FCC and ISED Test Report

MiX Telematics International (Pty) Ltd
Model: Bluetooth HOS Driver ID

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

Prepared for: MiX Telematics International (Pty) Ltd
Blaauwklip Office Park 2
Cnr Strand & Webersvalley Roads
Stellenbosch
South Africa

FCC ID: 2AFMS-BLEDID IC: Not Applicable

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Document 75952029-12 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	16 February 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, 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	Neil Rousell	16 February 2023	
Testing	Graeme Lawler	16 February 2023	

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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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	16-February-2023

Table 1

1.2 Introduction

Applicant	MiX Telematics International (Pty) Ltd
Manufacturer	MiX Telematics International (Pty) Ltd
Model Number(s)	Bluetooth HOS Driver ID
Manufacturer's Declared Variant(s)	Bluetooth Driver ID (P0022MT)
Serial Number(s)	17000057 and 17000065
Hardware Version(s)	1
Software Version(s)	1.0.0
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2020 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021)
Order Number Date	P0094972 20-April-2021
Date of Receipt of EUT	26-May-2022
Start of Test	23-June-2022
Finish of Test	31-August-2022
Name of Engineer(s)	Neil Rousell and Graeme Lawler
Related Document(s)	ANSI C63.10 (2013) 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
	FCC Part 15C	RSS-247	RSS-GEN			
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	
2.4	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	

Table 2

1.4 Manufacturer's Declared Variant(s)

P0022MT Bluetooth Driver ID

P0032MT Bluetooth HOS Driver ID

Both product variants use the same enclosure, circuitry, PCB, and components, apart from the memory integrated circuit, that is only populated on the "Bluetooth HOS Driver ID". This memory supports Hours of Service (HOS) functionality.

1.5 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	The Bluetooth Driver ID (BT DID) comprises: a) Green Button (upper): Transmit the Driver Identification message in order to identify the driver in the vehicle. b) Red Button (lower): Road Side Assist/Panic The product is designed with an RF range that limits it to in-cab use of the Driver ID and Roadside Assist/Panic buttons only. The BT DID forms part of the MiX6000, MiX 3000, and MiX 4000 range of products, and soon to be integrated with other products, such as MiX Vision. It communicates with the mobile host (e.g. MiX3000 or MiX4000) via a bi-directional Bluetooth LE RF link. There is also a variant with more memory that supports Hours of Service (HOS) functionality. Both product variants use the same PCB.
Manufacturer:	MiX Telematics International (Pty) Ltd.
Model:	Bluetooth Driver ID Bluetooth HOS Driver ID
Part Number:	P0022MT P0032MT
Hardware Version:	1
Software Version:	1.0.0
FCC ID of the product under test – see guidance here	2AFMS-BLEDID
IC ID of the product under test – see guidance here	-

Table 3

Intentional Radiators

Technology	SRD2400
Frequency Band (MHz)	2400-2480
Conducted Declared Output Power (dBm)	-5
Antenna Gain (dBi)	2.5
Supported Bandwidth(s) (MHz)	1
Modulation Scheme(s)	GFSK
ITU Emission Designator	1M00F1D
Bottom Frequency (MHz)	2402
Middle Frequency (MHz)	2440
Top Frequency (MHz)	2480

Table 4

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	2480 MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	2400 MHz
Class A Digital Device (Use in commercial, industrial or business environment) ☐ Class B Digital Device (Use in residential environment only) ☒	

Table 5

AC Power Source

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

Table 6

DC Power Source

Nominal voltage:	3	V
Extreme upper voltage:	3.1	V
Extreme lower voltage:	1.8	V
Max current:	0.018	A

Table 7

Battery Power Source

Voltage:	3.0	V
End-point voltage:	2.0	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:	-20	°C
Maximum temperature:	60	°C

Table 10

Cable Loss

Adapter Cable Loss (Conducted sample)		dB

Table 11

Antenna Characteristics

Antenna connector ☒			State impedance	50	Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	BLE	Gain	2.5	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:	N/A	Part Number:	N/A
Model:	N/A	Country of Origin:	N/A

Table 13

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

Name: Ben van der Merwe
Position held: Senior Engineer
Date: 27 May 2022

1.6 Product Information

1.6.1 Technical Description

The Bluetooth Driver ID (BT DID) comprises:
a) Green Button (upper): Transmit the Driver Identification message in order to identify the driver in the vehicle.

b) Red Button (lower): Road Side Assist/Panic

The product is designed with an RF range that limits it to in-cab use of the Driver ID and Roadside Assist/Panic buttons only.

The BT DID forms part of the MiX6000, MiX 3000, and MiX 4000 range of products, and soon to be integrated with other products, such as MiX Vision. It communicates with the mobile host (e.g. MiX3000 or MiX4000) via a bi-directional Bluetooth LE RF link.

There is also a variant with more memory that supports Hours of Service (HOS) functionality. Both product variants use the same PCB.

1.7 Deviations from the Standard

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

1.8 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: Bluetooth HOS Driver ID, Serial Number: 17000057			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: Bluetooth HOS Driver ID, Serial Number: 17000065			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 14

1.9 Test Location

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

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz Bluetooth Low Energy		
Restricted Band Edges	Graeme Lawler	UKAS
Emission Bandwidth	Neil Rousell	UKAS
Maximum Conducted Output Power	Neil Rousell	UKAS
Authorised Band Edges	Graeme Lawler	UKAS
Spurious Radiated Emissions	Graeme Lawler	UKAS
Power Spectral Density	Neil Rousell	UKAS

Table 15

Office Address:

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

2 Test Details

2.1 Restricted Band Edges

2.1.1 Specification Reference

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

2.1.2 Equipment Under Test and Modification State

Bluetooth HOS Driver ID, S/N: 17000065 - Modification State 0

2.1.3 Date of Test

31-August-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).

2.1.5 Environmental Conditions

Ambient Temperature	22.2 °C
Relative Humidity	54.1 %

2.1.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390	56.17	44.58
GFSK	2480	2483.5	56.87	45.21

Table 16

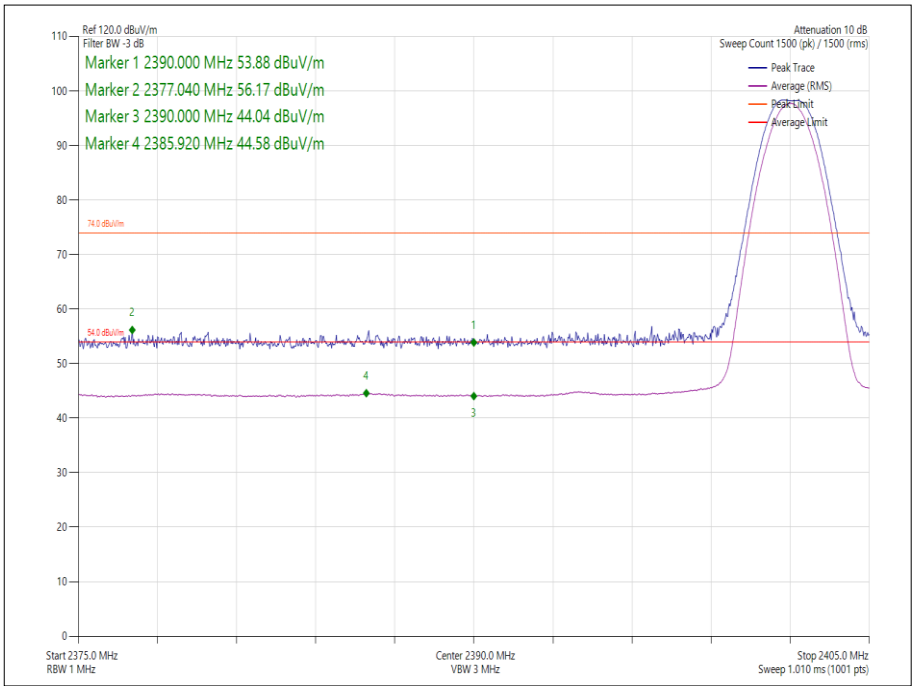

Figure 1 - GFSK - 2402 MHz - Band Edge Frequency 2390 MHz

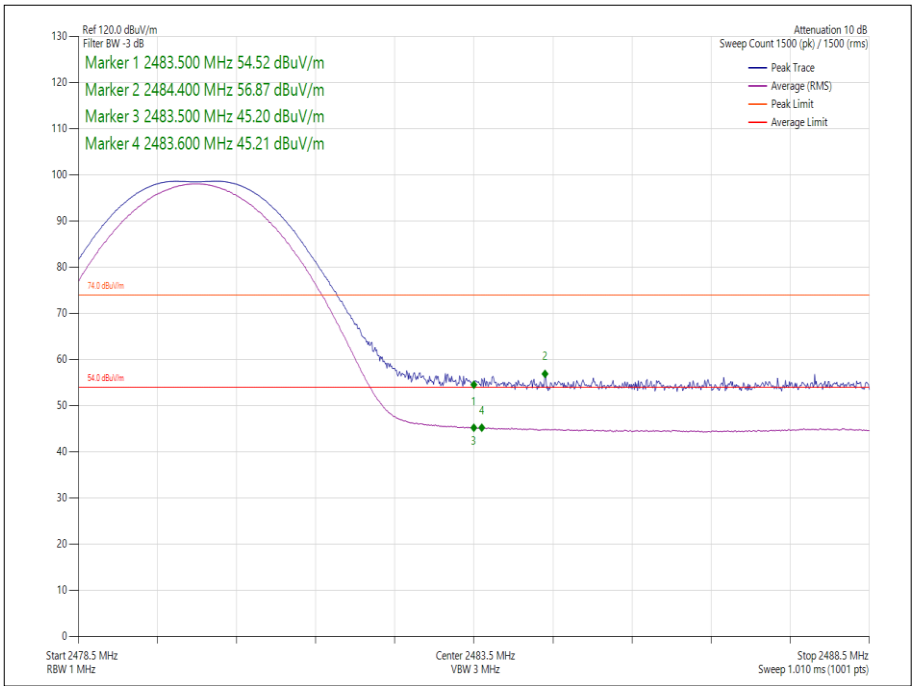

Figure 2 - GFSK - 2480 MHz - Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.209

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

Table 17

ISED RSS-GEN, Limit Clause 8.9

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

Table 18

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

2.1.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 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
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Emissions Software	TUV SUD	EmX V3.1.4	5125	-	Software
Cable (sma to sma 2m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	22-Sep-2022

Table 19

TU - Traceability Unscheduled

2.2 Emission Bandwidth

2.2.1 Specification Reference

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

2.2.2 Equipment Under Test and Modification State

Bluetooth HOS Driver ID, S/N: 17000057 - Modification State 0

2.2.3 Date of Test

23-June-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.

2.2.5 Environmental Conditions

Ambient Temperature	23.8 °C
Relative Humidity	48.8 %

2.2.6 Test Results

2.4 GHz Bluetooth Low Energy

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

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

Test Frequency (MHz)	6 dB Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2402	0.728	-	-	-	≥500.0
2440	0.732	-	-	-	≥500.0
2480	0.752	-	-	-	≥500.0

Table 20 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)				Limit (kHz)
	A	B	C	D	
2402	1.096	-	-	-	-
2440	1.092	-	-	-	-
2480	1.096	-	-	-	-

Table 21 - 99% Bandwidth Results

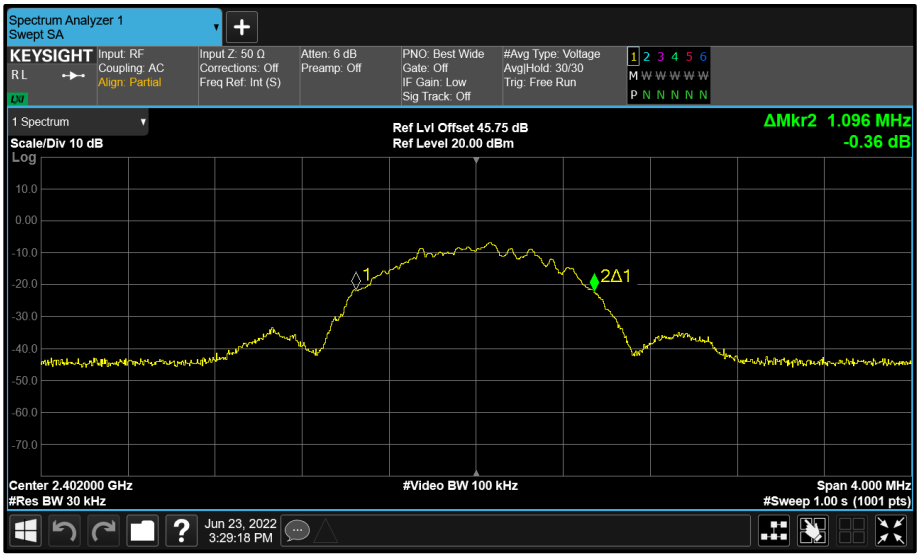

Figure 3 - A (A) 2402 MHz (CH37) 99% Bandwidth

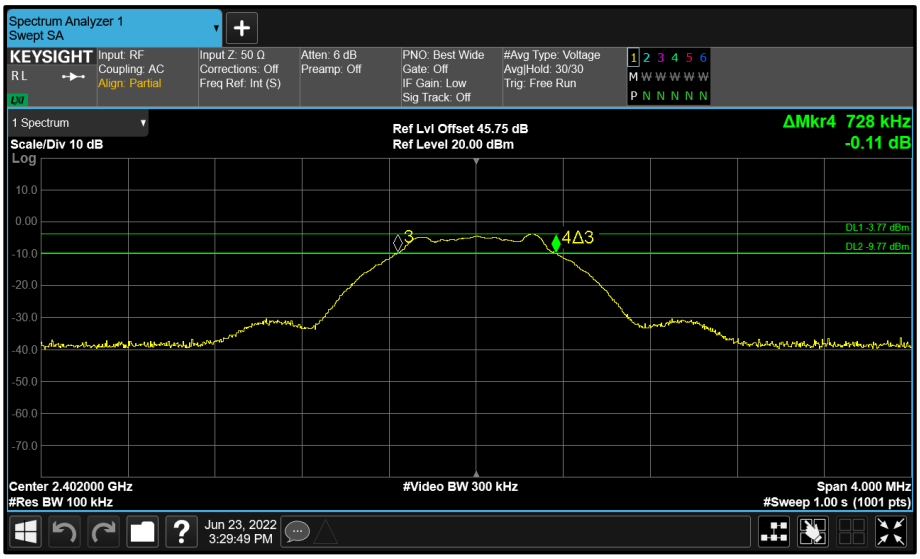

Figure 4 - A (A) 2402 MHz (CH37) 6 dB Bandwidth

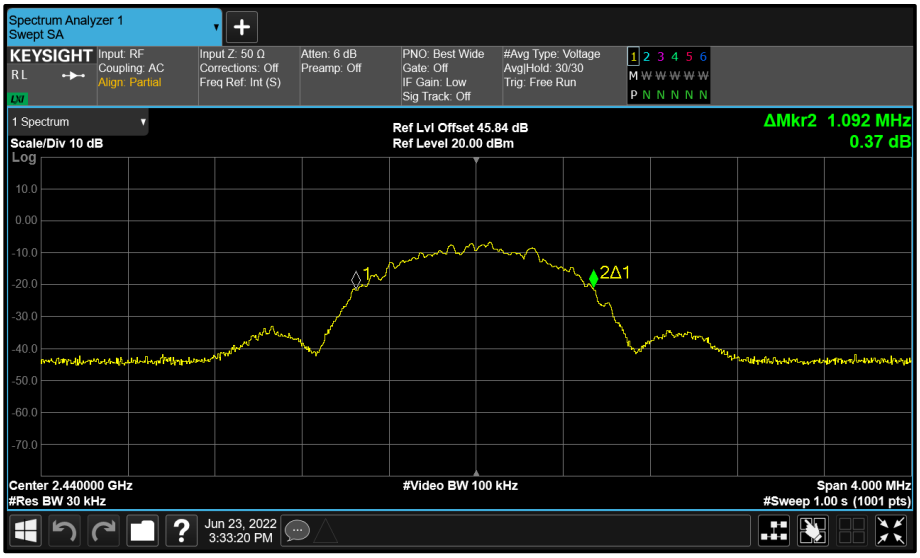

Figure 5 - A (A) 2440 MHz (CH17) 99% Bandwidth

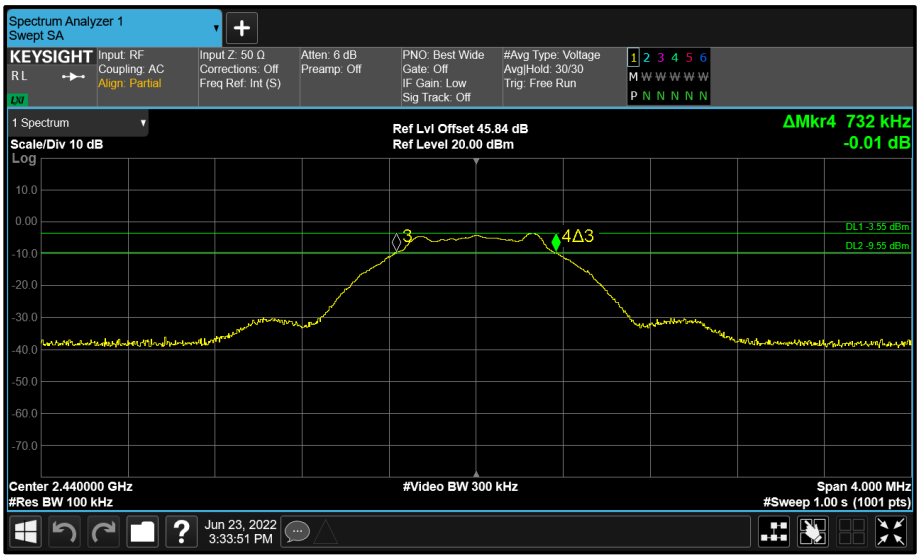

Figure 6 - A (A) 2440 MHz (CH17) 6 dB Bandwidth

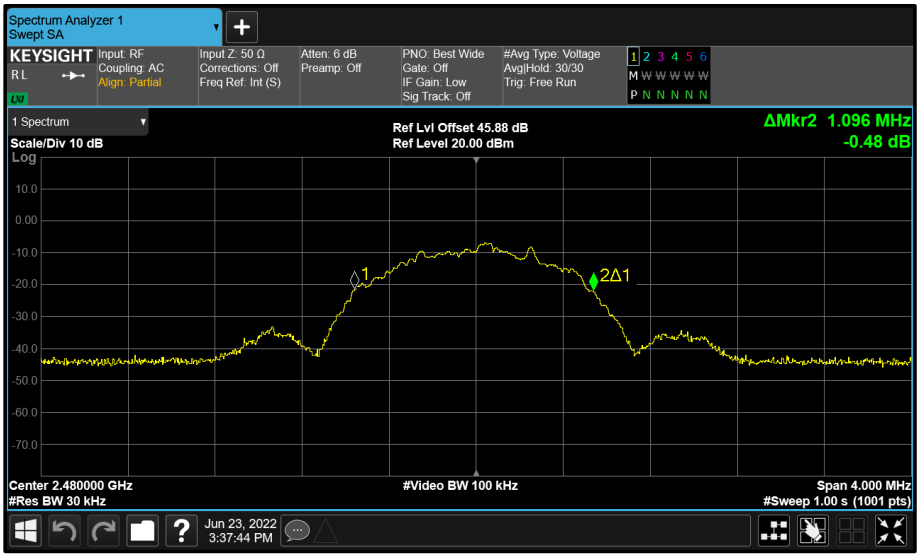

Figure 7 - A (A) 2480 MHz (CH39) 99% Bandwidth

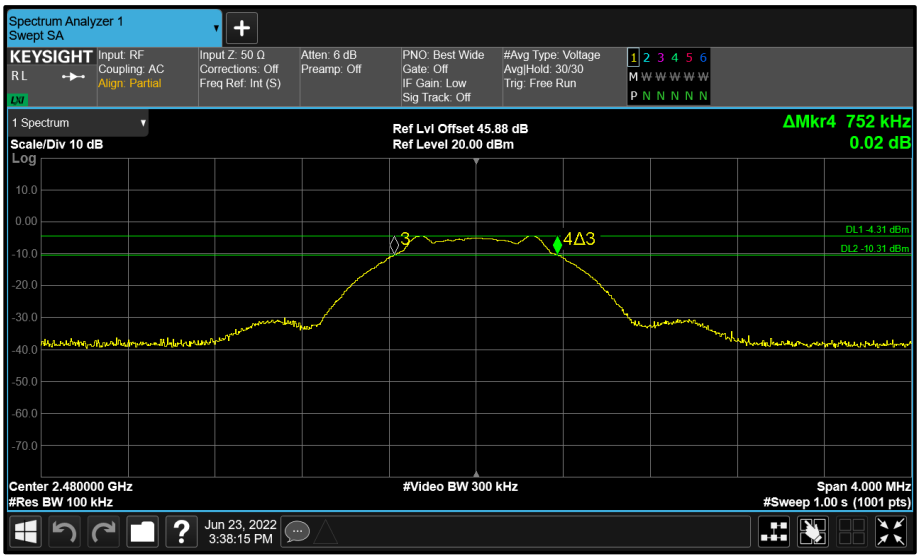

Figure 8 - A (A) 2480 MHz (CH39) 6 dB Bandwidth

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 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Antenna (Double Ridge Guide)	EMCO	3115	34	12	15-Oct-2022
Attenuator (10 dB)	Weinschel	47-10-34	481	12	26-Jul-2022
Network Analyser	Keysight Technologies	E5063A	5018	12	30-Jul-2022
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	22-Jul-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5495	12	11-Oct-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	21-Mar-2024
Signal Conditioning Unit	TUV SUD	SPECTRUM SCU001	5546	12	06-Apr-2023
Coupler	Narda	4202B-20	5990	12	O/P Mon

Table 22

O/P Mon – Output Monitored using calibrated equipment

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

Bluetooth HOS Driver ID, S/N: 17000057 - Modification State 0

2.3.3 Date of Test

23-June-2022

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10 clause 11.9.1.3 Method PKPM1.

2.3.5 Environmental Conditions

Ambient Temperature	23.8 °C
Relative Humidity	48.8 %

2.3.6 Test Results

2.4 GHz Bluetooth Low Energy

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

DUT Configuration			
Mode:	BLE GFSK (LE 1M)	Duty Cycle (%):	100.0
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (A)	Peak Antenna Gain (dBi):	2.50

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					Limit (dBm)	Margin (dB)
	A	B	C	D	∑		
2402	-1.62	-	-	-	-	30.00	-31.22
2440	-1.53	-	-	-	-	30.00	-31.13
2480	-1.77	-	-	-	-	30.00	-31.37

Table 23 - 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	-1.62	-	-	-	-	30.00	-31.62	0.88	36.00	-35.12
2440	-1.53	-	-	-	-	30.00	-31.53	0.97	36.00	-35.03
2480	-1.77	-	-	-	-	30.00	-31.77	0.73	36.00	-35.27

Table 24 - ISED Maximum Conducted (peak) Output Power Results

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

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

ISED RSS-247, Limit Clause 5.4 (d)

For 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 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Antenna (Double Ridge Guide)	EMCO	3115	34	12	15-Oct-2022
Attenuator (10 dB)	Weinschel	47-10-34	481	12	26-Jul-2022
Network Analyser	Keysight Technologies	E5063A	5018	12	30-Jul-2022
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	22-Jul-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5495	12	11-Oct-2022
Signal Conditioning Unit	TUV SUD	SPECTRUM SCU001	5546	12	06-Apr-2023
USB Power Sensor	Boonton	RTP5008	5820	12	06-Apr-2023
Coupler	Narda	4202B-20	5990	12	O/P Mon

Table 25

O/P Mon – Output Monitored using calibrated equipment

2.4 Authorised Band Edges

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

Bluetooth HOS Driver ID, S/N: 17000065 - Modification State 0

2.4.3 Date of Test

31-August-2022

2.4.4 Test Method

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

2.4.5 Environmental Conditions

Ambient Temperature	22.2 °C
Relative Humidity	54.1 %

2.4.6 Test Results

2.4 GHz Bluetooth Low Energy

Modulation	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	2402	2400	-50.20
GFSK	2480	2483.5	-52.45

Table 26

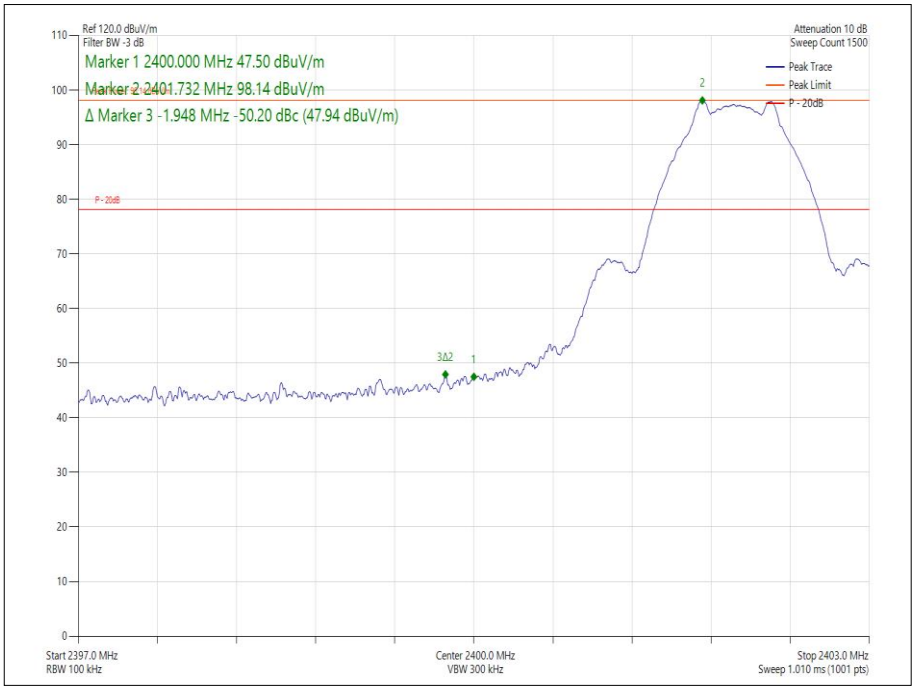

Figure 9 - GFSK, 2402 MHz - Band Edge Frequency 2400 MHz

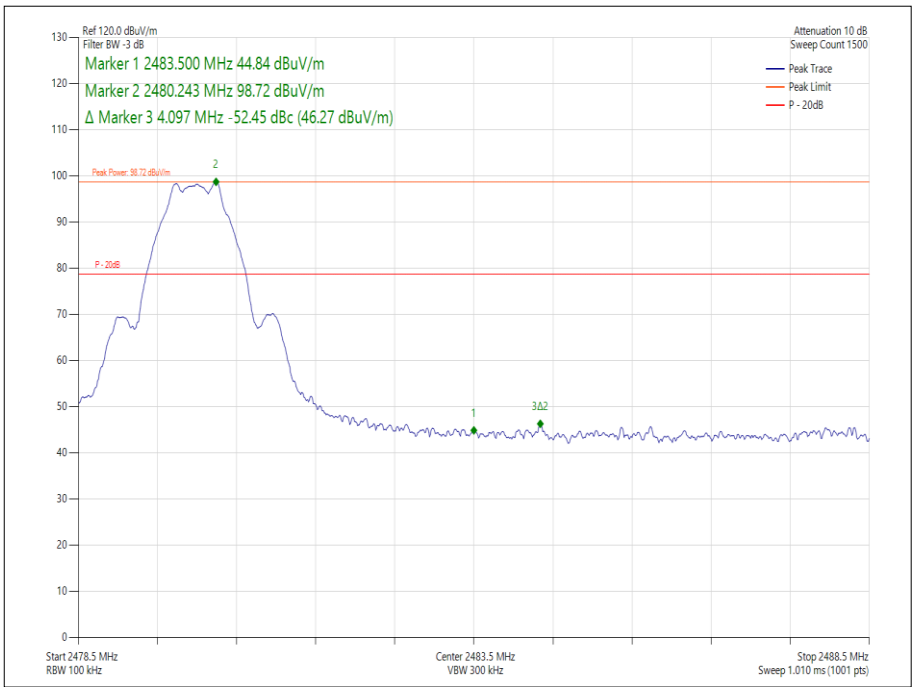

Figure 10 - GFSK, 2480 MHz - Band Edge Frequency 2483.5 MHz

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

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

ISED RSS-247, Limit Clause 5.5

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

2.4.7 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
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Emissions Software	TUV SUD	EmX V3.1.4	5125	-	Software
Cable (sma to sma 2m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	22-Sep-2022

Table 27

TU - Traceability Unscheduled

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

Bluetooth HOS Driver ID, S/N: 17000065 - Modification State 0

2.5.3 Date of Test

16-August-2022 to 28-August-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 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 plots shown are the characterisation of the EUT. The limits on the plots represent the most stringent case for restricted bands, (74/54 dBuV/m) when compared to 20 dBc outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:

10^ (Field Strength in dBµV/m/20).

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

Representative noise floor plots for each channel have been presented for the X orientation only.

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.

The EUT was tested with the fundamental set to a power level of 0 dBm.

2.5.5 Example Test Setup Diagram

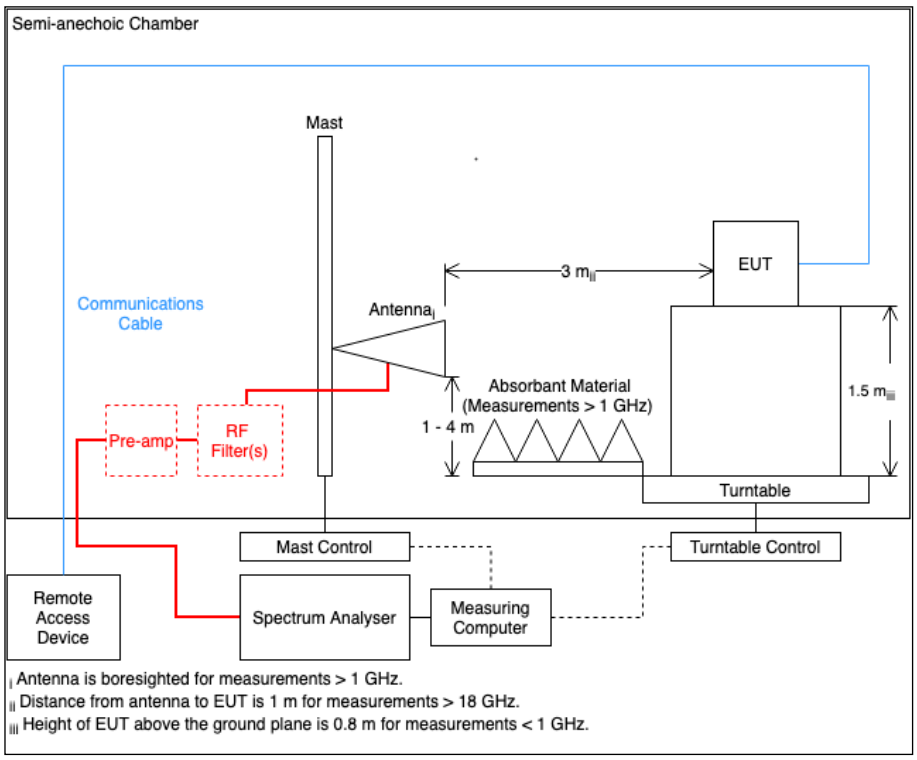

Figure 11

2.5.6 Environmental Conditions

Ambient Temperature	22.8 - 23.2 °C
Relative Humidity	56.6 - 64.4 %

2.5.7 Test Results

2.4 GHz Bluetooth Low Energy

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2274.004	50.4	54.0	-3.6	RMS	290	100	Horizontal
2289.866	44.0	54.0	-10.0	RMS	290	142	Horizontal

Table 28 - 2402 MHz (CH37), LE1M – X Orientation, 1 GHz to 25 GHz

No other emissions found within 10 dB of the limit.

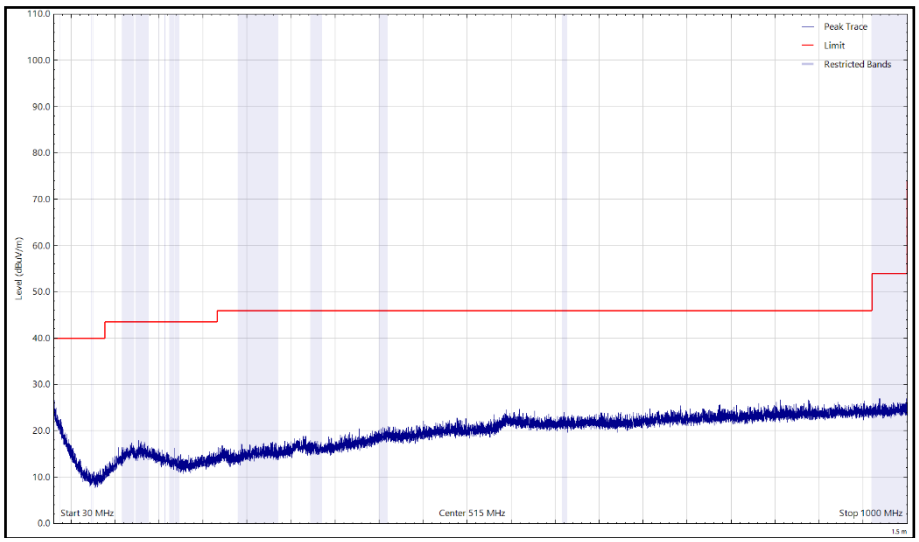

Figure 12 - 2402 MHz (CH37), LE1M – X Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

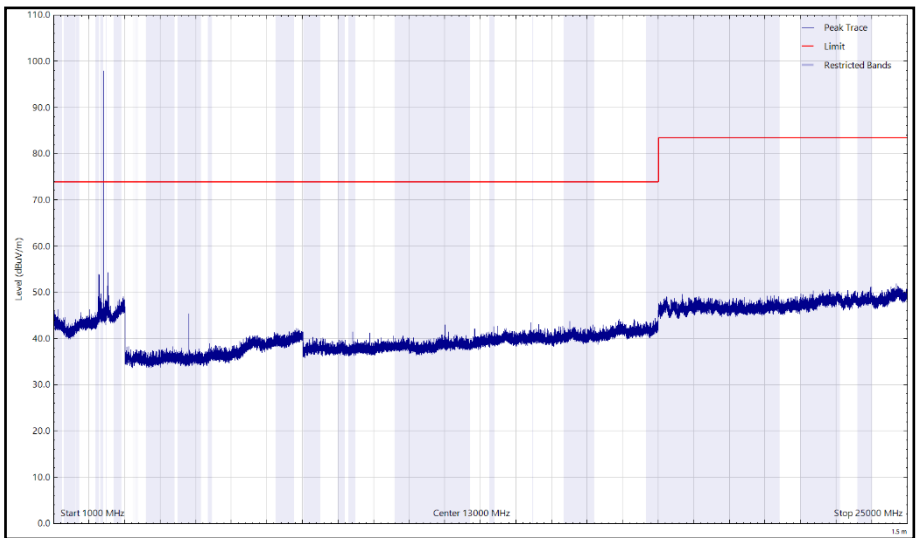

Figure 13 - 2402 MHz (CH37), LE1M – X Orientation, 1 GHz to 25 GHz, Horizontal (Peak)

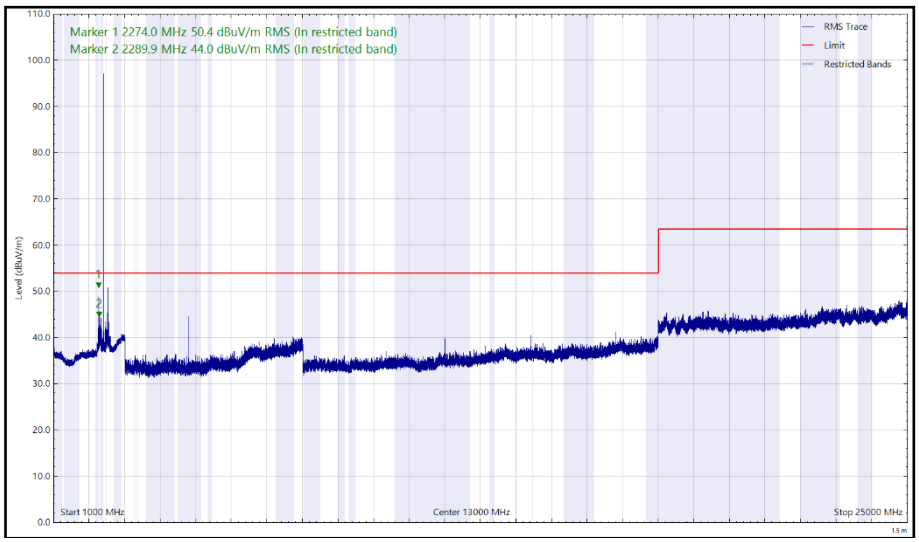

Figure 14 - 2402 MHz (CH37), LE1M, 1 GHz to 25 GHz, Horizontal (rms)

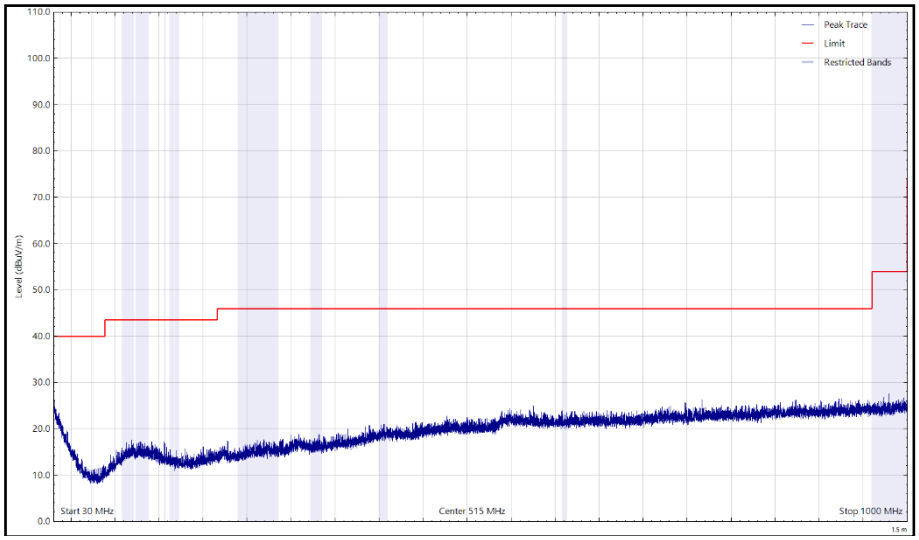

Figure 15 - 2402 MHz (CH37), LE1M – X Orientation, 30 MHz to 1 GHz, Vertical (Peak)

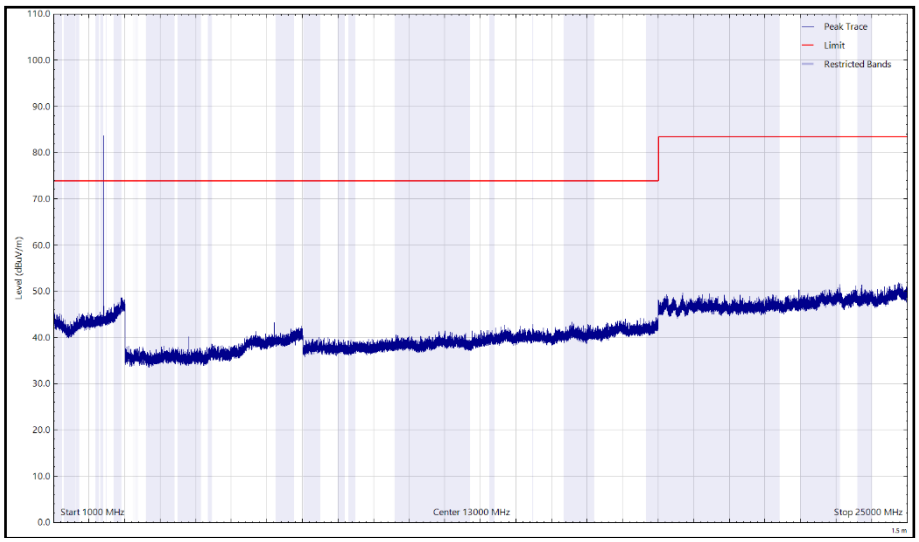

Figure 16 - 2402 MHz (CH37), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (Peak)

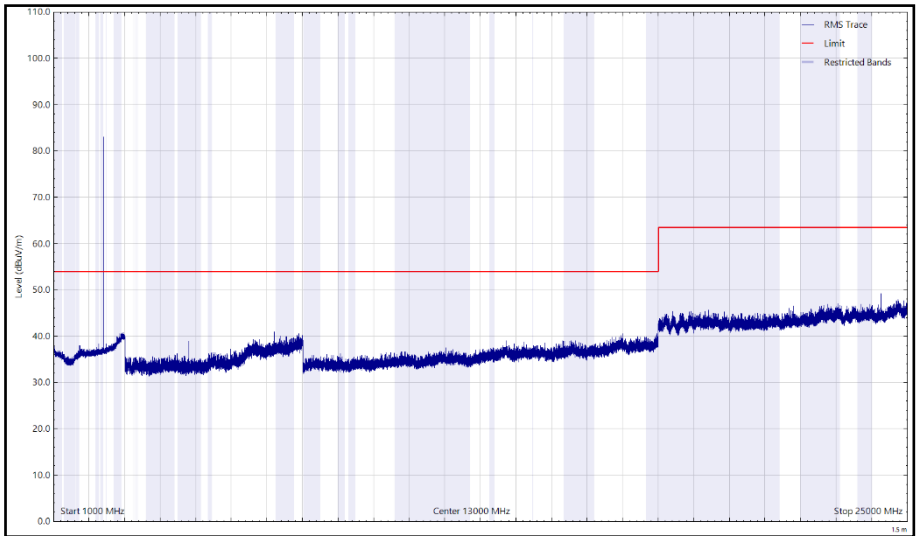

Figure 17 - 2402 MHz (CH37), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2311.992	51.2	54.0	-2.8	RMS	276	129	Horizontal
2376.016	45.5	54.0	-8.5	RMS	278	100	Horizontal

Table 29 - 2440 MHz (CH17), LE1M – X Orientation, 1 GHz to 25 GHz

No other emissions found within 10 dB of the limit.

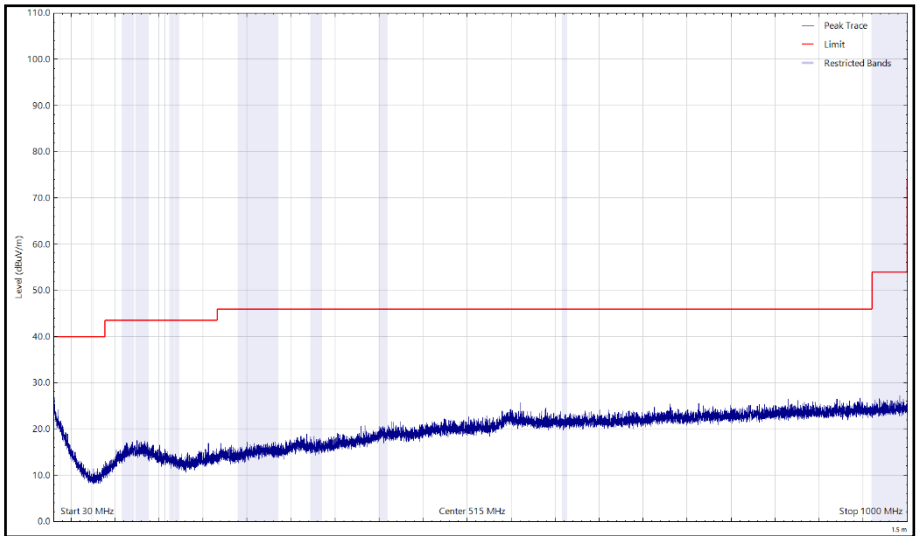

Figure 18 - 2440 MHz (CH17), LE1M – X Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

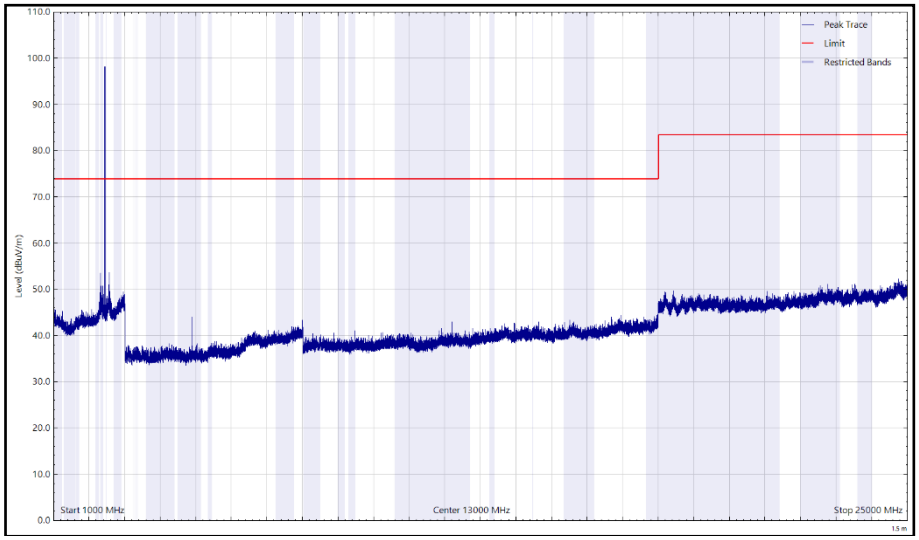

Figure 19 - 2440 MHz (CH17), LE1M – X Orientation, 1 GHz to 25 GHz, Horizontal (Peak)

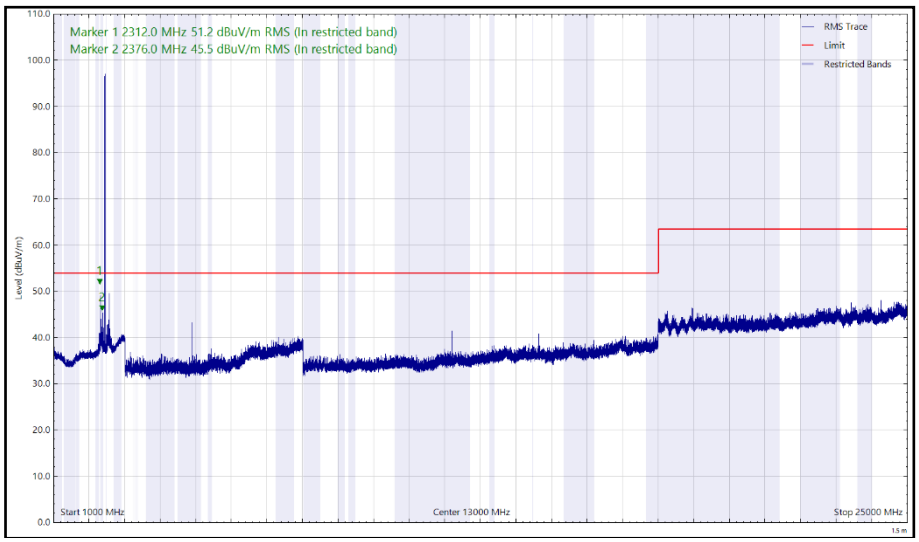

Figure 20 - 2440 MHz (CH17), LE1M – X Orientation, 1 GHz to 25 GHz, Horizontal (rms)

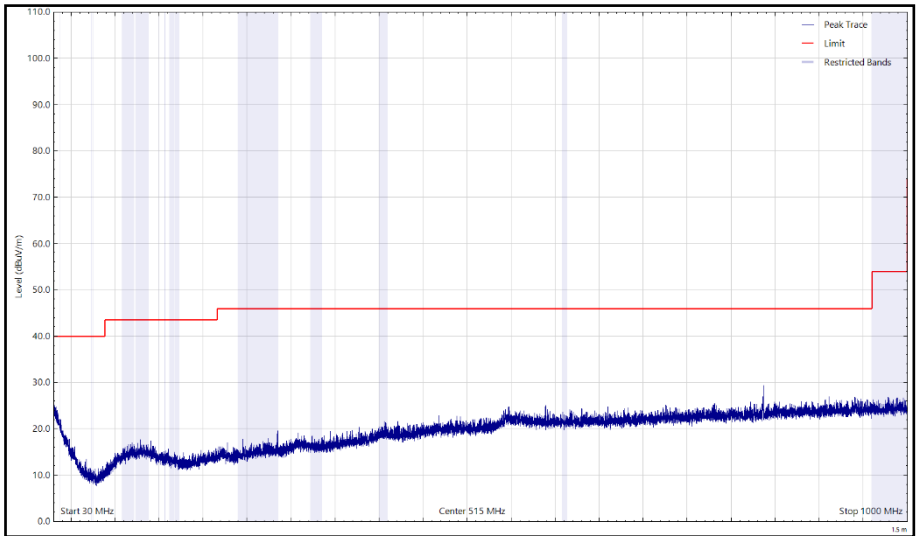

Figure 21 - 2440 MHz (CH17), LE1M – X Orientation, 30 MHz to 1 GHz, Vertical (Peak)

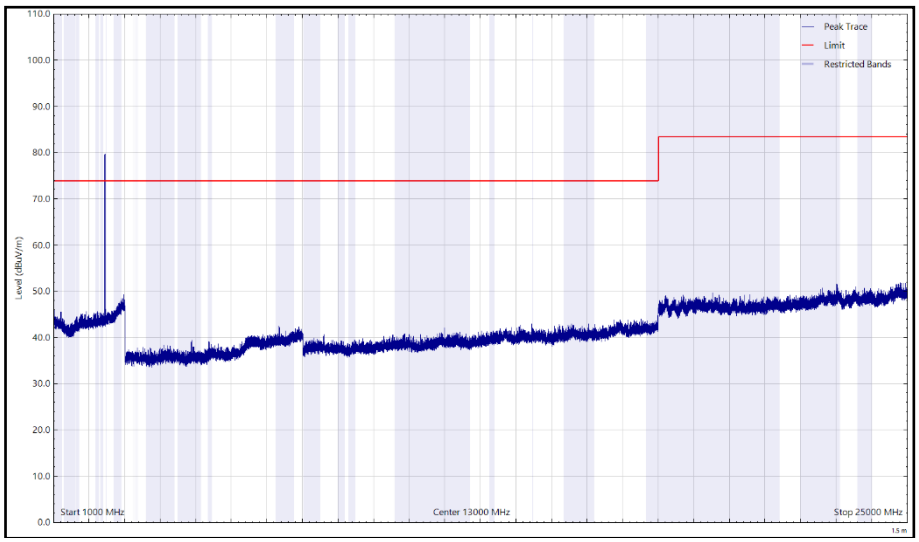

Figure 22 - 2440 MHz (CH17), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (Peak)

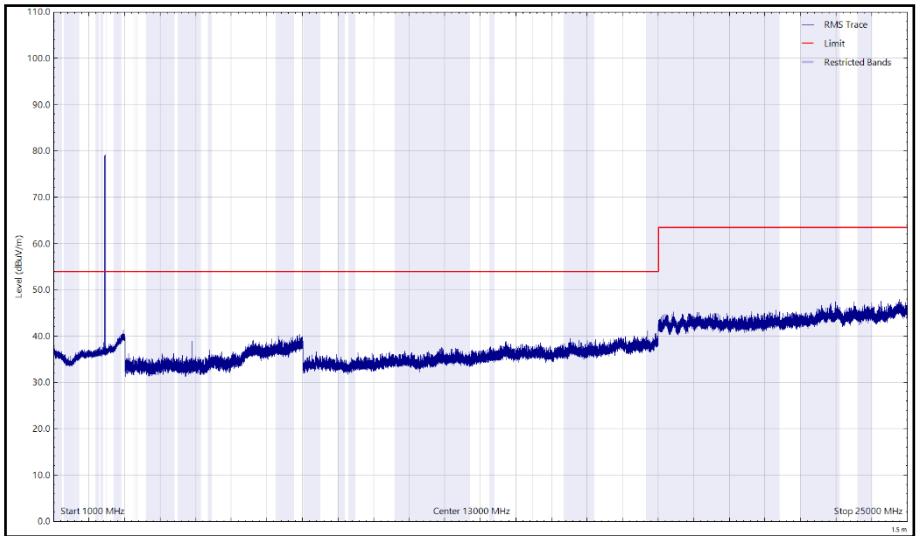

Figure 23 - 2440 MHz (CH17), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2351.997	50.3	54.0	-3.7	RMS	266	130	Horizontal

Table 30 - 2480 MHz (CH39), LE1M – X Orientation, 1 GHz to 25 GHz

No other emissions found within 10 dB of the limit.

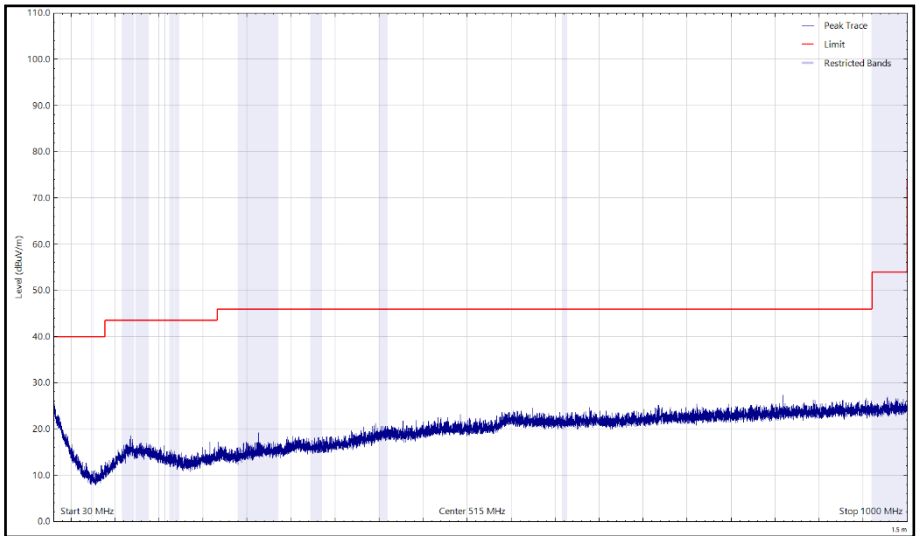

Figure 24 - 2480 MHz (CH39), LE1M – X Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

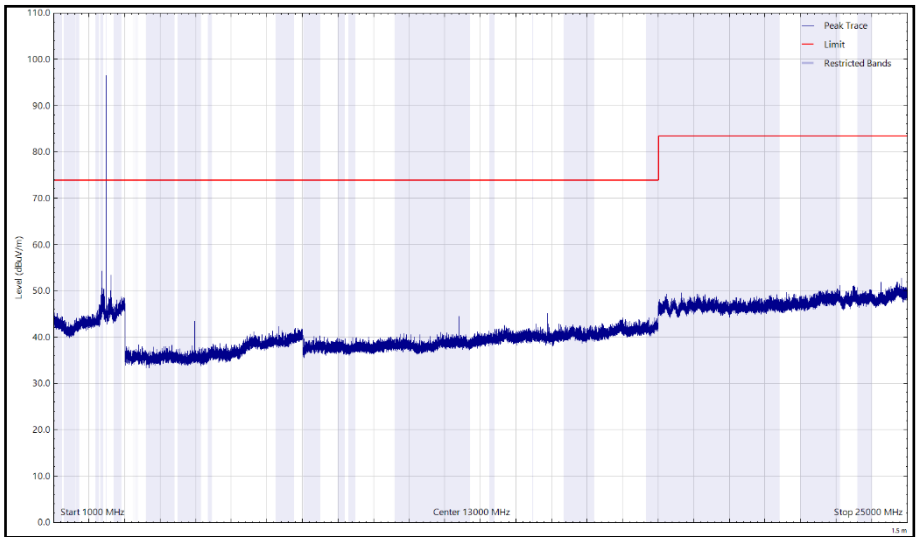

Figure 25 - 2480 MHz (CH39), LE1M – X Orientation, 1 GHz to 25 GHz, Horizontal (Peak)

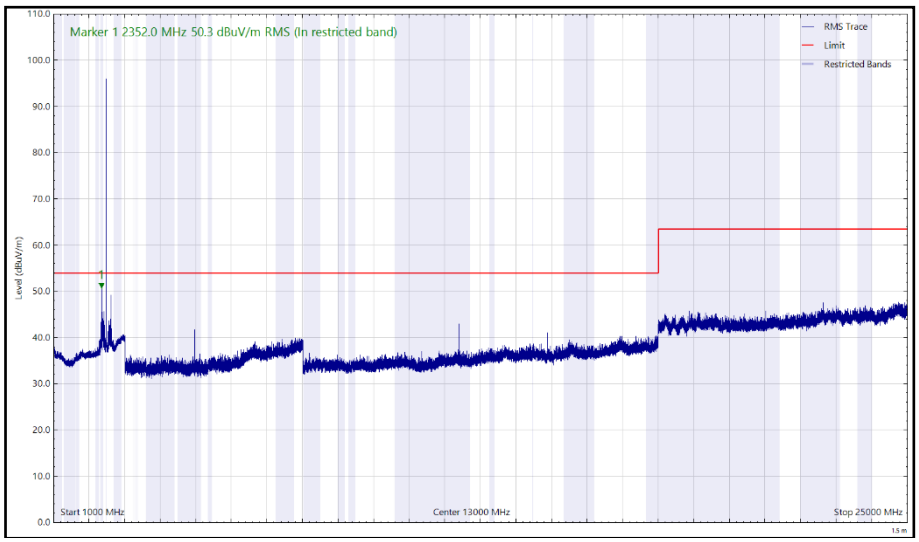

Figure 26 - 2480 MHz (CH39), LE1M – X Orientation, 1 GHz to 25 GHz, Horizontal (rms)

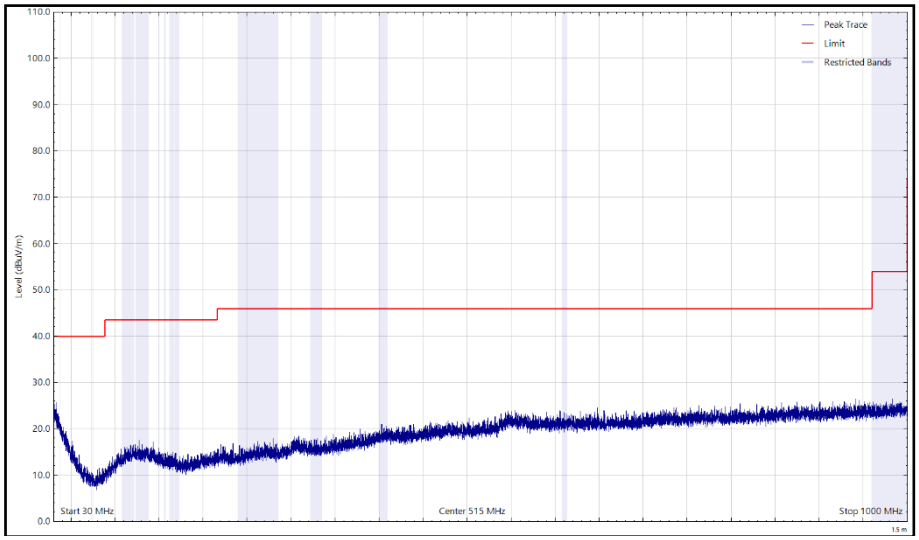

Figure 27 - 2480 MHz (CH39), LE1M – X Orientation, 30 MHz to 1 GHz, Vertical (Peak)

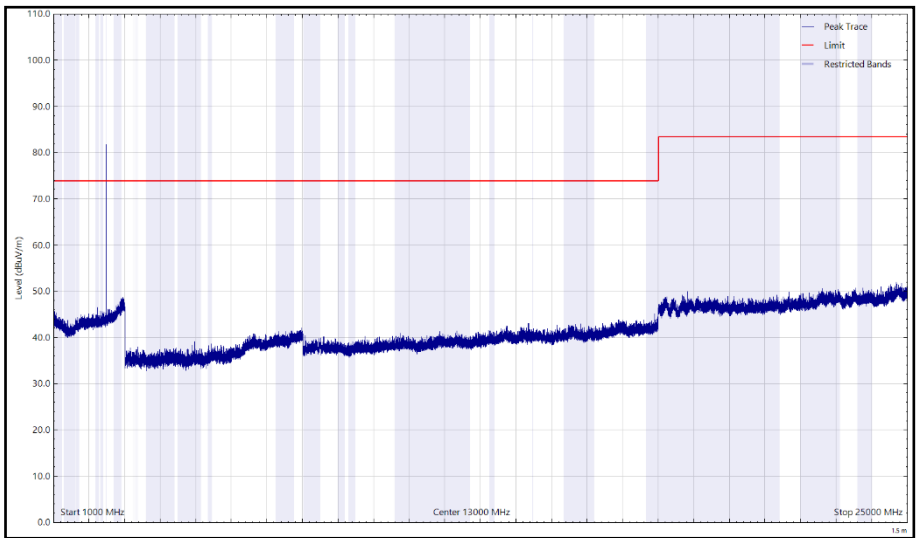

Figure 28 - 2480 MHz (CH39), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (Peak)

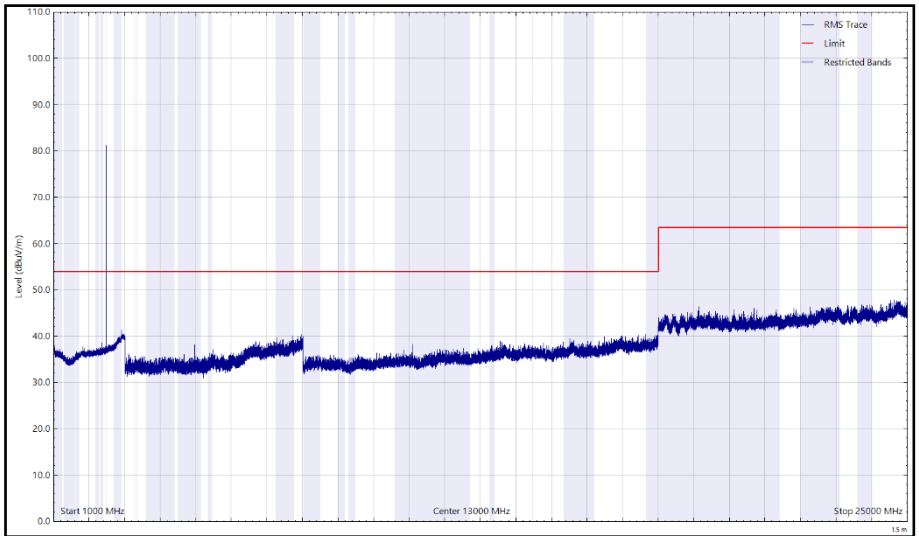

Figure 29 - 2480 MHz (CH39), LE1M – X Orientation, 1 GHz to 25 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2274.049	49.6	54.0	-4.3	RMS	195	110	Vertical
2338.017	46.4	54.0	-7.6	RMS	264	100	Vertical

Table 31 - 2402 MHz (CH37), LE1M – Y Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

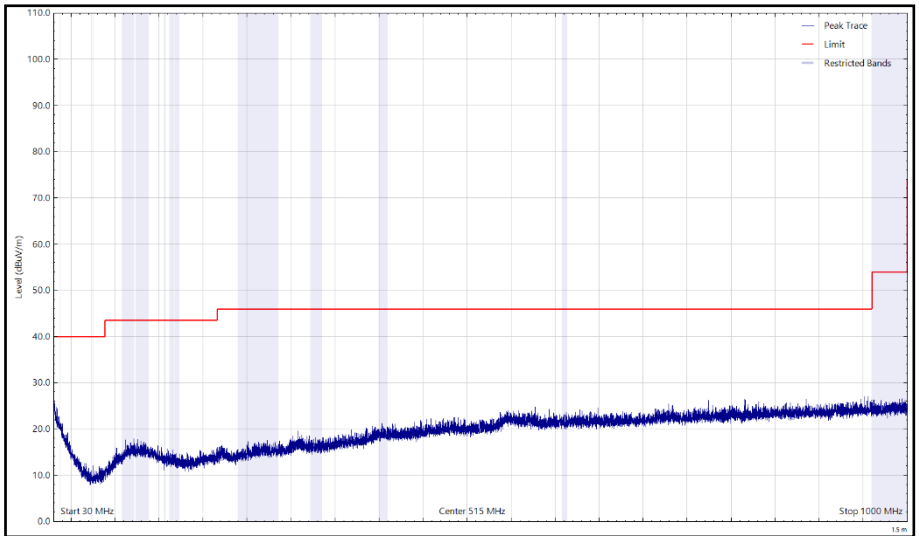

Figure 30 - 2402 MHz (CH37), LE1M – Y Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

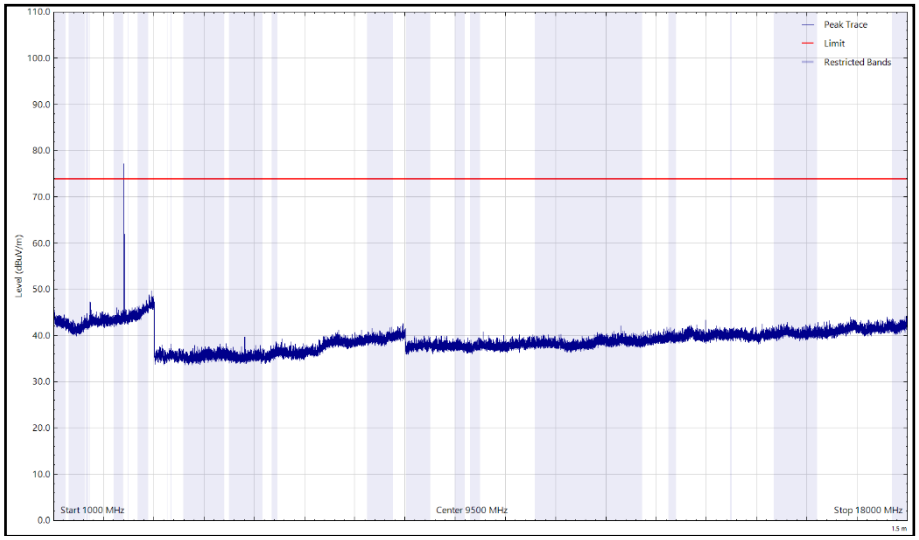

Figure 31 - 2402 MHz (CH37), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

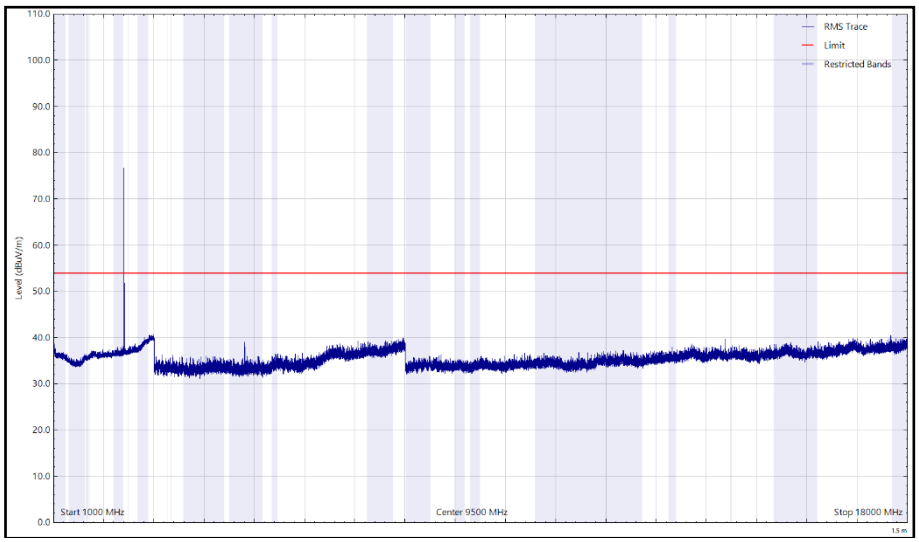

Figure 32 - 2402 MHz (CH37), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (rms)

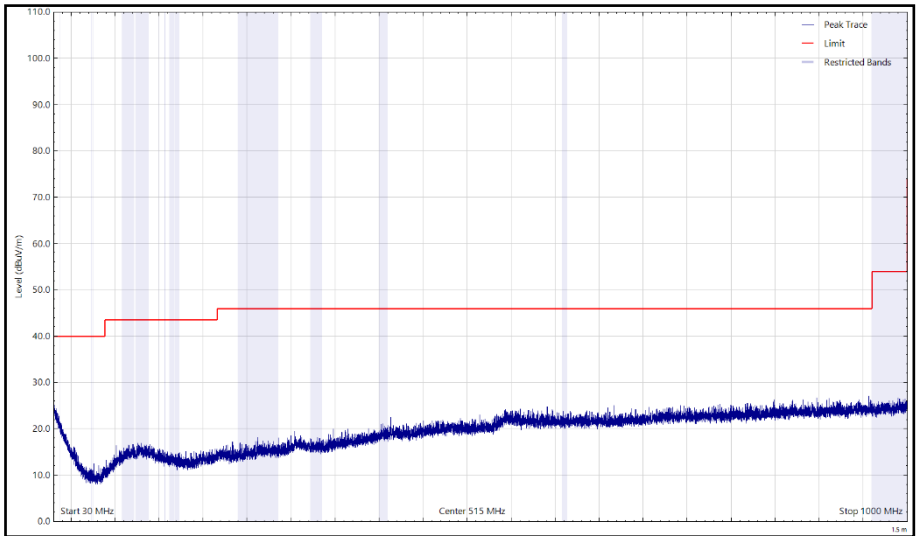

Figure 33 - 2402 MHz (CH37), LE1M – Y Orientation, 30 MHz to 1 GHz, Vertical (Peak)

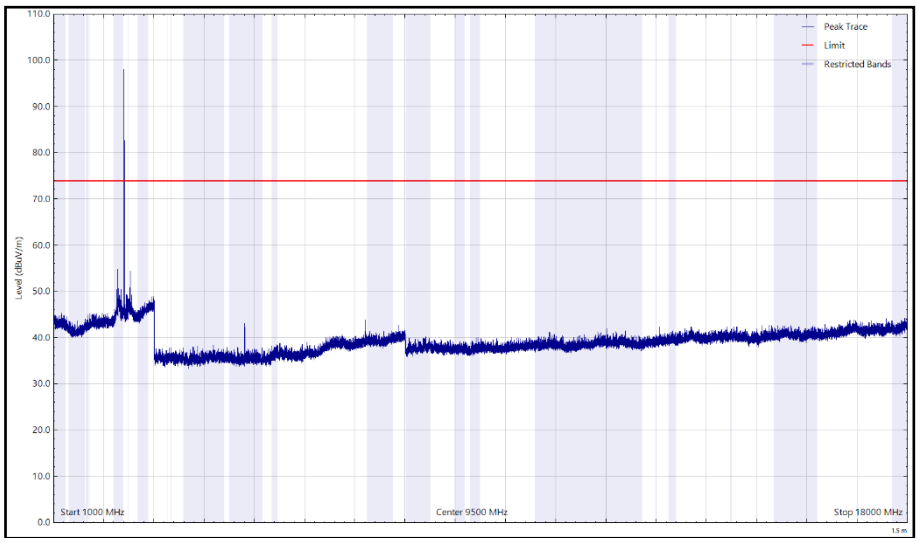

Figure 34 - 2402 MHz (CH37), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (Peak)

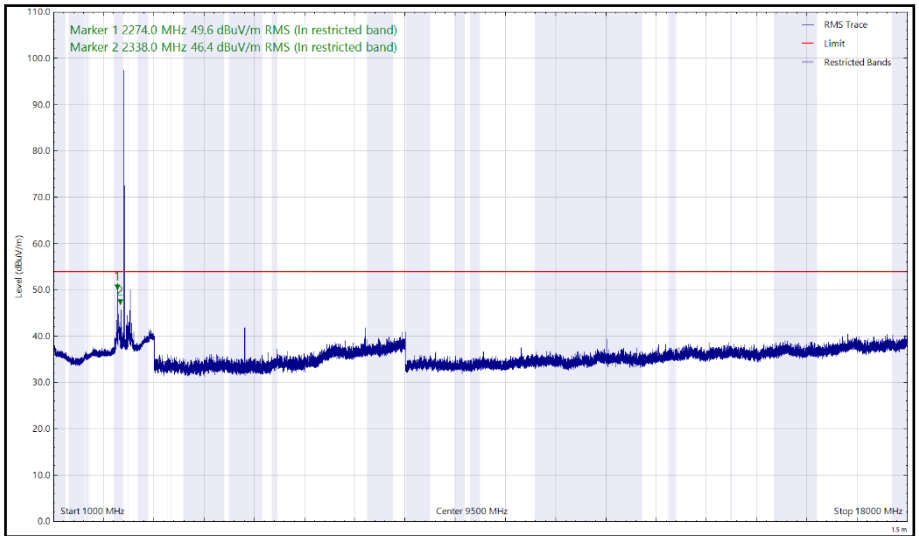

Figure 35 - 2402 MHz (CH37), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2311.988	50.8	54.0	-3.2	RMS	223	116	Vertical
2375.964	44.9	54.0	-9.0	RMS	314	100	Vertical

Table 32 - 2440 MHz (CH17), LE1M – Y Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

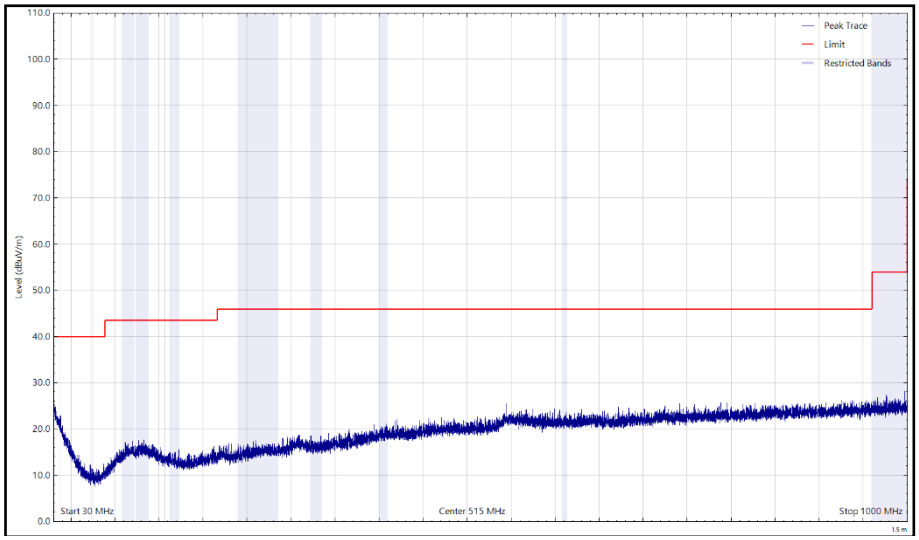

Figure 36 - 2440 MHz (CH17), LE1M – Y Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

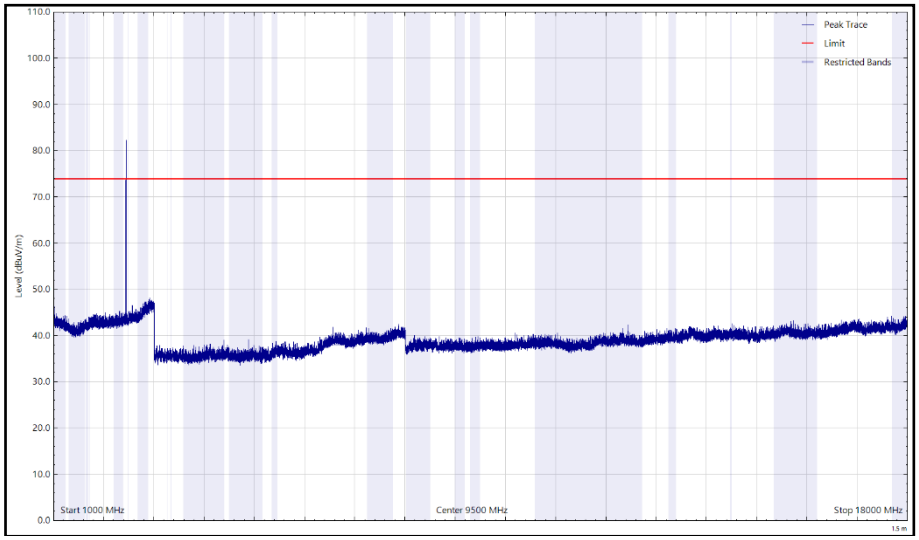

Figure 37 - 2440 MHz (CH17), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

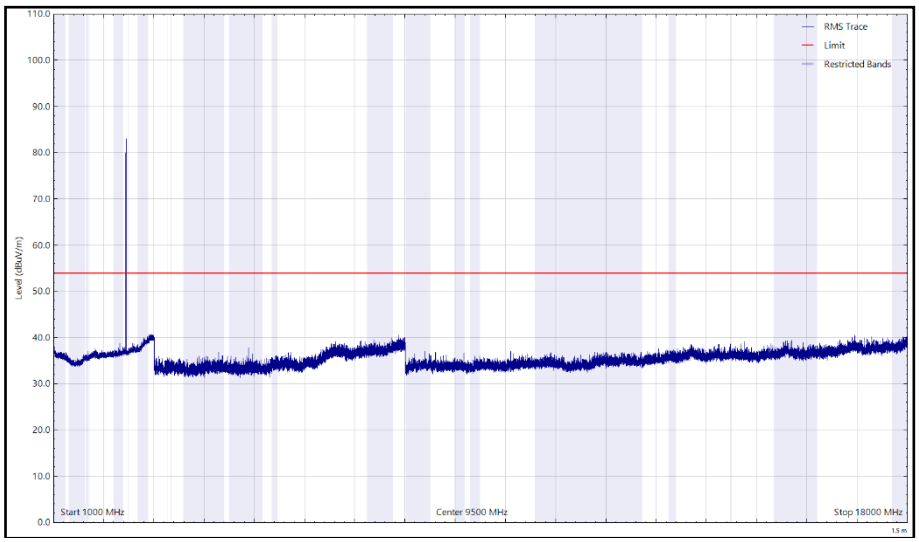

Figure 38 - 2440 MHz (CH17), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (rms)

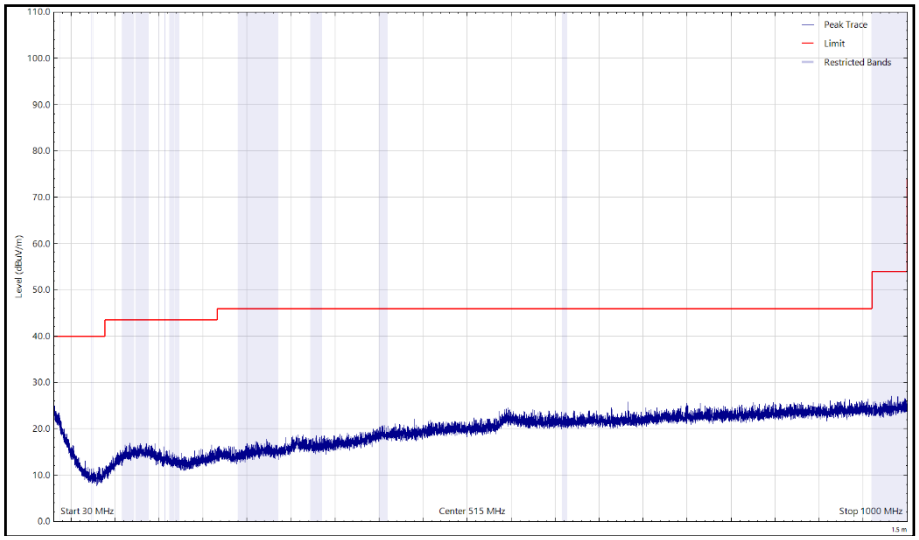

Figure 39 - 2440 MHz (CH17), LE1M – Y Orientation, 30 MHz to 1 GHz, Vertical (Peak)

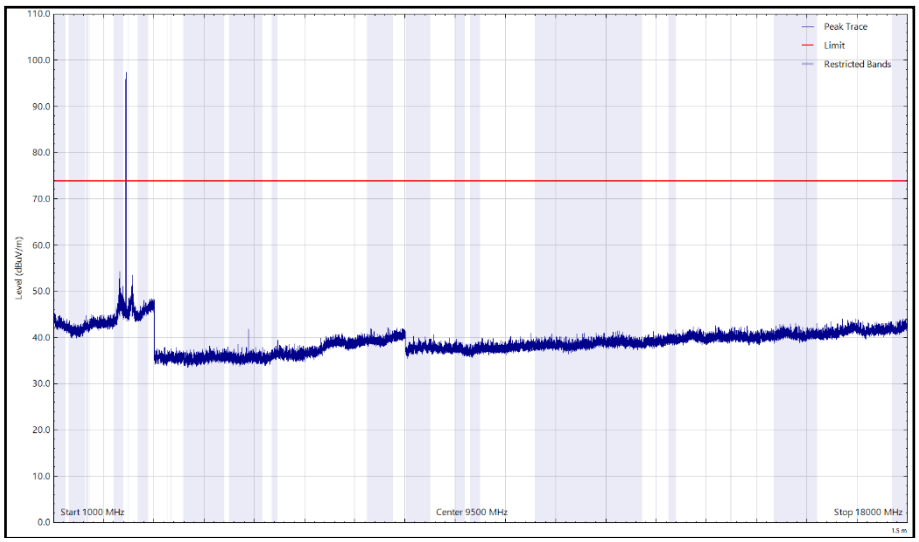

Figure 40 - 2440 MHz (CH17), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (Peak)

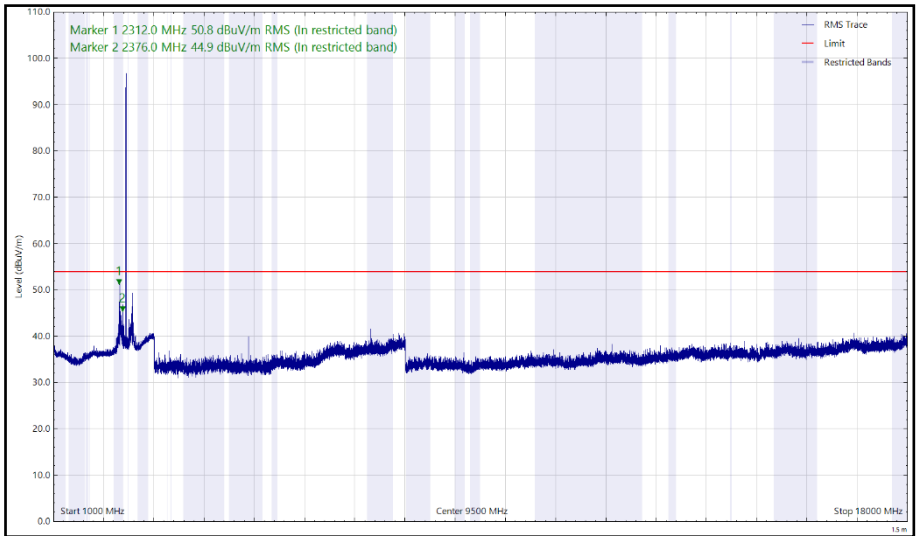

Figure 41 - 2440 MHz (CH17), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2351.983	51.2	54.0	-2.8	RMS	270	132	Vertical
2367.937	49.0	54.0	-5.0	RMS	257	168	Vertical

Table 33 - 2480 MHz (CH39), LE1M – Y Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

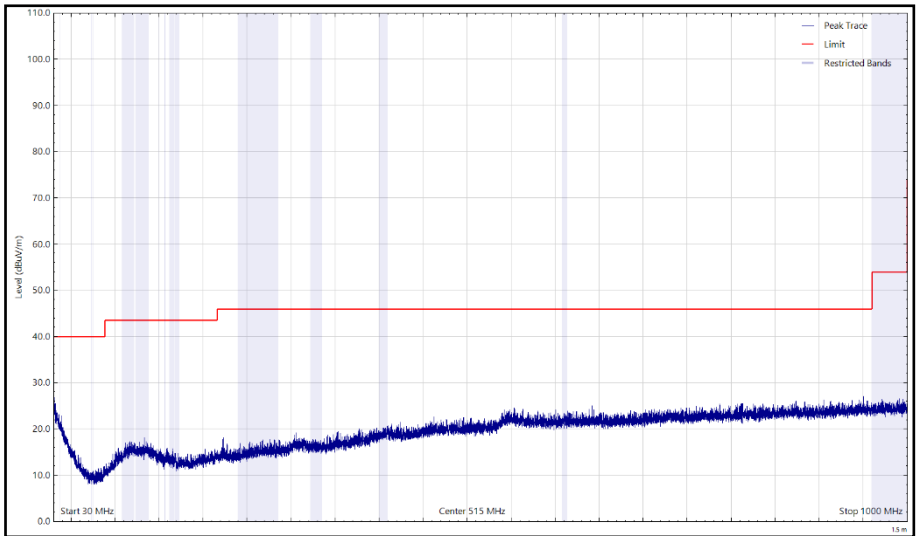

Figure 42 - 2480 MHz (CH39), LE1M – Y Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

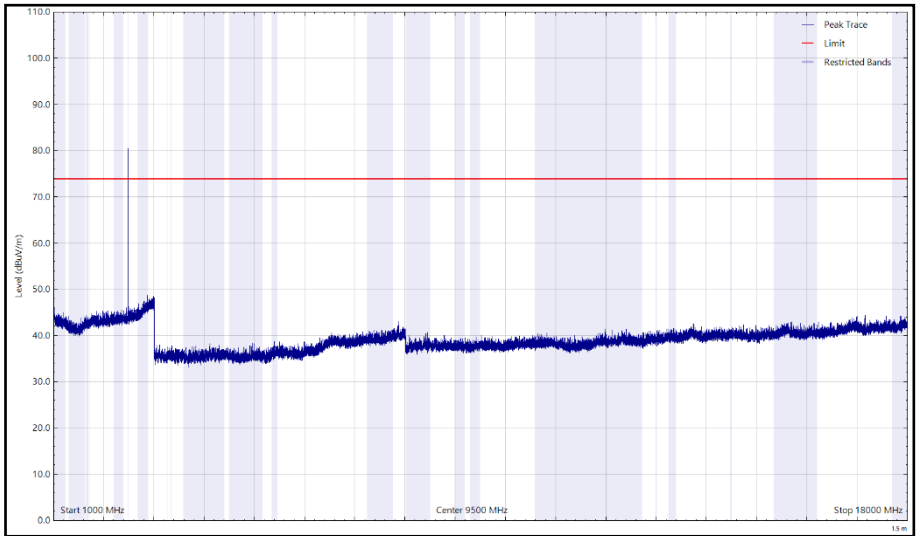

Figure 43 - 2480 MHz (CH39), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

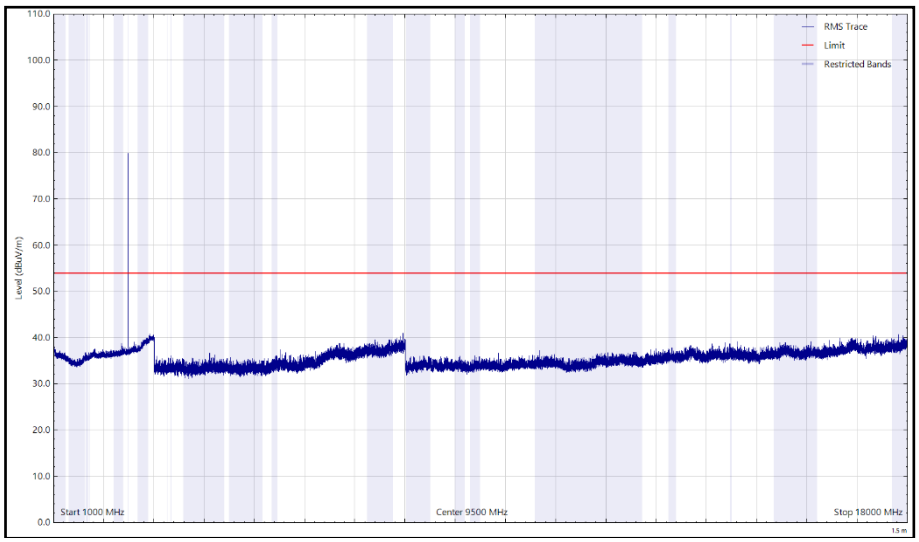

Figure 44 - 2480 MHz (CH39), LE1M – Y Orientation, 1 GHz to 18 GHz, Horizontal (rms)

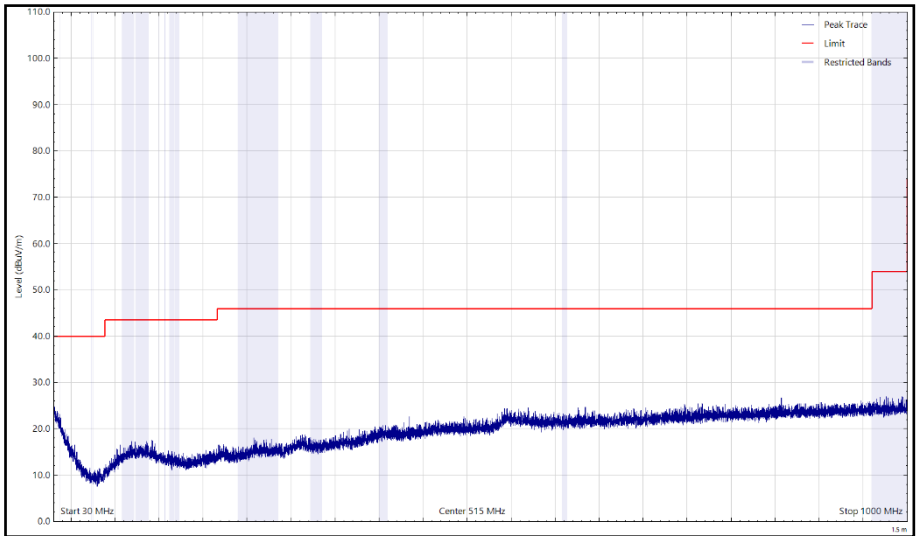

Figure 45 - 2480 MHz (CH39), LE1M – Y Orientation, 30 MHz to 1 GHz, Vertical (Peak)

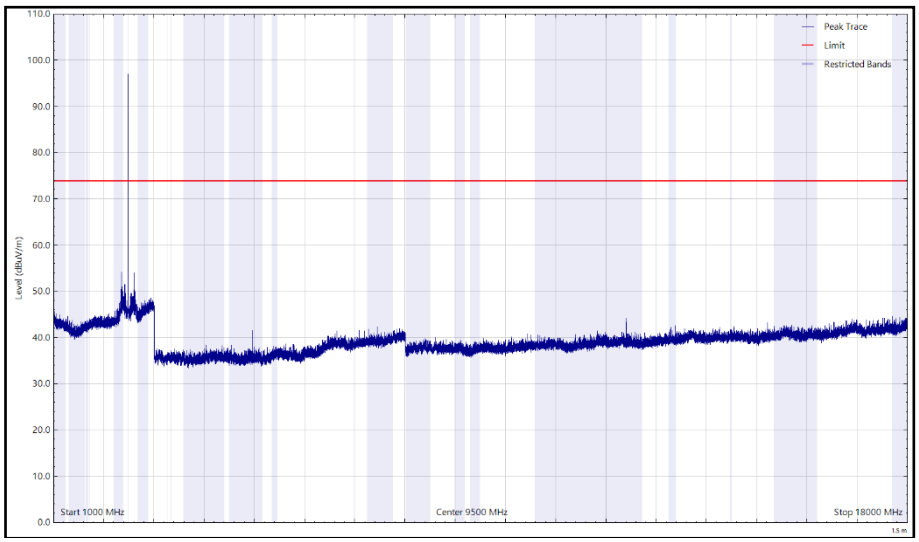

Figure 46 - 2480 MHz (CH39), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (Peak)

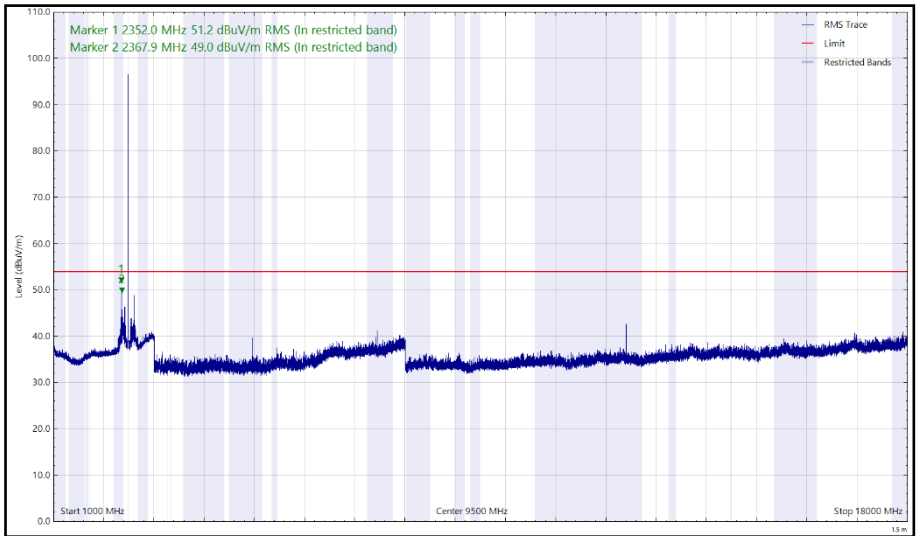

Figure 47 - 2480 MHz (CH39), LE1M – Y Orientation, 1 GHz to 18 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2274.014	49.9	54.0	-4.0	RMS	355	100	Horizontal
2337.923	44.2	54.0	-9.8	RMS	0	100	Horizontal

Table 34 - 2402 MHz (CH37), LE1M – Z Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

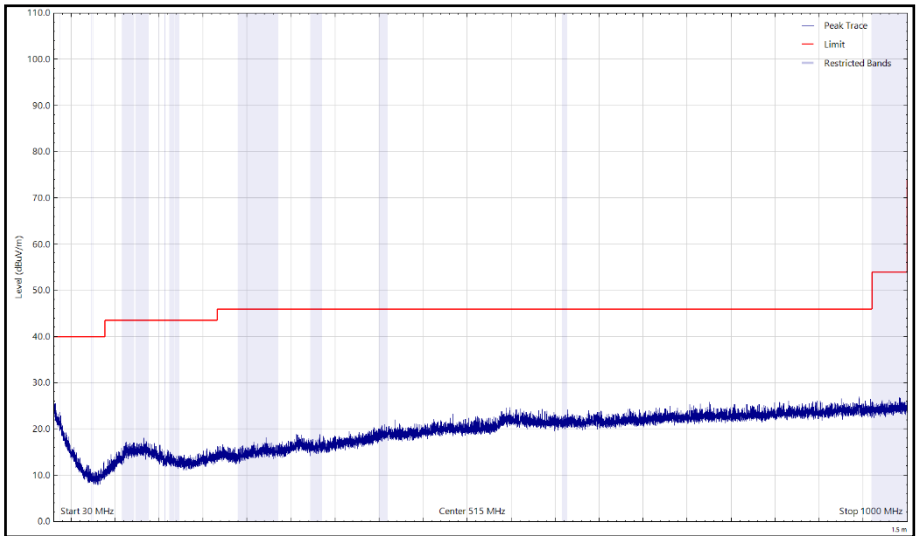

Figure 48 - 2402 MHz (CH37), LE1M – Z Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

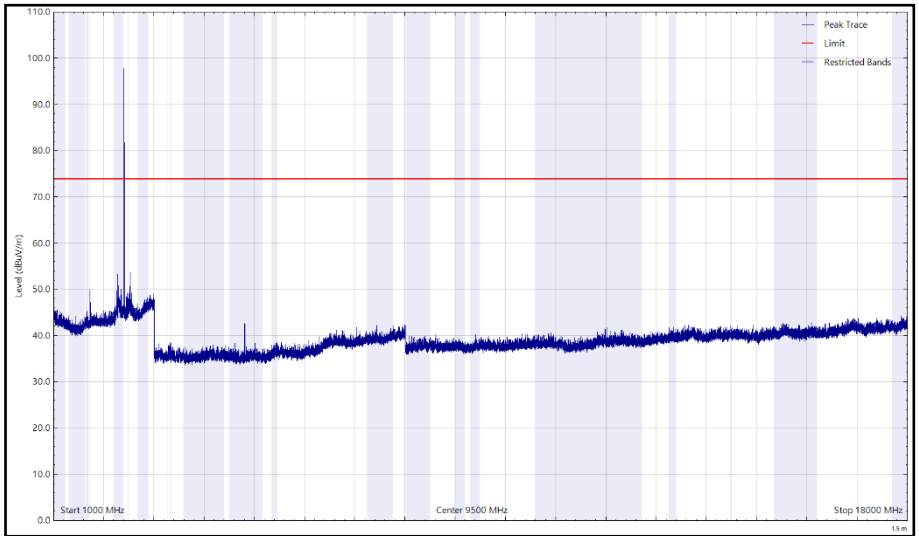

Figure 49 - 2402 MHz (CH37), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

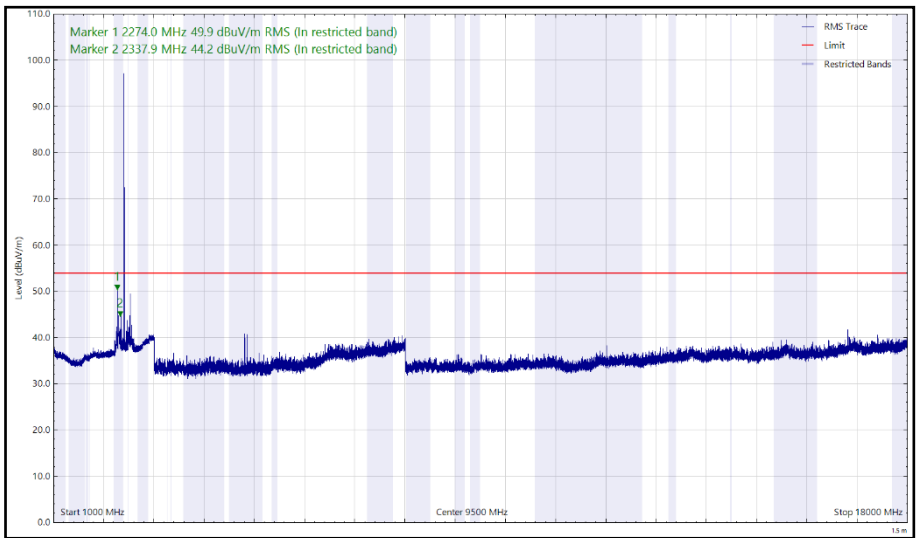

Figure 50 - 2402 MHz (CH37), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (rms)

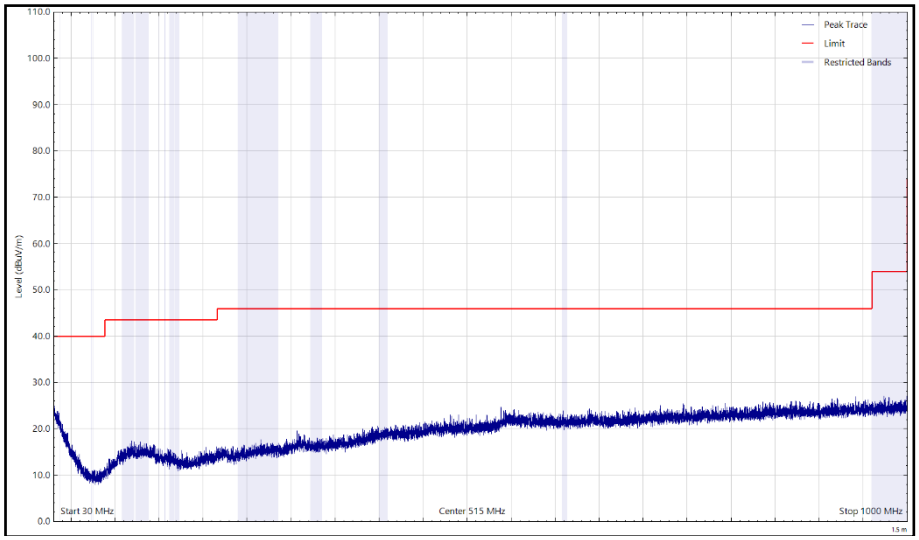

Figure 51 - 2402 MHz (CH37), LE1M – Z Orientation, 30 MHz to 1 GHz, Vertical (Peak)

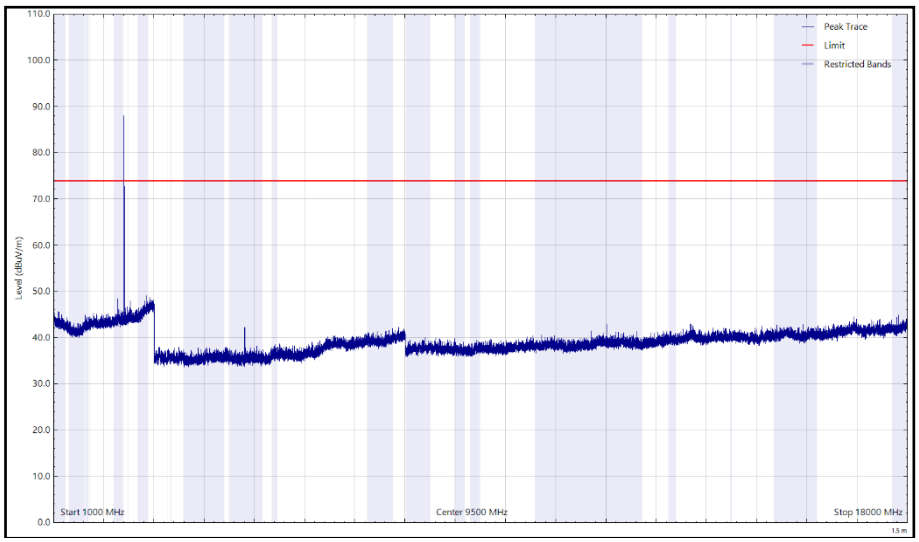

Figure 52 - 2402 MHz (CH37), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (Peak)

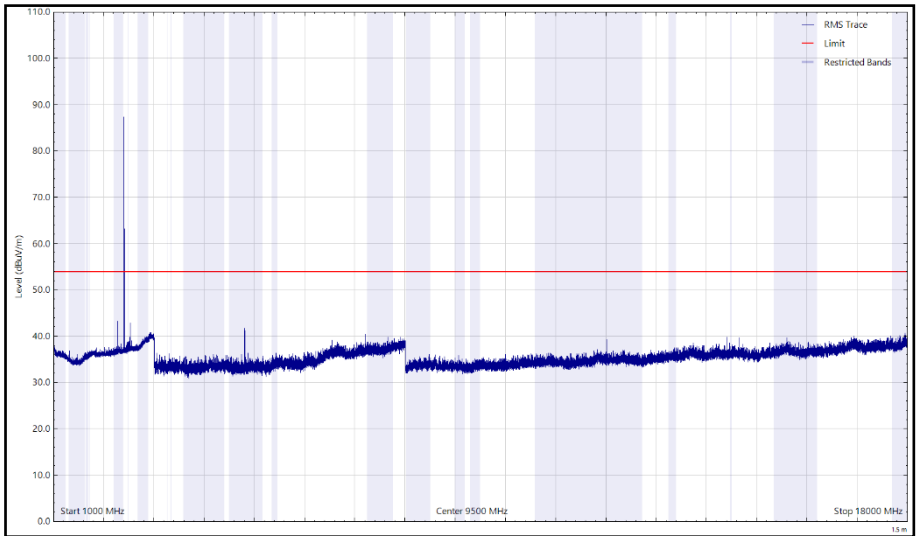

Figure 53 - 2402 MHz (CH37), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2312.032	49.6	54.0	-4.4	RMS	178	124	Horizontal
2375.948	45.5	54.0	-8.5	RMS	0	106	Horizontal

Table 35 - 2440 MHz (CH17), LE1M – Z Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

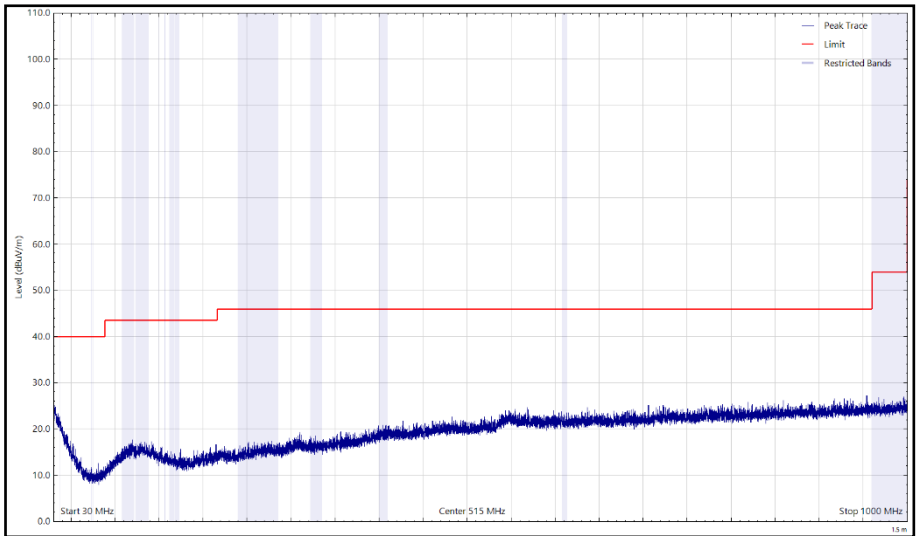

Figure 54 - 2440 MHz (CH17), LE1M – Z Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

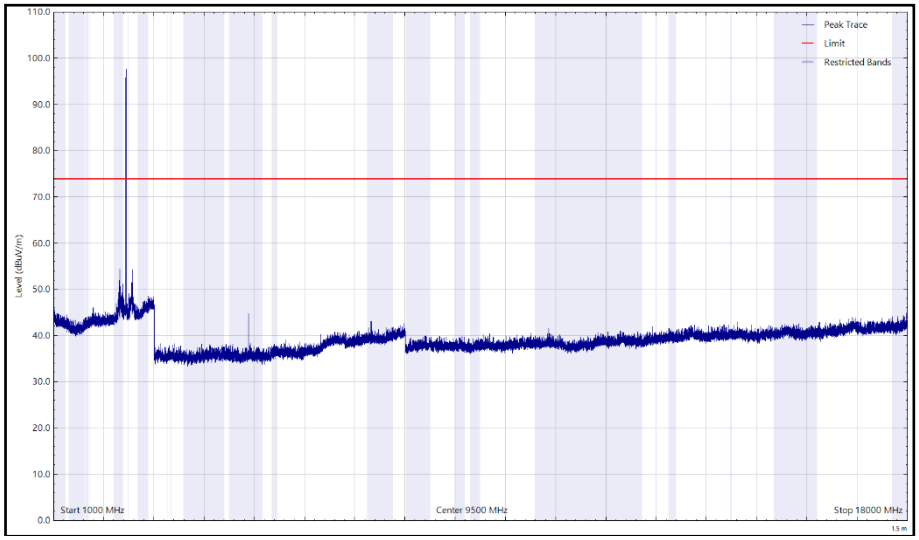

Figure 55 - 2440 MHz (CH17), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

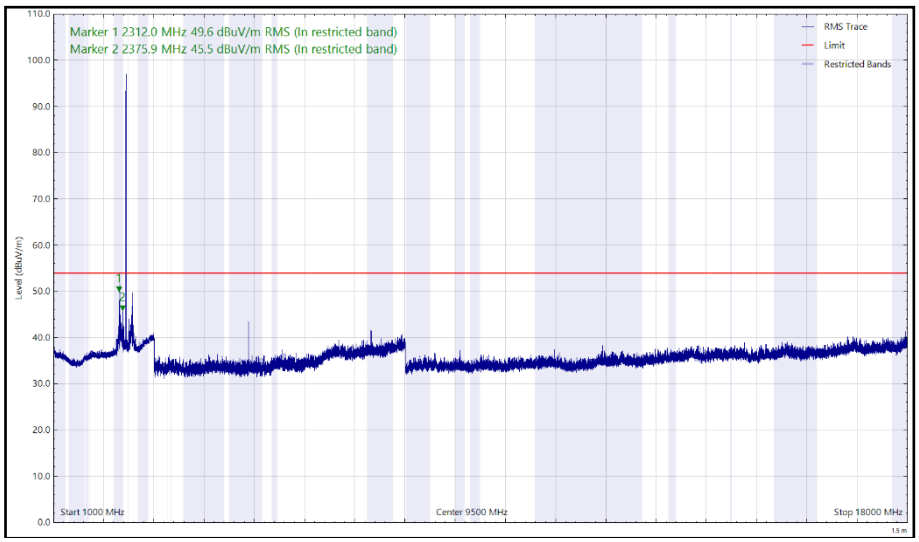

Figure 56 - 2440 MHz (CH17), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (rms)

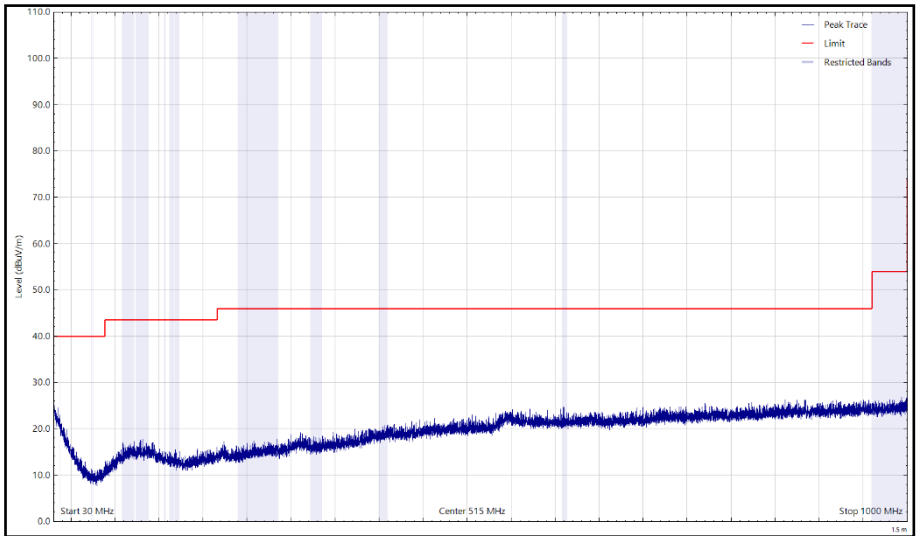

Figure 57 - 2440 MHz (CH17), LE1M – Z Orientation, 30 MHz to 1 GHz, Vertical (Peak)

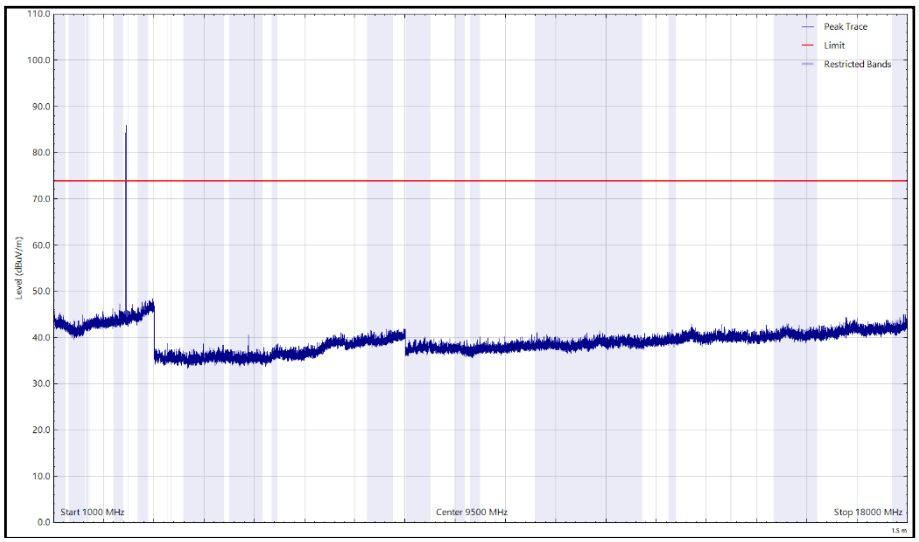

Figure 58 - 2440 MHz (CH17), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (Peak)

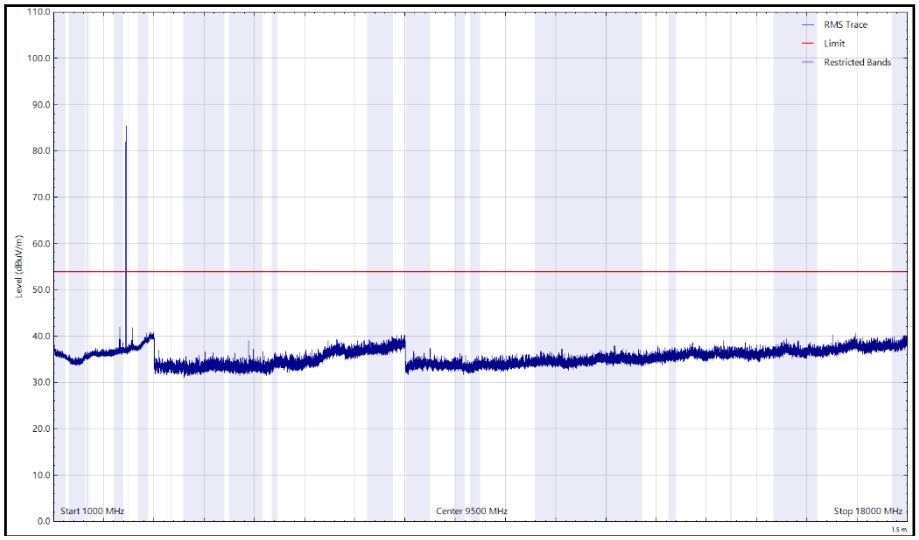

Figure 59 - 2440 MHz (CH17), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (rms)

Frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation
2351.931	50.9	54.0	-3.0	RMS	179	211	Horizontal

Table 36 - 2480 MHz (CH39), LE1M – Z Orientation, 1 GHz to 18 GHz

No other emissions found within 10 dB of the limit.

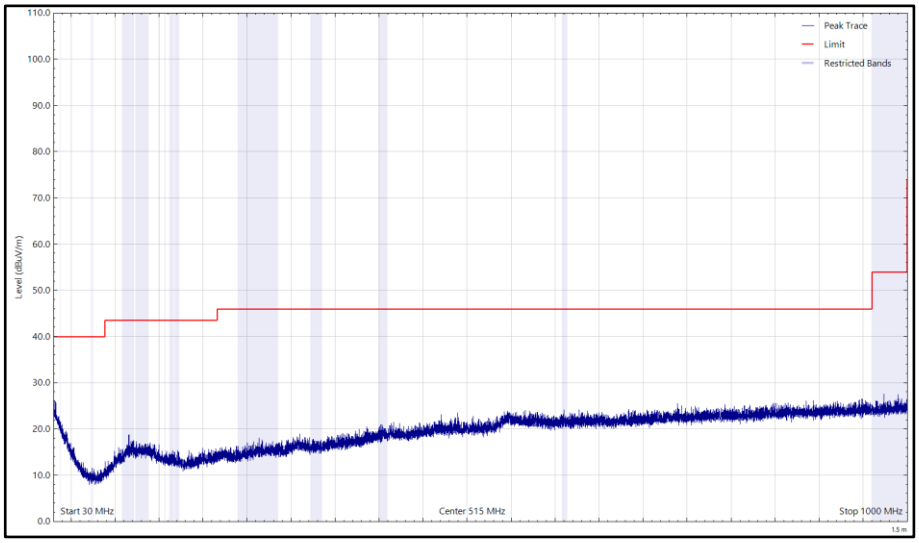

Figure 60 - 2480 MHz (CH39), LE1M – Z Orientation, 30 MHz to 1 GHz, Horizontal (Peak)

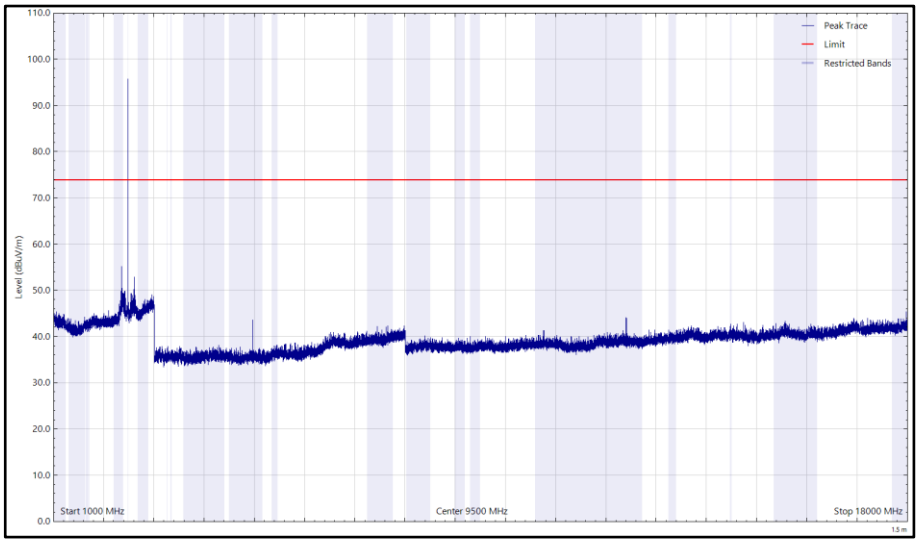

Figure 61 - 2480 MHz (CH39), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (Peak)

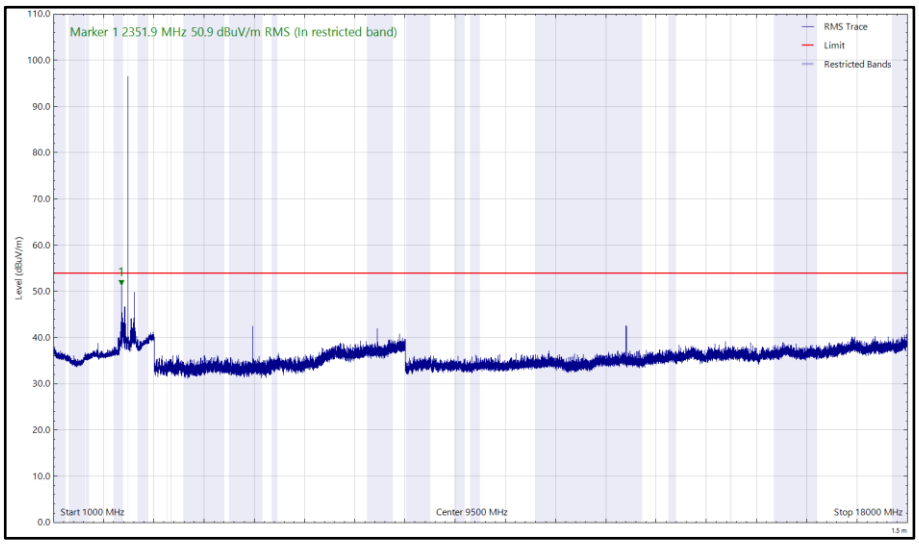

Figure 62 - 2480 MHz (CH39), LE1M – Z Orientation, 1 GHz to 18 GHz, Horizontal (rms)

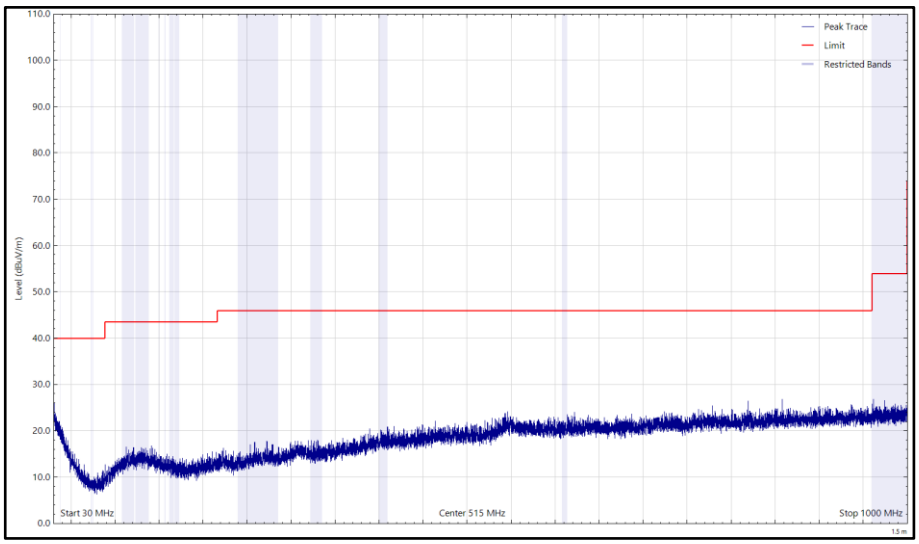

Figure 63 - 2480 MHz (CH39), LE1M – Z Orientation, 30 MHz to 1 GHz, Vertical (Peak)

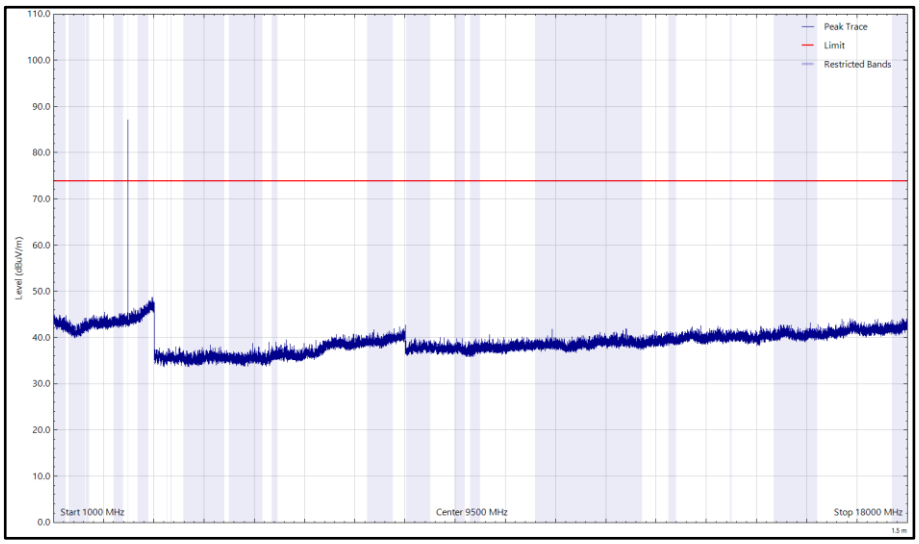

Figure 64 - 2480 MHz (CH39), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (Peak)

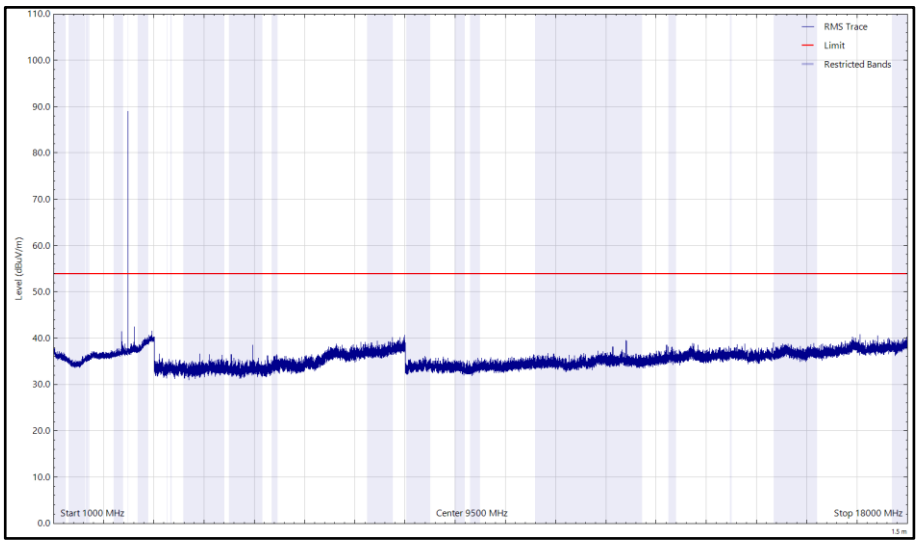

Figure 65 - 2480 MHz (CH39), LE1M – Z Orientation, 1 GHz to 18 GHz, Vertical (rms)

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)

ISED RSS-247, Limit Clause 5.5

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

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

2.5.8 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
Antenna with attenuator (Bilog, 30 MHz to 3 GHz)	Schaffner	CBL6143	287	24	14-Oct-2022
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
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	4811	-	TU
Antenna (DRG 1-10.5GHz)	Schwarzbeck	BBHA9120B	4848	12	28-May-2023
Emissions Software	TUV SUD	EmX V3.1.4	5125	-	Software
Antenna (DRG, 15 GHz to 40 GHz)	Schwarzbeck	BBHA 9170	5217	12	25-Jan-2023
Pre-Amplifier (18 GHz to 40 GHz)	Schwarzbeck	BBV 9721	5218	12	25-Jan-2023
Antenna (DRG Horn 7.5-18GHz)	Schwarzbeck	HWRD750	5348	12	15-Oct-2022
1m -SMA Cable	Junkosha	MWX221-01000AMSAMS/A	5514	12	12-Apr-2023
Cable (sma to sma 2m)	Junkosha	MWX221-02000AMSAMS/A	5517	12	12-Apr-2023
Cable (N to N 8m)	Junkosha	MWX221-08000NMSNMS/B	5520	12	24-Mar-2023
EMI Test Receiver	Rohde & Schwarz	ESW44	5527	12	28-Apr-2023
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	22-Sep-2022
Cable (K Type 2m)	Junkosha	MWX241-01000KMSKMS/B	5934	12	14-May-2023

Table 37

TU - Traceability Unscheduled

2.6 Power Spectral Density

2.6.1 Specification Reference

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

2.6.2 Equipment Under Test and Modification State

Bluetooth HOS Driver ID, S/N: 17000057 - Modification State 0

2.6.3 Date of Test

23-June-2022

2.6.4 Test Method

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

2.6.5 Environmental Conditions

Ambient Temperature	23.8 °C
Relative Humidity	48.8 %

2.6.6 Test Results

2.4 GHz Bluetooth Low Energy

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

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

Test Frequency (MHz)	RBW (kHz)	PSD (dBm/RBW)					Limit (dBm/3 kHz)	Margin (dB)
		A	B	C	D	∑		
2402	3.0	-15.75	-	-	-	-	8.00	-23.75
2440	3.0	-16.99	-	-	-	-	8.00	-24.99
2480	3.0	-15.30	-	-	-	-	8.00	-23.30

Table 38 - Maximum Power Spectral Density Results

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

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

ISED RSS-247, Limit Clause 5.2(b)

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

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Antenna (Double Ridge Guide)	EMCO	3115	34	12	15-Oct-2022
Attenuator (10 dB)	Weinschel	47-10-34	481	12	26-Jul-2022
True RMS Multimeter	Fluke	179	4006	12	29-Mar-2023
Network Analyser	Keysight Technologies	E5063A	5018	12	30-Jul-2022
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	22-Jul-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	25-Apr-2023
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5495	12	11-Oct-2022
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	21-Mar-2024
Signal Conditioning Unit	TUV SUD	SPECTRUM SCU001	5546	12	06-Apr-2023
Coupler	Narda	4202B-20	5990	-	O/P Mon

Table 39

O/P Mon – Output Monitored using calibrated equipment

3 Photographs

3.1 Test Setup Photographs

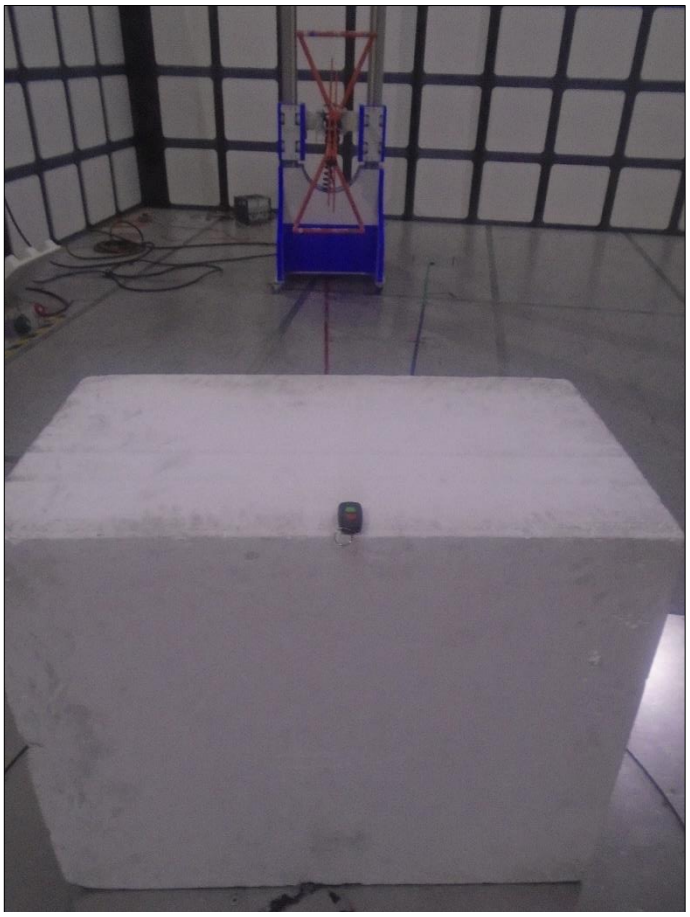

Figure 66 - Test Setup - 30 MHz to 1 GHz - X Orientation

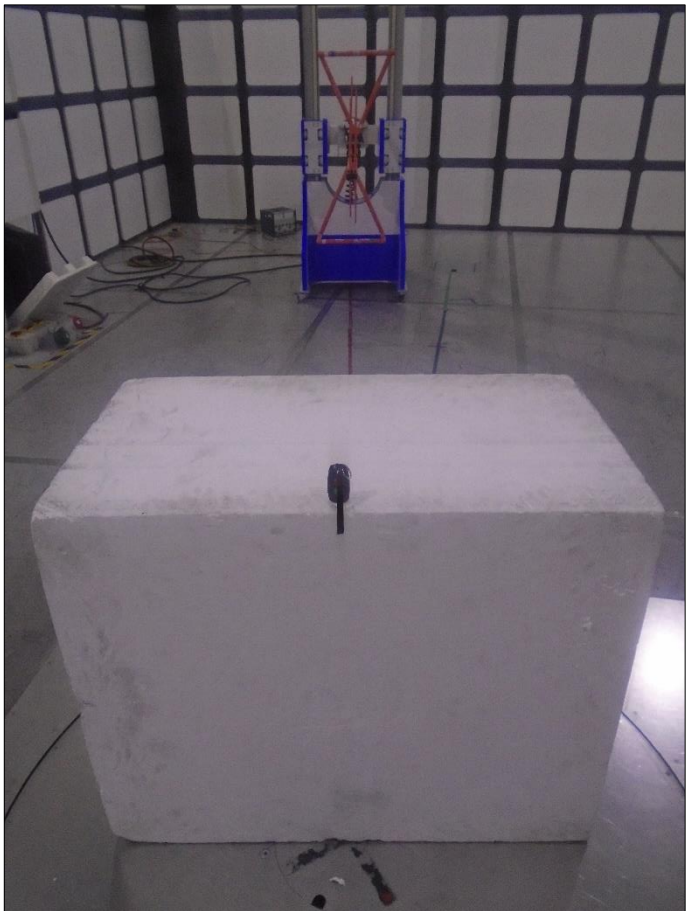

Figure 67 - Test Setup - 30 MHz to 1 GHz - Y Orientation

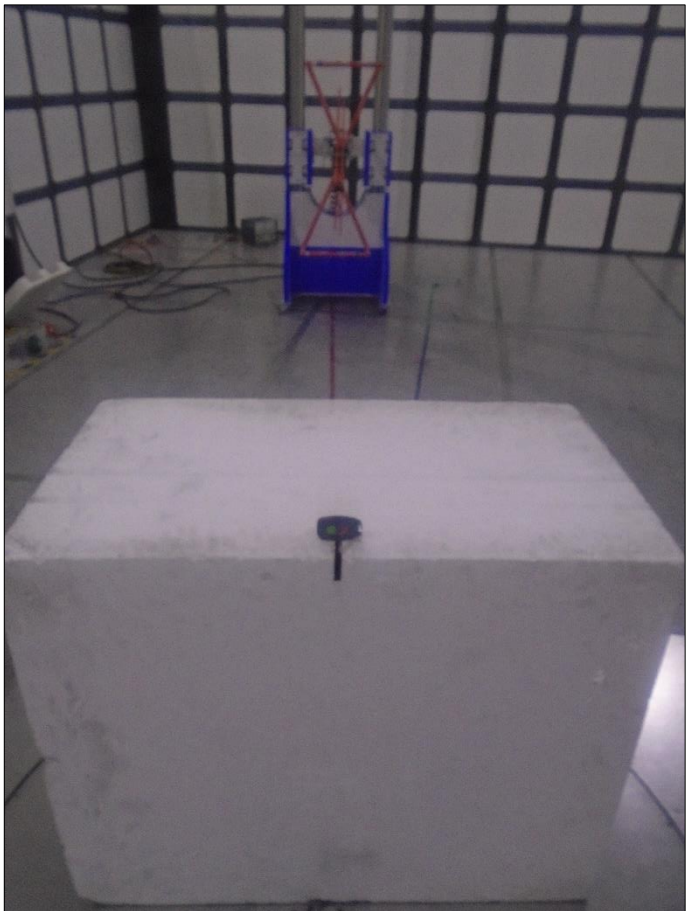

Figure 68 - Test Setup - 30 MHz to 1 GHz - Z Orientation

Figure 69 - Test Setup - 1 GHz to 18 GHz - X Orientation

Figure 70 - Test Setup - 1 GHz to 18 GHz - Y Orientation

Figure 71 - Test Setup - 1 GHz to 18 GHz - Z Orientation

Figure 72 - Test Setup - 18 GHz to 25 GHz - X Orientation

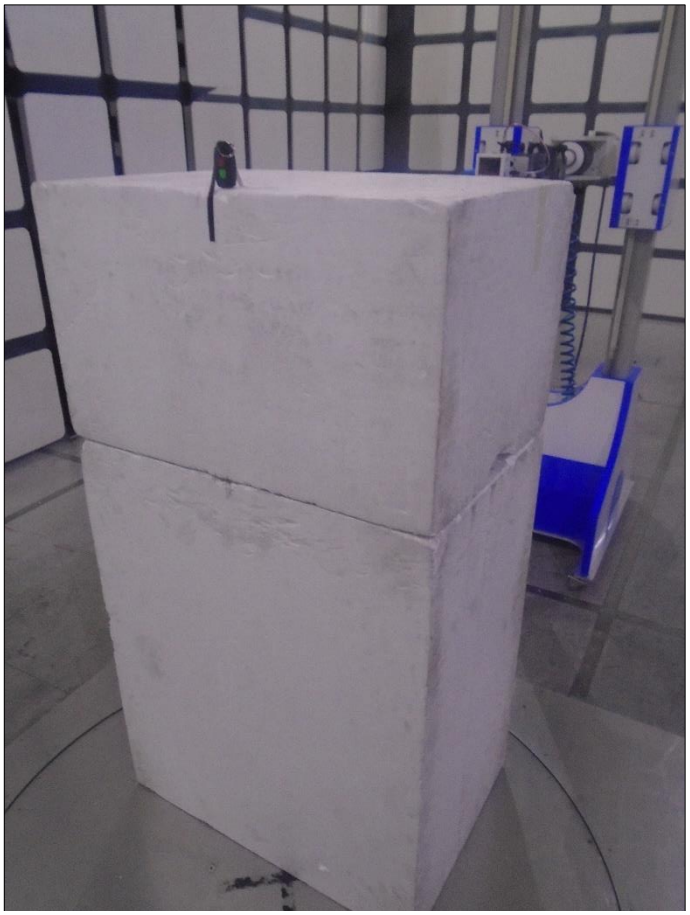

Figure 73 - Test Setup - 18 GHz to 25 GHz - Y Orientation

Figure 74 - Test Setup - 18 GHz to 25 GHz - Z Orientation

4 Measurement Uncertainty

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

Test Name	Measurement Uncertainty
Restricted Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Emission Bandwidth	± 50.1 kHz
Maximum Conducted Output Power	± 1.38 dB
Authorised Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 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 40

Measurement Uncertainty Decision Rule – Accuracy Method

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115:2007, Clause 4.4.3 and 4.5.1. (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.