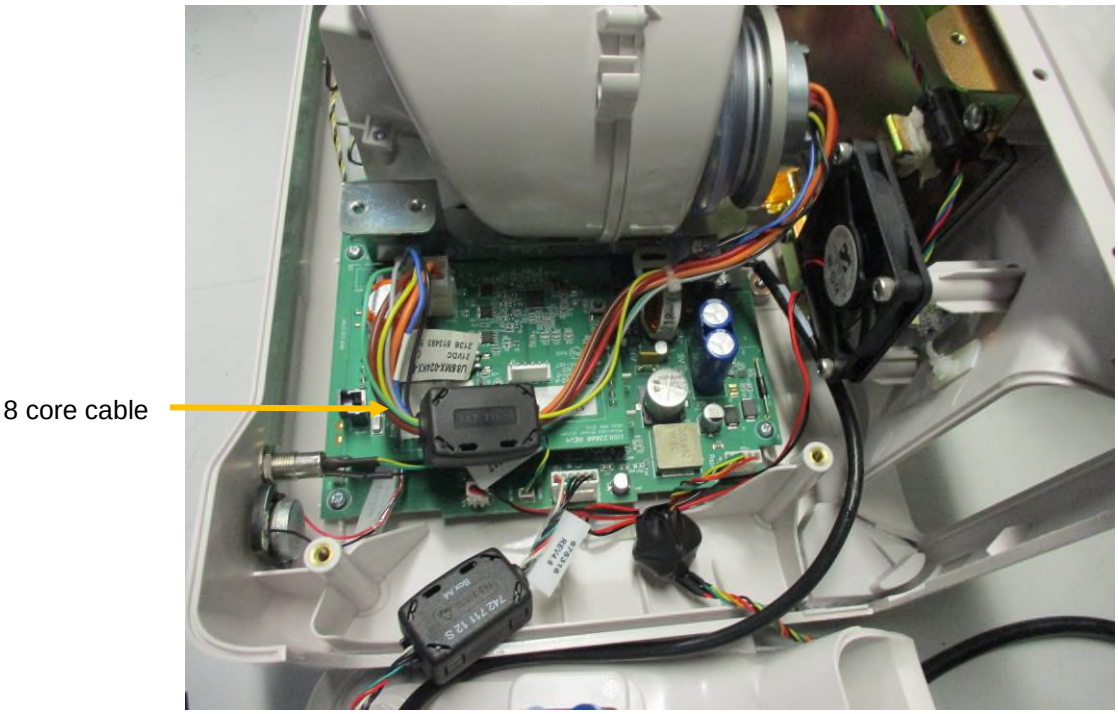
The Bluetooth sample internal cable routing for the CAP Switch, Fan, USB and 8 core cable bundle were re-routed to match that of the Wi-Fi unit supplied.



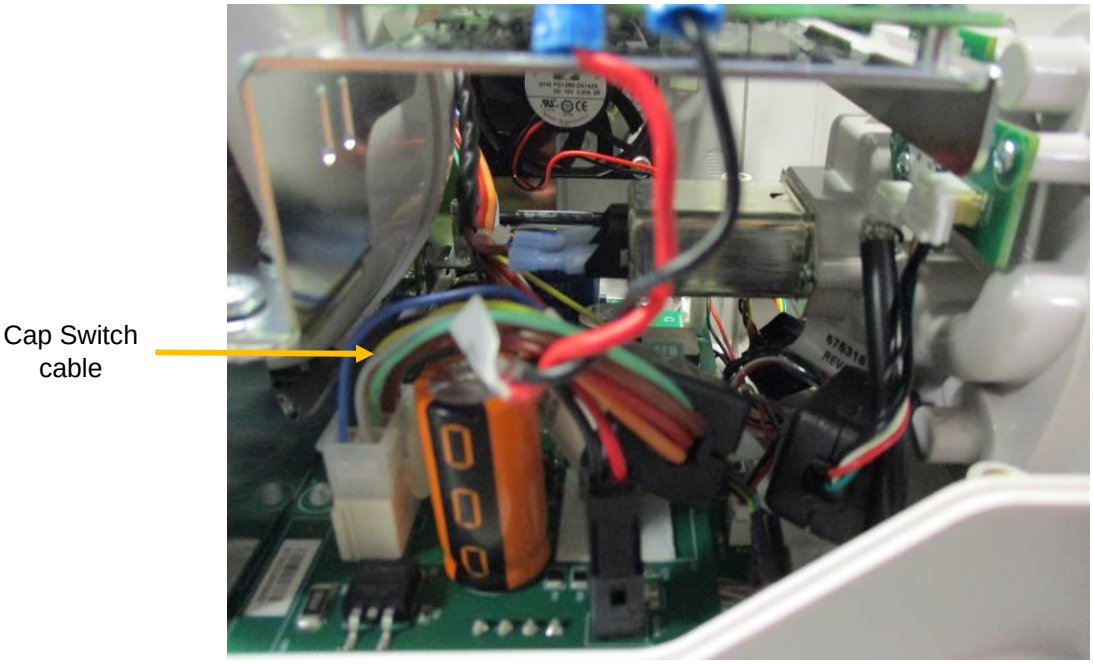
Fan Cable



USB Cable



8 core cable bundle



Cap Switch Cable

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 UK2015.

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

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