Radio Test Report

Senceive Ltd

FlatMesh F3N_NF PCB

F3N_NF

47 CFR Part 15.247 Effective Date 1st October 2022
DTS: Digital Transmission System
Test Date: 25th September 2023 to 28th September 2023
Report Number: 09-13825-2-23 Issue 02
Supersedes report: 09-13825-2-23 Issue 01

The testing was carried out by Kiwa Ltd t/a Kiwa Electrical Compliance, 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 13825-2

The equipment noted below has been fully tested 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:	FlatMesh F3N_NF PCB
Model Number:	F3N_NF
Unique Serial Number:	001BC50AA001853A (MAC address)
Applicant:	Senceive Ltd Davy Avenue Knowlhill Milton Keynes MK5 8PB
Full measurement results are detailed in Report Number:	09-13825-2-23 Issue 02
Test Standards:	47 CFR Part 15.247 Effective Date 1st October 2022 DTS: Digital Transmission System

NOTE:
Certain tests were not performed based upon applicant's declarations. 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:	25th September 2023 to 28th September 2023
Test Engineer: Graham Blake	Graham Blake Digitally signed by: Graham Blake DN: CN = Graham Blake email = graham.blake@kiwa.com C = GB OU = Kiwa Electrical Compliance Date: 2024.04.09 09:52:51 Z
Approved By: Radio Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims email = Daniel.Sims@kiwa.com C = GB O = Kiwa Electrical Compliance - Brentwood Date: 2024.04.09 09:44:32 Z
Customer Representative:	

0 Revision History

Issue Number	Revision History	Page Reference(s)
01	First Issue	-
02	Removed all references to RN Electronics due to Company name change to Kiwa Ltd t/a Kiwa Electrical Compliance and UKAS/FCC test lab listing requirements.	1, 2, 3, 9,69, 71, 74 and all footers.

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2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Senceive Ltd Davy Avenue Knowlhill Milton Keynes MK5 8PB	
Manufacturer of EUT	Senceive Ltd	
Full Name of EUT	FlatMesh F3N_NF PCB	
Model Number of EUT	F3N_NF	
Serial Number of EUT	001BC50AA001853A (MAC address)	
Date Received	26th September 2023	
Date of Test:	25th September 2023 to 28th September 2023	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	8th April 2024	
Main Function	The Digital Node is an addition to Senceive's 'Interface Node' portfolio, which will provide system (Flatmesh, and GeoWAN) integration capability for instruments with digital serial interfaces (RS485, RS422, RS232 and SDI-12, CAN) and potential higher power requirements, as is the case for many In-Place Inclinometers, Weather stations, voidmeters, liquid levelling cells and many more	
Information Specification	Height	70 mm
	Width	33 mm
	Depth	5 mm
	Weight	0.015 kg
	Voltage	3.6 VDC
	Current	Not declared

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Integrated into other products
Choice of model(s) for type tests	Sample
Antenna details	External Dual Band OS-ISMDB-0507-C0-WL +3.4dBi
Antenna port	On board connector
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2475 MHz
Lowest Signal generated in EUT	Not declared
Hardware Version (HVIN)	F3N_NF.AAA
Software Version	V0.1.101.
Firmware Version (FVIN)	Node Firmware version: 00.00-07 Radio: mote ip 1.4.4
Type of Equipment	PCB assembly
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	2405 - 2475 MHz
EUT Declared Modulation Parameters	OQPSK
EUT Declared Power level	8 dBm Conducted / 11.4 dBmi radiated
EUT Declared Signal Bandwidths	2.7 MHz
EUT Declared Channel Spacing's	5 MHz
EUT Declared Duty Cycle	32% Max (100% used for test purposes)
Unmodulated carrier available?	No
Declared frequency stability	Not declared
RX Parameters	
Alignment range – receiver	2405 - 2475 MHz
EUT Declared RX Signal Bandwidth	2.7 MHz
FCC Parameters	
FCC Transmitter Class	DTS: Digital Transmission System

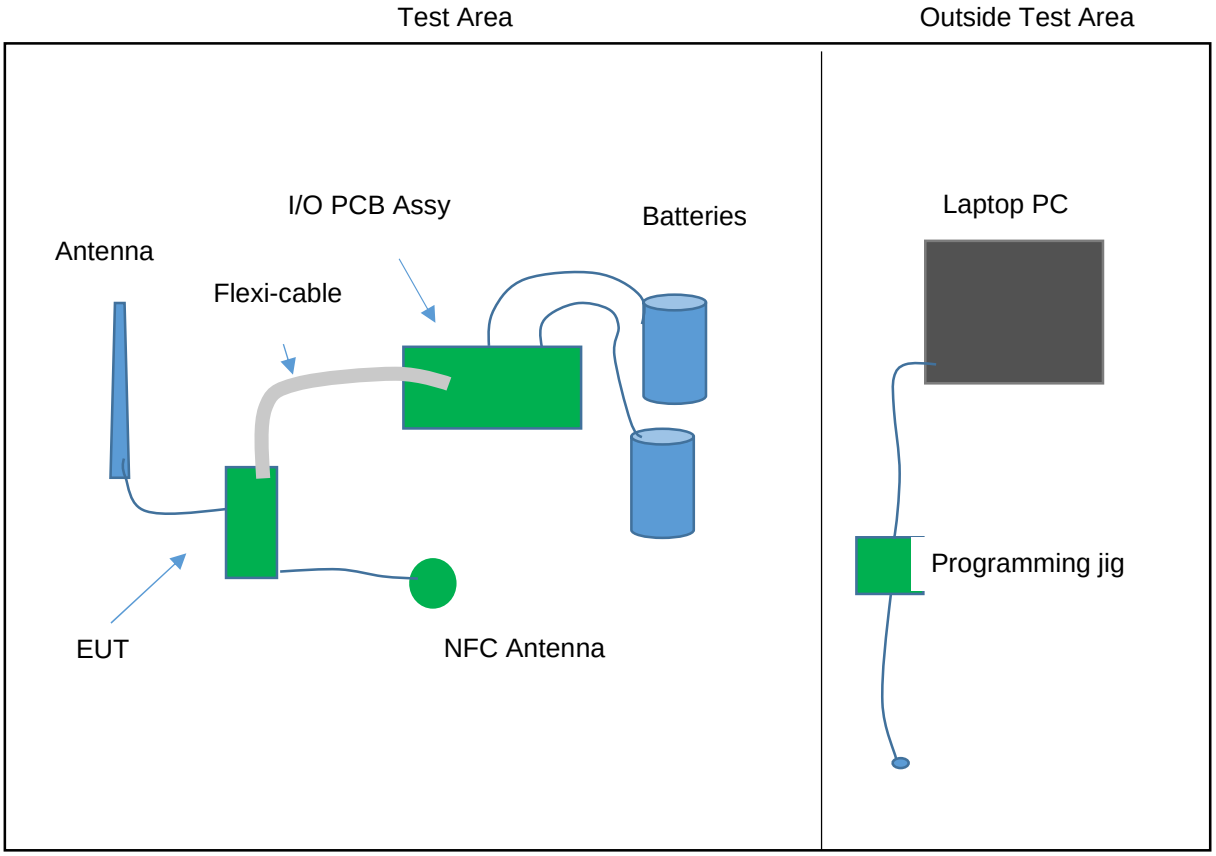
2.3 Functional description

The internal battery powered Digital Node will log data measurements from instruments with digital serial interfaces (RS485, RS422, RS232 and SDI-12, CAN) and potential higher power requirements, and will transfer data to a FlatMesh LTE Gateway for Senceive's clients to access via Senceive's secure Webmonitor portal. The EUT operates over the frequency range 2405 – 2475 MHz.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX Low	Transmitting continuously at 2405 MHz using system modulation.	Yes
TX Mid	Transmitting continuously at 2440 MHz using system modulation.	Yes
TX High	Transmitting continuously at 2475 MHz using system modulation.	Yes

2.5 Emissions configuration



The EUT was connected to typical ancillary equipment so that each of the EUT's ports were populated and functional. The EUT and all ancillary equipment was pinned to a Styrofoam block and 10 cm separation between items was maintained so the PCB could be tested per the FCC's module testing requirements. The EUT was connected to the I/O PCB assembly using a flexi cable. The EUT was powered using two brand new batteries via the I/O PCB assembly. The supplied antenna was connected to the EUT via a UFL to N-type coax cable. An NFC coil antenna was connected to the EUT using a 4-way cable assembly.

The EUT was configured into the test modes stated in section 2.4 using a laptop PC and programming jig running 'Putty' terminal software. The applicant provided the commands to set low, mid and high channels. A fixed power level of +8 dBm was used throughout testing. Radiated tests were performed with the antenna in place and for conducted tests measurements were made directly at the on-board connector.

The transmit mode was 100% continuous with modulation and the power settings for each channel were as stated below:-

Low Channel (2405 MHz) +8 dBm power setting
Mid Channel (2440 MHz) +8 dBm power setting
High Channel (2475 MHz) +8 dBm power setting

2.5.1 Signal leads

Port Name	Cable Type	Connected
RF	UFL to N-Type coax	Yes
Battery	2-core	No*
I/O & Power	14-Way flexi	Yes
NFC	4 way ribbon	Yes

*The EUT was powered via the 14-Way flexi cable as worst case.

3 Summary of test results

The FlatMesh F3N_NF PCB, F3N_NF was tested for compliance to the following standard(s):

47 CFR Part 15.247 Effective Date 1st October 2022
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	NOT APPLICABLE[1]
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[2]
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(a)(2)	PASSED
9. Maximum Average conducted output power	47 CFR Part 15C Part 15.247(b3)	NOT APPLICABLE[3]
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(d)	PASSED
13. Duty cycle	47 CFR Part 15C Part 15.35(c)	NOT APPLICABLE[4]
14. FHSS carrier frequency separation	47 CFR Part 15C Part 15.247(a1)	NOT APPLICABLE[5]
15. Average time of occupancy	47 CFR Part 15C Part 15.247(a)(1)(iii)	NOT APPLICABLE[5]
16. Number of Hop Channels	47 CFR Part 15C Part 15.247(a)(1)(iii)	NOT APPLICABLE[5]

[1] EUT has no provisions to connect to a mains supply.
[2] Spectrum investigated up to a frequency of 25 GHz based on 10 times the highest channel/ signal generated in equipment of 2475 MHz.
[3] Peak Conducted power measured instead.
[4] No limits apply, however duty cycle measurement performed to verify any possible correction factors for average emissions. EUT Duty was confirmed as operating at 100% constant transmit state for tests.
[5] EUT does not employ FHSS technology

4 Specifications

The tests were performed and operated in accordance with Kiwa Electrical Compliance procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	47 CFR Part 15C	2022	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
4.1.4	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

NOT APPLICABLE: EUT has no provisions to connect to a mains supply.

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 the equipment powered using a new battery.
No discernible difference in emissions was observed between channel settings, therefore for full tests the EUT was operated in TX Mid mode.

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, E534, E411

See Section 9 for more details

5.2.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2440 MHz

Plot refs
13825-2 Rad 1 9k-150kHz Para
13825-2 Rad 1 9k-150kHz Perp

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

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
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 the equipment powered using a new battery.
No discernible difference in emissions was observed between channel settings, therefore for full tests the EUT was operated in TX Mid mode.

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, E534, E411

See Section 9 for more details

5.3.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2440 MHz

Plot refs
13825-2 Rad 1 150k-30MHz Para
13825-2 Rad 1 150k-30MHz Perp

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

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
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 the equipment powered using a new battery.
No discernible difference in emissions was observed between channel settings, therefore for full tests the EUT was operated in TX Mid mode.

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

E411, E534, E743, LPE364, NSA-M, ZSW1

See Section 9 for more details

5.4.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2440 MHz

Plot refs
13825-2 Rad 1 VHF Horiz
13825-2 Rad 1 VHF Vert
13825-2 Rad 1 UHF Horiz
13825-2 Rad 1 UHF Vert

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report. Whilst Low, Mid and High channels were tested, plots are for illustrative purposes only and only Mid channel plots are shown in 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:
30MHz - 1000MHz ±6.1dB

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 the equipment powered using a new battery.

No discernible difference in emissions was observed between channel settings, therefore for full tests the EUT was operated in TX Mid mode.

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 – 25 GHz.

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

Tests were performed using Test Site M.

5.5.4 Test equipment

E136, E534, E755, TMS78, TMS82, TMS89

See Section 9 for more details

5.5.5 Test results

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

Setup Table

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
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 present.						

Setup Table

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
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 present.						

Plots
13825-2 Rad 1 1-2GHz Horiz
13825-2 Rad 1 1-2GHz Horiz
13825-2 Rad 1 2-2.7GHz Horiz
13825-2 Rad 1 2-2.7GHz Horiz
13825-2 Rad 1 2.7-5.15GHz Horiz
13825-2 Rad 1 2.7-5.15GHz Horiz
13825-2 Rad 1 5.15-6GHz Horiz
13825-2 Rad 1 5.15-6GHz Horiz
13825-2 Rad 1 6upto10GHz Horiz
13825-2 Rad 1 6upto10GHz Horiz
13825-2 Rad 1 10upto12_5GHz Horiz
13825-2 Rad 1 10upto12_5GHz Horiz
J13825-2 Radiated Emissions 12.5 - 15 GHz Horizontal
J13825-2 Radiated Emissions 12.5 - 15 GHz Horizontal
J13825-2 Radiated Emissions 15 - 18 GHz Horizontal
J13825-2 Radiated Emissions 15 - 18 GHz Horizontal
J13825-2 Radiated Emissions 18 - 22 GHz Horizontal
J13825-2 Radiated Emissions 18 - 22 GHz Horizontal
J13825-2 Radiated Emissions 22 - 25 GHz Horizontal
J13825-2 Radiated Emissions 22 - 25 GHz Horizontal

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

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

Setup Table

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
High channel	2475 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 present.						

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 – 25 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 6.5/6.6 [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.

Tests were performed in test site M.

5.6.4 Test equipment

E136, E411, E534, E932, F130, TMS82

See Section 9 for more details

5.6.5 Test results

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

Band	2400-2483.5 MHz
Power Level	10 dBm
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2475 MHz

	Low channel	Mid channel	High channel
Duty Cycle (%)	100	100	100
Duty Cycle correction	0.0	0.0	0.0

	Low channel	Mid channel	High channel
Peak Level (dBµV/m)	103.0	104.2	104.4
Plot reference	13825-2 ERP Low	13825-2 ERP Mid	13825-2 ERP High
Antenna Polarisation	Vert	Vert	Vert
EUT Polarisation	Upright	Upright	Upright

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

LIMITS:
The maximum output power in all cases is 30dBm/ 1watt. = 125.2 dBuV/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 6.10 [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 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. For restricted band Average measurements, 100 trace averages were used as per ANSI C63.10, Clause 11.12.2.5.1

Tests were performed using Test Site M.

5.7.4 Test equipment

E136, E411, E534, E932, TMS82

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	60%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2475 MHz

Restricted Band Edges	Low channel	High channel
Restricted Peak Level measured (dBuV/m)	41.69	55.82
Restricted band edge Peak Plot	13825-2 Restricted Band Edge Low Channel PK	13825-2 Restricted Band Edge High Channel PK
Restricted Average Level measured (dBuV/m)	Peak complies with Average limit	46.1
Restricted band edge Average Plot	Not applicable	13825-2 Restricted Band Edge High Channel AVG

Authorised Band Edge	Low channel	High channel
Authorised Band Edge (dBc) value measured	42.4	58.0
Authorised Band Edge Plot	13825-2 Authorised Band Edge Low Channel PK	13825-2 Authorised Band Edge High Channel PK

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 6.9 [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 in the maximised field strength position. 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 M.

5.8.4 Test equipment

E136, E411, E534, E932, F130, TMS82

See Section 9 for more details

5.8.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2475 MHz

	Low channel	Mid channel	High channel
6 dB Bandwidth Result (MHz)	1.623	1.53	2.586
Plot for 6 dB Bandwidth Result (MHz)	13825-2 DSSS OBW Low	13825-2 DSSS OBW Mid	13825-2 DSSS OBW High
99 % Bandwidth Result (MHz)	2.4043	2.4111	2.3871
Frequency Error (kHz) (include sign)	45.595	43.203	61.04
Operating frequency (MHz)	2405	2440	2475
6 dB FLOW Worst case (MHz)	2404.234095	2439.278203	2473.76804
6 dB FHIGH Worst case (MHz)	2405.857095	2440.808203	2476.35404

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 measured 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 [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 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. In this case 3MHz RBW was used. Measurements were made on a test bench in site M.

5.10.4 Test equipment

F130, E534, E932, F073-1

See Section 9 for more details

5.10.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2475 MHz

Nominal voltage result (dBm)	5.6	6.7	5.9
Nominal voltage result (mW)	3.6	4.6	3.9
Limit (mW) / (dBm)	1000 / 30	1000 / 30	1000 / 30
Plot reference	13825-2 Peak Conducted Power Low Channel	13825-2 Peak Conducted Power Mid Channel	13825-2 Peak Conducted Power High Channel
Margin to limit (dB)	-24.4	-23.3	-24.1

LIMITS:
15.247(b)(3)
For systems using digital modulation in the 902-928, 2400-2483.5 or 5725-5850 MHz bands 1 Watt / (30 dBm).

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 10.10 [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.
Measurements were made directly at the RF port. Peak power was recorded with the span set to 1.5 times the measured DTS bandwidth for each modulation scheme setting, using a RBW of 3kHz.
Tests were performed using Test Site M.

5.11.4 Test equipment

E411, E534, E932, F073-1, F130

See Section 9 for more details

5.11.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz
Mid channel	2440 MHz
High channel	2475 MHz

	Low channel	Mid channel	High channel
Duty Cycle (%)	100	100	100
dBm (in 3kHz RBW) at antenna port	-7.06	-5.82	-6.44
Limit (dBm)	8	8	8
Margin (dB)	-15.06	-13.82	-14.44
Plot reference	13825-2 Power Spectral Density Low Channel	13825-2 Power Spectral Density Mid Channel	13825-2 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

5.12.1 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 6.7 [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]

5.12.2 Configuration of EUT

The EUT was operated on a test bench. Measurements were made at the on-board RF port. The EUT was operated in TX Low, TX Mid and TX High modes for this test.

5.12.3 Test procedure

Tests were made in accordance with the Test Method noted above using the measuring equipment listed in the 'Test Equipment' Section. A complete scan of emissions from the lowest frequency generated/ used within the equipment up to 10 times the highest frequency generated/ used was made, to identify any signals within 20dB of the limits. Any identified spurious signals were measured in the required bandwidths. Tests were performed in test site M.

5.12.4 Test equipment

E433, E755, F073-1, F078

See Section 9 for more details

5.12.5 Test results

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

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Low channel	2405 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
No emissions within 20 dB of the limit were observed		

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
Mid channel	2440 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
No emissions within 20 dB of the limit were observed		

Plots
13825-2 Conducted Emissions Mid Channel 30 - 1000 MHz
13825-2 Conducted Emissions Mid Channel 1 - 5 GHz
13825-2 Conducted Emissions Mid Channel 5 - 9 GHz
13825-2 Conducted Emissions Mid Channel 9 - 13 GHz
13825-2 Conducted Emissions Mid Channel 13 - 17 GHz
13825-2 Conducted Emissions Mid Channel 17 - 21 GHz
13825-2 Conducted Emissions Mid Channel 21 - 25 GHz

Band	2400-2483.5 MHz
Power Level	8 dBm (conducted)
Channel Spacing	5 MHz
Mod Scheme	OQPSK
High channel	2475 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
No emissions within 20 dB of the limit were observed		

Note: There was no discernible difference between channels. Only plots for the middle channel have been included in section 6.

The plots referred to in the above table may be found in section 6.

LIMITS:
Note: limits based on lowest peak fundamental power measured in 100kHz RBW of 99.9dBuV/m @ 3m – 20dBc (79.9dBuV/m equivalent). Converted to dBm limit above 1GHz using: dBuV/m = EIRP – 20 Log (d) +104.77 therefore dBm = dBuV/m @3m – 95.2 = -15.3 dBm above 1GHz. For emissions 30-1000MHz an additional ground reflection factor of -4.9 dB is to be applied, giving -20.2 dBm for limit 30-1000MHz. Refer to ANSI C63.10:2013.

15.247(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

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: <± 2.8 dB

5.13 Duty cycle

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

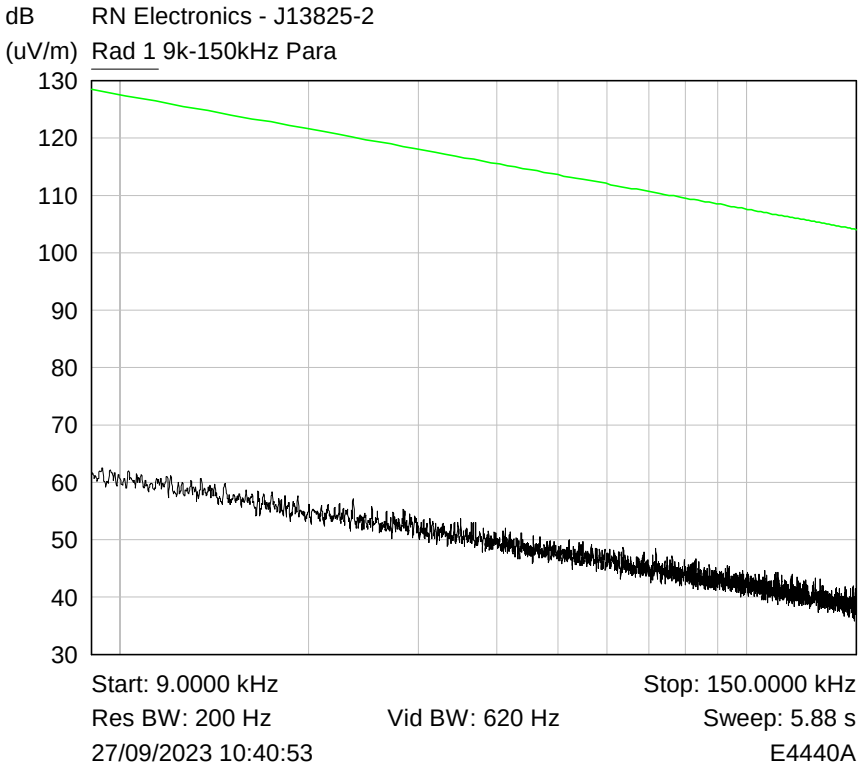
5.16 Number of Hop Channels

NOT APPLICABLE: EUT does not employ FHSS technology

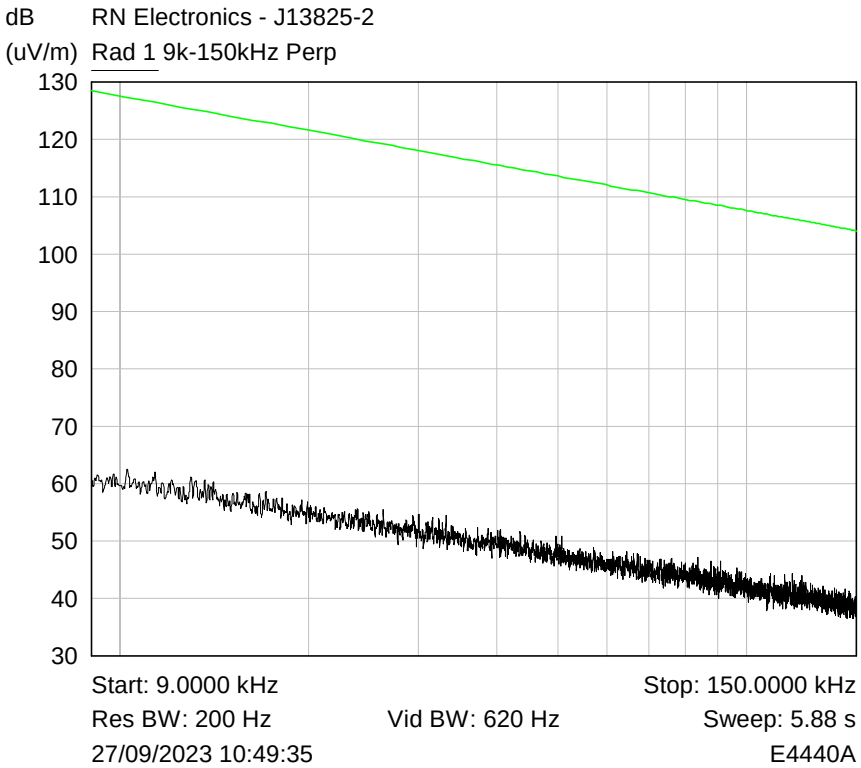
6 Plots/Graphical results

6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



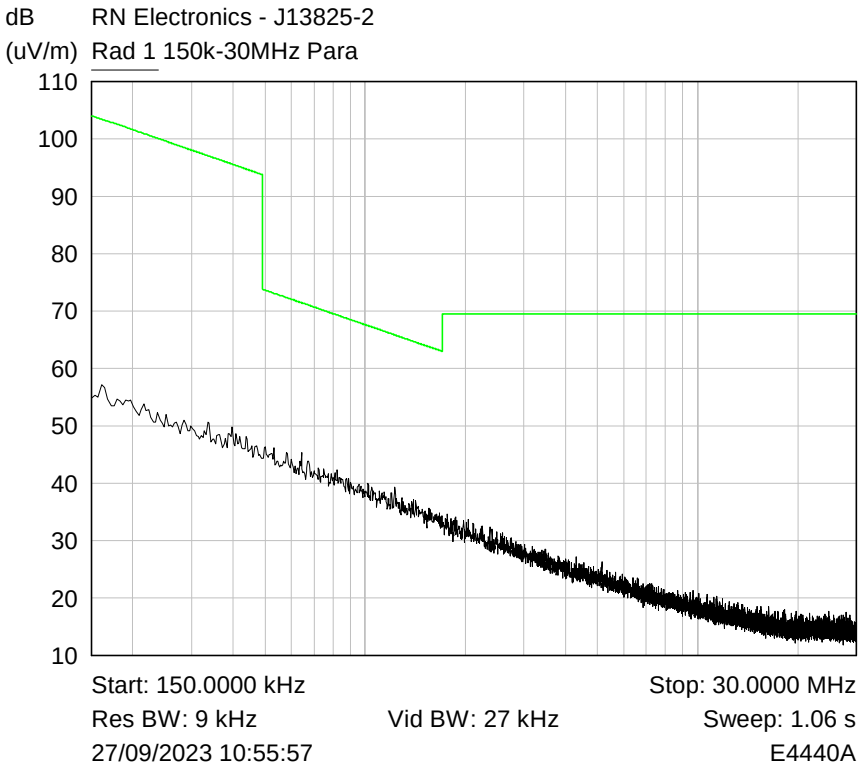
Plot of 9k-150kHz Parallel



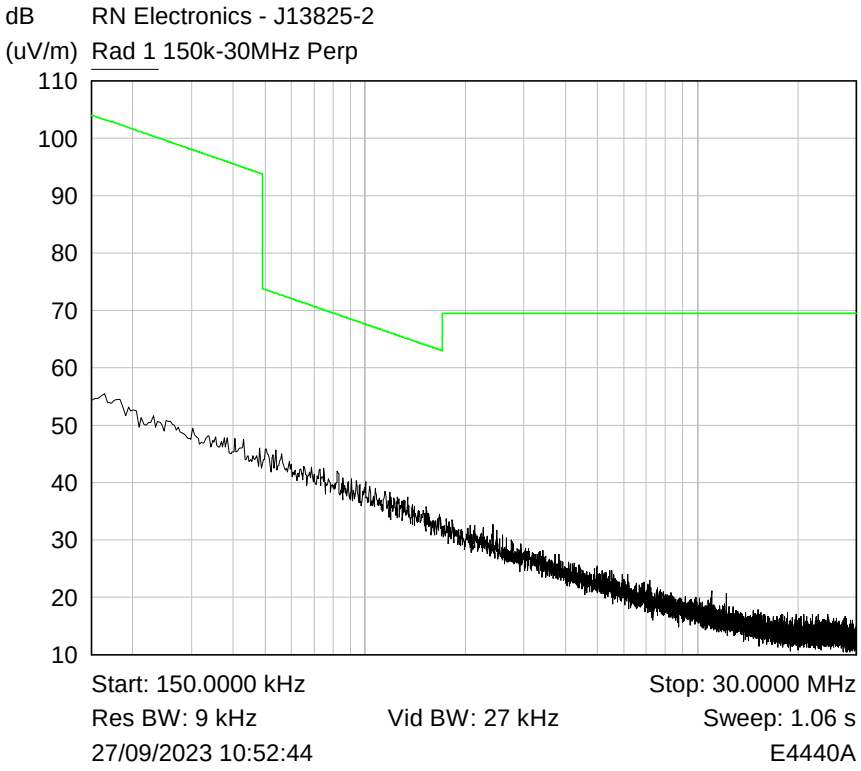
Plot of 9k-150kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



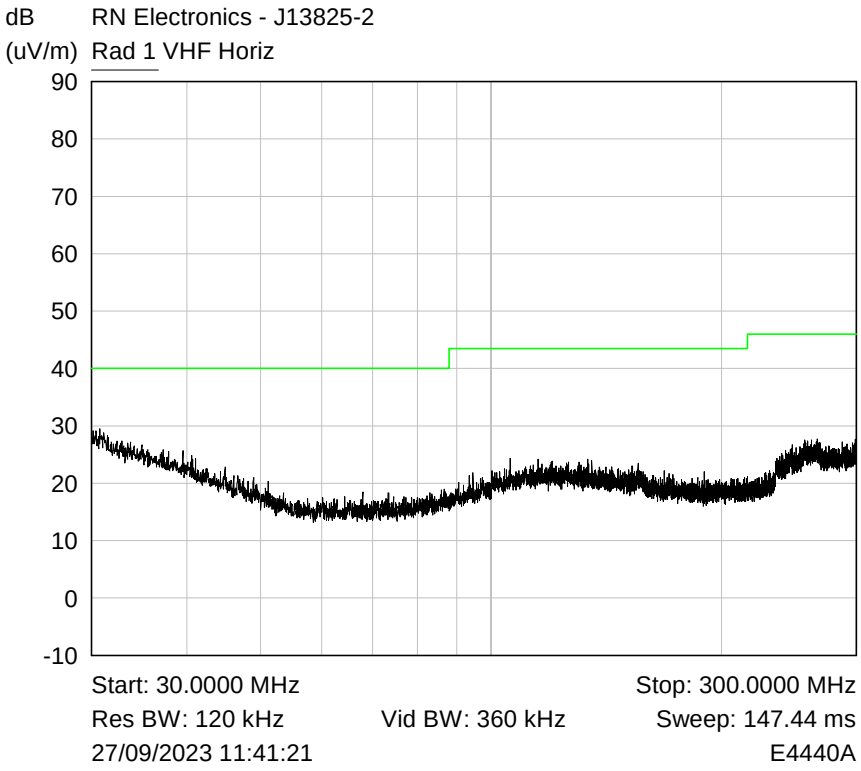
Plot of 150kHz-30MHz Parallel



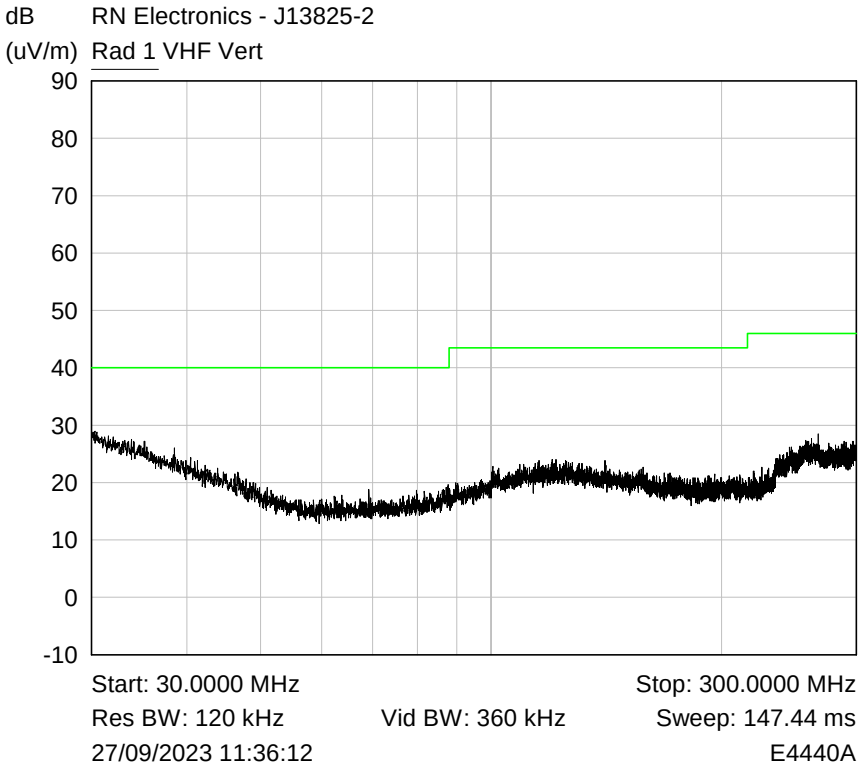
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

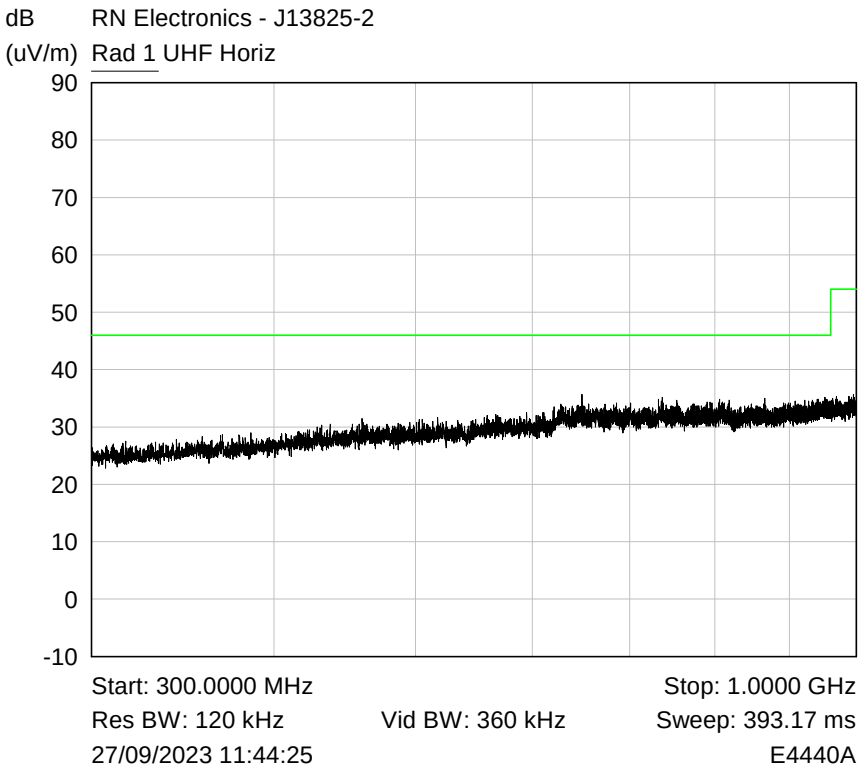
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



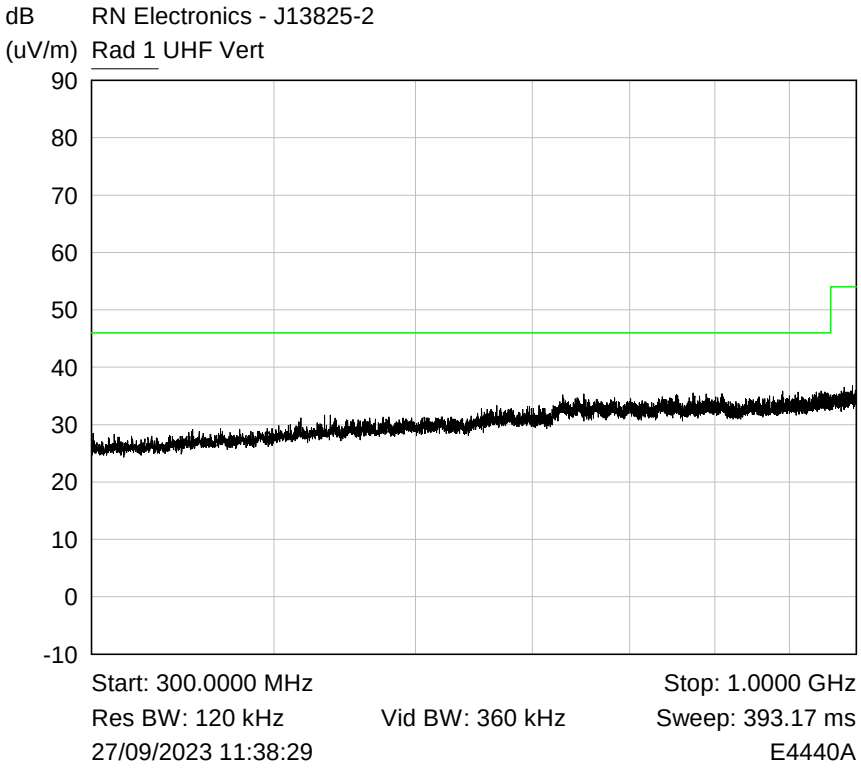
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



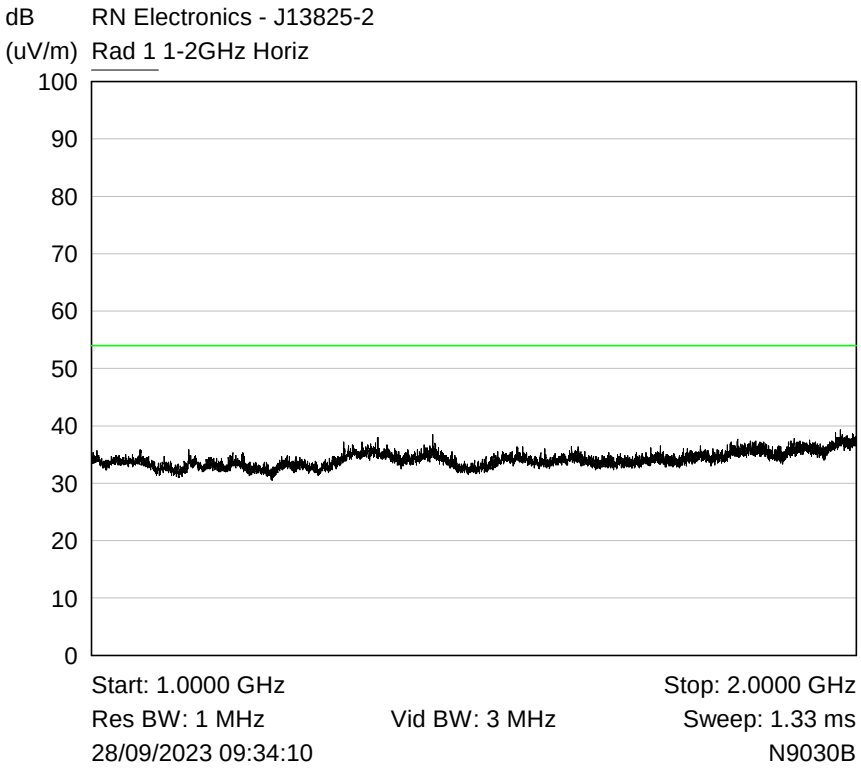
Plot of Peak emissions for UHF Horizontal against the QP limit line.

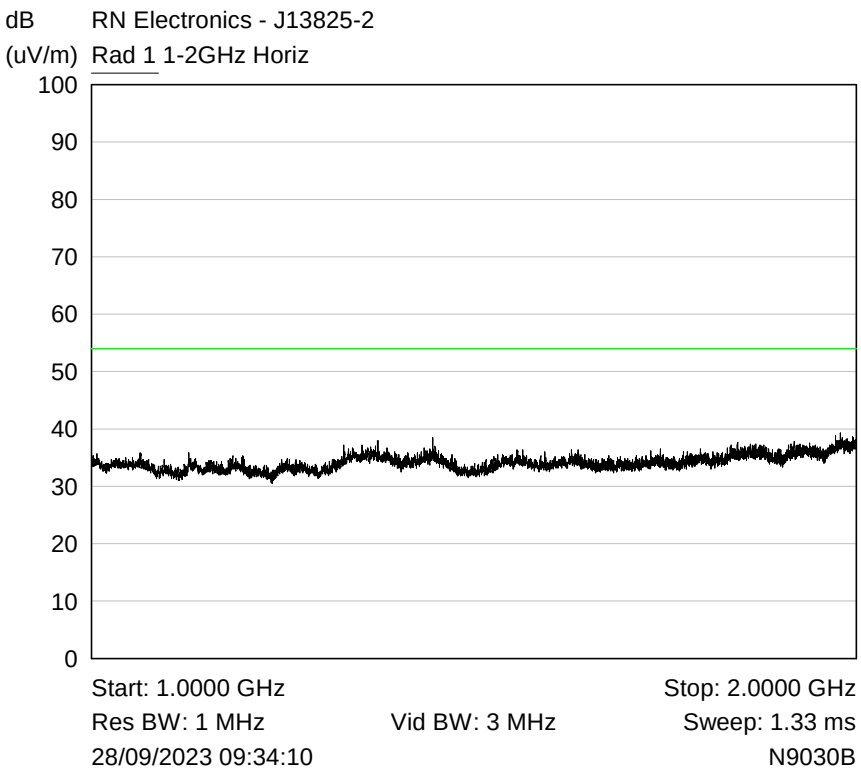


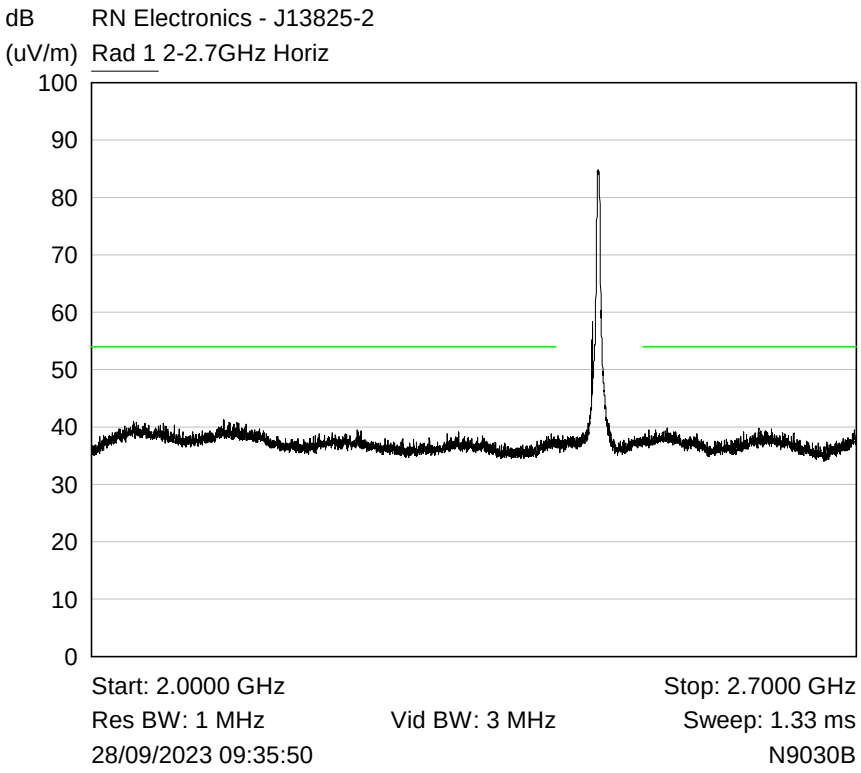
Plot of Peak emissions for UHF Vertical against the QP limit line.

6.4 Radiated emissions above 1 GHz

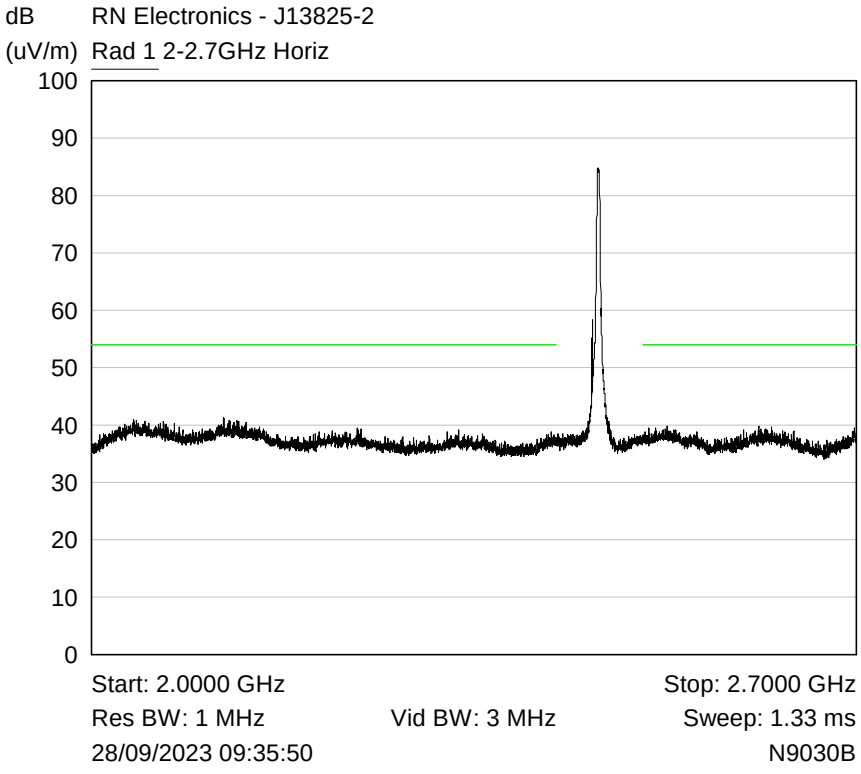
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2440 MHz



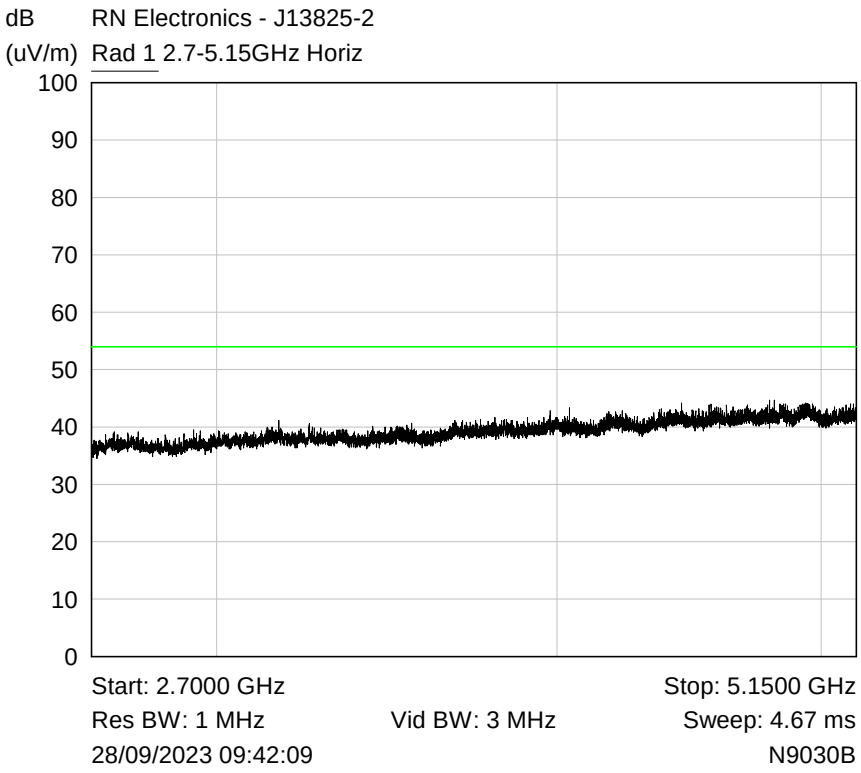


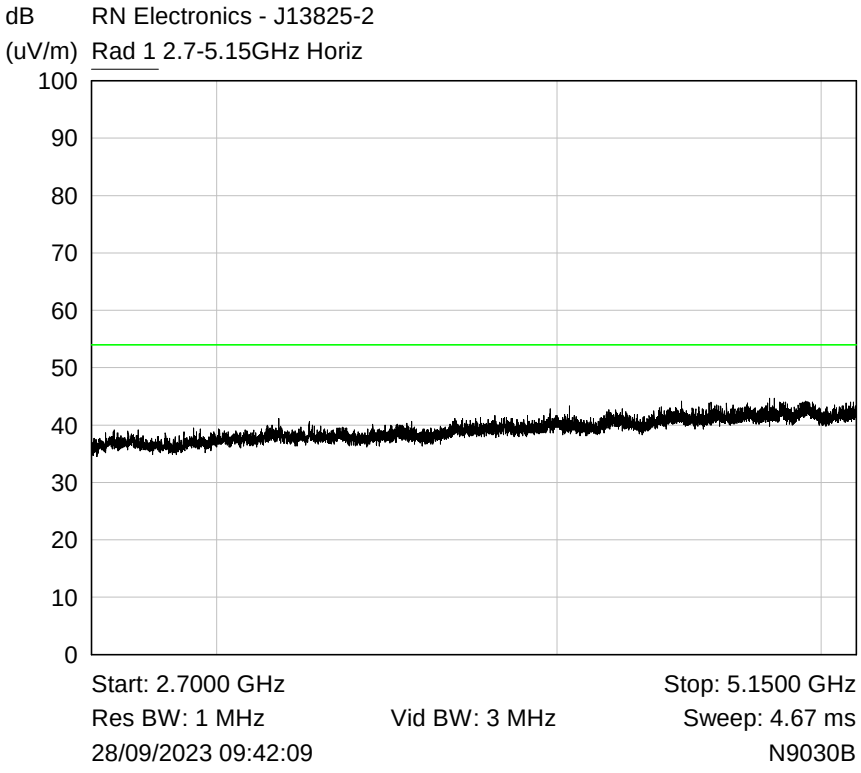


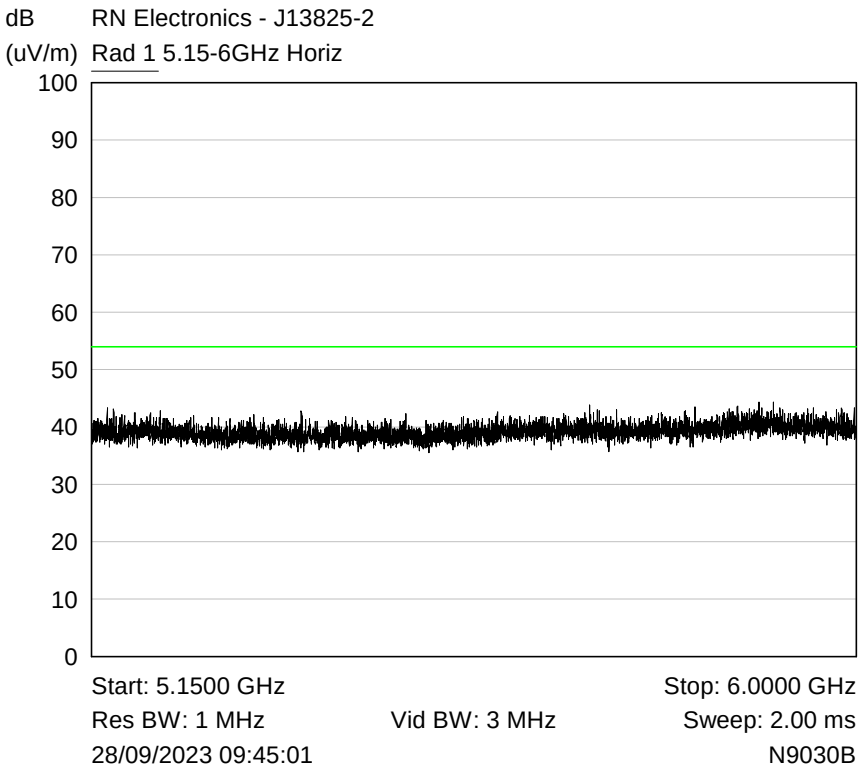
Plot shows the fundamental transmit carrier

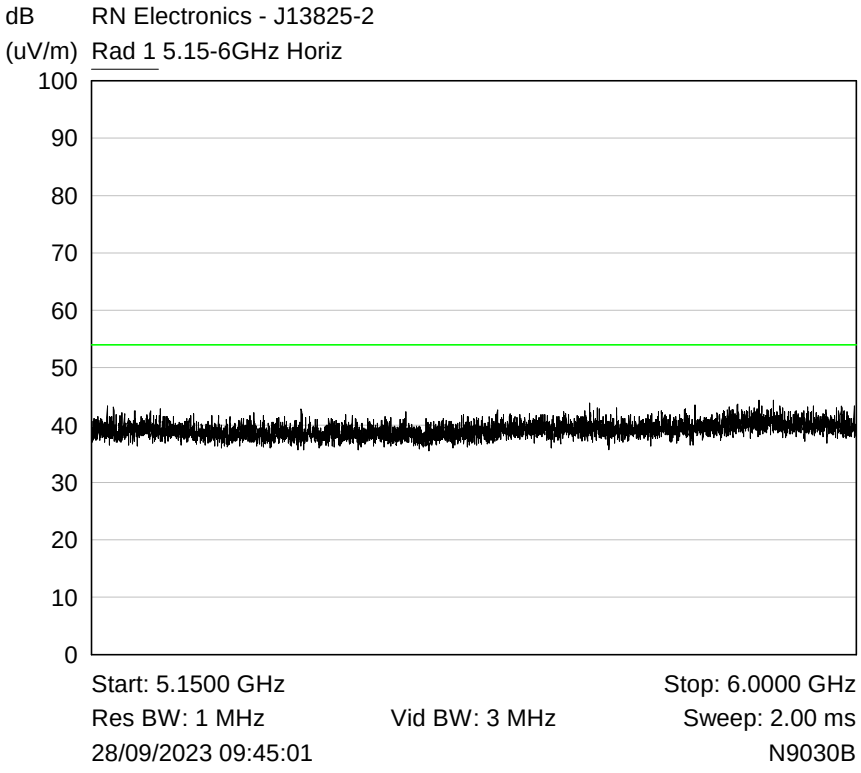


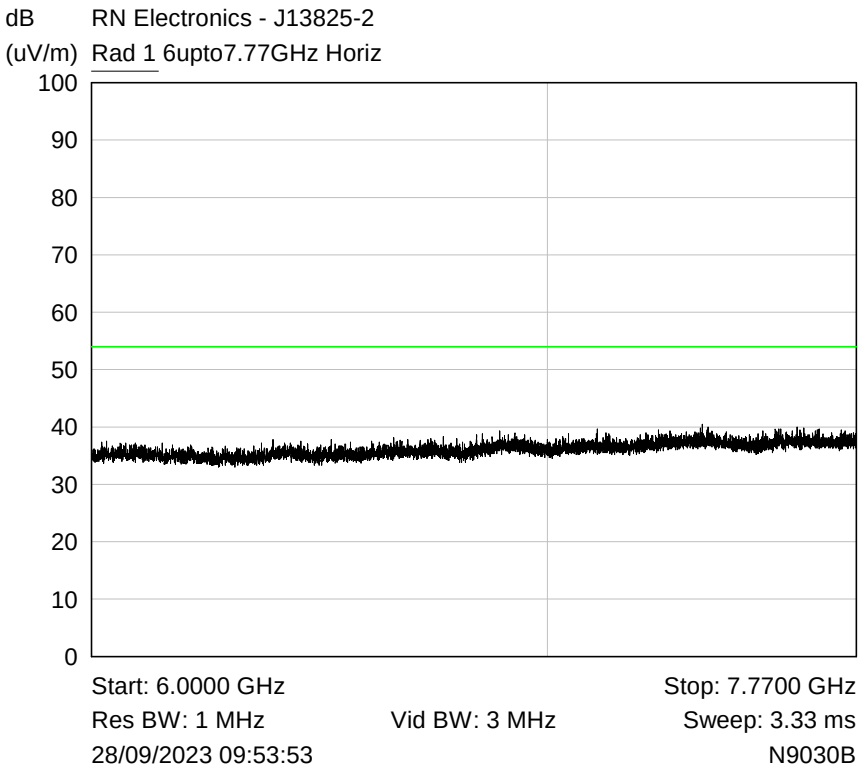
Plot shows the fundamental transmit carrier

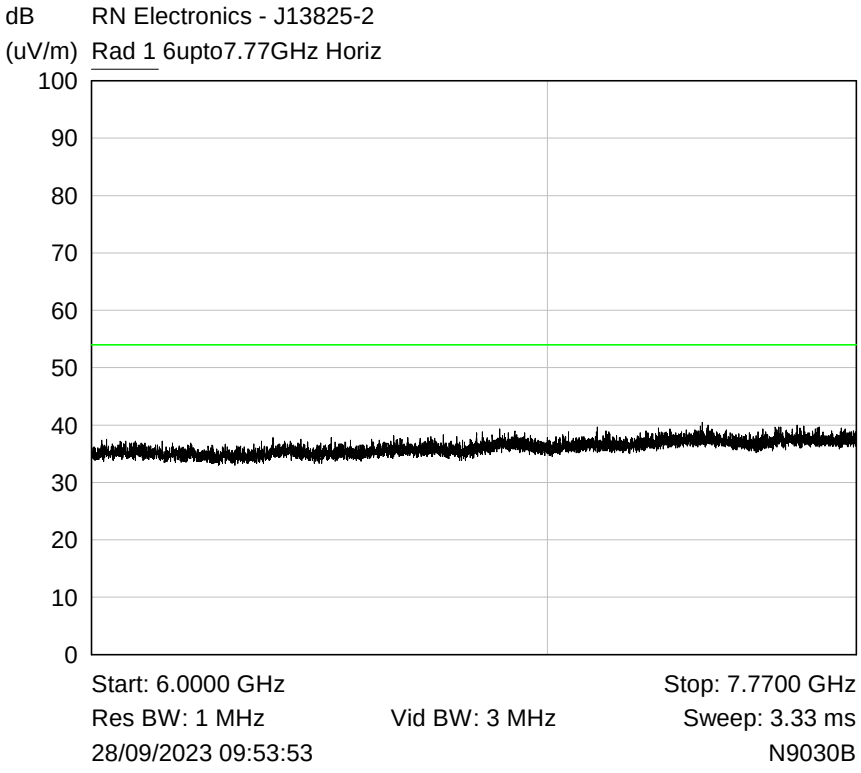

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 2.7-5.15GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 2.7000 GHz
Stop: 5.1500 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.67 ms
28/09/2023 09:42:09
N9030B

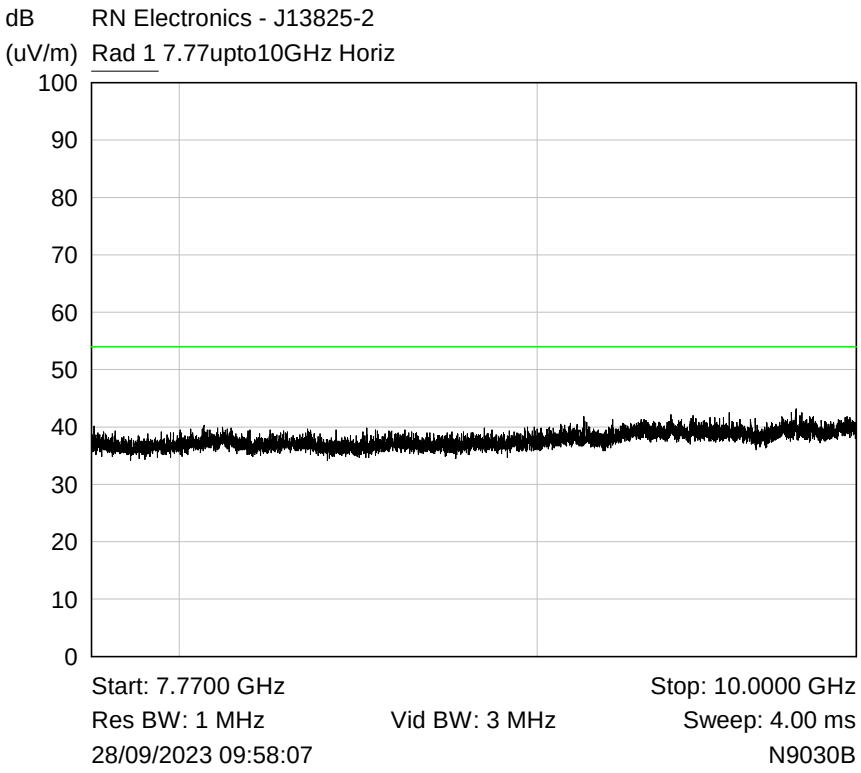

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 2.7-5.15GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 2.7000 GHz
Stop: 5.1500 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.67 ms
28/09/2023 09:42:09
N9030B

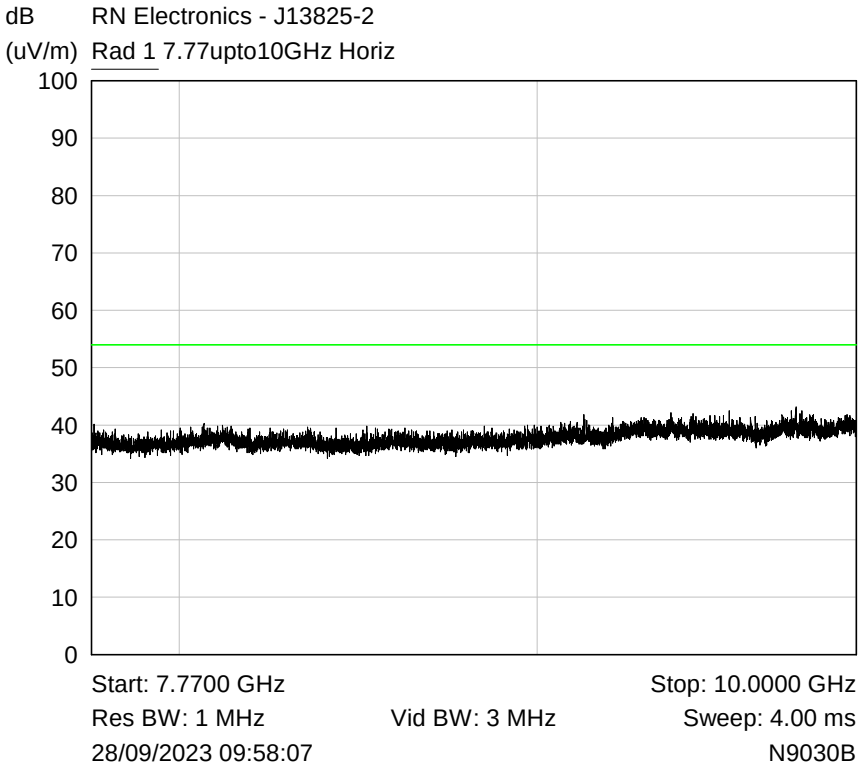

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 5.15-6GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 5.1500 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
28/09/2023 09:45:01
N9030B

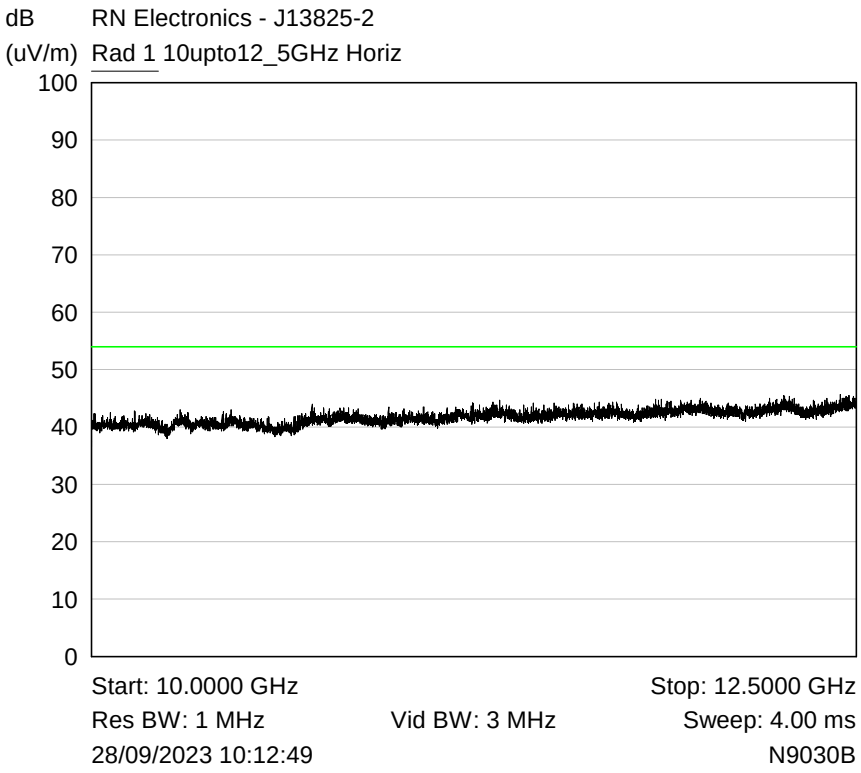

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 5.15-6GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 5.1500 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.00 ms
28/09/2023 09:45:01
N9030B

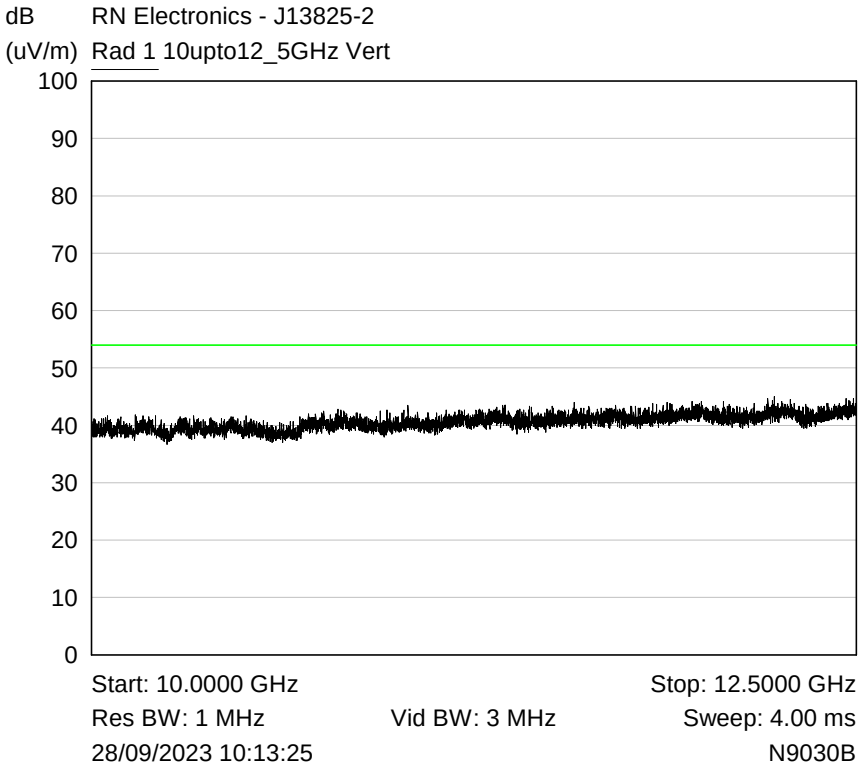

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 6upto7.77GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 3.33 ms
28/09/2023 09:53:53
N9030B

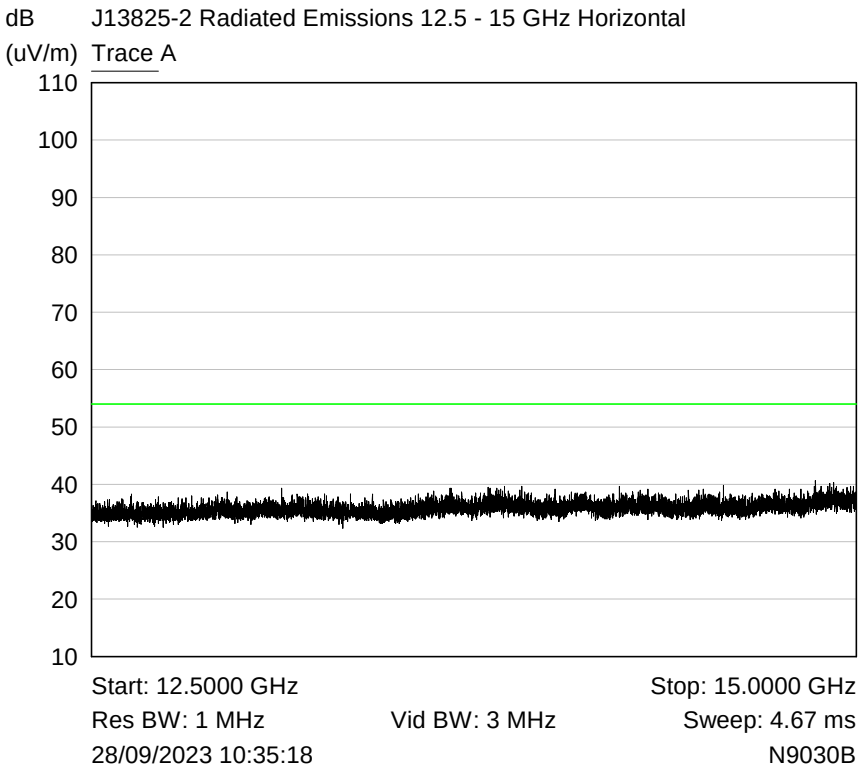

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 6upto7.77GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 6.0000 GHz
Stop: 7.7700 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 3.33 ms
28/09/2023 09:53:53
N9030B

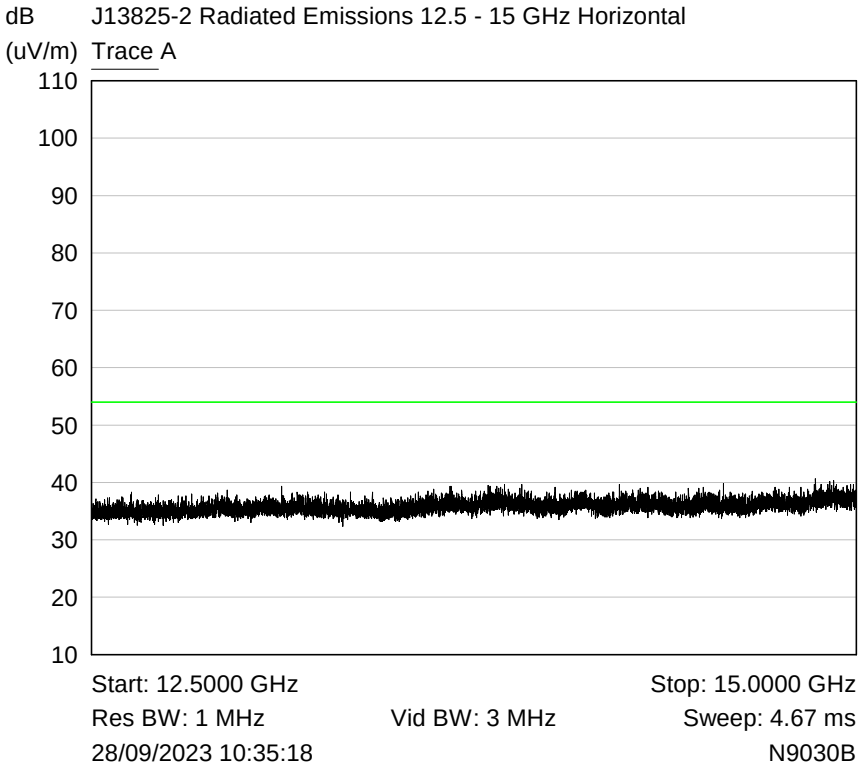

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 7.77upto10GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
28/09/2023 09:58:07
N9030B

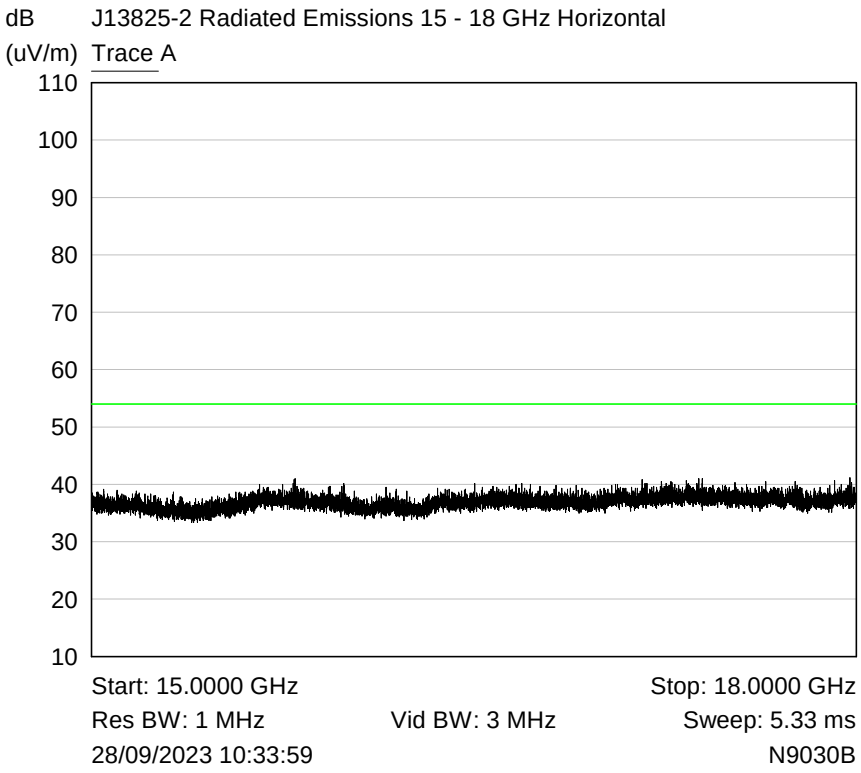

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 7.77upto10GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 7.7700 GHz
Stop: 10.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
28/09/2023 09:58:07
N9030B

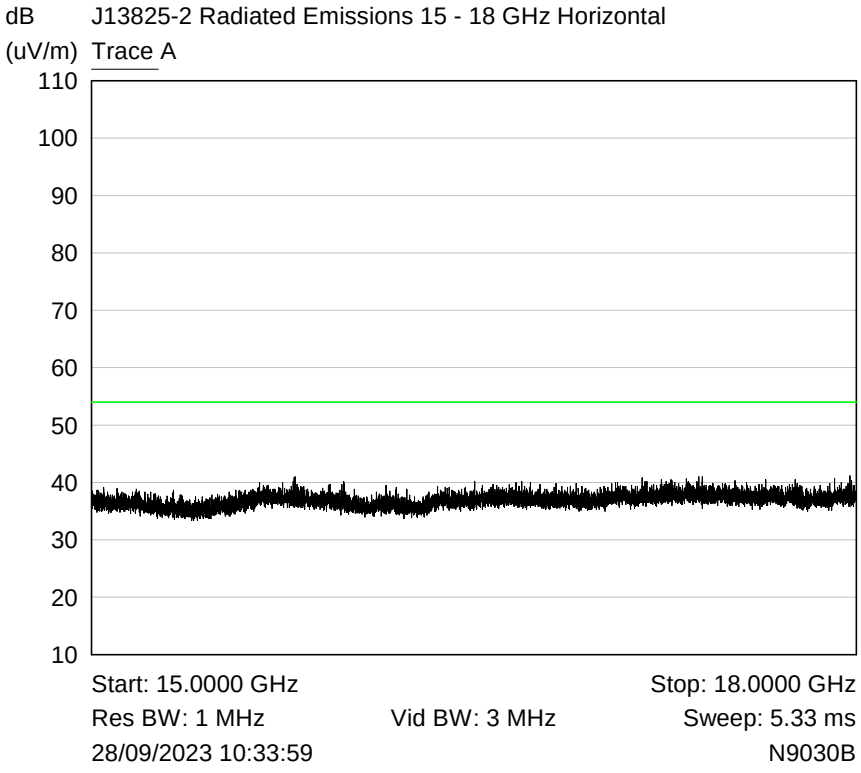

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 10upto12_5GHz Horiz
100
90
80
70
60
50
40
30
20
10
0
Start: 10.0000 GHz
Stop: 12.5000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
28/09/2023 10:12:49
N9030B

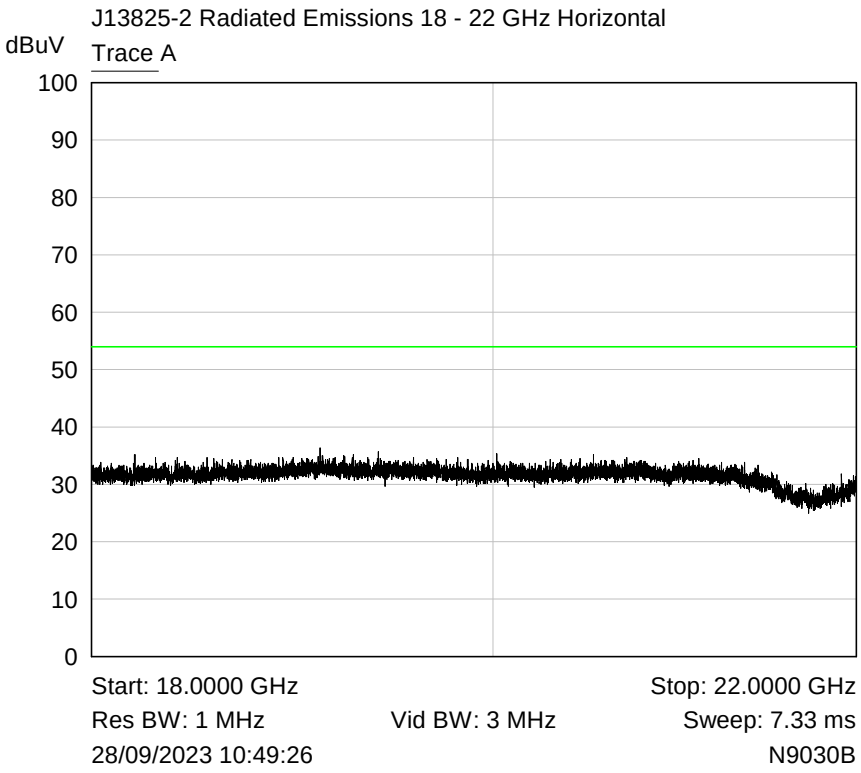

dB
(uV/m)
RN Electronics - J13825-2
Rad 1 10upto12_5GHz Vert
100
90
80
70
60
50
40
30
20
10
0
Start: 10.0000 GHz
Stop: 12.5000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 4.00 ms
28/09/2023 10:13:25
N9030B

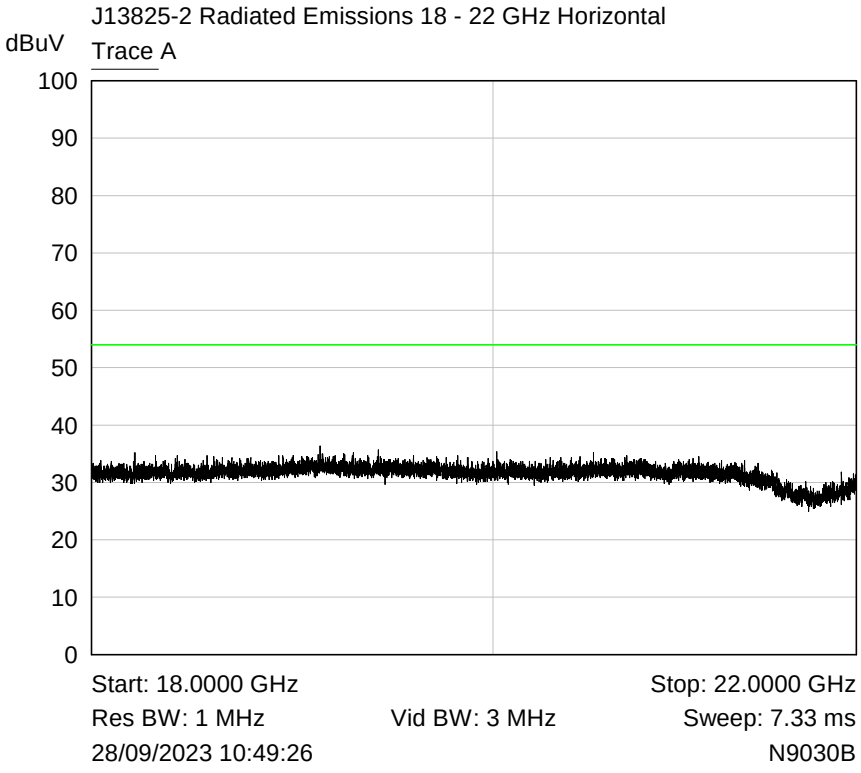


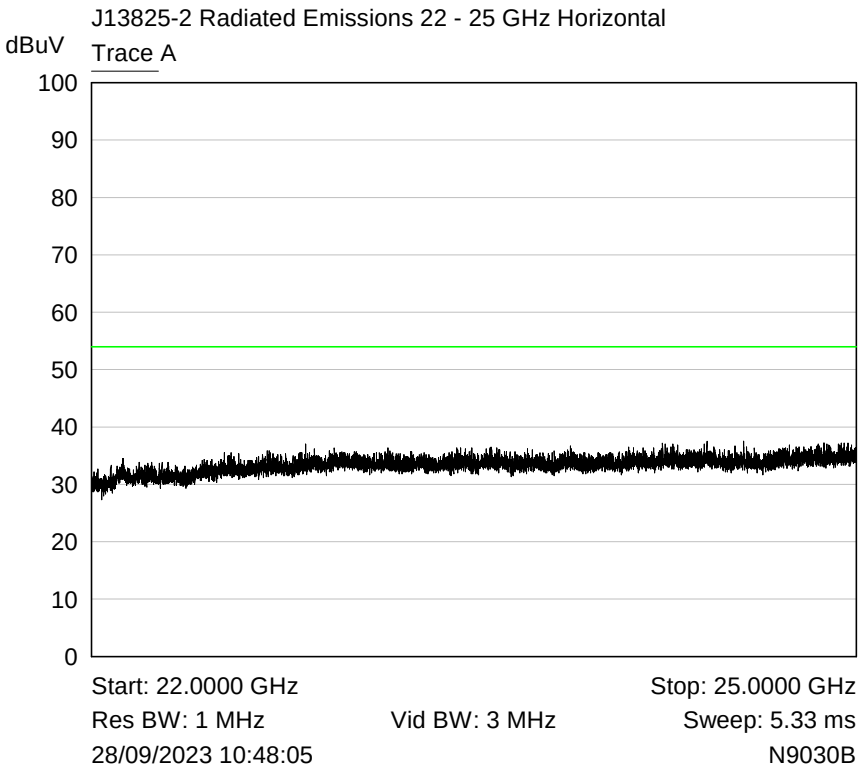


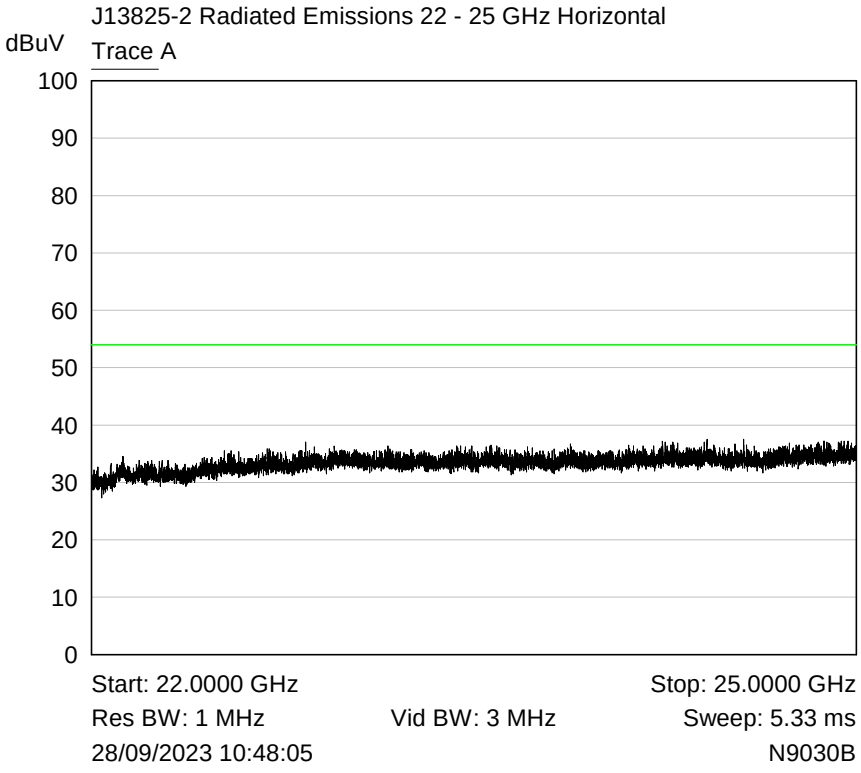

dB
(uV/m)
J13825-2 Radiated Emissions 15 - 18 GHz Horizontal
Trace A
110
100
90
80
70
60
50
40
30
20
10
Start: 15.0000 GHz
Stop: 18.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.33 ms
28/09/2023 10:33:59
N9030B


dB
(uV/m)
J13825-2 Radiated Emissions 15 - 18 GHz Horizontal
Trace A
110
100
90
80
70
60
50
40
30
20
10
Start: 15.0000 GHz
Stop: 18.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.33 ms
28/09/2023 10:33:59
N9030B


J13825-2 Radiated Emissions 18 - 22 GHz Horizontal
dBuV
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 18.0000 GHz
Stop: 22.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 7.33 ms
28/09/2023 10:49:26
N9030B

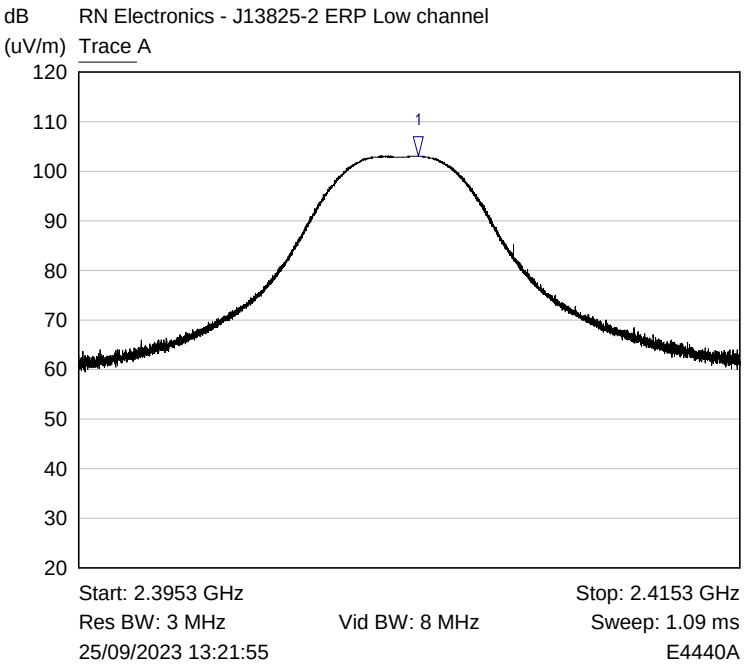

J13825-2 Radiated Emissions 18 - 22 GHz Horizontal
dBuV
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 18.0000 GHz
Stop: 22.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 7.33 ms
28/09/2023 10:49:26
N9030B


J13825-2 Radiated Emissions 22 - 25 GHz Horizontal
dBuV
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 22.0000 GHz
Stop: 25.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.33 ms
28/09/2023 10:48:05
N9030B


J13825-2 Radiated Emissions 22 - 25 GHz Horizontal
dBuV
Trace A
100
90
80
70
60
50
40
30
20
10
0
Start: 22.0000 GHz
Stop: 25.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.33 ms
28/09/2023 10:48:05
N9030B

6.5 Effective radiated power field strength

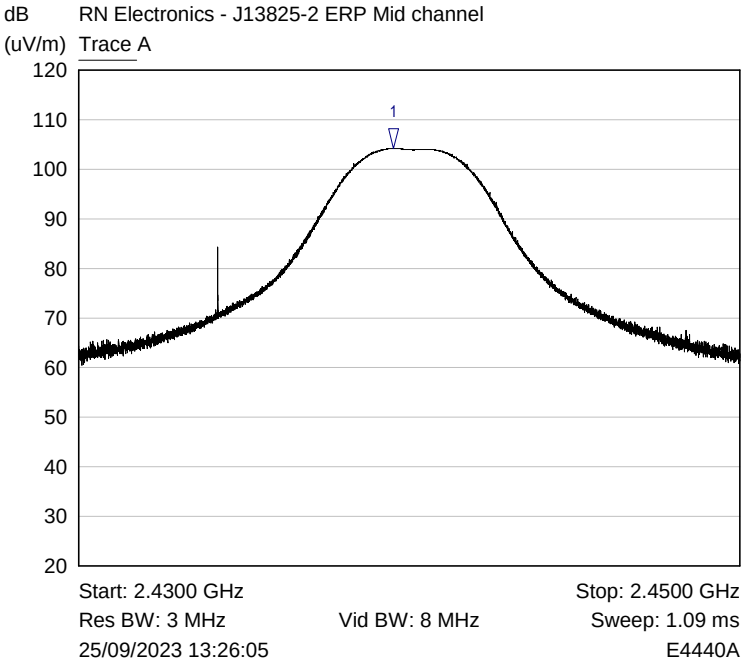
RF Parameters: Band 2400-2483.5 MHz, Power 10 dBm, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4056 GHz	102.99 dB(uV/m)	

Plot ref of Vert polarisation and EUT in Upright position

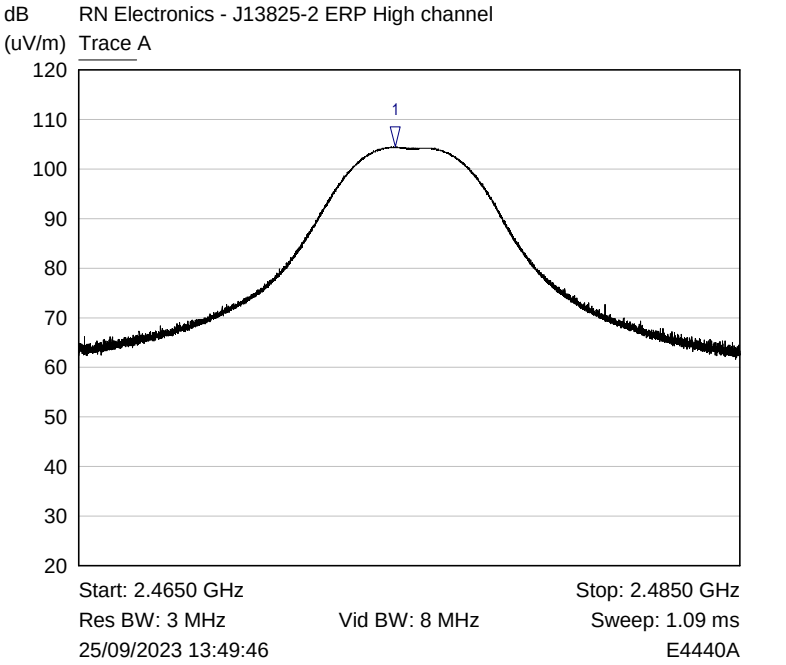
RF Parameters: Band 2400-2483.5 MHz, Power 10 dBm, Channel Spacing 5 MHz, Modulation OQPSK, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4395 GHz	104.17 dB(uV/m)	

Plot ref of Vert polarisation and EUT in Upright position

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

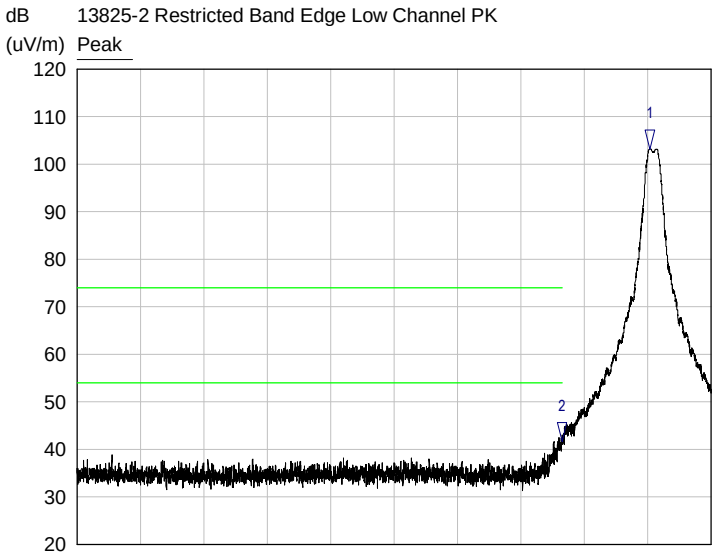


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	2.4745 GHz	104.44 dB(uV/m)	

Plot ref of Vert polarisation and EUT in Upright position

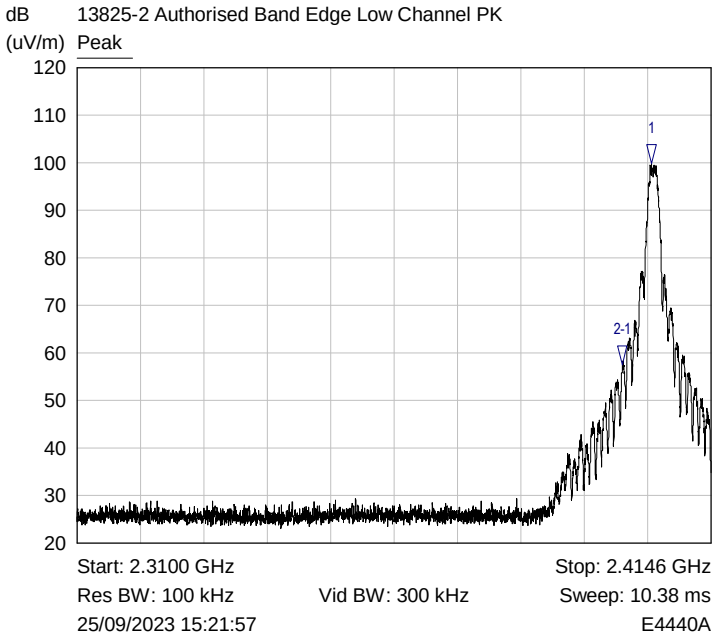
6.6 Band Edge Compliance

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation 802.15.4, Channel 2405 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Peak	2.4045 GHz	103.24 dB(uV/m)	
2	Peak	2.3900 GHz	41.69 dB(uV/m)	

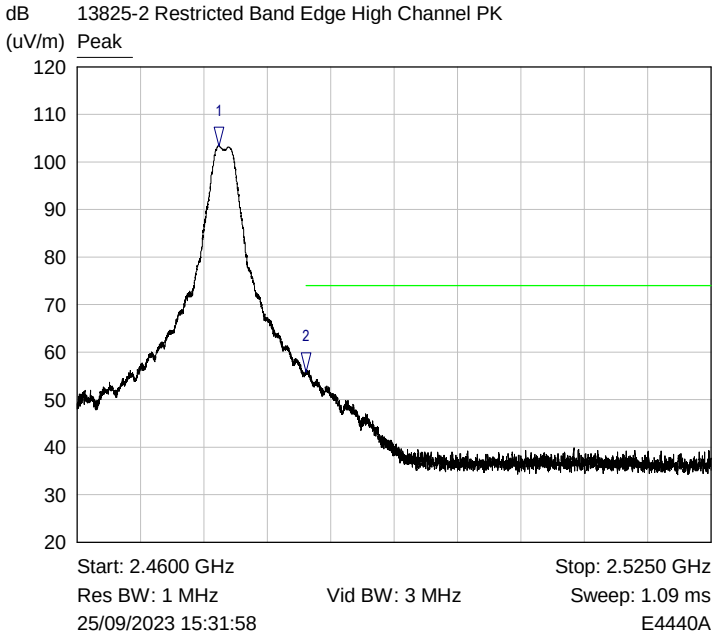
Restricted band edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1	Peak	2.4048 GHz	99.88 dB(uV/m)	
2-1	Peak	2.4000 GHz	-42.40 dB	

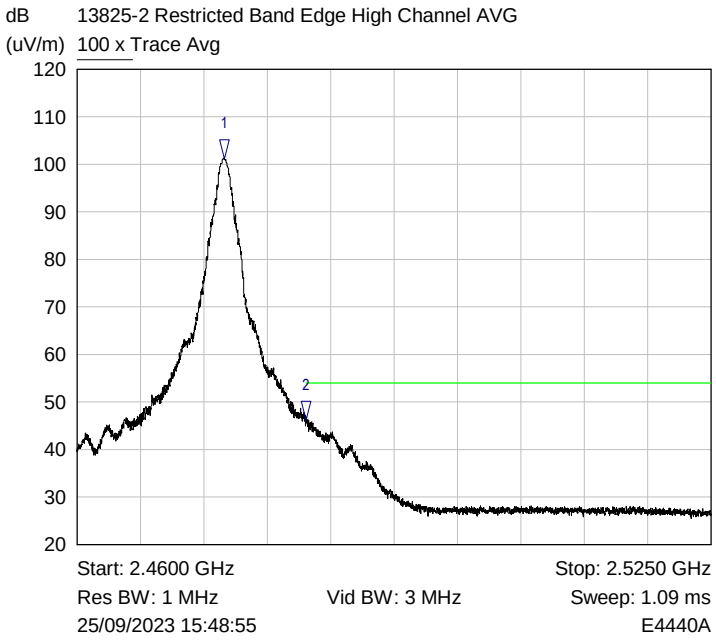
Authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation 802.15.4, Channel 2480 MHz



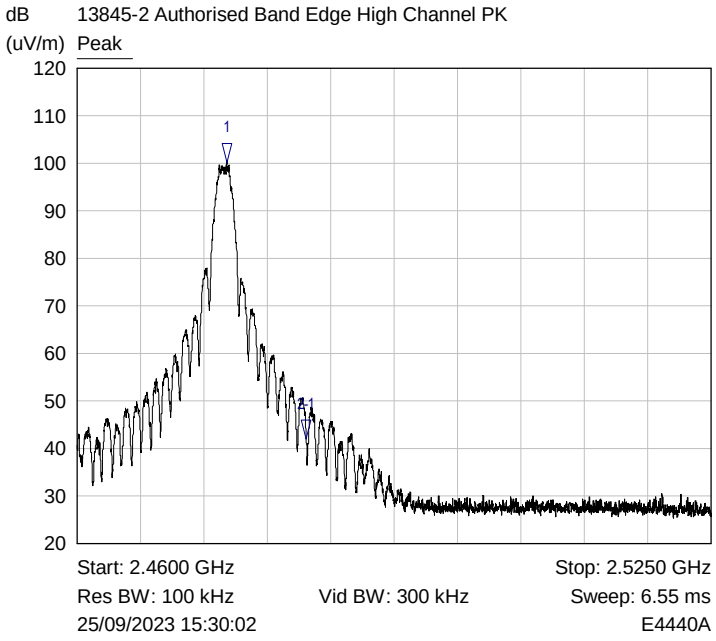
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4746 GHz	103.40 dB(uV/m)	
2 ▽	Peak	2.4835 GHz	55.82 dB(uV/m)	

Restricted band edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	100 x Trace Avg	2.4751 GHz	101.14 dB(uV/m)	
2 ▽	100 x Trace Avg	2.4835 GHz	46.10 dB(uV/m)	

Restricted band edge Average Plot

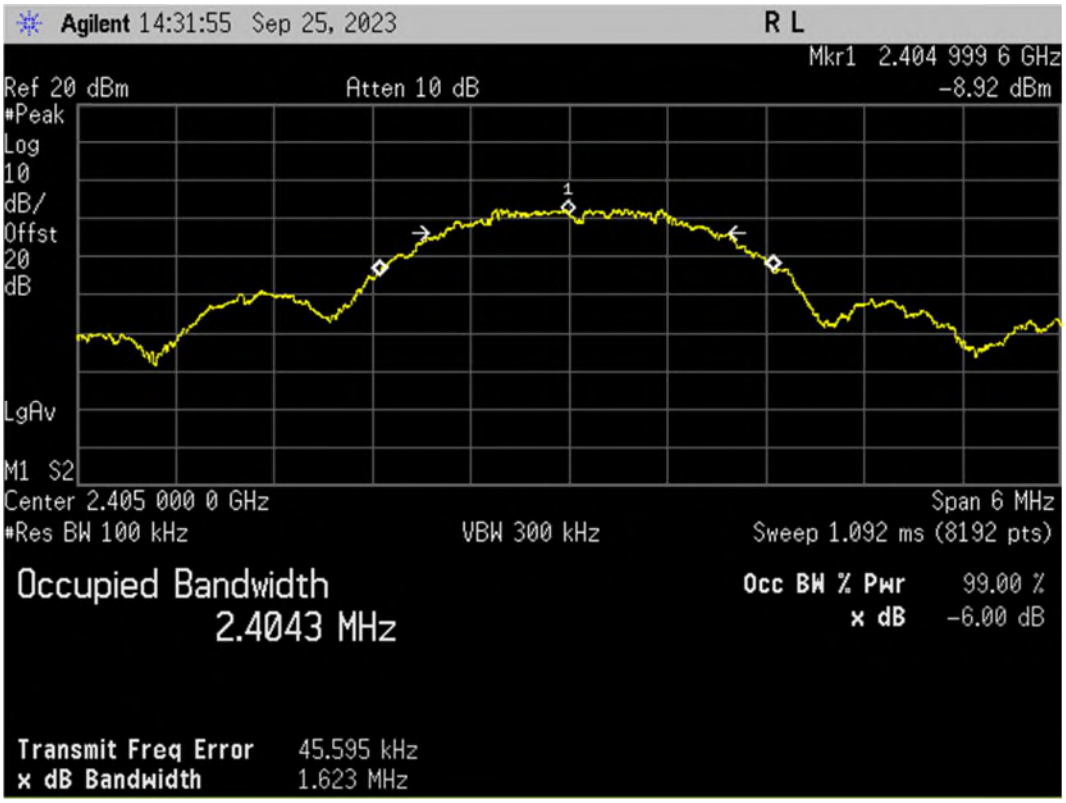


Mkr	Trace	X-Axis	Value	Notes
1	Peak	2.4753 GHz	100.11 dB(uV/m)	
2-1	Peak	2.4835 GHz	-58.03 dB	

Authorised Band Edge Plot

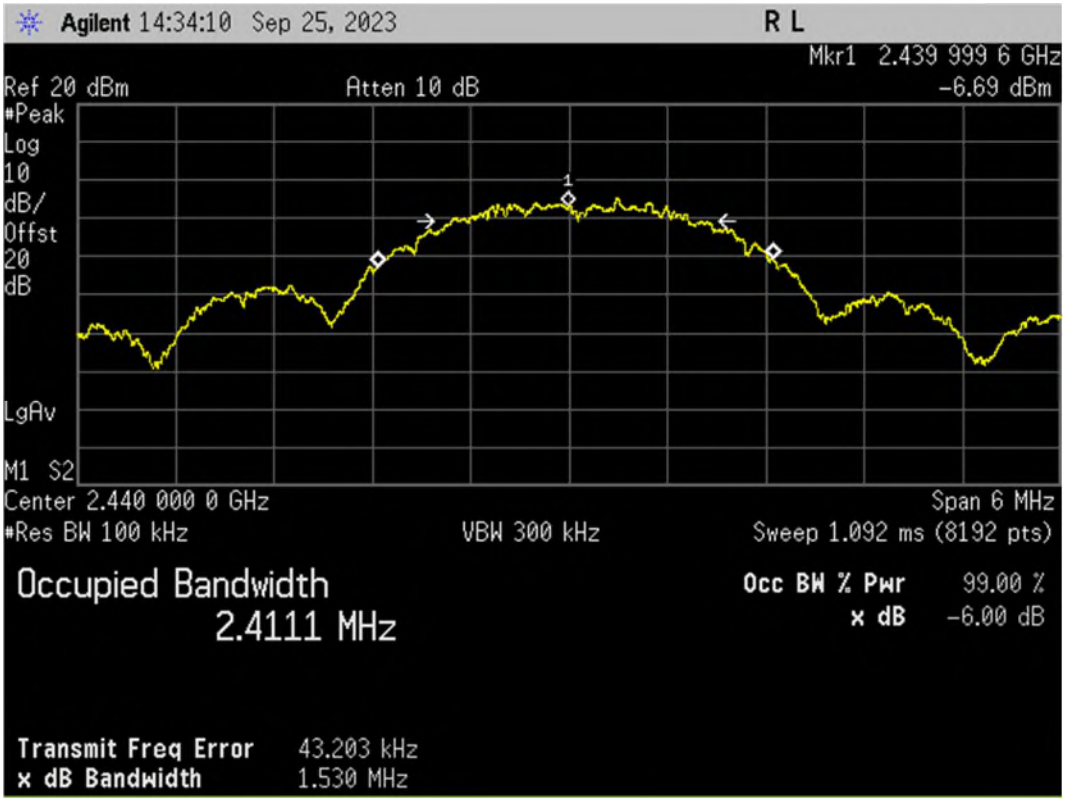
6.7 Occupied bandwidth

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation 802.15.4, Channel 2405 MHz



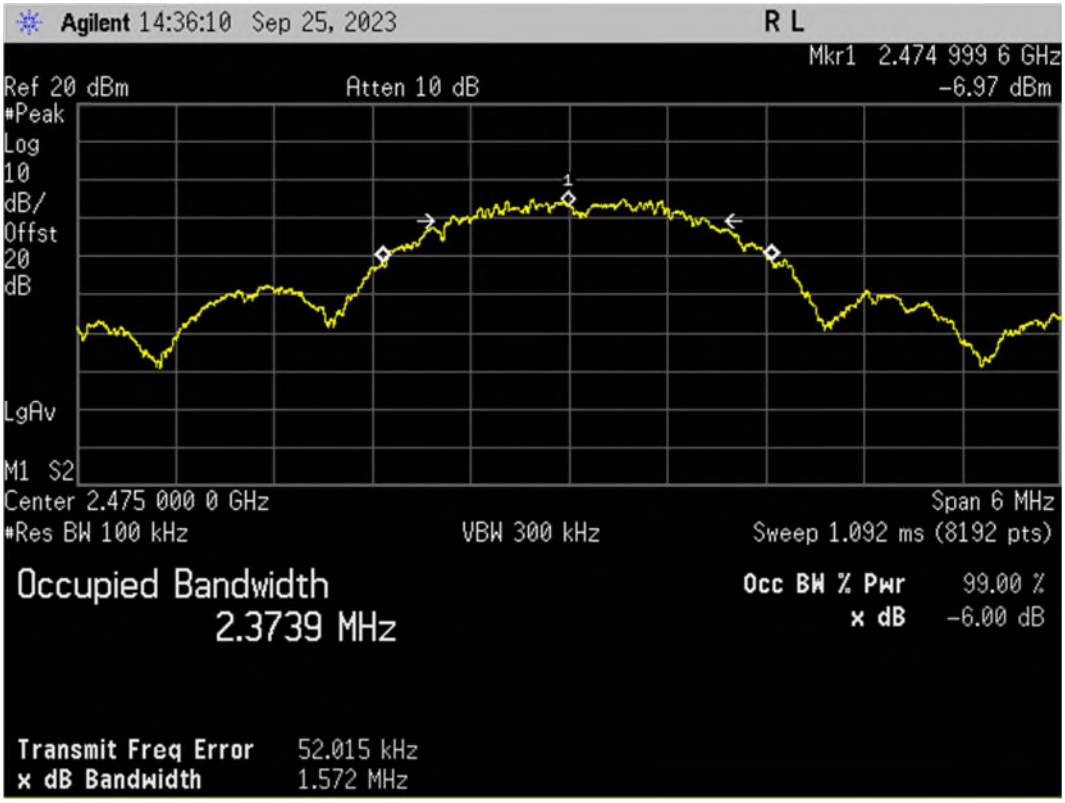
Plot for 6 dB Bandwidth Result (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation 802.15.4, Channel 2440 MHz



Plot for 6 dB Bandwidth Result (MHz)

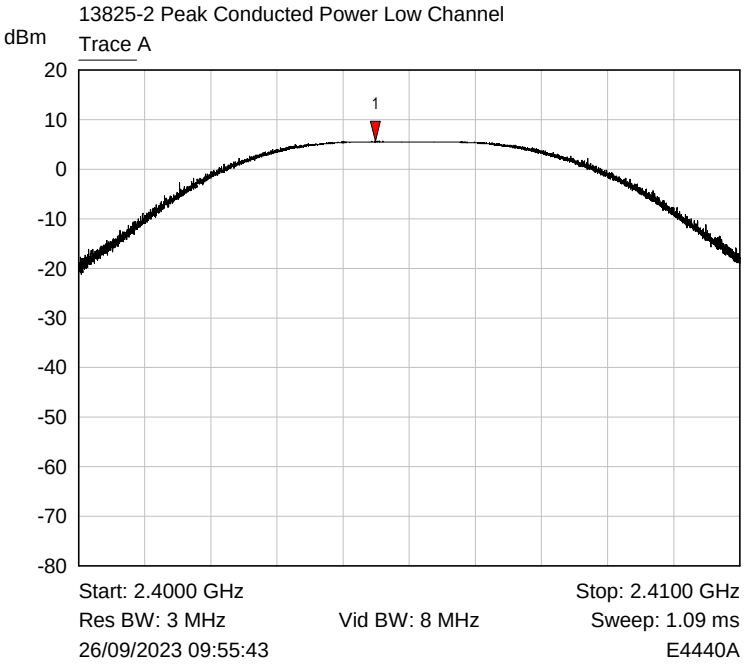
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation 802.15.4, Channel 2480 MHz



Plot for 6 dB Bandwidth Result (MHz)

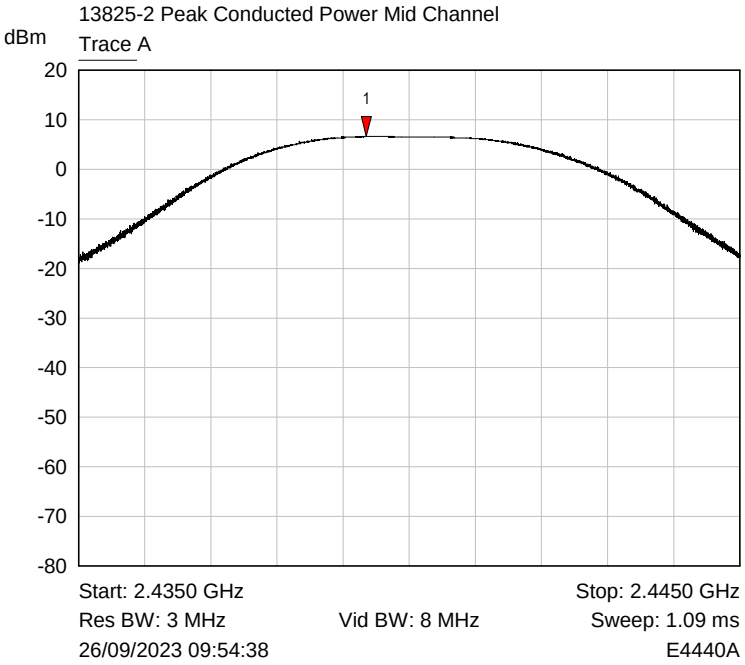
6.8 Maximum Peak conducted output power

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



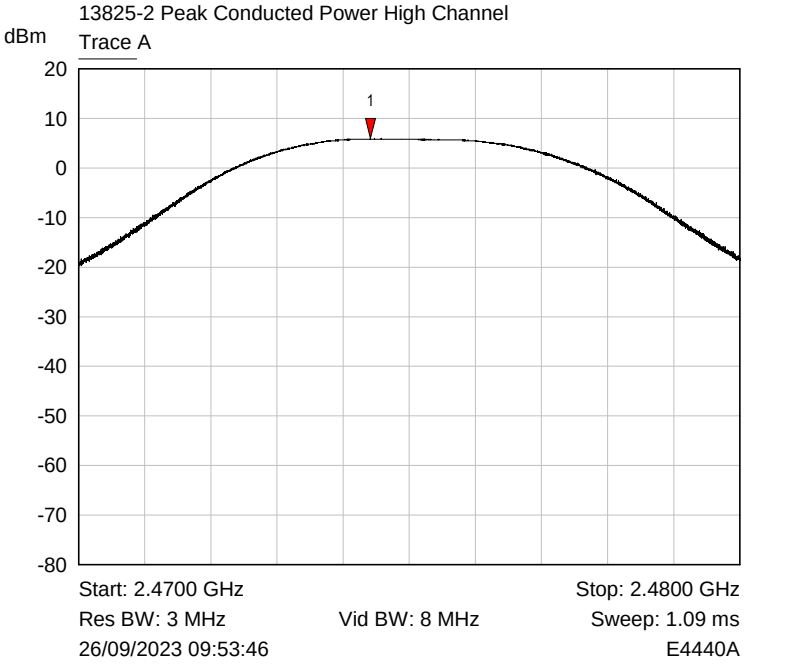
Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4045 GHz	5.60 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4394 GHz	6.65 dBm	

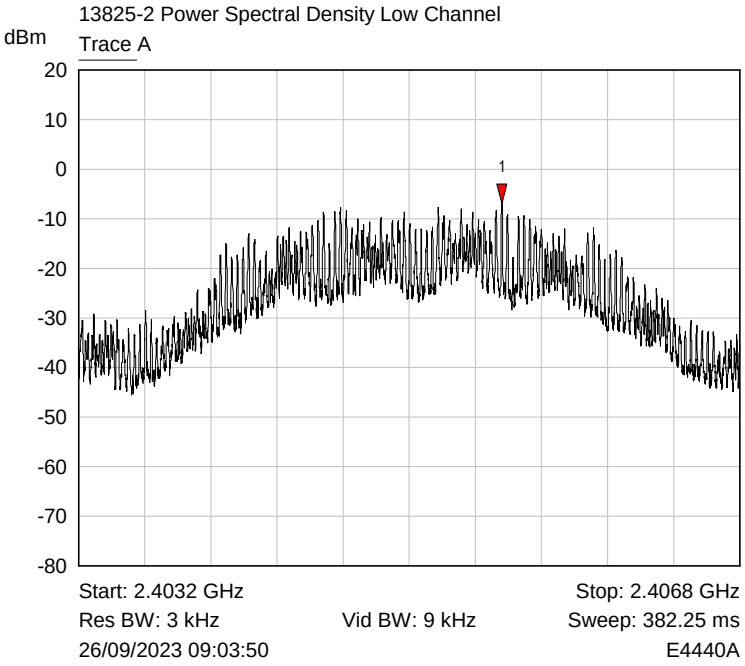
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2475 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4744 GHz	5.92 dBm	

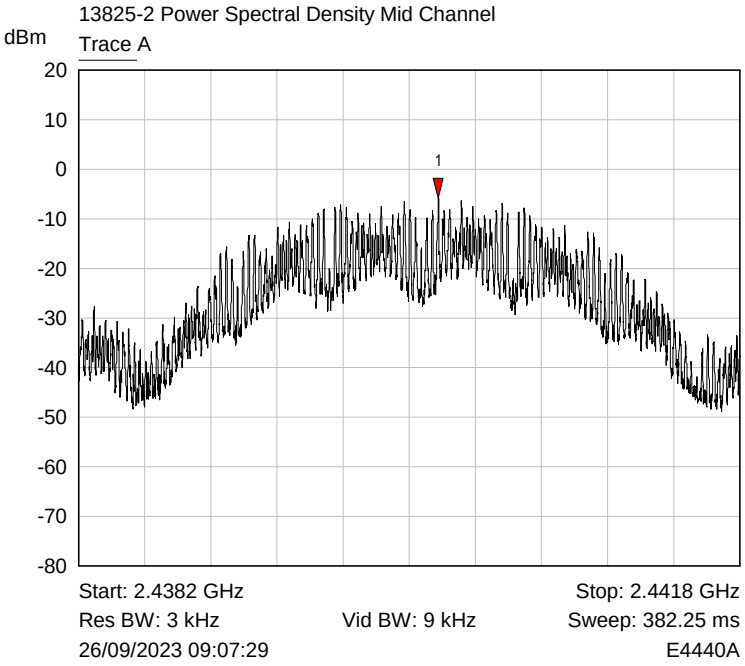
6.9 Maximum Power Spectral Density

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2405 MHz



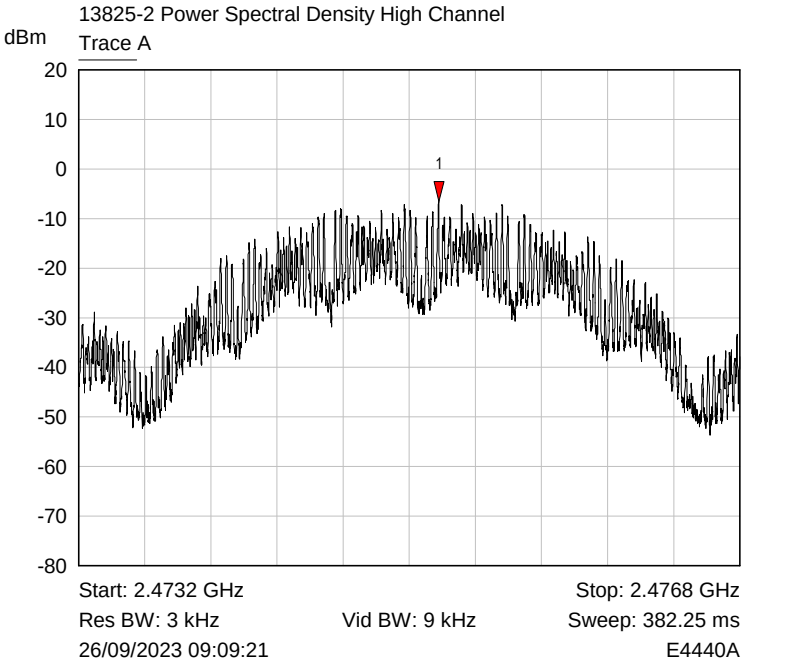
Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4055 GHz	-7.06 dBm	

RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4402 GHz	-5.82 dBm	

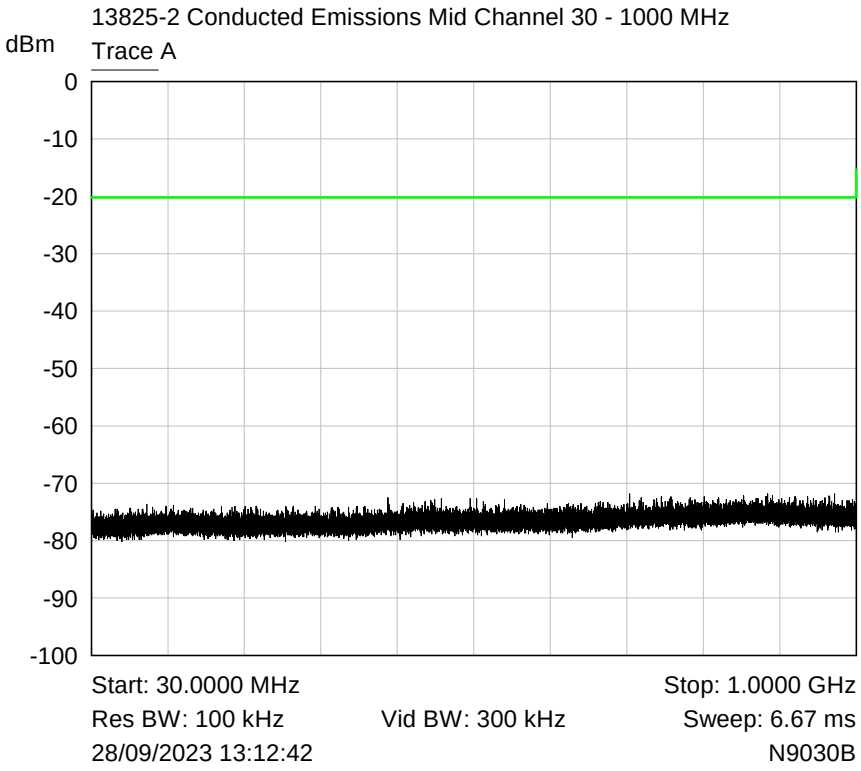
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK, Channel 2475 MHz

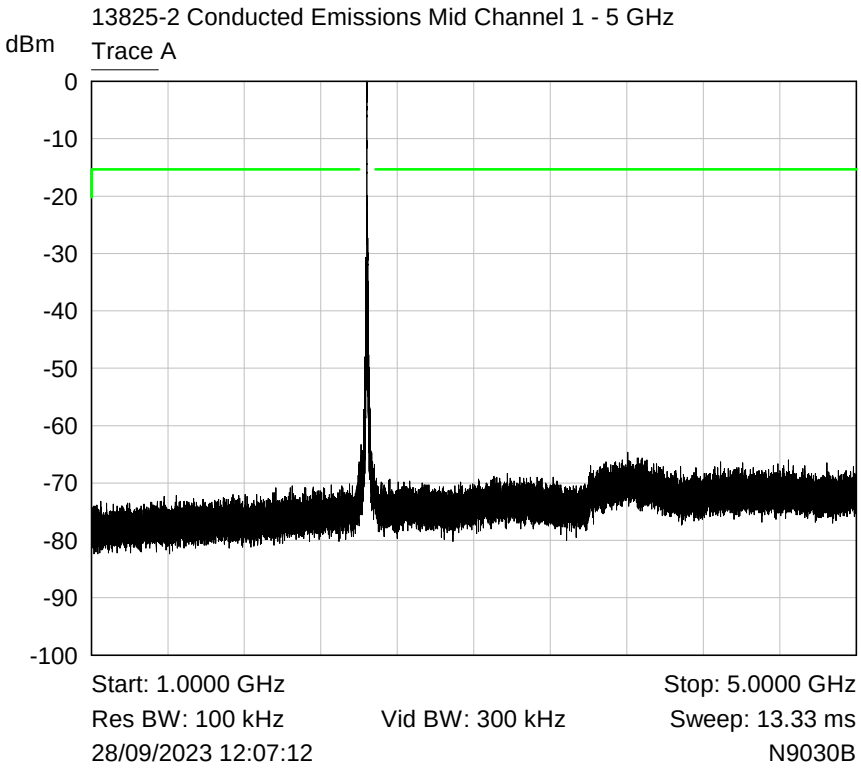


Mkr	Trace	X-Axis	Value	Notes
1	Trace A	2.4752 GHz	-6.44 dBm	

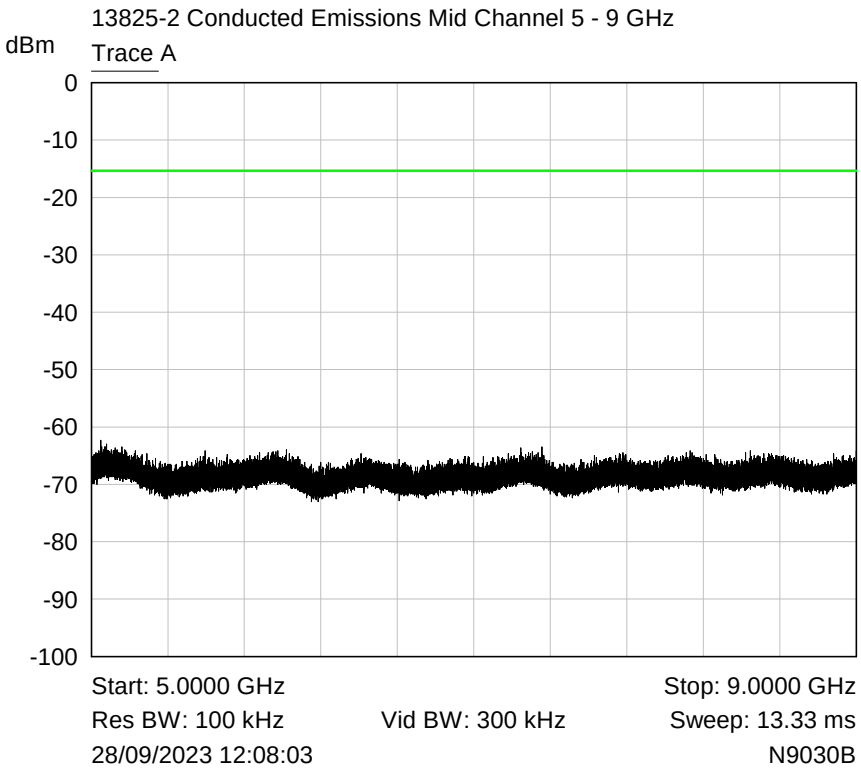
6.10 Antenna power conducted emissions

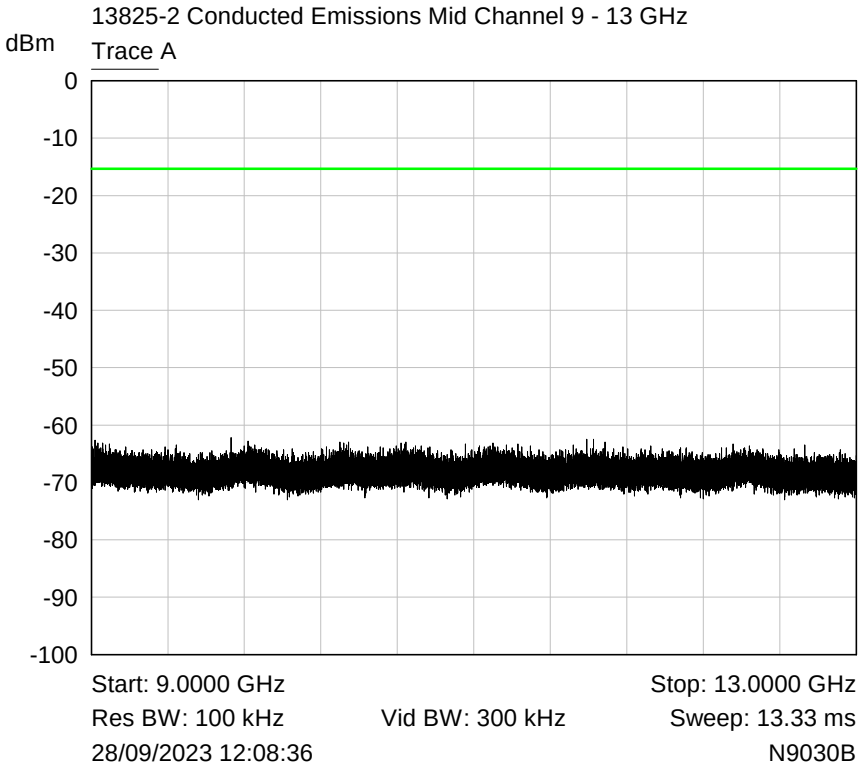
RF Parameters: Band 2400-2483.5 MHz, Power 8 dBm (conducted), Channel Spacing 5 MHz, Modulation OQPSK

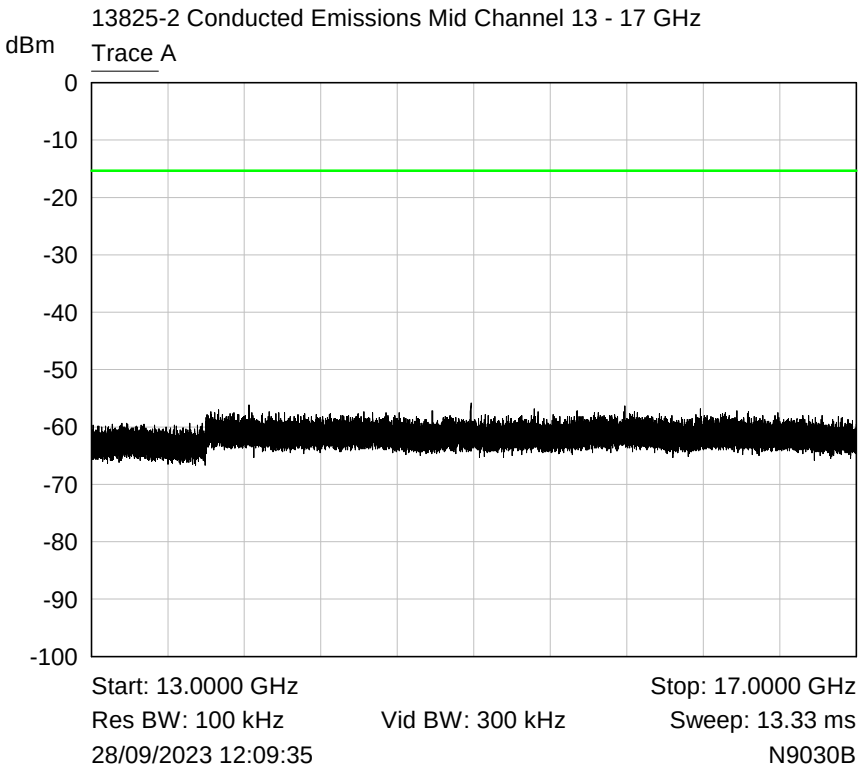


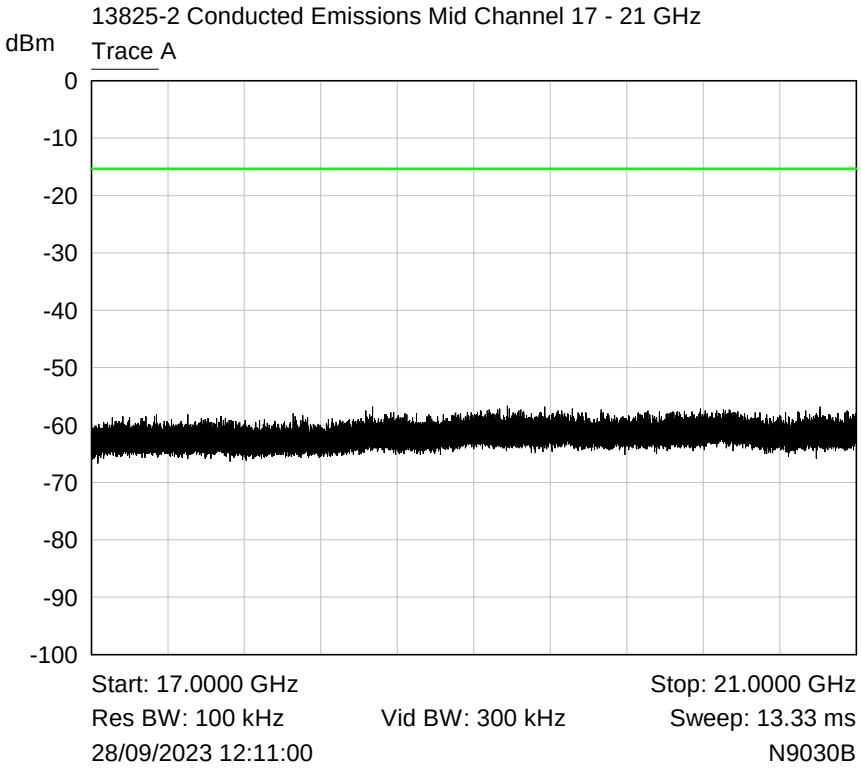


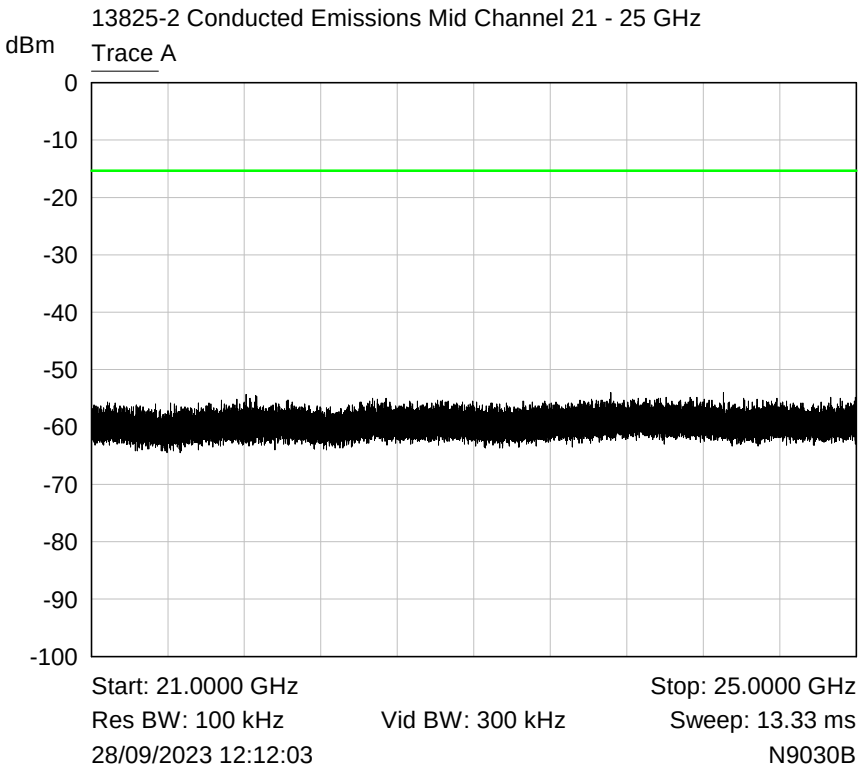
Plot shows the fundamental transmit carrier


13825-2 Conducted Emissions Mid Channel 5 - 9 GHz
dBm
Trace A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Start: 5.0000 GHz
Stop: 9.0000 GHz
Res BW: 100 kHz
Vid BW: 300 kHz
Sweep: 13.33 ms
28/09/2023 12:08:03
N9030B


13825-2 Conducted Emissions Mid Channel 9 - 13 GHz
dBm
Trace A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Start: 9.0000 GHz
Stop: 13.0000 GHz
Res BW: 100 kHz
Vid BW: 300 kHz
Sweep: 13.33 ms
28/09/2023 12:08:36
N9030B


13825-2 Conducted Emissions Mid Channel 13 - 17 GHz
dBm
Trace A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Start: 13.0000 GHz
Stop: 17.0000 GHz
Res BW: 100 kHz
Vid BW: 300 kHz
Sweep: 13.33 ms
28/09/2023 12:09:35
N9030B


13825-2 Conducted Emissions Mid Channel 17 - 21 GHz
dBm
Trace A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Start: 17.0000 GHz
Stop: 21.0000 GHz
Res BW: 100 kHz
Vid BW: 300 kHz
Sweep: 13.33 ms
28/09/2023 12:11:00
N9030B



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. Kiwa Electrical Compliance 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

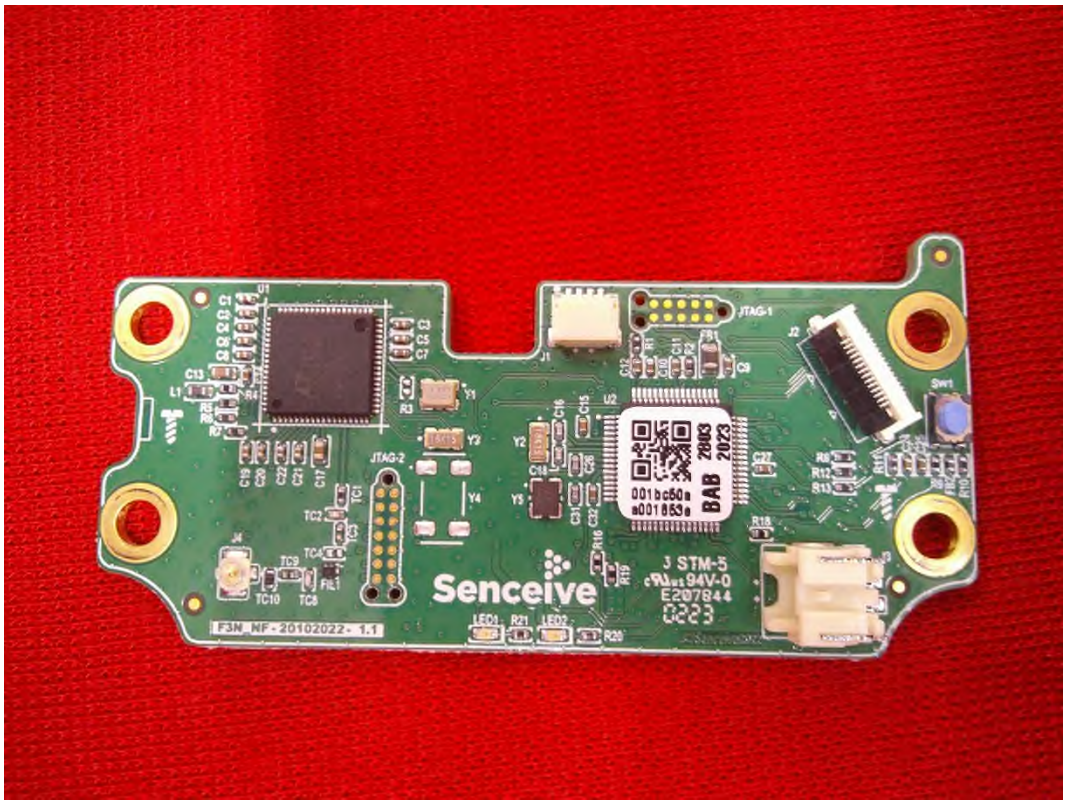
Equation 26 transposed: $E_{Spec\ limit} = \sqrt{(0.9x10^{-6} \times 377)} = 0.01842$ V/m.

And

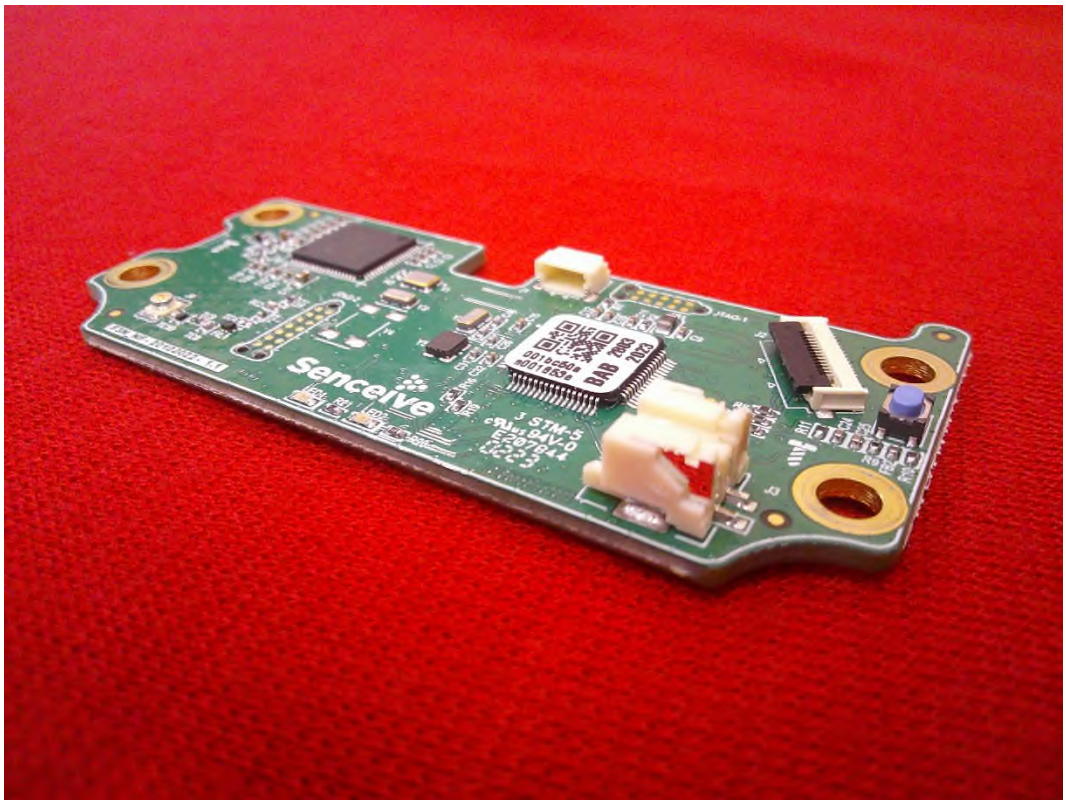
Equation 21 transposed: $E_{Log} = 20Log(0.01842) +120 = 85.3dB\mu V/m$ @ 3m.

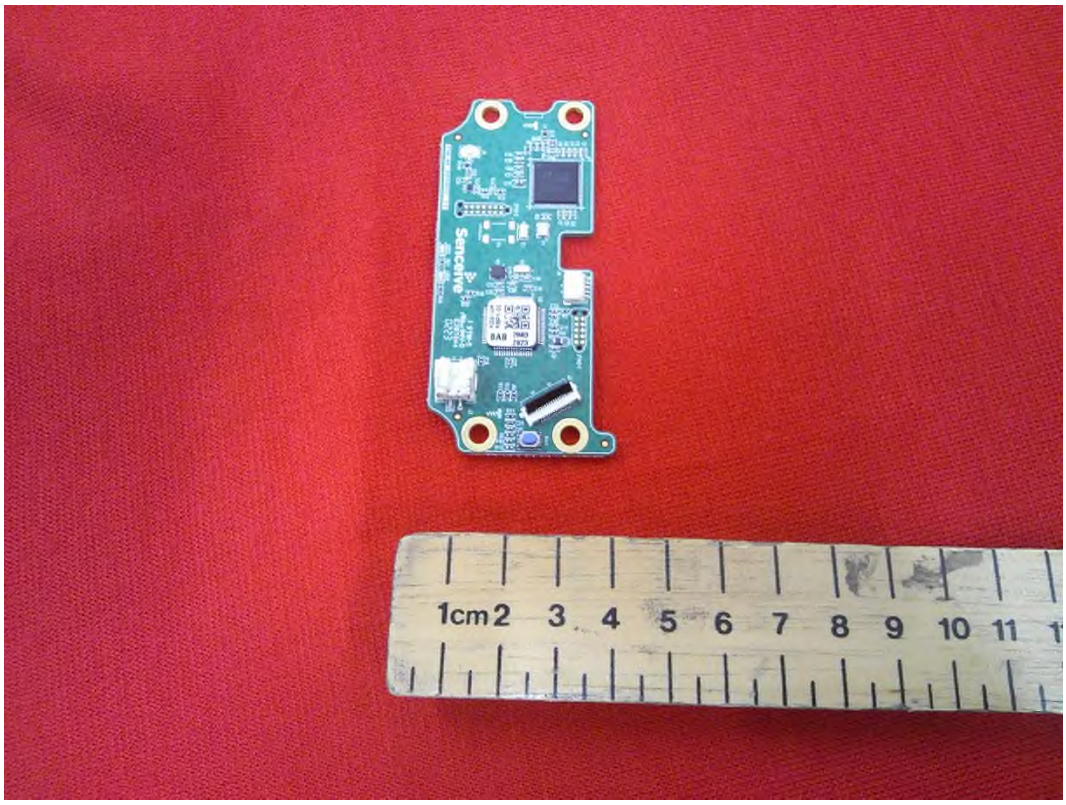
8 Photographs

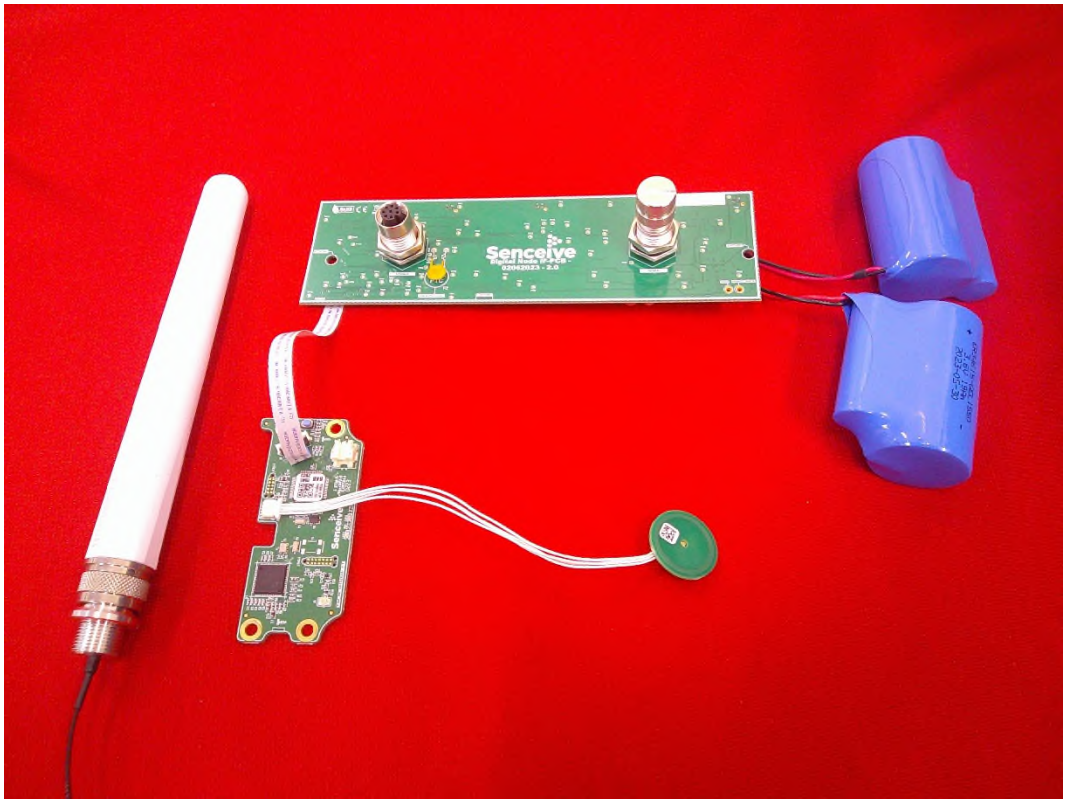
8.1 EUT Front View



EUT

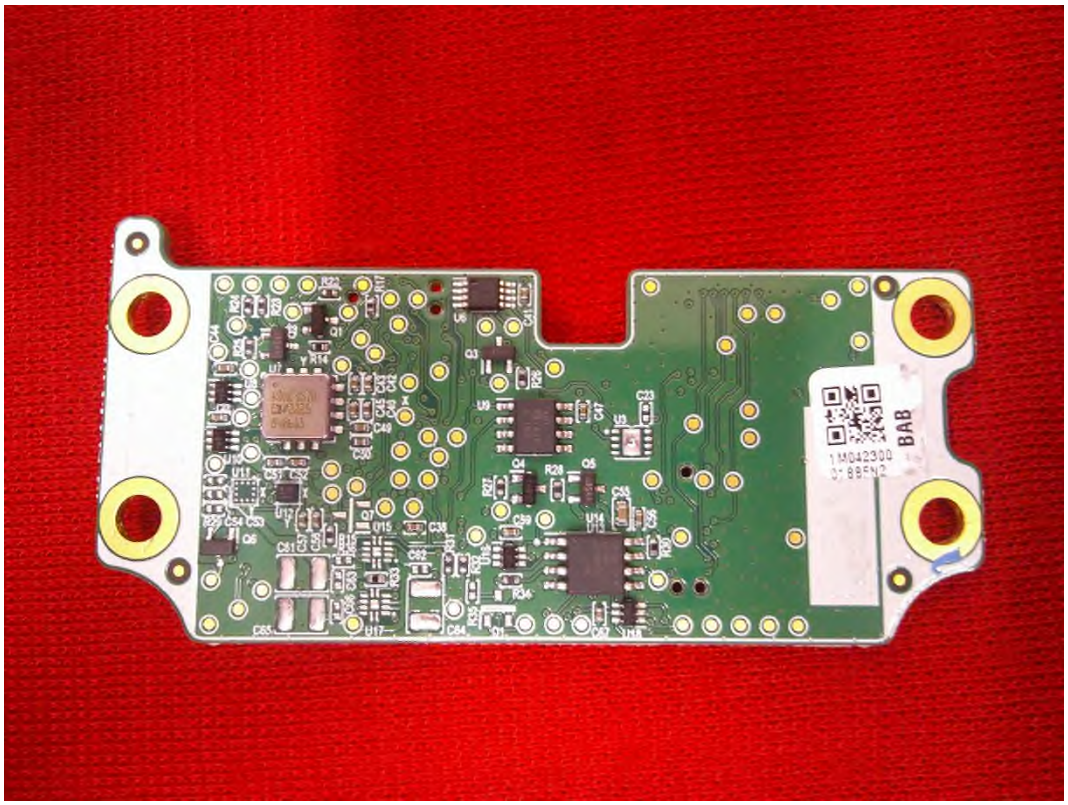




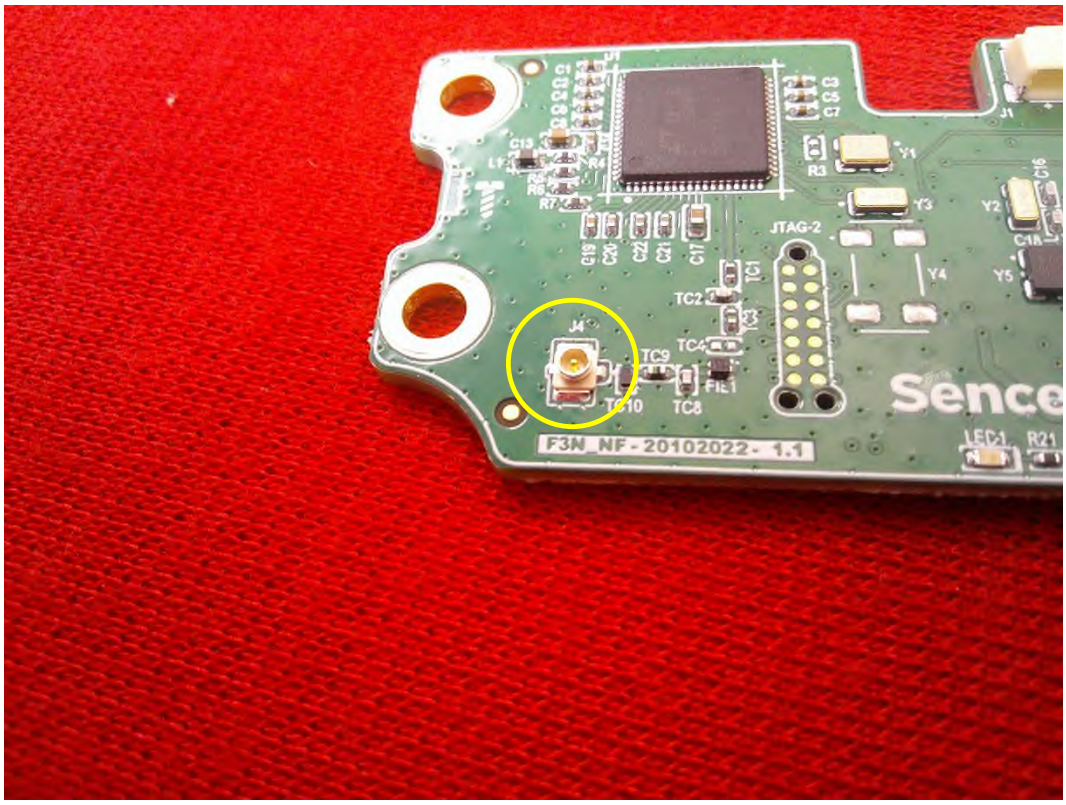


Photograph shows the EUT, I/O PCB assembly, batteries, 2.4GHz antenna and NFC antenna

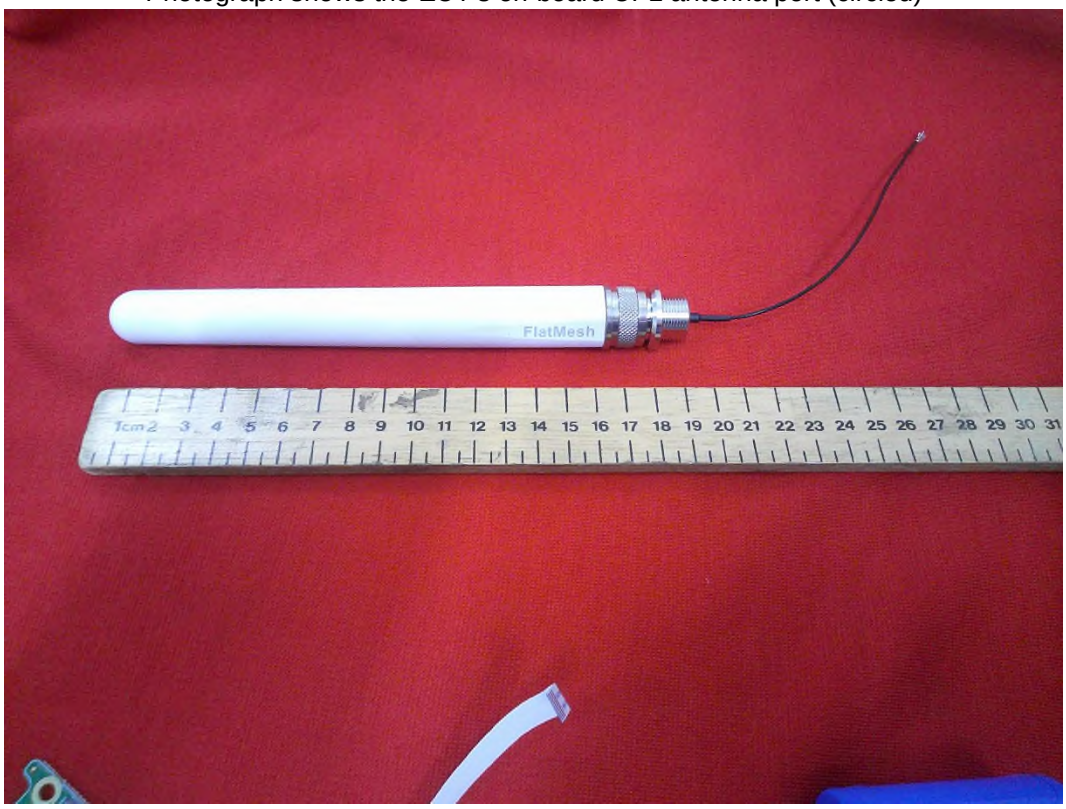
8.2 EUT Reverse Angle



8.3 EUT Antenna Port



Photograph shows the EUT's on-board UFL antenna port (circled)



Photograph shows the 2.4 GHz antenna

8.4 EUT Display & Controls

The EUT is a PCB assembly and has no display or controls.

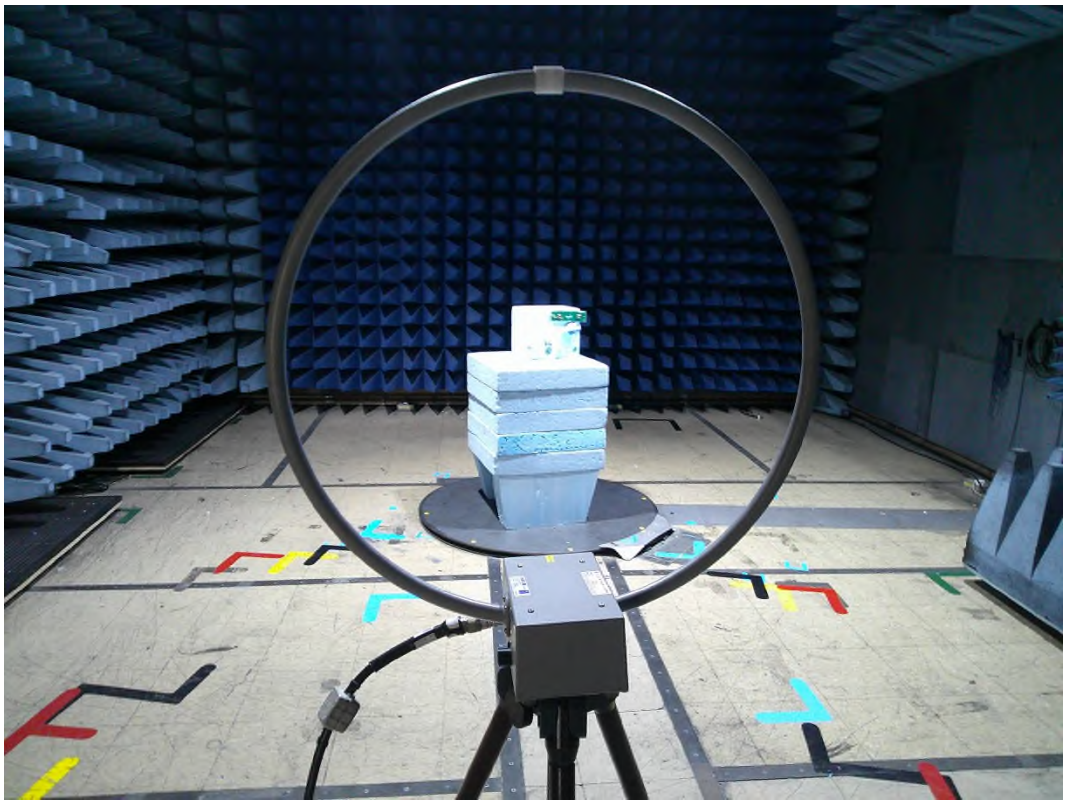
8.5 EUT ID Label

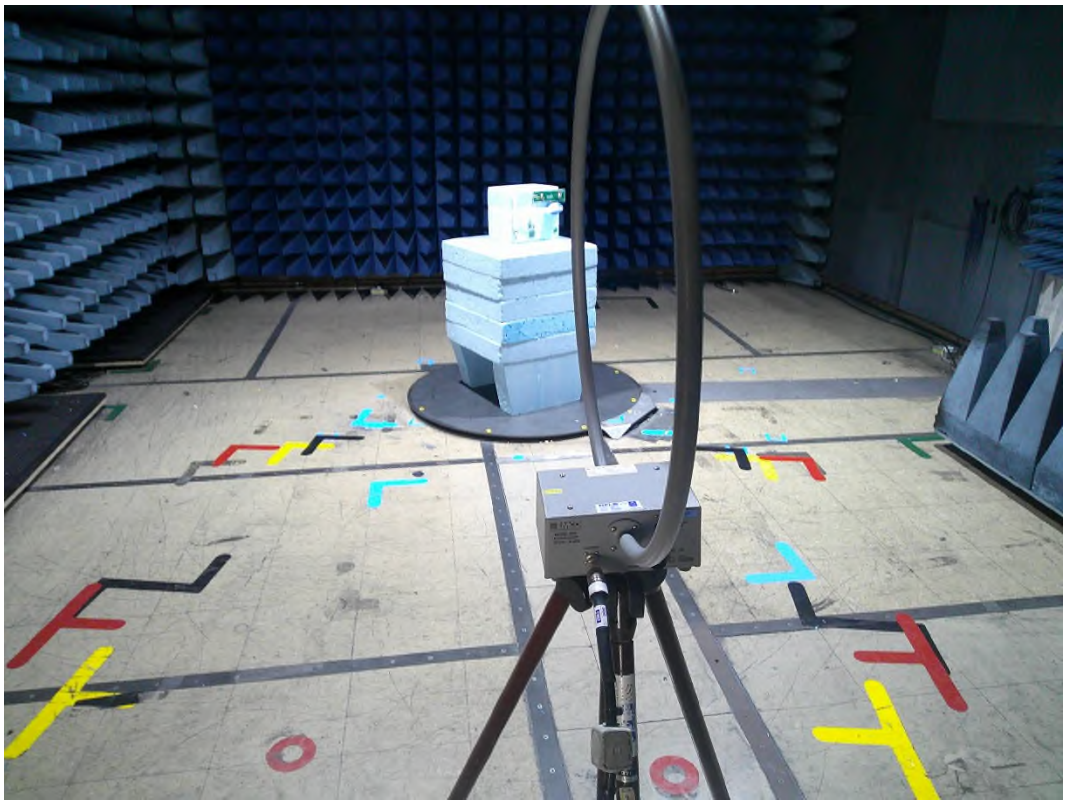
The EUT is a PCB assembly and has no label

8.6 EUT Chassis

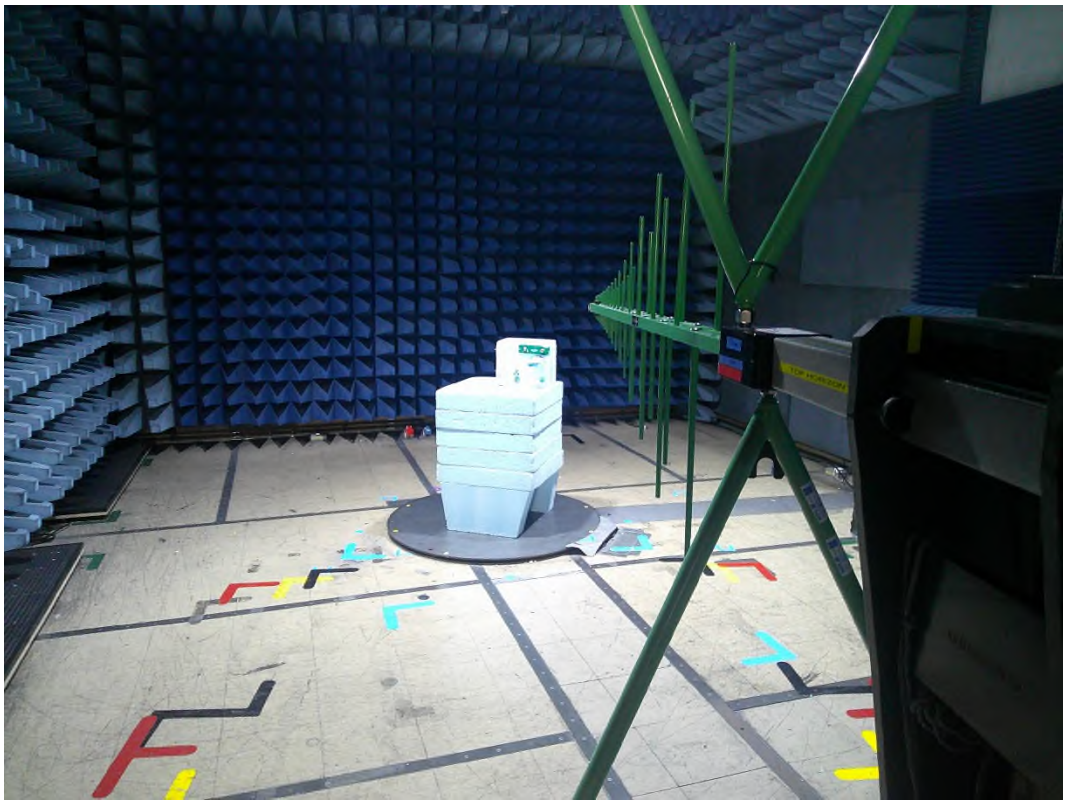
The EUT has no chassis

8.7 Radiated emissions 150 kHz - 30 MHz

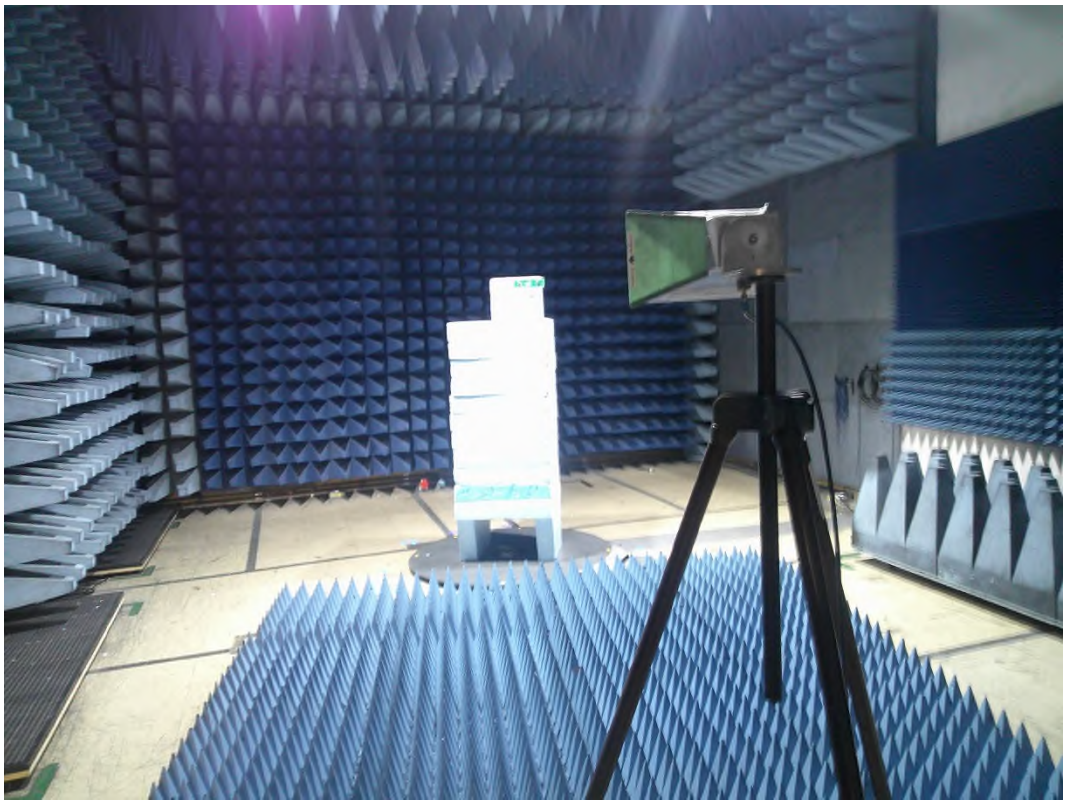


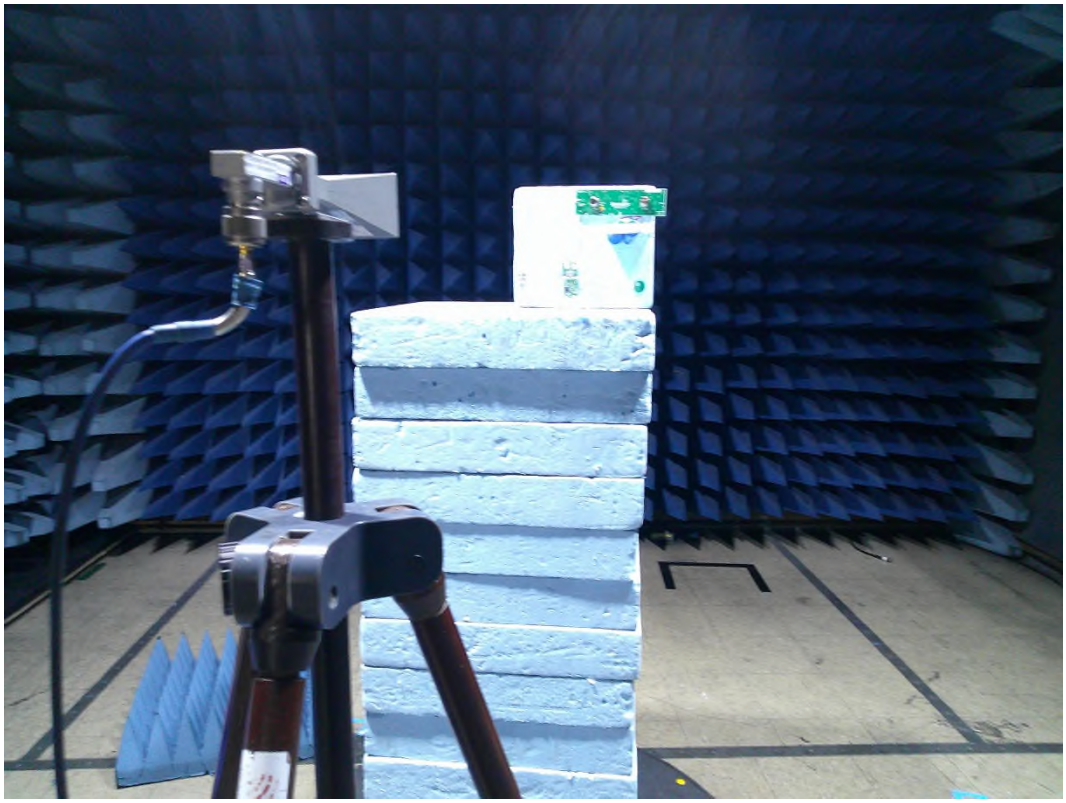


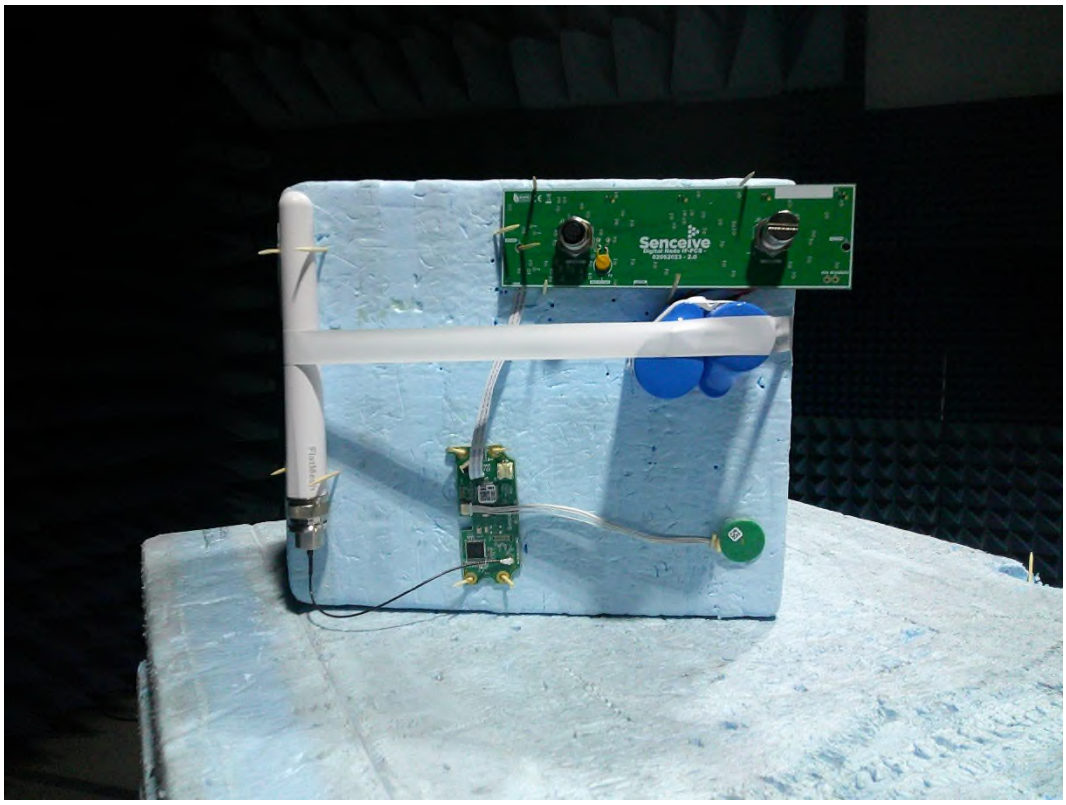
8.8 Radiated emissions 30 MHz -1 GHz



8.9 Radiated emissions above 1 GHz






Senceive

8.10 Radiated emission diagrams

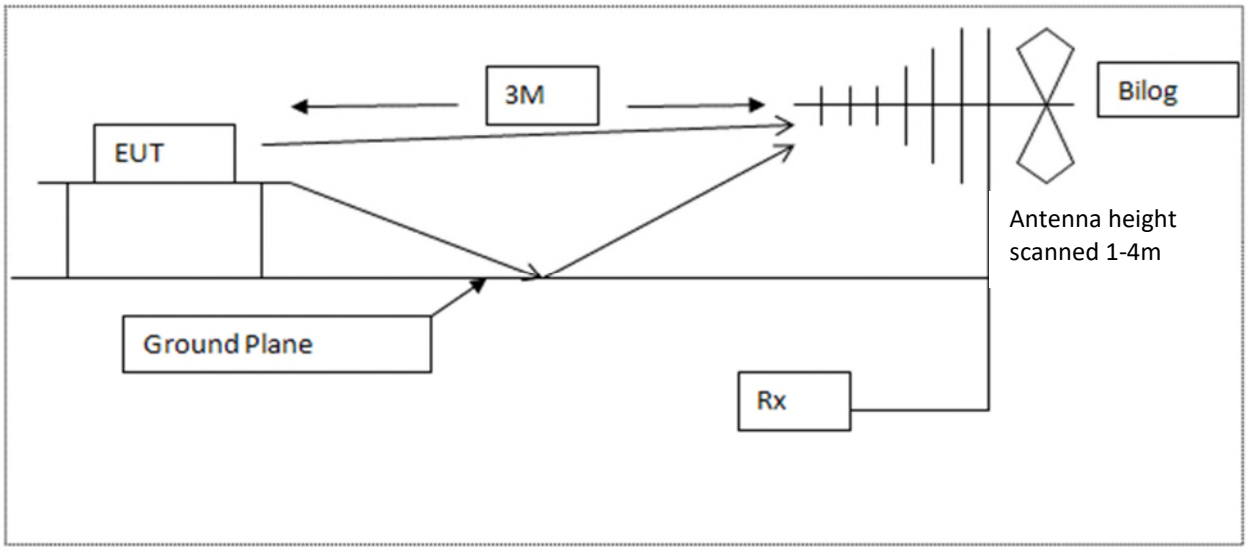


Diagram of the radiated emissions test setup 30 - 1000 MHz

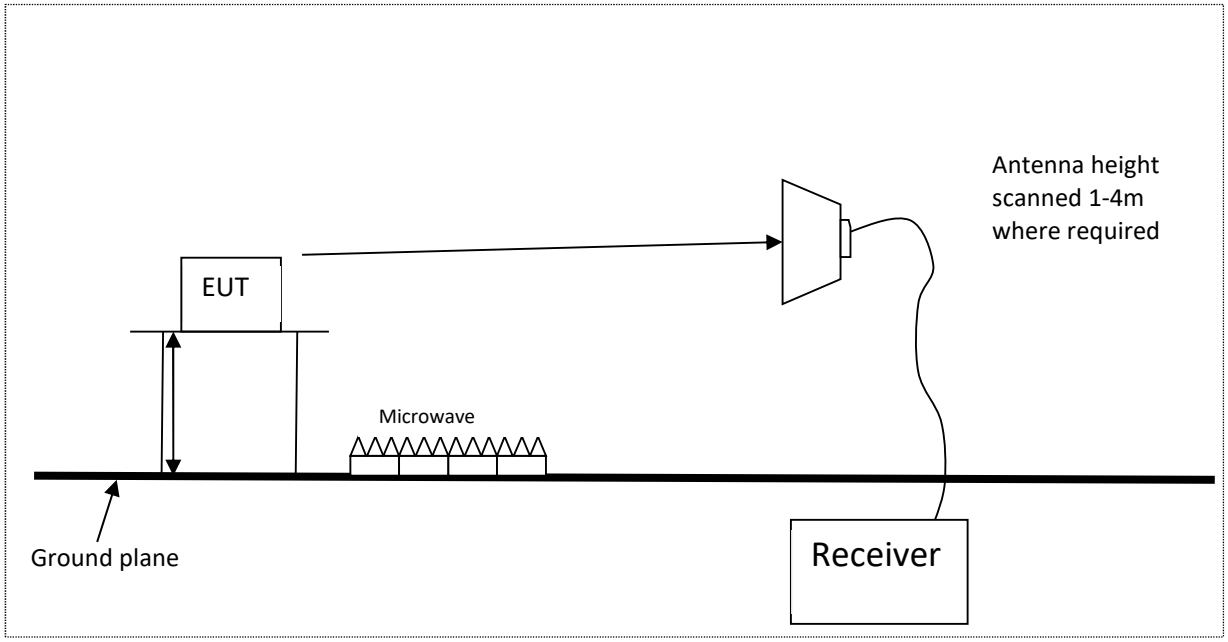


Diagram of the radiated emissions test setup above 1GHz

9 Test equipment calibration list

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

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
E136	3105	Horn Antenna 1 - 12.5 GHz	EMCO	02-Apr-2023	12 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	05-Jul-2023	12 months
E433	MG3693A	Signal Generator 2 GHz - 30 GHz	Anritsu	#02-Oct-2023	12 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	30-Aug-2023	24 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	15-Mar-2023	12 months
E755	N9030B	PXA Signal Analyser 3 Hz to 50 GHz	Keysight Technologies	14-Aug-2023	12 months
E932	N5181A	Signal Generator 100kHz to 6GHz	Agilent Technologies	13-Jun-2023	12 months
F078	AA18-10H	Attenuator SMA 10dB 18GHz	AtlanTecRF	31-Jul-2023	12 months
F130	AA18-20H	Attenuator SMA 20dB 18GHz	AtlanTecRF	13-Sep-2023	12 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	28-Mar-2022	36 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	#05-Oct-2023	12 months
TMS81	6502	Antenna Active Loop	EMCO	17-Aug-2023	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	

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

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Not stated	Dual Band OS-ISMDB-0507-C0-WL +3.4dBi	MULTICOMP PRO	Not stated
2	02062023 – 2.0	I/O PCB assembly	Senceive Ltd	“12”
3	Not stated	NFC Antenna PCB assembly	Not stated	Not stated
4	ER34615	Battery	Not stated	Not stated
5	Latitude 5490	Laptop PC	Dell	(L23) 9VS6PQ2

10.2 Kiwa Electrical Compliance supplied equipment

No Kiwa Electrical Compliance supplied equipment was used.

11 Condition of the equipment tested

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

11.1 Modifications before test

No modifications were made before test by Kiwa Electrical Compliance.

11.2 Modifications during test

No modifications were made during test by Kiwa Electrical Compliance.

12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 654321, 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. 654321, 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. 654321, 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. 654321, ISED Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

CAB identifier as issued by Innovation, Science and Economic Development Canada is UK0002
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
°C	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 Repetition Frequency
PSD	Power Spectral Density
PSU	Power Supply Unit
pW	picoWatts
QAM	Quadrature Amplitude Modulation
QP	Quasi Peak
QPSK	Quadrature Phase Shift Keying
RBW	Resolution 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 ======