FCC and ISED Test Report

XYZ Reality Ltd
Model: Atom Hard Hat

In accordance with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN (2.4 GHz Bluetooth)

Prepared for: XYZ Reality Ltd
Unit G0, G02, 338-346
Goswell Road, Angel
Clerkenwell
EC1V 7LQ
United Kingdom

FCC ID: 2A3C5-TBA IC: Not Applicable

COMMERCIAL-IN-CONFIDENCE

Document 75952587-12 Issue 01

SIGNATURE			
			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	22 December 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 with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Graeme Lawler	22 December 2021	
Testing	Daniel Cameron	22 December 2021	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

ISED Accreditation
12669A 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: 2020, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) for the tests detailed in section 1.3.

TÜV SÜD
is a trading name of TUV SUD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TUV SUD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuvsud.com/en

TÜV SÜD
Octagon House
Concorde Way
Fareham
Hampshire PO15 5RL
United Kingdom

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	22-December-2021

Table 1

1.2 Introduction

Applicant	XYZ Reality Ltd
Manufacturer	XYZ Reality Ltd
Model Number(s)	Atom Hard Hat
Serial Number(s)	Not serialised (Storix-ID 599374-18) and Not serialised (Storix-ID 599374-99)
Hardware Version(s)	Not Applicable
Software Version(s)	Windows Certification Build
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2020 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021)
Order Number Date	XYZ0179 21-June-2021
Date of Receipt of EUT	06-September-2021
Start of Test	07-September-2021
Finish of Test	29-September-2021
Name of Engineer(s)	Graeme Lawler and Daniel Cameron
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, ISED RSS-247 and ISED RSS-GEN is shown below.

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: Hard Hat - 2.4 GHz Bluetooth						
-	15.203	-	-	Antenna Requirement	N/T	The device complies with the provisions of this section, as it uses permanently attached integral antennas.
2.1	15.205	-	8.10	Restricted Band Edges	Pass	
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Number of Hopping Channels	Pass	
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	
2.4	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	
2.5	15.247 (a)(1)	5.1	6.7	Frequency Hopping Systems - 20 dB Bandwidth	Pass	
2.6	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.7	15.247 (d) and 15.209	3.3 and 5.5	6.13 and 8.9	Spurious Radiated Emissions	Pass	
2.8	15.247 (d)	5.5	-	Authorised Band Edges	Pass	

Table 2

1.4 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	Protective hard Hat with integrated eye protection and augmented reality
Manufacturer:	XYZ Reality Ltd
Model:	Atom Hard Hat
Part Number:	XYZ-12-01
Hardware Version:	Not Applicable
Software Version:	Windows Certification Build
FCC ID of the product under test – see guidance here	2A3C5-TBA (contains FCC ID PD992260NG)
IC ID of the product under test – see guidance here	N/A (Contains IC 1000M-9260NG)

Table 3

Intentional Radiators

Technology	Bluetooth	BLE	WLAN 2.4 GHz	Proprietary ISM 2.4GHz
Frequency Range (MHz to MHz)	2402-2480	2402-2480	2412-2462	2402-2480
Conducted Declared Output Power (dBm)	5	5	19	0
Antenna Gain (dBi)	2.8	2.8	2.8	2.8
Supported Bandwidth(s) (MHz) (e.g 1 MHz, 20 MHz, 40 MHz)	1	1	20 / 40	840
Modulation Scheme(s) (e.g GFSK, QPSK etc)	GFSK / π/4 DQPSK / 8-DPSK	GFSK	OFDM / OFDM-HT / CCK	GFSK / DQPSK
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)	1M00F1D	1M00F1D	20M3D1W / 40M3D1W	1M00F1D
Bottom Frequency (MHz)	2402	2402	2412	2402
Middle Frequency (MHz)	2441	2440	2437	2440
Top Frequency (MHz)	2480	2480	2472	2480

Table 4

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	
Lowest frequency generated or used in the device or on which the device operates or tunes	
Class A Digital Device (Use in commercial, industrial or business environment) ☐ Class B Digital Device (Use in residential environment only) ☒	

Table 5

AC Power Source

AC supply frequency:		Hz
Voltage		V
Max current:		A
Single Phase ☐ Three Phase ☐		

Table 6

DC Power Source

Nominal voltage:		V
Extreme upper voltage:		V
Extreme lower voltage:		V
Max current:		A

Table 7

Battery Power Source

Voltage:	7.4	V
End-point voltage:		V *(Point at which the battery will terminate)*
Alkaline ☐ Leclanche ☐ Lithium ☐ Nickel Cadmium ☐ Lead Acid* ☐ **(Vehicle regulated)*		
Other ☒ Please detail:	Li Ion	

Table 8

Charging

Can the EUT transmit whilst being charged	Yes ☐ No ☒

Table 9

Temperature

Minimum temperature:	0	°C
Maximum temperature:	40	°C

Table 10

Cable Loss

Adapter Cable Loss (Conducted sample)	1.3	dB

Table 11

Antenna Characteristics

Antenna connector ☒			State impedance	50	Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	Flexible	Gain	2.8	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 ☐					

Table 12

Ancillaries (if applicable)

Manufacturer:		Part Number:	
Model:		Country of Origin:	

Table 13

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

Name: Dave Williams
Position held: Director of Engineering, DitroniX Ltd
Date: 04 November 2021

1.5 Product Information

1.5.1 Technical Description

Protective hard Hat with integrated eye protection and augmented reality.

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
Model: Atom Hard Hat, Serial Number: Not serialised (Storix-ID 599374-18)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: Atom Hard Hat, Serial Number: Not serialised (Storix-ID 599374-99)			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 14

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: Hard Hat - 2.4 GHz Bluetooth		
Restricted Band Edges	Graeme Lawler	UKAS
Frequency Hopping Systems - Number of Hopping Channels	Daniel Cameron	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Daniel Cameron	UKAS
Frequency Hopping Systems - Channel Separation	Daniel Cameron	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Daniel Cameron	UKAS
Maximum Conducted Output Power	Daniel Cameron	UKAS
Spurious Radiated Emissions	Graeme Lawler	UKAS
Authorised Band Edges	Graeme Lawler	UKAS

Table 15

Office Address:

TÜV SÜD
Octagon House
Concorde Way
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
ISED RSS-GEN, Clause 8.10

2.1.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-18) - Modification State 0

2.1.3 Date of Test

12-September-2021

2.1.4 Test Method

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

Plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.3. 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	18.9 °C
Relative Humidity	60.8 %

2.1.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Modulation	Packet Type	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	DH5 - Static	2402	2390.0	52.83	36.41
GFSK	DH5 - Static	2480	2483.5	59.55	42.81
π/4 DQPSK	2-DH5 - Static	2402	2390.0	53.38	37.09
π/4 DQPSK	2-DH5 - Static	2480	2483.5	57.47	43.56
8-DPSK	3-DH5 - Static	2402	2390.0	53.75	36.94
8-DPSK	3-DH5 - Static	2480	2483.5	58.68	44.25
GFSK	DH5 - Hopping	2402	2390.0	52.82	36.41
GFSK	DH5 - Hopping	2480	2483.5	55.67	37.40
π/4 DQPSK	2-DH5 - Hopping	2402	2390.0	52.87	37.11
π/4 DQPSK	2-DH5 - Hopping	2480	2483.5	57.77	37.82
8-DPSK	3-DH5 - Hopping	2402	2390.0	53.54	36.95
8-DPSK	3-DH5 - Hopping	2480	2483.5	60.83	39.42

Table 16

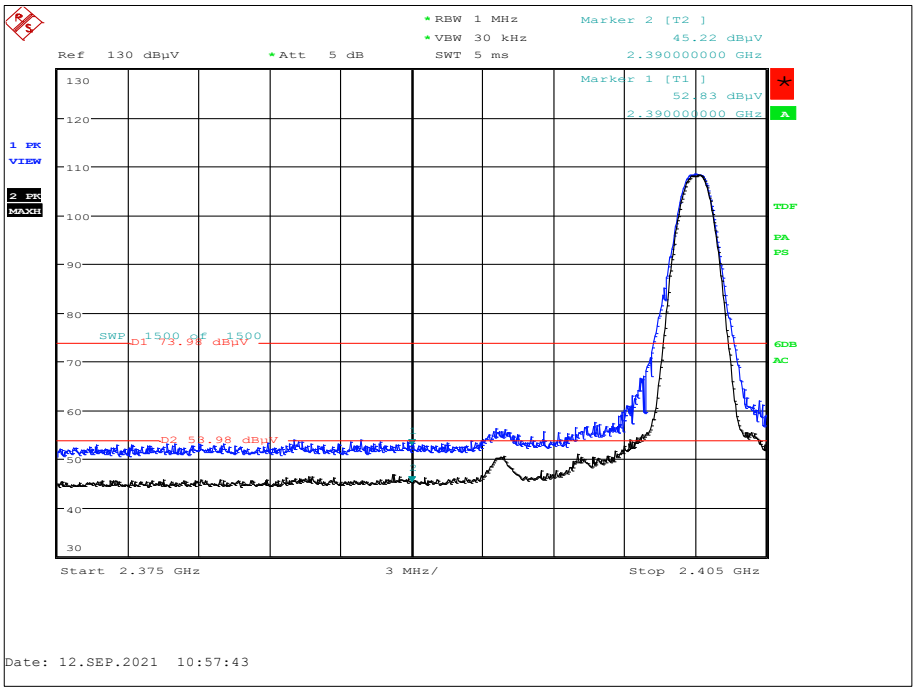

Figure 1 - GFSK/DH5 - Static - 2402 MHz – Band Edge Frequency 2390.0 MHz

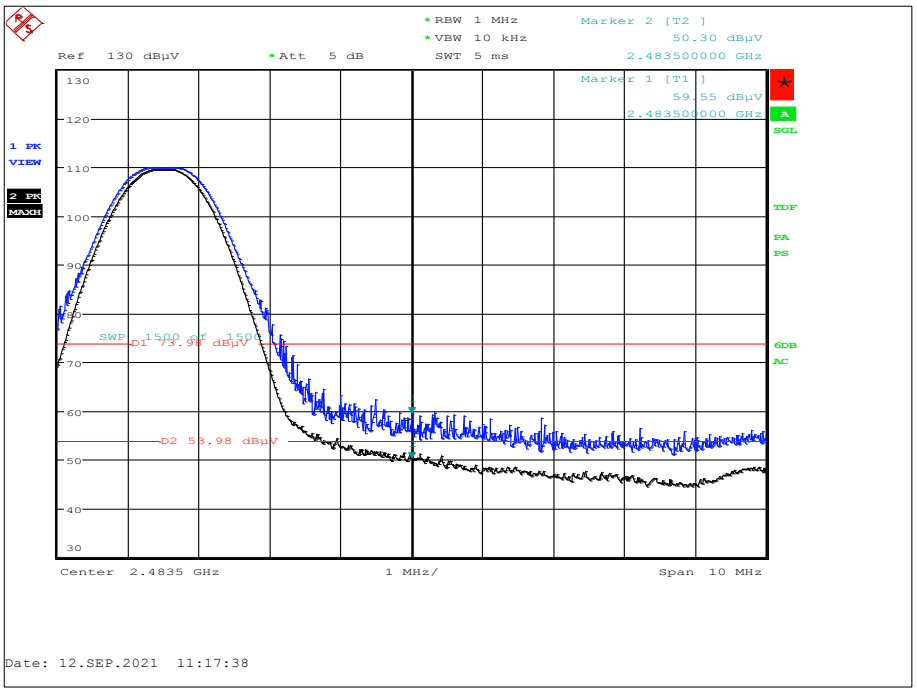

Figure 2 - GFSK/DH5 - Static - 2480 MHz – Band Edge Frequency 2483.5 MHz

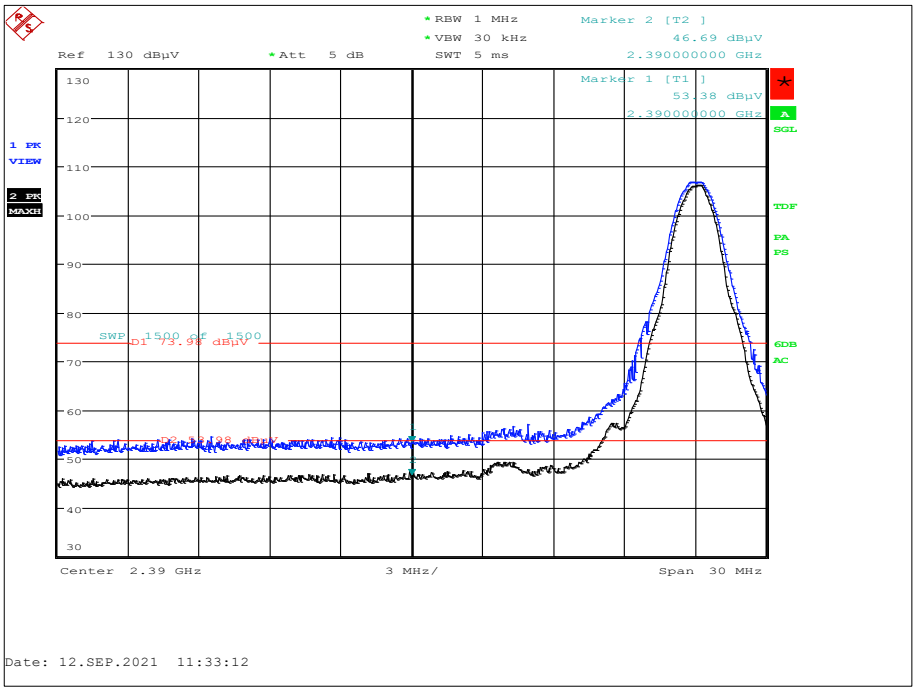

Figure 3 - π/4 DQPSK/2-DH5 - Static - 2402 MHz – Band Edge Frequency 2390.0 MHz

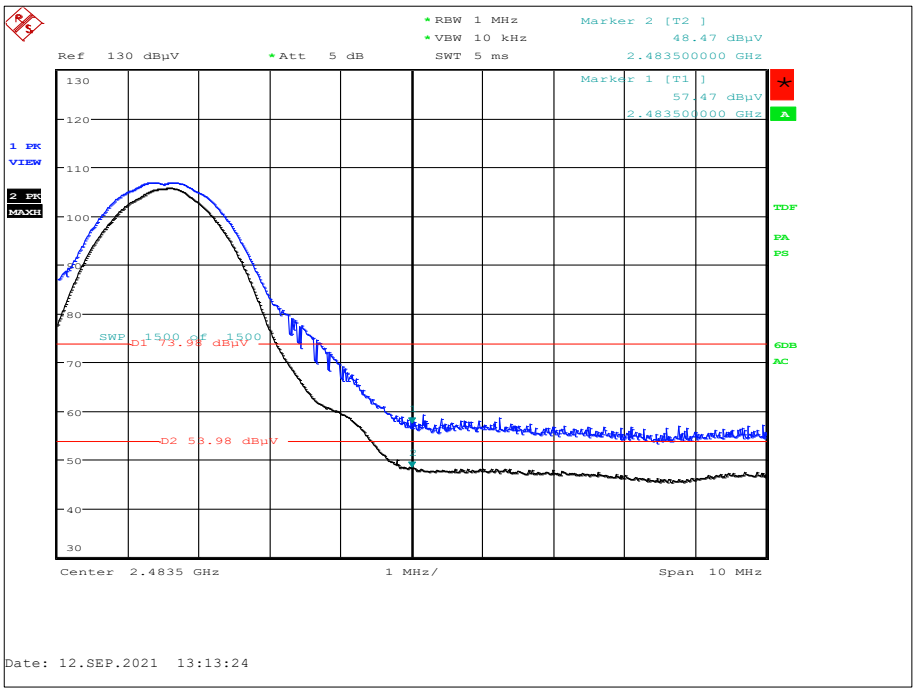

Figure 4 - π/4 DQPSK/2-DH5 - Static - 2480 MHz – Band Edge Frequency 2483.5 MHz

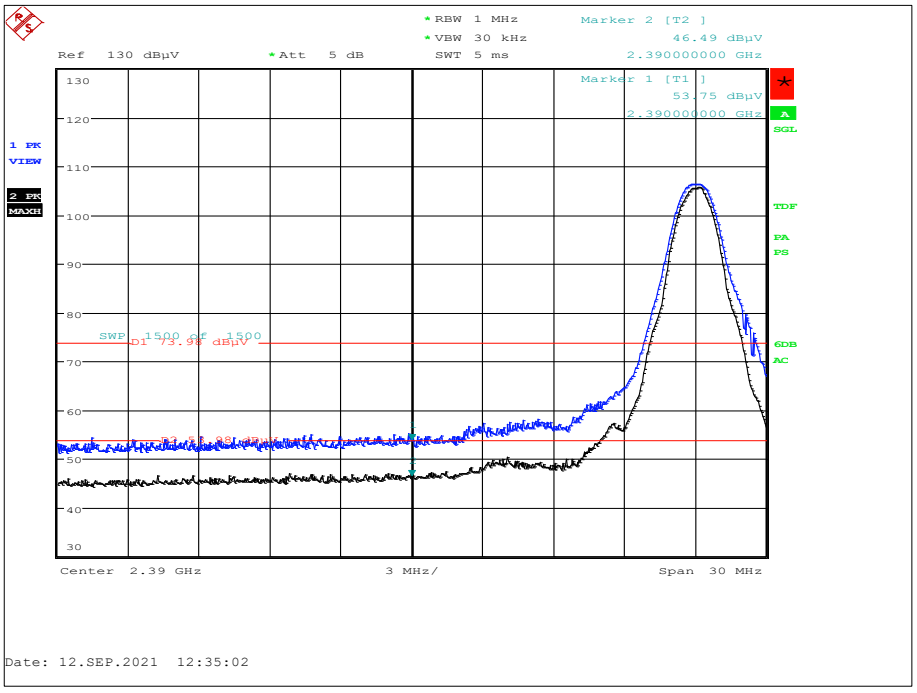

Figure 5 - 8-DPSK/3-DH5 - Static - 2402 MHz – Band Edge Frequency 2390.0 MHz

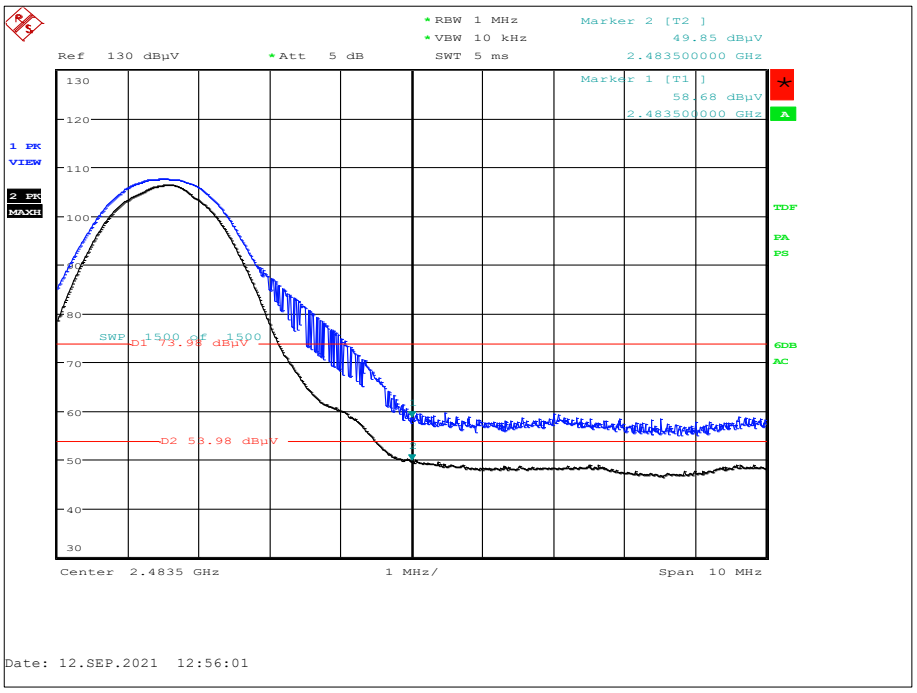

Figure 6 - 8-DPSK/3-DH5 - Static - 2480 MHz – Band Edge Frequency 2483.5 MHz

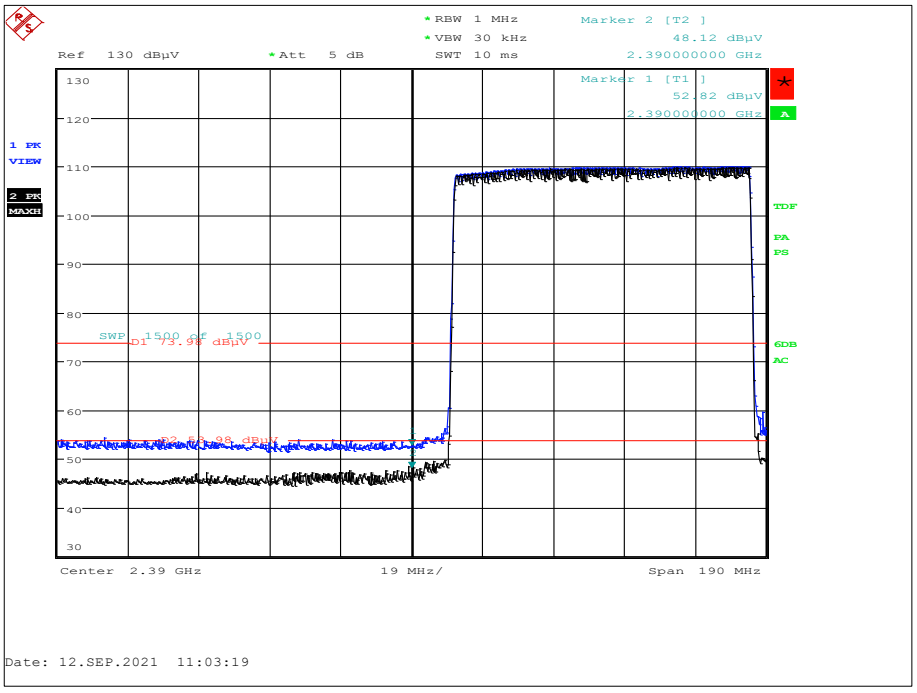

Figure 7 - GFSK/DH5 - Hopping - 2402 MHz – Band Edge Frequency 2390.0 MHz

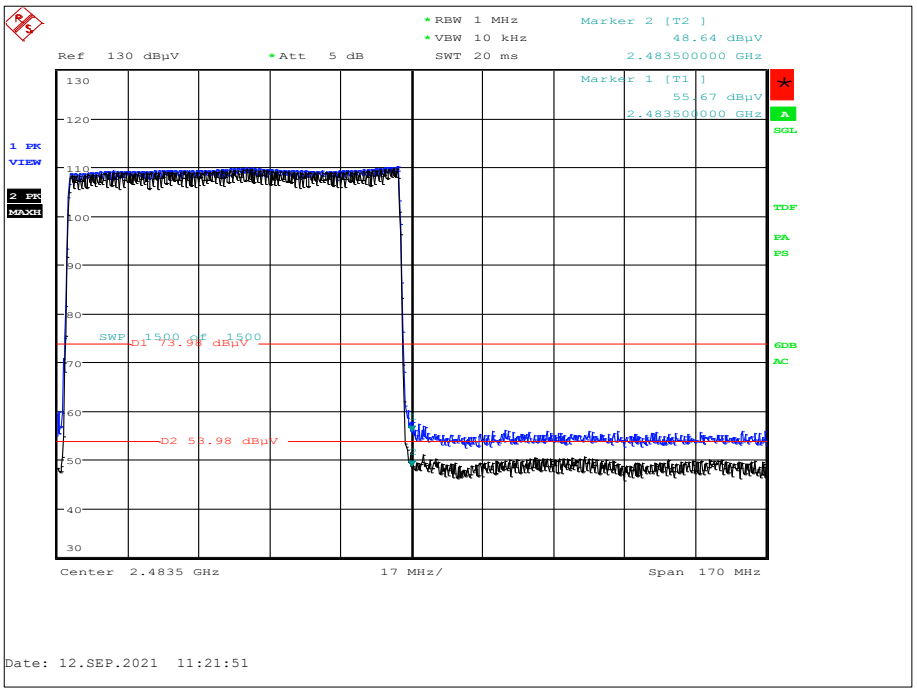

Figure 8 - GFSK/DH5 - Hopping - 2480 MHz – Band Edge Frequency 2483.5 MHz

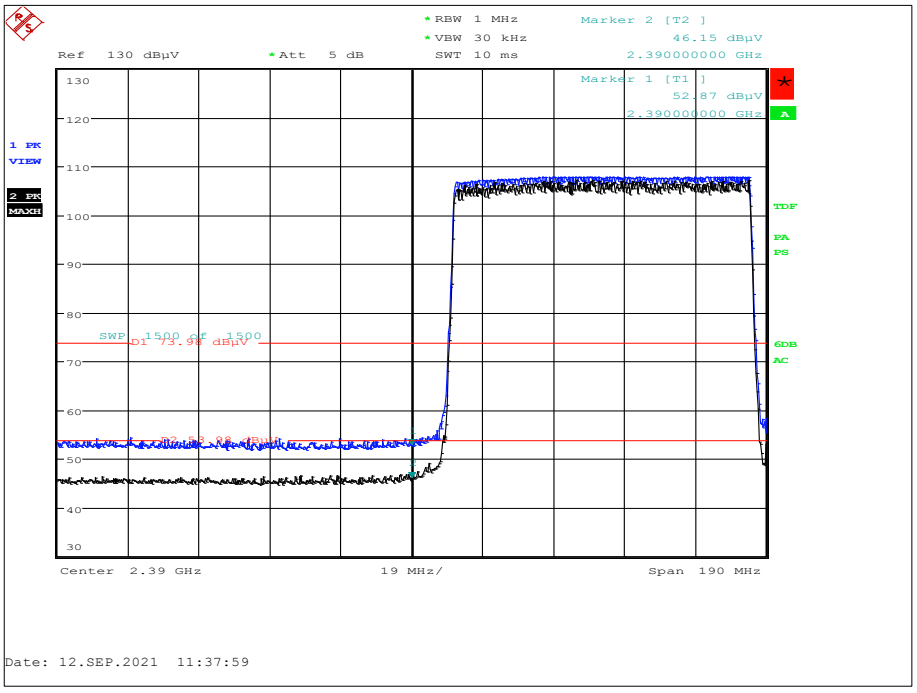

Figure 9 - π/4 DQPSK/2-DH5 - Hopping - 2402 MHz – Band Edge Frequency 2390.0 MHz

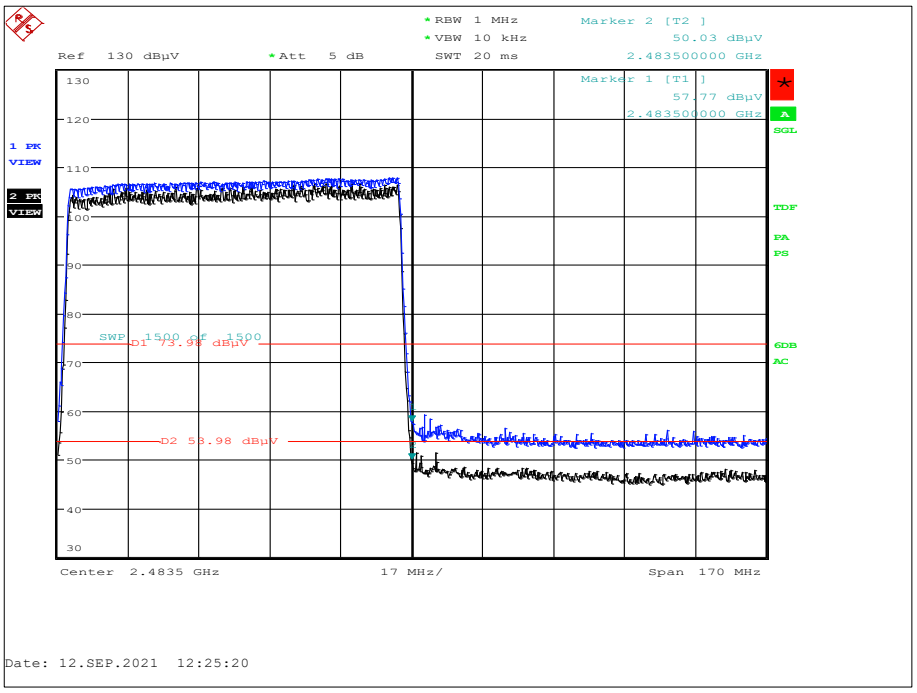

Figure 10 - π/4 DQPSK/2-DH5 - Hopping - 2480 MHz – Band Edge Frequency 2483.5 MHz

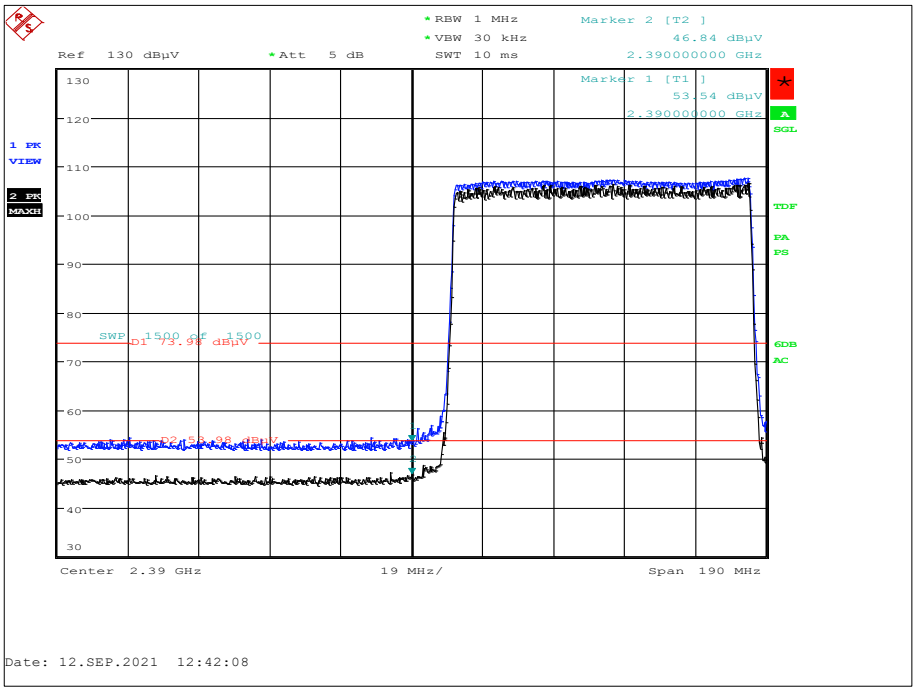

Figure 11 - 8-DPSK/3-DH5 - Hopping - 2402 MHz – Band Edge Frequency 2390.0 MHz

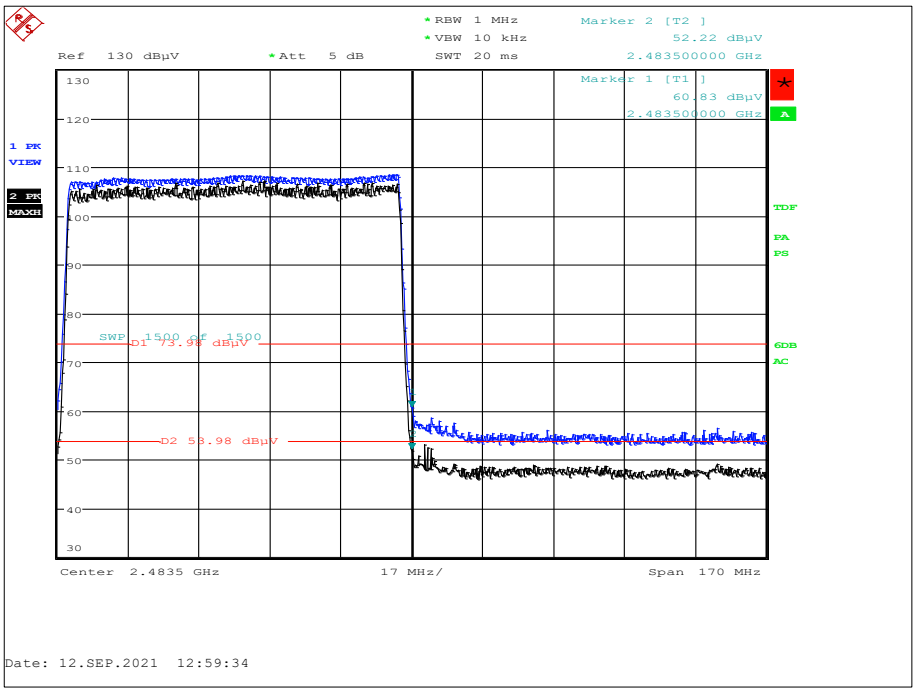

Figure 12 - 8-DPSK/3-DH5 - Hopping - 2480 MHz – Band Edge Frequency 2483.5 MHz

Remarks

The red asterixis on the above plots is due to a second trace being used after the first trace, with a VBW of 3 MHz had been set to view. TUV SUD confirms that no other settings had been changed.

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 17

ISED RSS-GEN, Limit Clause 8.9

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 18

*Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

2.1.7 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 Expires
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
EmX Emissions Software	TUV SUD	V2.1.11	5125	-	Software
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
8 Meter Cable	Teledyne	PR90-088-8MTR	5450	6	08-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	31-Mar-2022
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
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 19

TU - Traceability Unscheduled

2.2 Frequency Hopping Systems - Number of Hopping Channels

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
ISED RSS-247, Clause 5.1

2.2.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-99) - Modification State 0

2.2.3 Date of Test

27-September-2021

2.2.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.3.

2.2.5 Environmental Conditions

Ambient Temperature	21.6 °C
Relative Humidity	42.1 %

2.2.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 20 - Number of Hopping Frequencies Results

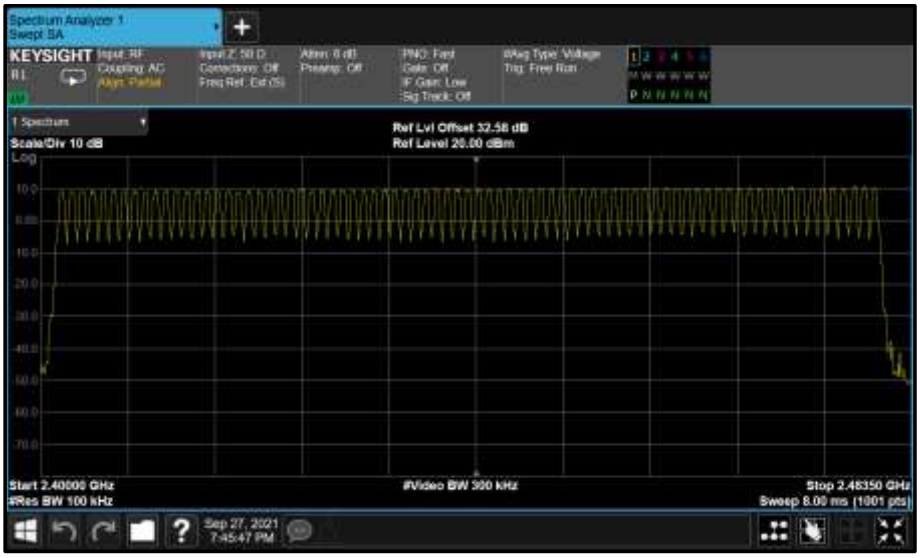

Figure 13 - GFSK (DH5) - Number of Hopping Channels

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 21 - Number of Hopping Frequencies Results

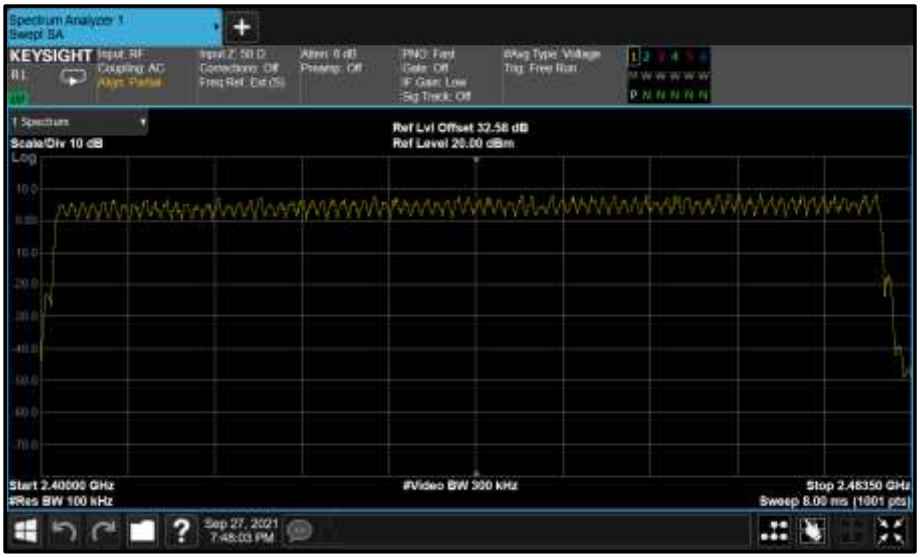

Figure 14 - π/4 DQPSK (2-DH5) - Number of Hopping Channels

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 22 - Number of Hopping Frequencies Results

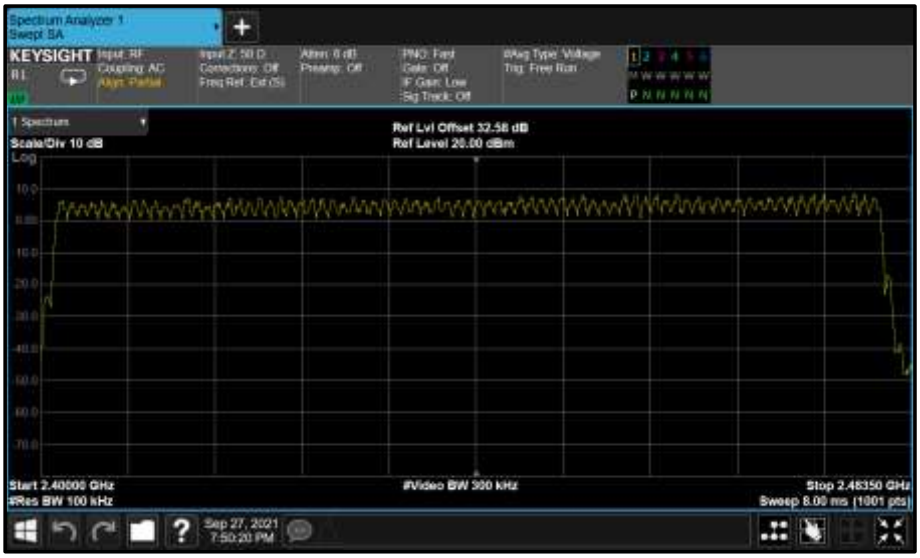

Figure 15 - 8-DPSK (3-DH5) - Number of Hopping Channels

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

≥ 15 channels

ISED RSS-247, Limit Clause 5.1 (d)

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels.

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	03-Dec-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Dec-2021
Climatic Chamber	Aralab	FitoTerm 300E45	4823	12	12-Apr-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 23

2.3 Frequency Hopping Systems - Average Time of Occupancy

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
ISED RSS-247, Clause 5.1

2.3.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-99) - Modification State 0

2.3.3 Date of Test

29-September-2021

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.4.

2.3.5 Environmental Conditions

Ambient Temperature	20.9 °C
Relative Humidity	44.6 %

2.3.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.886	104	300.1	400.0

Table 24 - Time of Occupancy Results

Figure 16 - GFSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	π/4 DQPSK (2-DH5)	Duty Cycle (%):	77.1
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.891	103	297.7	400.0

Table 25 - Time of Occupancy Results

Figure 17 - π/4 DQPSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	FCC 8-DPSK (3-DH5)	Duty Cycle (%):	76.9
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.892	106	306.6	400.0

Table 26 - Time of Occupancy Results

Figure 18 - 8-DPSK - 2402 MHz Accumulated Transmit Time

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

Frequency hopping systems operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that a minimum of 15 hopping channels are used.

Industry Canada RSS-247, Limit Clause 5.1 (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed.

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	03-Dec-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Dec-2021
Climatic Chamber	Aralab	FitoTerm 300E45	4823	12	12-Apr-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 27

2.4 Frequency Hopping Systems - Channel Separation

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
ISED RSS-247 Clause 5.1

2.4.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-99) - Modification State 0

2.4.3 Date of Test

28-September-2021

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.2.

2.4.5 Environmental Conditions

Ambient Temperature	21.7 °C
Relative Humidity	54.0 %

2.4.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	FCC GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.939	2441.005	2442.002	0.997	≥626.0

Table 28 - Carrier Frequency Separation Results

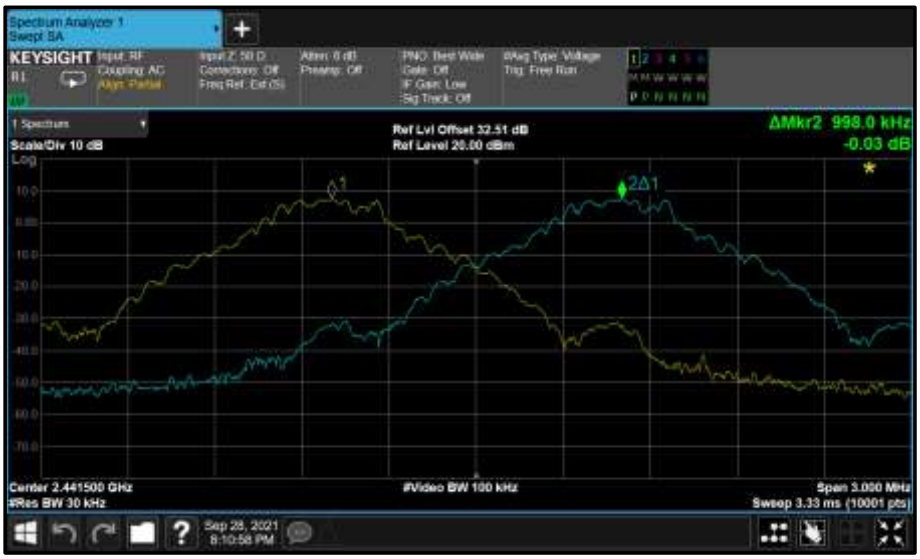

Figure 19 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.405	2440.985	2441.983	0.998	≥936.7

Table 29 - Carrier Frequency Separation Results

Figure 20 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.475	2440.993	2441.994	1.001	≥983.3

Table 30 - Carrier Frequency Separation Results

Figure 21 - 8-DPSK - 2441 MHz (CH39)

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Alternatively, frequency hopping systems operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 0.125 W.

ISED RSS-247, Limit Clause 5.1 (b)

FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	03-Dec-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Dec-2021
Climatic Chamber	Aralab	FitoTerm 300E45	4823	12	12-Apr-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 31

2.5 Frequency Hopping Systems - 20 dB Bandwidth

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
ISED RSS-247, Clause 5.1
ISED RSS-GEN, Clause 6.7

2.5.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-99) - Modification State 0

2.5.3 Date of Test

28-September-2021

2.5.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.9.2.

2.5.5 Environmental Conditions

Ambient Temperature	21.7 °C
Relative Humidity	54.0 %

2.5.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1) RSS-247 5.1	Test Method(s):	C63.10 6.9.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)			
	A	B	C	D
2402	0.939	-	-	-
2441	0.939	-	-	-
2480	0.945	-	-	-

Table 32 - 20 dB Bandwidth Results

Figure 22 - A (A) 2402 MHz (CH0) 20 dB Bandwidth

Figure 23 - A (A) 2441 MHz (CH39) 20 dB Bandwidth

Figure 24 - A (A) 2480 MHz (CH78) 20 dB Bandwidth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1) RSS-247 5.1	Test Method(s):	C63.10 6.9.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)			
	A	B	C	D
2402	1.410	-	-	-
2441	1.405	-	-	-
2480	1.435	-	-	-

Table 33 - 20 dB Bandwidth Results

Figure 25 - A (A) 2402 MHz (CH0) 20 dB Bandwidth

Figure 26 - A (A) 2441 MHz (CH39) 20 dB Bandwidth

Figure 27 - A (A) 2480 MHz (CH78) 20 dB Bandwidth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1) RSS-247 5.1	Test Method(s):	C63.10 6.9.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)			
	A	B	C	D
2402	1.490	-	-	-
2441	1.475	-	-	-
2480	1.485	-	-	-

Table 34 - 20 dB Bandwidth Results

Figure 28 - A (A) 2402 MHz (CH0) 20 dB Bandwidth

Figure 29 - A (A) 2441 MHz (CH39) 20 dB Bandwidth

Figure 30 - A (A) 2480 MHz (CH78) 20 dB Bandwidth

FCC 47 CFR Part 15 and ISED RSS-247 Limit Clause

None specified.

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	03-Dec-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Dec-2021
Climatic Chamber	Aralab	FitoTerm 300E45	4823	12	12-Apr-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 35

2.6 Maximum Conducted Output Power

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)
ISED RSS-247, Clause 5.4
ISED RSS-GEN, Clause 6.12

2.6.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-99) - Modification State 0

2.6.3 Date of Test

28-September-2021

2.6.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.5.

2.6.5 Environmental Conditions

Ambient Temperature	21.7 °C
Relative Humidity	54.0 %

2.6.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(1) RSS-247 5.4 b)	Test Method(s):	C63.10 7.8.5
Additional Reference(s):	-		

DUT Configuration			
Mode:	GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	2.80

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2402	9.24	-	-	-	-	30.00	-20.76
2441	9.87	-	-	-	-	30.00	-20.13
2480	10.38	-	-	-	-	30.00	-19.62

Table 36 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2402	9.24	-	-	-	-	30.00	-20.76	12.04	36.00	-23.96
2441	9.87	-	-	-	-	30.00	-20.13	12.67	36.00	-23.33
2480	10.38	-	-	-	-	30.00	-19.62	13.18	36.00	-22.82

Table 37 - ISED Maximum Conducted (peak) Output Power Results

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(1) RSS-247 5.4 b)	Test Method(s):	C63.10 7.8.5
Additional Reference(s):	-		

DUT Configuration			
Mode:	π/4 DQPSK (2-DH5)	Duty Cycle (%):	77.1
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	2.80

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2402	8.25	-	-	-	-	30.00	-21.75
2441	8.77	-	-	-	-	30.00	-21.23
2480	8.74	-	-	-	-	30.00	-21.26

Table 38 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2402	8.25	-	-	-	-	30.00	-21.75	11.05	36.00	-24.95
2441	8.77	-	-	-	-	30.00	-21.23	11.57	36.00	-24.43
2480	8.74	-	-	-	-	30.00	-21.26	11.54	36.00	-24.46

Table 39 - ISED Maximum Conducted (peak) Output Power Results

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(1) RSS-247 5.4 b)	Test Method(s):	C63.10 7.8.5
Additional Reference(s):	-		

DUT Configuration			
Mode:	8-DPSK (3-DH5)	Duty Cycle (%):	76.8
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	2.80

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2402	8.34	-	-	-	-	30.00	-21.66
2441	8.84	-	-	-	-	30.00	-21.16
2480	8.84	-	-	-	-	30.00	-21.16

Table 40 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2402	8.34	-	-	-	-	30.00	-21.66	11.14	36.00	-24.86
2441	8.84	-	-	-	-	30.00	-21.16	11.64	36.00	-24.36
2480	8.84	-	-	-	-	30.00	-21.16	11.64	36.00	-24.36

Table 41 - ISED Maximum Conducted (peak) Output Power Results

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.

ISED RSS-247, Limit Clause 5.4 (b)

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e) of the specification.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	03-Dec-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Dec-2021
Climatic Chamber	Aralab	FitoTerm 300E45	4823	12	12-Apr-2022
USB Power Sensor	Boonton	RTP5006	5184	12	19-Apr-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 42

2.7 Spurious Radiated Emissions

2.7.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.209
ISED RSS-247, Clause 3.3 and 5.5
ISED RSS-GEN, Clause 6.13 and 8.9

2.7.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-18) - Modification State 0

2.7.3 Date of Test

07-September-2021 to 27-September-2021

2.7.4 Test Method

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

The EUT was placed on the non-conducting platform in a manner typical of a normal installation. The EUT could be used in multiple planes, therefore, pre-scans were performed with the EUT orientated in X, Y and Z planes with reference to the ground plane.

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).

For measurements > 18 GHz the distance was reduced to 1 meter and the limit line was increased by 20*LOG(3/1) = 9.54 dB. Where formal measurements have been necessary, the results have been presented in the emissions table.

2.7.5 Environmental Conditions

Ambient Temperature	18.4 - 21.1 °C
Relative Humidity	55.9 - 68.4 %

2.7.6 Example Test Setup Diagram

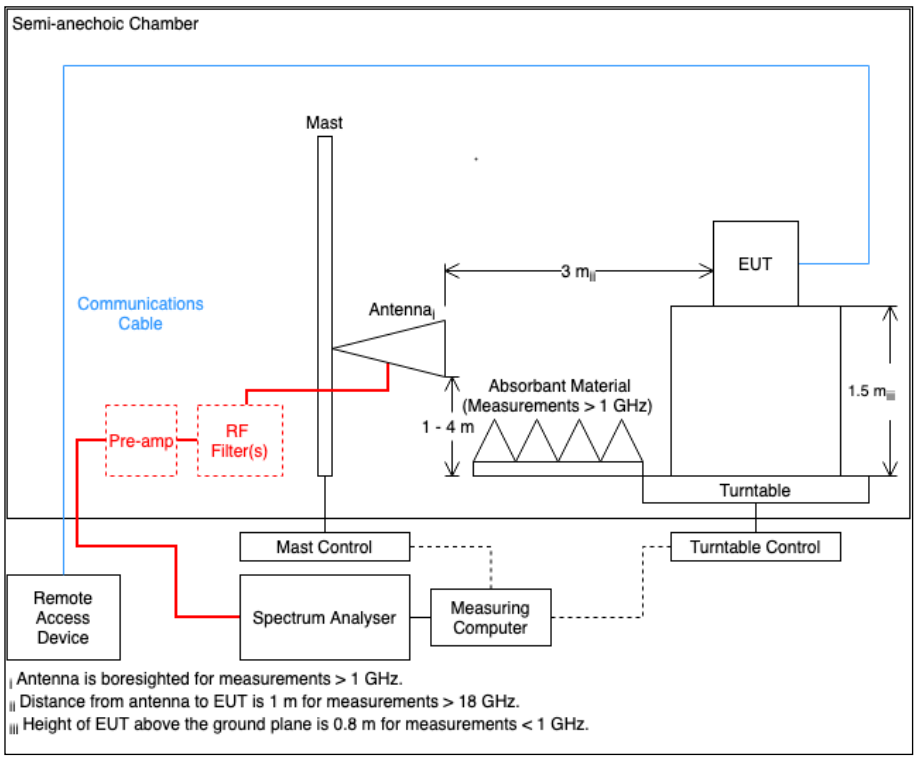

Figure 31

2.7.7 Test Results

Hard Hat - 2.4 GHz Bluetooth

Testing was performed on the modulation and packet type which resulted in the highest conducted output power. The Modulation/Packet type was DH5.

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
73.028	30.96	40.00	9.04	Q-Peak	132	110	Vertical	X
74.083	30.26	40.00	9.74	Q-Peak	83	109	Vertical	Z
114.427	37.57	43.52	5.95	Q-Peak	70	101	Vertical	X
115.223	37.99	43.52	5.53	Q-Peak	62	390	Horizontal	X
124.985	35.09	43.52	8.43	Q-Peak	191	100	Vertical	Z
124.997	35.66	43.52	7.86	Q-Peak	162	100	Vertical	Y
132.865	35.97	43.52	7.55	Q-Peak	222	129	Horizontal	Z
168.005	35.56	43.52	7.96	Q-Peak	1	100	Vertical	X
249.990	39.65	46.02	6.37	Q-Peak	253	100	Vertical	X
250.016	41.00	46.02	5.02	Q-Peak	225	101	Vertical	Z
611.514	38.45	46.02	7.57	Q-Peak	44	116	Horizontal	Z
611.519	38.65	46.02	7.37	Q-Peak	216	100	Horizontal	Y
611.522	40.41	46.02	5.61	Q-Peak	175	100	Vertical	X

Table 43 - 2402 MHz, 30 MHz to 1 GHz

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

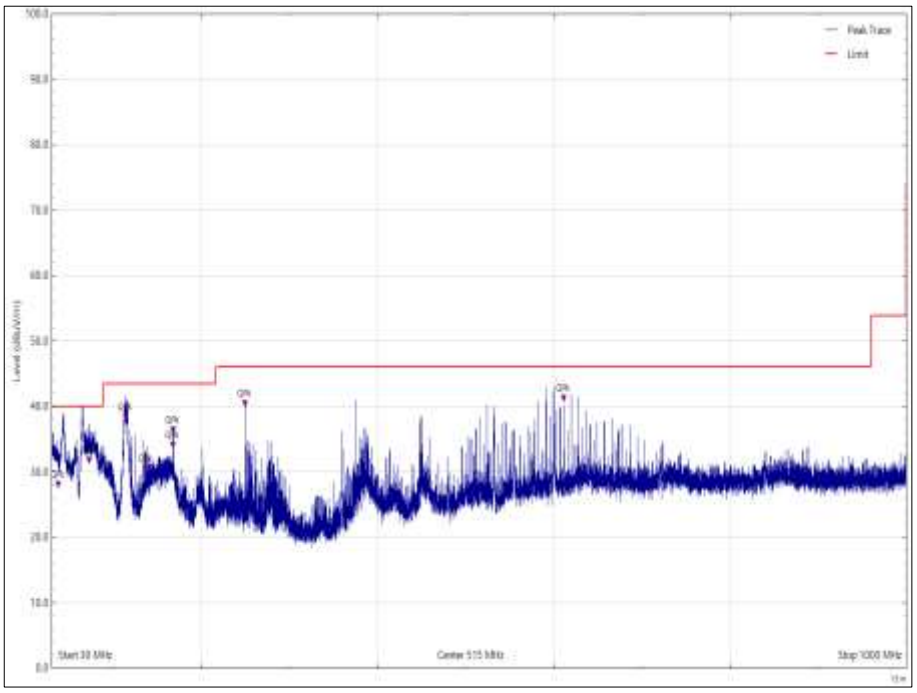

Figure 32 - 2402 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

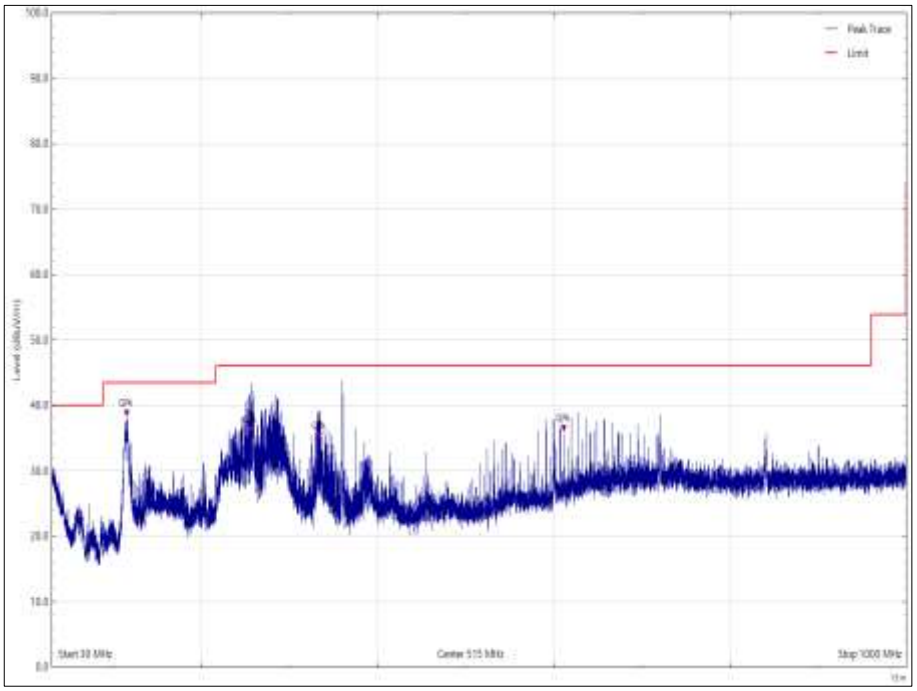

Figure 33 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

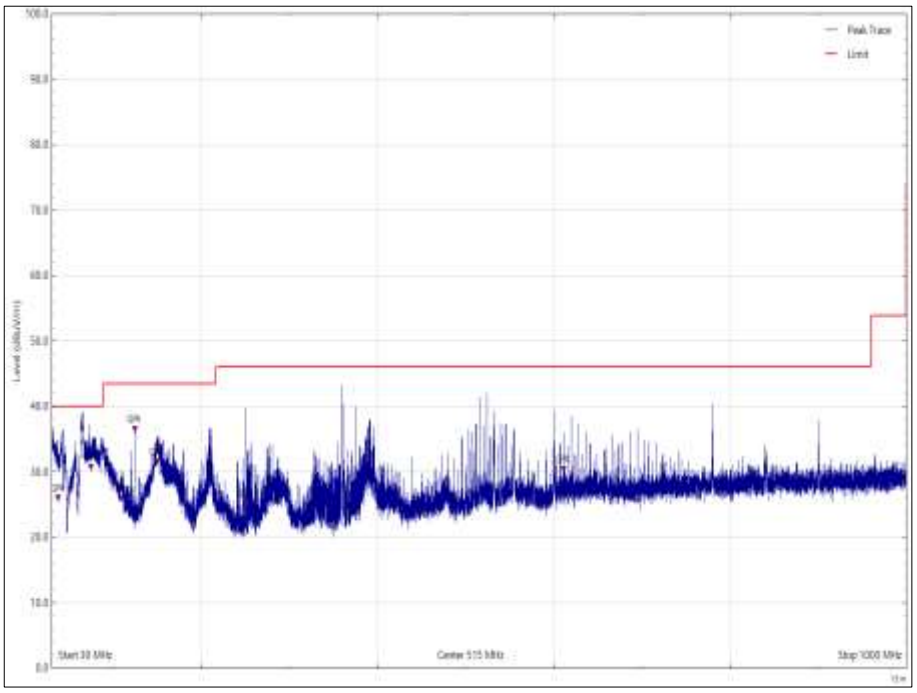

Figure 34 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

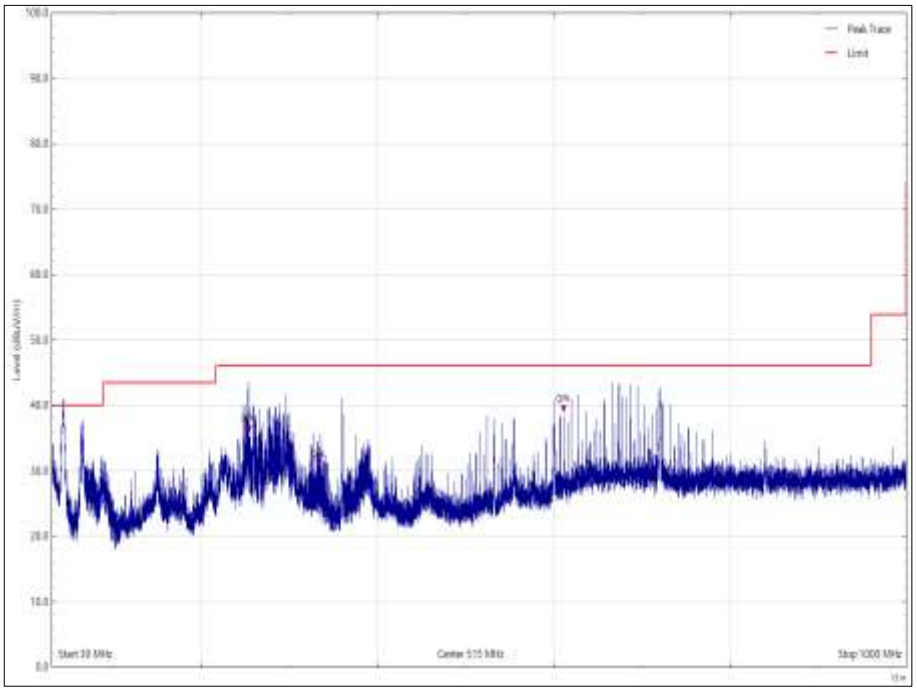

Figure 35 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

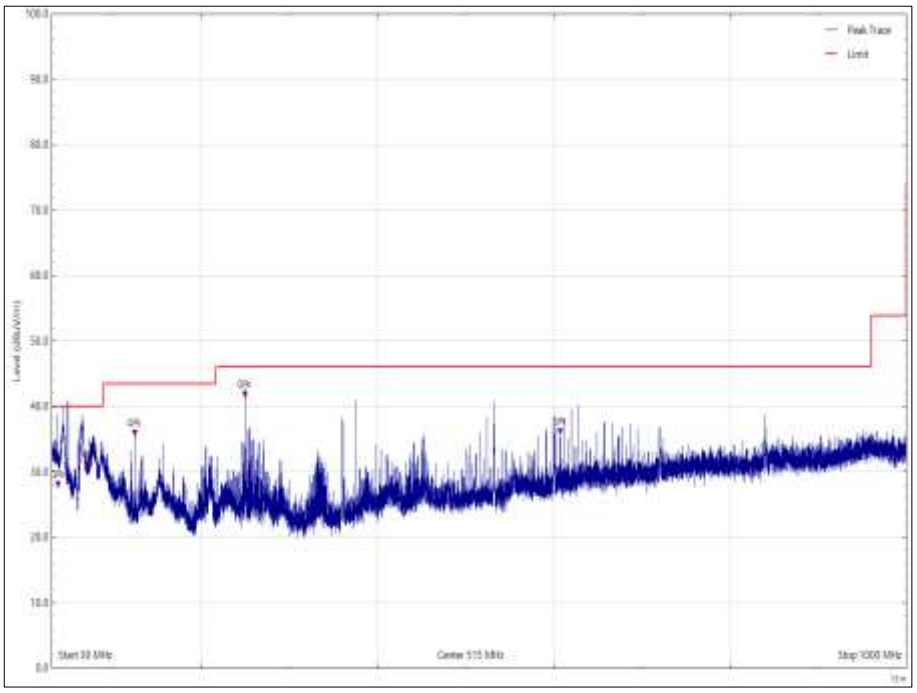

Figure 36 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

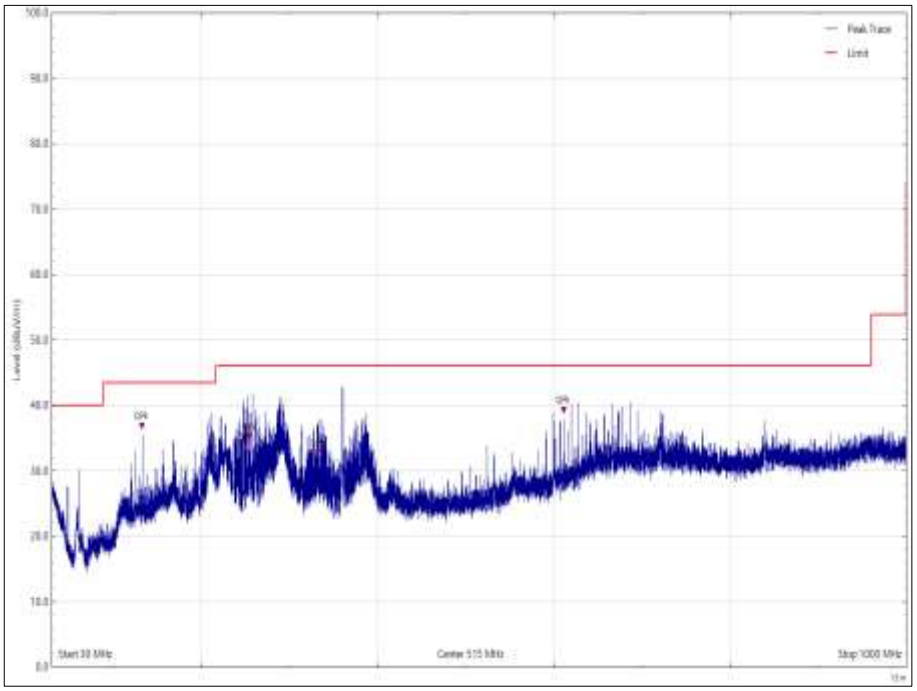

Figure 37 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4999.761	46.92	53.98	7.06	CISPR Average	239	150	Vertical	X

Table 44 - 2402 MHz, 1 GHz to 25 GHz

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

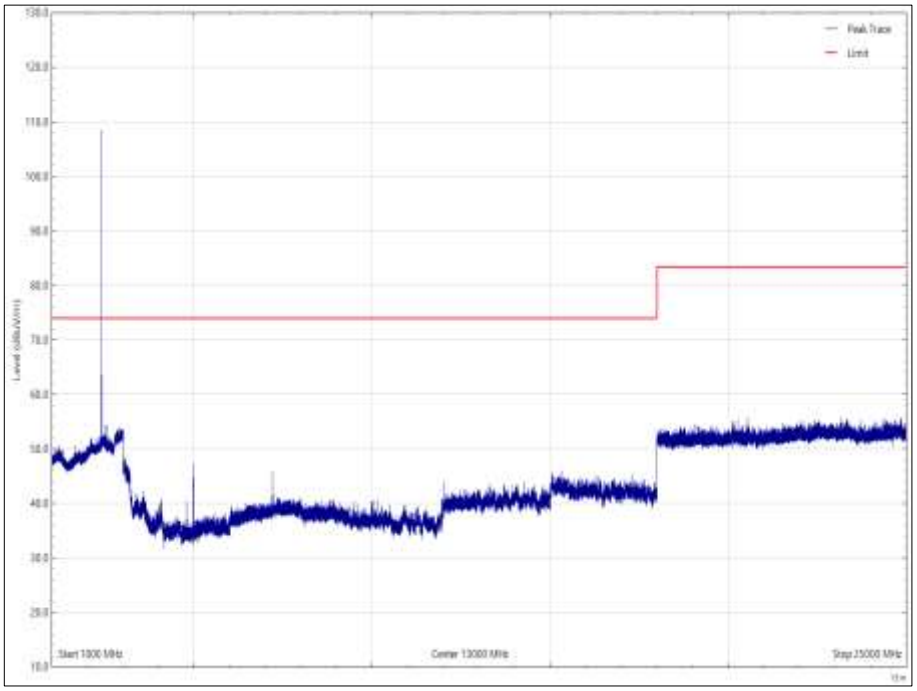

Figure 38 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation - Peak

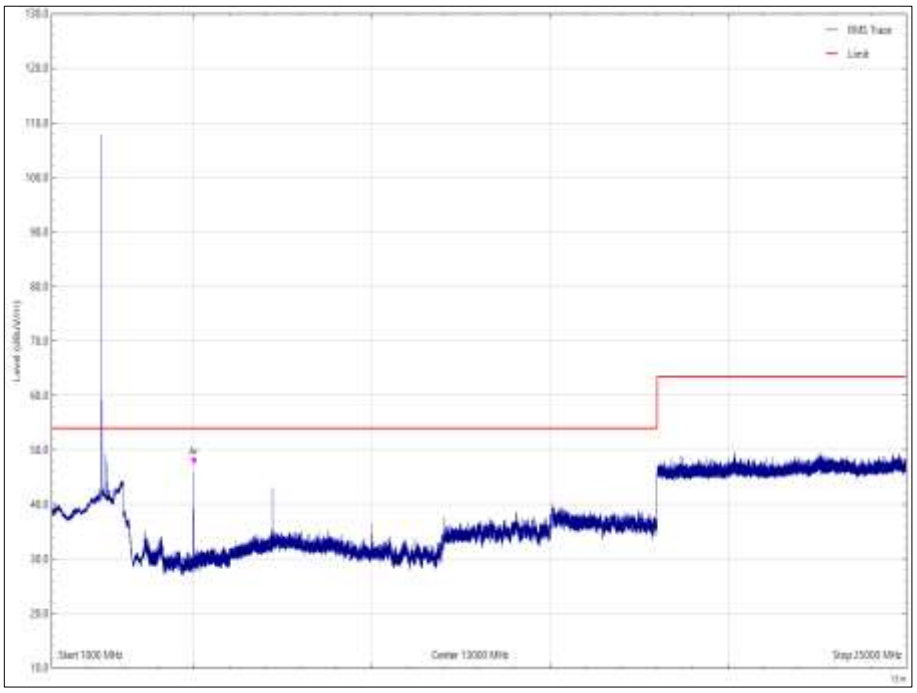

Figure 39 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation - Average

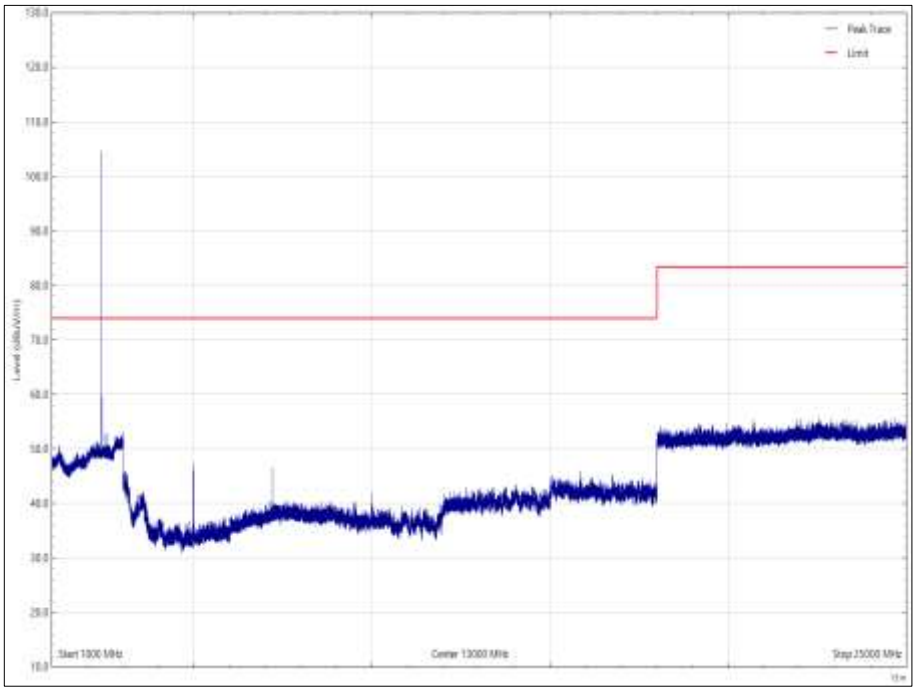

Figure 40 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation - Peak

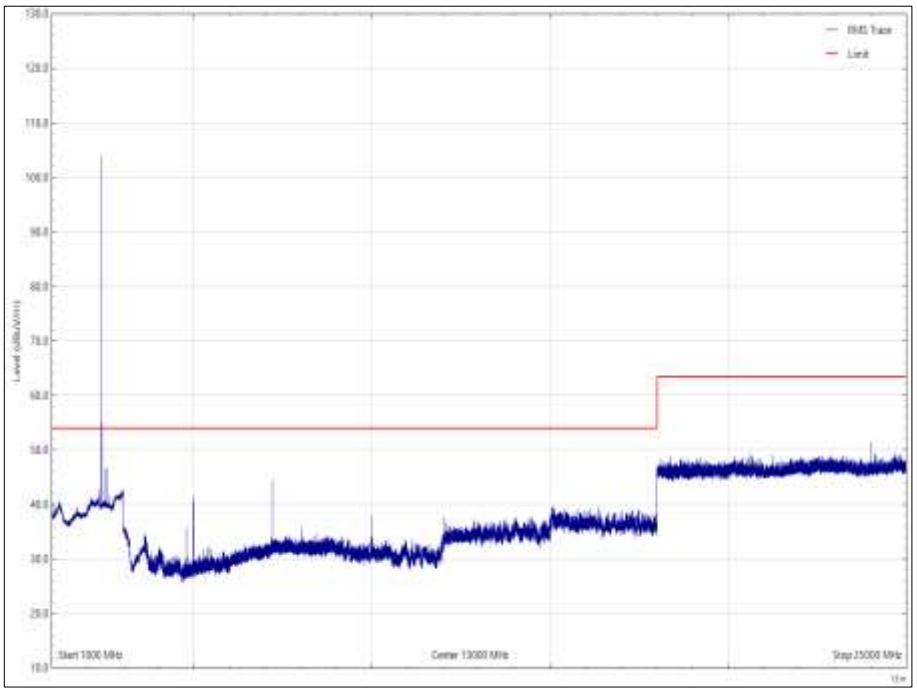

Figure 41 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation - Average

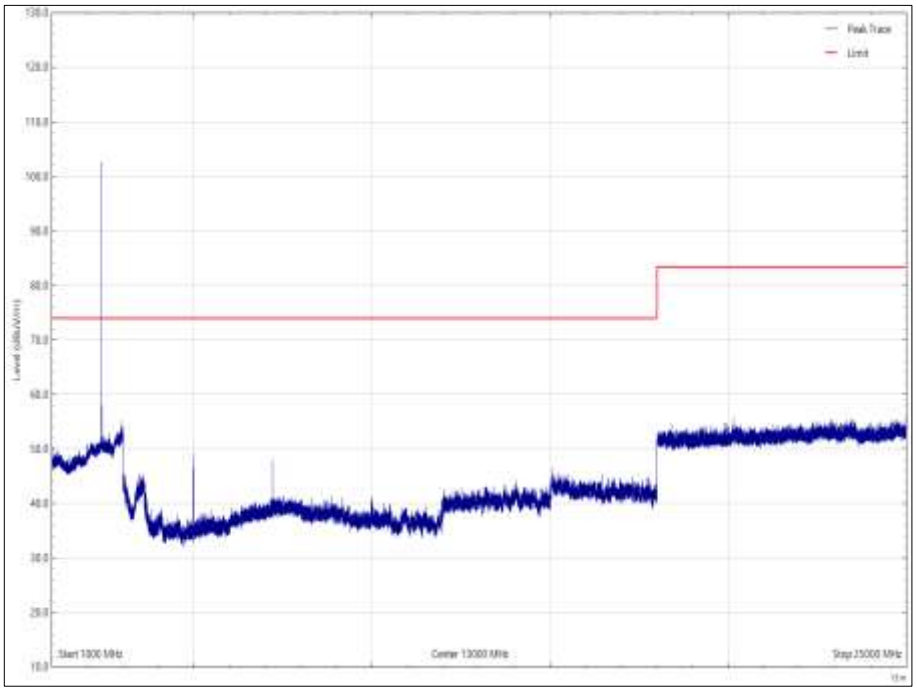

Figure 42 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation - Peak

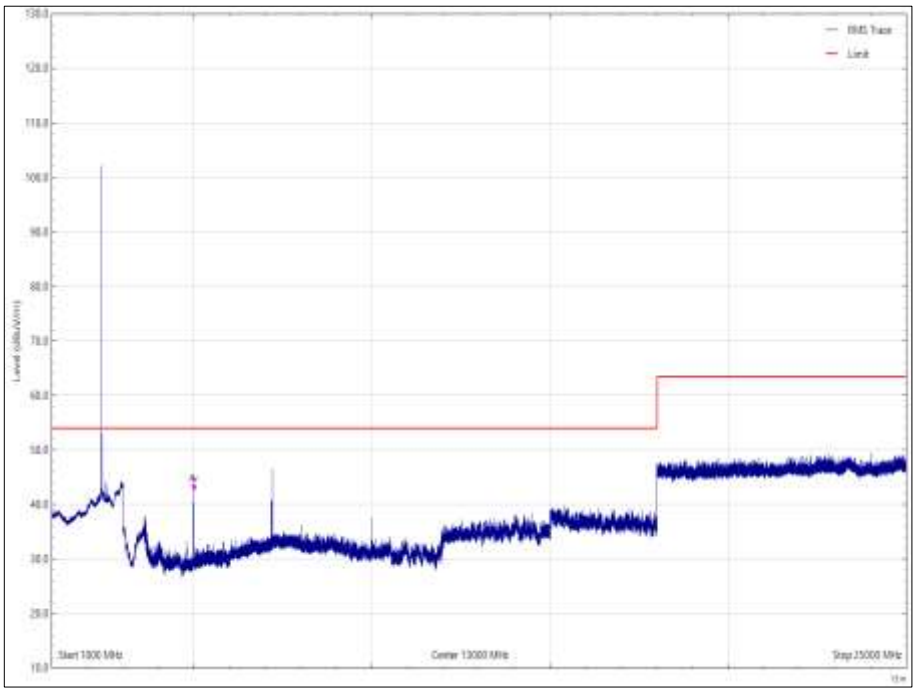

Figure 43 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation - Average

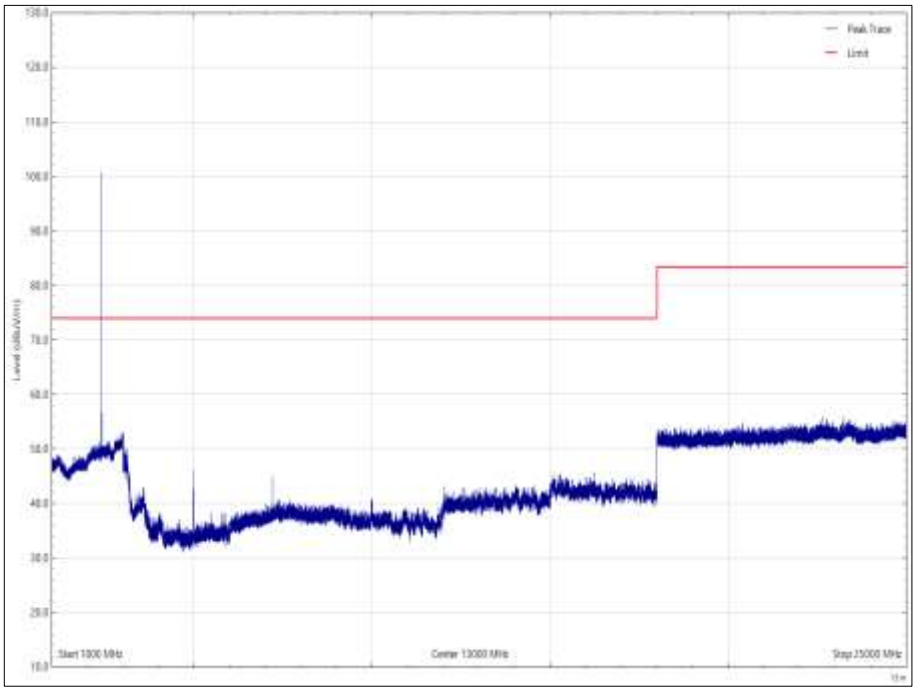

Figure 44 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation - Peak

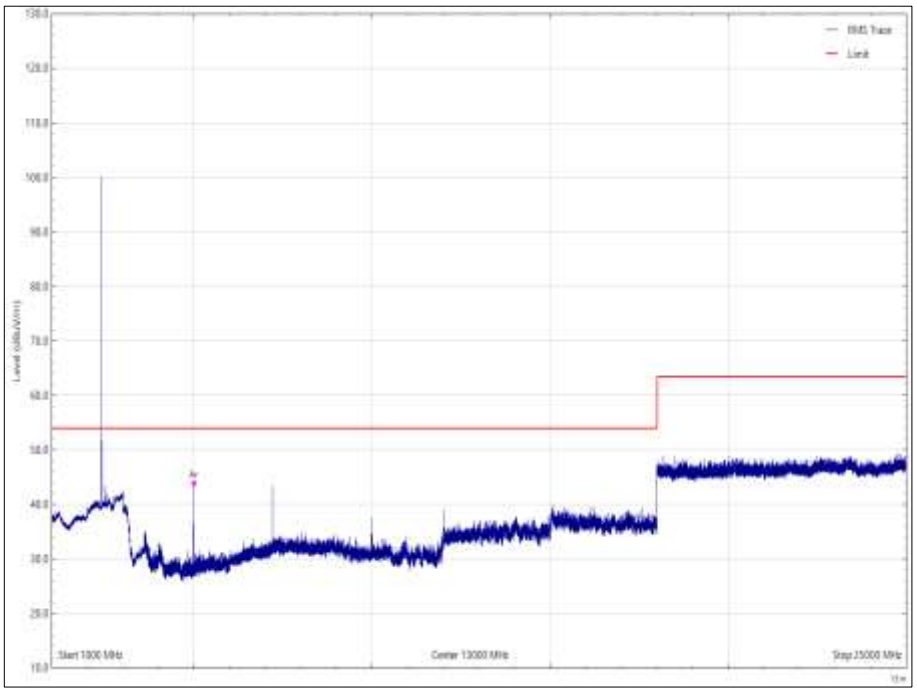

Figure 45 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation - Average

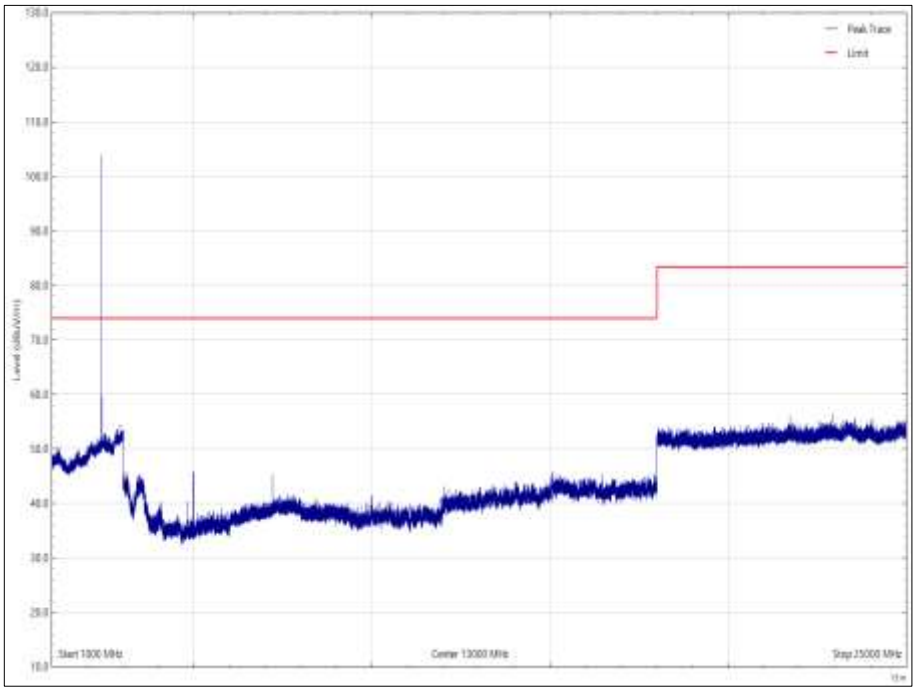

Figure 46 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation - Peak

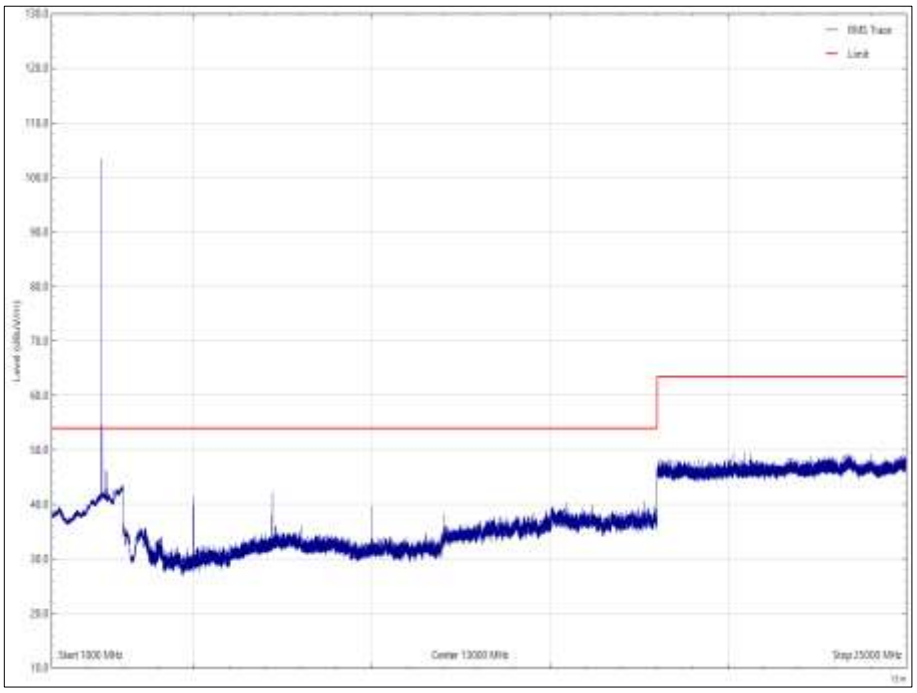

Figure 47 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation - Average

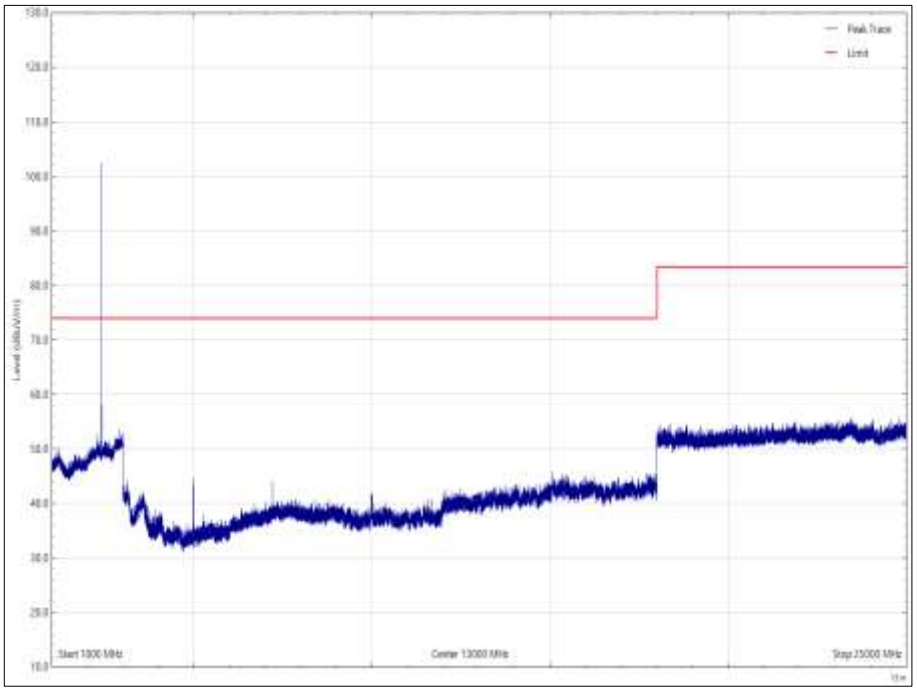

Figure 48 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation - Peak

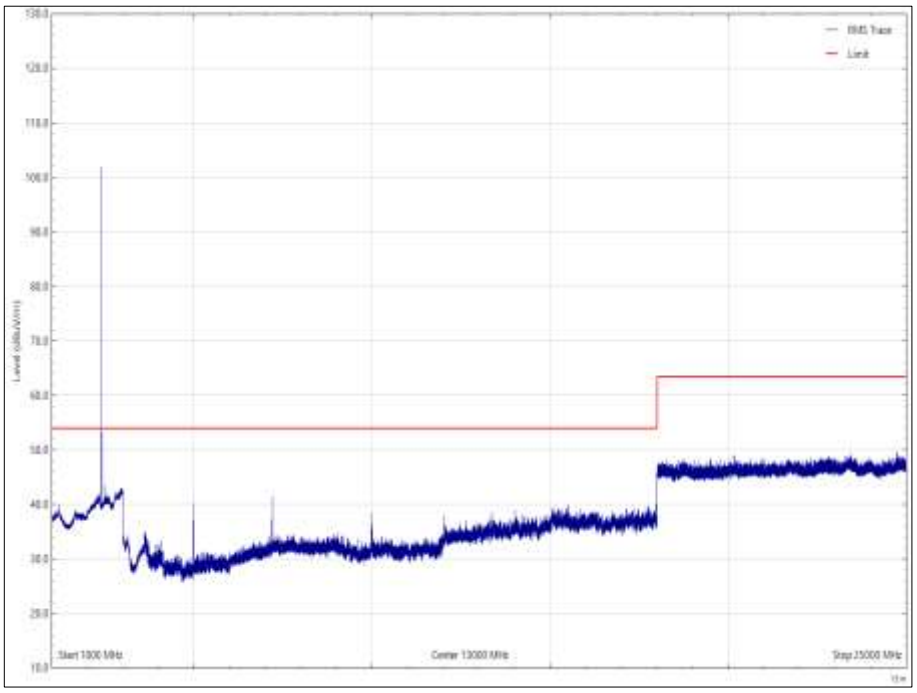

Figure 49 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation - Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
73.555	30.84	40.00	9.16	Q-Peak	195	100	Vertical	X
74.971	30.47	40.00	9.53	Q-Peak	117	112	Vertical	X
113.429	37.40	43.52	6.12	Q-Peak	31	110	Vertical	X
125.002	35.11	43.52	8.41	Q-Peak	181	100	Vertical	Y
125.004	35.22	43.52	8.30	Q-Peak	194	104	Vertical	Z
132.981	36.24	43.52	7.28	Q-Peak	193	156	Horizontal	Z
167.992	35.53	43.52	7.99	Q-Peak	1	100	Vertical	X
249.993	41.25	46.02	4.77	Q-Peak	239	100	Vertical	X
250.009	41.02	46.02	5.00	Q-Peak	242	100	Vertical	Y
250.030	39.81	46.02	6.21	Q-Peak	228	104	Vertical	Z
254.098	36.11	46.02	9.91	Q-Peak	294	118	Horizontal	Y
333.015	39.18	46.02	6.84	Q-Peak	85	100	Horizontal	X
607.368	36.18	46.02	9.84	Q-Peak	150	100	Vertical	Z
611.511	36.12	46.02	9.90	Q-Peak	330	100	Horizontal	X
611.528	40.34	46.02	5.68	Q-Peak	186	100	Vertical	X
611.537	38.57	46.02	7.45	Q-Peak	220	112	Horizontal	Y
611.540	37.30	46.02	8.72	Q-Peak	28	100	Horizontal	Z

Table 45 - 2441 MHz, 30 MHz to 1 GHz

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

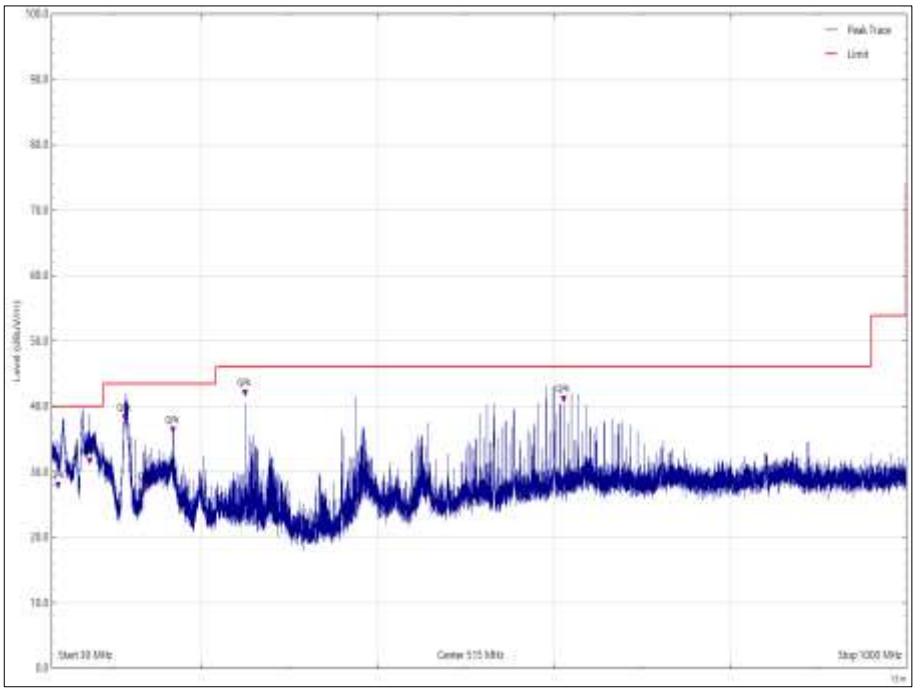

Figure 50 - 2441 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

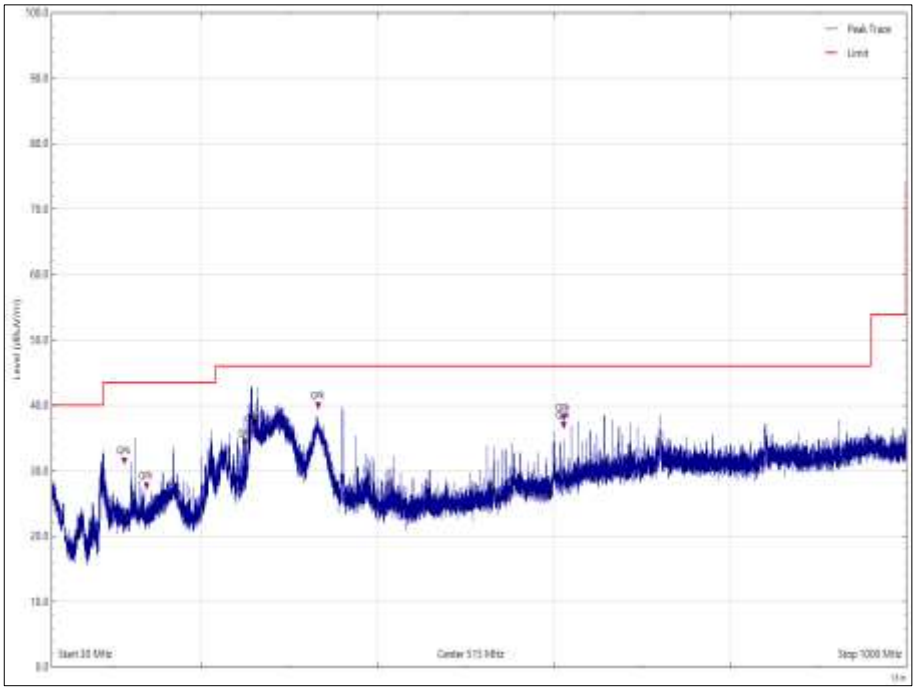

Figure 51 - 2441 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

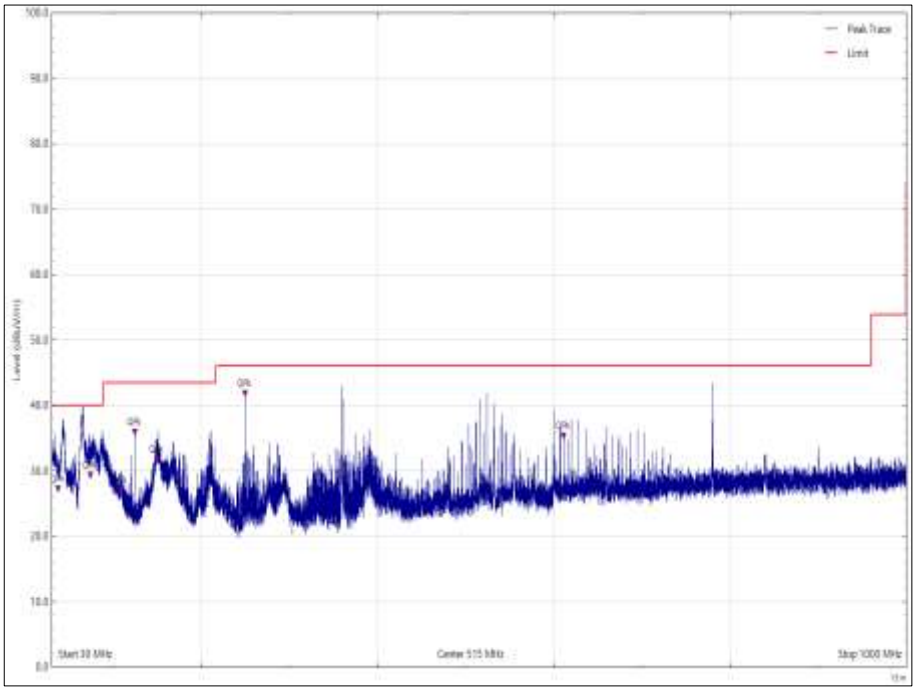

Figure 52 - 2441 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

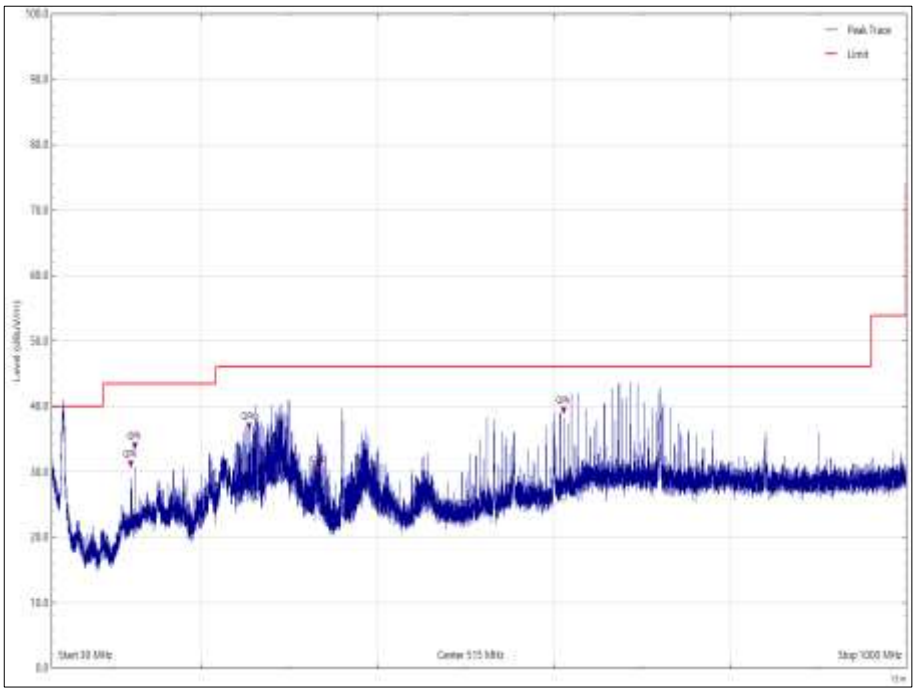

Figure 53 - 2441 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

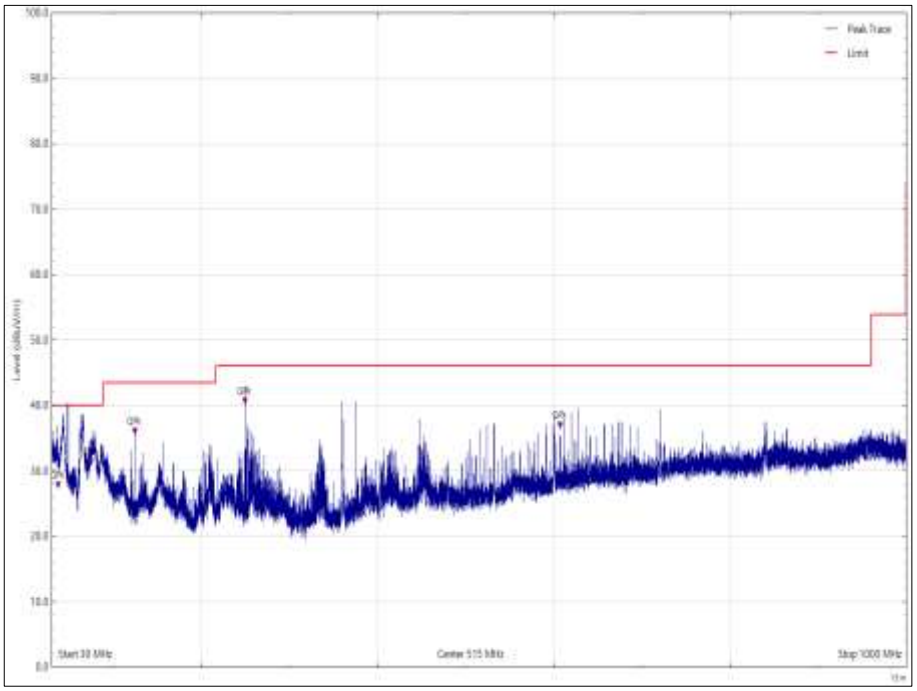

Figure 54 - 2441 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

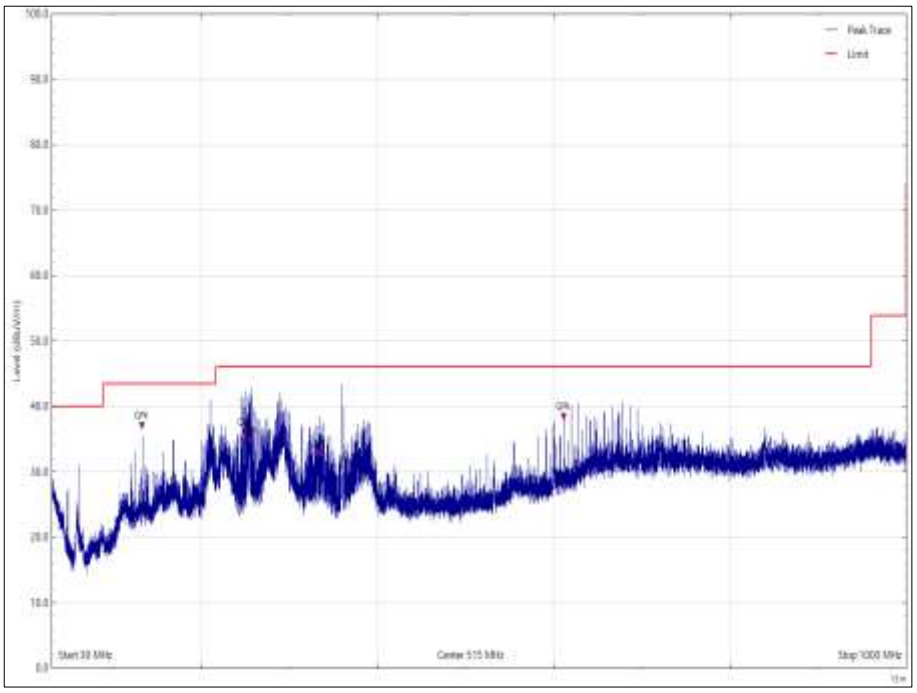

Figure 55 - 2441 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4999.777	46.87	53.98	7.11	CISPR Average	238	157	Vertical	X

Table 46 - 2441 MHz - 1 GHz to 25 GHz

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

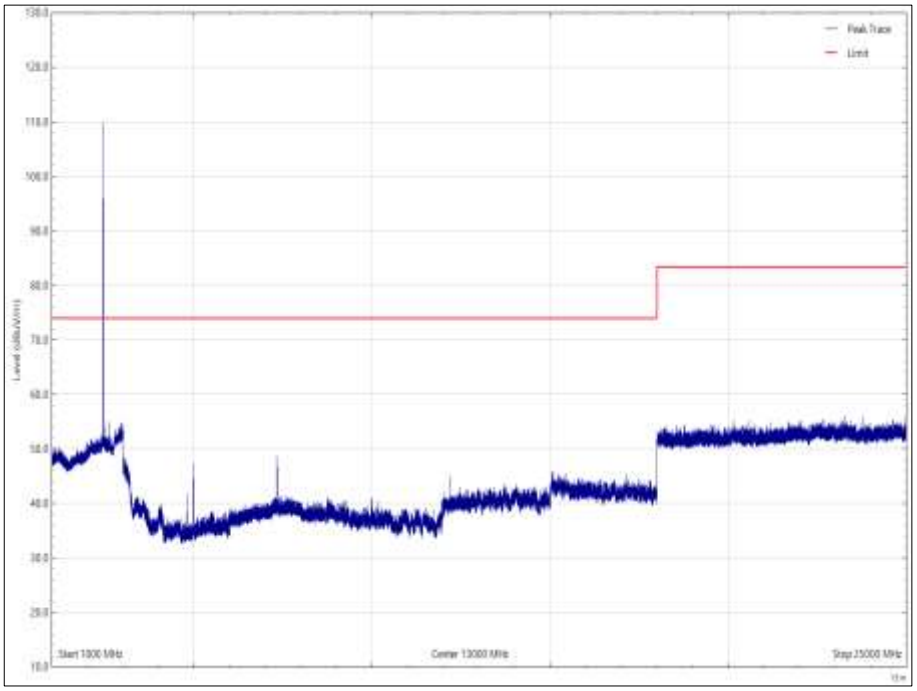

Figure 56 - 2441 MHz - 1 GHz to 25 GHz, Vertical, X Orientation - Peak

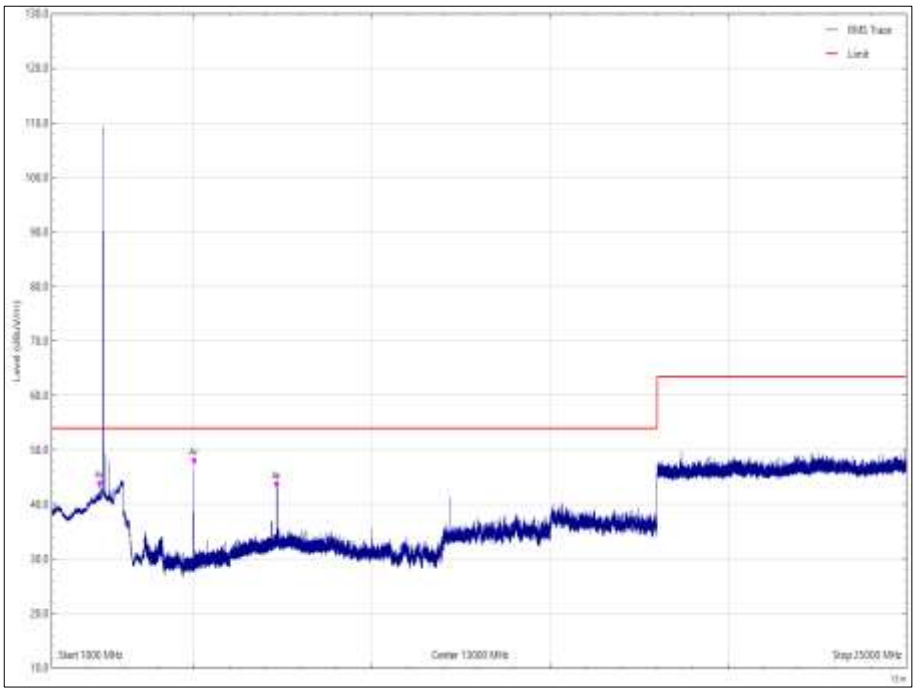

Figure 57 - 2441 MHz - 1 GHz to 25 GHz, Vertical, X Orientation - Average

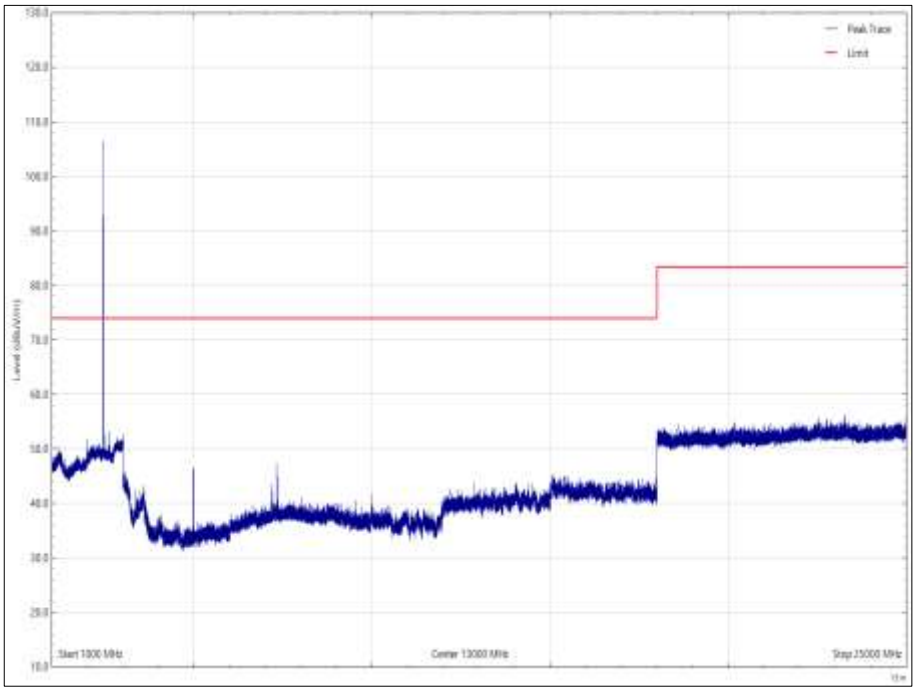

Figure 58 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, X Orientation - Peak

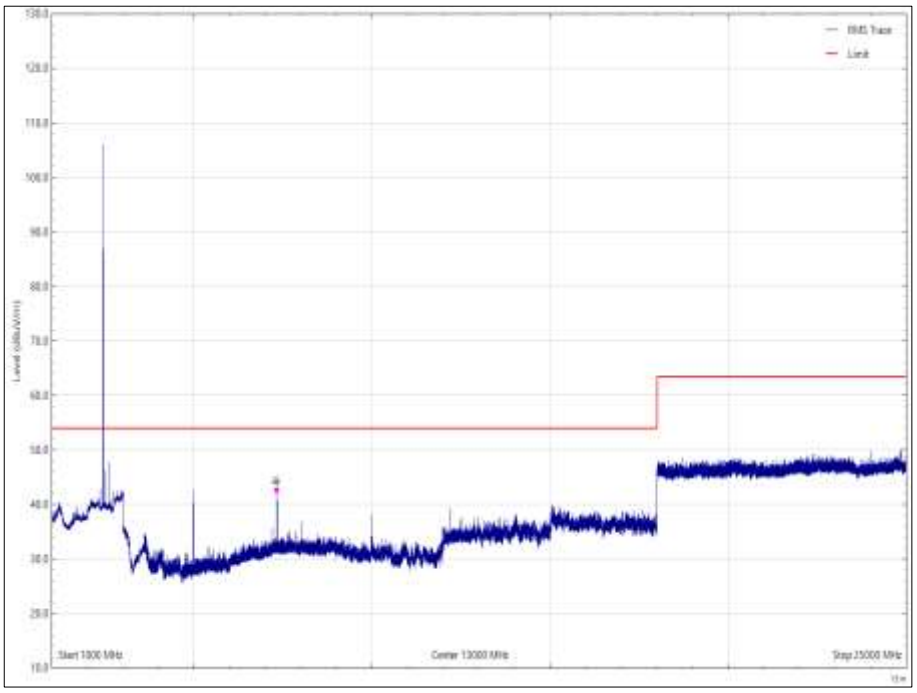

Figure 59 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, X Orientation - Average

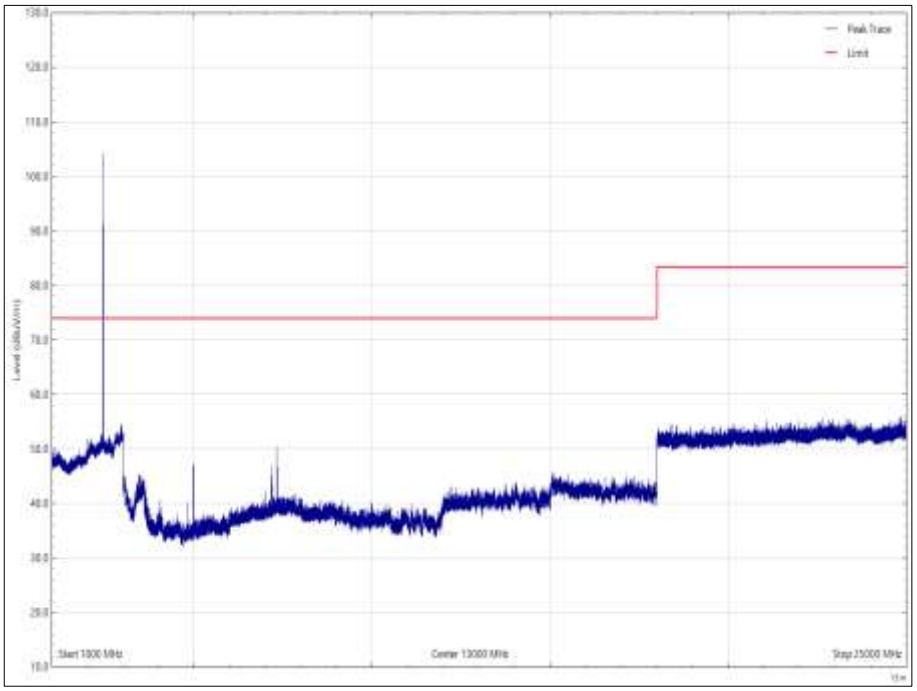

Figure 60 - 2441 MHz - 1 GHz to 25 GHz, Vertical, Y Orientation - Peak

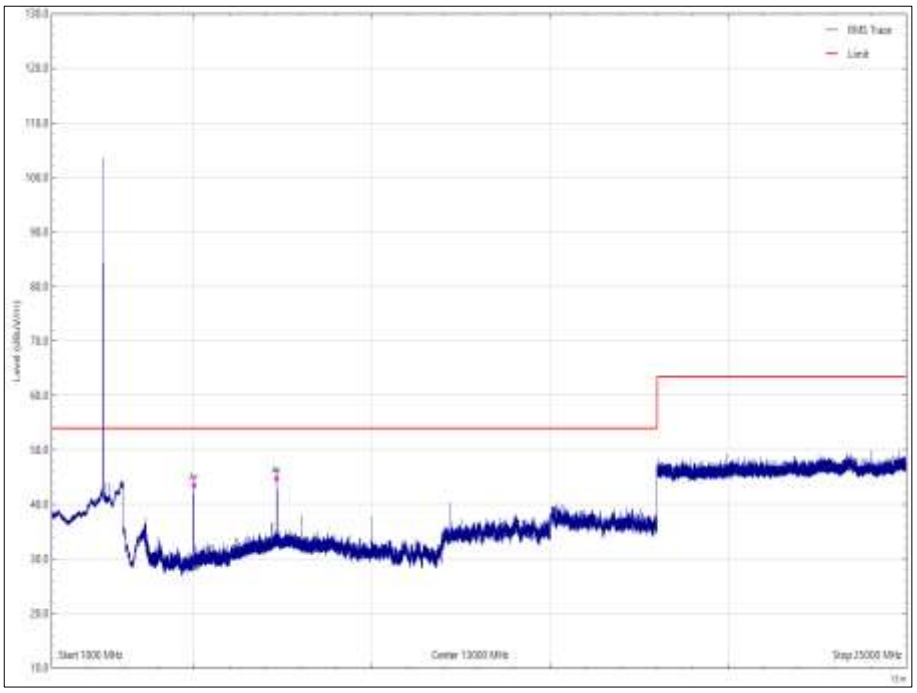

Figure 61 - 2441 MHz - 1 GHz to 25 GHz, Vertical, Y Orientation - Average

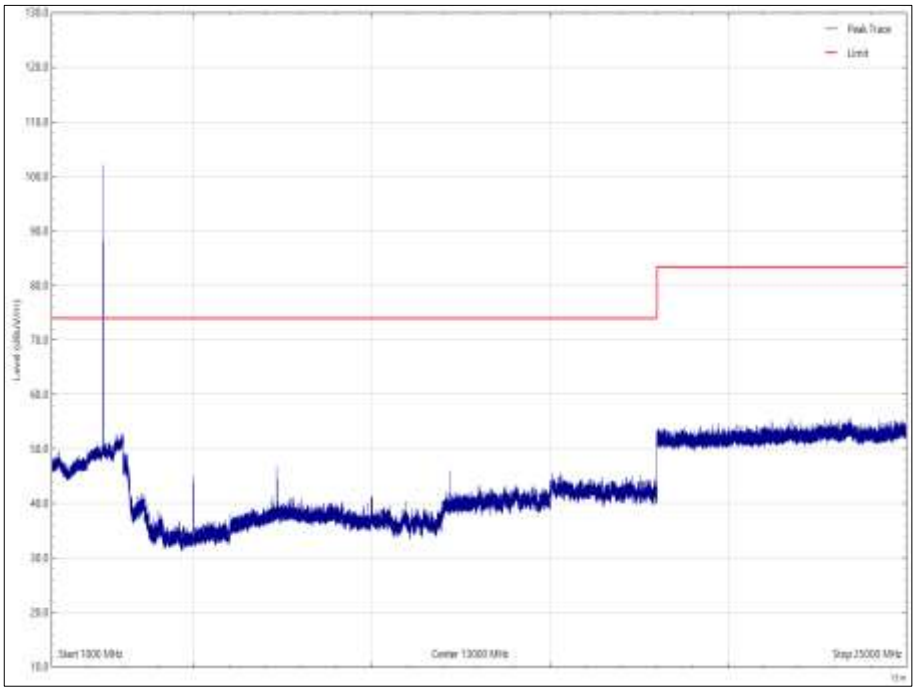

Figure 62 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, Y Orientation - Peak

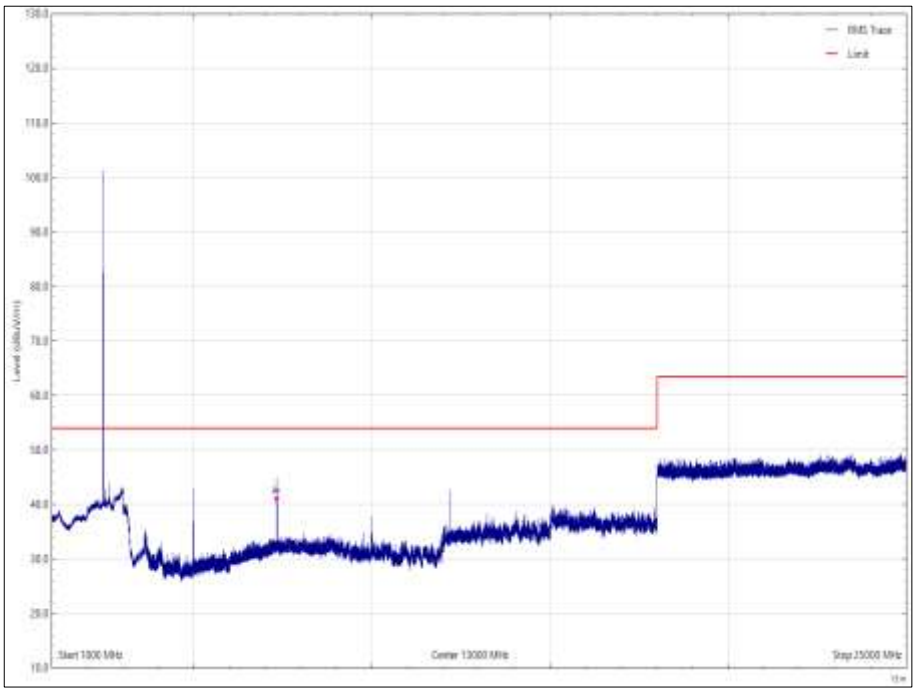

Figure 63 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, Y Orientation - Average

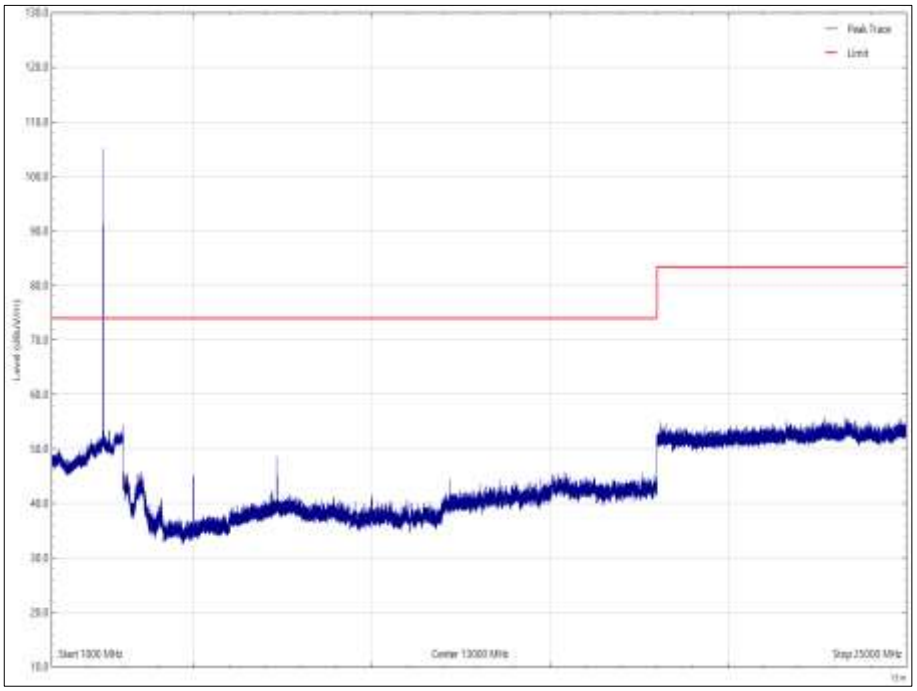

Figure 64 - 2441 MHz - 1 GHz to 25 GHz, Vertical, Z Orientation - Peak

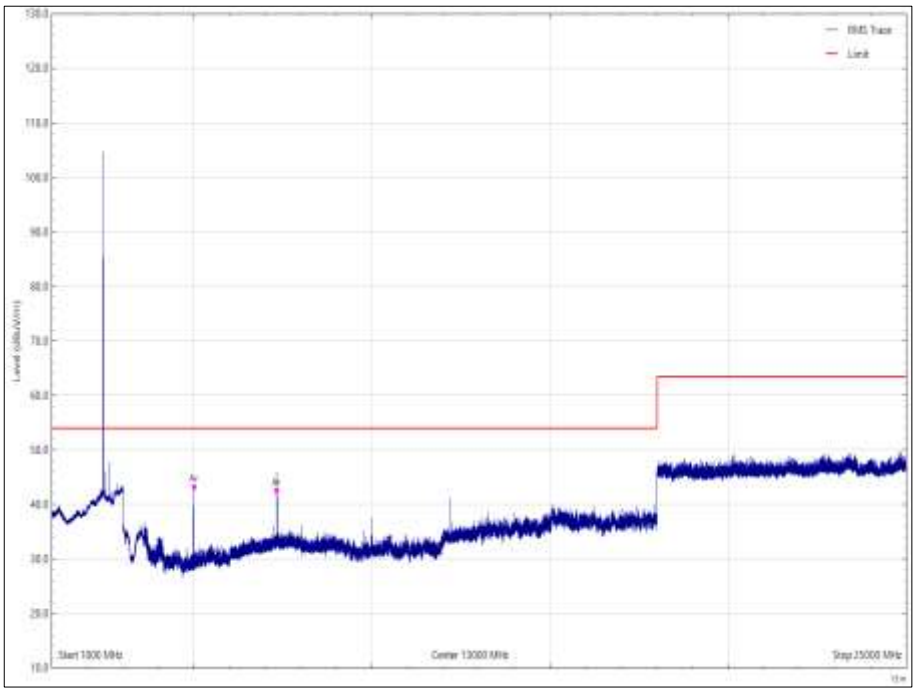

Figure 65 - 2441 MHz - 1 GHz to 25 GHz, Vertical, Z Orientation - Average

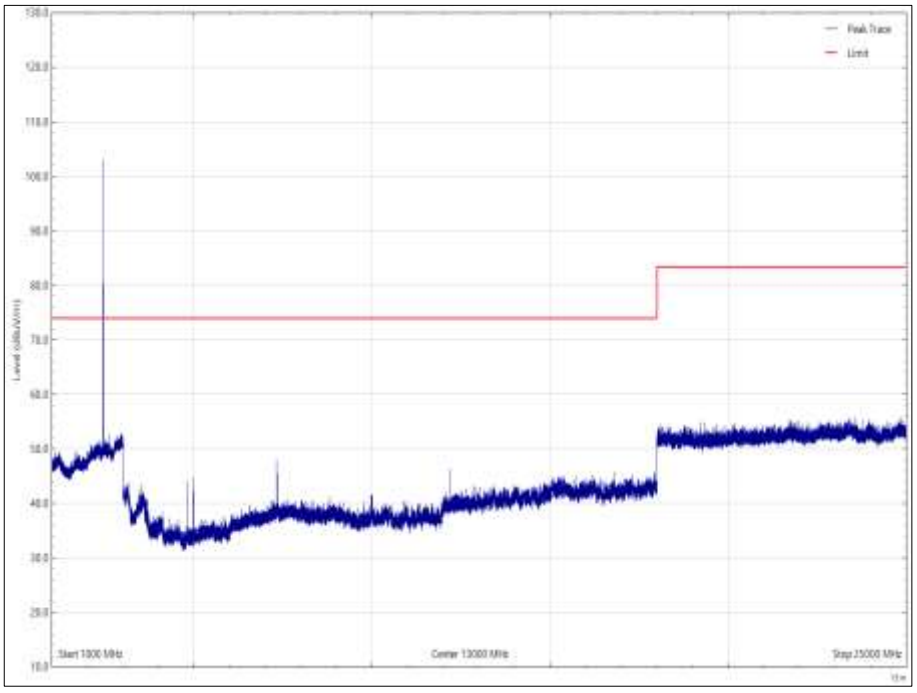

Figure 66 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, Z Orientation - Peak

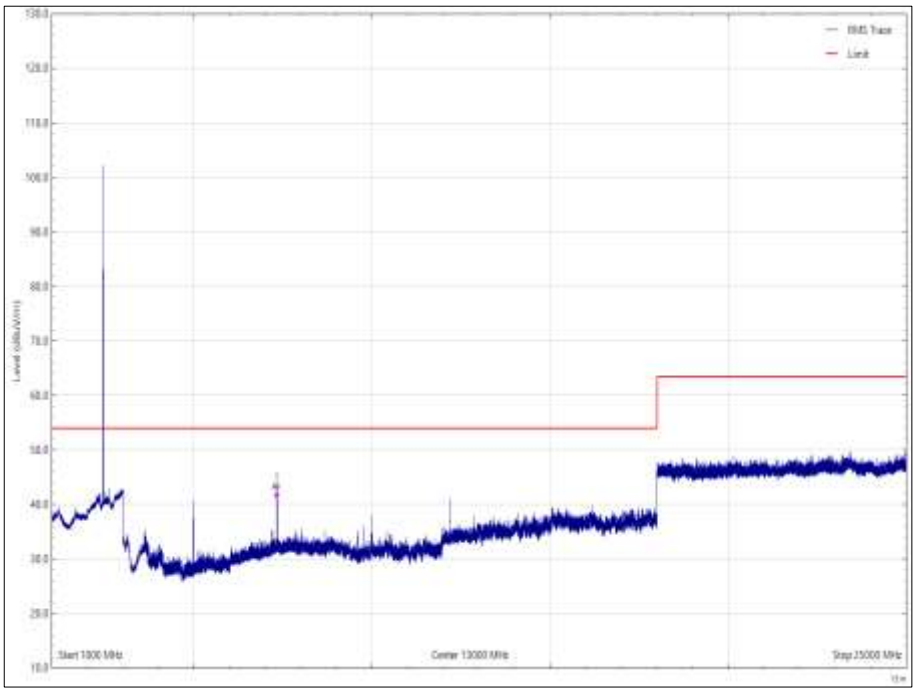

Figure 67 - 2441 MHz - 1 GHz to 25 GHz, Horizontal, Z Orientation - Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
73.048	30.19	40.00	9.81	Q-Peak	316	101	Vertical	Y
74.771	30.92	40.00	9.08	Q-Peak	125	100	Vertical	Z
74.928	35.81	40.00	4.19	Q-Peak	316	101	Vertical	X
124.994	35.32	43.52	8.20	Q-Peak	191	101	Vertical	Z
133.049	33.81	43.52	9.71	Q-Peak	227	213	Horizontal	Z
167.987	36.47	43.52	7.05	Q-Peak	0	100	Vertical	X
249.951	38.95	46.02	7.07	Q-Peak	226	100	Vertical	Y
250.011	36.46	46.02	9.56	Q-Peak	4	100	Horizontal	Z
250.034	39.61	46.02	6.41	Q-Peak	246	100	Vertical	Z
250.046	38.98	46.02	7.04	Q-Peak	226	100	Vertical	X
255.690	36.33	46.02	9.69	Q-Peak	269	100	Horizontal	Y
258.147	37.28	46.02	8.74	Q-Peak	3	110	Horizontal	X
332.765	37.72	46.02	8.30	Q-Peak	100	104	Horizontal	X
611.515	37.62	46.02	8.40	Q-Peak	192	143	Horizontal	X
611.517	38.02	46.02	8.00	Q-Peak	148	101	Vertical	Z
611.518	40.67	46.02	5.35	Q-Peak	174	100	Vertical	X
611.525	38.53	46.02	7.49	Q-Peak	222	100	Horizontal	Y

Table 47 - 2480 MHz, 30 MHz to 1 GHz

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

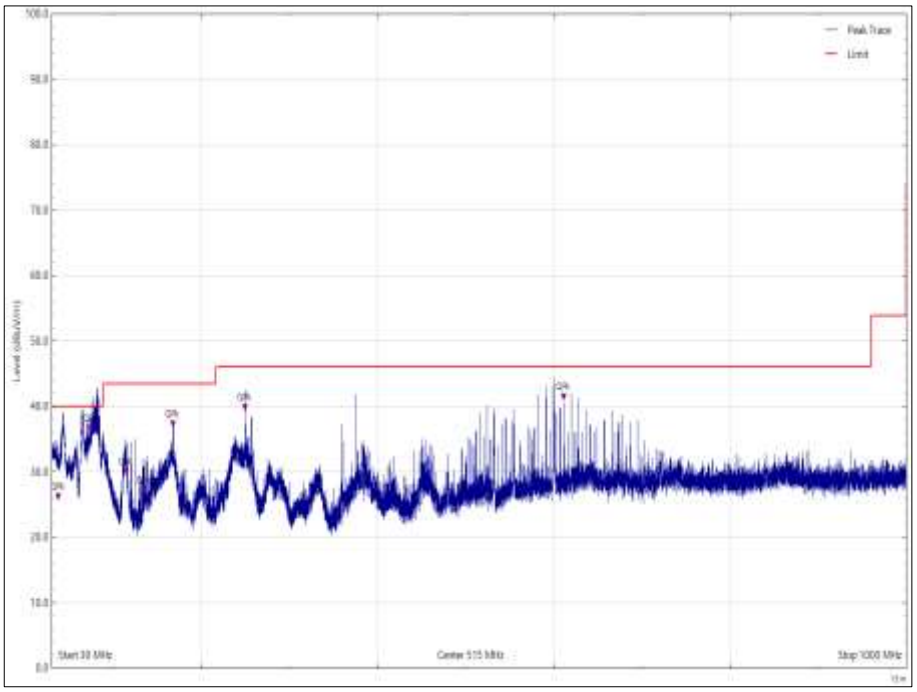

Figure 68 - 2480 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

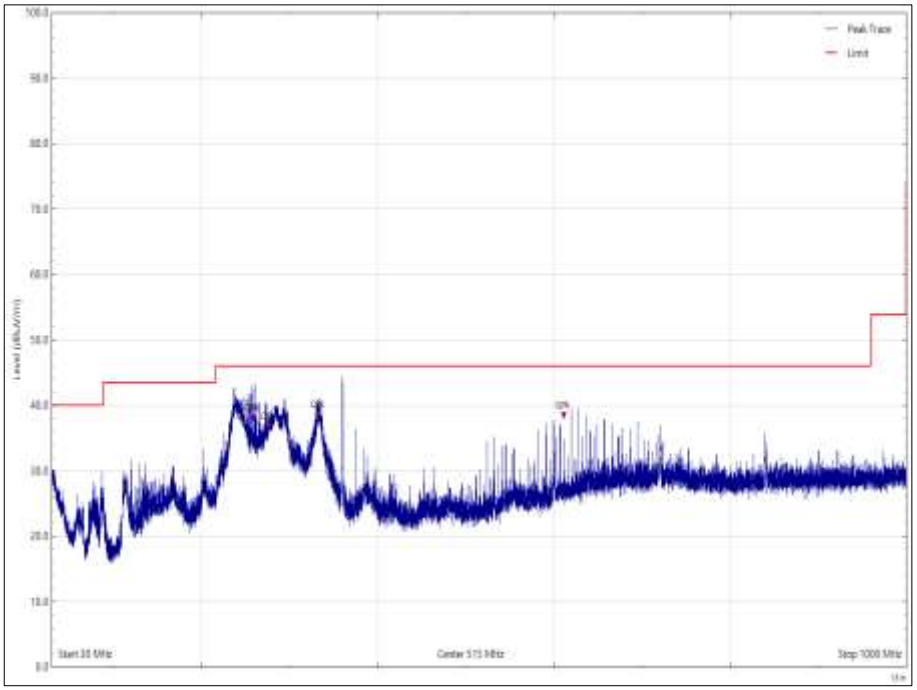

Figure 69 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

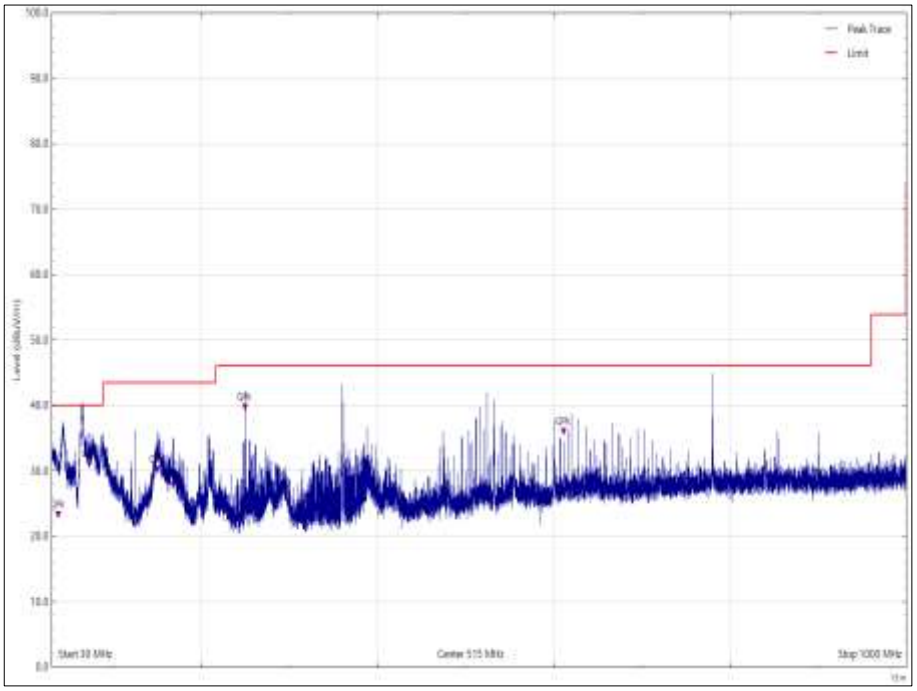

Figure 70 - 2480 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

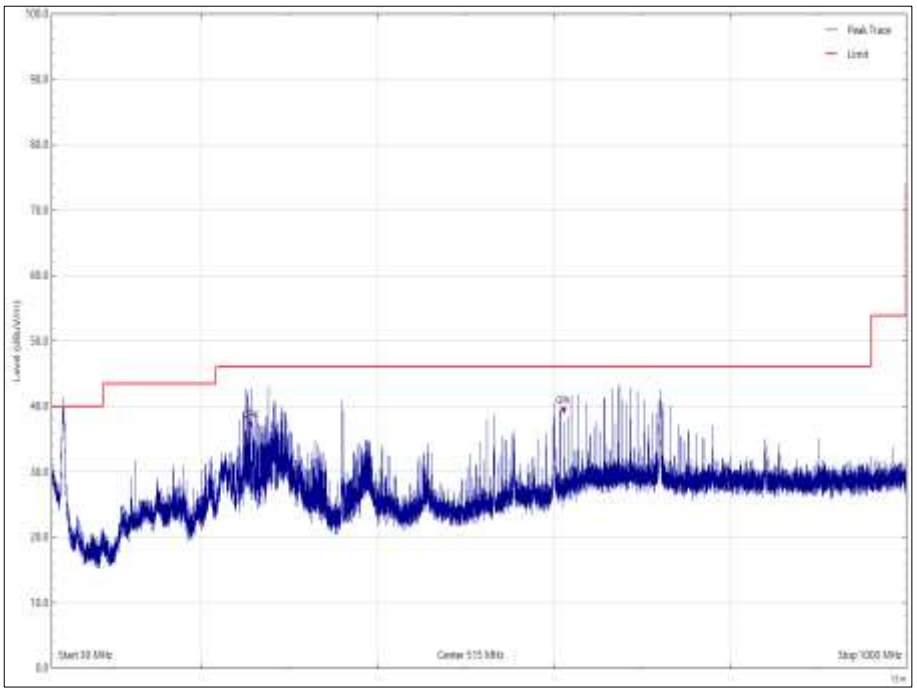

Figure 71 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

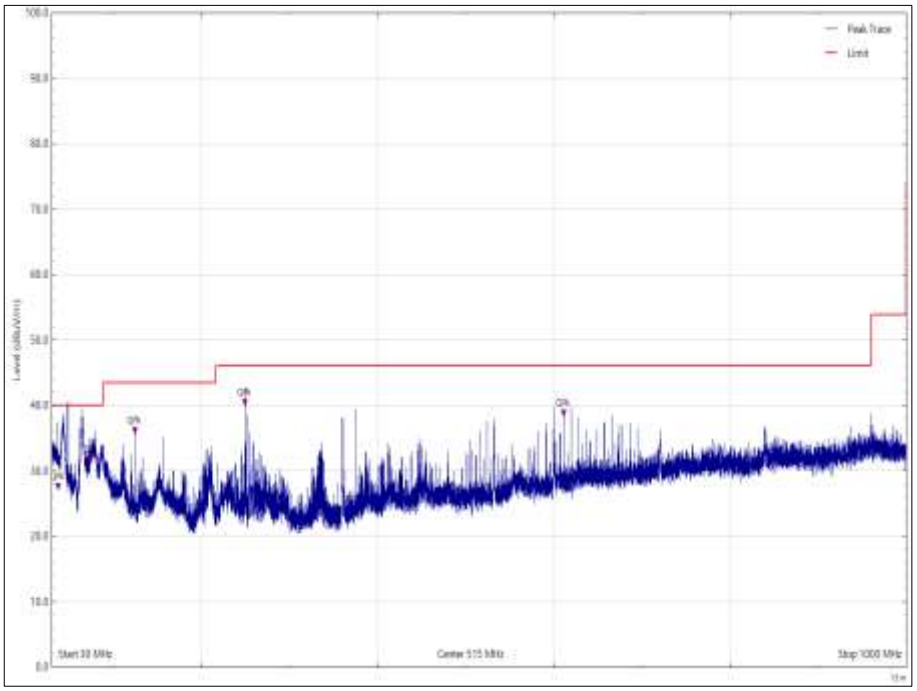

Figure 72 - 2480 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

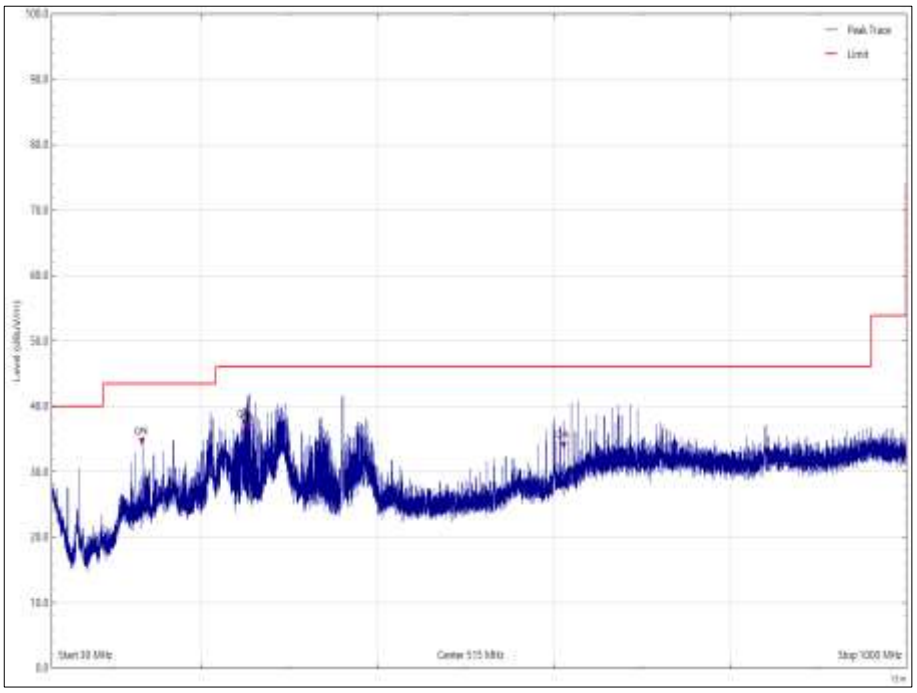

Figure 73 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4999.718	47.04	53.98	6.94	CISPR Average	238	155	Vertical	X
7439.960	46.58	53.98	7.40	CISPR Average	187	186	Horizontal	X

Table 48 - 2480 MHz - 1 GHz to 25 GHz

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

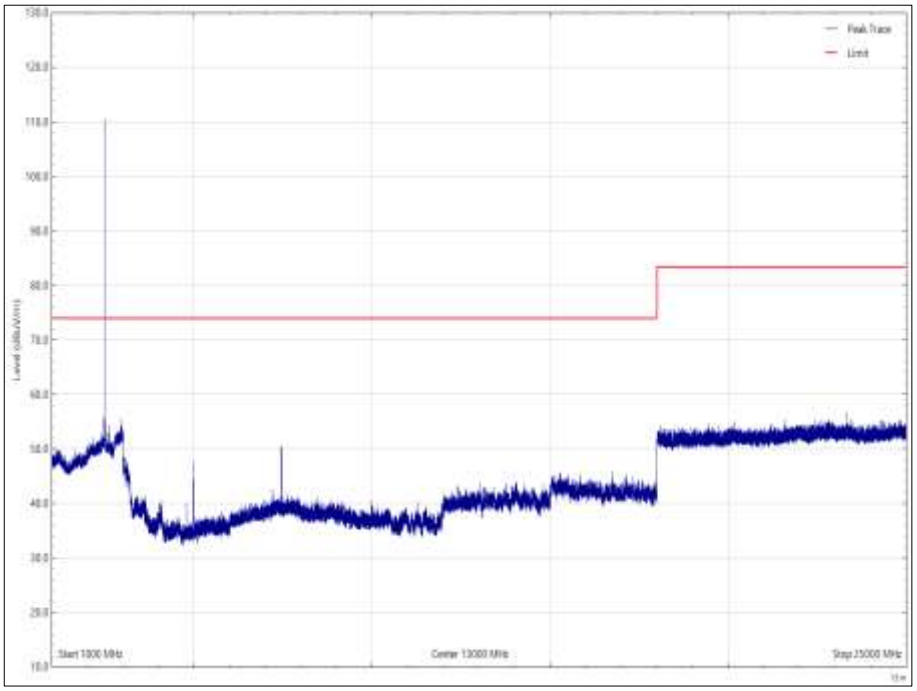

Figure 74 - 2480 MHz - 1 GHz to 25 GHz, Vertical, X Orientation - Peak

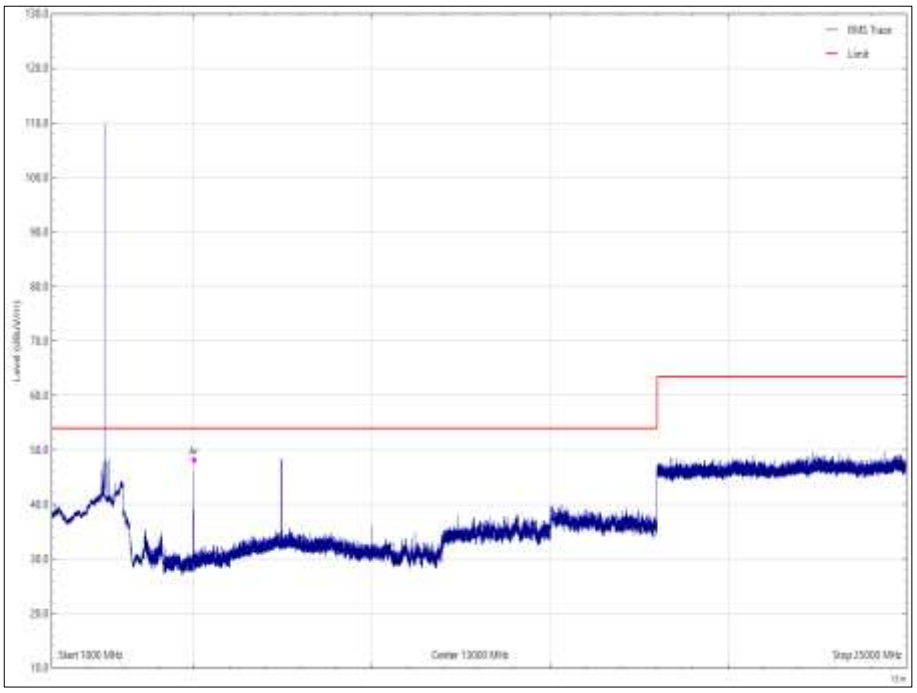

Figure 75 - 2480 MHz - 1 GHz to 25 GHz, Vertical, X Orientation - Average

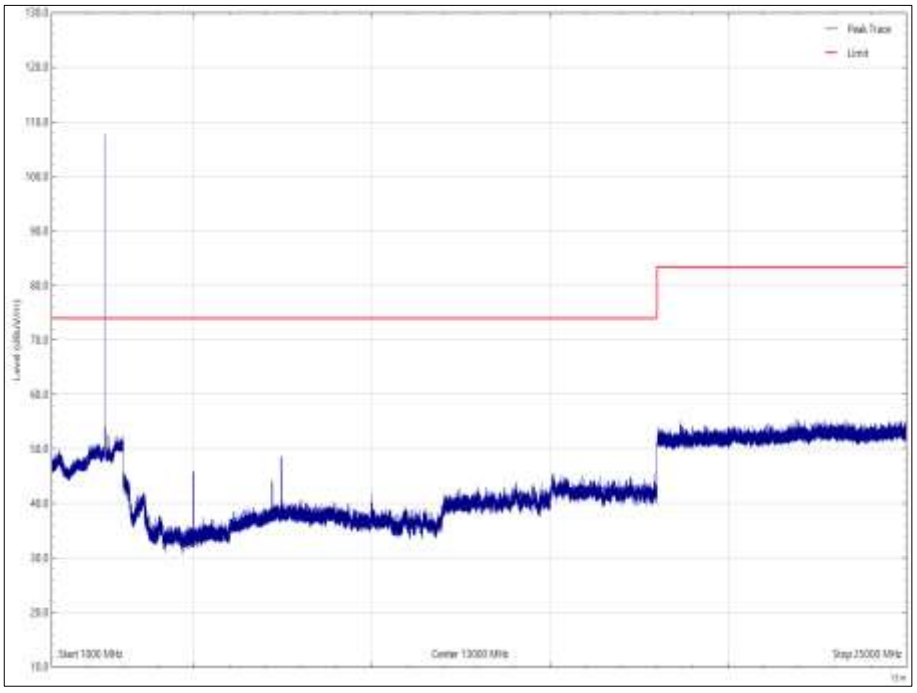

Figure 76 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, X Orientation - Peak

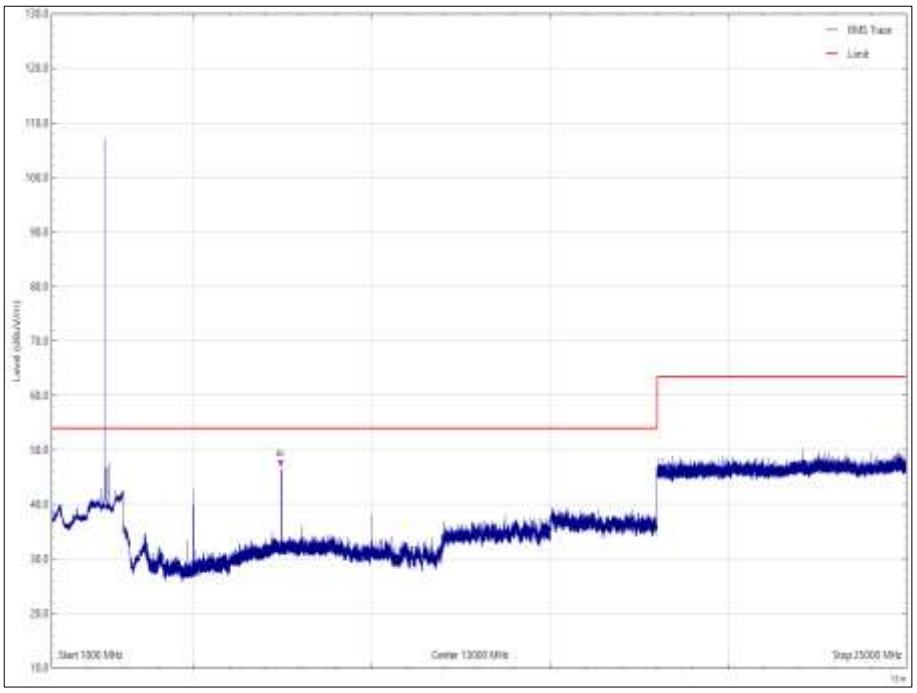

Figure 77 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, X Orientation - Average

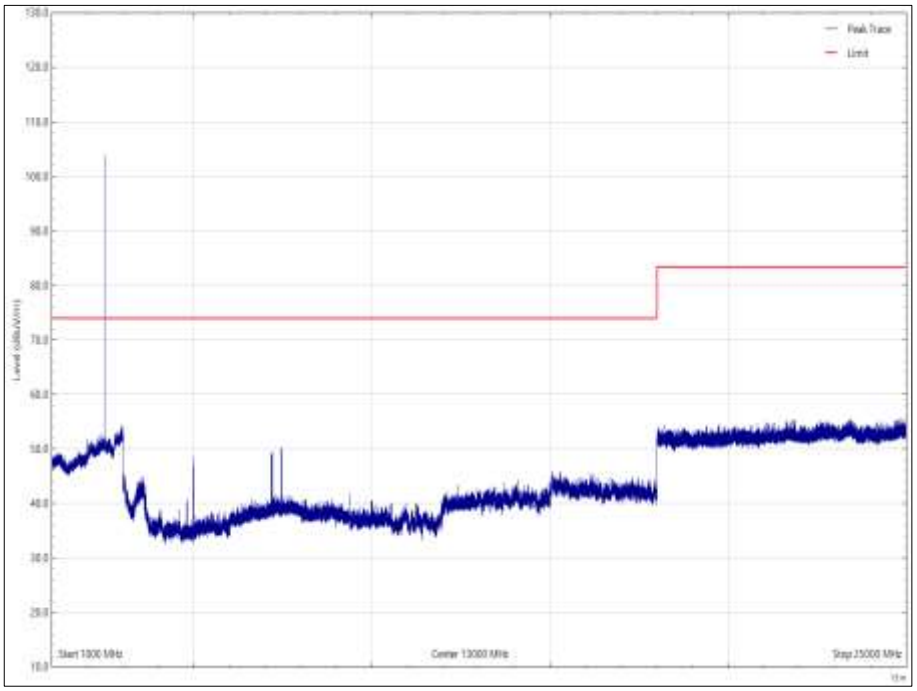

Figure 78 - 2480 MHz - 1 GHz to 25 GHz, Vertical, Y Orientation - Peak

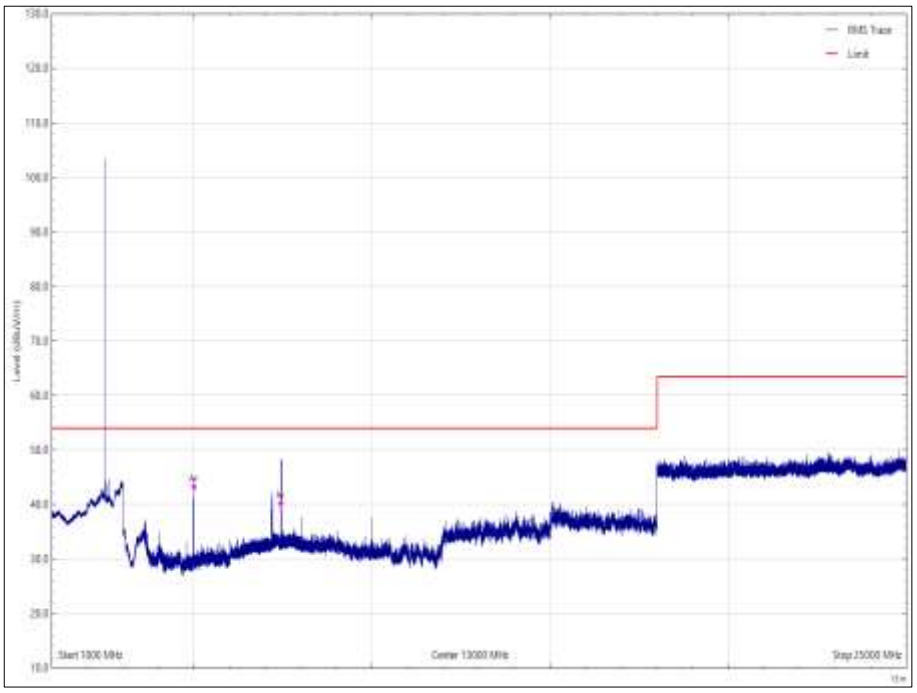

Figure 79 - 2480 MHz - 1 GHz to 25 GHz, Vertical, Y Orientation - Average

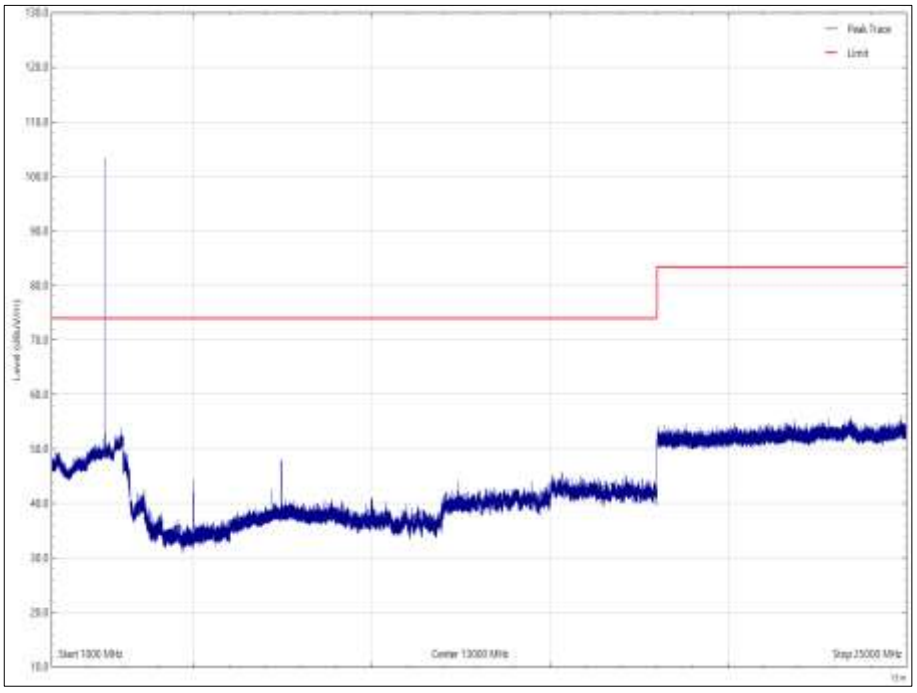

Figure 80 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, Y Orientation - Peak

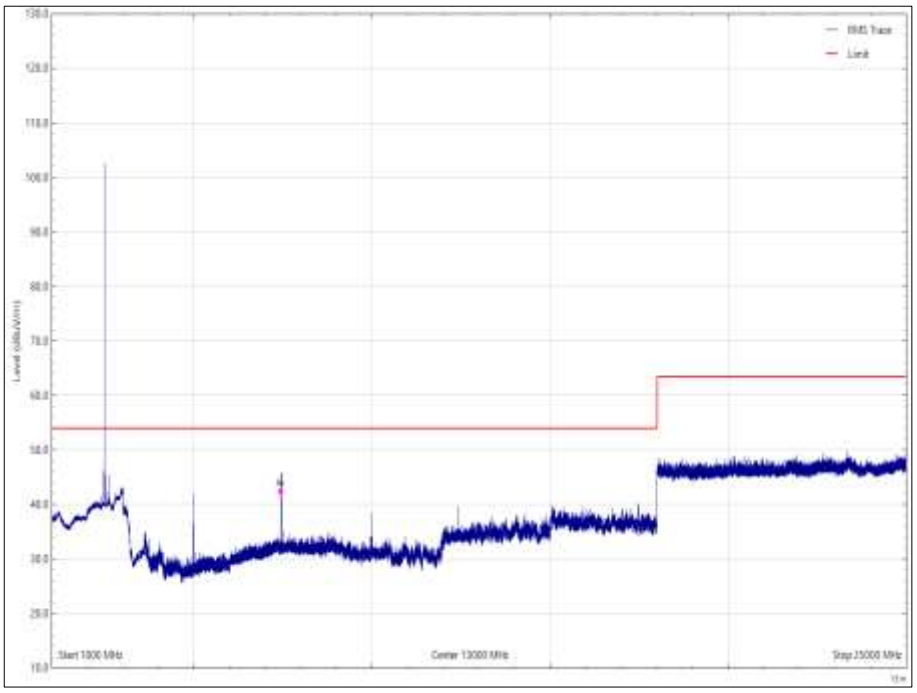

Figure 81 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, Y Orientation - Average

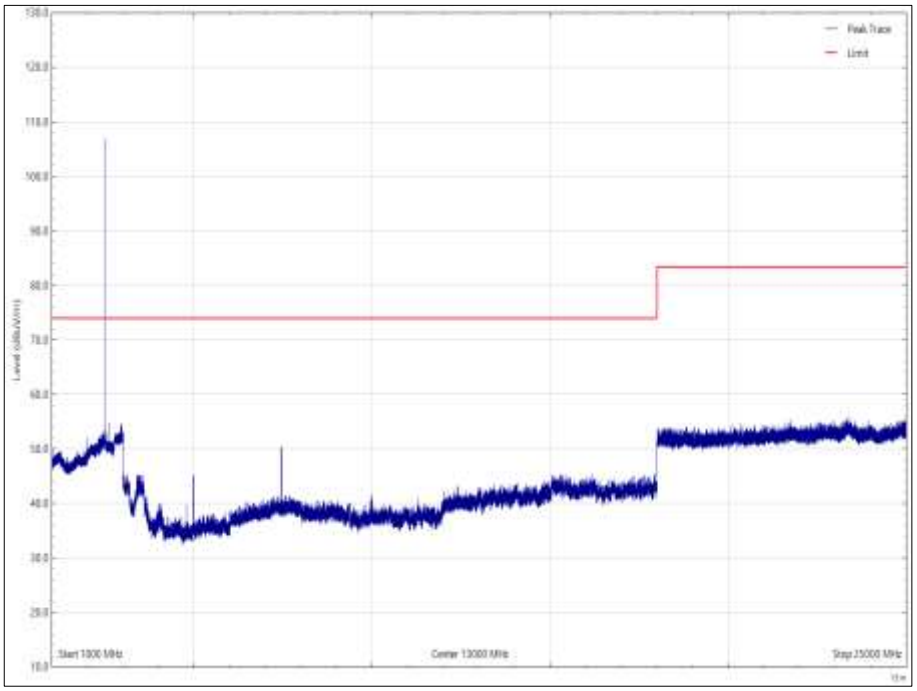

Figure 82 - 2480 MHz - 1 GHz to 25 GHz, Vertical, Z Orientation - Peak

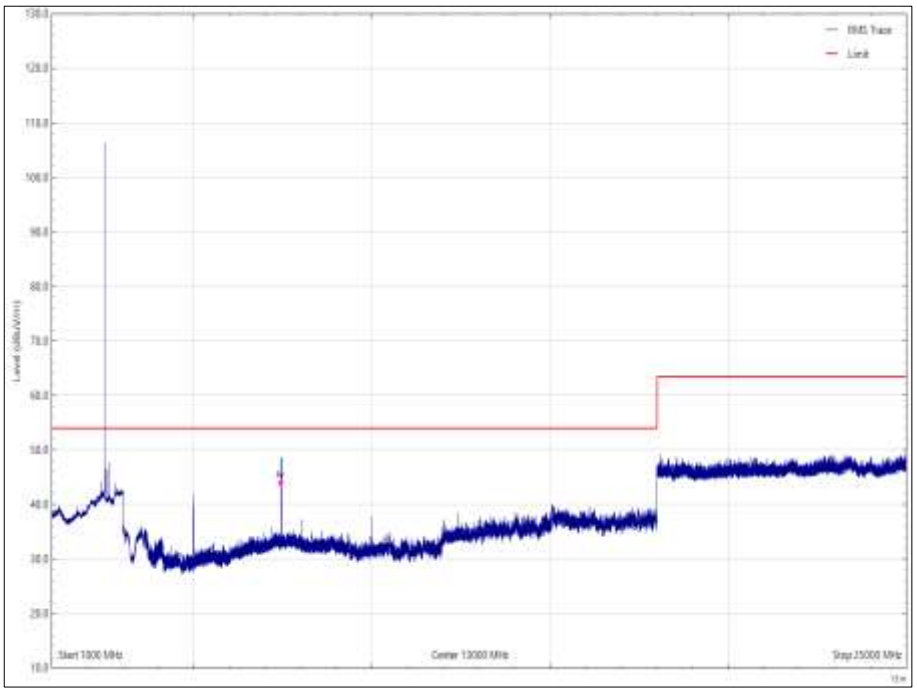

Figure 83 - 2480 MHz - 1 GHz to 25 GHz, Vertical, Z Orientation - Average

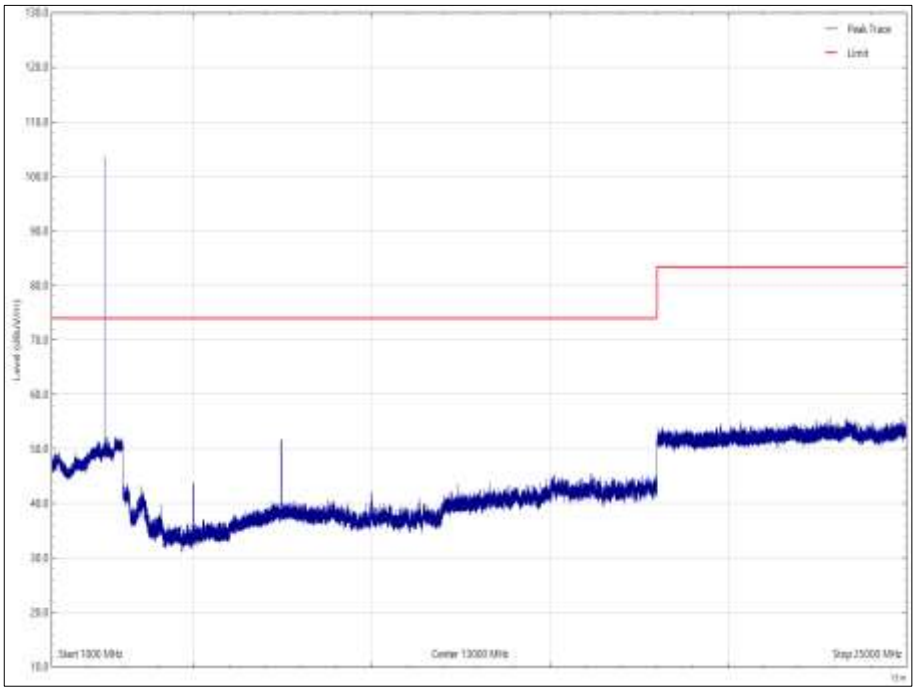

Figure 84 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, Z Orientation - Peak

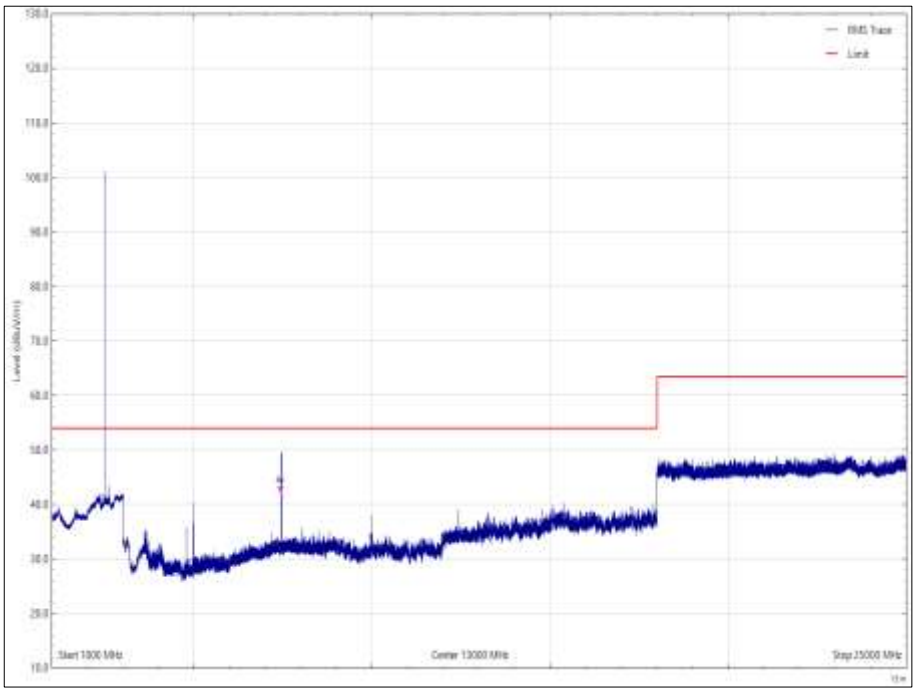

Figure 85 - 2480 MHz - 1 GHz to 25 GHz, Horizontal, Z Orientation - Average

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)

ISED RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

In addition, radiated emissions which fall in the restricted bands, as defined in RSS-GEN, clause 8.10, must also comply with the radiated emission limits specified in RSS-GEN clause 8.9.

2.7.8 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 Expires
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	27-Jul-2022
Antenna with permanent attenuator (Bilog)	Schaffner	CBL6143	287	24	14-Oct-2022
Pre-Amplifier, (8 GHz to 18 GHz)	Phase One	PS04-0086	1533	12	05-Feb-2022
18GHz - 40GHz Pre-Amplifier	Phase One	PSO4-0087	1534	12	02-Aug-2022
Comb Generator	Schaffner	RSG1000	3034	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
Cable 1503 2M 2.92(P)m 2.92(P)m	Rhophase	KPS-1503A-2000-KPS	4293	12	16-Nov-2021
Cable (18 GHz)	Rosenberger	LU7-036-1000	5031	12	23-Jul-2022
EmX Emissions Software	TUV SUD	V2.1.11	5125	-	Software
Preamplifier (30dB 1GHz to 18GHz)	Schwarzbeck	BBV 9718 C	5350	12	21-Sep-2021
Preamplifier (30dB 1GHz to 18GHz)	Schwarzbeck	BBV 9718 C	5350	12	22-Sep-2022
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
8 Meter Cable	Teledyne	PR90-088-8MTR	5450	6	08-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	31-Mar-2022
1m K-Type Cable	Junkosha	MWX241-01000KMSKMS/A	5511	12	09-Apr-2022
3 GHz High pass Filter	Wainwright	WHKX12-2580-3000-18000-80SS	5548	12	07-May-2022
DRG Horn Antenna (7.5-18GHz)	Schwarzbeck	HWRD750	5610	12	22-Sep-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
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
CBL 6111D 30-1000MHz Bi-Log Antenna	Teseq	CBL6111D	5615	24	16-Oct-2022
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 49

TU - Traceability Unscheduled

2.8 Authorised Band Edges

2.8.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d),
ISED RSS-247, Clause 5.5

2.8.2 Equipment Under Test and Modification State

Atom Hard Hat, S/N: Not serialised (Storix-ID 599374-18) - Modification State 0

2.8.3 Date of Test

12-September-2021

2.8.4 Test Method

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

2.8.5 Environmental Conditions

Ambient Temperature	18.9 °C
Relative Humidity	60.8 %

2.8.6 Test Results

Hard Hat - 2.4 GHz Bluetooth

Mode	Modulation	Packet Type	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
Static	GFSK	DH5	2402	2400.0	-57.83
Static	GFSK	DH5	2480	2483.5	-60.22
Static	π/4 DQPSK	2DH5	2402	2400.0	-45.83
Static	π/4 DQPSK	2DH5	2480	2483.5	-58.68
Static	8-DPSK	3DH5	2402	2400.0	-46.00
Static	8-DPSK	3DH5	2480	2483.5	-57.82

Table 50

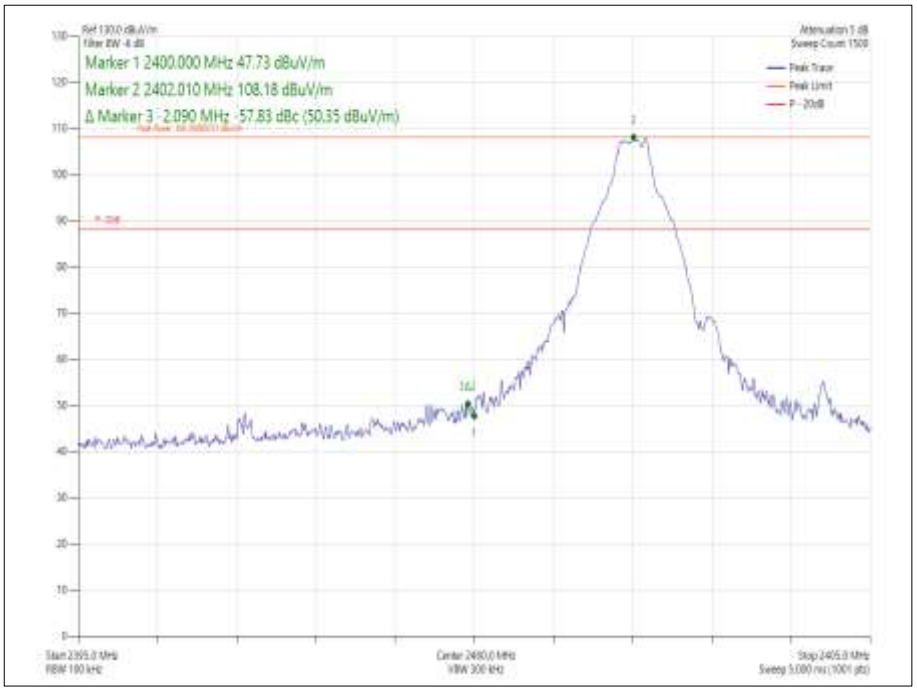

Figure 86 - Static - GFSK/DH5
2402 MHz - Measured Frequency 2400.0 MHz

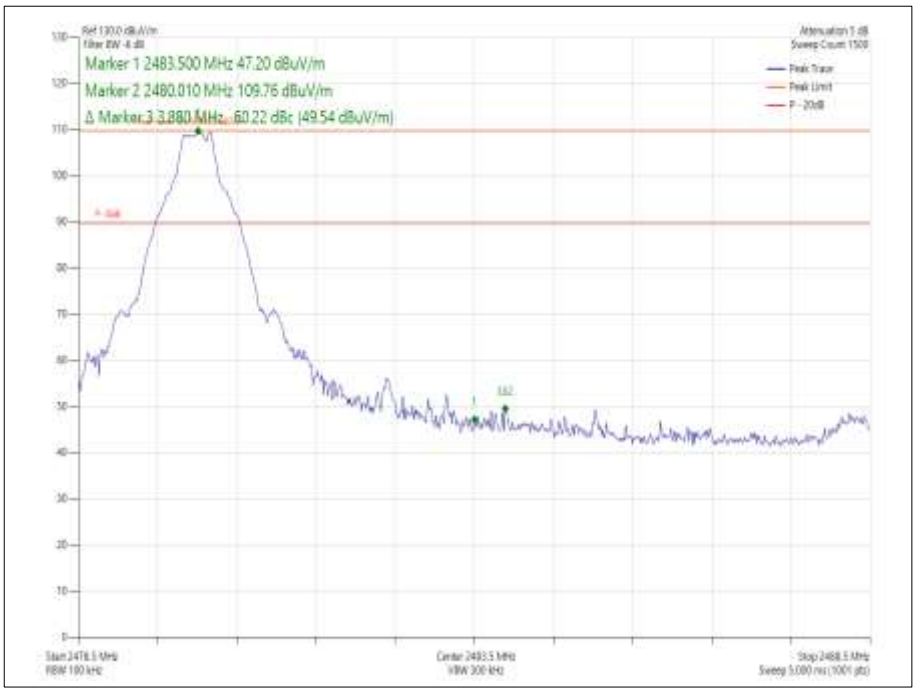

Figure 87 - Static - GFSK/DH5
2480 MHz - Measured Frequency 2483.5 MHz

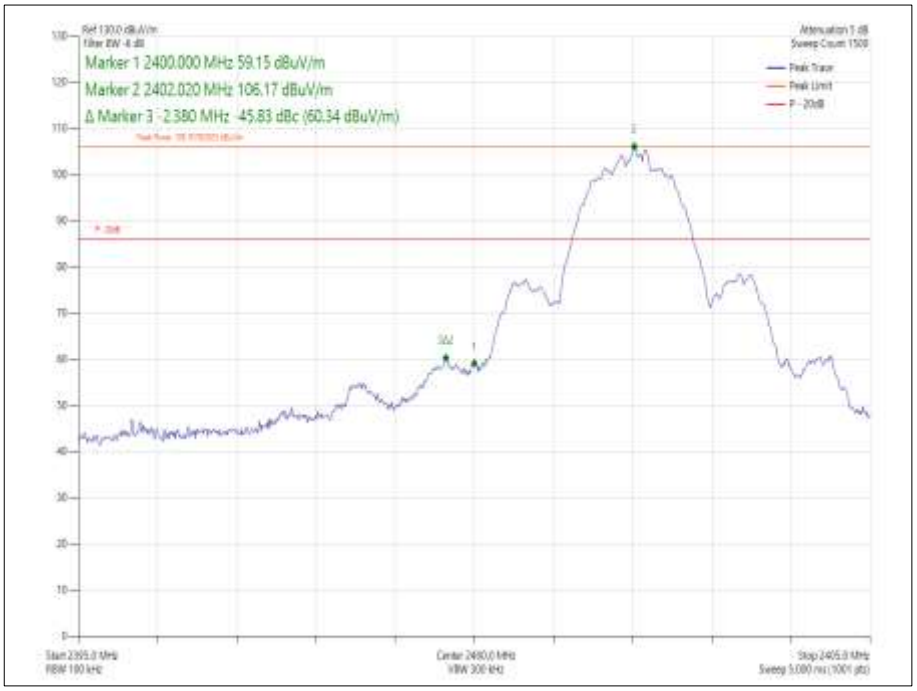

Figure 88 - Static - π/4 DQPSK/2DH5
2402 MHz - Measured Frequency 2400.0 MHz

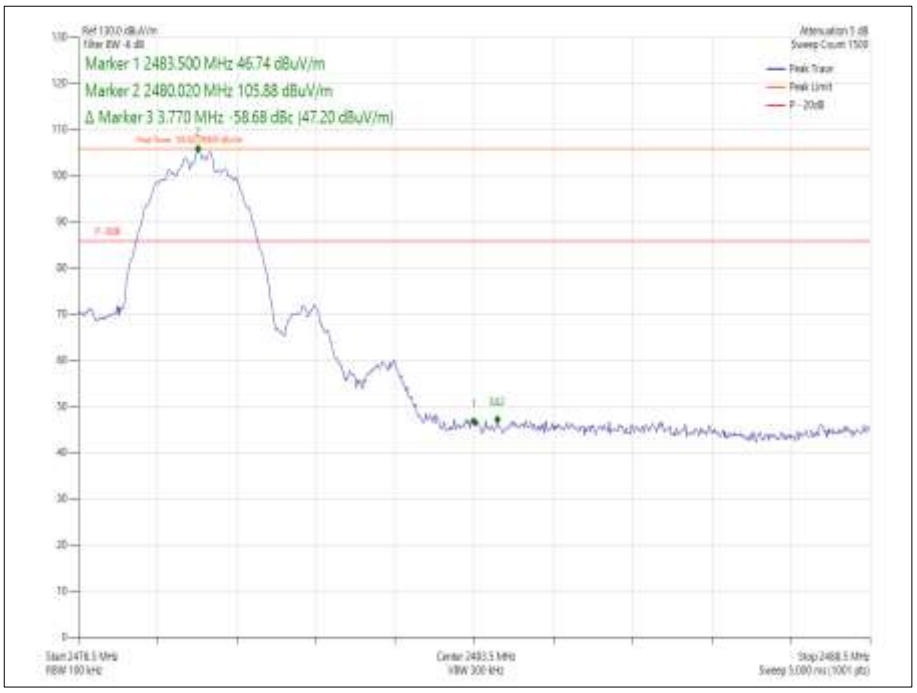

Figure 89 - Static - π/4 DQPSK/2DH5
2480 MHz - Measured Frequency 2483.5 MHz

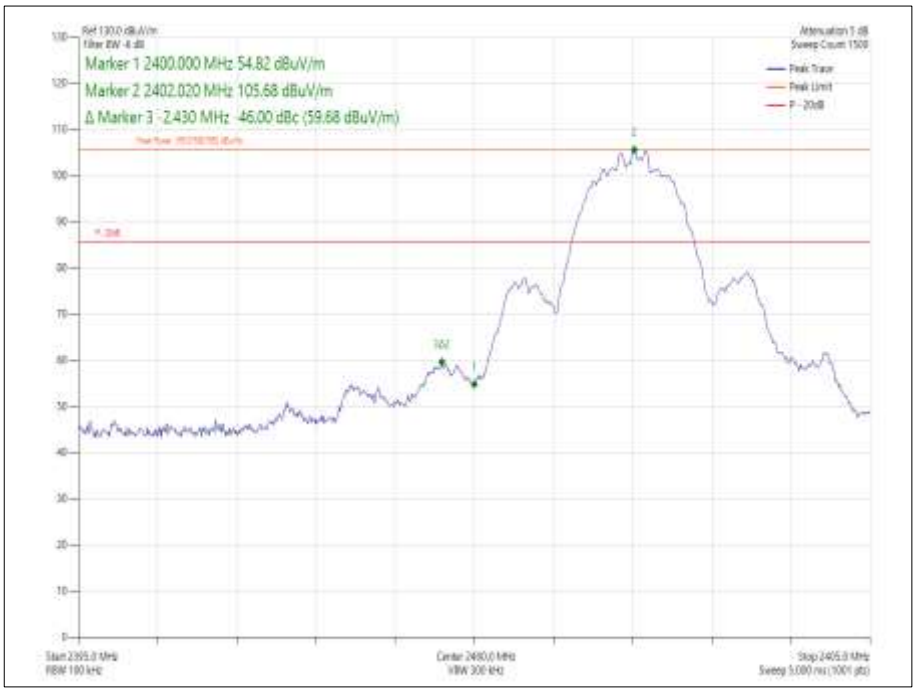

Figure 90 - Static - 8-DPSK/3DH5
2402 MHz - Measured Frequency 2400.0 MHz

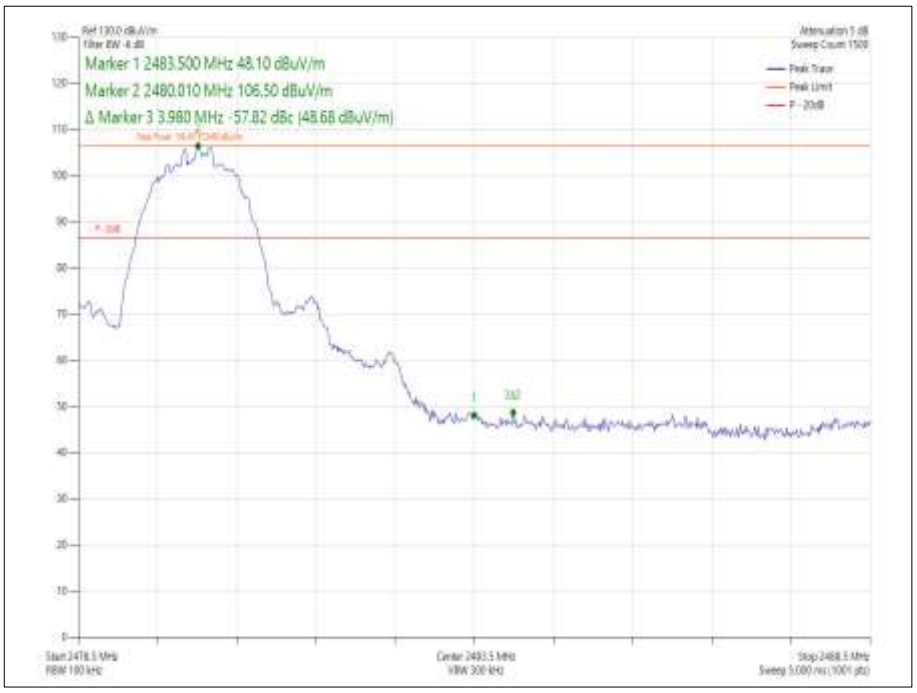

Figure 91 - Static - 8-DPSK/3DH5
2480 MHz - Measured Frequency 2483.5 MHz

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.

ISED RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

2.8.7 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 Expires
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
EmX Emissions Software	TUV SUD	V2.1.11	5125	-	Software
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
8 Meter Cable	Teledyne	PR90-088-8MTR	5450	6	08-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	31-Mar-2022
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
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023

Table 51

TU - Traceability Unscheduled

3 Photographs

3.1 Test Setup Photographs

Figure 92 - Test Setup - 30 MHz to 1 GHz - X Orientation

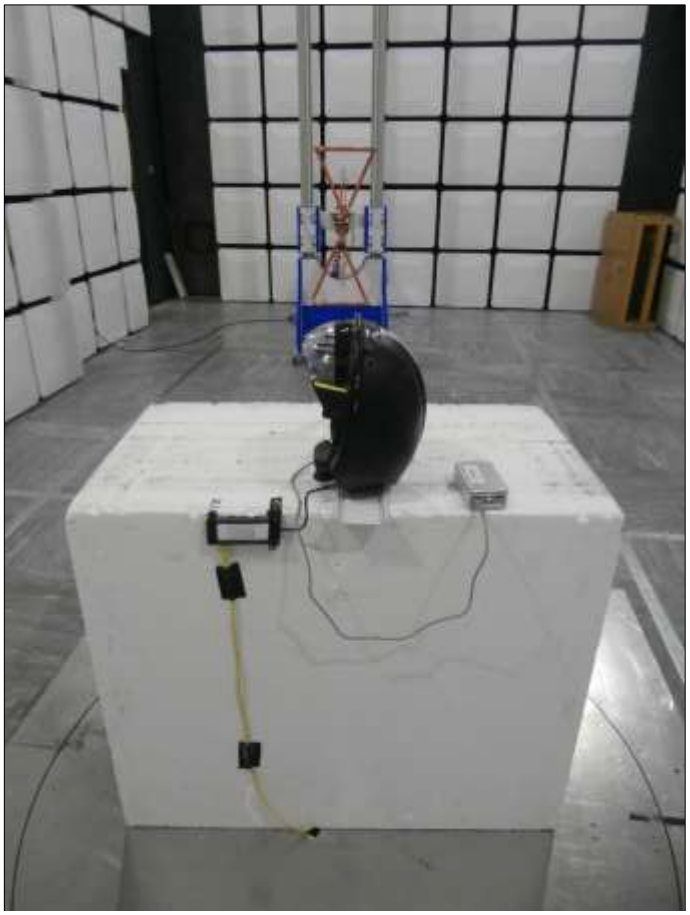

Figure 93 - Test Setup - 30 MHz to 1 GHz - Y Orientation

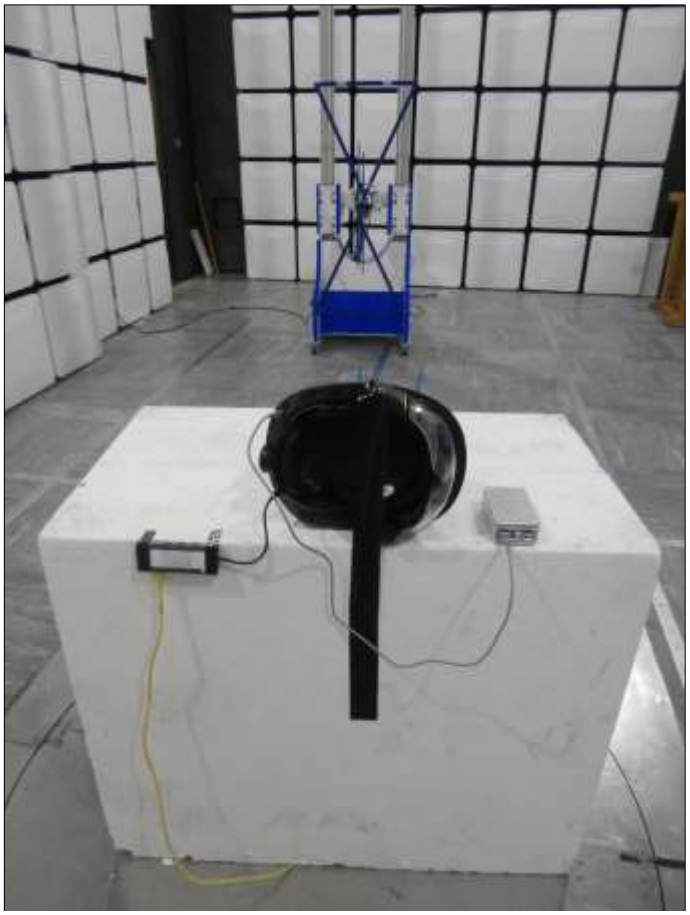

Figure 94 - Test Setup - 30 MHz to 1 GHz - Z Orientation

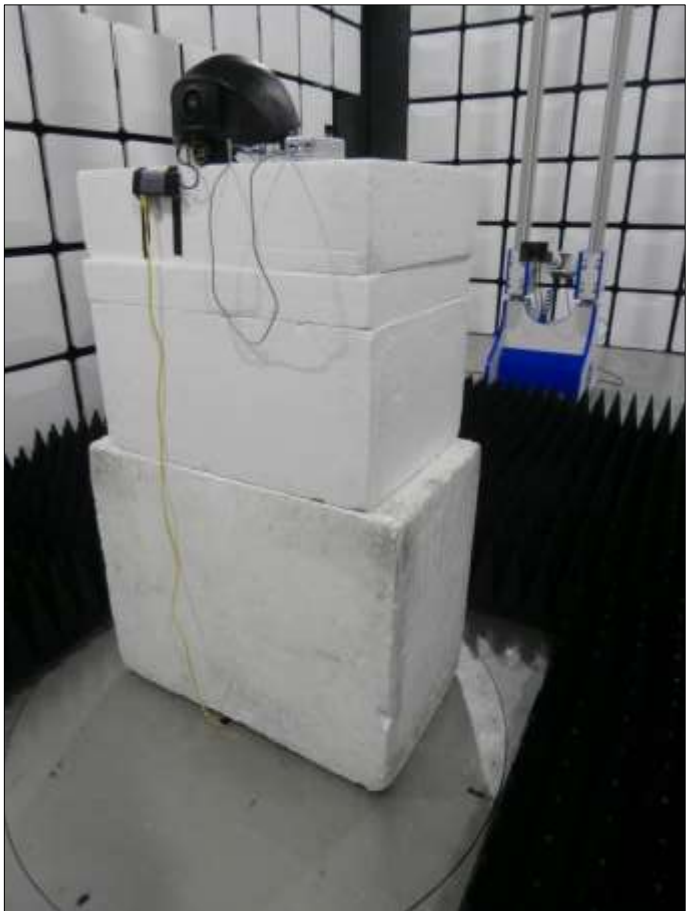

Figure 95 - Test Setup - 1 GHz to 18 GHz - X Orientation

Figure 96 - Test Setup - 1 GHz to 18 GHz - Y Orientation

Figure 97 - Test Setup - 1 GHz to 18 GHz - Z Orientation

Figure 98 - Test Setup - 18 GHz to 25 GHz - X Orientation

Figure 99 - Test Setup - 18 GHz to 25 GHz - Y Orientation

Figure 100 - Test Setup - 18 GHz to 25 GHz - Z Orientation

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
Frequency Hopping Systems - Number of Hopping Channels	-
Frequency Hopping Systems - Average Time of Occupancy	-
Frequency Hopping Systems - Channel Separation	± 58.342 kHz (Same as 20 dB Bandwidth)
Frequency Hopping Systems - 20 dB Bandwidth	± 23.512 kHz
Maximum Conducted Output Power	± 3.2 dB
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Authorised Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB

Table 52

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.