Radio Test Report

Salunda Ltd

6891

D10

47 CFR Part 15.247 Effective Date 1st October 2021
DTS: Digital Transmission System
Test Date: 3rd January 2023 to 6th January 2023
Report Number: 01-13917-2-23 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).

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

Certificate of Test 13917-2

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:	6891
Model Number:	D10
Unique Serial Number:	0044 (Radiated tests) 0055 (Conducted tests)
Applicant:	Salunda Ltd Unit 6 Avonbury Business Park Howes Lane Bicester, Oxfordshire OX26 2UA
Proposed FCC ID	2ALTW18016891
Full measurement results are detailed in Report Number:	01-13917-2-23 Issue 01
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2021 DTS: Digital Transmission System

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. This report pertains to 2.4GHz ZigBee operation, for UWB operation please refer to RN report 02-13917-5-23.

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:	3rd January 2023 to 6th January 2023
Test Engineer:	Graham Blake Digitally signed by: Graham Blake DN: CN = Graham Blake email = graham.blake@rnelectronics.com C = AD O = RN Electronics OU = Engineer Date: 2023.07.27 13:18:49 Z
Approved By: Radio Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2023.07.26 12:39:32 Z
Customer Representative:	

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Salunda Ltd Unit 6 Avonbury Business Park Howes Lane Bicester Oxfordshire OX26 2UA	
Manufacturer of EUT	Salunda Ltd	
Full Name of EUT	6891	
Model Number of EUT	D10	
Serial Number of EUT	0044 (Radiated tests) 0055 (Conducted tests)	
Date Received	6th October 2022	
Date of Test:	3rd January 2023 to 6th 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	26th July 2023	
Main Function	Personal/Equipment Locator	
Information Specification	Height	71.5 mm
	Width	41.5 mm
	Depth	5 mm
	Weight	0.002 kg
	Voltage	3 - 4.2 V
	Current	Not declared

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Body-worn
Choice of model(s) for type tests	Sample
Antenna details	Integral antenna -2 dBi gain maximum (Johanson 2450AT42E0100)
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	6.5 GHz
Lowest Signal generated in EUT	12 MHz
Hardware Version (HVIN)	Version 1
Software Version	'Salunda NFC Lite' Phone App: 1.7
Firmware Version (FVIN)	2.4GHz RF Processor: 4.251 – GIT Hash: 6b72d63 UWB Main processor: 5.251 – GIT Hash: 67e984d IMU: 1.14
Type of Equipment	Radio board / module
Technology Type	Zigbee
TX Parameters	
Alignment range – transmitter	2405 - 2480 MHz
EUT Declared Modulation Parameters	DSSS
EUT Declared Power level	13 dBm conducted
EUT Declared Signal Bandwidths	2 MHz
EUT Declared Channel Spacing's	5 MHz
EUT Declared Duty Cycle	5%
Unmodulated carrier available?	Yes
Declared frequency stability	Not declared
RX Parameters	
Alignment range – receiver	2405 - 2480 MHz
EUT Declared RX Signal Bandwidth	2 MHz
Receiver Signal Level (RSL)	-108 dBm
FCC Parameters	
FCC Transmitter Class	DTS: Part 15 Digital Transmission System

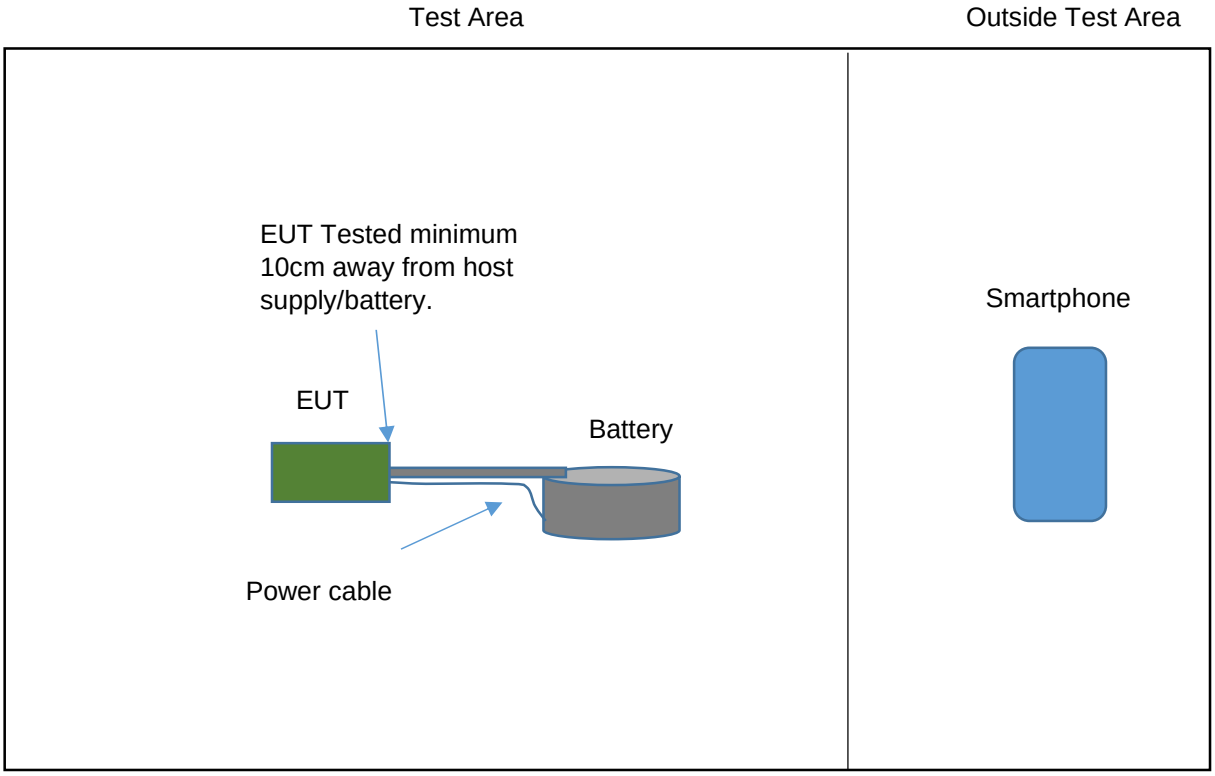
2.3 Functional description

Locates via UWB and sends location back to server, configuration over the 2.4GHz network, can also operate as gateway which responds to request to range.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX LOW	Transmitting continuous bursts of data at 2405 MHz using system modulation. UWB also transmitting 6.5GHz.	Yes
TX MID	Transmitting continuous bursts of data at 2440 MHz using system modulation. UWB also transmitting 6.5GHz.	Yes
TX HIGH	Transmitting continuous bursts of data at 2480 MHz using system modulation. UWB also transmitting 6.5GHz.	Yes

2.5 Emissions configuration



The unit was powered from a fully charged battery pack. The applicant provided a bracket assembly so that the EUT could be positioned 10 centimetres away from the battery pack for a module certification/test requirement. For conducted tests a modified EUT was provided where the antenna had been removed and a coax cable soldered in its place. For AC conducted emissions the EUT and battery were connected to a AC mains powered charger at 120V AC 60Hz. To configure the EUT into transmit modes a Smartphone was used which was running engineering software (Salunda NFC Lite). Prior to test the required settings were configured into the Smartphone and were transferred to the EUT by moving the smartphone into close proximity to the EUTs NFC antenna. The transmit mode was 100% continuous with modulation and the power settings for each channel were as stated below:-

Low Channel (2405 MHz) = level 13
Mid Channel (2440 MHz) only = level 13
High Channel (2480 MHz) = level 10

In conjunction with the ZigBee test channels above, the UWB transmitter was operating so any intermodulation emissions occurring could be measured.

2.5.1 Signal leads

Port Name	Cable Type	Connected
DC Power	2 x single core	Yes

3 Summary of test results

The 6891, D10 was tested for compliance to the following standard:

47 CFR Part 15.247 Effective Date 1st October 2021
DTS: Digital Transmission System

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	PASSED
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.247(d) & 15.209	PASSED[1]
6. Effective radiated power field strength	47 CFR Part 15C Part 15.247(d)	PASSED
7. Band Edge Compliance	47 CFR Part 15C Part 15.215 & 15.247(d)	PASSED
8. Occupied bandwidth	47 CFR Part 15C Part 15.247(2)	PASSED
9. Maximum Average conducted output power	47 CFR Part 15C Part 15.247	NOT APPLICABLE[2]
10. Maximum Peak conducted output power	47 CFR Part 15C Part 15.247(b)(3)	PASSED
11. Maximum Power Spectral Density	47 CFR Part 15C Part 15.247(e)	PASSED
12. Antenna power conducted emissions	47 CFR Part 15C Part 15.247	NOT APPLICABLE[4]
13. Duty cycle	47 CFR Part 15C Part 15.35	NOT APPLICABLE[5]
14. FHSS carrier frequency separation	47 CFR Part 15C Part 15.247	NOT APPLICABLE[3]
15. Average time of occupancy	47 CFR Part 15C Part 15.247	NOT APPLICABLE[3]
16. Number of Hop Channels	47 CFR Part 15C Part 15.247	NOT APPLICABLE[3]

[1] Spectrum investigated up to a frequency of 40 GHz based on the highest channel/ signal generated in equipment of 6500 MHz associated with the UWB Transmitter.

[2] Peak conducted power tested instead.

[3] EUT does not employ FHSS technology

[4] Applies to EUT's with an antenna port. The EUT has an integral antenna only, the EUT was tested for radiated emissions with its dedicated antenna in position.

[5] No limits apply. Duty cycle verified as 100% 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	2017	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
4.1.4	KDB 558074 D01 v05r02	2019	Federal Communications Commission Office of Engineering and Technology Laboratory Division; GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

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 in the charging station on a wooden table 0.8m above the ground plane and power supply was 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 it was found that there was no perceivable difference between channels and therefore the EUT was operated in TX MID mode for full test.

5.1.3 Test procedure

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

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

Tests were performed in Test Site F.

5.1.4 Test equipment

E150, E035, ZSW1, E412, 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	101 kPa

Band	2400-2483.5 MHz
Power Level	13
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Mid channel	2440 MHz

Plot refs
13917-2 Cond 1 AC Live 150k-30M Average
13917-2 Cond 1 AC Live 150k-30M Quasi-Peak
13917-2 Cond 1 AC Neutral 150k-30M Average
13917-2 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	0.156	48.8	47.9	-17.8	37.0	-18.7
2	0.187	43.0	42.0	-22.2	32.4	-21.8
3	0.343	44.1	43.5	-15.6	42.0	-7.1
4	0.374	43.2	42.5	-15.9	41.6	-6.8
5	0.374	43.4	42.3	-16.1	41.5	-6.9
6	19.935	38.9	37.1	-22.9	34.7	-15.3

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	0.156	48.8	47.9	-17.8	37.3	-18.4
2	0.343	44.0	43.5	-15.6	41.9	-7.2
3	0.374	43.2	42.4	-16.0	41.6	-6.8
4	0.467	33.9	33.0	-23.6	31.5	-15.1
5	19.798	32.7	29.1	-30.9	22.0	-28.0
6	19.932	39.9	38.6	-21.4	36.6	-13.4
7	20.201	39.1	37.5	-22.5	34.7	-15.3

No discernible difference was noted in emissions between channels (exploratory measurements); therefore the final measurements are presented for TX mid channel mode only.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report./ 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:
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 15.209/15.247(d) [Reference 4.1.1 of this report]

5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX LOW, TX MID and TX HIGH modes.

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 M.

5.2.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	18°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	13
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Mid channel	2440 MHz

Plot refs
13917-2 Rad 1 9k-150kHz Para
13917-2 Rad 1 9k-150kHz Perp

Note: Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Middle channel plots are shown in this report.

No emissions were observed within 20dB of limits.

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

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

9kHz - 30MHz ±3.9dB

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

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

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX LOW, TX MID and TX HIGH modes.

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 M.

5.3.4 Test equipment

TMS81, ZSW1, E412, E411

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	12°C
Humidity of test environment	60%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	13
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Mid channel	2440 MHz

Plot refs
13917-2 Rad 1 150k-30MHz Para
13917-2 Rad 1 150k-30MHz Perp

Note: Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Middle channel plots are shown in this report.

No emissions were observed within 20dB of limits.

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

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
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:
9kHz - 30MHz ±3.9dB

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

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

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX LOW, TX MID and TX HIGH modes.

5.4.3 Test procedure

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

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

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

Tests were performed using Test Site M.

5.4.4 Test equipment

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

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	12°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

Plot refs
13917-2 Rad 1 VHF Horiz
13917-2 Rad 1 VHF Vert
13917-2 Rad 1 UHF Horiz
13917-2 Rad 1 UHF Vert

Note: Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Middle channel plots are shown in this report.

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	164.730	30.4	24.9	-18.6
2	214.611	37.0	31.5	-12.0
3	351.290	34.0	28.6	-17.4
4	451.665	36.2	31.1	-14.9
5	621.665	41.5	36.8	-9.2
6	915.000	36.9	31.5	-14.5

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	214.702	32.2	26.3	-17.2
2	355.894	31.6	25.5	-20.5
3	459.894	37.7	30.5	-15.5
4	613.054	36.2	31.0	-15.0
5	630.051	34.7	28.8	-17.2
6	918.050	36.9	31.3	-14.7

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

Results shown above are valid for Low, Mid and High channels setting as no difference was observed between channel settings in this test range, UWB transmitter was also on for these measurements.

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

These results show that the EUT has PASSED this test.

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

30MHz - 1000MHz ±5.6dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

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

5.5.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery.

The EUT was operated in TX LOW, TX MID and TX HIGH modes.

5.5.3 Test procedure

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

Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. Horn antennas were used at heights where the whole of the EUT was contained within the main beam. The EUT was rotated through 360 degrees to record the worst-case emissions. A measurement distance of 3m was used between the test range 1 - 6GHz, 1.2m was used in the test range 6 - 18GHz and 0.3m was used in the test range 18 - 40GHz.

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

Tests were performed using Test Site M and Site B.

5.5.4 Test equipment

E136, E296-2, E330, E411, E412, E429, TMS78, TMS79, TMS82

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	16°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Note: Channels below were also tested in simultaneous TX mode with the UWB transmission.

Setup Table

Band	2400-2483.5 MHz
Power Level	13
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz

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 emissions within 20 dB of the limit were observed						

Setup Table

Band	2400-2483.5 MHz
Power Level	13
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Mid channel	2440 MHz

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 emissions within 20 dB of the limit were observed						

Plots
13917-2 Rad 1 1-2GHz Horiz
13917-2 Rad 1 1-2GHz Vert
13917-2 Rad 1 2-2.7GHz Horiz
13917-2 Rad 1 2-2.7GHz Vert
13917-2 Rad 1 2.7-5.15GHz Horiz
13917-2 Rad 1 2.7-5.15GHz Vert
13917-2 Rad 1 5.15-6GHz Horiz
13917-2 Rad 1 5.15-6GHz Vert
13917-2 Rad 1 6upto7.77GHz Horiz
13917-2 Rad 1 6upto7.77GHz Vert
13917-2 Rad 1 7.77upto10GHz Horiz
13917-2 Rad 1 7.77upto10GHz Vert
13917-2 Rad 1 10upto12_5GHz Horiz
13917-2 Rad 1 10upto12_5GHz Vert
13917-2 Rad 1 12.5 - 15 GHz Horiz
13917-2 Rad 1 12.5 - 15 GHz Vert
13917-2 Rad 1 15 - 18 GHz Horiz
13917-2 Rad 1 15 - 18 GHz Vert
13917-2 Rad 1 18 - 22 GHz Horiz
13917-2 Rad 1 18 - 22 GHz Vert
13917-2 Rad 1 22 - 26 GHz Horiz
13917-2 Rad 1 22 - 26 GHz Vert
13917-2 Rad 1 26 - 26.5 GHz Horiz
13917-2 Rad 1 26 - 26.5 GHz Vert
13917-2 Rad 1 26.5 - 30 GHz Horiz
13917-2 Rad 1 26.5 - 30 GHz Vert
13917-2 Rad 1 30 - 34 GHz Horiz
13917-2 Rad 1 30 - 34 GHz Vert
13917-2 Rad 1 34 - 38 GHz Horiz
13917-2 Rad 1 34 - 38 GHz Vert
13917-2 Rad 1 38 - 40 GHz Horiz
13917-2 Rad 1 38 - 40 GHz Vert

Setup Table

Band	2400-2483.5 MHz
Power Level	10
Channel Spacing	5 MHz
Mod Scheme	Zigbee
High channel	2480 MHz

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 emissions within 20 dB of the limit were observed						

Note: Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Middle channel plots are shown in this report.

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

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.247(d) other emissions, outside the intentional band, must be attenuated by at least 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 – 18 GHz ±3.5dB, 18 – 26.5 GHz ±3.9dB, 26.5 – 40 GHz ±3.9dB

5.6 Effective radiated power field strength

5.6.1 Test methods

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

5.6.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was rotated in all three orthogonal planes to maximise emissions. Final measurements were taken at 3m. The EUT was operated in TX LOW, TX MID and TX HIGH modes.

5.6.3 Test procedure

Tests were made in accordance with the Test Method noted above using the measuring equipment listed in the 'Test Equipment used' section. The power stated is Peak field strength with EUT in a maximised position. Tests were performed in test site B.

5.6.4 Test equipment

E428, E624, E904, E927, F128

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low channel	Mid channel	High channel
Peak Level (dBµV/m)	99.2	98.8	95.5
Plot reference	13917-2 Radiated Power Low Channel	13917-2 Radiated Power Mid Channel	13917-2 Radiated Power High Channel
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Side	Side	Side

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

LIMITS:
The maximum output power in all cases is 30dBm / 1watt, where 30 dBm = 125.2 dBµV/m@3 m.

These results show that the EUT has PASSED this test.

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

5.7 Band Edge Compliance

5.7.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.215 & 15.247(d) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 11.12 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.209(a) & 15.247(d) [Reference 4.1.1 of this report]

5.7.2 Configuration of EUT

The EUT was placed on a 1.5 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres.

The EUT was operated in TX LOW, TX MID and TX HIGH modes.

5.7.3 Test procedure

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

Tests were performed using Test Site A.

5.7.4 Test equipment

E428, E624, E904, E927, F128

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

Restricted Band Edges	Low channel	High channel
Restricted Peak Level measured (dBuV/m)	59.58	67.77
Restricted band edge Peak Plot	13917-2 Restricted Band Edge, Low Channel, Peak Detector	13917-2 Restricted Band Edge, High Channel, Peak Detector
Restricted Average Level measured (dBuV/m)	37.94	50.99
Restricted band edge Average Plot	13917-2 Restricted Band Edge, Average Detector, Low Channel, Trace Average	13917-2 Restricted Band Edge, Average Detector, High Channel, Trace Average

Authorised Band Edges	Low channel	High channel
Authorised Band Edge (dBc) value measured	-48.98	-47.59
Authorised Band Edge Plot	13917-2 Authorised Band, Low Channel, Peak Detector	13917-2 Authorised Band, High Channel, Peak Detector

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. These show the 20/30dBc requirement of 15.247(d) are met at the band edges of 2400 and 2483.5 MHz. Restricted band edge plots are also shown in section 6.

The tables list the field strengths observed in the adjacent restricted bands, which are required to meet the tighter 15.209 limits.

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

The restricted band edges closest to the EUT frequency of 2400-2483.5MHz are 2390 & 2483.5MHz.

Further wider span plots have been taken to show the fact that there are no spurious emissions above the restricted limits of 15.209.

These results show that the EUT has PASSED this test.

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

5.8 Occupied bandwidth

5.8.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(a)(2) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 11.8 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(a)(2) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was 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 operated in TX LOW, TX MID and TX HIGH modes.

5.8.3 Test procedure

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

Tests were performed using Test Site B.

5.8.4 Test equipment

E428, E624, E904, E927, F128

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	18°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low channel	Mid channel	High channel
6 dB Bandwidth Result (MHz)	1.58	1.55	1.57
Plot for 6 dB Bandwidth Result (MHz)	13917-2 LOW	13917-2 MID	13917-2 HIGH
99 % Bandwidth Result (MHz)	2.33	2.33	2.33
Frequency Error (kHz)	-7.25	-11.68	-17.53
Operating frequency (MHz)	2405	2440	2480
6 dB FLOW Worst case (MHz)	2404.20275	2439.21332	2479.19747
6 dB FHIGH Worst case (MHz)	2405.78275	2440.76332	2480.76747

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

LIMITS:

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

These results show that the EUT has PASSED this test.

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

5.9 Maximum Average conducted output power

NOT APPLICABLE: Peak conducted power tested instead.

5.10 Maximum Peak conducted output power

5.10.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(b)(3) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 11.9 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(b)(3) [Reference 4.1.1 of this report]

5.10.2 Configuration of EUT

The EUT was measured on a bench using a spectrum analyser connected to the temporary RF port.
The EUT was set to each mode and test signal in turn (see section 2.4) and highest power levels recorded.
The EUT was operated in TX LOW, TX MID and TX HIGH modes for this test.

5.10.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Peak stated reading is maximum power observed using a spectrum analyser RBW > 6dB BW of the EUT.
Measurements were made in site A.

5.10.4 Test equipment

E253, E266, E755, E927

See Section 9 for more details

5.10.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low channel	Mid channel	High channel
Nominal voltage result (dBm)	9.56	9.98	5.33
Plot reference	13917-1 Peak Conducted Power 2405 MHz	13917-1 Peak Conducted Power 2440 MHz	13917-1 Peak Conducted Power 2480 MHz
Limit in dBm	30.00	30.00	30.00
Maximum result (dBm)	9.56	9.98	5.33
Margin to Limit (dB)	-20.44	-20.02	-24.67
Result in (W)	0.009	0.010	0.003

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

These results show that the EUT has PASSED this test.

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

5.11 Maximum Power Spectral Density

5.11.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 11.10 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.247(e) [Reference 4.1.1 of this report]

5.11.2 Configuration of EUT

The EUT was configured as for the peak conducted power test. The EUT was operated in TX LOW, TX MID and TX HIGH modes for this test.

5.11.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. PEP was recorded in the required span and bandwidth. Measurements & plots were taken with the span set to 1.5 times the measured DTS bandwidth for each modulation scheme setting. Tests were performed using Test Site A.

5.11.4 Test equipment

E253, E266, E755, E927

See Section 9 for more details

5.11.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	13 for Low and Mid, 10 for High channel
Channel Spacing	5 MHz
Mod Scheme	Zigbee
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low channel	Mid channel	High channel
Duty Cycle (%)	100	100	100
PSD (dBm/3kHz)	-0.7	-0.07	-4.89
Plot reference	13917-2 Power spectral density - Low channel	13917-2 Power spectral density - Mid channel	13917-2 Power spectral density - High channel

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

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

These results show that the EUT has PASSED this test.

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

<± 2 dB

5.12 Antenna power conducted emissions

NOT APPLICABLE: Applies to EUT's with an antenna port. The EUT has an integral antenna only & the EUT was tested for radiated emissions with its dedicated antenna in position.

5.13 Duty cycle

NOT APPLICABLE: No limits apply. Duty cycle verified as 100% for tests.

5.14 FHSS carrier frequency separation

NOT APPLICABLE: EUT does not employ FHSS technology

5.15 Average time of occupancy

NOT APPLICABLE: EUT does not employ FHSS technology

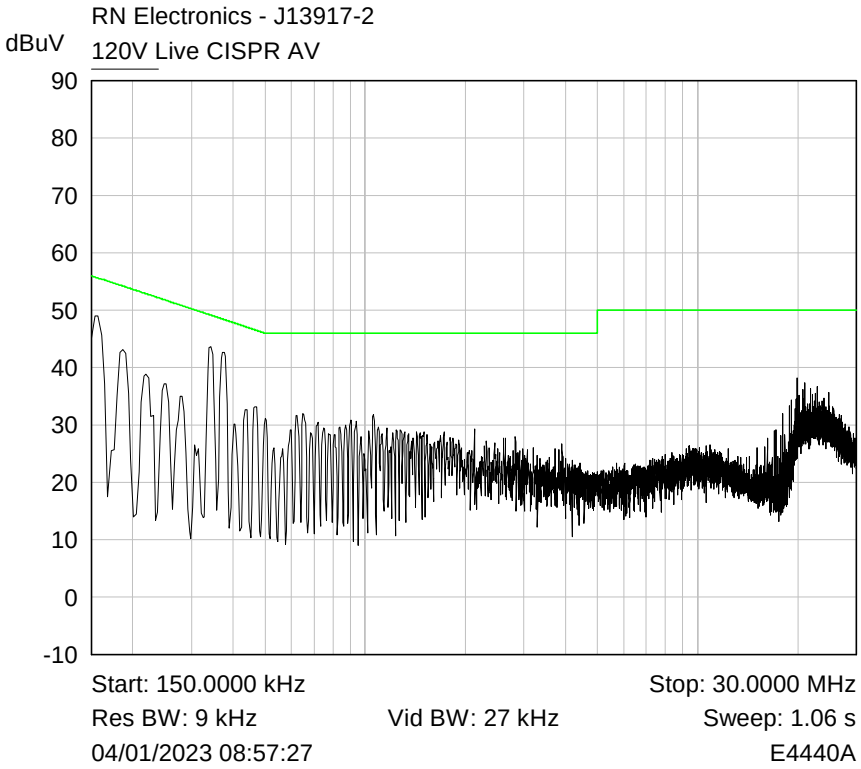
5.16 Number of Hop Channels

NOT APPLICABLE: EUT does not employ FHSS technology

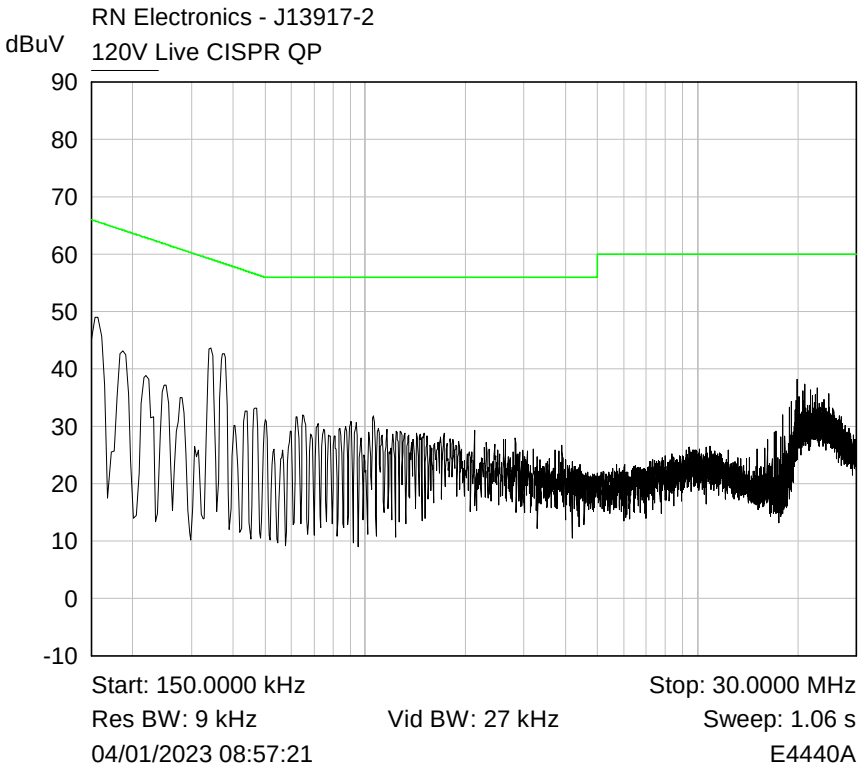
6 Plots/Graphical results

6.1 AC power line conducted emissions

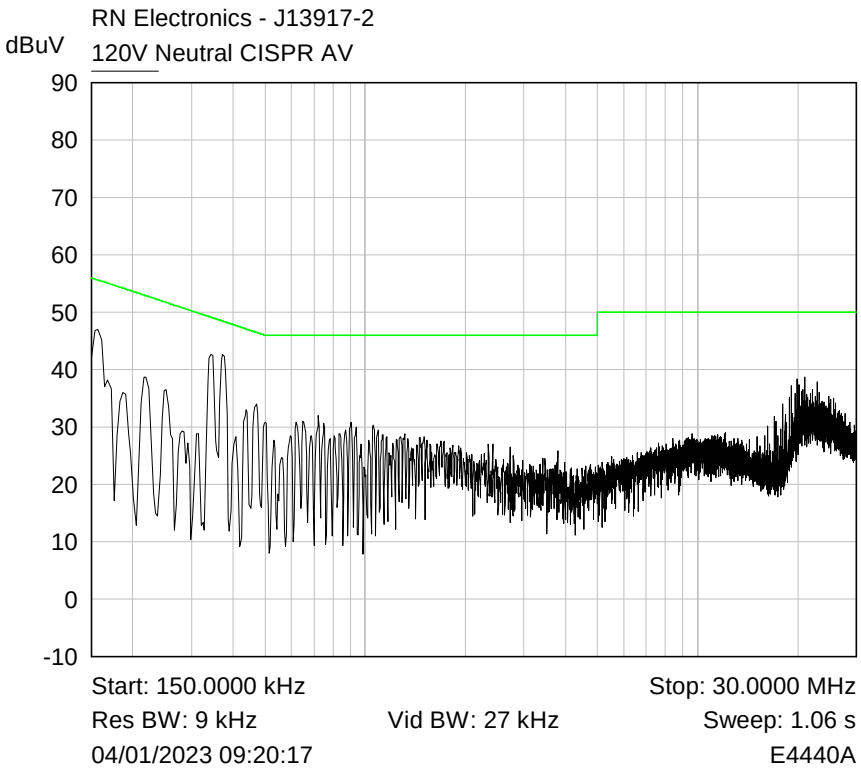
RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



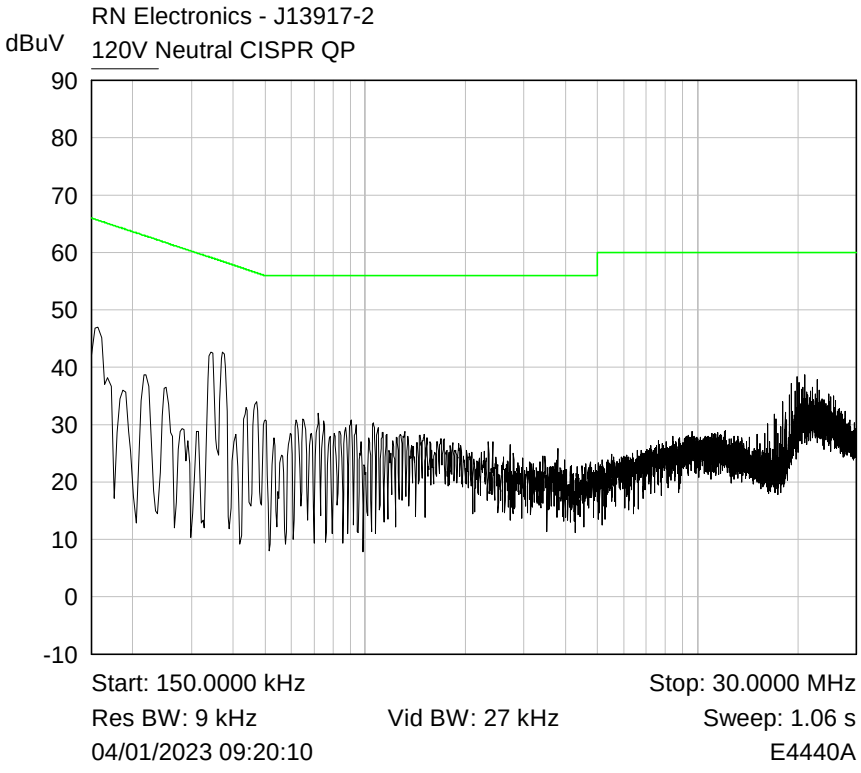
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



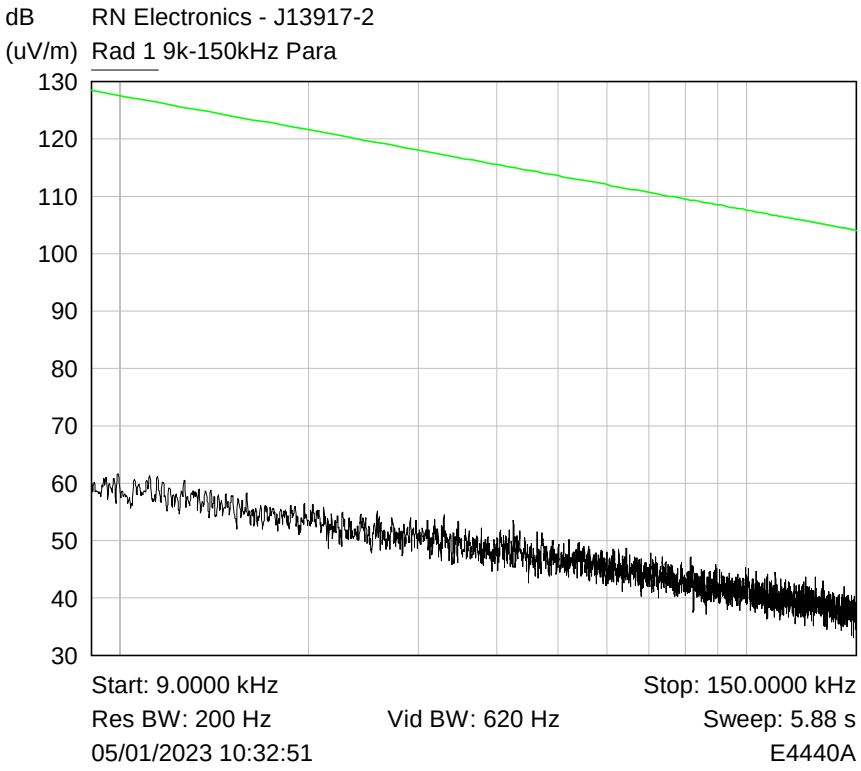
Plot of Neutral150k-30M Average



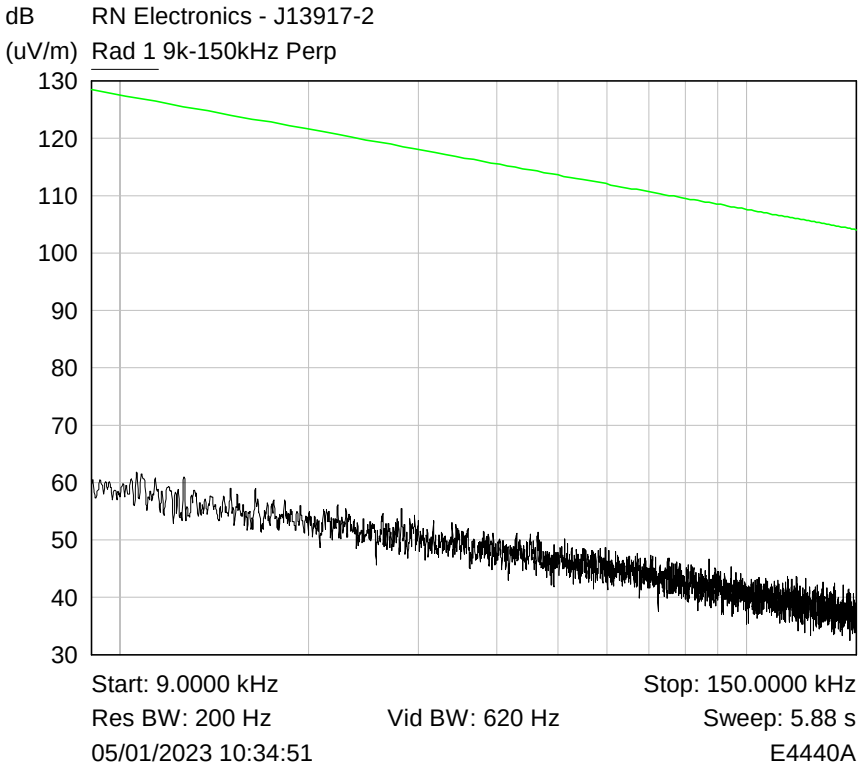
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



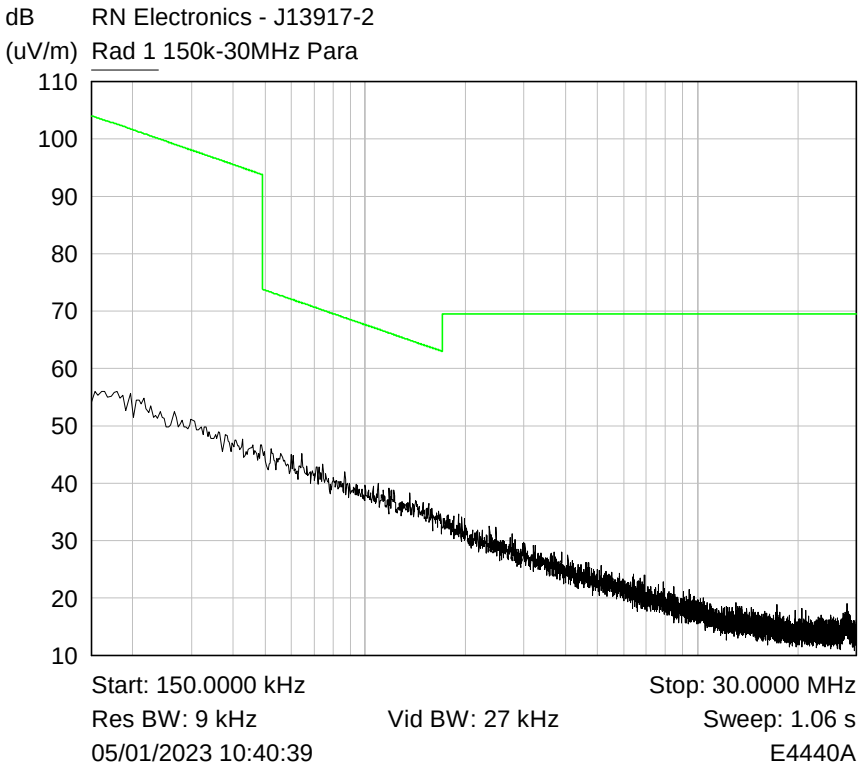
Plot of 9-150kHz Parallel



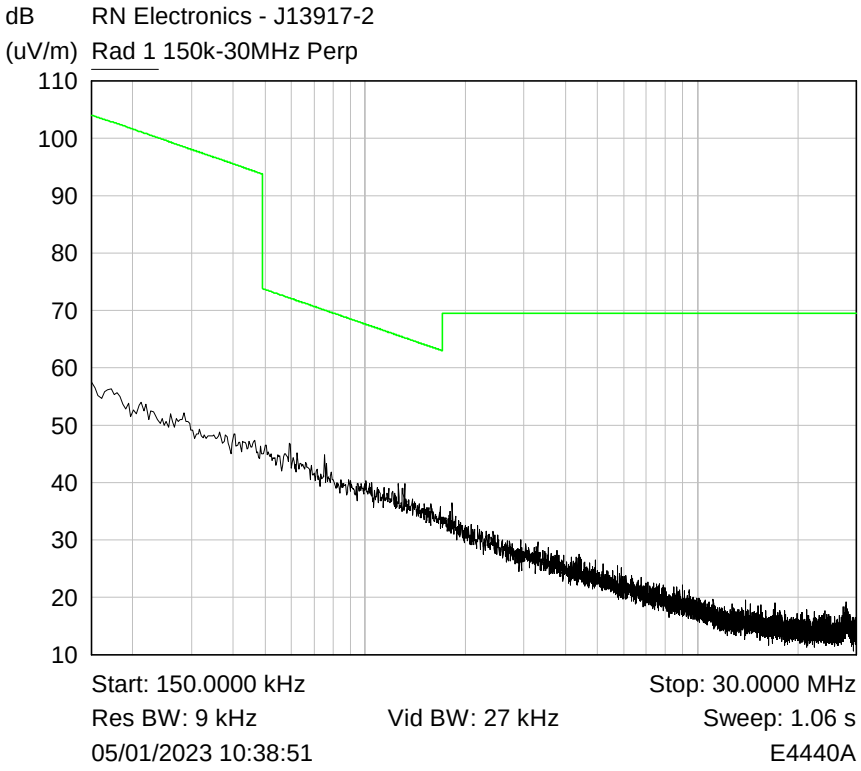
Plot of 9-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



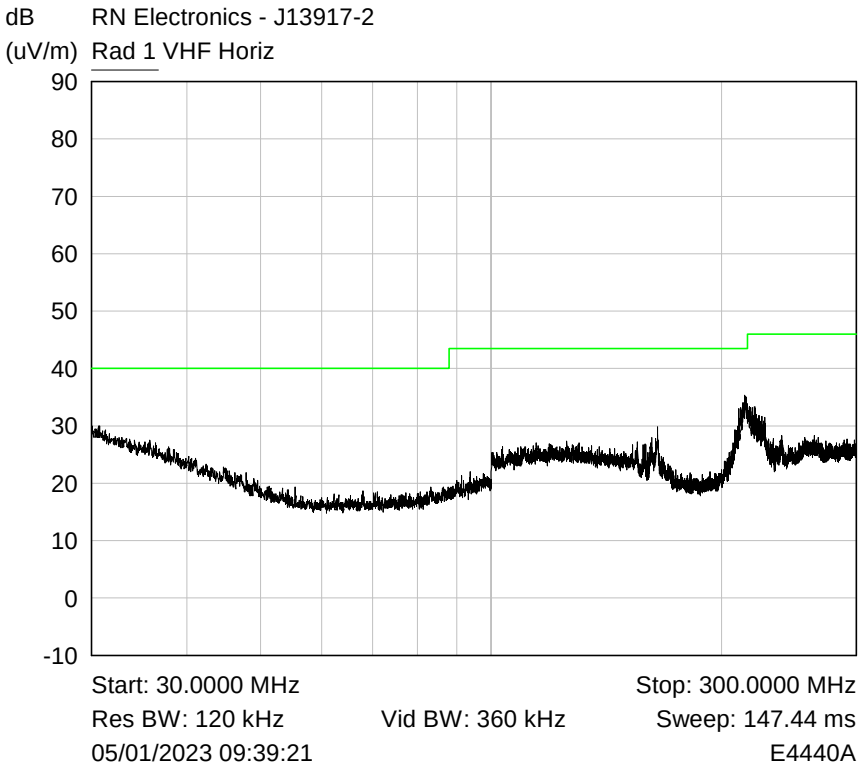
Plot of 150kHz-30MHz Parallel



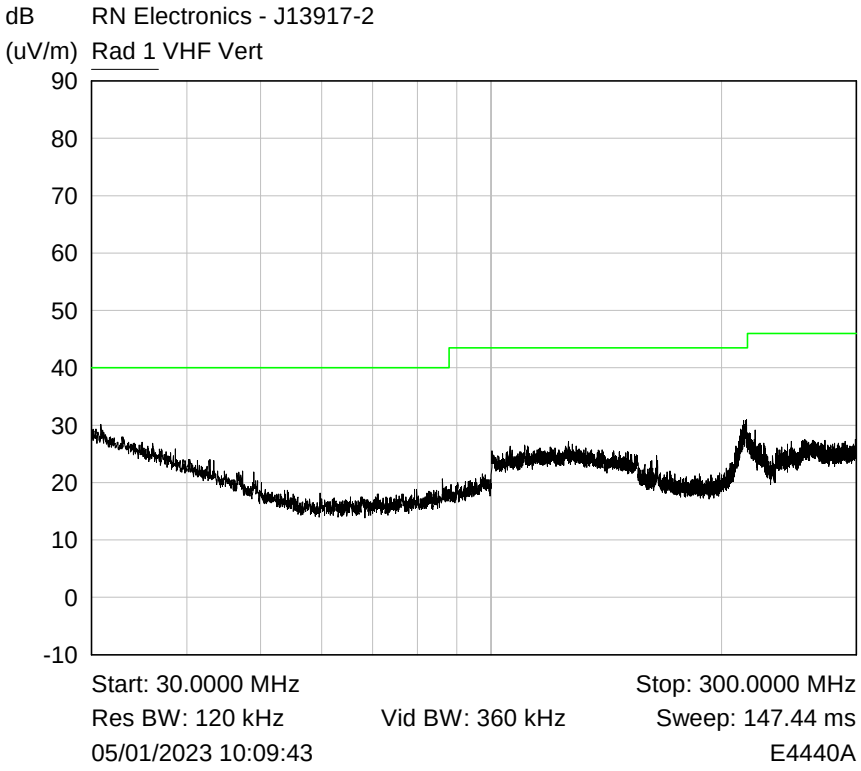
Plot of 150kHz-30MHz Perpendicular

6.4 Radiated emissions 30 MHz -1 GHz

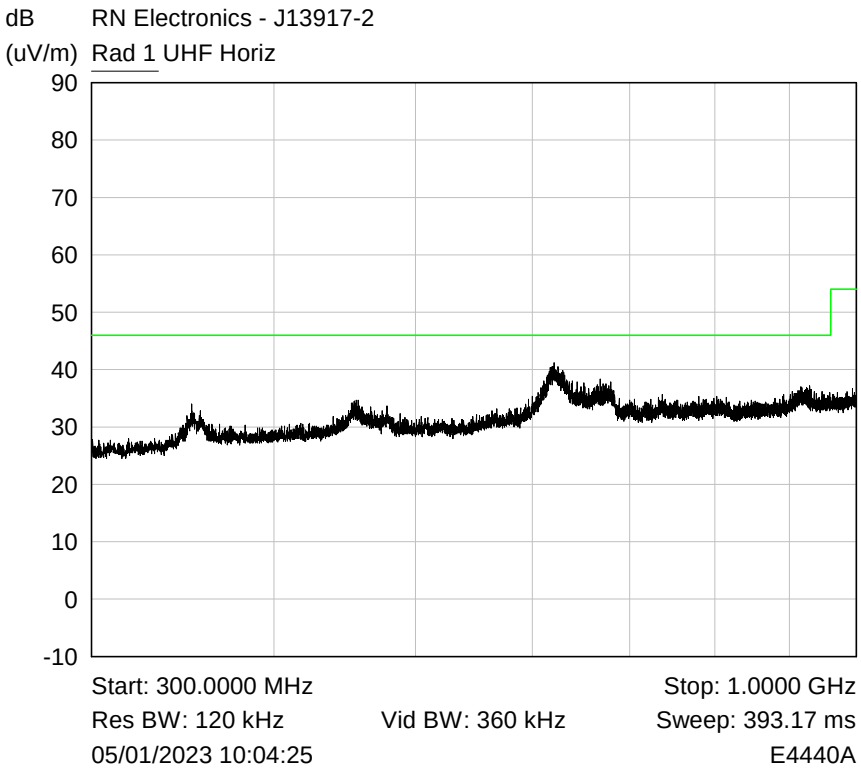
RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



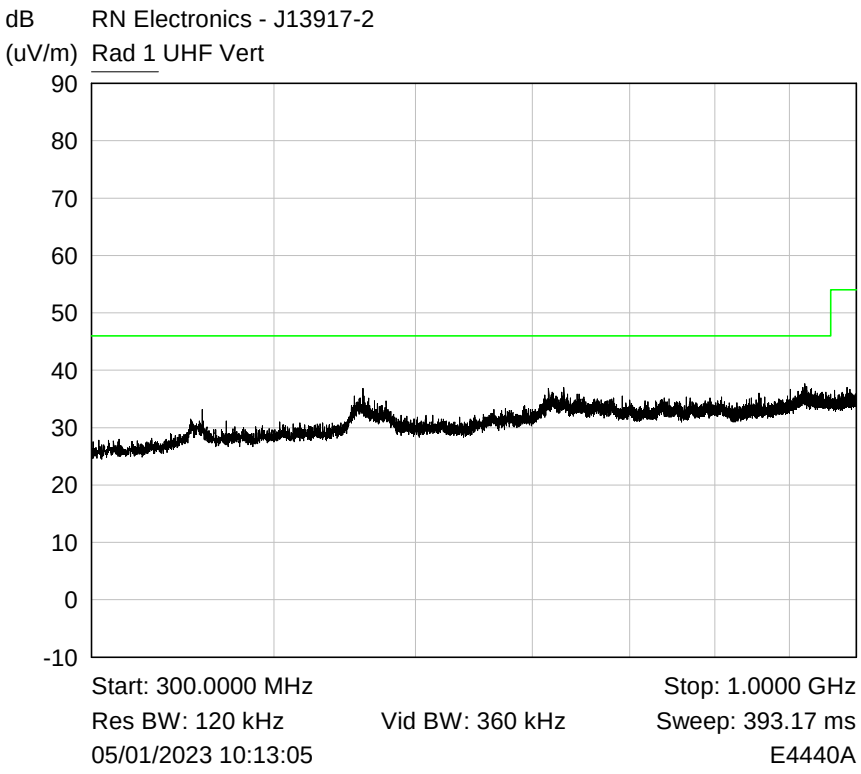
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



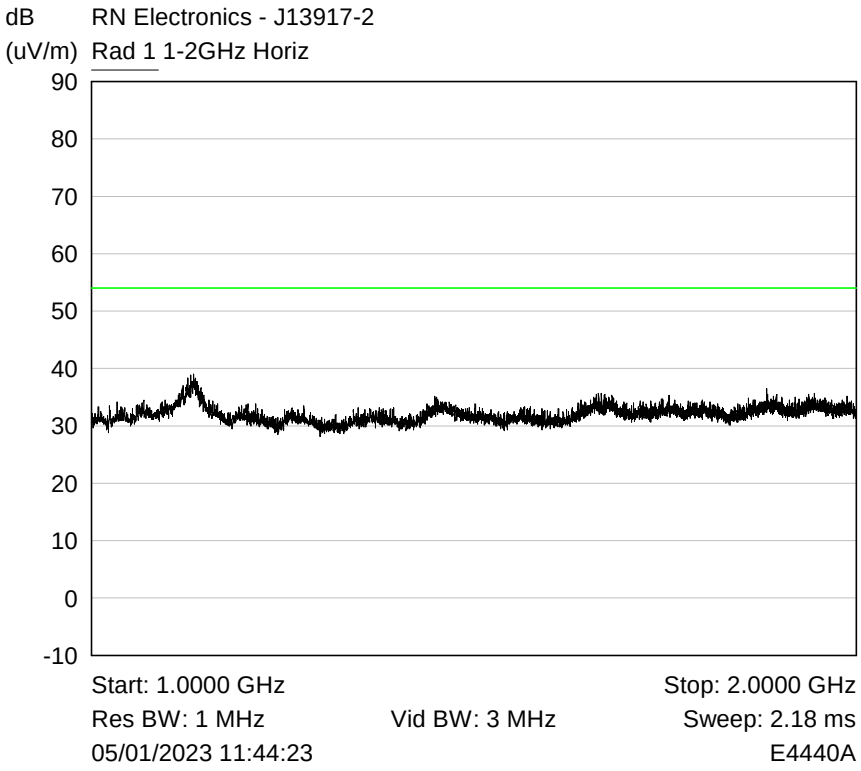
Plot of Peak emissions for UHF Horizontal against the QP limit line.

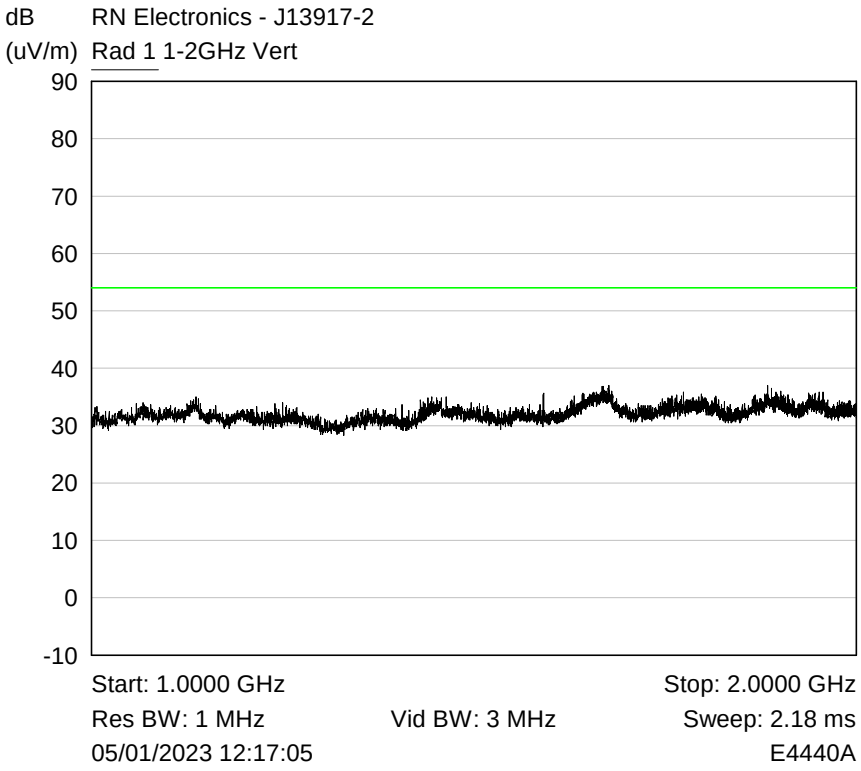


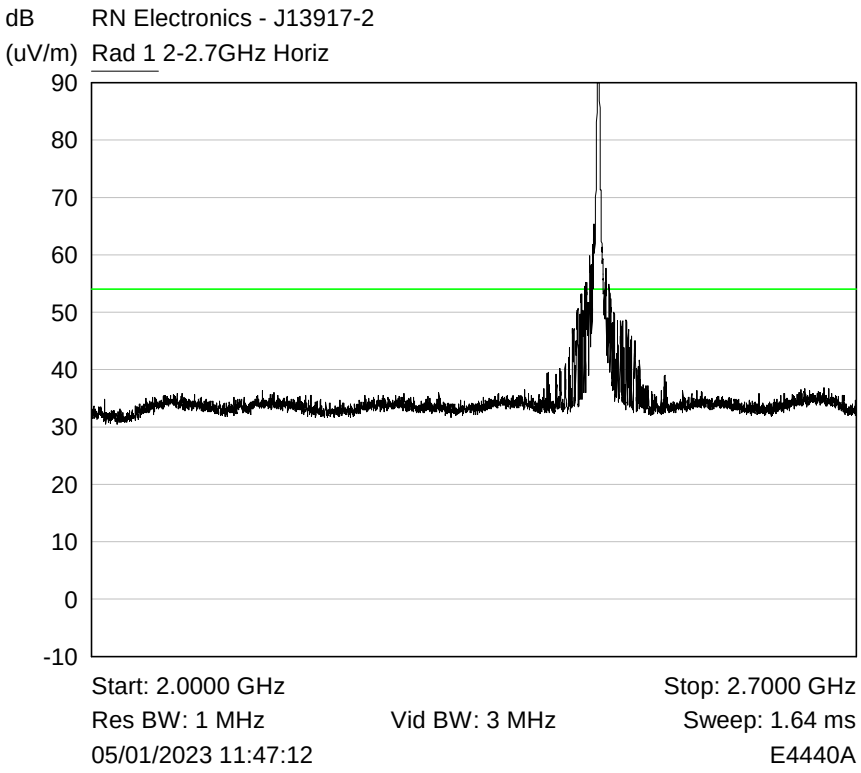
Plot of Peak emissions for UHF Vertical against the QP limit line.

6.5 Radiated emissions above 1 GHz

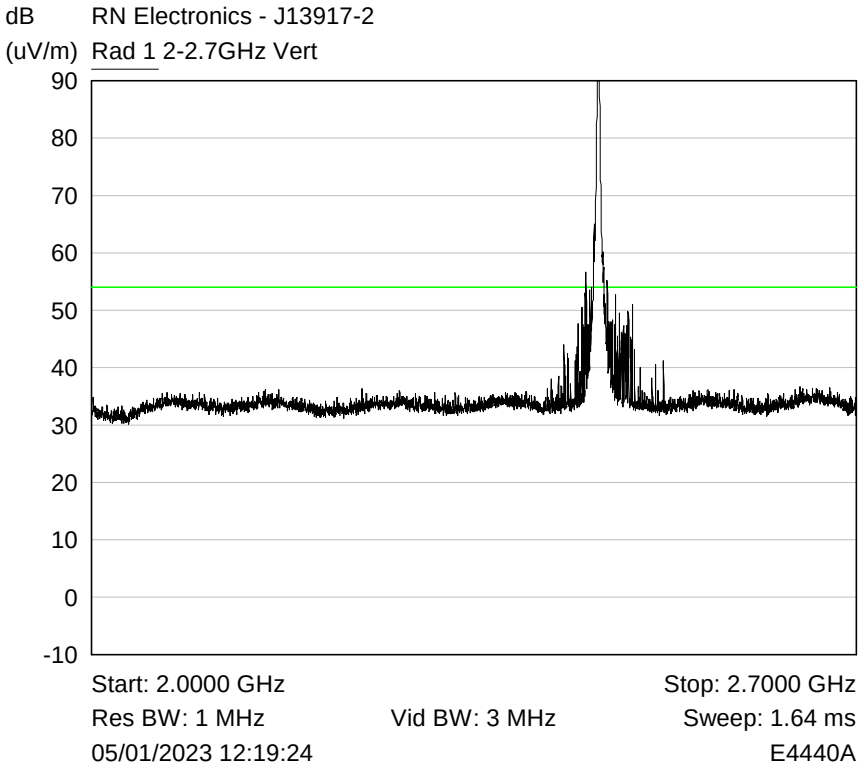
RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



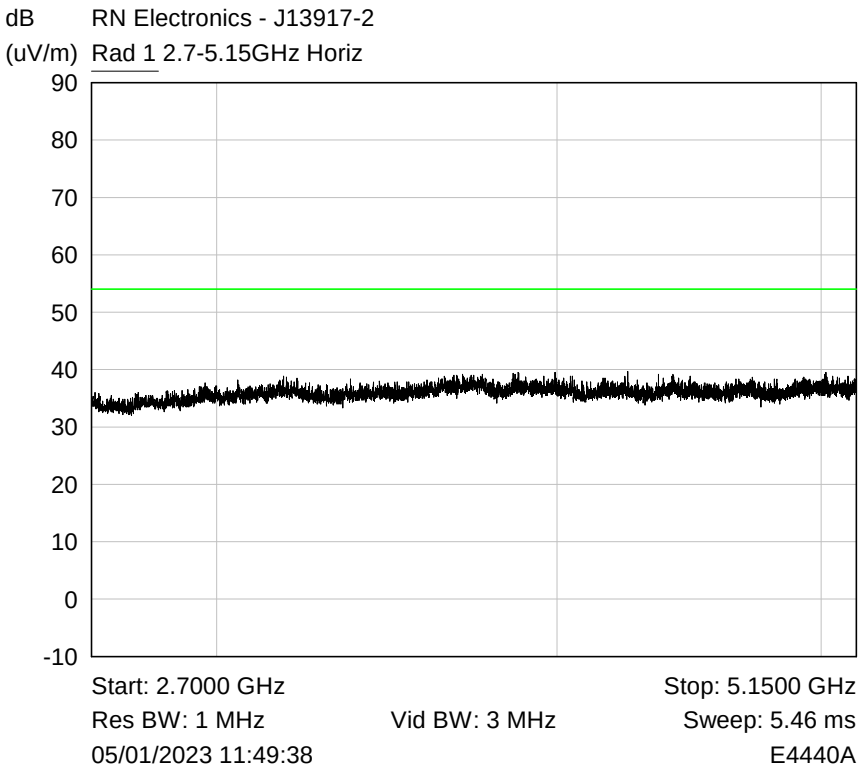


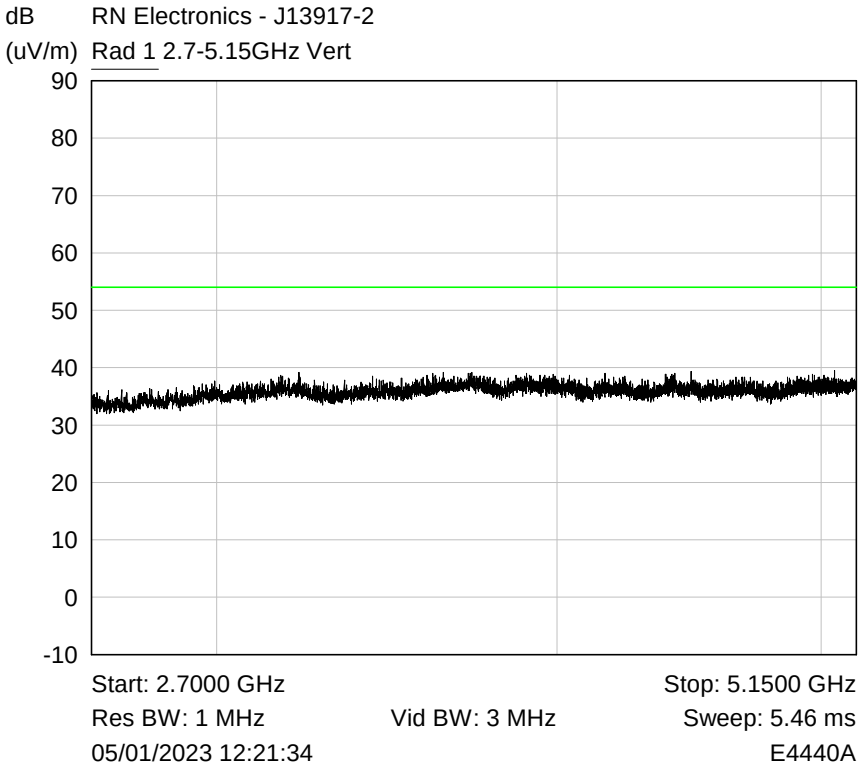


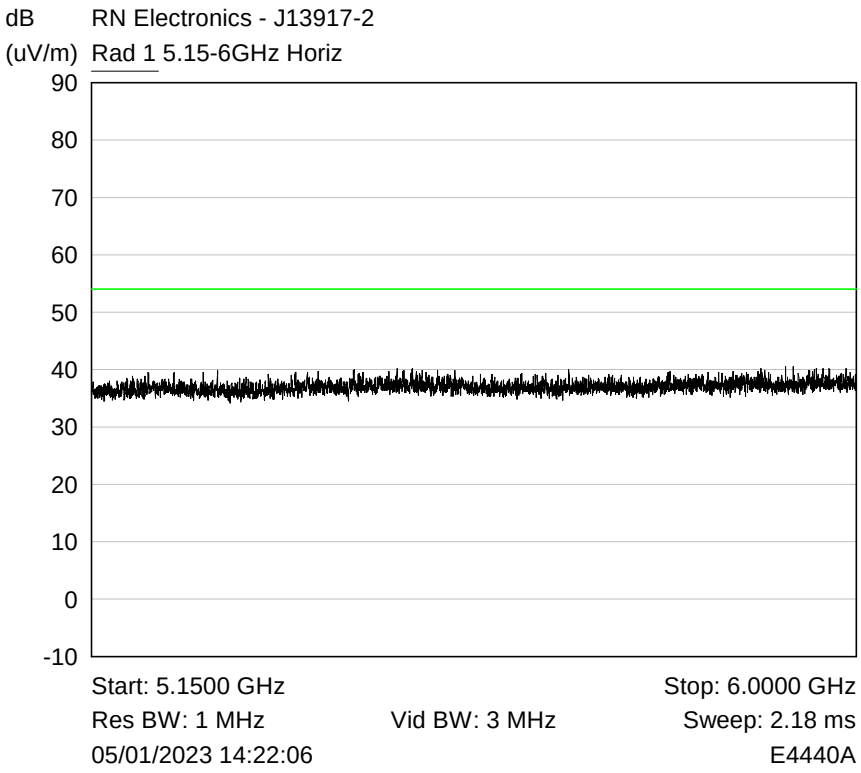
The signal that exceeds the limit line is the fundamental transmit carrier

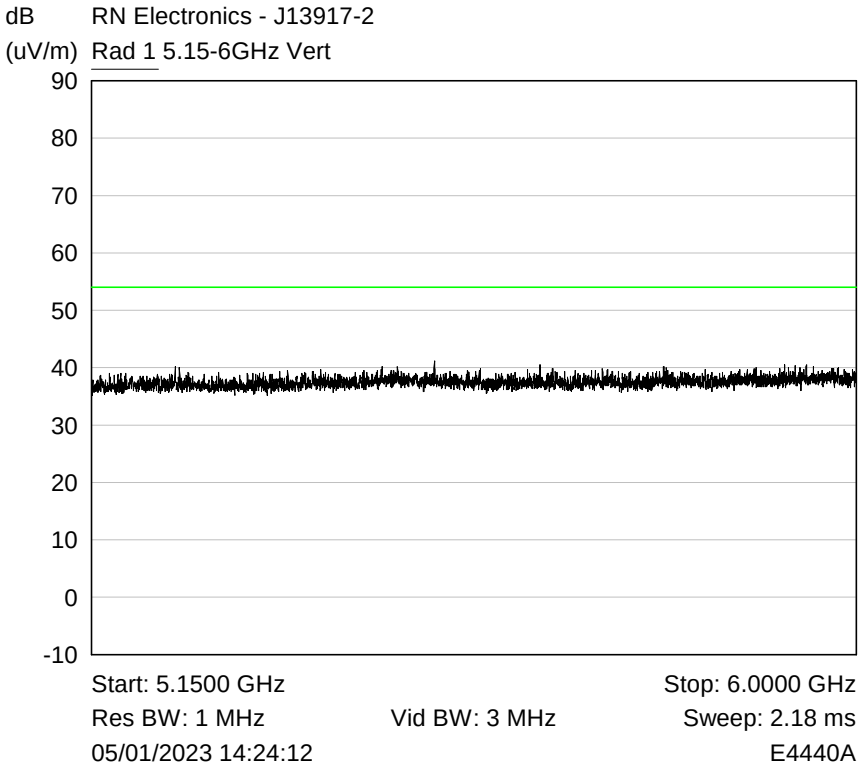


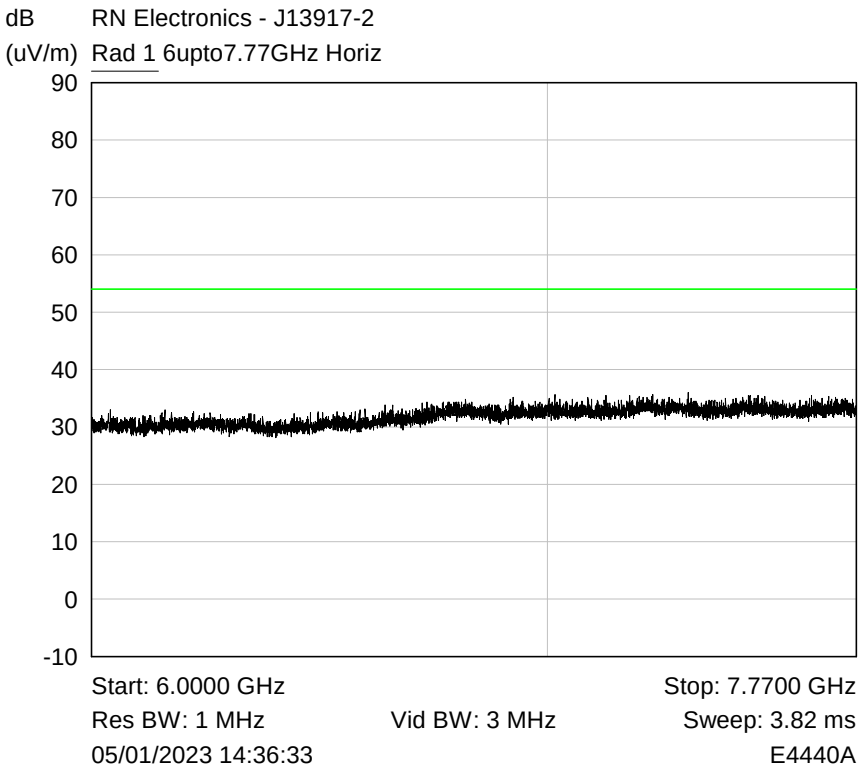
The signal that exceeds the limit line is the fundamental transmit carrier

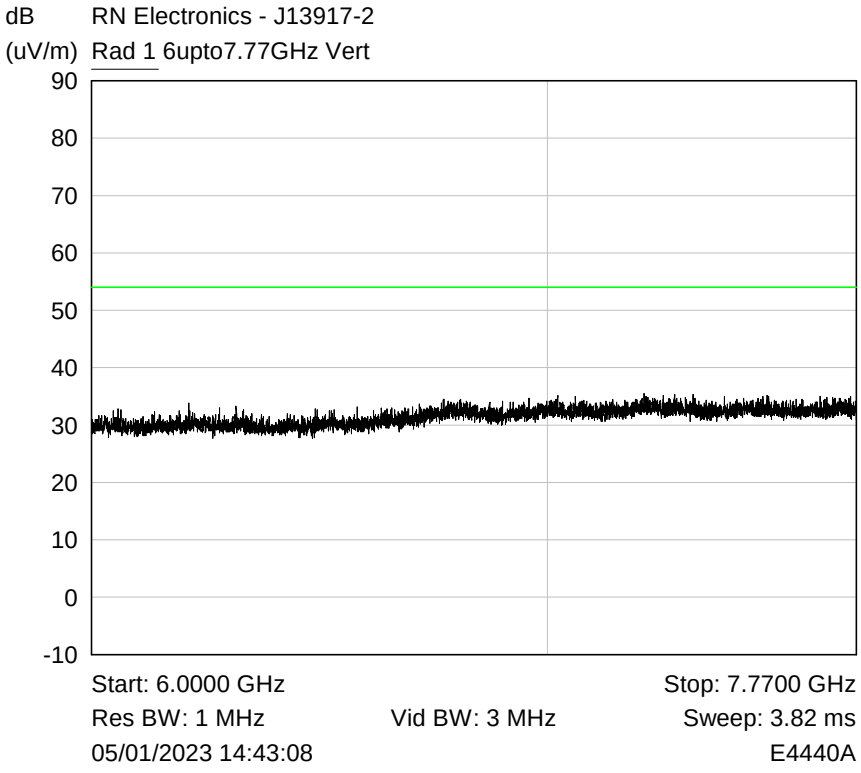

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 2.7-5.15GHz Horiz
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.7000 GHz
Stop: 5.1500 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.46 ms
05/01/2023 11:49:38
E4440A


dB
(uV/m)
RN Electronics - J13917-2
Rad 1 2.7-5.15GHz Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.7000 GHz
Stop: 5.1500 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.46 ms
05/01/2023 12:21:34
E4440A

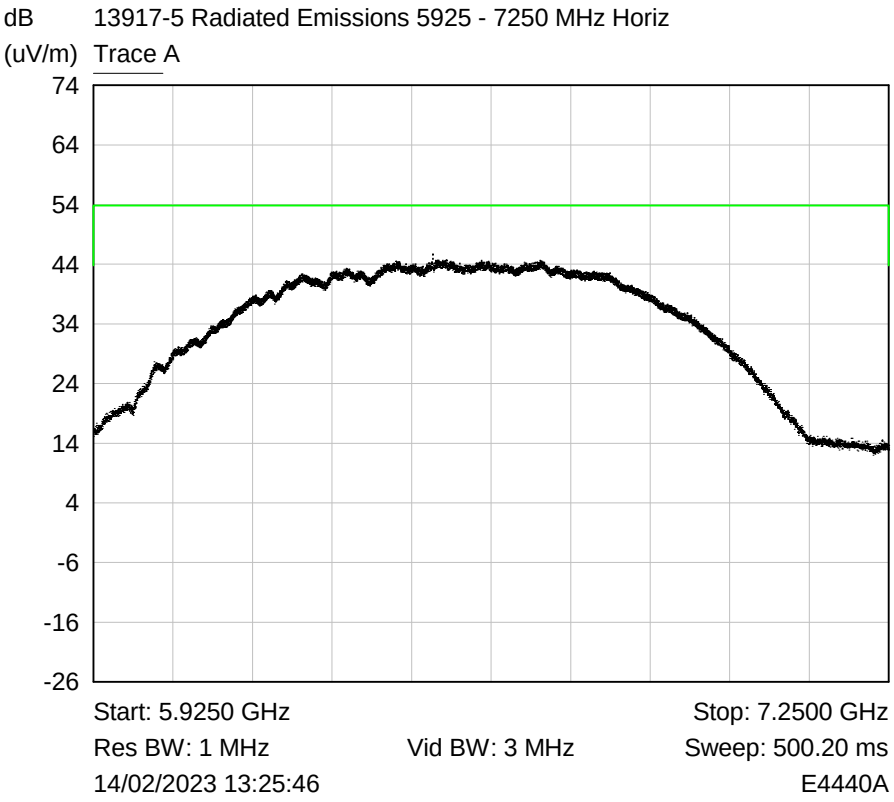

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 5.15-6GHz Horiz
90
80
70
60
50
40
30
20
10
0
-10
Start: 5.1500 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.18 ms
05/01/2023 14:22:06
E4440A

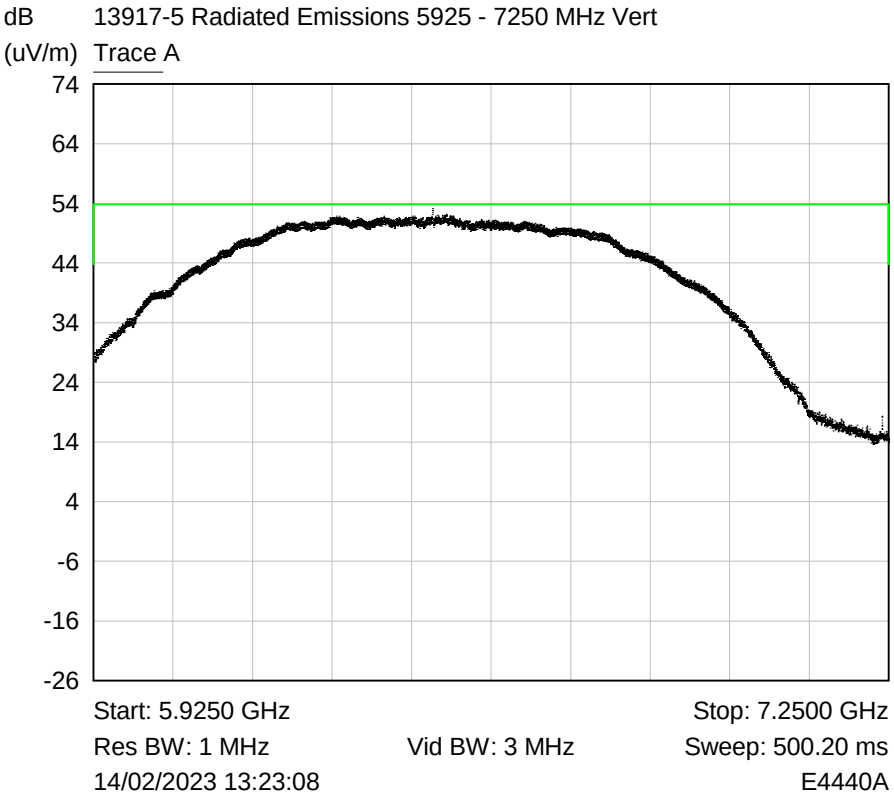

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 5.15-6GHz Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 5.1500 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.18 ms
05/01/2023 14:24:12
E4440A

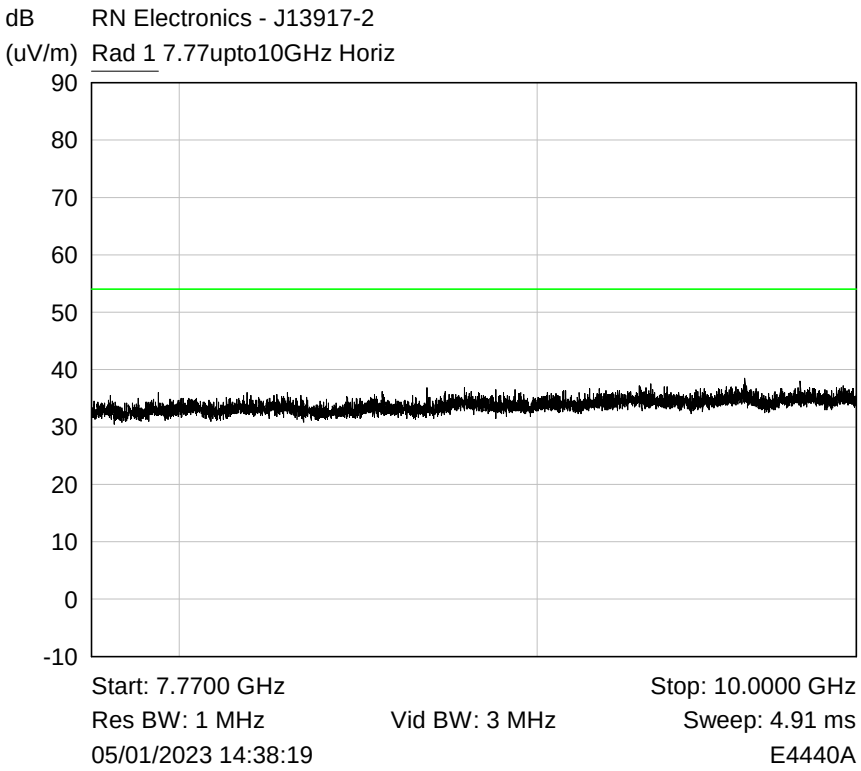

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 6upto7.77GHz Horiz
90
80
70
60
50
40
30
20
10
0
-10
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 3.82 ms
05/01/2023 14:36:33
E4440A

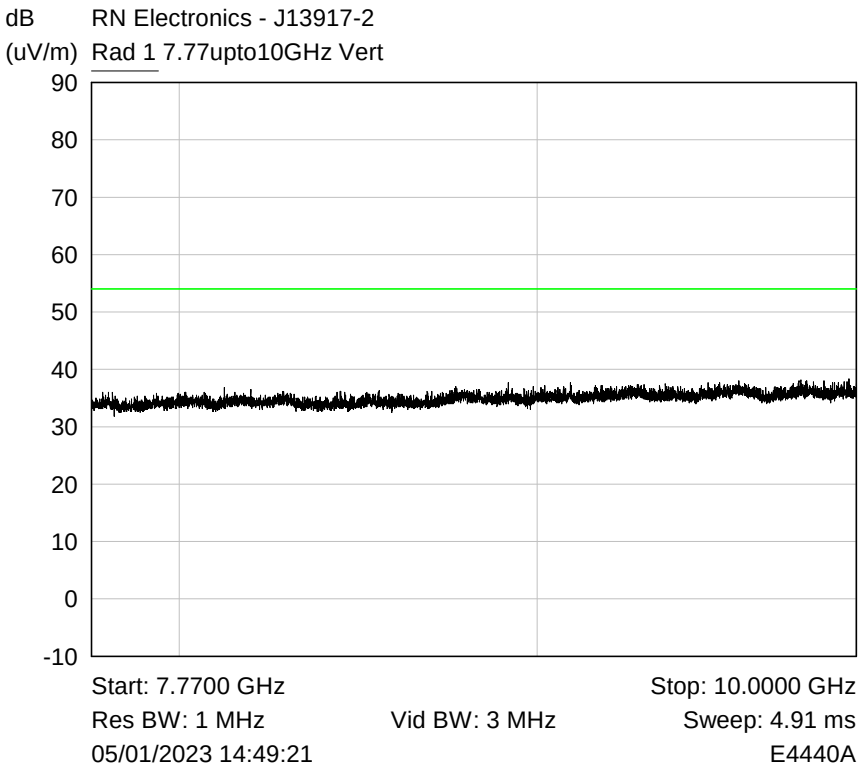

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 6upto7.77GHz Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 3.82 ms
05/01/2023 14:43:08
E4440A

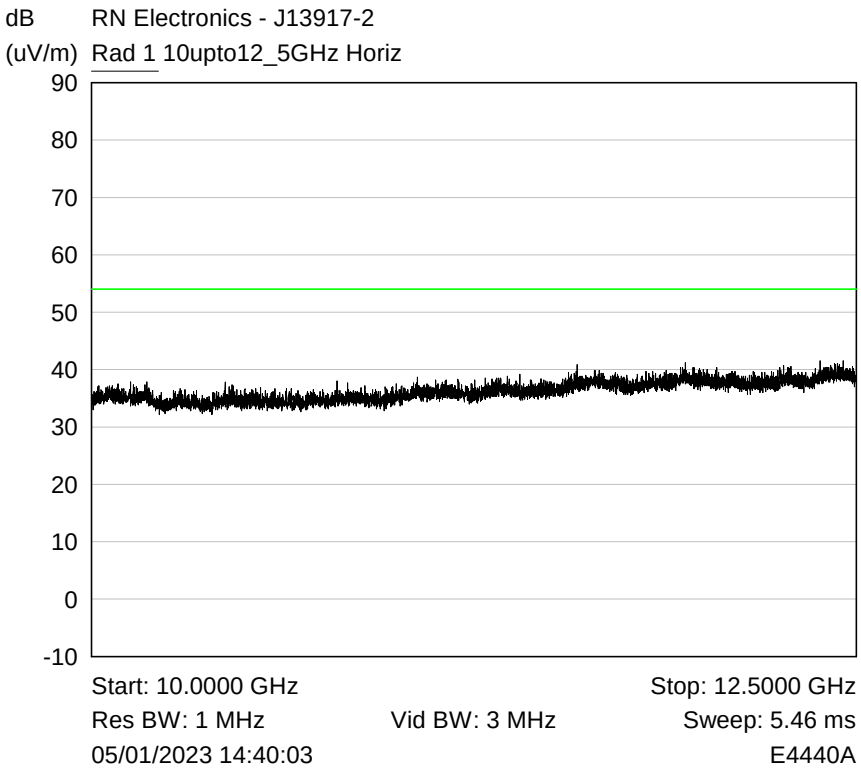
Additional plots showing UWB emission

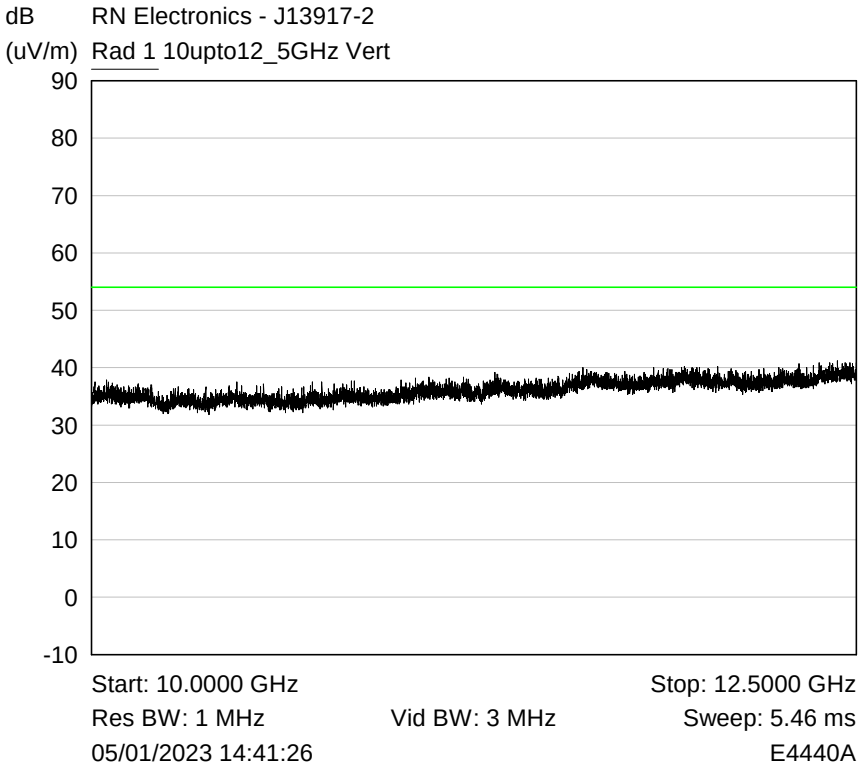


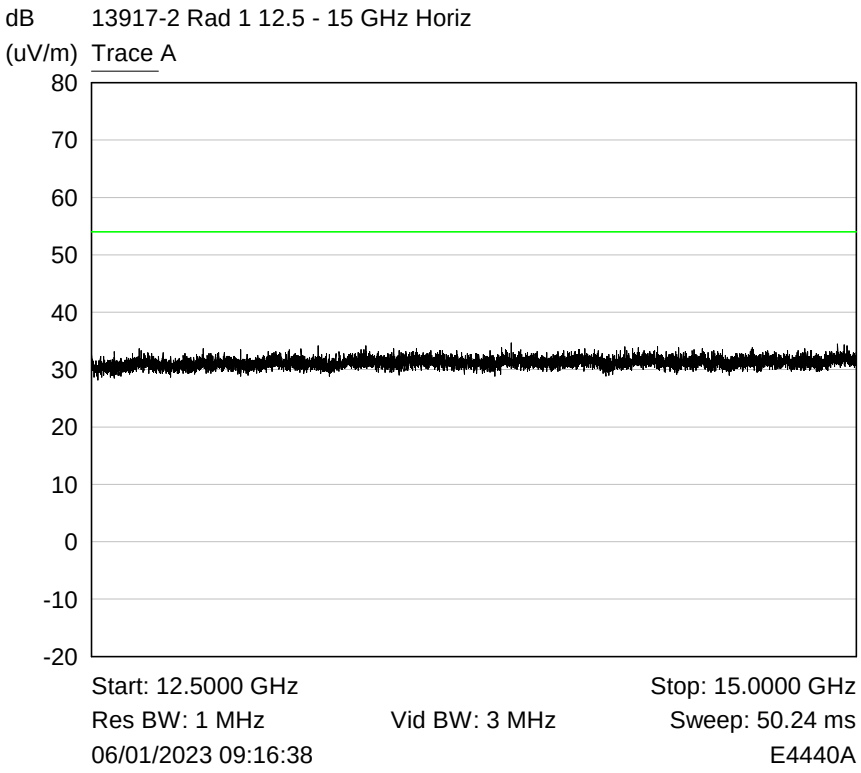


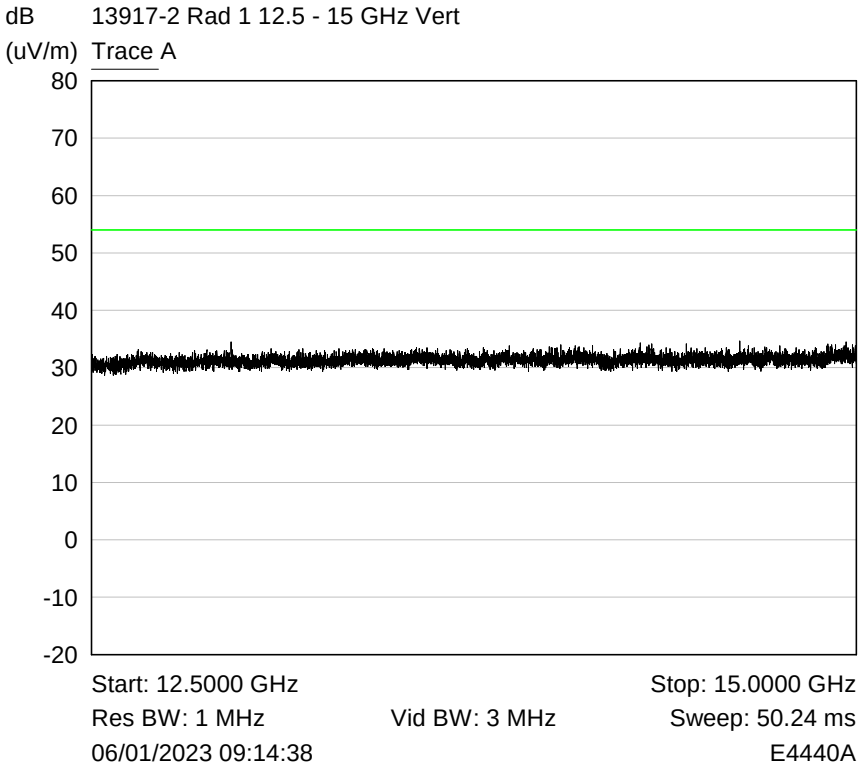

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 7.77upto10GHz Horiz
90
80
70
60
50
40
30
20
10
0
-10
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.91 ms
05/01/2023 14:38:19
E4440A

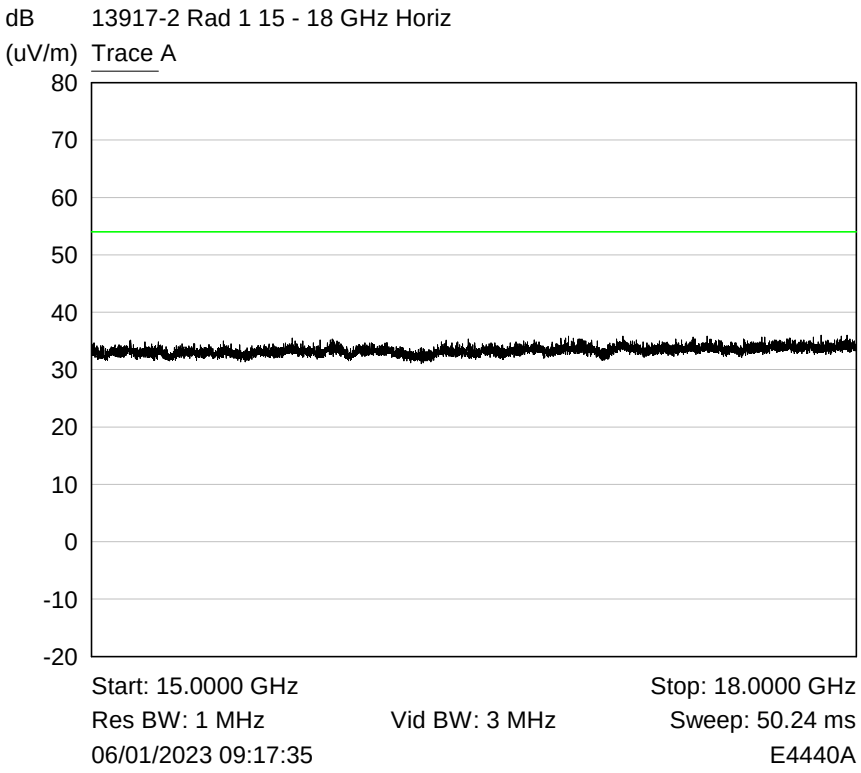

dB
(uV/m)
RN Electronics - J13917-2
Rad 1 7.77upto10GHz Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.91 ms
05/01/2023 14:49:21
E4440A

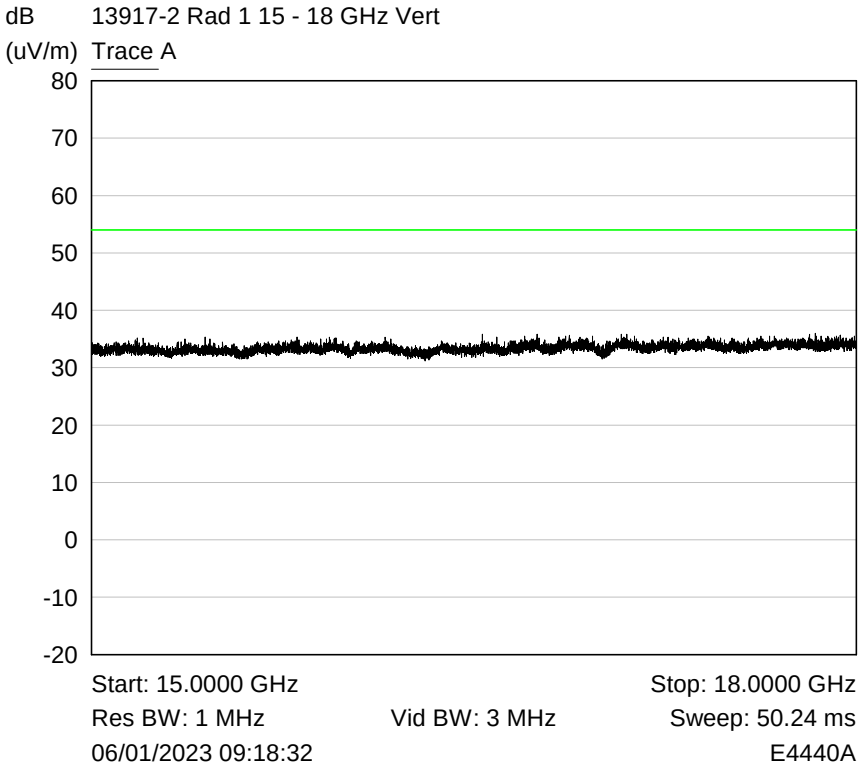


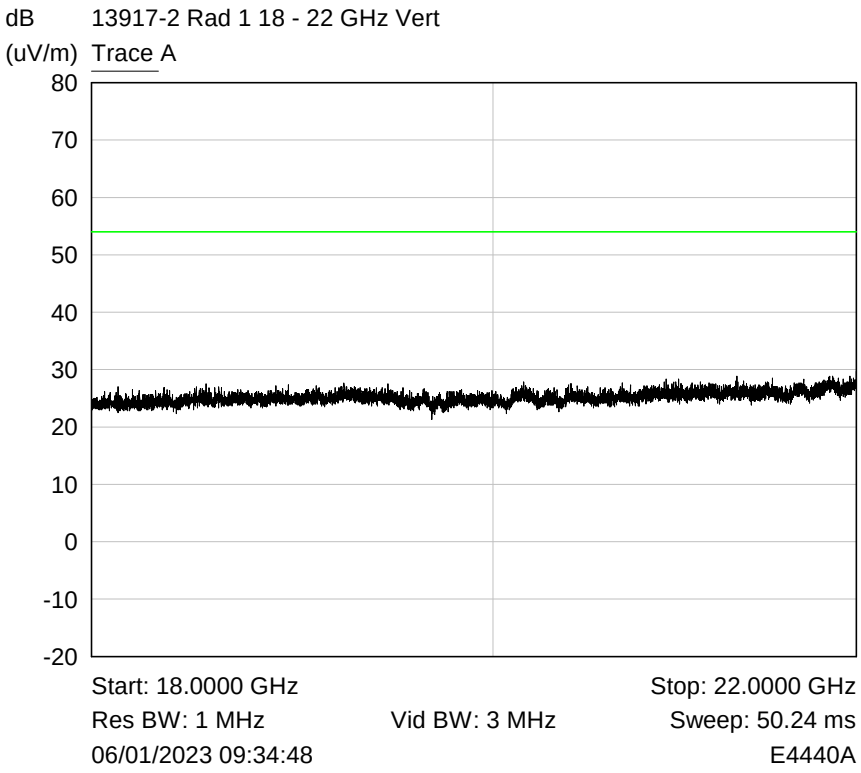


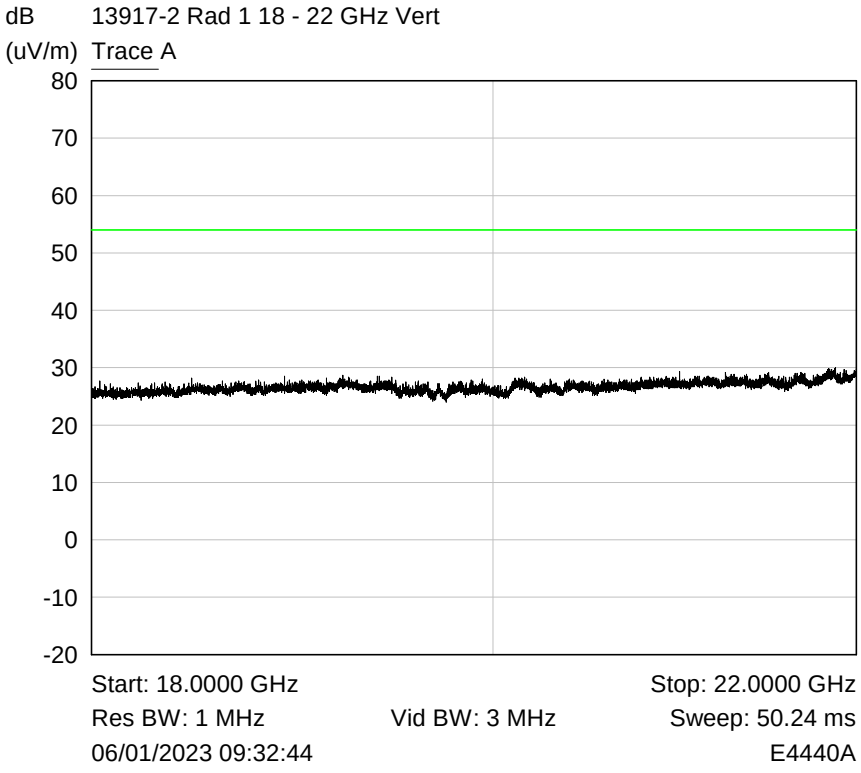


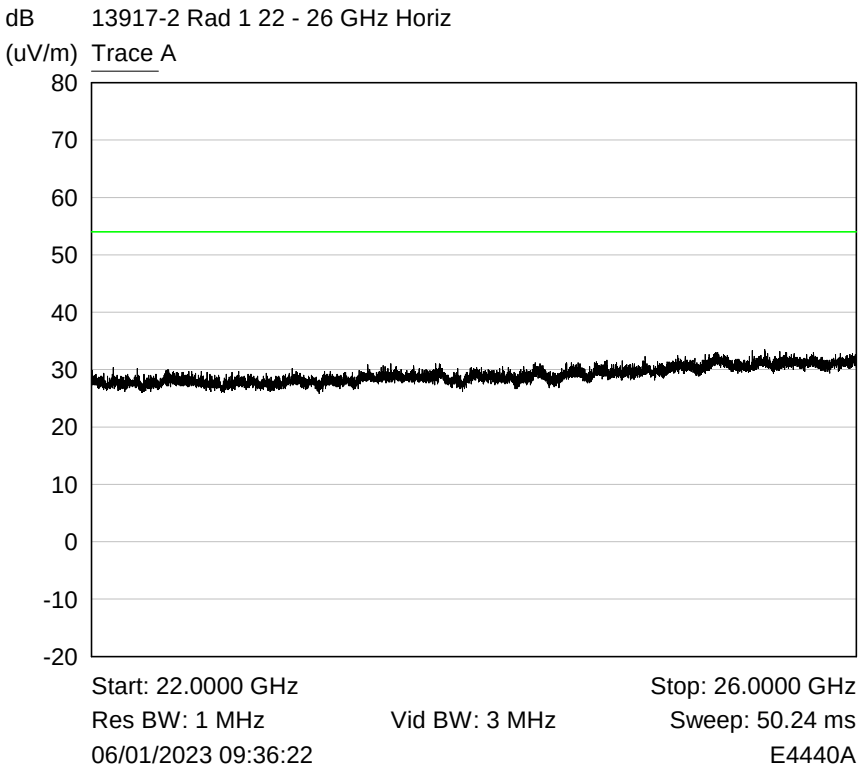


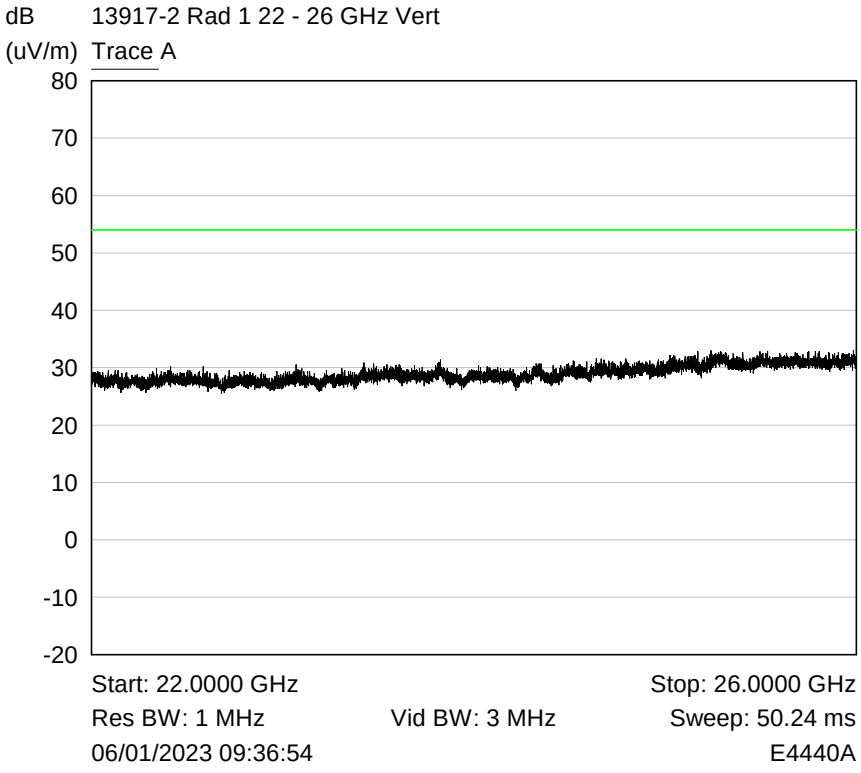


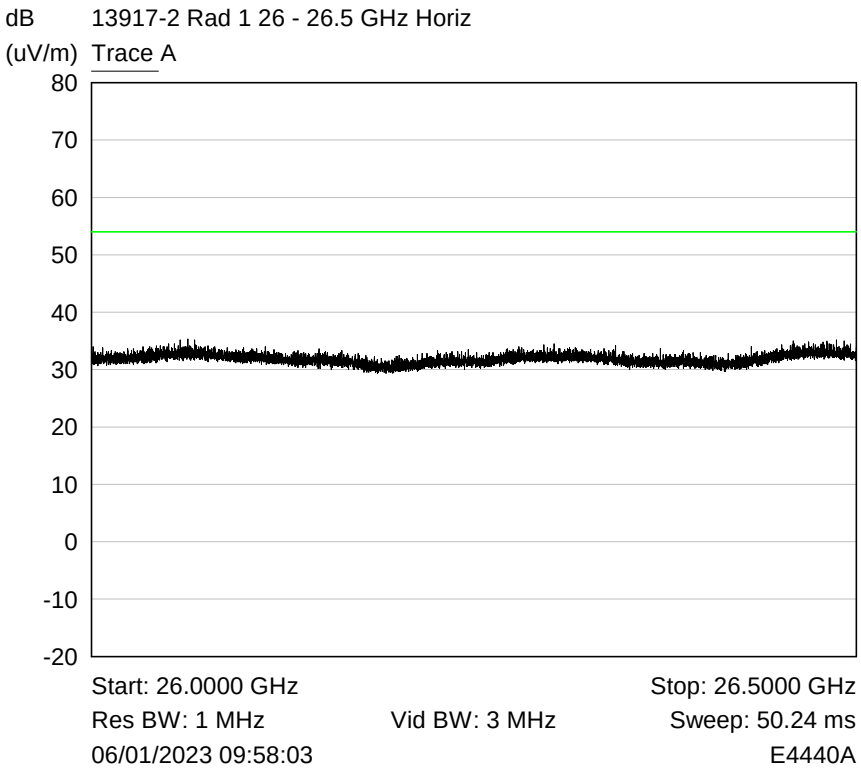


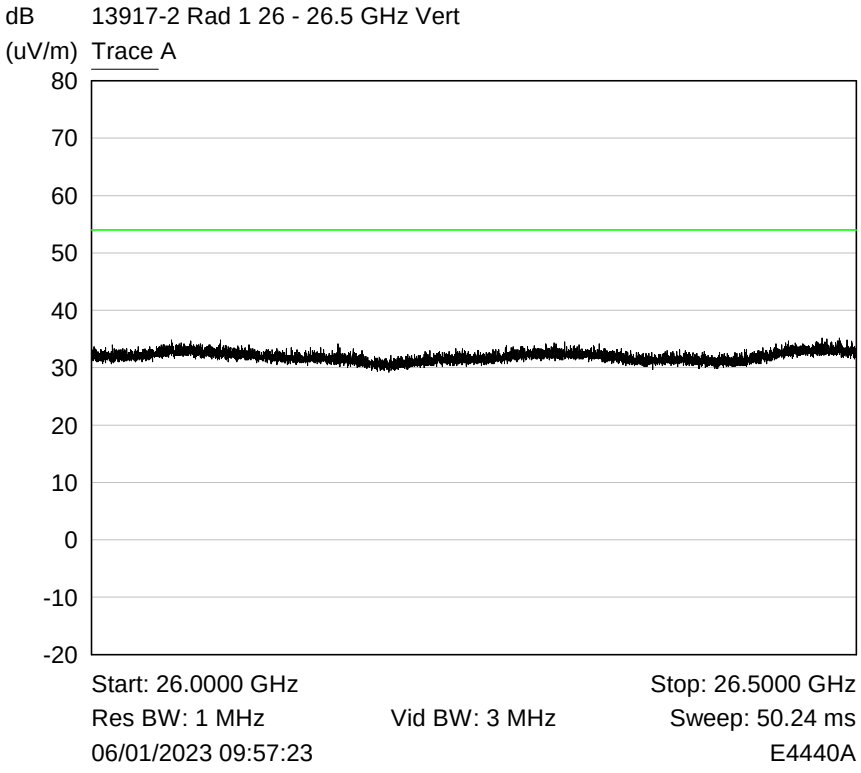


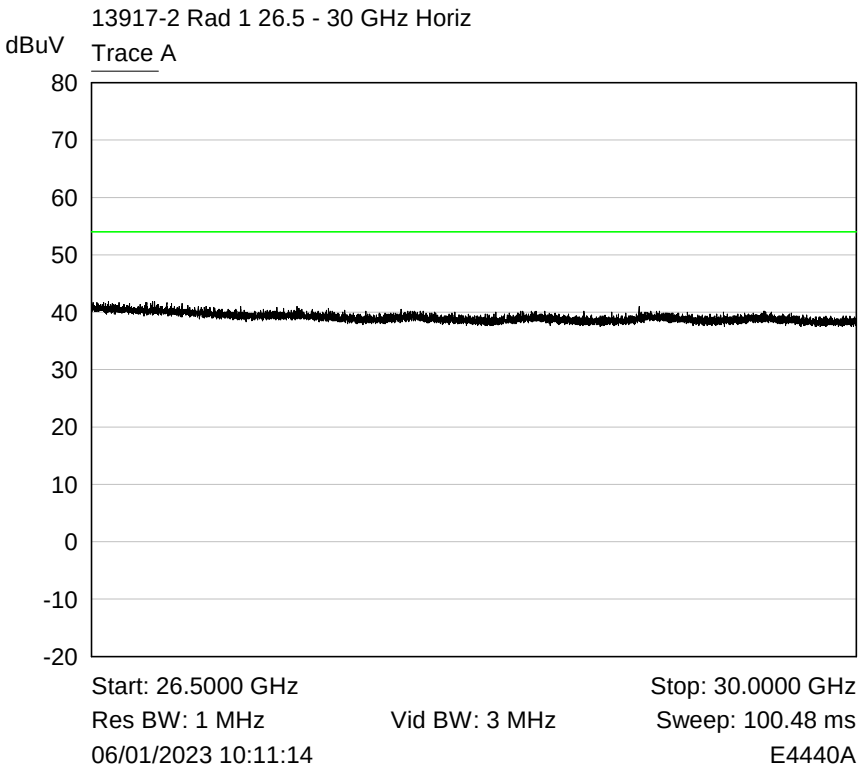


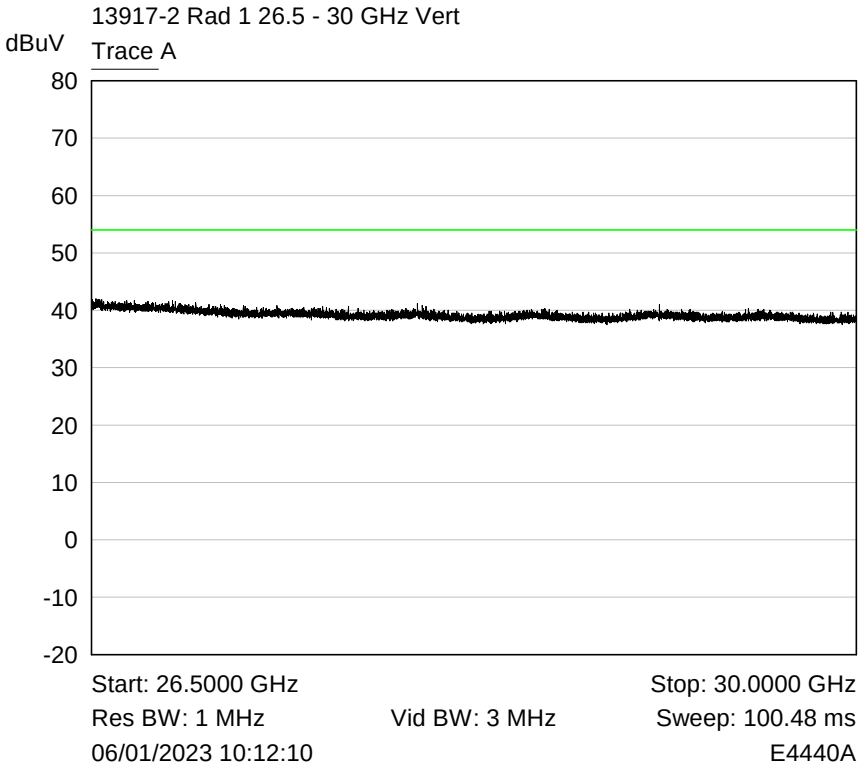


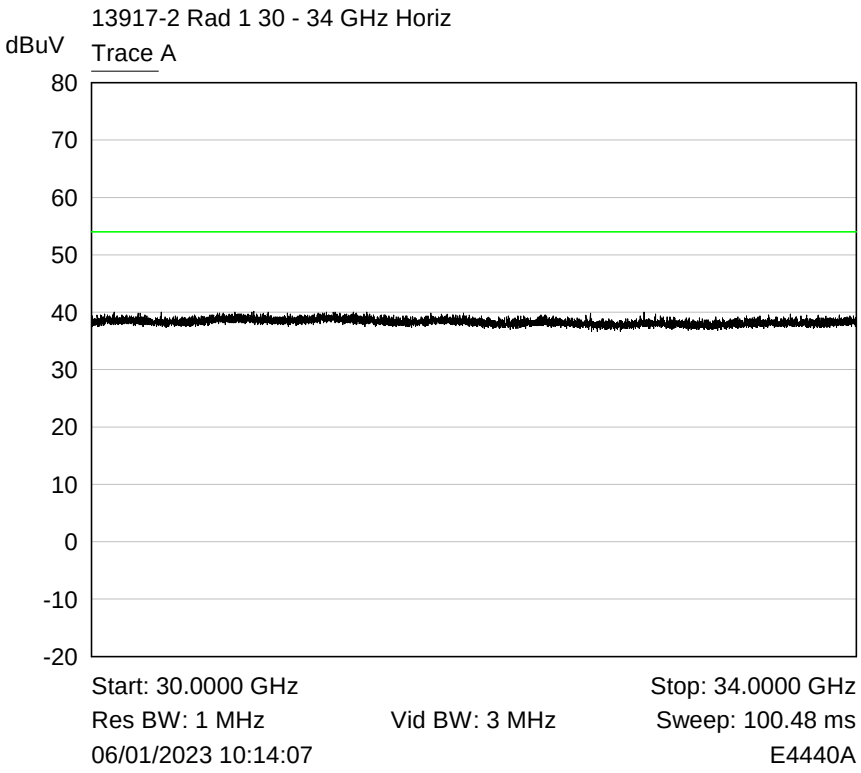


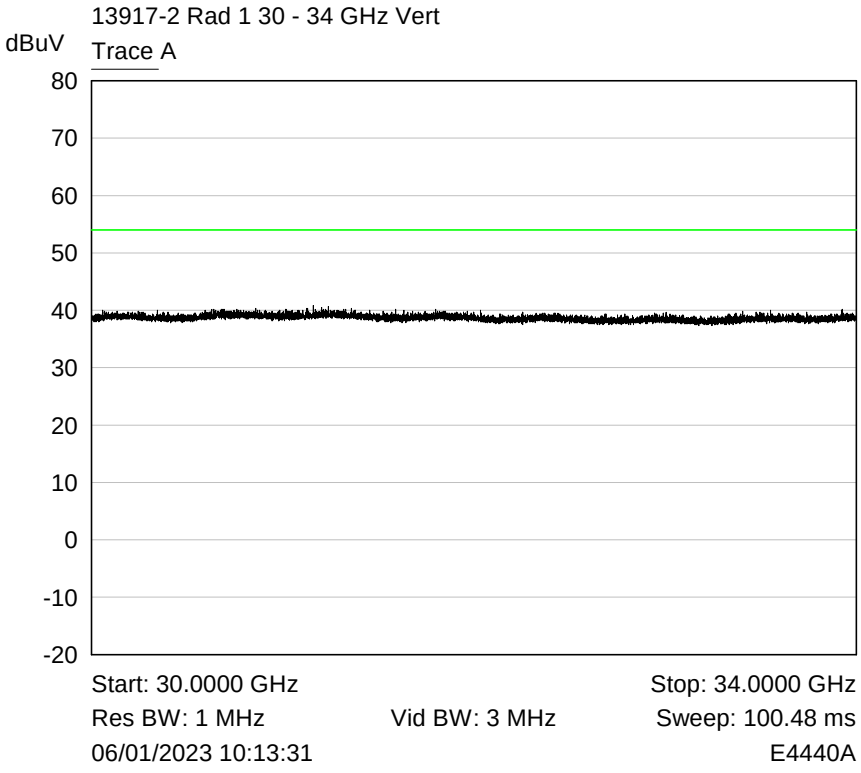


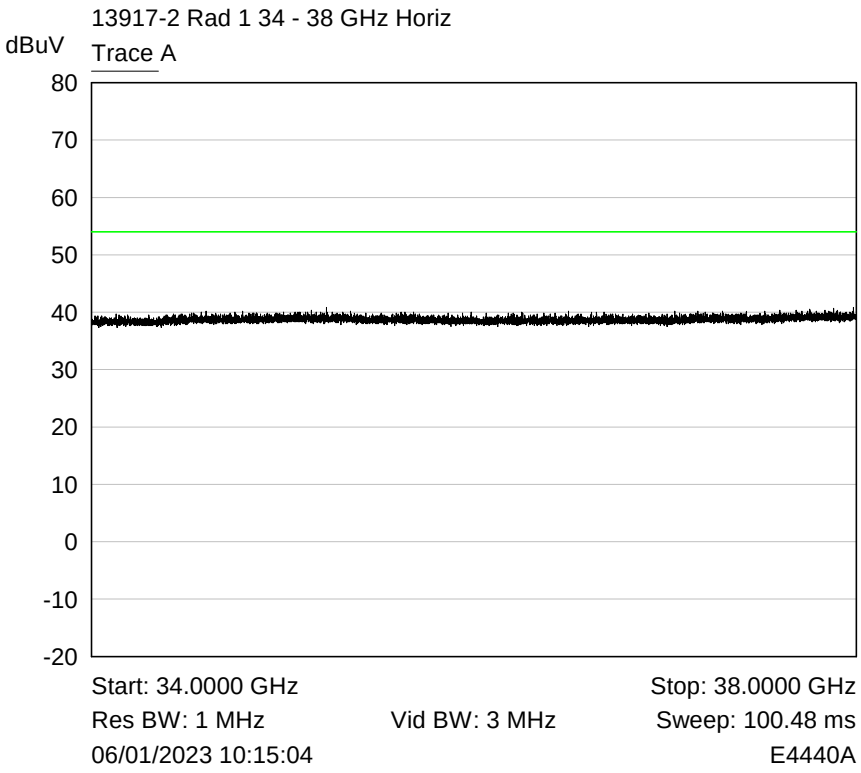


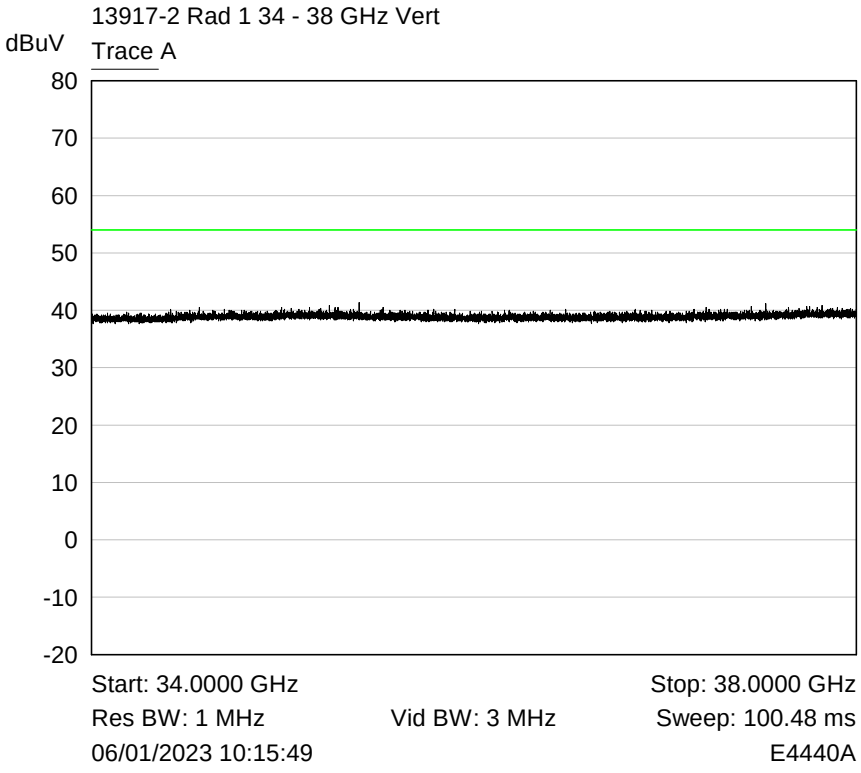


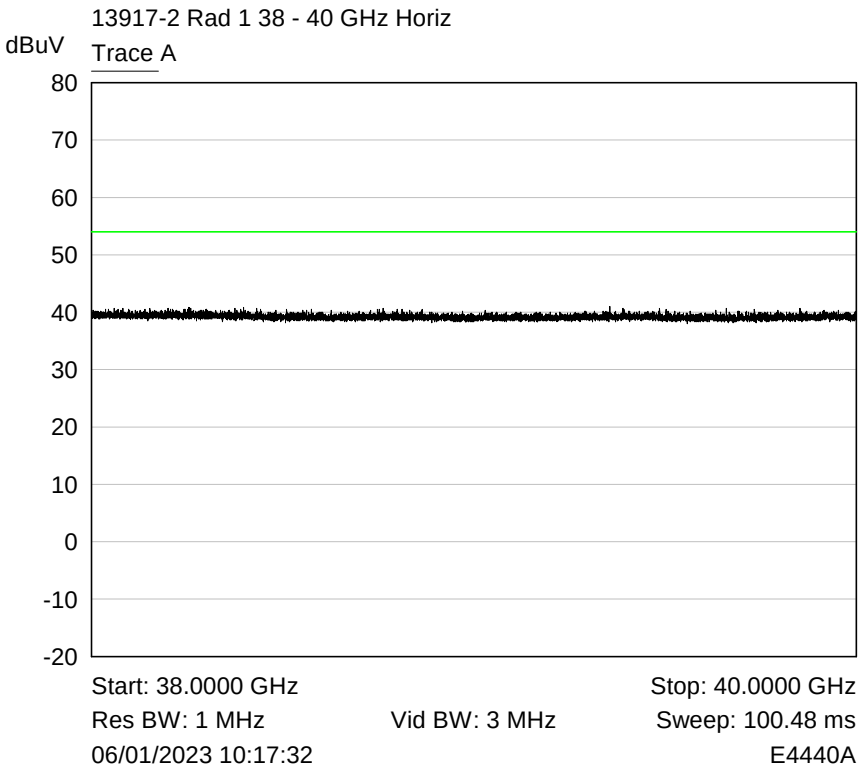


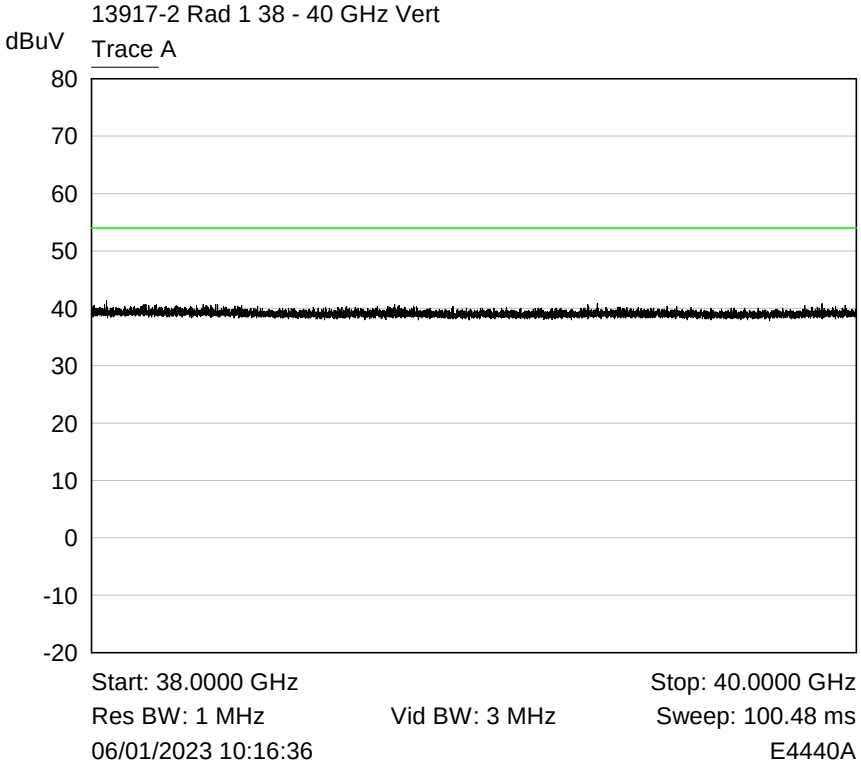






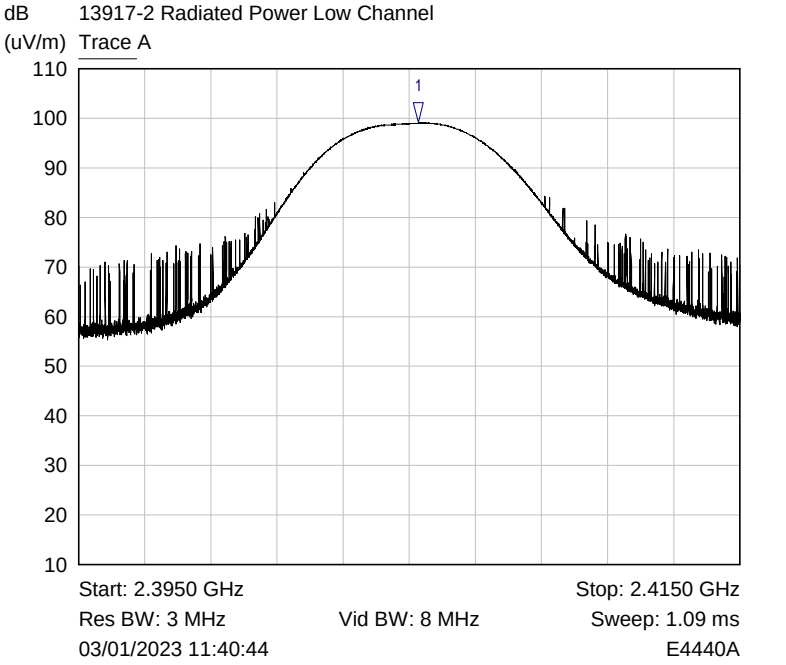






6.6 Effective radiated power field strength

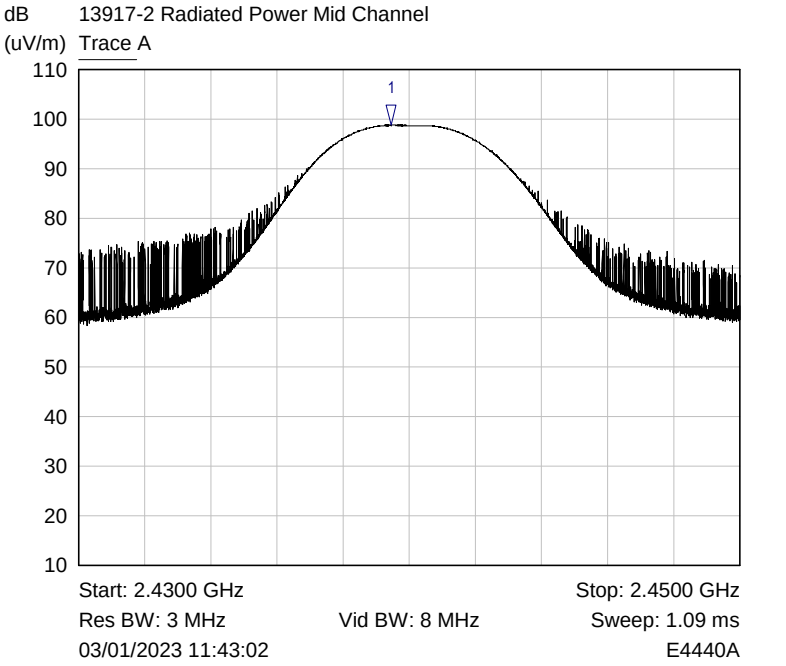
RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2405 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4053 GHz	99.15 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side position

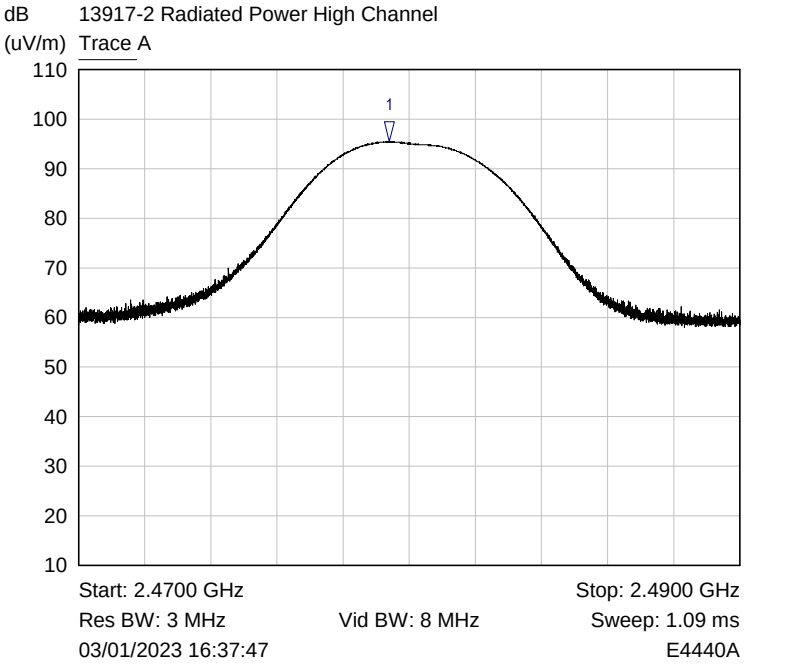
RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4395 GHz	98.84 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side position

RF Parameters: Band 2400-2483.5 MHz, Power 10, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2480 MHz

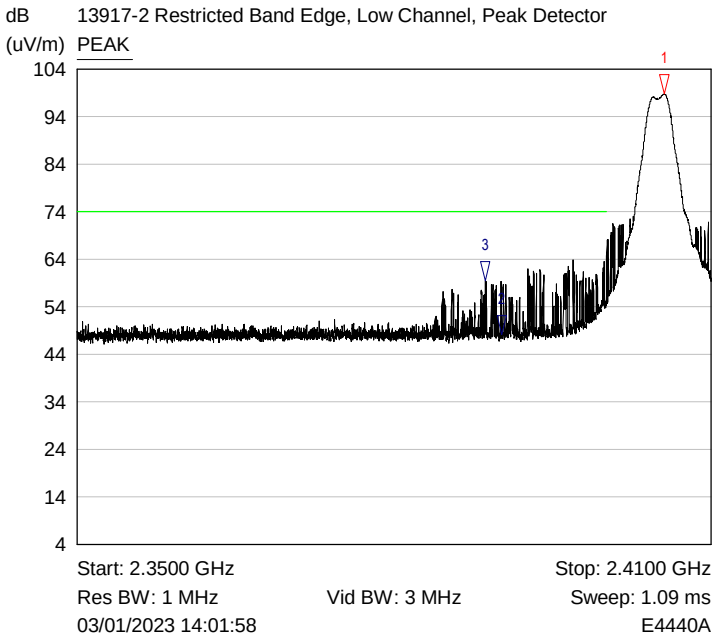


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4794 GHz	95.47 dB(uV/m)	

Plot of Horiz polarisation and EUT inside position

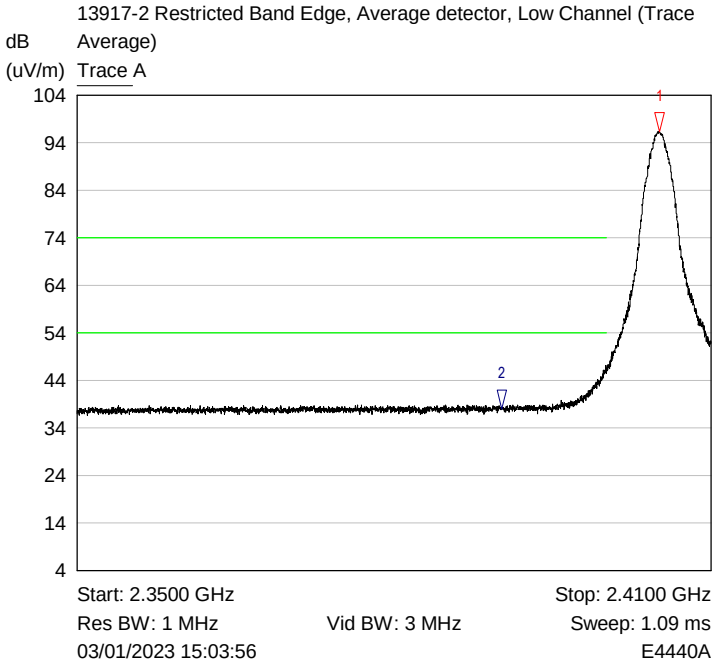
6.7 Band Edge Compliance

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2405 MHz



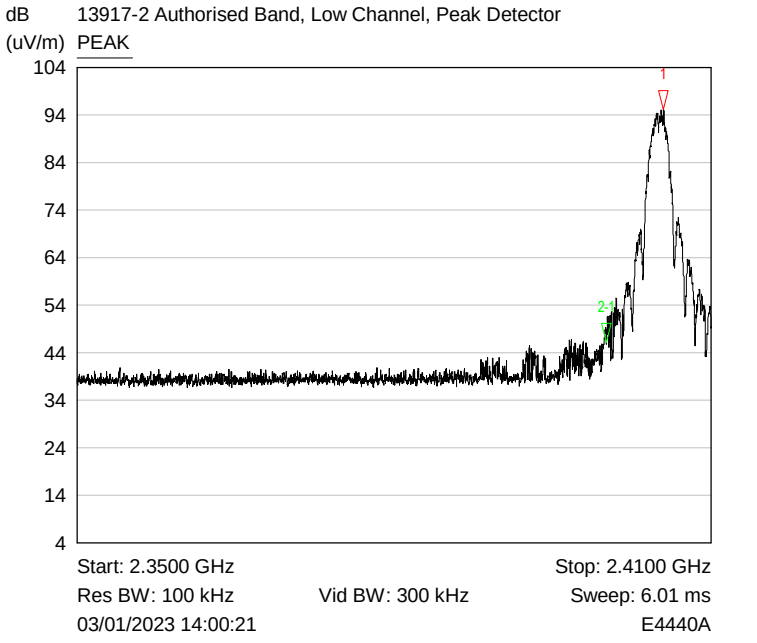
Mkr	Trace	X-Axis	Value	Notes
1	PEAK	2.4055 GHz	98.77 dB(uV/m)	
2	PEAK	2.3900 GHz	48.10 dB(uV/m)	
3	PEAK	2.3884 GHz	59.58 dB(uV/m)	

Restricted band edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4051 GHz	96.26 dB(uV/m)	
2	Trace A	2.3900 GHz	37.94 dB(uV/m)	

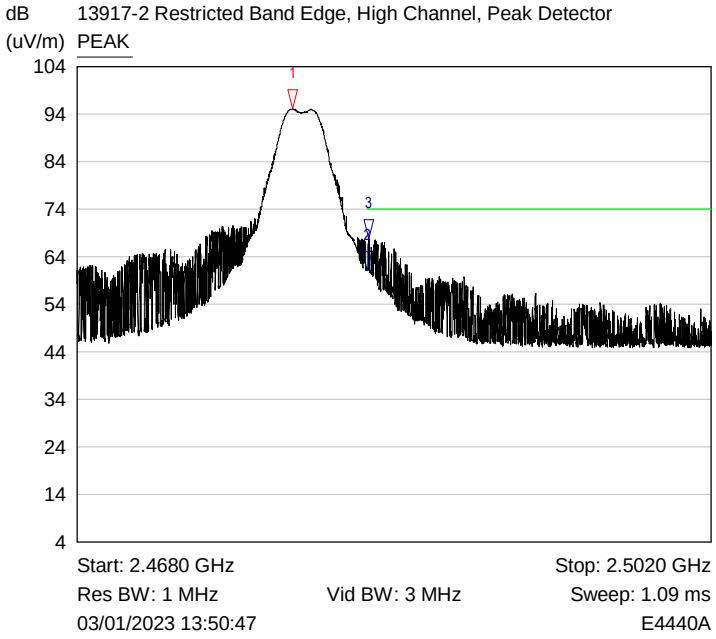
Restricted band edge Average Plot



Mkr	Trace	X-Axis	Value	Notes
1	PEAK	2.4055 GHz	95.14 dB(uV/m)	
2-1	PEAK	2.4000 GHz	-48.98 dB	

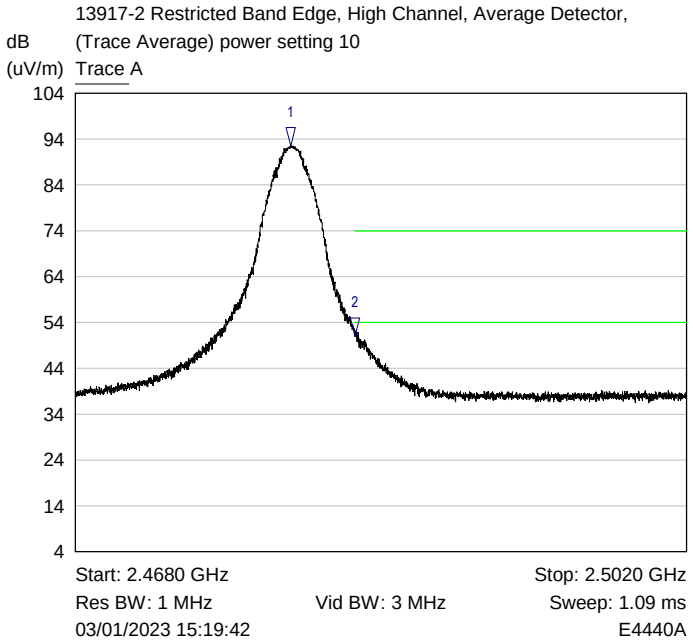
Authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 10 dBm, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2480 MHz



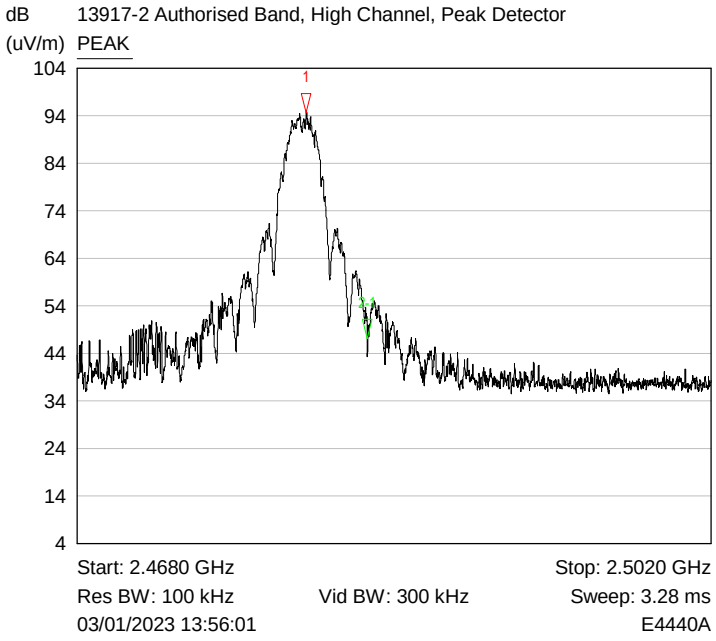
Mkr	Trace	X-Axis	Value	Notes
1	PEAK	2.4795 GHz	95.10 dB(uV/m)	
2	PEAK	2.4835 GHz	61.24 dB(uV/m)	
3	PEAK	2.4836 GHz	67.77 dB(uV/m)	

Restricted band edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4799 GHz	92.47 dB(uV/m)	
2	Trace A	2.4835 GHz	50.99 dB(uV/m)	

Restricted band edge Average Plot

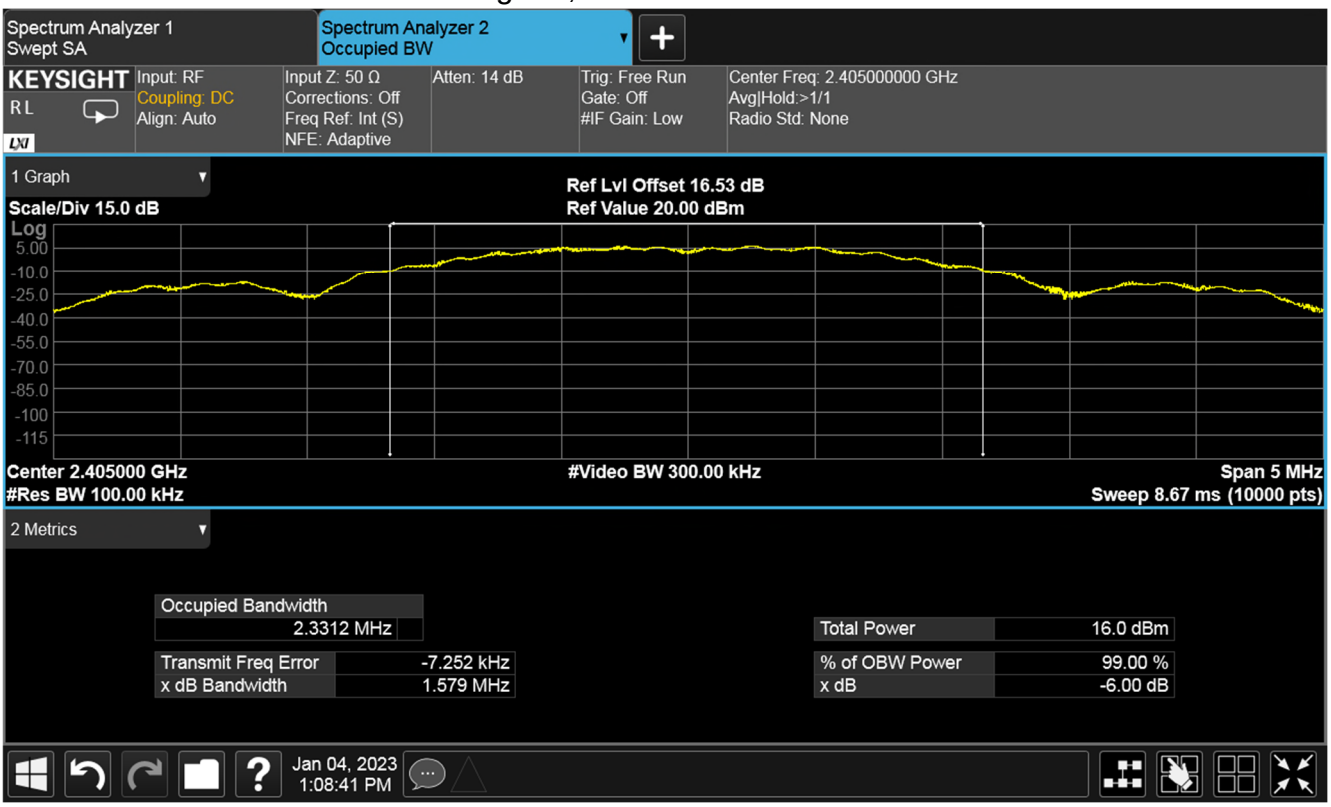


Mkr	Trace	X-Axis	Value	Notes
1	PEAK	2.4802 GHz	94.71 dB(uV/m)	
2-1	PEAK	2.4835 GHz	-47.59 dB	

Authorised Band Edge Plot

6.8 Occupied bandwidth

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2405 MHz



Plot for 6 dB Bandwidth Result (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz

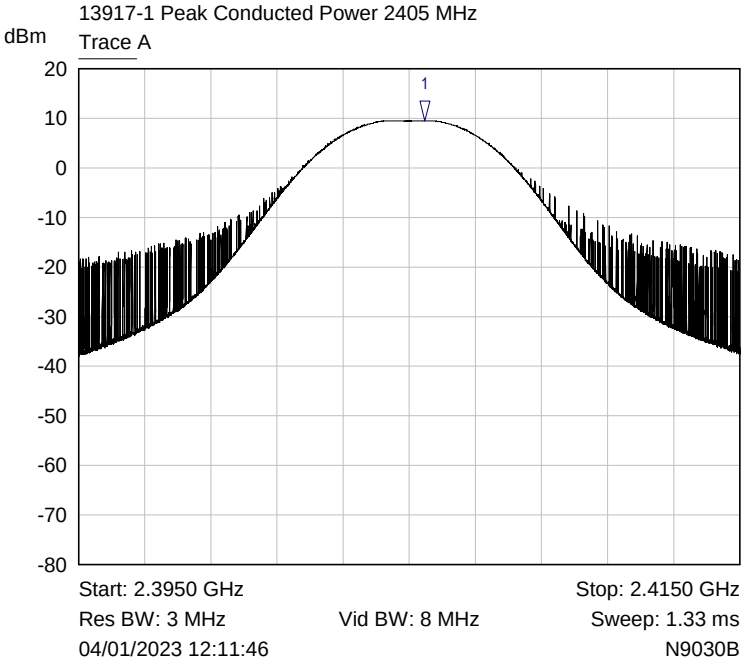
Plot for 6 dB Bandwidth Result (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 10, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2480 MHz

Plot for 6 dB Bandwidth Result (MHz)

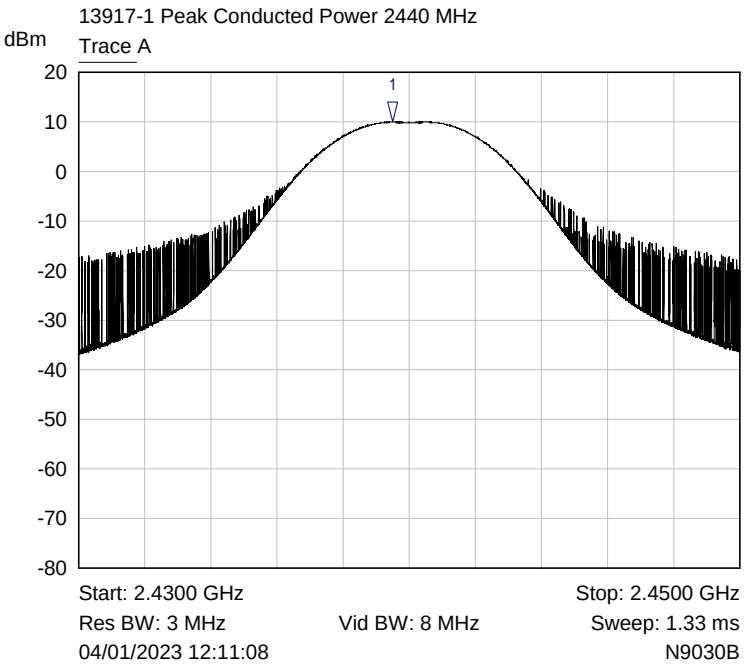
6.9 Maximum Peak conducted output power

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2405 MHz



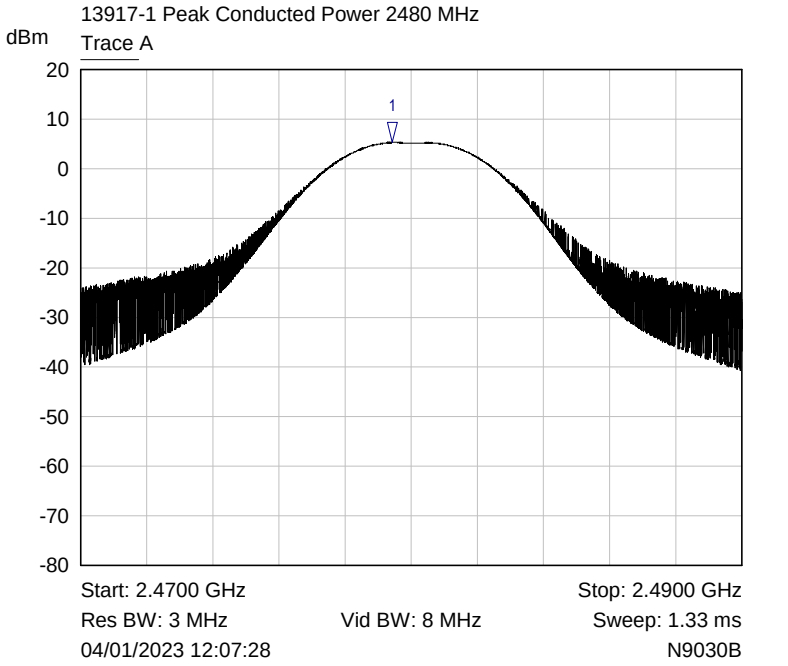
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4055 GHz	9.56 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4395 GHz	9.98 dBm	

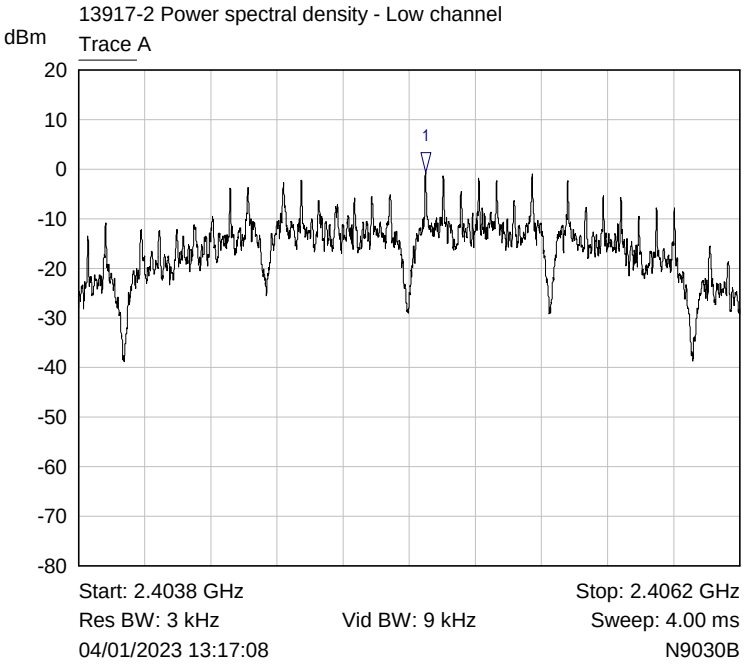
RF Parameters: Band 2400-2483.5 MHz, Power 10, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4794 GHz	5.33 dBm	

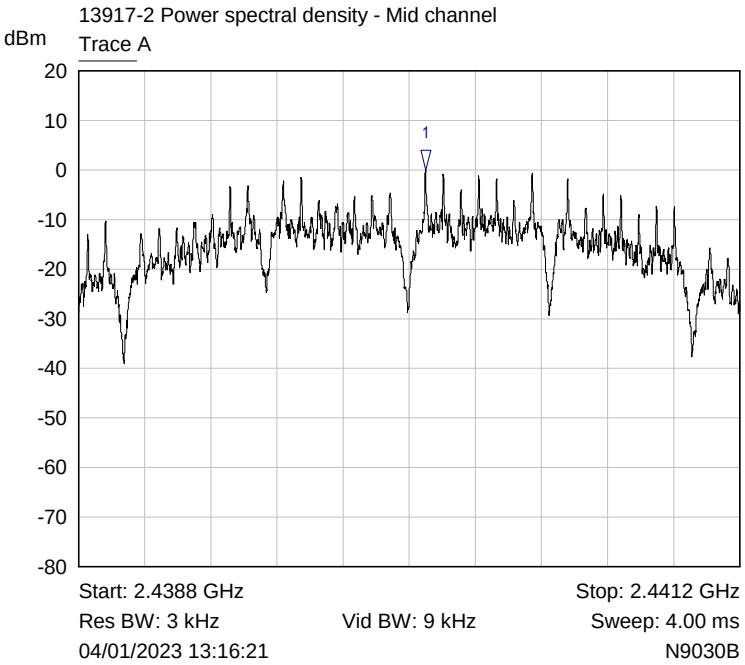
6.10 Maximum Power Spectral Density

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2405 MHz



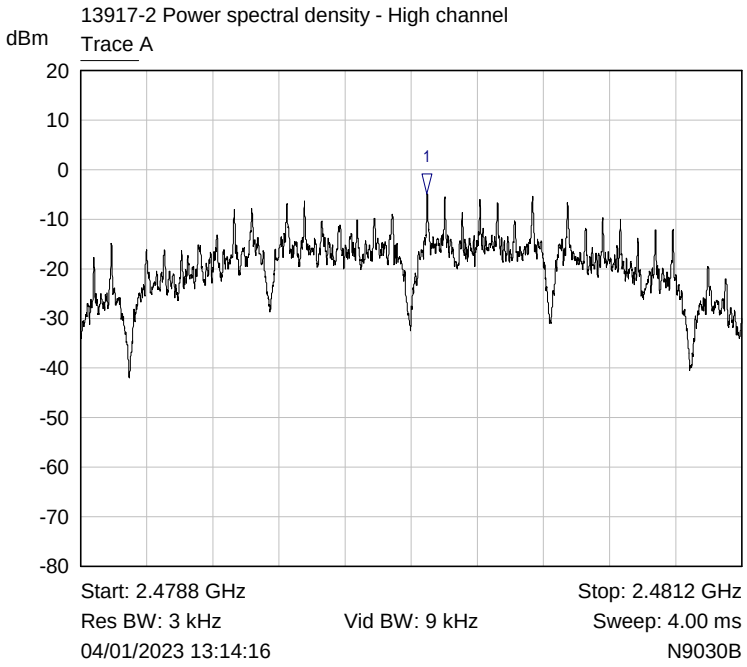
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4051 GHz	-0.70 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power 13, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4401 GHz	-0.07 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power 10, Channel Spacing 5 MHz, Modulation Zigbee, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4801 GHz	-4.89 dBm	

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

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

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

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

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

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

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

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

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

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

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

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

7.2 Explanation of limit line calculations for radiated measurements

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

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

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

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

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

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

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

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: $E_{Log} = 20Log(0.01842) +120 = 85.3$dBµV/m @ 3m.

8 Photographs

No photos included due to confidentiality requested by client towards FCC certification.

8.1 Radiated emission diagrams

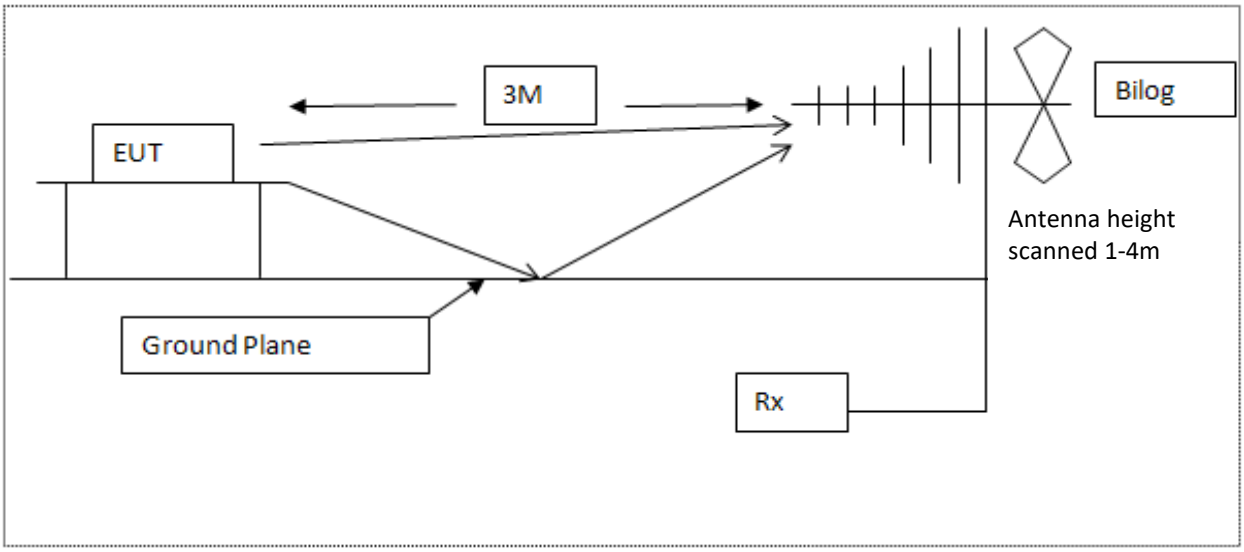


Diagram of the radiated emissions test setup 30 - 1000 MHz

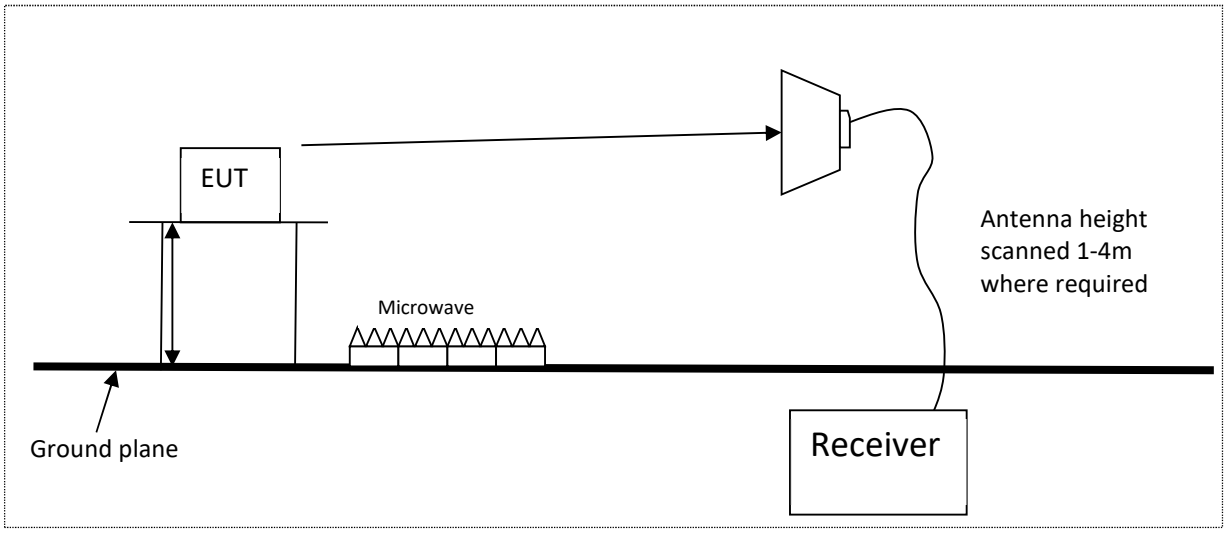


Diagram of the radiated emissions test setup above 1GHz

8.2 AC powerline conducted emission diagram

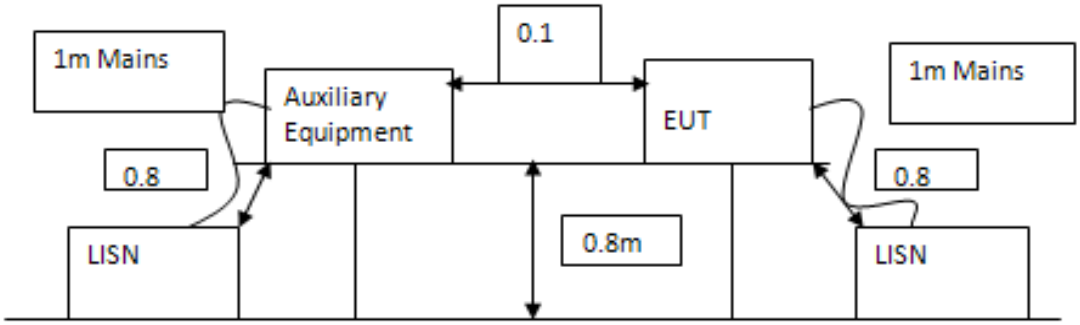


Diagram of the AC conducted emissions test setup

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
E253	6810.19.A	Attenuator 10dB 18GHz	Suhner	08-Jul-2022	12 months
E266	2032	Signal Generator 10kHz - 5.4GHz	Marconi Instruments	24-Jan-2022	12 months
E296-2	11970A	Harmonic Mixer 26.5-40GHz	Hewlett Packard	27-Jun-2022	12 months
E330	2224-20	Horn Antenna 26.5-40GHz	Flann (FMI)	22-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-Jun-2022	24 months
E428	HF906	Horn Antenna 1 - 18 GHz	Rohde & Schwarz	02-Apr-2022	12 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
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	10-Mar-2022	12 months
E755	N9030B	PXA Signal Analyser 3 Hz to 50 GHz	Keysight Technologies	03-Aug-2022	12 months
E904	5086-7805	Pre-Amplifier 1GHz - 26.5GHz	Hewlett Packard	04-Mar-2022	12 months
E927	BW-S6-2W263+	Attenuator SMA 6dB 26GHz	Mini-Circuits	29-Nov-2022	12 months
F128	AA18-10H	Attenuator SMA 10dB 18GHz	AtlanTecRF	13-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
ZSW1	V2.5.2	Measurement Software Suite	RN Electronics	Not applicable	

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	XT2173-3	Smartphone	Motorola	ZY22FCH44T
2	1801A-ELC-6L	Battery charger	Salunda	3
3	GST120A24	Battery charger PSU	Mean Well	ECO51A6911

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
P260	36V5	PSU 36V 5A	Kingshill	205

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

Test	Modification	Time of modification
TX ERP FCC15_247	Power setting reduced on high channel from 13 to 10	Before testing

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
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 ======