FCC and ISED Test Report

Silicon Laboratories Finland Oy
Radio Module, Model: MGM240L

In accordance with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN (2.4 GHz 802.15.4 + Bluetooth Low Energy)

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

FCC ID: QOQ-MGM240L IC: 5123A-MGM240L

Add value.
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Document 75955217-03 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Matthew Russell	Senior Engineer	Authorised Signatory	13 June 2022

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	Ahmad Javid	13 June 2022	
Testing	Daniel Cameron	13 June 2022	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

ISED Accreditation
12669A Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2020, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) for the tests detailed in section 1.3.

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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 June 2022

Table 1

1.2 Introduction

Applicant	Silicon Laboratories Finland Oy
Manufacturer	Silicon Laboratories Finland Oy
Model Number(s)	MGM240L
Serial Number(s)	Not Serialised Storix ID (643242-05), Not Serialised Storix ID (643242-07), Not Serialised Storix ID (643242-08) and Not Serialised Storix ID (643242-11)
Hardware Version(s)	1.0
Software Version(s)	4.0.x (Gecko SDK)
Number of Samples Tested	4
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2020 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021)
Order Number Date	6000479546 / 00 / 03 24-March-2022
Date of Receipt of EUT	30-March-2022
Start of Test	11-April-2022
Finish of Test	12-May-2022
Name of Engineer(s)	Ahmad Javid and Daniel Cameron
Related Document(s)	ANSI C63.10 (2020)

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: 2.4 GHz 802.15.4						
-	15.203	-	-	Antenna Requirements	Pass	The equipment under test uses an integral antenna and therefore complies with the requirements of 15.203. See section 1.4 for details.
2.1	15.205	3.3	8.10	Restricted Band Edges	Pass	
2.2	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	
2.3	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	
2.5	15.247 (d) and 15.209	3.3 and 5.5	6.13 and 8.9	Spurious Radiated Emissions	Pass	
2.6	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	
Configuration and Mode: 2.4 GHz Bluetooth Low Energy						
2.1	15.205	3.3	8.10	Restricted Band Edges	Pass	
2.2	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	
2.3	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.5	15.247 (d) and 15.209	3.3 and 5.5	6.13 and 8.9	Spurious Radiated Emissions	Pass	
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	
2.6	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	

Table 2

1.4 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	Internally regulated, and shielded, PCB radio module implementing the Bluetooth Low Energy (BLE) and 802.15.4 wireless standard protocols, to enable low-power wireless communication for IoT applications. The BLE portion supports the 1M, 2M, and 125/500K coded PHYs from the spec, all based on the GFSK modulation. The 802.15.4 portion provides the base wireless protocol for higher-level communication standards like Zigbee and Thread. The product comes in a single hardware variant with an integral antenna, a meandered inverted F PCB trace.
Manufacturer:	*Silicon Laboratories Finland Oy* (address: Alberga Business Park, Bertel Jungin aukio 3, FI-02600 Espoo, Finland)
Model Name:	***MGM240L***
Brand Name:	Silicon Labs
Hardware Version:	1.0
Software Version:	4.0.x (Gecko SDK)
FCC ID of the product under test – see guidance here	QOQ-MGM240L
IC ID of the product under test – see guidance here	5123A-MGM240L

Table 3

Intentional Radiators

Technology	Bluetooth Low Energy	802.15.4	
Frequency Range (MHz to MHz)	2400 to 2483.5	2400 to 2483.5	
Conducted Declared Output Power (dBm)	10	10	
Antenna Gain (dBi)	0.64	0.64	
Supported Bandwidth(s) (MHz) (e.g. 1 MHz, 20 MHz, 40 MHz)	1M PHY: 1 2M PHY: 2	3.5	
Modulation Scheme(s) (e.g. GFSK, QPSK etc)	GFSK	O-QPSK	
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)	1M00F1D/2M00F1D	3M500G1D	
Bottom Frequency (MHz)	2402	2405	
Middle Frequency (MHz)	2440	2445	
Top Frequency (MHz)	2480	2480	

Table 4

Un-intentional Radiators

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

Table 5

AC Power Source

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

Table 6

DC Power Source

Nominal voltage:	3.0	V
Extreme upper voltage:	3.8	V
Extreme lower voltage:	1.8	V
Max current:	30	mA

Table 7

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:		

Table 8

Charging

Can the EUT transmit whilst being charged	Yes ☐ No ☐

Table 9

Temperature

Minimum temperature:	-40	°C
Maximum temperature:	+125	°C

Table 10

Cable Loss

Adapter Cable Loss (Conducted sample)	0.3	dB

Table 11

Antenna Characteristics

Antenna connector ☐			State impedance		Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	Meandered Inverted-F PCB trace	Gain	0.64	dBi
External antenna ☐	Type:		Gain		dBi
For external antenna only: Standard Antenna Jack ☐ If yes, describe how user is prohibited from changing antenna (if not professional installed): Equipment is only ever professionally installed ☐ Non-standard Antenna Jack ☐					

Table 12

Ancillaries (if applicable)

Manufacturer:		Part Number:	
Model:		Country of Origin:	

Table 13

The above information was provided by the applicant.

1.5 Product Information

1.5.1 Technical Description

Internally regulated, and shielded, PCB radio module implementing the Bluetooth Low Energy (BLE) and 802.15.4 wireless standard protocols, to enable low-power wireless communication for IoT applications. The BLE portion supports the 1M, 2M, and 125/500K coded PHYs from the spec, all based on the GFSK modulation. The 802.15.4 portion provides the base wireless protocol for higher-level communication standards like Zigbee and Thread. The product comes in a single hardware variant with an integral antenna, a meandered inverted F PCB trace.

1.5.2 Test Modes

The manufacturer provided test software running on a support laptop which was connected to the equipment under test via a USB cable. The power configurations used for testing was as per the table below:

Config-Mode	Power Setting
802.15.4	100 (Max Power)
Bluetooth Low Energy	100 (Max Power)

Table 14 – EUT Power Settings

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: MGM240L, Serial Number: Not Serialised Storix ID (643242-05)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: MGM240L, Serial Number: Not Serialised Storix ID (643242-07)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: MGM240L, Serial Number: Not Serialised Storix ID (643242-08)			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: MGM240L, Serial Number: Not Serialised Storix ID (643242-11)			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 15

1.8 Test Location

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

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz 802.15.4		
Restricted Band Edges	Ahmad Javid	UKAS
Emission Bandwidth	Daniel Cameron	UKAS
Maximum Conducted Output Power	Daniel Cameron	UKAS
Authorised Band Edges	Ahmad Javid	UKAS
Spurious Radiated Emissions	Ahmad Javid	UKAS
Power Spectral Density	Daniel Cameron	UKAS
Configuration and Mode: 2.4 GHz Bluetooth Low Energy		
Restricted Band Edges	Ahmad Javid	UKAS
Emission Bandwidth	Daniel Cameron	UKAS
Maximum Conducted Output Power	Daniel Cameron	UKAS
Spurious Radiated Emissions	Ahmad Javid	UKAS
Authorised Band Edges	Ahmad Javid	UKAS
Power Spectral Density	Daniel Cameron	UKAS

Table 16

Office Address:

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

2 Test Details

2.1 Restricted Band Edges

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205
ISED RSS-247, Clause 3.3
ISED RSS-GEN, Clause 8.10

2.1.2 Equipment Under Test and Modification State

MGM240L, S/N: Not Serialised Storix ID (643242-05) - Modification State 0
MGM240L, S/N: Not Serialised Storix ID (643242-07) - Modification State 0

2.1.3 Date of Test

11-April-2022 to 12-May-2022

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).

Alongside LE2M, LE 8-coding was selected for testing as the customer declared that LE 8-coding is the worst case out of the supported 1MBaud PHYs.

2.1.5 Environmental Conditions

Ambient Temperature	19.7 - 22.3 °C
Relative Humidity	27.3 – 43.8 %

2.1.6 Test Results

2.4 GHz 802.15.4

Mode	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	2405	2390.0	49.85	39.19
Static	2480	2483.5	62.29	52.98

Table 17

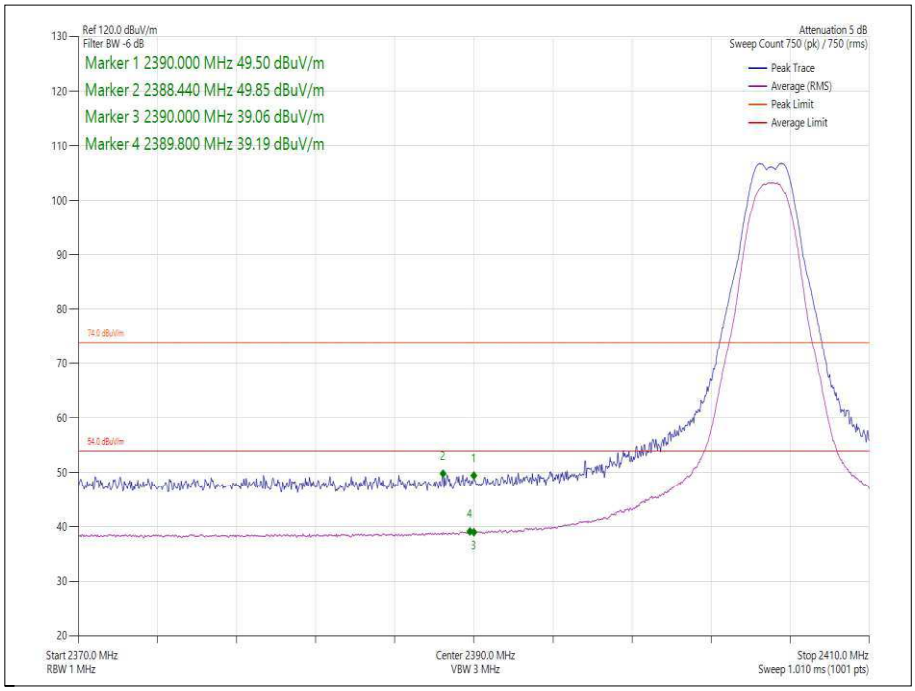

Figure 1 - 2405 MHz - Band Edge Frequency 2390.0 MHz

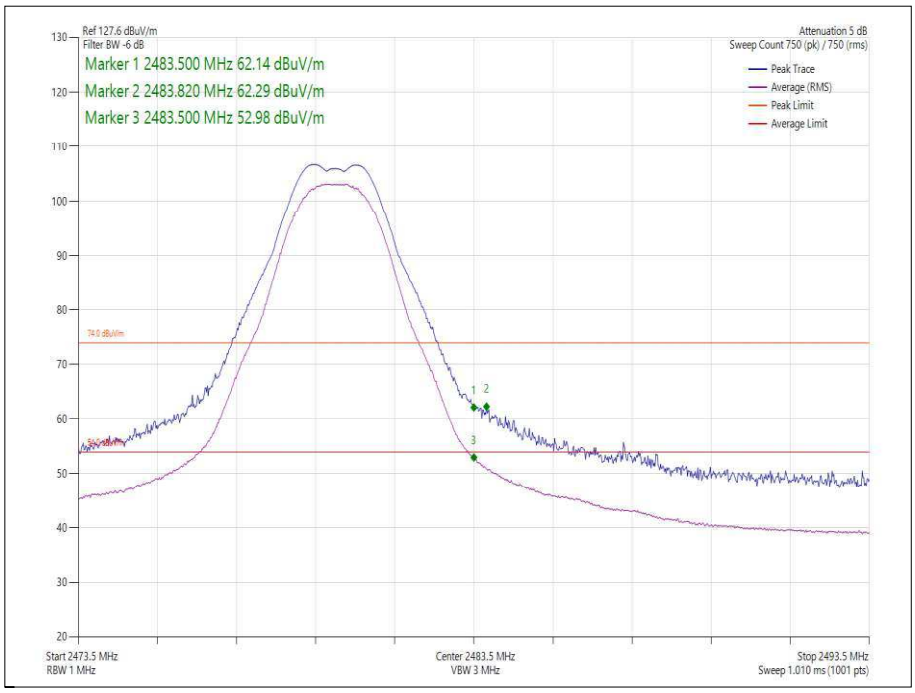

Figure 2 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK (LE 8-Coding)	2402	2390	53.57	40.22
GFSK (LE 8-Coding)	2480	2483.5	57.27	46.91
GFSK (LE 2M)	2404	2390	51.27	42.65
GFSK (LE 2M)	2478	2483.5	61.70	46.17

Table 18

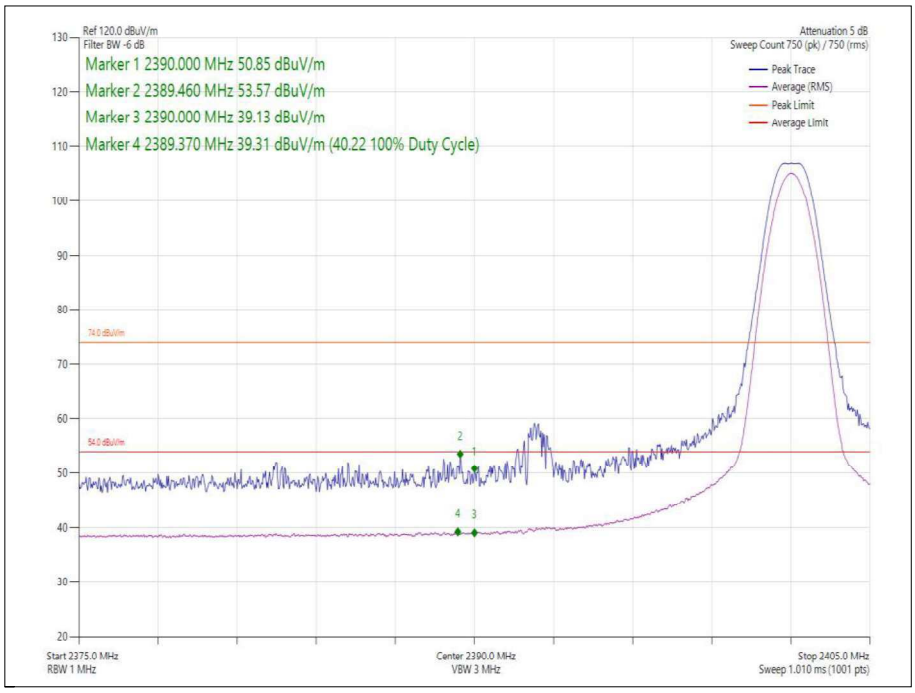

Figure 3 - GFSK (LE 8-Coding) - 2402 MHz - Band Edge Frequency 2390 MHz

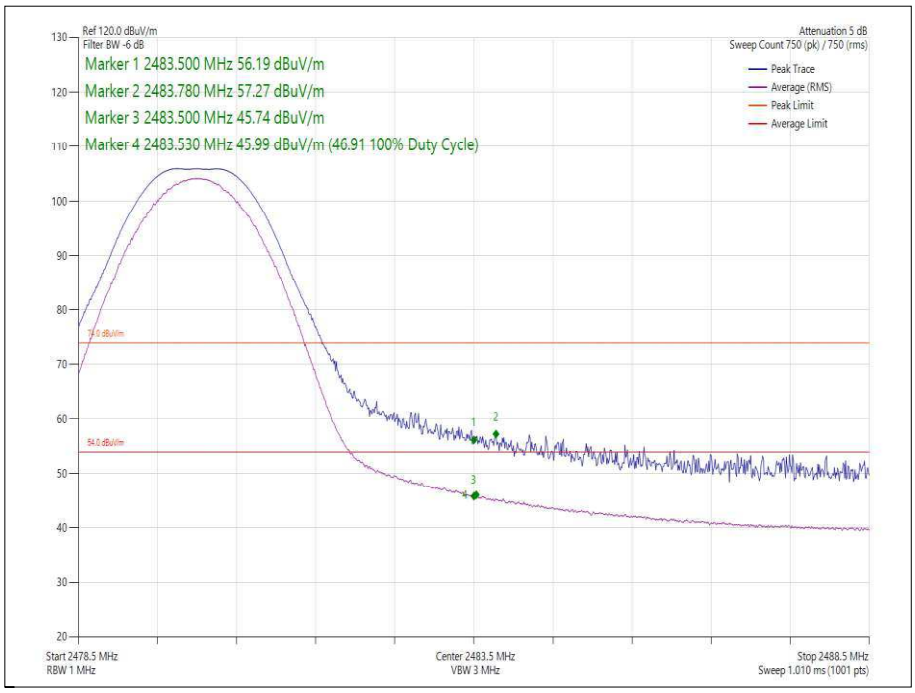

Figure 4 - GFSK (LE 8-Coding) - 2480 MHz - Band Edge Frequency 2483.5 MHz

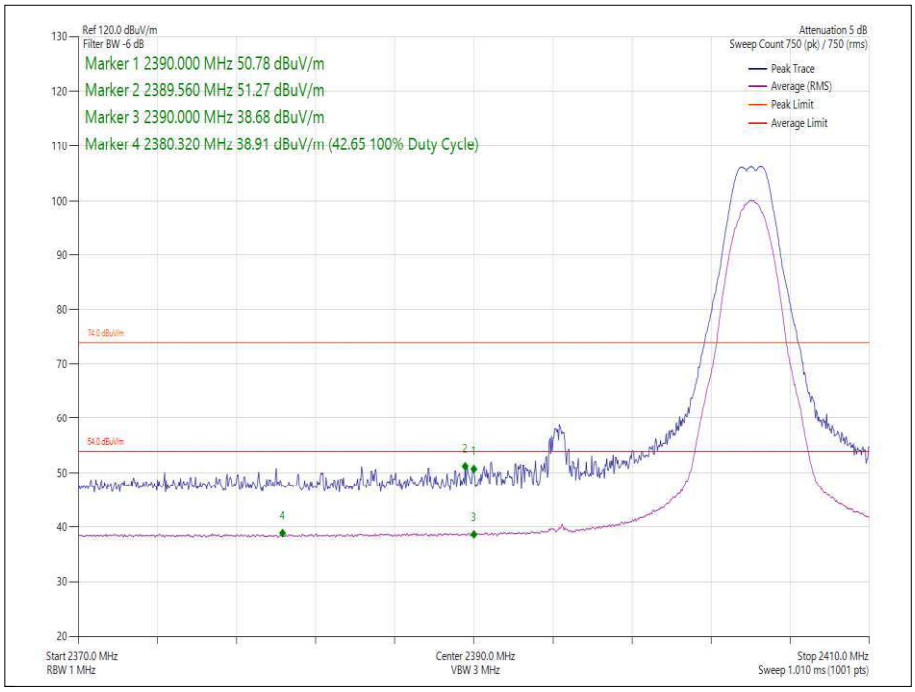

Figure 5 - GFSK (LE 2M)- 2404 MHz - Band Edge Frequency 2390 MHz

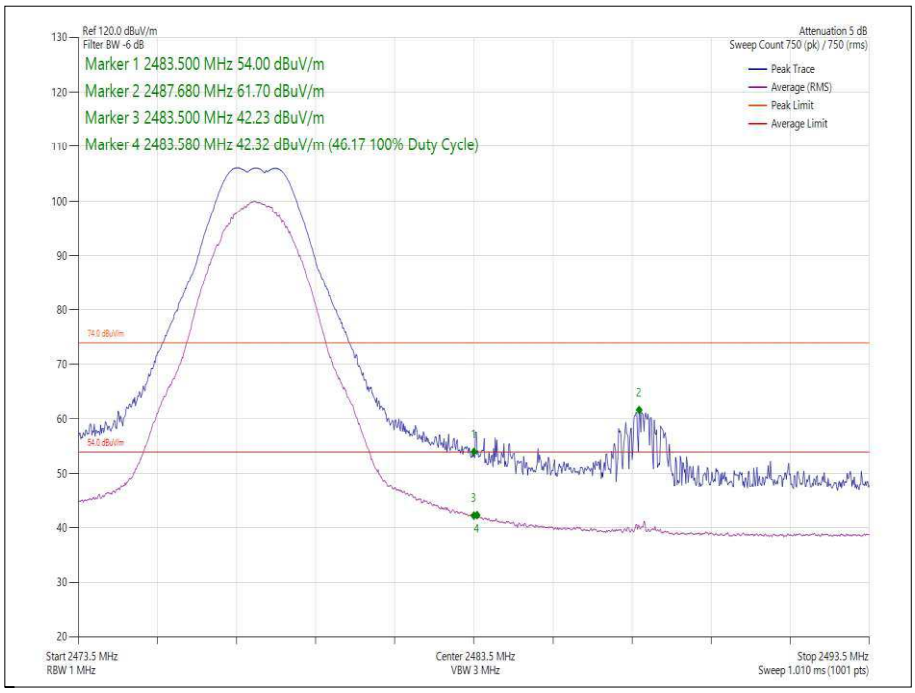

Figure 6 - GFSK (LE 2M)- 2478 MHz - Band Edge Frequency 2483.5 MHz

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 19

ISED RSS-GEN, Limit Clause 8.9

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

Table 20

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

2.1.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 12.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Power Supply Unit	Farnell	D302T	609	12	O/P Mon
Multimeter	Fluke	79 Series II	3057	12	23-Aug-2022
Cable (SMA to SMA, 2 m)	Rhophase	3PS-1801A-2000-3PS	4113	12	27-Jan-2023
Cable (N to N 8m)	Teledyne	PR90-088-8MTR	5212	12	06-Sep-2022
Thermo-hygro-Barometer	PCE Instruments	PCE-THB-40	5472	12	25-Mar-2023
Antenna (DRG, 1 GHz to 10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	15-Oct-2022
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	5613	-	TU
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
Screened Room (12)	MVG	EMC-3	5621	36	11-Aug-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5914	12	21-Feb-2023

Table 21

TU - Traceability Unscheduled
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
ISED RSS-GEN, Clause 6.7

2.2.2 Equipment Under Test and Modification State

MGM240L, S/N: Not Serialised Storix ID (643242-08) - Modification State 0
MGM240L, S/N: Not Serialised Storix ID (643242-11) - Modification State 0

2.2.3 Date of Test

15-April-2022 to 28-April-2022

2.2.4 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.

Alongside LE2M, LE 8-coding was selected for testing as the customer declared that LE 8-coding is the worst case out of the supported 1MBaud PHYs.

The device was powered from its USB port.

2.2.5 Environmental Conditions

Ambient Temperature	23.4 - 26.2 °C
Relative Humidity	30.9 - 32.6 %

2.2.6 Test Results

2.4 GHz 802.15.4

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

DUT Configuration			
Mode:	802.15.4	Duty Cycle (%):	100.0
Data Rate:	-	DCCF (dB):	-
Antenna Configuration:	SISO	Peak Antenna Gain (dBi):	0.64
Active Port(s):	A (A)	Active Chain(s):	0

Test Frequency (MHz)	6 dB Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2405	1.656	-	-	-	≥500.0
2440	1.656	-	-	-	≥500.0
2480	1.668	-	-	-	≥500.0

Table 22 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2405	2.240	-	-	-	-
2440	2.240	-	-	-	-
2480	2.244	-	-	-	-

Table 23 - 99% Bandwidth Results

Figure 7 - A (A) 2405 MHz (CH11) 99% Bandwidth

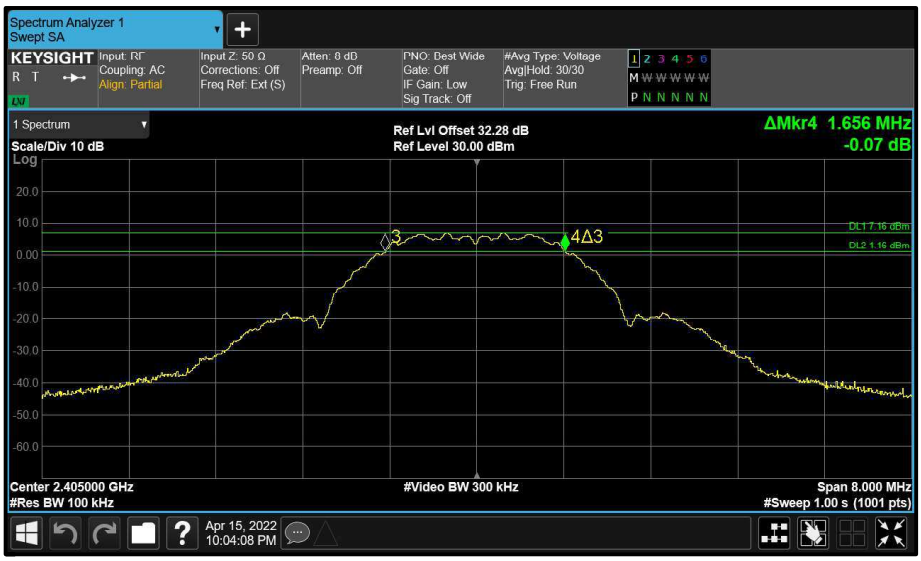

Figure 8 - A (A) 2405 MHz (CH11) 6 dB Bandwidth

Figure 9 - A (A) 2440 MHz (CH18) 99% Bandwidth

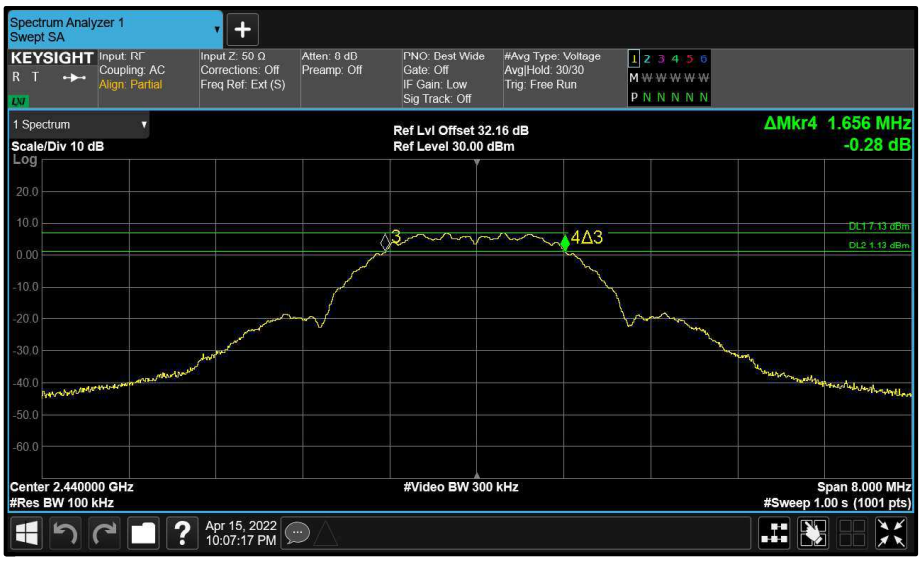

Figure 10 - A (A) 2440 MHz (CH18) 6 dB Bandwidth

Figure 11 - A (A) 2480 MHz (CH26) 99% Bandwidth

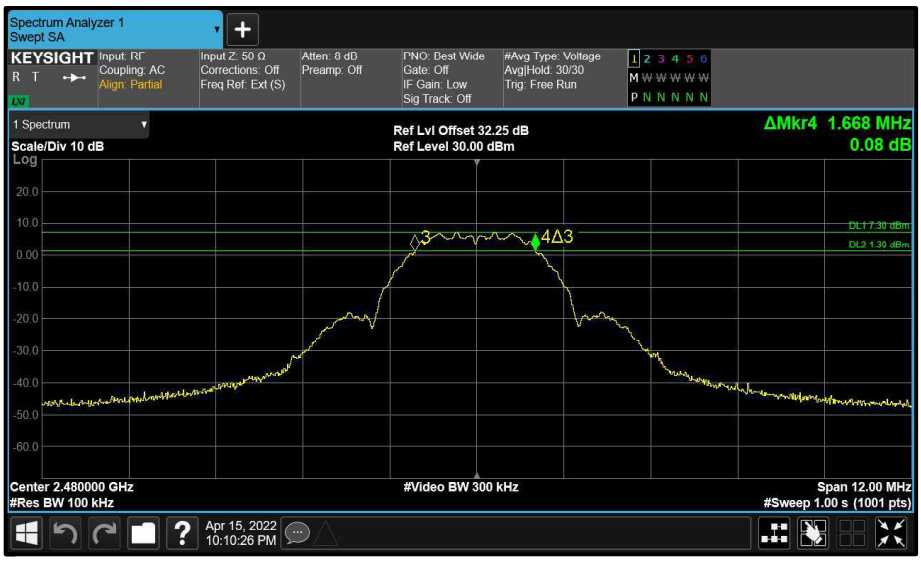

Figure 12 - A (A) 2480 MHz (CH26) 6 dB Bandwidth

2.4 GHz Bluetooth Low Energy

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

DUT Configuration			
Mode:	BLE GFSK (LE 2M)	Duty Cycle (%):	35.6
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Main)	Peak Antenna Gain (dBi):	0.64

Test Frequency (MHz)	6 dB Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2404	1.112	-	-	-	≥500.0
2440	1.112	-	-	-	≥500.0
2478	1.112	-	-	-	≥500.0

Table 24 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2404	2.048	-	-	-	-
2440	2.048	-	-	-	-
2478	2.064	-	-	-	-

Table 25 - 99% Bandwidth Results

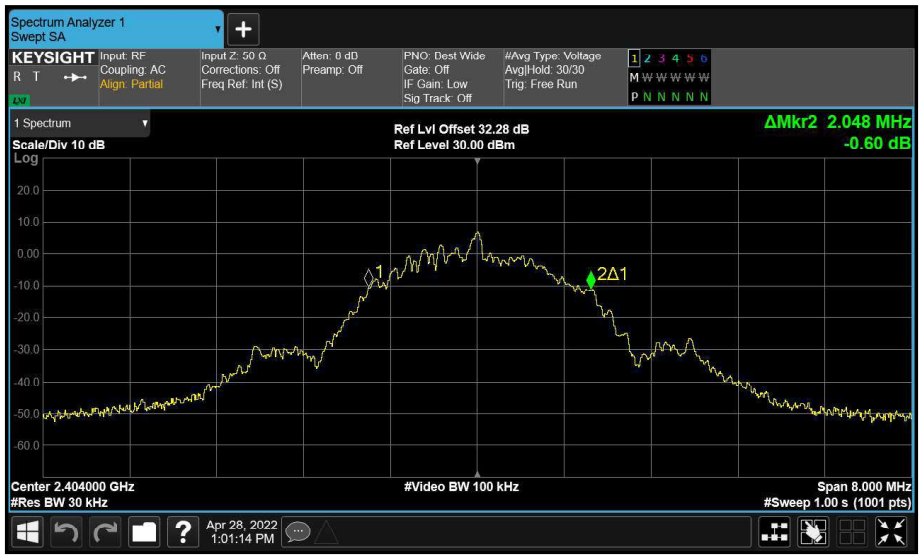

Figure 13 - Main (A) 2404 MHz (CH0) 99% Bandwidth

Figure 14 - Main (A) 2404 MHz (CH0) 6 dB Bandwidth

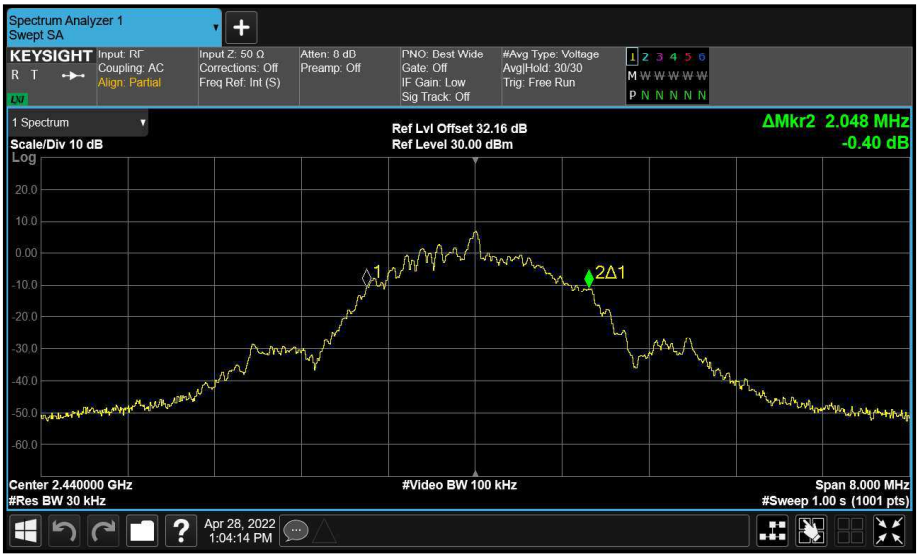

Figure 15 - Main (A) 2440 MHz (CH17) 99% Bandwidth

Figure 16 - Main (A) 2440 MHz (CH17) 6 dB Bandwidth

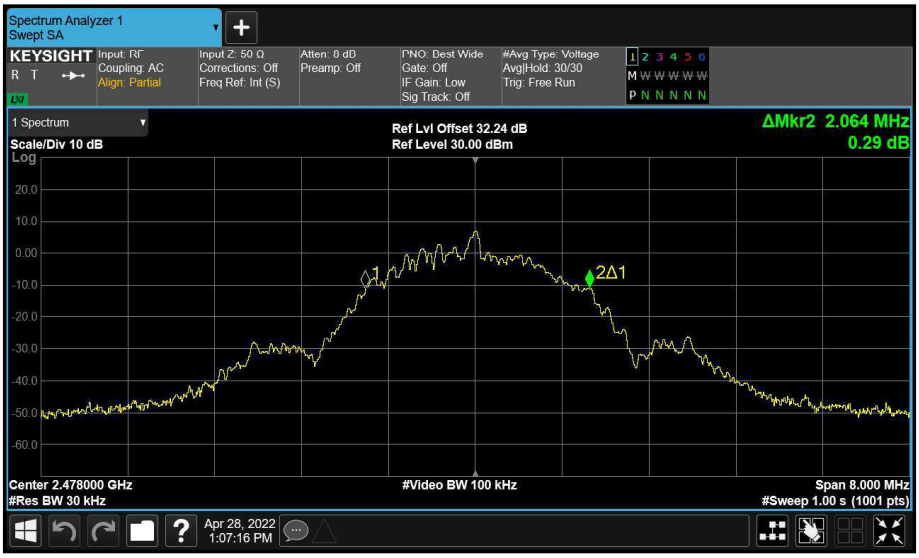

Figure 17 - Main (A) 2478 MHz (CH36) 99% Bandwidth

Figure 18 - Main (A) 2478 MHz (CH36) 6 dB Bandwidth

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

DUT Configuration			
Mode:	BLE GFSK (LE 8-Coding)	Duty Cycle (%):	82.8
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Main)	Peak Antenna Gain (dBi):	0.64

Test Frequency (MHz)	6 dB Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2402	0.608	-	-	-	≥500.0
2440	0.604	-	-	-	≥500.0
2480	0.604	-	-	-	≥500.0

Table 26 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2402	1.052	-	-	-	-
2440	1.052	-	-	-	-
2480	1.052	-	-	-	-

Table 27 - 99% Bandwidth Results

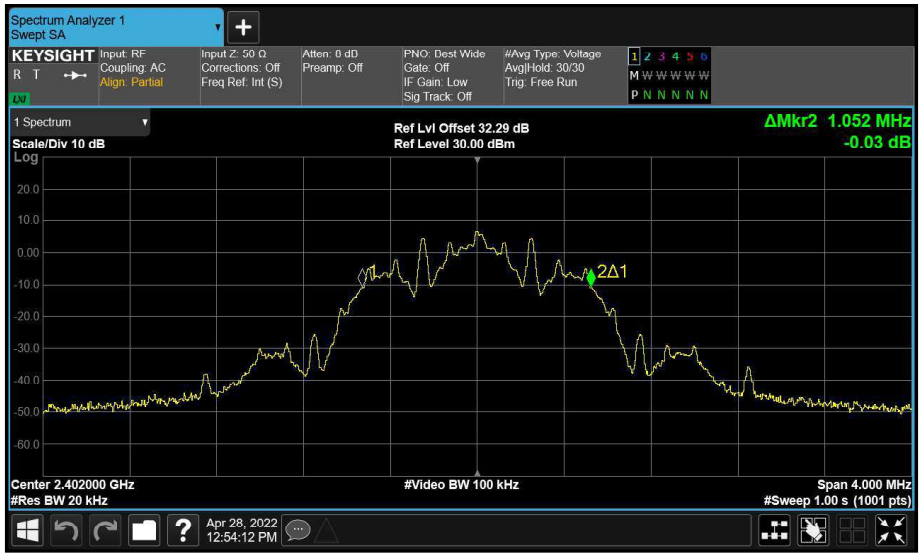

Figure 19 - Main (A) 2402 MHz (CH37) 99% Bandwidth

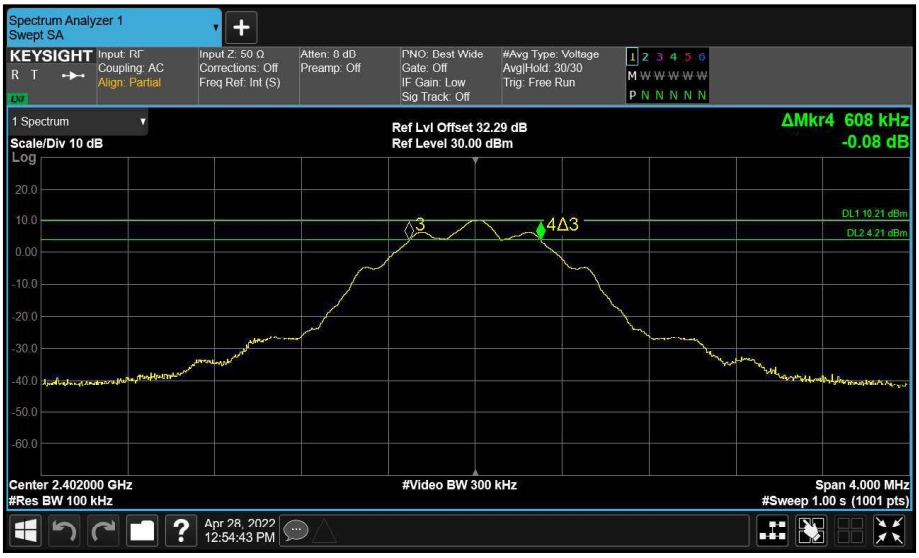

Figure 20 - Main (A) 2402 MHz (CH37) 6 dB Bandwidth

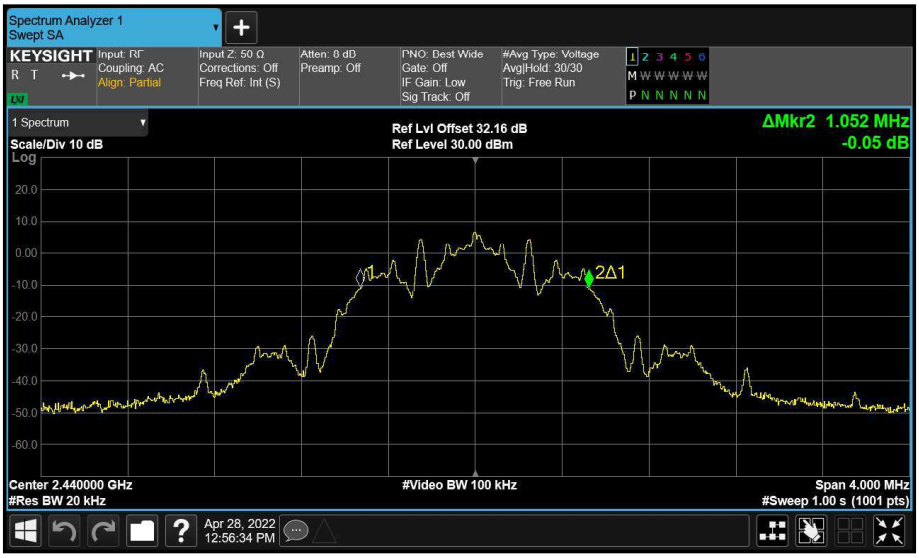

Figure 21 - Main (A) 2440 MHz (CH17) 99% Bandwidth

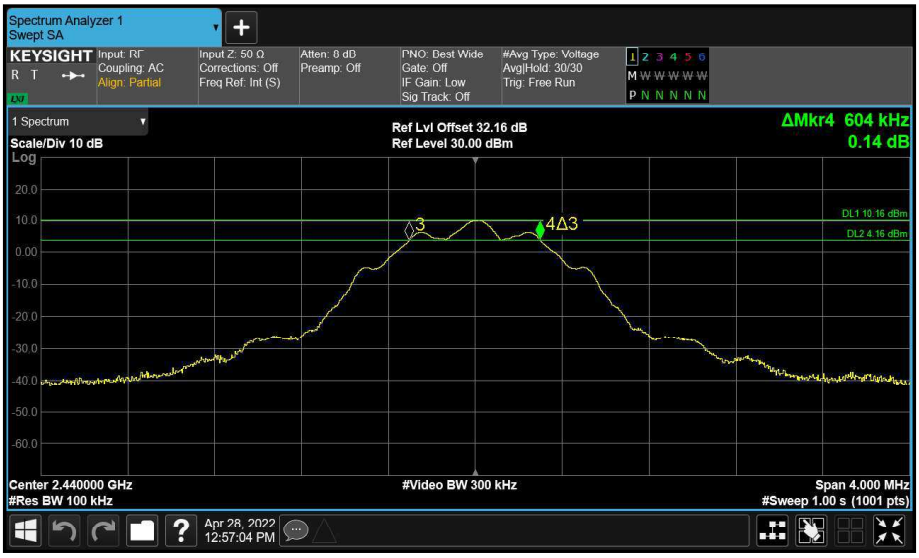

Figure 22 - Main (A) 2440 MHz (CH17) 6 dB Bandwidth

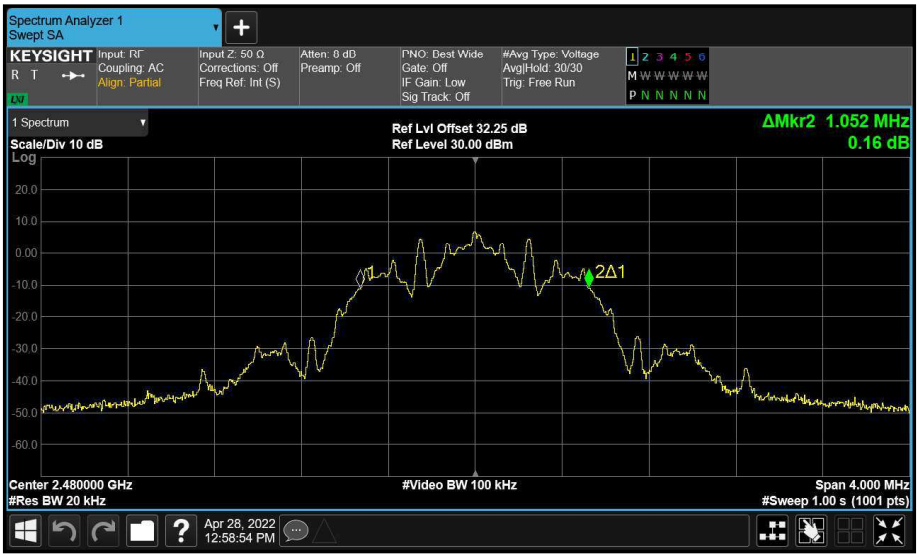

Figure 23 - Main (A) 2480 MHz (CH39) 99% Bandwidth

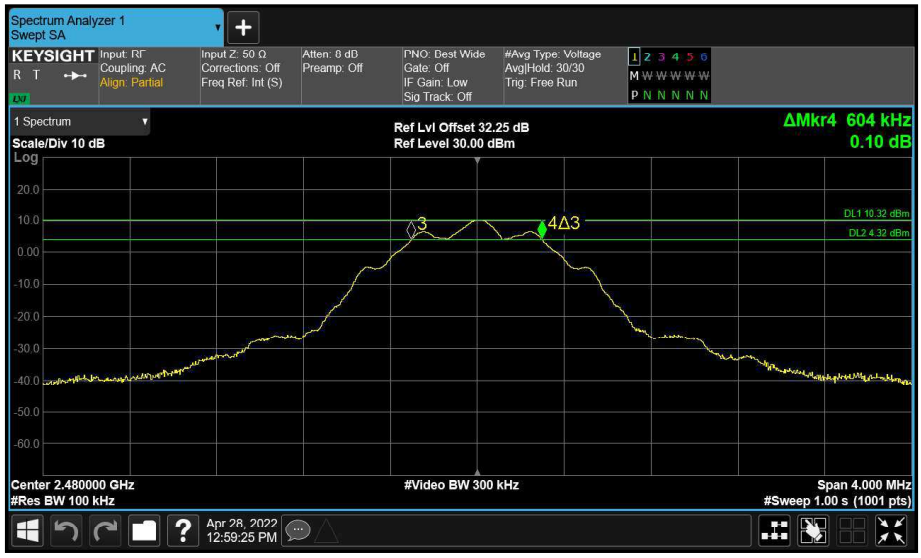

Figure 24 - Main (A) 2480 MHz (CH39) 6 dB Bandwidth

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 Expires
Hygrometer	Rotronic	I-1000	3220	12	05-Nov-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5529	24	06-Jun-2022
Signal Conditioning Unit	TUV SUD	SCU002	5759	12	30-Jun-2022

Table 28

2.3 Maximum Conducted Output Power

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

MGM240L, S/N: Not Serialised Storix ID (643242-08) - Modification State 0
MGM240L, S/N: Not Serialised Storix ID (643242-11) - Modification State 0

2.3.3 Date of Test

15-April-2022 to 28-April-2022

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10 clause 11.9.1.2.

Alongside LE2M, LE 8-coding was selected for testing as the customer declared that LE 8-coding is the worst case out of the supported 1MBaud PHYs.

The device was powered from its USB port.

2.3.5 Environmental Conditions

Ambient Temperature	23.4 - 26.2 °C
Relative Humidity	30.9 - 32.6 %

2.3.6 Test Results

2.4 GHz 802.15.4

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

DUT Configuration			
Mode:	802.15.4	Duty Cycle (%):	100.0
Data Rate:	-	DCCF (dB):	-
Antenna Configuration:	SISO	Peak Antenna Gain (dBi):	0.64
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	10.28	-	-	-	-	30.00	-19.72
2440	10.30	-	-	-	-	30.00	-19.70
2480	10.30	-	-	-	-	30.00	-19.70

Table 29 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2405	10.28	-	-	-	-	30.00	-19.72	10.92	36.00	-25.08
2440	10.30	-	-	-	-	30.00	-19.70	10.94	36.00	-25.06
2480	10.30	-	-	-	-	30.00	-19.70	10.94	36.00	-25.06

Table 30 - ISED Maximum Conducted (peak) Output Power Results

2.4 GHz Bluetooth Low Energy

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(3) RSS-247 5.4 d)	Test Method(s):	C63.10 11.9.1.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	BLE GFSK (LE 2M)	Duty Cycle (%):	35.6
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Main)	Peak Antenna Gain (dBi):	0.64

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2404	10.17	-	-	-	-	30.00	-19.83
2440	10.27	-	-	-	-	30.00	-19.73
2478	10.21	-	-	-	-	30.00	-19.79

Table 31 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2404	10.17	-	-	-	-	30.00	-19.83	10.81	36.00	-25.19
2440	10.27	-	-	-	-	30.00	-19.73	10.91	36.00	-25.09
2478	10.21	-	-	-	-	30.00	-19.79	10.85	36.00	-25.15

Table 32 - ISED Maximum Conducted (peak) Output Power Results

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	15.247 (b)(3) RSS-247 5.4 d)	Test Method(s):	C63.10 11.9.1.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	BLE GFSK (LE 8-Coding)	Duty Cycle (%):	82.8
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Main)	Peak Antenna Gain (dBi):	0.64

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2402	10.19	-	-	-	-	30.00	-19.81
2440	10.22	-	-	-	-	30.00	-19.78
2480	10.22	-	-	-	-	30.00	-19.78

Table 33 - FCC Maximum Conducted (peak) Output Power Results

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
	A	B	C	D	∑					
2402	10.19	-	-	-	-	30.00	-19.81	10.83	36.00	-25.17
2440	10.22	-	-	-	-	30.00	-19.78	10.86	36.00	-25.14
2480	10.22	-	-	-	-	30.00	-19.78	10.86	36.00	-25.14

Table 34 - ISED Maximum Conducted (peak) Output Power Results

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

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

ISED RSS-247, Limit Clause 5.4 (b)

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

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Hygrometer	Rotronic	I-1000	3220	12	05-Nov-2022
Signal Conditioning Unit	TUV SUD	SCU002	5759	12	30-Jun-2022
USB Power Sensor	Boonton	RTP5008	5832	12	10-May-2022

Table 35

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

MGM240L, S/N: Not Serialised Storix ID (643242-05) - Modification State 0
MGM240L, S/N: Not Serialised Storix ID (643242-07) - Modification State 0

2.4.3 Date of Test

11-April-2022 to 12-May-2022

2.4.4 Test Method

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

Alongside LE2M, LE 8-coding was selected for testing as the customer declared that LE 8-coding is the worst case out of the supported 1MBaud PHYs.

Authorised band edge measurements were only performed at the lower edge of the operating band where the authorised and restricted band edges are different frequencies. Attenuation below the limits specified in FCC 47 CFR Part 15.209 and ISED RSS-GEN Table 5 is not required and therefore compliance with the restricted band edge at 2483.5 MHz is sufficient evidence of compliance.

2.4.5 Environmental Conditions

Ambient Temperature	19.7 - 22.3 °C
Relative Humidity	27.3 - 43.8 %

2.4.6 Test Results

2.4 GHz 802.15.4

Mode	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
Static	2405	2400.0	-55.47

Table 36

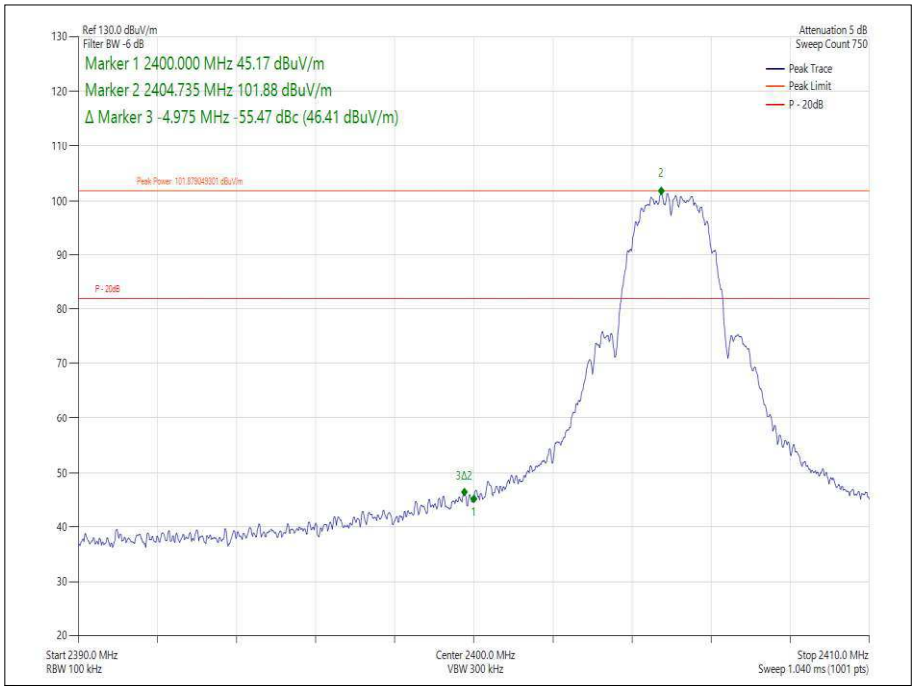

Figure 25 - Static, 2405 MHz - Measured Frequency 2400.0 MHz

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK (LE 8-Coding)	2402	2390	51.15
GFSK (LE 2M)	2404	2390	48.50

Table 37

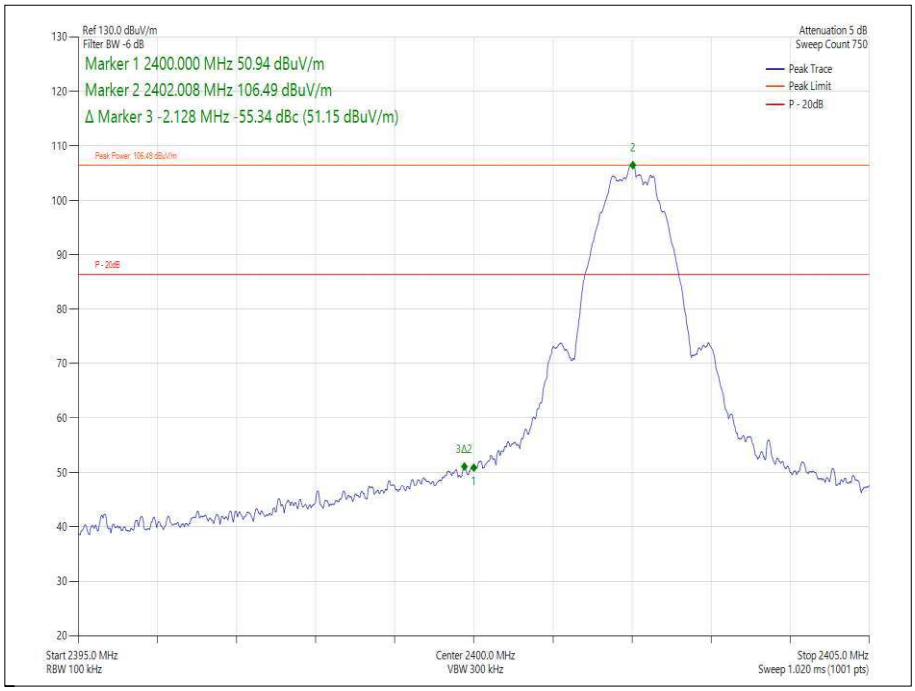

Figure 26 - GFSK (LE 8-Coding), 2402 MHz - Measured Frequency 2390 MHz

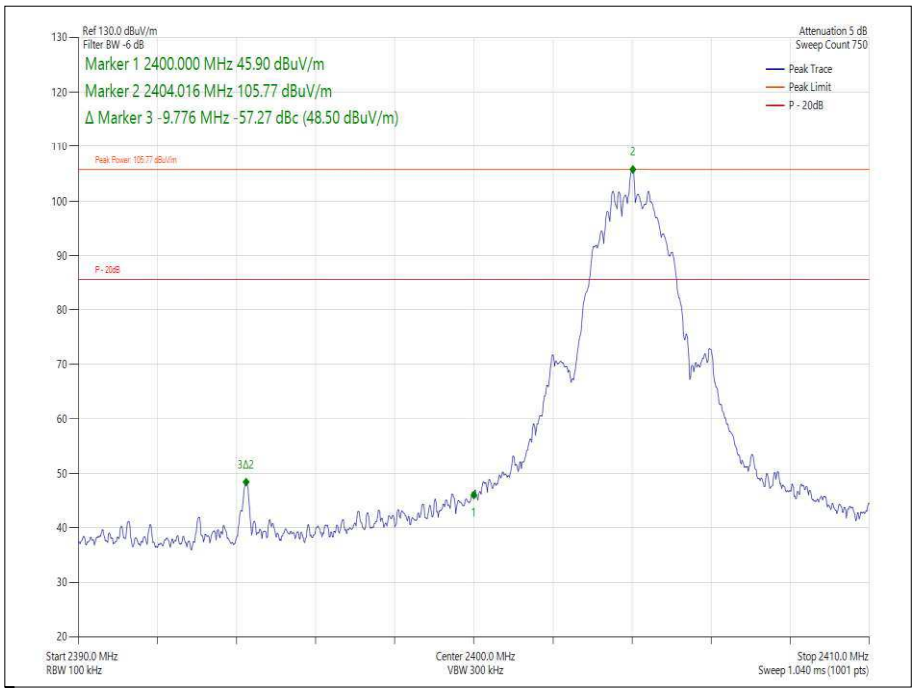

Figure 27– GFSK (LE 2M), 2404 MHz - Measured Frequency 2390 MHz

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 EMC Chamber 12.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Power Supply Unit	Farnell	D302T	609	12	O/P Mon
Multimeter	Fluke	79 Series II	3057	12	23-Aug-2022
Cable (SMA to SMA, 2 m)	Rhophase	3PS-1801A-2000-3PS	4113	12	27-Jan-2023
Cable (N to N 8m)	Teledyne	PR90-088-8MTR	5212	12	06-Sep-2022
Thermo-hygro-Barometer	PCE Instruments	PCE-THB-40	5472	12	25-Mar-2023
Antenna (DRG, 1 GHz to 10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	15-Oct-2022
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	5613	-	TU
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
Screened Room (12)	MVG	EMC-3	5621	36	11-Aug-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5914	12	21-Feb-2023

Table 38

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

2.5 Spurious Radiated Emissions

2.5.1 Specification Reference

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

2.5.2 Equipment Under Test and Modification State

MGM240L, S/N: Not Serialised Storix ID (643242-05) - Modification State 0
MGM240L, S/N: Not Serialised Storix ID (643242-07) - Modification State 0

2.5.3 Date of Test

14-April-2022 to 24-April-2022

2.5.4 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 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 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 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.

2.5.5 Example Test Setup Diagram

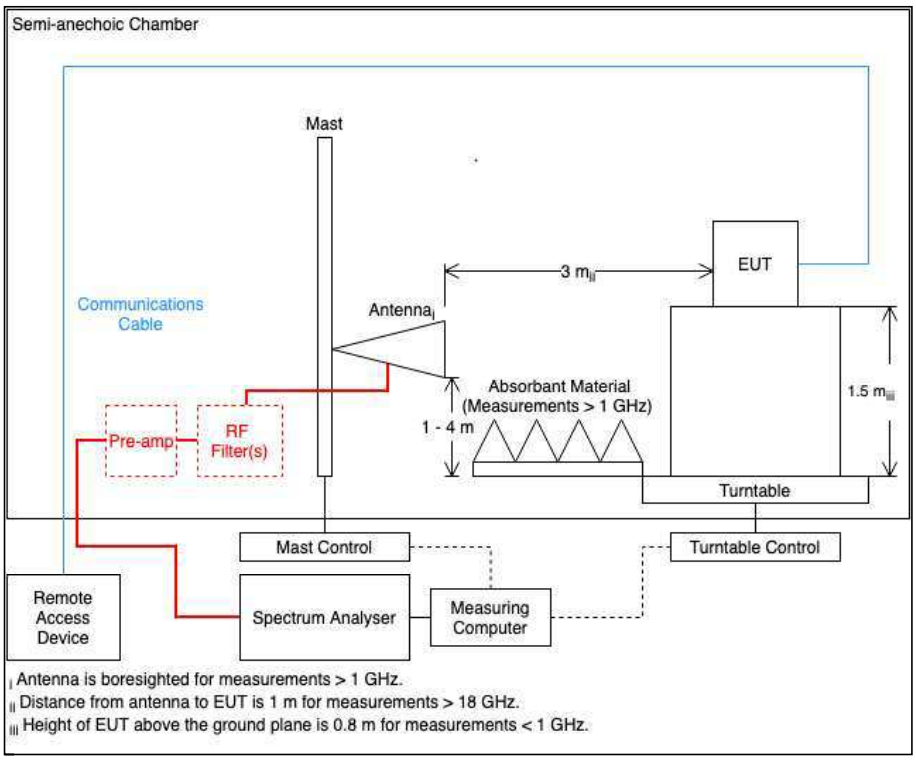

Figure 28

2.5.6 Environmental Conditions

Ambient Temperature	19.7 - 23.1 °C
Relative Humidity	29.7 - 42.2 %

2.5.7 Test Results

2.4 GHz 802.15.4

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
4808.954	46.7	54.0	-7.3	CISPR Avg	143	188	Horizontal
4811.064	48.0	54.0	-6.0	CISPR Avg	166	177	Vertical

Table 39 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 30 MHz to 25 GHz

No other emissions found within 10 dB of the limit.

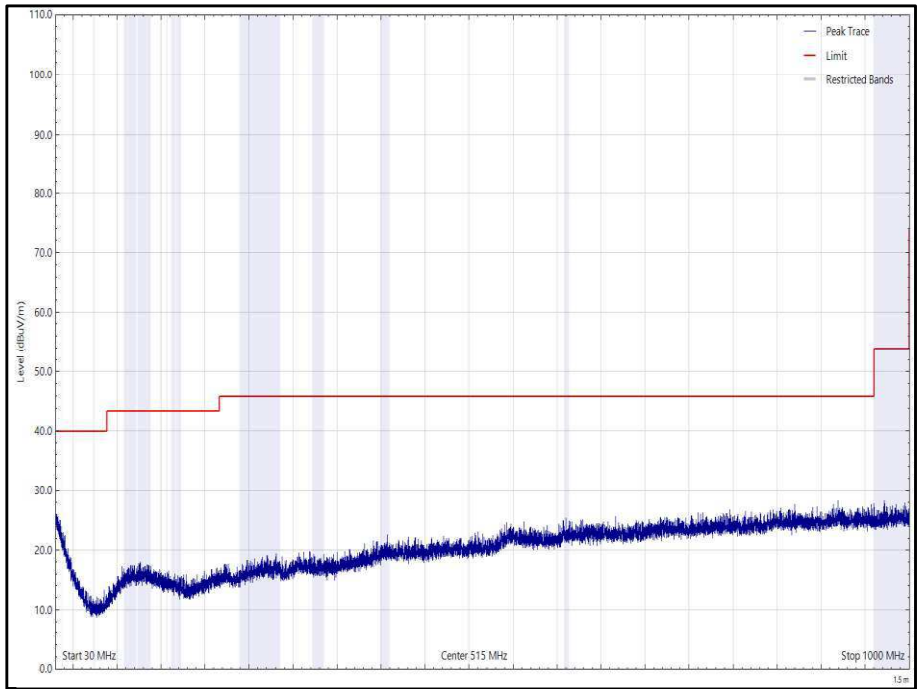

Figure 29 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

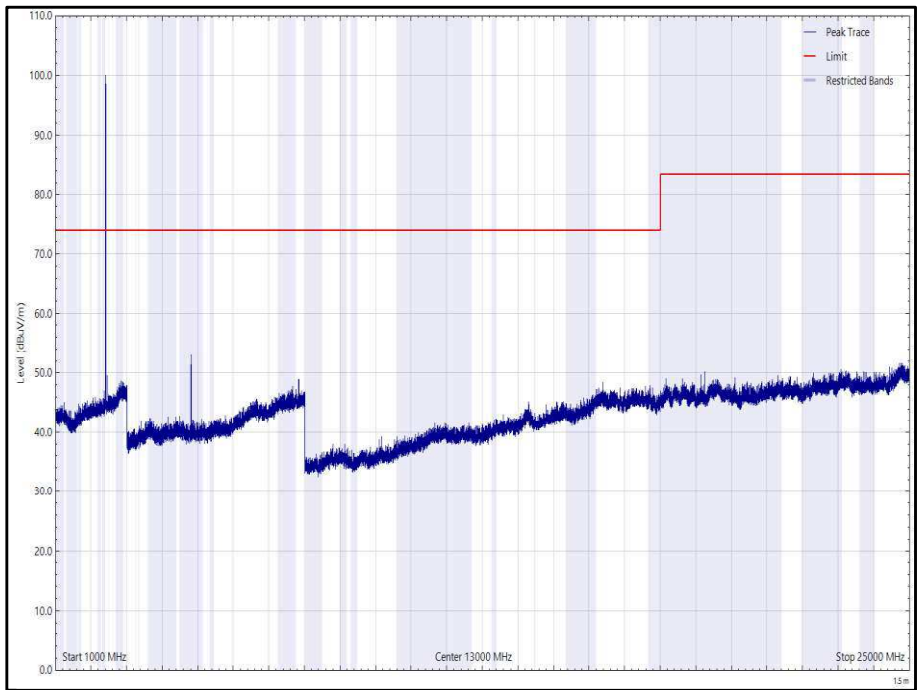

Figure 30 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

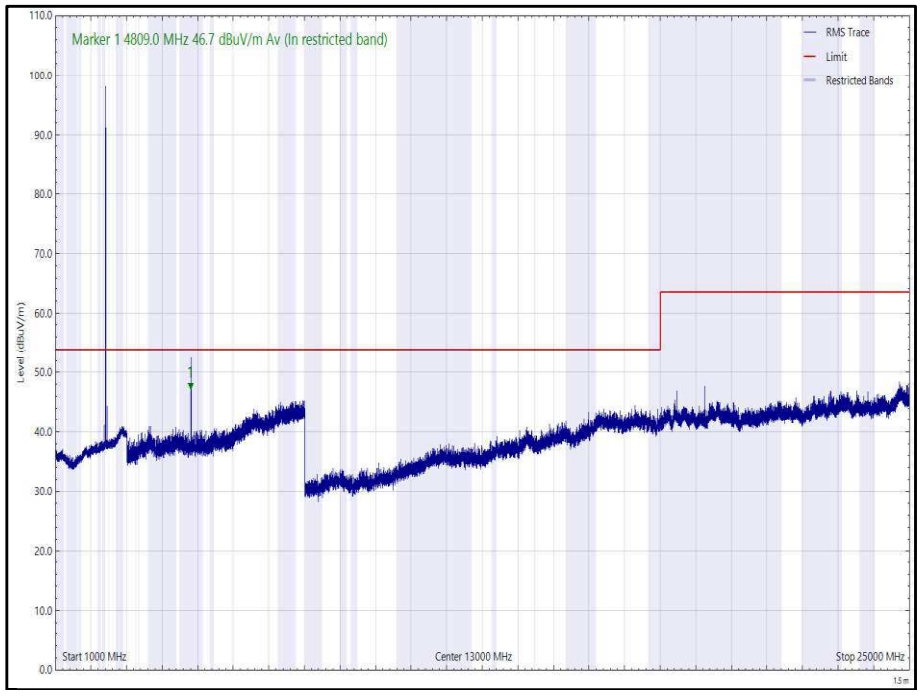

Figure 31 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

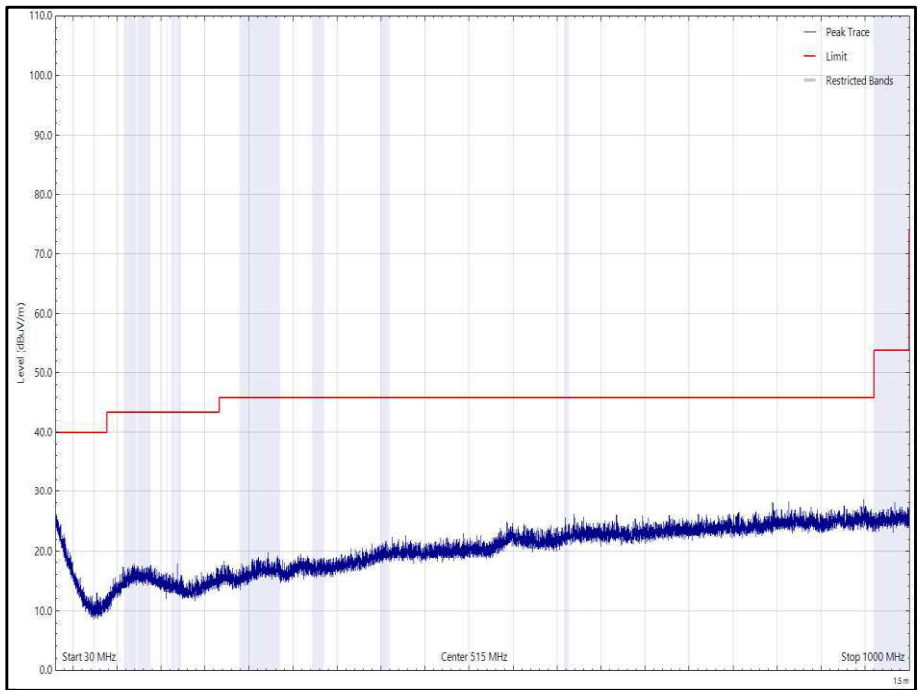

Figure 32 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

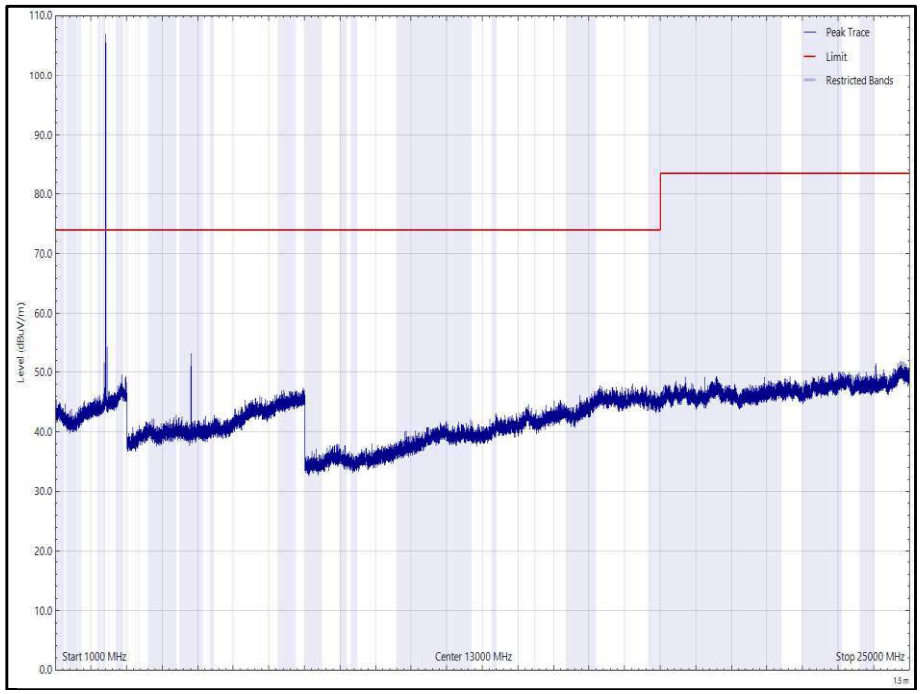

Figure 33 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

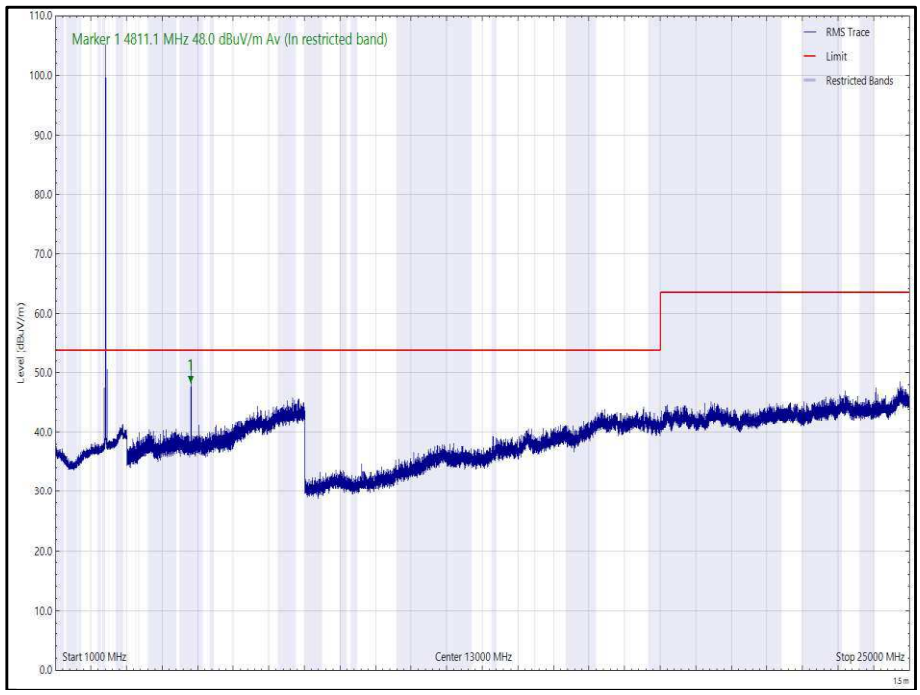

Figure 34 - 2.4 GHz 802.15.4-CH11-X, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
4808.914	47.0	54.0	-7.0	CISPR Avg	270	103	Vertical
4809.009	47.4	54.0	-6.6	CISPR Avg	102	129	Horizontal

Table 40 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 30 MHz to 25 GHz

No other emissions found within 10 dB of the limit.

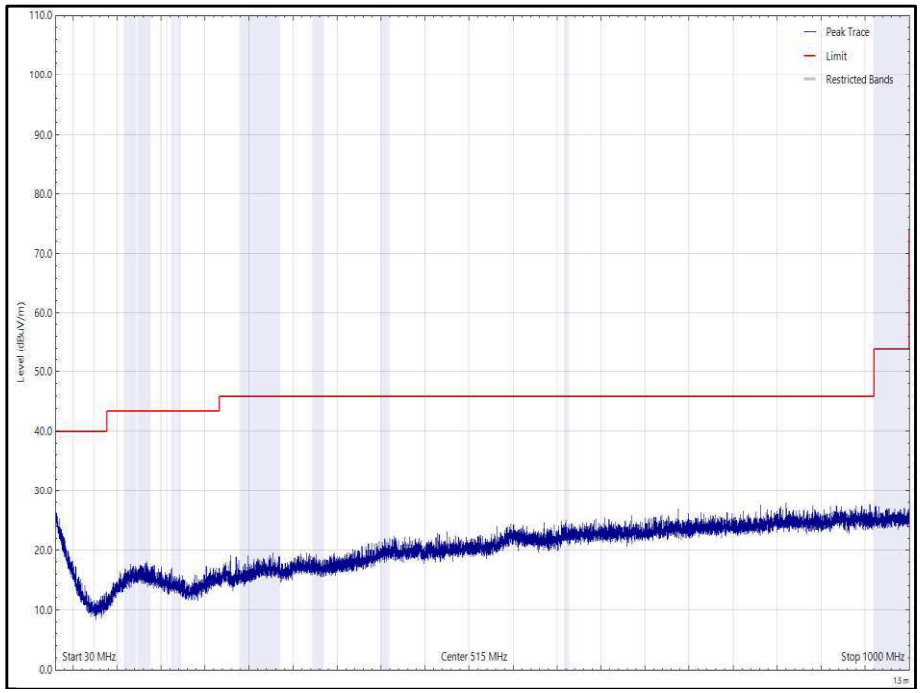

Figure 35 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

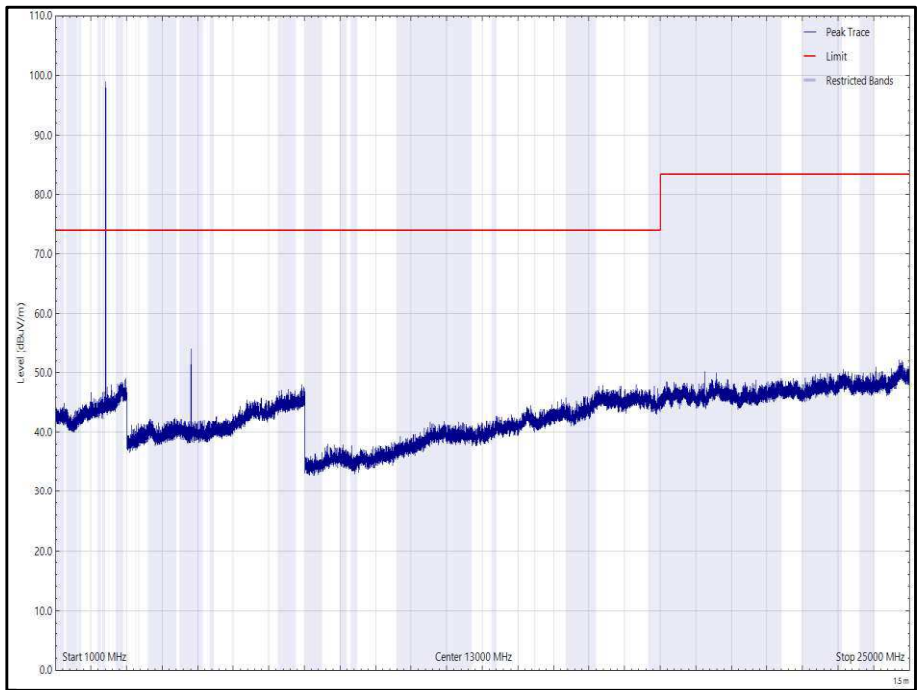

Figure 36 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

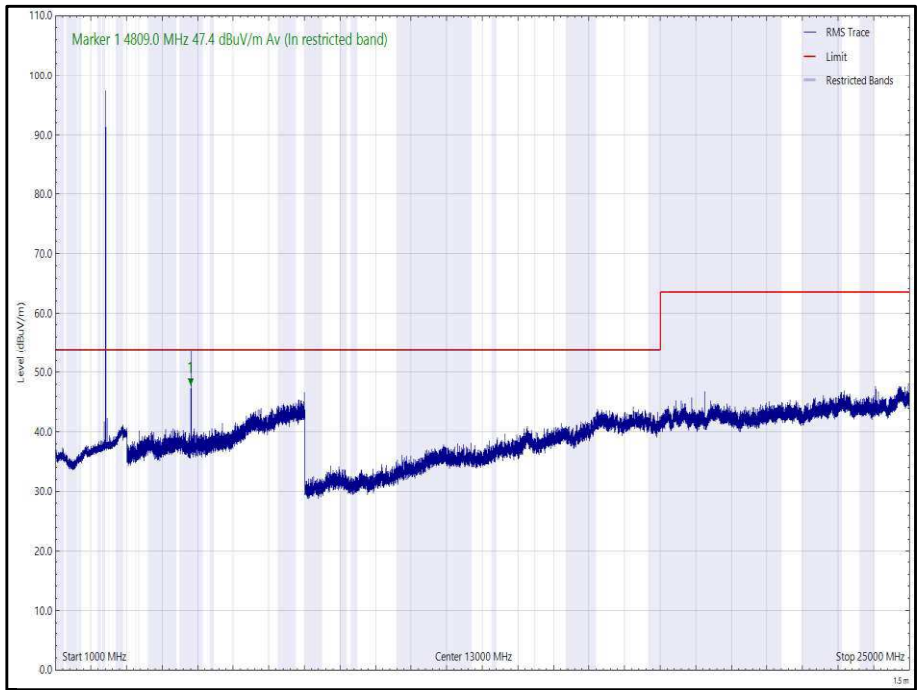

Figure 37 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

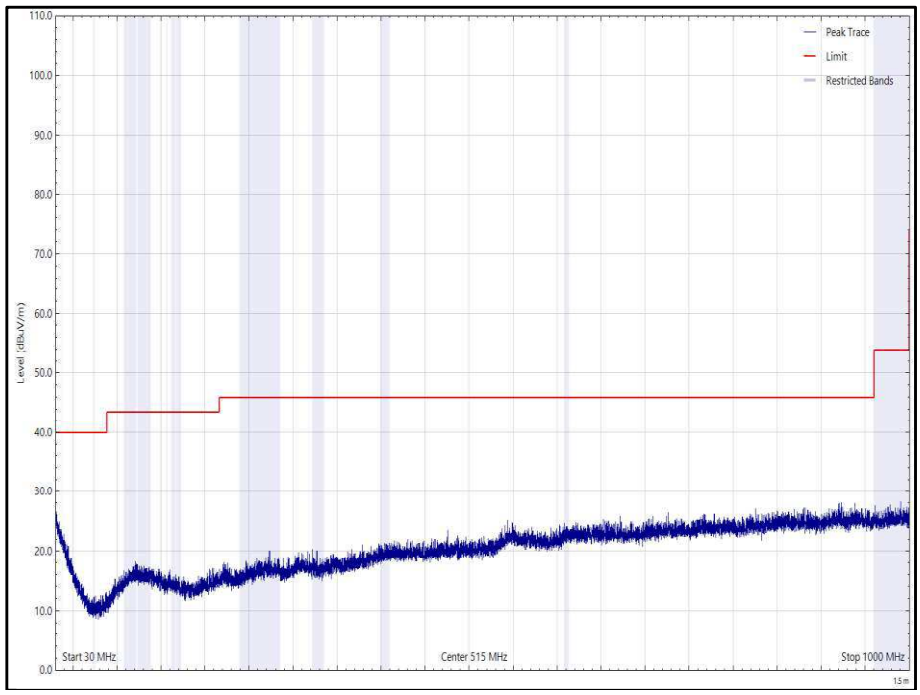

Figure 38 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

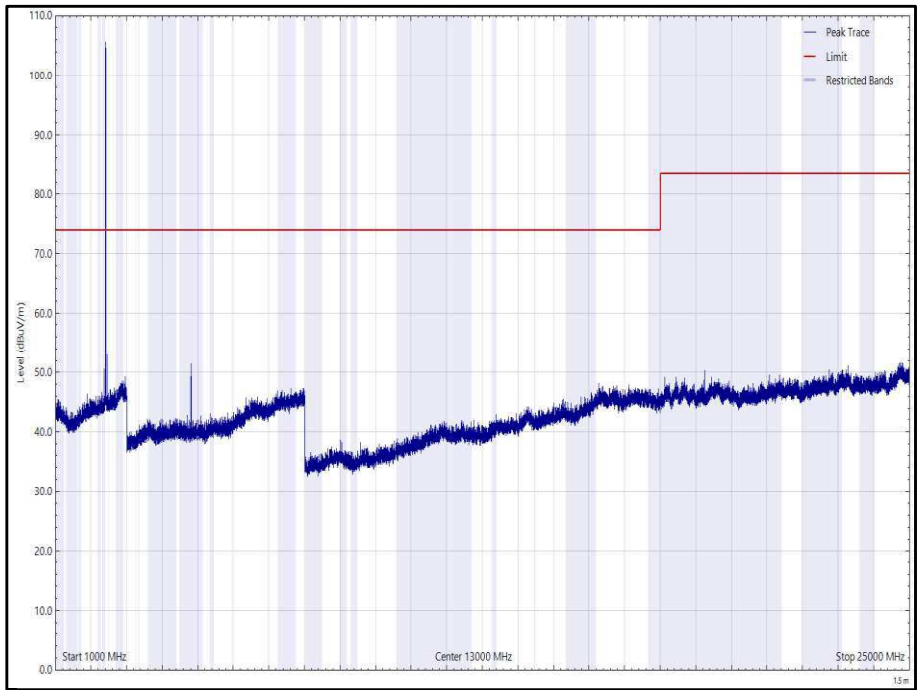

Figure 39 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

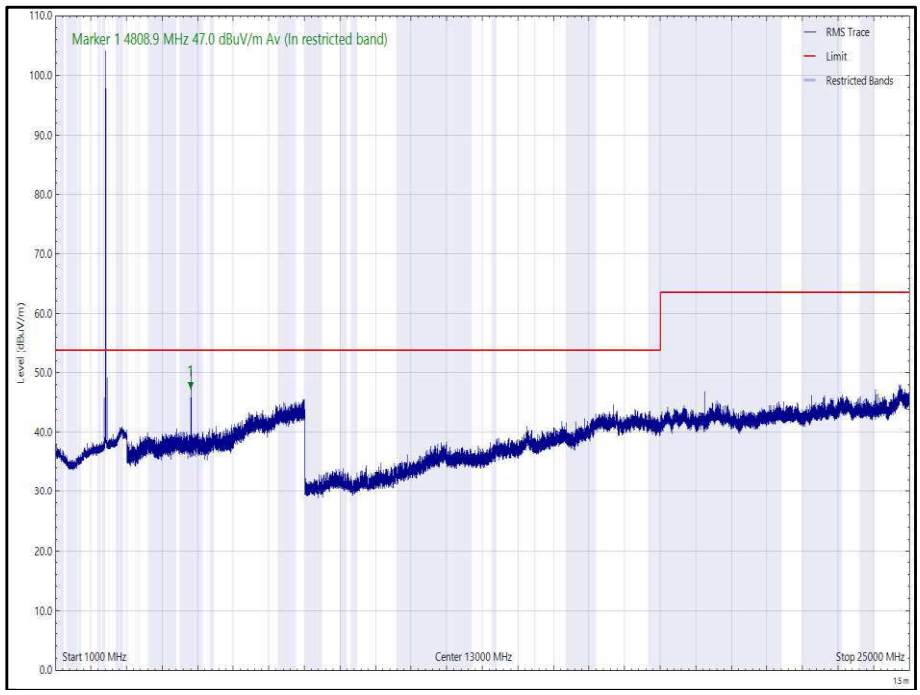

Figure 40 - 2.4 GHz 802.15.4-CH11-Y, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
4808.989	45.8	54.0	-8.2	CISPR Avg	92	123	Horizontal

Table 41 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 30 MHz to 25 GHz

No other emissions found within 10 dB of the limit.

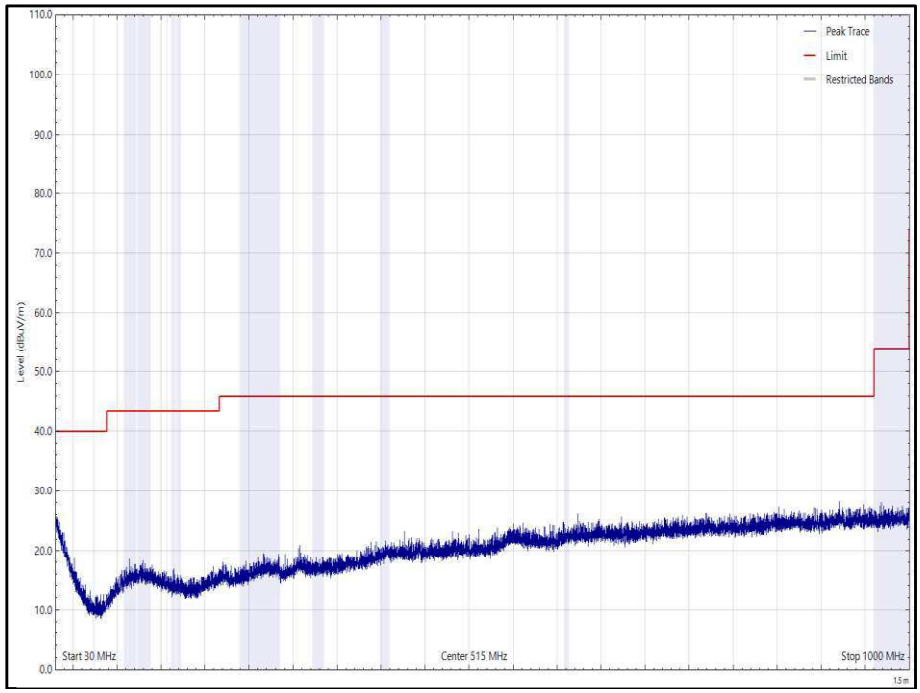

Figure 41 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

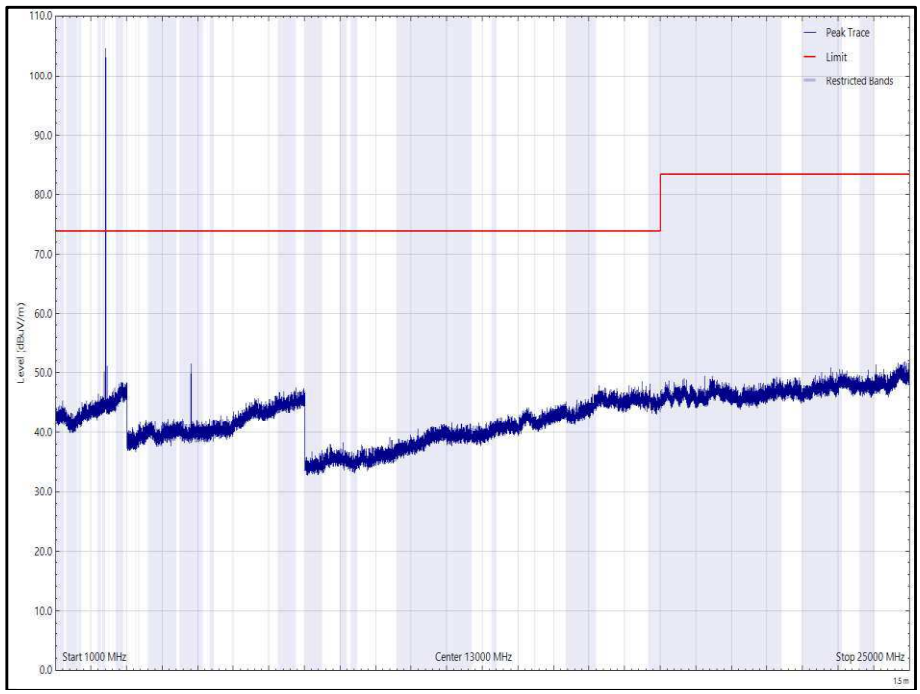

Figure 42 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

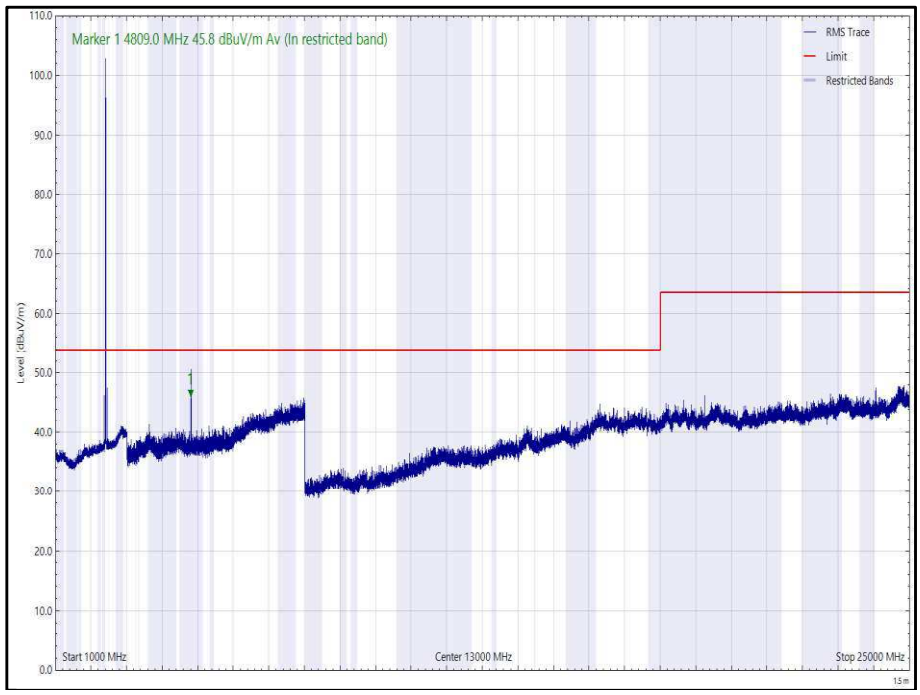

Figure 43 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 1 GHz to 25 GHz, Horizontal (rms)

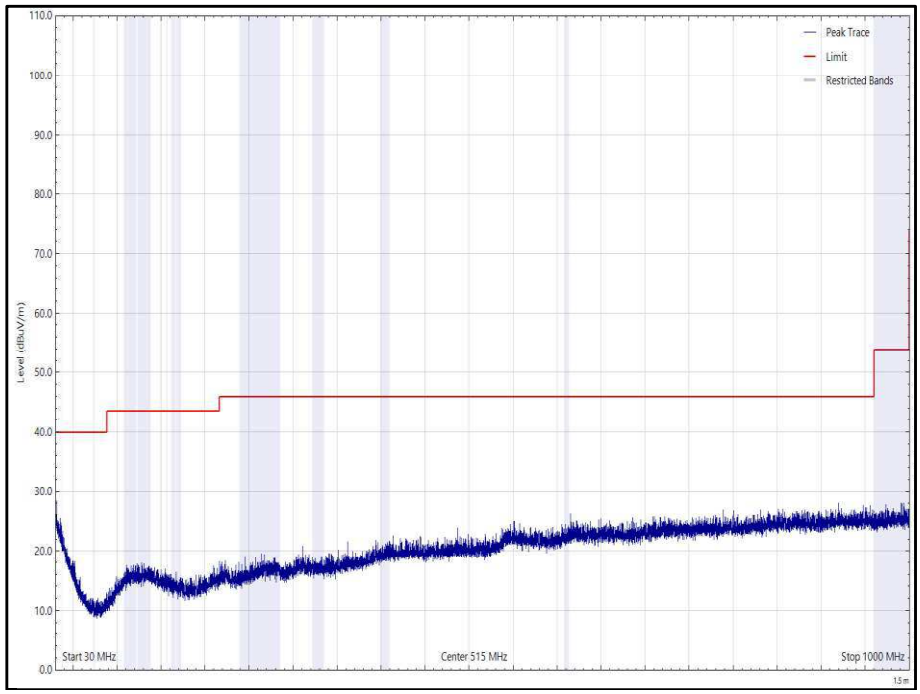

Figure 44 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 30 MHz to 1 GHz, Vertical (Peak)

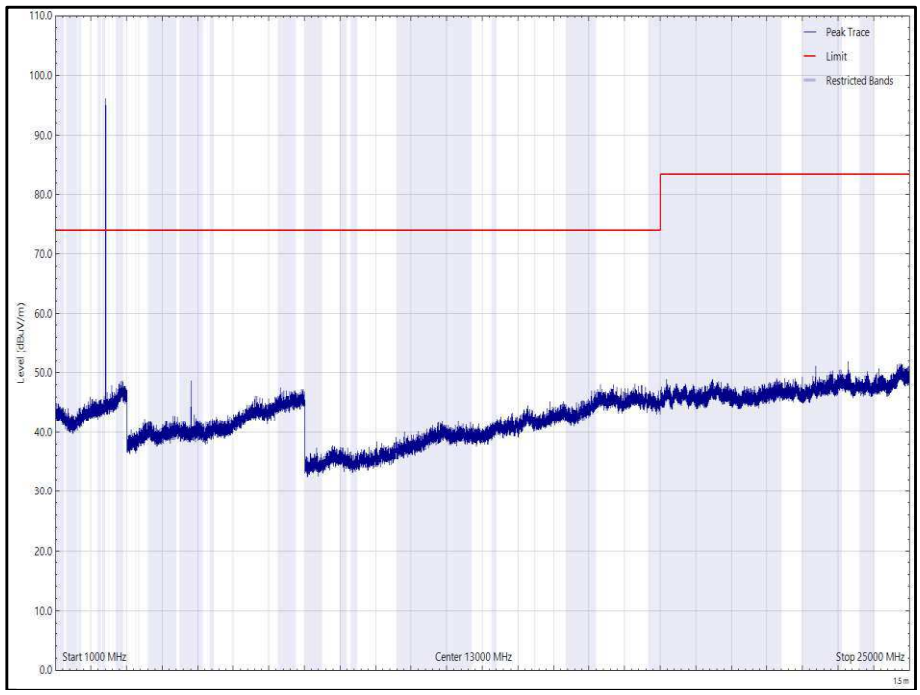

Figure 45 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 1 GHz to 25 GHz, Vertical (Peak)

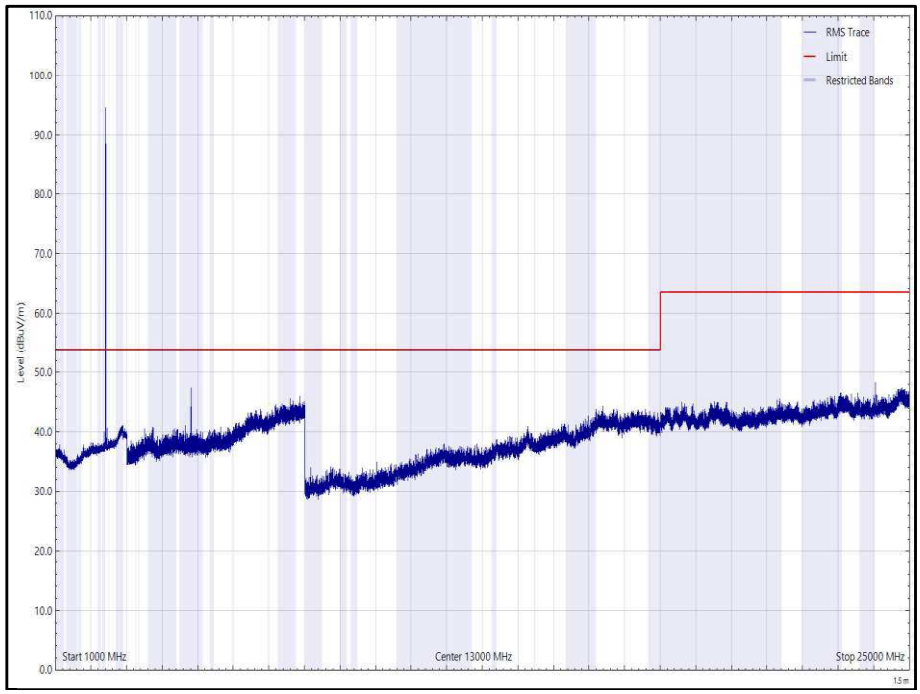

Figure 46 - 2.4 GHz 802.15.4-CH11-Z, 2405 MHz, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2484.547	45.8	54.0	-8.2	CISPR Avg	167	131	Vertical

Table 42 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 30 MHz to 25 GHz

No other emissions found within 10 dB of the limit.

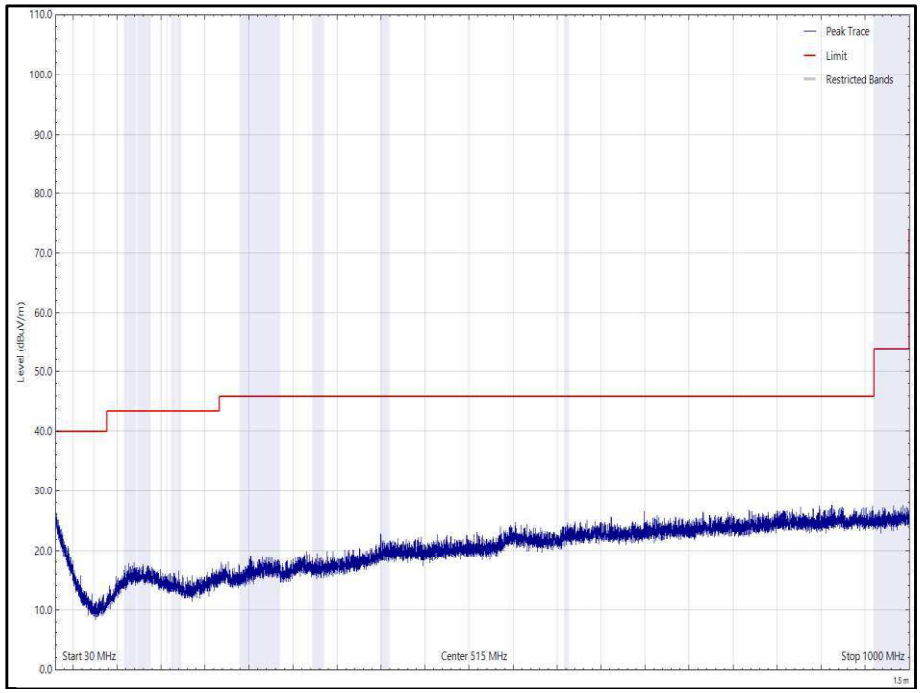

Figure 47 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

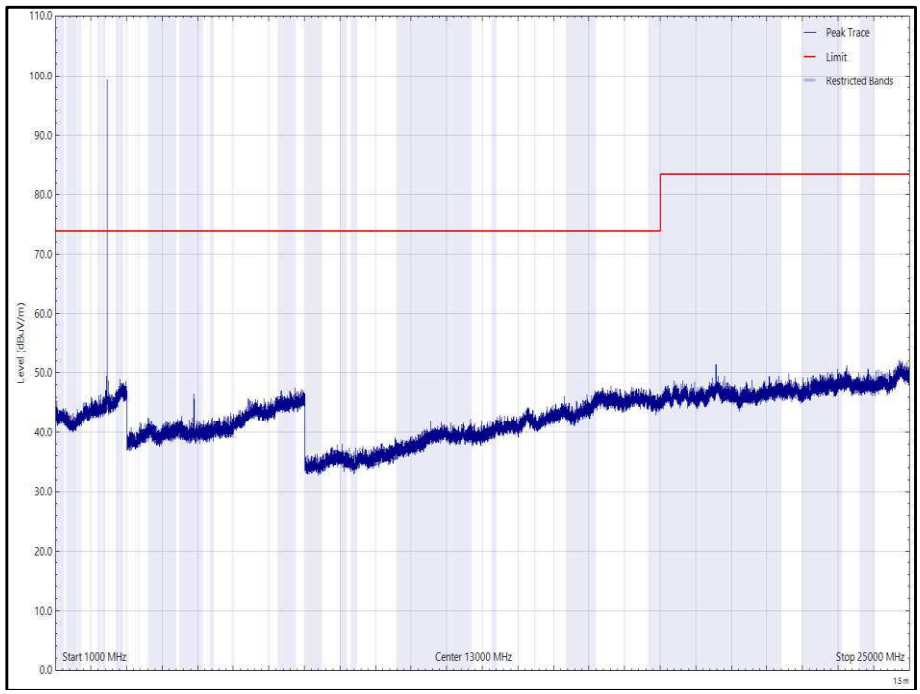

Figure 48 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

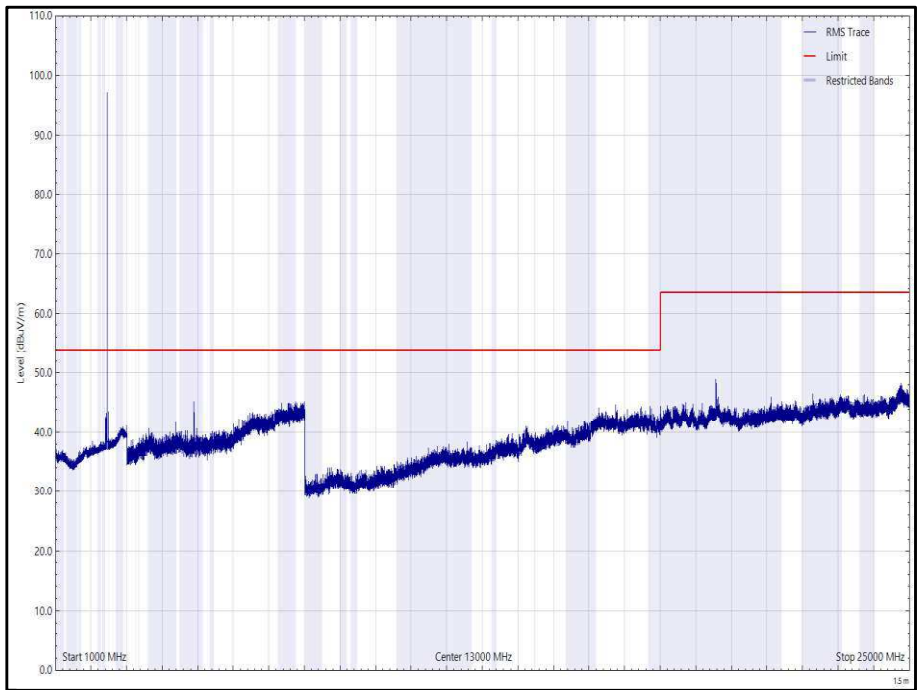

Figure 49 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

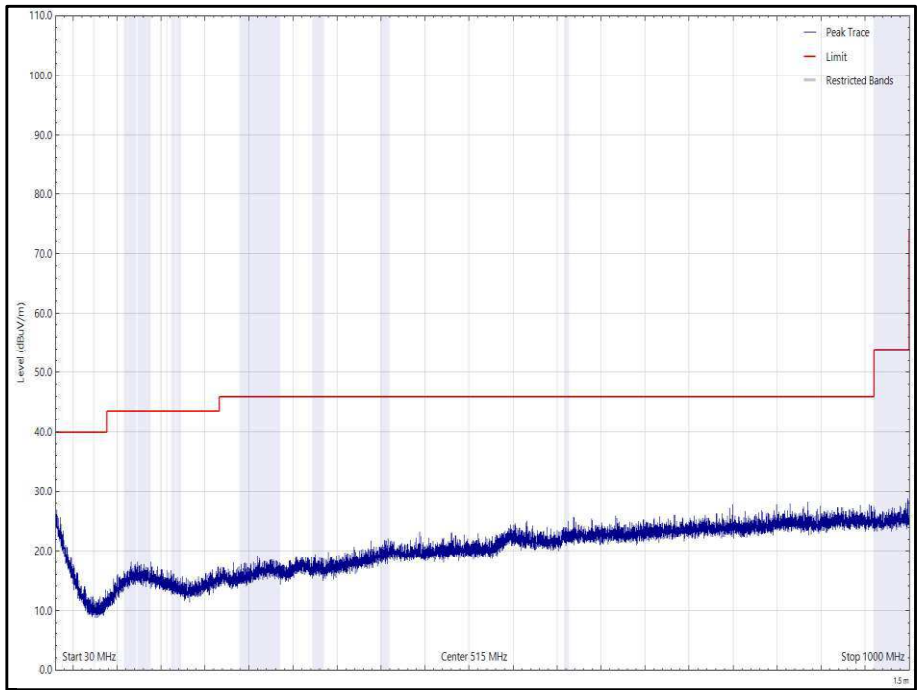

Figure 50 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)

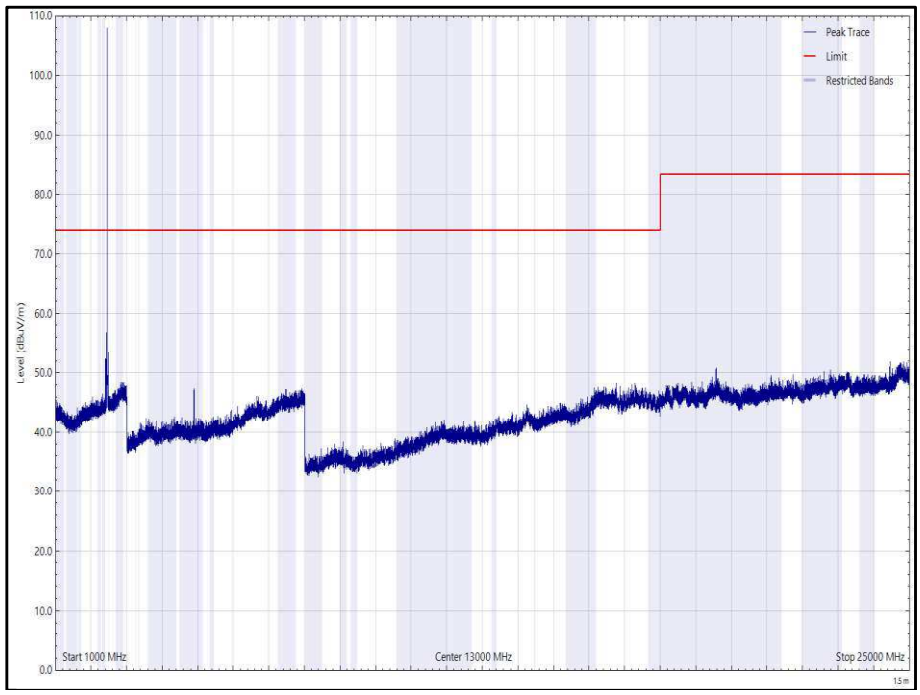

Figure 51 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 1 GHz to 25 GHz, Vertical (Peak)

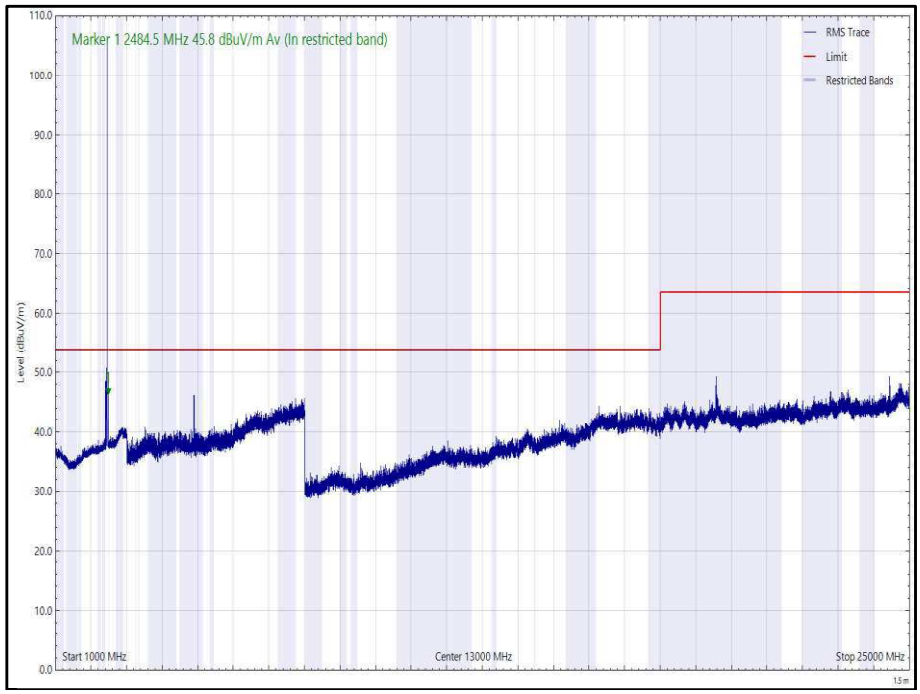

Figure 52 - 2.4 GHz 802.15.4-CH19-X, 2445 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 43 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

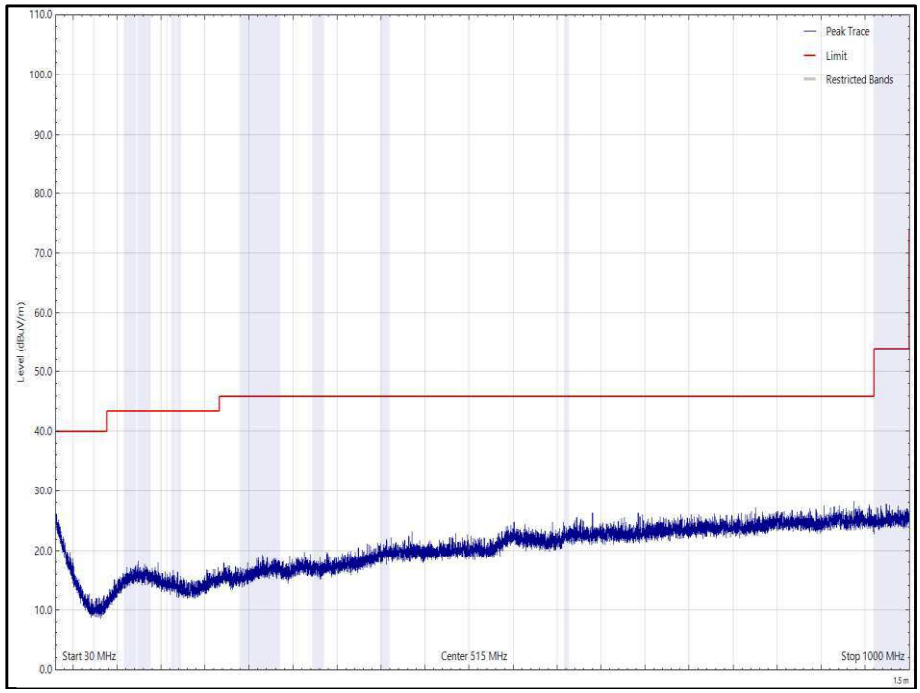

Figure 53 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

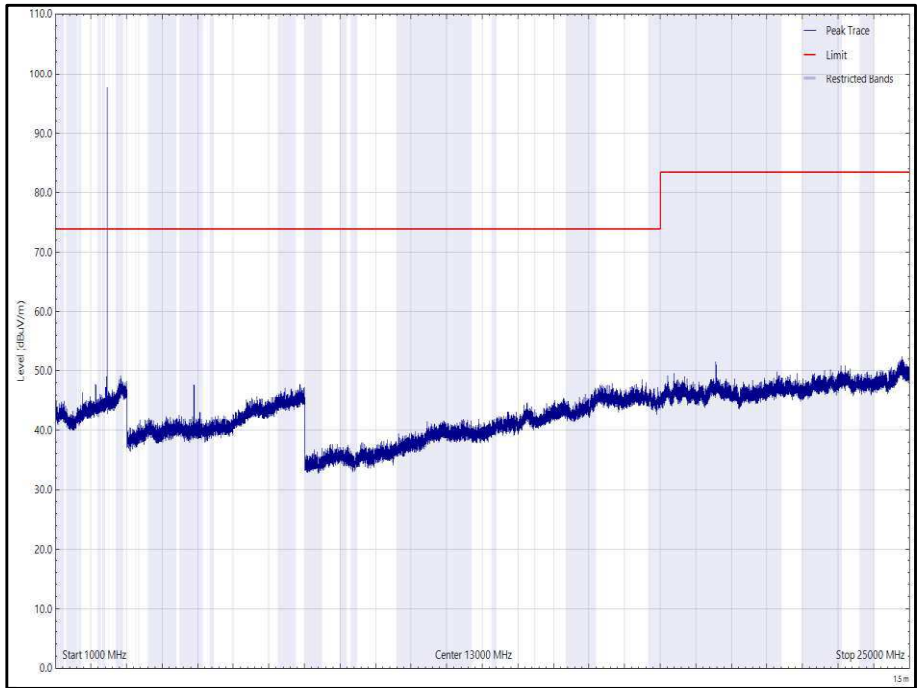

Figure 54 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

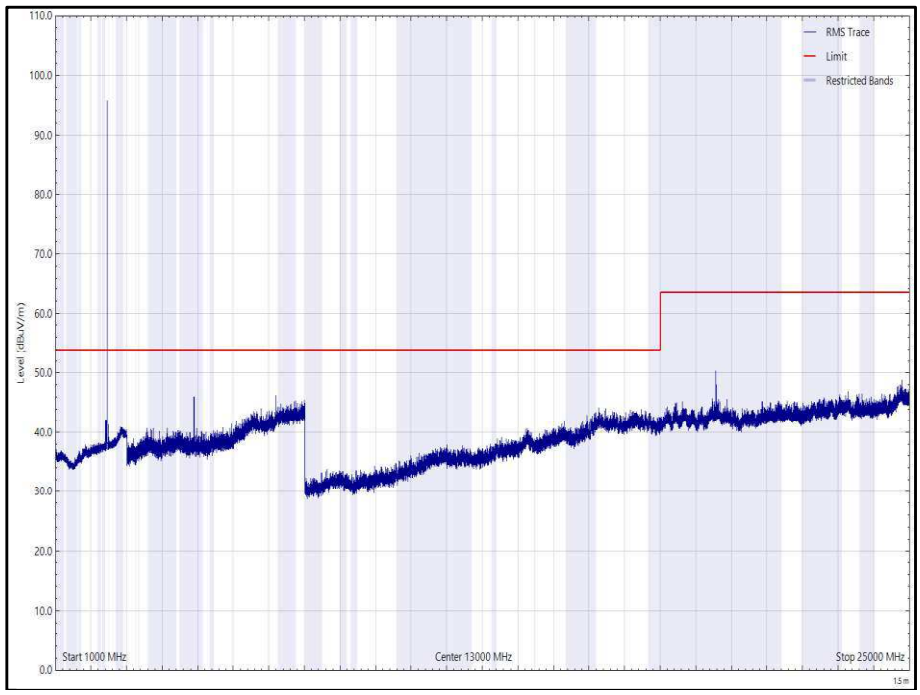

Figure 55 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

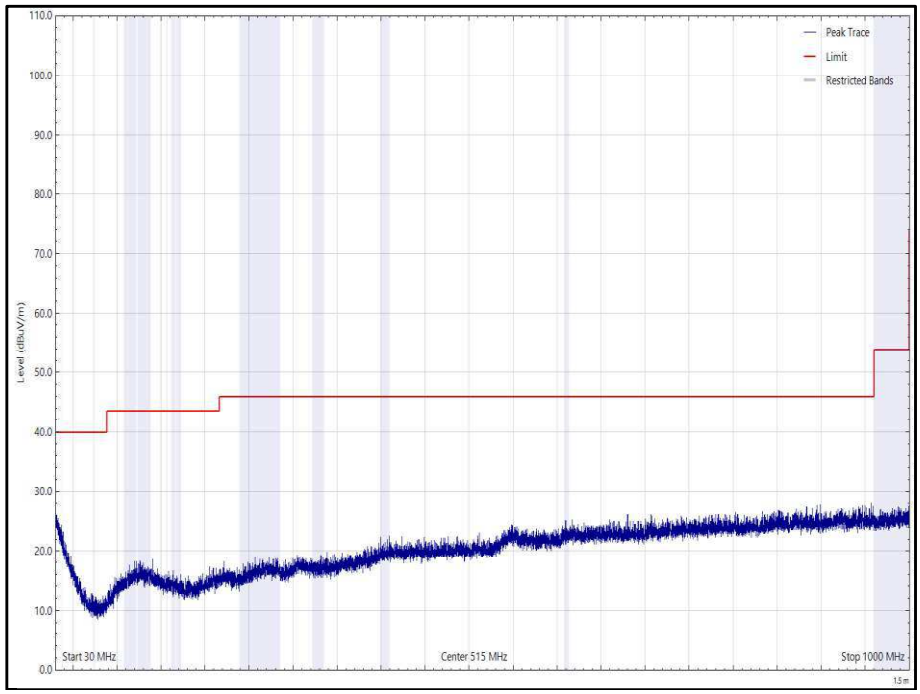

Figure 56 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)

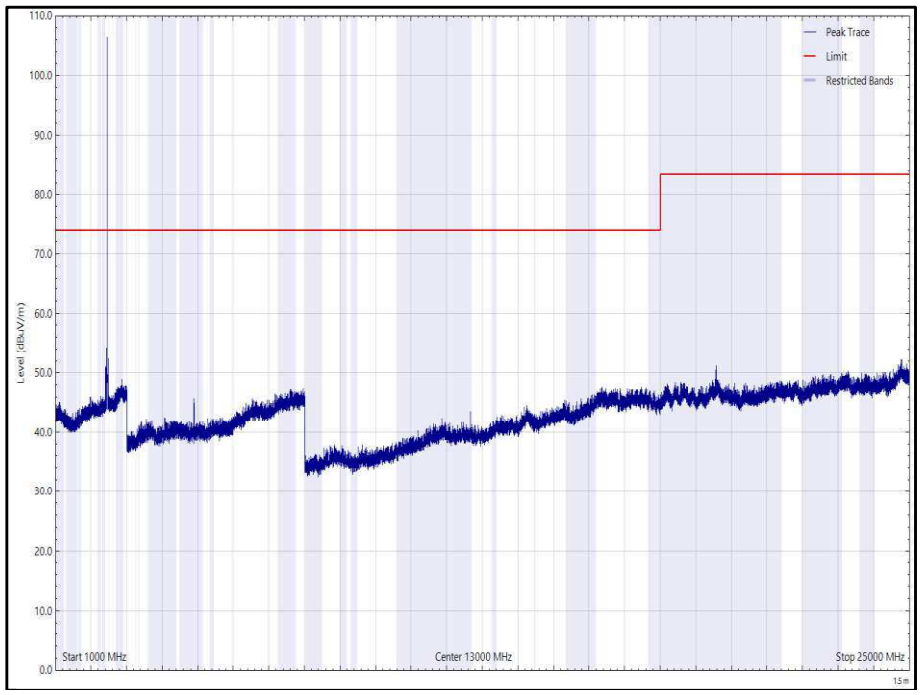

Figure 57 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 1 GHz to 25 GHz, Vertical (Peak)

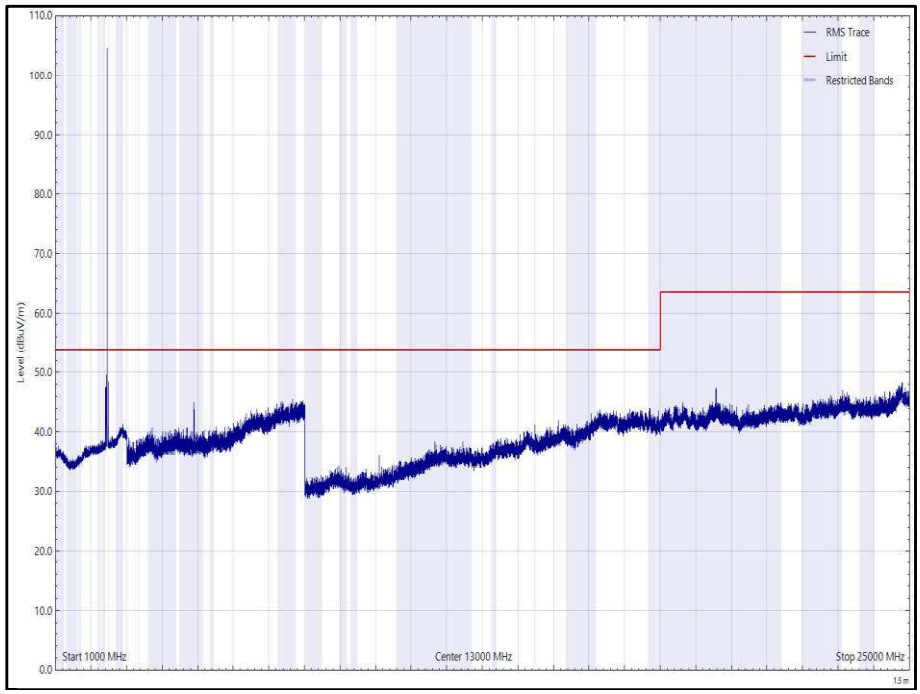

Figure 58 - 2.4 GHz 802.15.4-CH19-Y, 2445 MHz, 1 GHz to 25 GHz, Vertical (rms)

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

Table 44 - 2.4 GHz 802.15.4-CH19-Z, 2445 MHz, 30 MHz to 25 GHz

*No emissions found within 10 dB of the limit.

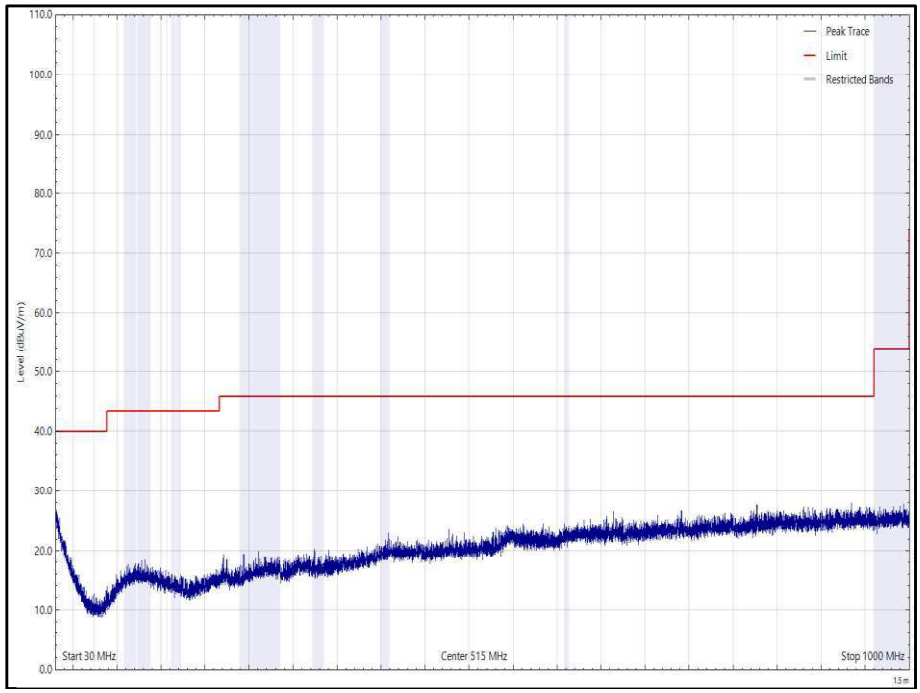

Figure 59 - 2.4 GHz 802.15.4-CH19-Z, 2445 MHz, 30 MHz to 1 GHz, Horizontal (Peak)

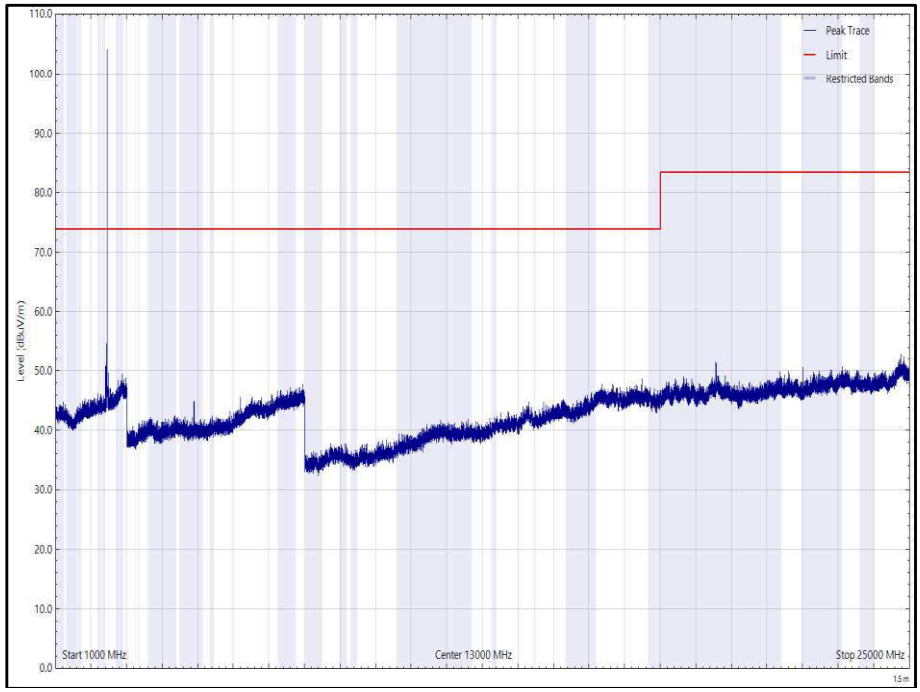

Figure 60 - 2.4 GHz 802.15.4-CH19-Z, 2445 MHz, 1 GHz to 25 GHz, Horizontal (Peak)

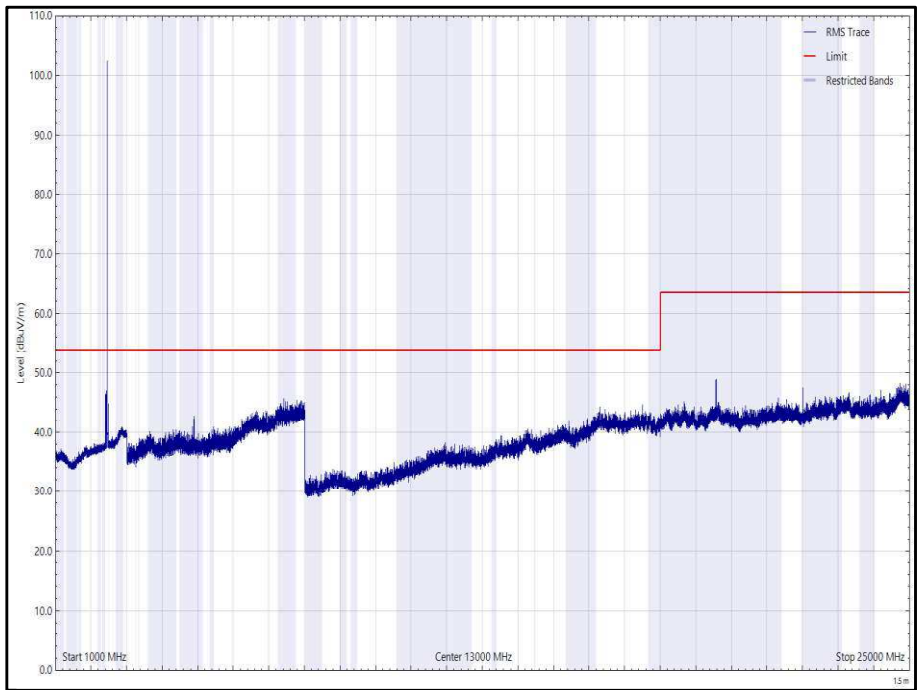

Figure 61 - 2.4 GHz 802.15.4-CH19-Z, 2445 MHz, 1 GHz to 25 GHz, Horizontal (rms)

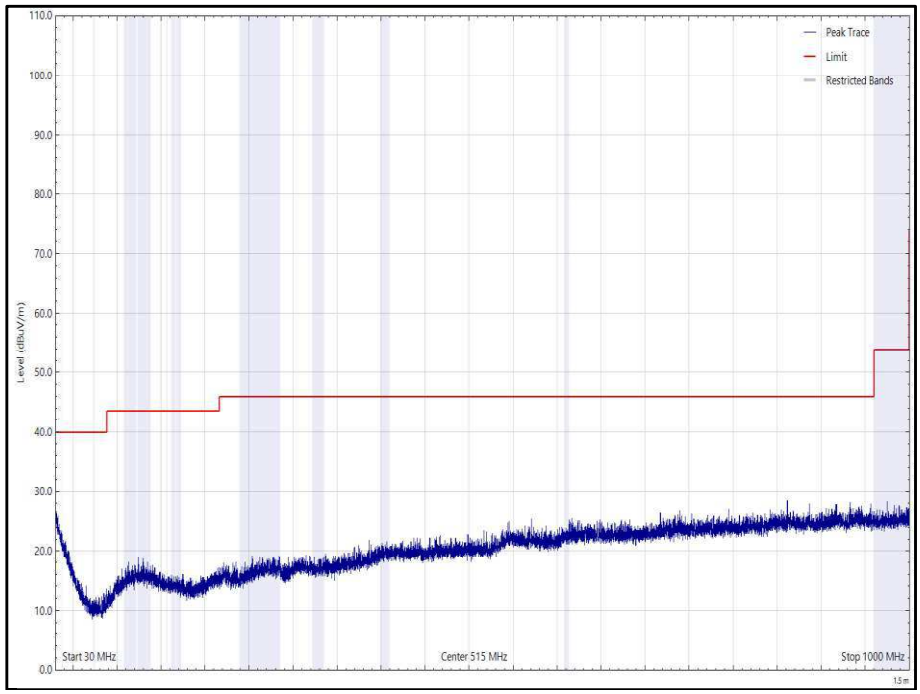

Figure 62 - 2.4 GHz 802.15.4-CH19-Z, 2445 MHz, 30 MHz to 1 GHz, Vertical (Peak)