

FCC and ISCED Test Report

GRUNDFOS Holding A/S
Radio Module, Model: MSR – Multistandard Radio
module

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

Prepared for: GRUNDFOS Holding A/S
Poul Due Jensens Vej 7
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Add value.
Inspire trust.

FCC ID: OG3-RA2G4MSR IC: 10447A-RA2G4MSR

COMMERCIAL-IN-CONFIDENCE

Document 75951634-02 Issue 01

SIGNATURE

		RESPONSIBLE FOR	ISSUE DATE
Steve Marshall	Senior Engineer	Authorised Signatory	30 June 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, ISCED RSS-247 and ISCED RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	George Porter	30 June 2021	
Testing	Anthony Hubbard	30 June 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: 2019, ISCED RSS-247: Issue 2 (02-2017) and ISCED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) for the tests detailed in section 1.3.



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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	30-June-2021

Table 1

1.2 Introduction

Applicant	GRUNDFOS Holding A/S
Manufacturer	GRUNDFOS Holding A/S
Model Number(s)	MSR – Multistandard Radio module
Serial Number(s)	Not Applicable (FAR-560189-03) Not Applicable (FAR-560189-06)
Hardware Version(s)	R02 & R03
Software Version(s)	bleModule_CC2652R1_V04.40.04.xxxx
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2019 ISED RSS-247 Issue 2 (2017-02) ISED RSS-GEN: Issue 5 (2018-04) + A2 (02-2021)
Order Number	4513488246
Date	11-March-2021
Date of Receipt of EUT	30-March-2021
Start of Test	12-May-2021
Finish of Test	20-May-2021
Name of Engineer(s)	George Porter and Anthony Hubbard
Related Document(s)	ANSI C63.4 (2014) 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, ISSED RSS-247 and ISSED RSS-GEN is shown below.

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: 2.4 GHz Bluetooth Low Energy						
-	15.203	-	-	Antenna Requirement	N/T	Integrated F-type PCB antenna in host product, solder-connected to the module, with maximum 2.15 dBi gain.
2.1	15.205	-	8.10	Restricted Band Edges	Pass	
2.2	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	
2.3	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.4	15.247 (d) and 15.205	3.3 and 5.5	6.13	Spurious Radiated Emissions	Pass	
2.5	15.247 (d)	5.5	-	Authorised Band Edges	Pass	
2.6	15.247 (e)	5.2	6.12	Power Spectral Density	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)	The MSR module can be used in products for different types of wireless connectivity. The Bluetooth function can be used for smart devices and 802.15.4 based protocols e.g. Thread, GLoWPAN, etc. for monitoring, control or cloud services	
Manufacturer:	Grundfos Holding A/S	
Model:	MSR – Multistandard Radio module	
Part Number:	BLE Module 92542810; MSR Module 92542811	
Hardware Version:	R02 & R03	
Software Version:	bleModule_CC2652R1_V04.40.04.xxxx	
FCC ID of the product under test – see guidance here	OG3-RA2G4MSR	
IC ID of the product under test – see guidance here	10447A-RA2G4MSR	

Intentional Radiators

Technology	BLE					
Frequency Range (MHz to MHz)	2400 – 2483.5 MHz					
Conducted Declared Output Power (dBm)	4					
Antenna Gain (dBi)	2.15					
Supported Bandwidth(s) (MHz) (e.g 1 MHz, 20 MHz, 40 MHz)						
Modulation Scheme(s) (e.g GFSK, QPSK etc)	O-QPSK / GMSK					
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)	1M00X					
Bottom Frequency (MHz)	2400 MHz					
Middle Frequency (MHz)						
Top Frequency (MHz)	2483.5 MHz					

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	2483.5 MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	2400 MHz
Class A Digital Device (Use in commercial, industrial or business environment) ☒	
Class B Digital Device (Use in residential environment only) ☐	

AC Power Source

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



DC Power Source

Nominal voltage:	3.3	V
Extreme upper voltage:	3.8	V
Extreme lower voltage:	2.0	V
Max current:	100 m	A

Battery Power Source

Voltage:		V
End-point voltage:		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	°C
Maximum temperature:	+70	°C

Cable Loss

Adapter Cable Loss (Conducted sample)	1.0	dB
--	-----	----

Antenna Characteristics

Antenna connector ☐	State impedance		Ohm
Temporary antenna connector ☐	State impedance		Ohm
Integral antenna ☒	Type:		Gain
		2.15	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: Nikolaj Haahr Korshøj
Position held: Lead Digital Compliance Specialist
Date: 02.06.2021



1.5 Product Information

1.5.1 Technical Description

The MSR module can be used in products for different types of wireless connectivity. The Bluetooth function can be used for smart devices and 802.15.4 based protocols e.g. Thread, GLoWPAN, etc. for monitoring, control or cloud services.

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: MSR – Multistandard Radio module, Serial Number: Not Applicable (FAR-560189-03)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: MSR – Multistandard Radio module, Serial Number: Not Applicable (FAR-560189-06)			
0	As supplied by the customer	Not Applicable	Not Applicable

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	Anthony Hubbard	UKAS
Emission Bandwidth	George Porter	UKAS
Maximum Conducted Output Power	George Porter	UKAS
Spurious Radiated Emissions	Anthony Hubbard	UKAS
Authorised Band Edges	Anthony Hubbard	UKAS
Power Spectral Density	George Porter	UKAS

Table 4

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

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-06) - Modification State 0

2.1.3 Date of Test

18-May-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 4.1.4.2.5. 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 dB μ V/m to μ V/m:
 $10^{(\text{Field Strength in dB}\mu\text{V/m}/20)}$

2.1.5 Environmental Conditions

Ambient Temperature 21.8 °C
Relative Humidity 40.9 %

2.1.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dB μ V/m)	Average Level (dB μ V/m)
GFSK	2402	2390.0	60.21	47.91
GFSK	2480	2483.5	64.54	53.05

Table 5 - Restricted Band Edge Results

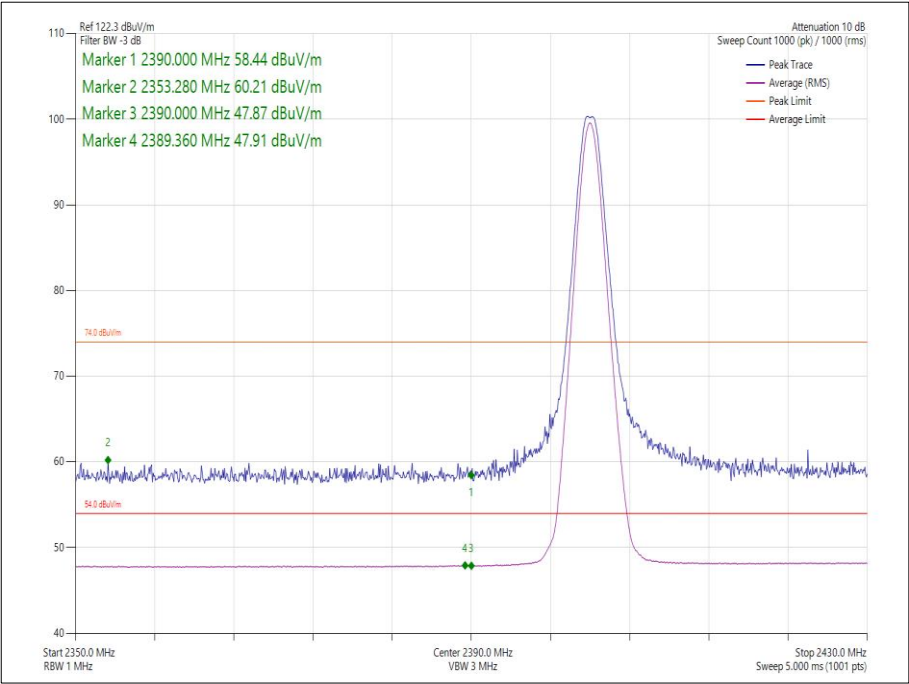


Figure 1 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

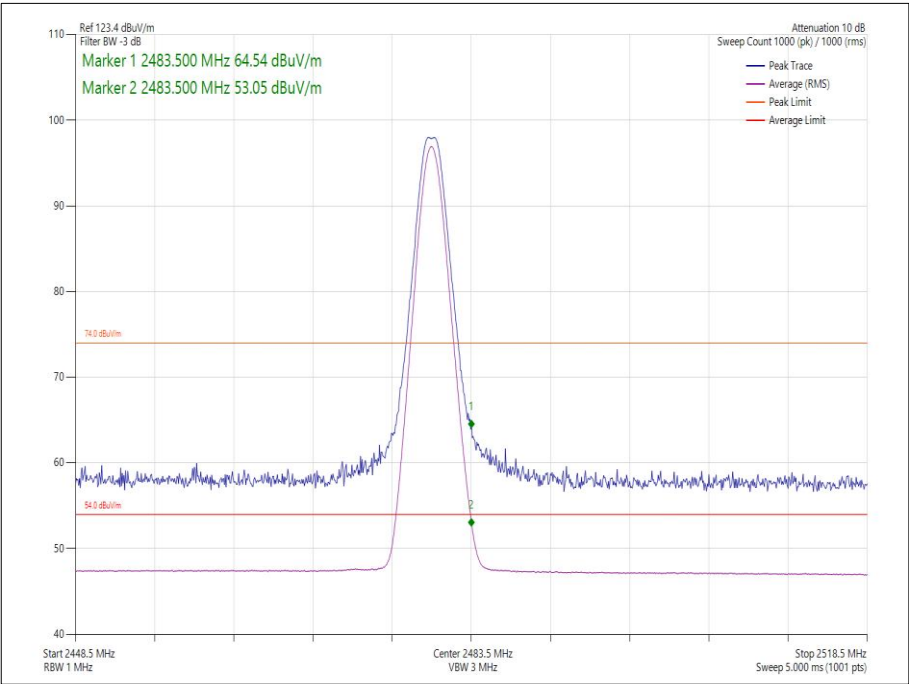


Figure 2 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz



FCC 47 CFR Part 15, Limit Clause 15.209

Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 6

ISED RSS-GEN, Limit Clause 8.9

Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$ at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

Table 7

*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
42 V 10 Amp Power Supply Unit	Thurlby Thandar Instruments	EX4210R	3547	-	TU
Multimeter	Fluke	177	3813	12	22-Dec-2021
EmX Emissions Software	TUV SUD	V2.1.6	5125	-	Software
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
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
Cable Assembly - 18GHz 8m	Junkosha	MWX221-08000NMSNMS/B	5732	6	05-Aug-2021

Table 8

TU - Traceability Unscheduled



2.2 Emission Bandwidth

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(2)
ISED RSS-247, Clause 5.2
ISED RSS-GEN, Clause 6.7

2.2.2 Equipment Under Test and Modification State

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-03) - Modification State 0

2.2.3 Date of Test

12-May-2021

2.2.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.1 for 6 dB bandwidth and 6.9.3 for 99% occupied bandwidth.

2.2.5 Environmental Conditions

Ambient Temperature	24.7 °C
Relative Humidity	32.1 %

2.2.6 Test Results

2.4 GHz Bluetooth Low Energy

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (a)(2) RSS-247 5.2 a)	Test Method(s):	C63.10 6.9.3 C63.10 11.8.1
Additional Reference(s):	-		

DUT Configuration			
Mode:	BLE GFSK (LE 1M)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (BLE)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	6 dB Bandwidth (MHz)					Limit (kHz)
	A	B	C	D	Minimum	
2402	0.704	-	-	-	0.704	≥500.0
2442	0.700	-	-	-	0.700	≥500.0
2480	0.688	-	-	-	0.688	≥500.0

Table 9 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)					Limit (kHz)
	A	B	C	D	Minimum	
2402	1.096	-	-	-	1.096	-
2442	1.084	-	-	-	1.084	-
2480	1.084	-	-	-	1.084	-

Table 10 - 99% Bandwidth Results

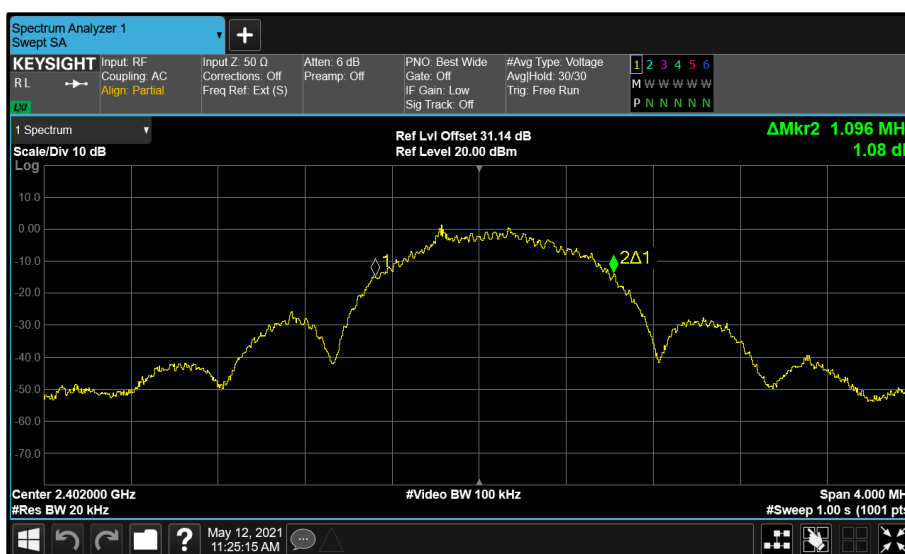


Figure 3 - BLE (A) 2402 MHz (CH37) 99% Bandwidth

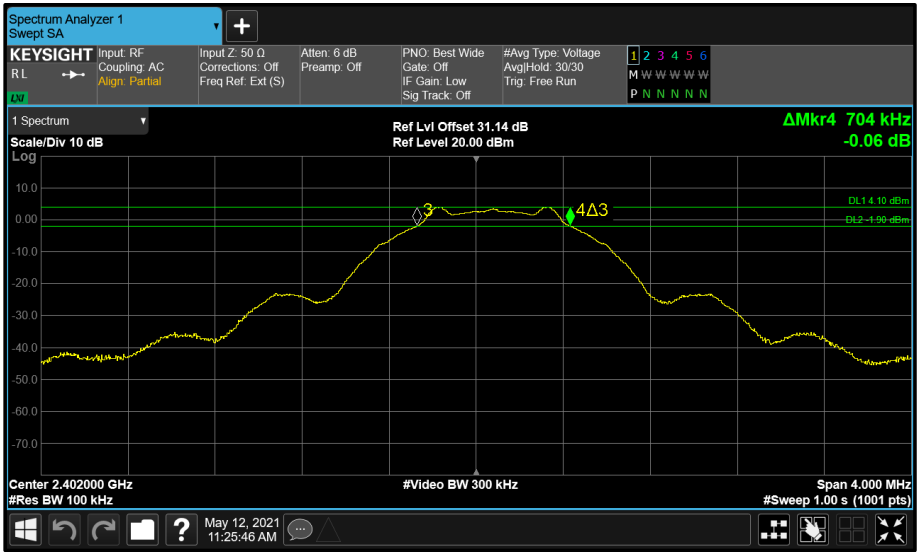


Figure 4 - BLE (A) 2402 MHz (CH37) 6 dB Bandwidth

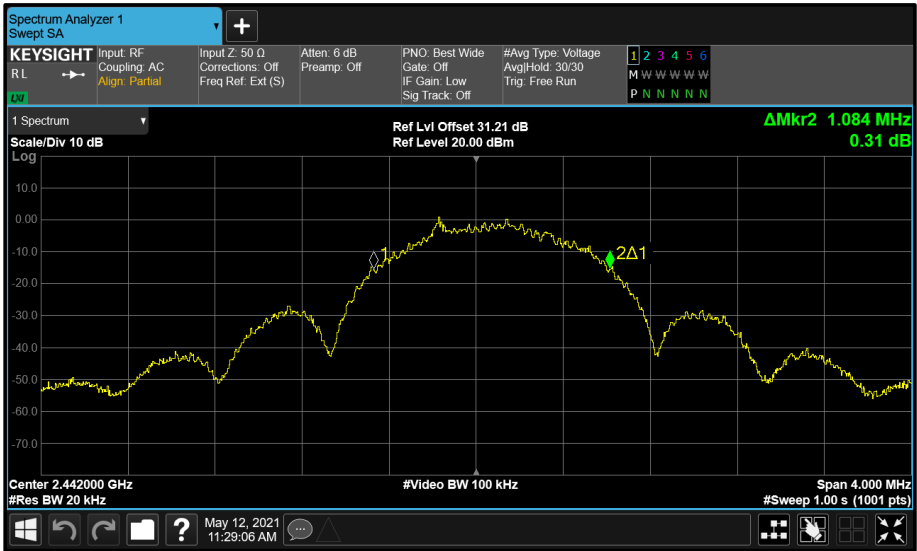


Figure 5 - BLE (A) 2442 MHz (CH18) 99% Bandwidth

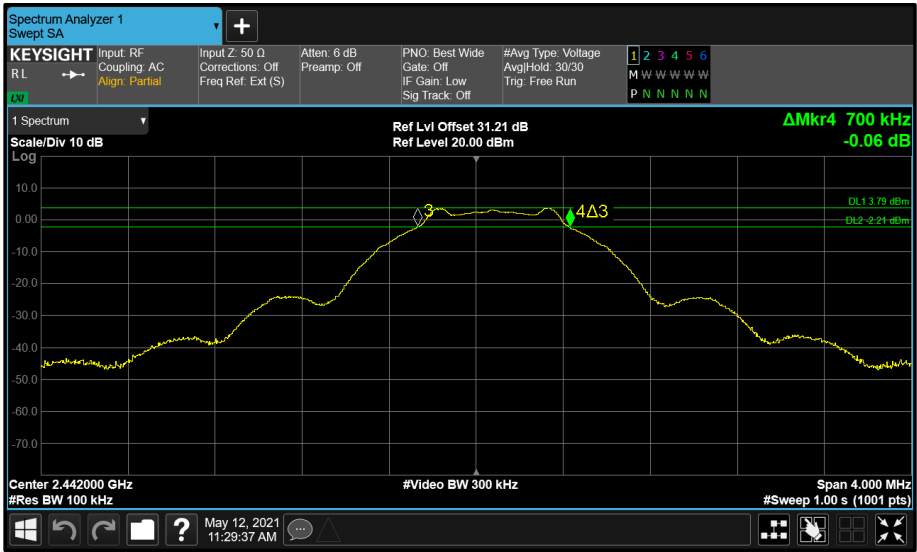


Figure 6 - BLE (A) 2442 MHz (CH18) 6 dB Bandwidth

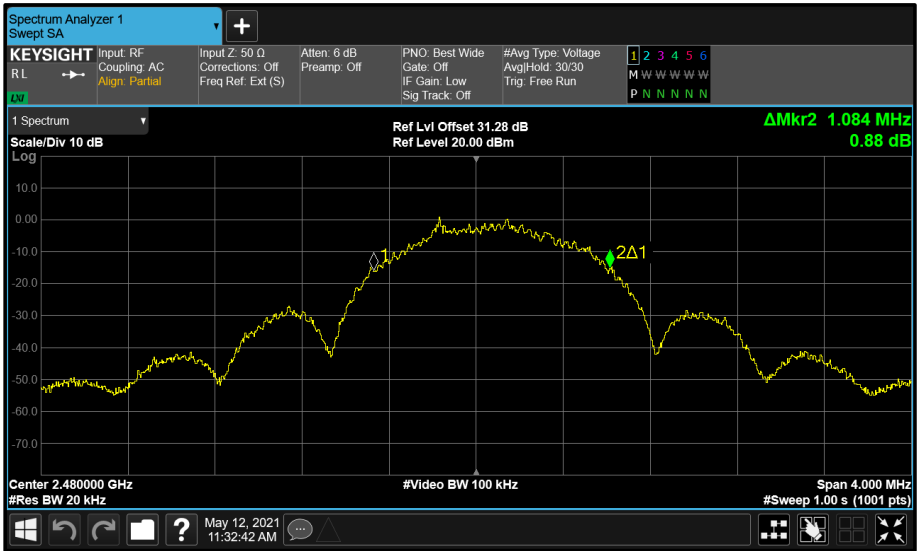


Figure 7 - BLE (A) 2480 MHz (CH39) 99% Bandwidth

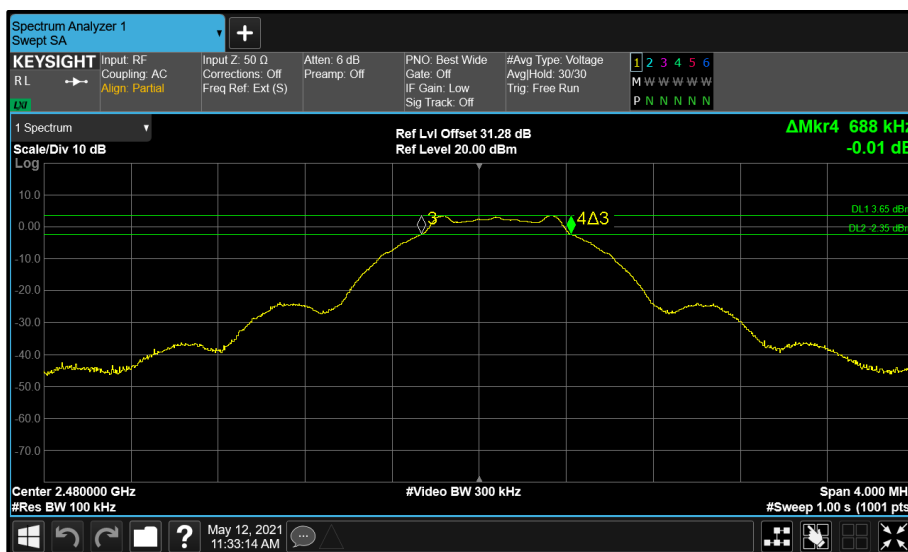


Figure 8 - BLE (A) 2480 MHz (CH39) 6 dB Bandwidth

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2) and ISSED RSS-247, Clause 5.2(a)

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

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	17-May-2021
Multimeter	Iso-tech	IDM101	2421	12	30-Oct-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	17-May-2021
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 11



2.3 Maximum Conducted Output Power

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-03) - Modification State 0

2.3.3 Date of Test

12-May-2021

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 11.9.1.3 (PKPM1).

2.3.5 Environmental Conditions

Ambient Temperature	24.7 °C
Relative Humidity	32.1 %



2.3.6 Test Results

2.4 GHz Bluetooth Low Energy

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(3) RSS-247 5.4 d)	Test Method(s):	C63.10 11.9.1.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	BLE GFSK (LE 1M)	Duty Cycle (%):	100.0
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (BLE)	Peak Antenna Gain (dBi):	2.15

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	Σ		
2402	3.35	-	-	-	-	30.00	-26.65
2442	3.04	-	-	-	-	30.00	-26.96
2480	2.79	-	-	-	-	30.00	-27.21

Table 12 - 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	Σ					
2402	3.35	-	-	-	-	30.00	-26.65	5.50	36.00	-30.50
2442	3.04	-	-	-	-	30.00	-26.96	5.19	36.00	-30.81
2480	2.79	-	-	-	-	30.00	-27.21	4.94	36.00	-31.06

Table 13 - 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 (d)

For DTSSs 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.



2.3.7 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
Multimeter	Iso-tech	IDM101	2421	12	30-Oct-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
USB Power Sensor	Boonton	RTP5006	5184	12	19-Apr-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	16-Apr-2022

Table 14



2.4 Spurious Radiated Emissions

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205
ISED RSS-247, Clause 3.3 and 5.5
ISED RSS-GEN, Clause 6.13

2.4.2 Equipment Under Test and Modification State

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-06) - Modification State 0

2.4.3 Date of Test

18-May-2021 to 20-May-2021

2.4.4 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. For an EUT which could reasonably 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 characterization 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:
 $10^{(\text{Field Strength in dB}\mu\text{V/m}/20)}$

To determine the emission characteristic of the EUT above 18 GHz, the test antenna distance was reduced to 1 meter and the limit line was increased by $20 \cdot \text{LOG}(3/1) = 9.54 \text{ dB}$.

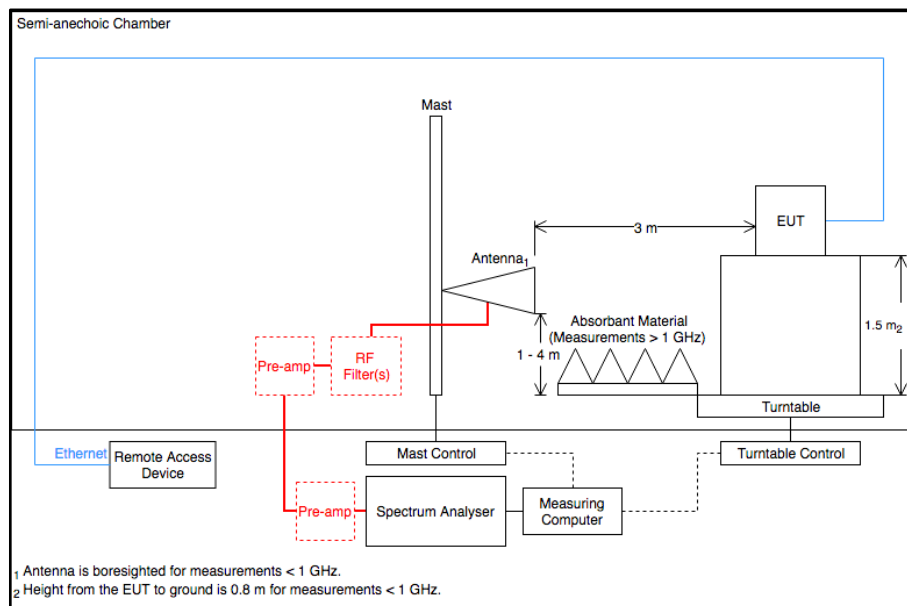


Figure 9 - Test Setup Diagram

2.4.5 Environmental Conditions

Ambient Temperature	21.8 - 22.3 °C
Relative Humidity	37.8 - 46.1 %



2.4.6 Test Results

2.4 GHz Bluetooth Low Energy

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

Table 15 – 2402 MHz, 30 MHz to 1 GHz

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

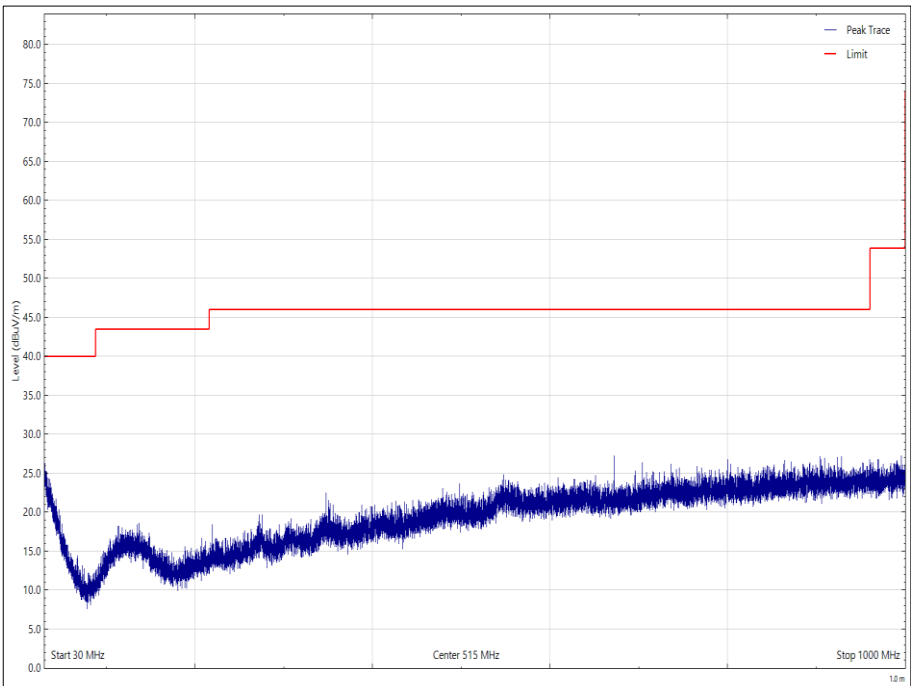


Figure 10 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

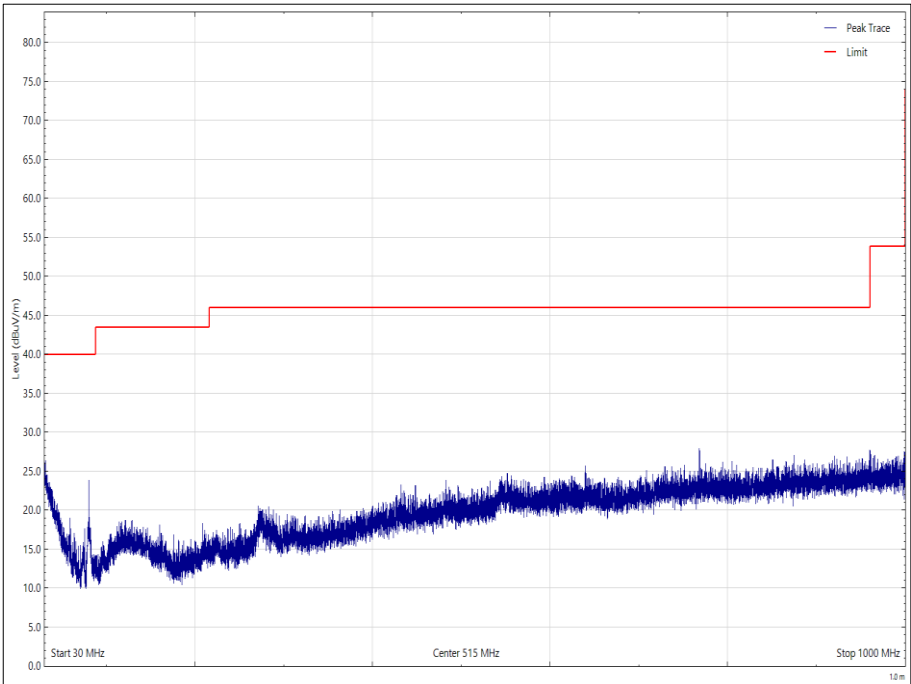


Figure 11 - 2402 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

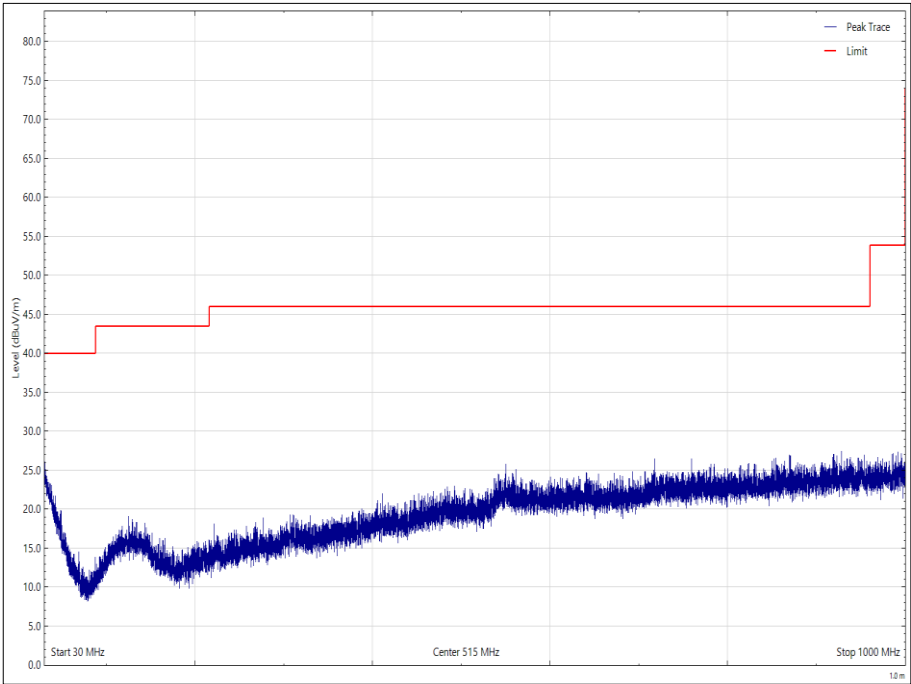


Figure 12 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

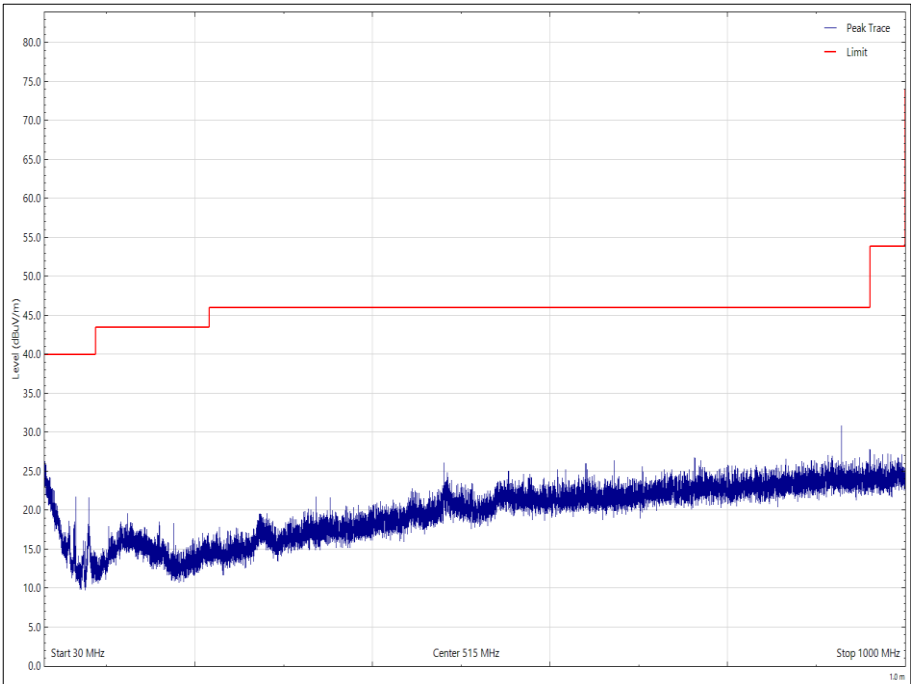


Figure 13 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

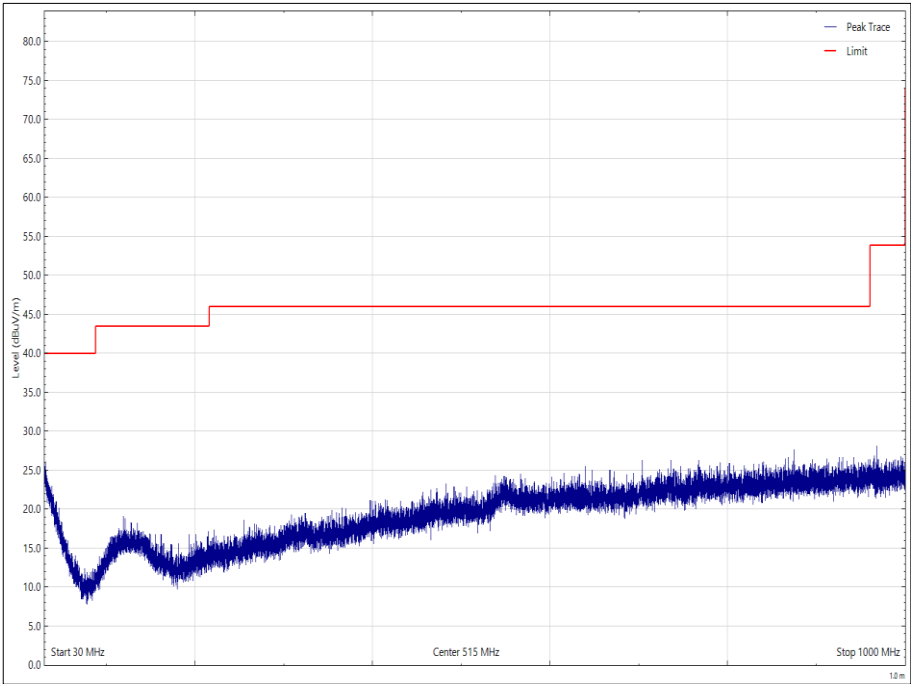


Figure 14 - 2402 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

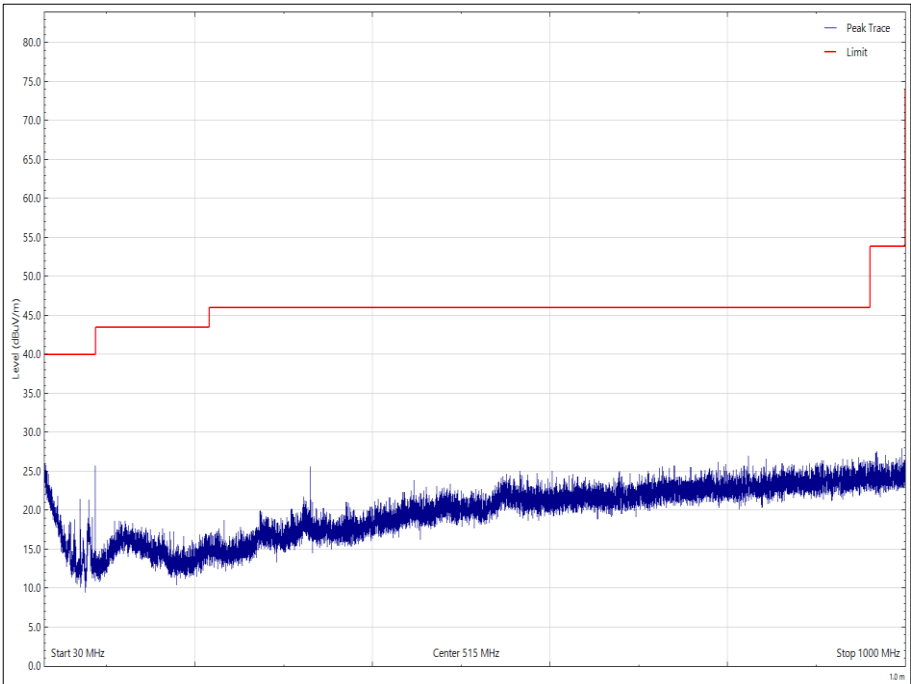


Figure 15 - 2402 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation



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

Table 16 - 2402 MHz - 1 GHz to 25 GHz

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

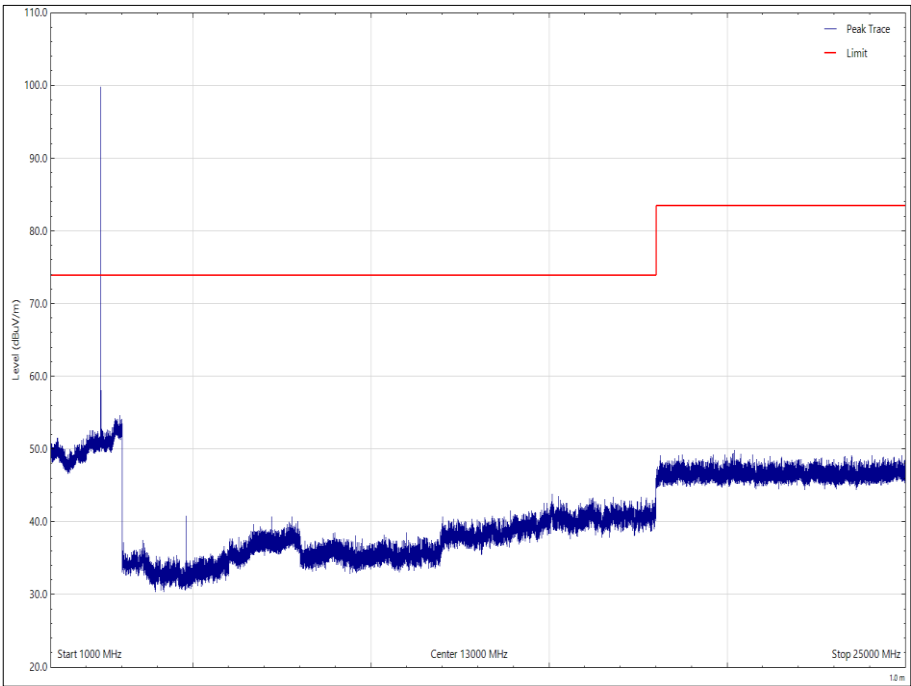


Figure 16 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Peak

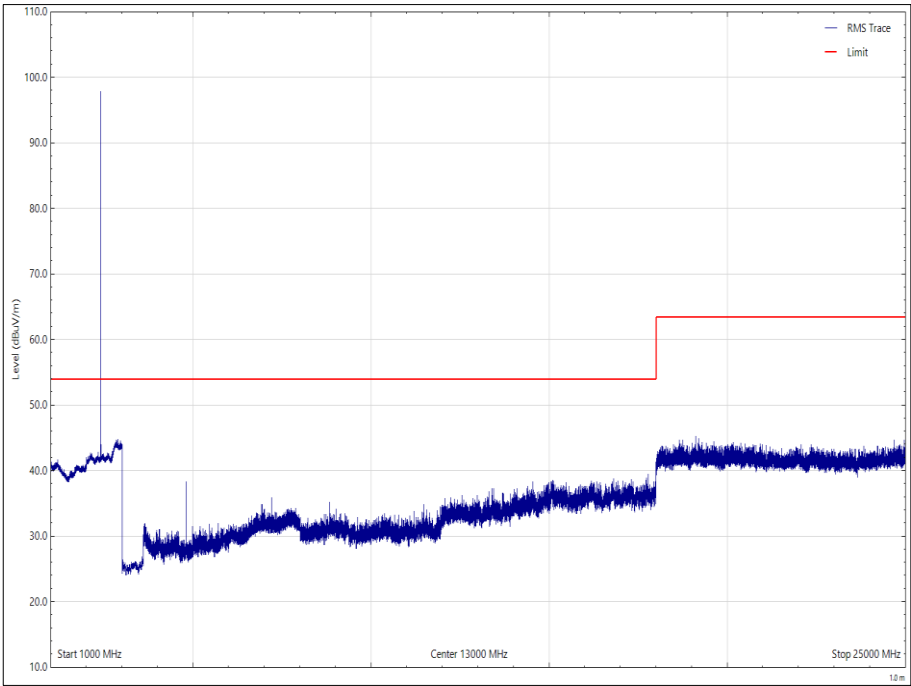


Figure 17 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Average

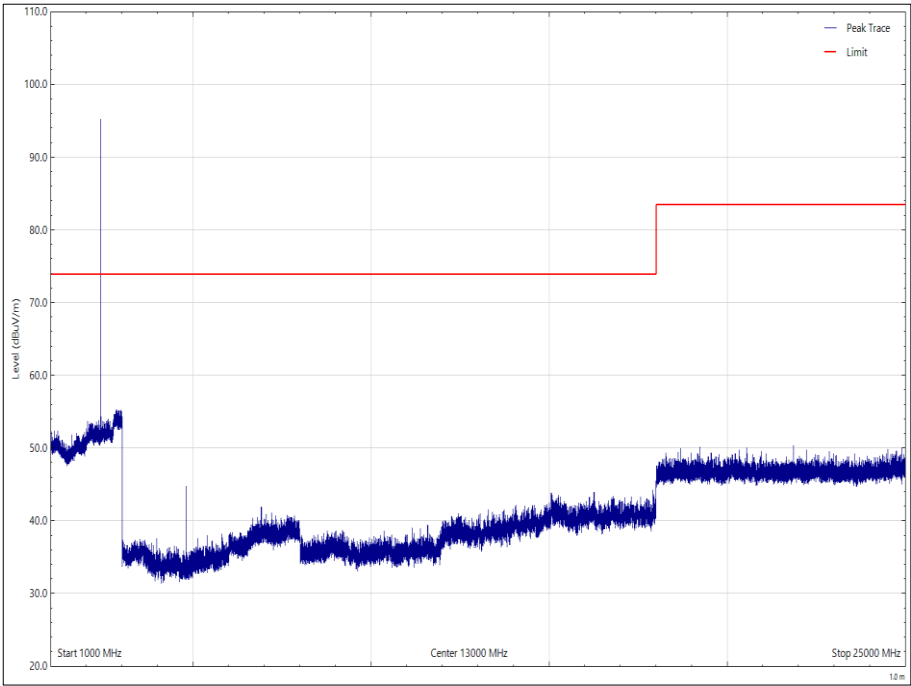


Figure 18 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Peak

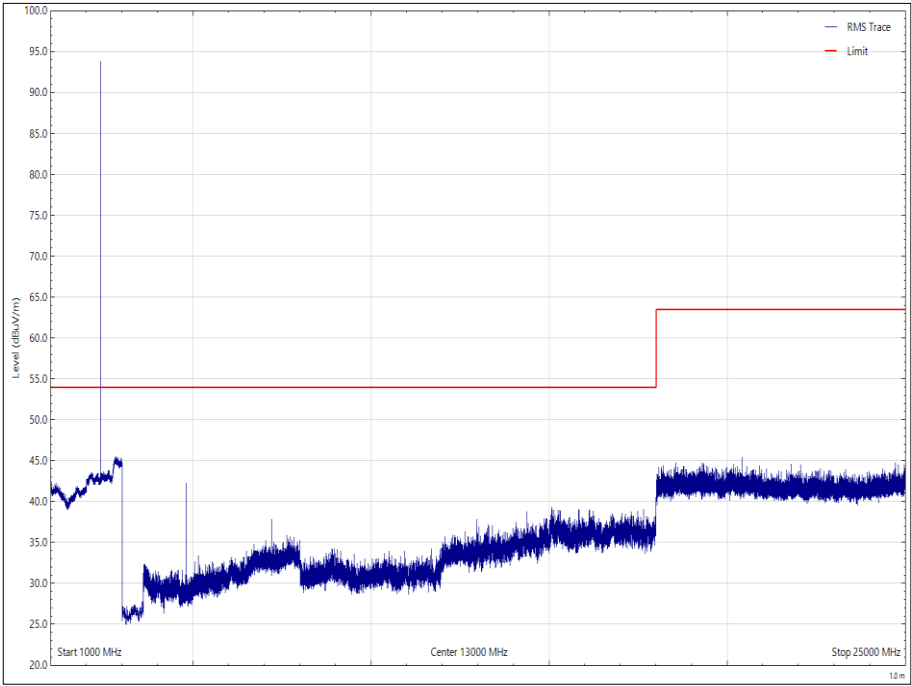


Figure 19 - 2402 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Average

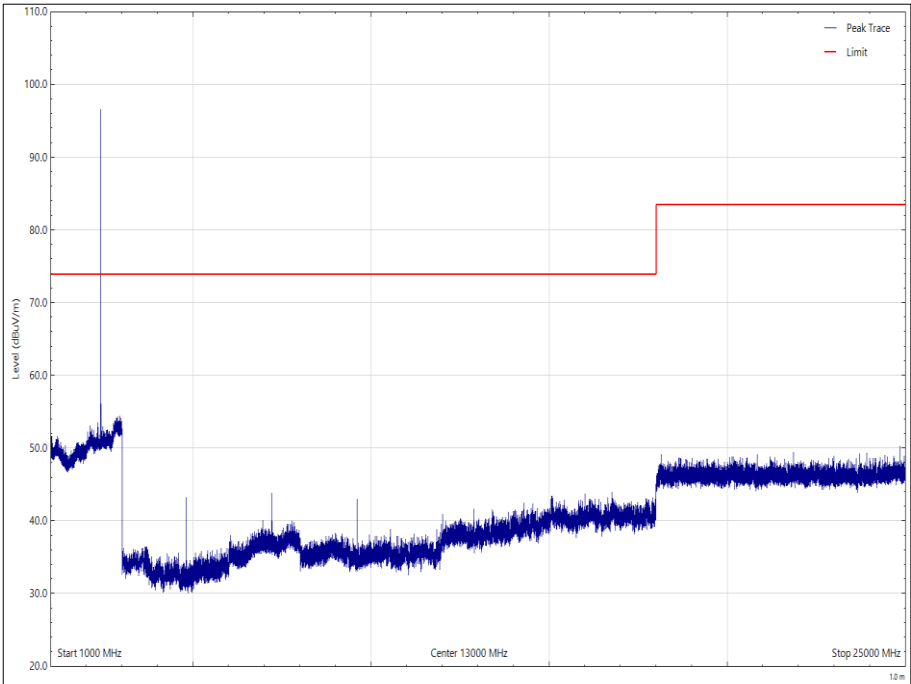


Figure 20 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Peak

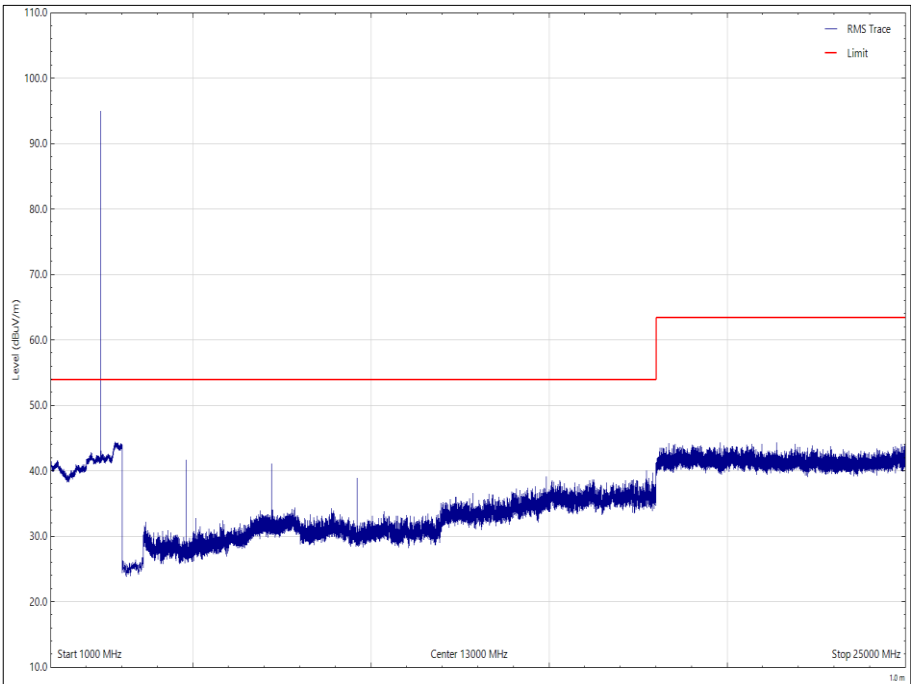


Figure 21 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Average

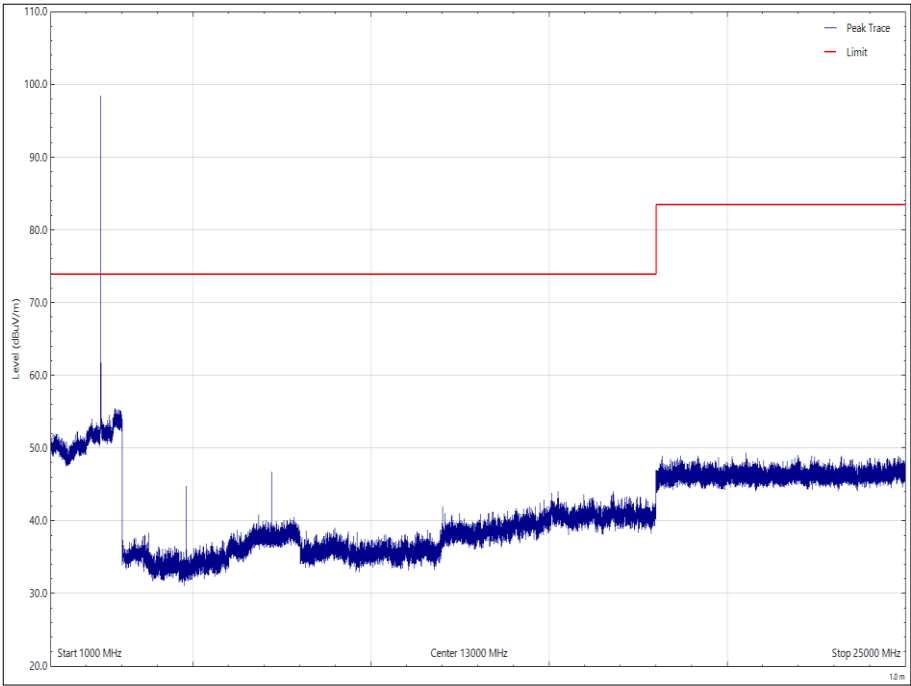


Figure 22 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Peak

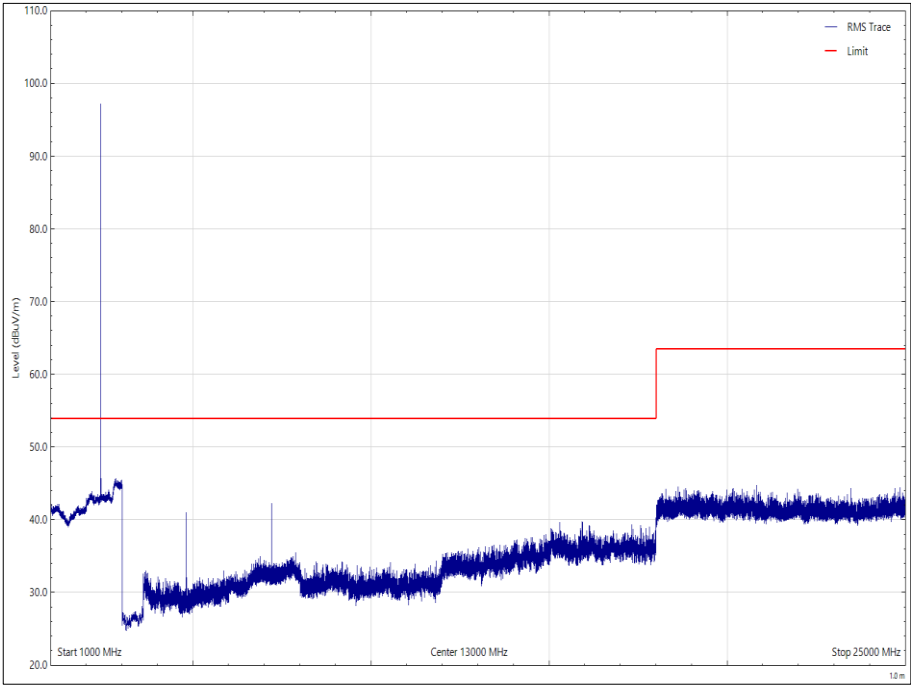


Figure 23 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Average

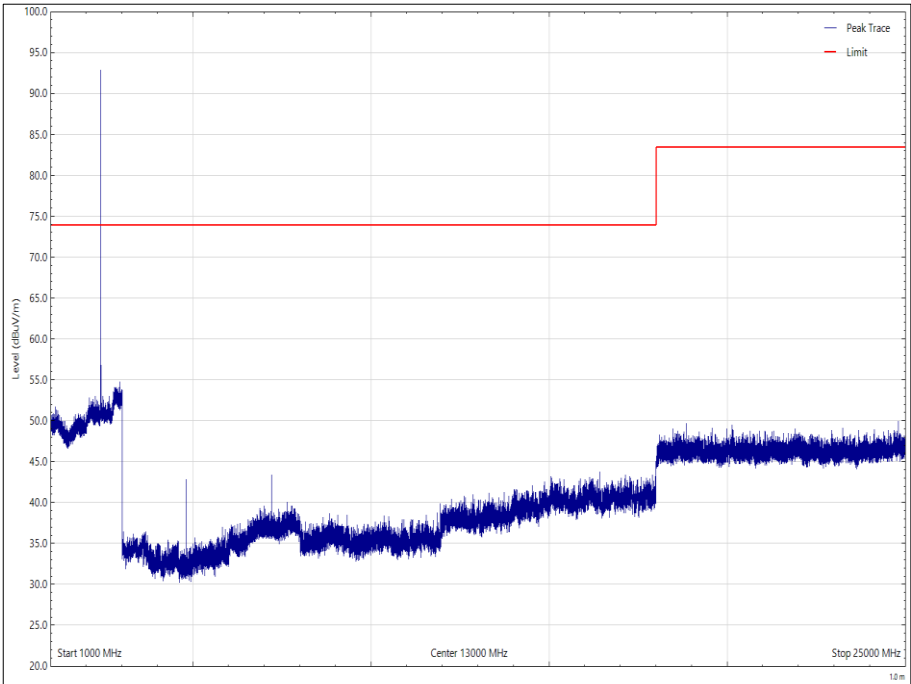


Figure 24 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Peak

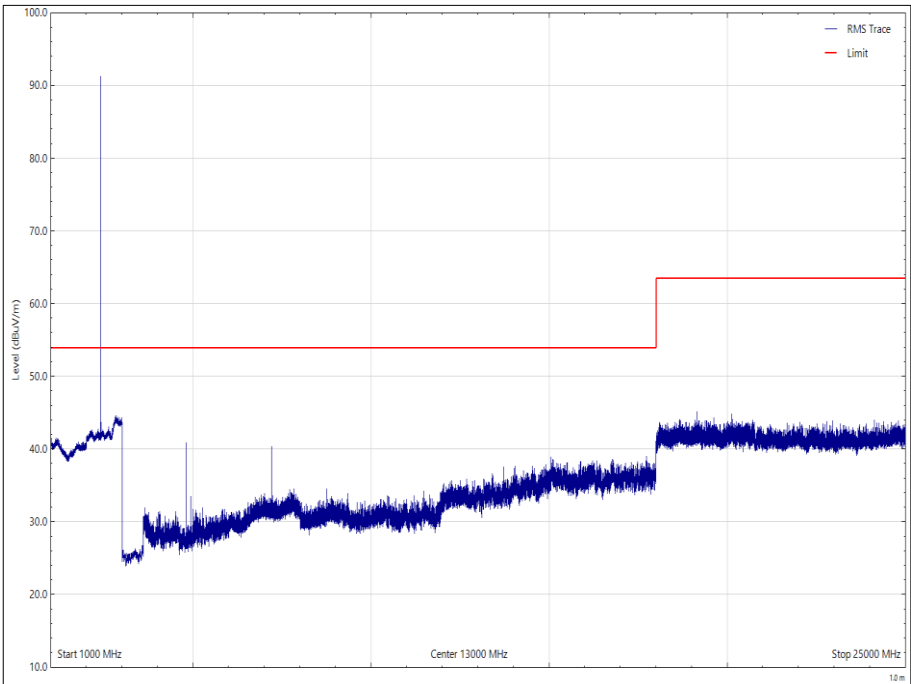


Figure 25 - 2402 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Average

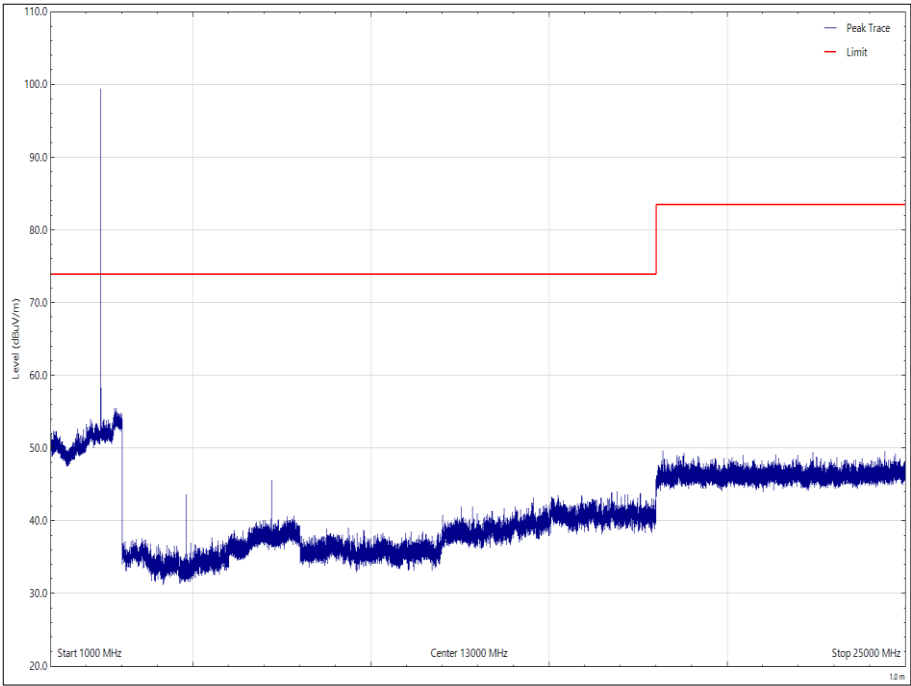


Figure 26 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Peak

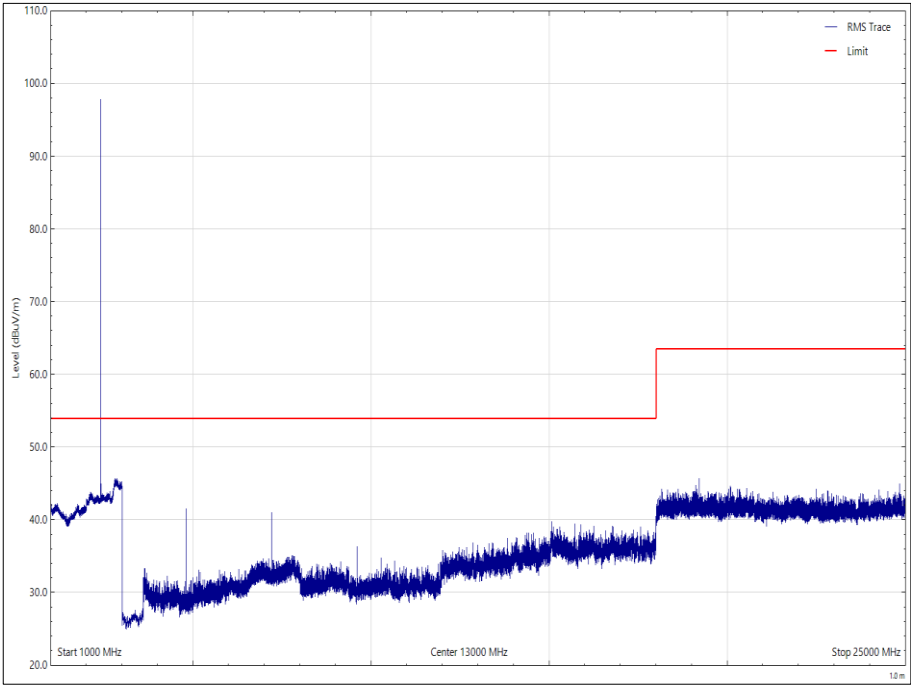


Figure 27 - 2402 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Average

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

Table 17 - 2442 MHz, 30 MHz to 1 GHz

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

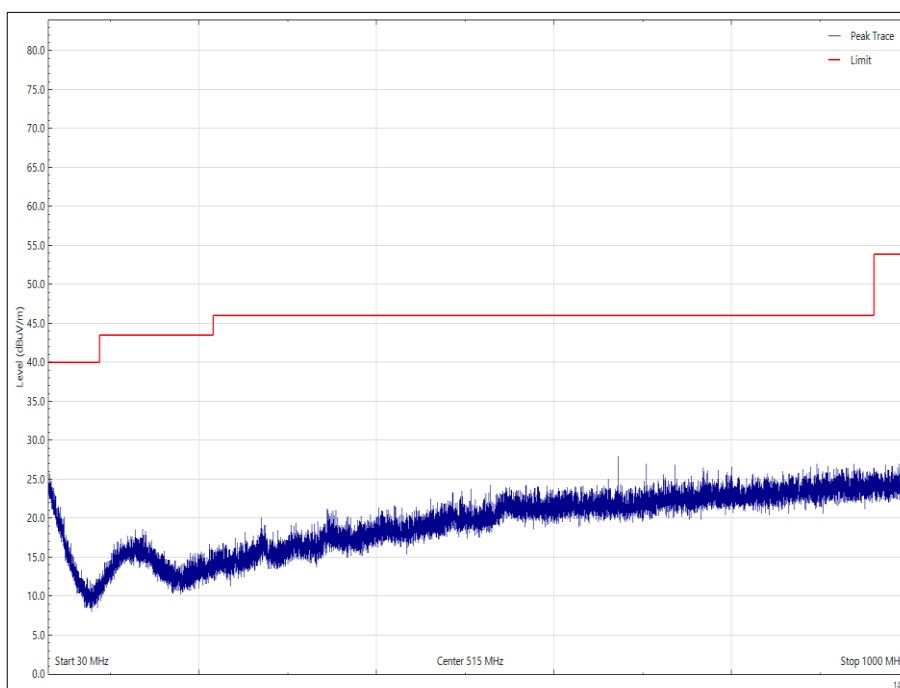


Figure 28 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, X Orientation

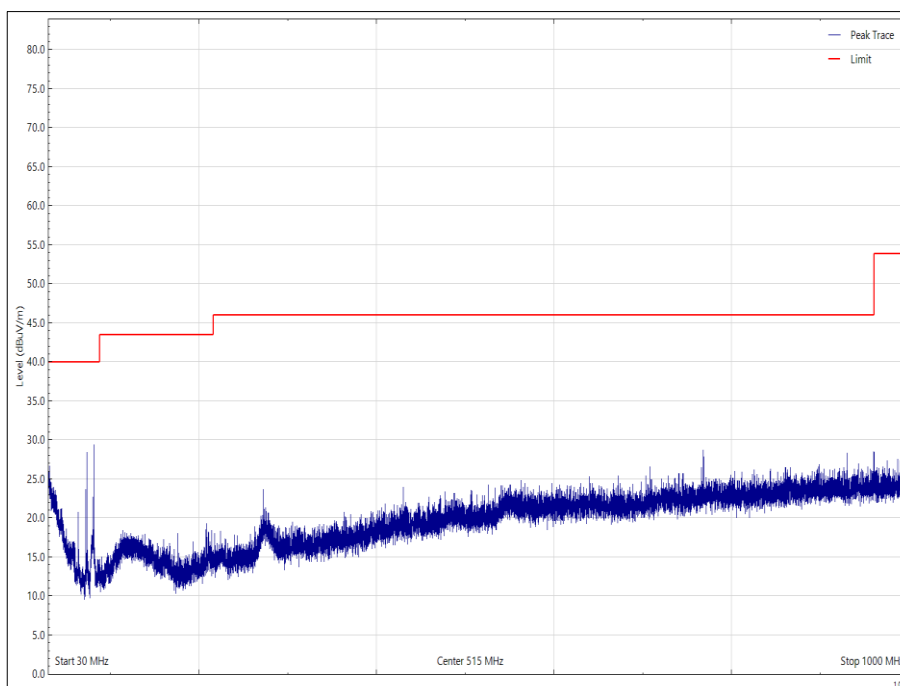


Figure 29 - 2442 MHz, 30 MHz to 1 GHz, Vertical, X Orientation

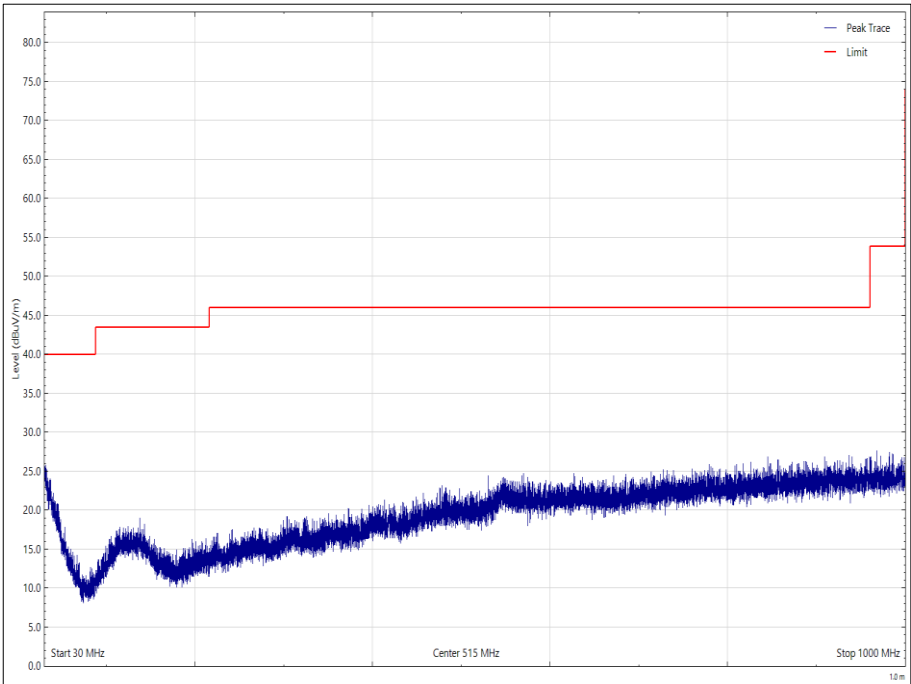


Figure 30 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, Y Orientation

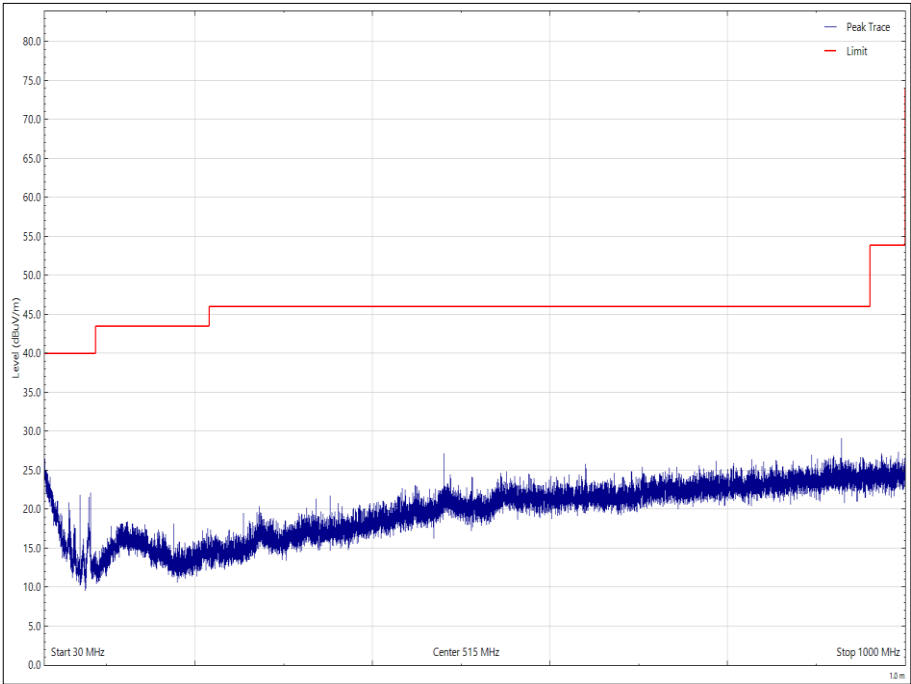


Figure 31 - 2442 MHz, 30 MHz to 1 GHz, Vertical, Y Orientation

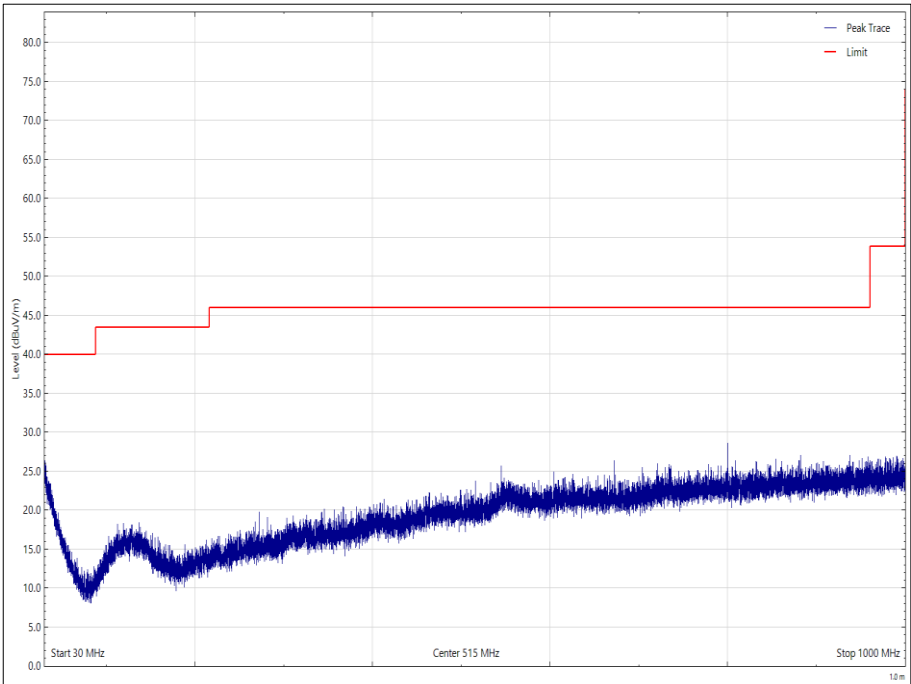


Figure 32 - 2442 MHz, 30 MHz to 1 GHz, Horizontal, Z Orientation

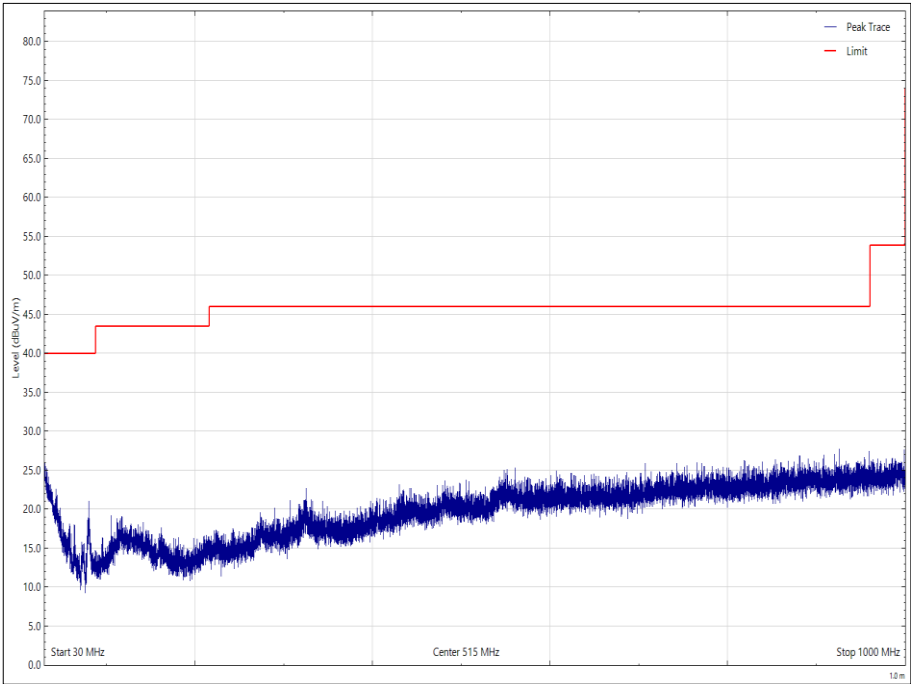


Figure 33 - 2442 MHz, 30 MHz to 1 GHz, Vertical, Z Orientation

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4884.093	45.80	53.98	-8.18	RMS	338	100	Vertical	X
4884.996	43.63	53.98	-10.35	RMS	359	100	Horizontal	Y
4884.082	43.37	53.98	-10.61	RMS	337	131	Vertical	Z
4884.151	44.58	53.98	-9.40	RMS	46	141	Horizontal	Z

Table 18 - 2442 MHz, 1 GHz to 25 GHz

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

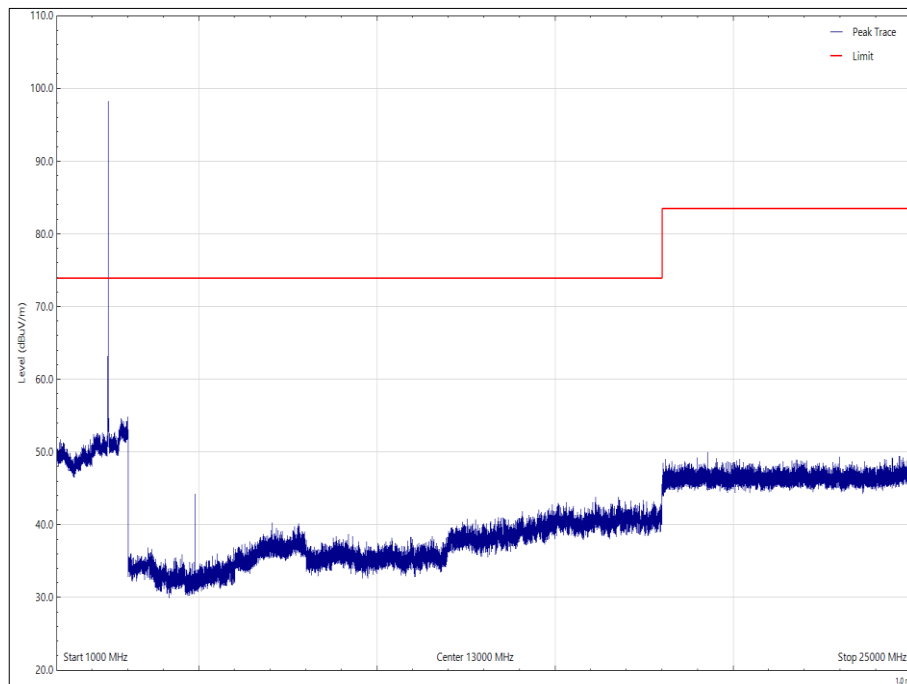


Figure 34 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Peak

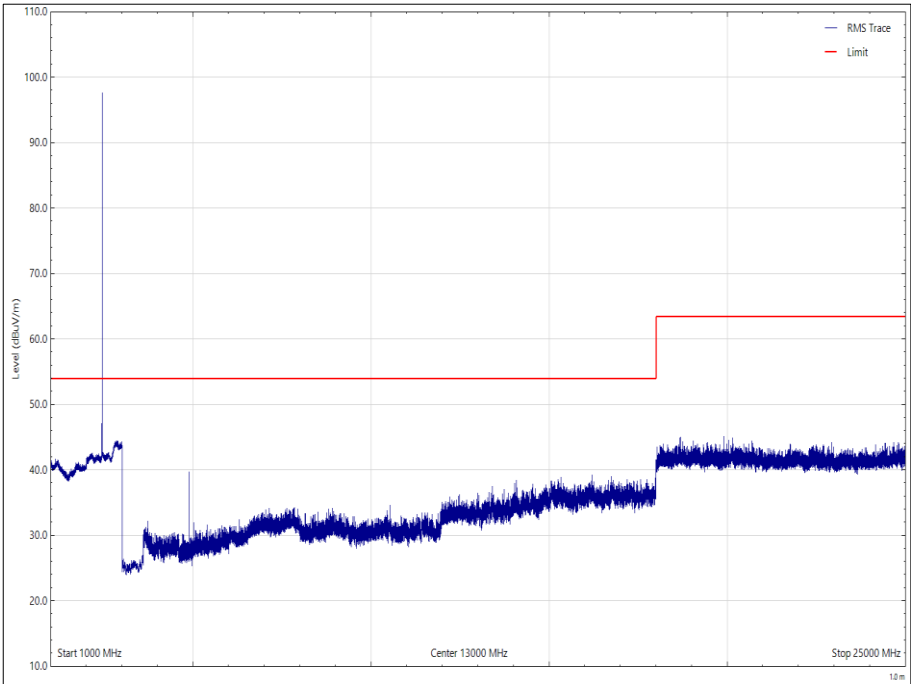


Figure 35 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Average

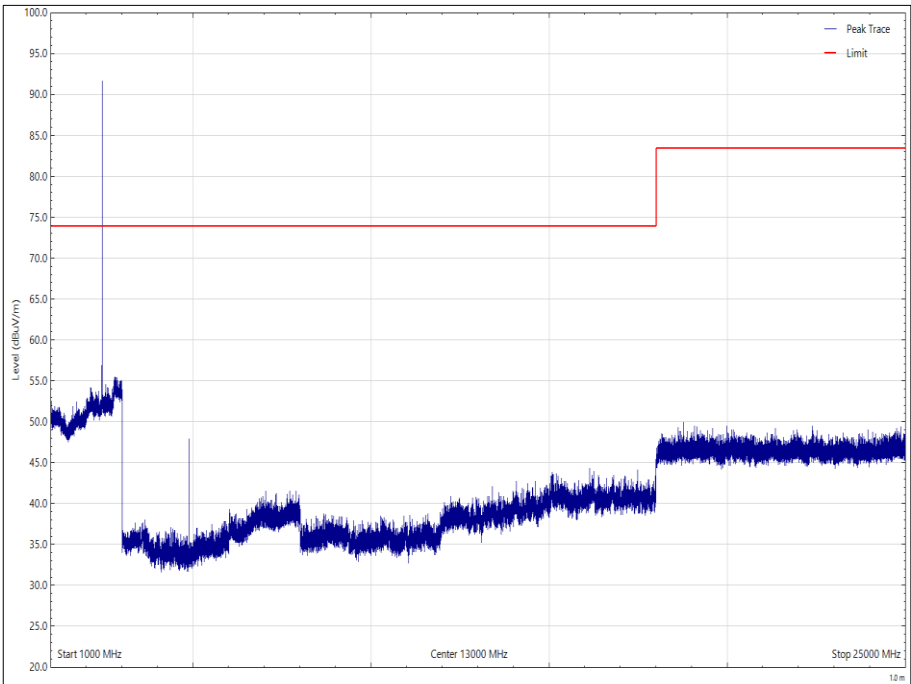


Figure 36 - 2442 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Peak

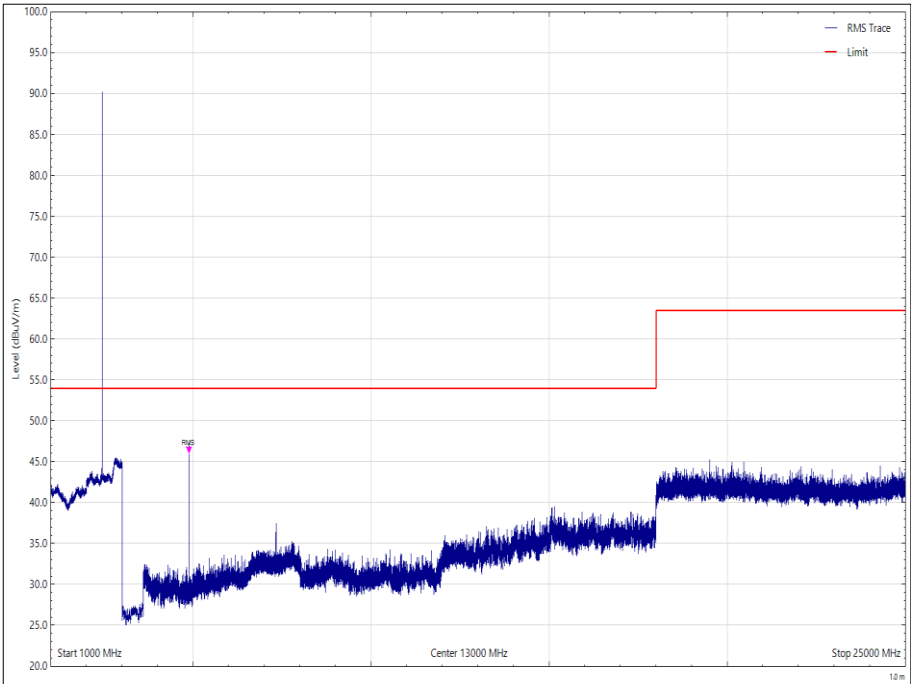


Figure 37 - 2442 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Average

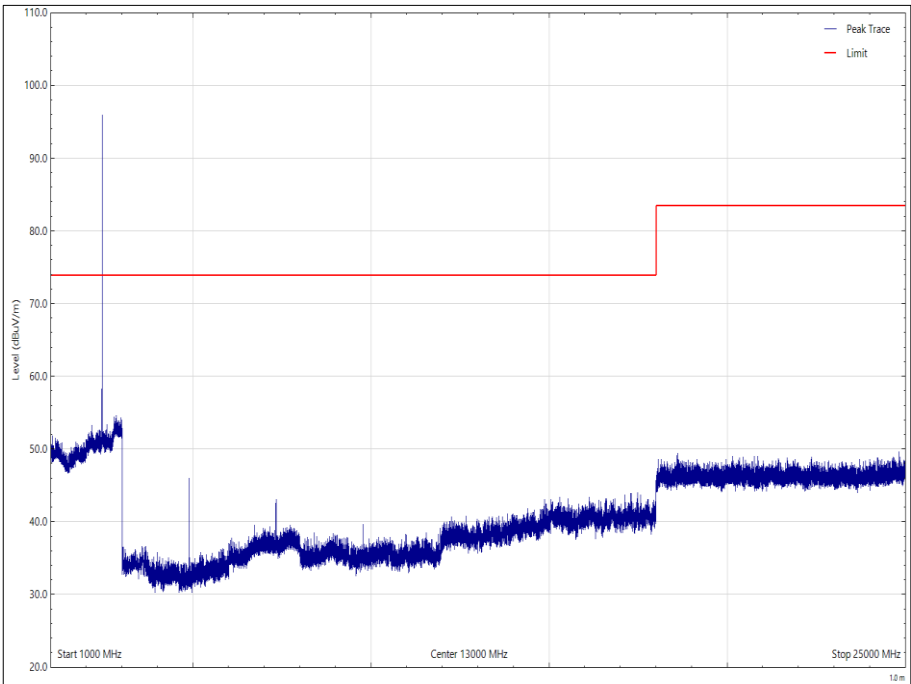


Figure 38 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Peak

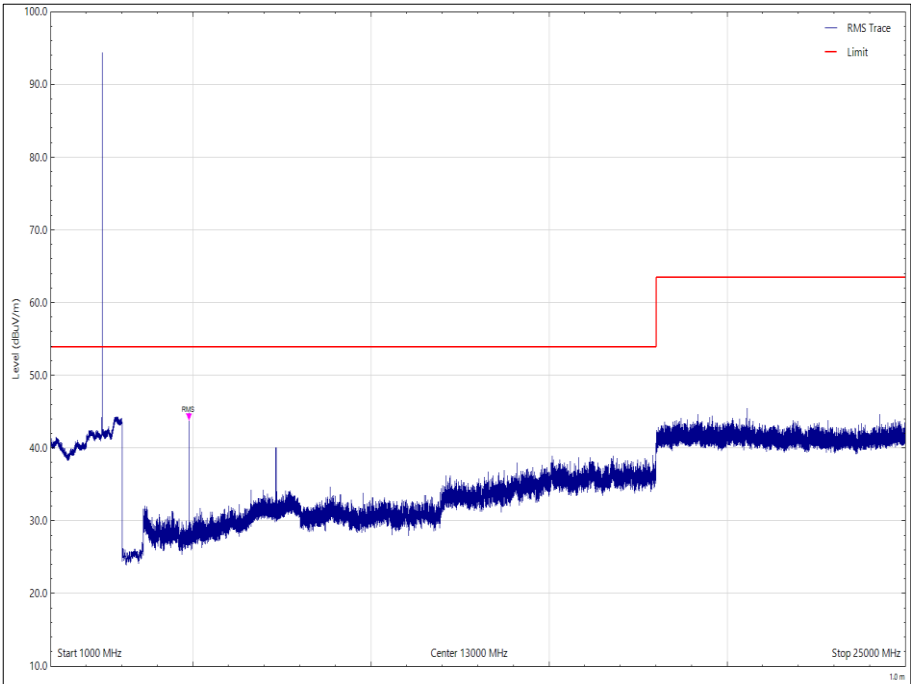


Figure 39 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Average

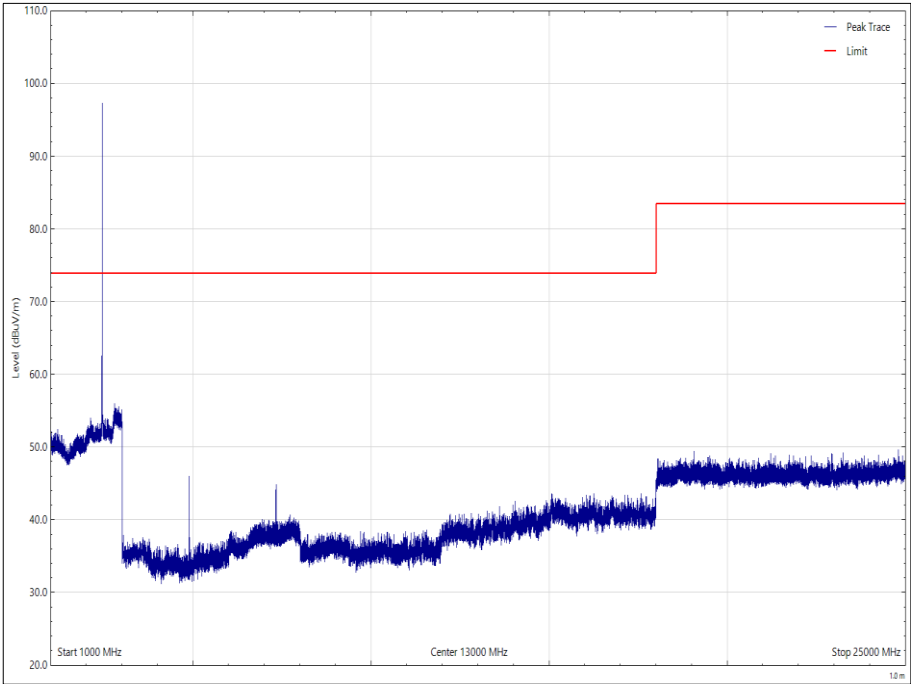


Figure 40 - 2442 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Peak

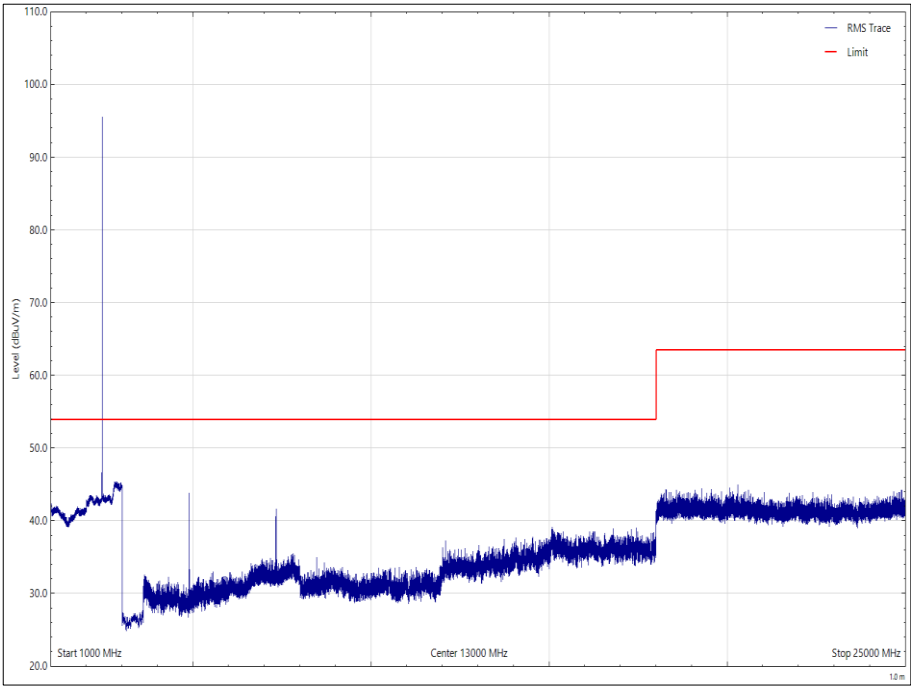


Figure 41 - 2442 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Average

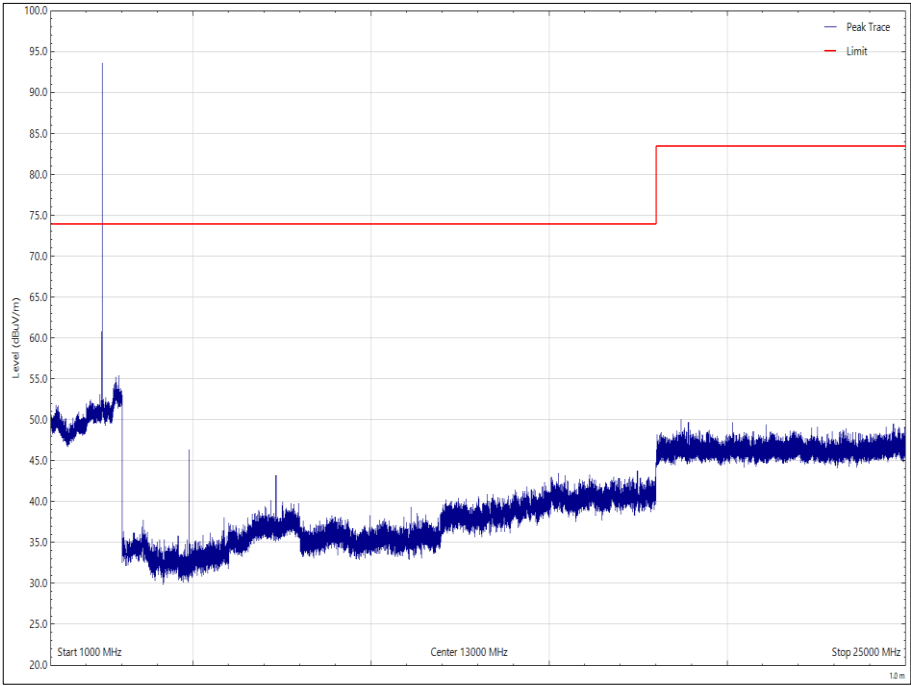


Figure 42 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Peak

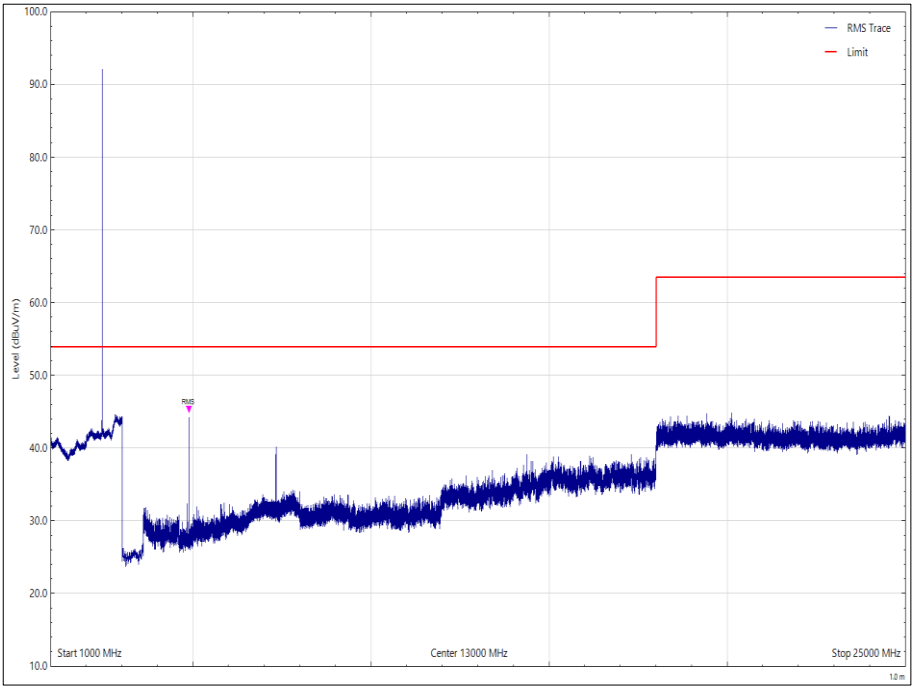


Figure 43 - 2442 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Average

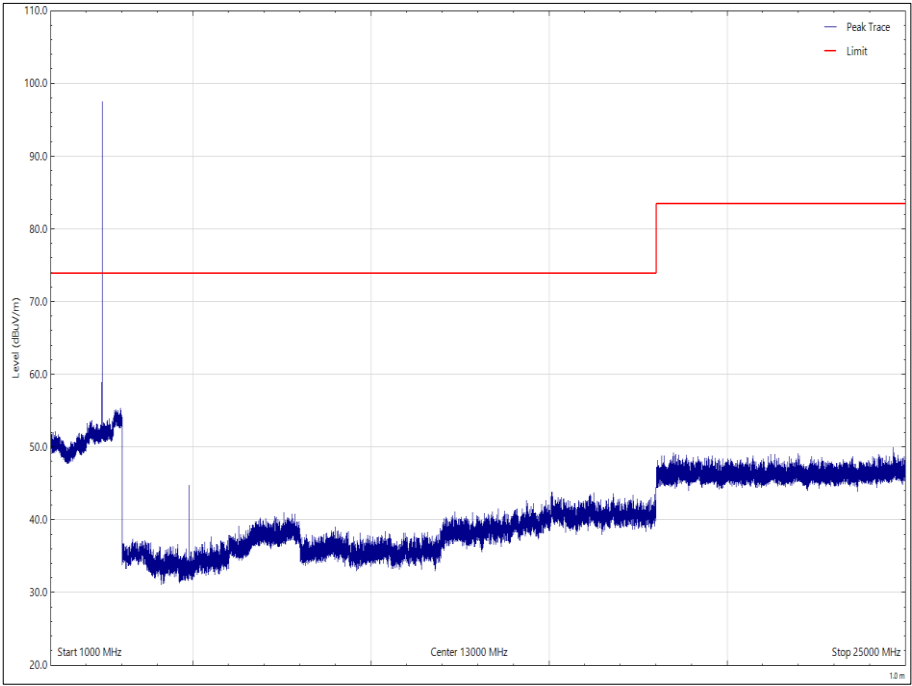


Figure 44 - 2442 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Peak

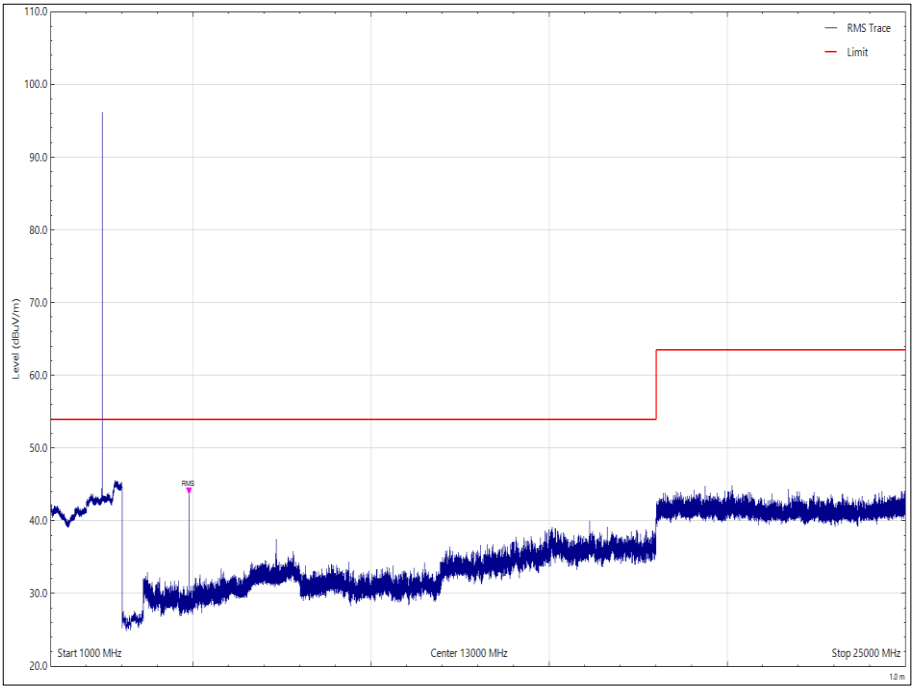


Figure 45 - 2442 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Average



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

Table 19 - 2480 MHz, 30 MHz to 1 GHz,

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

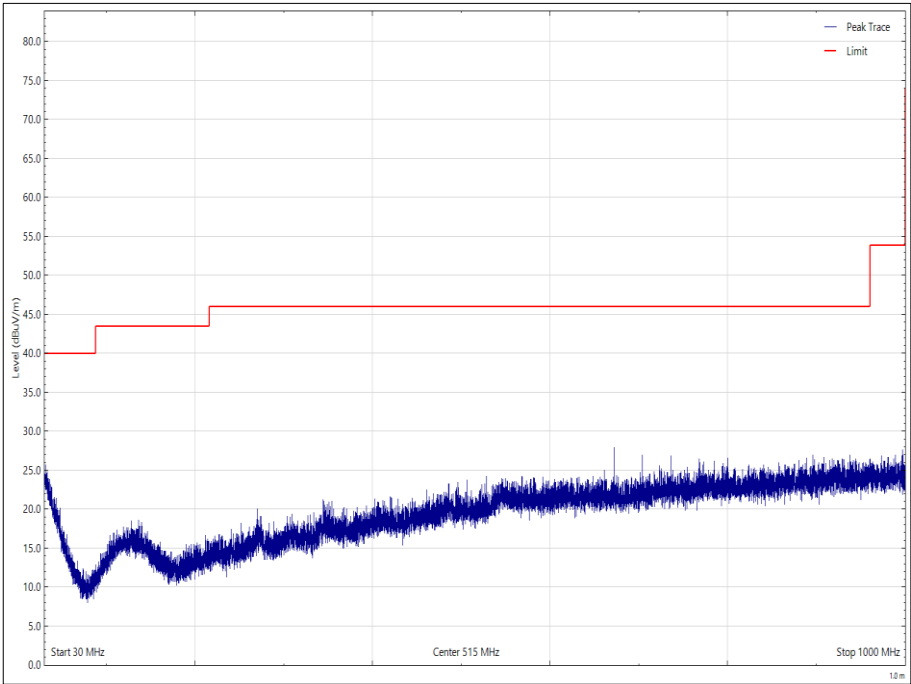


Figure 46 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, EUT Orientation X

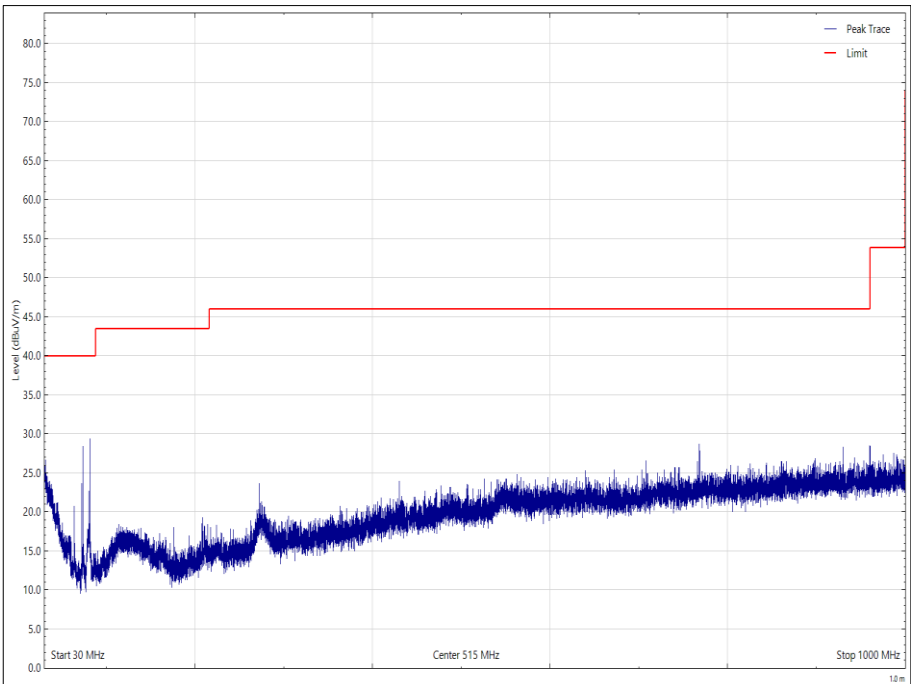


Figure 47 - 2480 MHz, 30 MHz to 1 GHz, Vertical, EUT Orientation X

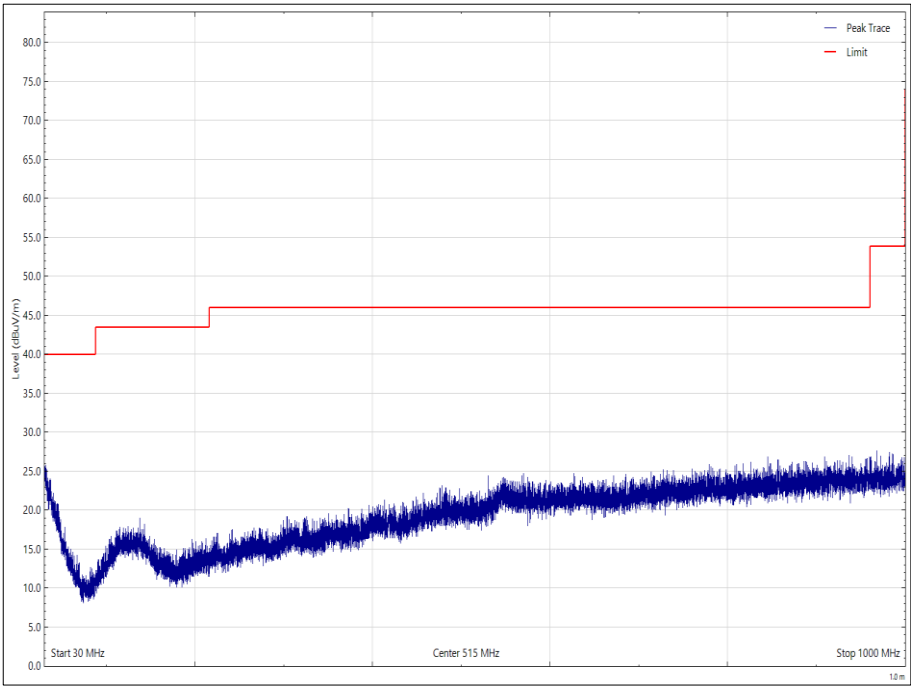


Figure 48 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, EUT Orientation Y

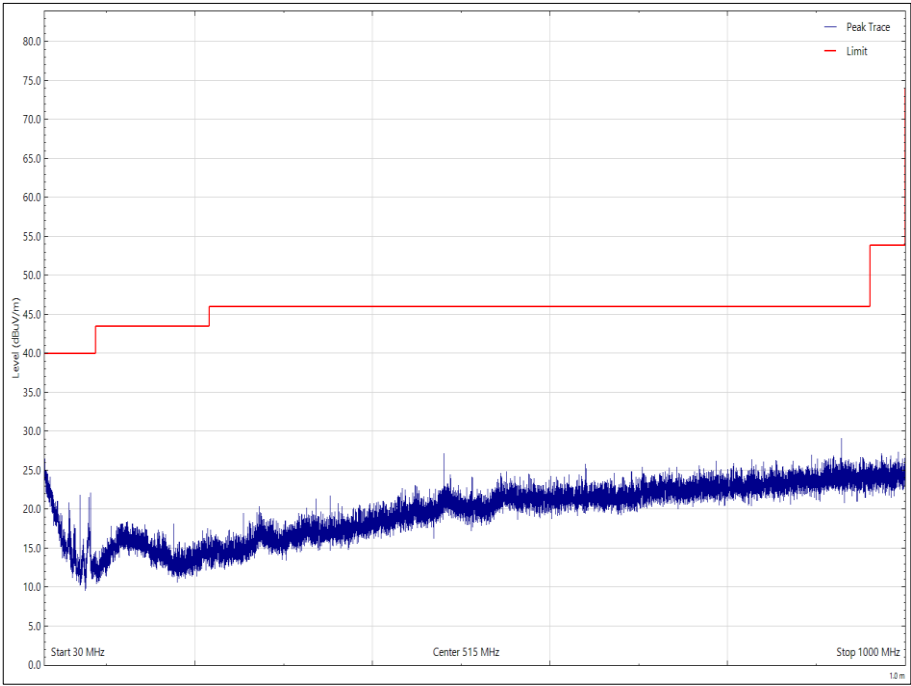


Figure 49 - 2480 MHz, 30 MHz to 1 GHz, Vertical, EUT Orientation Y

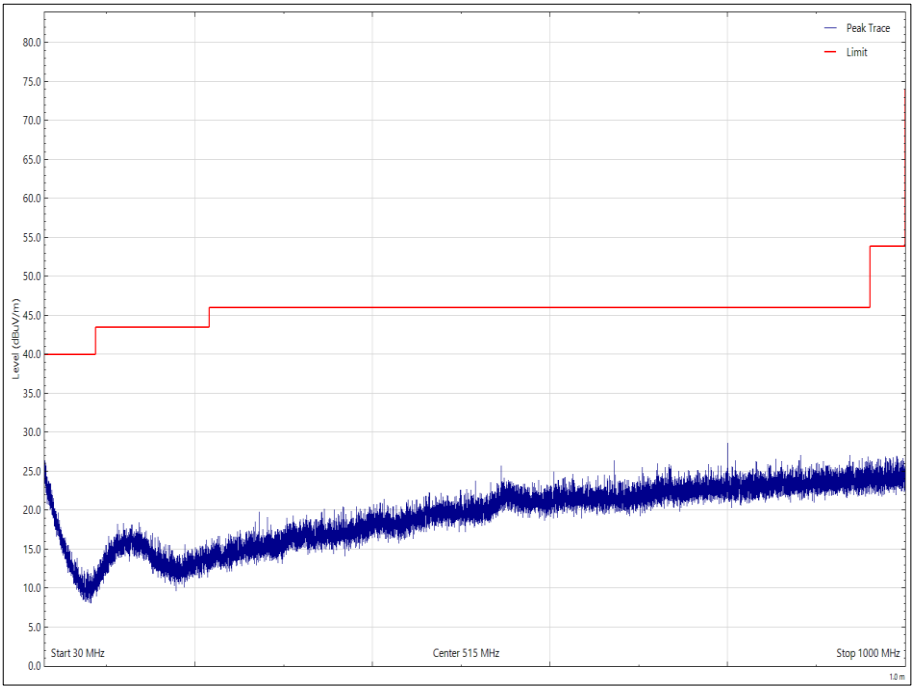


Figure 50 - 2480 MHz, 30 MHz to 1 GHz, Horizontal, EUT Orientation Z

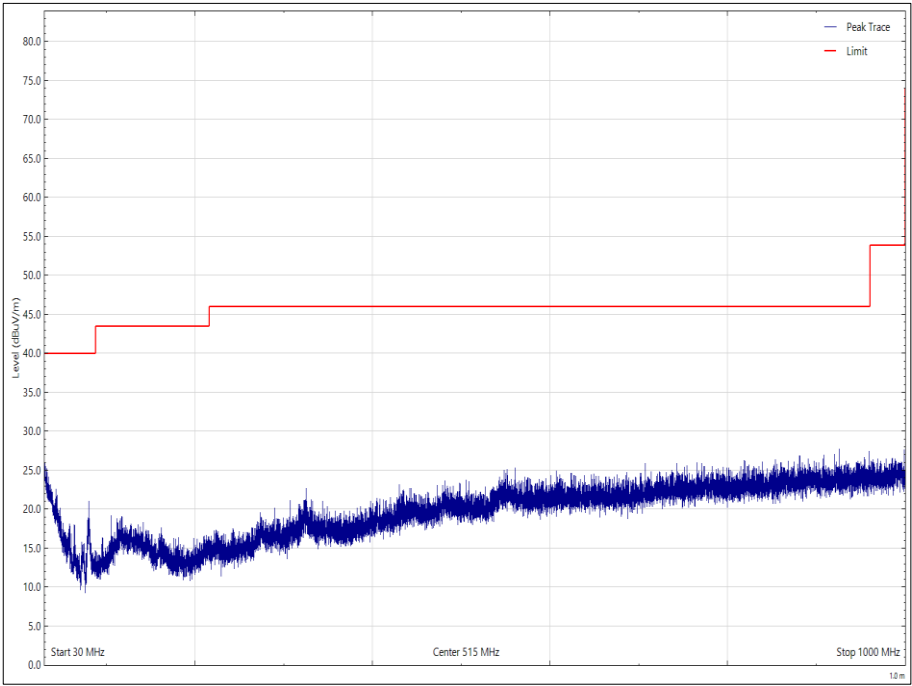


Figure 51 - 2480 MHz, 30 MHz to 1 GHz, Vertical, EUT Orientation Z



Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4959.996	43.63	53.98	-10.35	RMS	337	100	Verical	X
4959.955	45.57	53.98	-8.41	RMS	45	143	Horizontal	Z

Table 20 - 2480 MHz - 1 GHz to Emissions Results

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

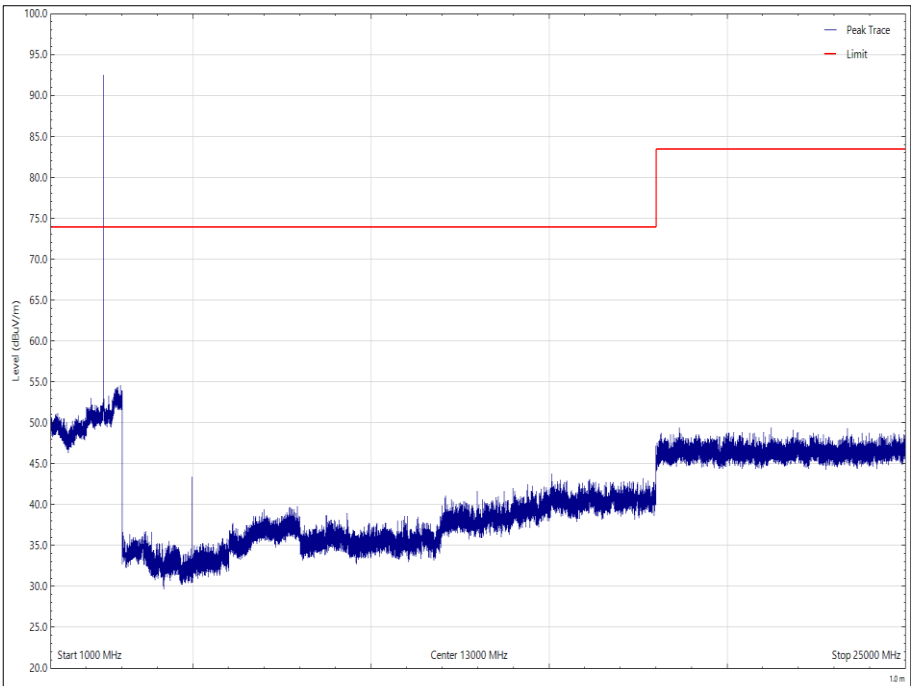


Figure 52 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Peak

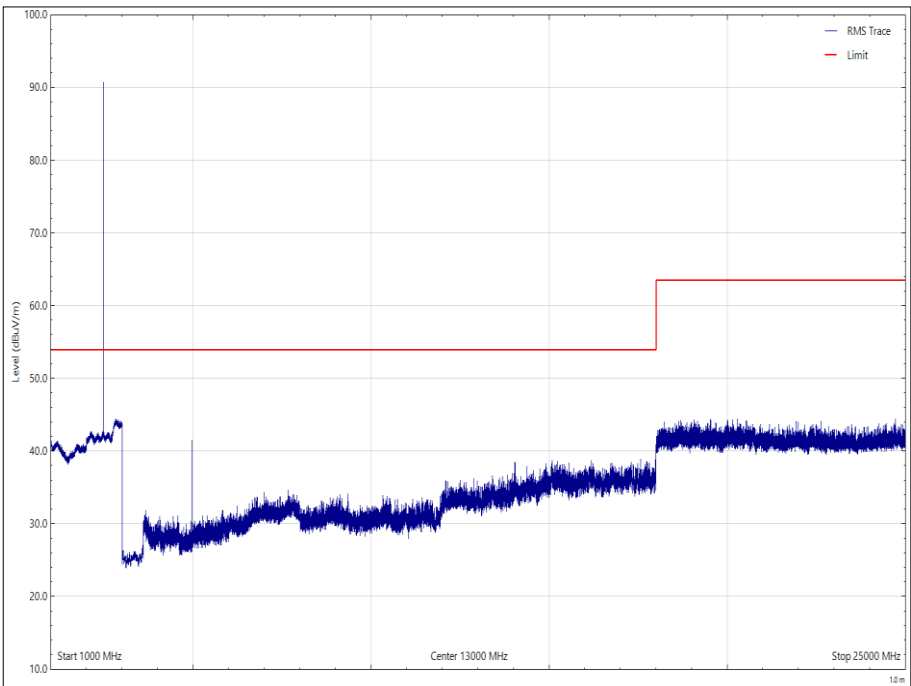


Figure 53 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, X Orientation, Average

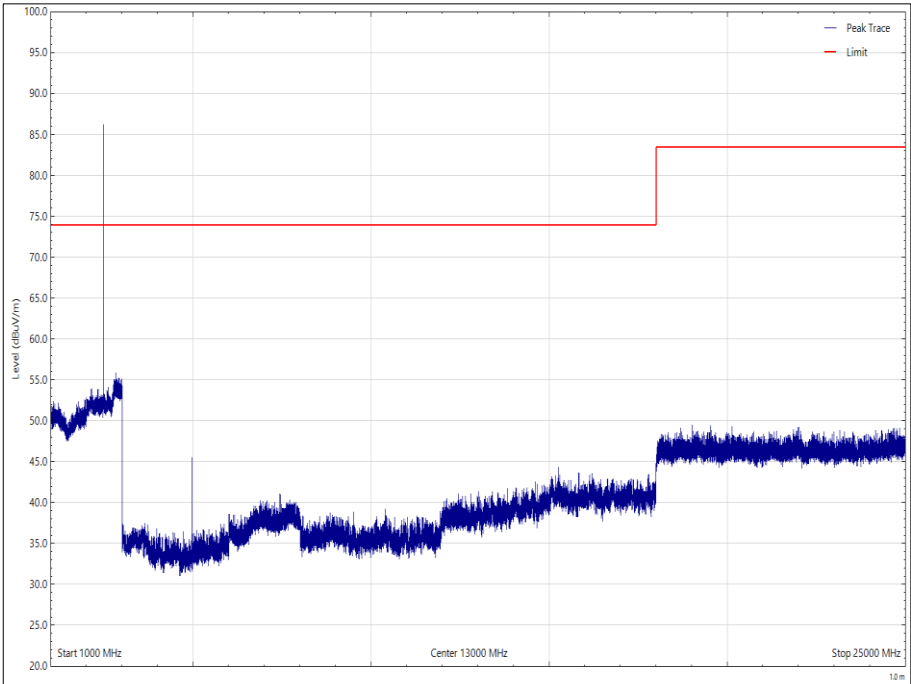


Figure 54 - 2480 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Peak

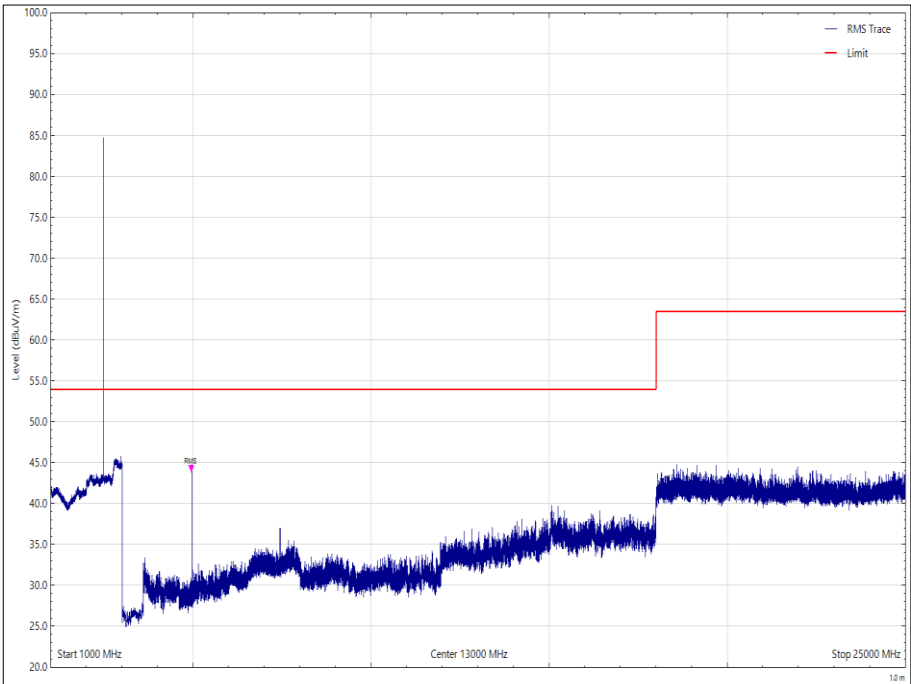


Figure 55 - 2480 MHz, 1 GHz to 25 GHz, Vertical, X Orientation, Average

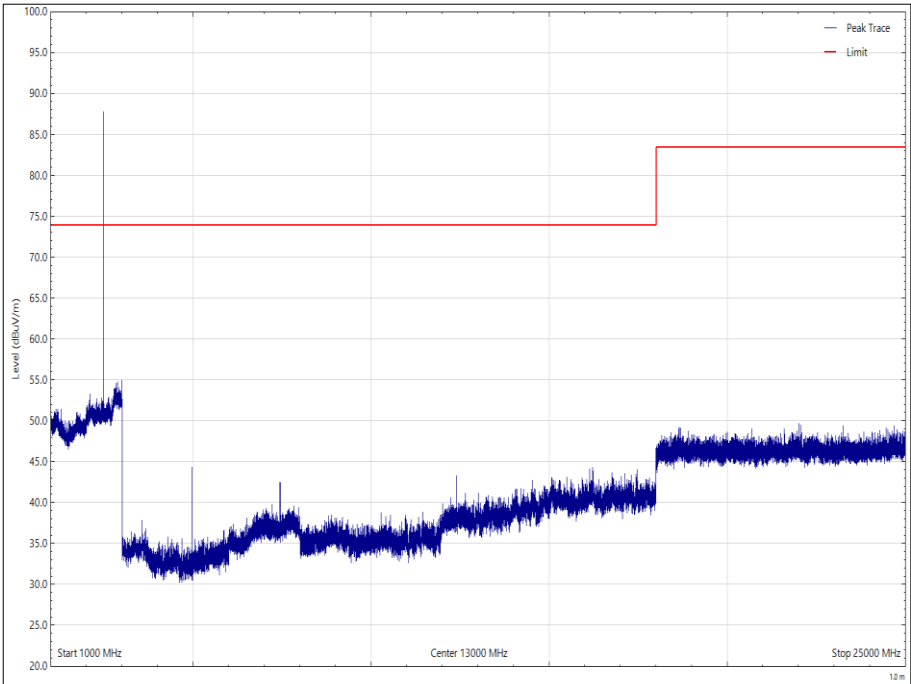


Figure 56 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Peak

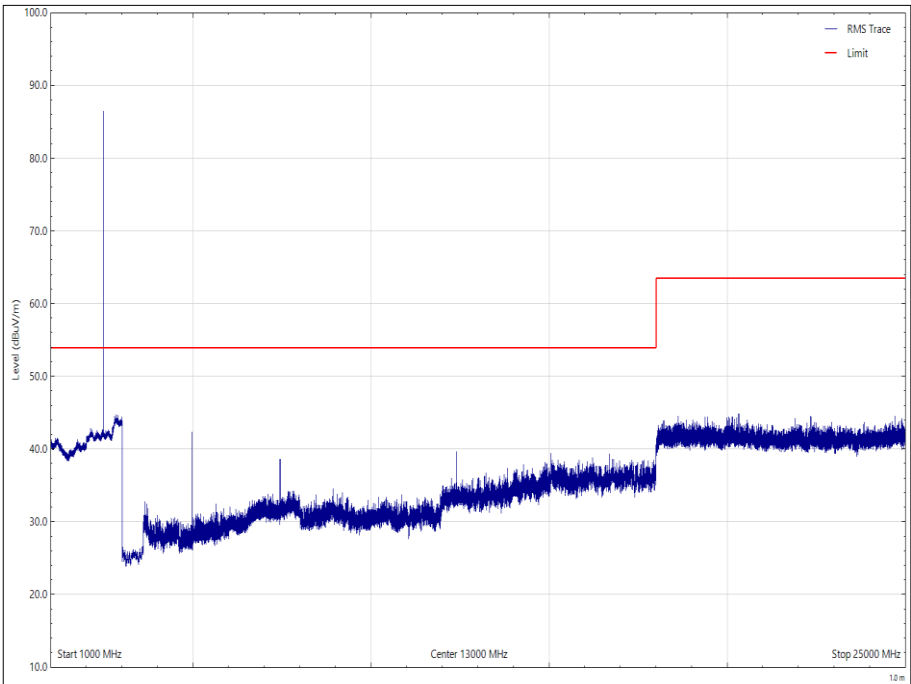


Figure 57 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, Y Orientation, Average

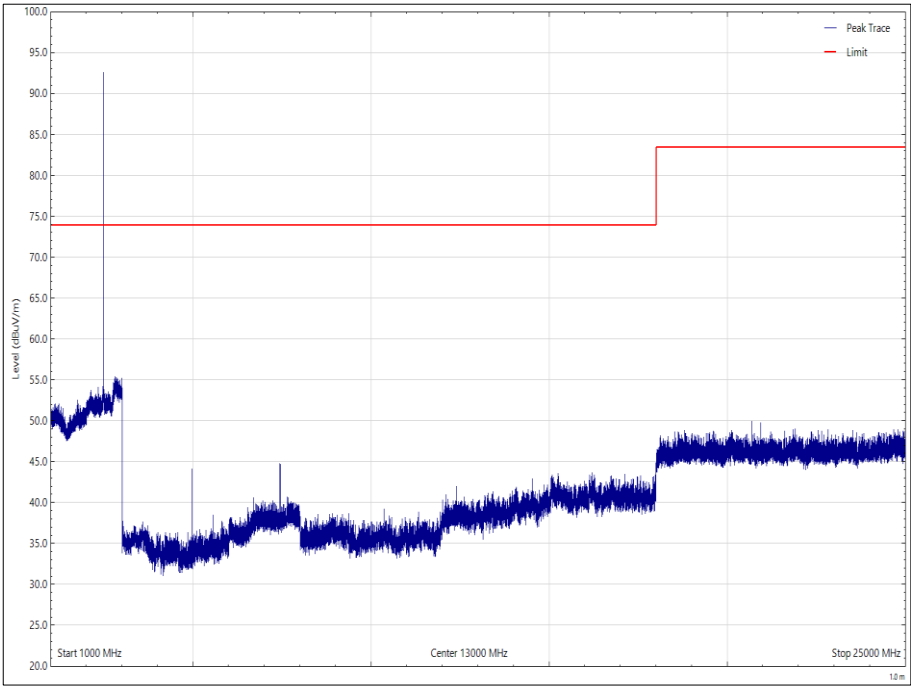


Figure 58 - 2480 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Peak

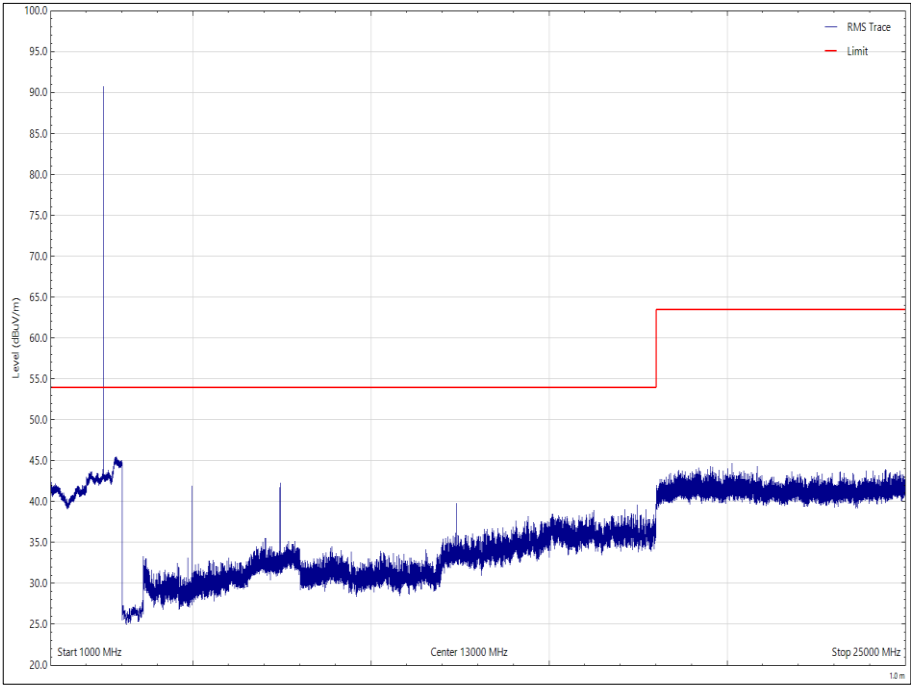


Figure 59 - 2480 MHz, 1 GHz to 25 GHz, Vertical, Y Orientation, Average

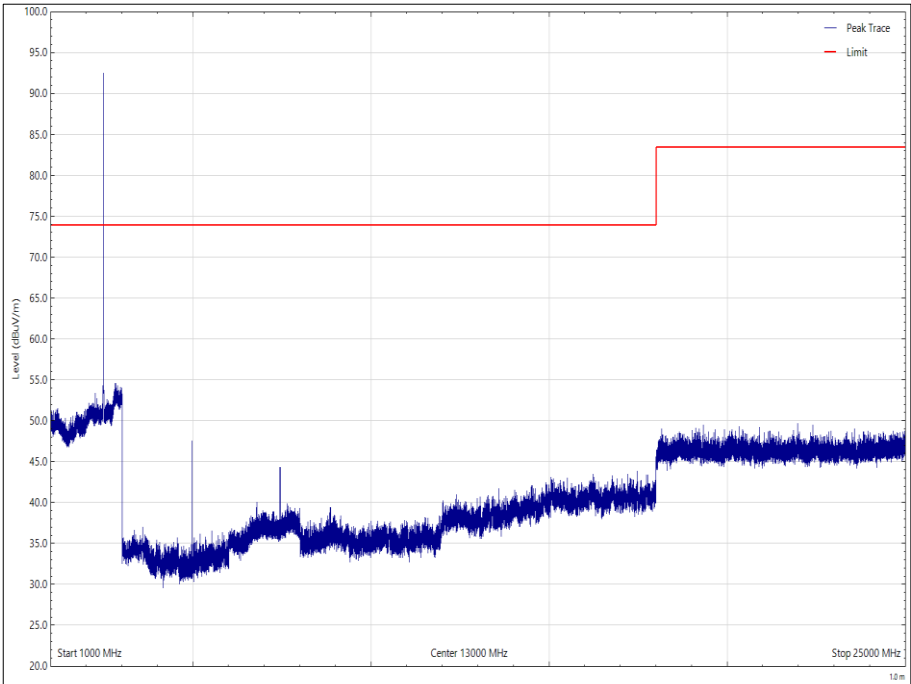


Figure 60 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Peak

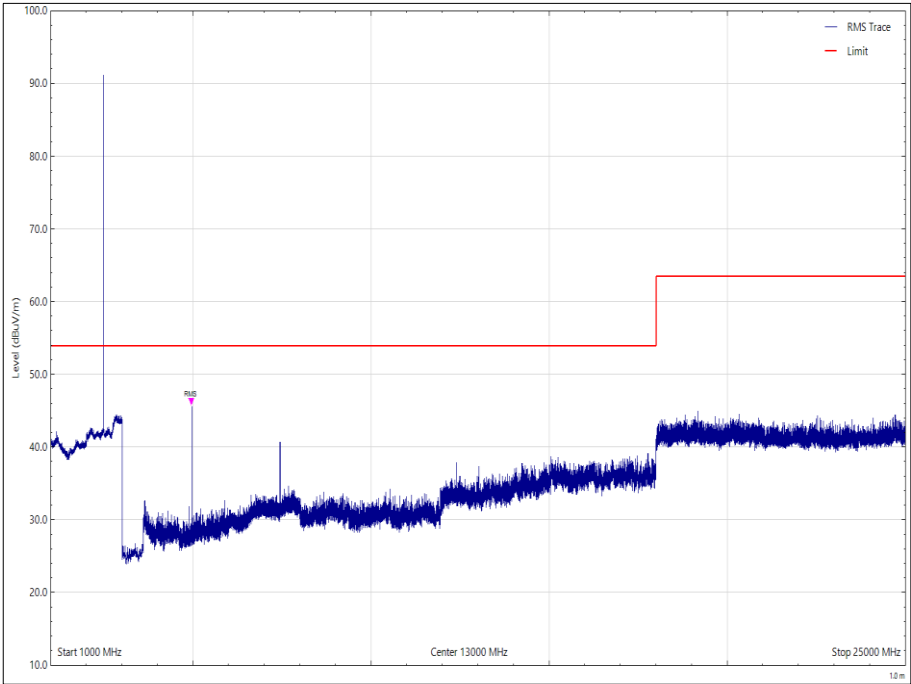


Figure 61 - 2480 MHz, 1 GHz to 25 GHz, Horizontal, Z Orientation, Average

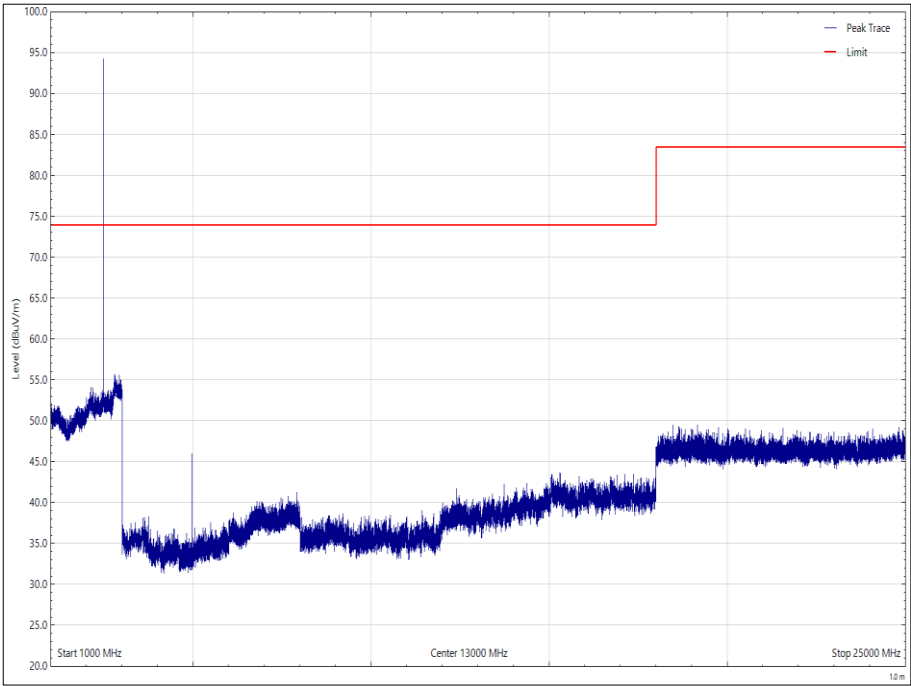


Figure 62 - 2480 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Peak

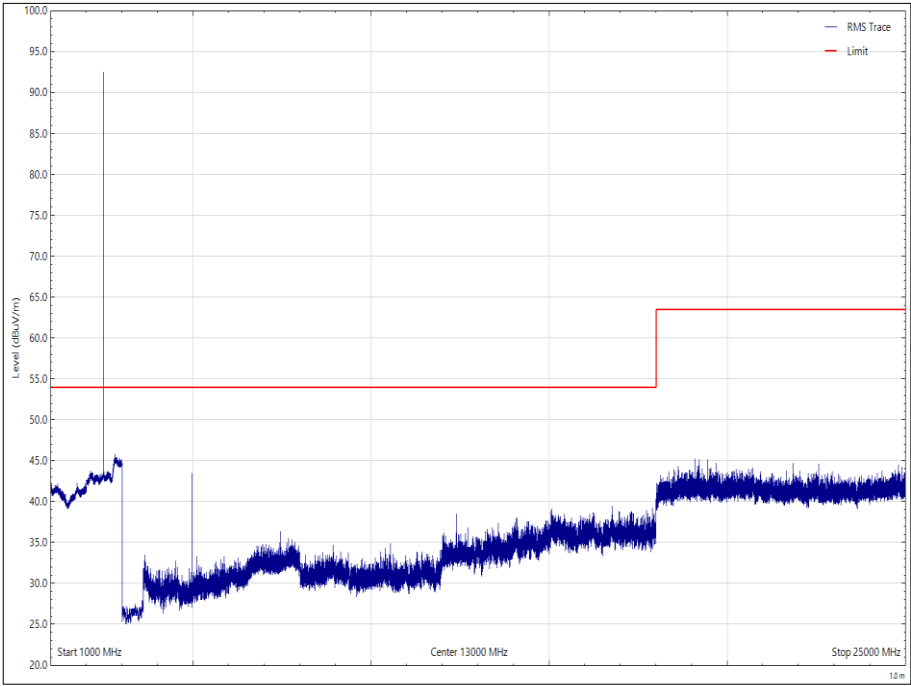


Figure 63 - 2480 MHz, 1 GHz to 25 GHz, Vertical, Z Orientation, Average

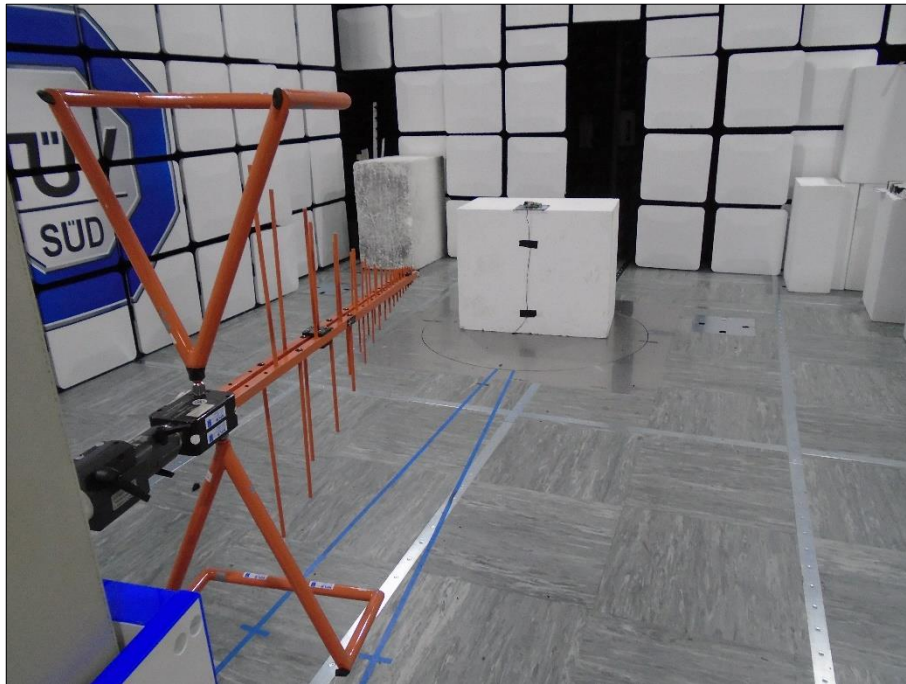


Figure 64 - Frequency Range: 30 MHz to 1 GHz

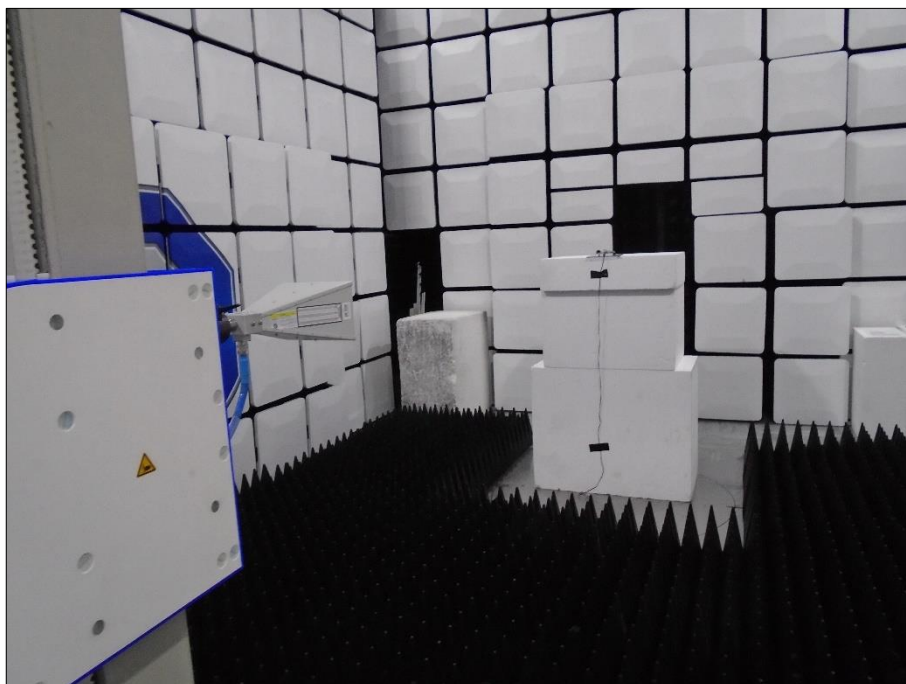


Figure 65 - Frequency Range: 1 GHz to 8 GHz

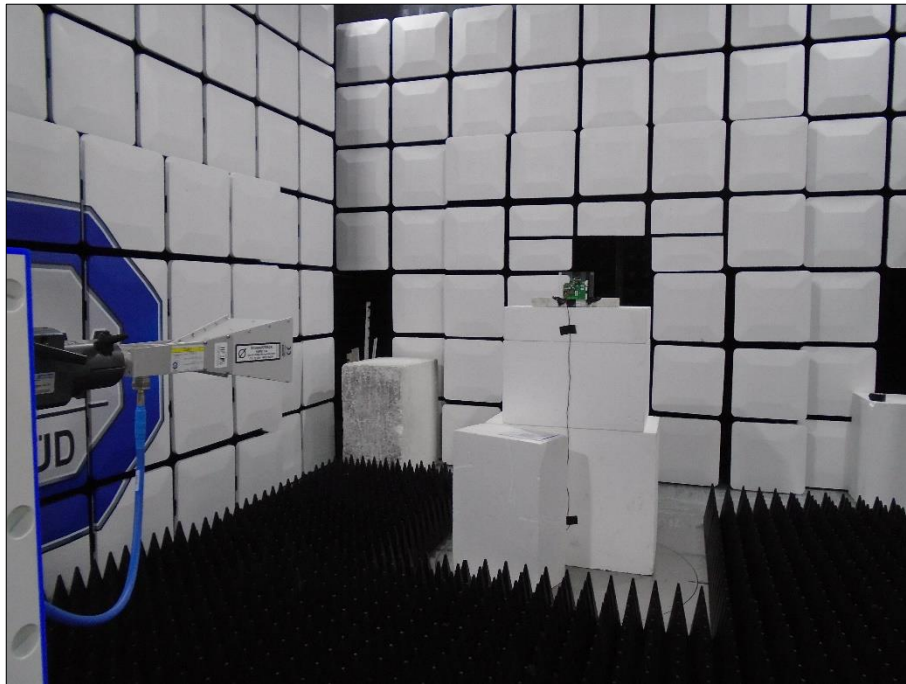


Figure 66 - Frequency Range: 8 GHz to 18 GHz



Figure 67 - Frequency Range: 18 GHz to 25 GHz

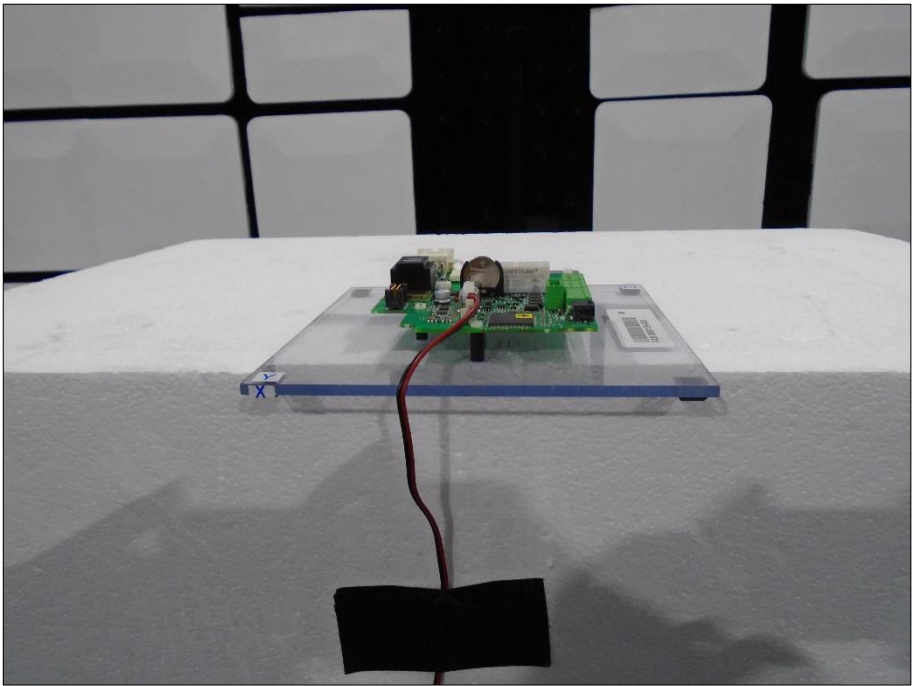


Figure 68 - Orientation X

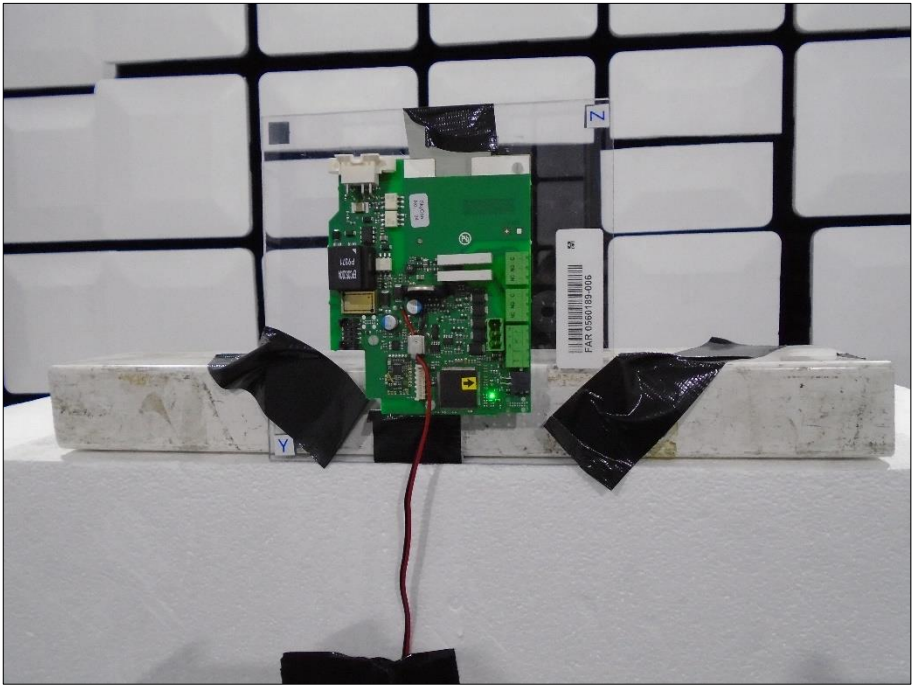


Figure 69 - Orientation Y

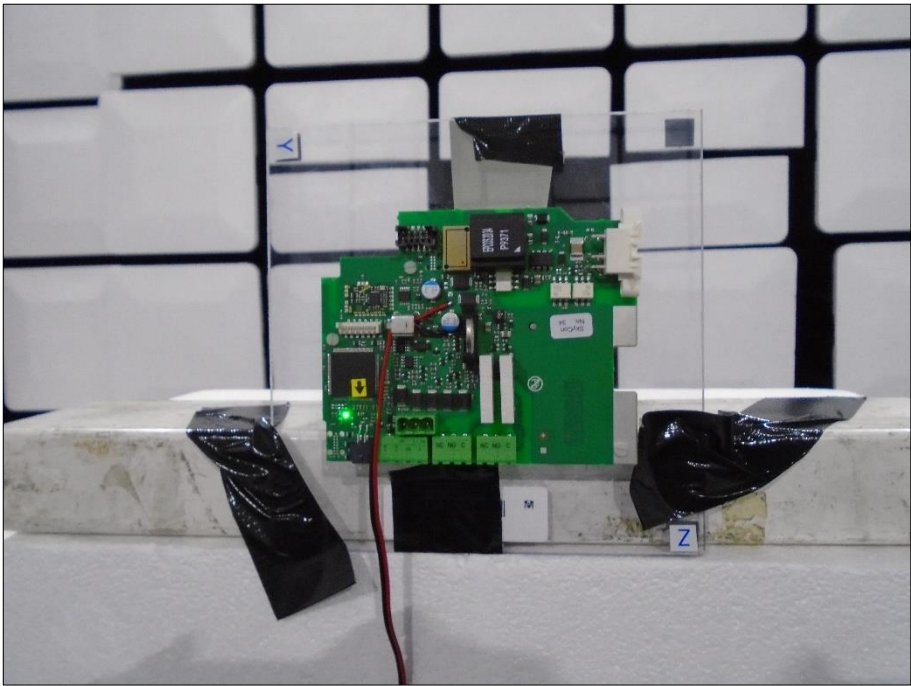


Figure 70 - Orientation Z



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.



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 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
Multimeter	Fluke	75 Mk3	455	12	30-Nov-2021
Pre-Amplifier, (8 GHz to 18 GHz)	Phase One	PS04-0086	1533	12	05-Feb-2022
18GHz - 40GHz Pre-Amplifier	Phase One	PS04-0087	1534	12	18-Feb-2022
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
42 V 10 Amp Power Supply Unit	Thurlby Thandar Instruments	EX4210R	3547	-	TU
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	24-Sep-2021
Cable (40 GHz)	Rosenberger	LU1-001-500	5021	12	22-Jun-2021
EmX Emissions Software	TUV SUD	V2.1.4	5125	-	Software
Preamplifier (30dB 1GHz to 18GHz)	Schwarzbeck	BBV 9718 C	5350	12	21-Sep-2021
Cable 2.92m	Junkosha	MWX241/B	5411	12	22-Jun-2021
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
3 GHz High pass Filter	Wainwright	WHKX12-2580-3000-18000-80SS	5548	12	05-May-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	08-Sep-2021
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
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023
Cable Assembly - 18GHz 8m	Junkosha	MWX221-08000NMSNMS/B	5732	6	05-Aug-2021

Table 21

TU - Traceability Unscheduled



2.5 Authorised Band Edges

2.5.1 Specification Reference

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

2.5.2 Equipment Under Test and Modification State

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-06) - Modification State 0

2.5.3 Date of Test

18-May-2021

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	21.8 °C
Relative Humidity	40.9 %

2.5.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400.0	-44.49
GFSK	2480	2483.5	-48.50

Table 22 - Authorised Band Edge Results

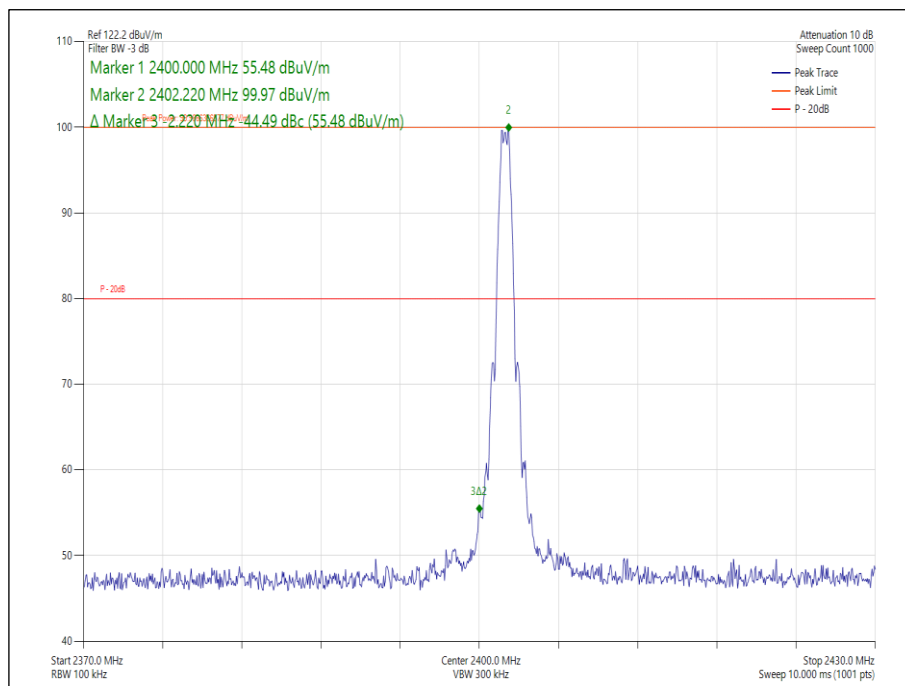


Figure 71 - GFSK – 2402.0 MHz - Band Edge Frequency 2400 MHz

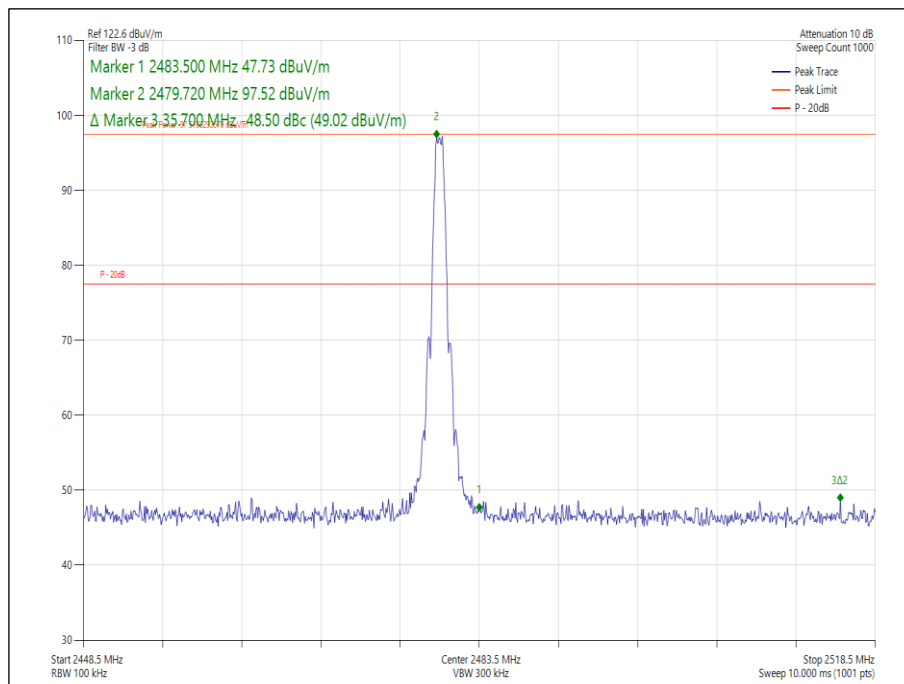


Figure 72 - GFSK– 2480.0 MHz - Band Edge Frequency 2483.5 MHz

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.

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.



2.5.7 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
Multimeter	Fluke	75 Mk3	455	12	30-Nov-2021
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
42 V 10 Amp Power Supply Unit	Thurlby Thandar Instruments	EX4210R	3547	-	TU
EmX Emissions Software	TUV SUD	V2.1.4	5125	-	Software
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5428	12	15-Oct-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	08-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
3m Semi Anechoic Chamber	MVG	EMC-3	5621	36	11-Aug-2023
Cable Assembly - 18GHz 8m	Junkosha	MWX221-08000NMSNMS/B	5732	6	05-Aug-2021

Table 23

TU - Traceability Unscheduled



2.6 Power Spectral Density

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (e)
ISED RSS-247, Clause 5.2
ISED RSS-GEN, Clause 6.12

2.6.2 Equipment Under Test and Modification State

MSR – Multistandard Radio module, S/N: Not Applicable (FAR-560189-03) - Modification State 0

2.6.3 Date of Test

12-May-2021

2.6.4 Test Method

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

2.6.5 Environmental Conditions

Ambient Temperature	24.7 °C
Relative Humidity	32.1 %



2.6.6 Test Results

2.4 GHz Bluetooth Low Energy

2.4 GHz Bluetooth Low Energy

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (e) RSS-247 5.2 b)	Test Method(s):	C63.10 11.10.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	BLE GFSK (LE 1M)	Duty Cycle (%):	100.0
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (BLE)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	RBW (kHz)	PSD (dBm/RBW)					Limit (dBm/3 kHz)	Margin (dB)
		A	B	C	D	Σ		
2402	3.0	-7.04	-	-	-	-	8.00	-15.04
2442	3.0	-6.92	-	-	-	-	8.00	-14.92
2480	3.0	-7.15	-	-	-	-	8.00	-15.15

Table 24 - Maximum Power Spectral Density Results

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.

ISED RSS-247, Limit Clause 5.2(b)

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



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	17-May-2021
Multimeter	Iso-tech	IDM101	2421	12	30-Oct-2021
Hygrometer	Rotronic	I-1000	3220	12	16-Oct-2021
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	17-May-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 25

3 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
Emission Bandwidth	± 25.354 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
Power Spectral Density	± 3.2 dB

Table 26

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.