FCC and ISED Test Report

Silicon Laboratories Finland Oy
Radio Module, Model: BGM220S12A

In accordance with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN

Prepared for: Silicon Laboratories Finland Oy
Bertel Jungin Aukio 3
Alberga Business Park
Espoo
02600
FINLAND

FCC ID: QOQ-BGM220S IC: 5123A-BGM220S

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Document 75947809-03 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	09 April 2020

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	Mehadi Choudhury	09 April 2020	
Testing	Jaiyanth Balendrarajah	09 April 2020	
Testing	Mohammad Malik	09 April 2020	
Testing	Ahmad Javid	09 April 2020	
Testing	Faisal Malyar	09 April 2020	

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, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) for the tests detailed in section 1.3.

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Contents

1 Report Summary

1.1 Report Modification Record

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

Issue	Description of Change	Date of Issue
1	First Issue	09 April 2020

Table 1

1.2 Introduction

Applicant	Silicon Laboratories Finland Oy
Manufacturer	Silicon Laboratories Finland Oy
Model Number(s)	BGM220S12A
Serial Number(s)	Not Serialised (0075947809-TSR0018), Not Serialised (0075947809-TSR0011) and Not Serialised (0075947809-TSR0017)
Hardware Version(s)	1.0
Software Version(s)	2.13.x
Number of Samples Tested	3
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2019 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019)
Order Number Date	6000380537 20-December-2019
Date of Receipt of EUT	03-February-2020
Start of Test	10-February-2020
Finish of Test	27-February-2020
Name of Engineer(s)	Mehadi Choudhury, Jaiyanth Balendrarajah, Mohamad Malik, Ahmad Javid and Faisal Malyar
Related Document(s)	ANSI C63.10 (2013)

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C, 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: Internal Antenna - Bluetooth Low Energy (1M PHY)						
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.6	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)
Configuration and Mode: External Antenna - Bluetooth Low Energy (1M PHY)						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013)
2.2	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	ANSI C63.10 (2013)
2.3	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	ANSI C63.10 (2013)
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.6	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)
Configuration and Mode: Internal Antenna - Bluetooth Low Energy (2M PHY)						
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: External Antenna - Bluetooth Low Energy (2M PHY)						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013)
2.2	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	ANSI C63.10 (2013)
2.3	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	ANSI C63.10 (2013)
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
Configuration and Mode: Internal Antenna - Custom Protocol - Alternative Channels						
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
Configuration and Mode: External Antenna - Custom Protocol - Alternative Channels						
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)

Table 2

1.4 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment)*	Unshielded wireless radio SiP (System-in-Package) module implementing the Bluetooth Low Energy (BLE) technology according to the 5.2 specification. The BLE stack implements the 1 and 2 Msym/s PHYs, but not the Coded PHYs, and has no direction finding capabilities. The module comes with an RF pin meant to route the RF signal to either an external antenna or to an adjacent pin for making use of the integral antenna.
Manufacturer:	Silicon Laboratories Finland Oy, Alberga Business Park, Bertel Jungin aukio 3, FI-02600 Espoo, Finland (Phone: +358 9 435 5060, www.silabs.com)
Model:	BGM220S12A
Part Number:	
Hardware Version:	1.0
Software Version:	2.13.x
FCC ID (if applicable)	QOQ-BGM220S
IC ID (if applicable)	5123A-BGM220S

Intentional Radiators

Technology	Bluetooth Low Energy (BLE), Custom Protocol
Frequency Band (MHz)	2400 to 2483.5 MHz
Conducted Declared Output Power (dBm)	-0.5
Antenna Gain (dBi)	Integral: 1.5 / Reference external: 3.2
Supported Bandwidth(s) (MHz)	1
Modulation Scheme(s)	GFSK, 1 and 2 Msym/s
ITU Emission Designator	1M00WDX
Bottom Frequency (MHz)	2402 (BLE), 2401 (Custom Protocol)
Middle Frequency (MHz)	2440 (BLE)
Top Frequency (MHz)	2480 (BLE), 2481 (Custom Protocol)

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) ☐	

AC Power Source

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

Power Source

Nominal voltage:	3.0	V
Extreme upper voltage:	3.8	V
Extreme lower voltage:	1.8	V
Max current:	0.0043	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:	-40	°C
Maximum temperature:	+85	°C

Antenna Characteristics

Antenna connector ☒ RF-PIN			State impedance	50	Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	Discrete	Gain	1.5	dBi
External antenna ☒	Type:	Dipole	Gain	3.2	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: Tom Nordman

Position held: Marketing Director of IoT Wireless Products at Silicon Laboratories Finland Oy, Alberga Business Park, Bertel Jungin aukio 3, FI-02600 Espoo, Finland

Date: 05 February 2020

1.5 Product Information

1.5.1 Technical Description

Unshielded wireless radio SiP (System-in-Package) module implementing the Bluetooth Low Energy (BLE) technology according to the 5.2 specification. The BLE stack implements the 1 and 2 Msym/s PHYs, but not the Coded PHYs, and has no direction-finding capabilities. The module comes with an RF pin meant to route the RF signal to either an external antenna or to an adjacent pin for making use of the integral antenna.

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: BGM220S12A, Serial Number: Not Serialised (0075947809-TSR0011)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: BGM220S12A, Serial Number: Not Serialised (0075947809-TSR0017)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: BGM220S12A, Serial Number: Not Serialised (0075947809-TSR0018)			
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: Internal Antenna - Bluetooth Low Energy (1M PHY)		
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Spurious Radiated Emissions	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Configuration and Mode: External Antenna - Bluetooth Low Energy (1M PHY)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Emission Bandwidth	Mehadi Choudhury	UKAS
Power Spectral Density	Mehadi Choudhury	UKAS
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Spurious Radiated Emissions	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Configuration and Mode: Internal Antenna - Bluetooth Low Energy (2M PHY)		
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Configuration and Mode: External Antenna - Bluetooth Low Energy (2M PHY)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Emission Bandwidth	Mehadi Choudhury	UKAS
Power Spectral Density	Mehadi Choudhury	UKAS
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Configuration and Mode: Internal Antenna - Custom Protocol - Alternative Channels		
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Configuration and Mode: External Antenna - Custom Protocol - Alternative Channels		
Authorised Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS
Restricted Band Edges	Jaiyanth Balendrarajah, Mohammad Malik, Ahmad Javid and Faisal Malyar	UKAS

Table 4

Office Address:

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

2 Test Details

2.1 Maximum Conducted Output Power

2.1.1 Specification Reference

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

2.1.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0018) - Modification State 0

2.1.3 Date of Test

10-February-2020

2.1.4 Test Method

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

2.1.5 Environmental Conditions

Ambient Temperature	24.3 °C
Relative Humidity	27.3 %

2.1.6 Test Results

External Antenna - Bluetooth Low Energy (1M PHY)

Frequency (MHz)	Modulation Scheme	Maximum Output Power	
		dBm	mW
2402	GFSK	-0.68	0.86
2440	GFSK	-0.78	0.84
2480	GFSK	-0.87	0.82

Table 5 - Maximum Conducted Output Power Results

Figure 1 - 2402 MHz - Maximum Output Power

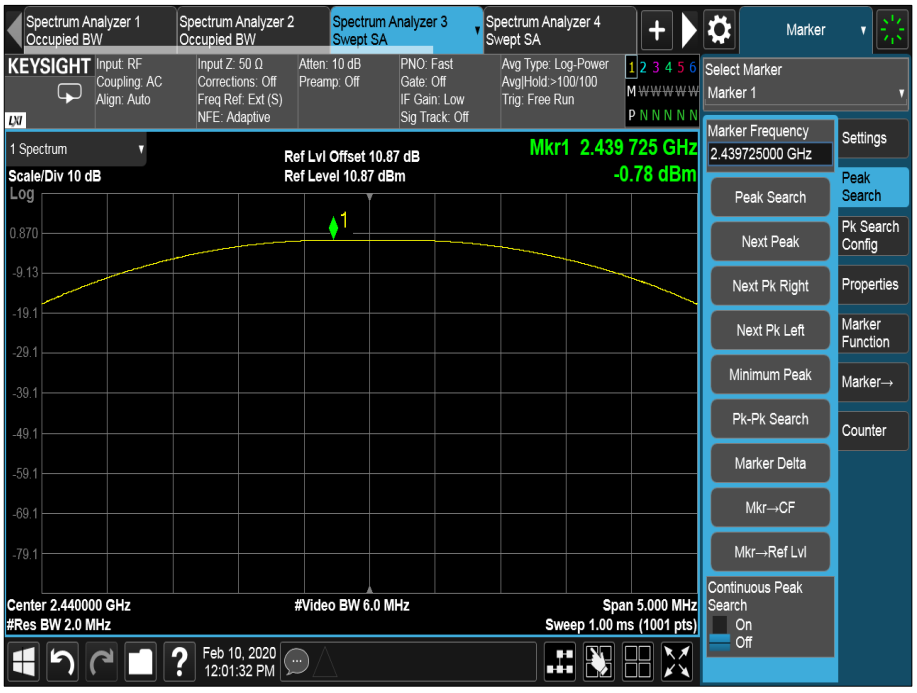


Figure 2 - 2440 MHz - Maximum Output Power

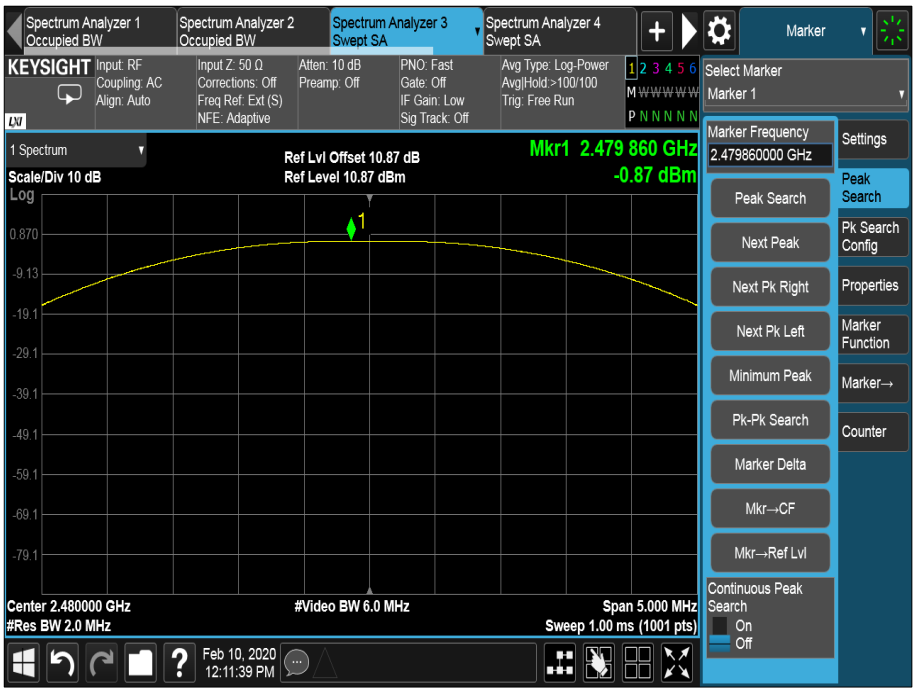


Figure 3 - 2480 MHz - Maximum Output Power

External Antenna - Bluetooth Low Energy (2M PHY)

Frequency (MHz)	Modulation Scheme	Maximum Output Power	
		dBm	mW
2402	GFSK	-0.66	0.86
2441	GFSK	-0.81	0.83
2480	GFSK	-0.78	0.84

Table 6 - Maximum Conducted Output Power Results

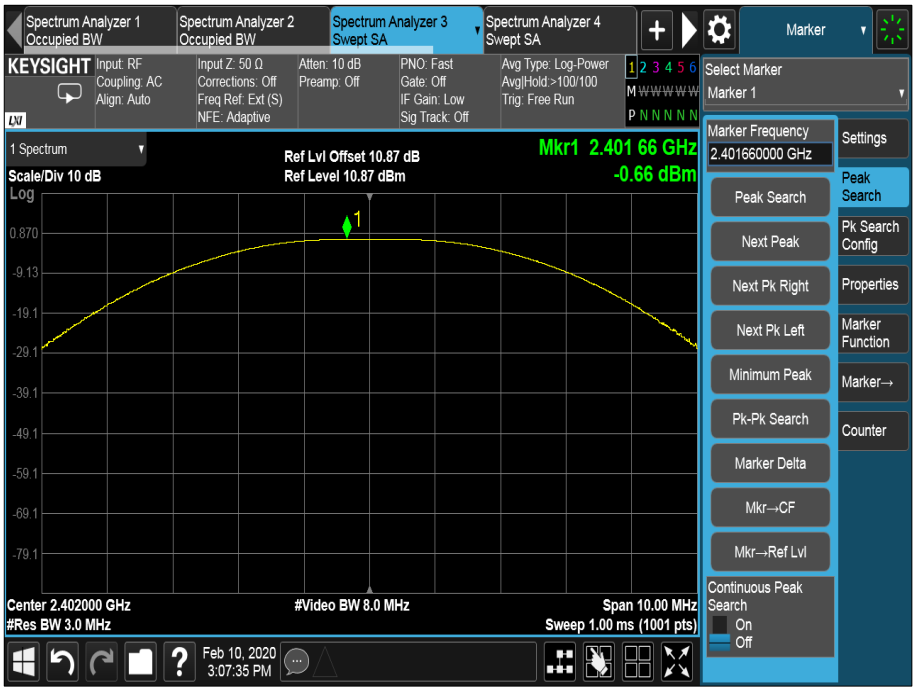


Figure 4 - 2402 MHz - Maximum Output Power

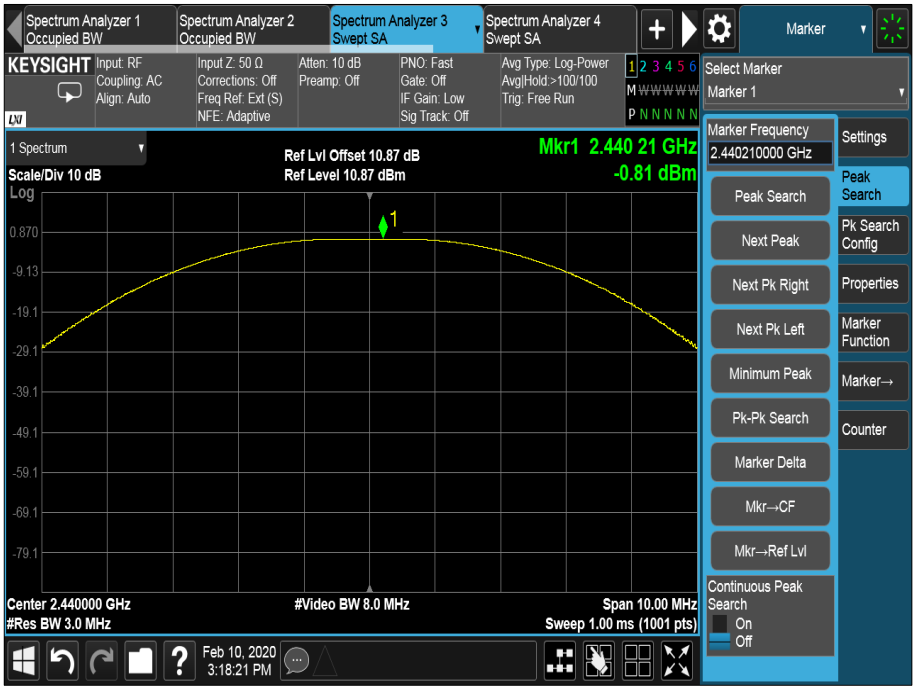


Figure 5 - 2441 MHz - Maximum Output Power

Figure 6 - 2480 MHz - Maximum Output Power

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

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non overlapping hopping channels, and all frequency hopping systems in the 5725-5850MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

ISED RSS-247, Limit Clause 5.4 (b)

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channel; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channel. The e.i.r.p. shall not exceed 4 W except as provided in section 5.4(e) of the specification.

2.1.7 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 Due
Multimeter	Iso-tech	IDM101	2419	12	28-Nov-2020
Programmable Power Supply	Iso-tech	IPS 2010	2437	-	O/P Mon
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-April-2020
EXA	Keysight Technologies	N9010B	4969	24	03-Feb-2022
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
10 dB Attenuator	Telegartner	J01156A0031	N/S	-	O/P Mon

Table 7

O/P Mon – Output Monitored using calibrated equipment

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
ISEDC RSS-GEN, Clause 6.7

2.2.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0018) - Modification State 0

2.2.3 Date of Test

10-February-2020

2.2.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.2.

For modes of operation using multiple cores, measurements were made on each core but only the worst case results are reported. Worst case was considered as the narrowest results for 6 dB bandwidth and the widest result for 26 dB bandwidth and 99% occupied bandwidth.

2.2.5 Environmental Conditions

Ambient Temperature	24.3 °C
Relative Humidity	27.3 %

2.2.6 Test Results

External Antenna - Bluetooth Low Energy (1M PHY)

Frequency (MHz)	6 dB Bandwidth (kHz)	99% Occupied Bandwidth (kHz)
2402	1029.1	647.1
2440	1033.0	646.5
2480	1032.1	646.9

Table 8 - Emission Bandwidth Results

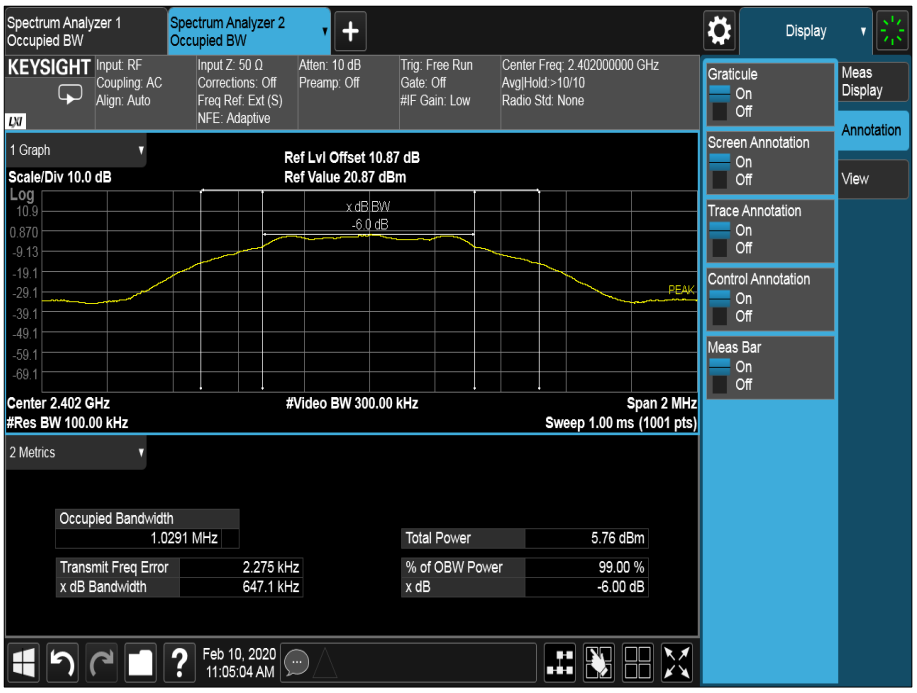


Figure 7 - 2402 MHz – Emission Bandwidth

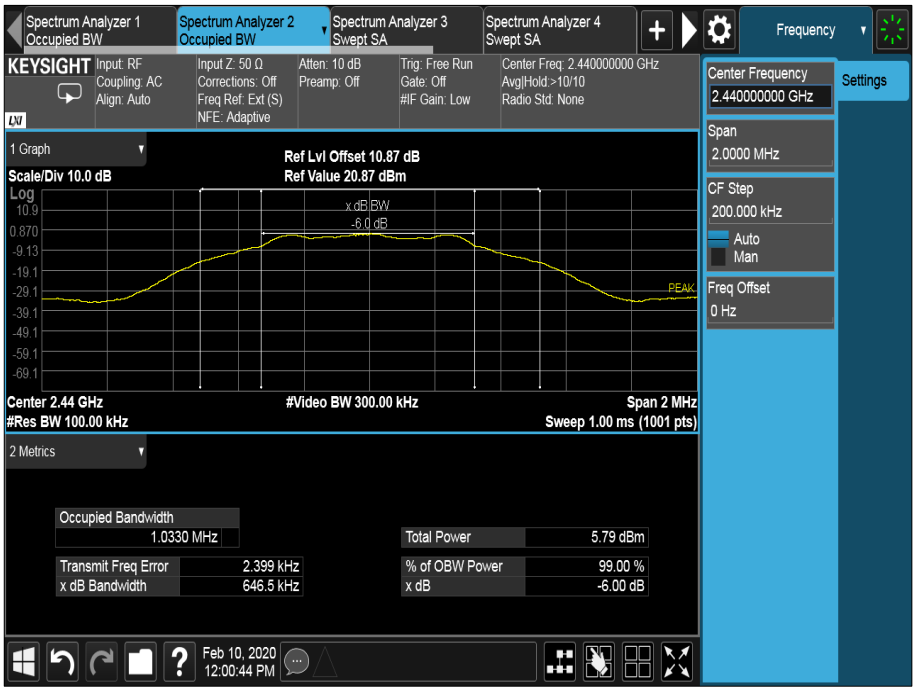


Figure 8 - 2440 MHz – Emission Bandwidth

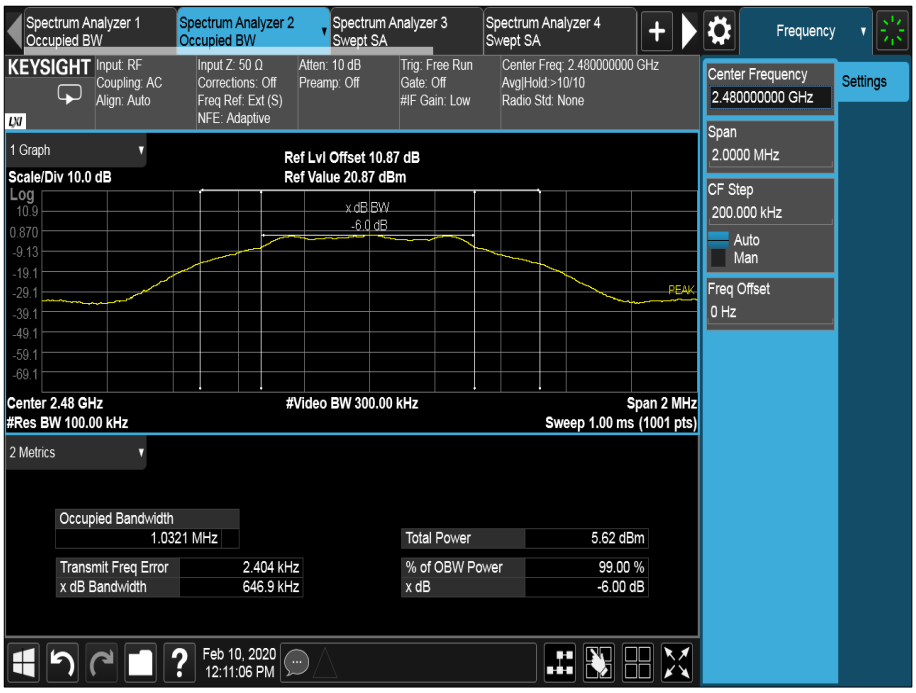


Figure 9 - 2480 MHz – Emission Bandwidth

External Antenna - Bluetooth Low Energy (2M PHY)

Frequency (MHz)	6 dB Bandwidth (kHz)	99% Occupied Bandwidth (kHz)
2402	2047.5	1164.0
2440	2047.6	1162.0
2480	2048.0	1160.0

Table 9 - Emission Bandwidth Results

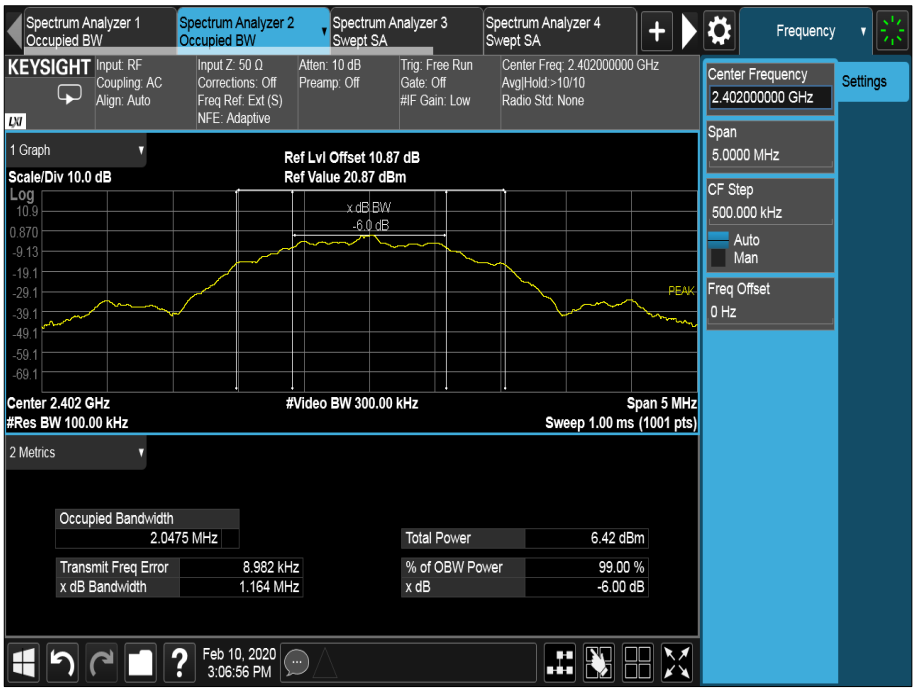


Figure 10 - 2402 MHz – Emission Bandwidth

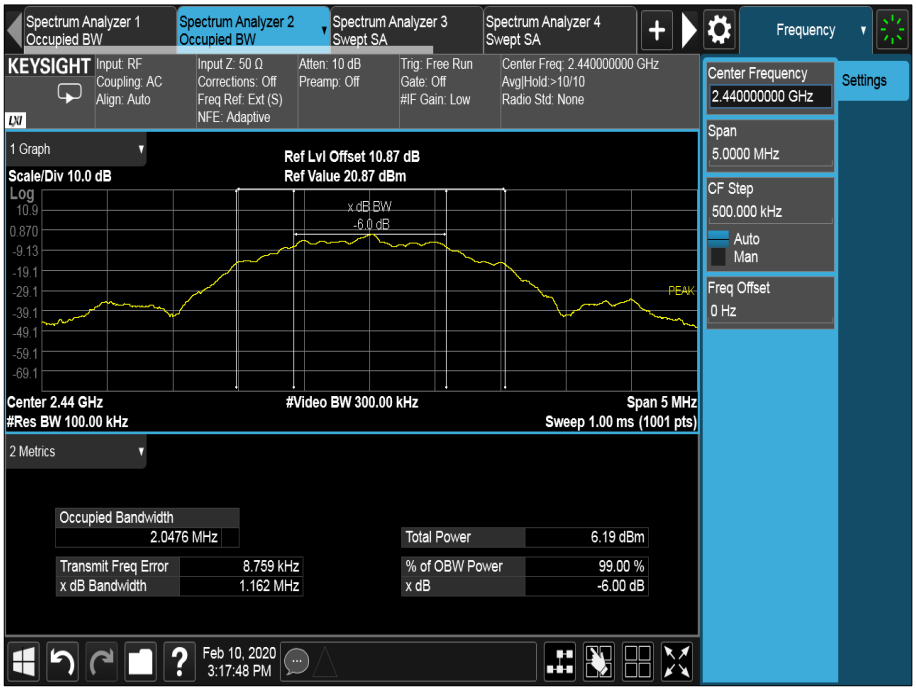


Figure 11 - 2440 MHz – Emission Bandwidth

Figure 12 - 2480 MHz – Emission Bandwidth

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2) and ISED 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 Due
Multimeter	Iso-tech	IDM101	2419	12	28-Nov-2020
Programmable Power Supply	Iso-tech	IPS 2010	2437	-	O/P Mon
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	03-Feb-2022
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
10 dB Attenuator	Telegartner	J01156A0031	N/S	-	O/P Mon

Table 10

O/P Mon – Output Monitored using calibrated equipment

2.3 Power Spectral Density

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0018) - Modification State 0

2.3.3 Date of Test

10-February-2020

2.3.4 Test Method

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

2.3.5 Environmental Conditions

Ambient Temperature	24.3 °C
Relative Humidity	27.3 %

2.3.6 Test Results

External Antenna - Bluetooth Low Energy (1M PHY)

Frequency (MHz)	Power Spectral Density (dBm)	Measurement Bandwidth (kHz)
2402	-10.46	10
2440	-10.60	10
2480	-10.66	10

Table 11 - Power Spectral Density

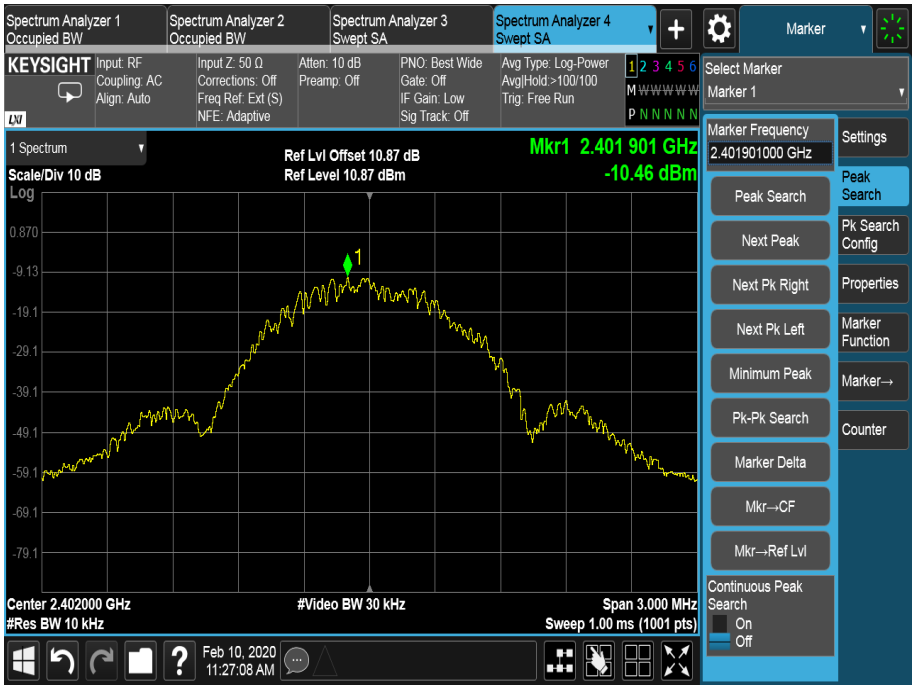


Figure 13 - 2402 MHz – Power Spectral Density

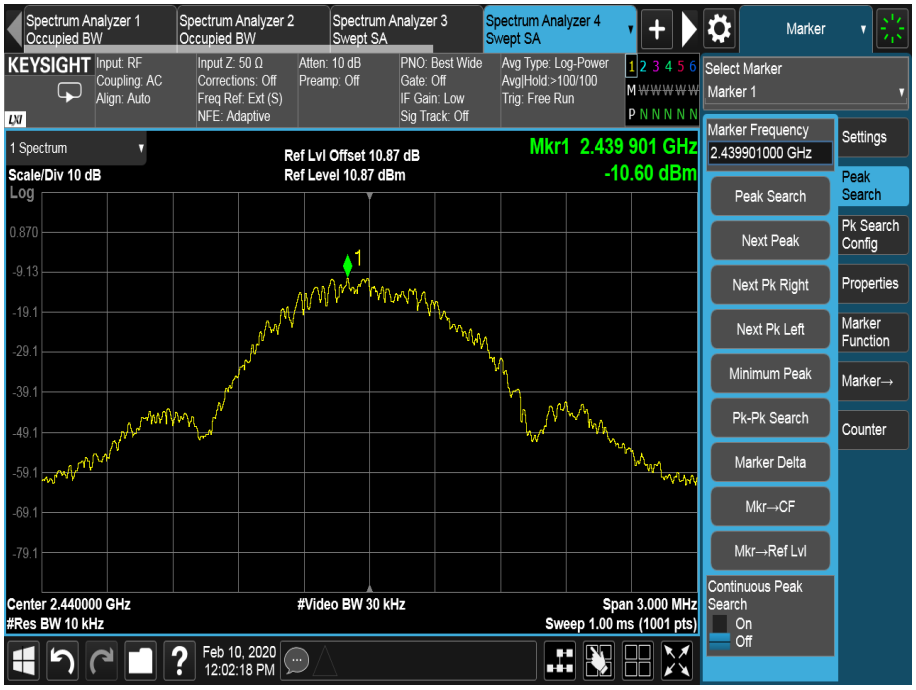


Figure 14 - 2440 MHz – Power Spectral Density

Figure 15 - 2480 MHz - Power Spectral Density

External Antenna - Bluetooth Low Energy (2M PHY)

Frequency (MHz)	Power Spectral Density (dBm)	Measurement Bandwidth (kHz)
2402	-12.18	10
2440	-11.94	10
2480	-13.43	10

Table 12 - Power Spectral Density

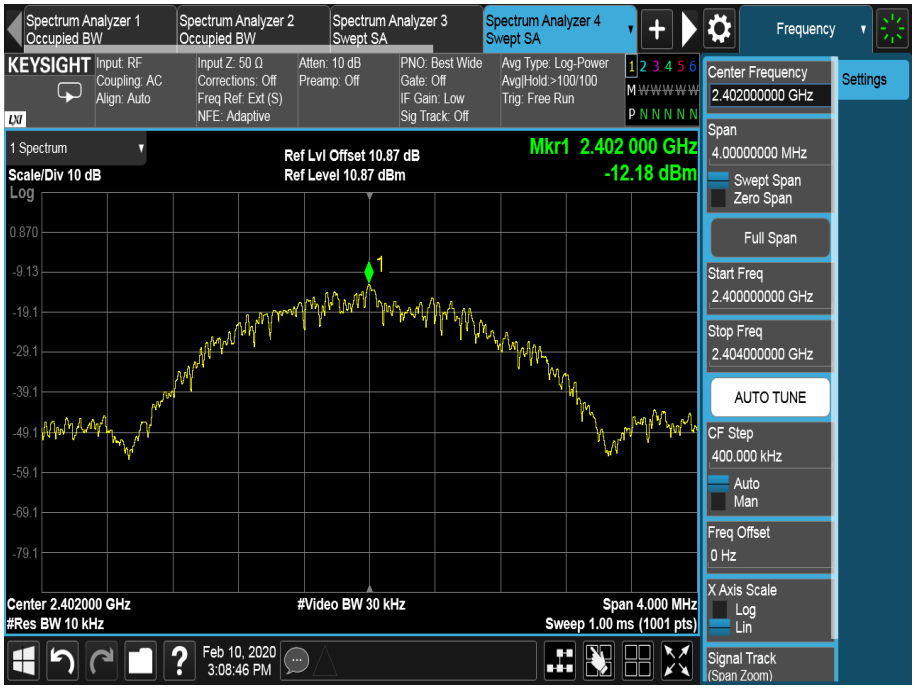


Figure 16 - 2402 MHz – Power Spectral Density

Figure 17 - 2440 MHz – Power Spectral Density

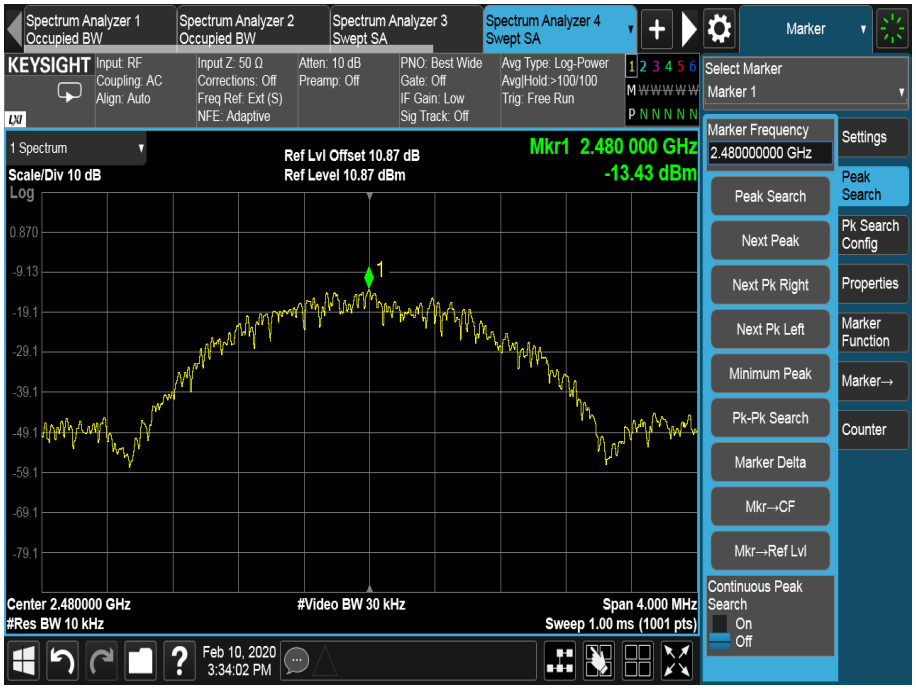


Figure 18 - 2480 MHz – Power Spectral Density

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

2.3.7 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 Due
Multimeter	Iso-tech	IDM101	2419	12	28-Nov-2020
Programmable Power Supply	Iso-tech	IPS 2010	2437	-	O/P Mon
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	03-Feb-2022
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
10 dB Attenuator	Telegartner	J01156A0031	N/S	-	O/P Mon

Table 13

O/P Mon – Output Monitored using calibrated equipment

2.4 Authorised Band Edges

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0011) - Modification State 0
BGM220S12A, S/N: Not Serialised (0075947809-TSR0017) - Modification State 0

2.4.3 Date of Test

18-February-2020 to 25-February-2020

2.4.4 Test Method

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

2.4.5 Environmental Conditions

Ambient Temperature	20.0 - 20.5 °C
Relative Humidity	38.3 - 40.7 %

2.4.6 Test Results

Internal Antenna - Bluetooth Low Energy (1M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400	-47.71

Table 14 - Authorised Band Edge Results

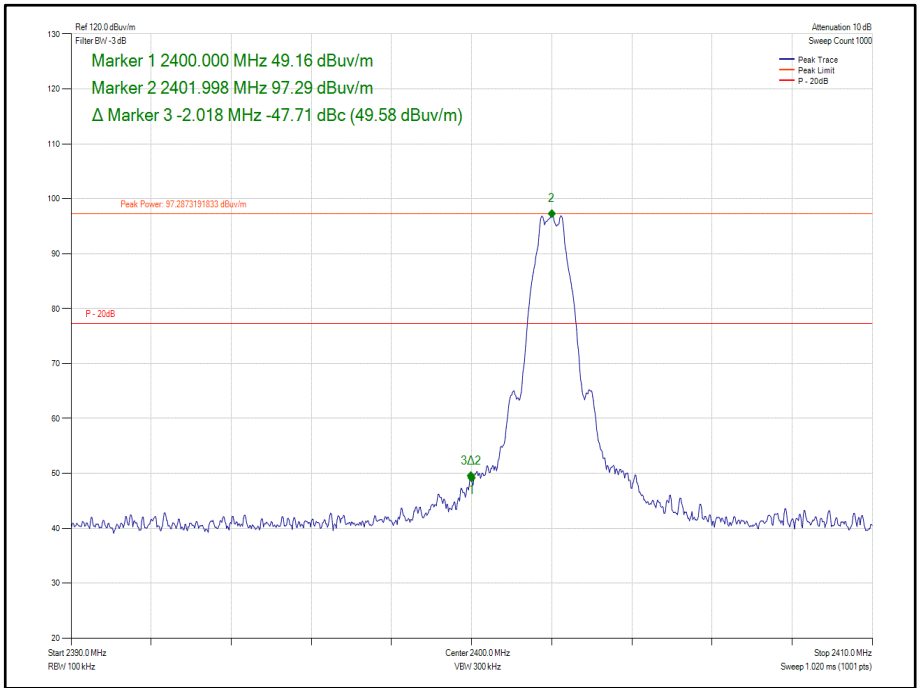


Figure 19 - 2402 MHz - Band Edge Frequency 2400 MHz

External Antenna - Bluetooth Low Energy (1M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400	-47.08

Table 15 - Authorised Band Edge Results

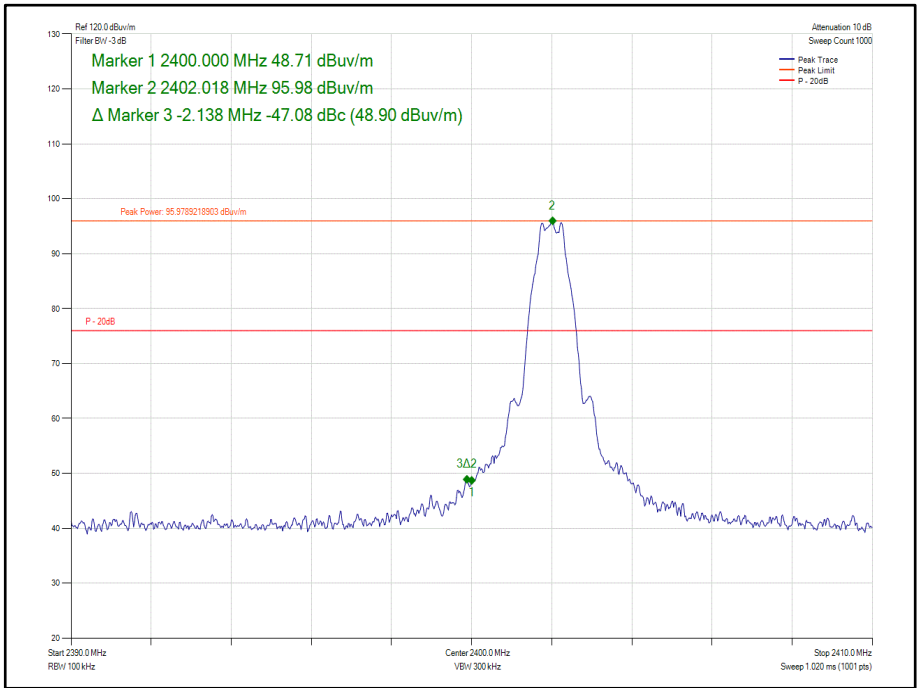


Figure 20 - 2402 MHz - Band Edge Frequency 2400 MHz

Internal Antenna - Bluetooth Low Energy (2M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400	-32.81

Table 16 - Authorised Band Edge Results

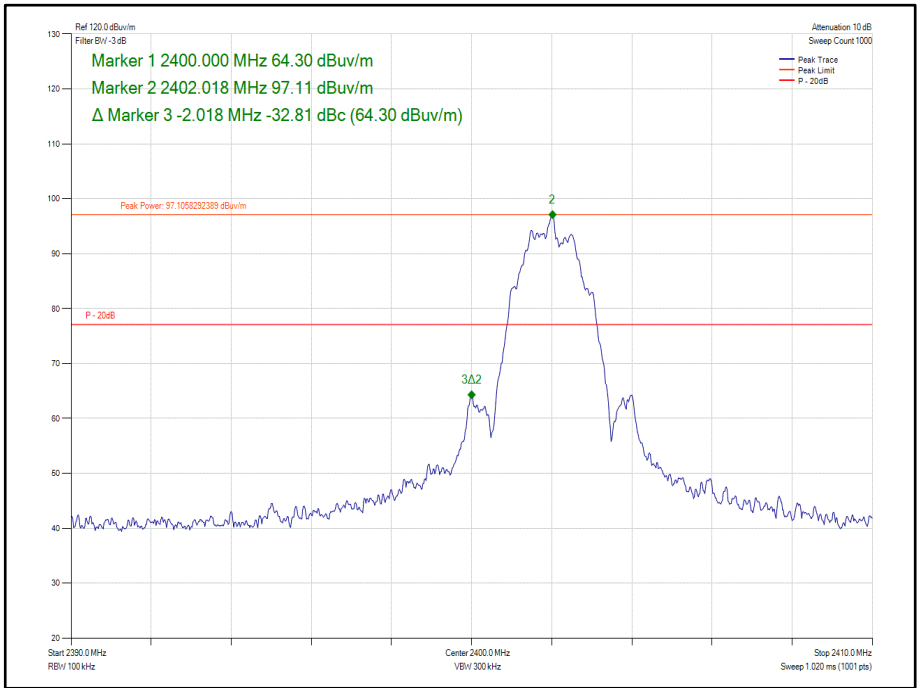


Figure 21 - 2402 MHz - Band Edge Frequency 2400 MHz

External Antenna - Bluetooth Low Energy (2M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400	-32.79

Table 17 - Authorised Band Edge Results

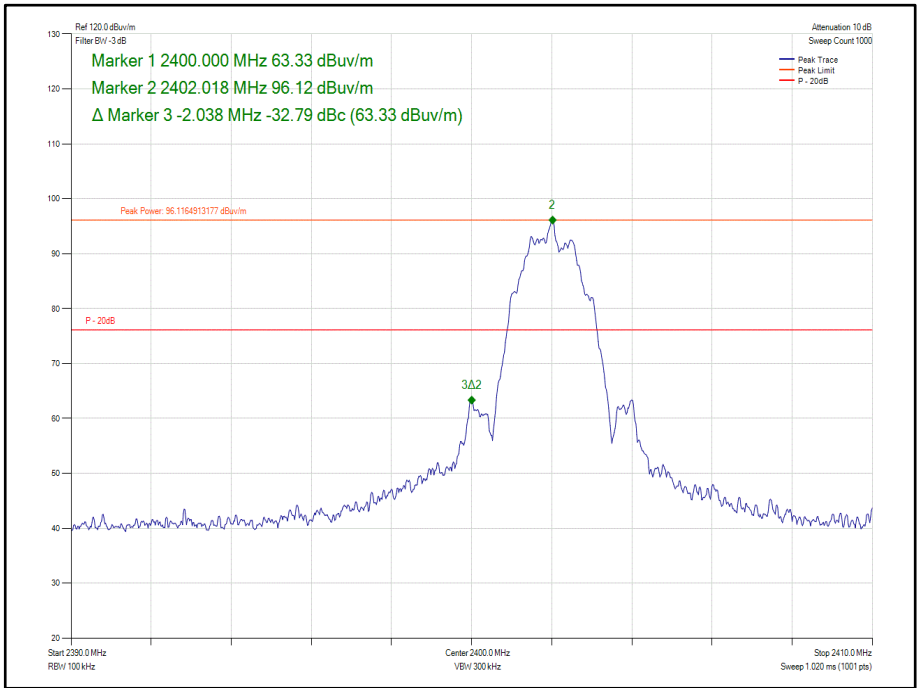


Figure 22 - 2402 MHz - Band Edge Frequency 2400 MHz

Internal Antenna - Custom Protocol - Alternative Channels

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2401	2400	-33.51

Table 18 - Authorised Band Edge Results

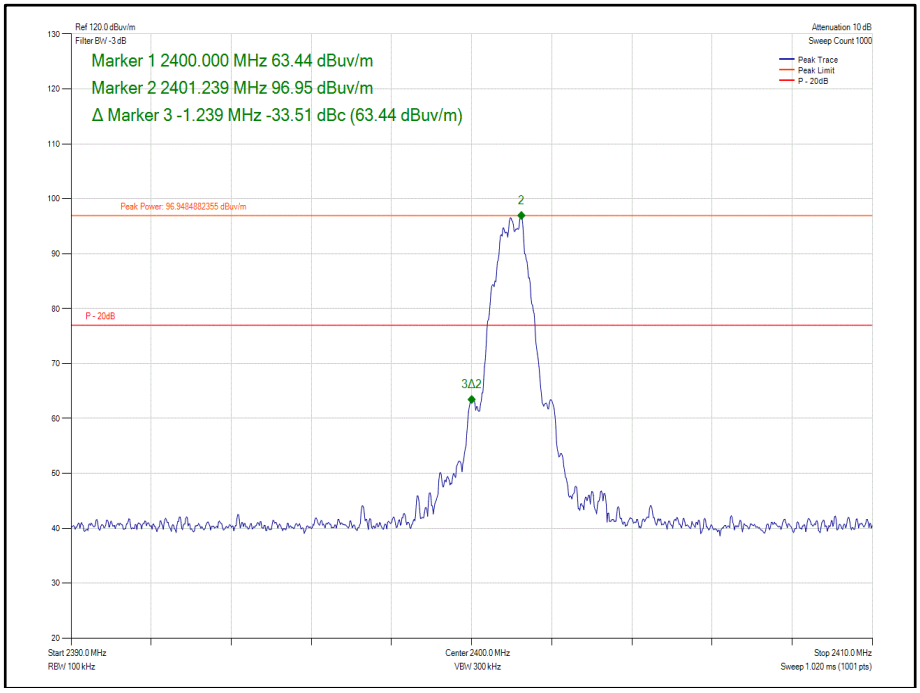


Figure 23 - 2401 MHz - Band Edge Frequency - 2400 MHz

External Antenna - Custom Protocol - Alternative Channels

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2401	2400	-33.36

Table 19 - Authorised Band Edge Results

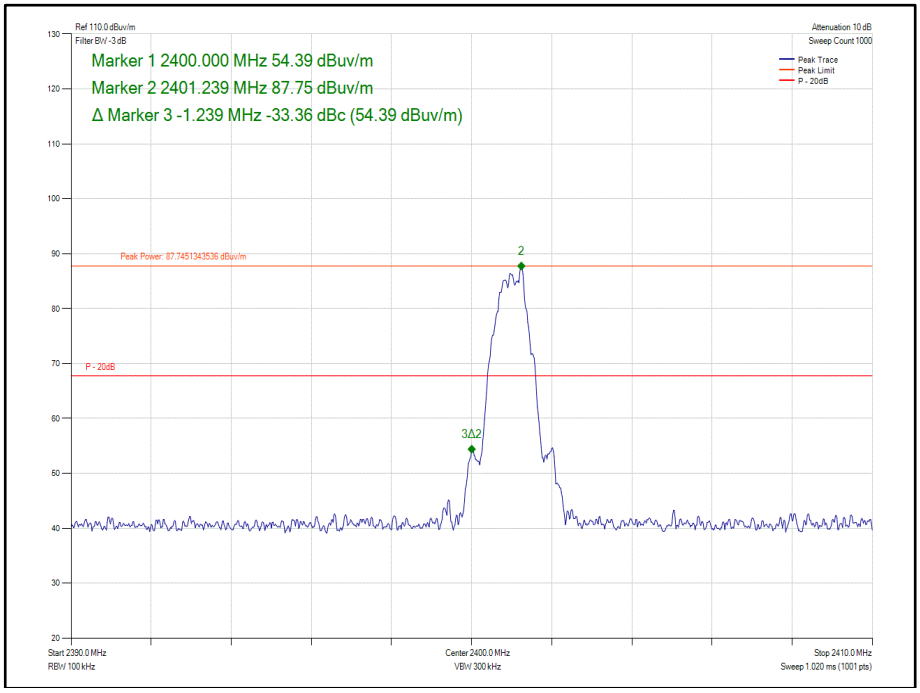


Figure 24 - 2401 MHz - Band Edge Frequency - 2400 MHz

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.

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Power Supply	Farnell	D302T	609	-	O/P Mon
Multimeter	Iso-tech	IDM 101	2118	12	07-Feb-2021
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5092	12	006-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	006-Oct-2020
EmX Emissions Software	TUV SUD	EmX V.V1.5.7	5125	-	Software
Screened Room (11)	Rainford	-	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020

Table 20

TU – Traceability Unscheduled
O/P Mon – Output Monitored using calibrated test equipment.

2.5 Restricted Band Edges

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205
ISED RSS-GEN, Clause 8.10

2.5.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0011) - Modification State 0
BGM220S12A, S/N: Not Serialised (0075947809-TSR0017) - Modification State 0

2.5.3 Date of Test

18-February-2020 to 25-February-2020

2.5.4 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 dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

2.5.5 Environmental Conditions

Ambient Temperature	20.0 - 20.5 °C
Relative Humidity	38.3 - 40.7 %

2.5.6 Test Results

Internal Antenna - Bluetooth Low Energy (1M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390	56.72	42.05
GFSK	2480	2483.5	60.39	43.59

Table 21 - Restricted Band Edge Results

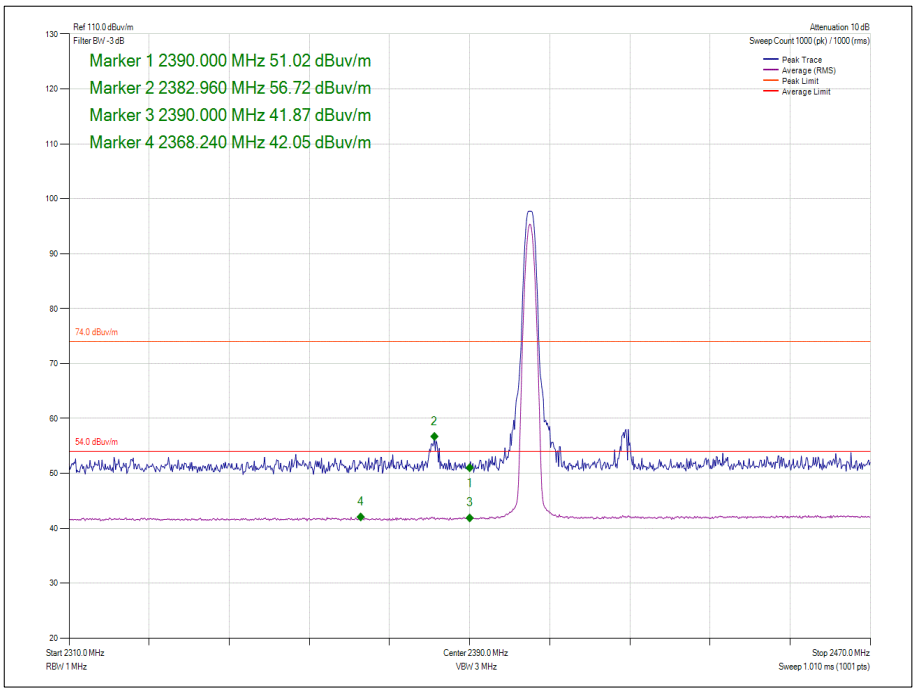


Figure 25 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

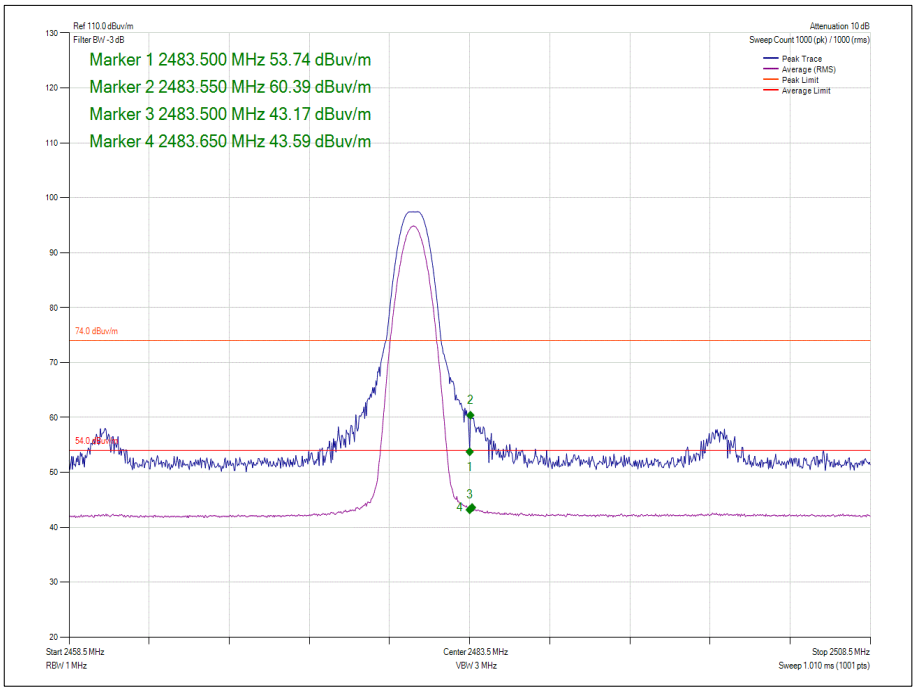


Figure 26 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

External Antenna - Bluetooth Low Energy (1M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390	56.69	42.06
GFSK	2480	2483.5	60.47	43.34

Table 22 - Restricted Band Edge Results

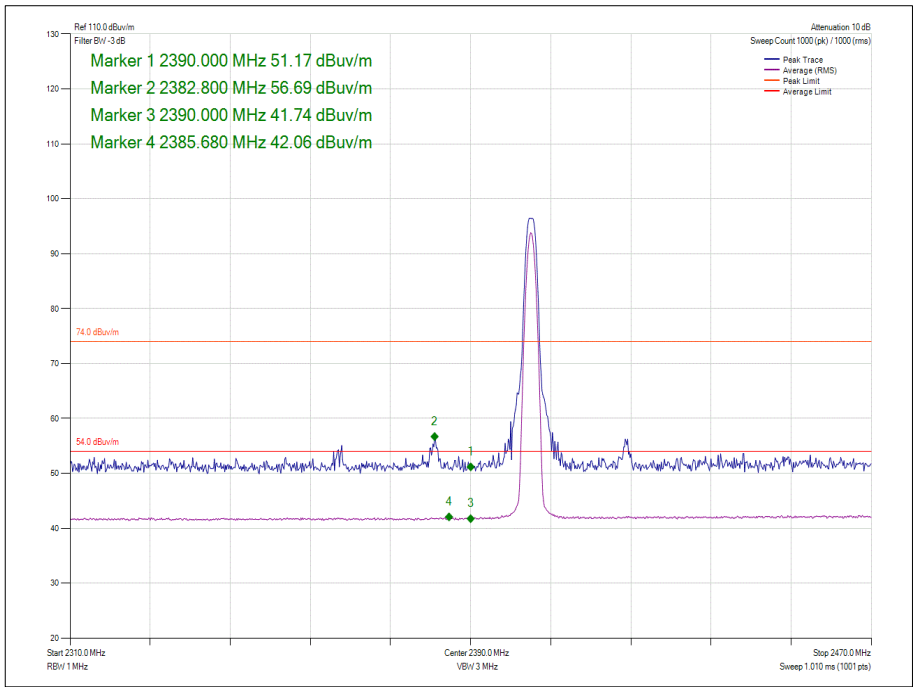


Figure 27 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

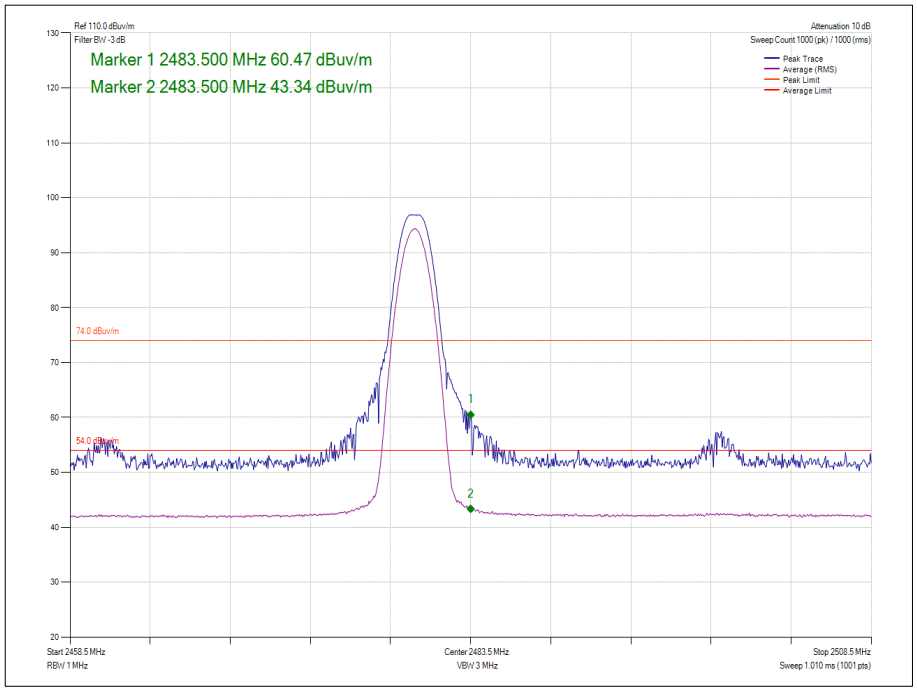


Figure 28 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

Internal Antenna - Bluetooth Low Energy (2M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390	57.10	41.94
GFSK	2480	2483.5	61.53	46.89

Table 23 - Restricted Band Edge Results

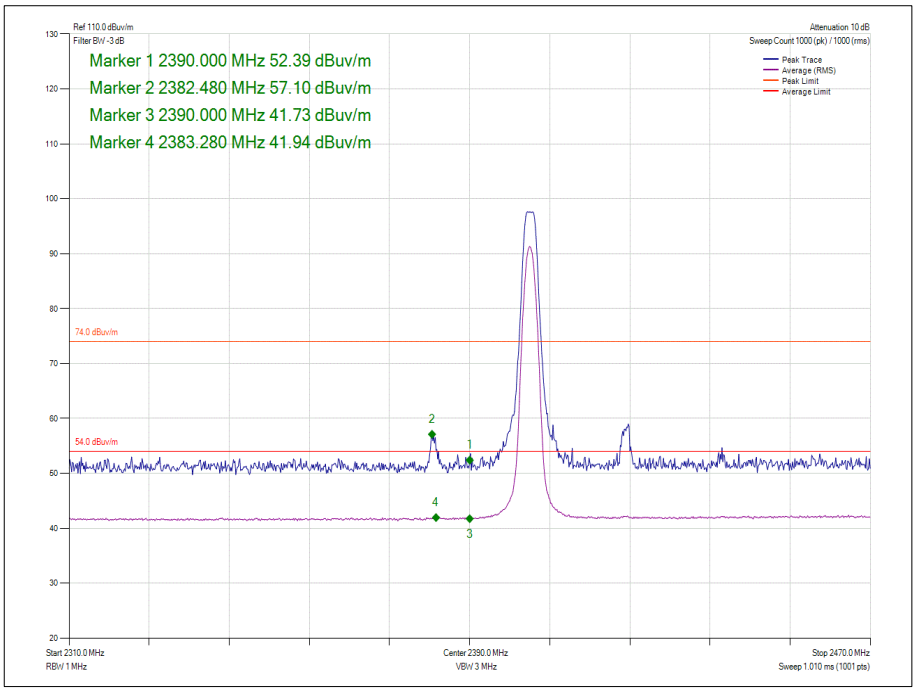


Figure 29 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

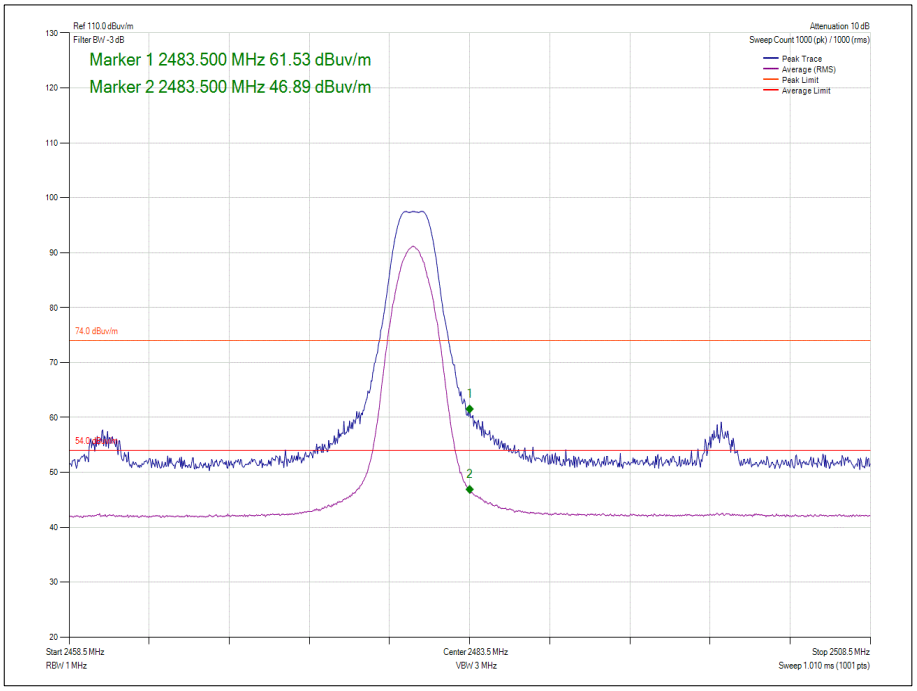


Figure 30 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

External Antenna - Bluetooth Low Energy (2M PHY)

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390	56.50	42.07
GFSK	2480	2483.5	60.43	46.91

Table 24 - Restricted Band Edge Results

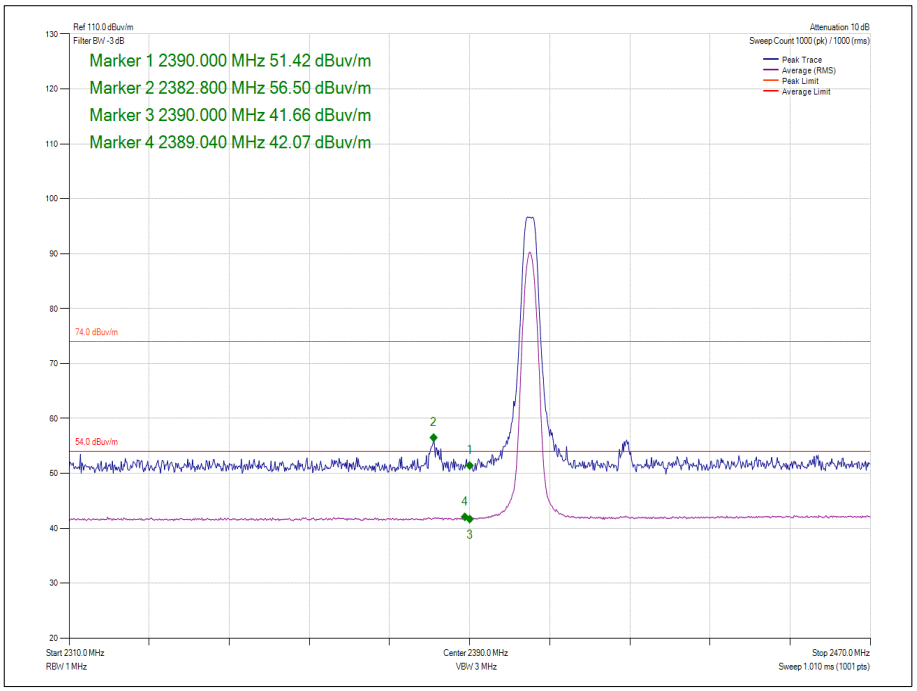


Figure 31 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

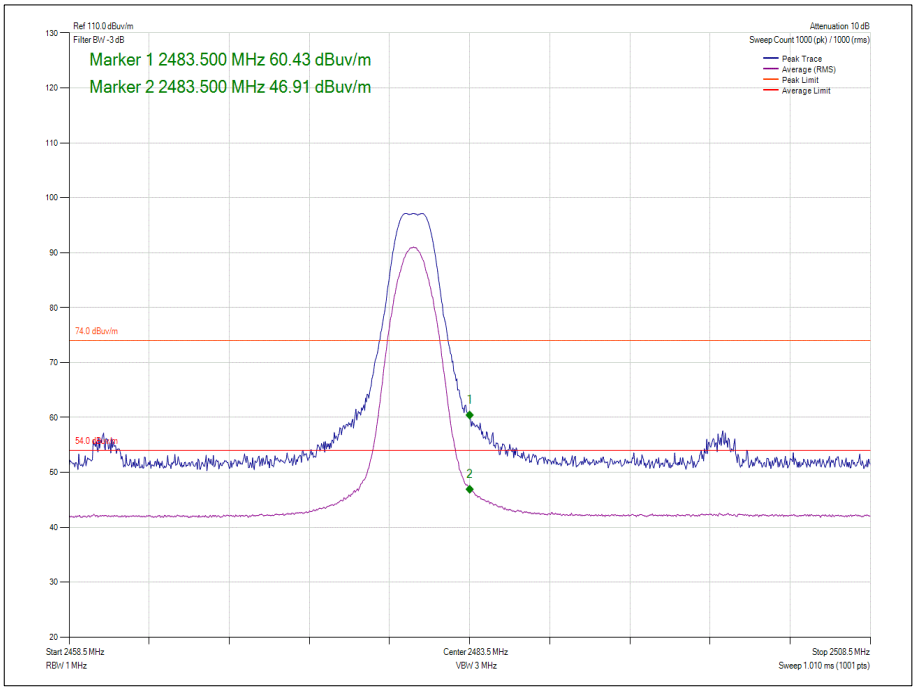


Figure 32 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

Internal Antenna - Custom Protocol - Alternative Channels

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2401	2390	55.64	41.93
GFSK	2481	2483.5	60.57	42.53

Table 25 - Restricted Band Edge Results

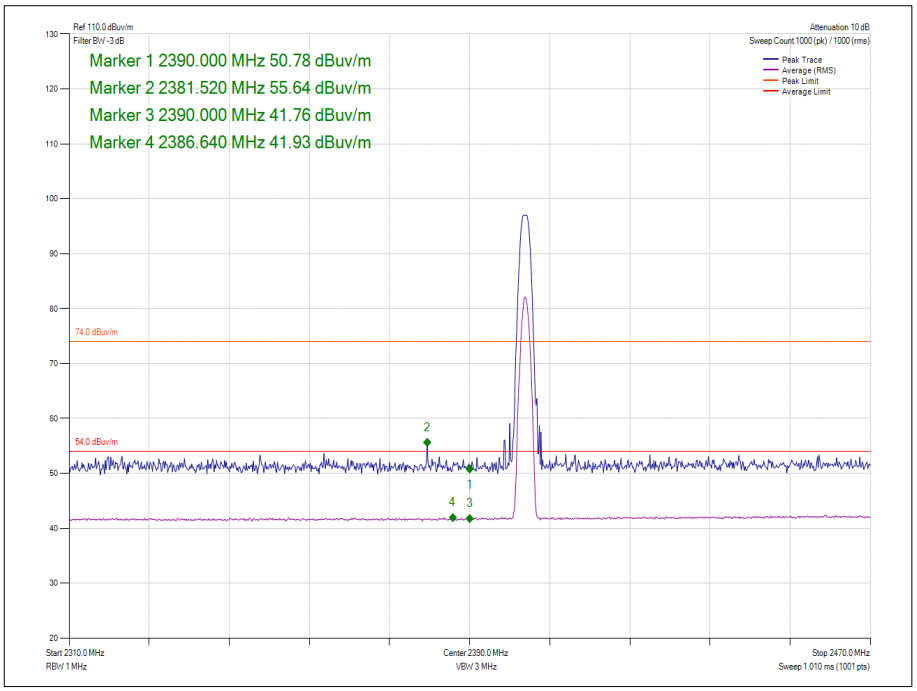


Figure 33 - GFSK - 2401 MHz - Band Edge Frequency 2390 MHz

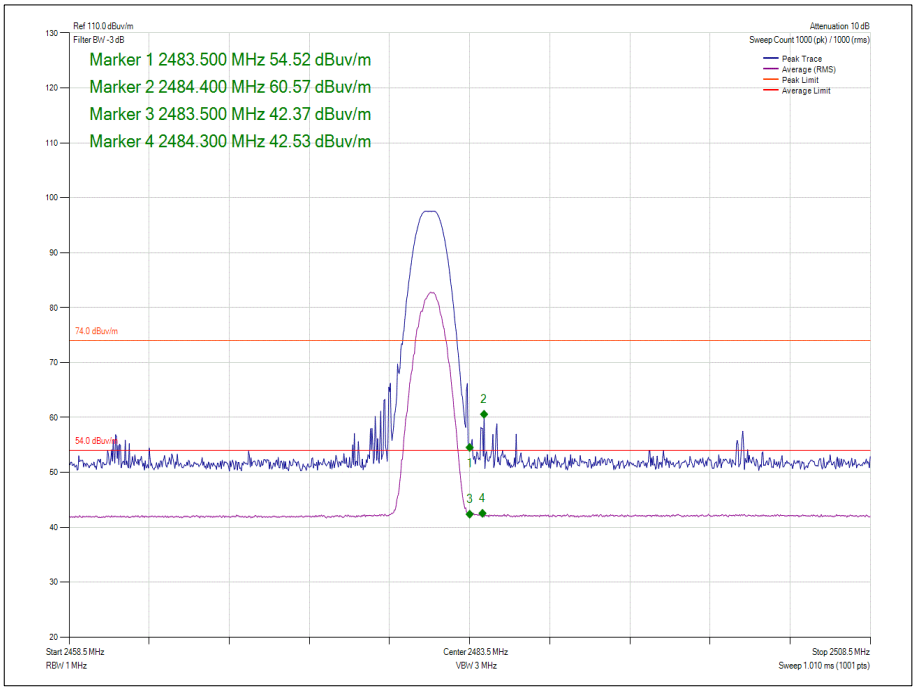


Figure 34 - GFSK - 2481 MHz - Band Edge Frequency 2483.5 MHz

External Antenna - Custom Protocol - Alternative Channels

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2401	2390	53.01	41.92
GFSK	2481	2483.5	60.10	42.49

Table 26 - Restricted Band Edge Results

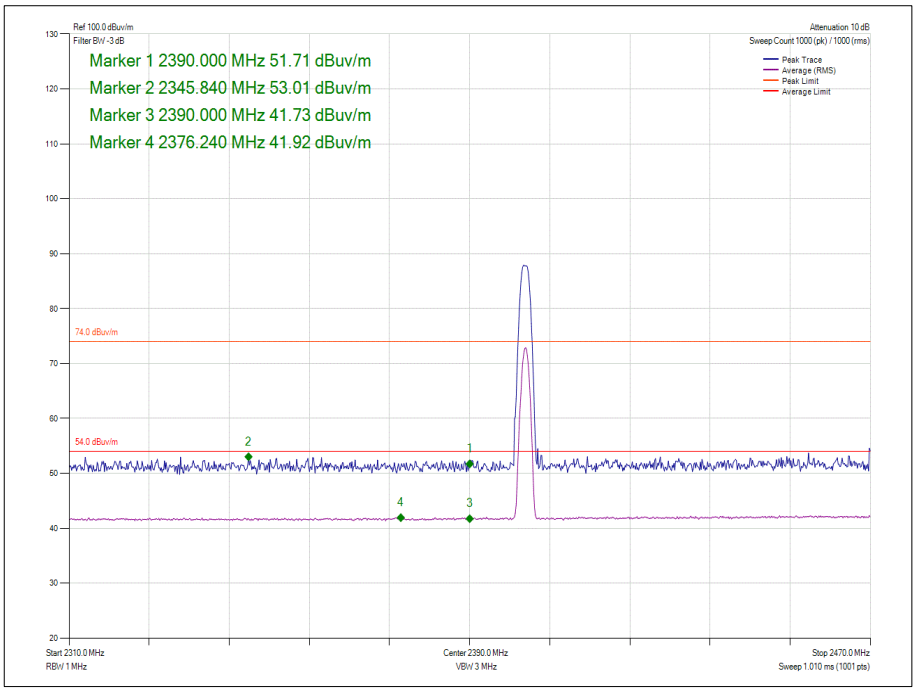


Figure 35 - GFSK - 2401 MHz - Band Edge Frequency 2390 MHz

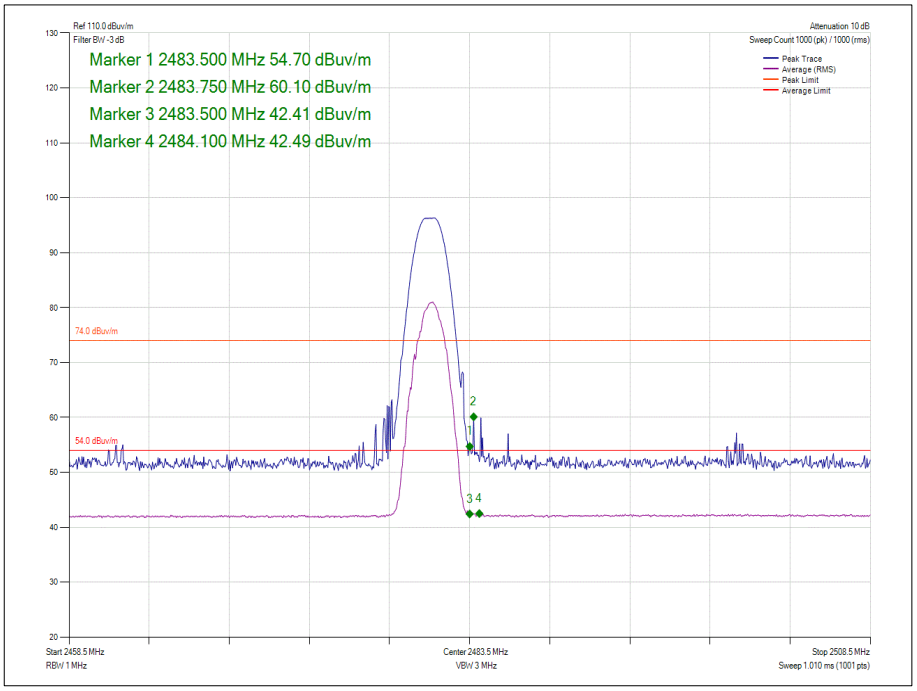


Figure 36 - GFSK - 2481 MHz - Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.209

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

Table 27

ISED RSS-GEN, Limit Clause 8.9

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

Table 28

*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.

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Power Supply	Farnell	D302T	609	-	O/P Mon
Multimeter	Iso-tech	IDM 101	2118	12	07-Feb-2021
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5092	12	006-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	006-Oct-2020
EmX Emissions Software	TUV SUD	EmX V.V1.5.7	5125	-	Software
Screened Room (11)	Rainford	-	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020

Table 29

TU – Traceability Unscheduled
O/P Mon – Output Monitored using calibrated test equipment.

2.6 Spurious Radiated Emissions

2.6.1 Specification Reference

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

2.6.2 Equipment Under Test and Modification State

BGM220S12A, S/N: Not Serialised (0075947809-TSR0011) - Modification State 0
BGM220S12A, S/N: Not Serialised (0075947809-TSR0017) - Modification State 0

2.6.3 Date of Test

20-February-2020 to 27-February-2020

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

Ports on the EUT were terminated with loads as described in ANSI C63.4 clause 6.2.4. For EUT's with multiple connectors of the same type, additional interconnecting cables were connected, and pre-scans performed to determine whether the level of the emissions were increased by >2 dB.

For frequencies > 1 GHz, plots for average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.5 to characterize the EUT. Where emissions were detected, final average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.2.

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

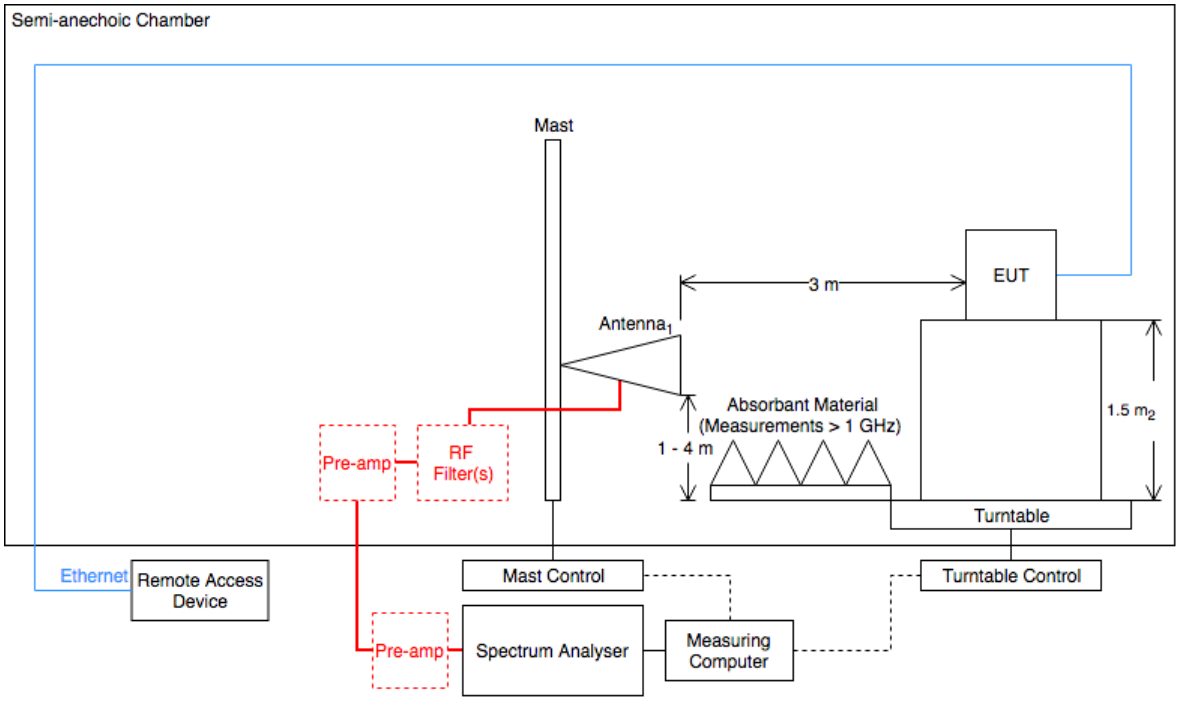
The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

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

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

Representative noise floor plots are presented in the plot section of the report for one operating channel only.

Where formal measurements have been necessary, the results have been presented in the emissions table.



1 Antenna is boresighted for measurements < 1 GHz.
2 Height from the EUT to ground is 0.8 m for measurements < 1 GHz.

Figure 37- Radiated Emissions Test Setup Diagram

2.6.5 Environmental Conditions

Ambient Temperature	20.2 - 21.5 °C
Relative Humidity	32.8 - 46.5 %

2.6.6 Test Results

Internal Antenna - Bluetooth Low Energy (1M PHY)

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

Table 30 - Radiated Emissions Results, 30 MHz to 1 GHz - 2402 MHz

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

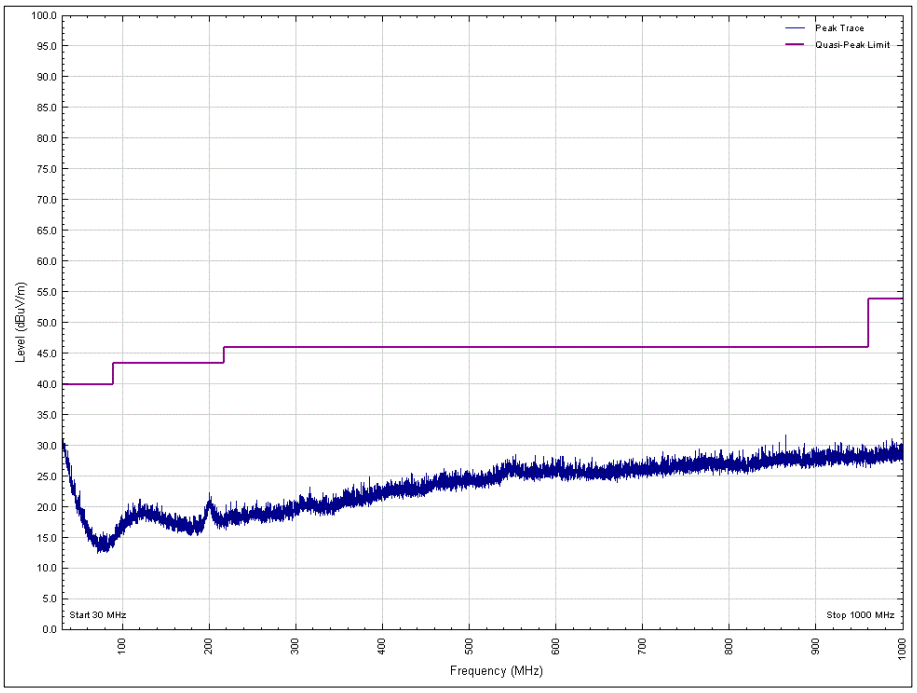


Figure 38 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation X

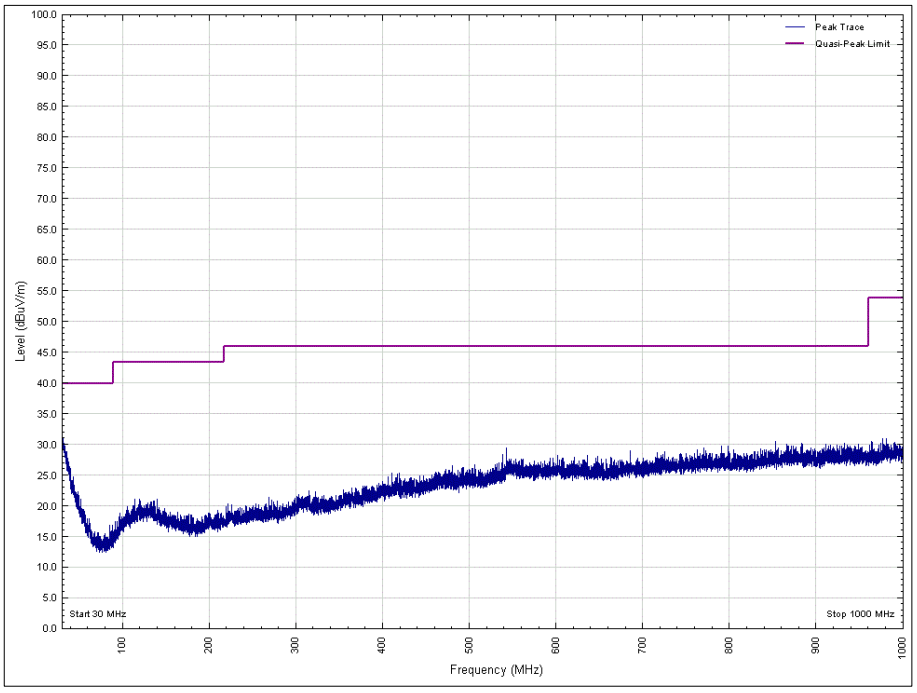


Figure 39 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation X

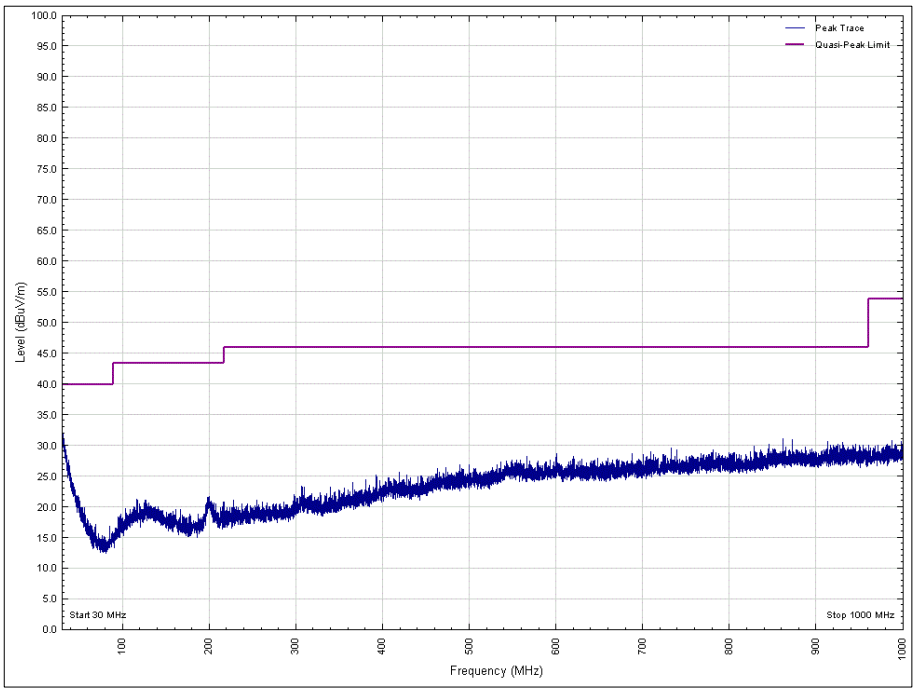


Figure 40 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation Y

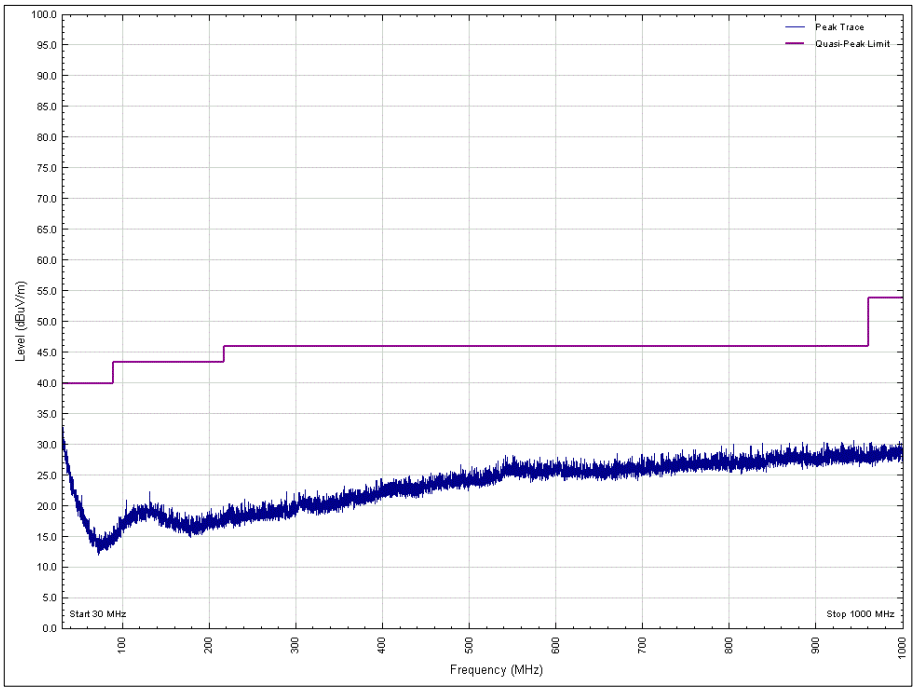


Figure 41 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation Y

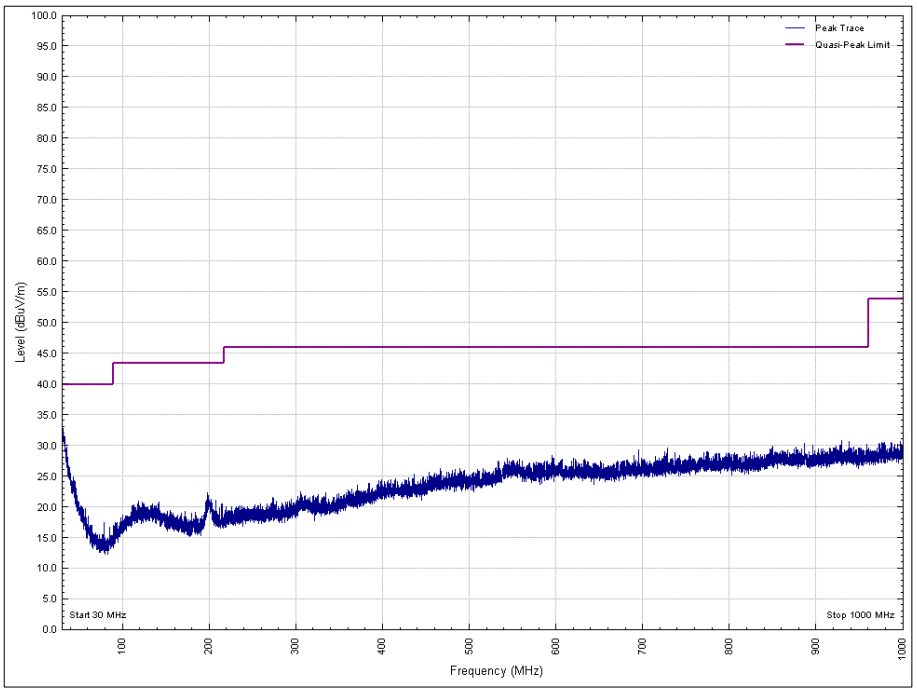


Figure 42 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation Z

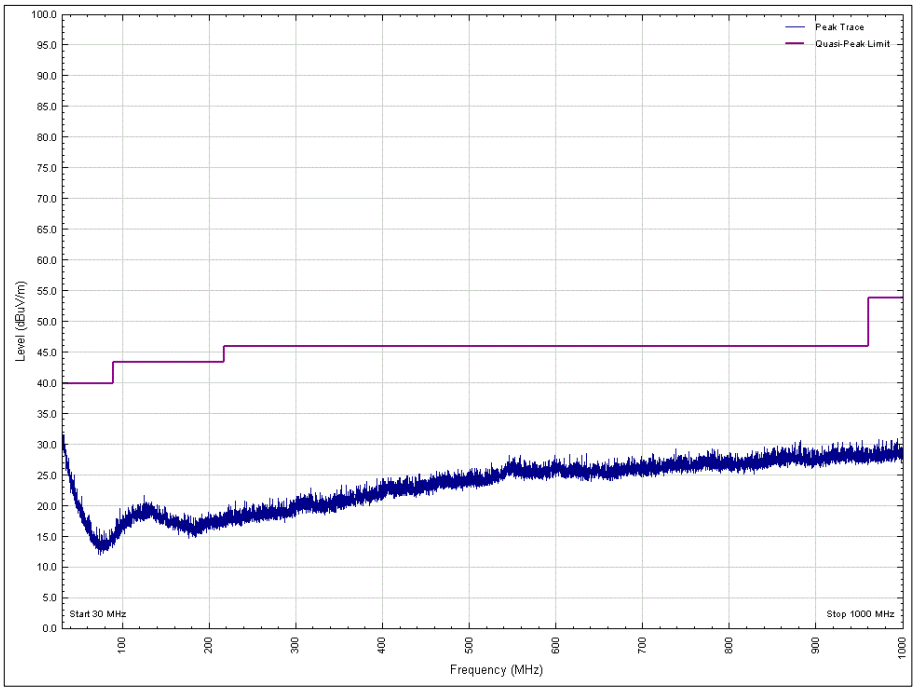


Figure 43 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation Z

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

Table 31 - 2402 MHz - 1 GHz to 25 GHz Emissions Results

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

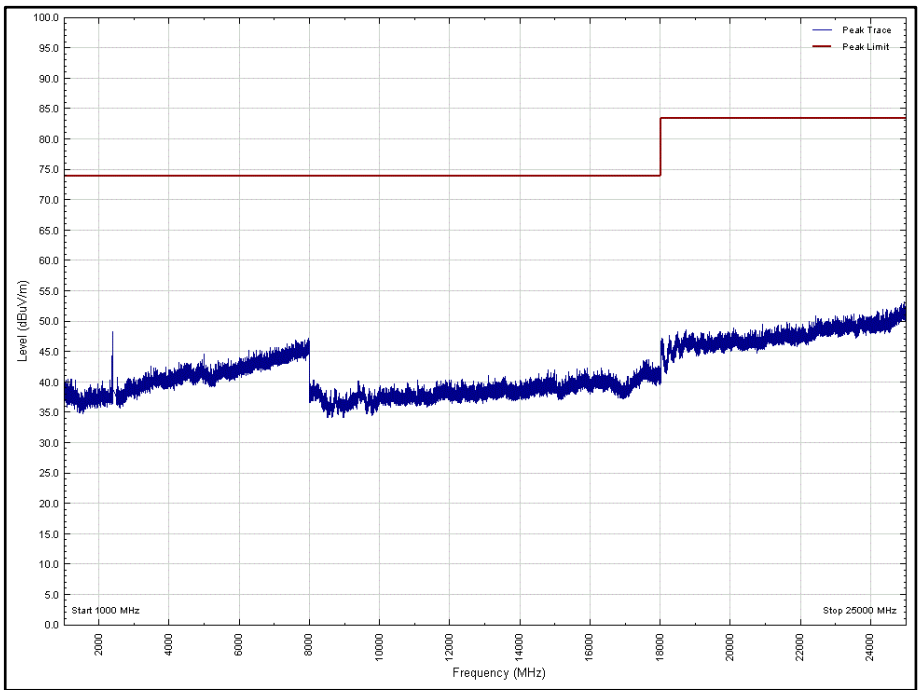


Figure 44 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

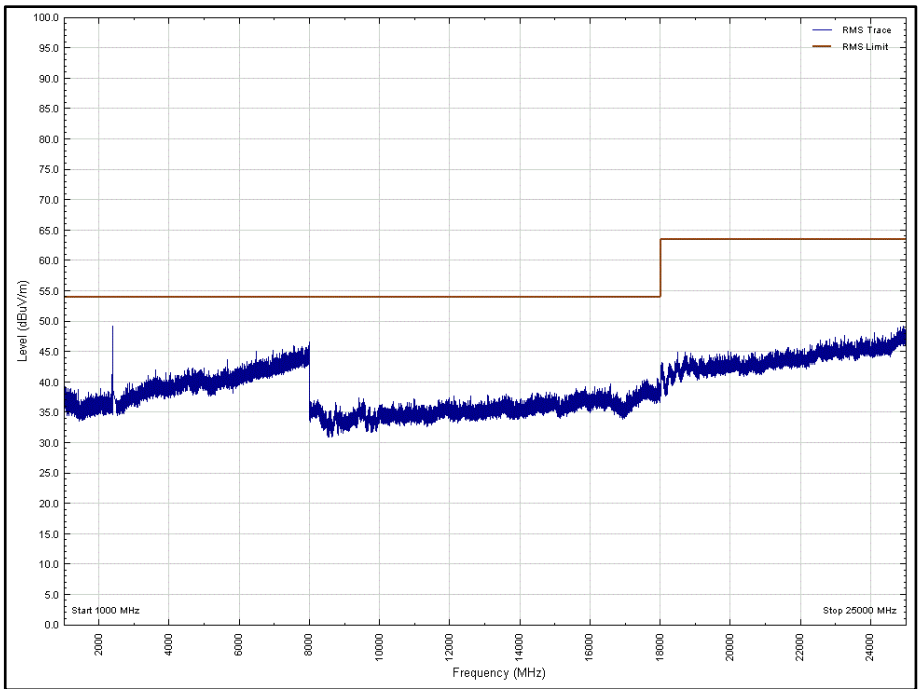


Figure 45 - 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

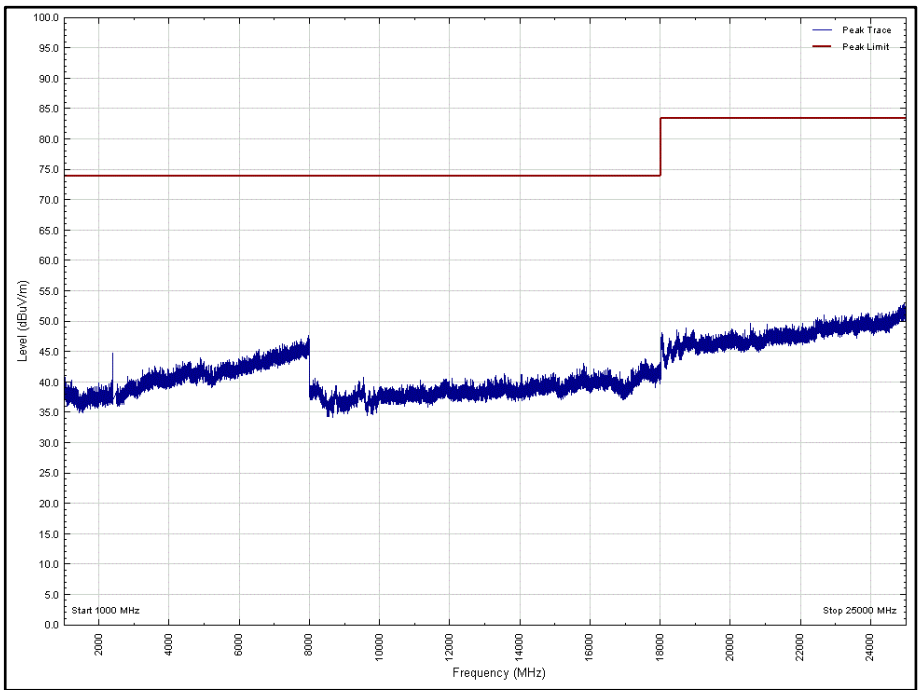


Figure 46 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

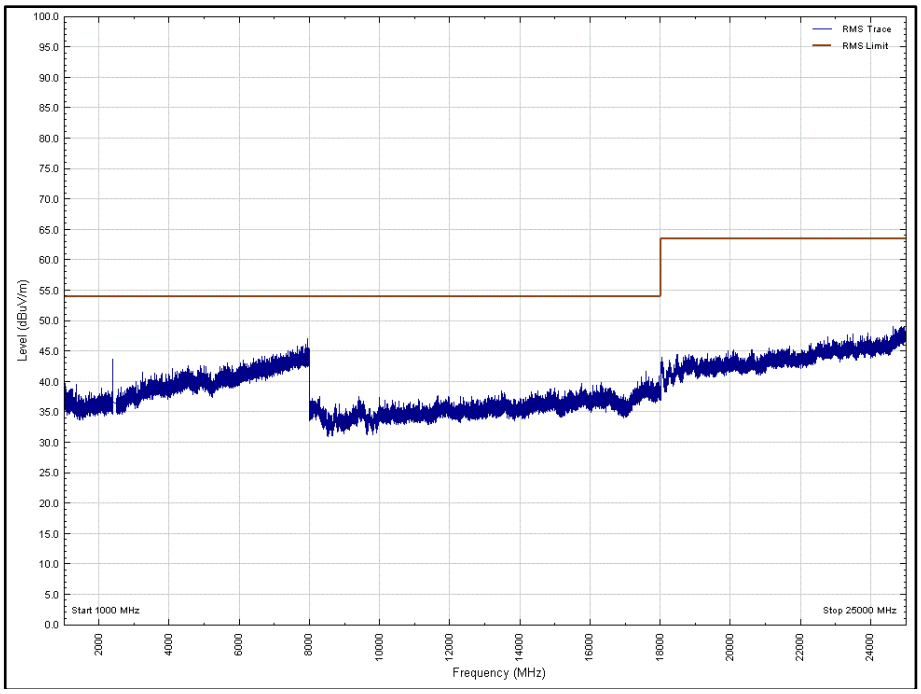


Figure 47 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

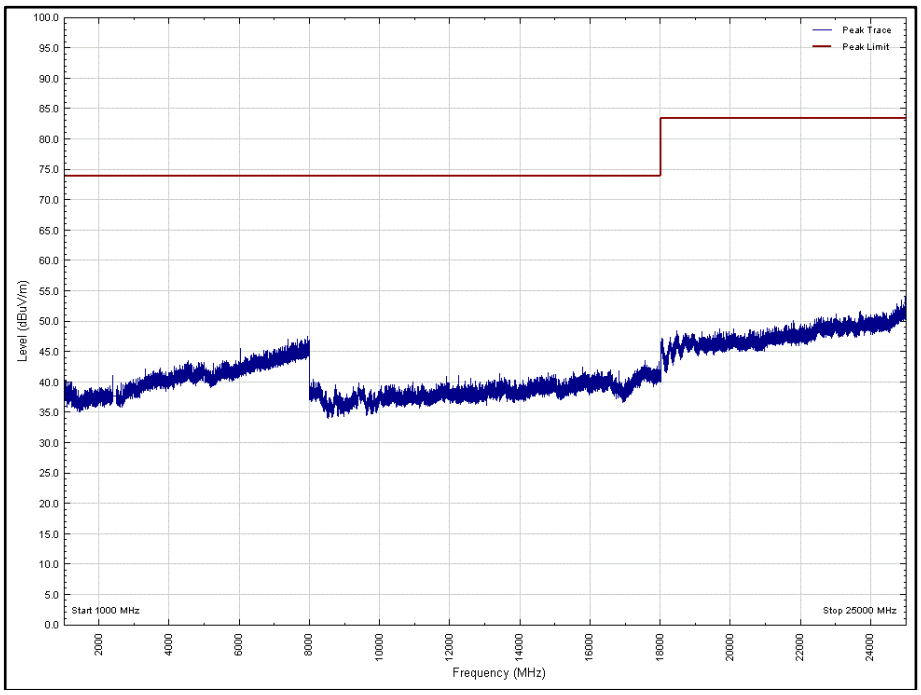


Figure 48 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

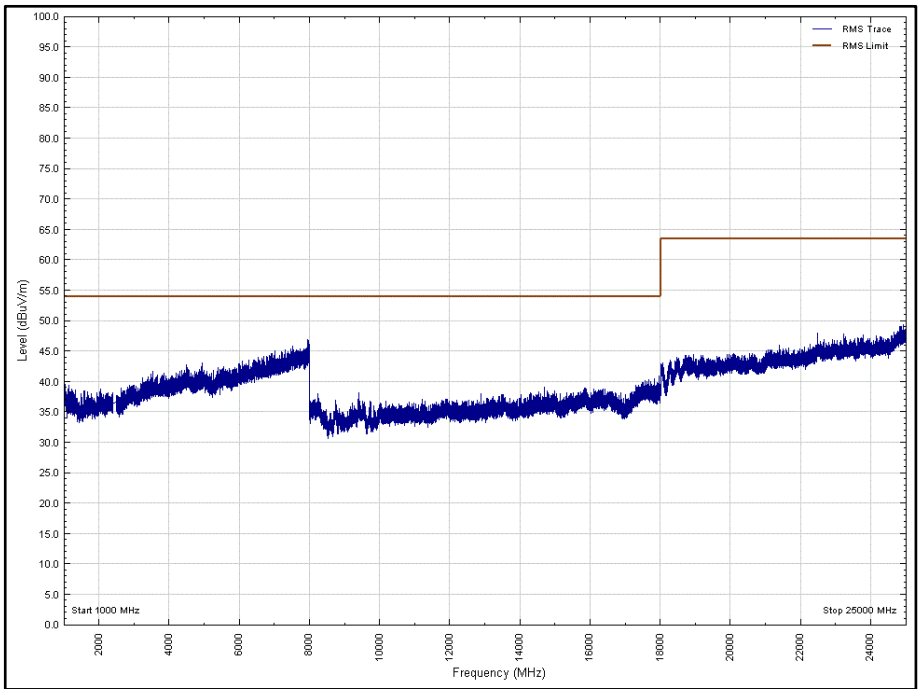


Figure 49 - 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

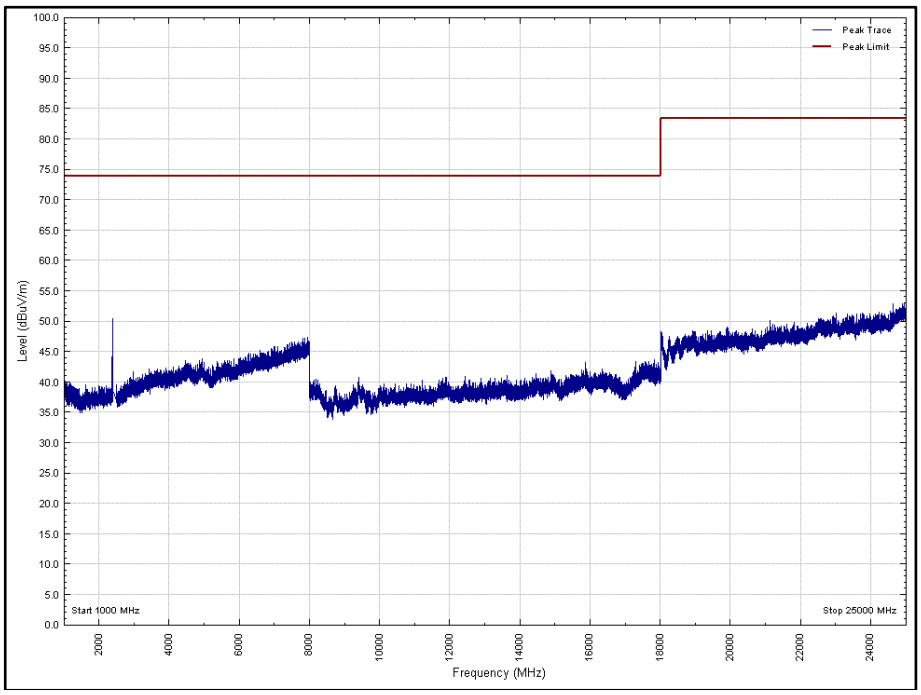


Figure 50 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

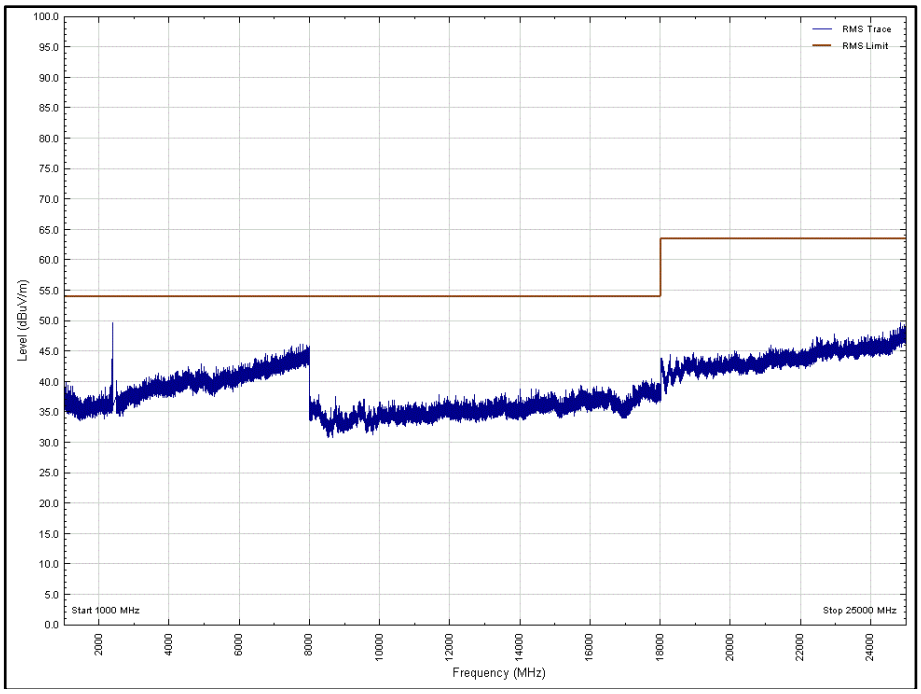


Figure 51 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

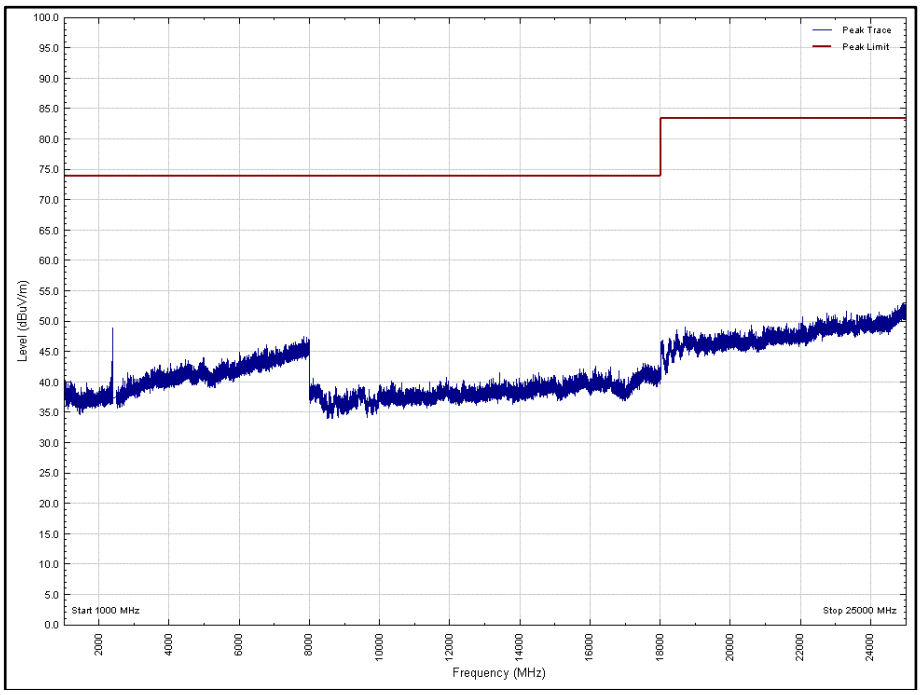


Figure 52 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

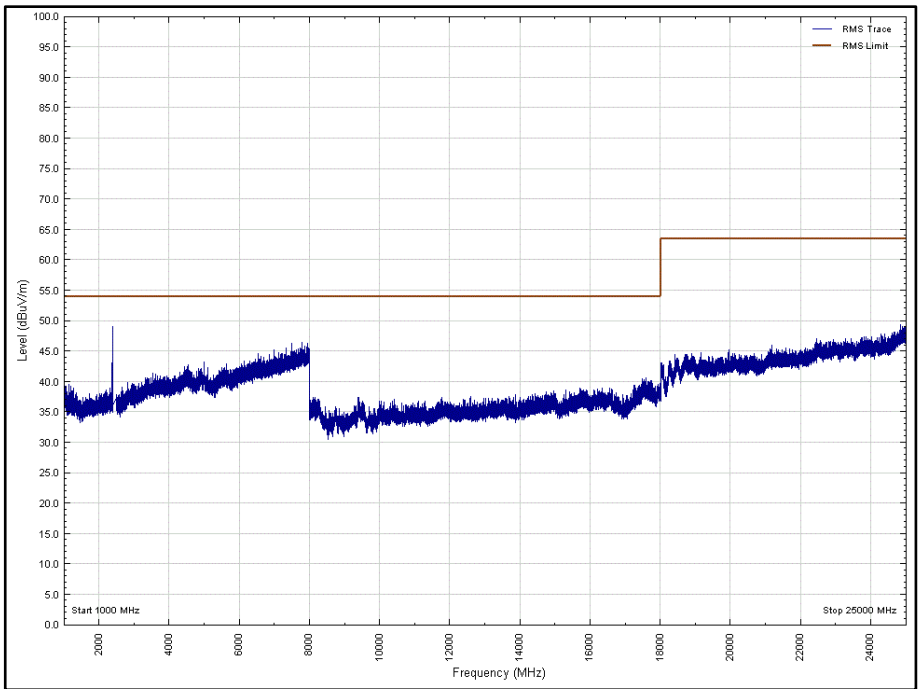


Figure 53 - 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

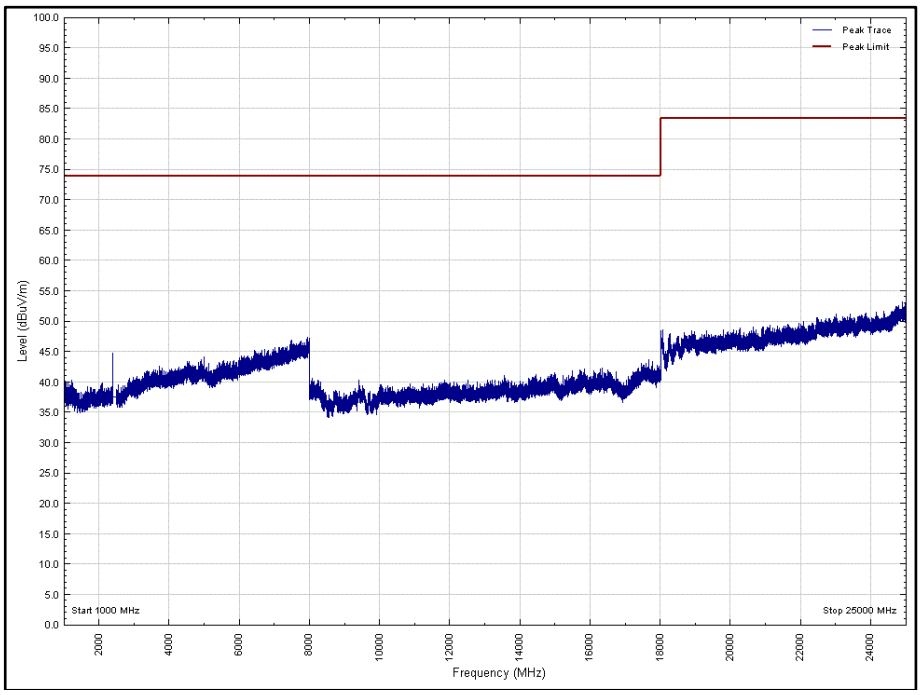


Figure 54 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

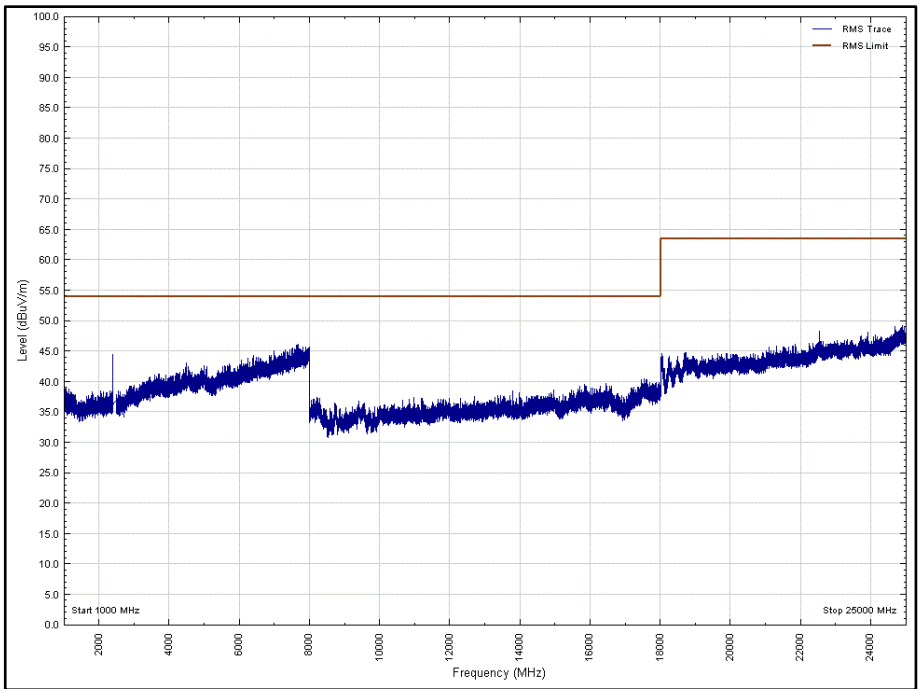


Figure 55 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

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

Table 32 - Radiated Emissions Results, 30 MHz to 1 GHz - 2440 MHz

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

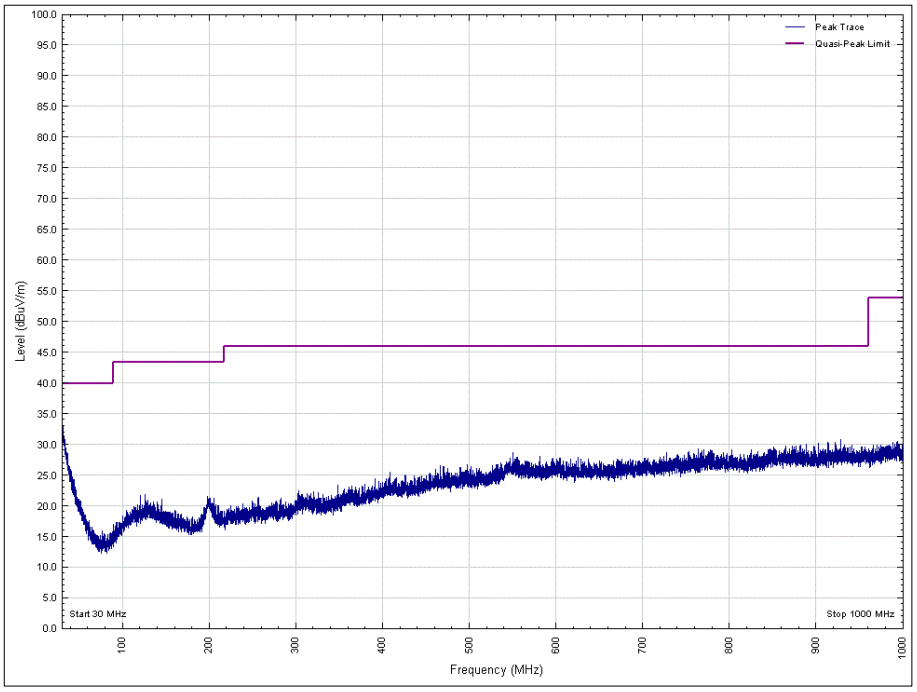


Figure 56 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation X

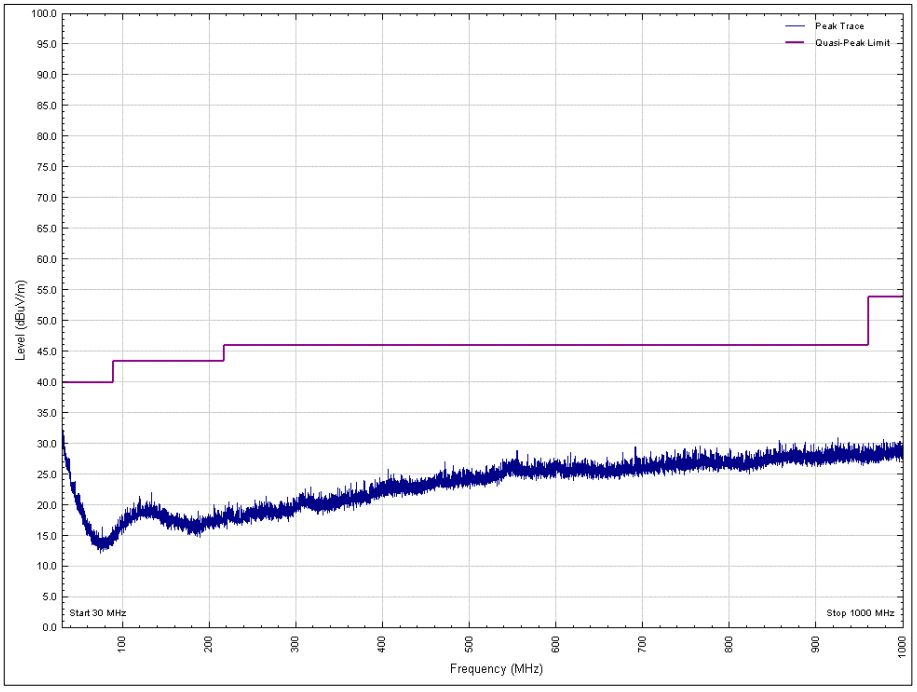


Figure 57 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation X

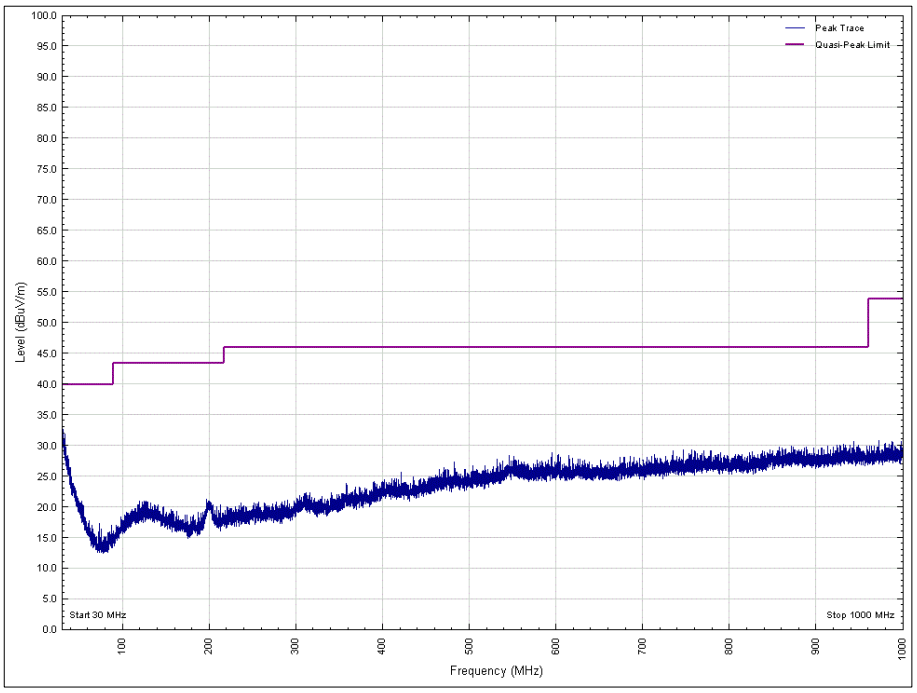


Figure 58 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation Y

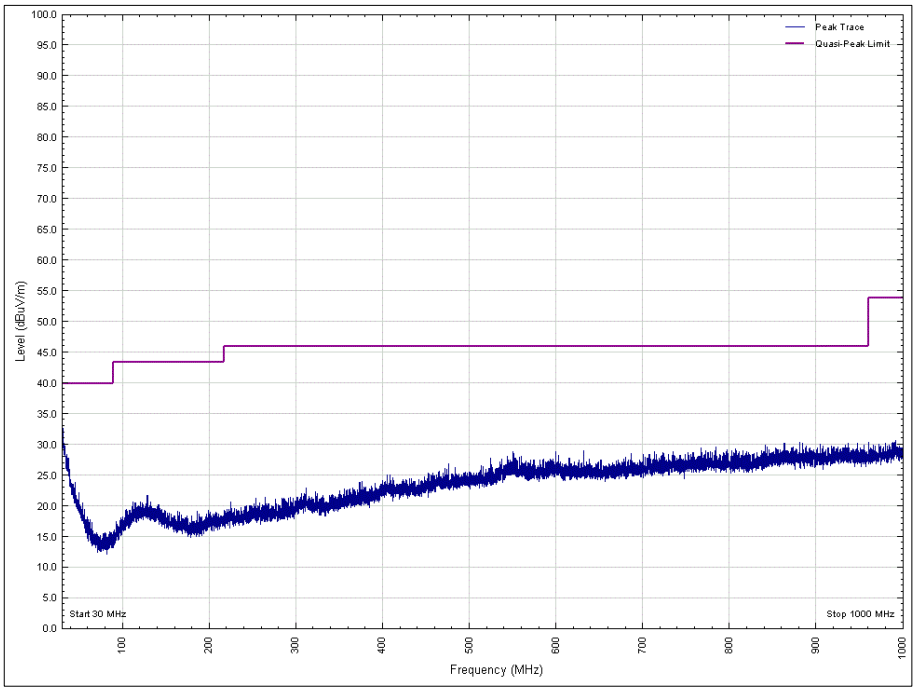


Figure 59 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation Y

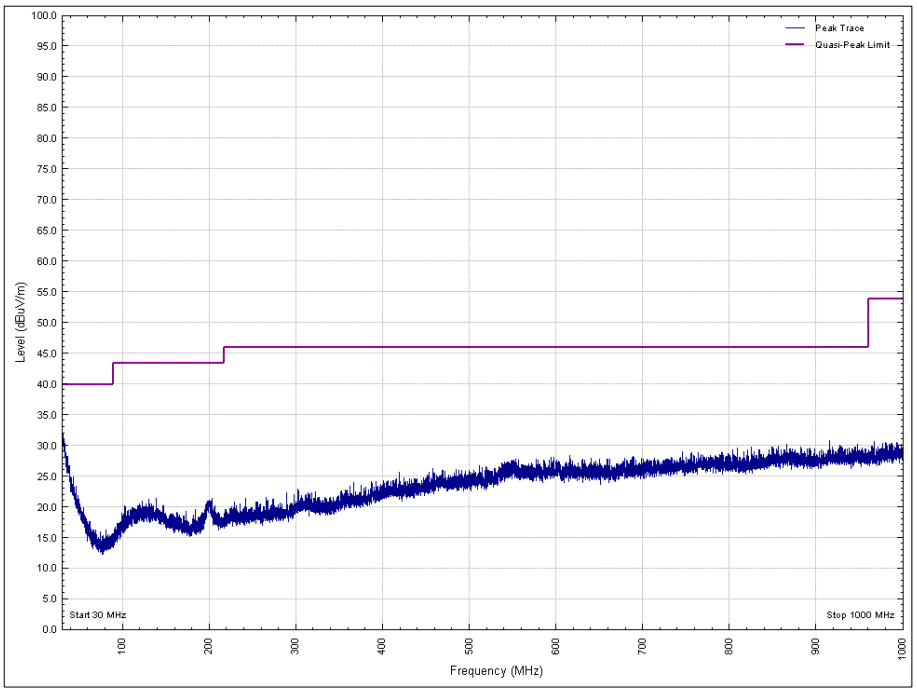


Figure 60 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation Z

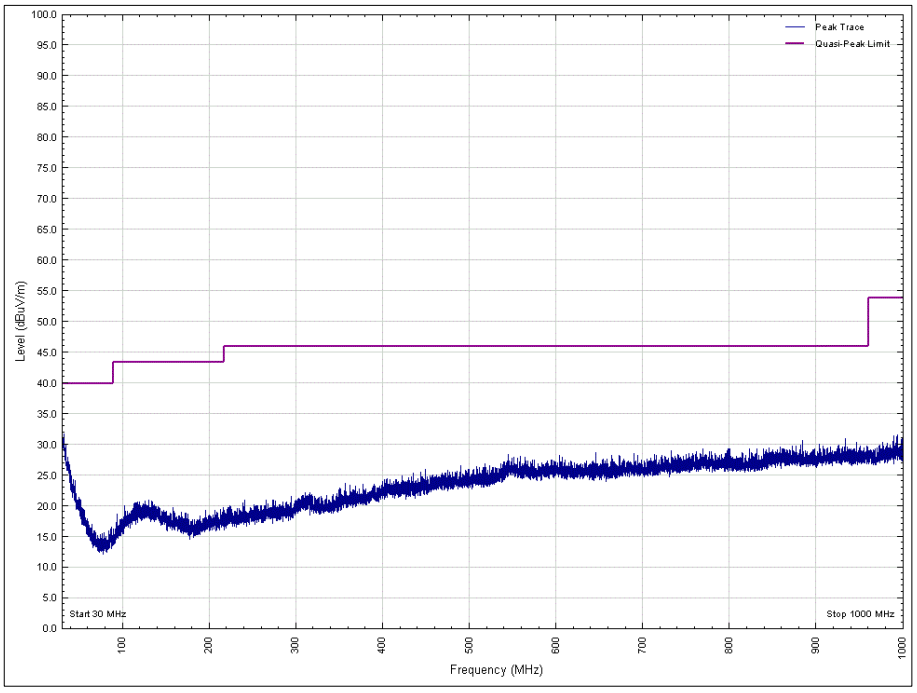


Figure 61 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation Z

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

Table 33 - 2440 MHz - 1 GHz to 25 GHz Emissions Results

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

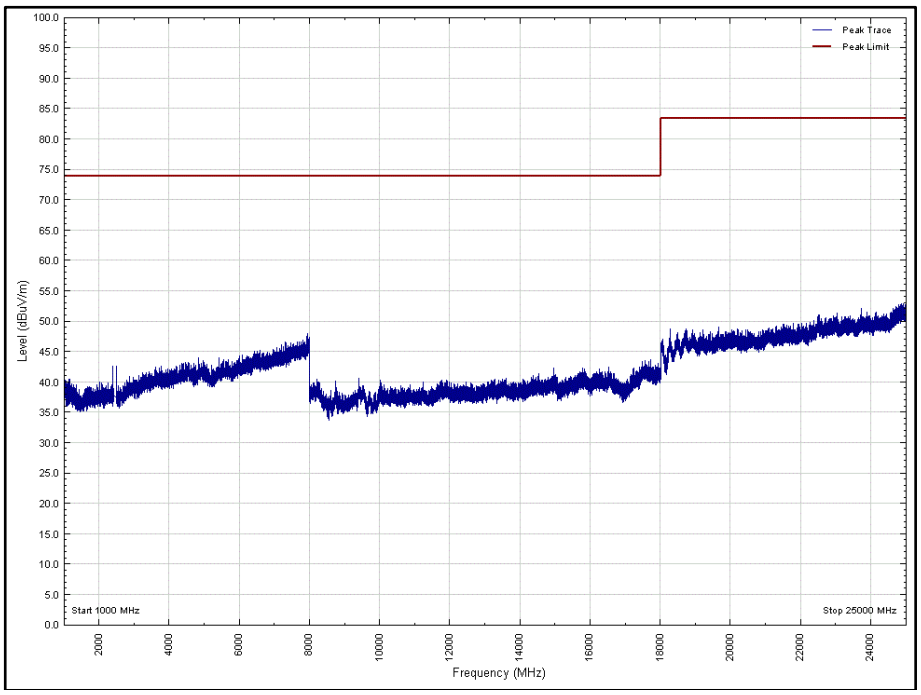


Figure 62 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

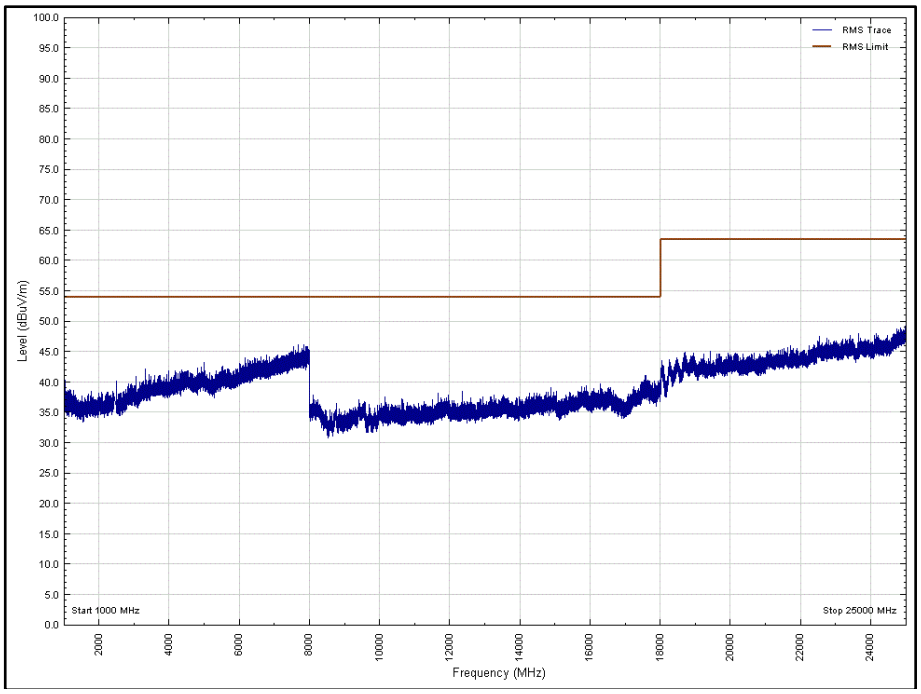


Figure 63 - 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

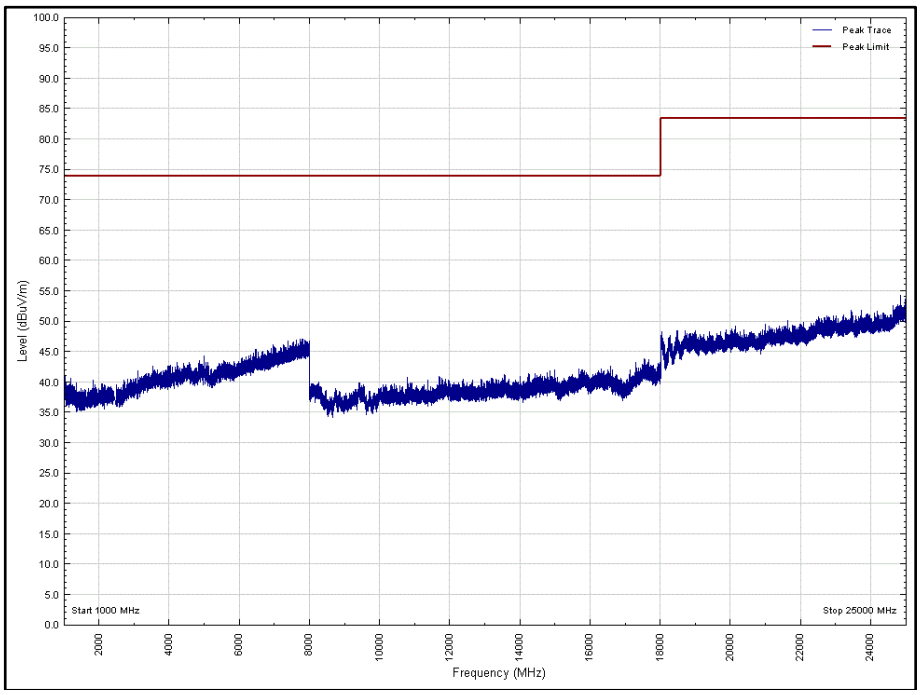


Figure 64 - 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

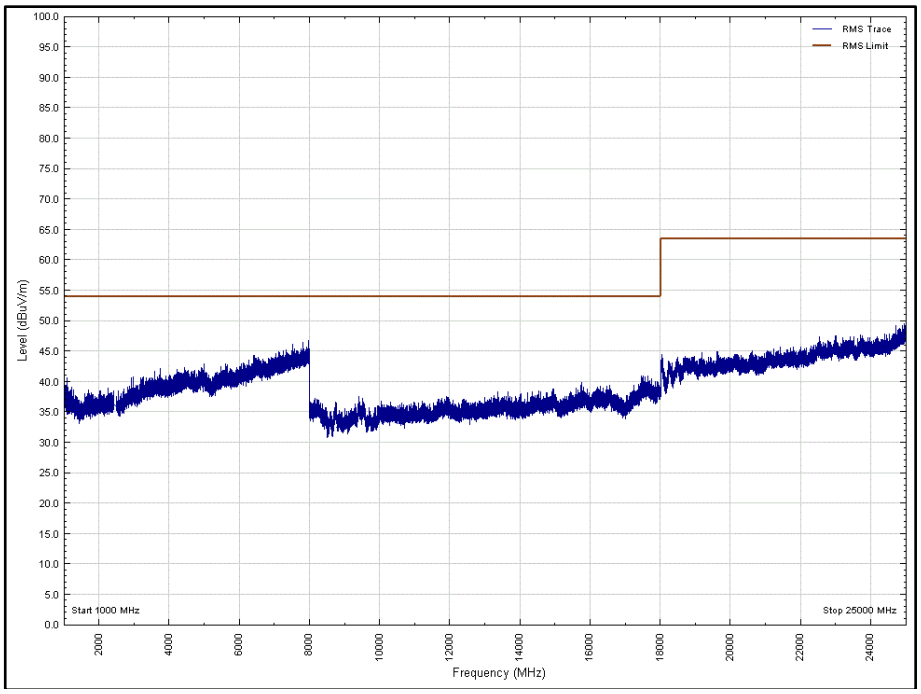


Figure 65 - 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

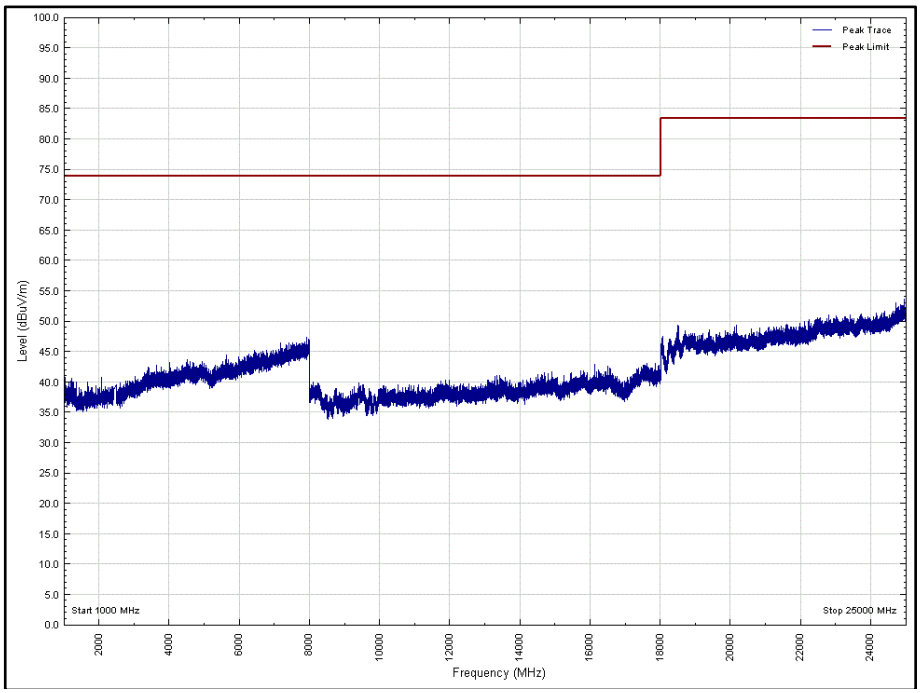


Figure 66 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

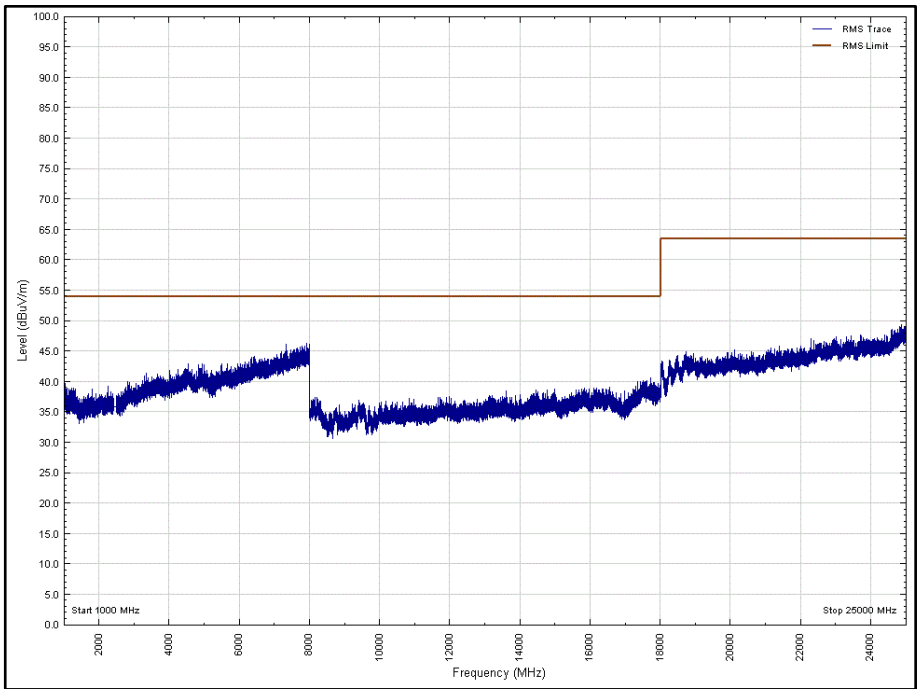


Figure 67 - 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

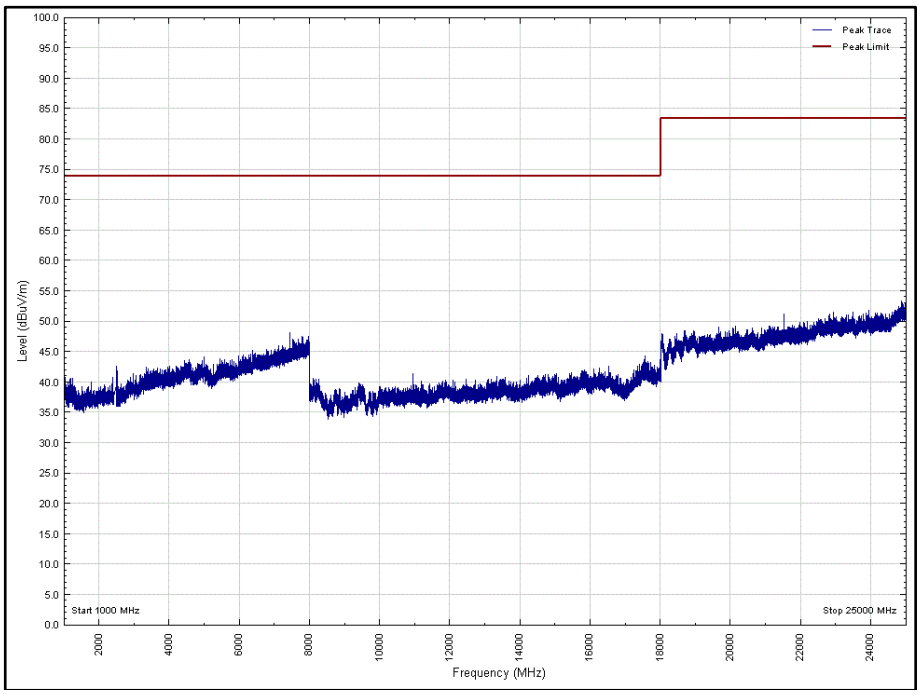


Figure 68 – 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

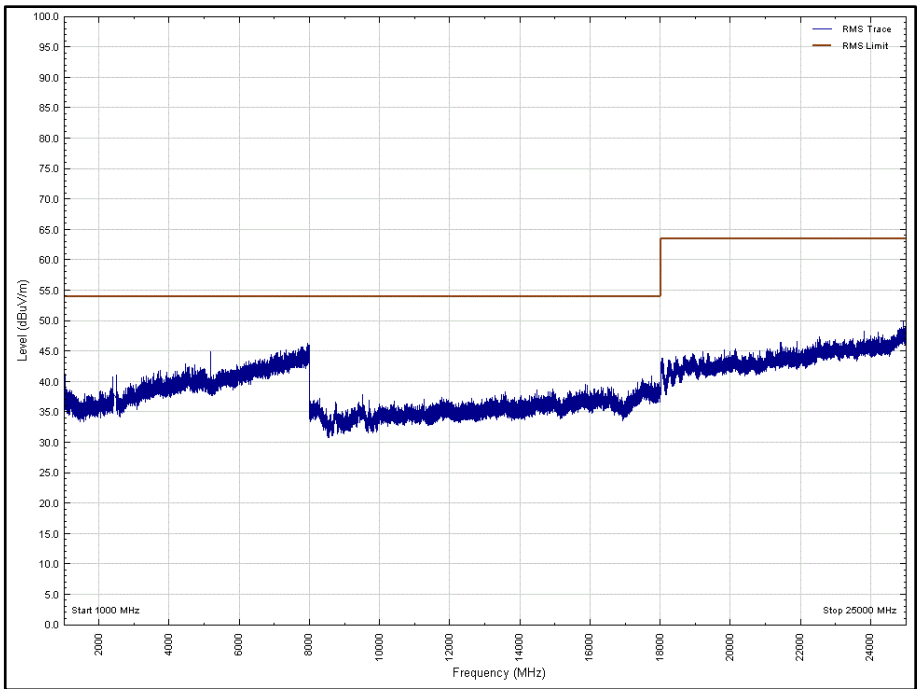


Figure 69 – 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

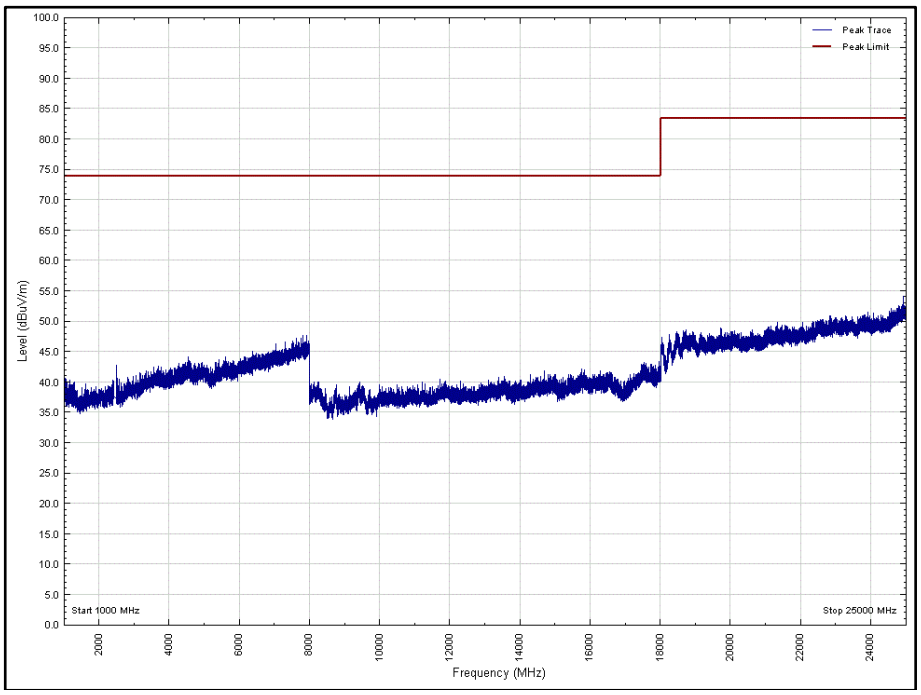


Figure 70 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

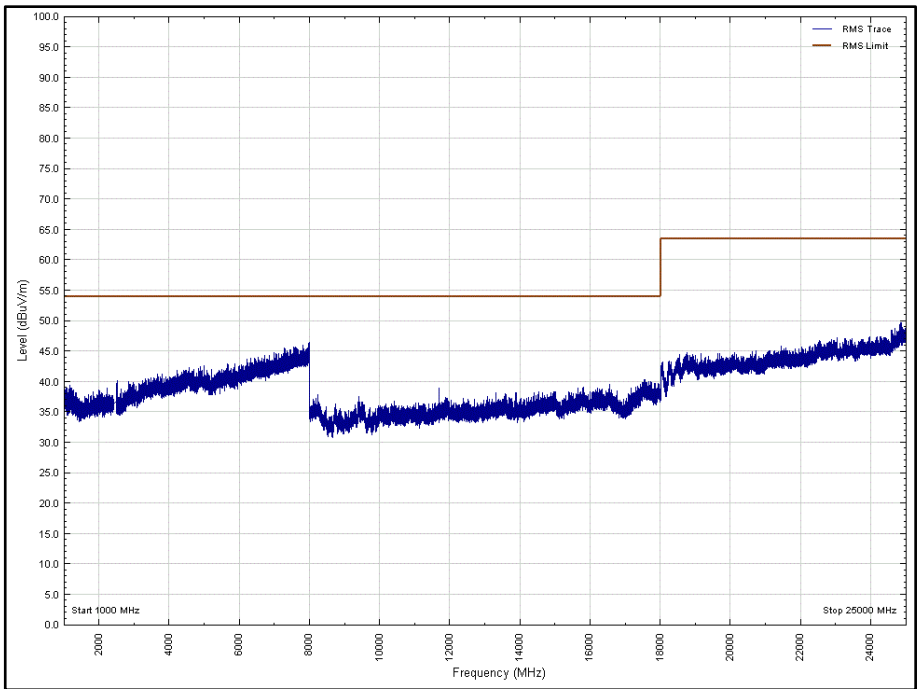


Figure 71 - 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

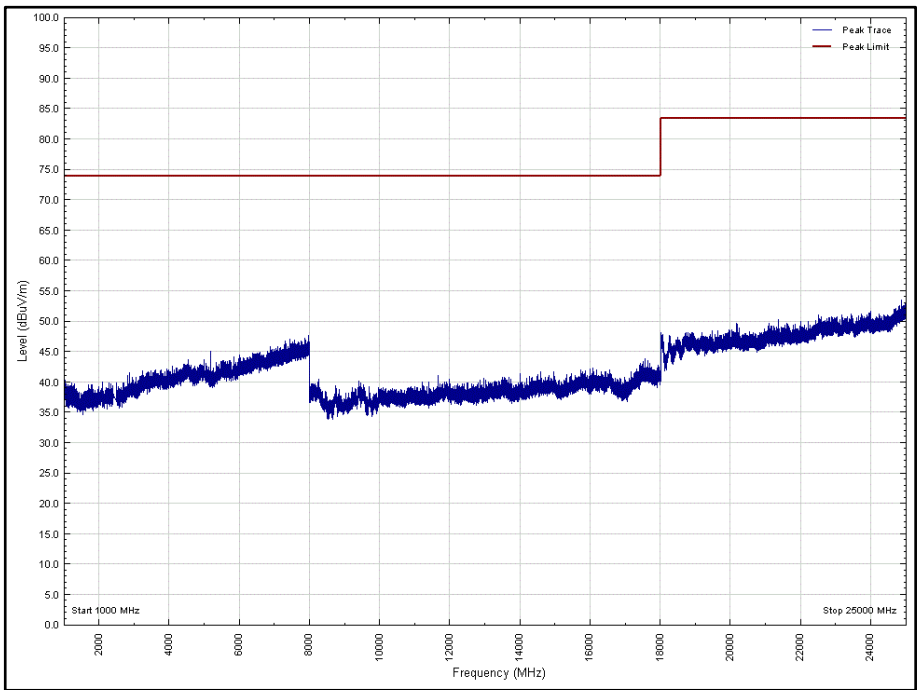


Figure 72 - 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

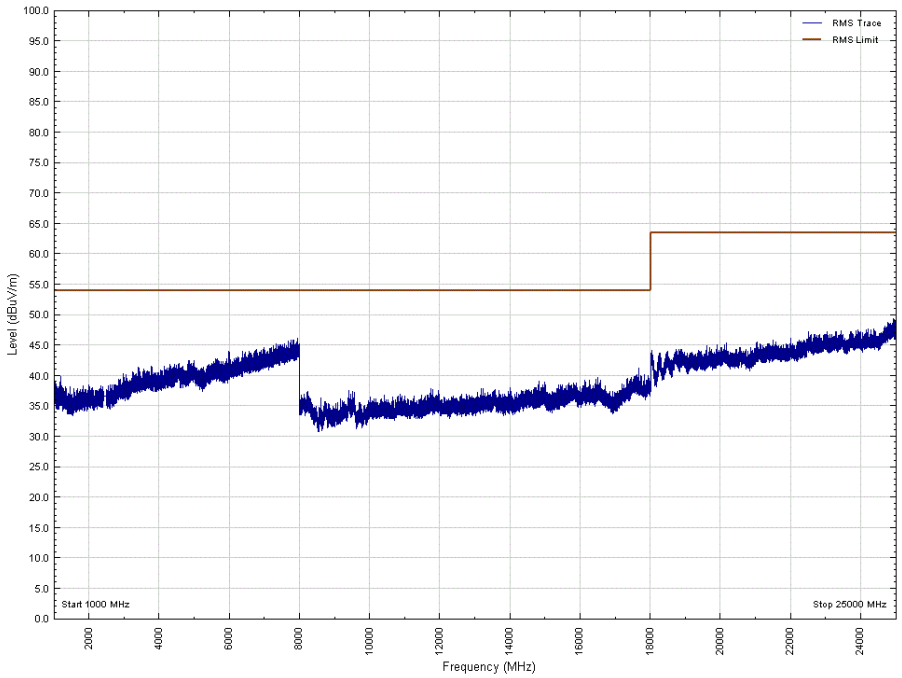


Figure 73 - 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

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

Table 34 - Radiated Emissions Results, 30 MHz to 1 GHz - 2480 MHz

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

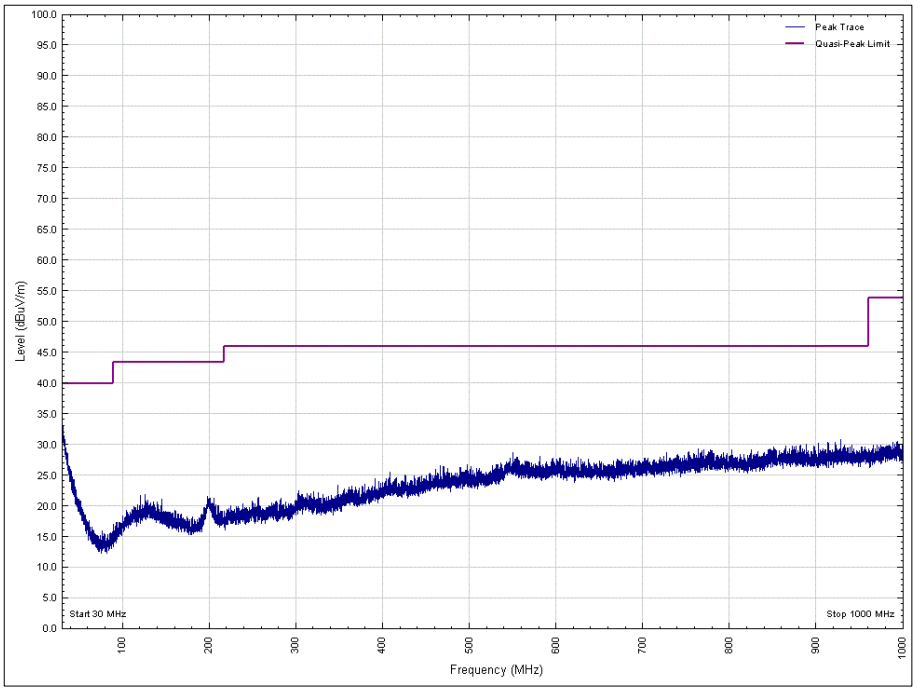


Figure 74 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation X

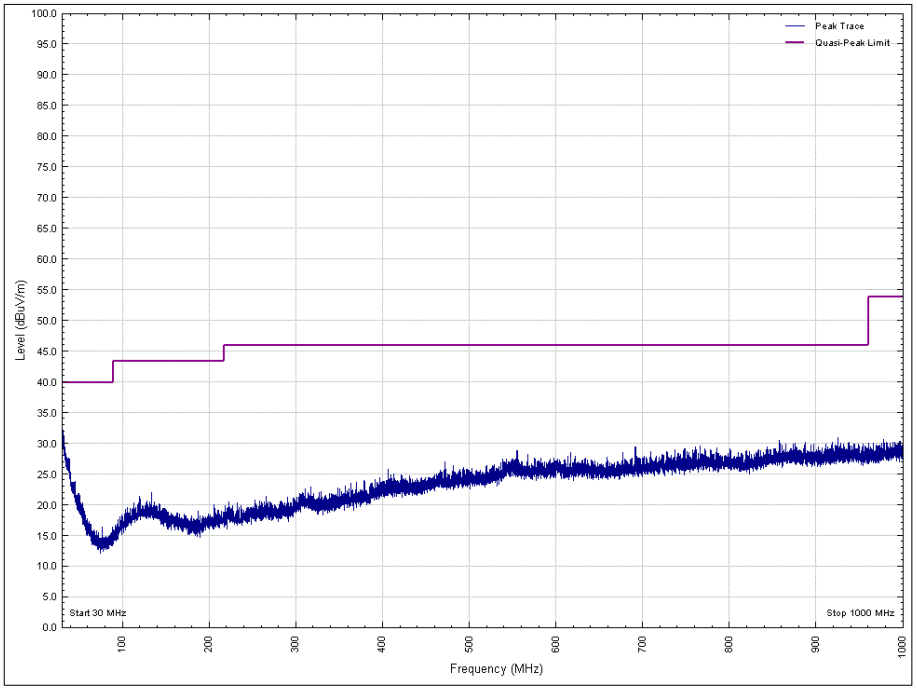


Figure 75 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation X

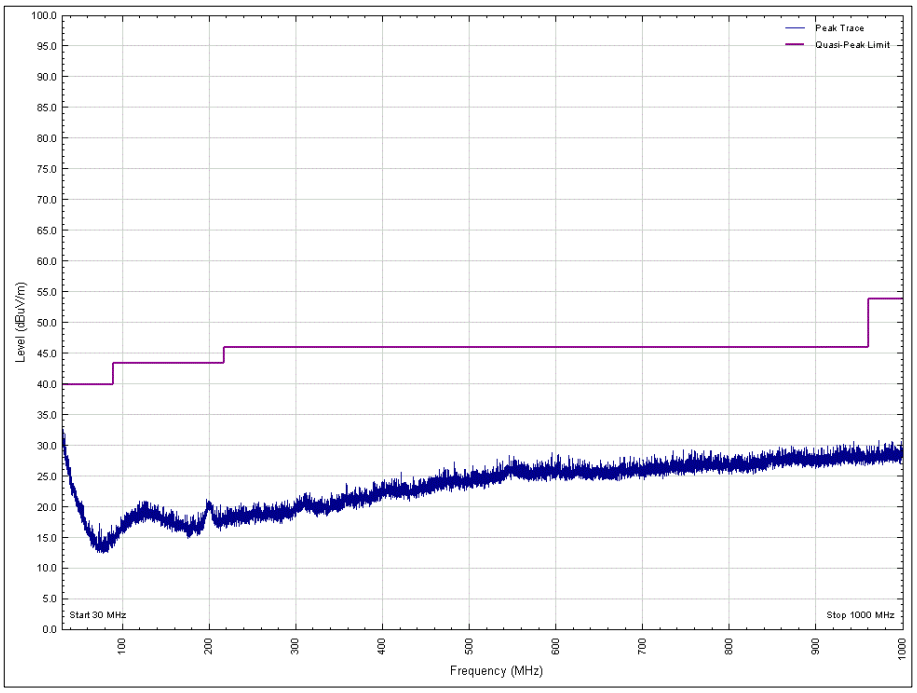


Figure 76 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation Y

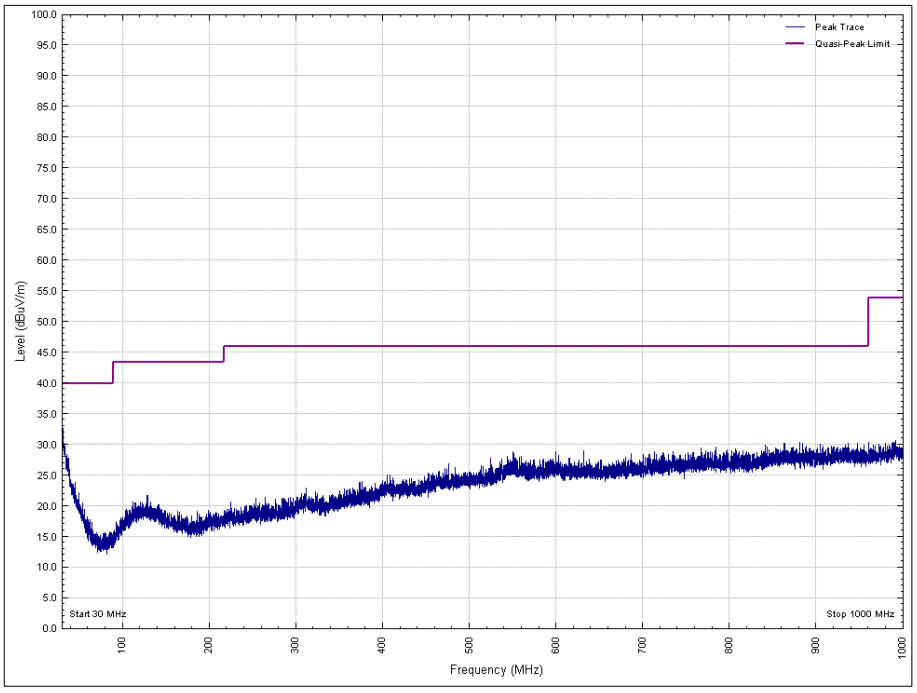


Figure 77 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation Y

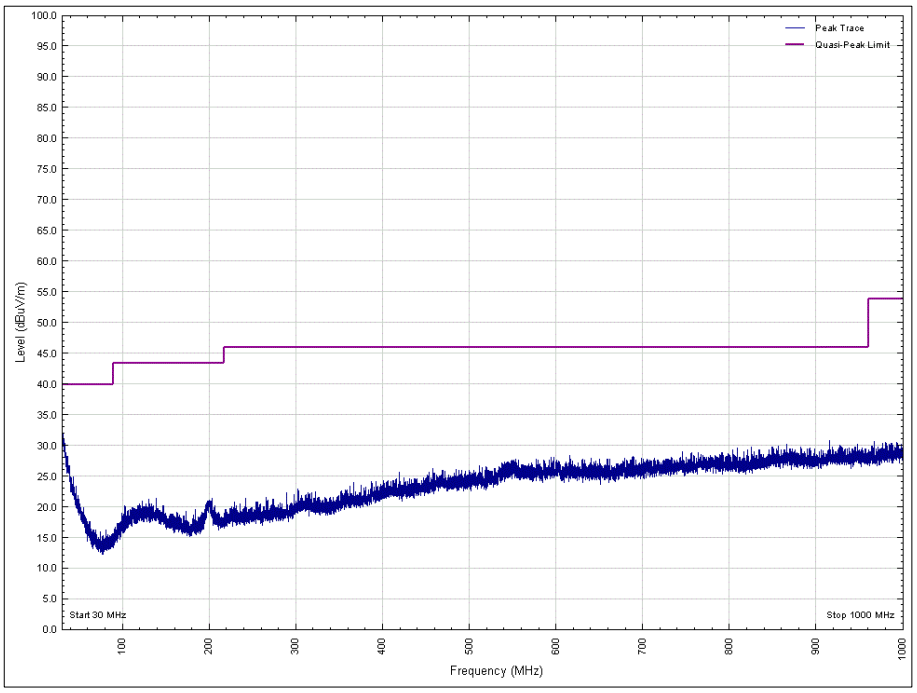


Figure 78 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation Z

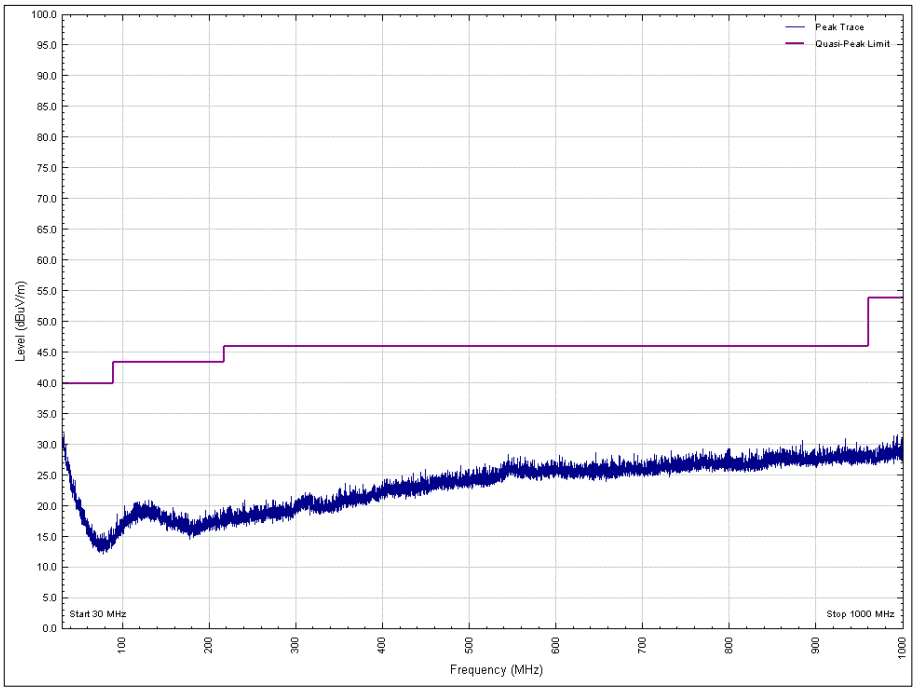


Figure 79 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation Z

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

Table 35 - 2480 MHz - 1 GHz to 25 GHz Emissions Results

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

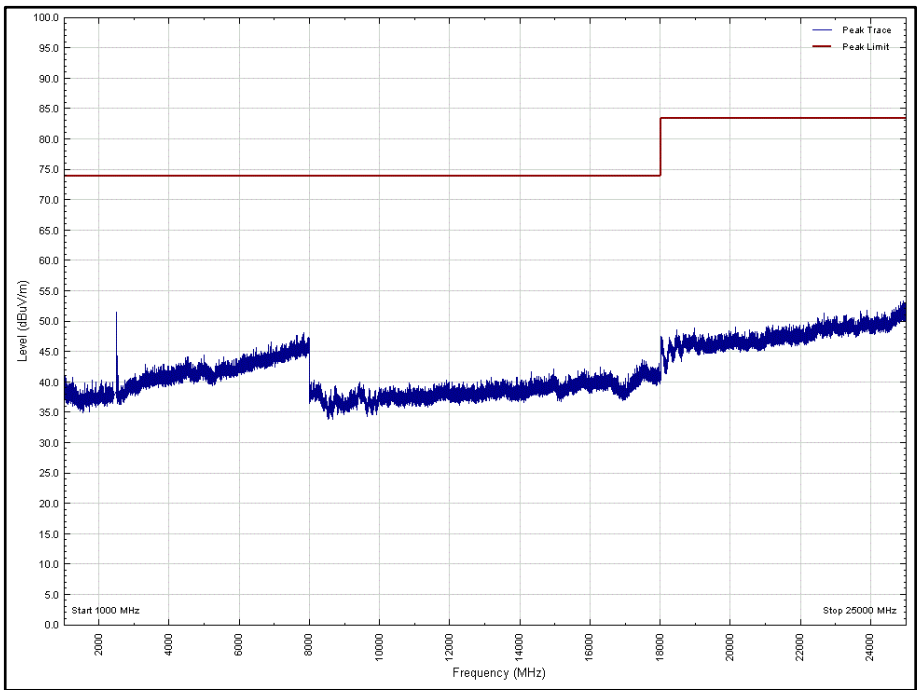


Figure 80 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

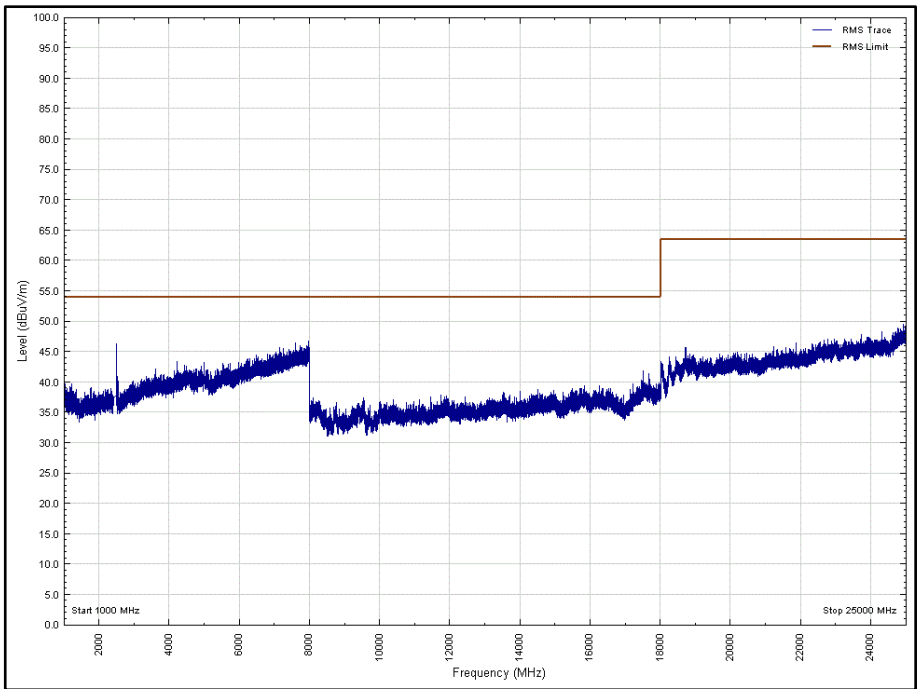


Figure 81 - 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

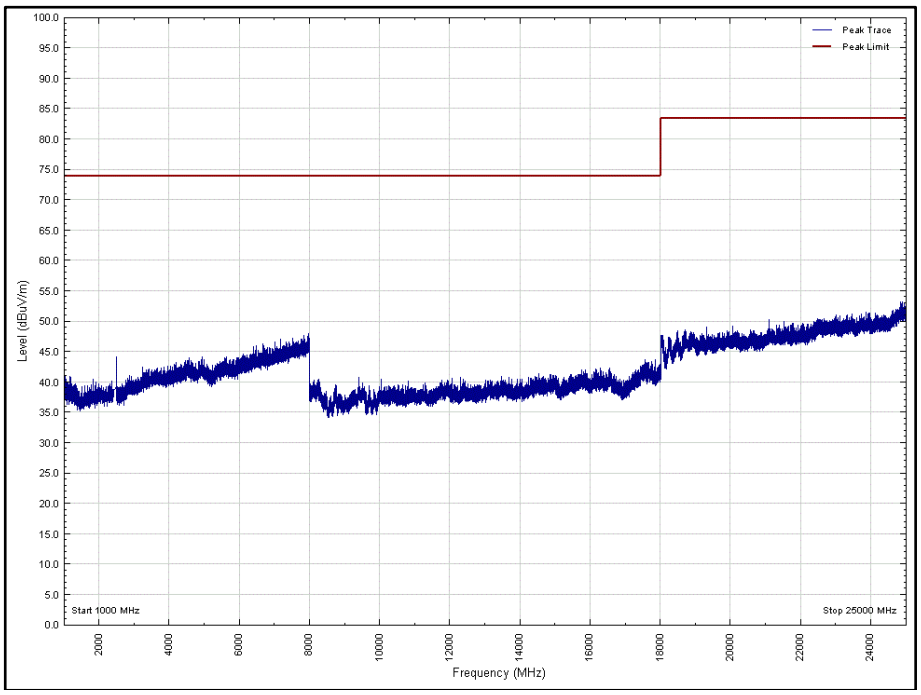


Figure 82 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

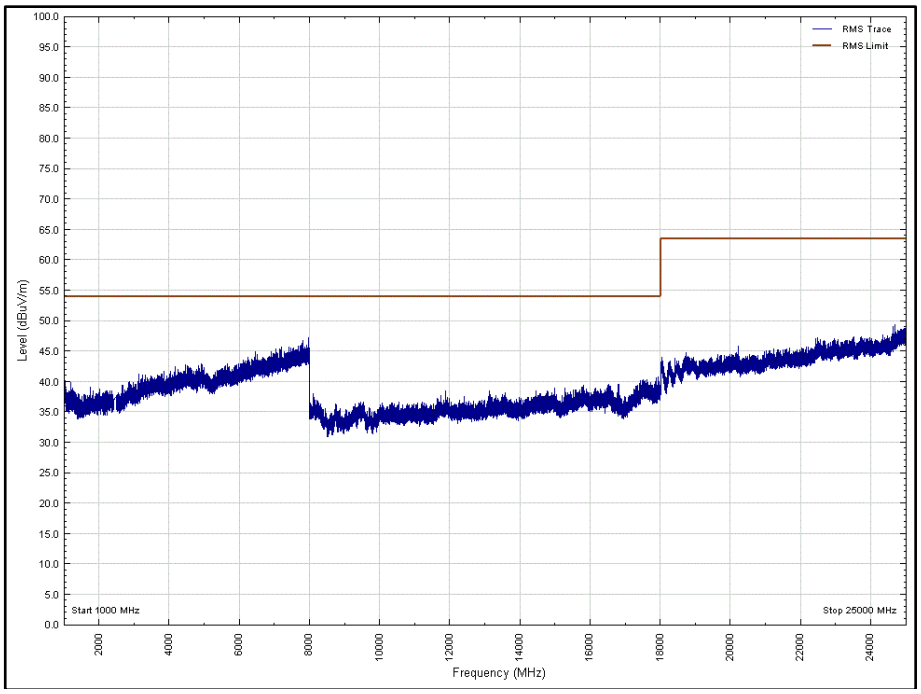


Figure 83 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

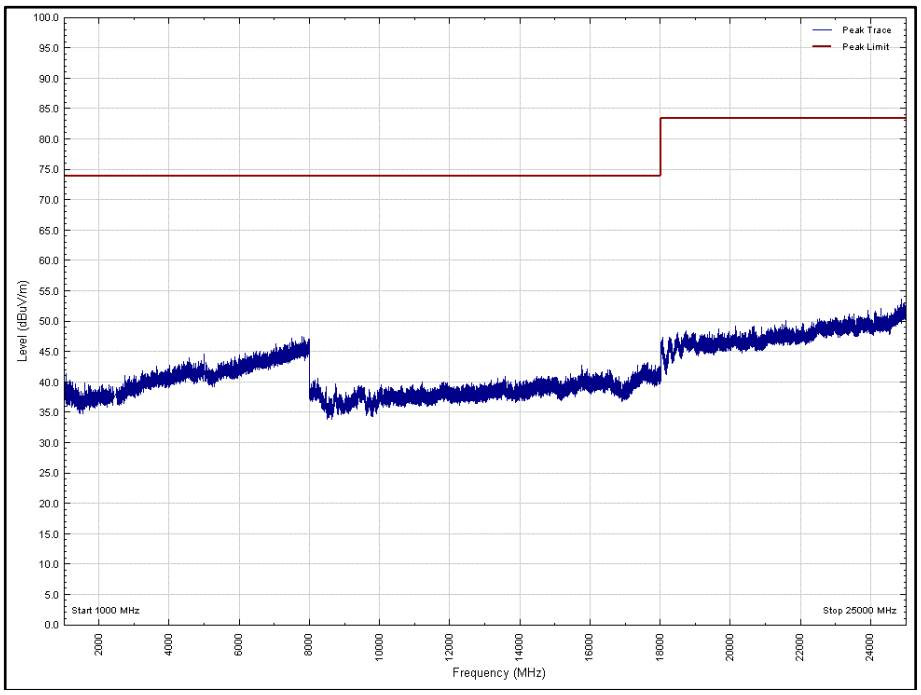


Figure 84 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

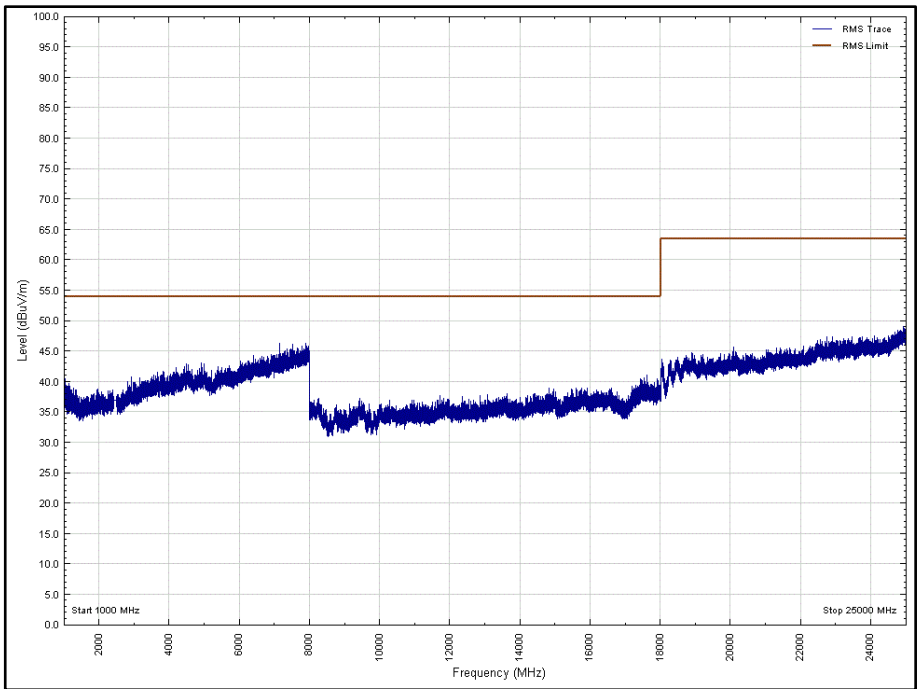


Figure 85 - 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

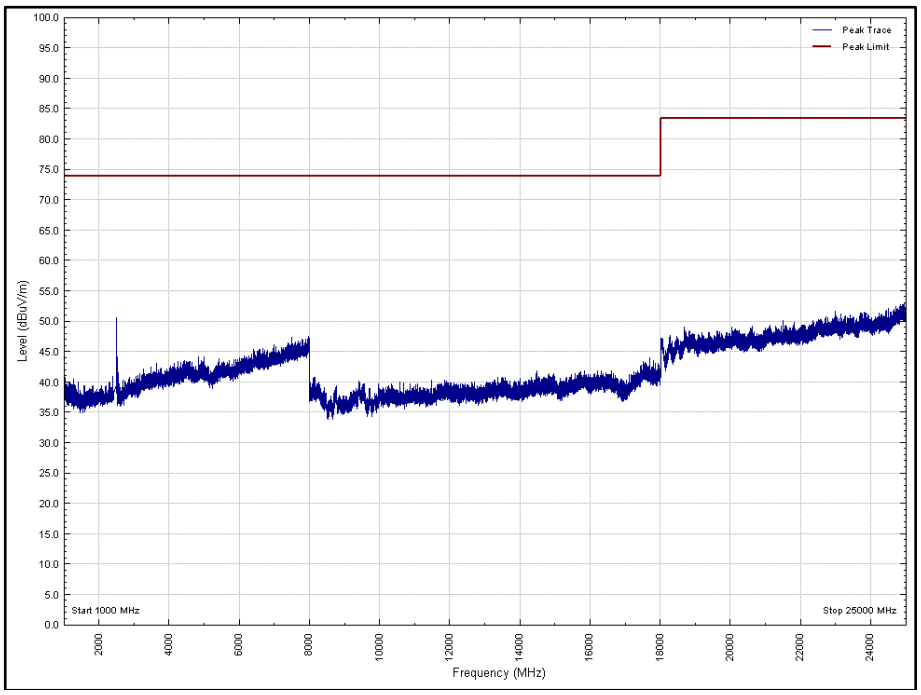


Figure 86 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

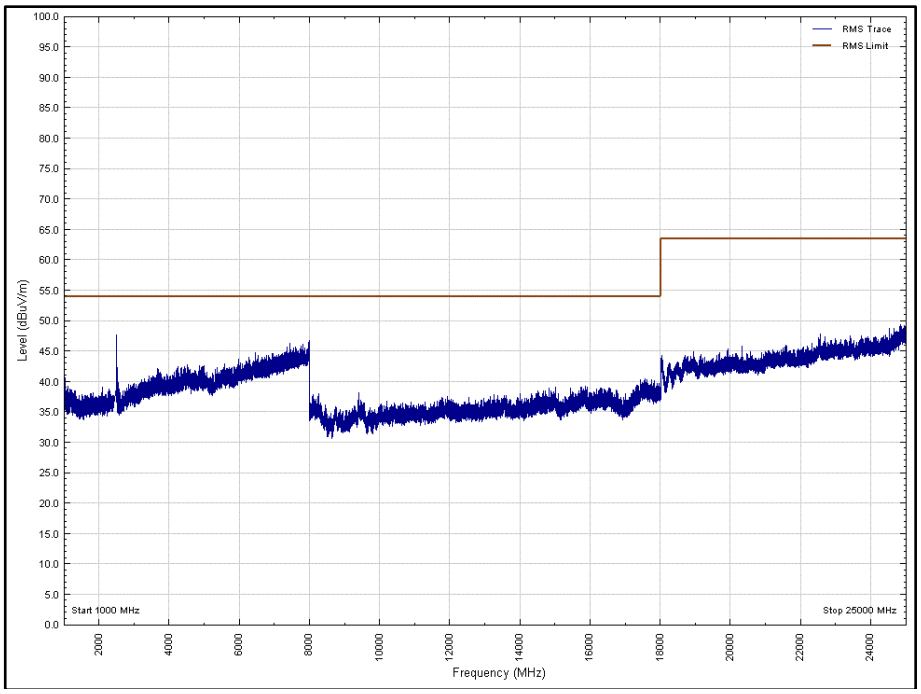


Figure 87 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

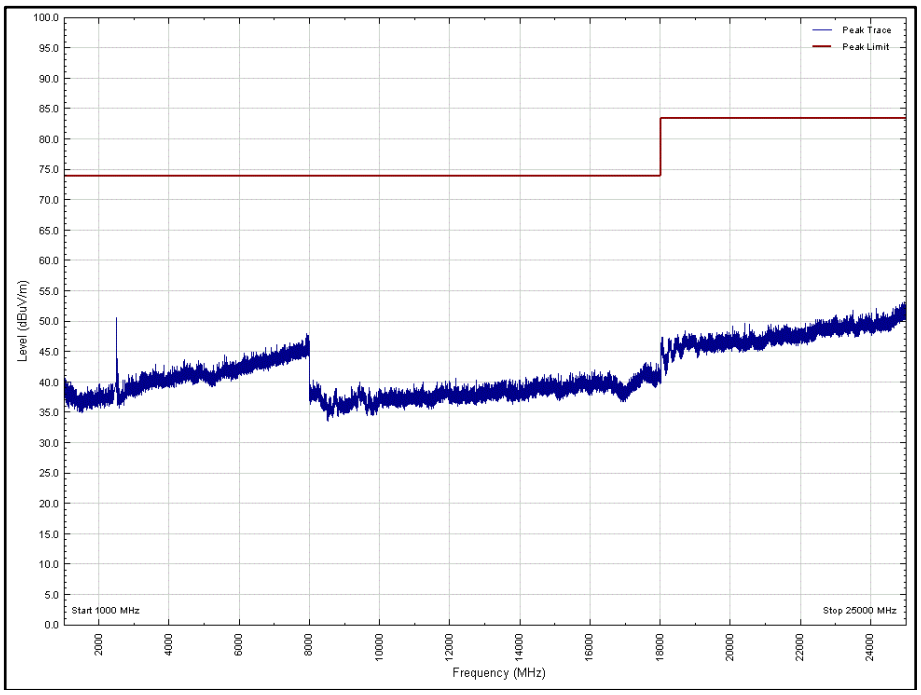


Figure 88 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

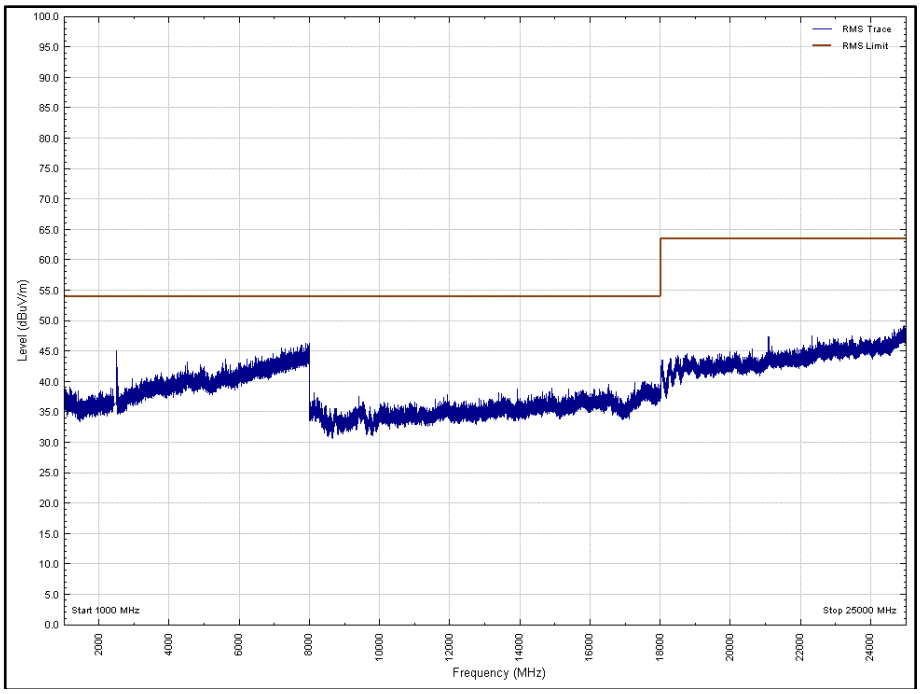


Figure 89 – 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

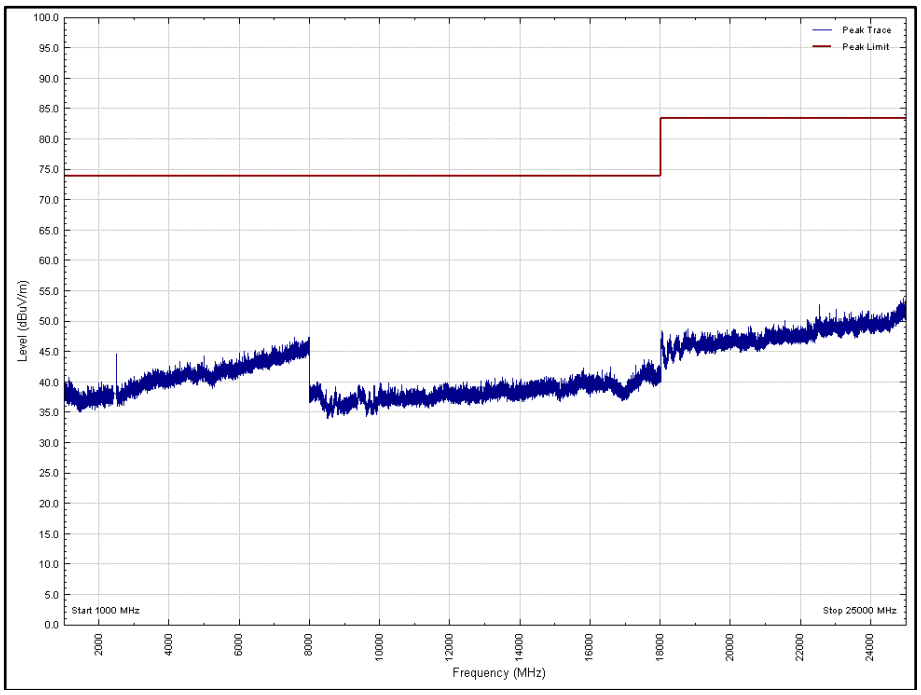


Figure 90 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

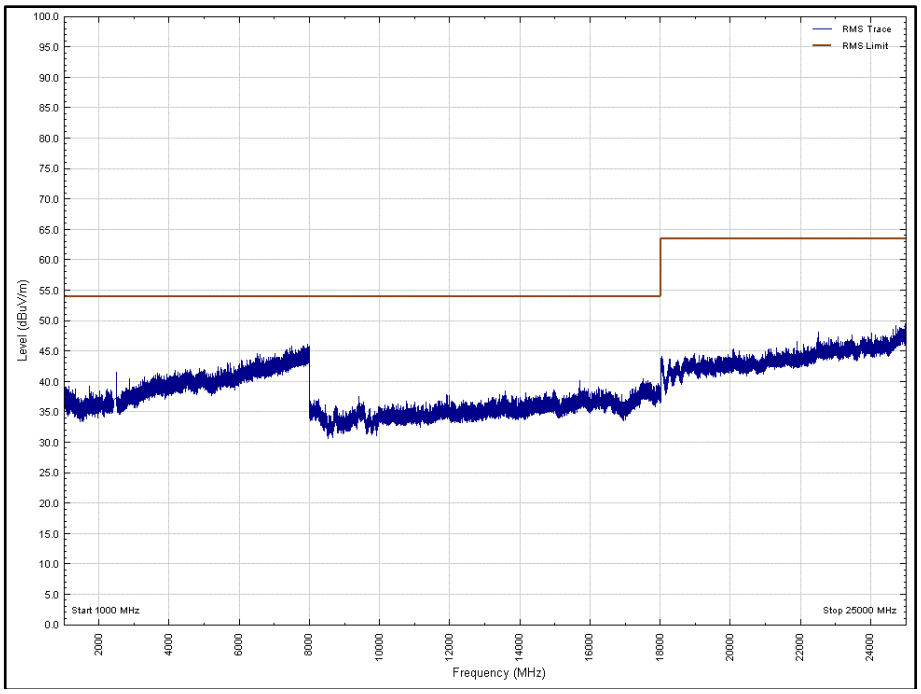


Figure 91 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

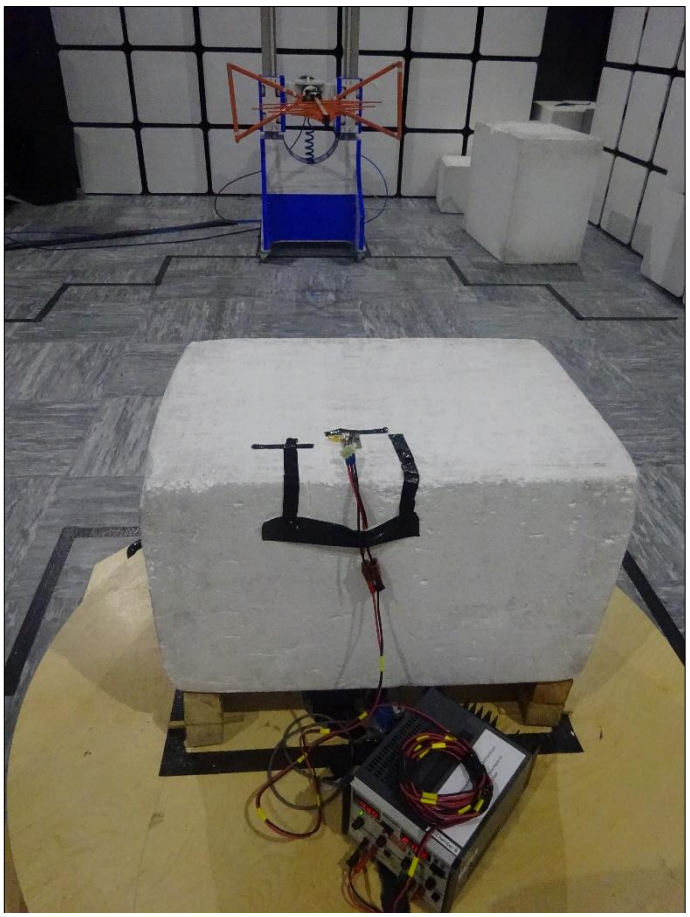


Figure 92 -30 MHz to 1 GHz, X Orientation

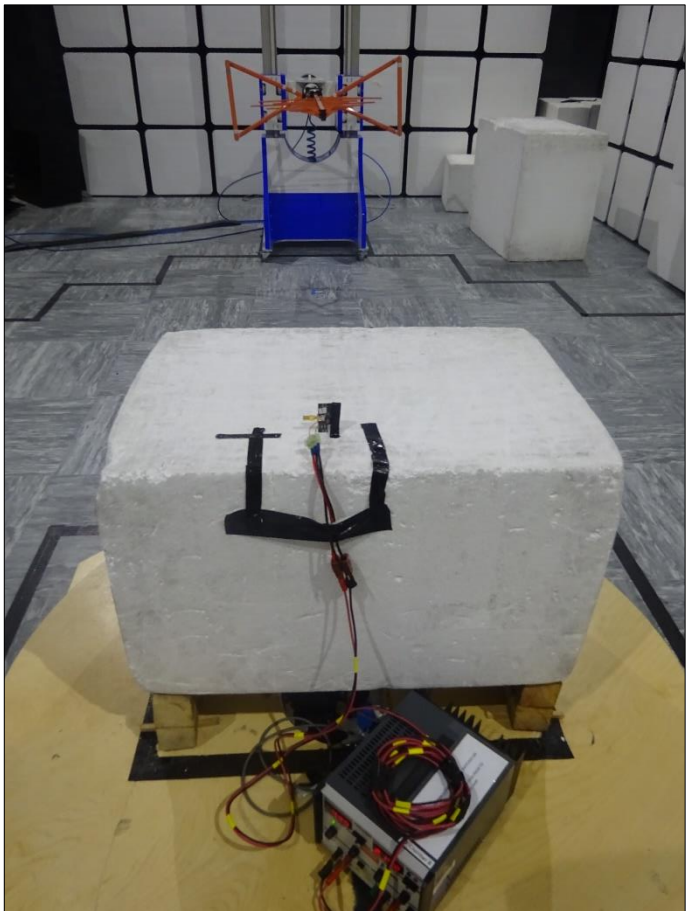


Figure 93 - 30 MHz to 1 GHz, Y Orientation

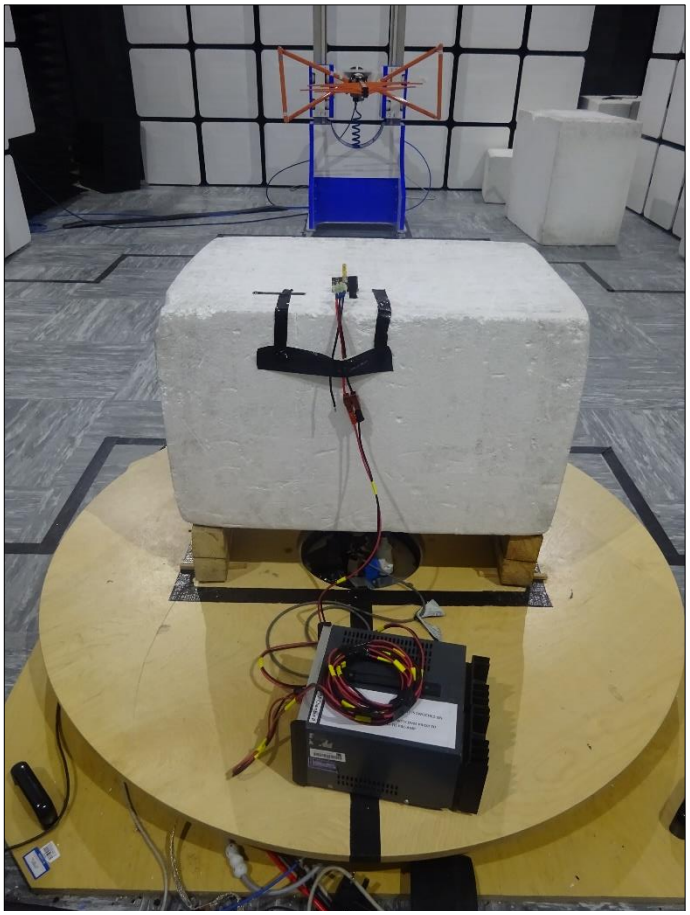


Figure 94 - 30 MHz to 1 GHz, Z Orientation

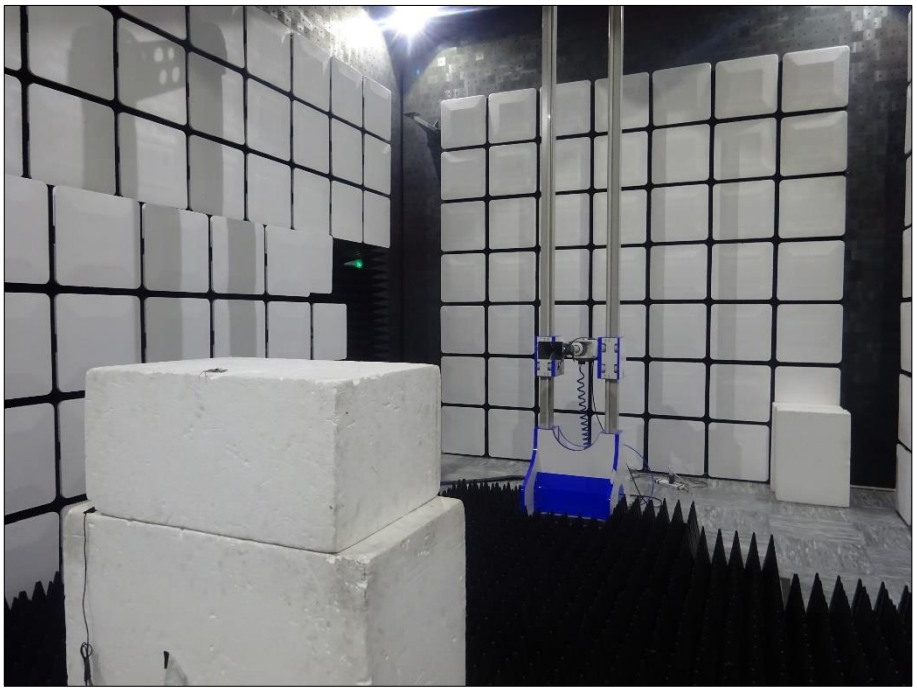


Figure 95 - 1 GHz to 18 GHz, X Orientation

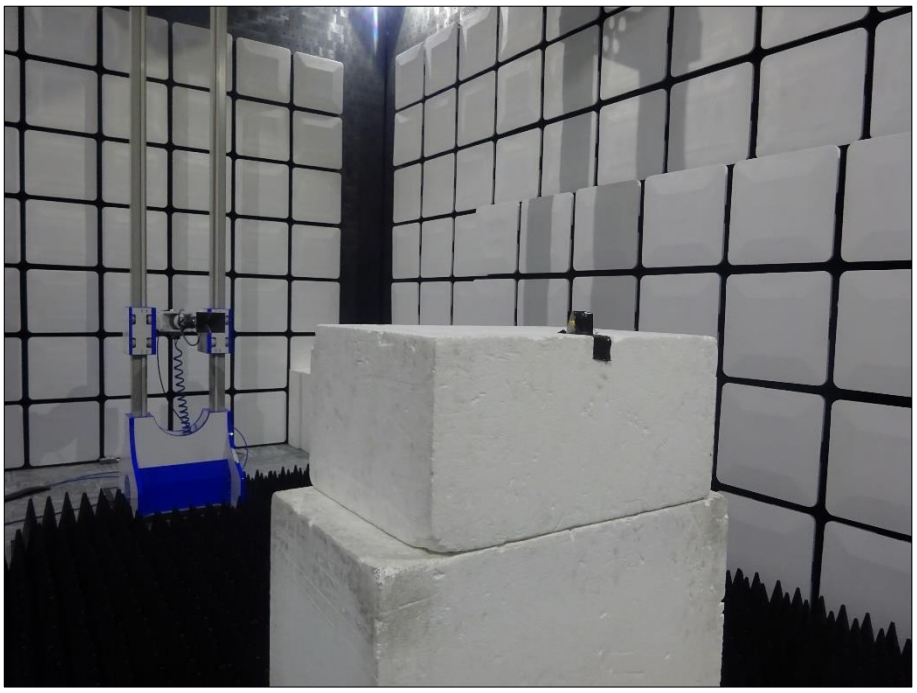


Figure 96 - 1 GHz to 18 GHz, Y Orientation

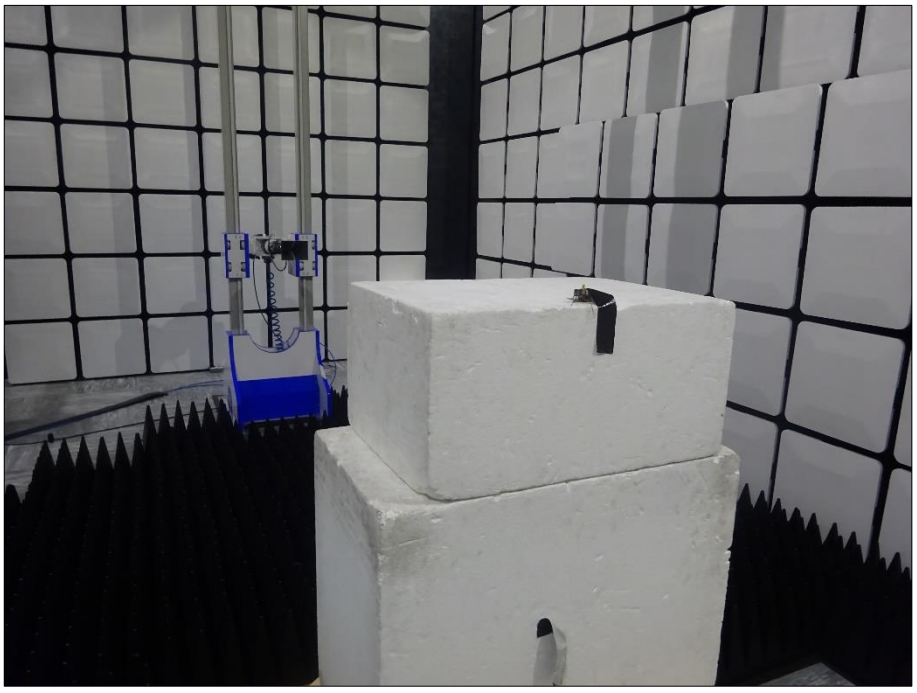


Figure 97 - 1 GHz to 18 GHz, Z Orientation

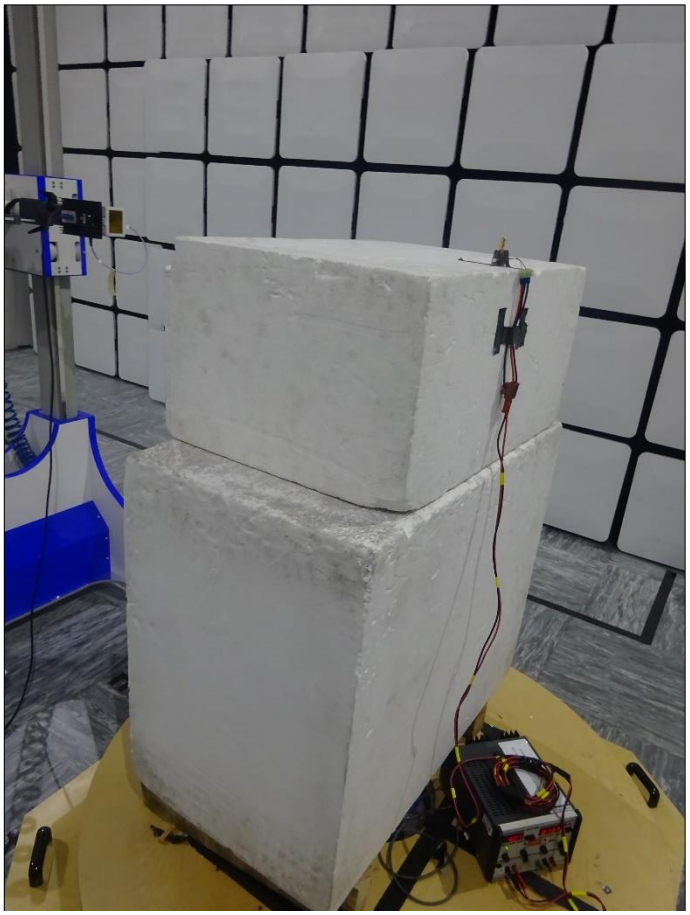


Figure 98 - 18 GHz to 25 GHz, X Orientation

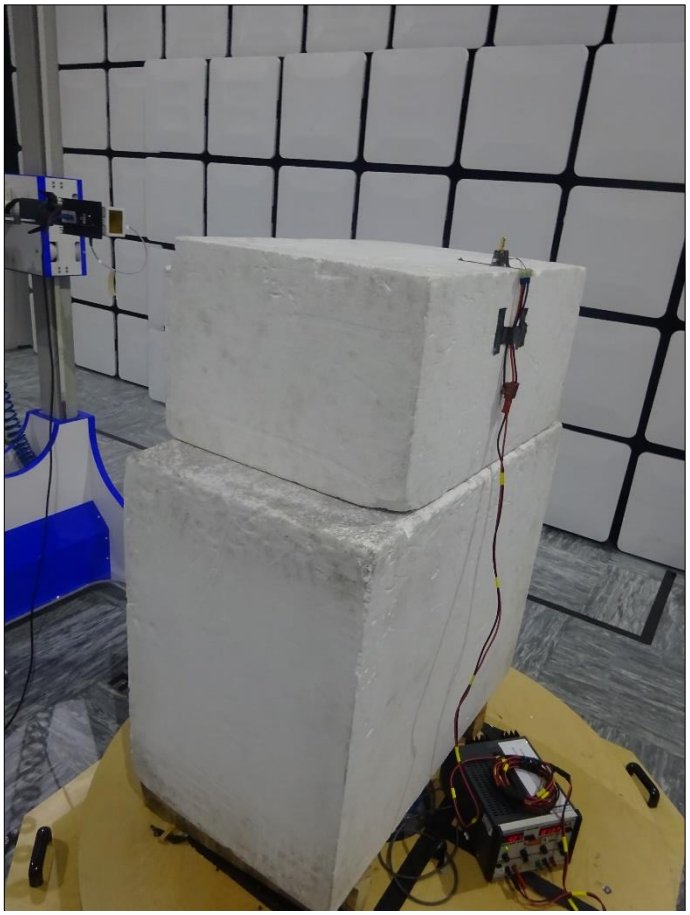


Figure 99 - 18 GHz to 25 GHz, Y Orientation

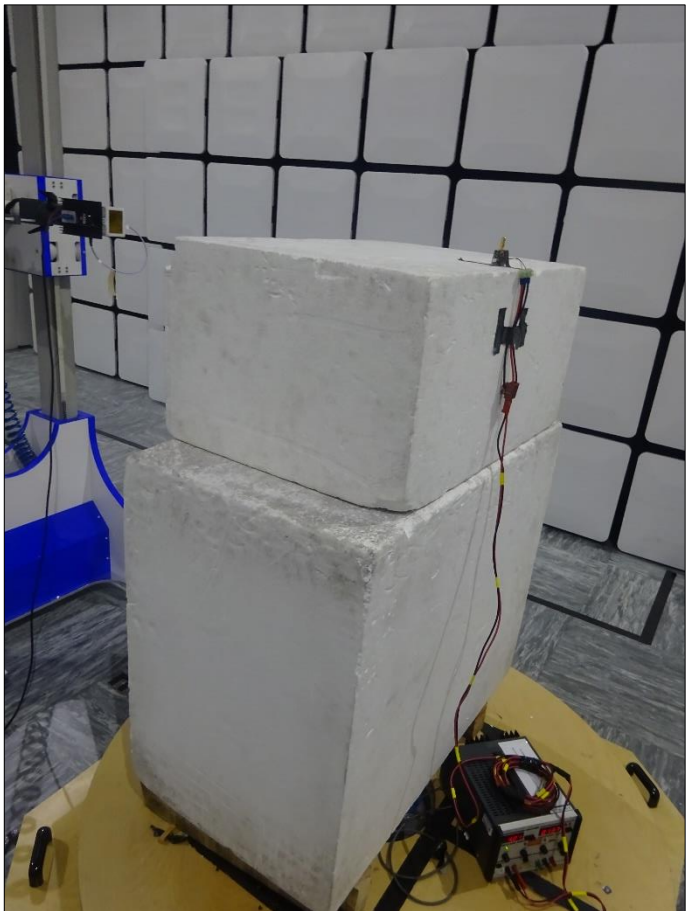


Figure 100, Frequency Range: 18 GHz to 25 GHz, Z Orientation

External Antenna - Bluetooth Low Energy (1M PHY)

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

Table 36 - Radiated Emissions Results, 30 MHz to 1 GHz - 2402 MHz

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

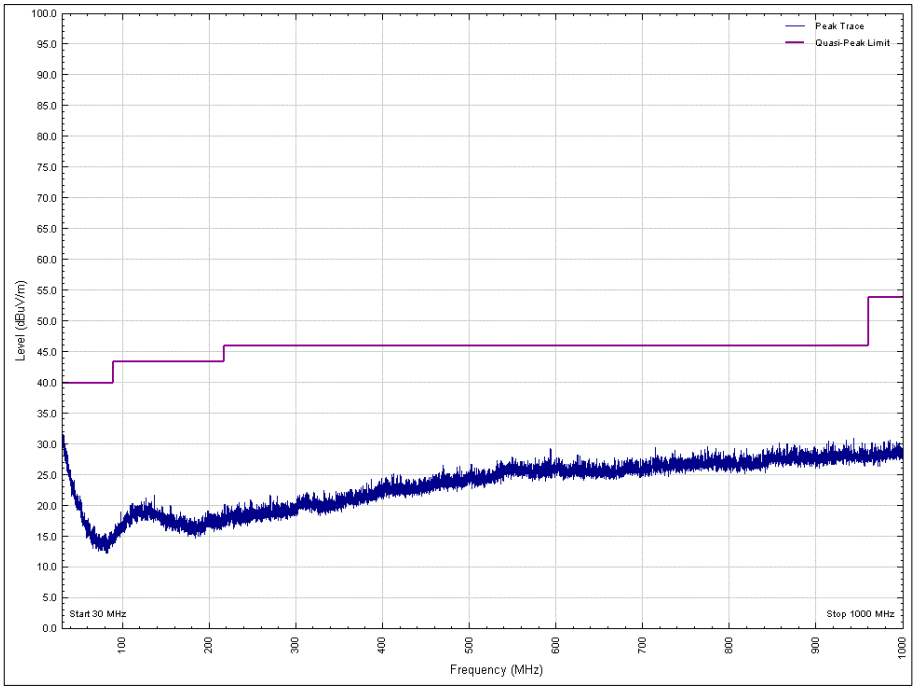


Figure 101 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation X

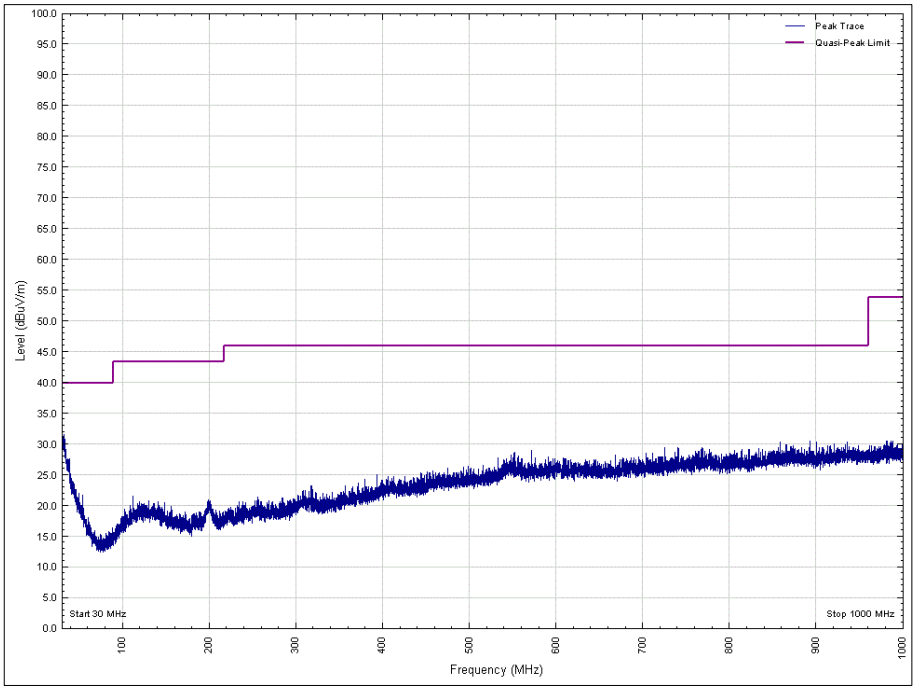


Figure 102 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation X

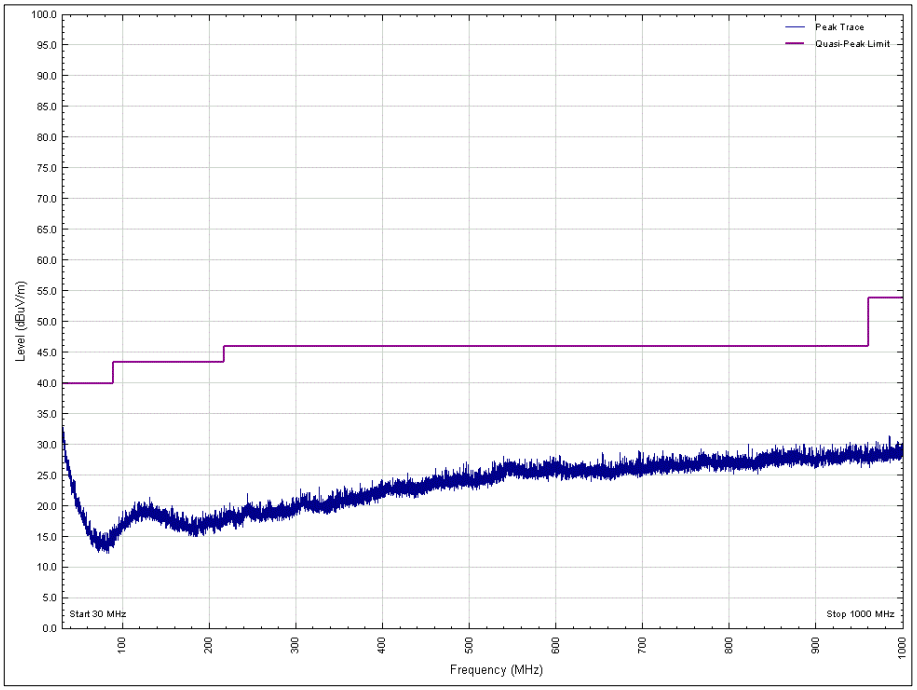


Figure 103 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation Y

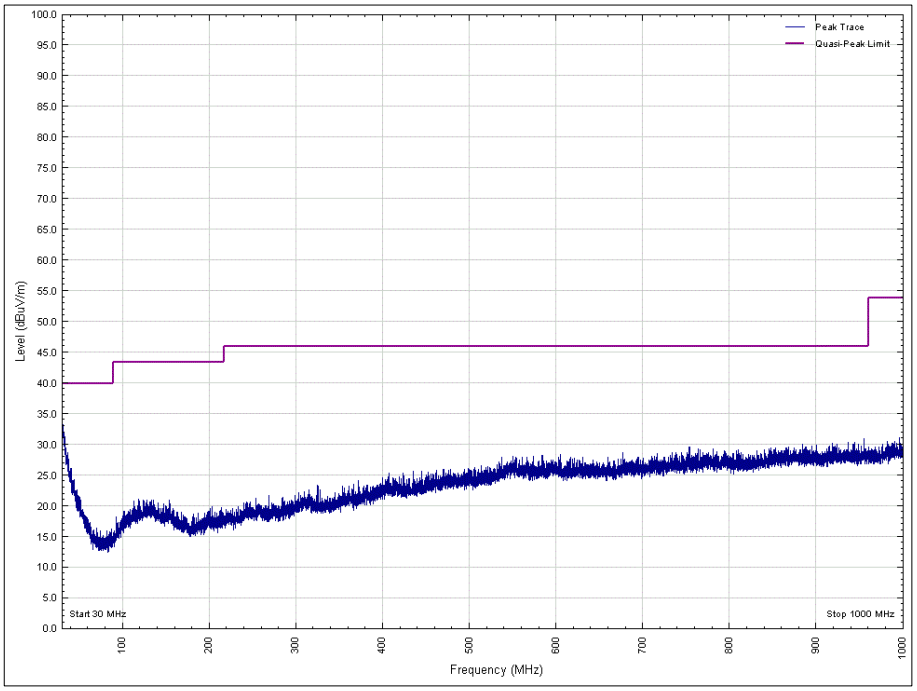


Figure 104 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation Y

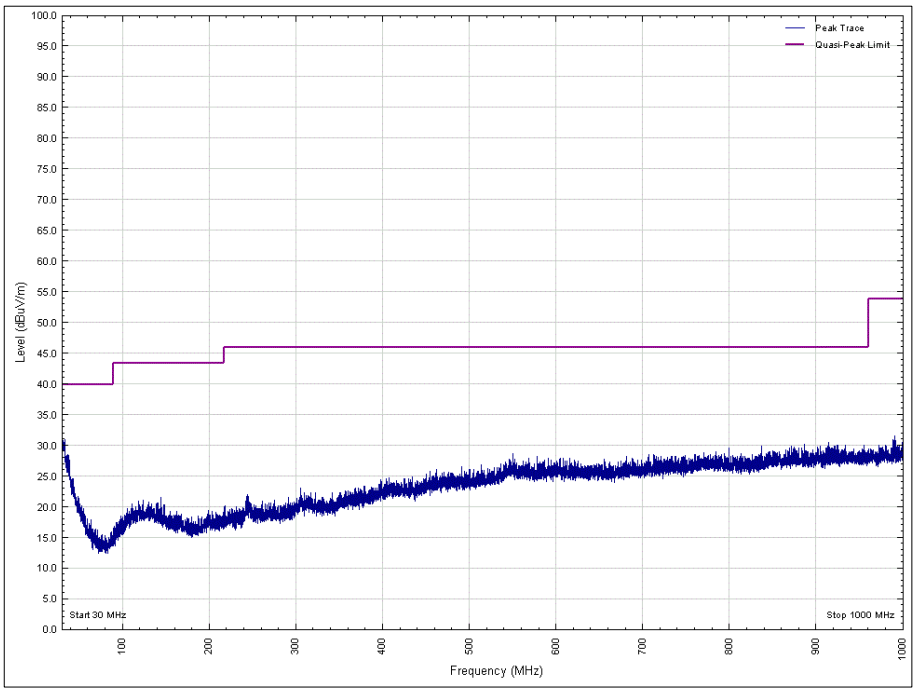


Figure 105 - 30 MHz to 1 GHz, 2402 MHz, Horizontal, EUT Orientation Z

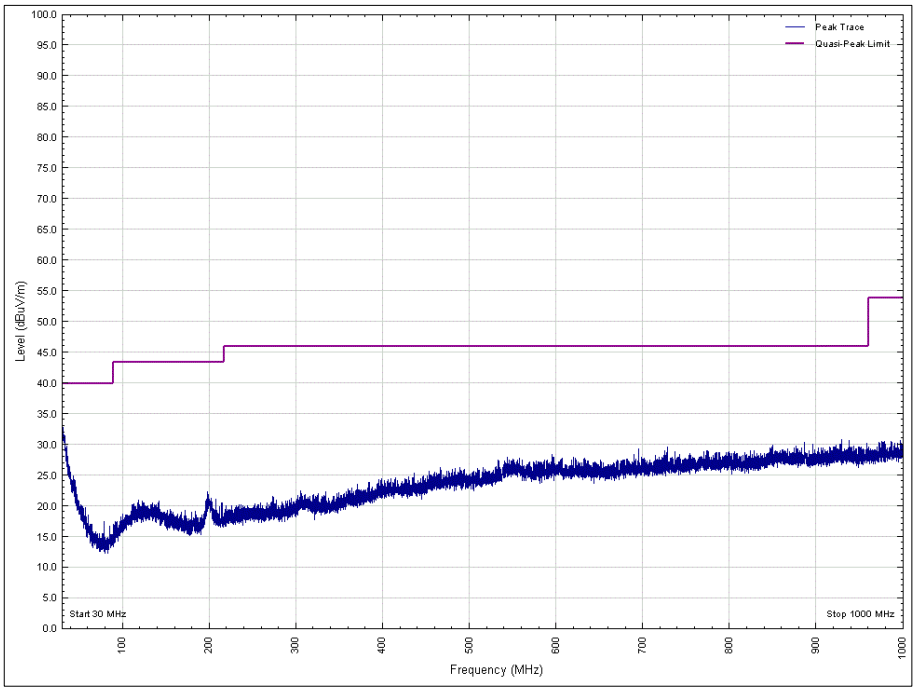


Figure 106 - 30 MHz to 1 GHz, 2402 MHz, Vertical, EUT Orientation Z

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

Table 37 - 2402 MHz - 1 GHz to 25 GHz Emissions Results

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

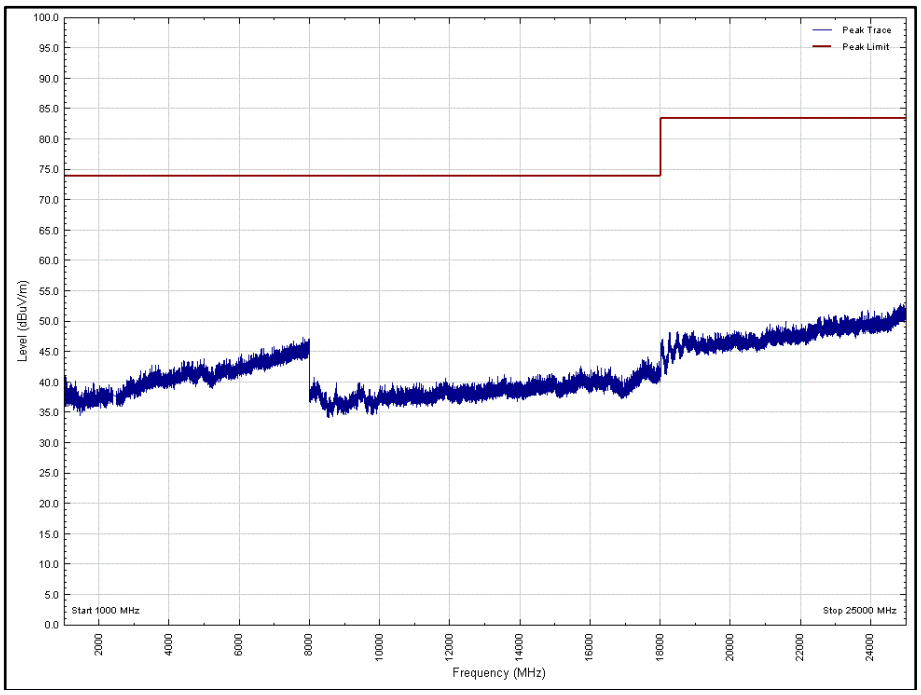


Figure 107 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

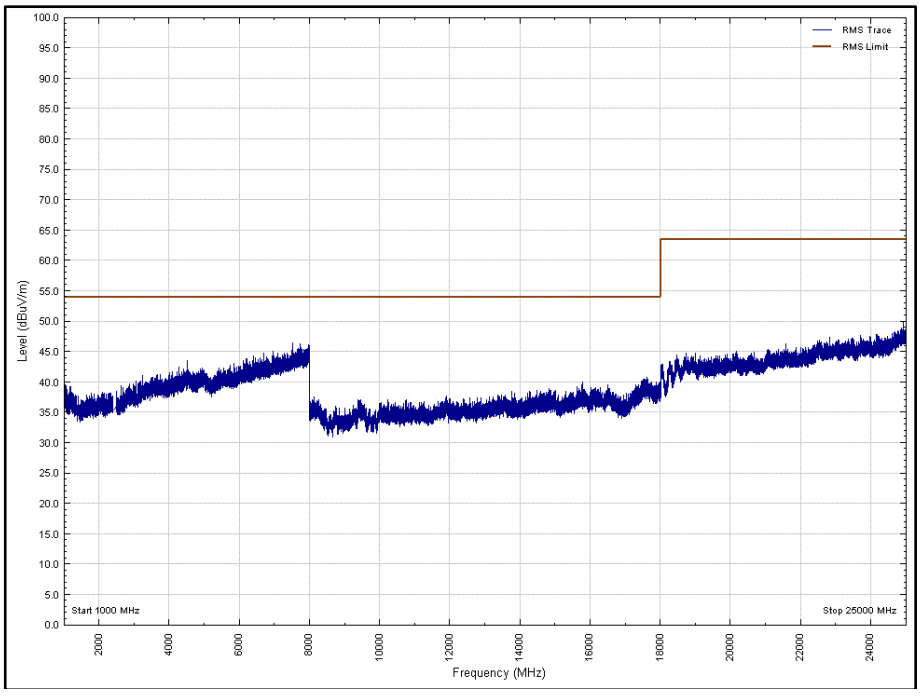


Figure 108 - 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

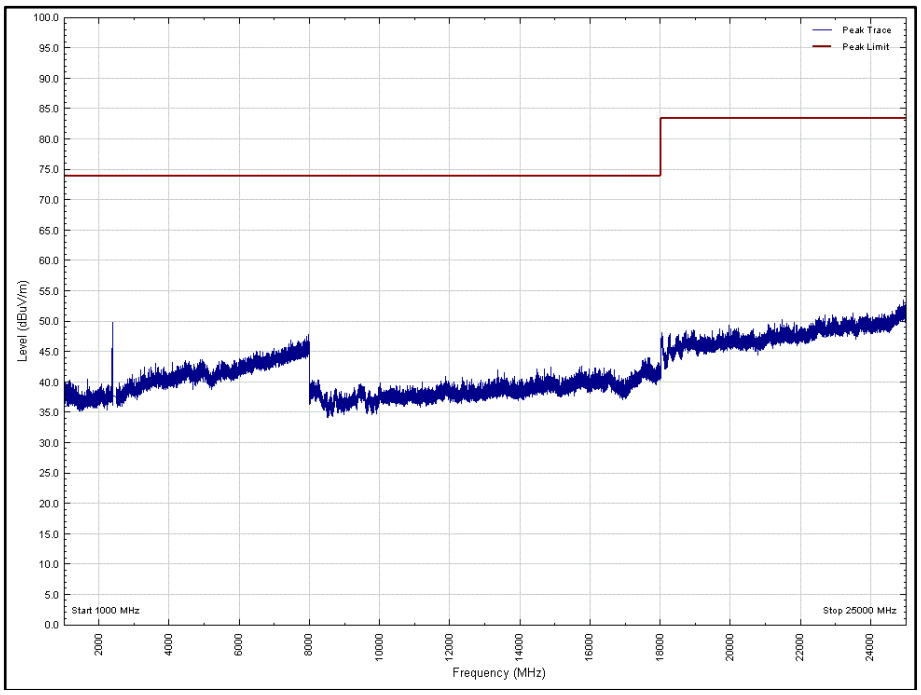


Figure 109 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

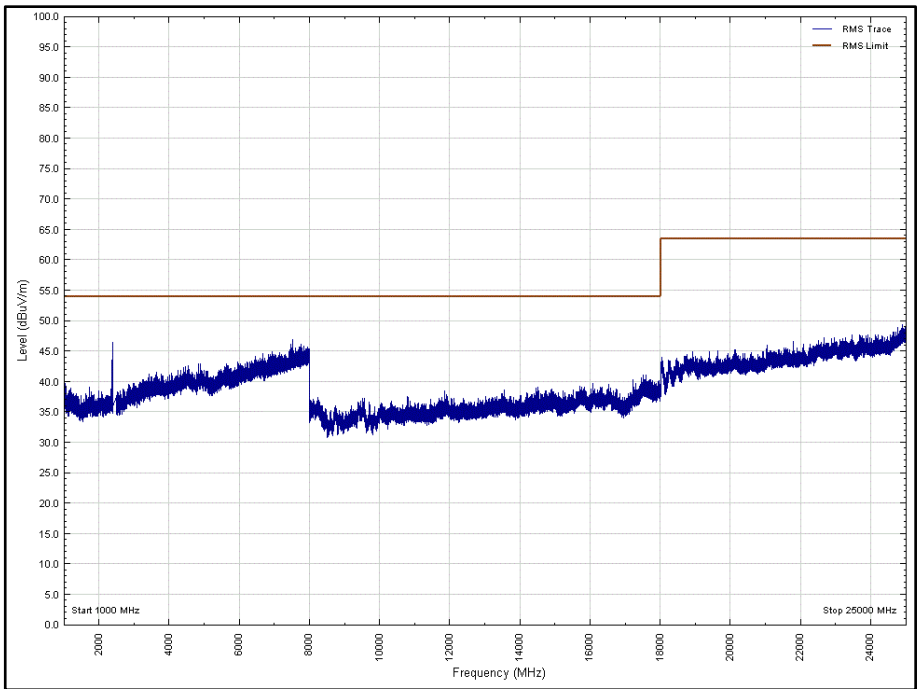


Figure 110 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

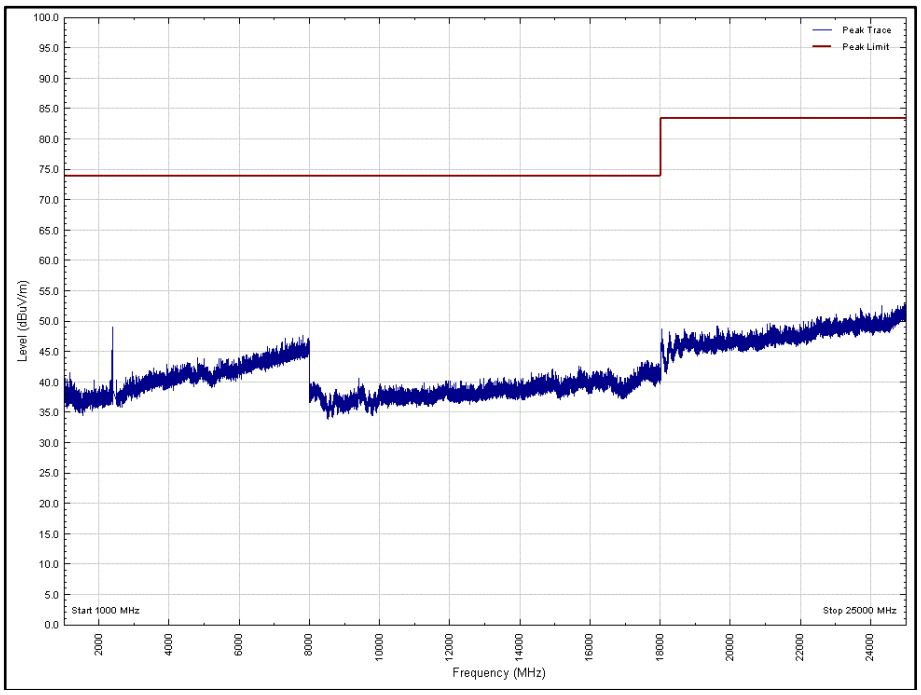


Figure 111 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

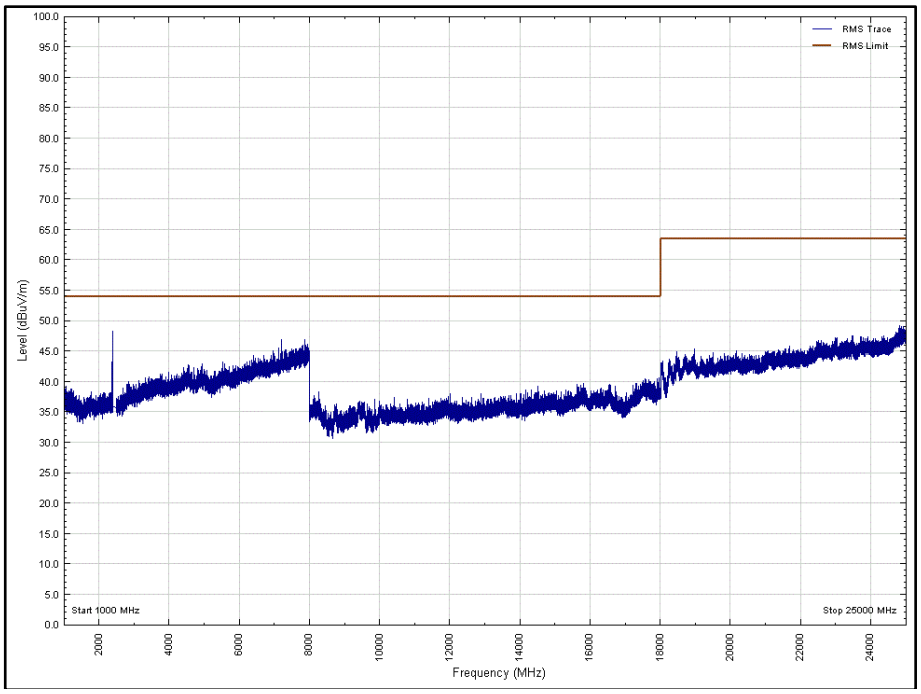


Figure 112 - 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

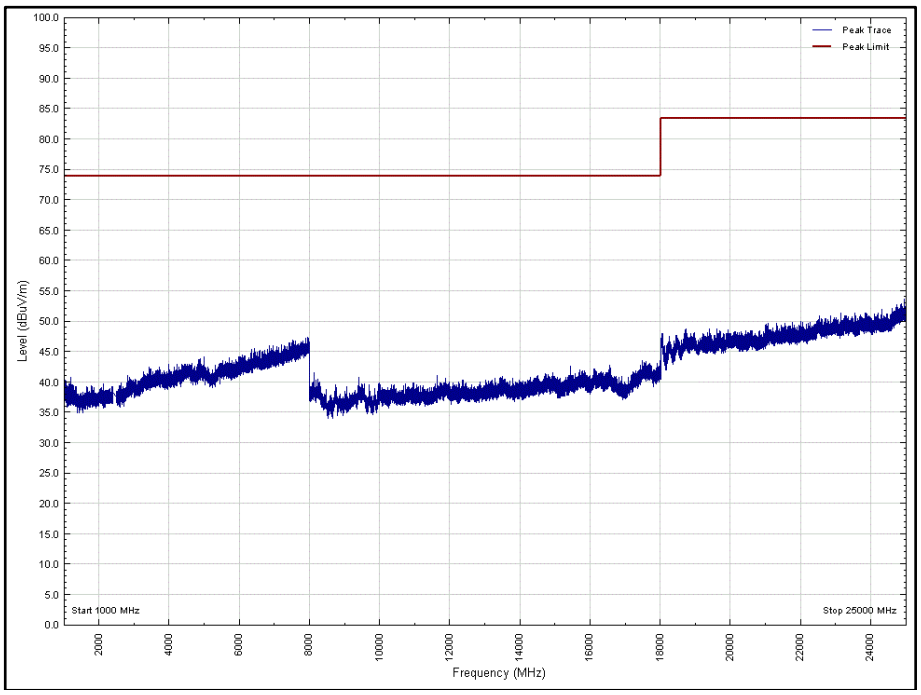


Figure 113 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

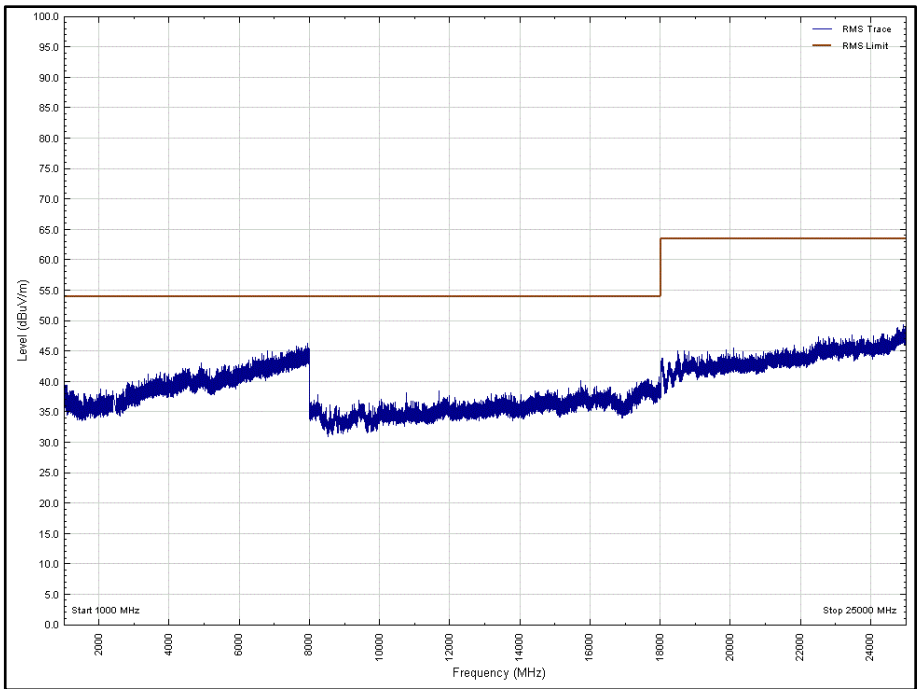


Figure 114 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

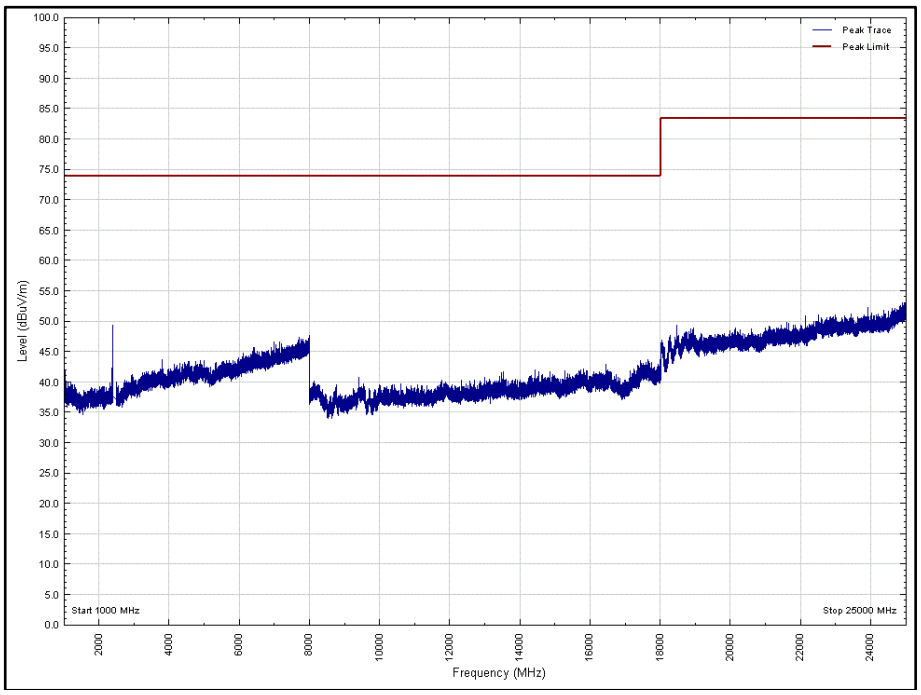


Figure 115 - 2402 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

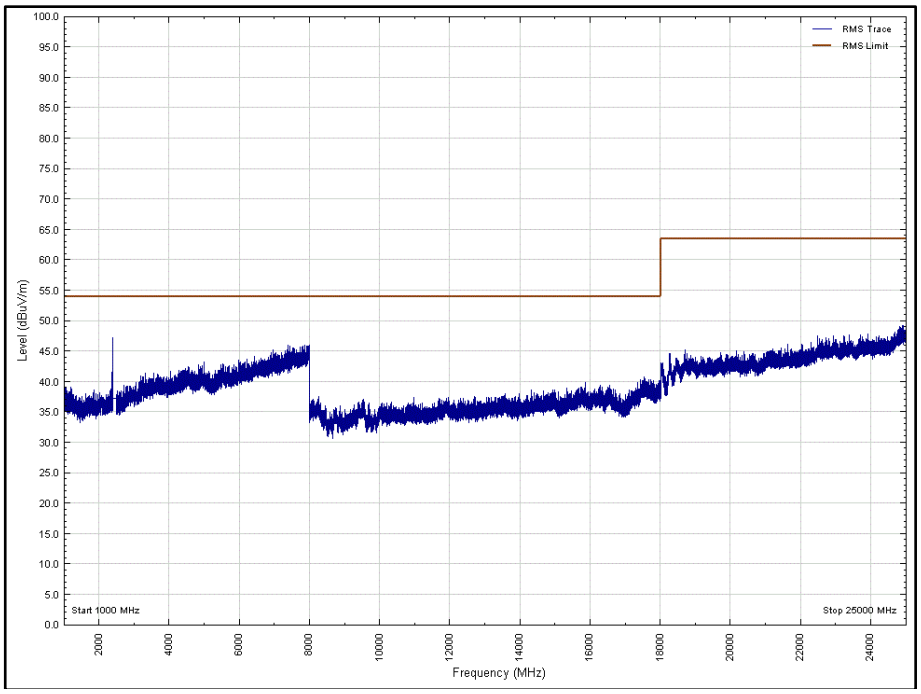


Figure 116 – 2402 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

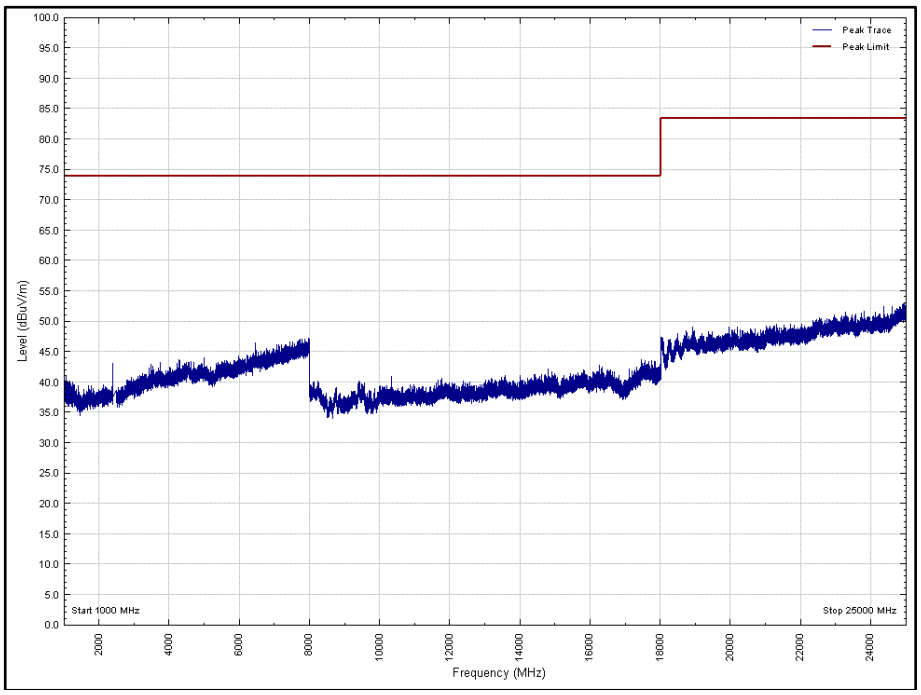


Figure 117 - 2402 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

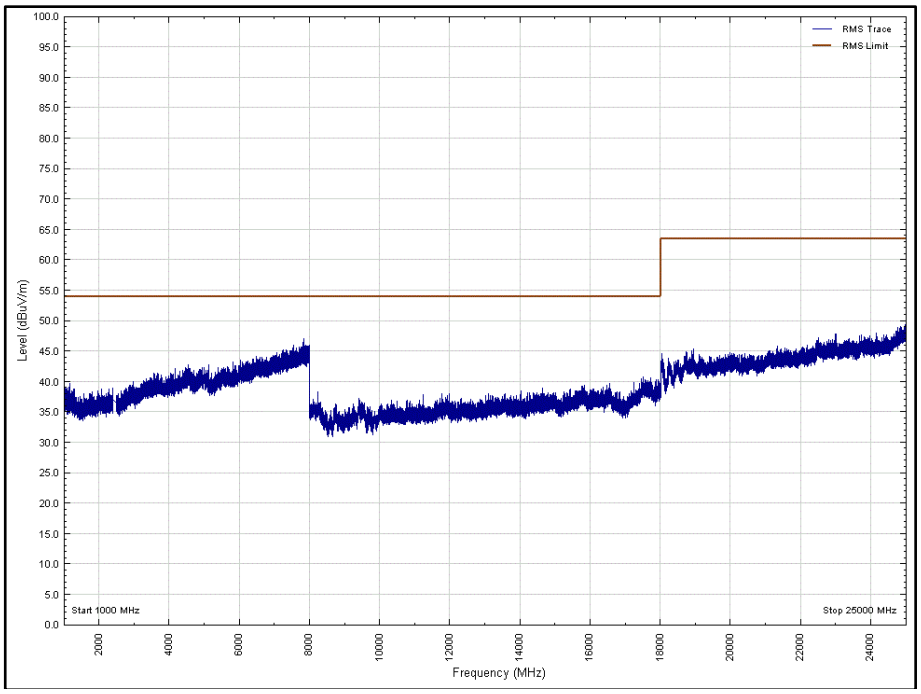


Figure 118 - 2402 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

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

Table 38 - Radiated Emissions Results, 30 MHz to 1 GHz - 2440 MHz

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

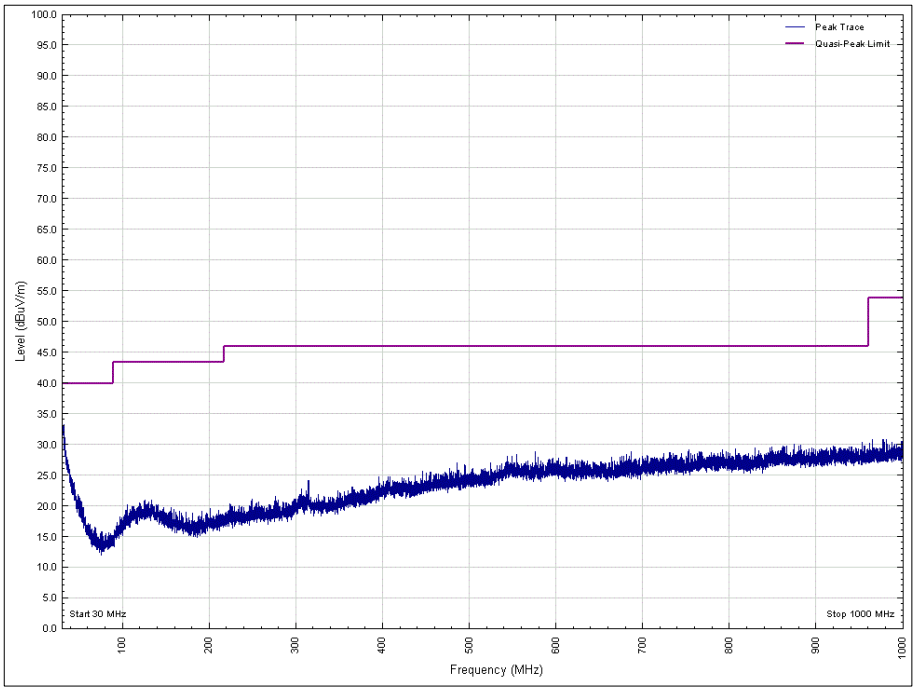


Figure 119 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation X

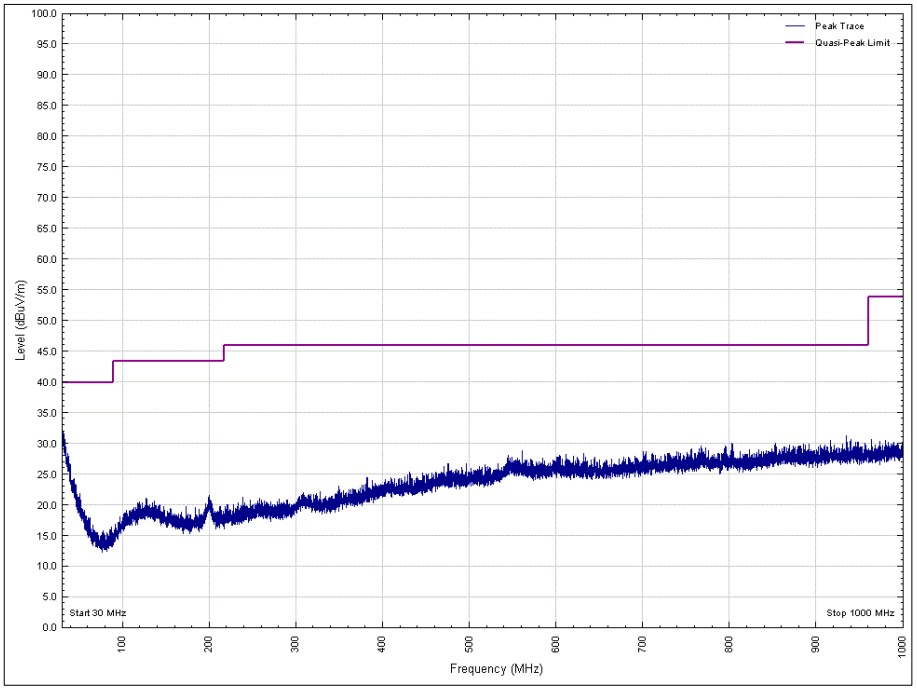


Figure 120 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation X

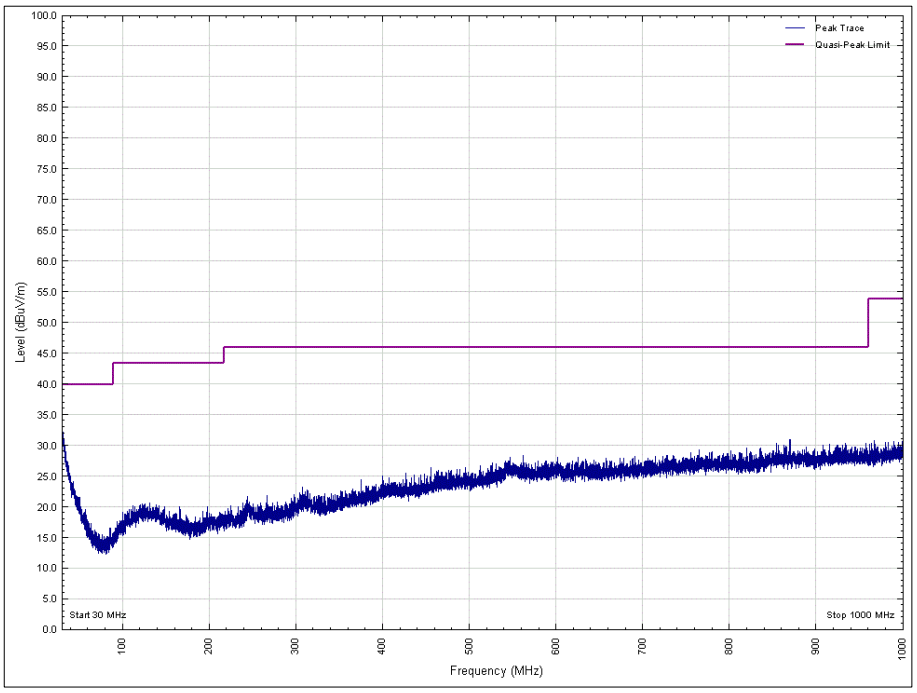


Figure 121 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation Y

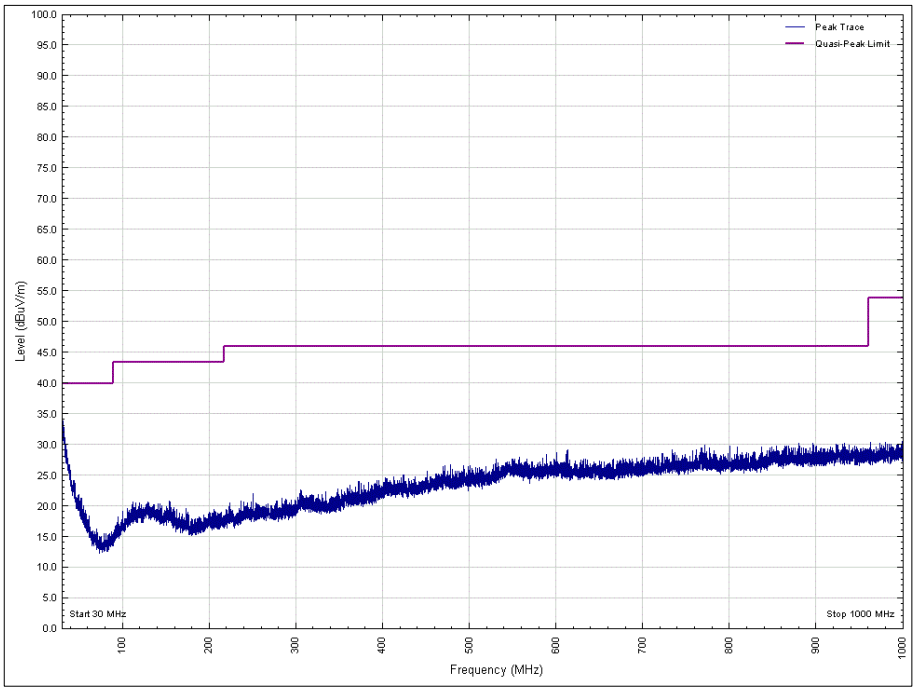


Figure 122 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation Y

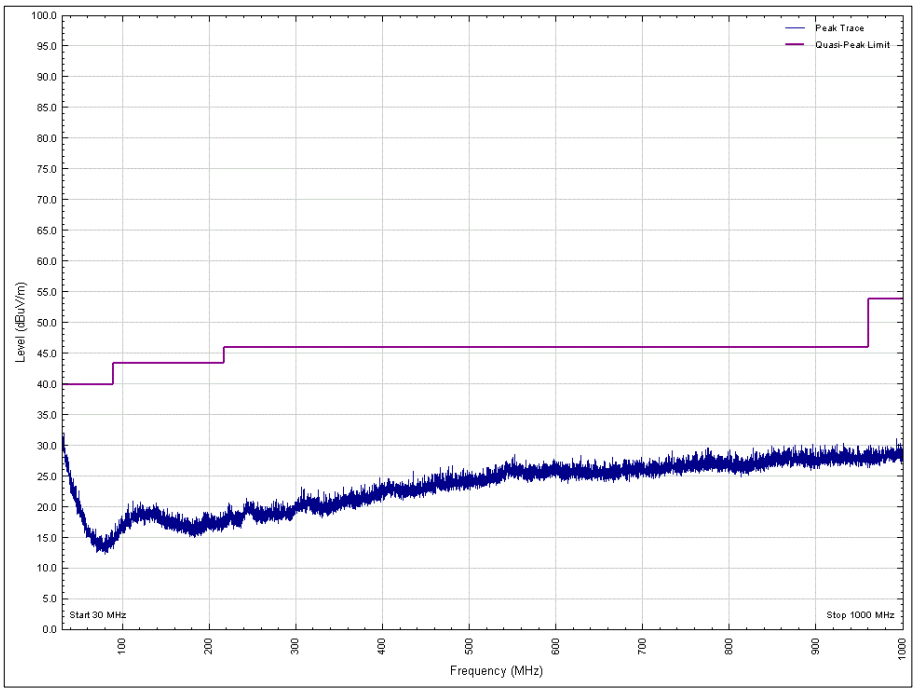


Figure 123 - 30 MHz to 1 GHz, 2440 MHz, Horizontal, EUT Orientation Z

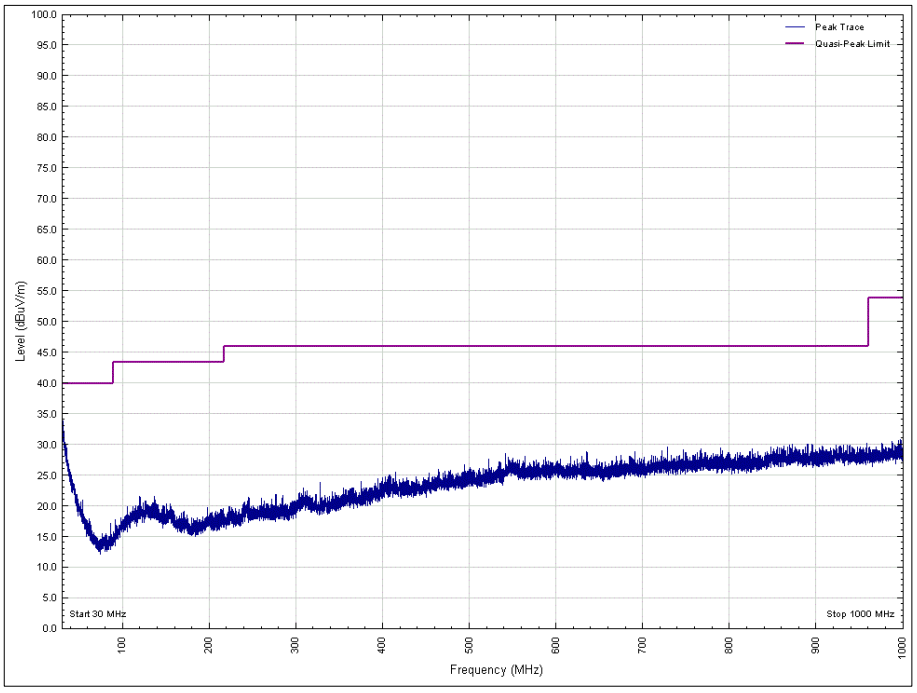


Figure 124 - 30 MHz to 1 GHz, 2440 MHz, Vertical, EUT Orientation Z

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

Table 39 - 2440 MHz - 1 GHz to 25 GHz Emissions Results

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

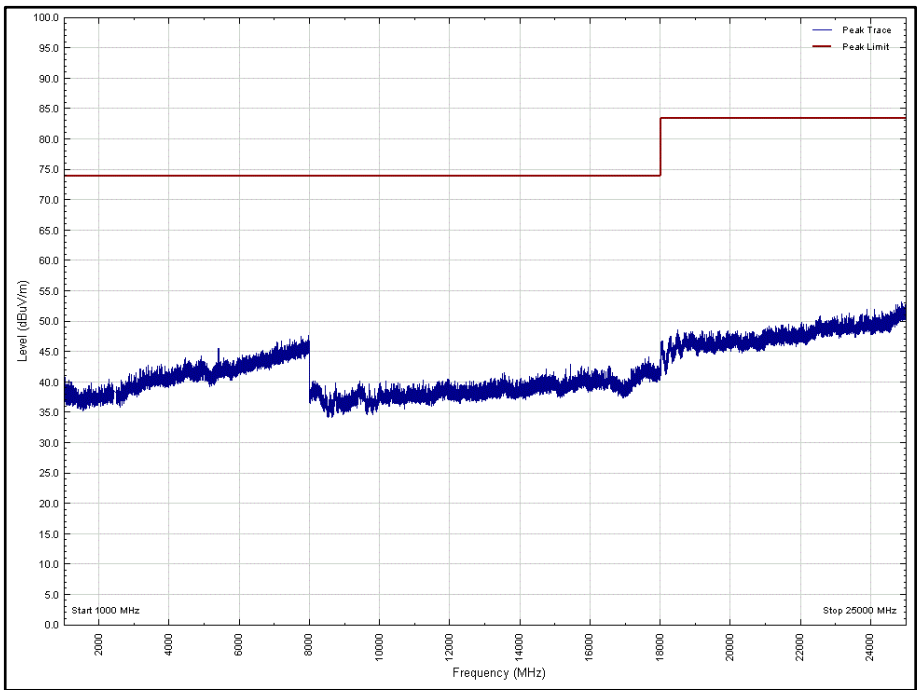


Figure 125 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

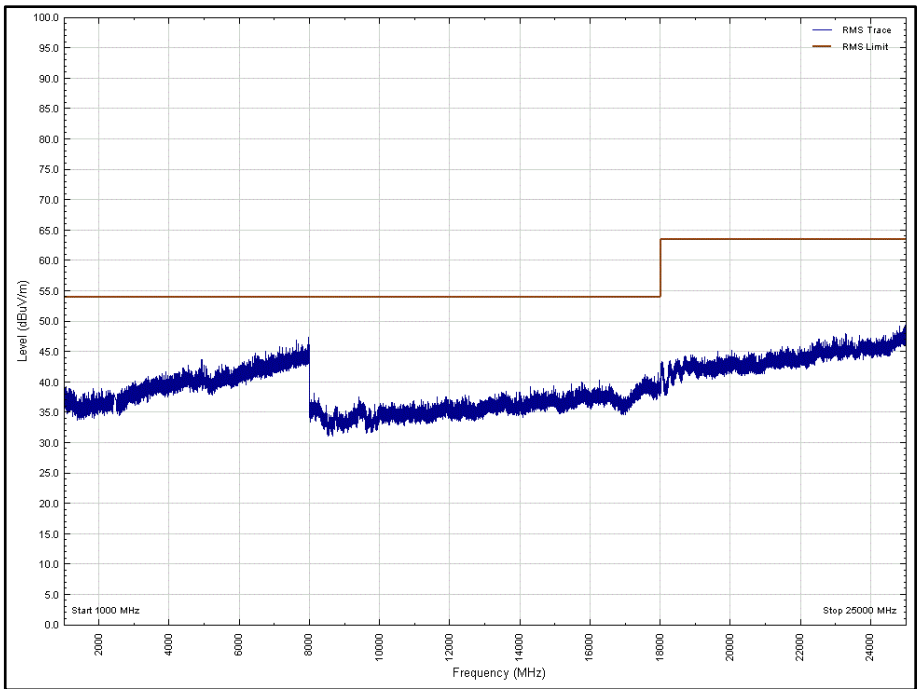


Figure 126 - 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

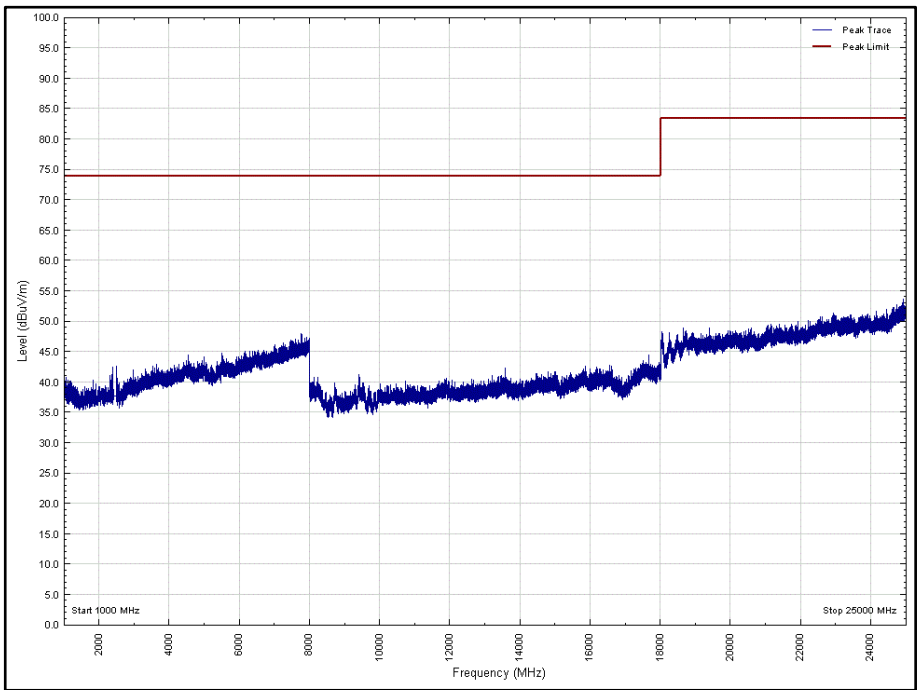


Figure 127 - 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

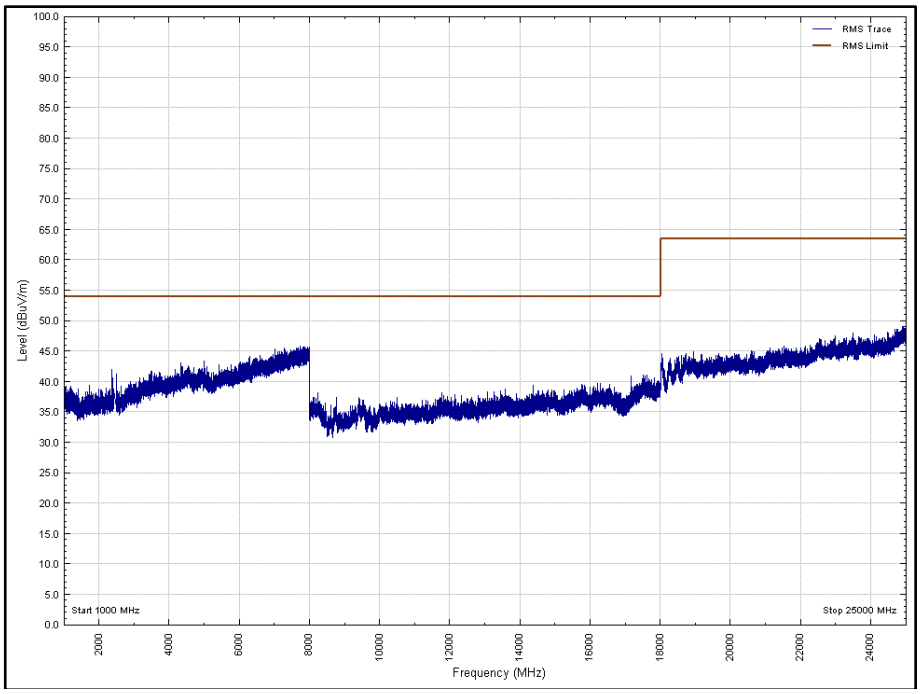


Figure 128 - 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

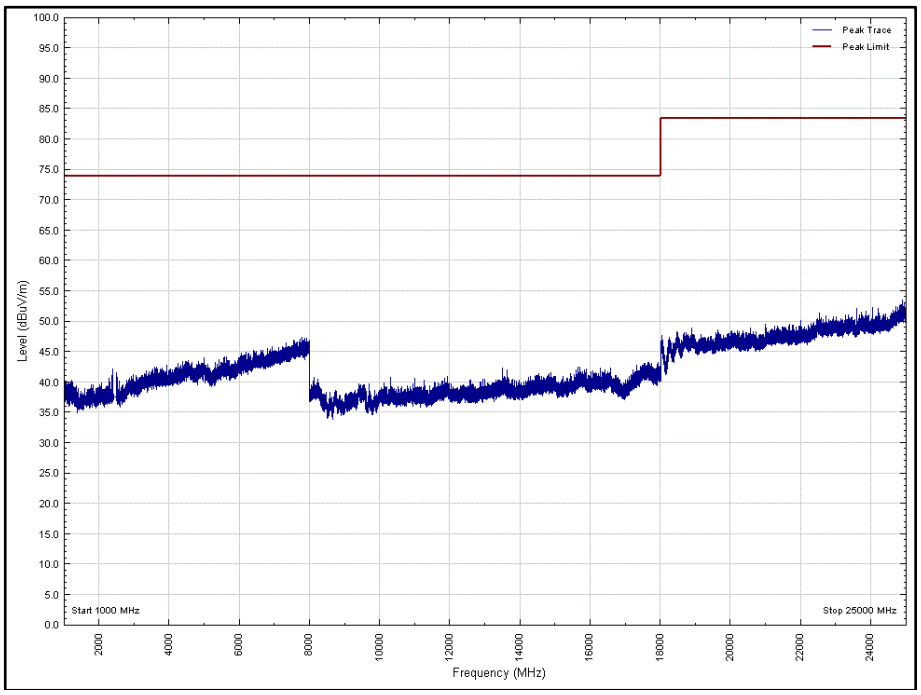


Figure 129 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

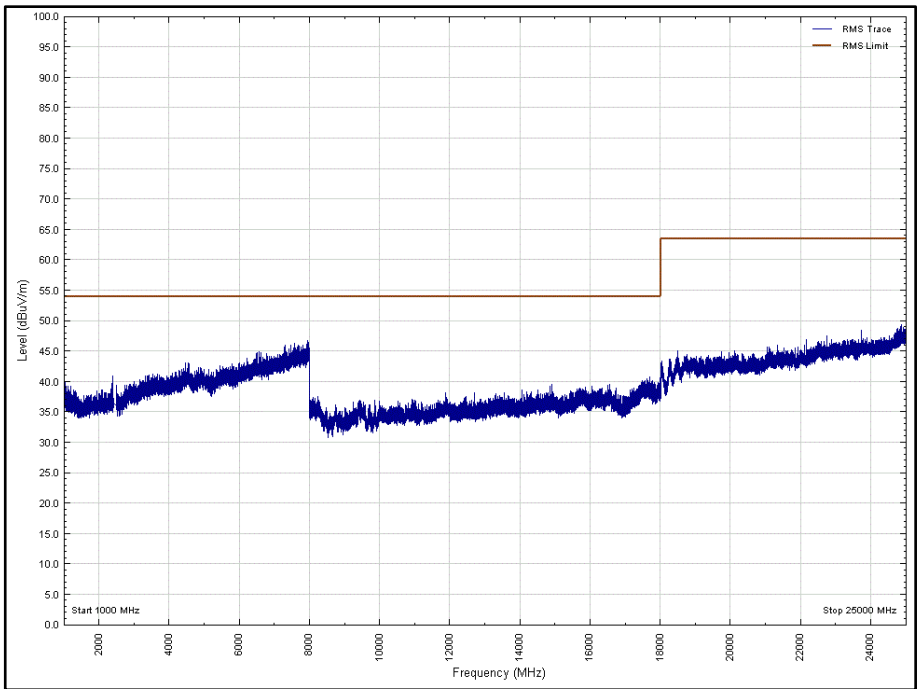


Figure 130 - 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

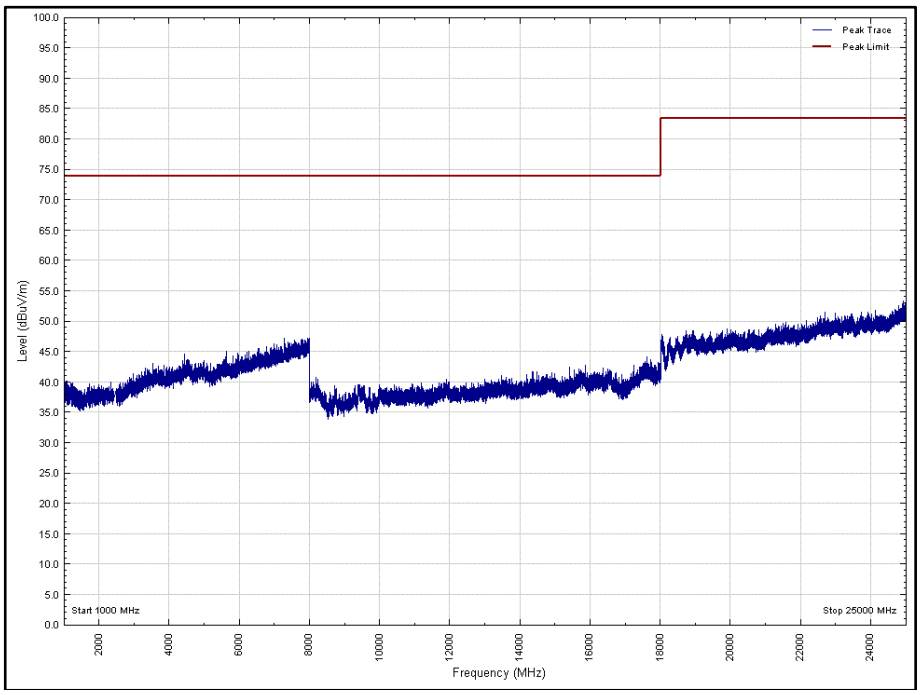


Figure 131 - 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

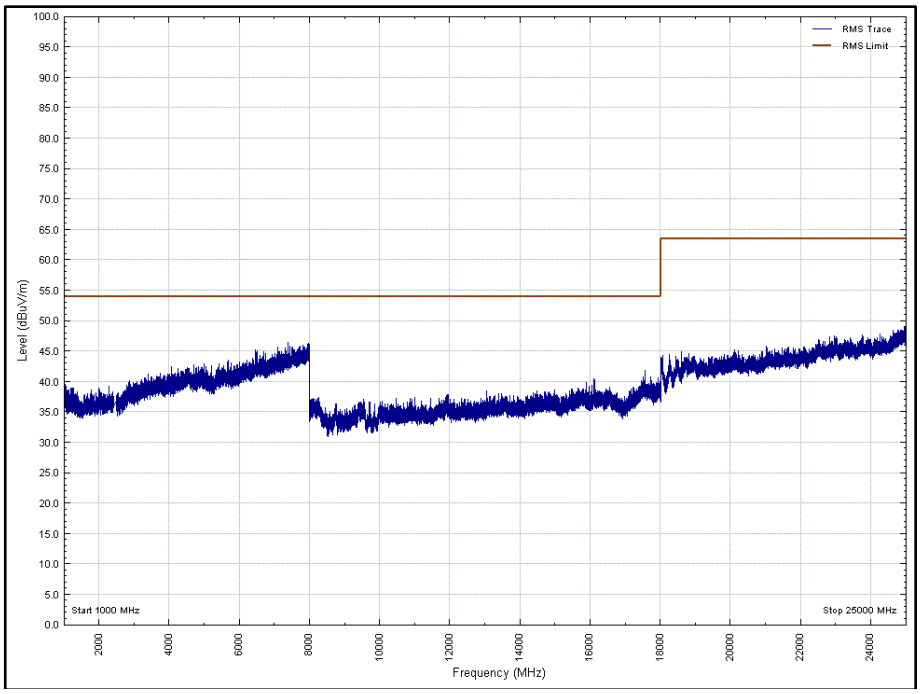


Figure 132 - 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

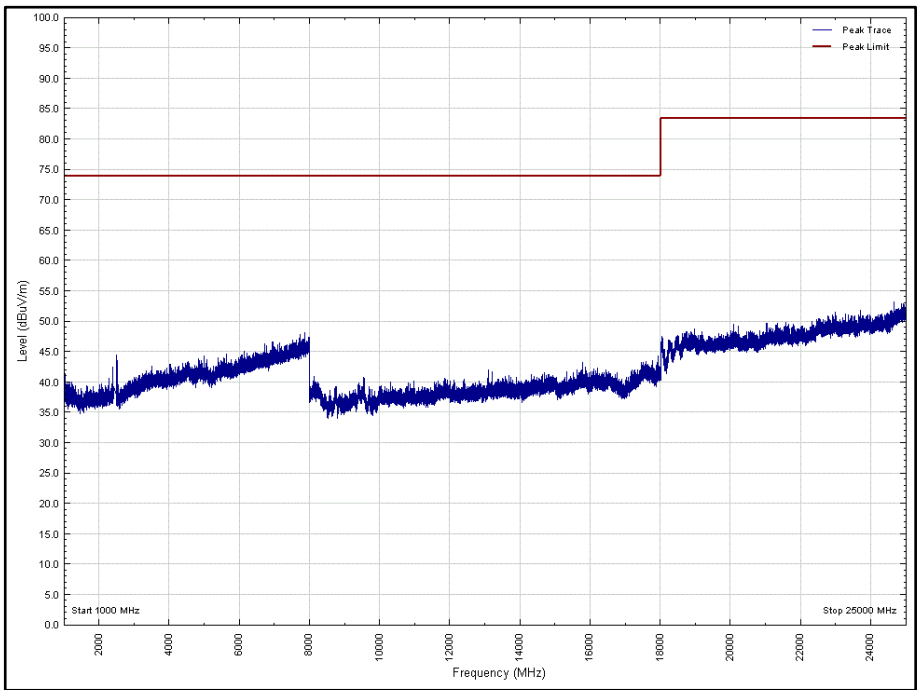


Figure 133 - 2440 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

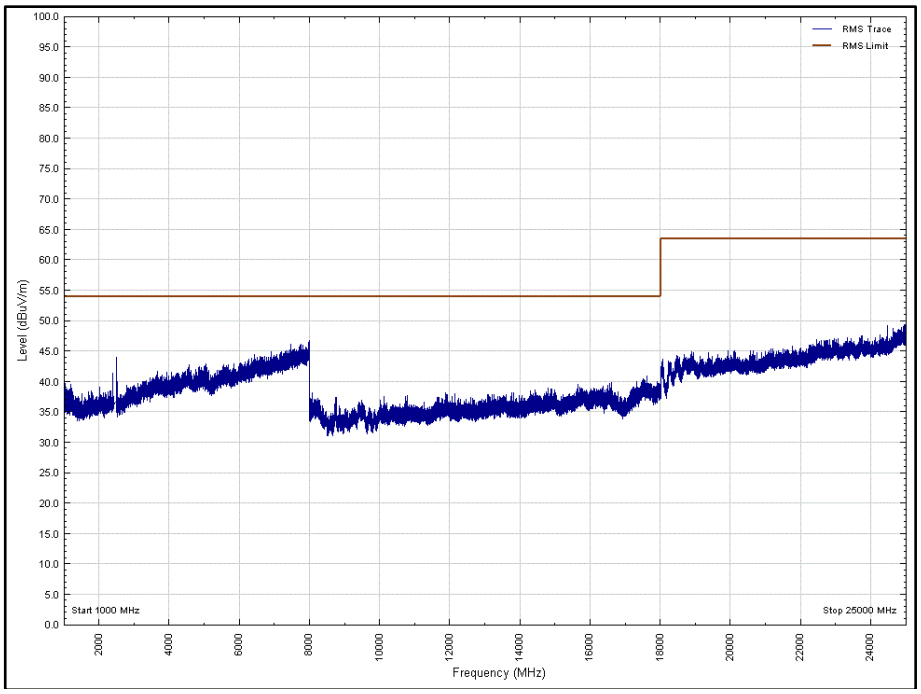


Figure 134 – 2440 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

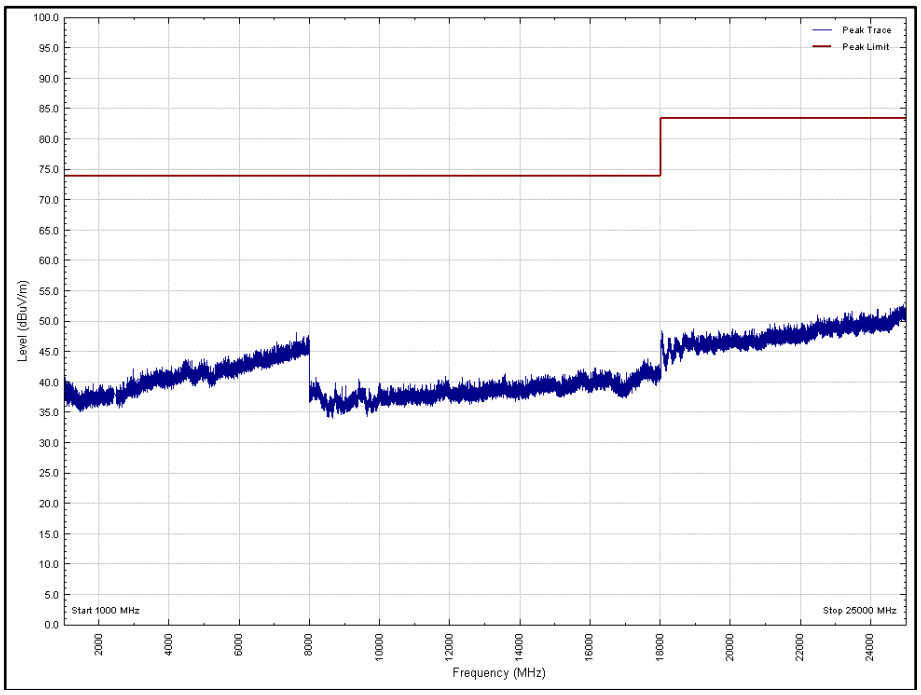


Figure 135 - 2440 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

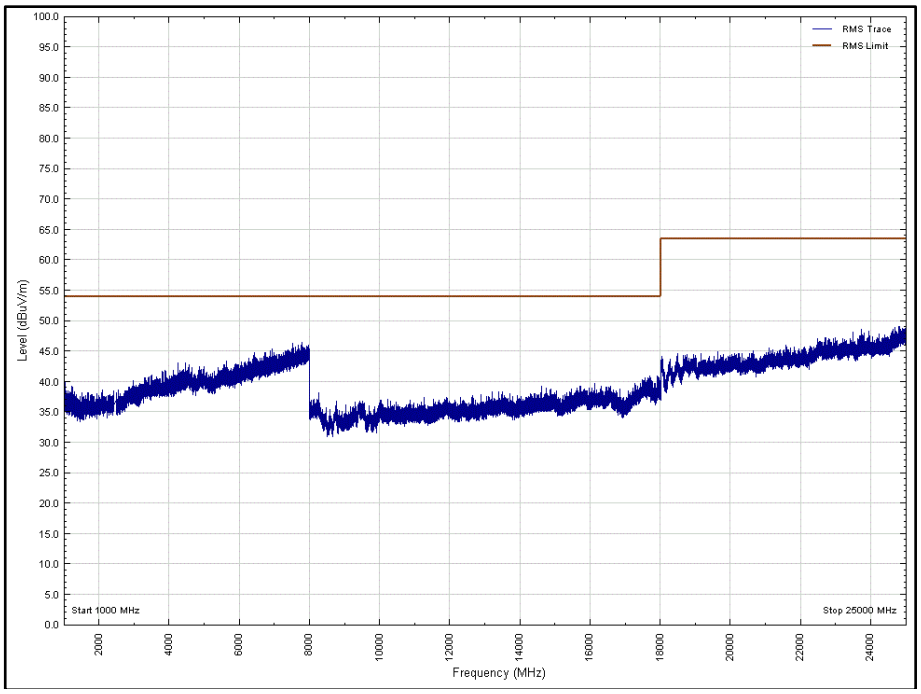


Figure 136 - 2440 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

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

Table 40 - Radiated Emissions Results, 30 MHz to 1 GHz – 2480 MHz

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

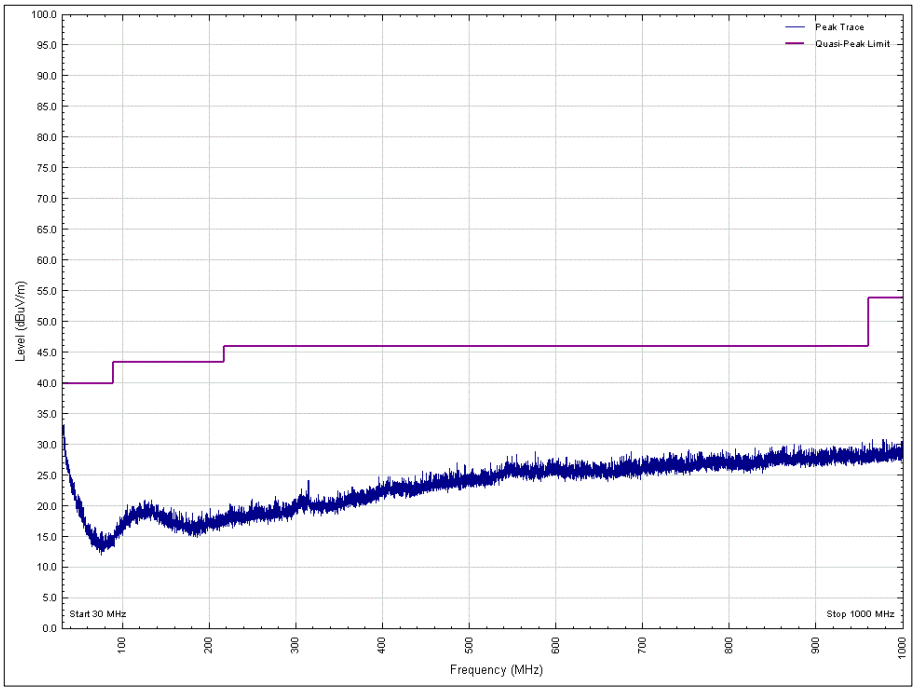


Figure 137 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation X

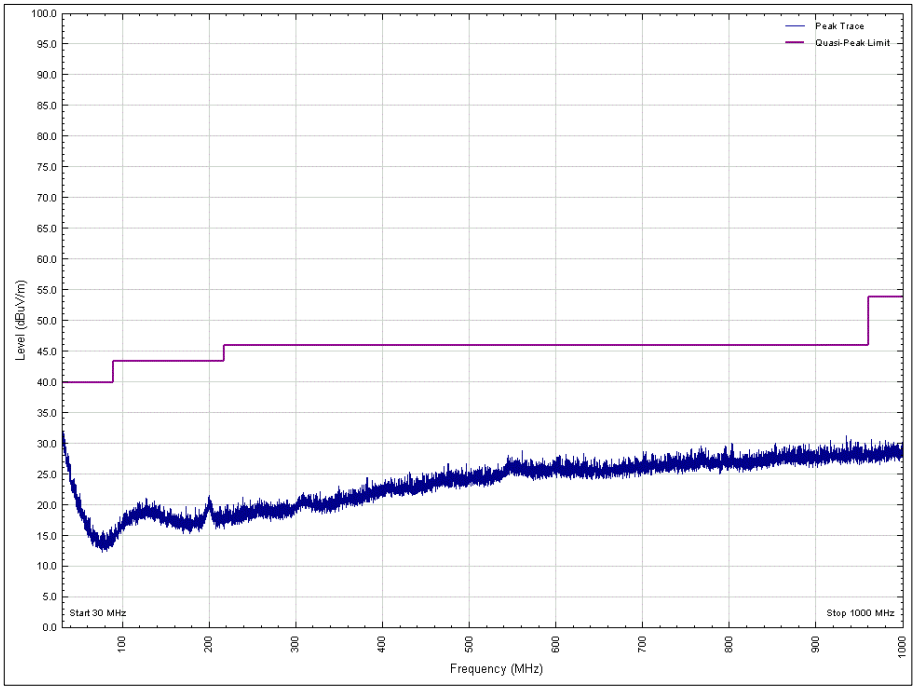


Figure 138 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation X

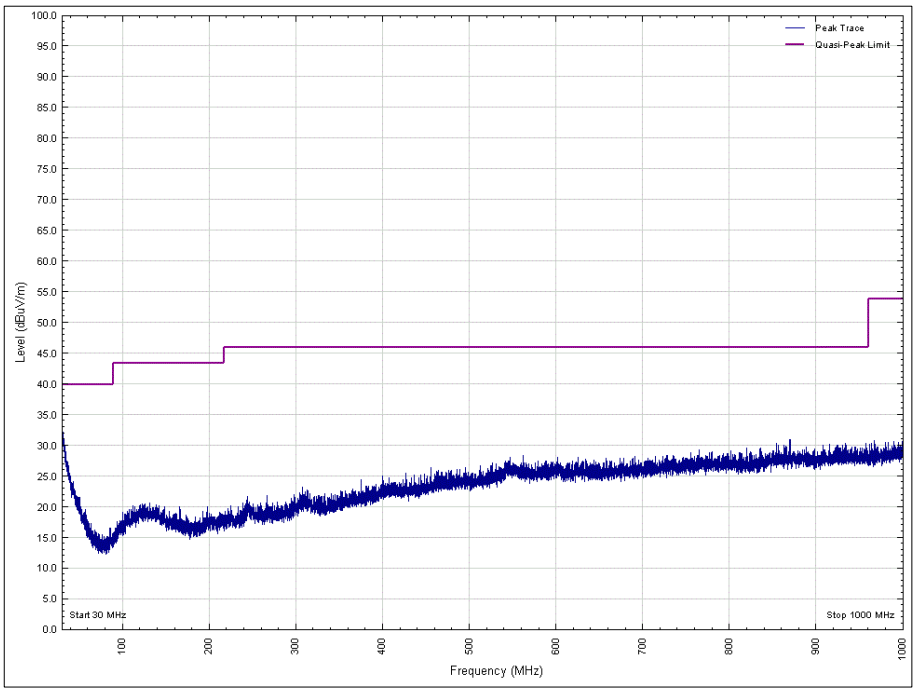


Figure 139 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation Y

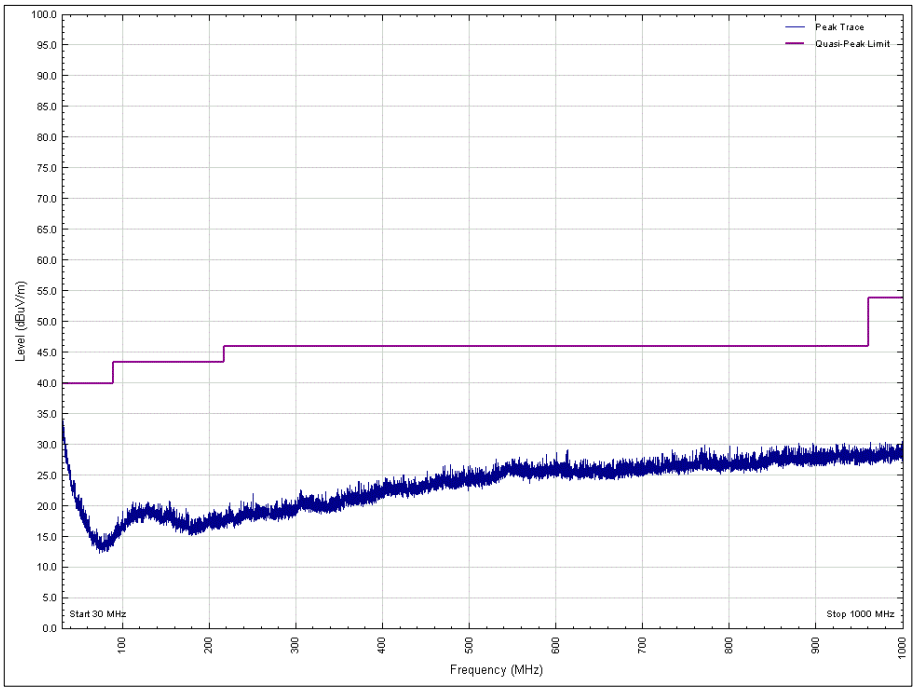


Figure 140 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation Y

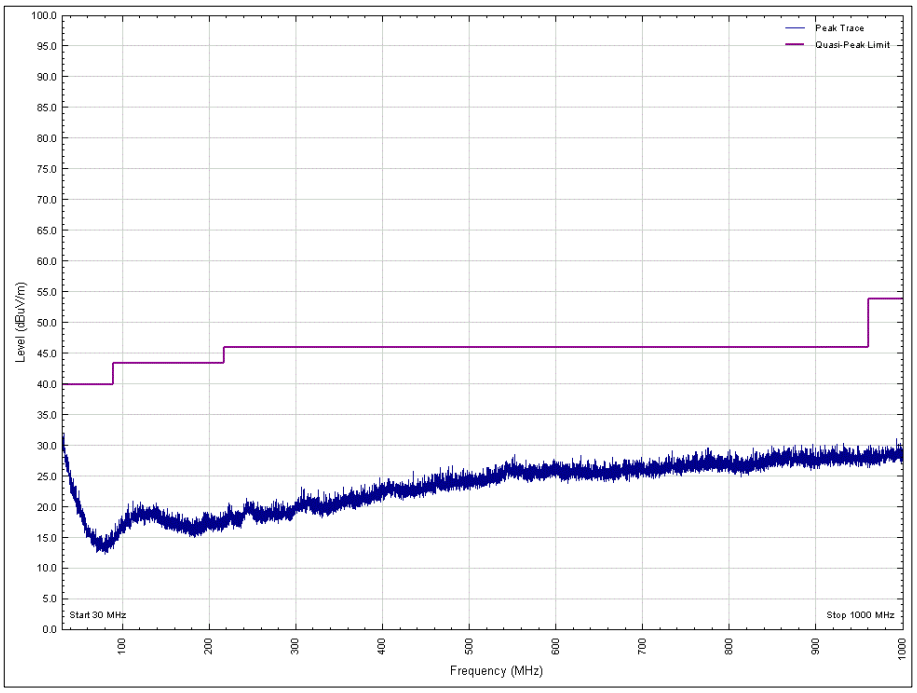


Figure 141 - 30 MHz to 1 GHz, 2480 MHz, Horizontal, EUT Orientation Z

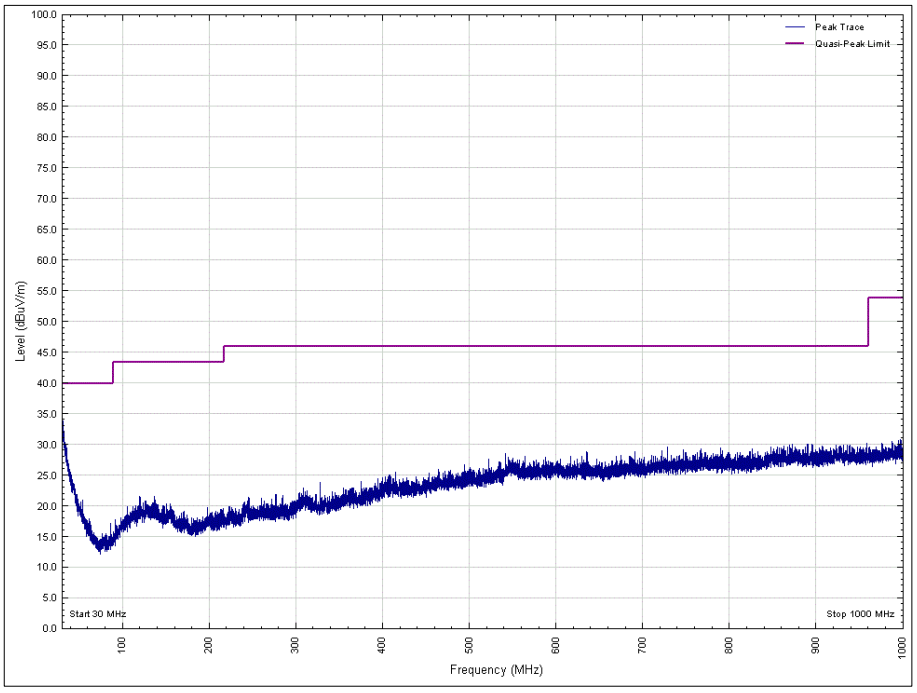


Figure 142 - 30 MHz to 1 GHz, 2480 MHz, Vertical, EUT Orientation Z

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

Table 41 - 2480 MHz - 1 GHz to 25 GHz Emissions Results

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

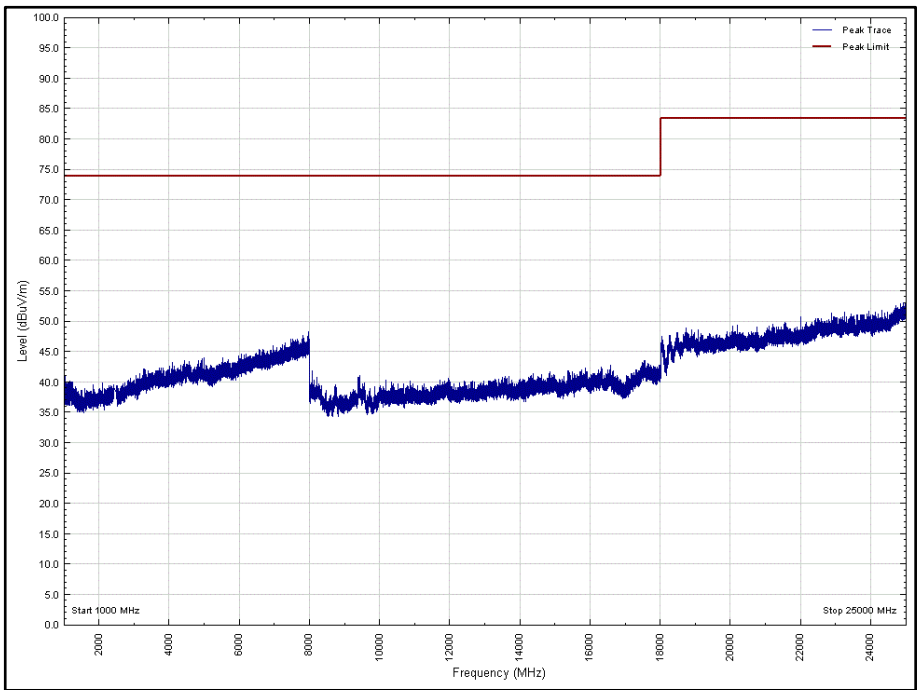


Figure 143 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: X

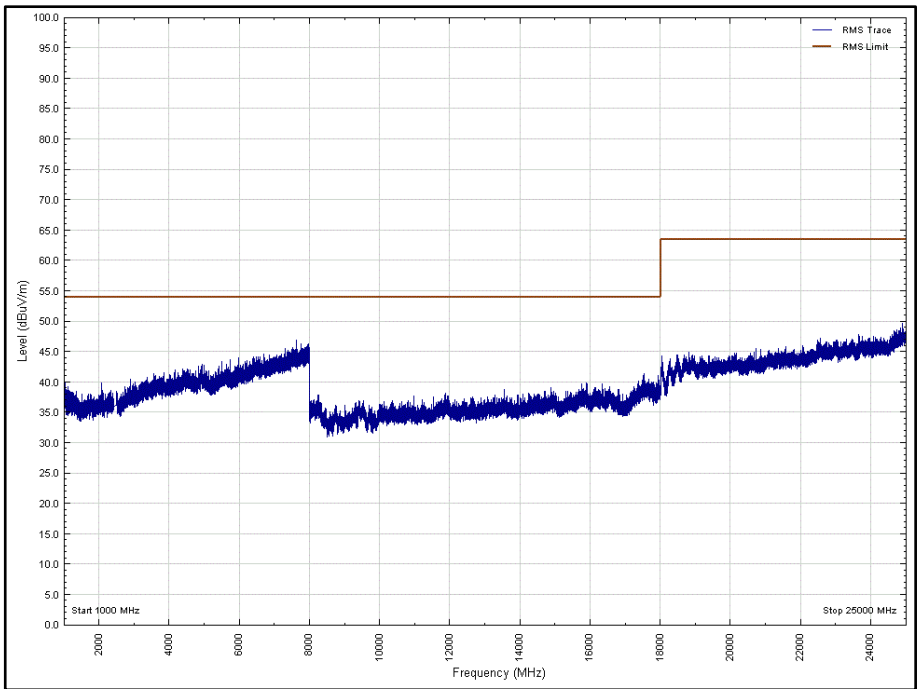


Figure 144 - 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: X

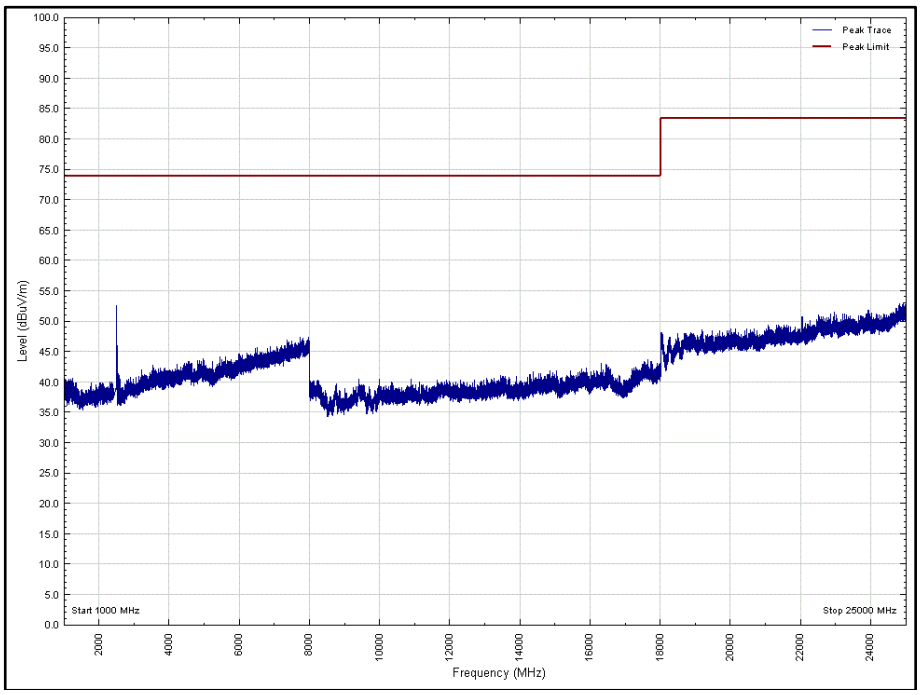


Figure 145 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: X

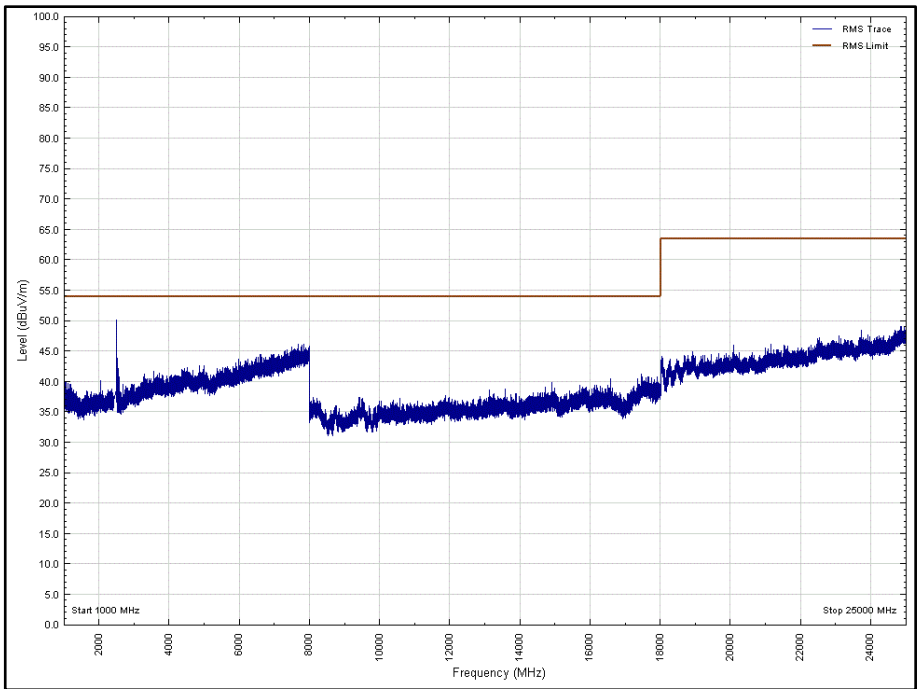


Figure 146 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: X

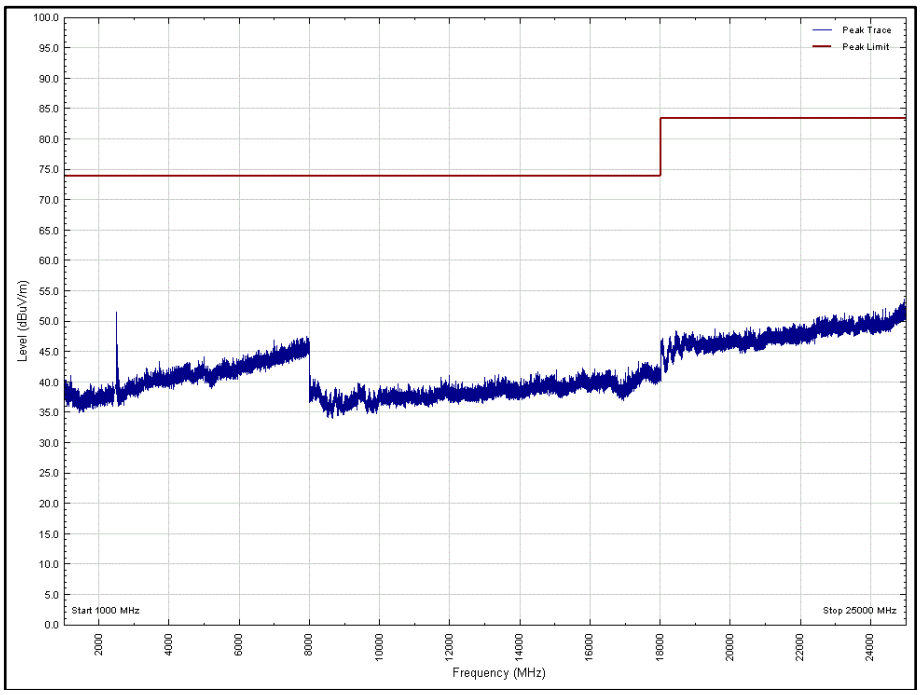


Figure 147 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Y

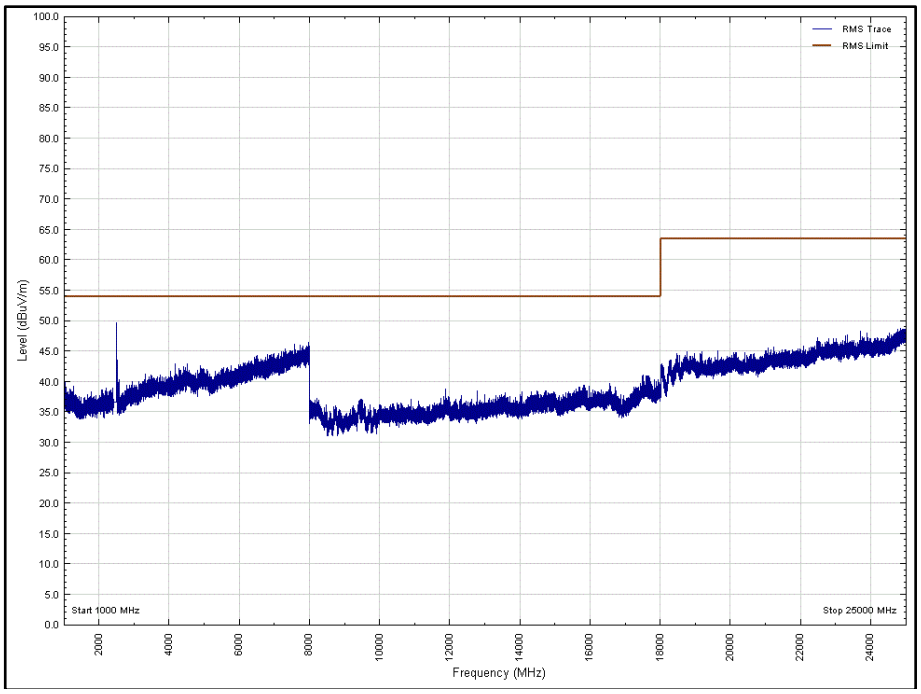


Figure 148 - 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Y

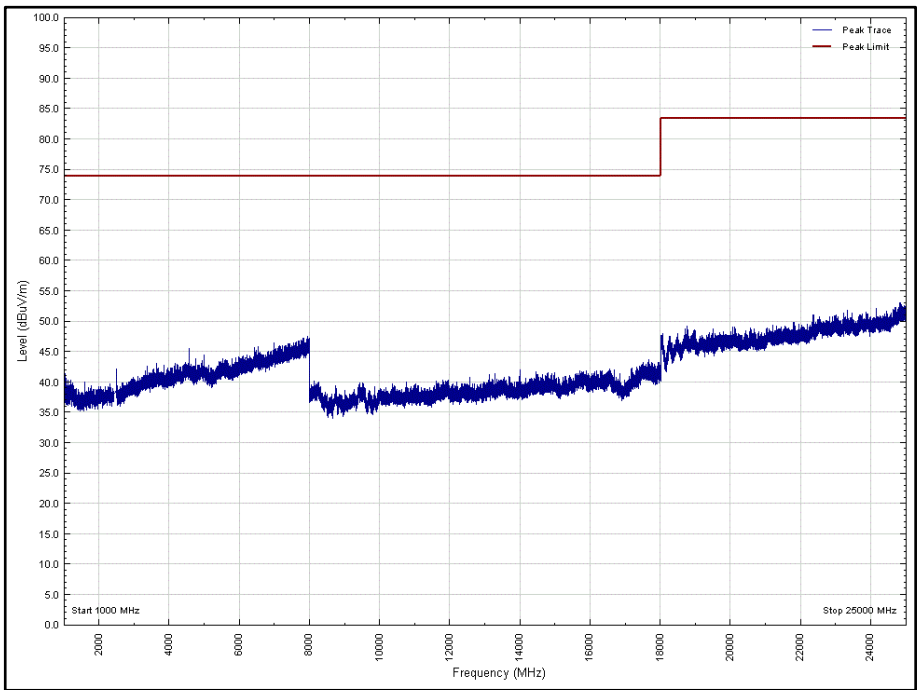


Figure 149 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Y

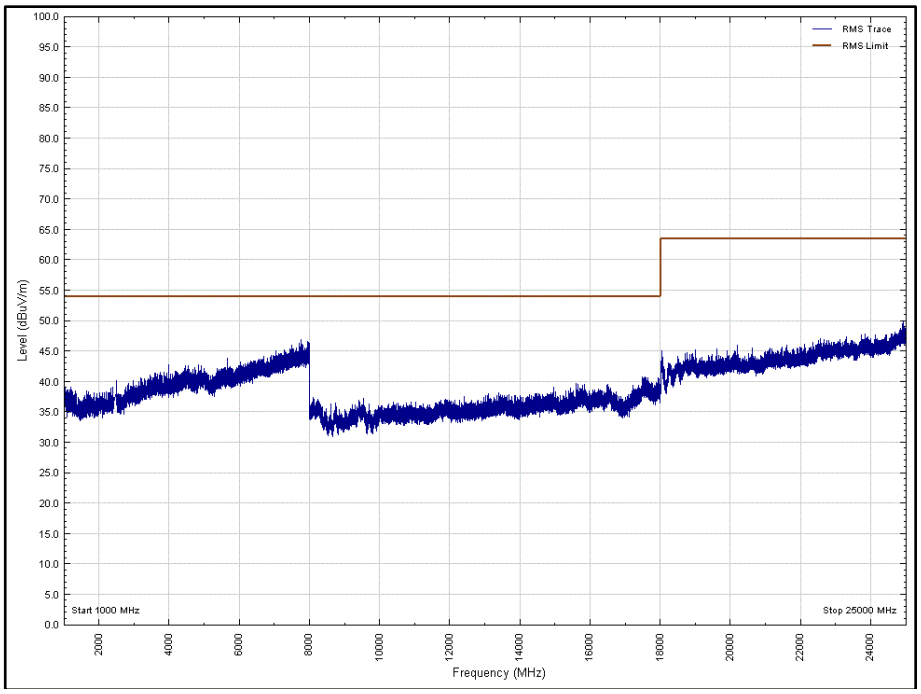


Figure 150 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Y

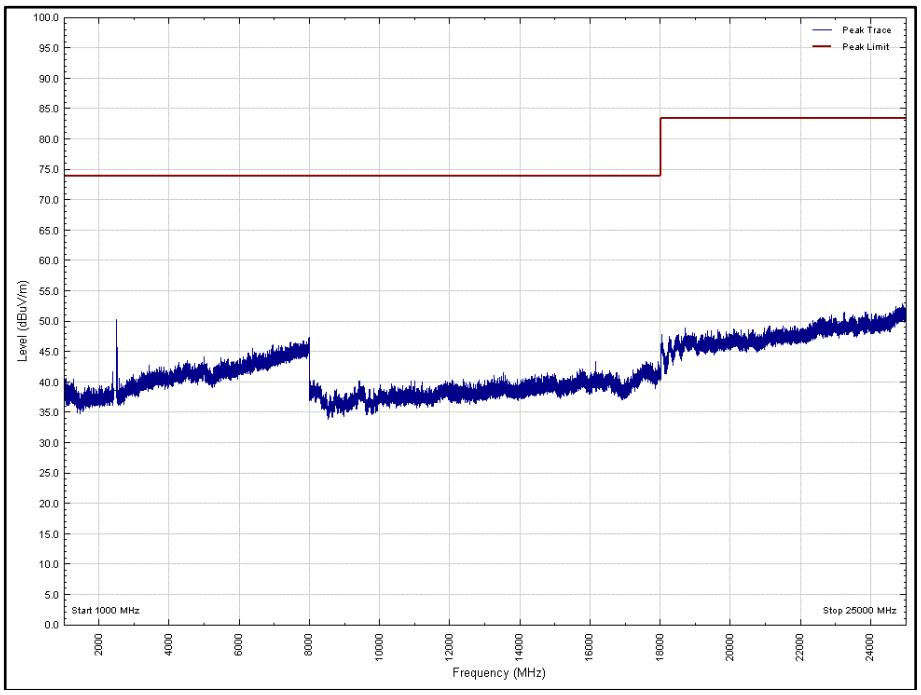


Figure 151 - 2480 MHz - 1 GHz to 25 GHz, Peak, Horizontal, EUT Orientation: Z

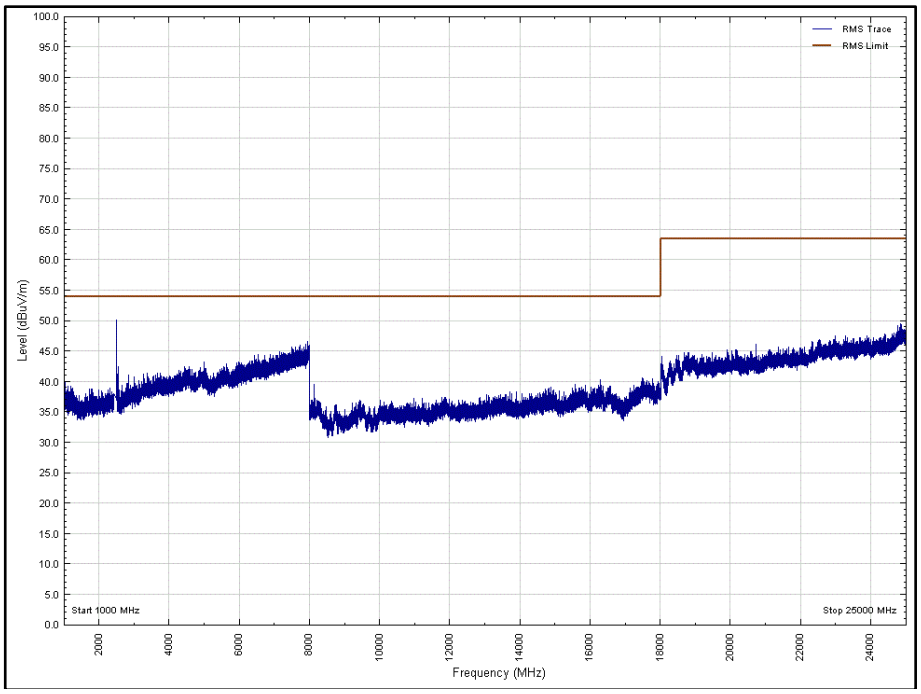


Figure 152 – 2480 MHz - 1 GHz to 25 GHz, Average, Horizontal, EUT Orientation: Z

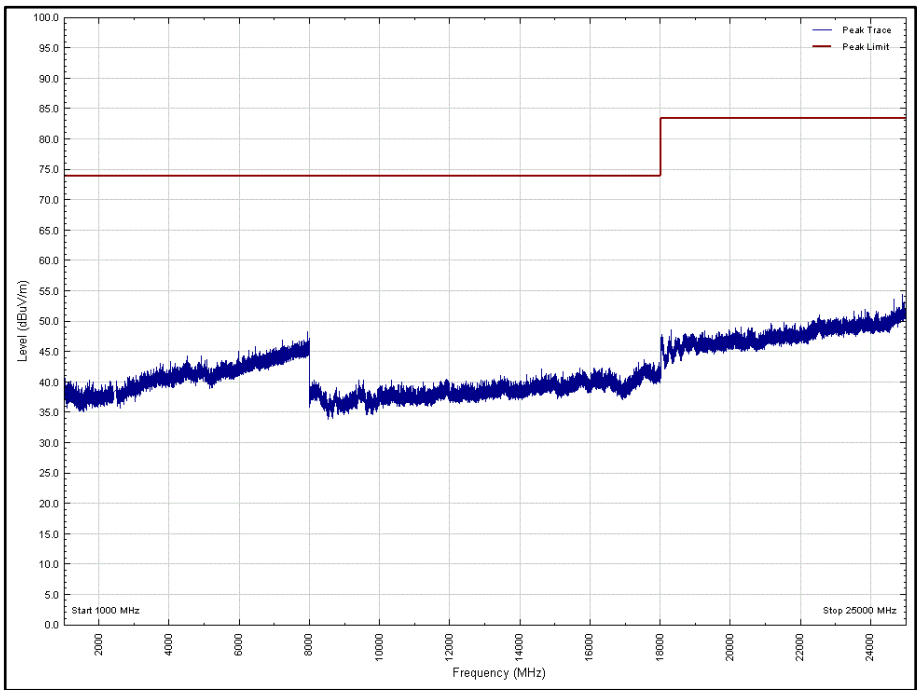


Figure 153 - 2480 MHz - 1 GHz to 25 GHz, Peak, Vertical, EUT Orientation: Z

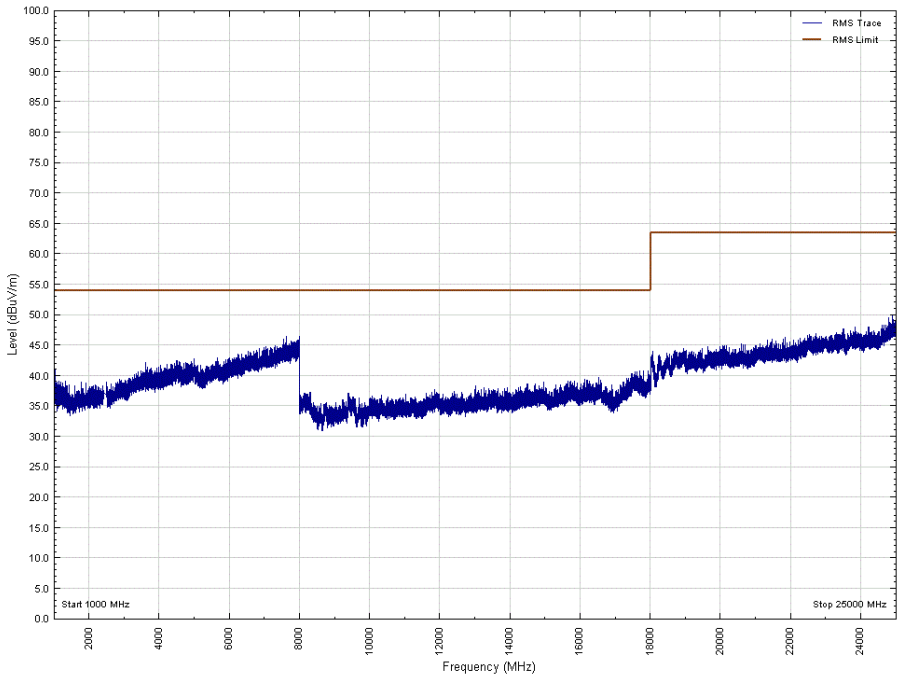


Figure 154 - 2480 MHz - 1 GHz to 25 GHz, Average, Vertical, EUT Orientation: Z

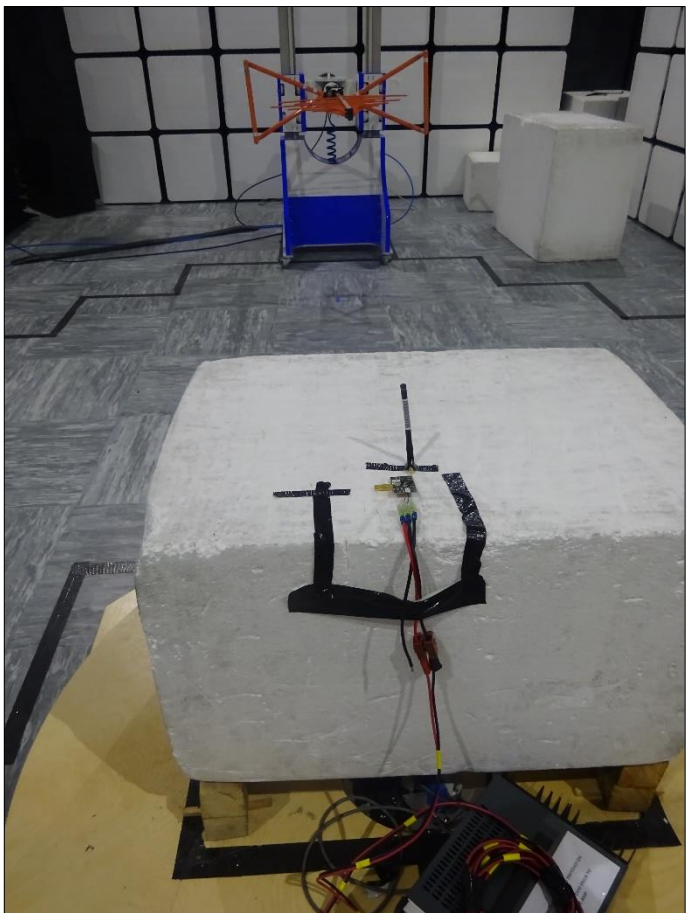


Figure 155 - 30 MHz to 1 GHz, X Orientation

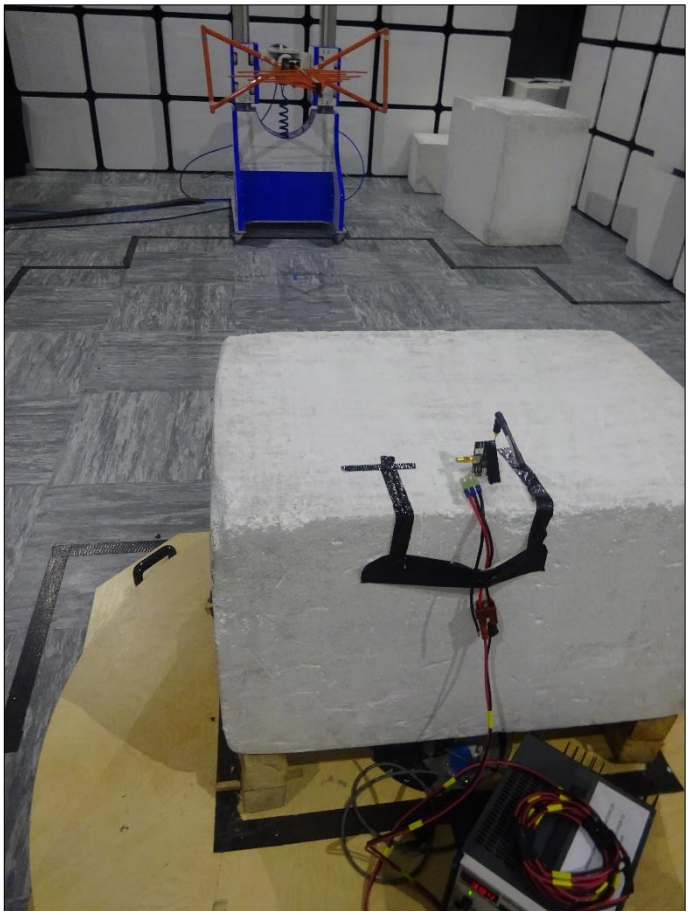


Figure 156 - 30 MHz to 1 GHz, Y Orientation

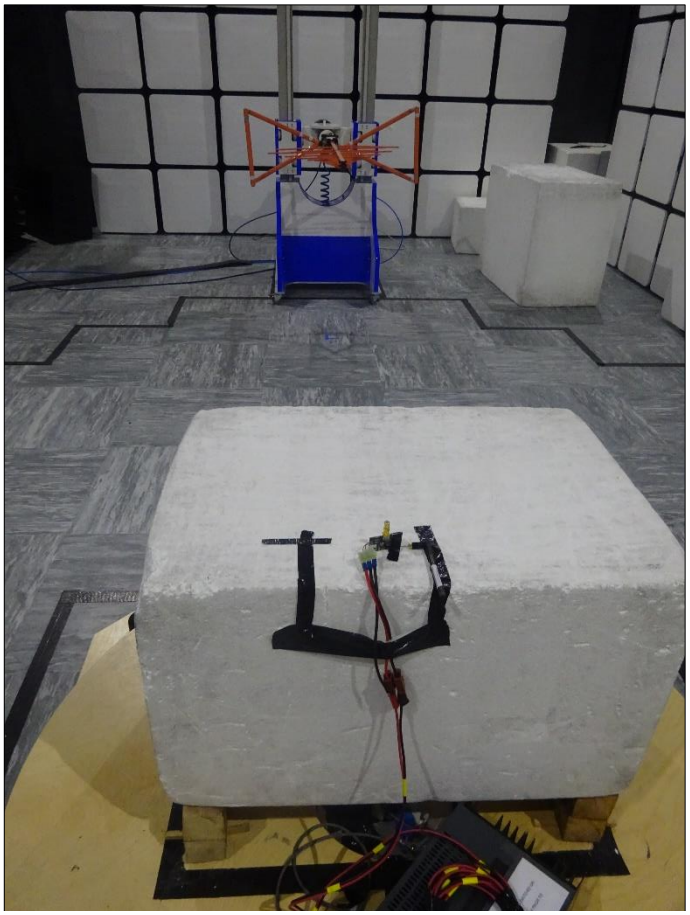


Figure 157 - 30 MHz to 1 GHz, Z Orientation

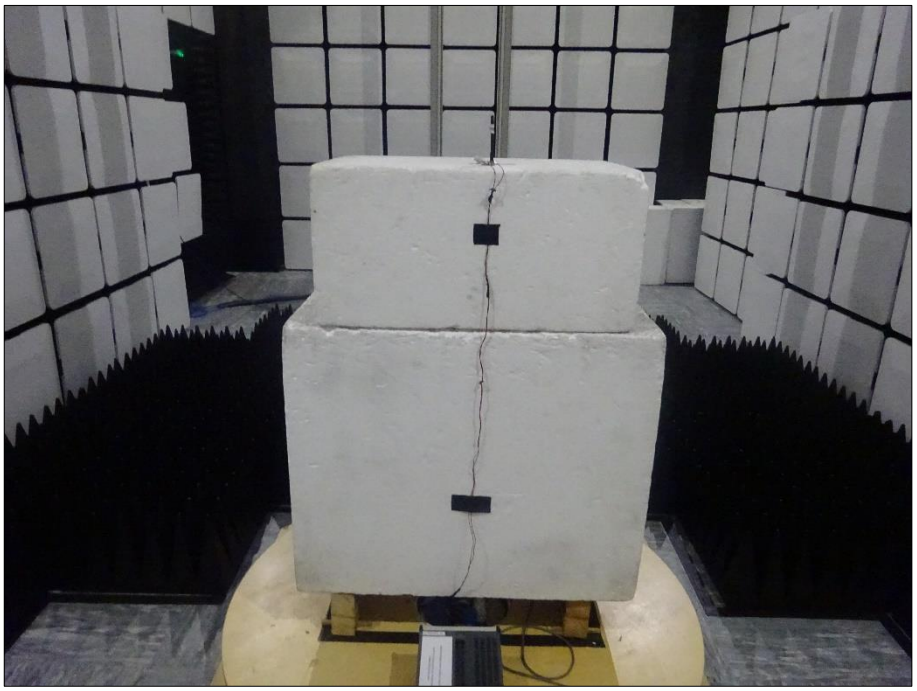


Figure 158 - 1 GHz to 18 GHz, X Orientation

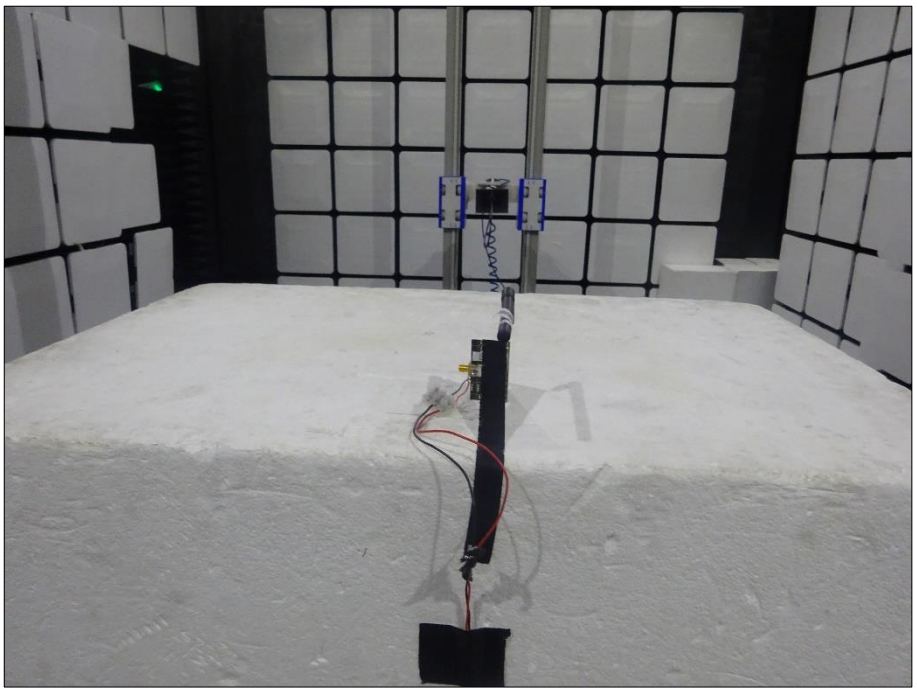


Figure 159 - 1 GHz to 18 GHz, Y Orientation

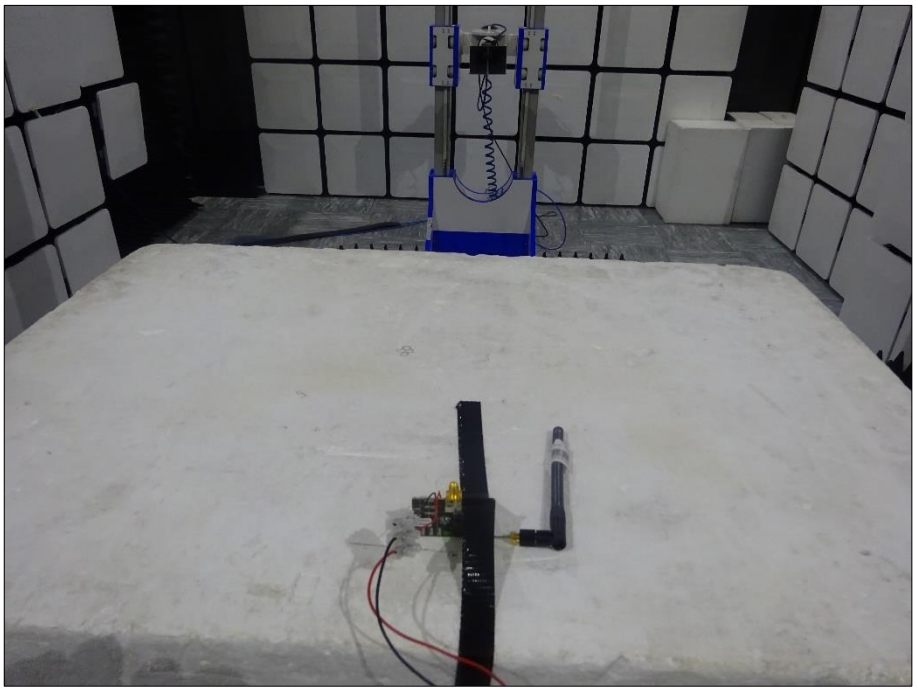


Figure 160 - 1 GHz to 18 GHz, Z Orientation

Figure 161 - 18 GHz to 25 GHz, X Orientation

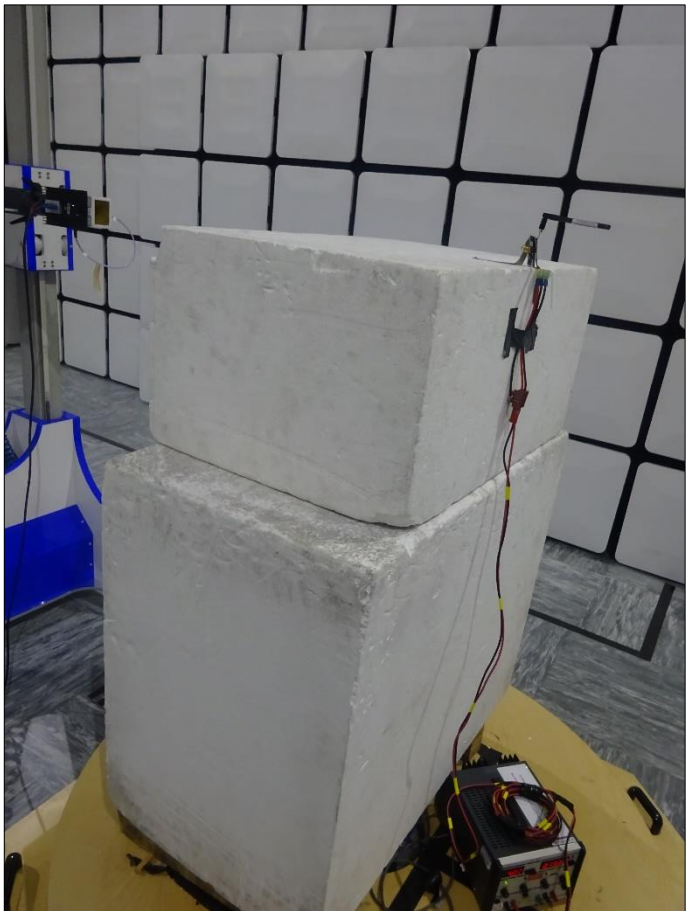


Figure 162 - 18 GHz to 25 GHz, Y Orientation

Figure 163 - 18 GHz to 25 GHz, Z Orientation

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

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in 15.209(a)

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.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna with permanent attenuator (Bilog)	Schaffner	CBL6143	287	24	15-May-2020
Power Supply	Farnell	D302T	609	-	O/P Mon
Pre-Amplifier	Phase One	PS04-0086	1533	12	04-Aug-2020
Multimeter	Iso-tech	IDM 101	2118	12	07-Feb-2021
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
8 - 18 GHz pre amp	Wright Technologies	PS06-0061	4971	12	23-Jan-2021
Band Reject Filter - 2.425 GHz	Wainwright	WRCGV14-2390-2400-2450-2460-50SS	5066	12	01-Oct-2020
Band Reject Filter - 2.4585 GHz	Wainwright	WRCGV14-2423.5-2433.5-2483.5-2493.5-50SS	5068	12	01-Oct-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5092	12	06-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5102	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5103	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5105	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	06-Oct-2020
EmX Emissions Software	TUV SUD	EmX V.V1.5.7	5125	-	Software
Screened Room (11)	Rainford	-	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
DRG Horn Antenna (7.5-18GHz)	Schwarzbeck	HWRD750	5216	12	11-Mar-2020
Horn Antenna (15-40GHz)	Schwarzbeck	BBHA 9170	5217	12	09-Apr-2020

Preamplifier (30dB 18-40GHz)	Schwarzbeck	BBV 9721	5218	12	09-Apr-2020
3 GHz High pass filter	Wainwright	WHKX12-2580-3000-18000-80SS	5219	12	11-Jan-2021

Table 42

TU – Traceability Unscheduled
O/P Mon – Output Monitored using calibrated test equipment.

3 Measurement Uncertainty

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

Test Name	Measurement Uncertainty
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Restricted Band Edges	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
Emission Bandwidth	± 33.079 kHz
Maximum Conducted Output Power	± 3.2 dB

Table 43

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.