FCC Test Report

EnerSys SARL
Model: Zigbee Interface

In accordance with FCC 47 CFR Part 15C (Zigbee)

Prepared for: EnerSys SARL
Rue A. Fleming
Z.I. EST
CS40962
62033 Arras Cedex
France

FCC ID: WT5-5188

COMMERCIAL-IN-CONFIDENCE

Document 75957249-02 Issue 01

SIGNATURE			
			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	13 November 2023

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 sample tested was found to comply with the requirements defined in the applied rules.

FCC Accreditation
492497/UK2010 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, 2021 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	13-November-2023

Table 1

1.2 Introduction

Applicant	EnerSys SARL
Manufacturer	EnerSys SARL
Model Number(s)	Zigbee Interface
Part Number	6LA12230C
Hardware Version(s)	C
Software Version(s)	N3.6
Number of Samples Tested	2
Serial Number(s)	TUV#6, and TUV#4
Test Specification/Issue/Date	FCC 47 CFR Part 15C, 2021
Order Number	4501551273-FAL
Date	01-December-2022
Date of Receipt of EUT	23-February-2023 and 13-February-2023
Start of Test	03-March-2023
Finish of Test	22-June-2023
Name of Engineer(s)	Aakash Rawal and Alexander McInnes
Related Document(s)	ANSI C63.10 (2013)

1.3 Brief Summary of Results

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

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: USB Powered - 2.4 GHz ZigBee				
-	15.203	Antenna Requirement	N/T	The EUT meets the requirements of 15.203 as it uses permanently attached integral antennas
2.1	15.205	Restricted Band Edges	Pass	
2.2	15.209 and 15.247 (d)	Spurious Radiated Emissions	Pass	
2.3	15.247 (a)(2)	Emission Bandwidth	Pass	
2.4	15.247 (b)	Maximum Conducted Output Power	Pass	
2.5	15.247 (d)	Authorised Band Edges	Pass	
2.6	15.247 (e)	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)*	Zigbee interface for Rf communication with EnerSys batteries
Manufacturer:	EnerSys SARL Rue A. Fleming – Z.I. EST – CS40962 62033 Arras Cedex
Model:	Zigbee Interface
Part Number:	6LA12230
Hardware Version:	C
Software Version:	N3.6
FCC ID of the product under test – see guidance here	WT5-5188
IC ID of the product under test – see guidance here	

Intentional Radiators

Technology	2.4 GHz Zigbee
Frequency Range (MHz to MHz)	2405 – 2480
Conducted Declared Output Power (dBm)	10
Antenna Gain (dBi)	-1
Supported Bandwidth(s) (MHz) (e.g. 1 MHz, 20 MHz, 40 MHz)	2
Modulation Scheme(s) (e.g. GFSK, QPSK etc)	O-QPSK
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)	
Bottom Frequency (MHz)	2405
Middle Frequency (MHz)	2445
Top Frequency (MHz)	2480

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	48 MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	12 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:	3.0	V
Extreme lower voltage:	3.6	V
Max current:	0.025	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:	-20	°C
Maximum temperature:	55	°C

Cable Loss

Adapter Cable Loss (Conducted sample)	Connector :0 Cable IPEX to RSMA 100 mm : -0.52	dB

Antenna Characteristics

Antenna connector ☐			State impedance		Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☐	Type:		Gain	-1	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 ☐					

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	Zigbee interface for Rf communication with EnerSys batteries	
Manufacturer:	EnerSys SARL Rue A. Fleming – Z.I. EST – CS40962 62033 Arras Cedex	
Model:	Zigbee Interface	
Part Number:	6LA12230	
Hardware Version:	C	
Software Version:	N3.6	
FCC ID of the product under test – see guidance here		WT5-5188
IC ID of the product under test – see guidance here		

Intentional Radiators

Technology	2.4 GHz Zigbee
Frequency Range (MHz to MHz)	2405 – 2480
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Modulation Scheme(s) (e.g. GFSK, QPSK etc)	O-QPSK
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)	
Bottom Frequency (MHz)	2405
Middle Frequency (MHz)	2445
Top Frequency (MHz)	2480

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	48 MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	12 MHz
Class A Digital Device (Use in commercial, industrial or business environment) ☐ Class B Digital Device (Use in residential environment only) ☐	

Ancillaries (if applicable)

Manufacturer:		Part Number:	
Model:		Country of Origin:	

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

Name: Francois Beaucamp
Position held: Design Engineer
Date: November 09 th 2023

1.4.1 Technical Description

Zigbee interface for RF communication with EnerSys batteries.

1.5 Deviations from the Standard

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

1.6 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: Zigbee interface, Serial Number: TUV#4			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: Zigbee interface, Serial Number: TUV#6			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 3

1.7 Test Location

TÜV SÜD conducted the following tests at our Octagon House Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: USB Powered - 2.4 GHz ZigBee		
Restricted Band Edges	Aakash Rawal	UKAS
Authorised Band Edges	Aakash Rawal	UKAS
Emission Bandwidth	Alexander McInnes	UKAS
Maximum Conducted Output Power	Alexander McInnes	UKAS
Spurious Radiated Emissions	Aakash Rawal	UKAS
Power Spectral Density	Alexander McInnes	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

2.1.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#4 - Modification State 0

2.1.3 Date of Test

22-March-2023 to 04-April-2023

2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5 and 11.12.1.

Plots for average measurements were taken in accordance with ANSI C63.10, clause 11.12.2.5.2.

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

2.1.5 Environmental Conditions

Ambient Temperature	18.2 - 20.1 °C
Relative Humidity	33.5 - 48.3 %

2.1.6 Test Results

USB Powered - 2.4 GHz ZigBee

Mode	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	2405	2390	50.46	39.15
Static	2480	2483.5	67.03	53.85

Table 5

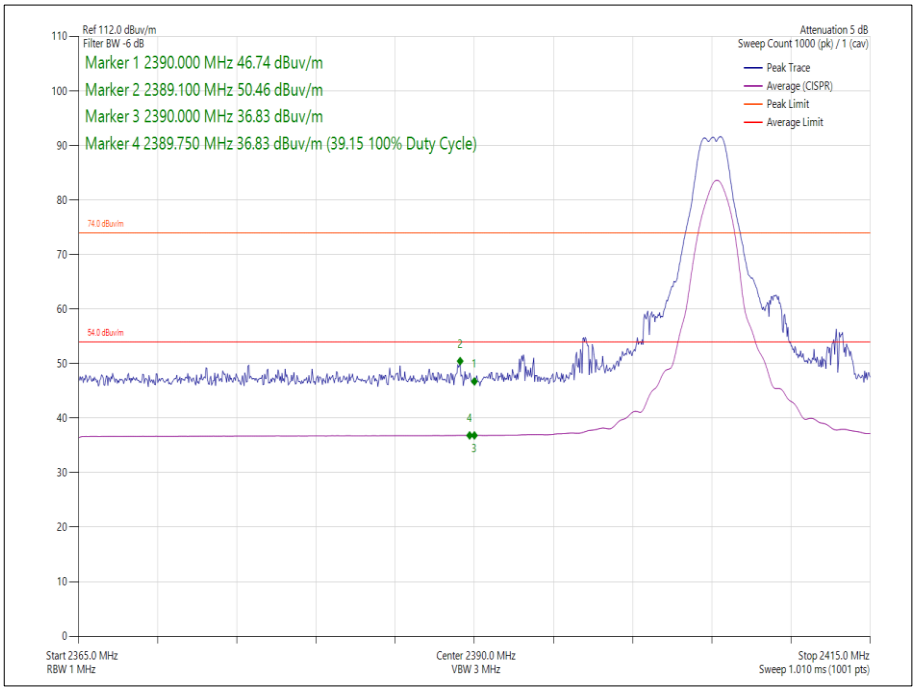

Figure 1 - 2405 MHz - Band Edge Frequency 2390 MHz

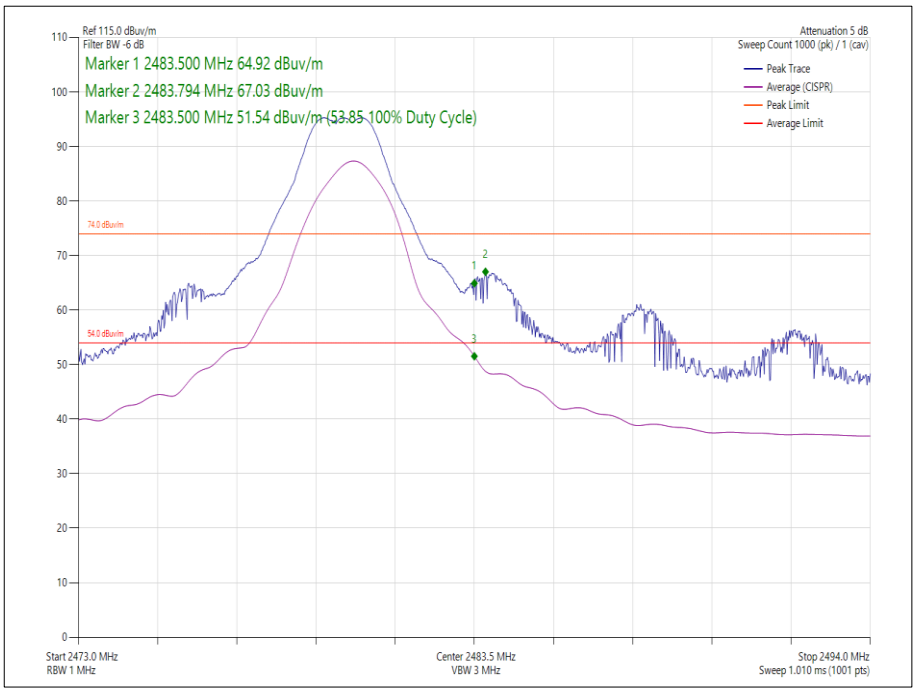

Figure 2 - 2480 MHz - Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.209

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

Table 6

2.1.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Screened Room (5)	Rainford	Rainford	1545	36	15-Apr-2024
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Emissions Software	TUV SUD	EmX V3.1.11	5125	-	Software
Cable (K Type 2m)	Junkosha	MWX241-02000KMS	5421	12	08-Mar-2024
Cable (SMA to SMA, 2 m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	6330	12	16-Feb-2024

Table 7

TU - Traceability Unscheduled

2.2 Spurious Radiated Emissions

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.209 and 15.247 (d)

2.2.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#4 - Modification State 0

2.2.3 Date of Test

05-April-2023 to 05-May-2023 and 22-June-2023

2.2.4 Test Method

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

For frequencies > 1 GHz, plots for average measurements were taken in accordance with ANSI C63.10, clause 11.12.2.5.2.

The EUT was placed on the non-conducting platform in a manner typical of a normal installation. As the EUT was considered mobile/portable and therefore reasonable to 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.

The USB port on the EUT was terminated using a powered-off laptop.

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).

Above 18 GHz, the measurement distance was reduced to 1 m. The limit line was increased by 20*LOG(3/1) = 9.54 dB.

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

2.2.5 Example Test Setup Diagram

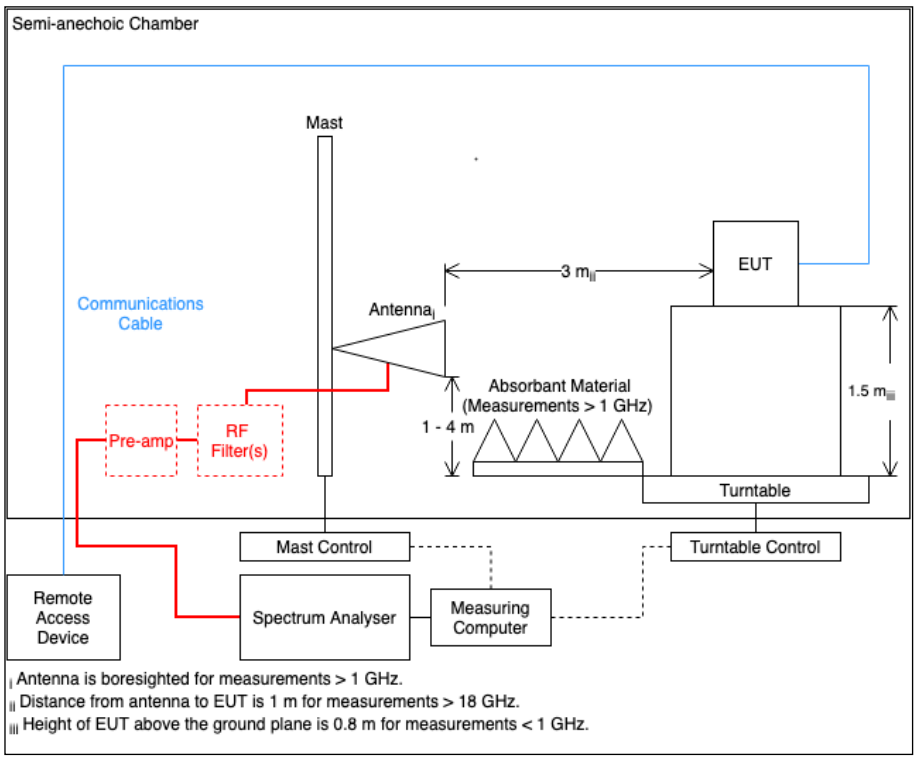

Figure 3

2.2.6 Environmental Conditions

Ambient Temperature	19.1 - 20.4 °C
Relative Humidity	33.5 - 52.4 %

2.2.7 Test Results

USB Powered - 2.4 GHz ZigBee

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

Table 8 - ZigBee - X, 2405 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

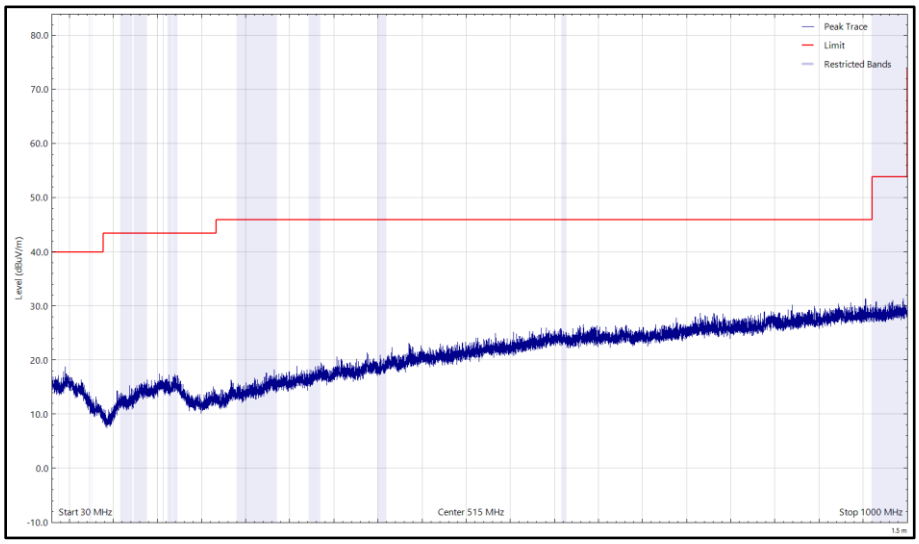

Figure 4 - ZigBee - X, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

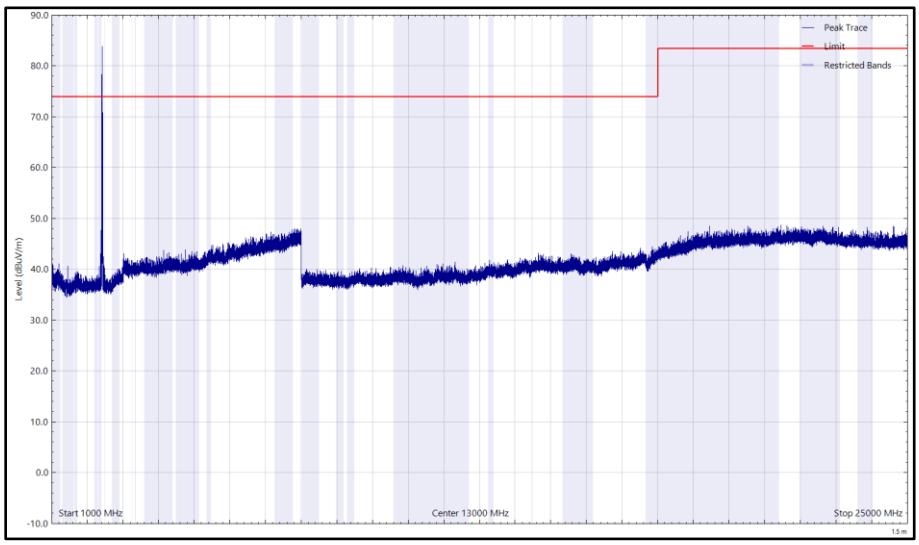

Figure 5 ZigBee - X, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

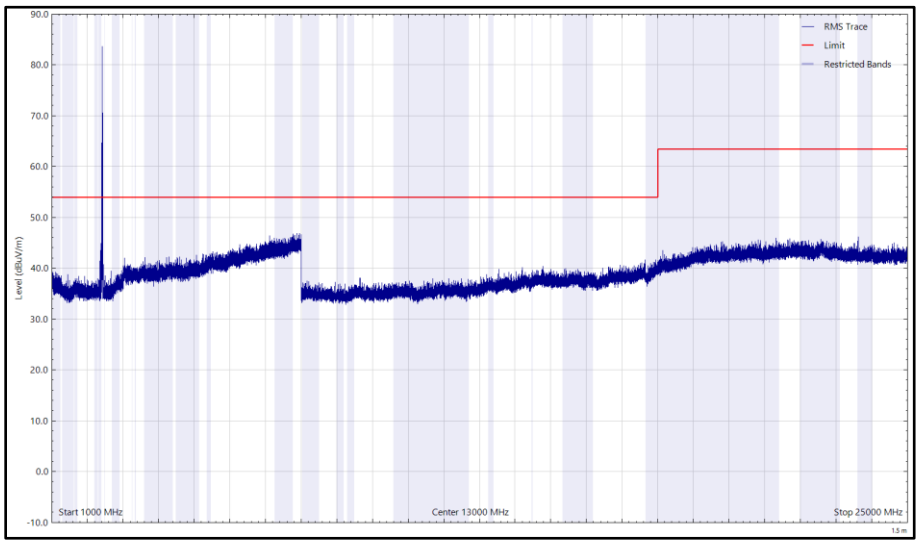

Figure 6 ZigBee - X, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

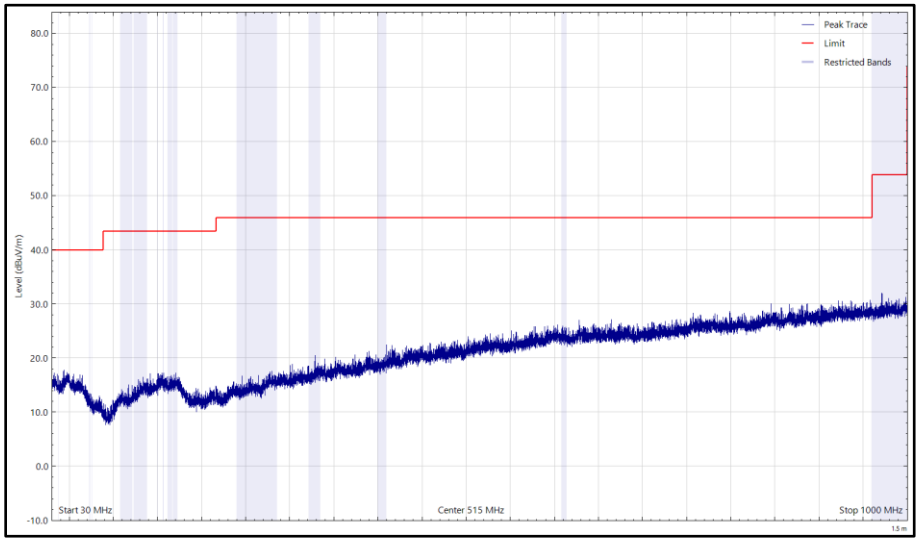

Figure 7 ZigBee - X, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

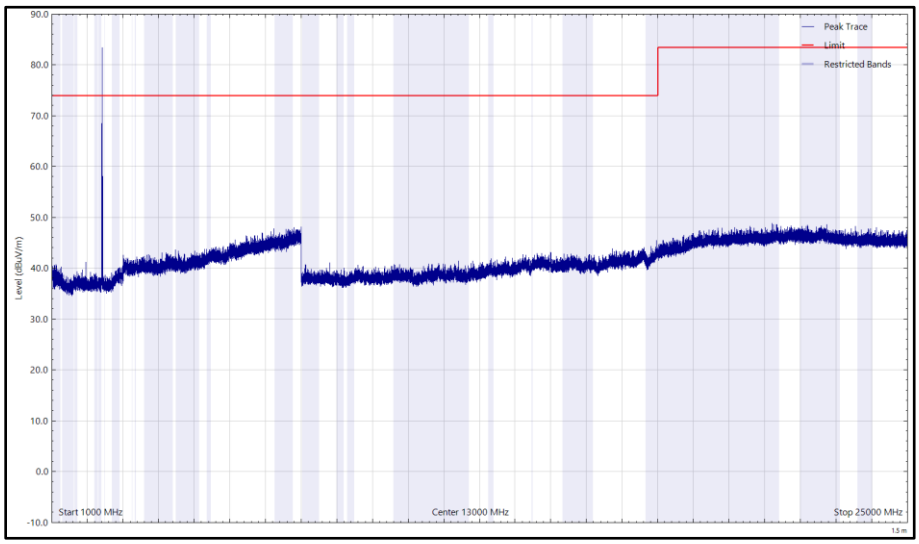

Figure 8 - ZigBee - X, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

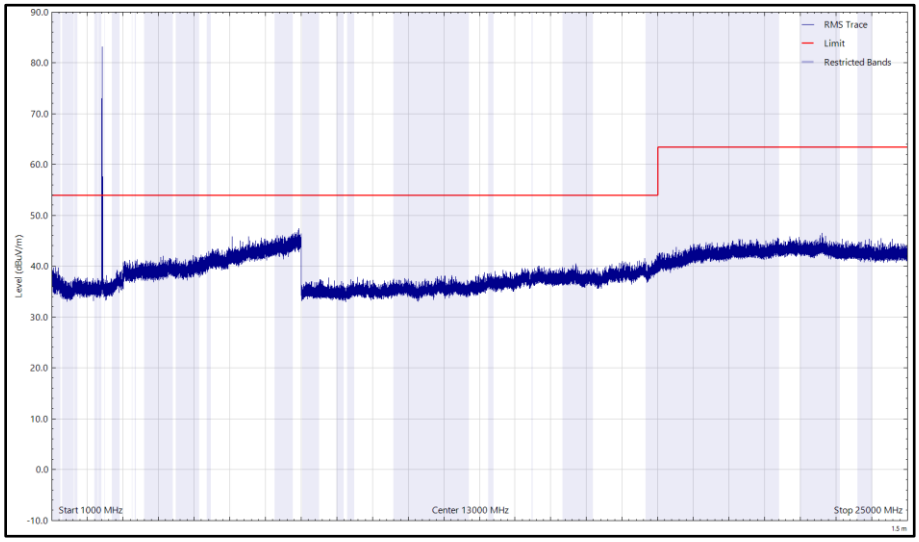

Figure 9 - ZigBee - X, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 9 - ZigBee - X, 2445 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

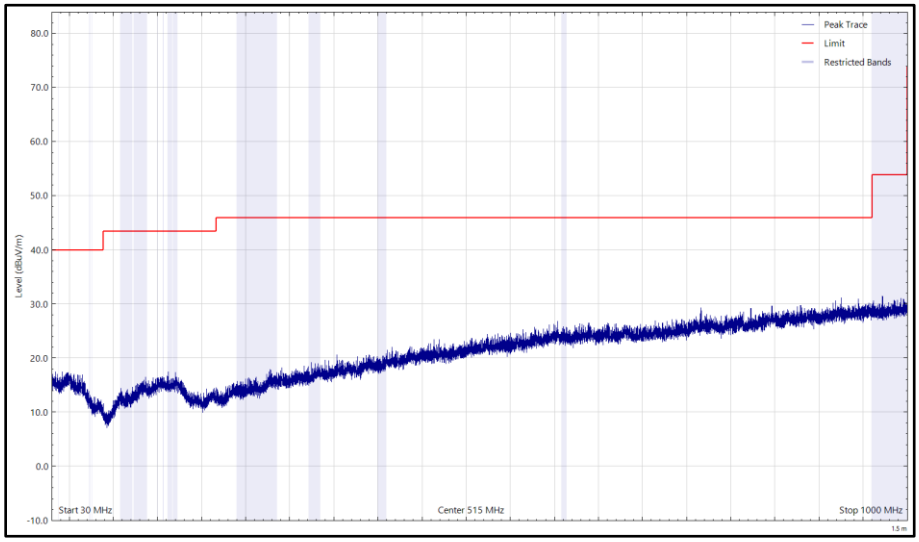

Figure 10 - ZigBee - X, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

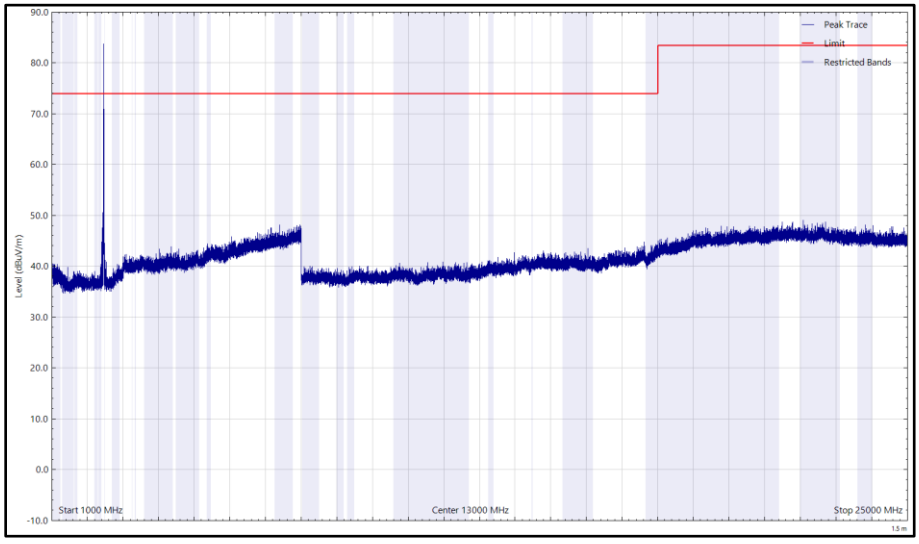

Figure 11 - ZigBee - X, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

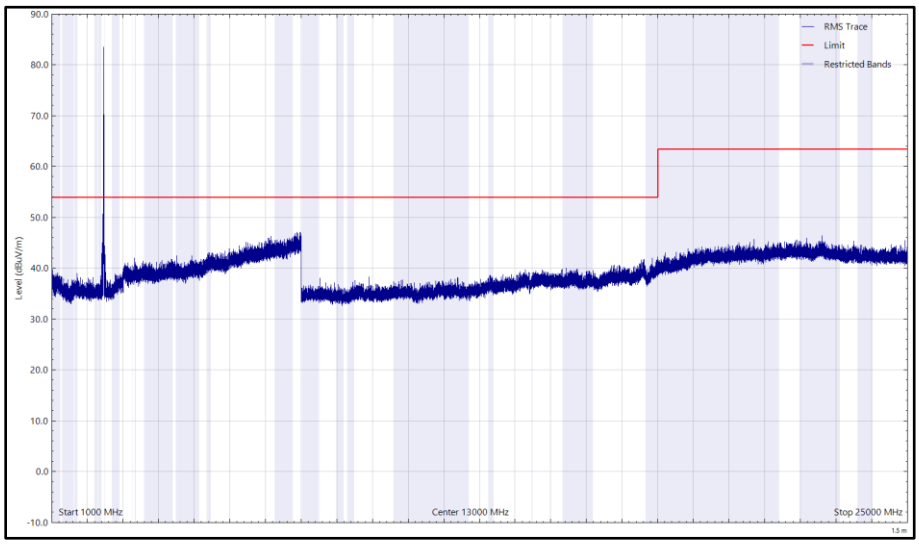

Figure 12 - ZigBee - X, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

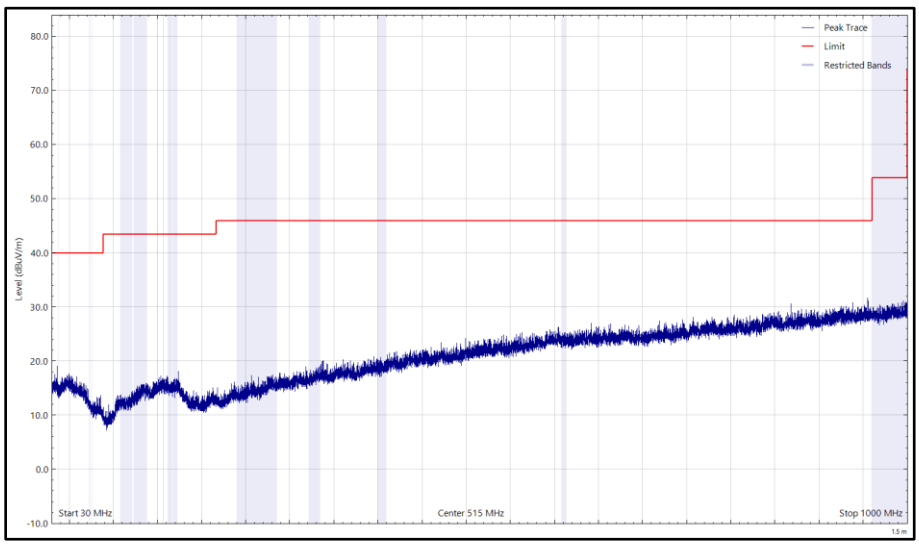

Figure 13 - ZigBee - X, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)

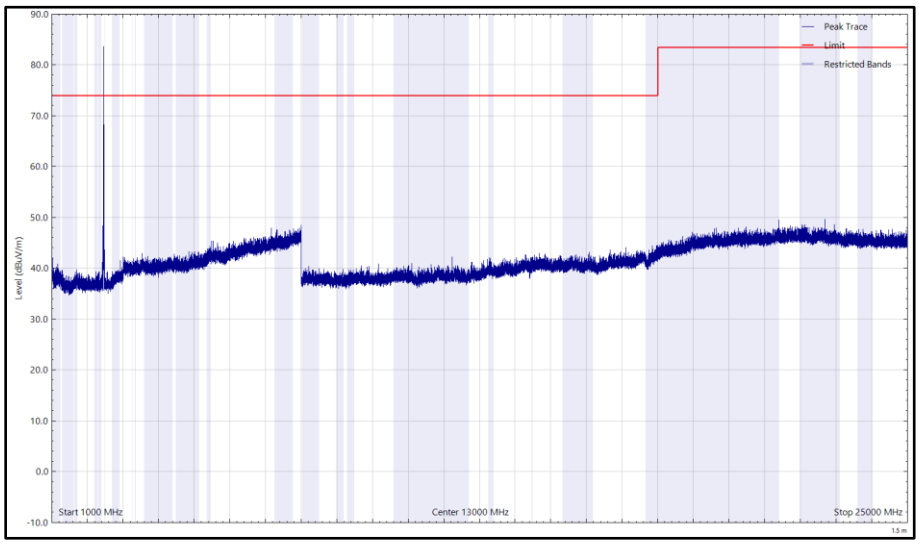

Figure 14 - ZigBee - X, 2445 MHz, 1 GHz to 25 GHz, Vertical (Peak)

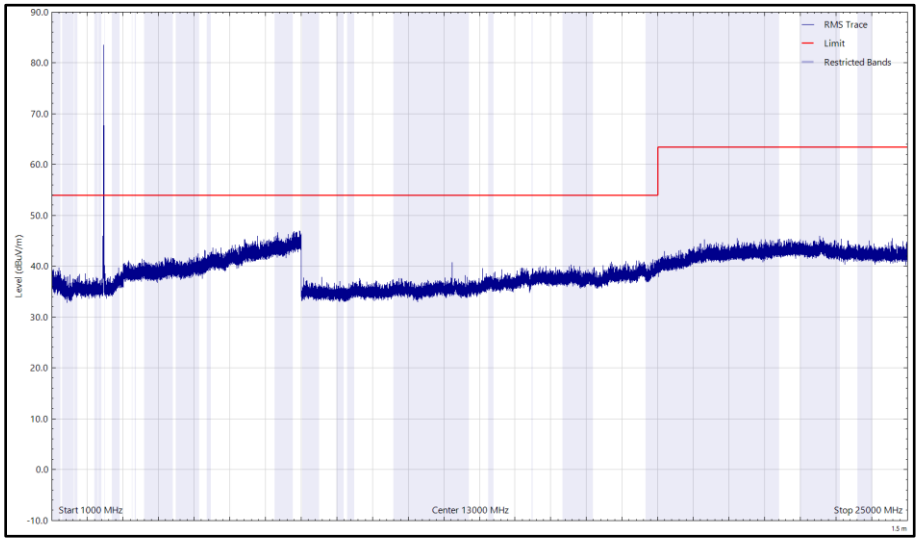

Figure 15 - ZigBee - X, 2445 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 10 - ZigBee - X, 2480 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

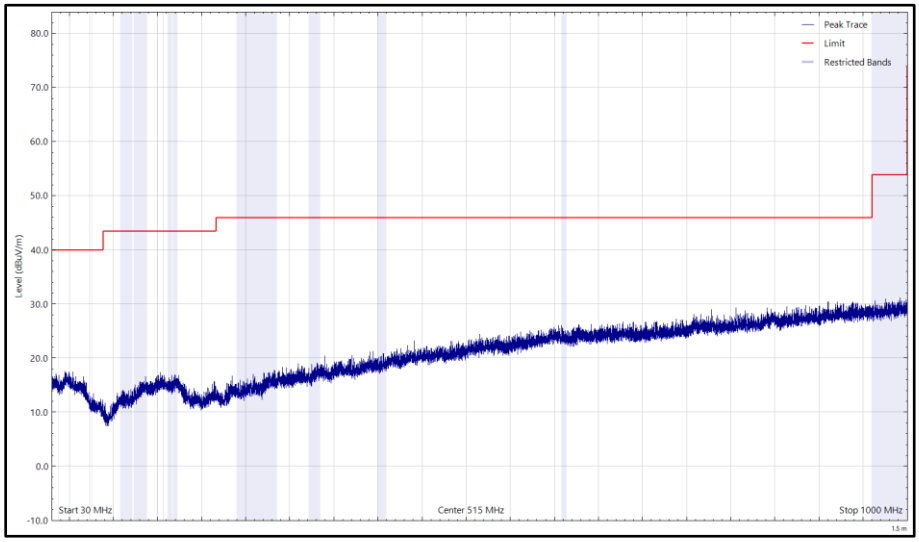

Figure 16 - ZigBee - X, 2480 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

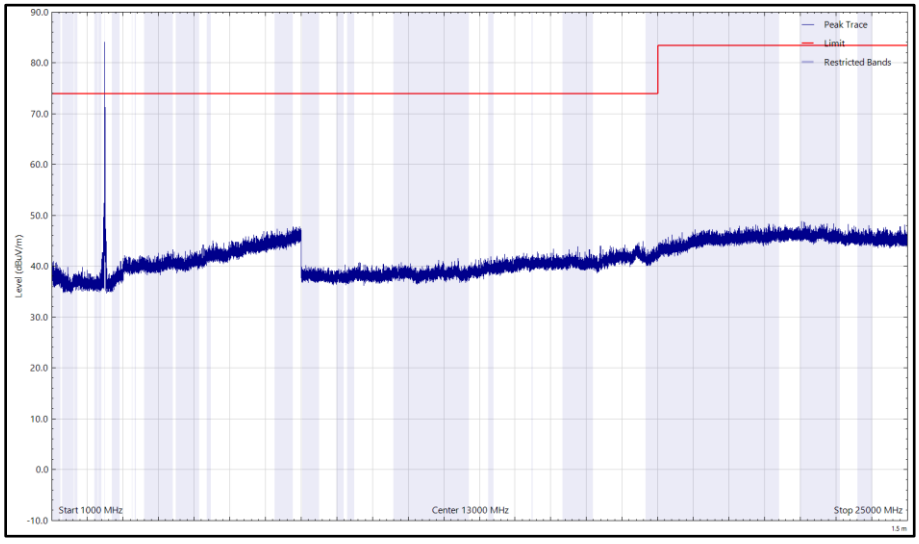

Figure 17 - ZigBee - X, 2480 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

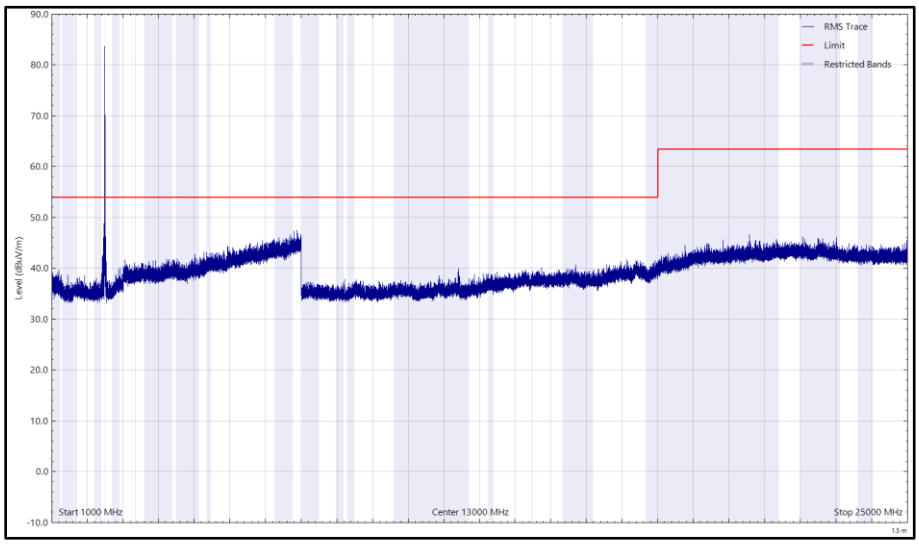

Figure 18 - ZigBee - X, 2480 MHz, 1 GHz to 25 GHz, Horizontal (rms)

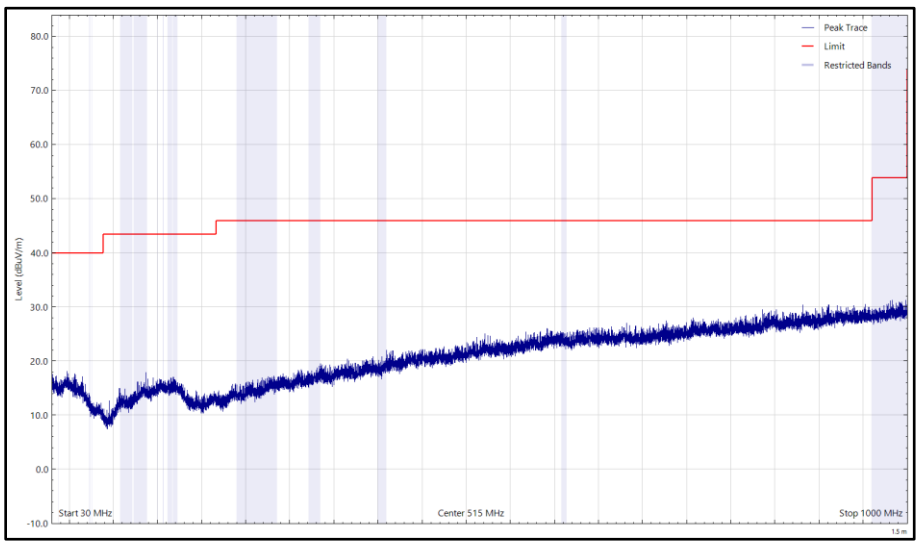

Figure 19 - ZigBee - X, 2480 MHz, 30 MHz to 1 GHz, Vertical (Peak)

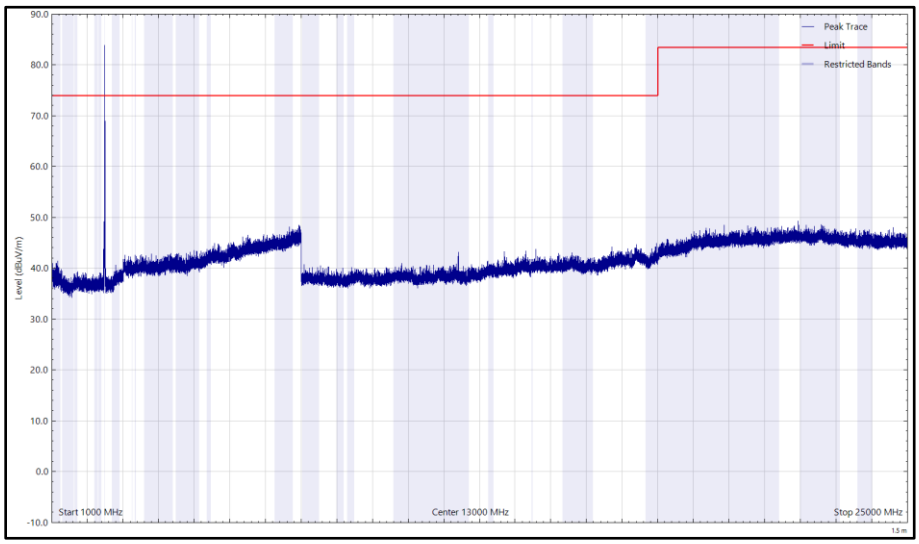

Figure 20 - ZigBee - X, 2480 MHz, 1 GHz to 25 GHz, Vertical (Peak)

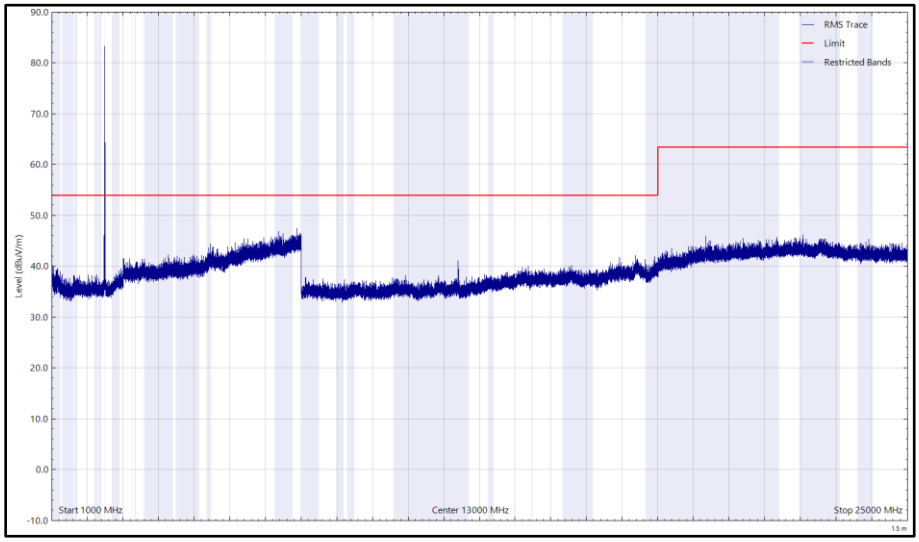

Figure 21 - ZigBee - X, 2480 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 11 - ZigBee - Y, 2405 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

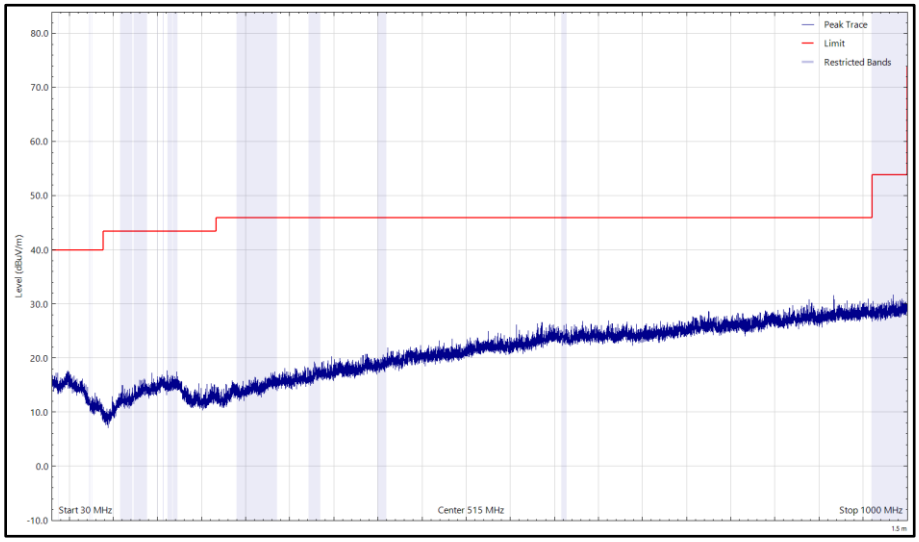

Figure 22 - ZigBee - Y, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

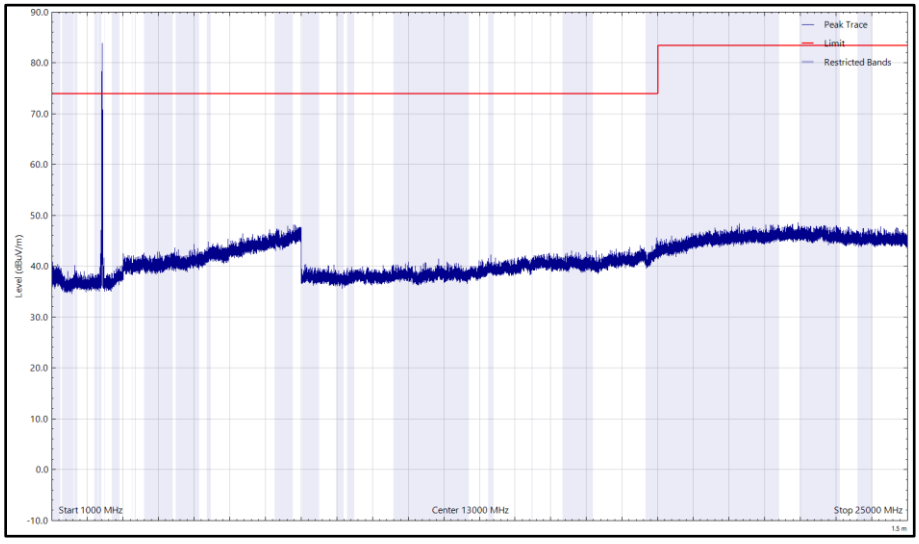

Figure 23 - ZigBee - Y, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

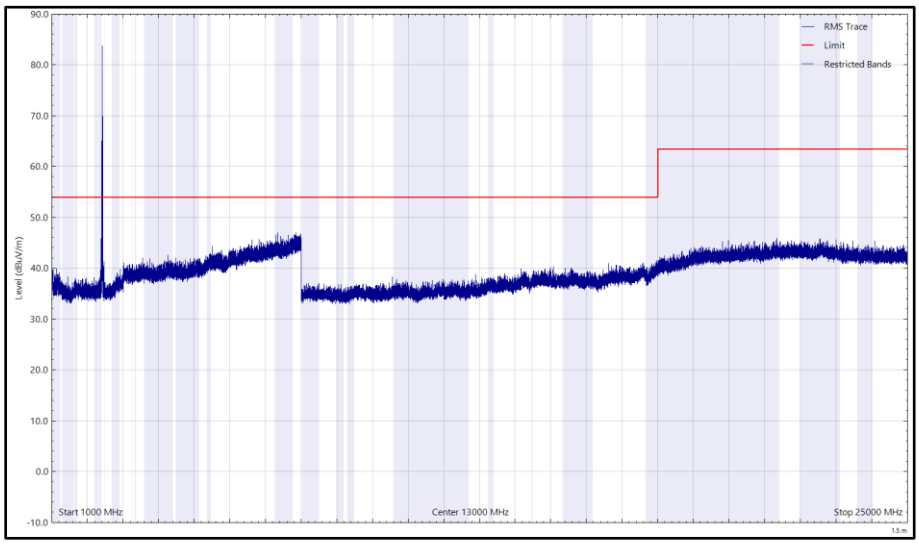

Figure 24 - ZigBee - Y, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

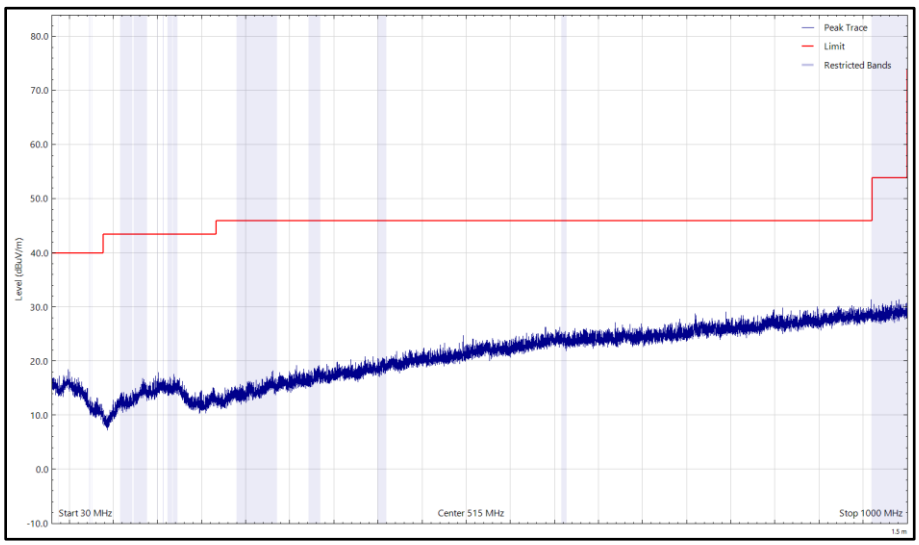

Figure 25 - ZigBee - Y, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

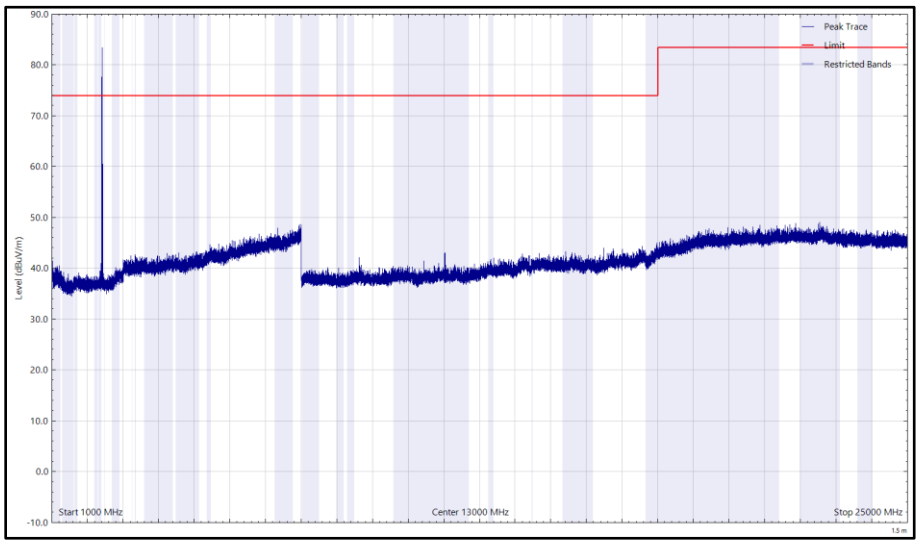

Figure 26 - ZigBee - Y, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

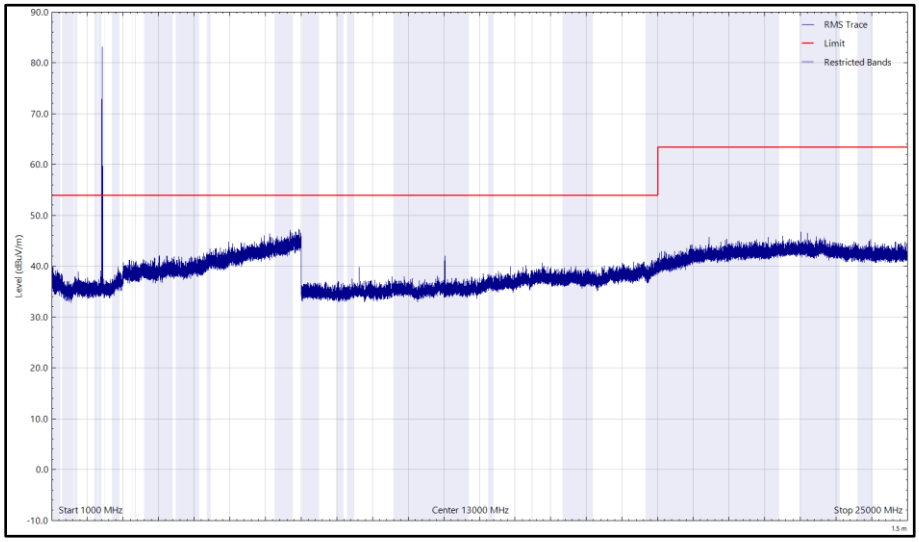

Figure 27 - ZigBee - Y, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 12 - ZigBee - Y, 2445 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

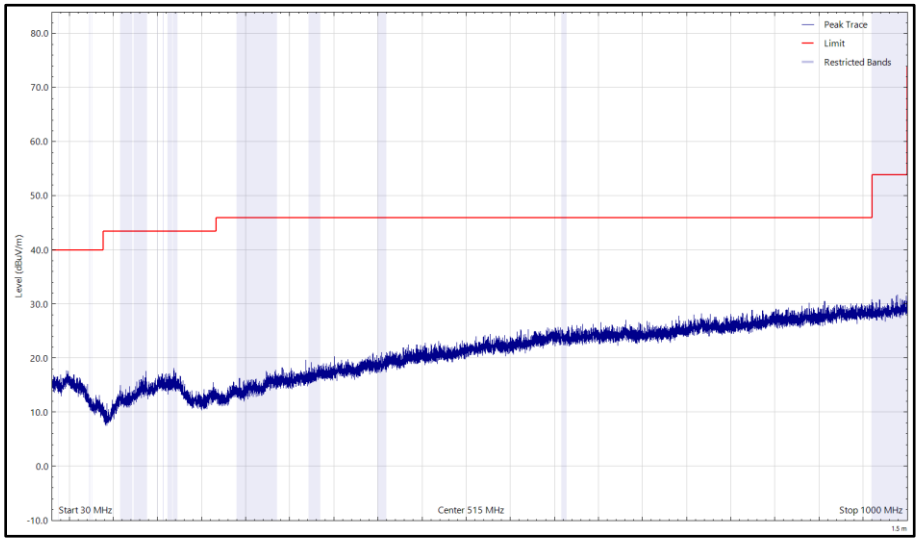

Figure 28 - ZigBee - Y, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

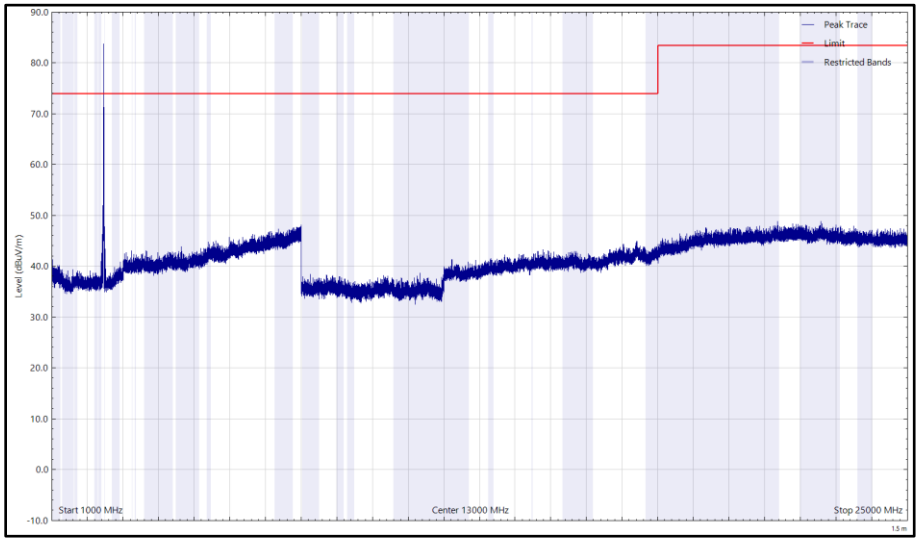

Figure 29 - ZigBee - Y, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

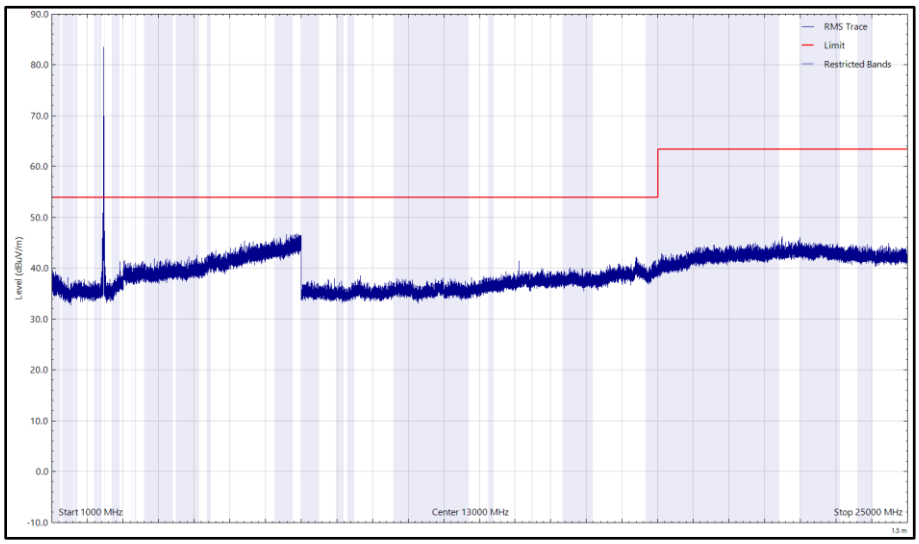

Figure 30 - ZigBee - Y, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

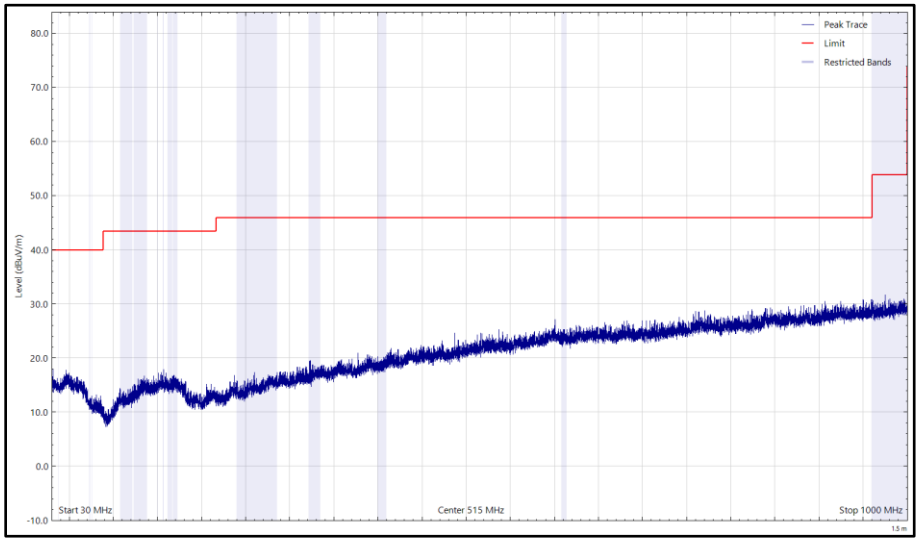

Figure 31 - ZigBee - Y, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)

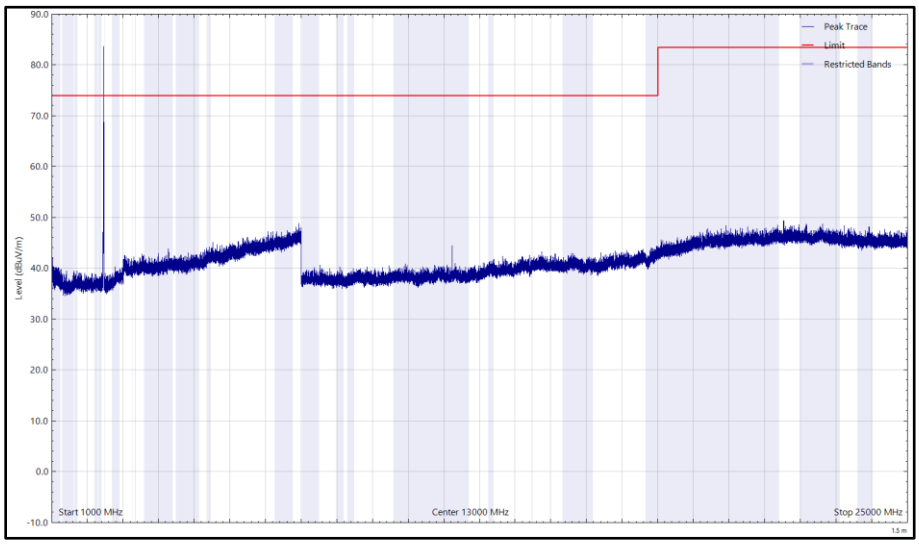

Figure 32 - ZigBee - Y, 2445 MHz, 1 GHz to 25 GHz, Vertical (Peak)

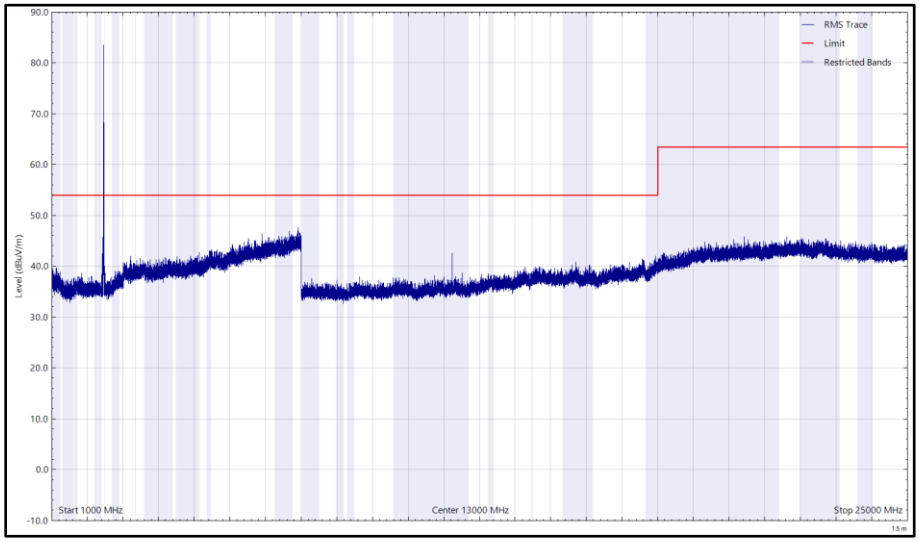

Figure 33 - ZigBee - Y, 2445 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 13- ZigBee - Y, 2480 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

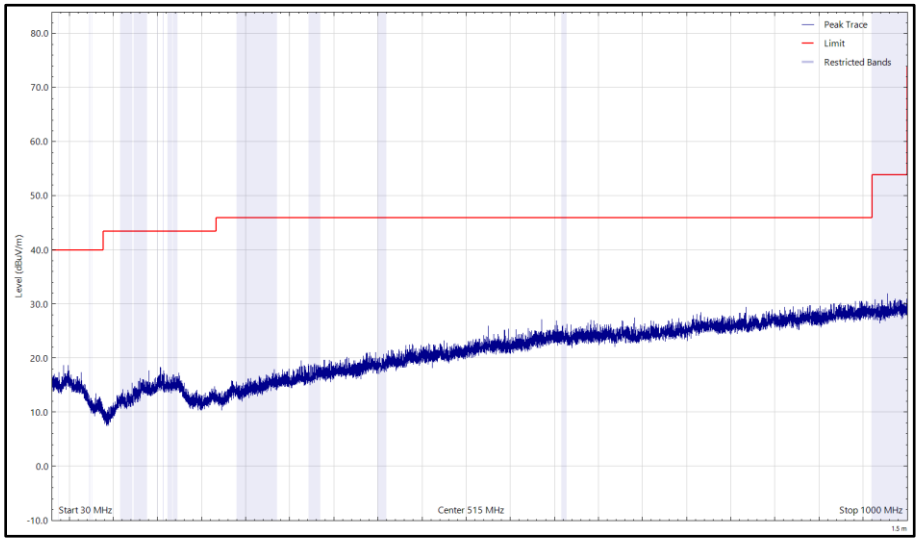

Figure 34 - ZigBee - Y, 2480 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

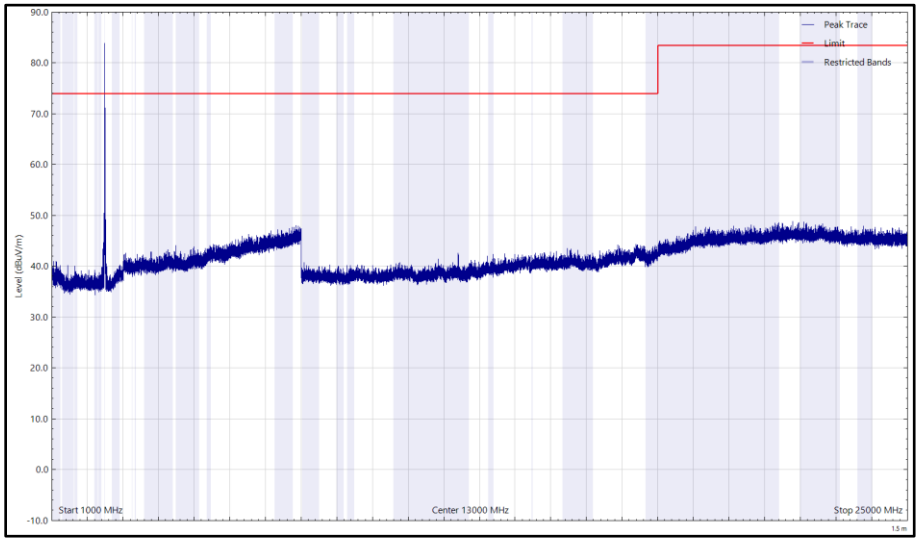

Figure 35 - ZigBee - Y, 2480 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

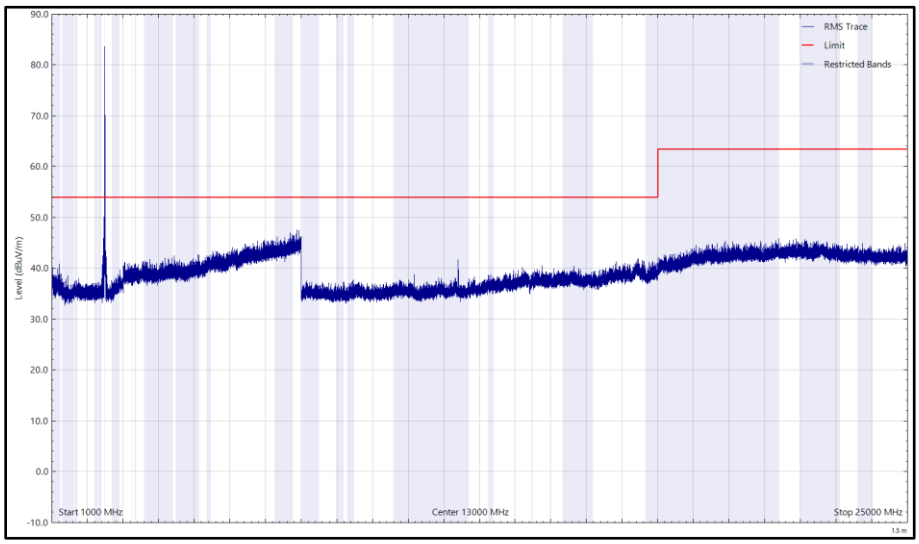

Figure 36 - ZigBee - Y, 2480 MHz, 1 GHz to 25 GHz, Horizontal (rms)

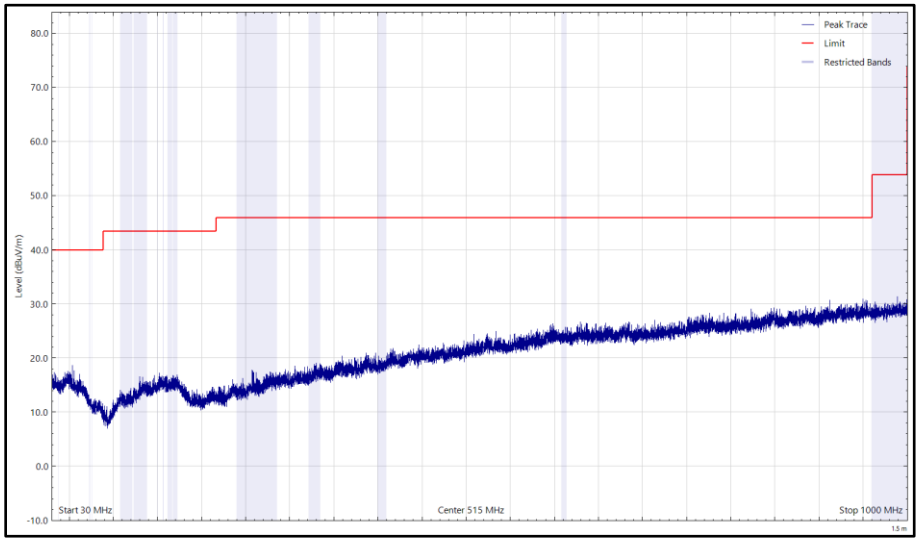

Figure 37 - ZigBee - Y, 2480 MHz, 30 MHz to 1 GHz, Vertical (Peak)

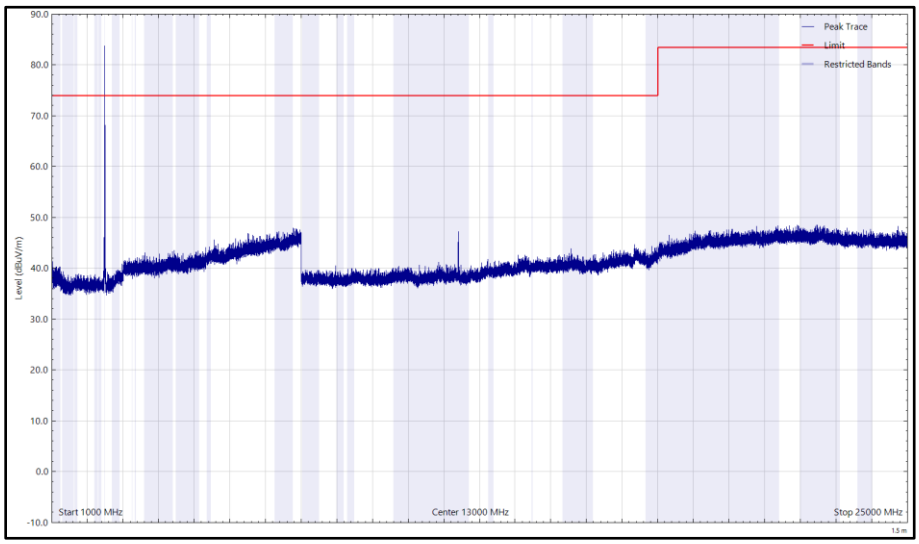

Figure 38 - ZigBee - Y, 2480 MHz, 1 GHz to 25 GHz, Vertical (Peak)

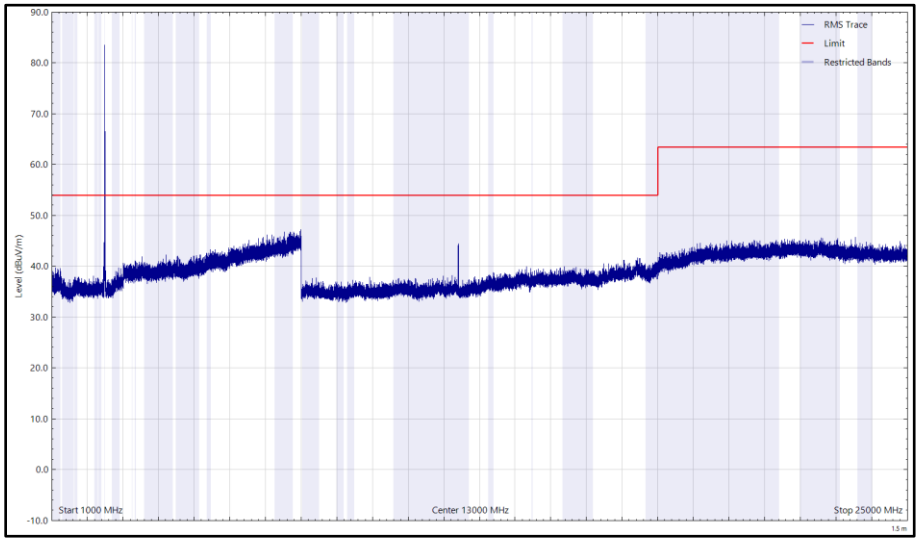

Figure 39 - ZigBee - Y, 2480 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 14 - ZigBee - Z, 2405 MHz, 30 MHz to 25 GHz

No other emissions found within 10 dB of the limit.

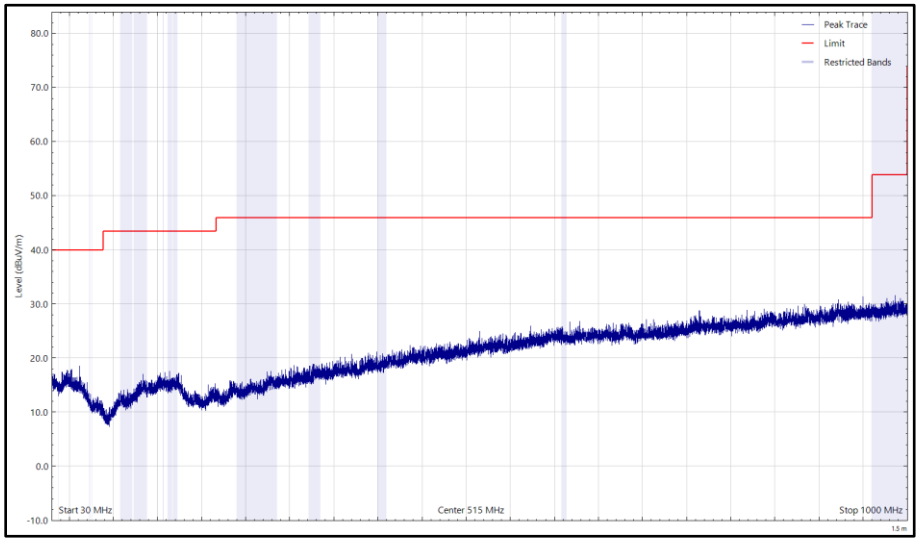

Figure 40 - ZigBee - Z, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

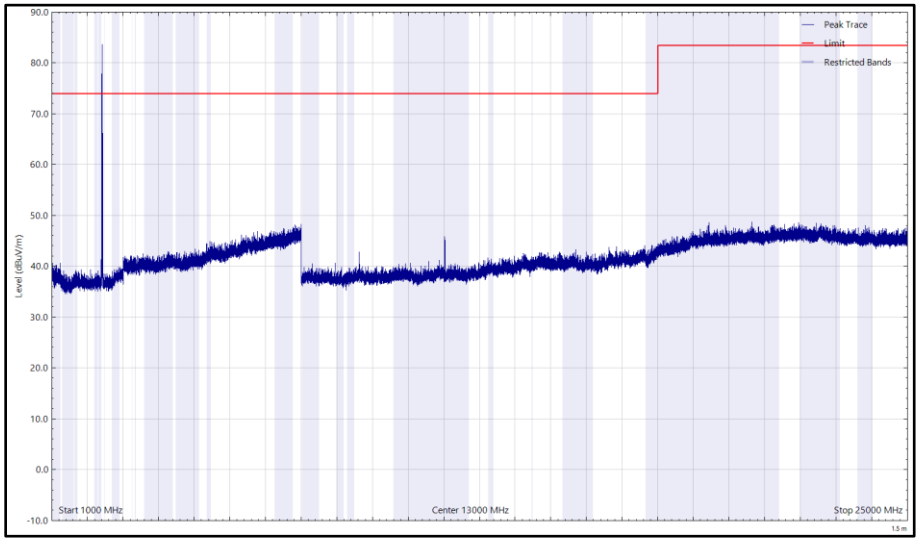

Figure 41 - ZigBee - Z, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

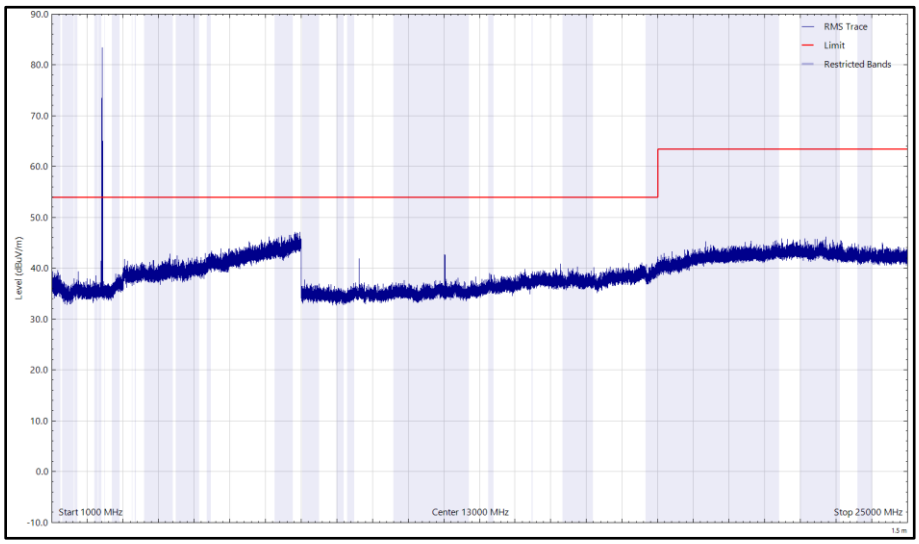

Figure 42 - ZigBee - Z, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

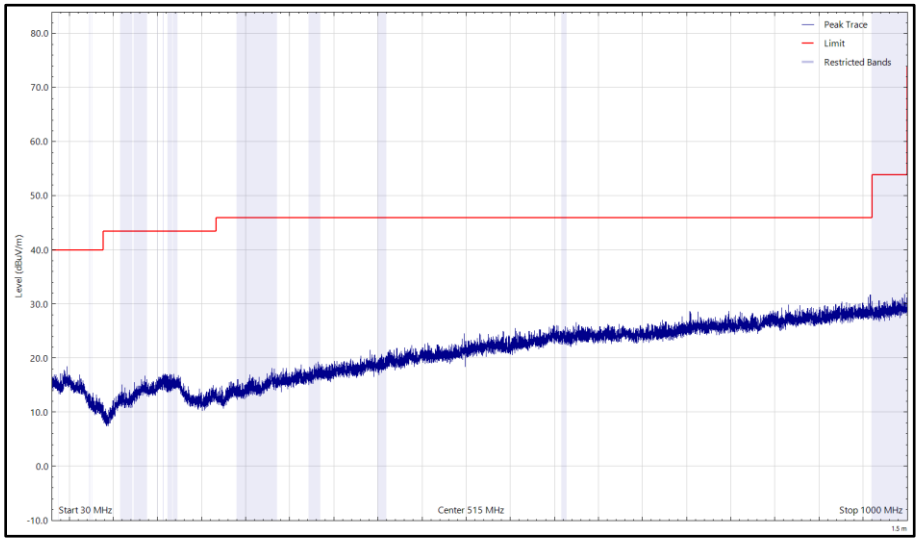

Figure 43 - ZigBee - Z, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

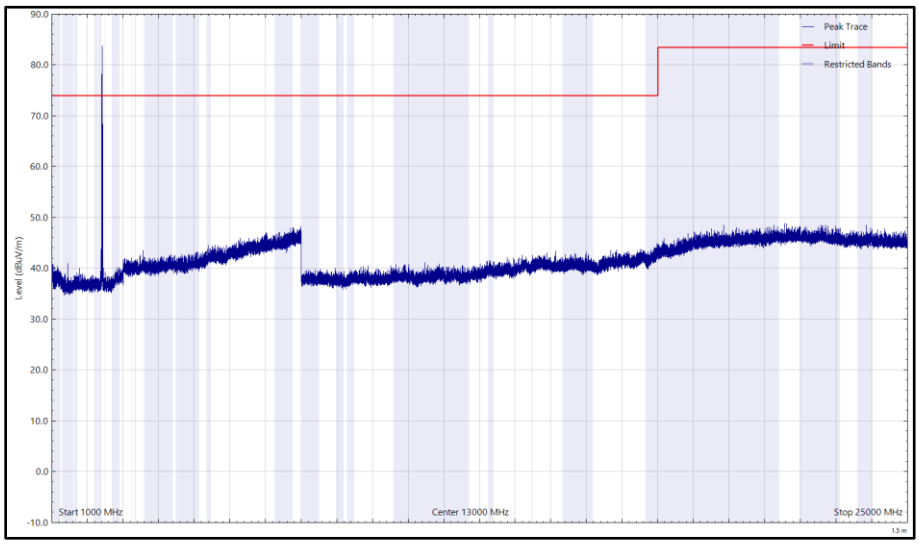

Figure 44 - ZigBee - Z, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

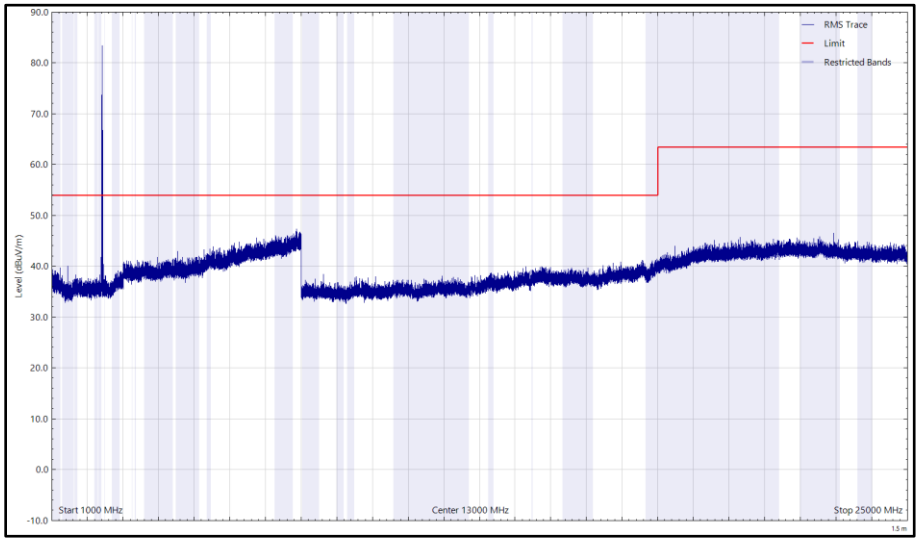

Figure 45 - ZigBee - Z, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 15 - ZigBee - Z, 2445 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

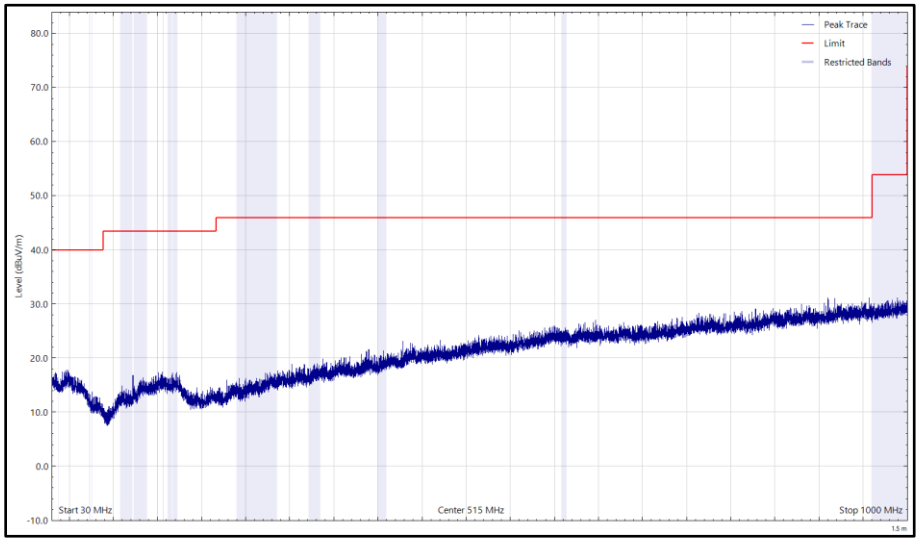

Figure 46 - ZigBee - Z, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

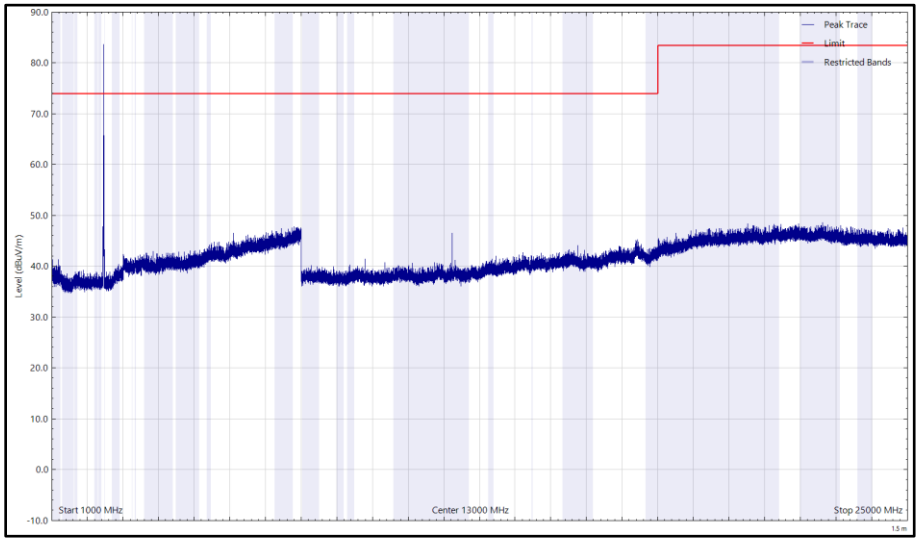

Figure 47 - ZigBee - Z, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

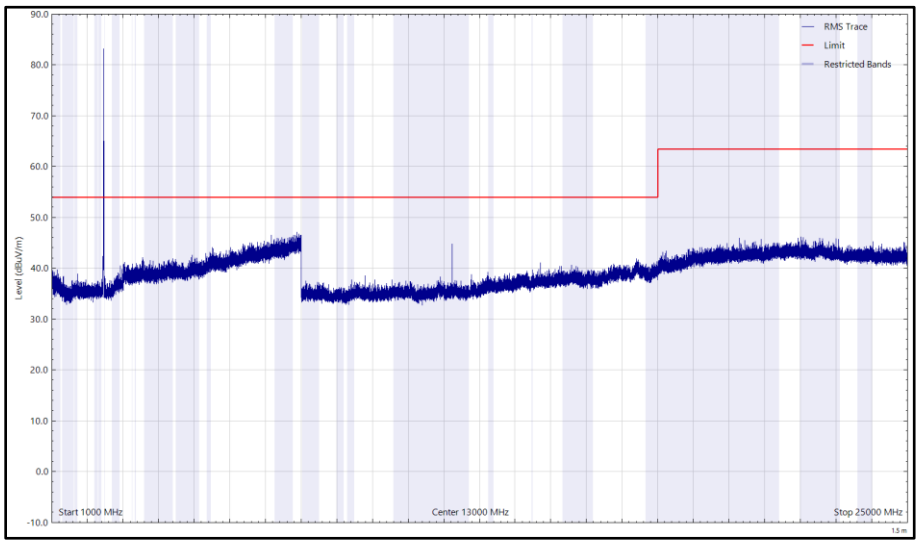

Figure 48 - ZigBee - Z, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

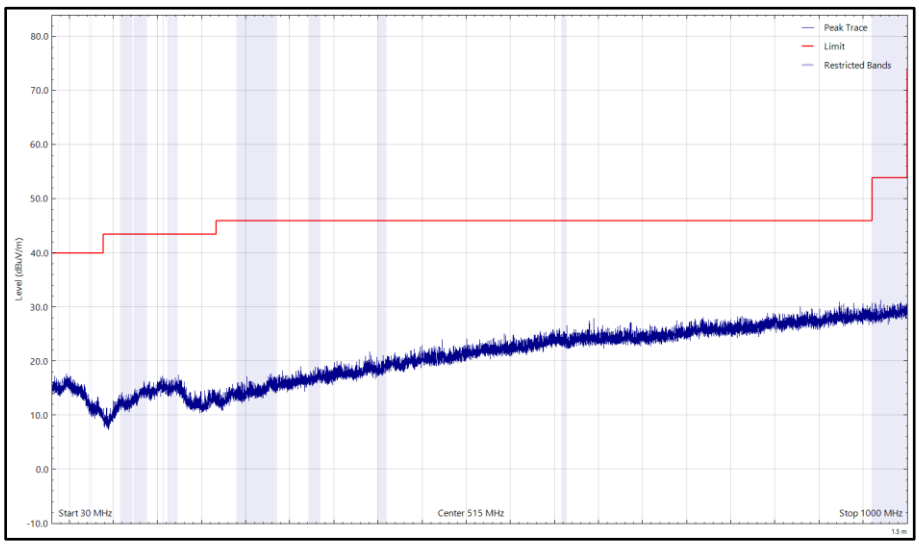

Figure 49 - ZigBee - Z, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)

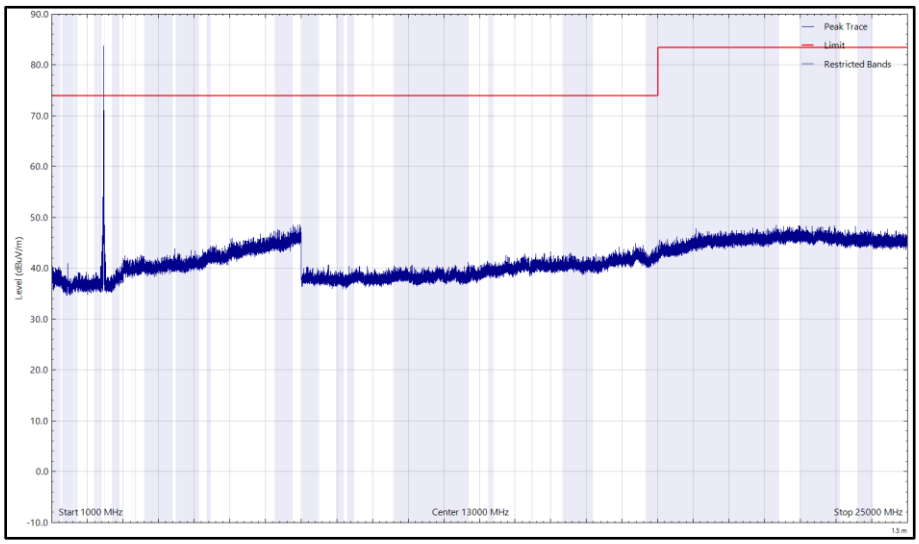

Figure 50 - ZigBee - Z, 2445 MHz, 1 GHz to 25 GHz, Vertical (Peak)

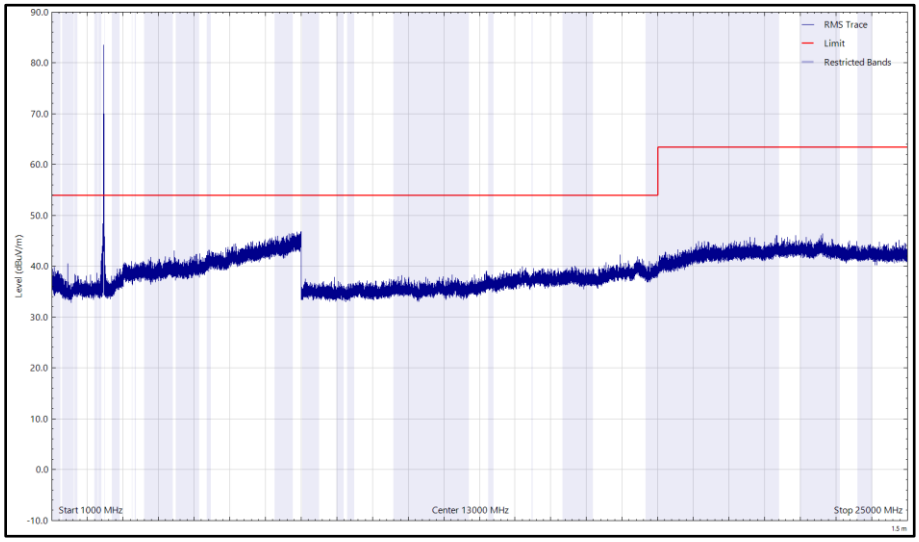

Figure 51 - ZigBee - Z, 2445 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 16- ZigBee - Z, 2480 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

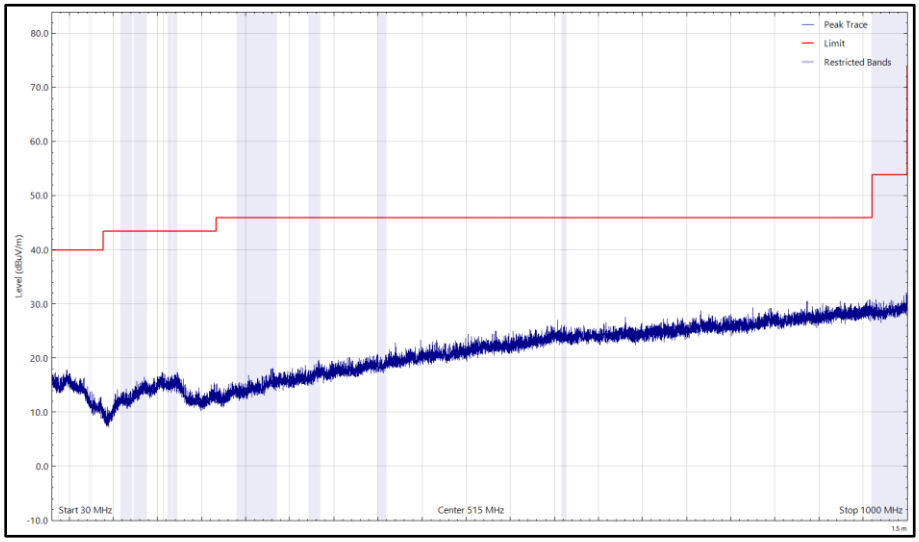

Figure 52 - ZigBee - Z, 2480 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

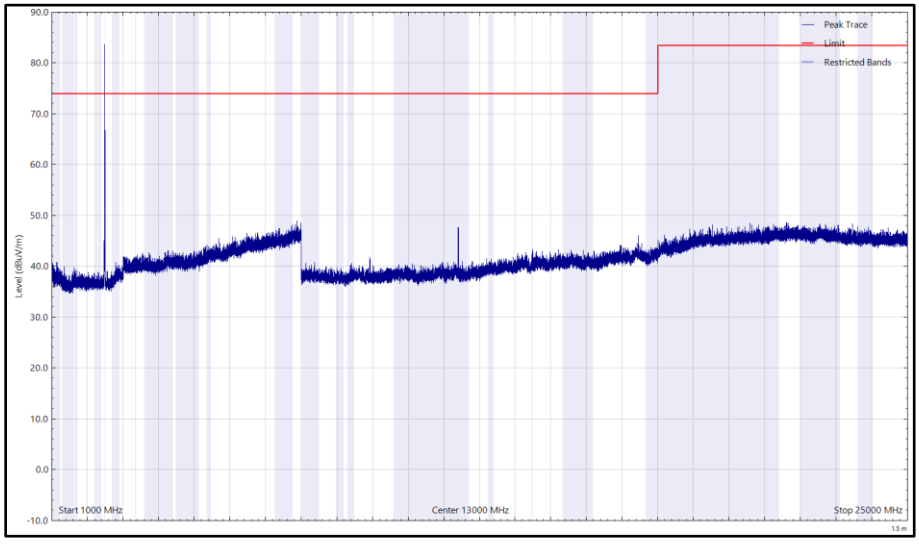

Figure 53 - ZigBee - Z, 2480 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

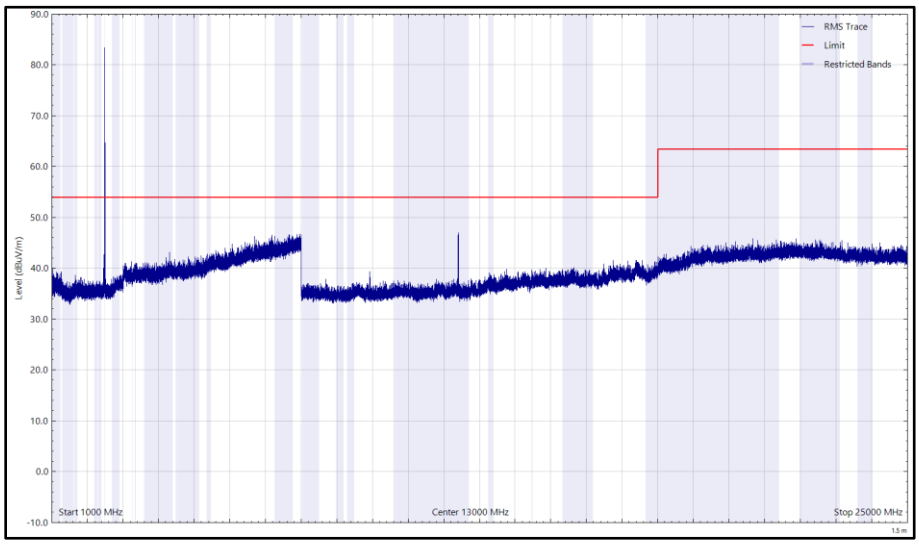

Figure 54 - ZigBee - Z, 2480 MHz, 1 GHz to 25 GHz, Horizontal (rms)

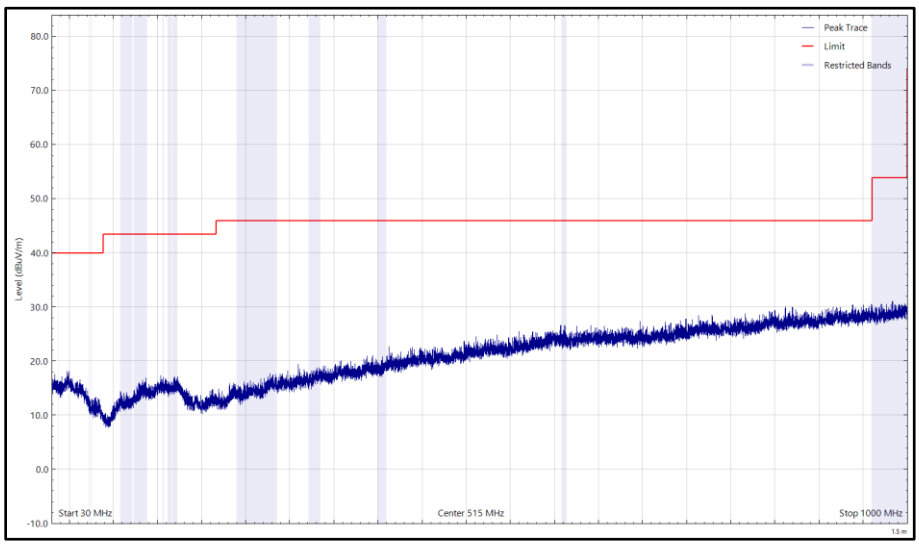

Figure 55 - ZigBee - Z, 2480 MHz, 30 MHz to 1 GHz, Vertical (Peak)

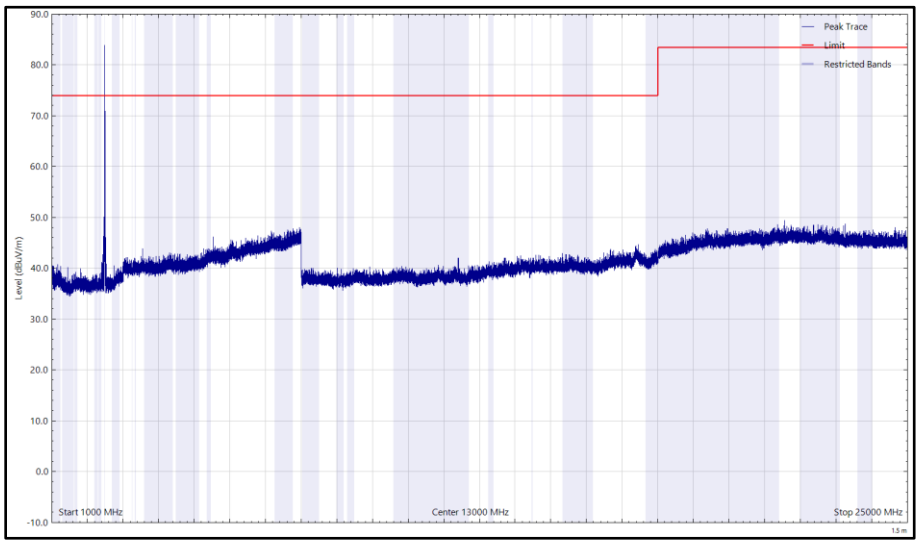

Figure 56 - ZigBee - Z, 2480 MHz, 1 GHz to 25 GHz, Vertical (Peak)

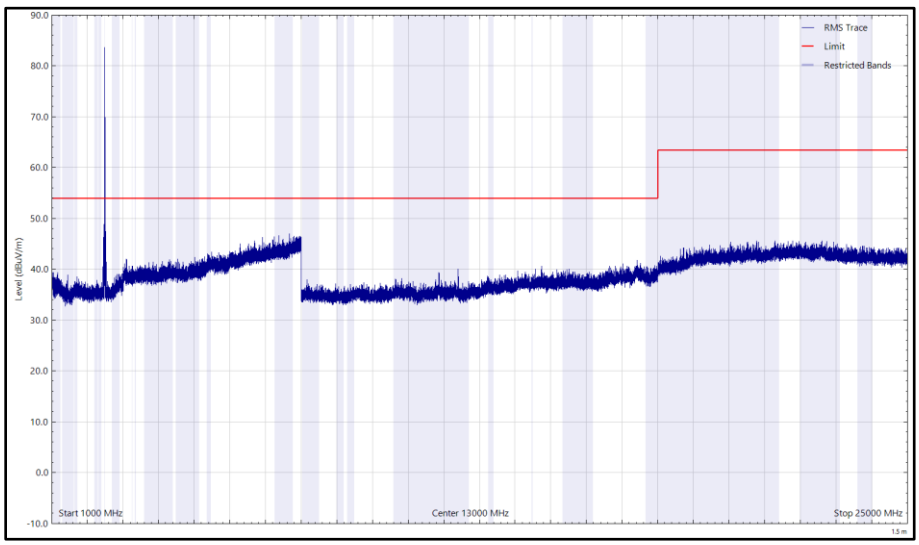

Figure 57 - ZigBee - Z, 2480 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

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

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

2.2.8 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Multimeter	Fluke	79 Series III	611	12	20-Dec-2023
Screened Room (5)	Rainford	Rainford	1545	36	15-Apr-2024
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Dual Power Supply (0-30V, 0-2A)	Farnell	LT30-2	3333		TU
High Pass Filter (4GHz)	K&L Microwave	11SH10-4000/X18000-0/0	4599	12	13-Oct-2023
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	29-Jan-2024
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	18-Dec-2023
Emissions Software	TUV SUD	EmX V3.1.11	5125	-	Software
Antenna (DRG, 15 GHz to 40 GHz)	Schwarzbeck	BBHA 9170	5217	12	06-Feb-2024
Pre-Amplifier (18 GHz to 40 GHz)	Schwarzbeck	BBV 9721	5218	12	06-Feb-2024
Pre-amplifier (30 dB, 1GHz to 18GHz)	Schwarzbeck	BBV 9718 C	5261	12	14-Apr-2024
Cable 2.92mm 1m	Junkosha	MWX241-01000KMS	5414	12	24-Jul-2023
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5416	12	06-Mar-2024
Cable (K Type 2m)	Junkosha	MWX241-02000KMS	5421	12	08-Mar-2024
Pre Amp 1 - 26.5 GHz	Agilent Technologies	8449B	5445	12	12-May-2023
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5476	12	06-Oct-2023
Cable (SMA to SMA, 2 m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
Cable (K-Type to K-Type, 2 m)	Junkosha	MWX241-02000KMSKMS/A	5524	12	24-Oct-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
3 GHz High pass Filter	Wainwright	WHKX12-2580-3000-18000-80SS	5547	12	11-May-2023
1200 MHz Low Pass Filter (01)	Mini-Circuits	VLF-1200+	5559	12	23-May-2023
Antenna (DRG, 7.5 GHz to 18 GHz)	Schwarzbeck	HWRD750	5610	12	16-Oct-2023
1m K-Type Cable	Junkosha	MWX221/B	5908	12	14-Apr-2023
TRILOG Super Broadband	Schwarzbeck	VULB 9168	5942	24	03-Feb-2024

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Test Antenna					
Double Ridge Active Horn Antenna (18-40 GHz)	Com-Power	AHA-840	6189	24	02-Jun-2024
Cable (SMA to SMA 1m)	Junkosha	MWX221/B	6304	12	04-Feb-2024
Pre-Amplifier (8 - 18GHz)	Wright Technologies	APS06-0061	6306	12	06-Feb-2024
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	6330	12	16-Feb-2024

Table 17

TU - Traceability Unscheduled

2.3 Emission Bandwidth

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#6 - Modification State 0

2.3.3 Date of Test

03-March-2023

2.3.4 Test Method

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

2.3.5 Environmental Conditions

Ambient Temperature	21.2 °C
Relative Humidity	33.4 %

2.3.6 Test Results

USB Powered - 2.4 GHz ZigBee

Protocol	6 dB Bandwidth (MHz)	
	Minimum	Maximum
Zigbee	1.310	1.330

Table 18 - 6 dB Bandwidth Summary Results – SISO

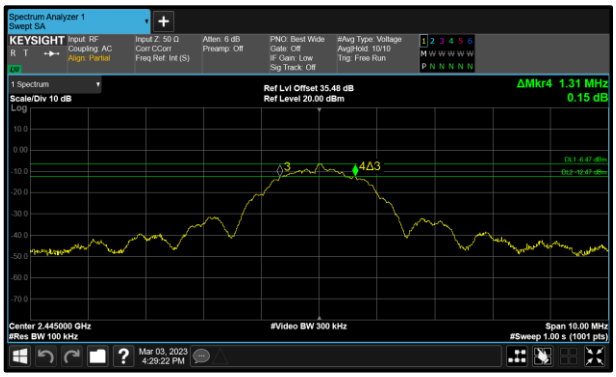

Figure 58 - Zigbee 2.00 MHz Minimum 6 dB EBW

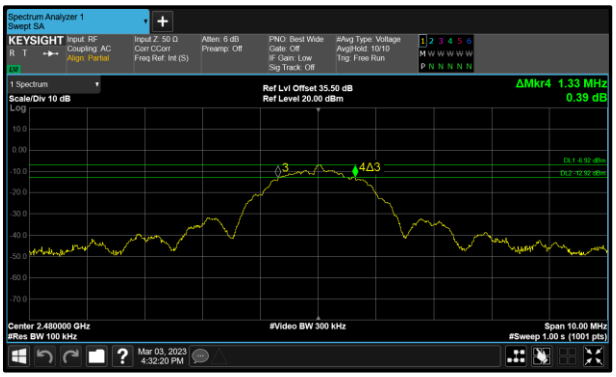

Figure 59 - Zigbee 2.00 MHz Maximum 6 dB EBW

Protocol	99% Bandwidth (MHz)	
	Minimum	Maximum
Zigbee	2.350	2.360

Table 19 - 99% Bandwidth Summary Results - SISO

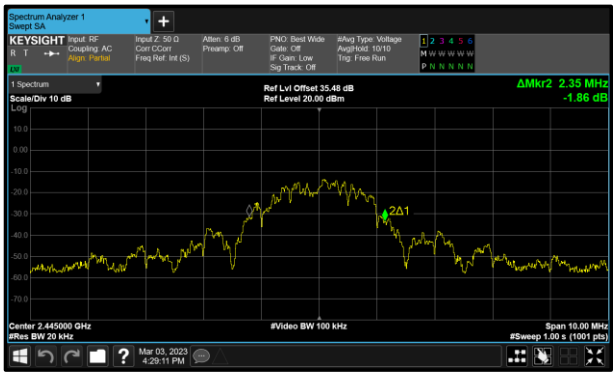

Figure 60 - Zigbee 2.00 MHz Minimum 99% OBW

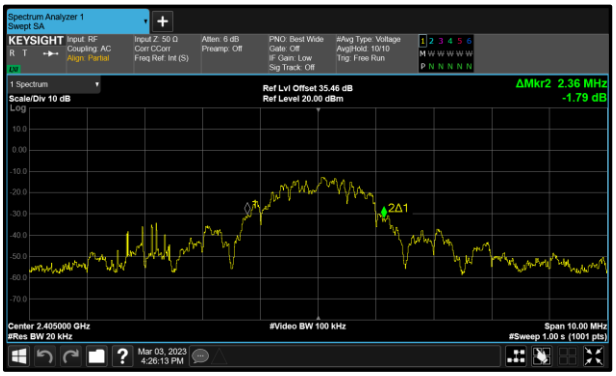

Figure 61 - Zigbee 2.00 MHz Maximum 99% OBW

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

DUT Configuration			
Mode:	Zigbee	Duty Cycle (%):	-
Data Rate:	250 kbps	DCCF (dB):	-
Antenna Configuration:	SISO	Peak Antenna Gain (dBi):	-
Active Port(s):	A (A)	Active Chain(s):	0

Test Frequency (MHz)	6 dB Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2405	1.320	-	-	-	≥500.0
2445	1.310	-	-	-	≥500.0
2480	1.330	-	-	-	≥500.0

Table 20 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2405	2.360	-	-	-	-
2445	2.350	-	-	-	-
2480	2.360	-	-	-	-

Table 21 - 99% Bandwidth Results

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

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

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	21-Mar-2024
Signal Conditioning Unit	TUV SUD	SPECTRUM_SCU001	5759	12	05-Jul-2023

Table 22

2.4 Maximum Conducted Output Power

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#6 - Modification State 0

2.4.3 Date of Test

03-March-2023

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10 clause 11.9.2.3.2 Method AVGPM-G.

2.4.5 Environmental Conditions

Ambient Temperature	21.2 °C
Relative Humidity	33.4 %

2.4.6 Test Results

USB Powered - 2.4 GHz ZigBee

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(3)	Test Method(s):	C63.10 11.9.2.3.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	Zigbee	Duty Cycle (%):	58.5
Data Rate:	250 kbps	DCCF (dB):	-
Antenna Configuration:	SISO	Peak Antenna Gain (dBi):	-1.00
Active Port(s):	A (A)	Active Chain(s):	0

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2405	-3.51	-	-	-	-	30.00	-33.51
2445	-4.46	-	-	-	-	30.00	-34.46
2480	-5.04	-	-	-	-	30.00	-35.04

Table 23 - FCC Maximum Conducted (average) 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.

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
Signal Conditioning Unit	TUV SUD	SPECTRUM_SCU001	5759	12	05-Jul-2023
USB Power Sensor	Boonton	RTP5008	5830	12	07-Jul-2023

Table 24

2.5 Authorised Band Edges

2.5.1 Specification Reference

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

2.5.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#4 - Modification State 0

2.5.3 Date of Test

04-April-2023

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	19.1 °C
Relative Humidity	33.5 %

2.5.6 Test Results

USB Powered - 2.4 GHz ZigBee

Mode	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
Static	2402	2400.0	-43.09
Static	2480	2483.5	-38.94

Table 25

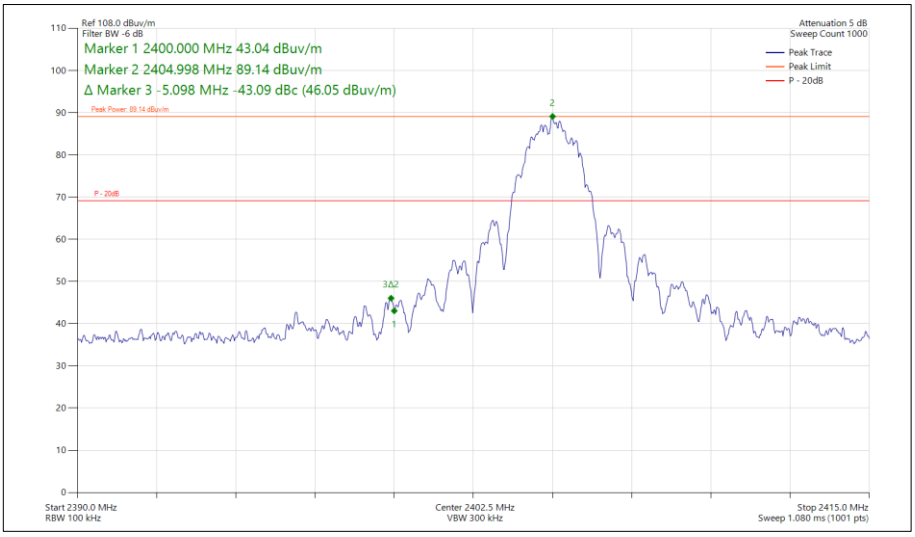

Figure 62 - Static, 2402 MHz - Band Edge Frequency 2400.0 MHz

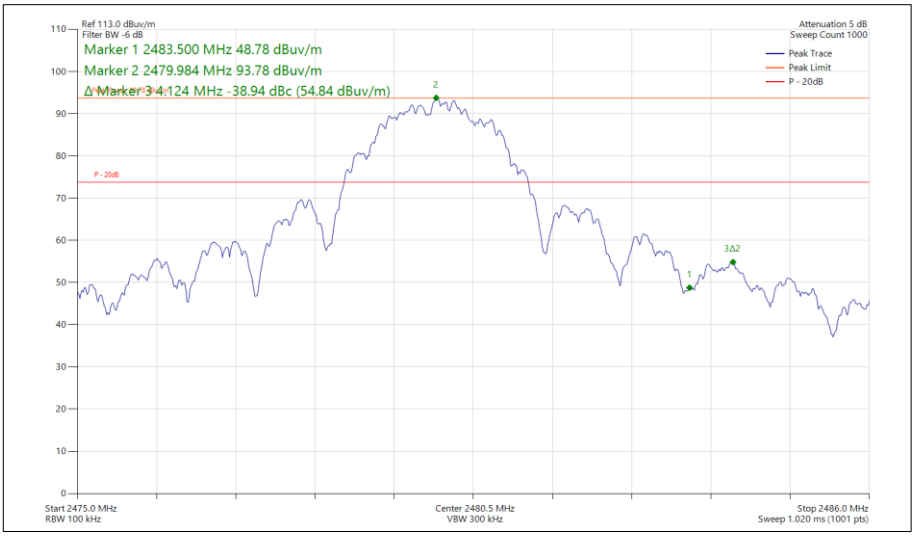

Figure 63 - Static, 2480 MHz - Band Edge Frequency 2483.5 MHz

Remark

Compliance with the maximum conducted output power has been demonstrated using average power, therefore the appropriate limit is -30 dBc for the above band edge measurements. As per the delta marker 3 value it can be seen that compliance with this requirement is shown.

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

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

2.5.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Screened Room (5)	Rainford	Rainford	1545	36	15-Apr-2024
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Mast Controller	Maturo Gmbh	NCD	4810	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Emissions Software	TUV SUD	EmX V3.1.11	5125	-	Software
Cable (K Type 2m)	Junkosha	MWX241-02000KMS	5421	12	08-Mar-2024
Cable (SMA to SMA, 2 m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	6330	12	16-Feb-2024

Table 26

TU - Traceability Unscheduled

2.6 Power Spectral Density

2.6.1 Specification Reference

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

2.6.2 Equipment Under Test and Modification State

Zigbee interface, S/N: TUV#6 - Modification State 0

2.6.3 Date of Test

03-March-2023

2.6.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.10.5.

Where the EUT duty cycle was < 98 % and repeatable within 2 %, the spectrum analyser was set to trace (power) averaging and a duty cycle correction was added as calculated in the result tables below (Method AVGPSD-2).

2.6.5 Environmental Conditions

Ambient Temperature	21.2 °C
Relative Humidity	33.4 %

2.6.6 Test Results

USB Powered - 2.4 GHz ZigBee

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (e)	Test Method(s):	C63.10 11.10.5
Additional Reference(s):	-		
Note(s):	DCCF was added to the spectrum analyser reference level offset.		

DUT Configuration			
Mode:	Zigbee	Duty Cycle (%):	58.5
Data Rate	250 kbps	DCCF (dB):	2.33
Antenna Configuration:	SISO	Peak Antenna Gain (dBi):	-
Active Port(s):	A (A)	Active Chain(s):	0

Test Frequency (MHz)	RBW (kHz)	PSD (dBm/RBW)					Limit (dBm/3 kHz)	Margin (dB)
		A	B	C	D	∑		
2405	3.0	-16.29	-	-	-	-	8.00	-24.29
2445	3.0	-17.34	-	-	-	-	8.00	-25.34
2480	3.0	-17.81	-	-	-	-	8.00	-25.81

Table 27 - 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.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	21-Mar-2024
Signal Conditioning Unit	TUV SUD	SPECTRUM_SCU001	5759	12	05-Jul-2023

Table 28

3 Photographs

3.1 Test Setup Photographs

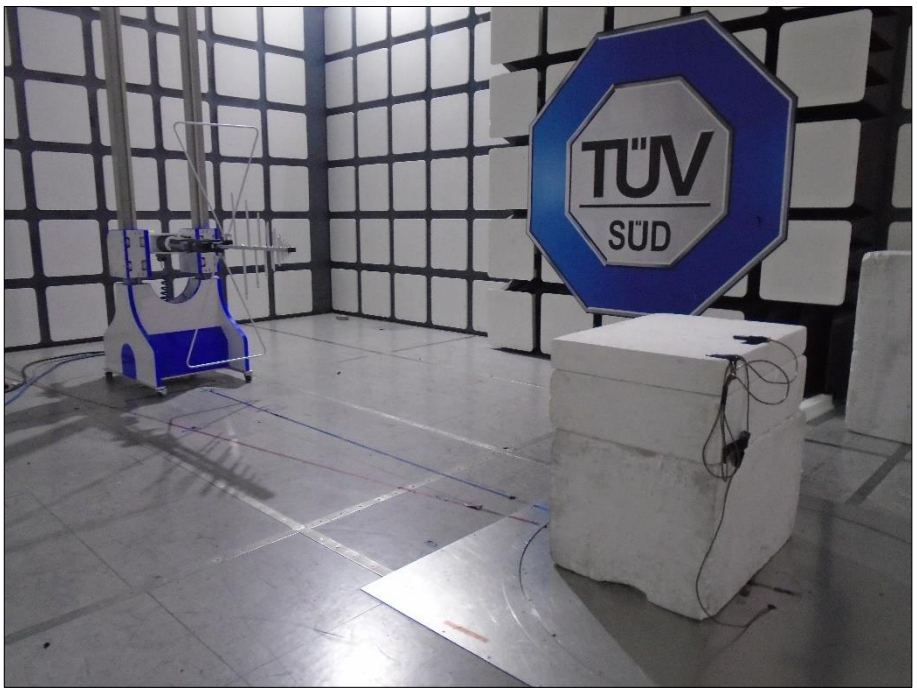

Figure 64 - Test Setup - 30 MHz to 1 GHz

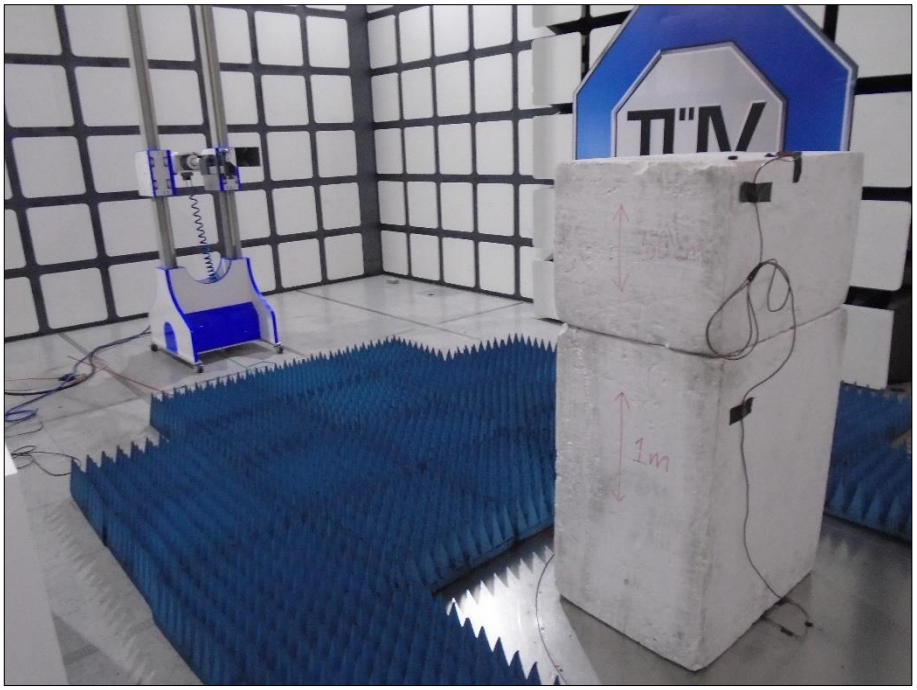

Figure 65 - Test Setup - 1 GHz to 8 GHz

Figure 66 - Test Setup - 8 GHz to 18 GHz

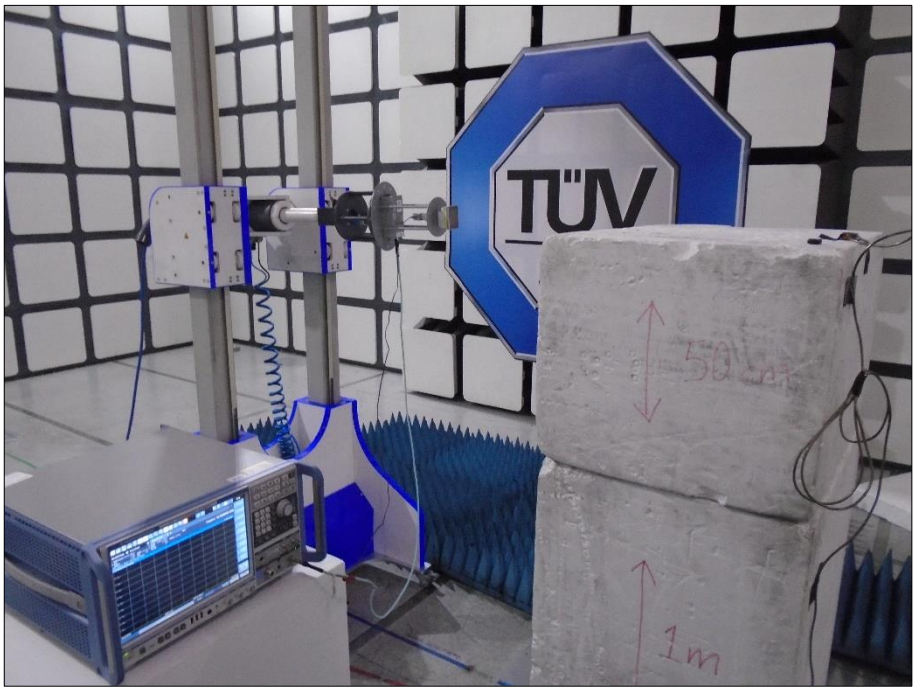

Figure 67 - Test Setup - 18 GHz to 25 GHz

Figure 68 - Test Setup - X Orientation

Figure 69 - Test Setup - Y Orientation

Figure 70 - Test Setup - Z Orientation

Table 29

4 Measurement Uncertainty

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

Test Name	Measurement Uncertainty
Antenna Requirement	-
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
Emission Bandwidth	± 114.78 kHz
Maximum Conducted Output Power	± 1.38 dB
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Power Spectral Density	± 1.49 dB

Table 30

Measurement Uncertainty Decision Rule – Accuracy Method

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115:2021, Clause 4.4.3 (Procedure 2). The measurement results are directly compared with the test limit to determine conformance with the requirements of the standard.

Risk: The uncertainty of measurement about the measured result is negligible with regard to the final pass/fail decision. The measurement result can be directly compared with the test limit to determine conformance with the requirement (compare IEC Guide 115). The level of risk to falsely accept and falsely reject items is further described in ILAC-G8.