FCC Test Report

Bioself Technology Limited
Vagus Nerve Stimulation Product, Model: Sensate

In accordance with FCC 47 CFR Part 15C
(2.4 GHz Bluetooth Low Energy)

Prepared for: Bioself Technology Limited
21 Constable Close, Lawford, Manningtree,
Essex, CO11 2LD, UNITED KINGDOM

FCC ID: 2AS9ESEN231

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Document 75950095-02 Issue 01

SIGNATURE			
			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	10 February 2021

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance FCC 47 CFR Part 15C. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Graeme Lawler	10 February 2021	
Testing	Faisal Malyar	10 February 2021	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2019 for the tests detailed in section 1.3.

TÜV SÜD
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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	10 February 2021

Table 1

1.2 Introduction

Applicant	Bioself Technology Limited
Manufacturer	Bioself Technology Limited
Model Number(s)	Sensate
Serial Number(s)	Not serialised (0075950095-TSR0002)
Hardware Version(s)	2.3.1
Software Version(s)	1.0
Number of Samples Tested	1
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2019
Order Number Date	TUV001 23-September-2020
Date of Receipt of EUT	05-October-2020
Start of Test	05-October-2020
Finish of Test	06-December-2020
Name of Engineer(s)	Graeme Lawler and Faisal Malyar
Related Document(s)	ANSI C63.10 (2013)

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C is shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: 2.4 GHz Bluetooth Low Energy				
-	15.203	Antenna Requirements	Pass	The EUT has an integral antenna therefore the requirement is met. See application form for details
2.1	15.205	Restricted Band Edges	Pass	
2.2	15.207	AC Power Line Conducted Emissions	Pass	
2.3	15.247 (a)(2)	Emission Bandwidth	Pass	
2.4	15.247 (b)	Maximum Conducted Output Power	Pass	
2.5	15.247 (d)	Authorised Band Edges	Pass	
2.6	15.247 (d) and 15.205	Spurious Radiated Emissions	Pass	
2.7	15.247 (e)	Power Spectral Density	Pass	

Table 2

1.4 Customer Supplied Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	Sensate is used for enhanced meditation to assist users in managing stress. It mechanically vibrates against the sternum of a user at mainly sub-audible frequencies of acoustic vibration under 150 Hz, playing back this sub-audible 'sound-track' from internal memory, in sync with audible sound tracks played back to the user from the Sensate app. The app runs on a selection of mobile devices (iOS and Android) and audio to sub-audio Synchronisation is managed via Bluetooth Low Energy communication to the Sensate device.
Manufacturer:	Bioself Technology Ltd
Model:	Sensate 2
Part Number:	n/a
Hardware Version:	2.3.1
Software Version:	1.0
FCC ID of the product under test – see guidance here	2AS9ESEN231
IC ID of the product under test – see guidance here	n/a

Intentional Radiators

Technology	Bluetooth Low Energy
Frequency Range (MHz to MHz)	2400 MHz - 2483.5 MHz
Conducted Declared Output Power (dBm)	0
Antenna Gain (dBi)	0
Supported Bandwidth(s) (MHz) (e.g 1 MHz, 20 MHz, 40 MHz)	1 MHz
Modulation Scheme(s) (e.g GFSK, QPSK etc)	GFSK
ITU Emission Designator (see guidance here)	1M12F1D
Bottom Frequency (MHz)	2402 MHz
Middle Frequency (MHz)	2442 MHz
Top Frequency (MHz)	2480 MHz

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	2. 5 GHz max
Lowest frequency generated or used in the device or on which the device operates or tunes	> 30 MHz
~~Class A Digital Device (Use in commercial, industrial or business environment) ☐~~ Class B Digital Device (Use in residential environment only) ☐X	

AC Power Source

AC supply frequency:	50	Hz
Voltage	230	V
Max current:	<5	A
Single Phase ☐ Three Phase ☐		

DC Power Source

Nominal voltage:	5.0	V
Extreme upper voltage:	N/A	V
Extreme lower voltage:	N/A	V
Max current:	1	A

Battery Power Source

Voltage:	3.7 (Nominal) (4.2 Max)	V
End-point voltage:	3.1	V *(Point at which the battery will terminate)*
Alkaline ☐ Leclanche ☐ Lithium ☒ Nickel Cadmium ☐ Lead Acid* ☐ **(Vehicle regulated)*		
Other ☐ Please detail:		

Charging

Can the EUT transmit whilst being charged	Yes ☒ No ☐

Temperature

Minimum temperature:	10.0	°C
Maximum temperature:	40.0	°C

Antenna Characteristics

Antenna connector ☐			State impedance	50	Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	2450BM15A0002E	Gain	0	dBi
External antenna ☐	Type:		Gain		dBi
For external antenna only: Standard Antenna Jack ☐ If yes, describe how user is prohibited from changing antenna (if not professional installed): Equipment is only ever professionally installed ☐ Non-standard Antenna Jack ☐					

Ancillaries (if applicable)

Manufacturer:		Part Number:	
Model:		Country of Origin:	

I hereby declare that the information supplied is correct and complete.

Name: Ben Wynn
Position held: CTO
Date: 09/02/2021

1.5 Product Information

1.5.1 Technical Description

Sensate is used for enhanced meditation to assist users in managing stress. It mechanically vibrates against the sternum of a user at mainly sub-audible frequencies of acoustic vibration under 150 Hz, playing back this sub-audible 'sound-track' from internal memory, in sync with audible sound tracks played back to the user from the Sensate app. The app runs on a selection of mobile devices (iOS and Android) and audio to sub-audio Synchronisation is managed via Bluetooth Low Energy communication to the Sensate device.

1.5.2 Test Mode

For all tests the EUT was put into a continuous transmit test mode using an application on a test laptop provided by applicant. The transmission was continuous and configured the EUT to transmit at the maximum supported output power with modulation enabled.

1.6 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test programme.

The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Vagus Nerve Stimulation Product, Model: Sensate, Serial Number: Not serialised (0075950095-TSR0002)			
0	As supplied by the customer	Not Applicable	Not Applicable
1	The addition of a Lithium Polymer Battery in order to perform test during charging.	Customer	30-November-2020

Table 3

1.8 Test Location

TÜV SÜD conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz Bluetooth Low Energy		
Restricted Band Edges	Graeme Lawler	UKAS
AC Power Line Conducted Emissions	Graeme Lawler	UKAS
Emission Bandwidth	Graeme Lawler	UKAS
Maximum Conducted Output Power	Graeme Lawler	UKAS
Authorised Band Edges	Graeme Lawler	UKAS
Spurious Radiated Emissions	Graeme Lawler and Faisal Malyar	UKAS
Power Spectral Density	Graeme Lawler	UKAS

Table 4

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Restricted Band Edges

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205

2.1.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.1.3 Date of Test

05-October-2020

2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5.

Peak measurements were performed in accordance with ANSI C63.10, clause 11.12.2.4.

Plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.5. These are shown for information purposes and were used to determine the worst-case measurement point. Final average measurements were then taken in accordance with ANSI C63.10, clause 4.1.4.2.2 to obtain the measurement result recorded in the test results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

2.1.5 Environmental Conditions

Ambient Temperature	20.6 °C
Relative Humidity	57.3 %

2.1.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390.0	51.03	39.68
GFSK	2480	2483.5	53.79	43.38

Table 5 - Restricted Band Edge Results

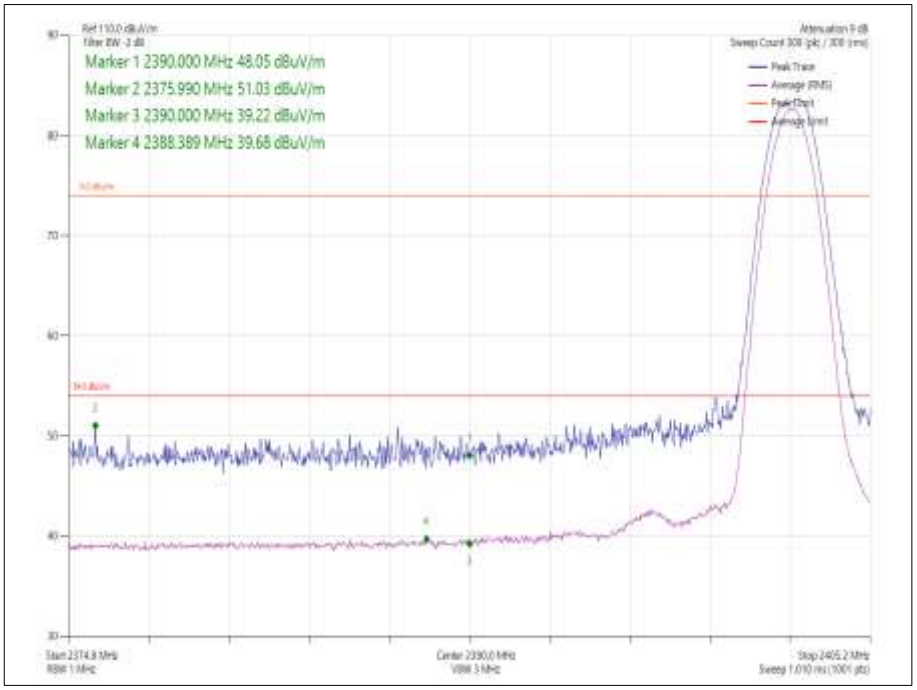


Figure 1 - GFSK - 2402 MHz - Band Edge Frequency 2390.0 MHz

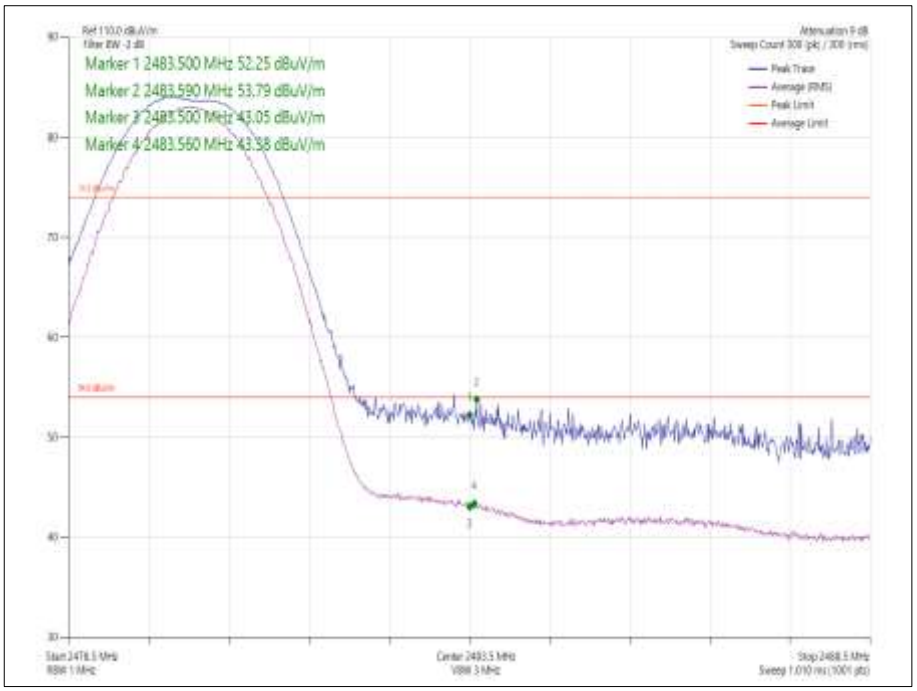


Figure 2 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.209

Frequency (MHz)	Field Strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 6

2.1.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	10-Mar-2021
EmX Emissions Software	TUV SUD	V2.0.1 V.V2.0.1	5125	-	N/A - Software
Thermo-Hygro-Barometer	PCE Instruments	OCE-THB-40	5470	12	16-Mar-2021
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5517	12	01-Apr-2021
8m N-Type Cable	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2021
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	06-Feb-2021

Table 7

TU – Traceability Unscheduled

2.2 AC Power Line Conducted Emissions

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.207

2.2.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 1

2.2.3 Date of Test

06-December-2020

2.2.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.2.

The EUT was configured to transmit on its middle channel.

2.2.5 Example Calculation

Quasi-Peak level (dBµV) = Receiver level (dBµV) + Correction Factor (dB)
Margin (dB) = Quasi-Peak level (dBµV) - Limit (dBµV)

CISPR Average level (dBµV) = Receiver level (dBµV) + Correction Factor (dB)
Margin (dB) = CISPR Average level (dBµV) - Limit (dBµV)

2.2.6 Example Test Setup Diagram

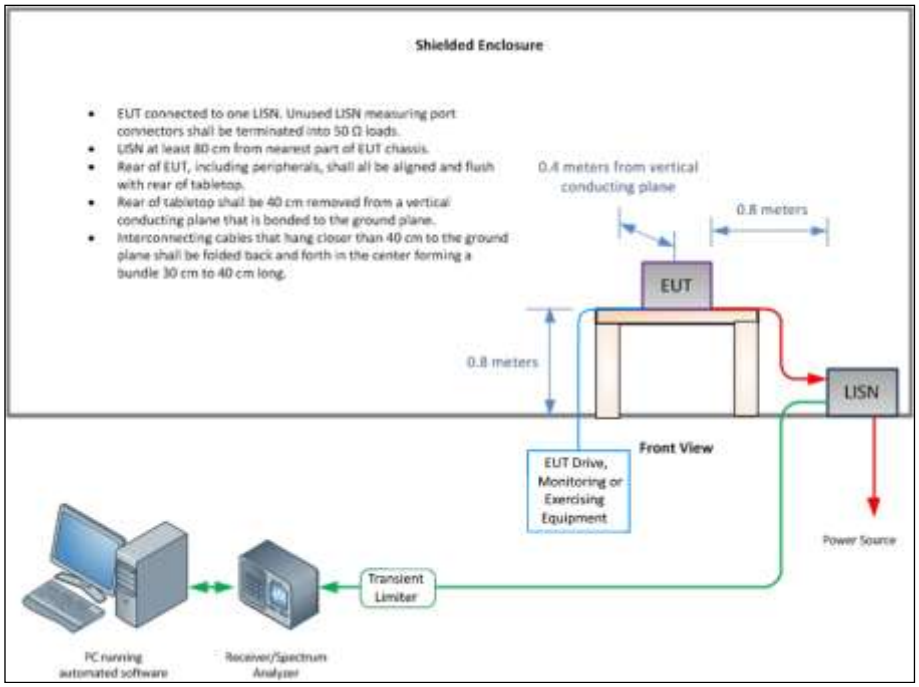


Figure 3 - Test Setup

2.2.7 Environmental Conditions

Ambient Temperature 18.3 °C
Relative Humidity 37.4 %

2.2.8 Test Results

2.4 GHz Bluetooth Low Energy

Applied supply voltage: 117.2 V AC
Applied supply frequency: 60 Hz

Frequency (MHz)	QP Level (dBµV)	QP Limit (dBµV)	QP Margin (dB)	AV Level (dBµV)	AV Limit (dBµV)	AV Margin (dBµ
2.299	37.5	56.0	-18.5	35.3	46.0	-10.7
4.597	38.2	56.0	-17.8	35.7	46.0	-10.3

Table 8 - Neutral Line Emissions Results

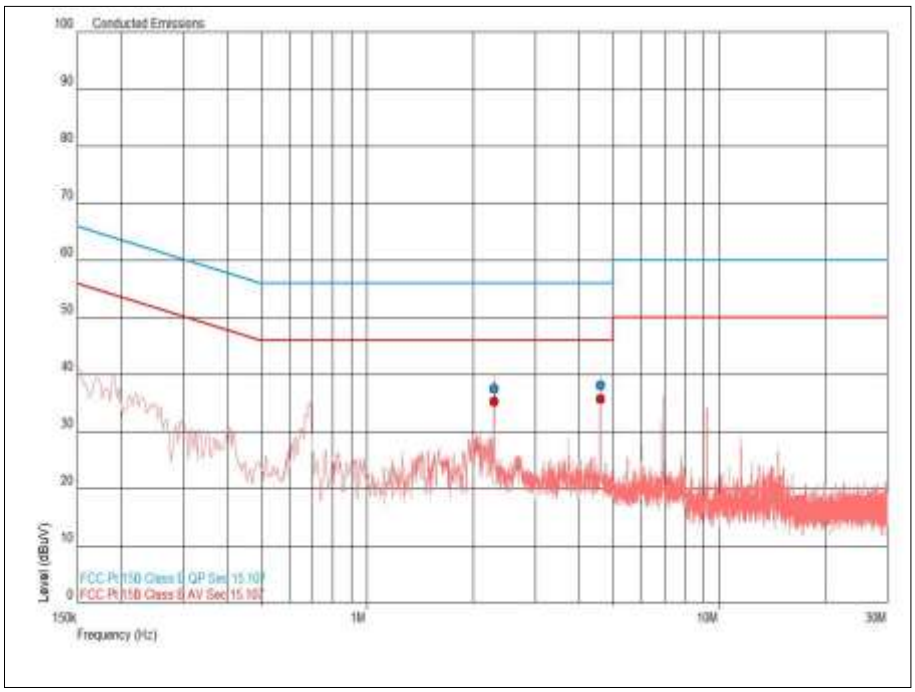


Figure 4 - Neutral Line - 150 kHz to 30 MHz

Frequency (MHz)	QP Level (dBµV)	QP Limit (dBµV)	QP Margin (dB)	AV Level (dBµV)	AV Limit (dBµV)	AV Margin (dB)
0.696	35.9	56.0	-20.1	28.6	46.0	-17.4
2.297	40.4	56.0	-15.6	35.1	46.0	-10.9
4.596	41.0	56.0	-15.0	35.8	46.0	-10.2

Table 9 - Live Line Emissions Results

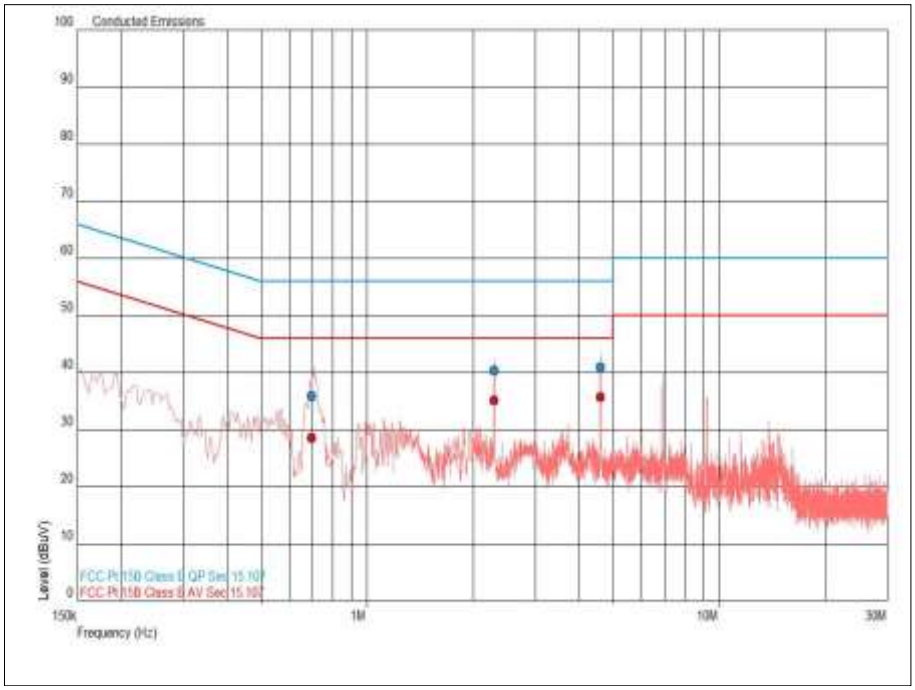


Figure 5 - Live Line - 150 kHz to 30 MHz

FCC 47 CFR Part 15, Limit Clause 15.207

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-Peak	CISPR Average
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

Table 10

*Decreases with the logarithm of the frequency.

2.2.9 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 12.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
LISN	Rohde & Schwarz	ESH3-Z5	1390	12	27-Jan-2021
Transient Limiter	Hewlett Packard	11947A	2377	12	26-Feb-2021
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	03-Jan-2021
Cable (18 GHz)	Rosenberger	LU7-071-2000	5106	12	09-Dec-2020
EmX Emissions Software	TUV SUD	V2.0.1 V.V2.0.1	5125	-	N/A - Software
N-Type to 2.92mm Cable	APC Technology	RFF24919	5443	12	10-Mar-2021
Termination (50ohm)	Diamond Antenna	DL-30N	5465	12	27-Feb-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	18-Mar-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5519	12	24-Mar-2021
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 11

2.3 Emission Bandwidth

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(2)

2.3.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.3.3 Date of Test

08-November-2020

2.3.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.1.

2.3.5 Environmental Conditions

Ambient Temperature	24.1 °C
Relative Humidity	46.4 %

2.3.6 Test Results

2.4 GHz Bluetooth Low Energy

Frequency (MHz)	99 % Occupied Bandwidth (kHz)	6 dB Bandwidth (kHz)
2402	1089.000	753.000
2442	1098.000	759.615
2480	1116.000	750.000

Table 12 - Emission Bandwidth Results

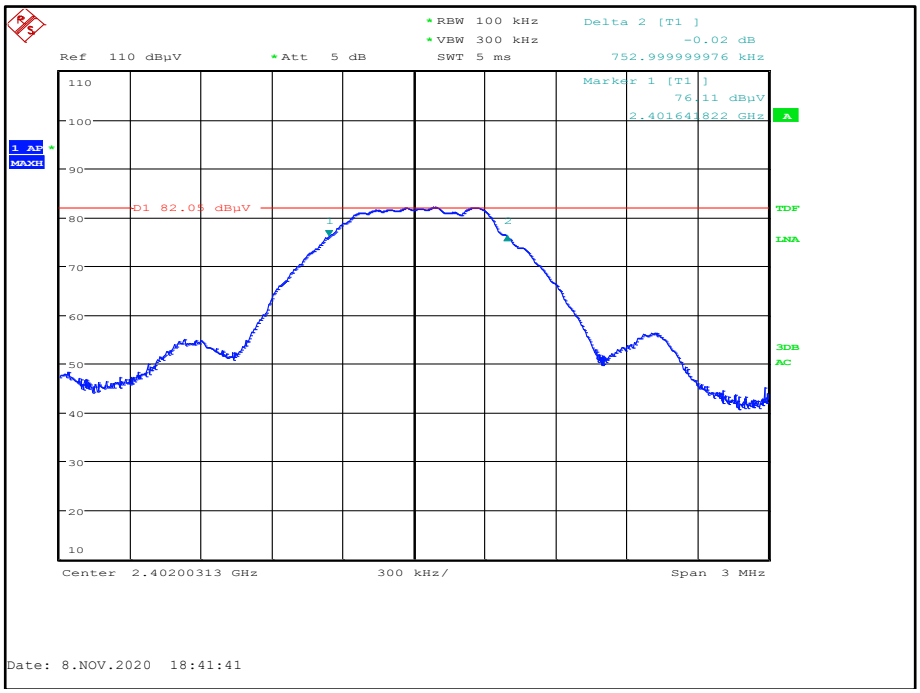


Figure 6 – 2402 MHz – 6 dB Bandwidth

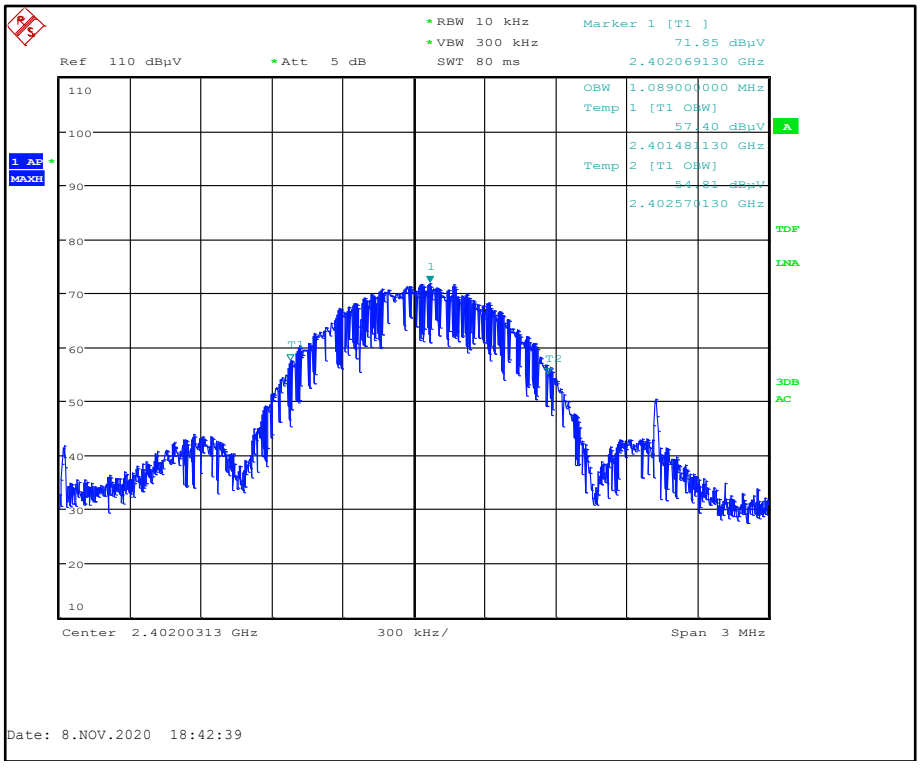


Figure 7 - 2402 MHz – 99% Occupied Bandwidth

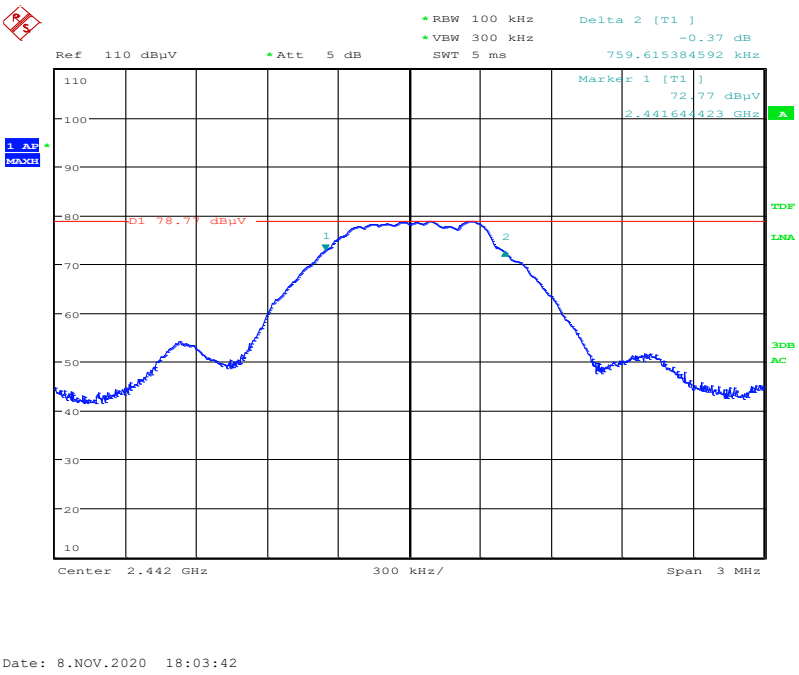


Figure 8 – 2442 MHz – 6 dB Bandwidth

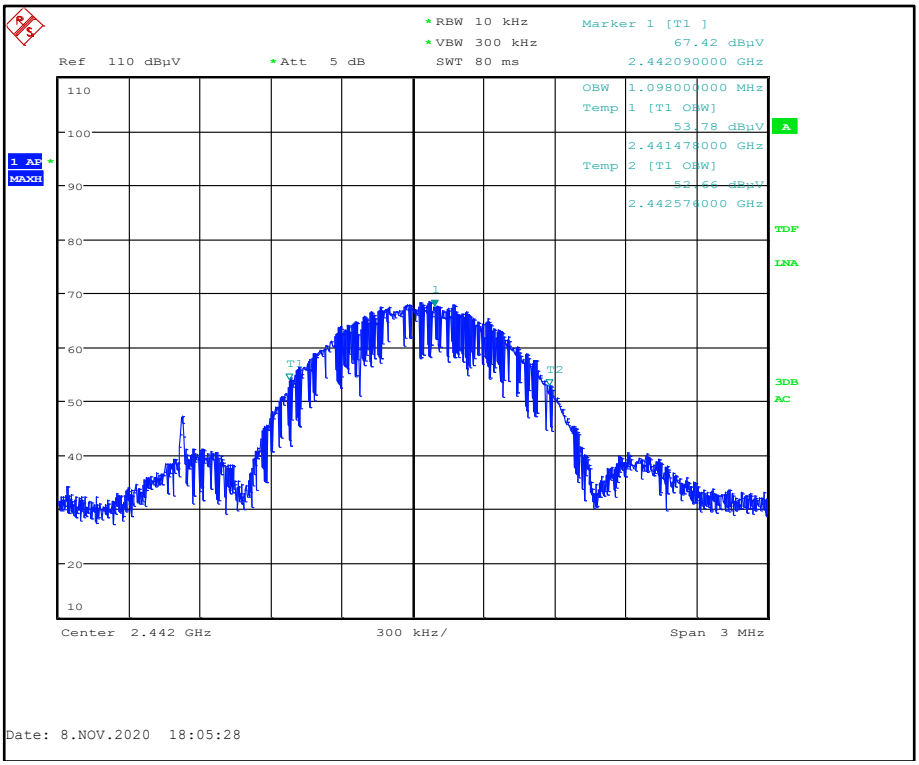


Figure 9 - 2442 MHz – 99% Occupied Bandwidth

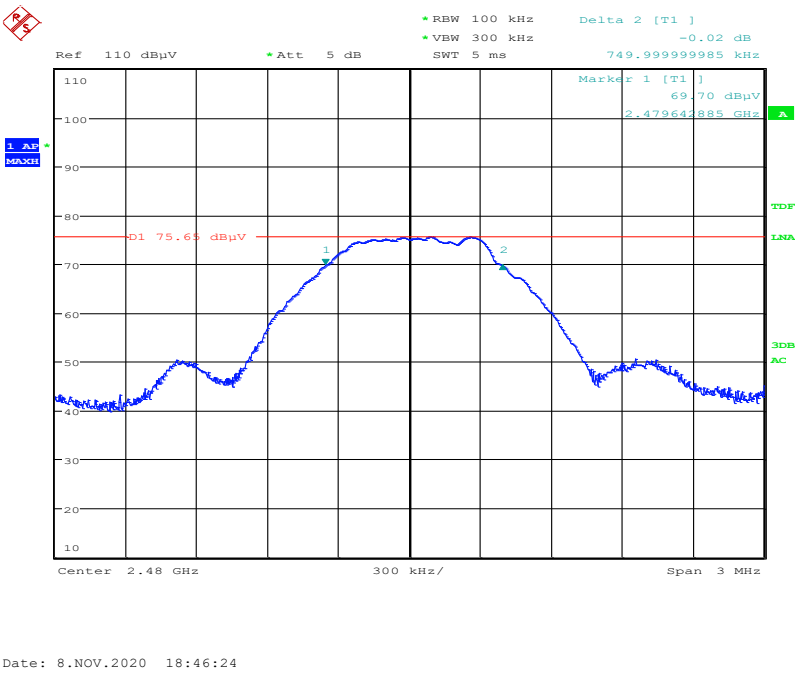


Figure 10 – 2480 MHz – 6 dB Bandwidth

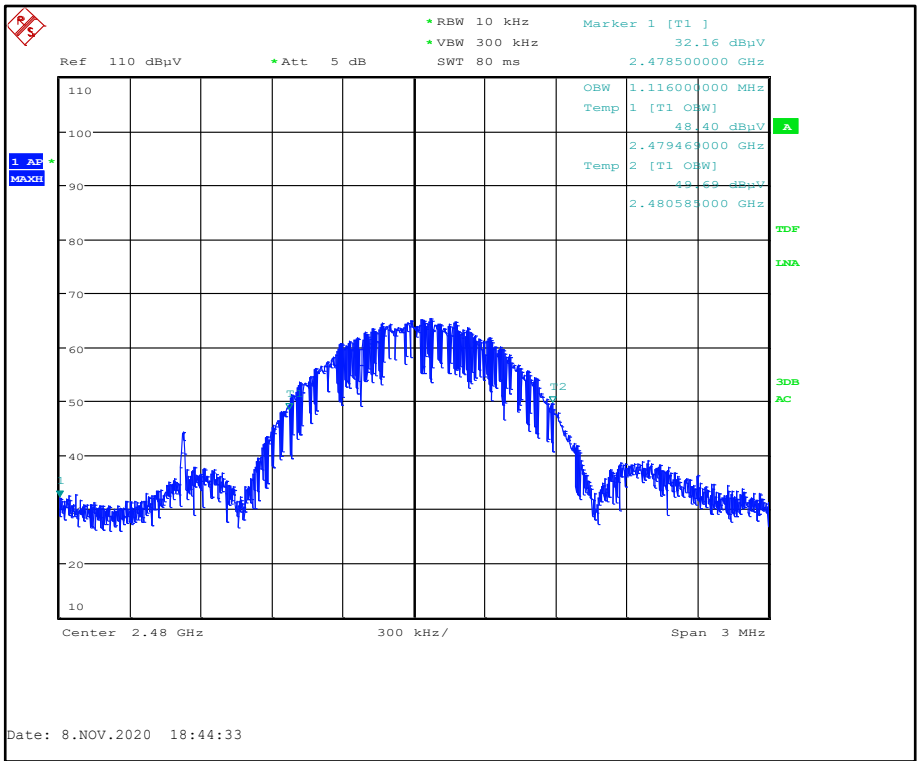


Figure 11 - 2480 MHz – 99% Occupied Bandwidth

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2)

The minimum 6 dB Bandwidth shall be at least 500 kHz.

2.3.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	03-Jan-2021
N-Type to 2.92mm Cable	APC Technology	RFF24919	5443	12	10-Mar-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	18-Mar-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5519	12	24-Mar-2021
Broadband Horn Antenna (1-10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	22-Sep-2021
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast TAM 4.0-P	Maturo Gmbh	TAM 4.0-P	5613	-	TU
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 13

TU – Traceability Unscheduled

2.4 Maximum Conducted Output Power

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)

2.4.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.4.3 Date of Test

08-November-2020

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 11.9.1.1.

This test was performed radiated in a 3m semi-anechoic chamber.

2.4.5 Environmental Conditions

Ambient Temperature	24.1 °C
Relative Humidity	46.4 %

2.4.6 Test Results

2.4 GHz Bluetooth Low Energy

Testing was performed on the modulation/packet type with the highest output power. This modulation/packet type was GFSK/DH1.

Frequency (MHz)	Modulation Scheme	Maximum Output Power	
		dBm	mW
2402	GFSK	-10.50	0.089
2441	GFSK	-12.60	0.055
2480	GFSK	-11.40	0.072

Table 14 - Maximum Conducted Output Power Results

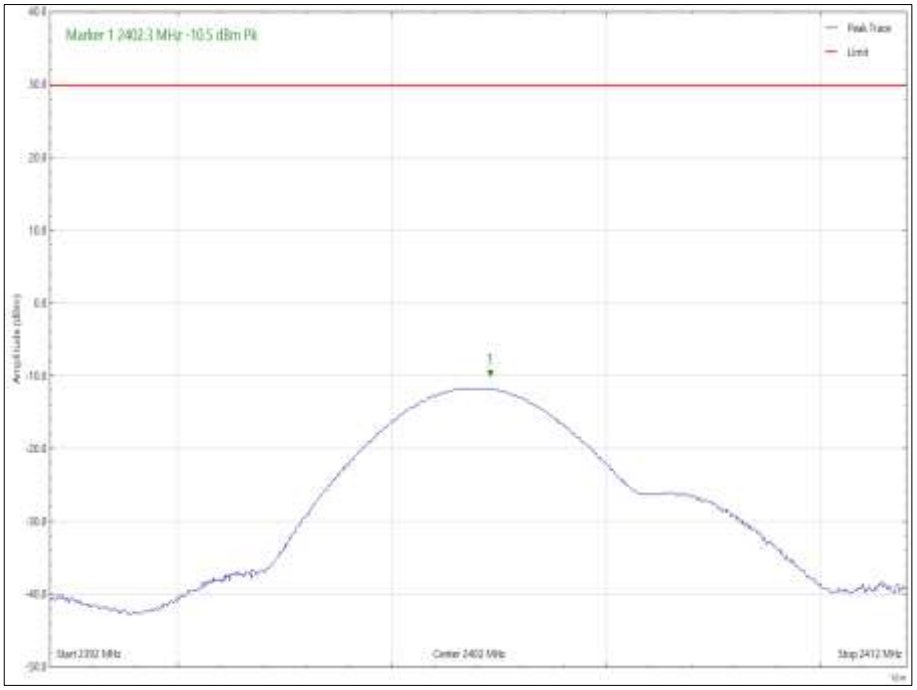


Figure 12 - 2402 MHz - Maximum Output Power

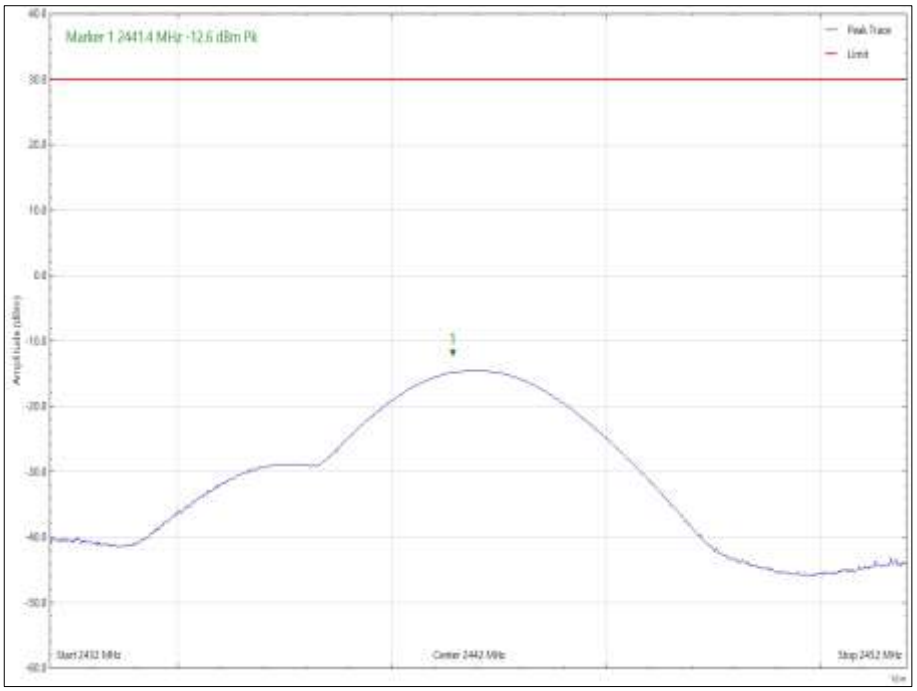


Figure 13 - 2441 MHz - Maximum Output Power

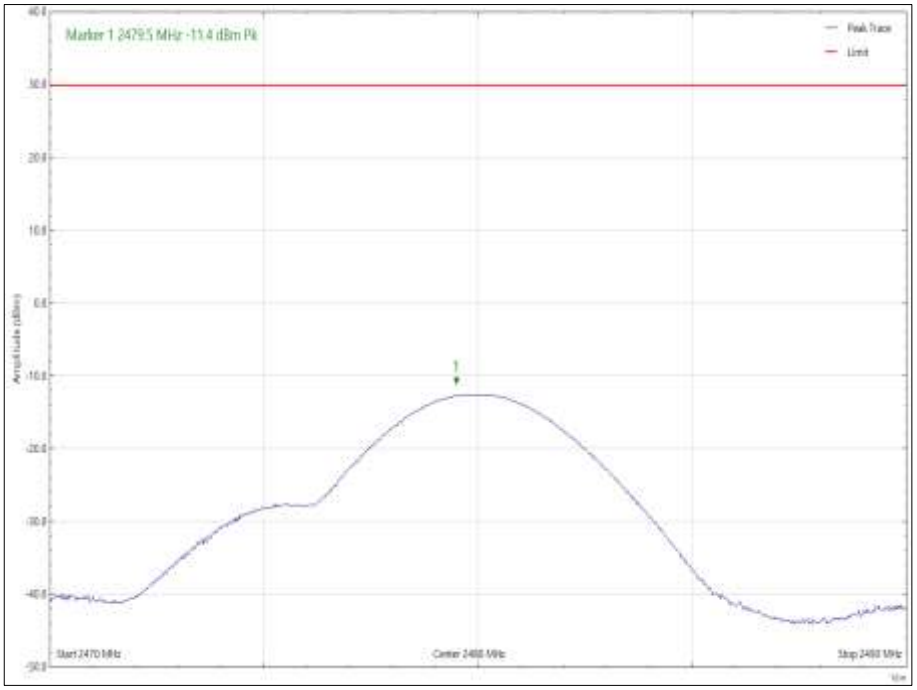


Figure 14 - 2480 MHz - Maximum Output Power

FCC 47 CFR Part 15, Limit Clause 15.247 (b)(3)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt.

2.4.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 12.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	03-Jan-2021
N-Type to 2.92mm Cable	APC Technology	RFF24919	5443	12	10-Mar-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	18-Mar-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5519	12	24-Mar-2021
Broadband Horn Antenna (1-10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	22-Sep-2021
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast TAM 4.0-P	Maturo Gmbh	TAM 4.0-P	5613	-	TU
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 15

TU – Traceability Unscheduled

2.5 Authorised Band Edges

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d)

2.5.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.5.3 Date of Test

05-October-2020

2.5.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.10.4.

2.5.5 Environmental Conditions

Ambient Temperature	20.6 °C
Relative Humidity	57.3 %

2.5.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz))	Level (dBc)
GFSK	2402	2400.0	-39.46
GFSK	2480	2483.5	-37.82

Table 16 - Authorised Band Edge Results

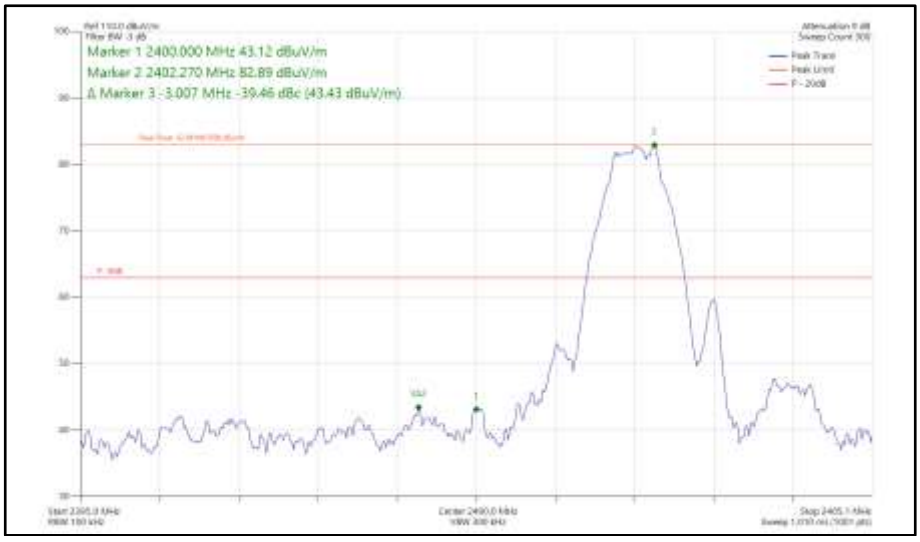


Figure 15- GFSK, 2402 MHz – Band Edge Frequency 2400.0 MHz

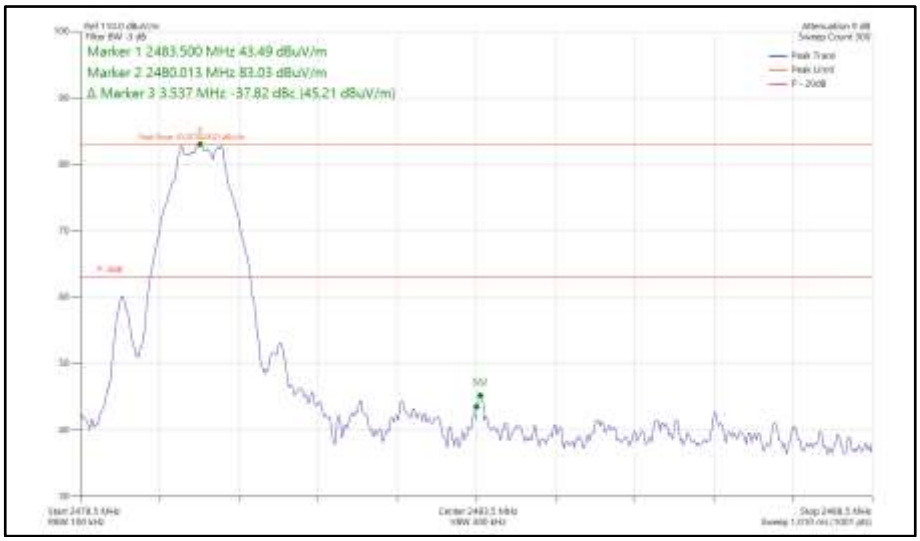


Figure 16- GFSK, 2480 MHz – Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

2.5.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	10-Mar-2021
EmX Emissions Software	TUV SUD	V2.0.1 V.V2.0.1	5125	-	N/A - Software
Thermo-Hygro-Barometer	PCE Instruments	OCE-THB-40	5470	12	16-Mar-2021
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5517	12	01-Apr-2021
8m N-Type Cable	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2021
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	06-Feb-2021

Table 17

TU – Traceability Unscheduled

2.6 Spurious Radiated Emissions

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205

2.6.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.6.3 Date of Test

05-October-2020 to 07-November-2020

2.6.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.3, 6.5 and 6.6.

As the EUT could reasonable be used in multiple planes, pre-scans were performed with the EUT orientated in X, Y and Z planes with reference to the ground plane.

Ports on the EUT were terminated with loads as described in ANSI C63.4 clause 6.2.4. For frequencies > 1 GHz, plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.5 to characterize the EUT. Where emissions were detected, final average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.2.

The plots shown are the characterisation of the EUT. The limits on the plots represent the most stringent case for restricted bands, (74/54 dBuV/m) when compared to 20 dBc outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:

10^(Field Strength in dBµV/m/20).

To determine the emission characteristic of the EUT above 18 GHz, the test antenna was swept over all faces of the EUT whilst observing a spectral display. The frequency of any emissions of interest was noted for formal measurement at the correct measurement distance of 1m. This procedure was repeated for all relevant transmit operating channels.

At a measurement distance of 1 meter the limit line was increased by 20*LOG(3/1) = 9.54 dB.

2.6.5 Example Test Setup Diagram

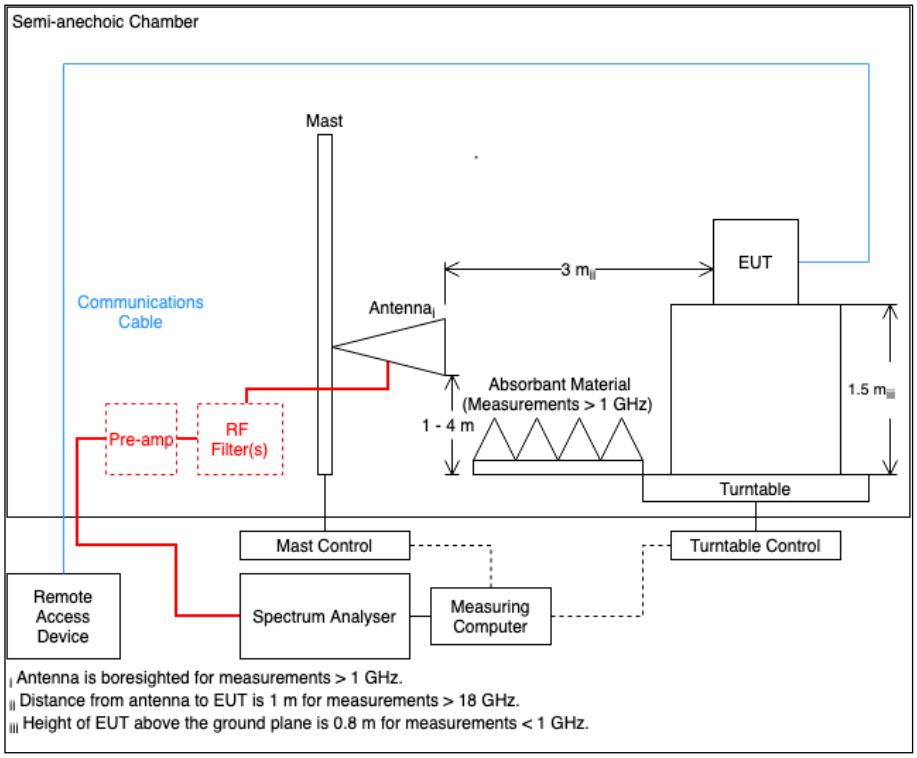


Figure 17

2.6.6 Environmental Conditions

Ambient Temperature	20.6 - 23.8 °C
Relative Humidity	51.4 - 57.3 %

2.6.7 Test Results

2.4 GHz Bluetooth Low Energy

Modulation/Packet Type: GFSK/DH1

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
43.102	32.07	40.00	7.93	Q-Peak	0	148	Vertical	Y

Table 18 - 2402 MHz, 30 MHz to 1 GHz - Emission Results

No other emissions were detected within 10 dB of the limit.

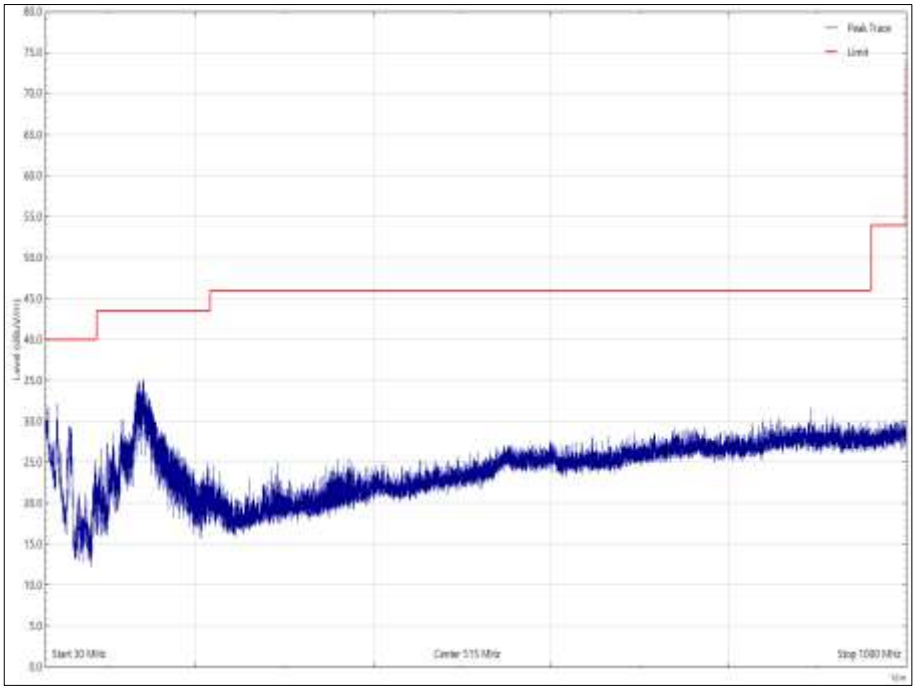


Figure 18 - 2402 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

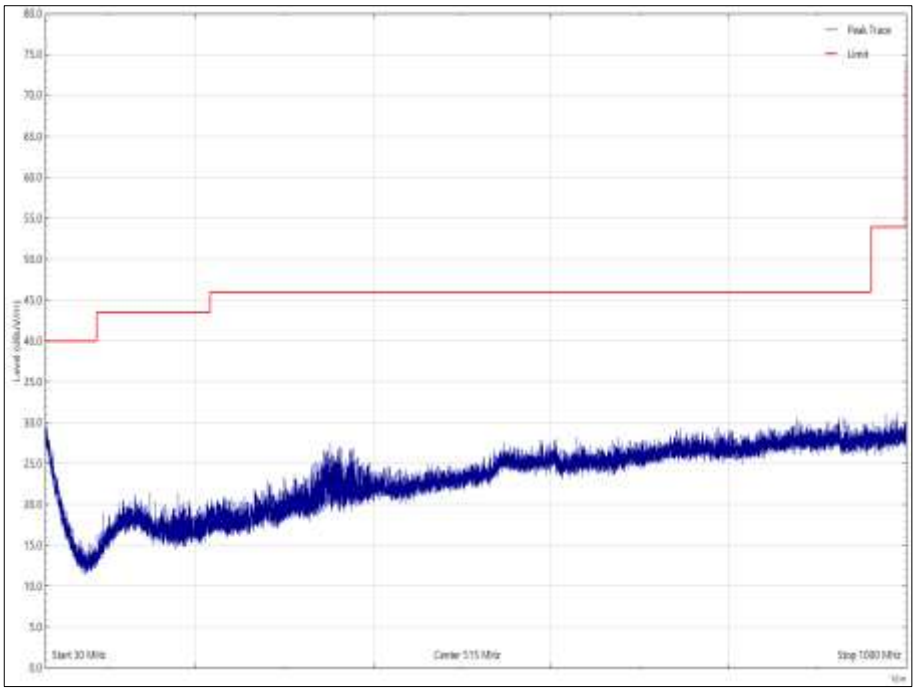


Figure 19 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

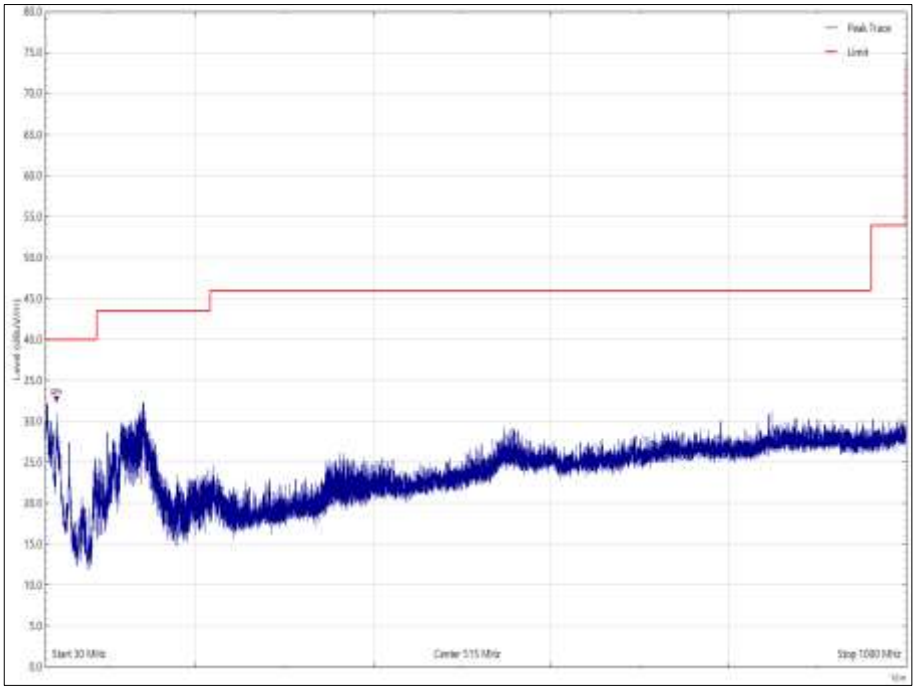
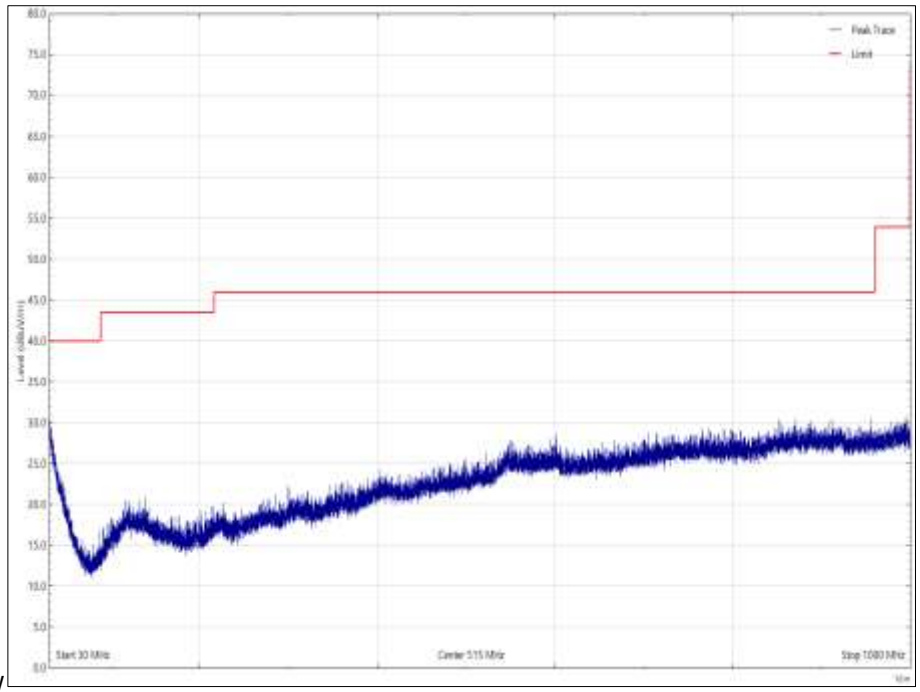


Figure 20 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation



W

Figure 21 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

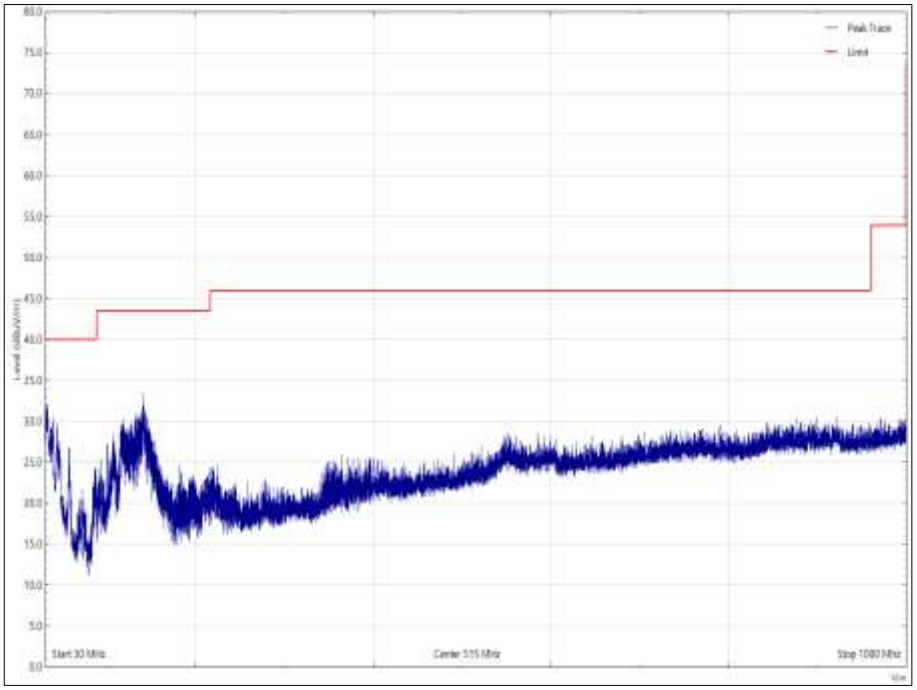


Figure 22 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

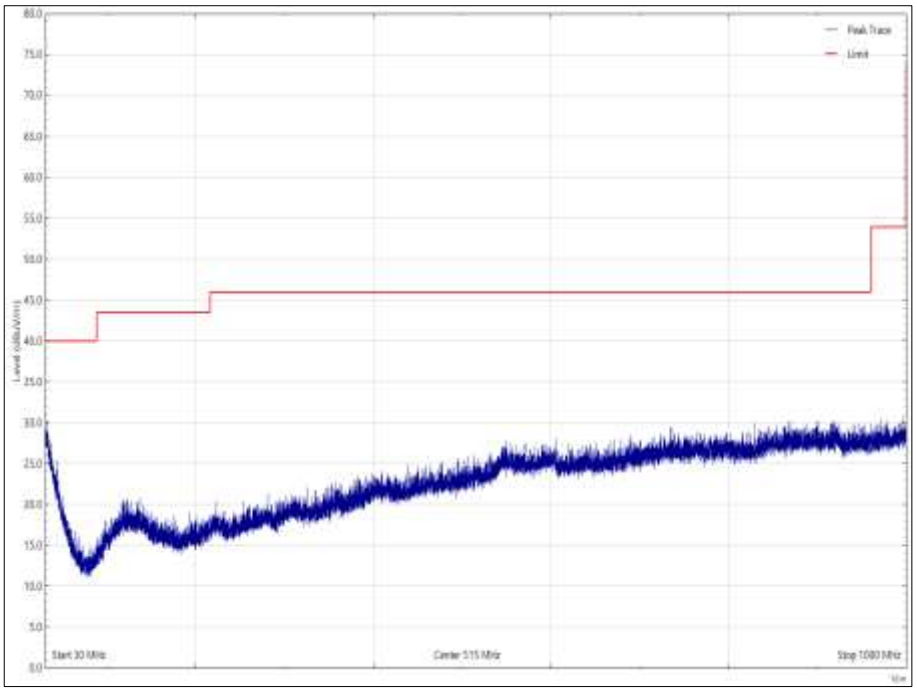


Figure 23 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 19 - 2402 MHz, 1 GHz to 25 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

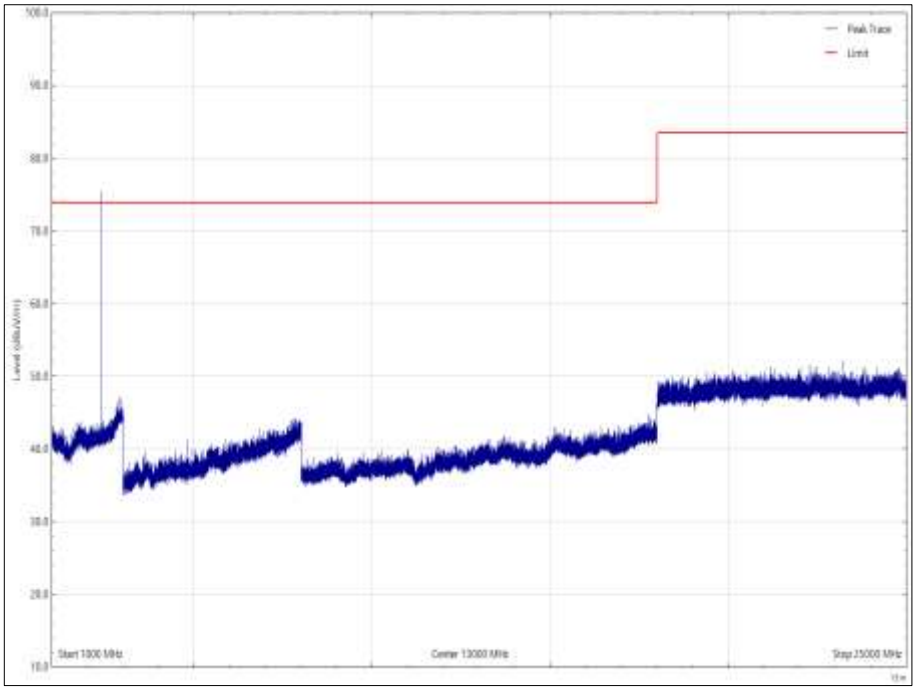


Figure 24 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation - Peak

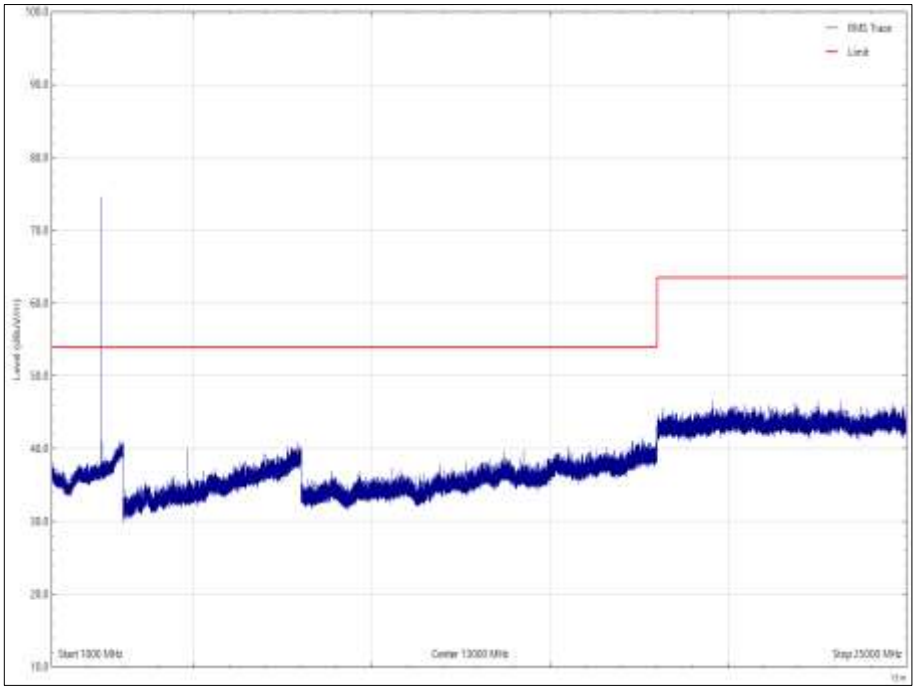


Figure 25 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation - Average

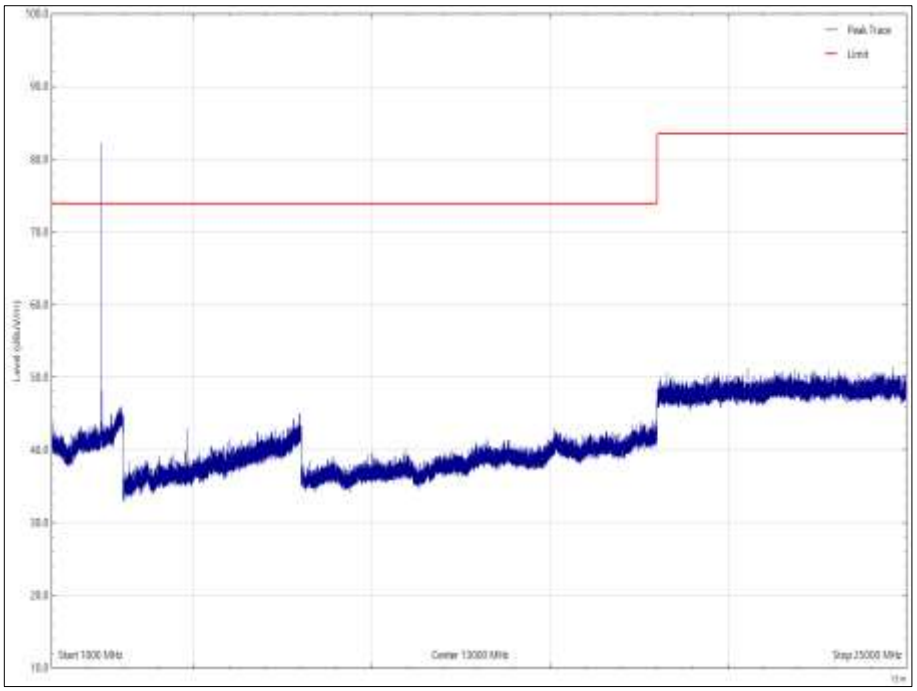


Figure 26 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation - Peak

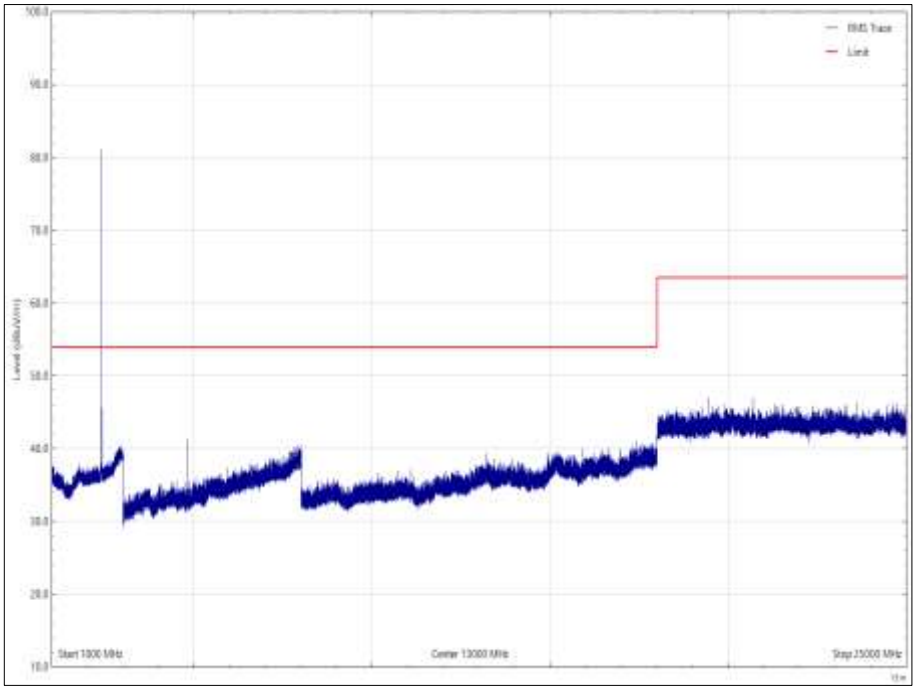


Figure 27 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation - Average

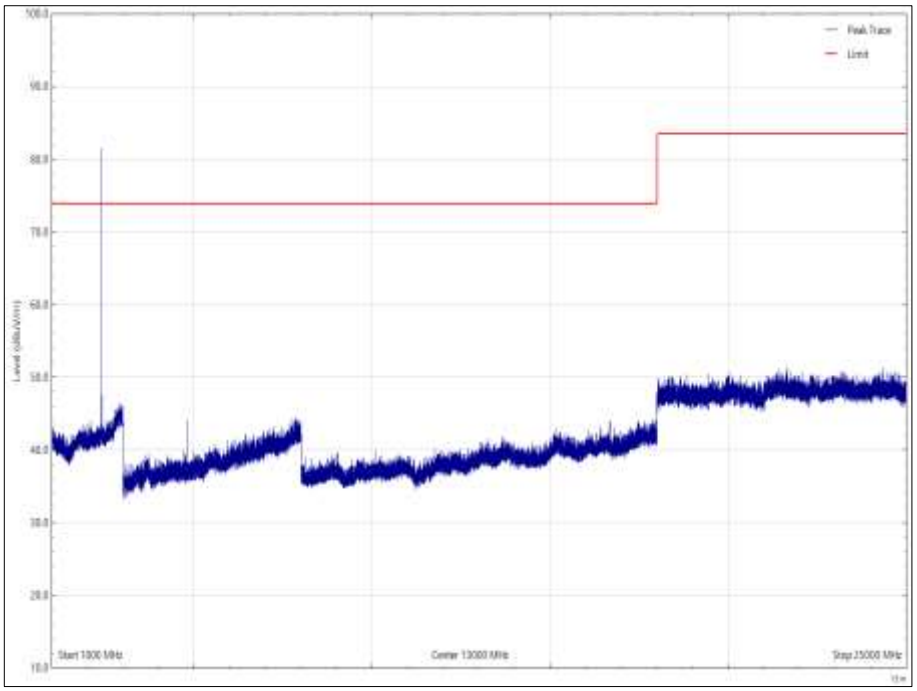


Figure 28 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation - Peak

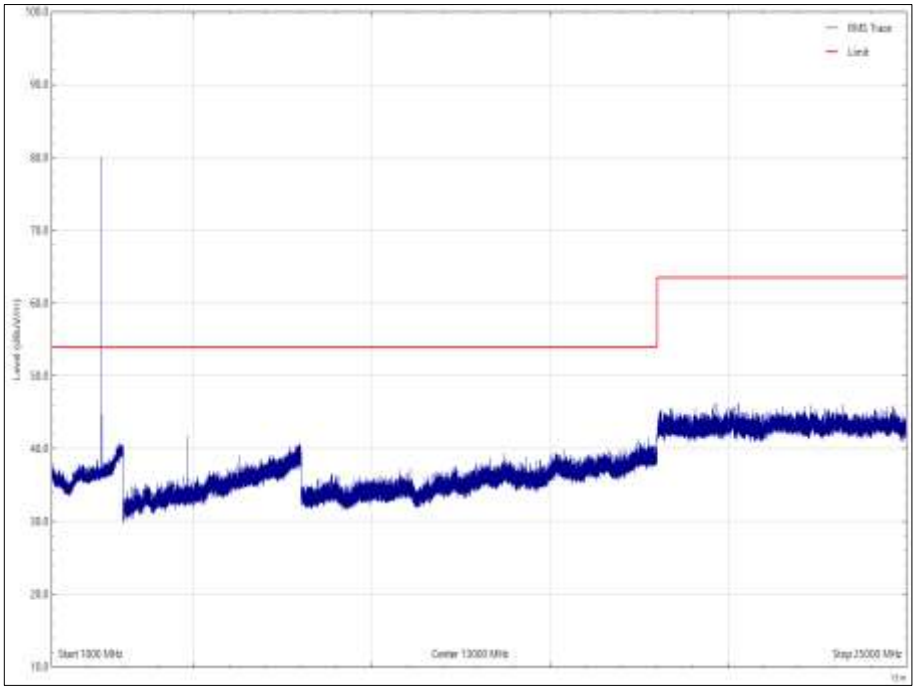


Figure 29 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation - Average

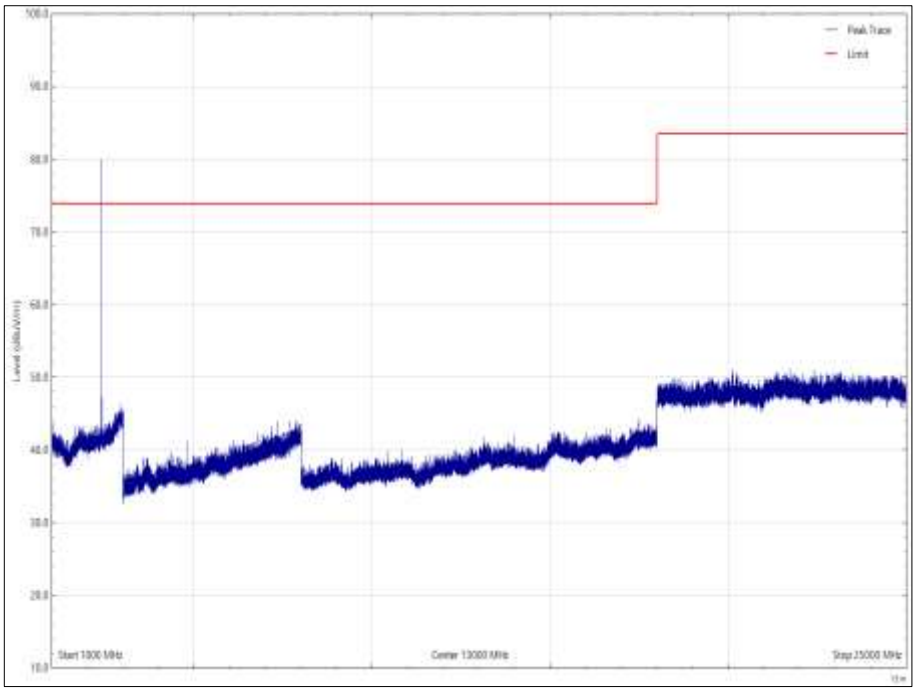


Figure 30 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation - Peak

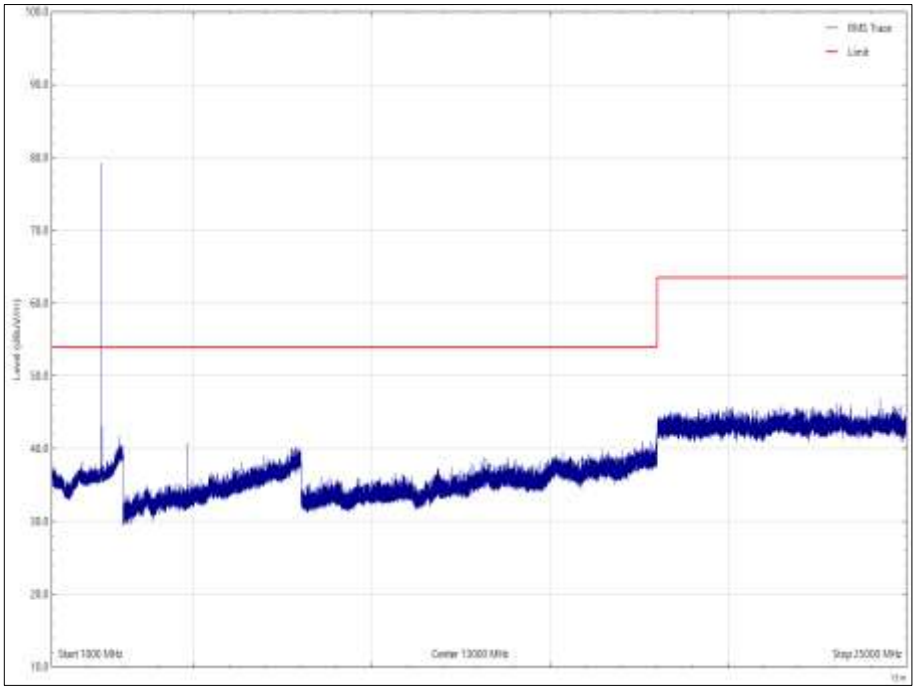


Figure 31 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation - Average

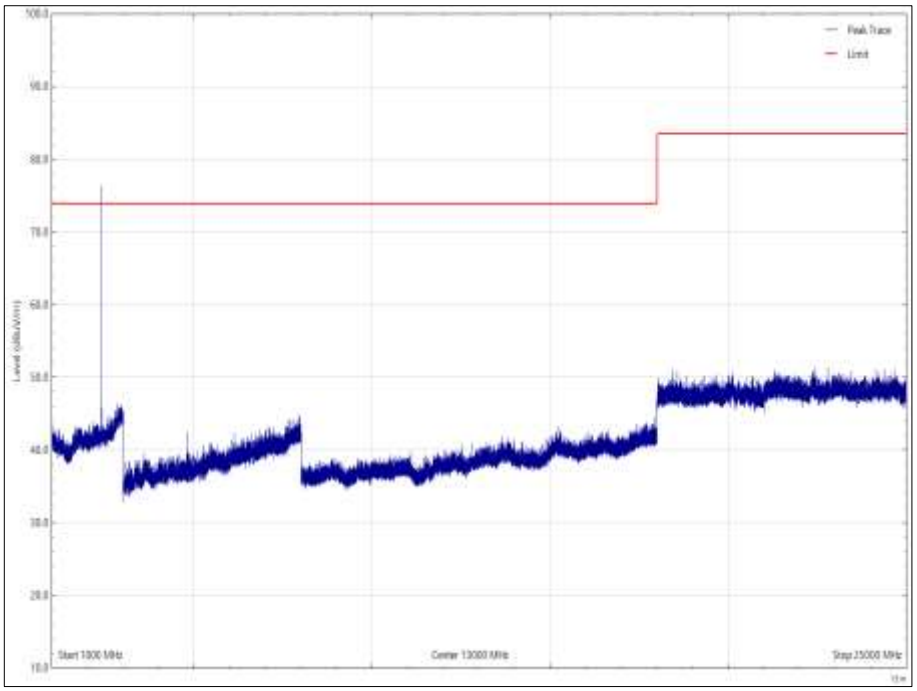


Figure 32 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation - Peak

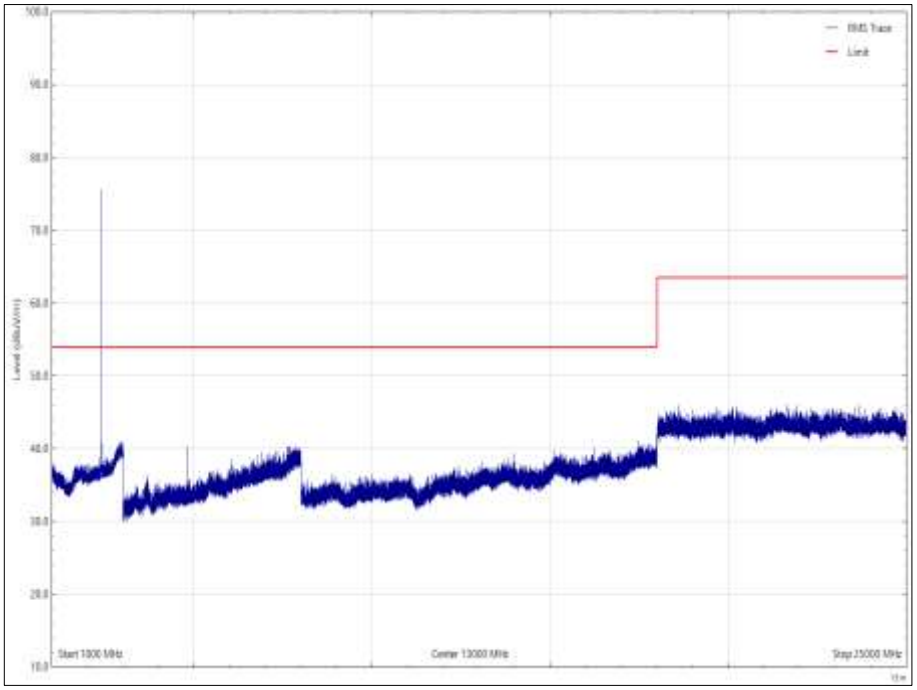


Figure 33 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation - Average

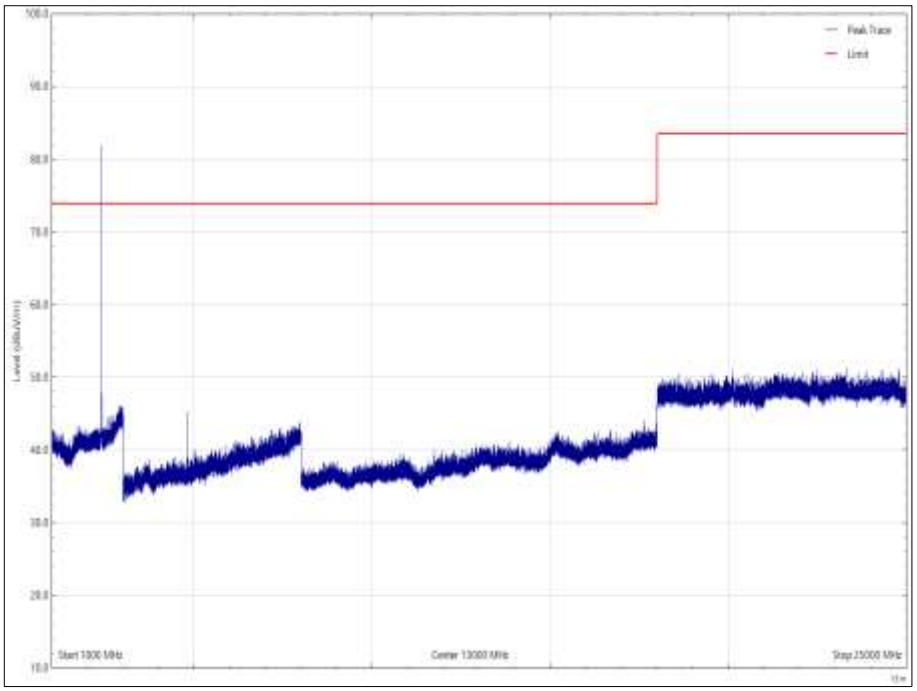


Figure 34 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation - Peak

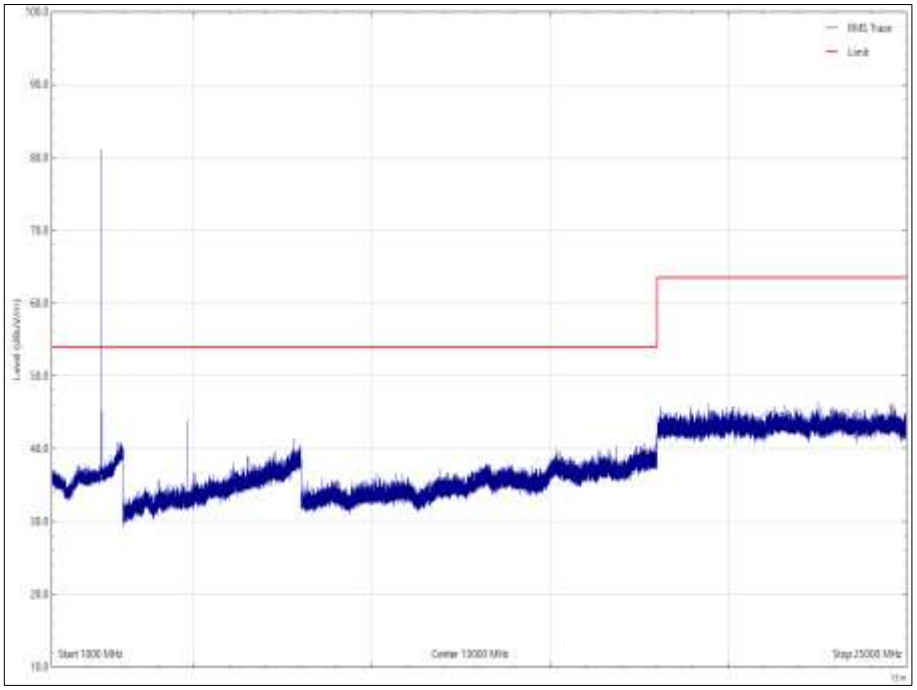


Figure 35 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation - Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
43.155	31.30	40.00	8.70	Q-Peak	70	137	Vertical	Z

Table 20 - 2442 MHz, 30 MHz to 1 GHz - Emission Results

No other emissions were detected within 10 dB of the limit.

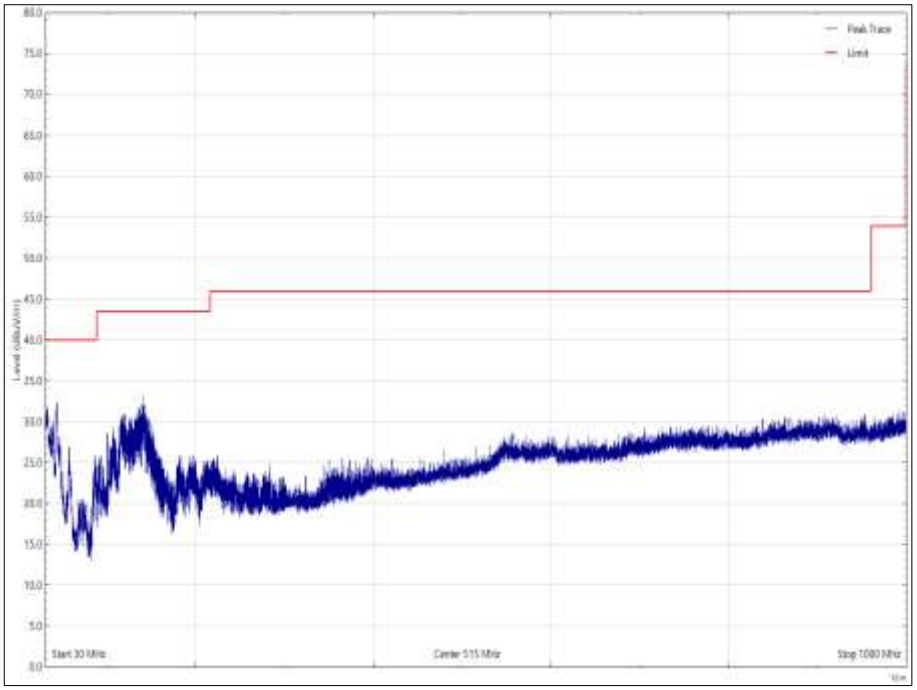


Figure 36 - 2442 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

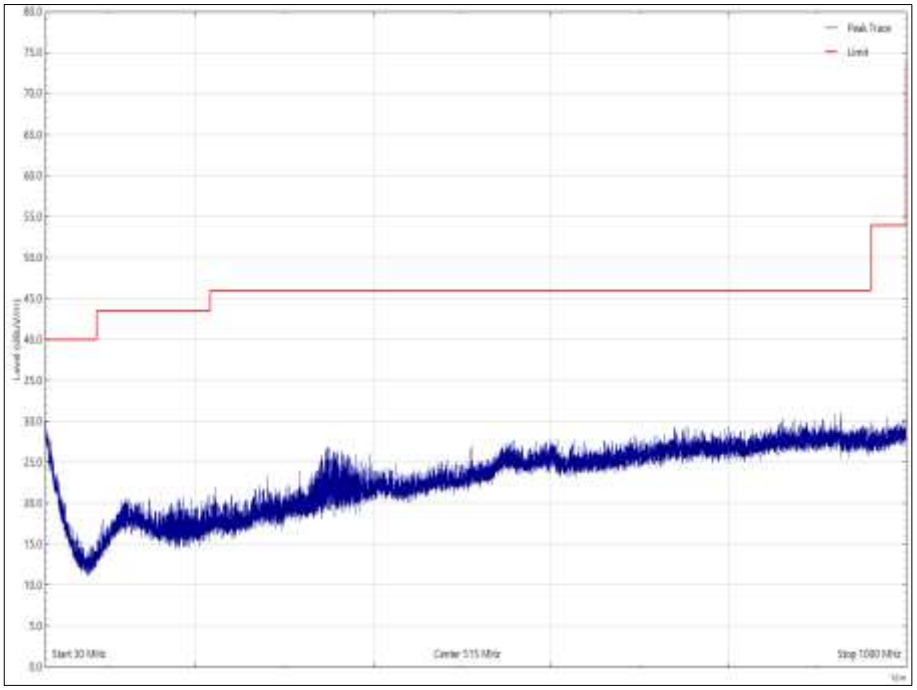


Figure 37 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

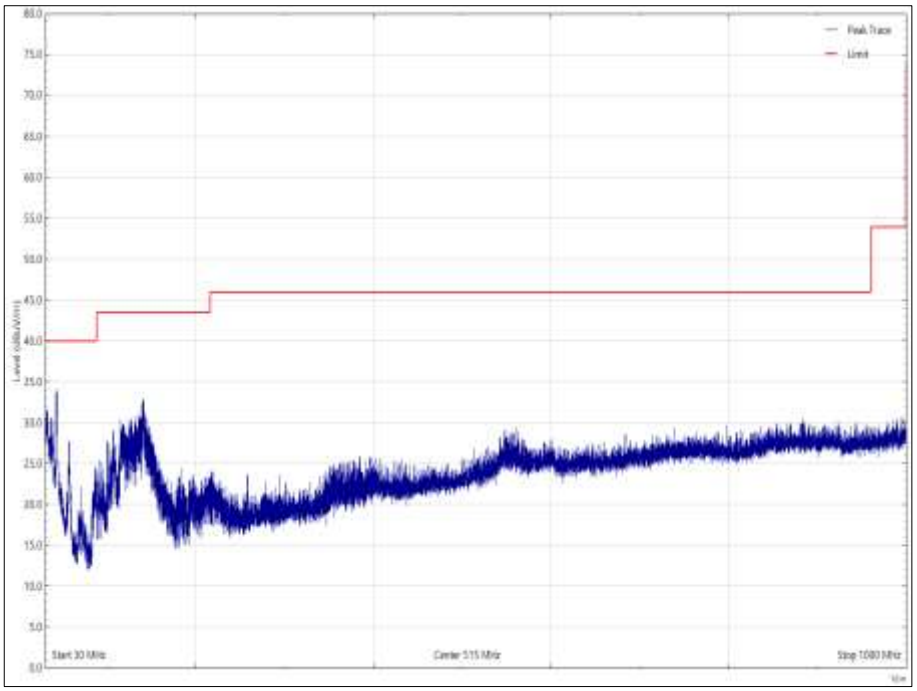


Figure 38 - 2442 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

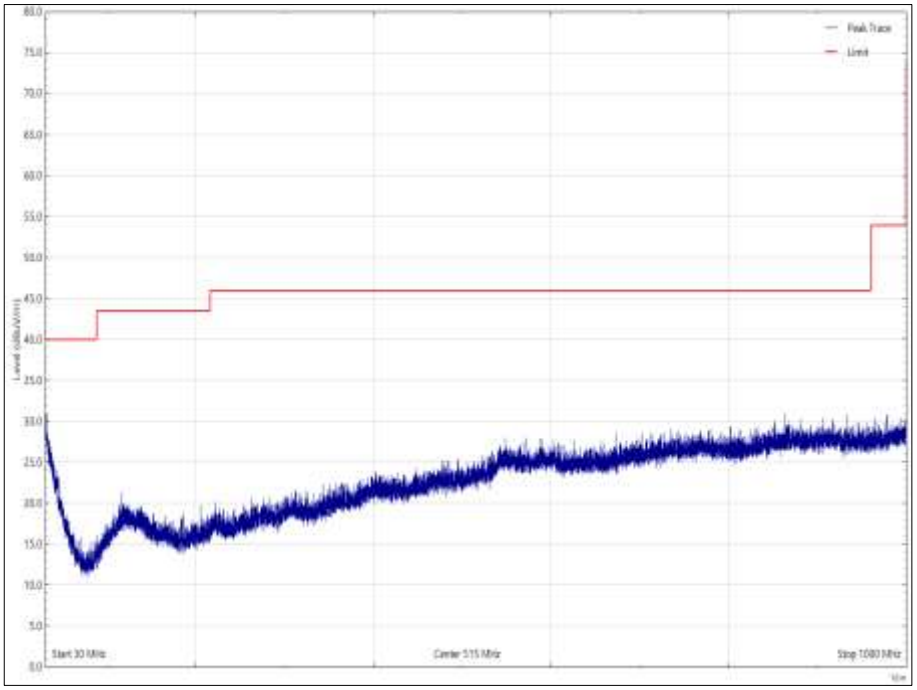


Figure 39 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

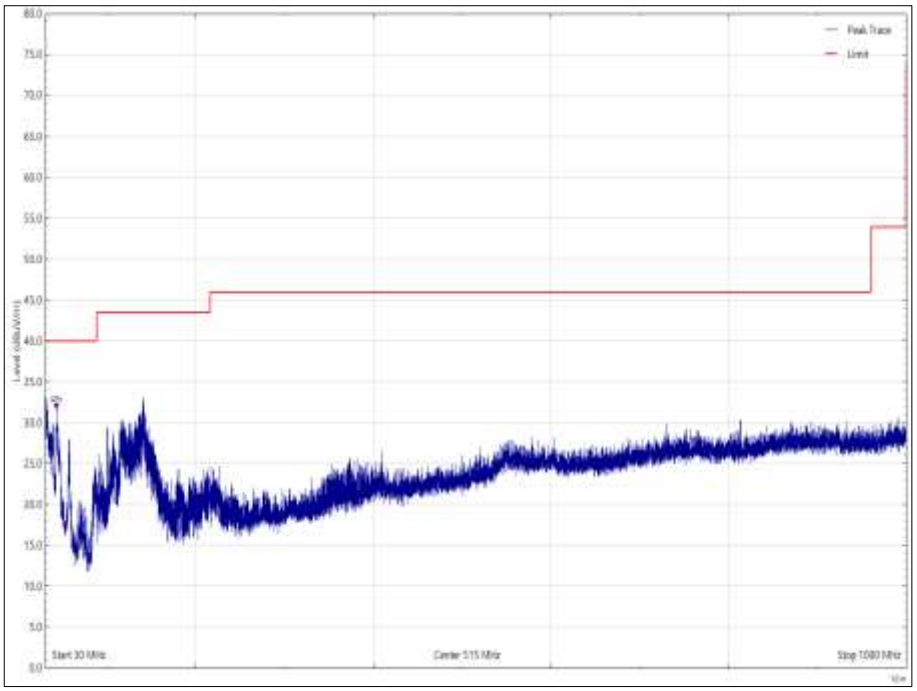


Figure 40 - 2442 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

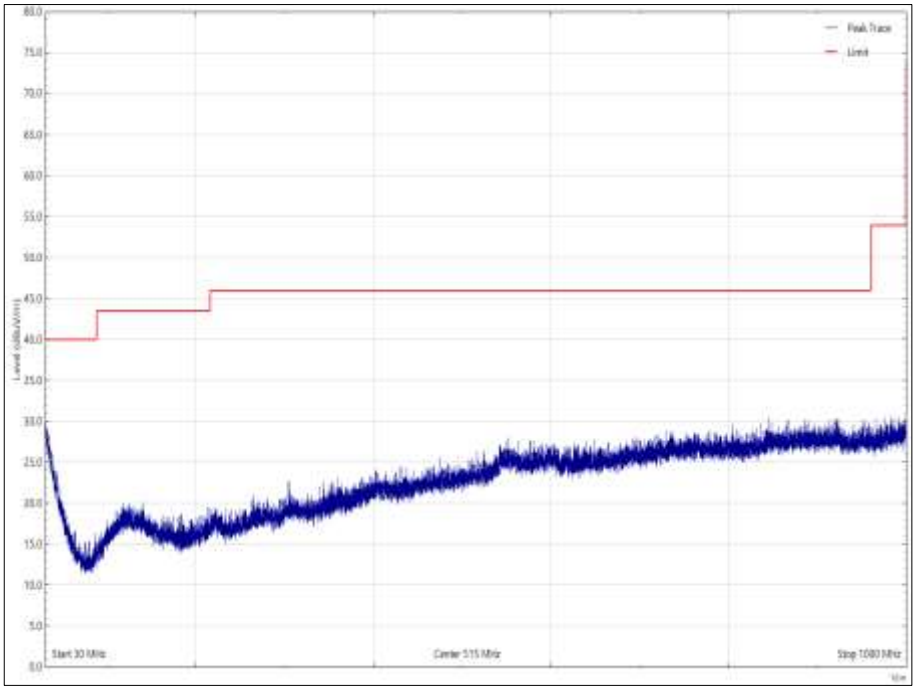


Figure 41 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4882.111	45.43	53.98	8.55	CISPR Average	238	103	Horizontal	Z

Table 21 - 2442 MHz - 1 GHz to 25 GHz Emissions Results

No other emissions were detected within 10 dB of the limit.

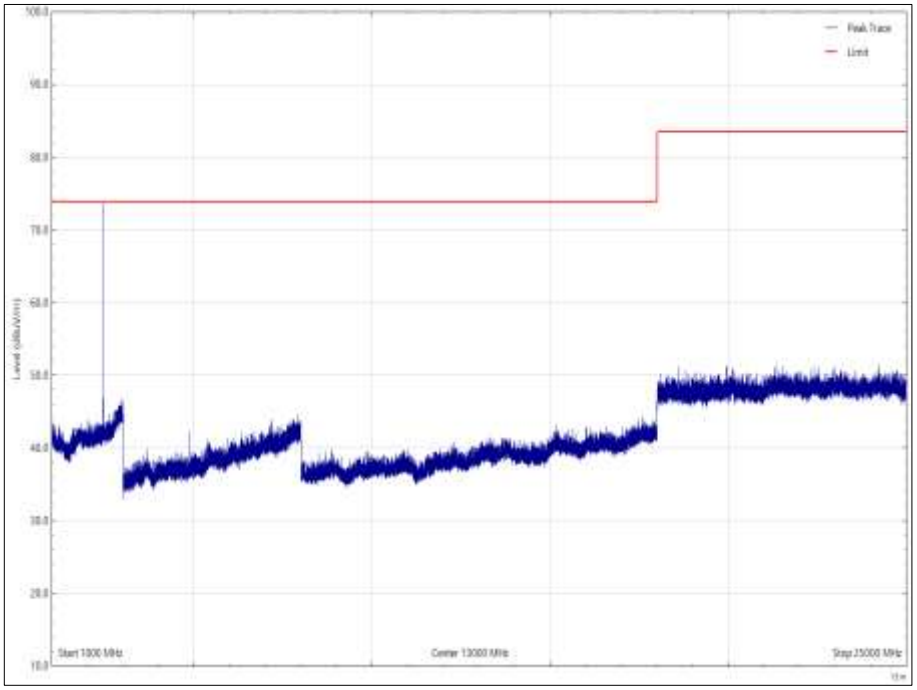


Figure 42 - 2442 MHz - 1 GHz to 25 GHz, X Orientation, Vertical, Peak

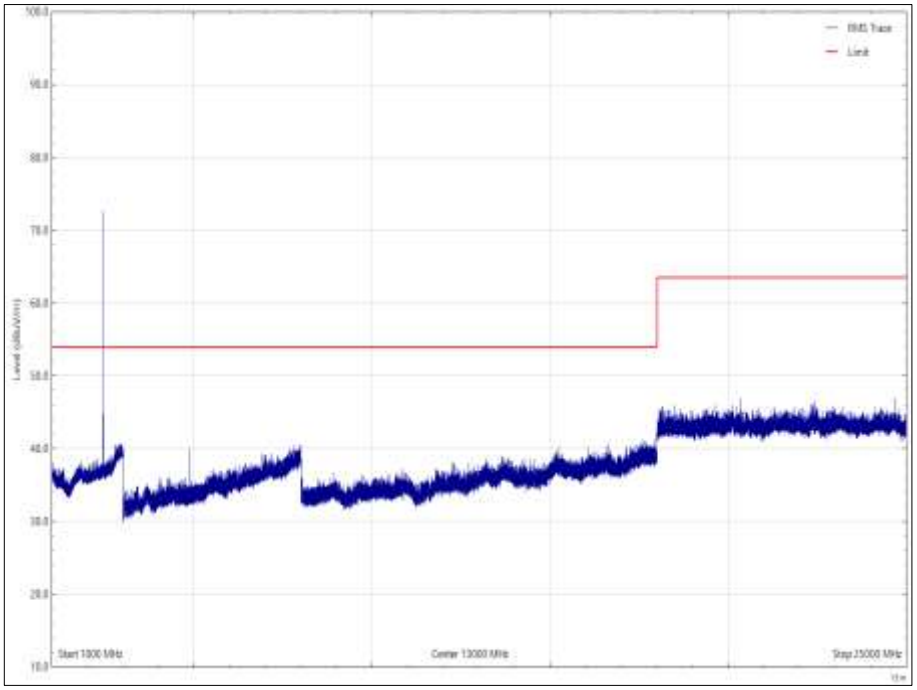


Figure 43 - 2442 MHz - 1 GHz to 25 GHz, X Orientation, Vertical, Average

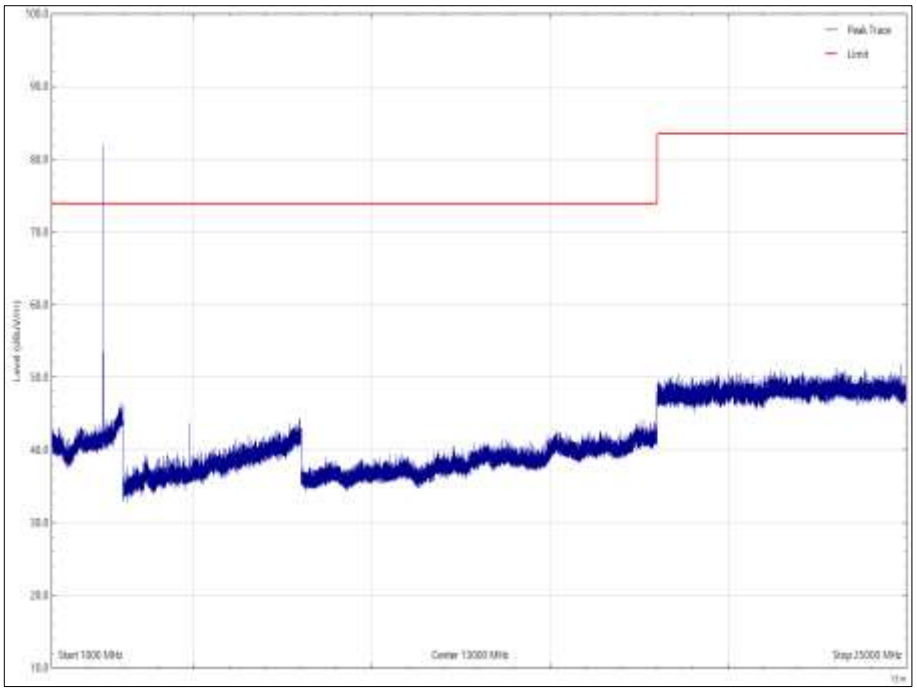


Figure 44 - 2442 MHz - 1 GHz to 25 GHz, X Orientation, Horizontal, Peak

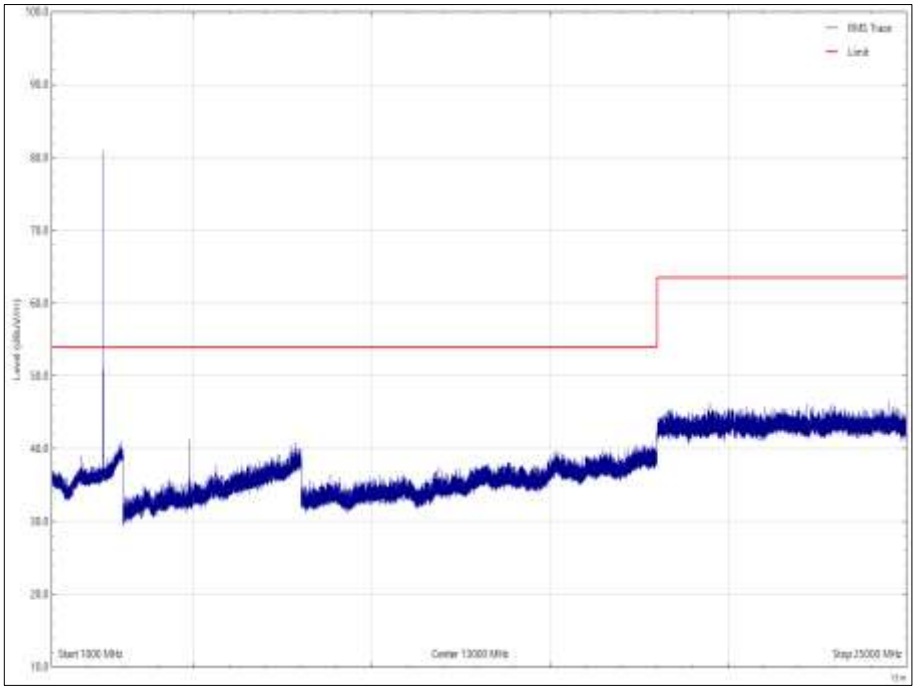


Figure 45 - 2442 MHz - 1 GHz to 25 GHz, X Orientation, Horizontal, Average

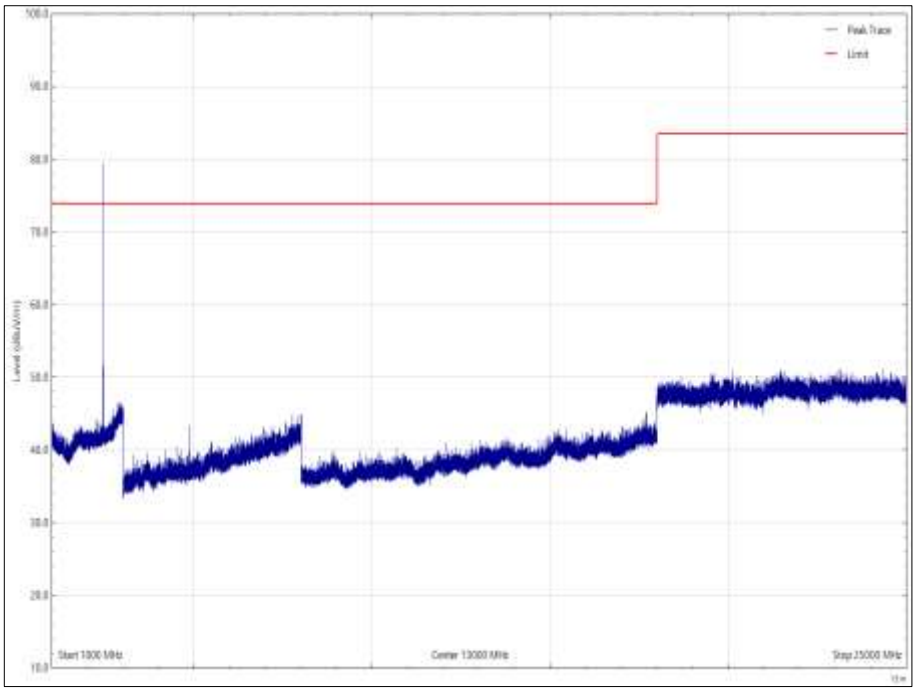


Figure 46 - 2442 MHz - 1 GHz to 25 GHz, Y Orientation, Vertical, Peak

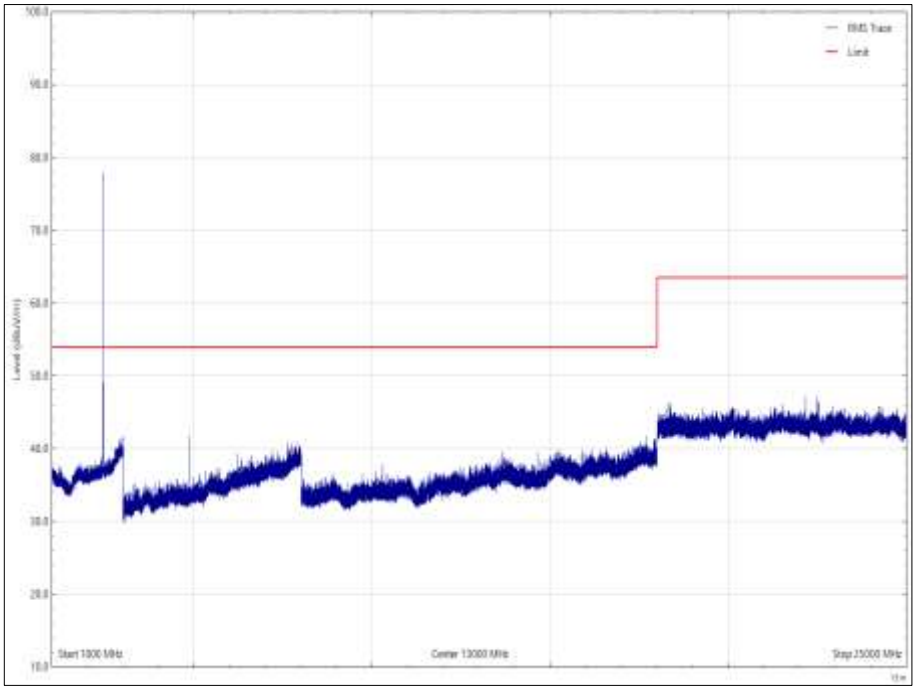


Figure 47 - 2442 MHz - 1 GHz to 25 GHz, Y Orientation, Vertical, Average

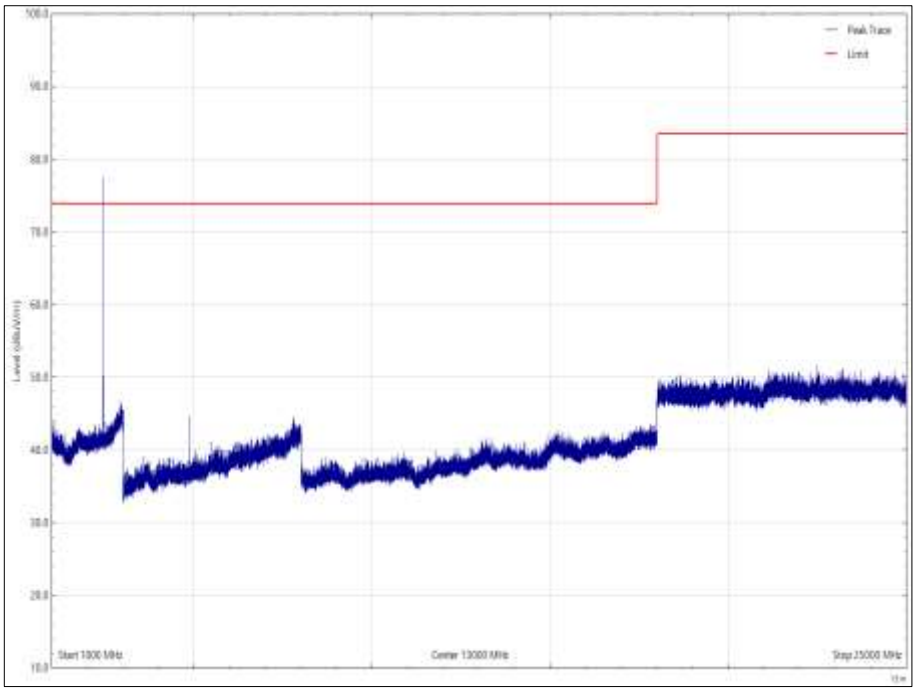


Figure 48 - 2442 MHz - 1 GHz to 25 GHz, Y Orientation, Horizontal, Peak

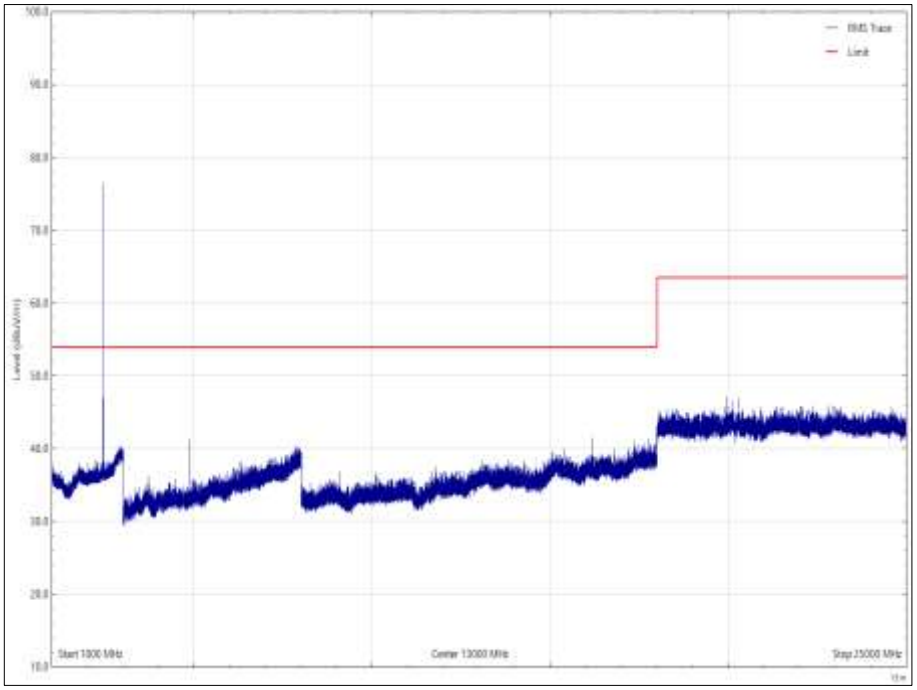


Figure 49 - 2442 MHz - 1 GHz to 25 GHz, Y Orientation, Horizontal, Average

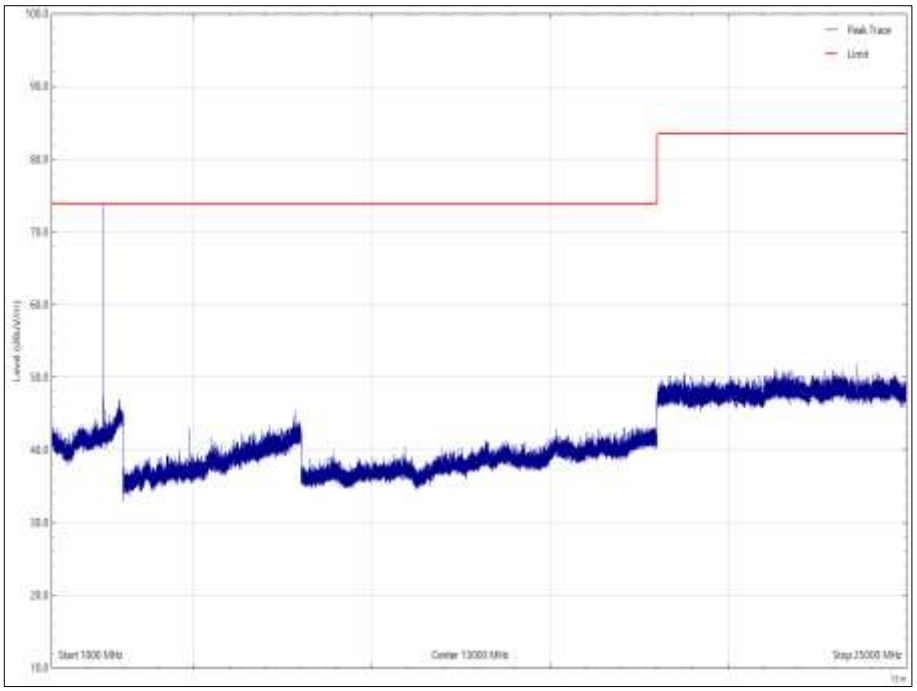


Figure 50 - 2442 MHz - 1 GHz to 25 GHz, Z Orientation, Vertical, Peak

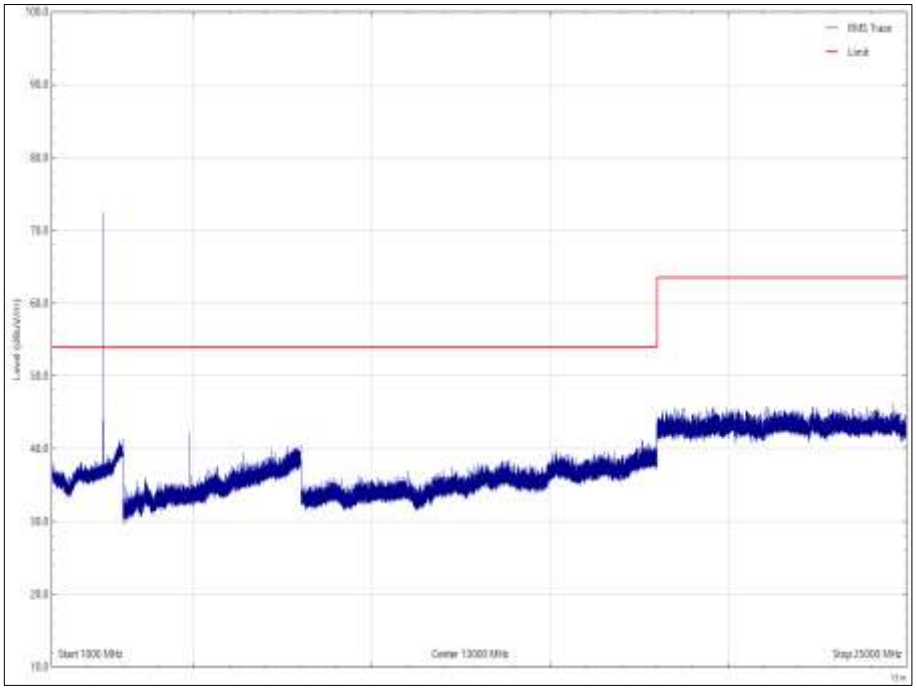


Figure 51 - 2442 MHz - 1 GHz to 25 GHz, Z Orientation, Vertical, Average

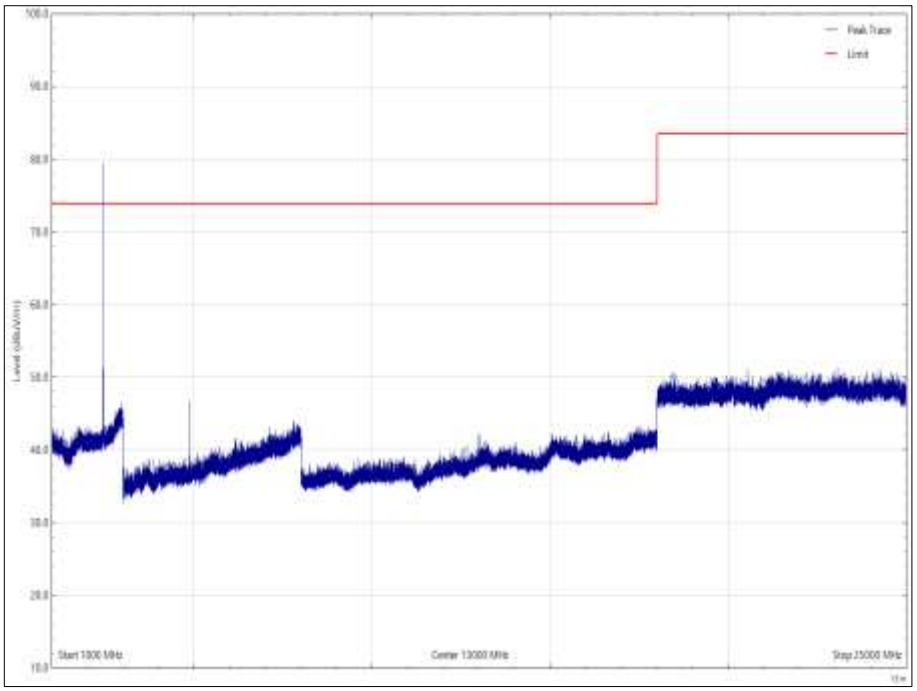


Figure 52 - 2442 MHz - 1 GHz to 25 GHz, Z Orientation, Horizontal, Peak

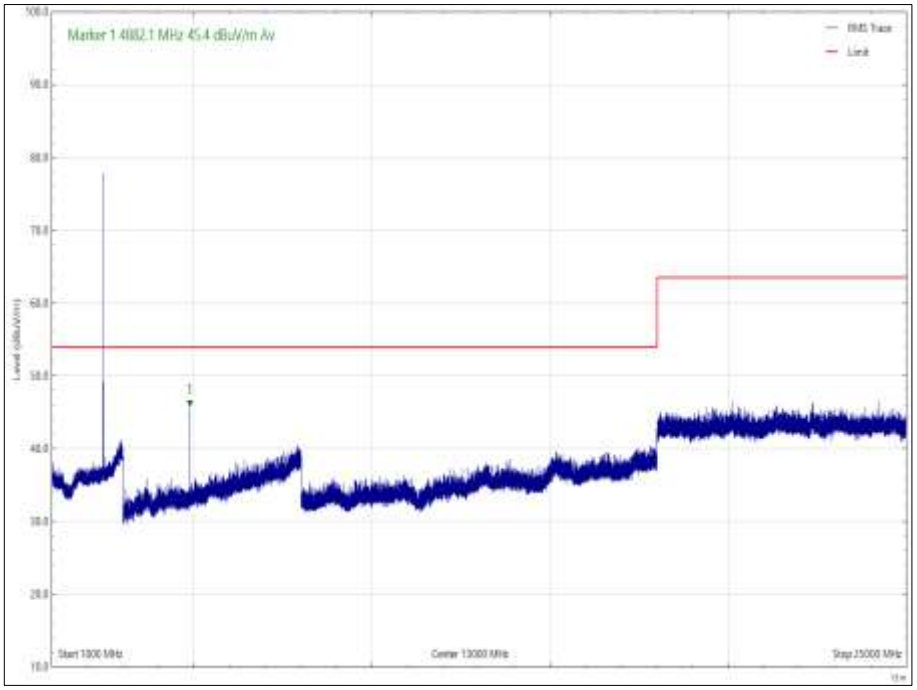


Figure 53 - 2442 MHz - 1 GHz to 25 GHz, Z Orientation, Horizontal, Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
42.481	32.12	40.00	7.88	Q-Peak	346	113	Vertical	X
43.117	30.47	40.00	9.53	Q-Peak	8	138	Vertical	Y
42.528	30.30	40.00	9.70	Q-Peak	3	137	Vertical	Z

Table 22 - 2480 MHz, 30 MHz to 1 GHz - Emission Results

No other emissions were detected within 10 dB of the limit.

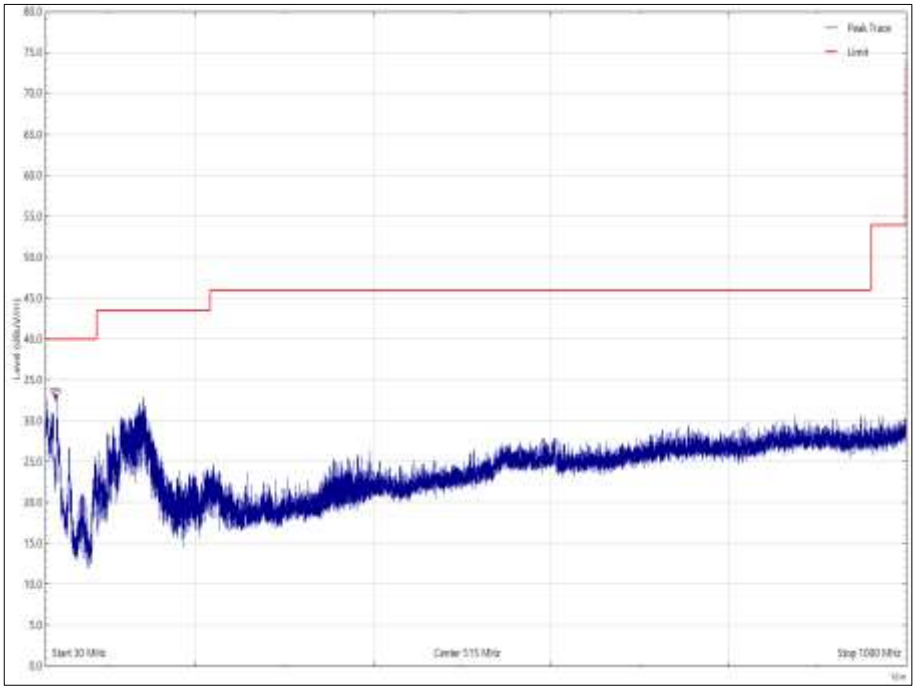


Figure 54 - 2480 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

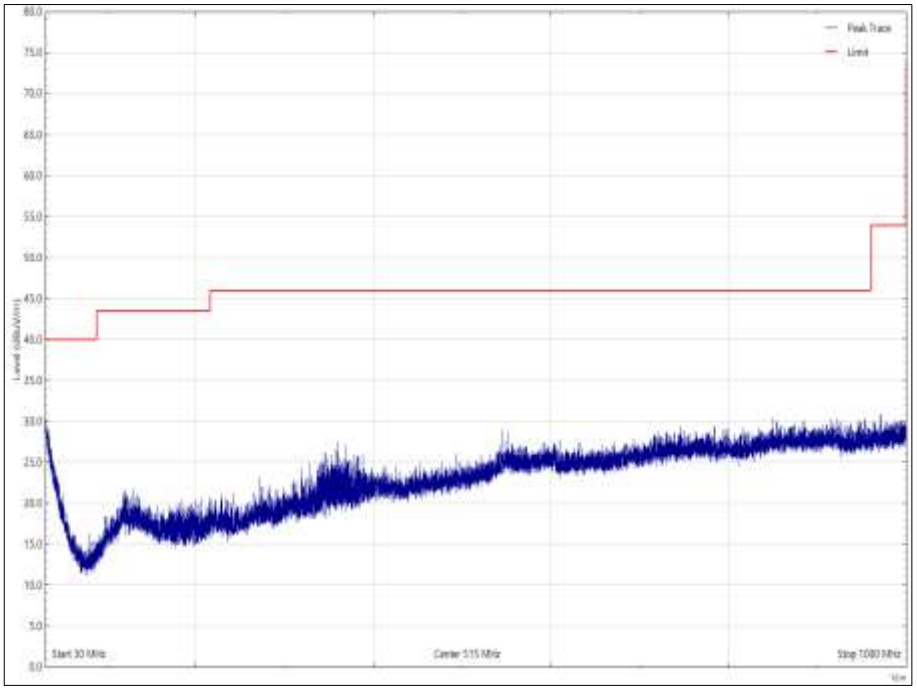


Figure 55 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

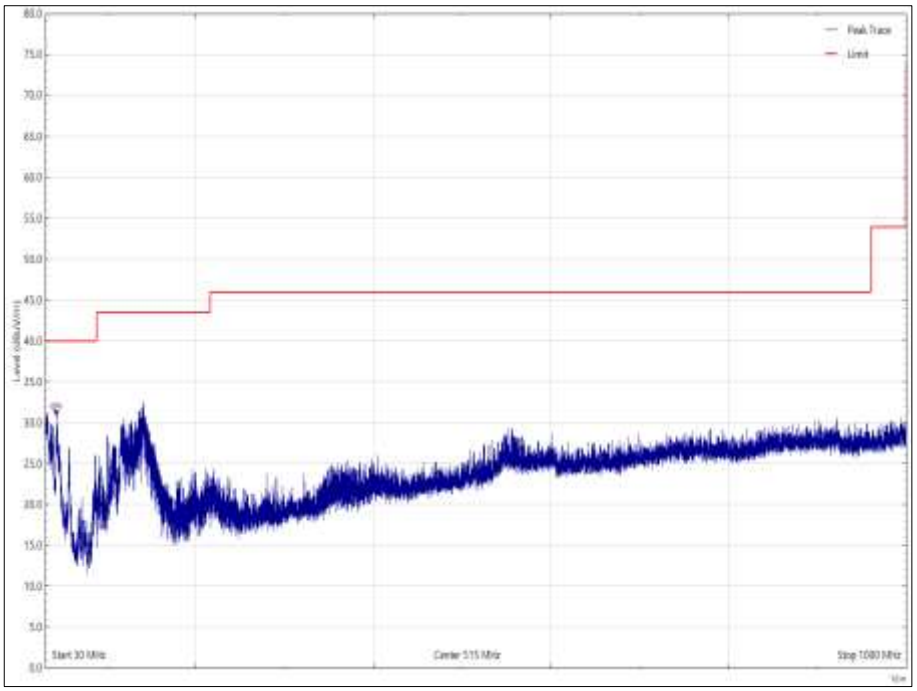


Figure 56 - 2480 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

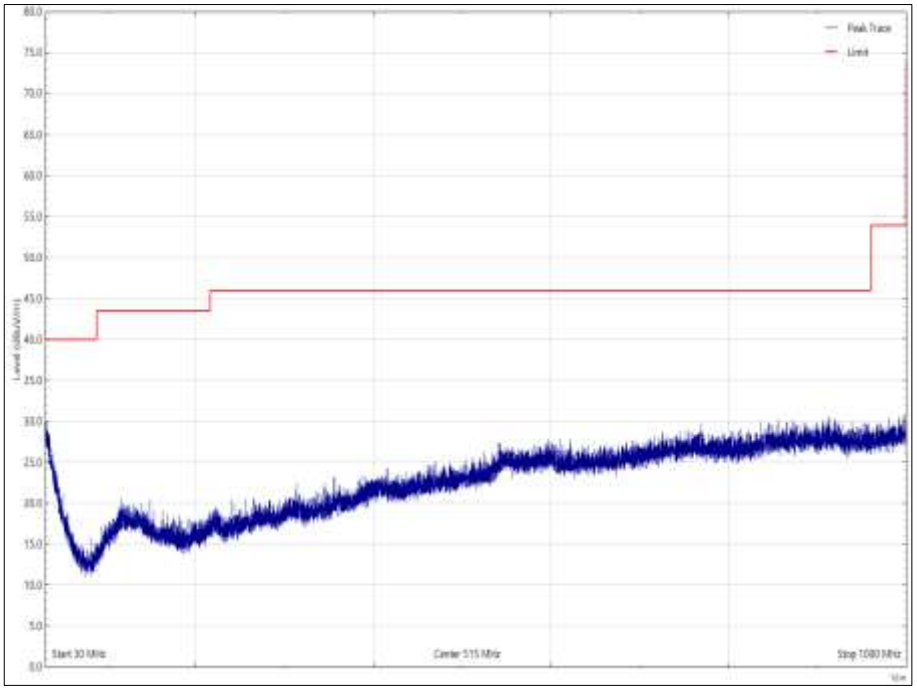


Figure 57 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

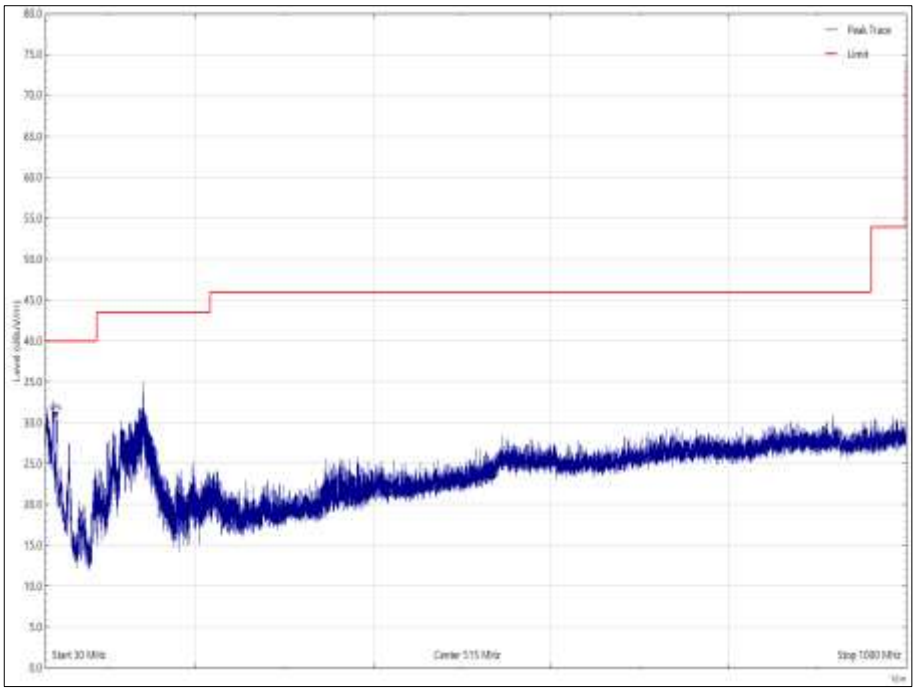


Figure 58 - 2480 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

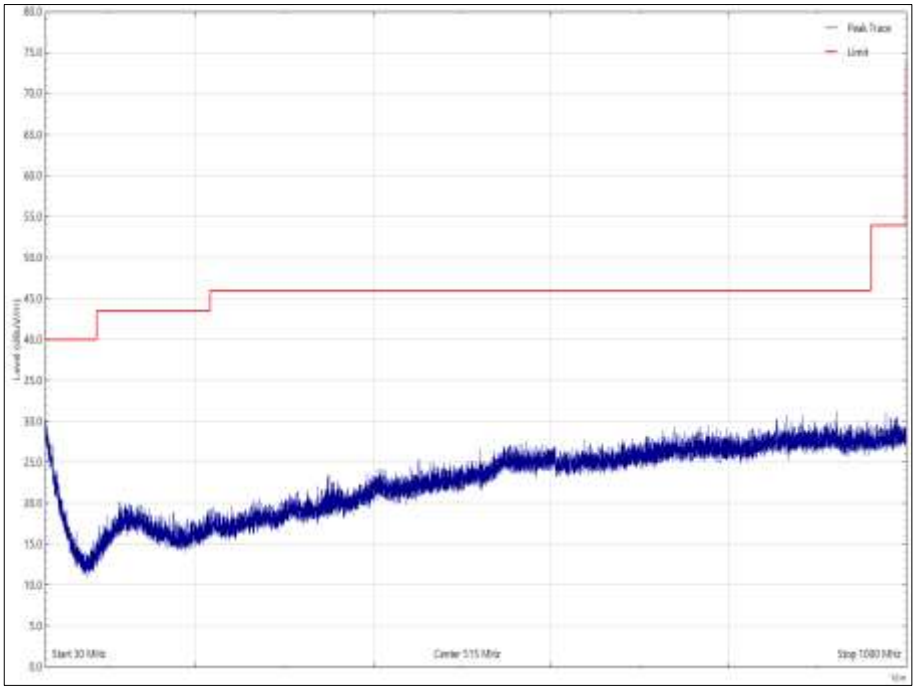


Figure 59 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4958.074	45.52	53.98	8.46	CISPR Average	228	104	Horizontal	Z

Table 23 - 2480 MHz - 1 GHz to 25 GHz Emissions Results

No other emissions were detected within 10 dB of the limit.

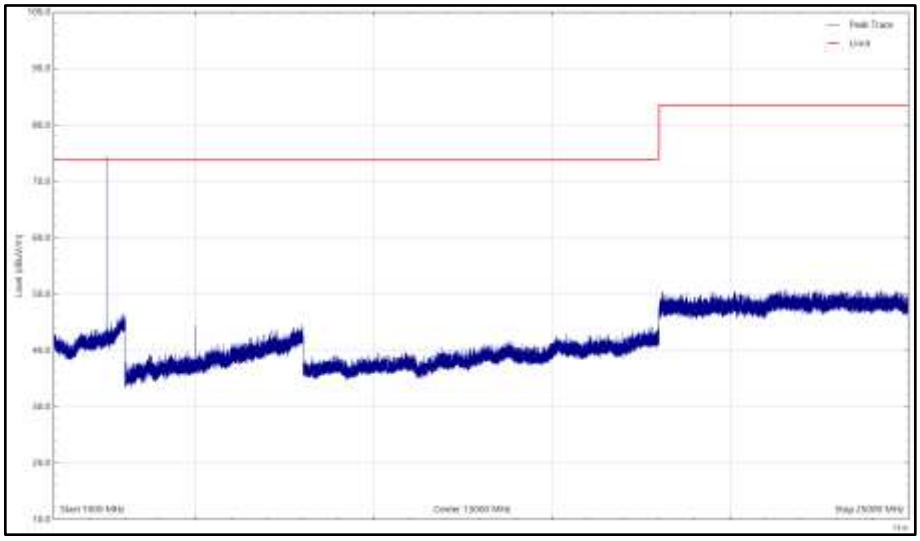


Figure 60 - 2480 MHz - 1 GHz to 25 GHz, X Orientation, Vertical, Peak

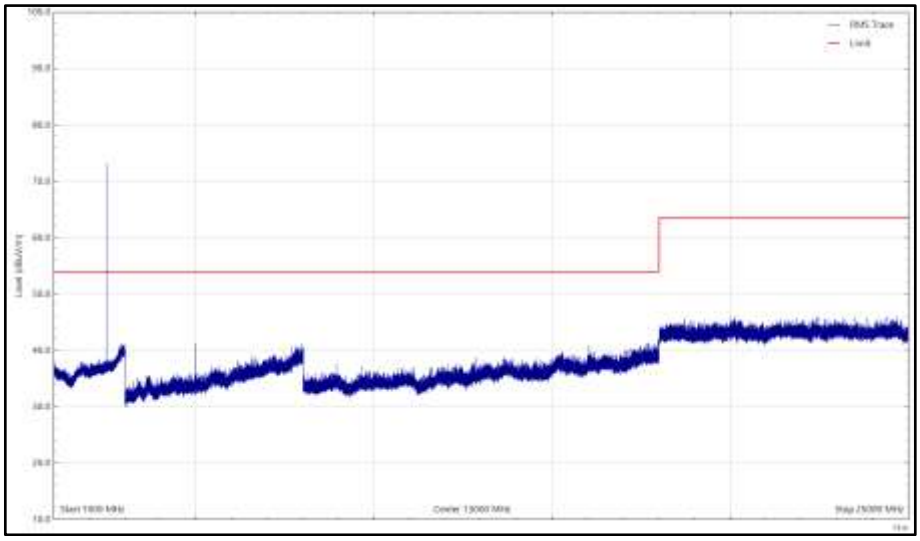


Figure 61 - 2480 MHz - 1 GHz to 25 GHz, X Orientation, Vertical, Average

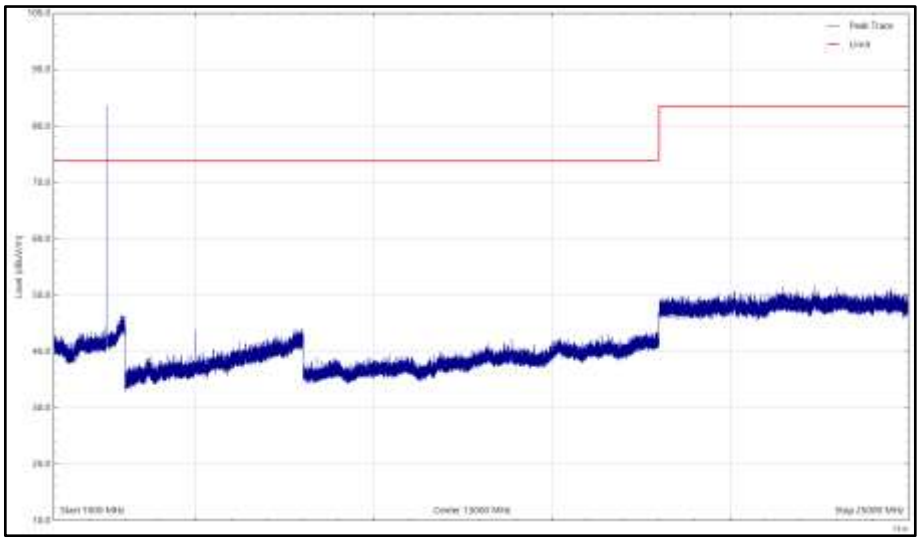


Figure 62 - 2480 MHz - 1 GHz to 25 GHz, X Orientation, Horizontal, Peak

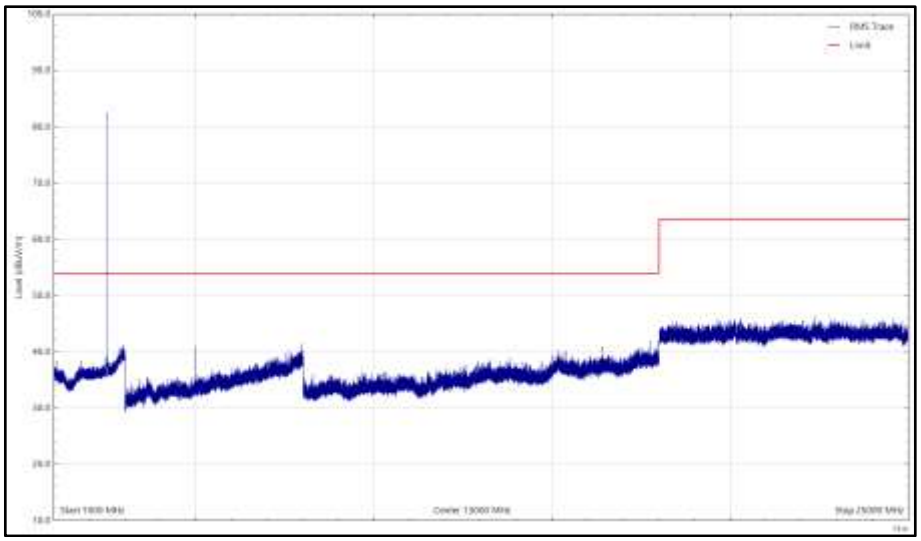


Figure 63 - 2480 MHz - 1 GHz to 25 GHz, X Orientation, Horizontal, Average

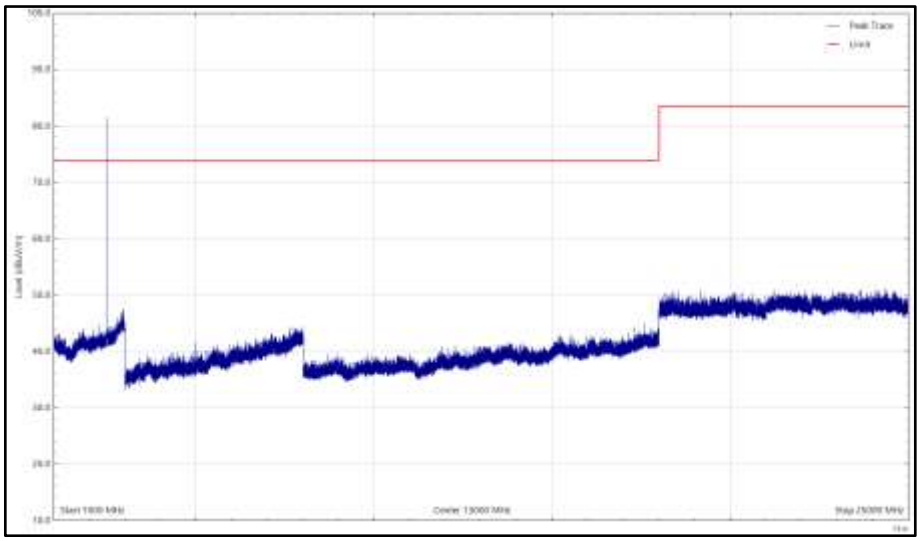


Figure 64 - 2480 MHz - 1 GHz to 25 GHz, Y Orientation, Vertical, Peak

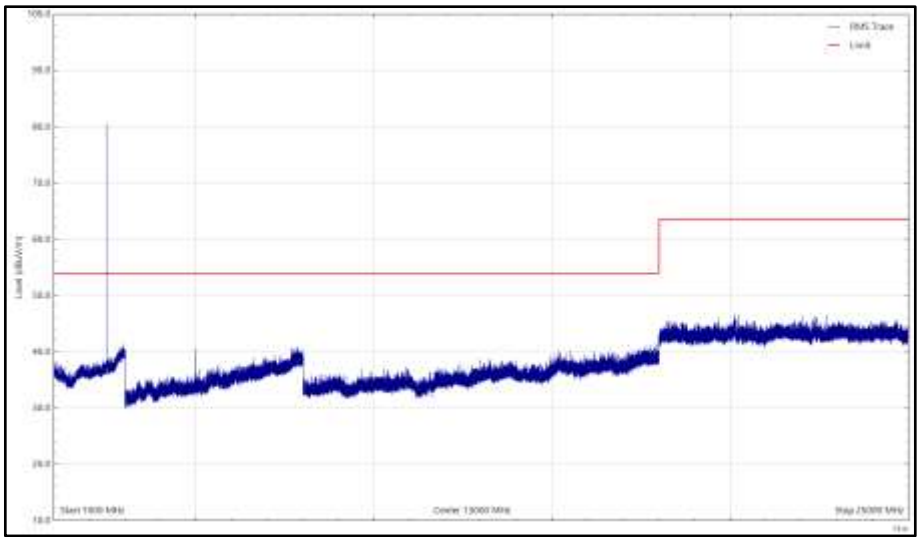


Figure 65 - 2480 MHz - 1 GHz to 25 GHz, Y Orientation, Vertical, Average

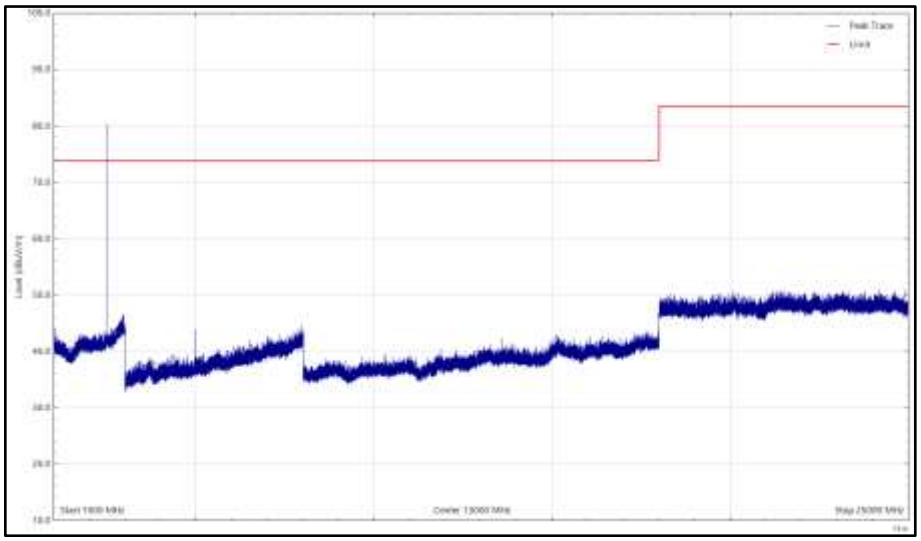


Figure 66 - 2480 MHz - 1 GHz to 25 GHz, Y Orientation, Horizontal, Peak

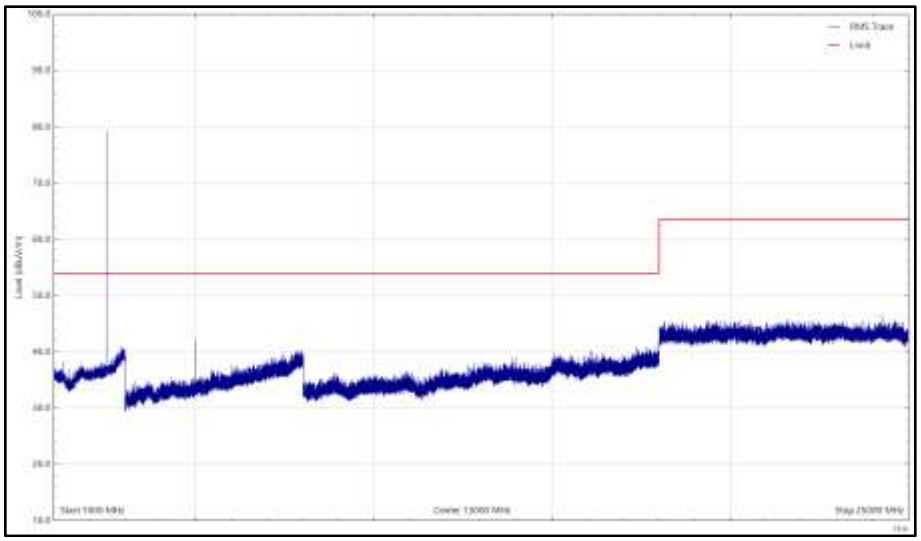


Figure 67 - 2480 MHz - 1 GHz to 25 GHz, Y Orientation, Horizontal, Average

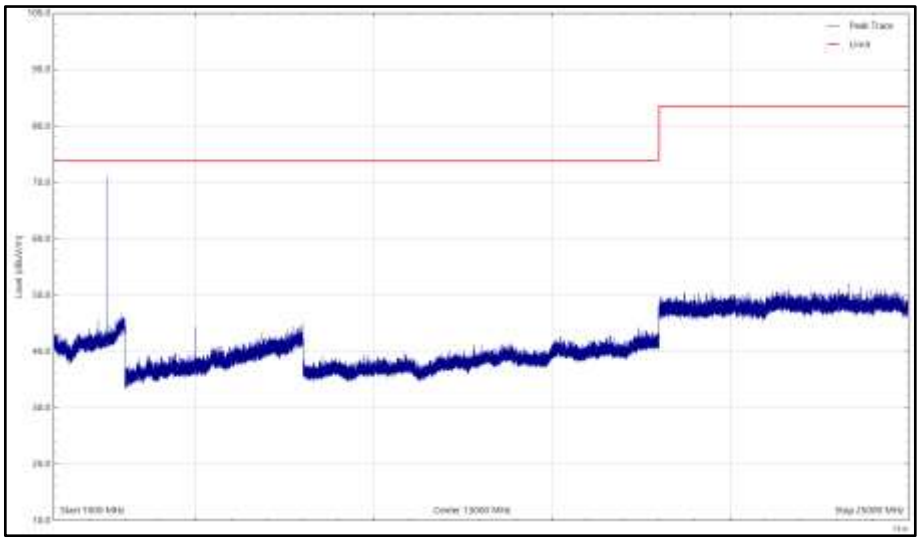


Figure 68 – 2480 MHz - 1 GHz to 25 GHz, Z Orientation, Vertical, Peak

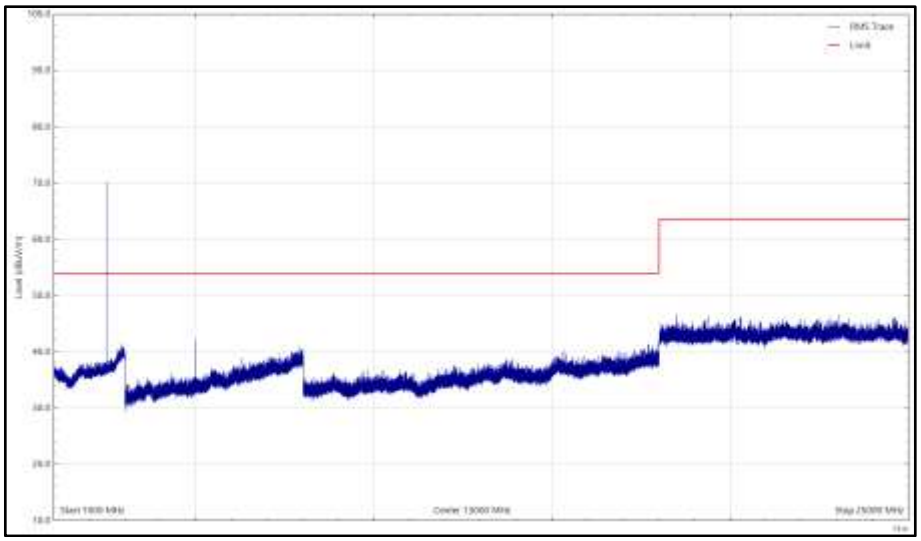


Figure 69 - 2480 MHz - 1 GHz to 25 GHz, Z Orientation, Vertical, Average

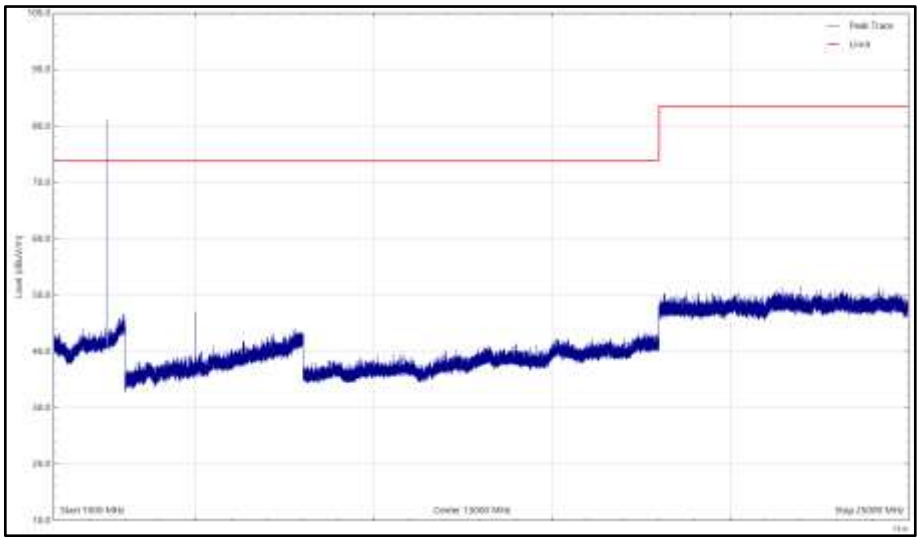


Figure 70 - 2480 MHz - 1 GHz to 25 GHz, Z Orientation, Horizontal, Peak

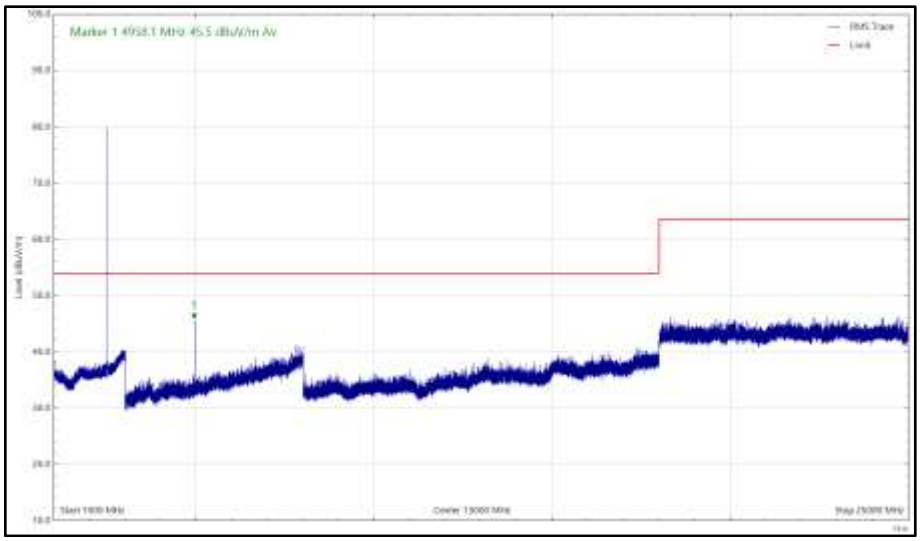


Figure 71 - 2480 MHz - 1 GHz to 25 GHz, Z Orientation, Horizontal, Average

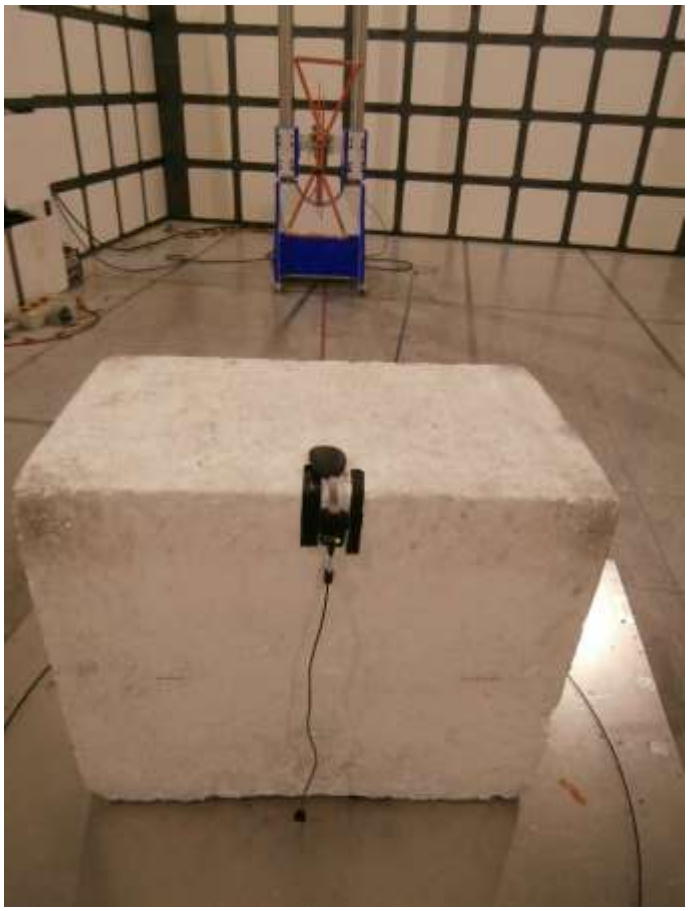


Figure 72 - Test Setup - 30 MHz to 1 GHz – X Orientation

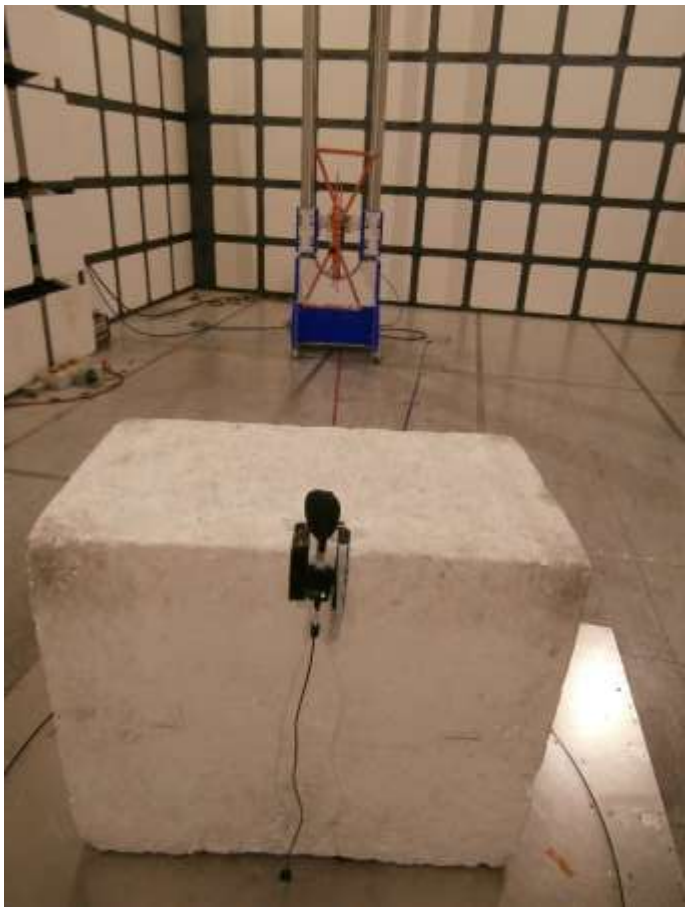


Figure 73 - Test Setup - 30 MHz to 1 GHz – Y Orientation

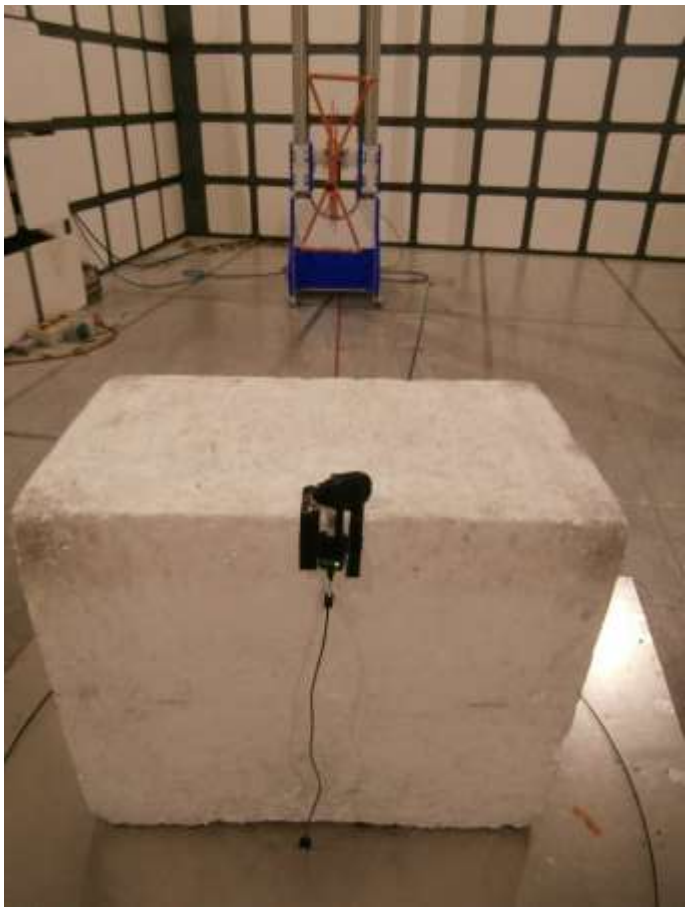


Figure 74 - Test Setup - 30 MHz to 1 GHz – Z Orientation

Figure 75 - Test Setup - 1 GHz to 18 GHz – X Orientation

Figure 76 - Test Setup - 1 GHz to 18 GHz – Y Orientation

Figure 77 - Test Setup - 1 GHz to 18 GHz – Z Orientation

Figure 78 - Test Setup - 1 GHz to 25 GHz – X Orientation

Figure 79 - Test Setup - 1 GHz to 25 GHz – Y Orientation

Figure 80 - Test Setup - 1 GHz to 25 GHz – Z Orientation

FCC 47 CFR Part 15, Limit Clause 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).

2.6.8 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	27-Jul-2022
Pre-Amplifier	Phase One	PS04-0086	1533	12	04-Feb-2021
18GHz - 40GHz Pre-Amplifier	Phase One	PSO4-0087	1534	12	18-Feb-2021
Antenna with permanent attenuator (Bilog)	Chase	CBL6143	2904	24	30-Sep-2021
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	03-Jan-2021
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	10-Mar-2021
EmX Emissions Software	TUV SUD	V2.0.1 V.V2.0.1	5125	-	N/A - Software
3 GHz High pass filter	Wainwright	WHKX12-2580-3000-18000-80SS	5220	12	25-Mar-2021
Preamplifier (30dB 1GHz to 18GHz)	Schwarzbeck	BBV 9718 C	5261	12	07-Apr-2021
Antenna (DRG Horn 7.5-18GHz)	Schwarzbeck	HWRD750	5348	12	22-Sep-2021
Thermo-Hygro-Barometer	PCE Instruments	OCE-THB-40	5470	12	16-Mar-2021
1m K-Type Cable	Junkosha	MWX241-01000KMSKMS/A	5511	12	03-Apr-2021
1m SMA Cable	Junkosha	MWX221-01000AMSAMS/A	5514	12	01-Apr-2021
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5517	12	01-Apr-2021
8m N-Type Cable	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2021
2 m K Type Cable	Junkosha	MWX241-02000KMSKMS/A	5523	12	03-Apr-2021

Table 24

TU – Traceability Unscheduled

2.7 Power Spectral Density

2.7.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (e)

2.7.2 Equipment Under Test and Modification State

Sensate, S/N: Not serialised (0075950095-TSR0002) - Modification State 0

2.7.3 Date of Test

08-November-2020

2.7.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.10.2.

This test was performed radiated in a 3m semi-anechoic chamber.

2.7.5 Environmental Conditions

Ambient Temperature	24.1 °C
Relative Humidity	46.4 %

2.7.6 Test Results

2.4 GHz Bluetooth Low Energy

Frequency (MHz)	Power Spectral Density (dBm)	Measurement Bandwidth (kHz)
2402	-28.23	3
2442	-31.37	3
2480	-29.27	3

Table 25 - Power Spectral Density

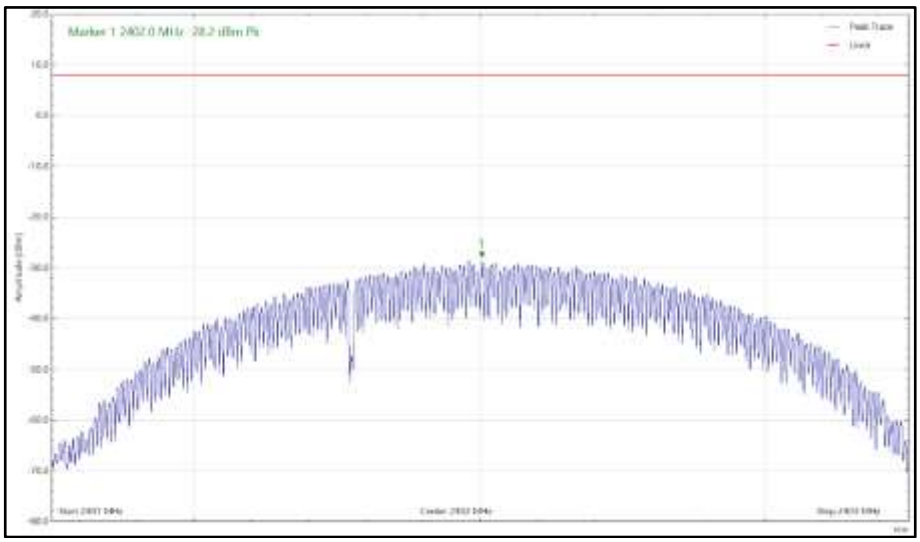


Figure 81 – 2402 MHz

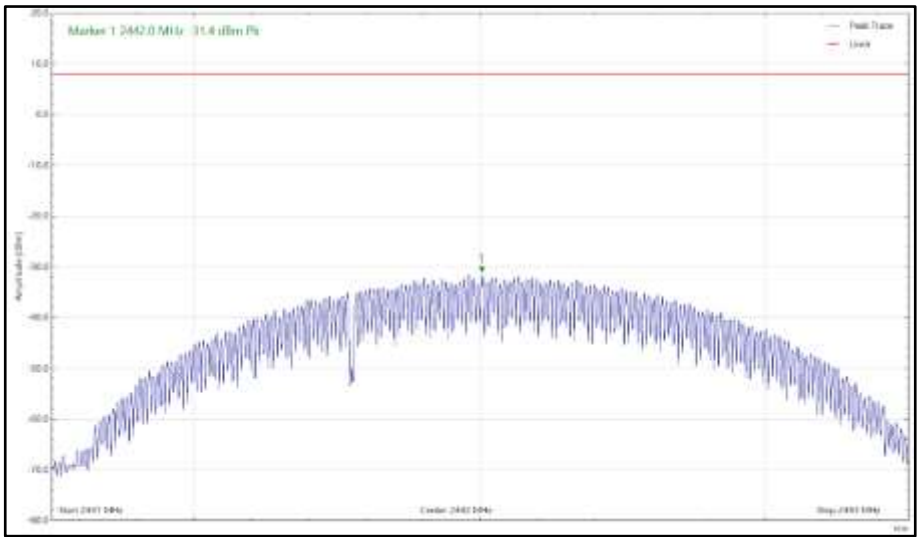


Figure 82 – 2442 MHz

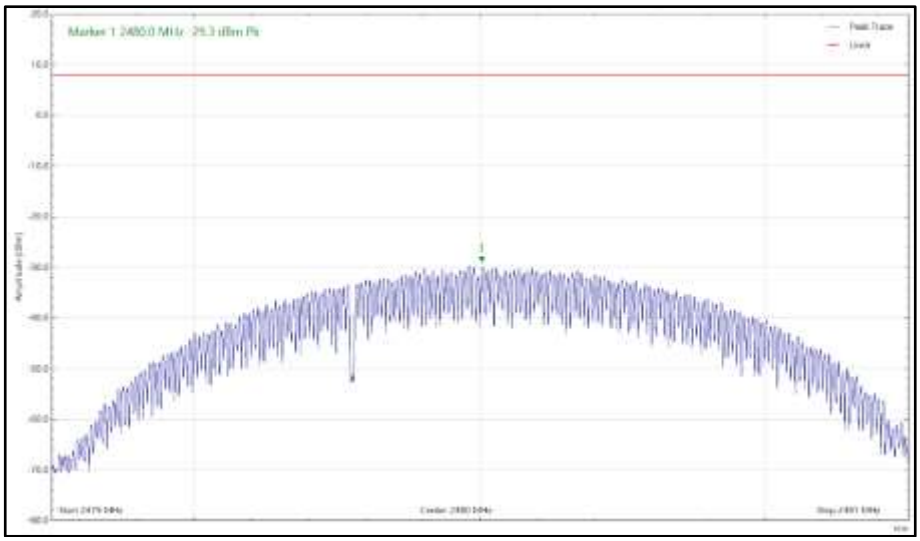


Figure 83 – 2480 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (e)

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

2.7.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	03-Jan-2021
N-Type to 2.92mm Cable	APC Technology	RFF24919	5443	12	10-Mar-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	18-Mar-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5519	12	24-Mar-2021
Broadband Horn Antenna (1-10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	22-Sep-2021
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast TAM 4.0-P	Maturo Gmbh	TAM 4.0-P	5613	-	TU
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 26

TU – Traceability Unscheduled

3 Incident Reports

No incidents reports were raised.

4 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Restricted Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
AC Power Line Conducted Emissions	150 kHz to 30 MHz, LISN, ±3.7 dB
Emission Bandwidth	± 1.118 MHz
Maximum Conducted Output Power	± 6.3 dB
Authorised Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Power Spectral Density	± 6.3 dB

Table 27

Measurement Uncertainty Decision Rule

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115: 2007, clause 4.4.3 and 4.5.1.