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Test Report for the FCC and ISED Testing of an Raspberry Pi Pico W (Bluetooth) to FCC Rule 47CFR 15.247 and ISED RSS-247 for Raspberry Pi Ltd

Test Report number: C14604TR2

Project number: B5109

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Issue	Description						Issue by	Date
2	Copy 1		Copy 2		PDF	√	MR	5th May 2022

Registered Address:
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Registered in England and Wales
Company Reg. No. 6048589
VAT Reg. No. GB 887 1276 83

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Test Report Change History

Issue	Date	Modification Details
1	22nd April 2022	First Issue
2	5th May 2022	Company name updated
3		
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8		
9		
10		

Section 1 Test Location

All testing was performed at;

Eurofins York	Unit 5
	Speedwell Road
	Castleford
	WF10 5PY
Tel:	01977 731173
Website	http://www.yorkemc.co.uk
UKAS Testing No.	1574

1.1 UKAS Accreditation

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

Eurofins York latest accreditation schedule can be found at:
http://www.ukas.org/testing/lab_detail.asp?lab_id=989&location_id=&vMenuOption=3

Eurofins York Castleford Laboratory, is an Accredited facility recognised by the Federal Communications Commission (FCC) for certification testing. The appropriate FCC Designation Number is UK2013, dated 1st March 2021.

Eurofins York Castleford Laboratory is recognised by ISED for certification testing.
ISED Assigned Code: 22959

Section 2 Customer Information

Company name	Raspberry Pi Ltd
Address	Maurice Wilkes Building
	St. John's Innovation Park
	Cowley Road
	Cambridge
	CB4 0DS
	United Kingdom
Contact	Tom Westcott
Email	tom.westcott@raspberrypi.com

Section 3 Equipment Details

3.1 Equipment Under Test (EUT)

Date received:	8th February 2022		
EUT name:	Raspberry Pi Pico W		
PMN:	Raspberry Pi Pico W		
HVIN:	Raspberry Pi Pico W		
FVIN:	N/A		
FCC ID:	2ABCB-PICOW		
ISED number:	20953-PICOW		
Serial no:	Rad 1, Con 1		
EUT description:	The Raspberry Pi Pico W is a small single board microprocessor board. The user connects the board to a host via a micro USB connector. This connection provides power and operation functionality. The product is supplied with an operating system. The board has a CYW43439 Bluetooth and Wi-Fi combo chip which allows the user to connect to a 2.4GHz Wi-Fi networks, BT Classic 5 compliant devices and BT-LE devices. The system uses a single PCB Niche single band antenna with a centre frequency of 2450 MHz.		
Antenna	Integral Antenna		
Transmission	Frequency Hopping Spread Spectrum (FHSS) Bluetooth Classic		
Modulation scheme	0xF0 8-bit Pattern		
Operating frequency band	2400MHz to 2483.5MHz		
No of units tested:	Two		
EUT power:	3.3V via USB port		
Highest internal frequency:	2.480GHz		
Size of EUT (m)	Width: 55 mm	Depth: 23 mm	Height: 4 mm
Mode/s of operation:	Continuous transmit of packetised data at top, middle and bottom channels. Channels used: 2402MHz, 2440MHz and 2480MHz		
Test software:	bt_mfg_test.uf2 Test Firmware installed		
Modifications incorporated during testing:	For radiated measurements a Wurth 742 711 31 S ferrite was placed on the USB cable between the EUT and the Auxiliary PC. This encompassed 2 turns of the USB cable and was positioned approximately 1m from the EUT.		

Ports and Cables	Cable Length	Screened/ unscreened	Connected to
USB cable	5m	unscreened	External PC

3.2 EUT Photographs

Photographs are supplied separately.

3.3 Configuration of EUT

The apparatus was supplied in one single possible configuration.

3.4 EUT Monitoring/Auxiliary Equipment

None.

3.5 Monitoring Software

None. The channel required was selected via software prior to the testing.

Section 4Test Specifications

For USA:

Regulation / Test Standard	Regulation: Title 47 of the Code of Federal Regulations (CFR) Part 15 (47CFR15) Subpart C – Intentional Radiators Measurement standard: ANSI C63.10-2013 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

Test description	Rule Part	Result Summary
Intentional emission, band occupancy, 20dB bandwidth	47 CFR 15.215(C) 47 CFR 15.247 (a)(1)	Pass
FHSS Requirements	Number of hopping channels 47CFR15.247(a)(1)(iii)	Pass
	Channel separation 47CFR15.247(a)(1)(iii)	Pass
	Hopping channel occupancy time 47CFR15.247(a)(1)(iii)	Pass
Peak power output (conducted)	47 CFR 15.247 b (1)	Pass
Radiated spurious emissions 30MHz to 25GHz	15.247(d)	Pass
Restricted band compliance	47CFR15.247(d) and 45CFR15.205 and 47CFR15.209	Pass
Conducted spurious emissions	FCC § 15.247(d)	Pass
Mains conducted emissions 150kHz to 30MHz Applicable if the apparatus connects to the AC supply directly or via other apparatus.	47 CFR Part 15C Section 15.207 Test standard: ANSI C63.10-2013 Not applicable – not mains powered	Not applicable

For Canada

Regulation / Test Standard	RSS-247 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices Issue 2 February 2017 And, RSS-Gen — General Requirements for Compliance of Radio Apparatus Issue 5 April 2018 +A1 March 2019 +A2 February 2021

Test description	**RSS Reference**	**Result Summary**
Intentional emission, band occupancy	-	Pass
99% Occupied Bandwidth	RSS-GEN Issue 5 April 2018 Section 6.7	Pass
FHSS Requirements	RSS-247 Issue 2 Section 5.1 Channel separation Hopping sequence System receiver bandwidth Number of hopping channels Hopping channel occupancy time	Pass
Peak power output (conducted)	RSS-247 Issue 2 Section 5.4 (b)	Pass
Radiated spurious emissions	RSS-247 Issue 2 Section 5.5	Pass
Restricted band compliance	RSS-247 Issue 2 Sections 3.3 and 5.5 RSS-Gen Issue 5 Section 8.10	Pass
Conducted spurious emissions	ISED RSS-247 § 5.5	Pass
AC power line conducted emissions	RSS-247 Section 3.1 RSS Gen Section 8.8	Not applicable

4.1 Knowledge Database References

The following KDBs were referenced during the testing.
The latest knowledge database references are available via the FCC KDB website at:

https://apps.fcc.gov/kdb

4.1.1 Radiated Emissions (30MHz to 1000MHz)

Publication Number	Keyword	Publication Date
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017

4.1.2 Radiated Emissions (1GHz to 40GHz)

Publication Number	Keyword	Publication Date
704992	Test Site Validation Requirements above 1 GHz.	12/06/2015
149045	Comparison Noise Emitter (CNE), reference noise source, .pdf	05/04/2007
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017
934285	Comparison Noise Emitters (CNE), test equipment, Broadband.pdf	05/04/2007

4.2 Compliance Statement

The Raspberry Pi Pico W, as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

Section 5 Spurious Emission Results – Radiated and Conducted

5.1 Test Specification

FCC Rule Part	47CFR 15.247 (d)
Standard	ANSI C63.10:2013
Measurement Uncertainty Radiated tests	The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95% is +/- 5.85dB for the frequency range 30MHz to 1GHz +/- 4.64dB for the frequency range from 1GHz to 6GHz +/- 4.96dB for the frequency range from 6GHz to 18GHz
Measurement Uncertainty Conducted tests	±1.4dB

5.2 Procedure and Test Software Version

Radiated tests:- 47CFR15.205 and 47CFR15.209

Eurofins York test procedure (30MHz to 1GHz)	CEP23b Issue 8
Eurofins York test procedure (1GHz to 40GHz)	CEP64b Issue 8
Test software	RadiMation Version 2016.2.8

Conducted Tests 47CFR 15.247(d)

ANSi C63.10-2013 Clause reference:	11.11.2 and 11.11.3
Test software	N/A

5.3 Radiated Emissions (30MHz to 1GHz)

Radiated electric field emission measurements are applied as defined in 47CFR15.205 and 47CFR15.209.

5.3.1 Limits at 3m

Frequency (MHz)	Electric Field strength Limit (dBµV/m) at 3m measurement distance
	Quasi Peak
30 - 88	40.0
88 -216	43.5
216 - 960	46.0
960- 1000	54.0

Note: FCC 47 CFR Part 15 Section 15.209 and 15.205 specifies test limits at 3m

Receiver Settings

Receiver Parameters	Setting
Detector Function	Quasi Peak
Start Frequency	30MHz
Stop Frequency	1000MHz
Resolution Bandwidth	120kHz
Video Bandwidth	Auto

5.3.2 Emissions measurements

5.3.3 Date of Test

28th March 2022

5.3.4 Test Area

LAB 1 (SAC)

5.3.5 Tested by

M Dyster

5.3.6 Test Setup

The EUT was configured in the SAC on an 80cm high polystyrene table.

The measurement was performed with an antenna to EUT separation distance of 3m. The results were maximised in orientation 0-360 degrees and height 1-4m.

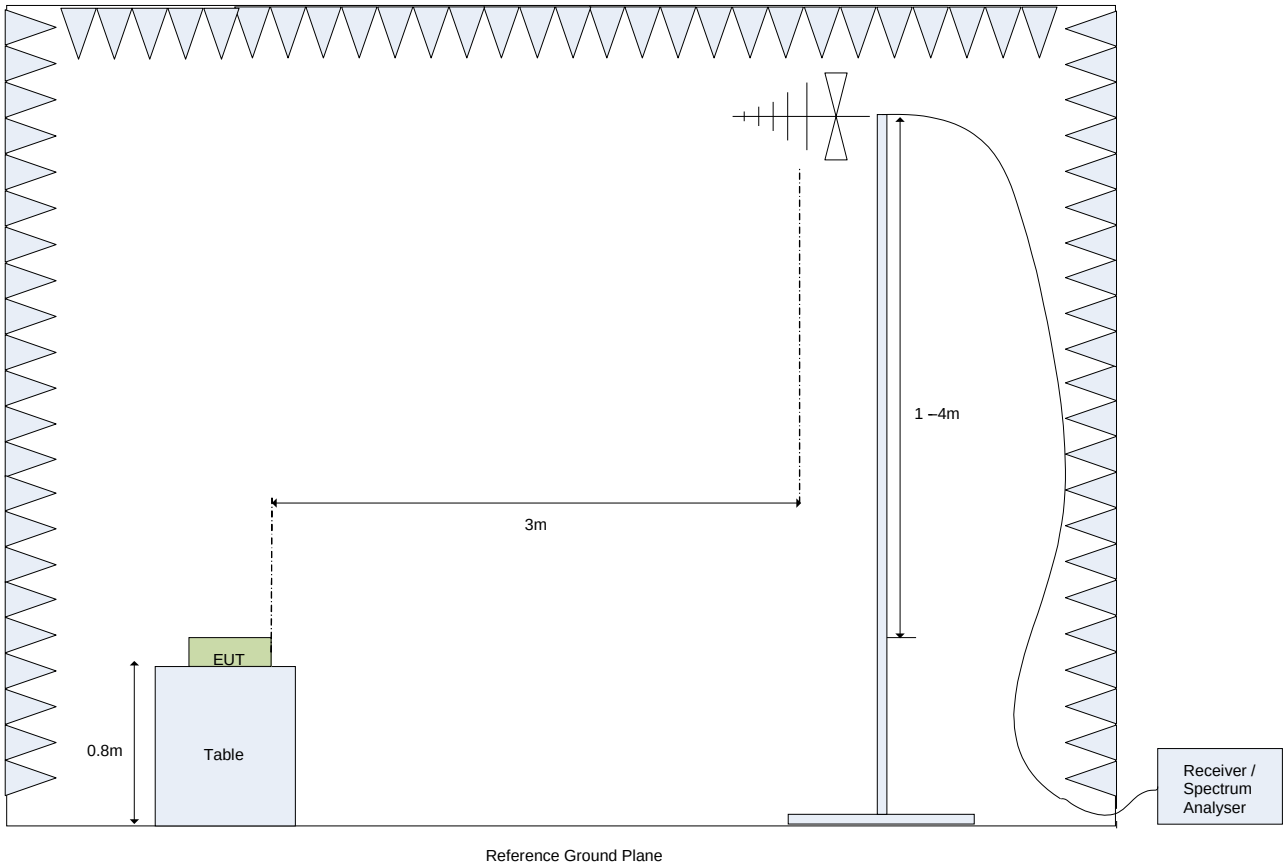

Figure 5.3.6.1: Test Setup for E-Field Measurements from 30MHz to 1GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.10-2013.

Note 2 : There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

Operating Mode During testing

During spurious emission testing the equipment under test was set to transmit at the same frequency on the following channels: 2402MHz, 2440MHz and 2480MHz for each modulation scheme used

The equipment under test was pre-scanned using peak detection when operating on all three channels for all three modulation schemes. Final measurements were performed for each modulation scheme with the equipment under test operating on 2480MHz

5.3.7 Electric field emissions, 30MHz to 1GHz

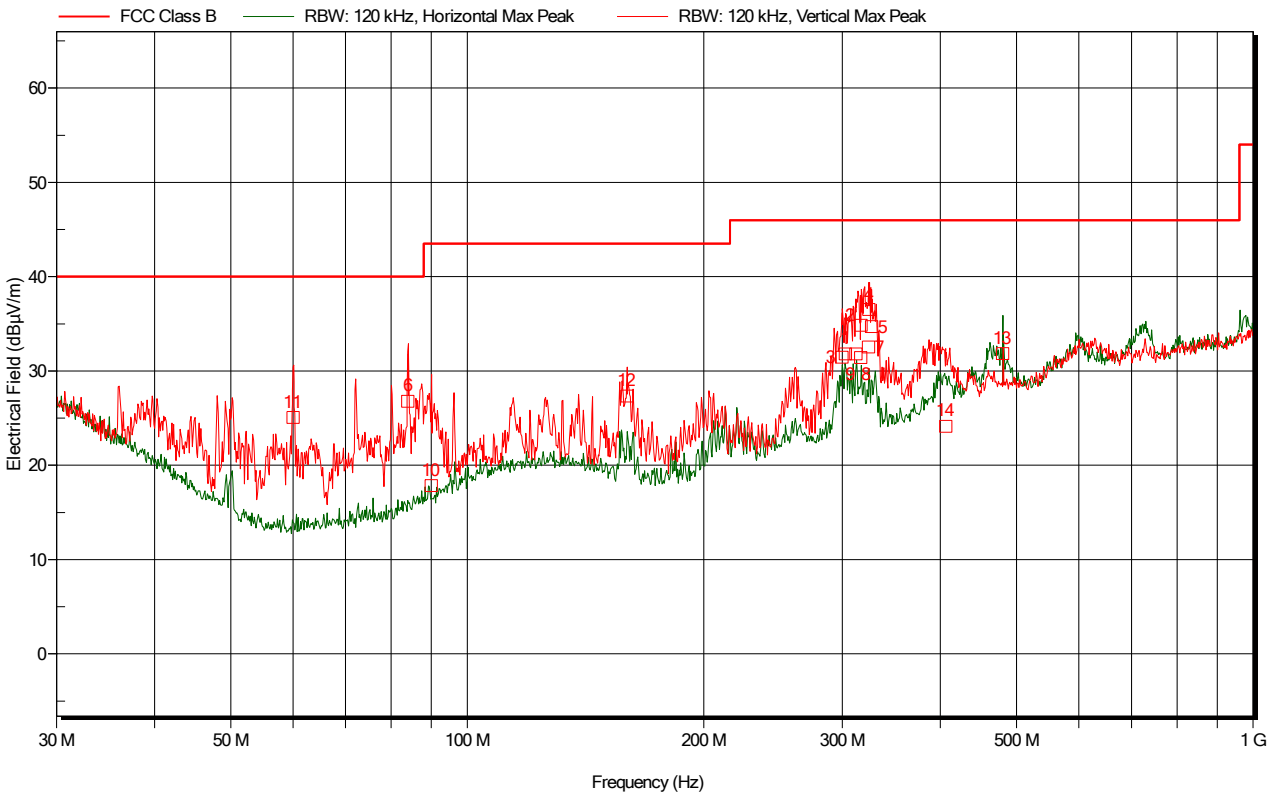

Figure 5.3.7.1: Electric field emissions Plot, 30MHz to 1GHz, 2480MHz Operation

Frequency	Quasi-Peak	Quasi Peak Limit	Quasi-Peak Difference	Quasi-Peak Status	Angle	Height	Polarization
MHz	dBµV/m	dBµV/m	dB		degrees	m	
302.760	31.8	46	-14.2	Pass	360	1.4	Vertical
316.800	34.8	46	-11.2	Pass	140	1.2	Vertical
299.820	31.5	46	-14.5	Pass	175	1.2	Vertical
324.180	36.5	46	-9.5	Pass	105	1.0	Vertical
326.880	34.7	46	-11.3	Pass	100	1.0	Vertical
84.018	26.8	40	-13.2	Pass	10	1.4	Vertical
323.820	32.6	46	-13.4	Pass	60	1.0	Vertical
316.500	31.4	46	-14.6	Pass	355	1.6	Vertical
312.240	31.8	46	-14.2	Pass	65	1.1	Vertical
90.000	17.8	43.5	-25.7	Pass	260	1.2	Vertical
60.006	25.1	40	-14.9	Pass	50	1.0	Vertical
159.660	27.4	43.5	-16.1	Pass	300	1.1	Vertical
480.072	31.9	46	-14.1	Pass	165	1.4	Horizontal
406.14	24.1	46	-21.9	Pass	95	1.0	Vertical

Table 5.3.7.1 Electric Field Emissions Peaks, 30MHz to 1GHz. 2480MHz Operation

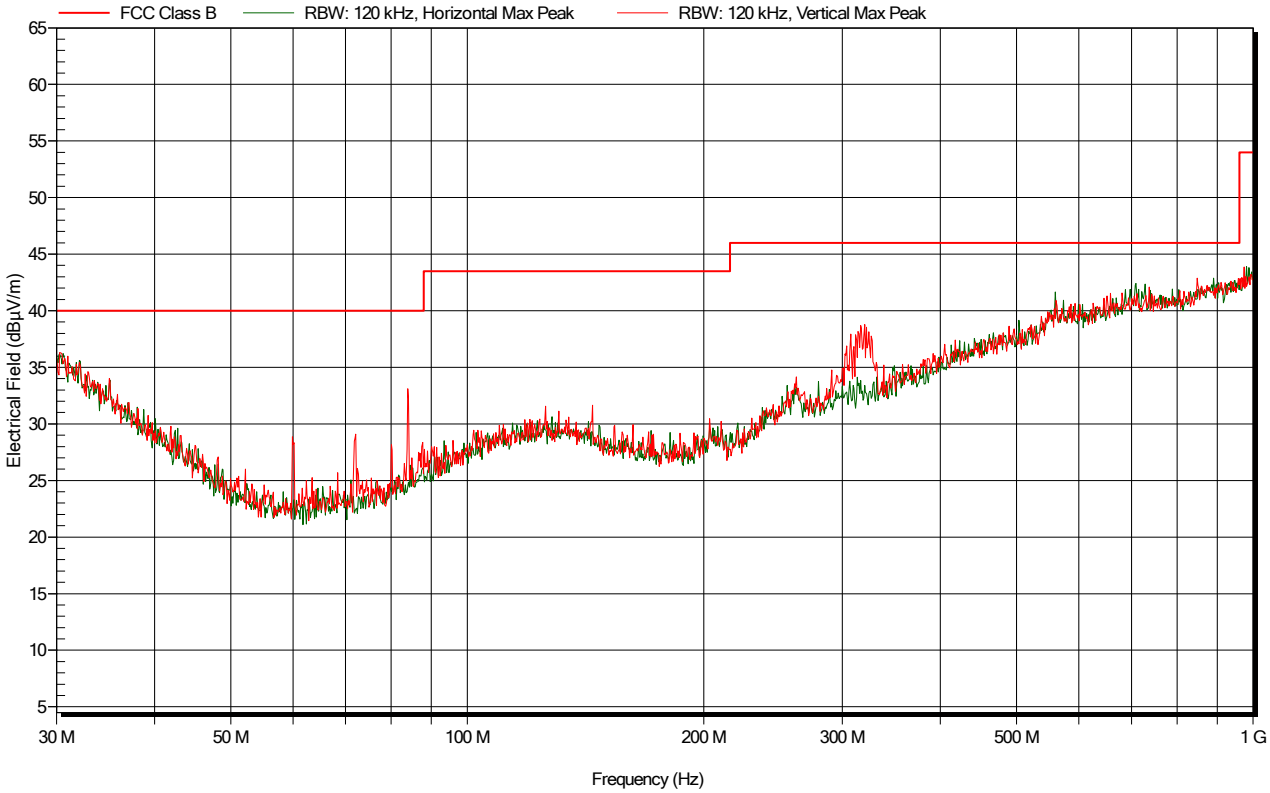

Figure 5.3.7.2: Electric field emissions Plot, 30MHz to 1GHz, Operation on 2402MHz - Peak detector scan

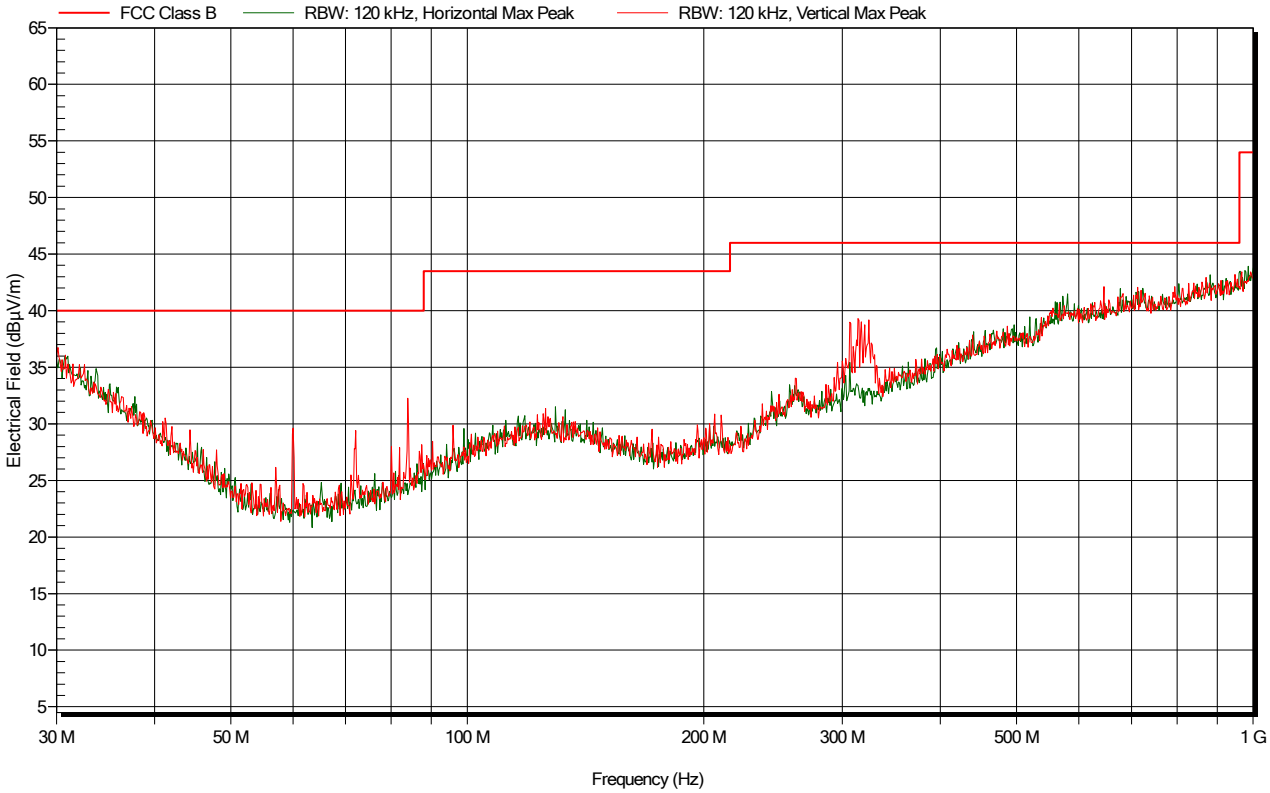

Figure 5.3.7.3: Electric field emissions Plot, 30MHz to 1GHz, Operation on 2440MHz - Peak detector scan

5.4 Radiated Emissions (1GHz to 18GHz)

5.4.1 Limits

Frequency (GHz)	Limit (dBµV/m)	Limit (dBµV/m)
	Peak	Average
1-18	74.0	54.0

5.4.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average and Peak
Start Frequency	1GHz
Stop Frequency	18GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.4.3 Emissions measurements

5.4.4 Date of Test

29th March 2022

5.4.5 Test Area

LAB 1 (SAC)

5.4.6 Tested by

M Dyster

5.4.7 Test Setup

The EUT was configured in the SAC on an 1.5m high table Exploratory measurements on the EUT were carried out to identify suspect frequencies and worst case orientations, see Section 5.4.8.

The measurement was then performed with an antenna to EUT separation distance of 3m.

The antenna was kept in the “cone of radiation” from the EUT and pointed at the area both in azimuth and elevation using the tilt mechanism on the antenna mast.

The results were maximised in orientation 0-360 degrees and height 1-4m.

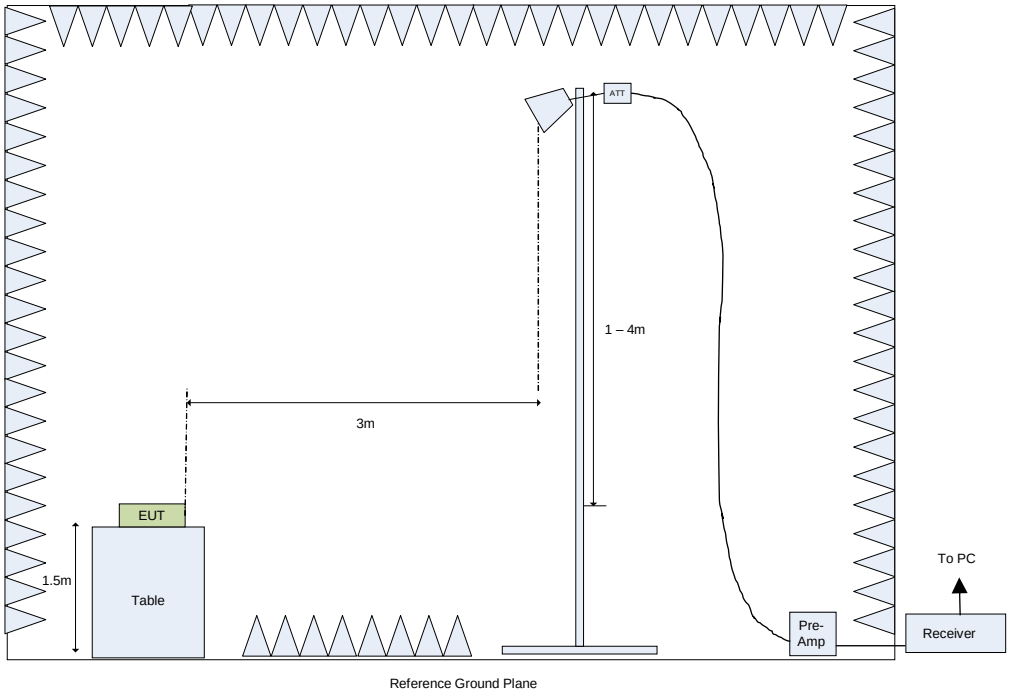

Figure 5.4.7.1: Test Setup for Final E-Field Measurements from 1GHz to 18GHz

Note 1 :There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

Note 3: For final measurements, between 10GHz and 18GHz the measurements were repeated with a measurement distance of 1m in order to reduce the measurement noise floor in this frequency range.

Note 4: On all swept and final measurements made between 1GHz and 18GHz a 2.4GHz Microtronics BRM50702 notch filter was placed in the measurement chain between the antenna and pre-amplifier in order to prevent the artificial generation of harmonics within the pre-amplifier.

5.4.8 Exploratory Radiated Emission Maximization

During exploratory testing, suspect emissions from the EUT were identified both in terms of the frequency and directionality. This was achieved by manually positioning the antenna close to the EUT and also by scanning it over all sides of the EUT whilst observing a spectral display. The typical distance between the surface of the EUT and the scanning antenna was circa 30cm.

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
1.4395	Transmitting on channel 2440MHz	front face	0	1.5	V
1.4395	Transmitting on channel 2480MHz	front face	0	1.5	V
1.4412	Transmitting on channel 2402MHz	front face	0	1.5	V
1.9206	Transmitting on channel 2402MHz	front face	0	1.5	V
1.9206	Transmitting on channel 2440MHz	front face	0	1.5	V
1.9206	Transmitting on channel 2480MHz	front face	0	1.5	V
3.8195	Transmitting on channel 2480MHz	front face	0	1.5	V
3.8433	Transmitting on channel 2402MHz	front face	0	1.5	V
3.9045	Transmitting on channel 2440MHz	front face	0	1.5	V
3.9691	Transmitting on channel 2480MHz	front face	0	1.5	V
4.8038	Transmitting on channel 2402MHz	front face	0	1.5	V
4.8803	Transmitting on channel 2440MHz	front face	0	1.5	V
4.9602	Transmitting on channel 2480MHz	front face	0	1.5	V

Frequencies identified during Exploratory Radiated Emission maximization

Note 1 : The front face of the EUT is deemed to be 0°, which is then turned in a clockwise direction through 360°.

5.4.9 Electric field emissions, 1GHz to 18GHz

The equipment under test was pre-scanned using peak detection when operating on all three channels. Final measurements were performed with the equipment under test operating on 2440MHz

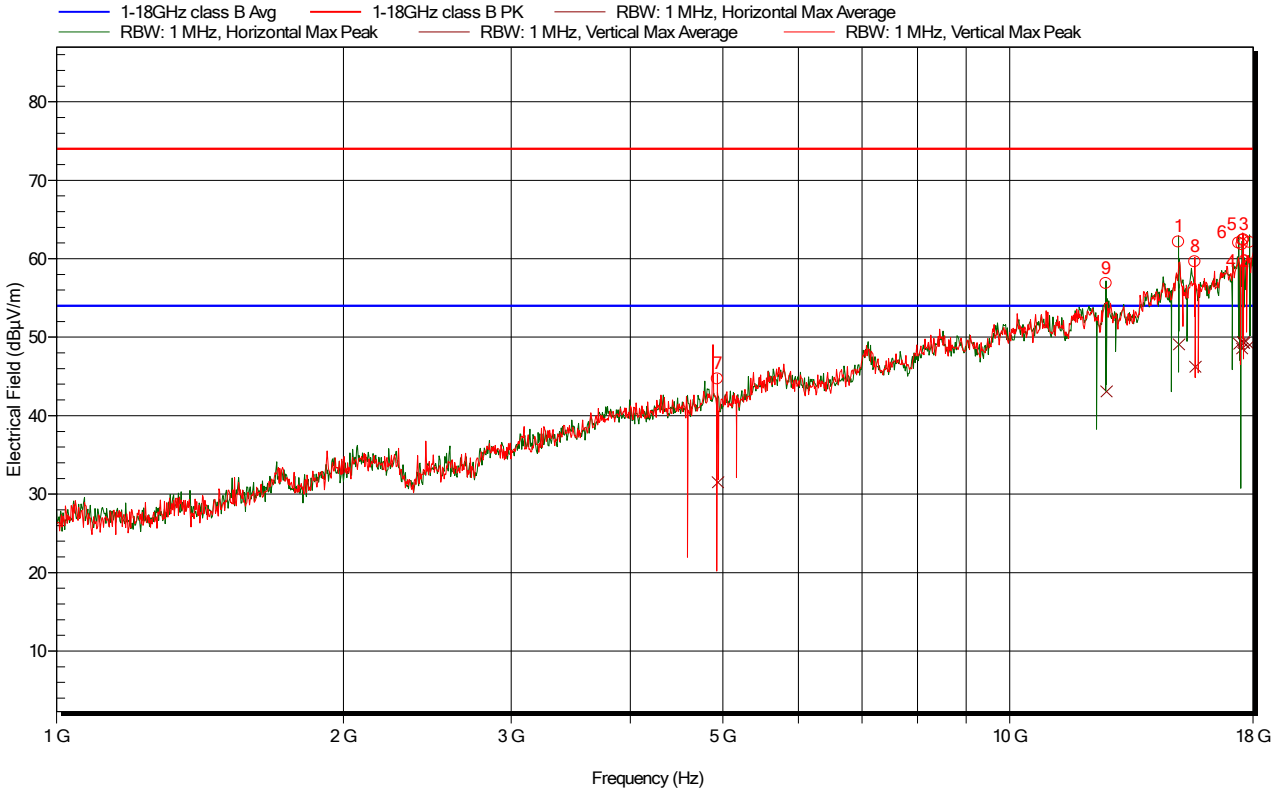

Figure 5.4.9.1: Electric field emissions Plot, 1GHz to 18GHz. Operation on 2440MHz

Frequency	Average	Average Limit	Average Difference	Average Status	Angle	Height	Polarization
GHz	dBµV/m	dBµV/m	dB		degrees	m	
15.033	49.14	54	-4.86	Pass	125	3.8	Horizontal
17.850	49.03	54	-4.97	Pass	190	3.8	Horizontal
17.586	49.32	54	-4.68	Pass	180	2.2	Vertical
17.526	48.55	54	-5.45	Pass	305	2.0	Horizontal
17.554	49.43	54	-4.57	Pass	360	1.1	Vertical
17.380	49.23	54	-4.77	Pass	350	3.1	Horizontal
4.934	31.56	54	-22.44	Pass	60	2.4	Vertical
15.639	46.30	54	-7.70	Pass	10	3.3	Vertical
12.620	43.14	54	-10.86	Pass	310	2.1	Horizontal

Table 5.4.9.1 Electric Field Emissions Peaks, 1GHz to 18GHz – Operation on 2440MHz

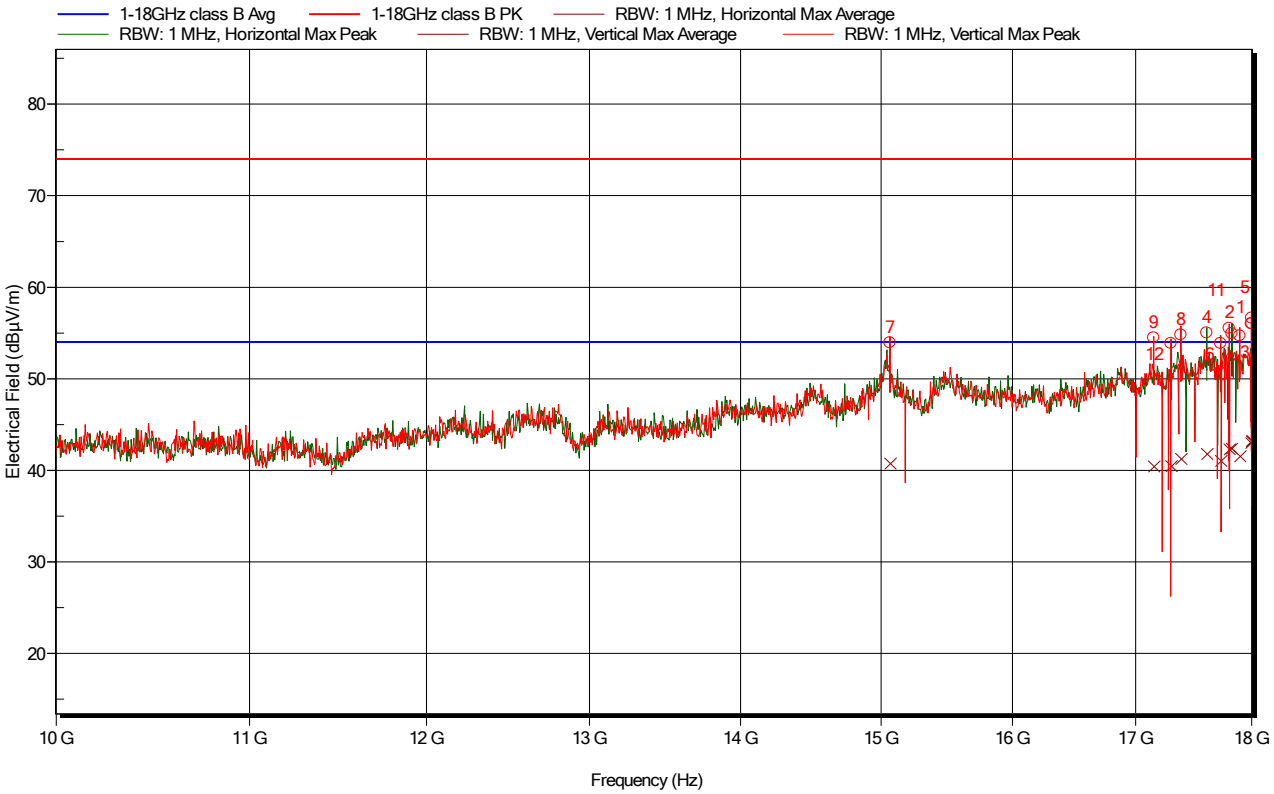

Figure 5.4.9.2: Electric field emissions Plot, 10GHz to 18GHz. 1m measurement distance. Operation on 2440MHz

Frequency	Average	Average Limit	Average Difference	Average Status	Angle	Height	Polarization
GHz	dBµV/m	dBµV/m	dB		degrees	m	
17.999	43.16	54	-10.84	Pass	115	3.6	Horizontal
17.992	42.97	54	-11.03	Pass	225	2.4	Vertical
17.889	41.58	54	-12.42	Pass	185	2.8	Vertical
17.603	41.81	54	-12.19	Pass	280	1.4	Horizontal
18.000	43.21	54	-10.79	Pass	315	1.1	Vertical
17.723	41.06	54	-12.94	Pass	345	1.7	Vertical
15.066	40.79	54	-13.21	Pass	95	2.6	Vertical
17.380	41.29	54	-12.71	Pass	135	2.1	Vertical
17.151	40.44	54	-13.56	Pass	100	2.3	Vertical
17.821	42.35	54	-11.65	Pass	35	3.9	Horizontal
17.798	42.34	54	-11.66	Pass	360	2.2	Vertical
17.296	40.48	54	-13.52	Pass	70	2.1	Vertical

Table 5.4.9.2 Electric Field Emissions Peaks, 10GHz to 18GHz. 1m measurement distance – Operation on 2440MHz

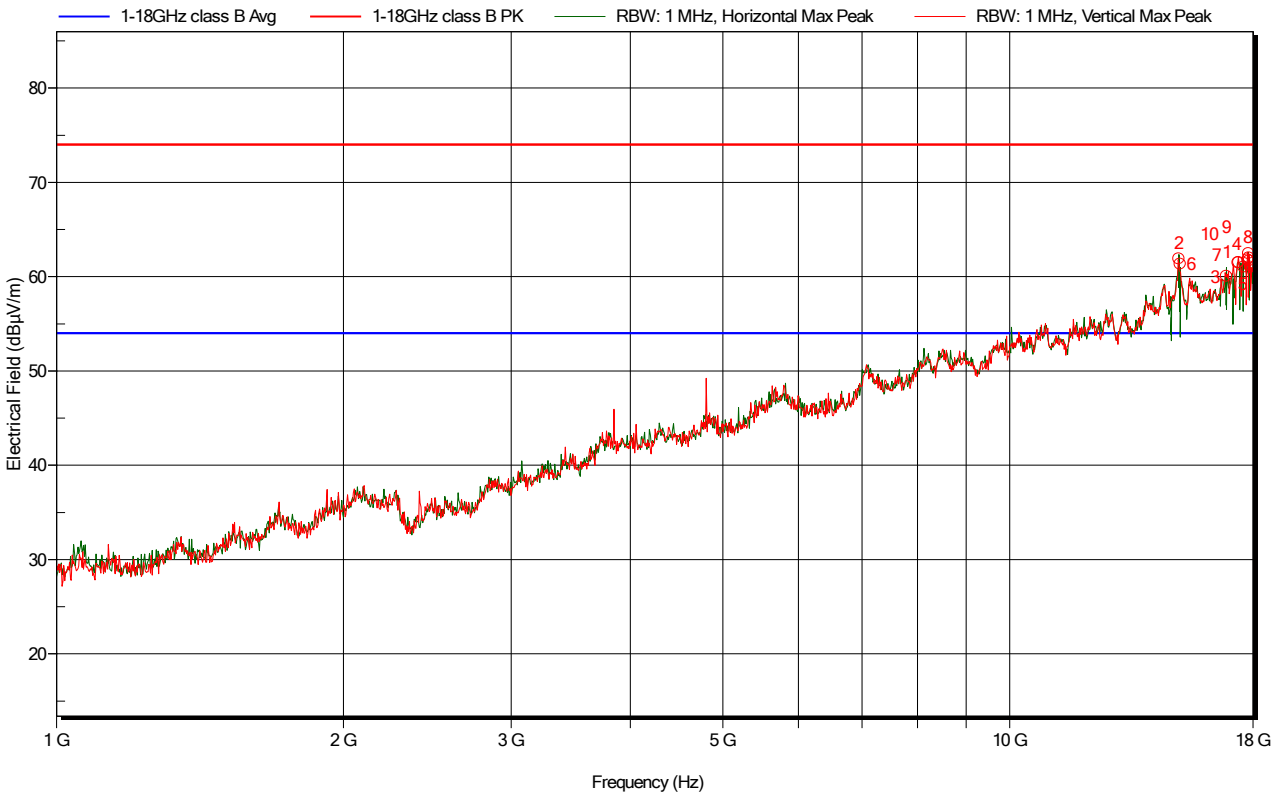

Figure 5.4.9.3: Electric field emissions Plot, 1GHz to 18GHz, Operation on 2402MHz - Peak detector scan

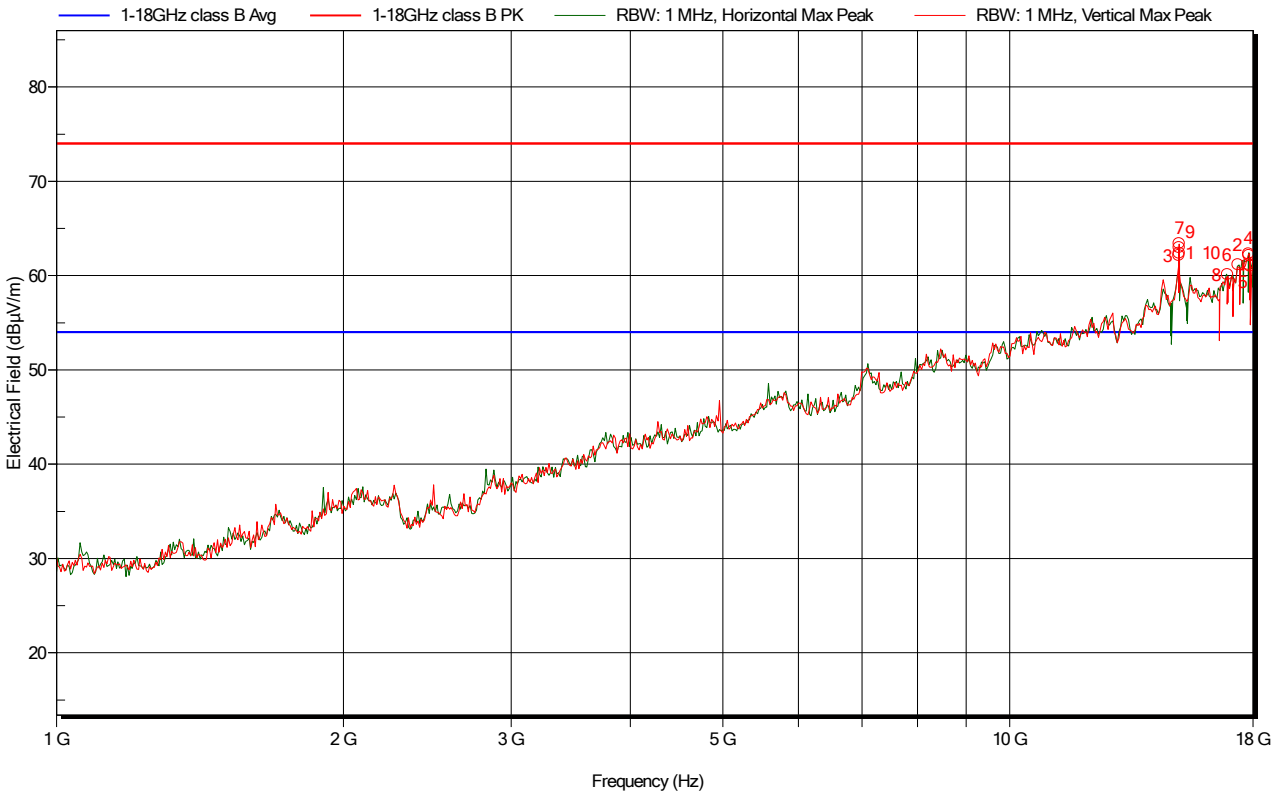

Figure 5.4.9.4: Electric field emissions Plot, 1GHz to 18GHz, Operation on 2480MHz – Peak detector scan

5.4.10 Example field strength calculation

The total average corrections are shown in the above table. This correction figure consists of Preamplifier gain (PG), Antenna factor (AF); and Cable loss (CL), and where necessary distance extrapolation factor (dB).

Field strength (FS) is calculated as follows:

FS (dBµV/m) = Indicated Signal Level (dBµV) + extrap(dB) - PG (dB) + AF (dB) + CL (dB)

5.4.11 Sample Data

From Figure 5.4.9.2 and table 5.4.9.2, The Average level at 17.999GHz is calculated as follows:

FS (dBµV/m) = 40.63(dBµV) - 9.5(dB) - 49.61(dB) +48.54(dB/m) +13.10 (dB) = 43.16BµV/m

Between 10GHz and 18GHz the final measurement was made at 1m distance. The data was then extrapolated to the value expected at 3.

The extrapolation value was calculated as:

$$= -20\log_{10}(\text{measurement distance (1m)} / \text{specification distance (3m)}$$

$$=20\log_{10}(1/3) = -9.5\text{dB}$$

5.5 Radiated Emissions (18GHz to 26GHz)

5.5.1 Limits

Frequency (GHz)	Limit (dBµV/m)	Limit (dBµV/m)
	Peak	Average
18-26	74.0	54.0

5.5.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average and Peak
Start Frequency	18GHz
Stop Frequency	26GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.5.3 Emissions measurements

5.5.4 Date of Test

29th March 2022

5.5.5 Test Area

LAB 1 (SAC)

5.5.6 Tested by

M Dyster

5.5.7 Test Setup

This is the same as for the 1-18GHz range for final measurements, except with a measurement distance of 1m.

5.5.8 Exploratory Radiated Emission Maximization

During exploratory testing, suspect emissions from the EUT were identified both in terms of the frequency and directionality. This was achieved by manually positioning the antenna close to the EUT and also by scanning it over all sides of the EUT whilst observing a spectral display. The typical distance between the surface of the EUT and the scanning antenna was circa 30cm.

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
-	Tx on channels 2402MHz, 2440MHz and 2480MHz.	-	-	-	-

Table 4: Frequencies identified during Exploratory Radiated Emission maximization

Note 2 : The front face of the EUT is deemed to be 0°, which is then turned in a clockwise direction through 360°.

No emissions were identified for further investigation above 18GHz.

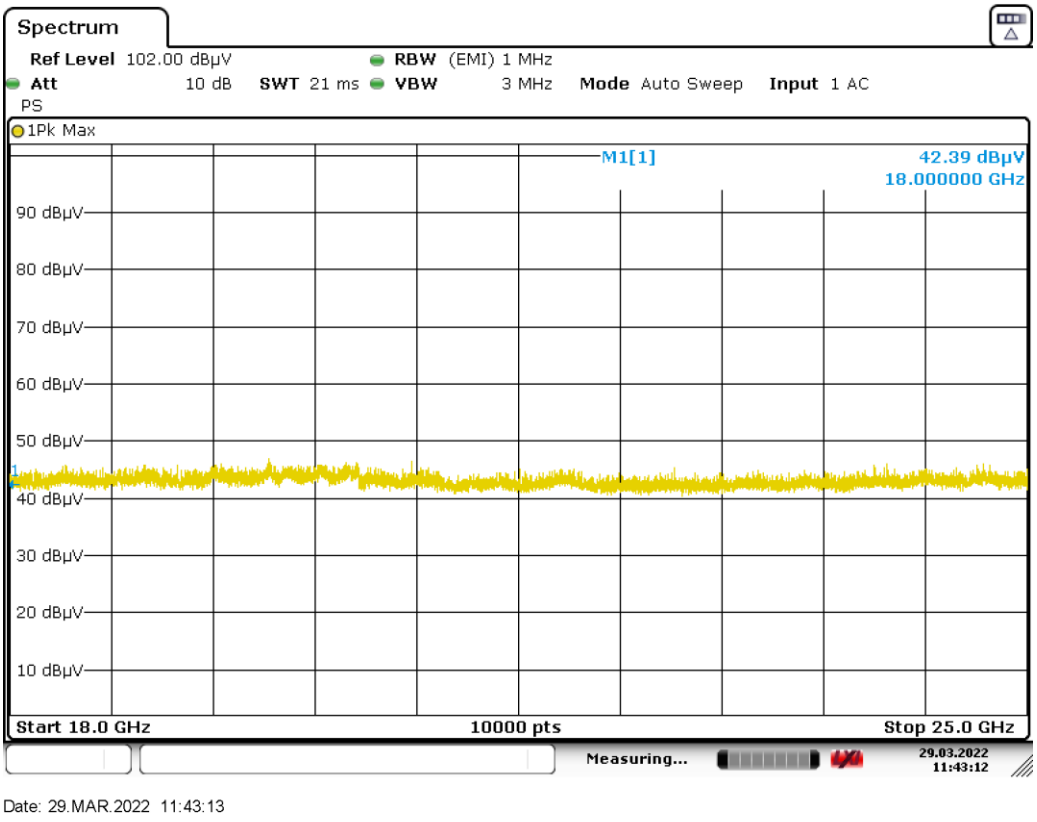

Figure 5.5.8.1 – manual investigation – Operating on channel 2402MHz

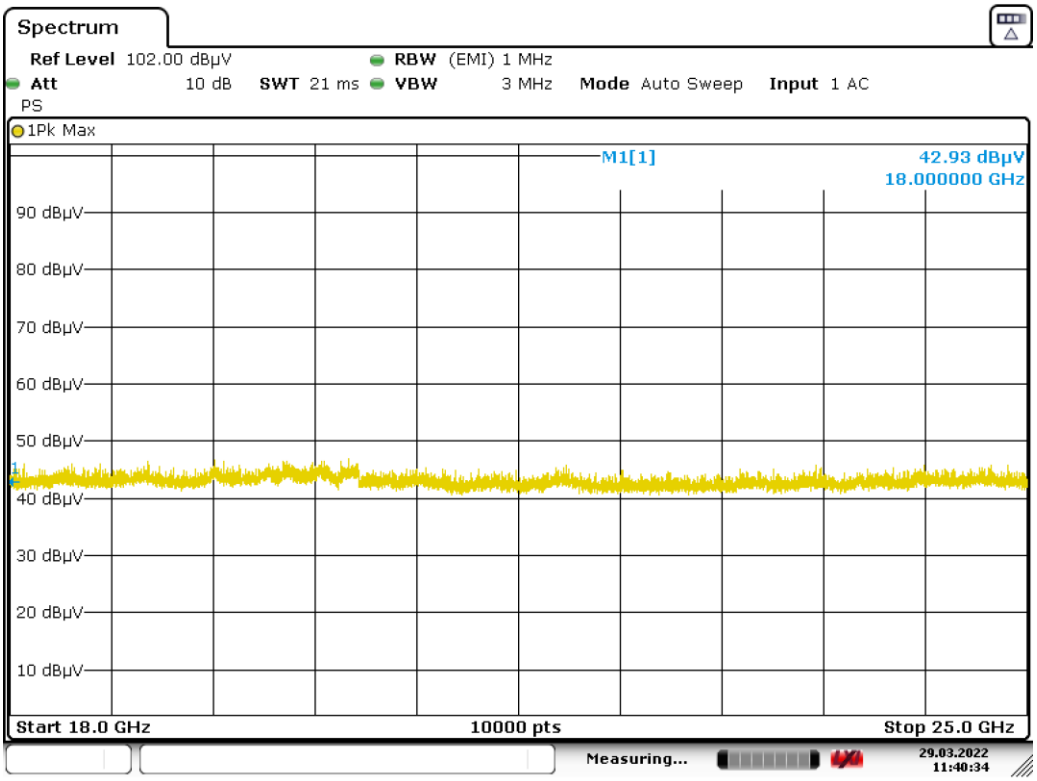

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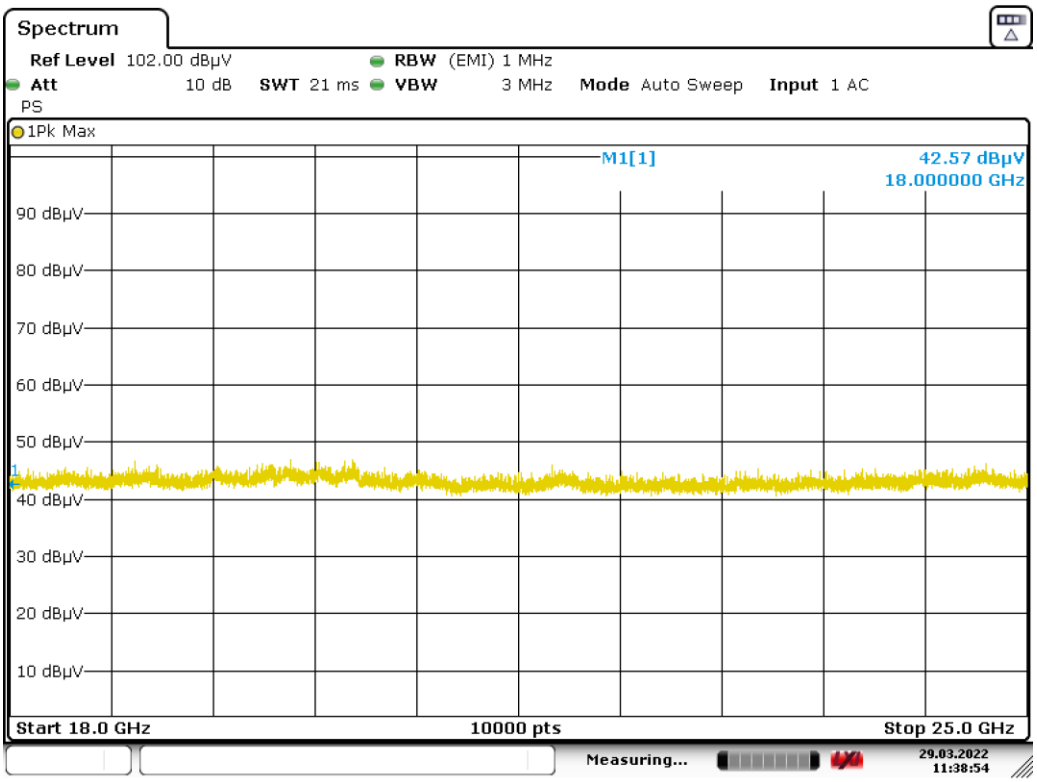
Figure 5.5.8.2 – manual investigation – Operating on channel 2440MHz



Date: 29.MAR.2022 11:38:54

Figure 5.5.8.3 – manual investigation – Operating on channel 2480MHz

5.6 Conducted Spurious Emissions 30MHz to 25GHz

5.6.1 Limits

Frequency (MHz)	Limit, 47CFR 15.247(d)
	Peak
30 – 25000	-20dBc

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.11.2

Receiver Parameters	Setting
Detector Function	Peak
Start Frequency	30MHz
Stop Frequency	1000MHz
Start Frequency	1000MHz
Stop Frequency	25000MHz
Resolution Bandwidth	100kHz
Video Bandwidth	300kHz
Sweep rate	Auto couple
Trace mode	Max hold

5.6.2 Emissions measurements

5.6.3 Date of Test

13th April 2022

5.6.4 Test Area

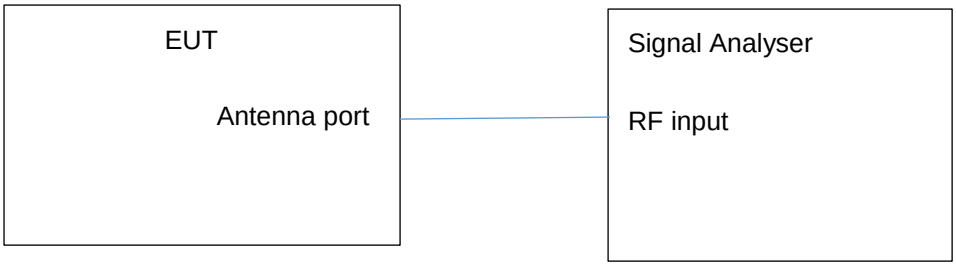
LAB 1

5.6.5 Tested by

J Beevers

5.6.6 Test Setup

The antenna port was connected directly to the signal analyser.

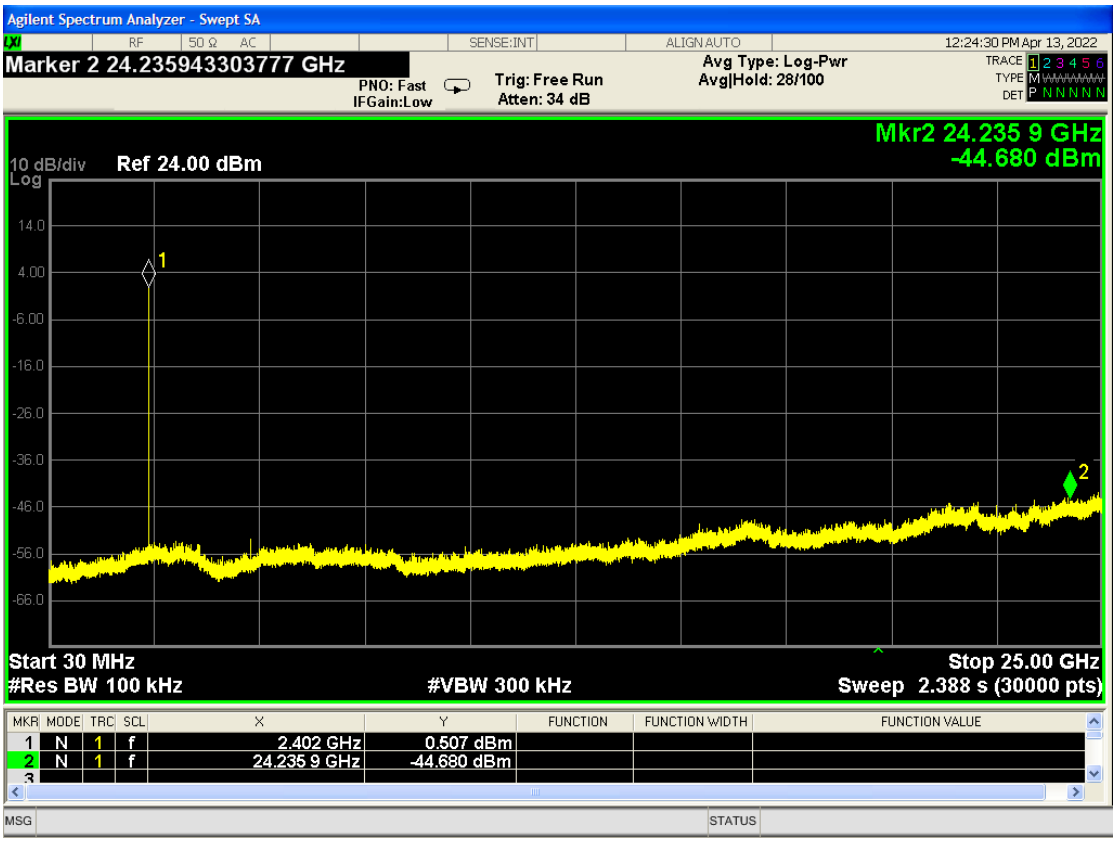


5.6.7 Test Results

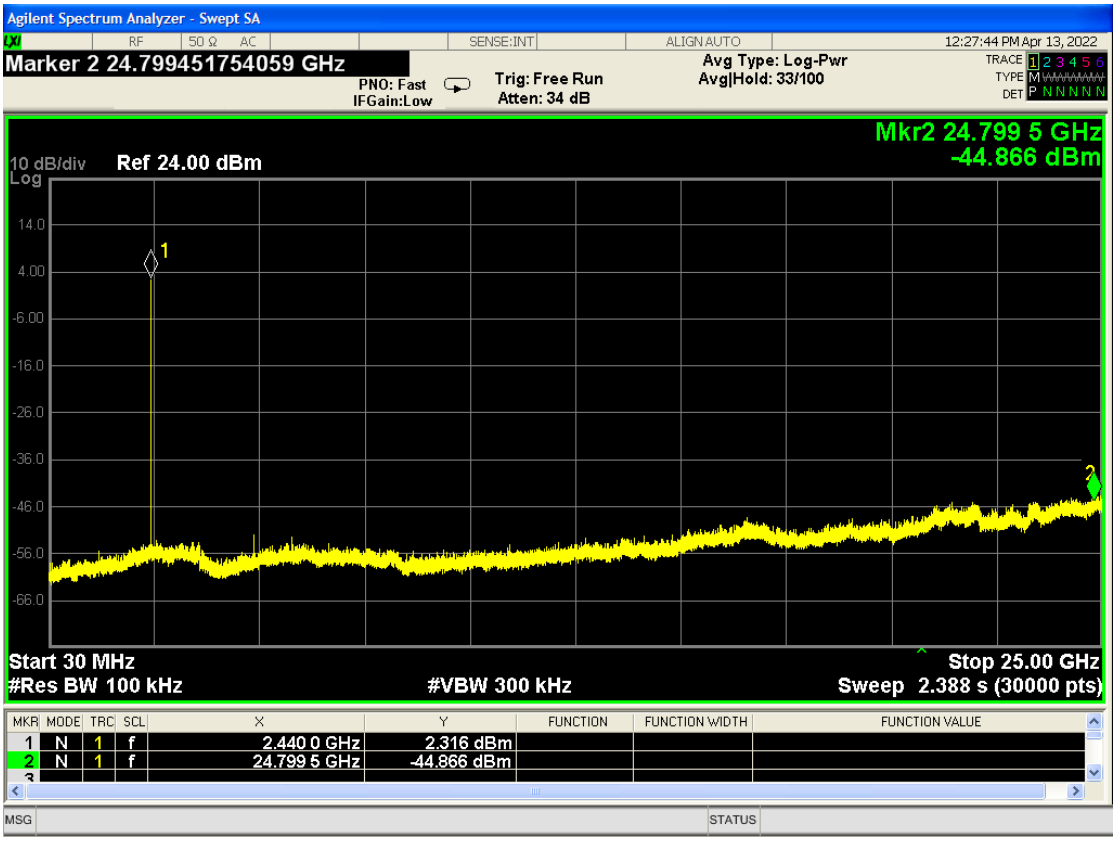
The results of the conducted spurious emissions are stated below and by the signal analyser images.

All disturbances detected were > 20dB below the carrier.

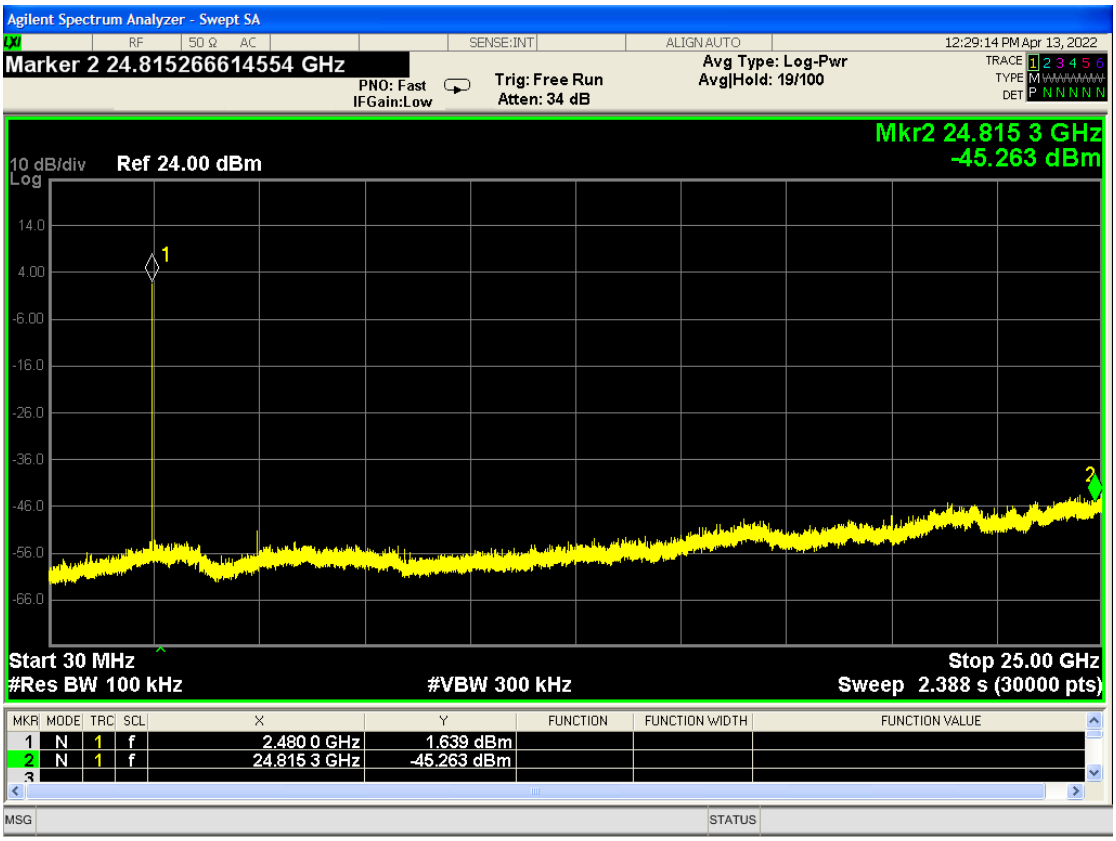
5.6.8 Antenna port conducted emissions, 30MHz to 25GHz



Conducted emissions 30MHz to 25GHz. Operation on channel 2402MHz.



Conducted emissions 30MHz to 25GHz. Operation on channel 2440MHz.



Conducted emissions 30MHz to 25GHz. Operation on channel 2480MHz.

Section 6 20dB Bandwidth and 99% Occupied Bandwidth

6.1 Test Specification

FCC Rule Part	46CFR 15.247 (a)(1)
Standard	ANSI C63.10:2013

6.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	7.8.7
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(a)(1) 20dB bandwidth
	Peak
2400MHz to 2483.5MHz	Less than or equal to 1.5 times the channel separation, provided the systems operate with an output power no greater than 125 mW.

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 6.9.2

Receiver Parameters	Setting
Detector Function	Peak
Span	5MHz
Resolution Bandwidth	50kHz
Video Bandwidth	150kHz
Sweep rate	Auto couple
Trace mode	Max hold

6.2.1 Emissions measurements

6.2.2 Date of Test

13th April 2022

6.2.3 Test Area

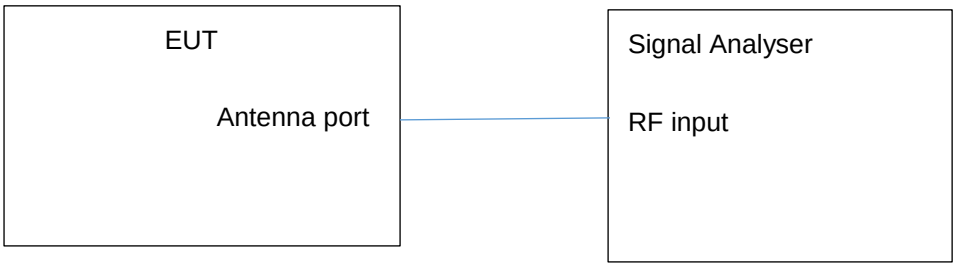
LAB 1

6.2.4 Tested by

J Beevers

6.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



6.2.6 Test Results

The results of the 20dB bandwidth measurements are stated in the table below and by the signal analyser images.

Channel (MHz)	99% Occupied Bandwidth (MHz)	Measured 20dB bandwidth (MHz)	limit (MHz)	Figure	Result
2402.0	1.1669	1.303	1.5	6.2.6.1	Pass
2440.0	1.1687	1.303	1.5	6.2.6.2	Pass
2480.0	1.1680	1.300	1.5	6.2.6.3	Pass

Bandwidth Measurements

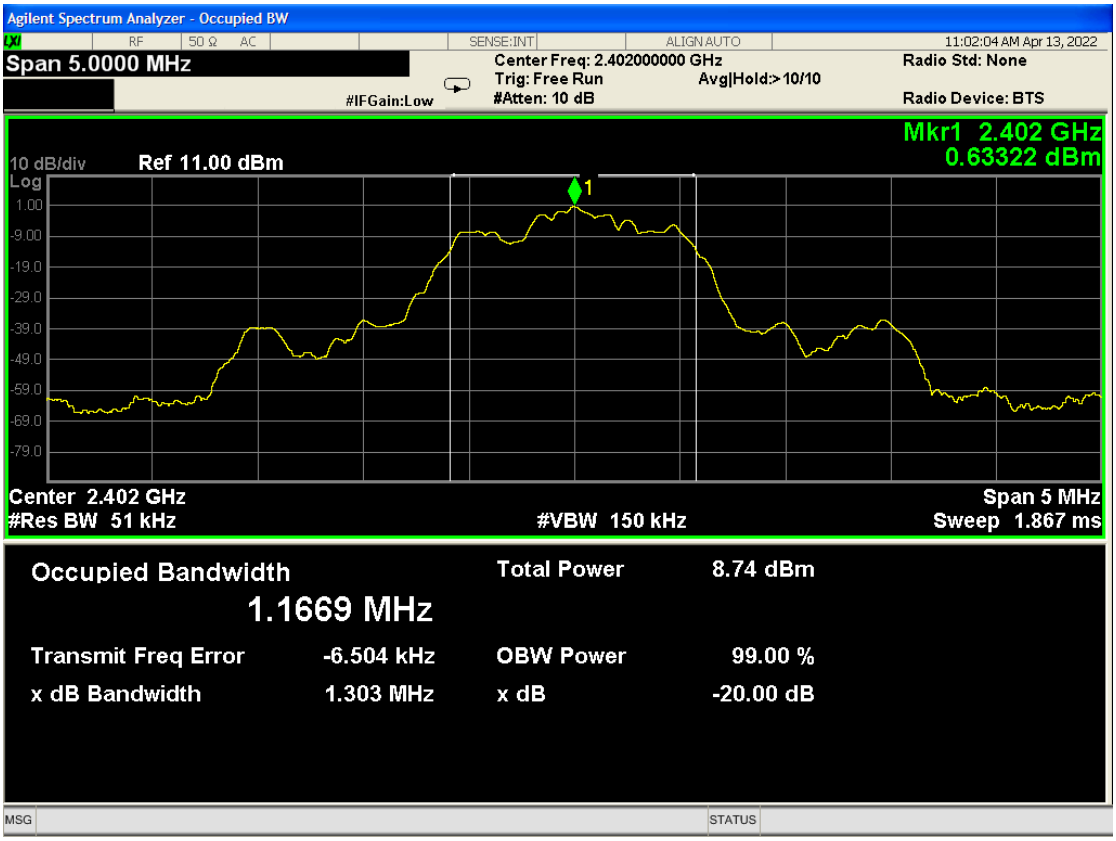


Figure 6.2.6.1 Bandwidth at 20dB Point and 99% Occupied Bandwidth. Operation on channel 2402MHz

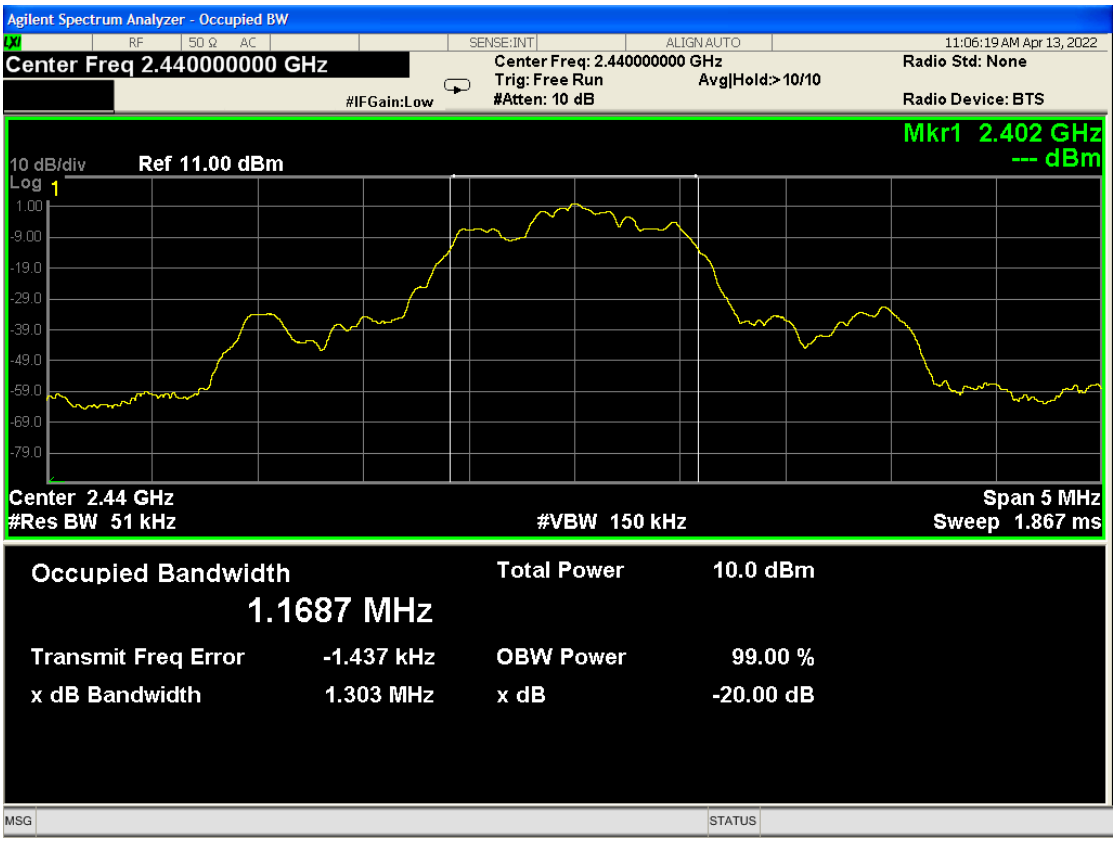


Figure 6.2.6.2 Bandwidth at 20dB Point and 99% Occupied Bandwidth. Operation on channel 2440MHz

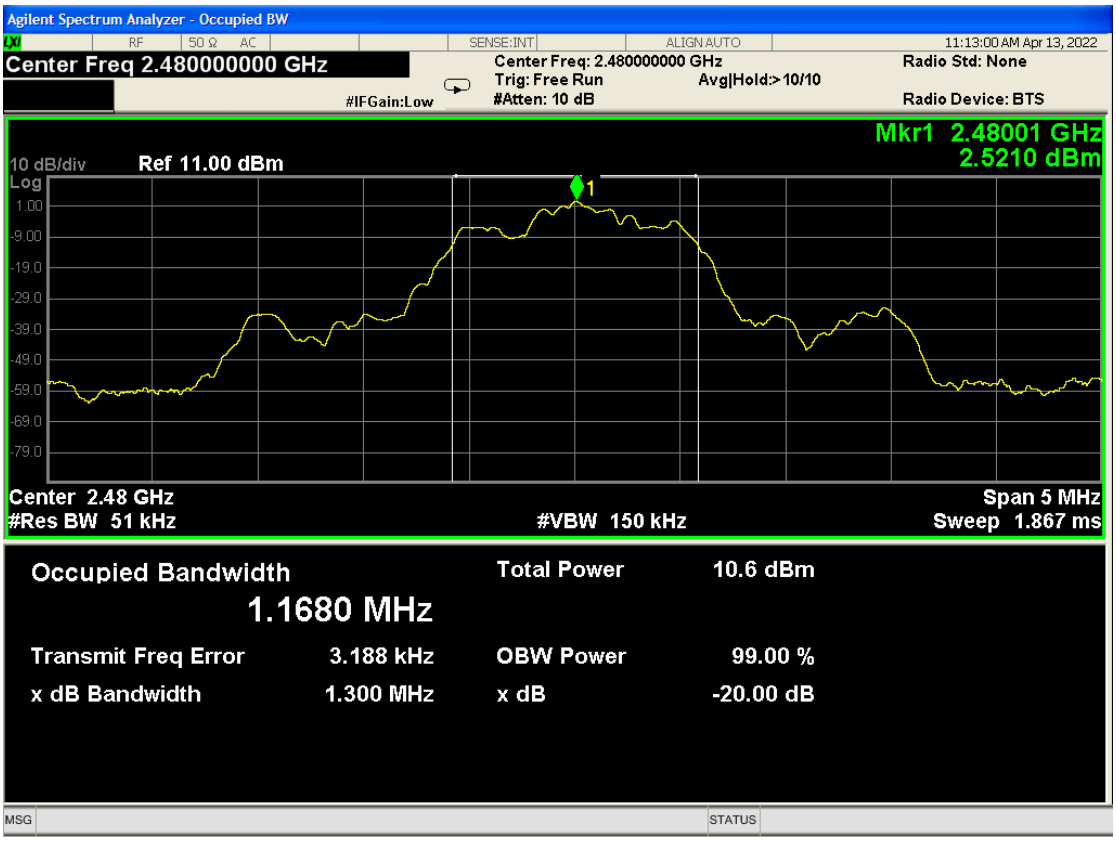


Figure 6.2.6.3 Bandwidth at 20dB Point and 99% Occupied Bandwidth. Operation on channel 2480MHz

Section 7 Peak Output Power

7.1 Test Specification

FCC Rule Part	46CFR 15.247 (b)(1)
Standard	ANSI C63.10:2013

7.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	7.8.5
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(b)(1)
	Peak
2400MHz to 2483.5MHz	0.125 watt

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 7.8.5

Receiver Parameters	Setting
Detector Function	Peak
Span	7MHz
Resolution Bandwidth	1.5MHz
Video Bandwidth	5MHz
Sweep rate	Auto couple
Trace mode	Max hold

7.2.1 Emissions measurements

7.2.2 Date of Test

13th April 2022

7.2.3 Test Area

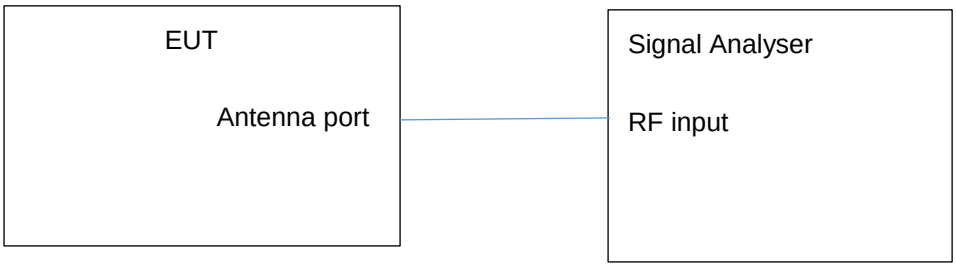
LAB 1

7.2.4 Tested by

J Beevers

7.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



7.2.6 Test Result

The results of the peak output power measurements are stated in the table below and by the signal analyser images.

Channel (MHz)	Peak Power (dBm)	Peak Power (Watts)	Limit (Watts)	Figure
2402	3.729	0.00236	0.125	7.2.6.1
2440	4.830	0.00304	0.125	7.2.6.2
2480	5.016	0.00317	0.125	7.2.6.3

Peak Output Power Measurement

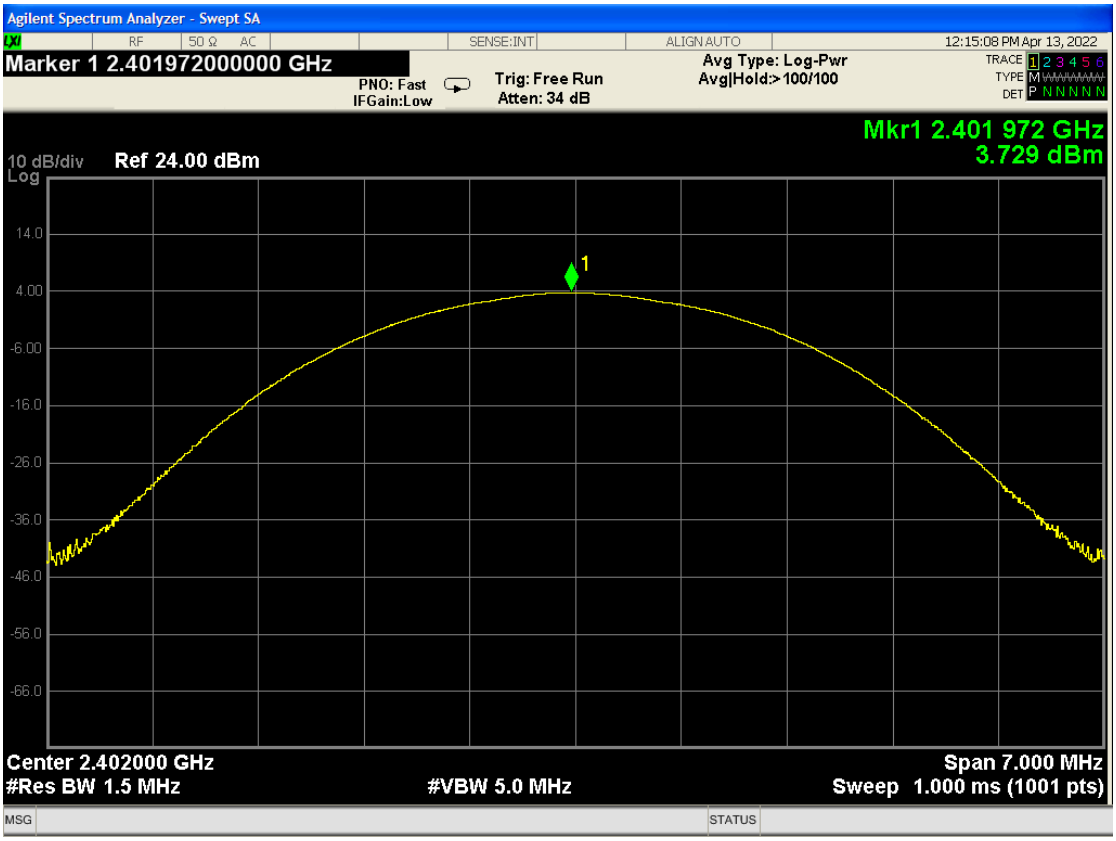


Figure 7.2.6.1 Peak output power, Operation on channel 2402MHz

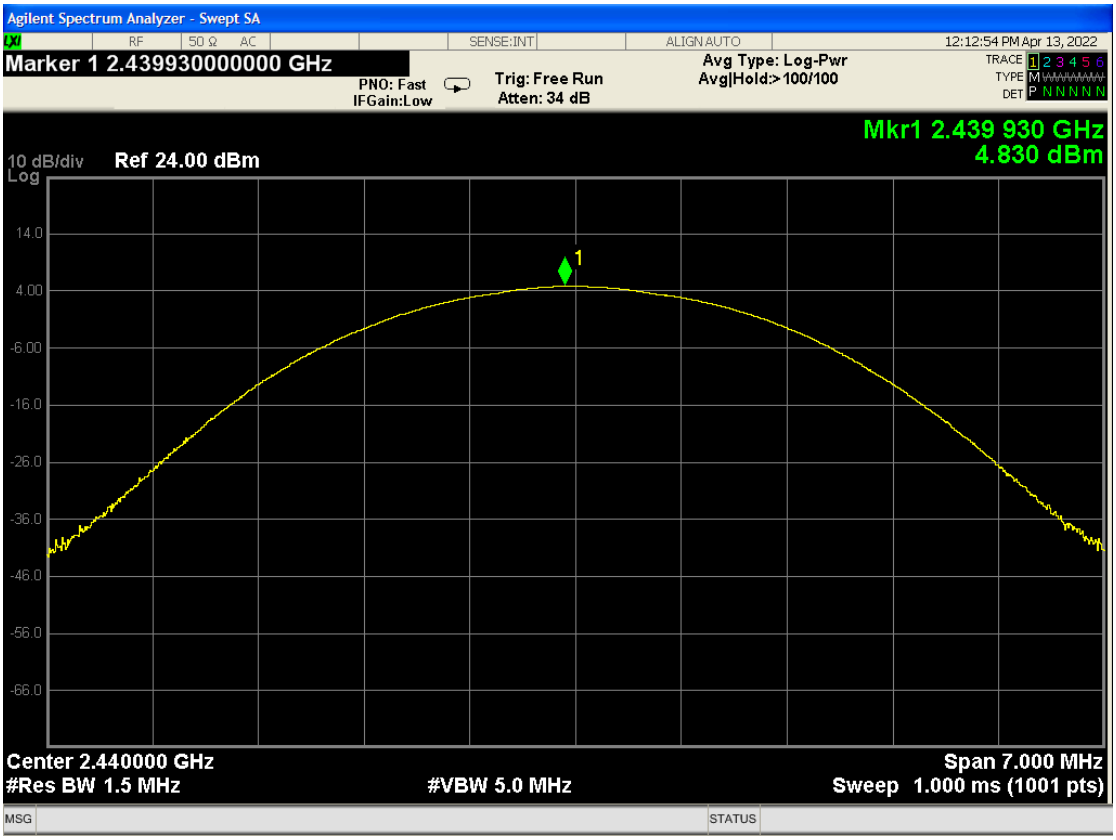


Figure 7.2.6.2 Peak output power, Operation on channel 2440MHz

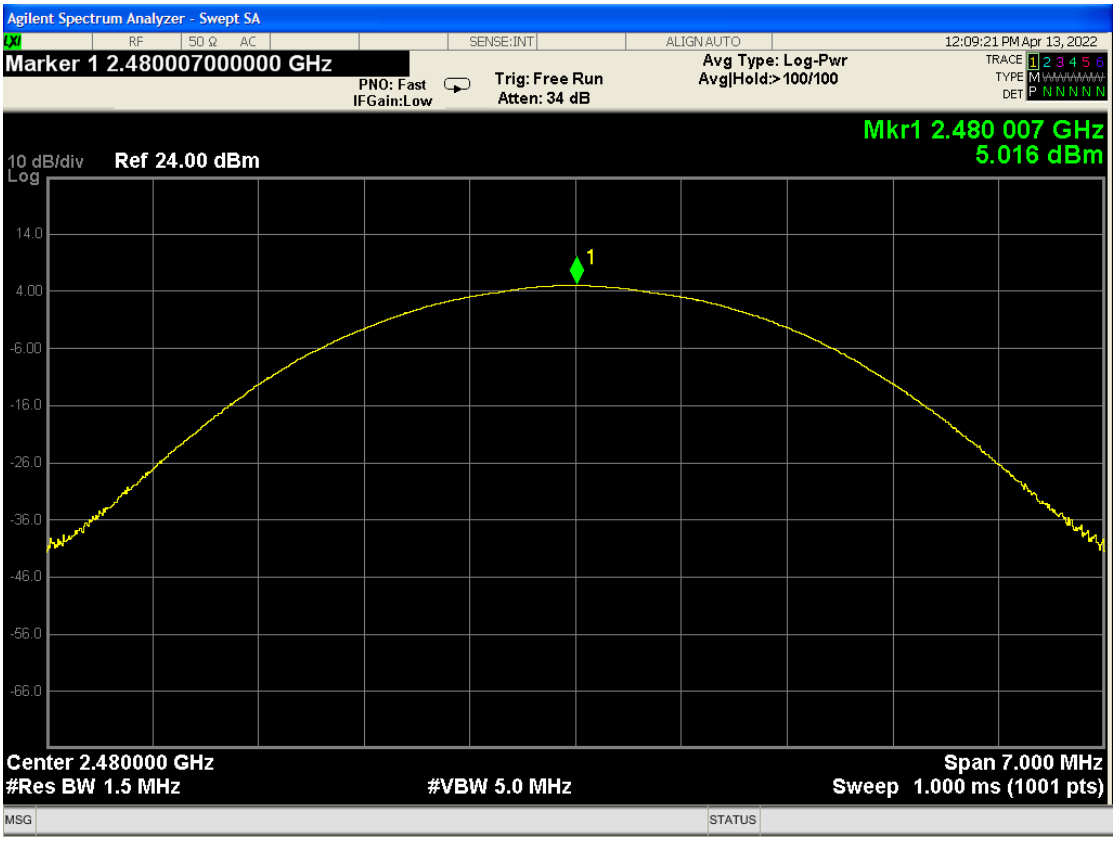


Figure 7.2.6.3 Peak output power, Operation on channel 2480MHz

Section 8 Frequency Hopping Spread Spectrum Requirements

8.1 Number of Hopping Frequencies

FCC Rule Part	47CFR15.247(a)(1)(iii)
Standard	ANSI C63.10:2013

Frequency hopping systems in the 2400-2483.5MHz band shall use at least 15 channels.

The procedure described in ANSI C63.10-2013 Clause 7.8.3 was followed.

8.1.1 Date of Test

14th April 2022

8.1.2 Test Area

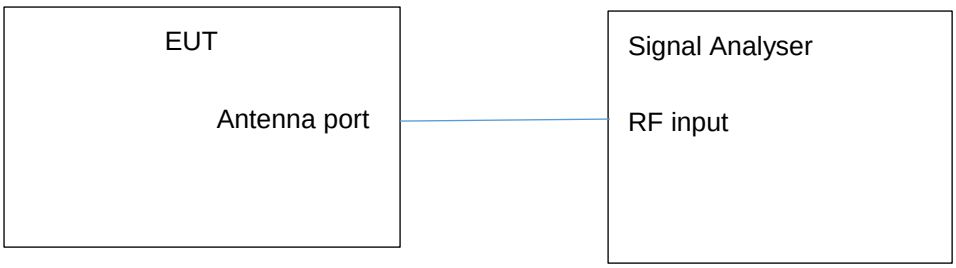
LAB 1

8.1.3 Tested by

J Beevers

8.1.4 Test Setup

The antenna port was connected directly to the signal analyser.



8.1.5 Test Results

The results show that 79 hopping channels were utilised. The analyser screen displays show the 79 hopping channels, split into three subranges:

Overall requirement of at least 15 channels was met.

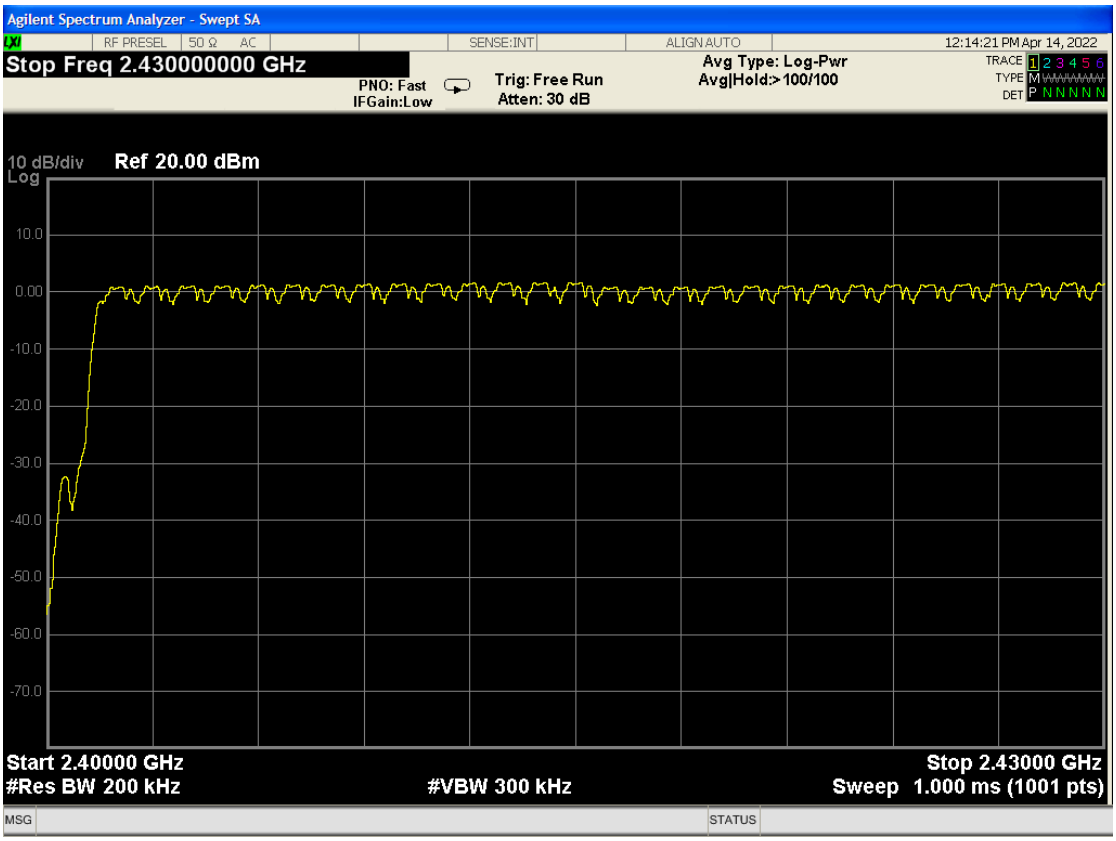


Figure 8.1.5.1 Number of hopping frequencies

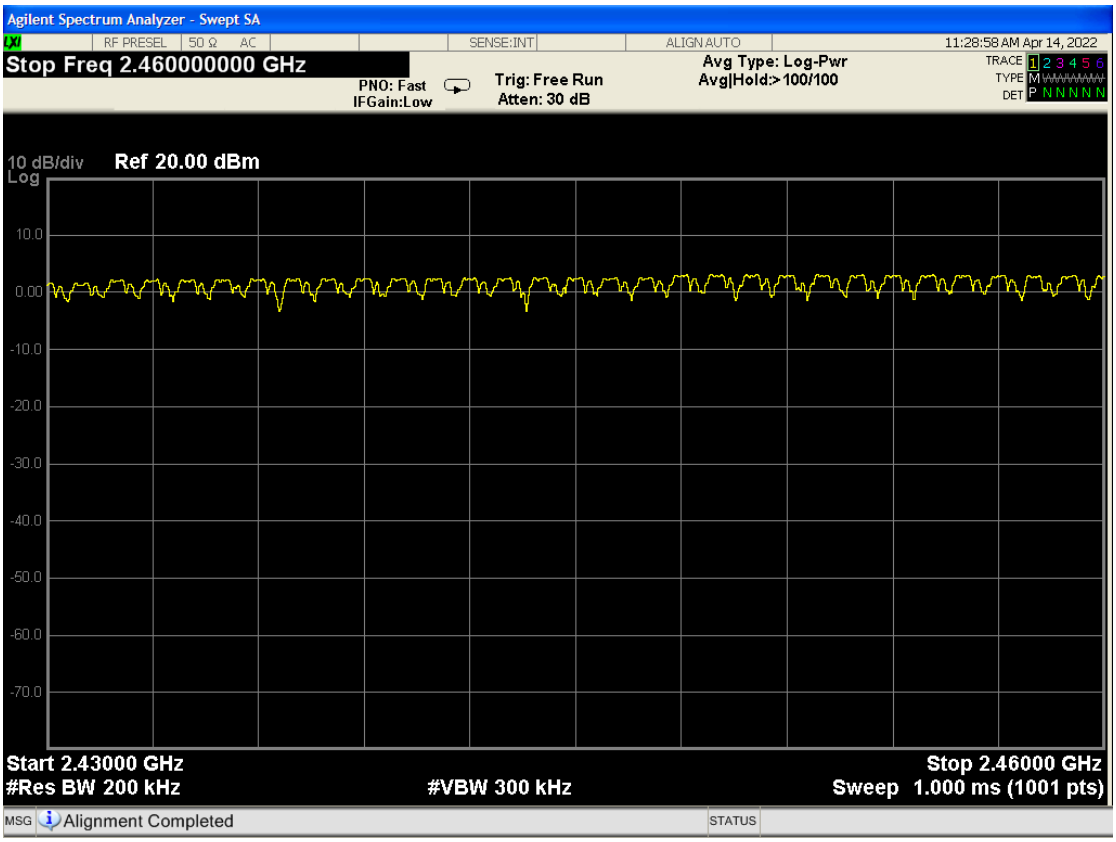


Figure 8.1.5.2 Number of hopping frequencies

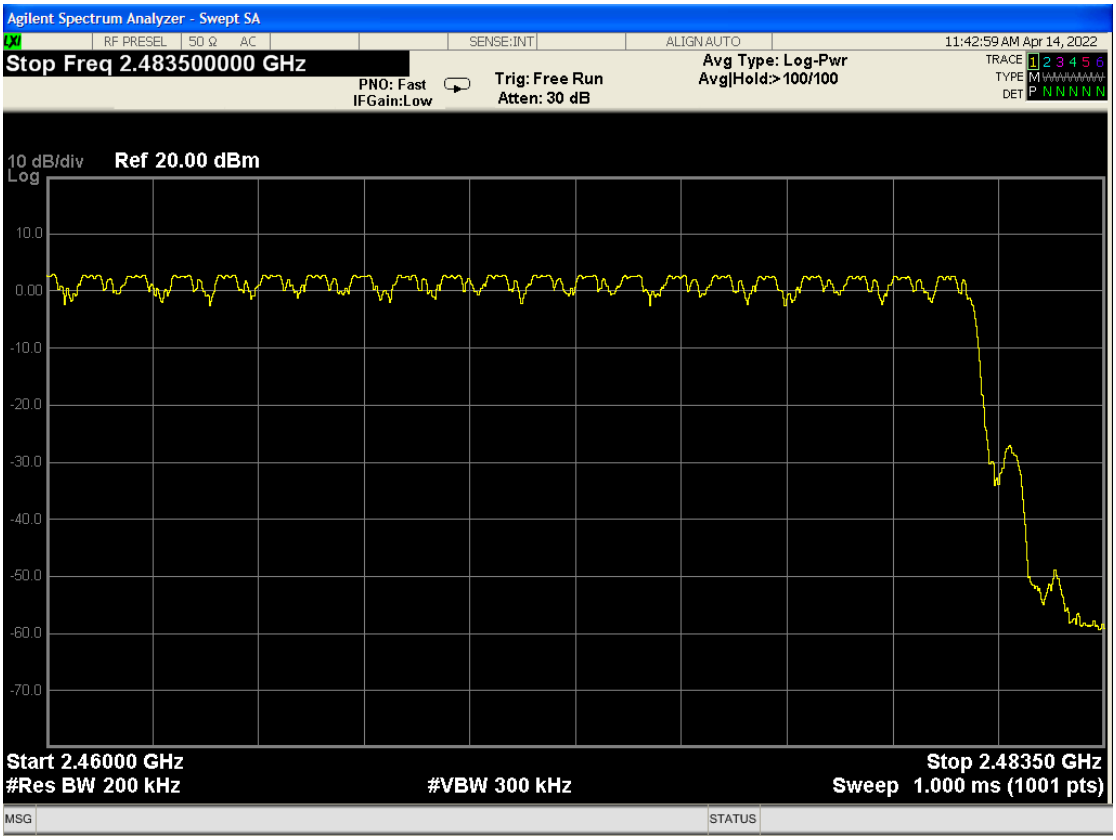


Figure 8.1.5.3 Number of hopping frequencies

8.2 Frequency Hopping Channel Separation

FCC Rule Part	47CFR15.247(a)(1)
Standard	ANSI C63.10:2013

8.2.1 Date of Test

14th April 2022

8.2.2 Test Area

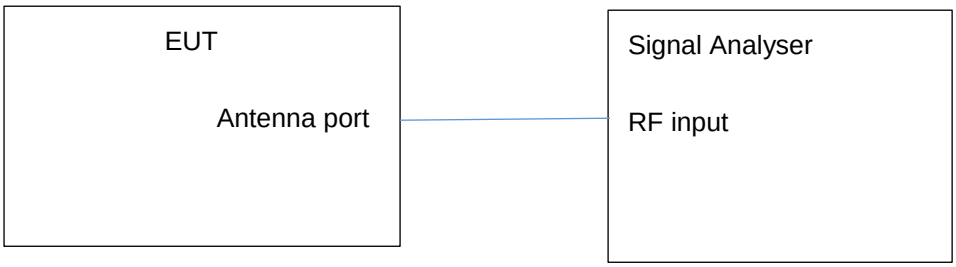
LAB 1

8.2.3 Tested by

J Beevers

8.2.4 Test Setup

The antenna port was connected directly to the signal analyser.



8.2.5 Requirement 47CFR15.247(a)(1)

Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

As the output power was measured to be less than 125 mW and since two thirds of the measured 20dB bandwidth is greater than 25kHz, the carrier frequency separation shall be > two thirds of the measured 20dB bandwidth.

8.2.6 Procedure

The procedure described in ANSI C63.10-2013 Clause 7.8.2 was followed.

8.2.7 Test Results

Between any two adjacent channels the carrier separation was measured to be, compliant with the requirement.

Measured Separation (kHz)	Limit (kHz)	Result
999.2	>868.6	Pass

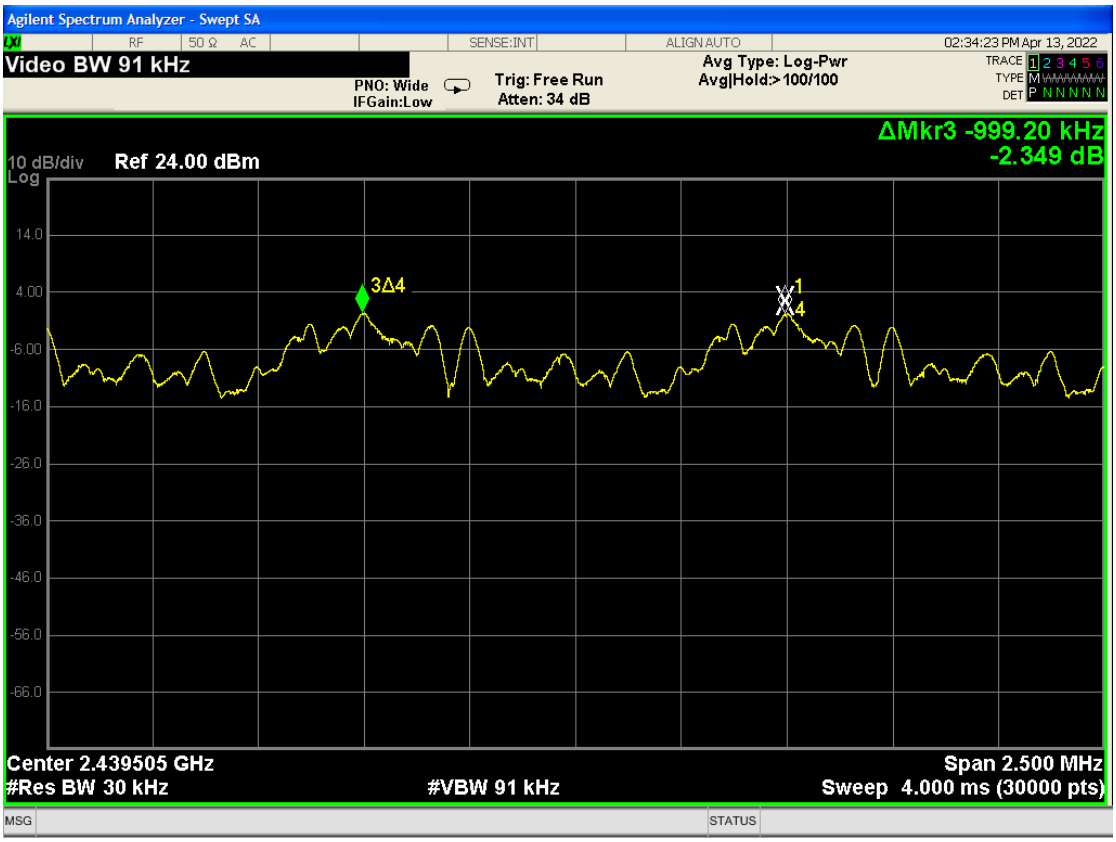


Figure 8.2.7.1: Carrier frequency separation

8.3 Hopping Channel Occupancy Time

FCC Rule Part	47CFR15.247(a)(1)(iii)
Standard	ANSI C63.10:2013

8.3.1 Date of Test

14th April 2022

8.3.2 Test Area

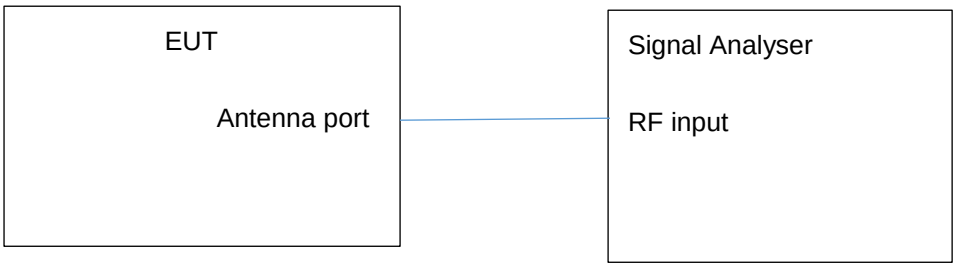
LAB 1

8.3.3 Tested by

J Beevers

8.3.4 Test Setup

The antenna port was connected directly to the signal analyser.



8.3.5 Requirement 47CFR15.247(a)(1)(iii)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

8.3.6 Procedure

The procedure described in ANSI C63.10-2013 Clause 7.8.4 was followed.

8.3.7 Test Results

Sweep time (s)	No of hops measured in sweep time	No of hopping channels used	period specified by requirements	No of hops in period specified by requirements	Occupancy time (s)	Limit (s)	Average time of occupancy (s)
1	10	79	31.6	316	3.88×10^{-04}	0.4	0.1227

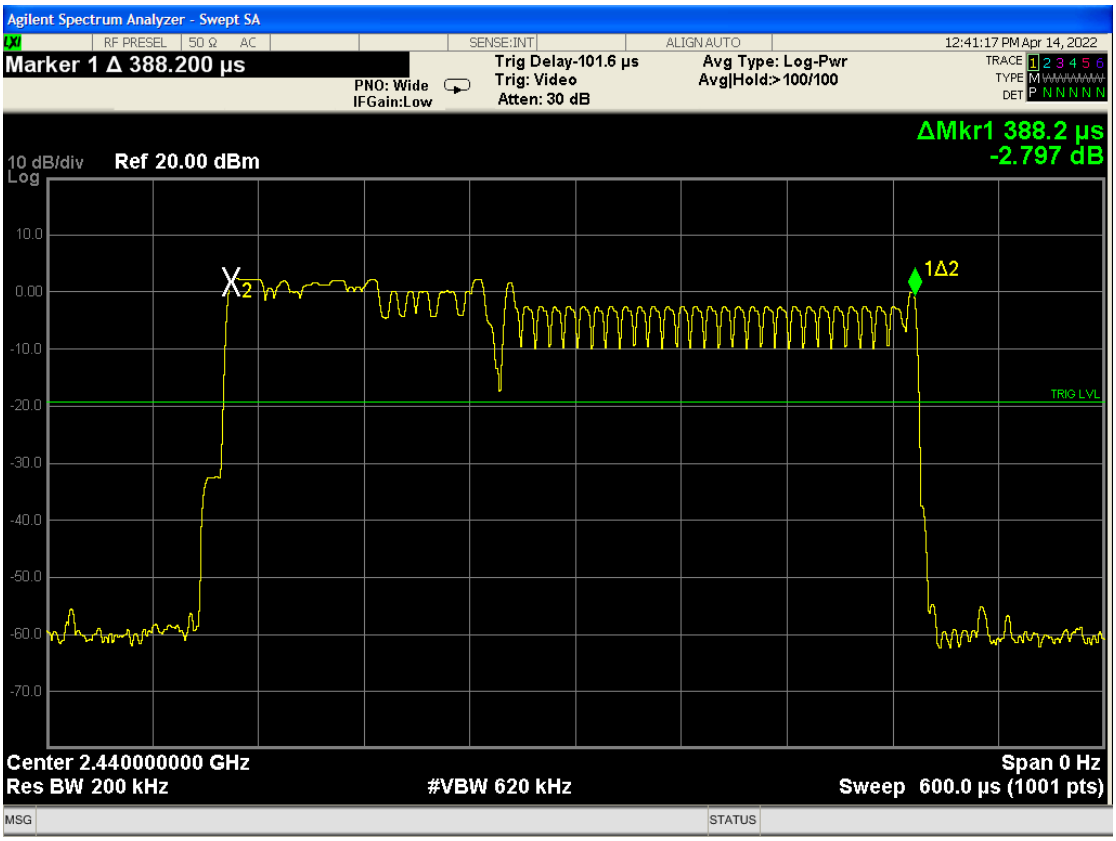


Figure 8.3.7.1: Transmit time per hop

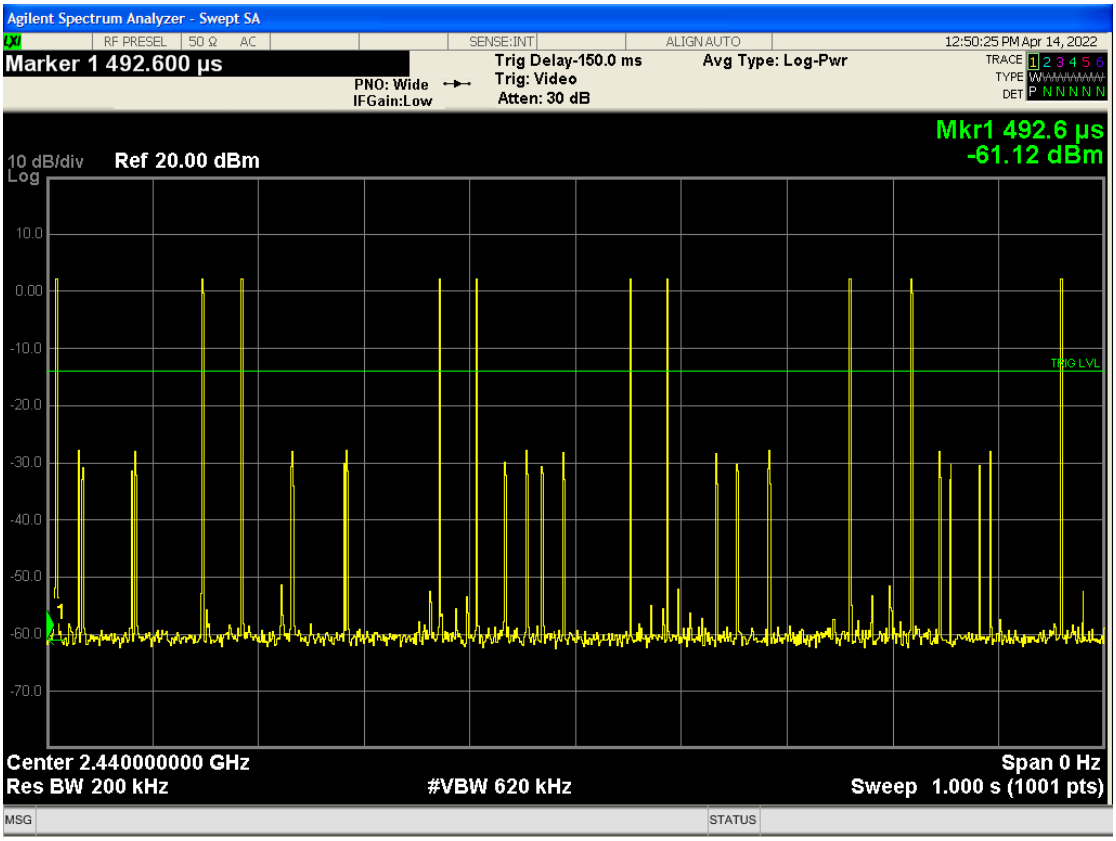


Figure 8.3.7.2: Number of Hops in specified period

Section 9 Band Edge Compliance

9.1 Test Specification

FCC Rule Part	46CFR 15.205 and 47CFR15.209
Standard	ANSI C63.10:2013

9.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	Clause 6.10.4 Authorised band-edge measurements
Test software	N/A

Frequency (MHz)	**Limit, 47CFR 15.247(e)**
	Peak
2400MHz to 2483.5MHz	Measured signal at the band edge must be below the radiated emission limits of 47CFR15.209

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 6.10.5 “Restricted band-edge measurements”

Receiver Parameters	**Setting**
Detector Function	Peak
Span	As necessary
Resolution Bandwidth	1MHz
Video Bandwidth	3 x RBW
Sweep rate	Auto couple
Trace mode	Max hold

9.2.1 Emissions measurements

9.2.2 Date of Test

4th April 2022

9.2.3 Test Area

LAB 1

9.2.4 Tested by

J Beevers

9.2.5 Test Setup

The test setup was identical to radiated emissions testing 1-18GHz.

9.2.6 Test Results

Results are presented in two formats:

Tabular results of measurements at the band edges. Manual measurements were performed to measure the maximum value of signal at the band edge. The tabular data includes the following:

1. Polarity of the measurement antenna
2. Frequency at the band edge
3. Amplitude of signal at the input of the test receiver
4. Pre-amplifier gain
5. Cable loss
6. Antenna factor
7. Resultant Electric field strength = 3-4+5+6

Spectrum analyser screen displays are also included. Please note that the screen displays do not include losses or antenna factor.

Tabular Data

The following radiated measurements were made at the band edges:

Upper band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	66.8	54.270	4.28	29.89	46.694	74	27.306
V	2483.5	80.3	54.270	4.28	29.89	60.194	74	13.806

Operation on 2480MHz Channel, Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	45.6	54.270	4.28	29.89	25.494	54	28.506
V	2483.5	46.2	54.270	4.28	29.89	26.094	54	27.906

Operation on Channel 2480MHz, average detector measurements

Lower band edge

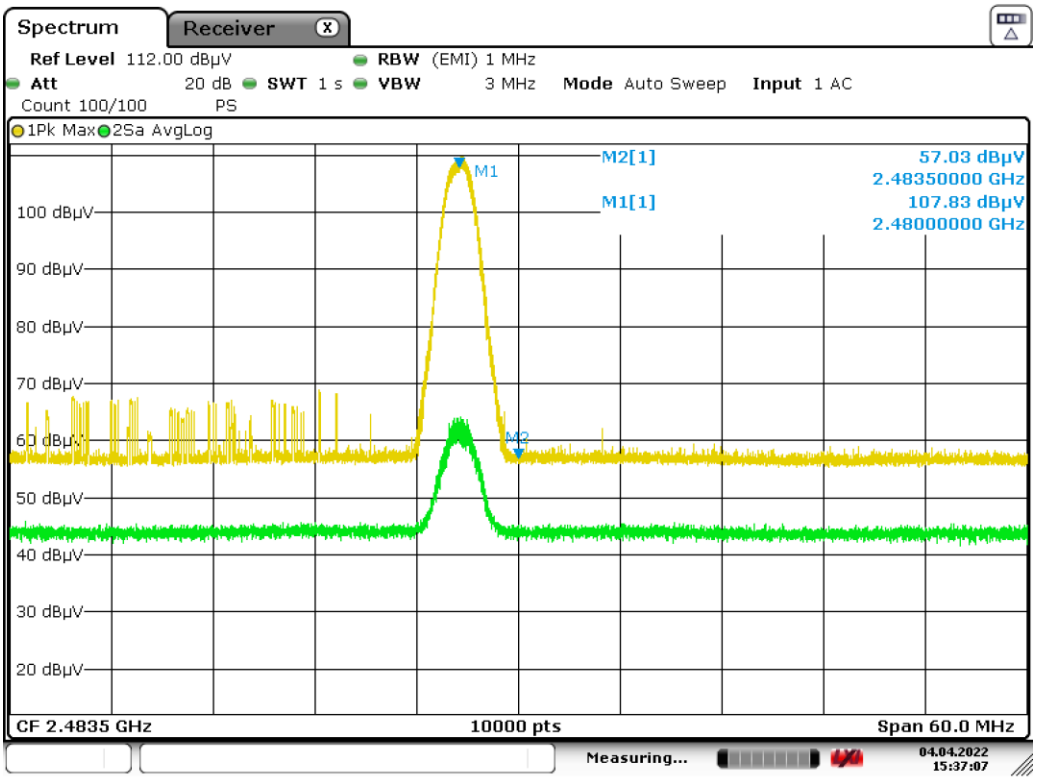
Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	76	54.242	4.16	29.67	55.588	74	18.412
V	2400	76	54.242	4.16	29.67	55.588	74	18.412

Operation on channel 2402MHz Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	51.1	54.242	4.16	29.67	30.688	54	23.312
V	2400	53.4	54.242	4.16	29.67	32.988	54	21.012

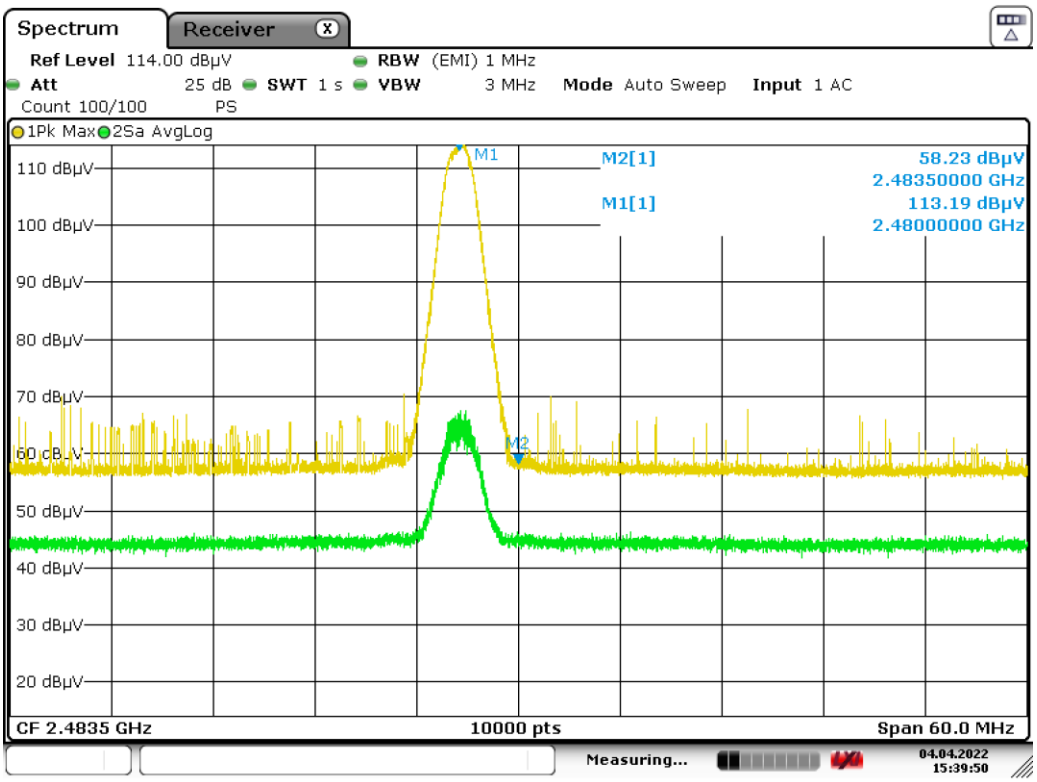
Operation on channel 2402MHz average detector measurements

Spectrum analyser displays



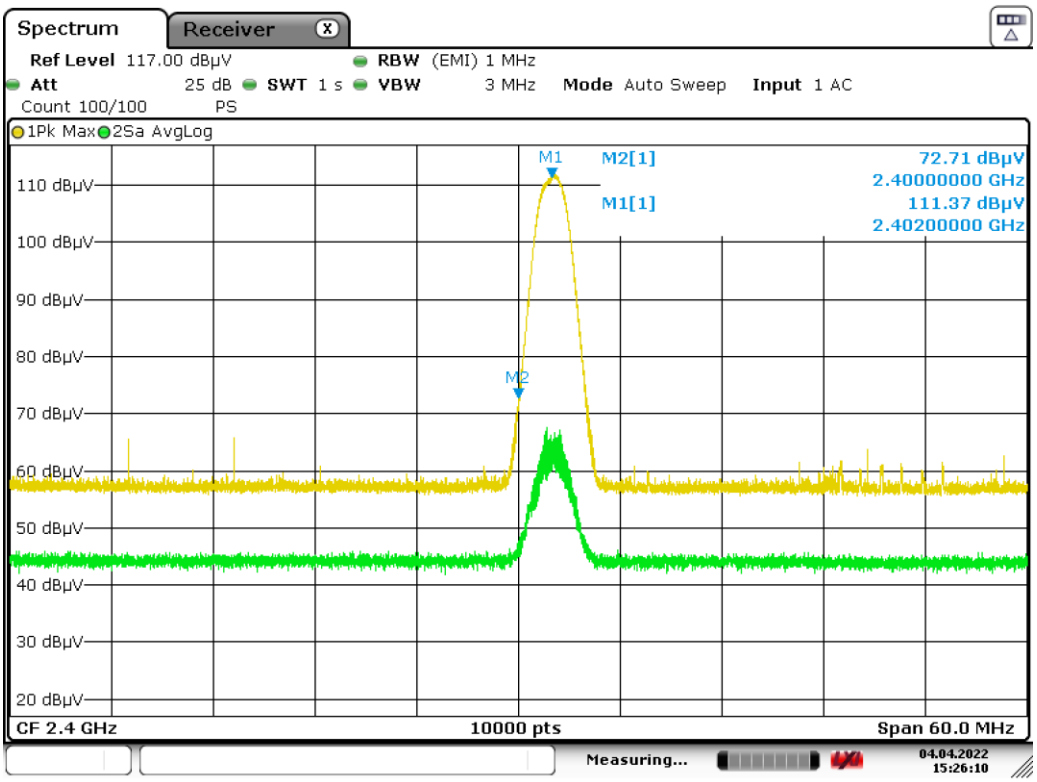
Date: 4.APR.2022 15:37:07

Band Edge Measurement – upper band edge - horizontal polarity



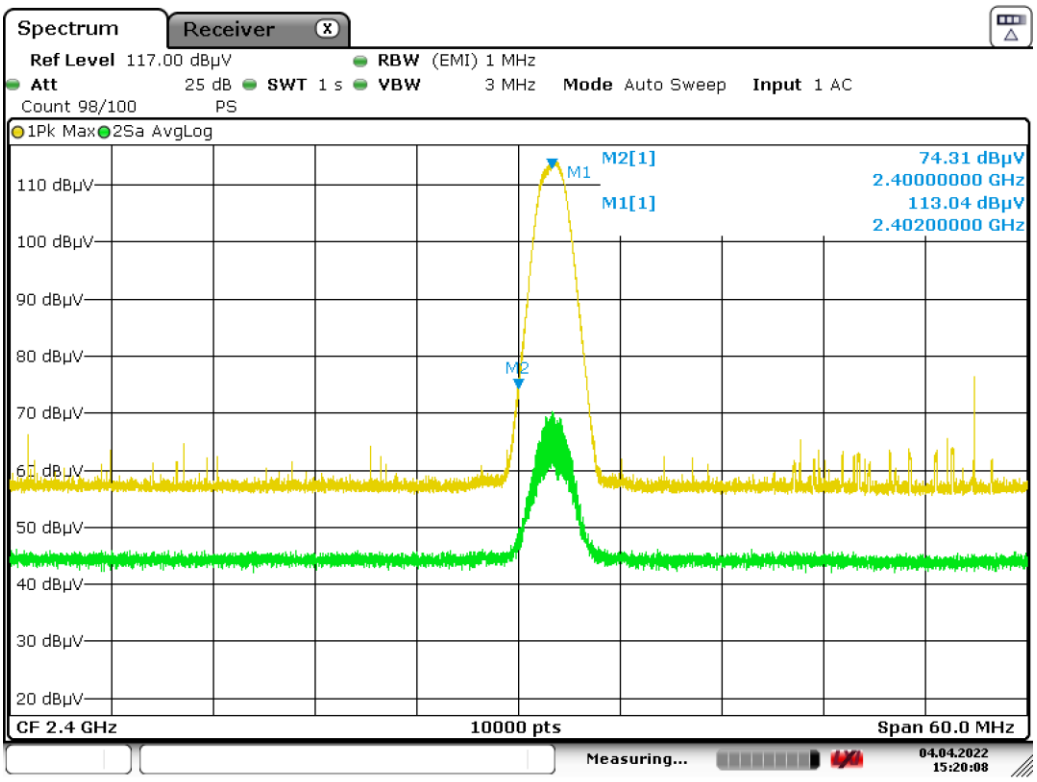
Date: 4.APR.2022 15:39:51

Band Edge Measurement – upper band edge - vertical polarity



Date: 4.APR.2022 15:26:10

Band Edge Measurement – lower band edge - horizontal polarity



Date: 4.APR.2022 15:20:08

Band Edge Measurement – lower band edge - vertical polarity

Appendix A EUT Test Photos

Test set up photographs are supplied separately.

Appendix B Test Equipment List

Conducted Emissions from Antenna Port

Item	Serial No.	Last Calibration Date	Calibration Interval
RF Cable	Cable 14	January 2022	12 Months
Agilent MXE EMI Receiver	C0339	25th January 2022	12 Months

Radiated Emissions Equipment

Item	Serial No.	Last Calibration Date	Calibration Interval
Laboratory 1 Semi-Anechoic Chamber	Lab 1	28th January 2020	36 Months
ETS Lindgren 2017B Mast (1 – 4m) with tilting mechanism	--	N/A	N/A
R & S ESR26	C0502	10th November 2021	12 Months
Teseq CBL 6112D Bilog antenna	C0506	*15th July 2021*	*36 Months*
6dB Attenuator (For use with Bilog Antenna)	C0506B	15th July 2021	36 Months
Teseq CBL6112D Bilog Antenna	C0506	15th July 2021	36 Months
HF26 Cable	HF26	17th January 2022	12 Months
HF35 Cable	HF35	17th January 2022	12 Months
HF27 Cable	HF27	17th January 2022	12 Months
Schwarzbeck D-69250 Antenna 1-18GHz	C0626	23rd December 2021	24 Months
2.4GHz Microtronics BRM50702 notch filter	C0473	11th January 2022	12 Months
BONN BLMA 0118-M Preamplifier	G0327	6th January 2022	12 Months
ETS Lingren 3116C-PA Horn Antenna 18-40GHz	C0433	17th October 2019	36 Months