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Test Report for the FCC and ISED Testing of a Zwift Hub Z004 to FCC Rule 47CFR 15.247 and ISED RSS-247 for Zwift Inc

Test Report number: C14776TR1

Project number: C6980

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Issue	Description						Issue by	Date
1	Copy 1		Copy 2		PDF	√	MR	12th August 2022

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Test Report Change History

Issue	Date	Modification Details
1	12th August 2022	First Issue
2		
3		
4		
5		
6		
7		
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	Zwift Inc
Address	111 W. Ocean Blvd
	Suite 1800
	Long Beach
	CA 90802
	USA
Contact	Xiaofei Zhang
Email	xiaofei.zhang@zwift.com

Section 3 Equipment Details

3.1 Equipment Under Test (EUT)

Date received:	21st July 2022		
EUT name:	Zwift Hub Z004		
PMN:	Zwift Hub Z004		
HVIN:	A.0		
FVIN:	v.3.1		
FCC ID:	2A4DF-Z004		
ISED number:	N/A		
Serial no's:	EMC Test 1 and EMC Test 2		
EUT description:	Zwift Hub Z004 is a stationary smart cycling training equipment designed for indoor exercises and it can be connected to the Zwift virtual training App via the built-in Bluetooth and ANT+ modules.		
Antenna	Integral Antenna		
Transmission	Digital Transmission System (DTS) Bluetooth Low Energy (BLE)		
Modulation schemes	PRBS9		
Operating frequency band	2400MHz to 2483.5MHz		
No of units tested:	Two		
EUT power:	120 V, 60 Hz AC mains		
Highest internal frequency:	2.480GHz		
Size of EUT (mm)	Width: 500 mm	Depth: 620 mm	Height: 470 mm
Mode/s of operation:	Continuous transmit of packetised data at top, middle and bottom channels. Channels used: 2402MHz, 2440MHz and 2480MHz		
Test software:	nRF connect (Nordic semiconductors direct test mode tool)		
Modifications incorporated during testing:	None		

Ports and Cables	**Cable Length**	**Screened/ unscreened**	**Connected to**
PSU cable	1.5m	unscreened	Power supply unit

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

Requirement	FCC Rule Part	Comments	Result Summary
6 dB Bandwidth	FCC § 15.247(a)(2)	Applies	Pass
Maximum peak conducted power	FCC § 15.247(b)(3)	Applies	Pass
Power spectral density	FCC § 15.247(e)	Applies	Pass
Band edge compliance	FCC § 15.247(d)	Applies	Pass
Conducted spurious emissions	FCC § 15.247(d)	Applies	Pass
Transmitter radiated spurious emissions – restricted bands	FCC § 15.247(d) FCC § 15.209	Applies	Pass
AC power line conducted emissions	FCC § 15.207	Applies	Pass

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

Requirement	**ISED Ragulation**	**Comments**	**Results Summary**
99% Occupied Bandwidth	RSS-Gen 6.6	Applies	Pass
6 dB Bandwidth	ISED RSS-247 § 5.2	Applies	Pass
Maximum peak conducted power	ISED RSS-247 § 5.4	Applies	Pass
Power spectral density	ISED RSS-247 § 5.2	Applies	Pass
Band edge compliance	ISED RSS-247 § 3.3 and 5.5 RSS-GEN Issue 5 Section 8.10	Applies	Pass
Conducted spurious emissions	ISED RSS-247 § 5.5	Applies	Pass
Transmitter radiated spurious emissions	ISED RSS-GEN § 8.9	Applies	Pass
AC power line conducted emissions	ISED RSS-247 § 3.1	Applies	Pass

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 Zwift Hub Z004, 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

25th July 2022

5.3.4 Test Area

LAB 1 (SAC)

5.3.5 Tested by

J Beevers

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.

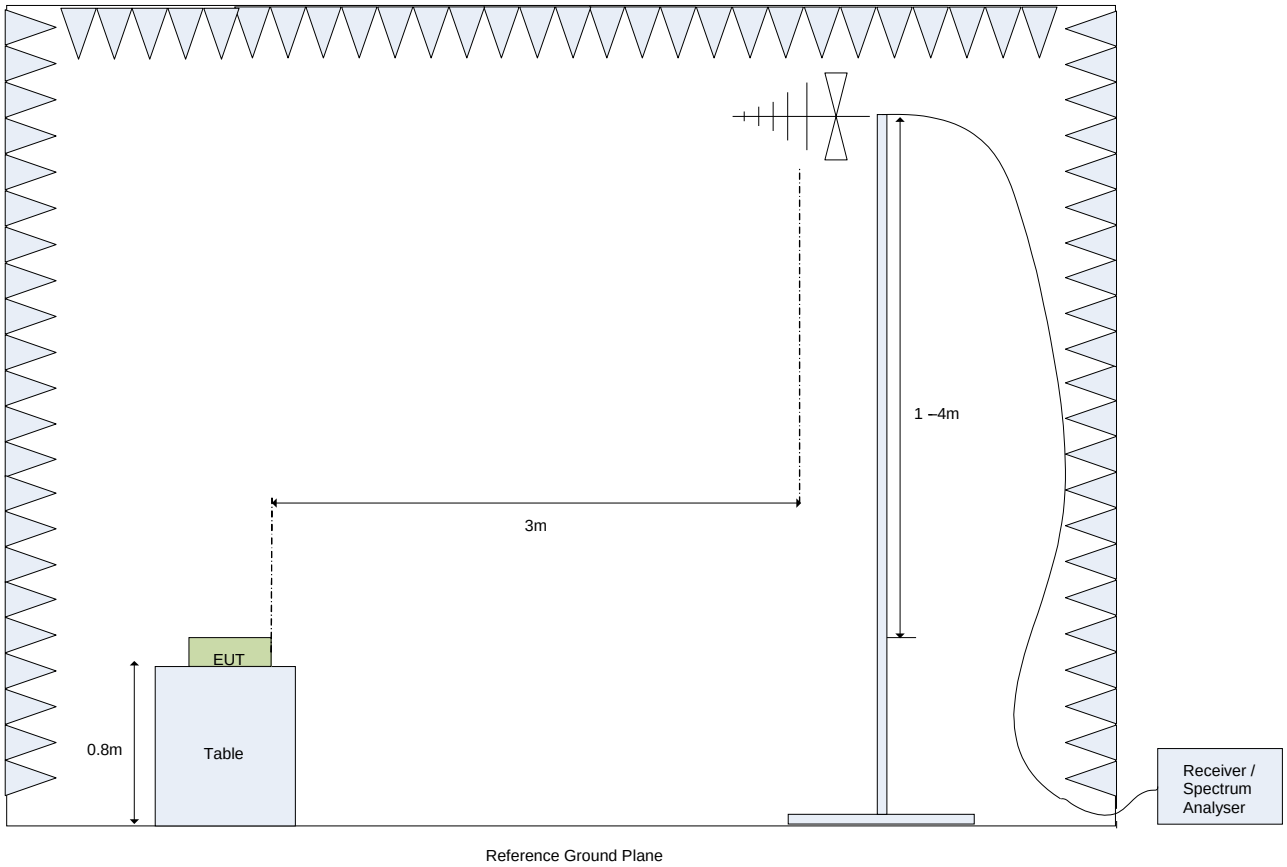


Figure 1 Test Setup for E-Field Measurements from 30MHz to 1GHz

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

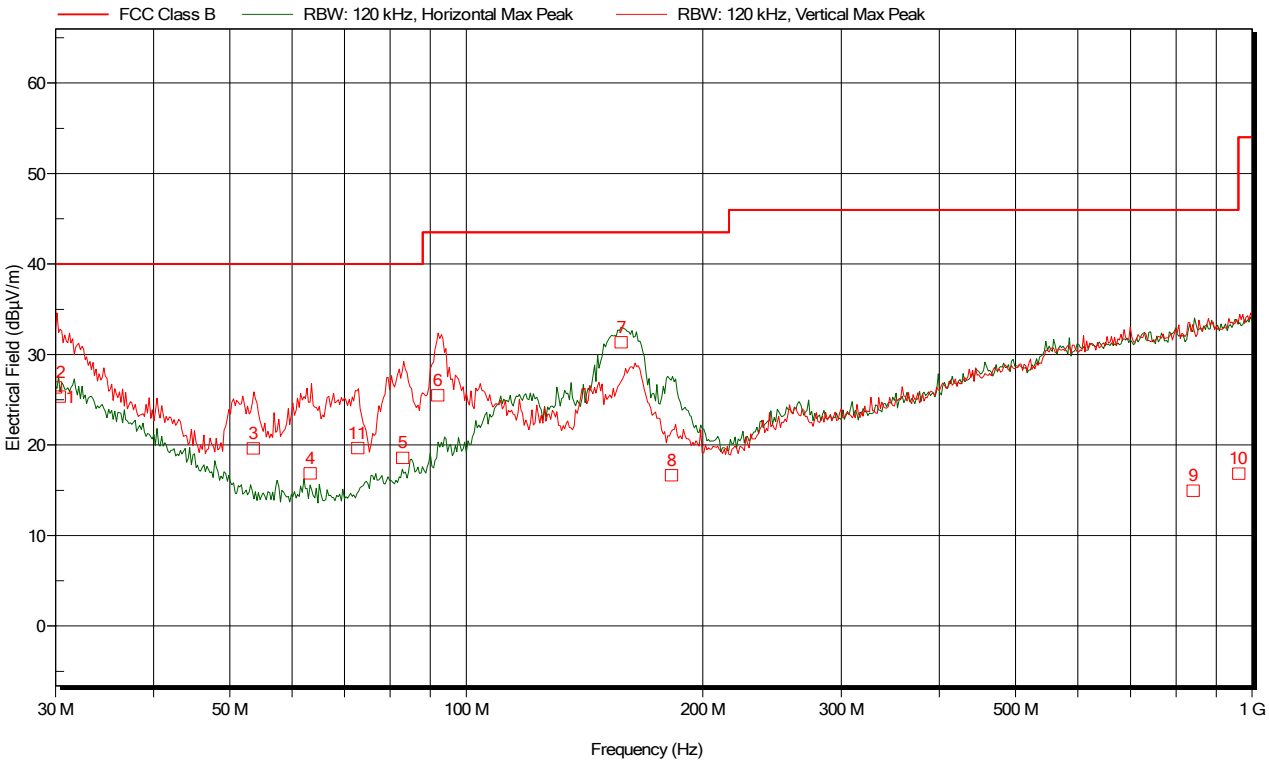


Figure 2 Electric field emissions Plot, 30MHz to 1GHz, 2480MHz Operation

Frequency	Quasi-Peak	Quasi Peak Limit	Quasi-Peak Difference	Quasi-Peak Status	Angle	Height	Polarization
MHz	dBµV/m	dBµV/m	dB		degrees	m	
30.36	25.4	40.0	-14.6	Pass	315	1.0	Vertical
30.00	26.4	40.0	-13.6	Pass	205	1.0	Vertical
53.58	19.6	40.0	-20.4	Pass	240	1.0	Vertical
63.30	16.9	40.0	-23.1	Pass	305	1.3	Vertical
82.98	18.6	40.0	-21.4	Pass	40	1.2	Vertical
91.92	25.5	43.5	-18.0	Pass	5	1.1	Vertical
157.32	31.4	43.5	-12.1	Pass	195	1.8	Horizontal
182.46	16.6	43.5	-26.9	Pass	360	1.3	Horizontal
840.84	14.9	46.0	-31.1	Pass	330	3.8	Horizontal
961.32	16.8	54.0	-37.2	Pass	205	3.3	Vertical
72.78	19.7	40.0	-20.3	Pass	25	1.6	Vertical

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

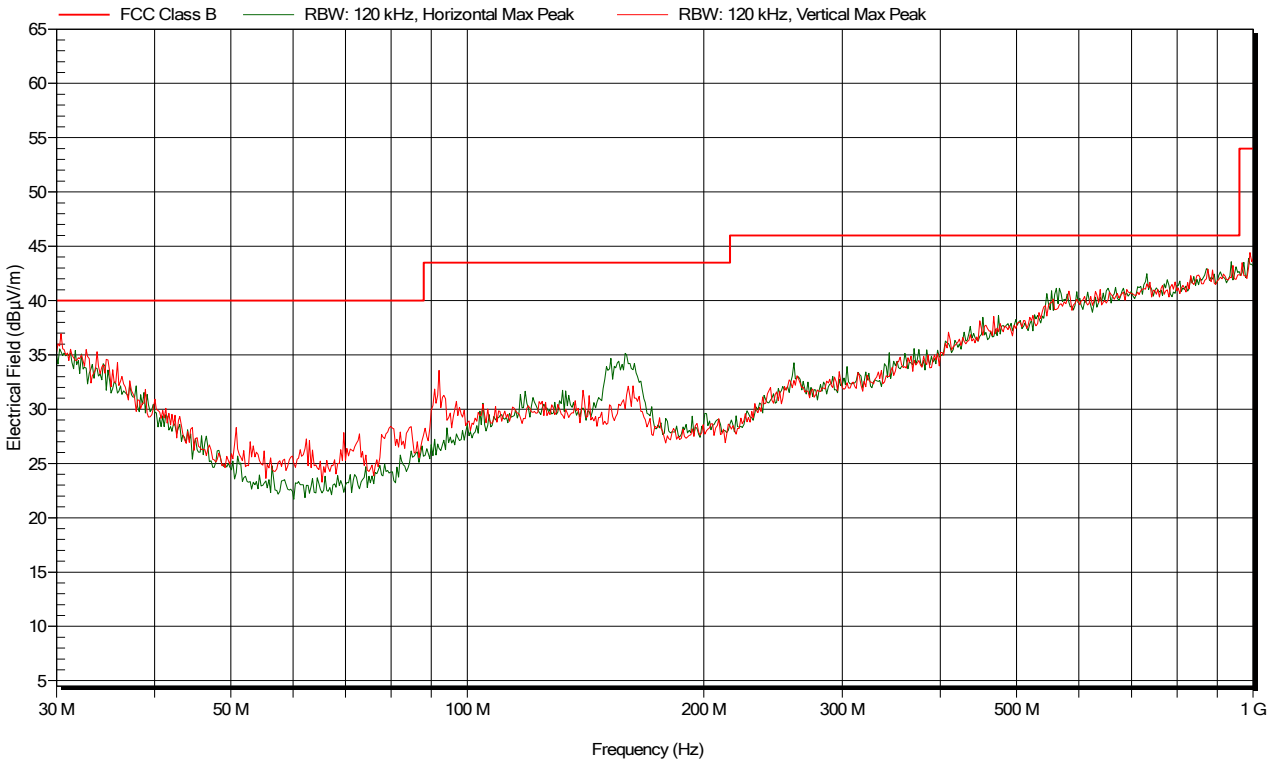


Figure 3 Electric field emissions Plot, 30MHz to 1GHz, Operation on 2402MHz - Peak detector scan

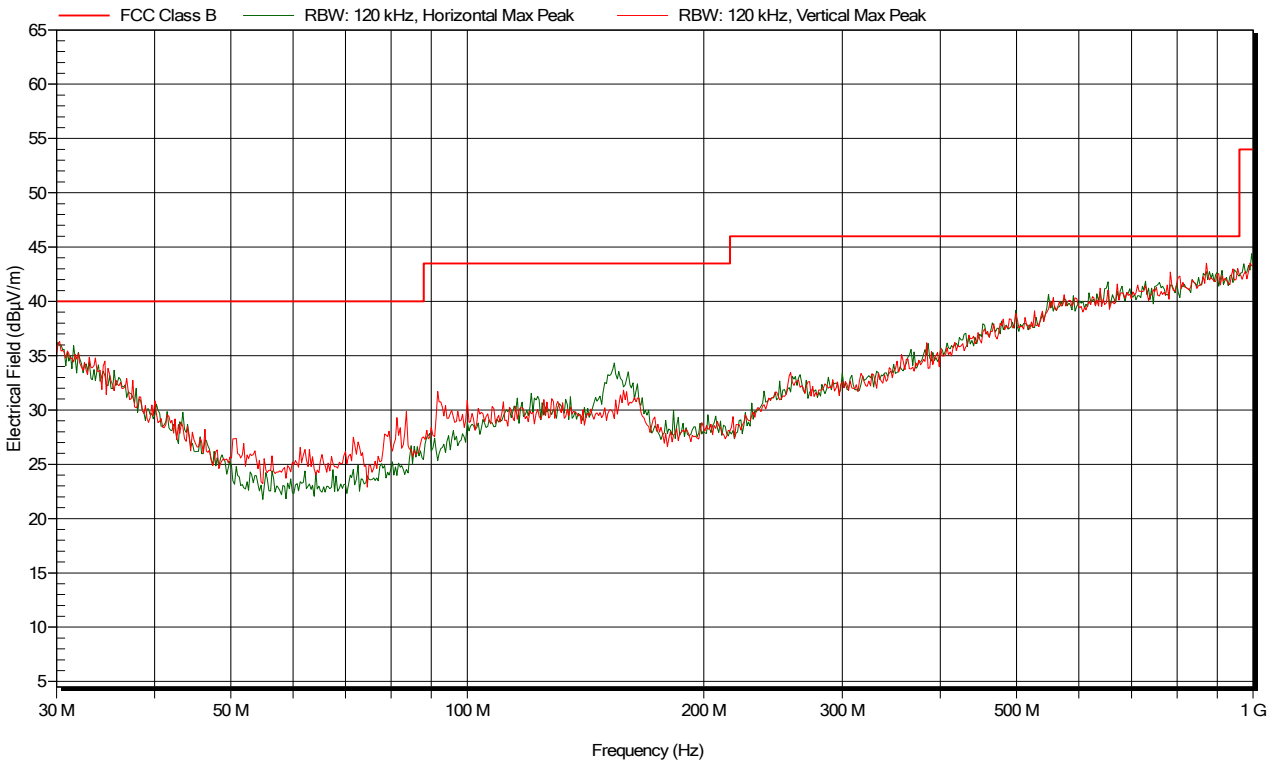


Figure 4 Electric field emissions Plot, 30MHz to 1GHz, Operation on 2440MHz - Peak detector scan

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

26th July 2022

5.4.5 Test Area

LAB 1 (SAC)

5.4.6 Tested by

J Beevers

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.

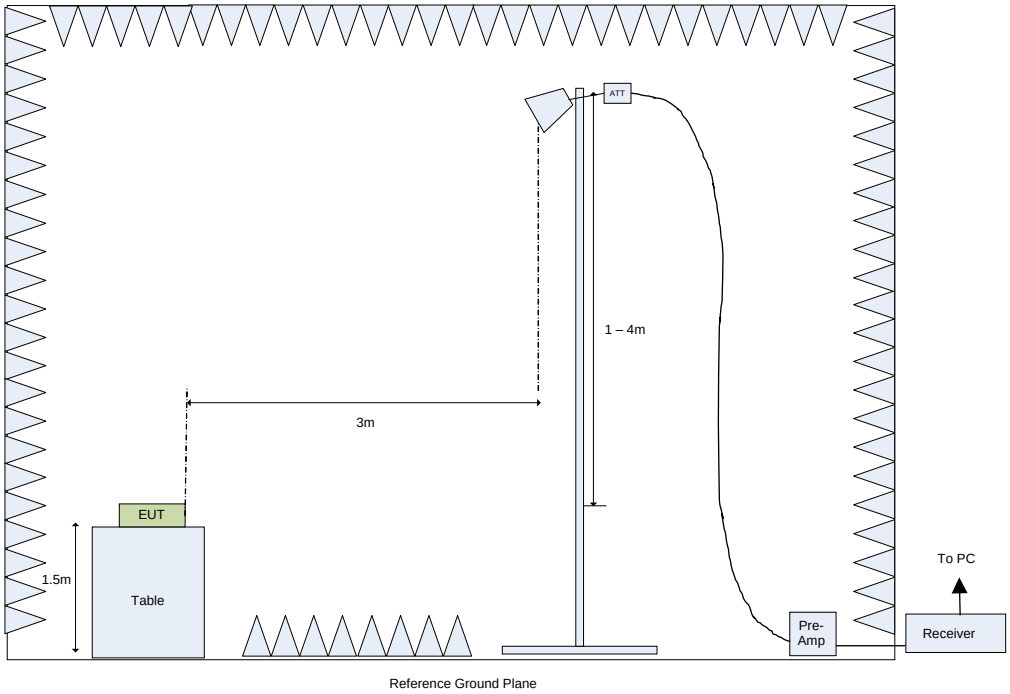


Figure 5.4.7.1: Test Setup for Final E-Field Measurements from 1GHz to 18GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.4-2010.

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.

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
2.228	Transmitting on channel 2402MHz	front face	90	2.0	H
4.624	Transmitting on channel 2402MHz	front face	90	2.0	H
4.804	Transmitting on channel 2402MHz	front face	90	2.0	H
7.206	Transmitting on channel 2402MHz	front face	90	2.0	H
12.012	Transmitting on channel 2402MHz	front face	90	2.0	H
2.203	Transmitting on channel 2440MHz	front face	90	2.0	H
4.625	Transmitting on channel 2440MHz	front face	90	2.0	H
4.909	Transmitting on channel 2440MHz	front face	90	2.0	H
7.319	Transmitting on channel 2440MHz	front face	90	2.0	H
12.199	Transmitting on channel 2440MHz	front face	90	2.0	H
2.160	Transmitting on channel 2480MHz	front face	90	2.0	H
4.960	Transmitting on channel 2480MHz	front face	90	2.0	H
7.439	Transmitting on channel 2480MHz	front face	90	2.0	H
12.401	Transmitting on channel 2480MHz	front face	90	2.0	H

Table 2 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 2480MHz

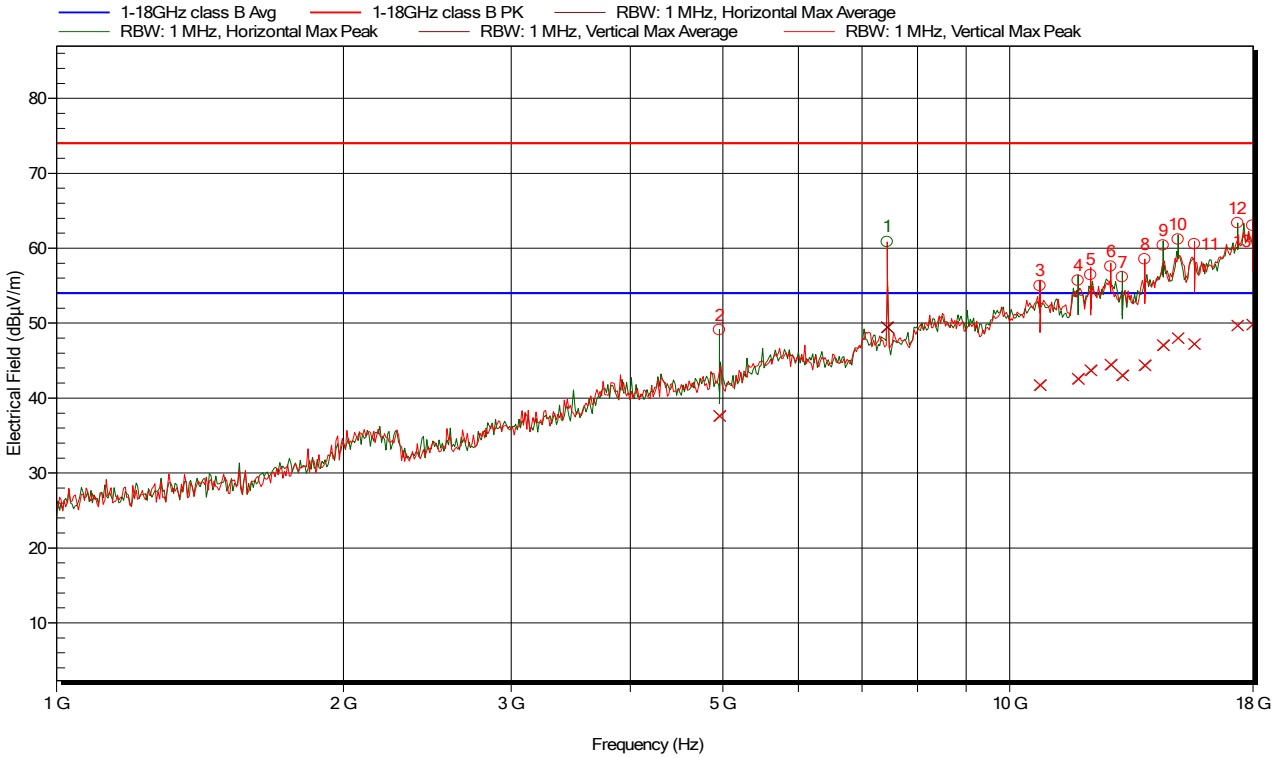


Figure 5 Electric field emissions Plot, 1GHz to 18GHz. Operation on 2480MHz

Frequency	Average	Average Limit	Average Difference	Average Status	Angle	Height	Polarization
GHz	dBµV/m	dBµV/m	dB		degrees	m	
7.440	49.48	54	-4.52	Pass	360	3.2	Vertical
4.960	37.63	54	-16.37	Pass	25	2.2	Horizontal
10.759	41.74	54	-12.26	Pass	145	1.8	Vertical
11.793	42.61	54	-11.39	Pass	255	3.5	Horizontal
12.160	43.71	54	-10.29	Pass	55	2.6	Vertical
12.762	44.49	54	-9.51	Pass	210	1.0	Vertical
13.122	43.07	54	-10.93	Pass	80	2.6	Horizontal
13.855	44.42	54	-9.58	Pass	50	3.4	Vertical
14.482	47.06	54	-6.94	Pass	165	3.5	Horizontal
15.015	47.99	54	-6.01	Pass	345	1.6	Horizontal
15.625	47.19	54	-6.81	Pass	350	3.8	Vertical
17.334	49.71	54	-4.29	Pass	155	1.0	Horizontal
17.976	49.80	54	-4.20	Pass	10	2.4	Vertical

Table 3 Electric Field Emissions Peaks, 1GHz to 18GHz – Operation on 2480MHz

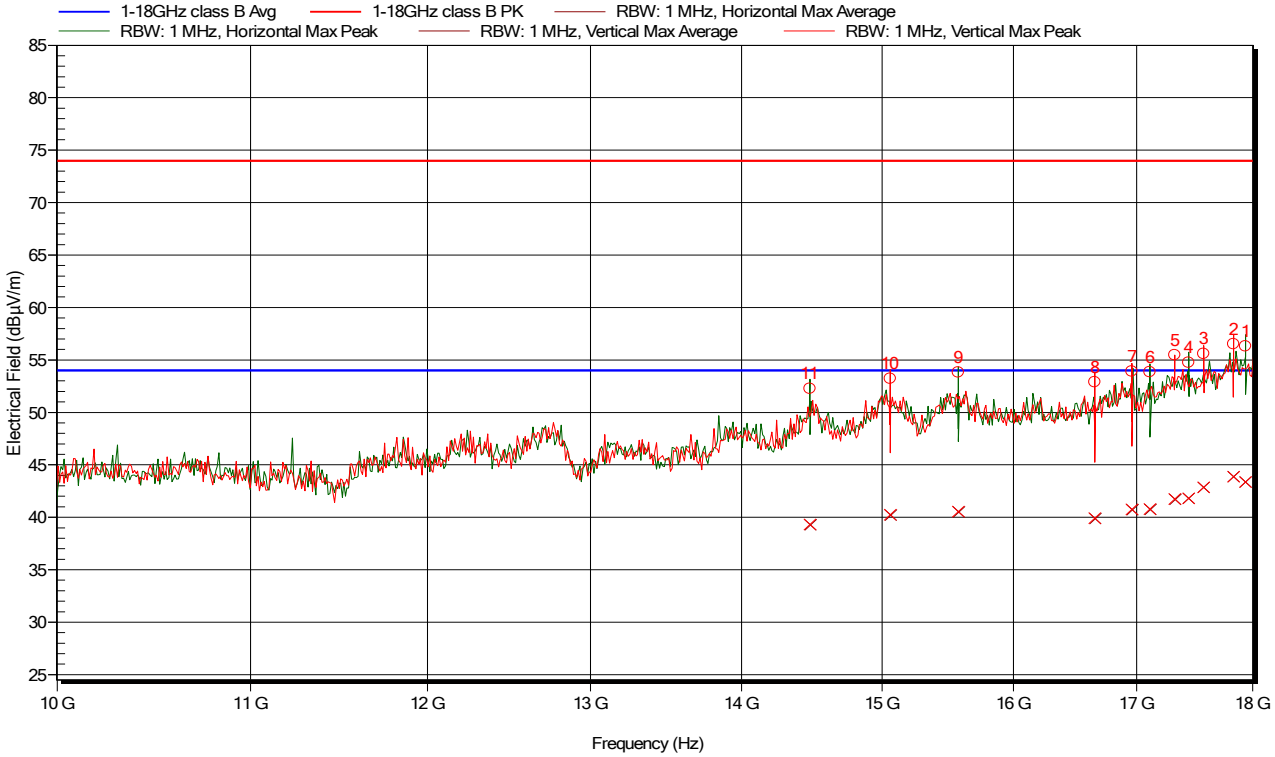


Figure 6 Electric field emissions Plot, 10GHz to 18GHz. 1m measurement distance. Operation on 2480MHz

Frequency	Average	Average Limit	Average Difference	Average Status	Angle	Height	Polarization
GHz	dBµV/m	dBµV/m	dB		degrees	m	
17.933	43.37	54	-10.63	Pass	265	1.8	Horizontal
17.826	43.88	54	-10.12	Pass	15	1.2	Vertical
17.569	42.84	54	-11.16	Pass	95	3.4	Vertical
17.440	41.80	54	-12.20	Pass	165	2.9	Horizontal
17.318	41.73	54	-12.27	Pass	340	2.0	Vertical
17.110	40.80	54	-13.20	Pass	320	2.4	Horizontal
16.958	40.75	54	-13.25	Pass	205	1.4	Vertical
16.653	39.91	54	-14.09	Pass	55	2.1	Vertical
15.573	40.56	54	-13.44	Pass	155	3.8	Horizontal
15.061	40.25	54	-13.75	Pass	90	2.4	Vertical
14.478	39.33	54	-14.67	Pass	140	2.8	Horizontal

Table 4 Electric Field Emissions Peaks, 10GHz to 18GHz. 1m measurement distance – Operation on 2480MHz

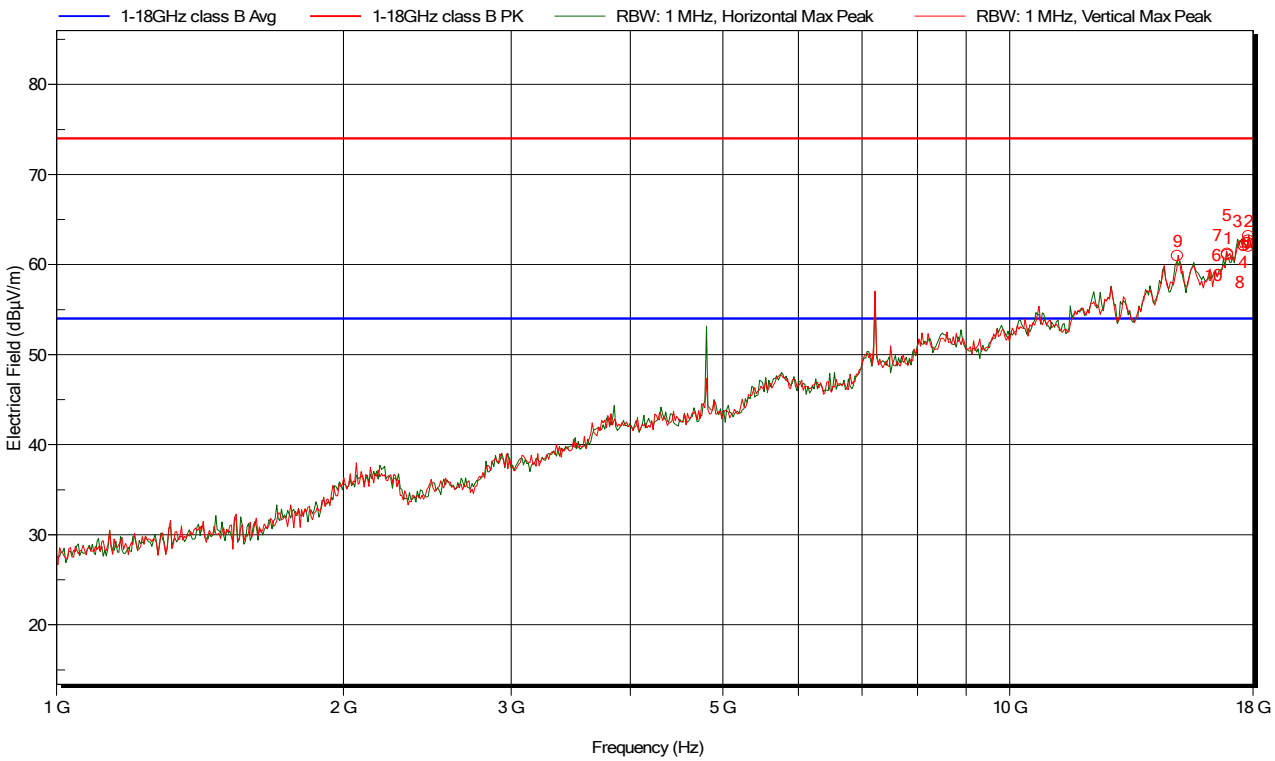


Figure 7 Electric field emissions Plot, 1GHz to 18GHz, Operation on 2402MHz - Peak detector scan

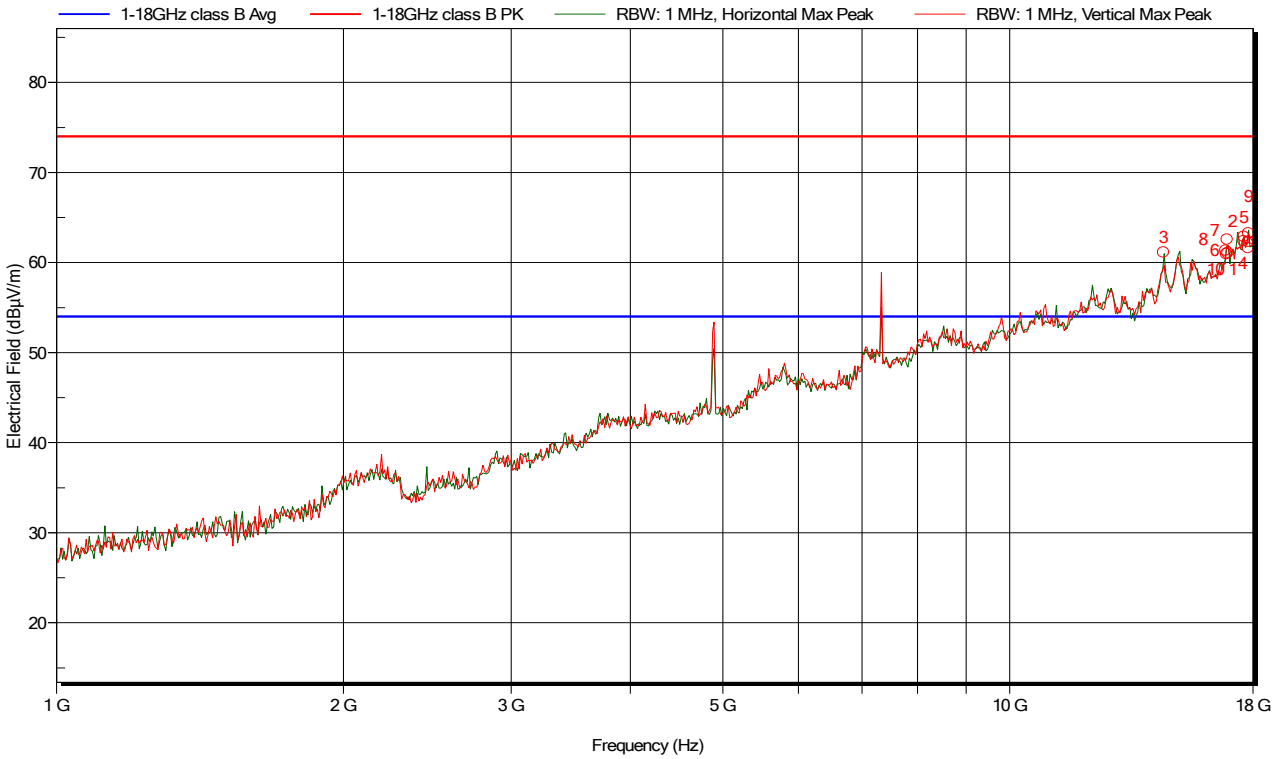


Figure 8 Electric field emissions Plot, 1GHz to 18GHz, Operation on 2440MHz – Peak detector scan

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) - PG (dB) + AF (dB) + CL (dB)

5.4.11 Sample Data

From Figure 5 and table 3, The Average level at 17.976GHz is calculated as follows:

FS (dBµV/m) = 42.5(dBµV) – 53.9(dB) +48.1(dB/m) +13.1 (dB) = 49.8µV/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
18-25	74.0	54.0

5.5.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average and Peak
Start Frequency	18GHz
Stop Frequency	25GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.5.3 Emissions measurements

5.5.4 Date of Test

26th July 2022

5.5.5 Test Area

LAB 1 (SAC)

5.5.6 Tested by

J Beevers

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.

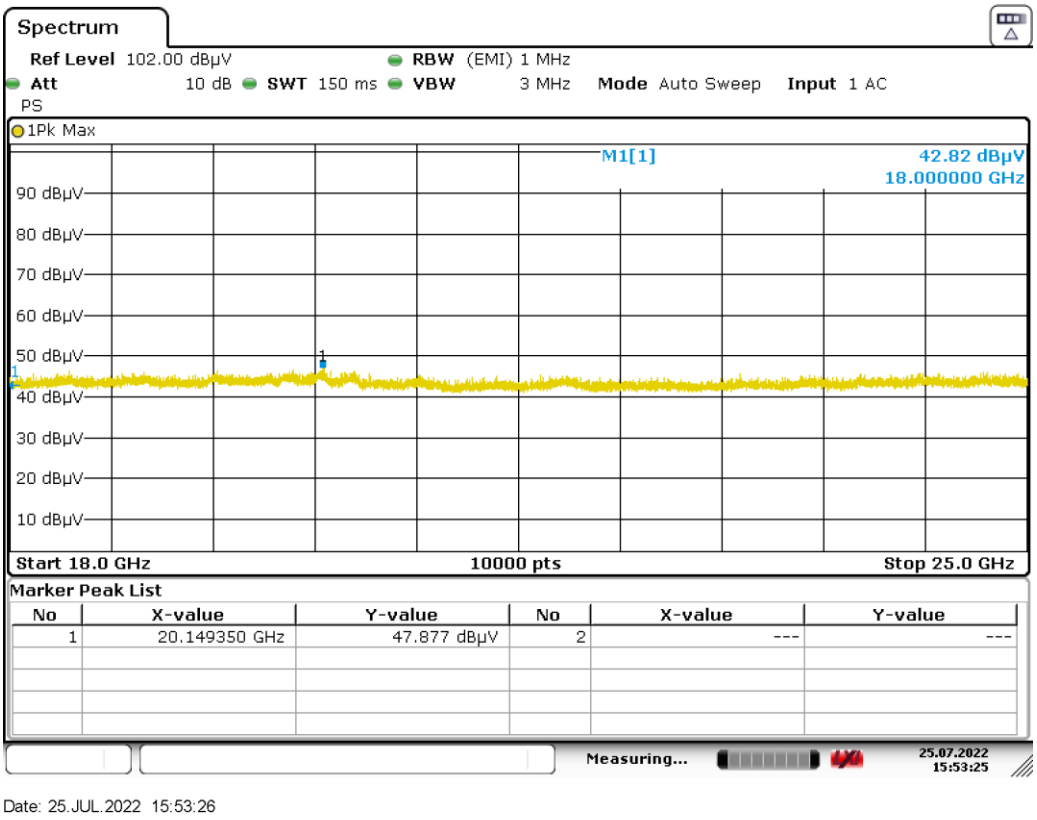
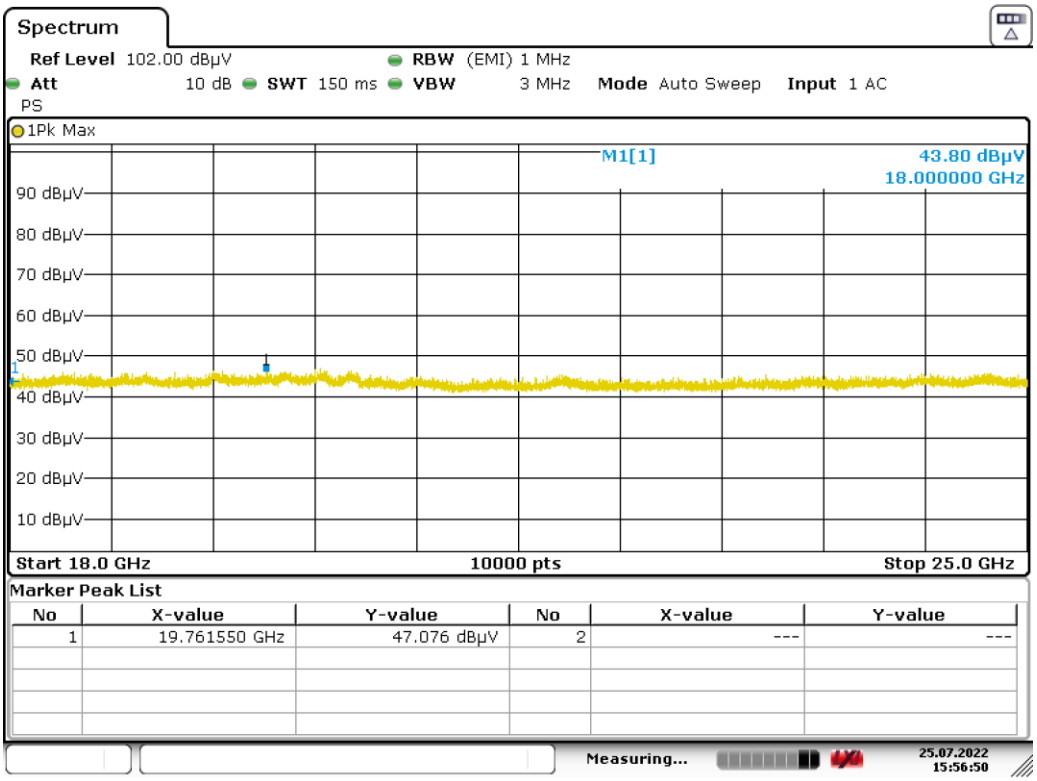
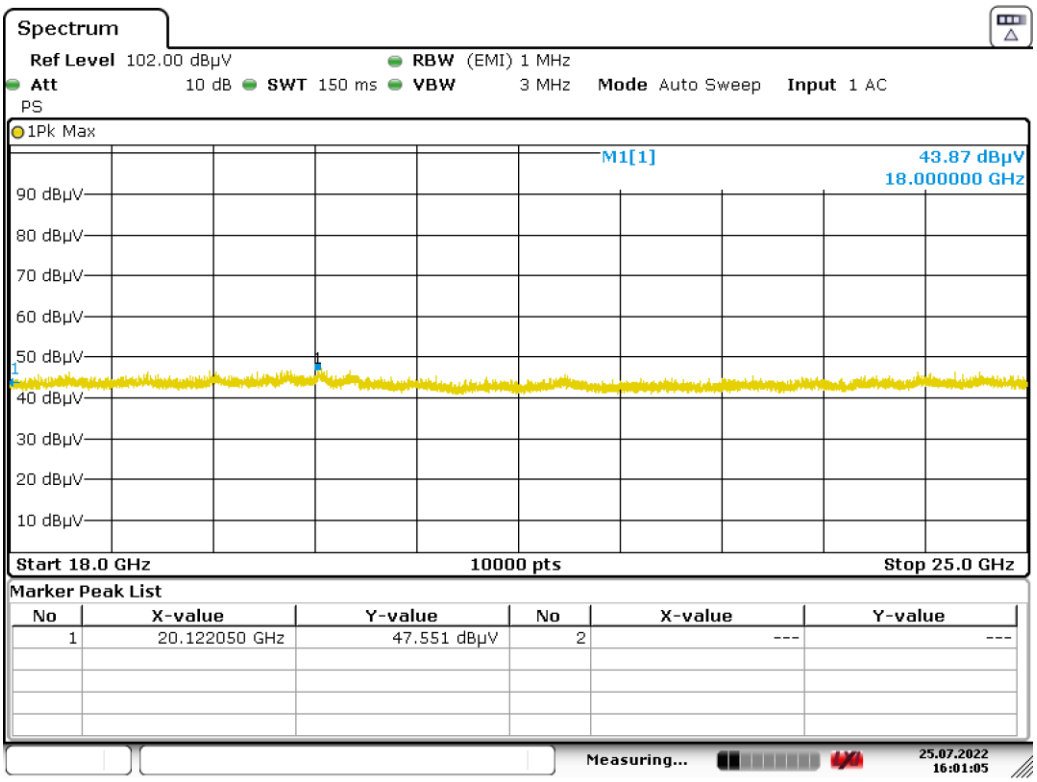


Figure 9 – manual investigation – Operating on channel 2402MHz



Date: 25.JUL.2022 15:56:50

Figure 10 – manual investigation – Operating on channel 2440MHz



Date: 25.JUL.2022 16:01:06

Figure 11 – 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

21st July 2022

5.6.4 Test Area

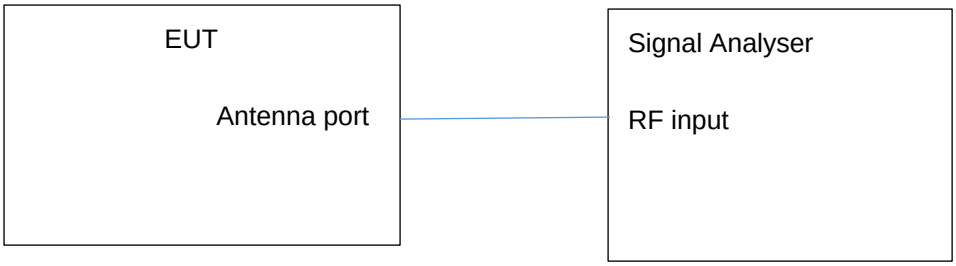
LAB 1

5.6.5 Tested by

J Beevers

5.6.6 Test Setup

The antenna port was connected directly to the signal analyser.

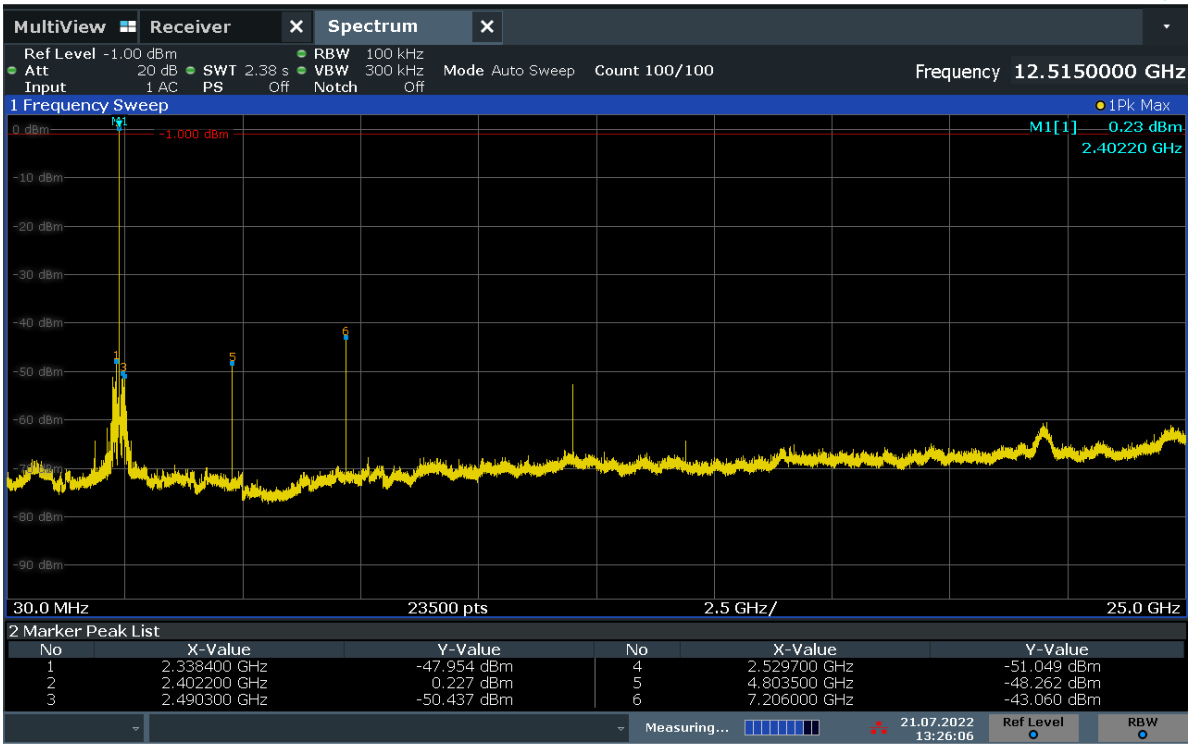


5.6.7 Test Results

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

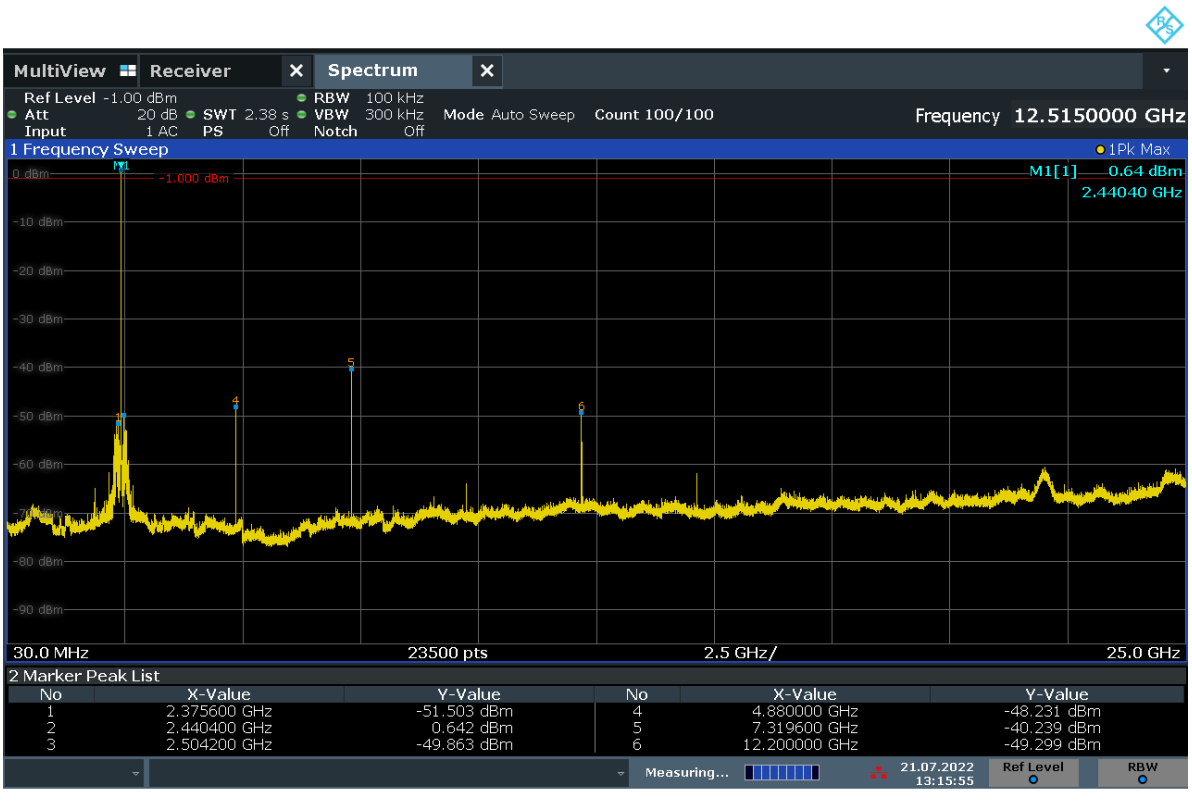
All disturbances detected were > 20dB below the carrier.

5.6.8 Antenna port conducted emissions, 30MHz to 25GHz



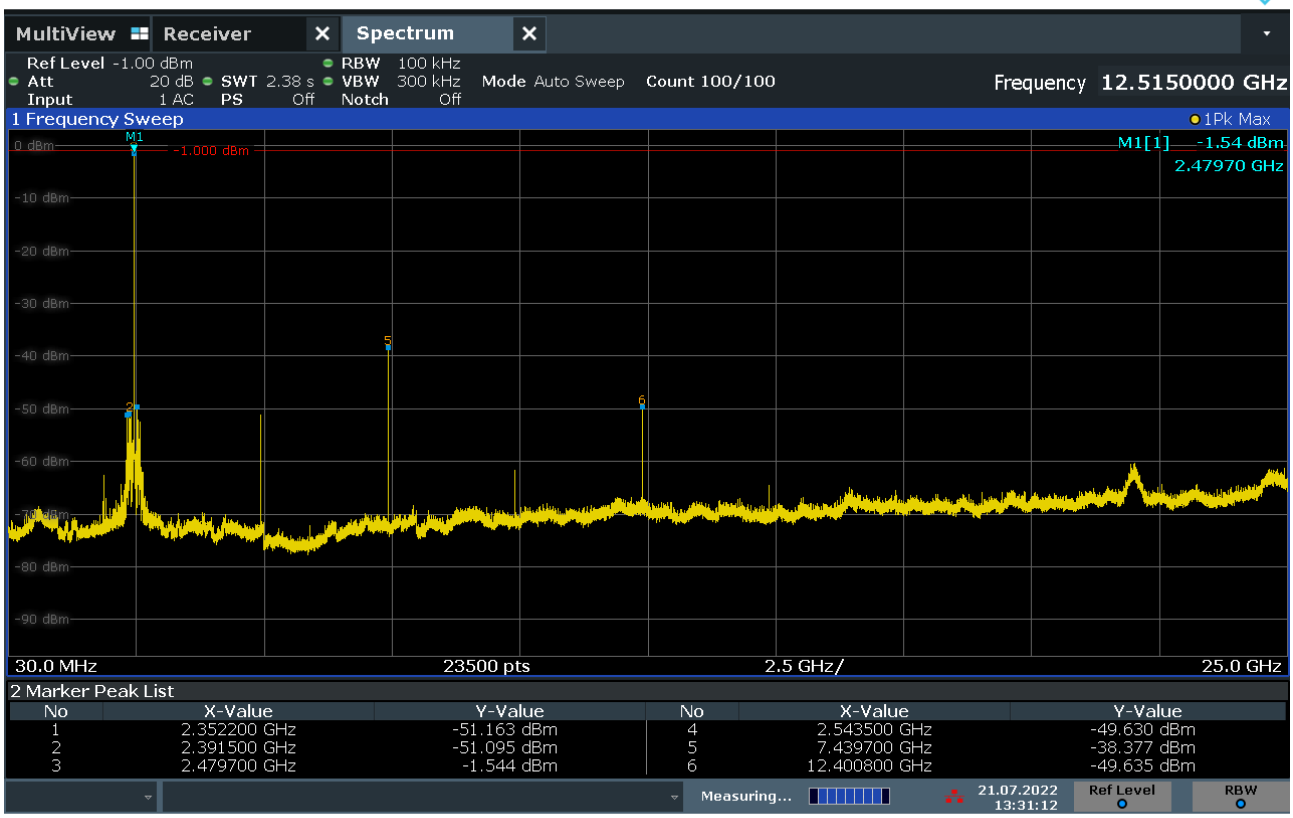
13:26:06 21.07.2022

Figure 12 Conducted emissions 30MHz to 25GHz. Operation on channel 2402MHz.



13:15:56 21.07.2022

Figure 13 Conducted emissions 30MHz to 25GHz. Operation on channel 2440MHz.



13:31:12 21.07.2022

Figure 14 Conducted emissions 30MHz to 25GHz. Operation on channel 2480MHz.

Section 6 6dB Bandwidth and 99% Occupied Bandwidth

6.1 Test Specification

FCC Rule Part	46CFR 15.247 (b)(2)
Standard	ANSI C63.10:2013

6.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	11.9.1.1 (RBW>DTS bandwidth)
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(a)(2) 6dB bandwidth
	Peak
2400MHz to 2483.5MHz	At least 500kHz

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.8.1

Receiver Parameters	Setting
Detector Function	Peak
Span	3MHz
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

21st July 2022

6.2.3 Test Area

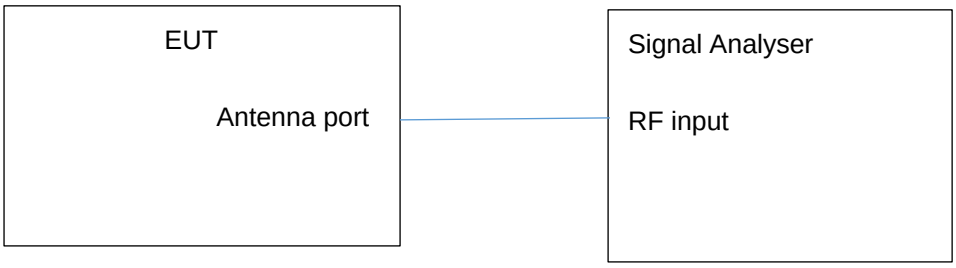
LAB 1

6.2.4 Tested by

J Beevers

6.2.5 Test Setup

The antenna port was connected directly to the signal analyser.

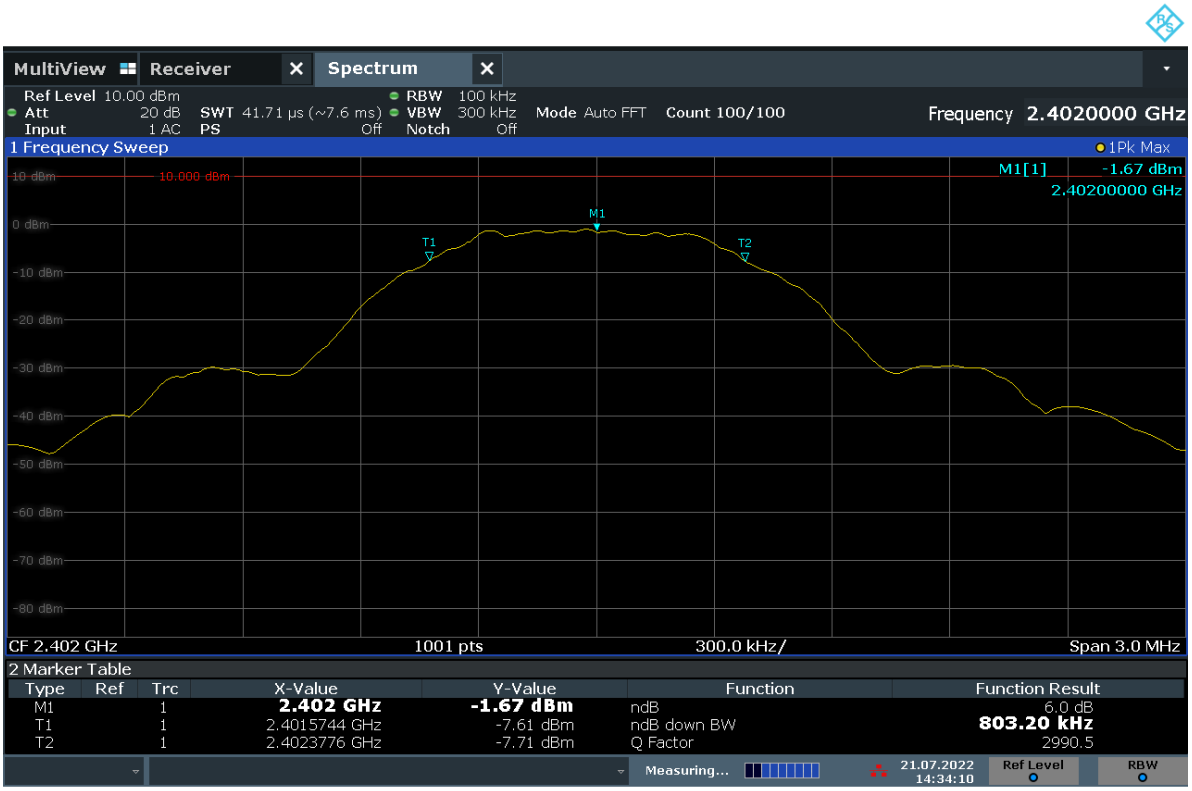


6.2.6 Test Results

The results of the 6dB bandwidth measurements are stated in the table below and by the signal analyser images.

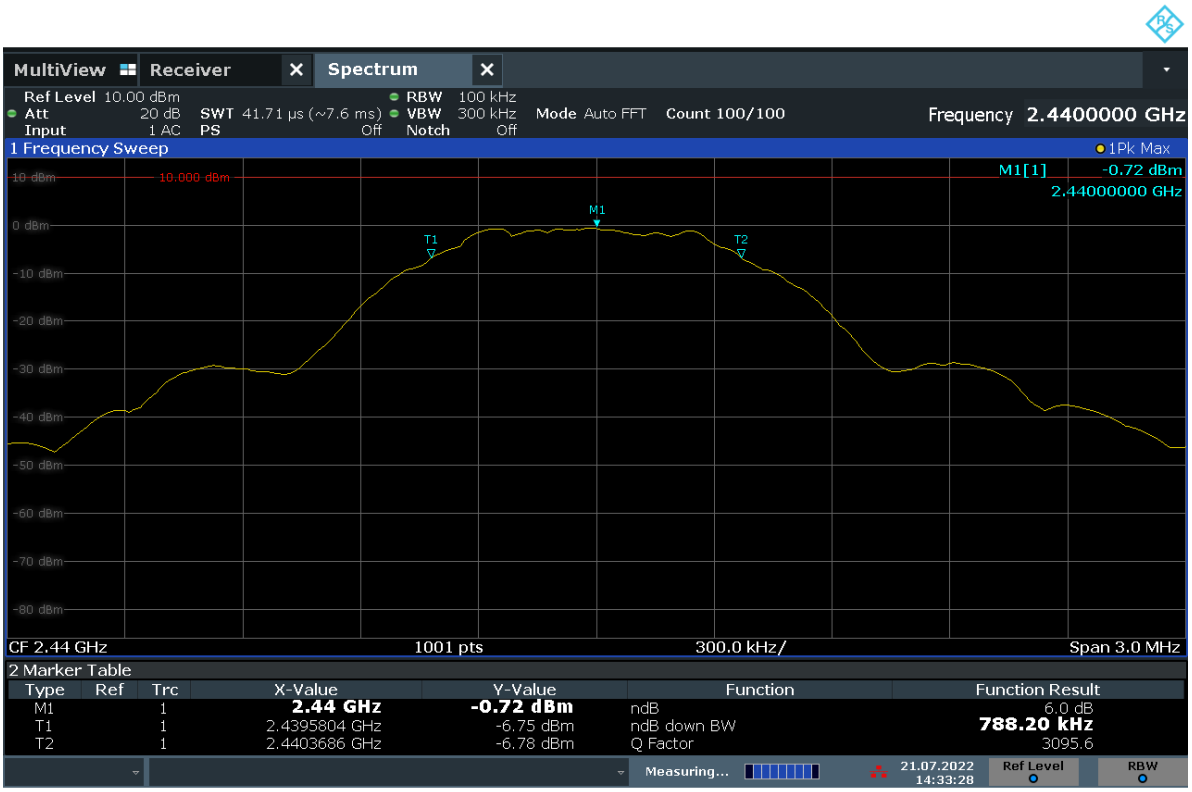
Channel (MHz)	99% Occupied Bandwidth (MHz)	Measured 6dB bandwidth (kHz)	Minimum requirement (kHz)	Figures	Result
2402.0	1.0828	803.2	500.0	15 and 18	Pass
2440.0	1.0886	788.2	500.0	16 and 19	Pass
2480.0	1.0891	737.3	500.0	17 and 20	Pass

Table 5 Bandwidth Measurements



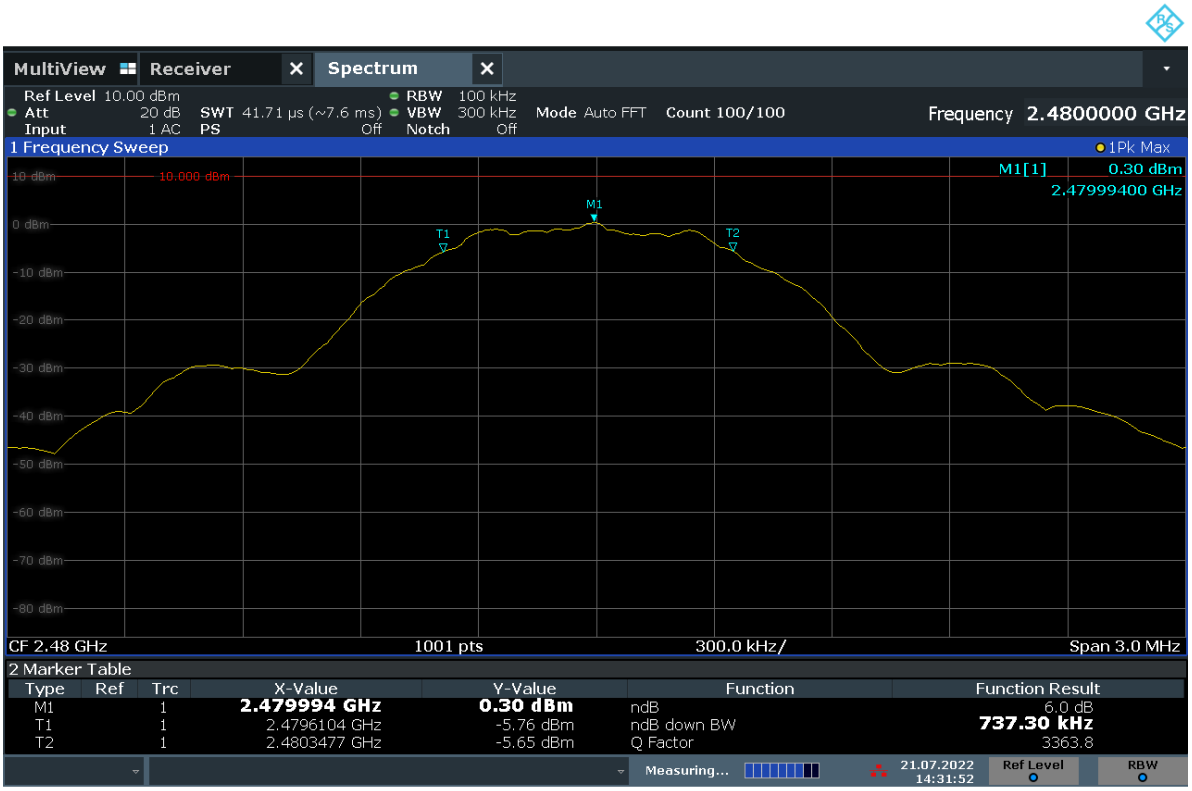
14:34:10 21.07.2022

Figure 15 Bandwidth at 6dB Point. Operation on channel 2402MHz



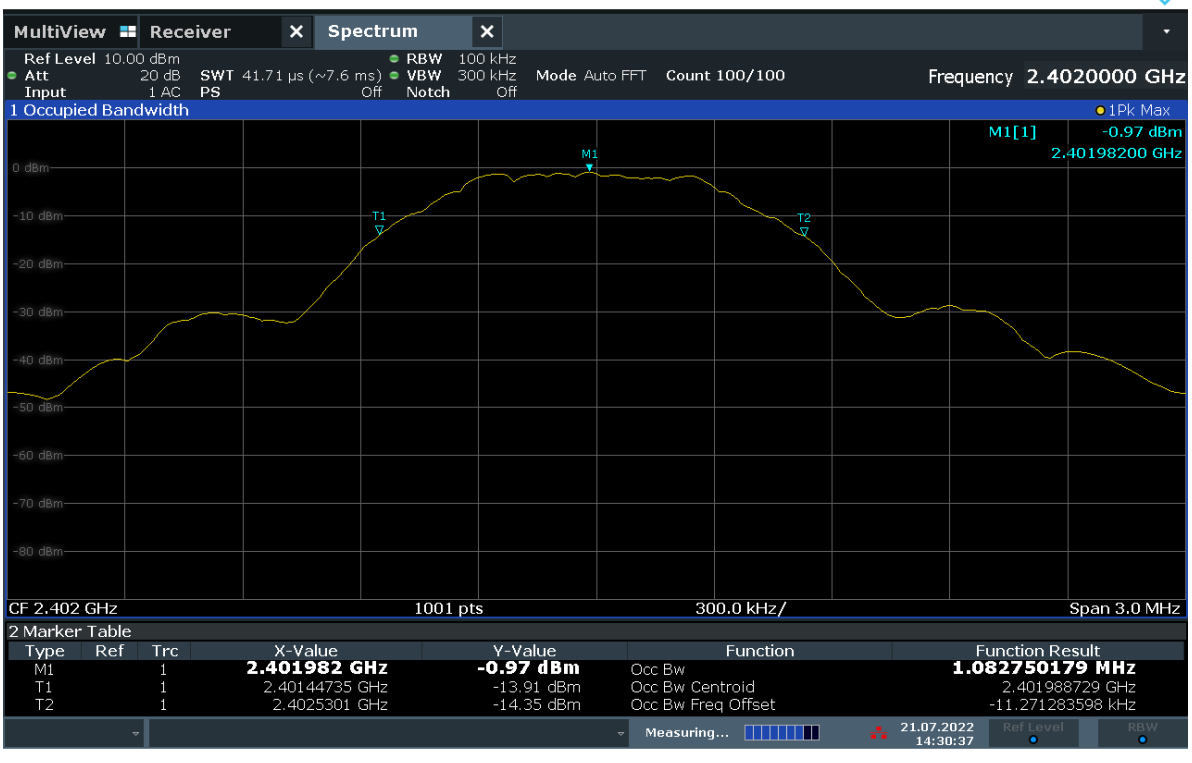
14:33:29 21.07.2022

Figure 16 Bandwidth at 6dB Point. Operation on channel 2440MHz



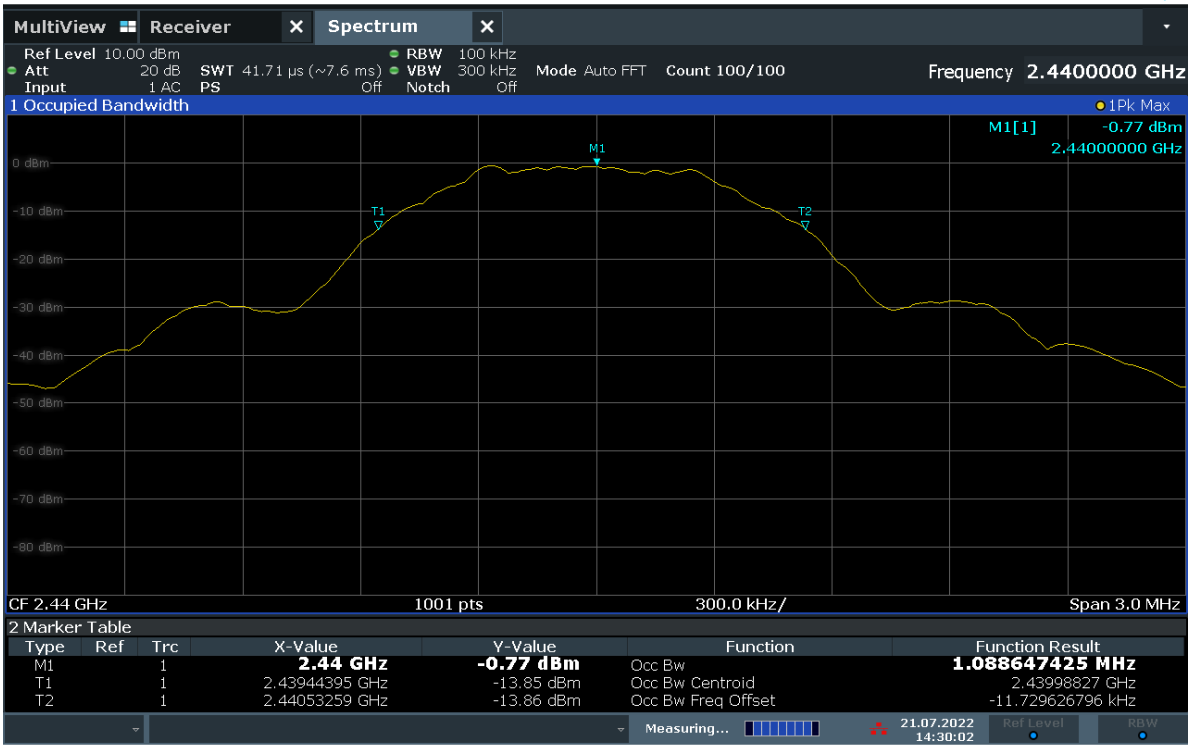
14:31:53 21.07.2022

Figure 17 Bandwidth at 6dB Point. Operation on channel 2480MHz



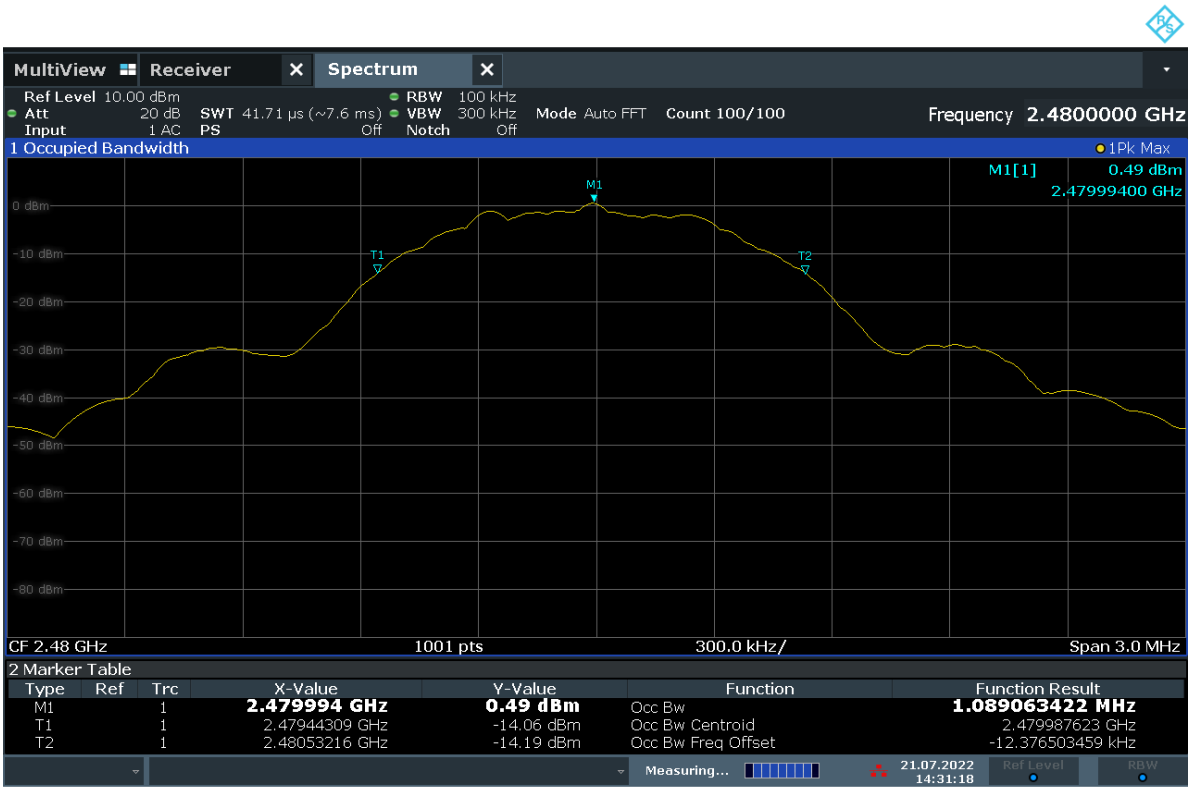
14:30:37 21.07.2022

Figure 18 99% Occupied Bandwidth. Operation on channel 2402MHz



14:30:03 21.07.2022

Figure 19 99% Occupied Bandwidth. Operation on channel 2440MHz



14:31:18 21.07.2022

Figure 20 99% Occupied Bandwidth. Operation on channel 2480MHz

Section 7 Peak Output Power

7.1 Test Specification

FCC Rule Part	46CFR 15.247 (b)(3)
Standard	ANSI C63.10:2013

7.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	11.9.1.1 (RBS>DTS bandwidth)
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(b)(2)
	Peak
2400MHz to 2483.5MHz	1 watt

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

Receiver Parameters	Setting
Detector Function	Peak
Span	10MHz
Resolution Bandwidth	2MHz (>DTS Bandwidth)
Video Bandwidth	6MHz
Sweep rate	Auto couple
Trace mode	Max hold

7.2.1 Emissions measurements

7.2.2 Date of Test

21st July 2022

7.2.3 Test Area

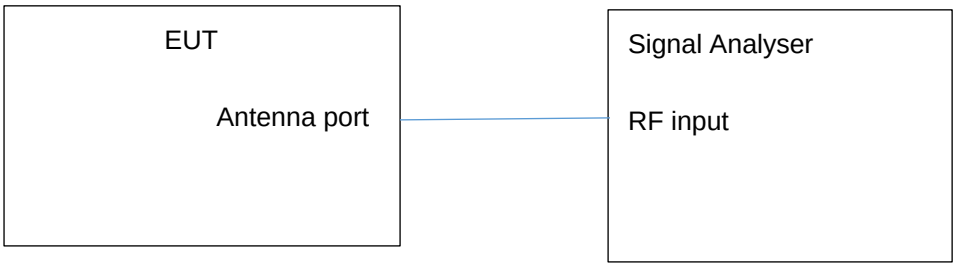
LAB 1

7.2.4 Tested by

J Beevers

7.2.5 Test Setup

The antenna port was connected directly to the signal analyser.

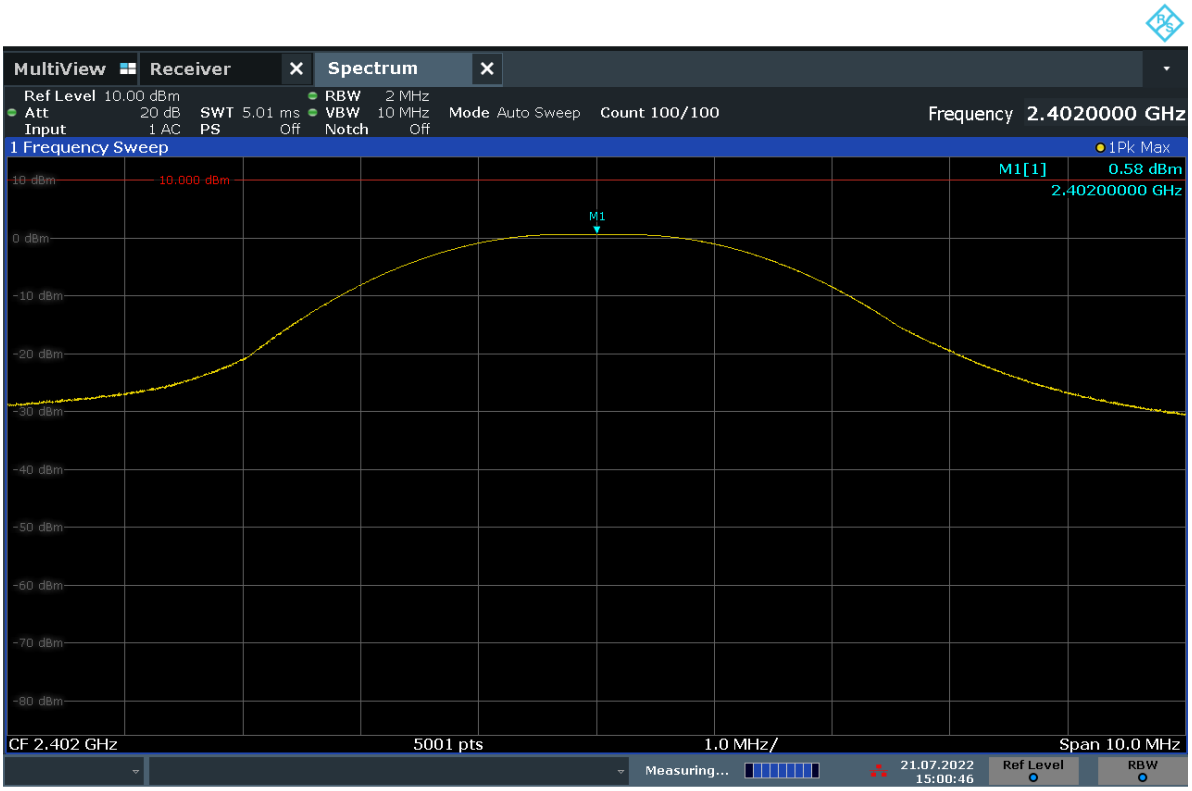


7.2.6 Test Result

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

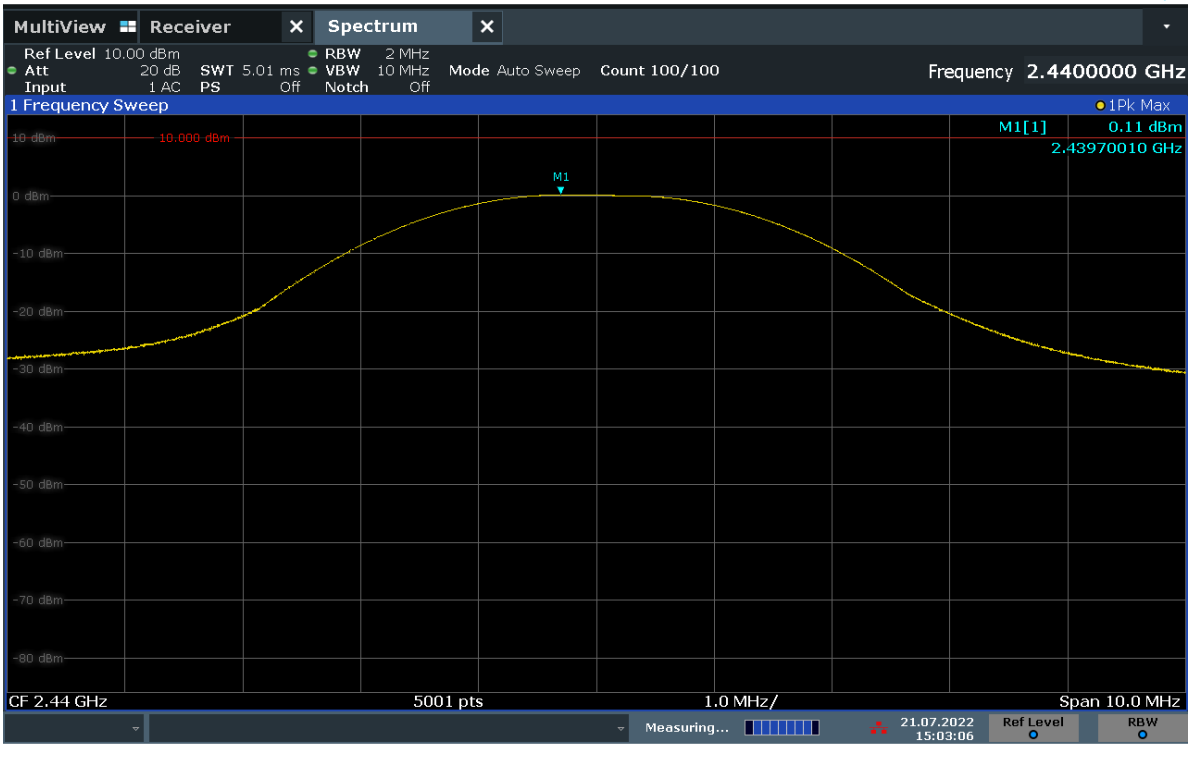
Channel (MHz)	Measured Power (dBm)	Cable Loss (dB)	Peak Power (dBm)	Peak Power (Watts)	Limit (Watts)	Figure
2402	0.58	2.30	2.88	0.00194	1	21
2440	0.11	2.30	2.41	0.00174	1	22
2480	0.95	2.30	3.25	0.00211	1	23

Table 6 Peak Output Power Measurements



15:00:46 21.07.2022

Figure 21 Peak output power, Operation on channel 2402MHz



15:03:07 21.07.2022

Figure 22 Peak output power, Operation on channel 2440MHz

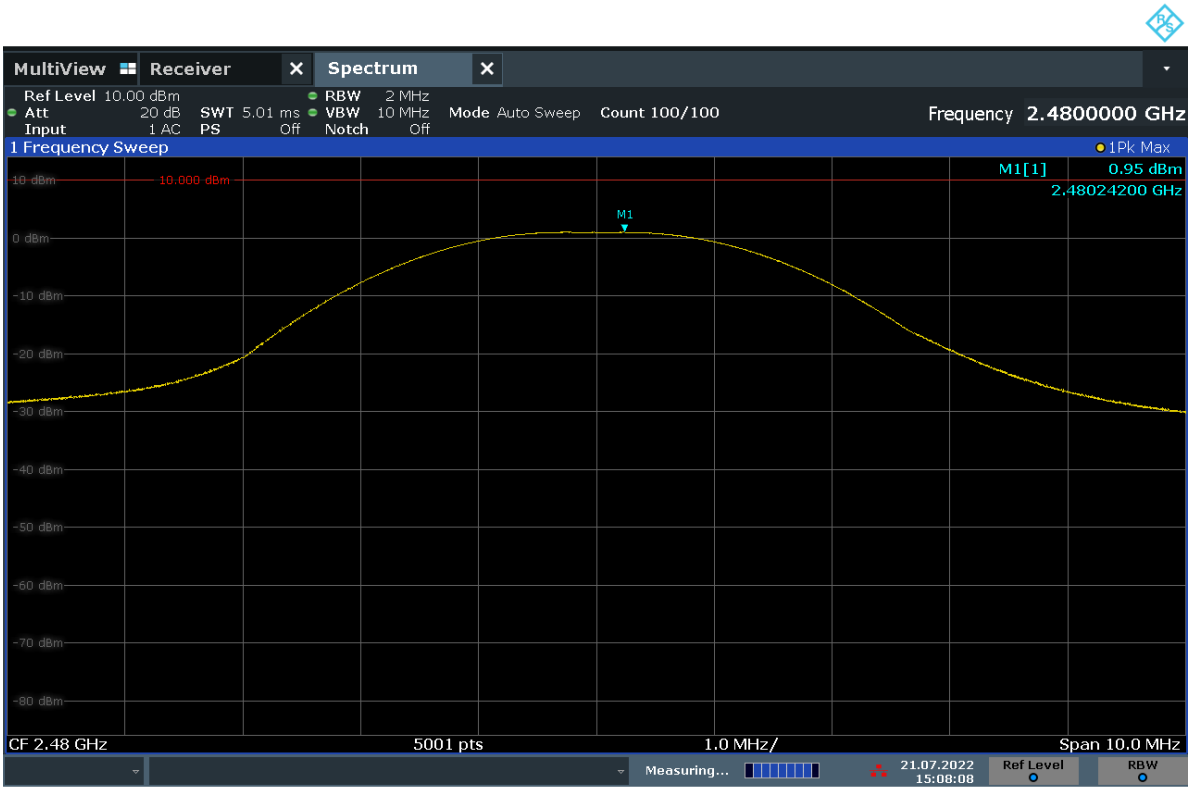


Figure 23 Peak output power, Operation on channel 2480MHz

Section 8 Power Spectral Density

8.1 Test Specification

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

8.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	Clause 11.10.2
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(e)
	Peak
2400MHz to 2483.5MHz	<8dBm in any 3kHz band during any time interval of complete transmission

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.10.2

Receiver Parameters	Setting
Detector Function	Peak
Span	1.5xDTS bandwidth
Resolution Bandwidth	3kHz ≤RBW ≤100kHz
Video Bandwidth	3 x RBW
Sweep rate	Auto couple
Trace mode	Max hold

8.2.1 Emissions measurements

8.2.2 Date of Test

21st July 2022

8.2.3 Test Area

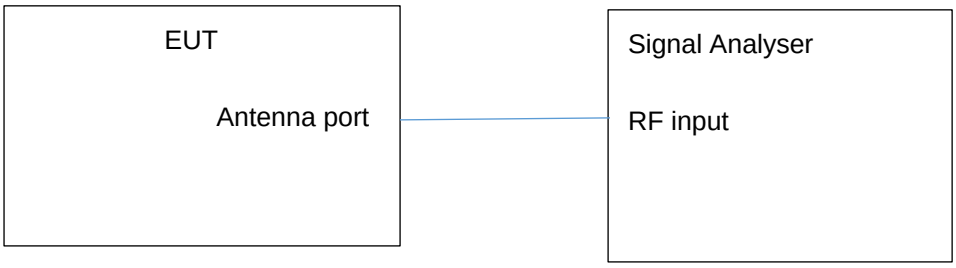
LAB 1

8.2.4 Tested by

J Beevers

8.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



8.2.6 Test Results

Channel (MHz)	Measured Power in 3kHz RBW (dBm)	Cable Loss (dB)	Power in 3kHz RBW (dBm)	Limit (dBm)	Figure	Result
2402	-14.42	2.30	-12.12	8.0	24	Pass
2440	-14.20	2.30	-11.90	8.0	25	Pass
2480	-14.59	2.30	-12.29	8.0	26	Pass

Table 7 Peak Spectral Density Measurements

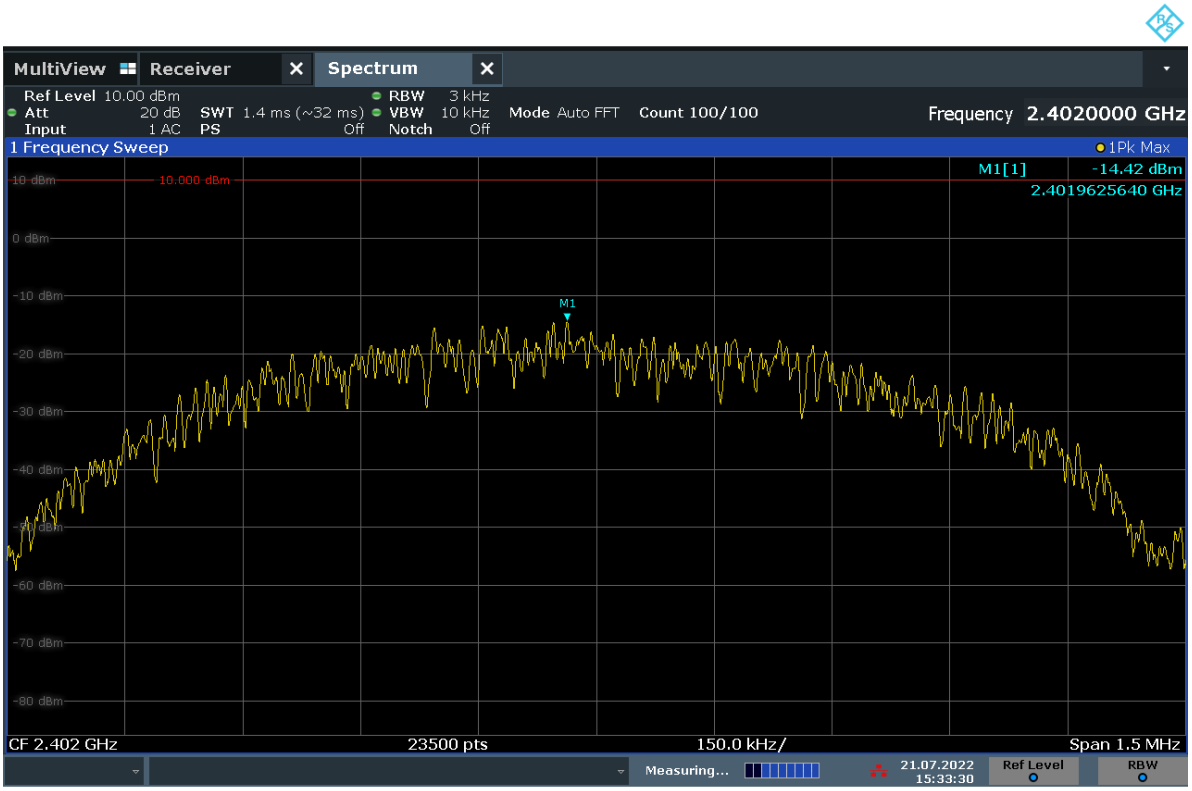


Figure 24 Power spectral density, Operation on channel 2402MHz

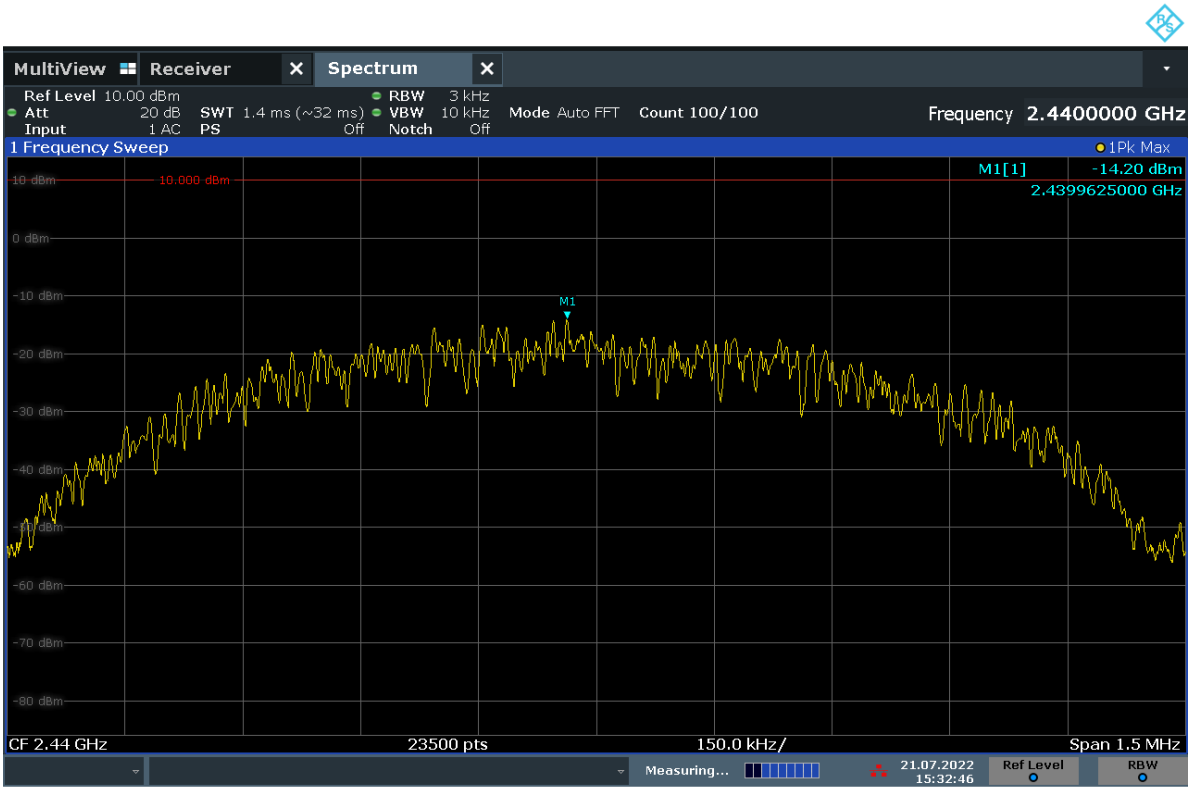


Figure 25 Power spectral density, Operation on channel 2440MHz

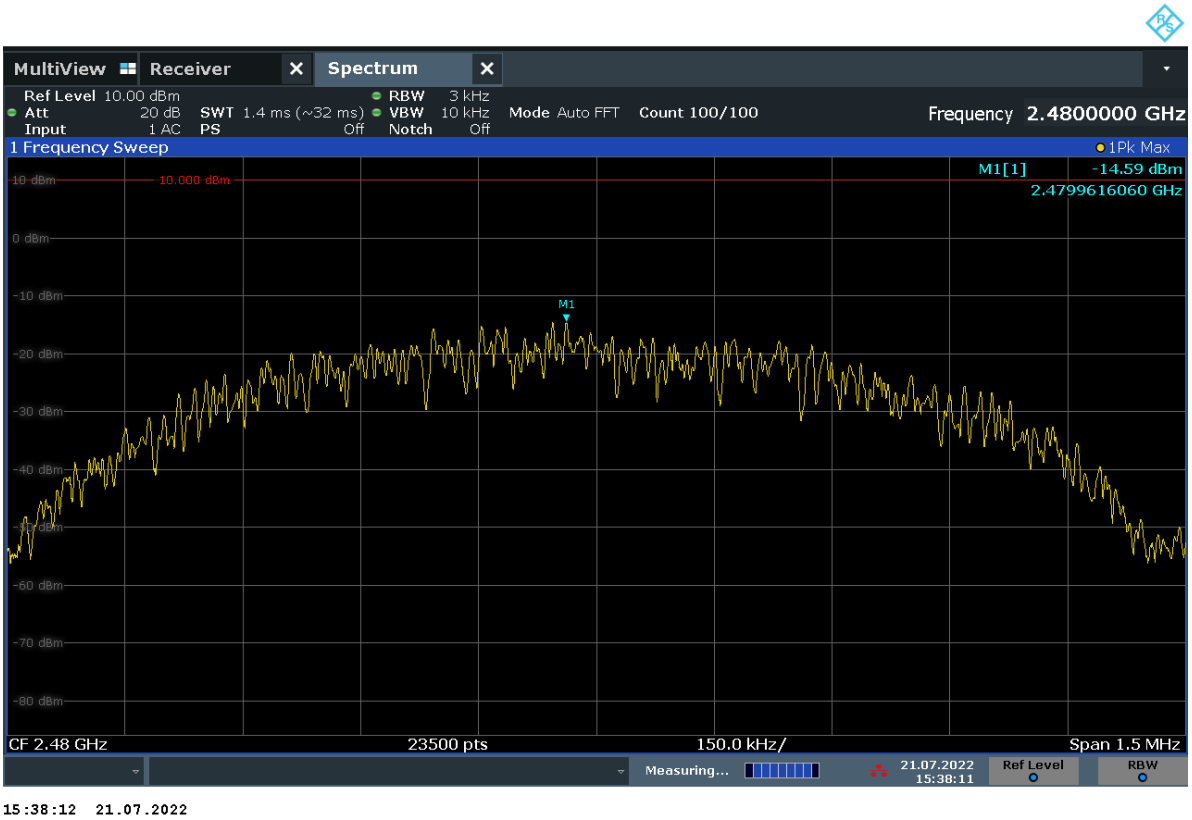


Figure 26 Power spectral density, Operation on channel 2480MHz

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

26th July 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	77.0	54.270	4.277	29.887	56.894	74.0	17.106
V	2483.5	82.7	54.270	4.277	29.887	62.594	74.0	11.406

Table 8 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	48.9	54.270	4.277	29.887	28.794	54.0	25.206
V	2483.5	48.9	54.270	4.277	29.887	28.794	54.0	25.206

Table 9 Operation on Channel 2480MHz, average detector measurements

Lower band edge

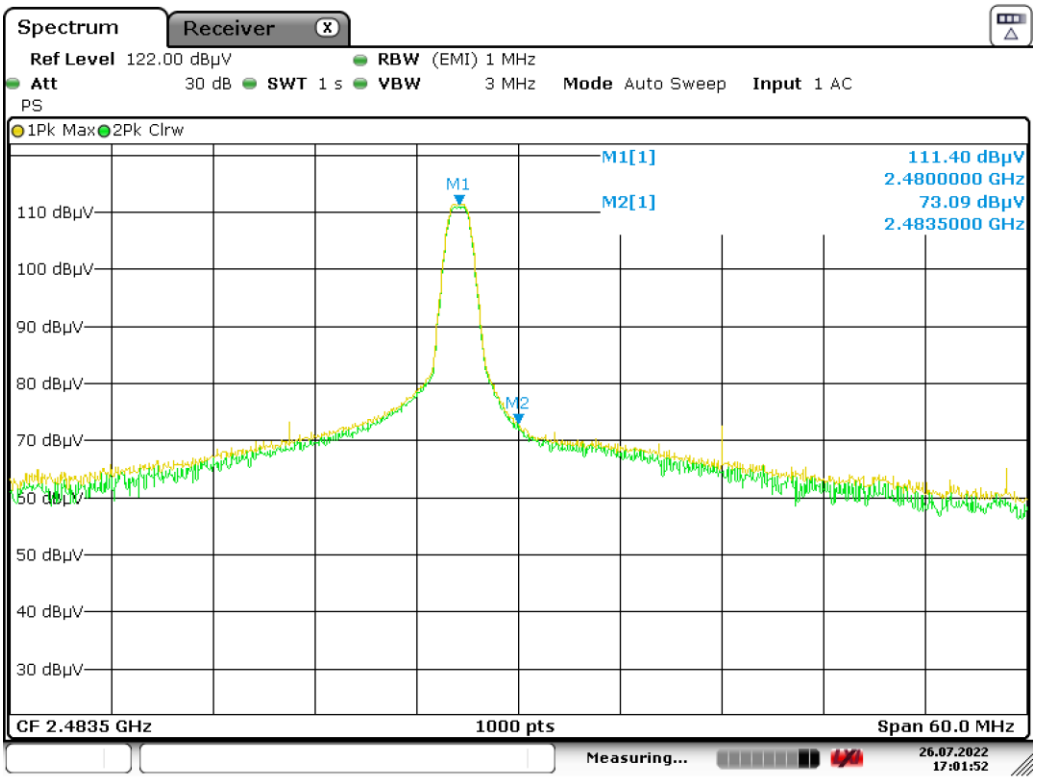
Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400.0	77.9	54.242	4.160	29.670	57.488	74.0	16.512
V	2400.0	82.0	54.242	4.160	29.670	61.588	74.0	12.412

Table 10 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	2400.0	52.8	54.242	4.160	29.670	32.388	54.0	21.612
V	2400.0	56.1	54.242	4.160	29.670	35.688	54.0	18.312

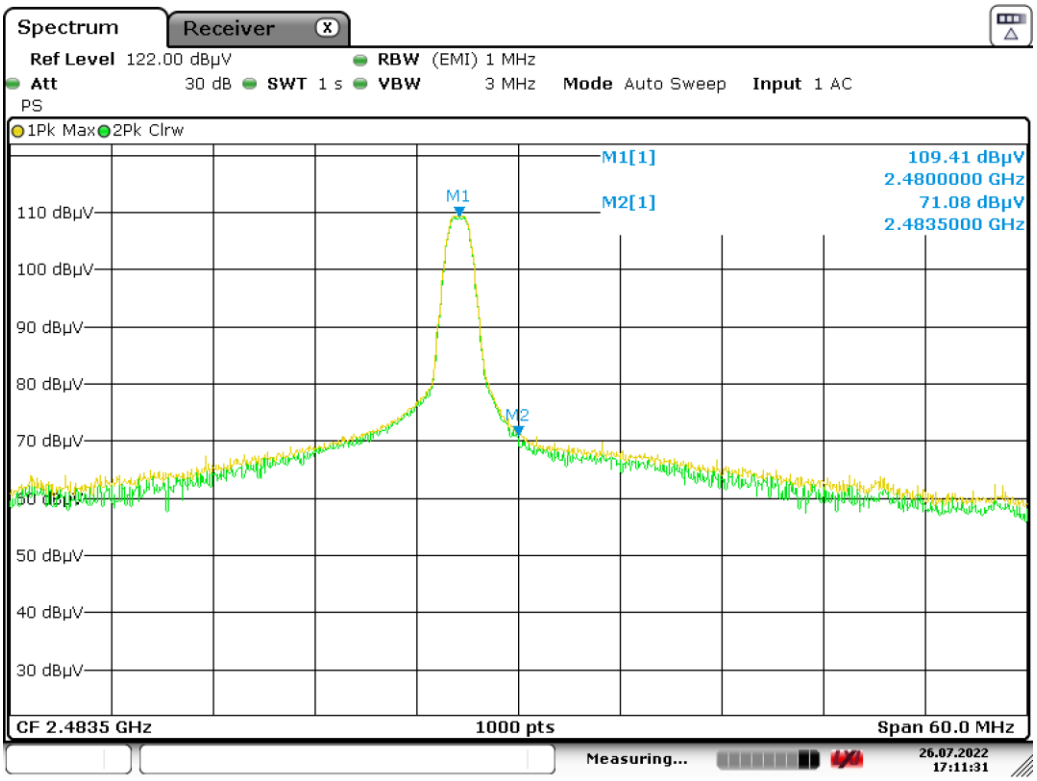
Table 11 Operation on channel 2402MHz average detector measurements

Spectrum analyser displays



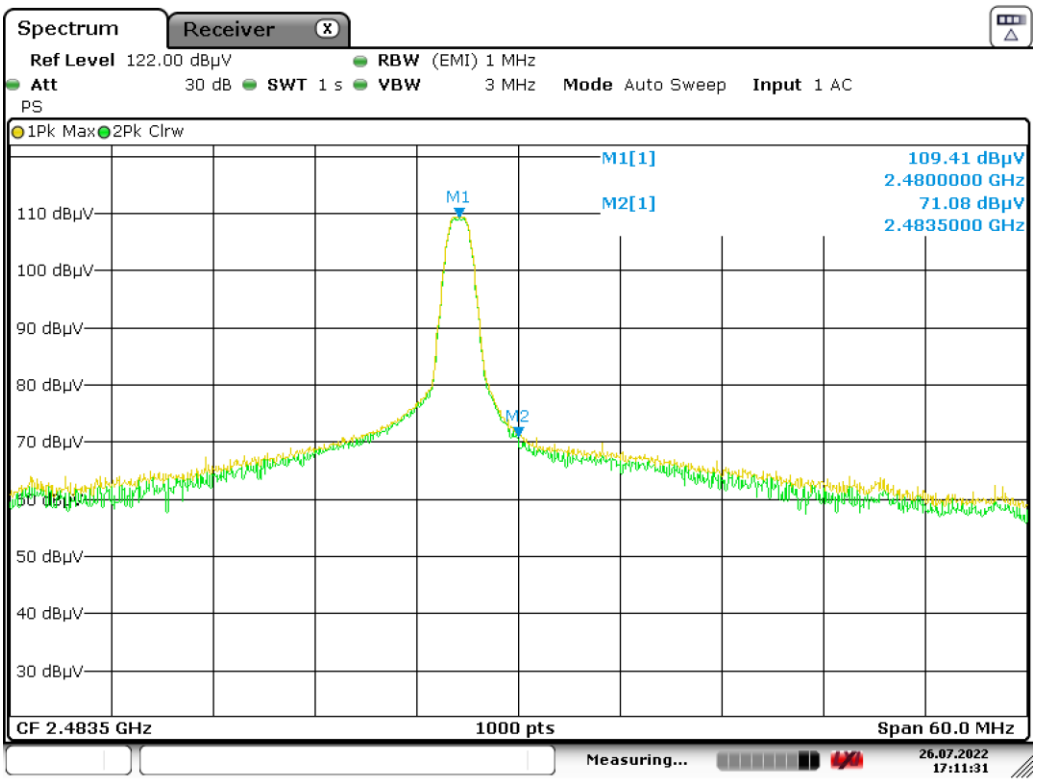
Date: 26.JUL.2022 17:01:53

Figure 27 Band Edge Measurement – upper band edge - horizontal polarity



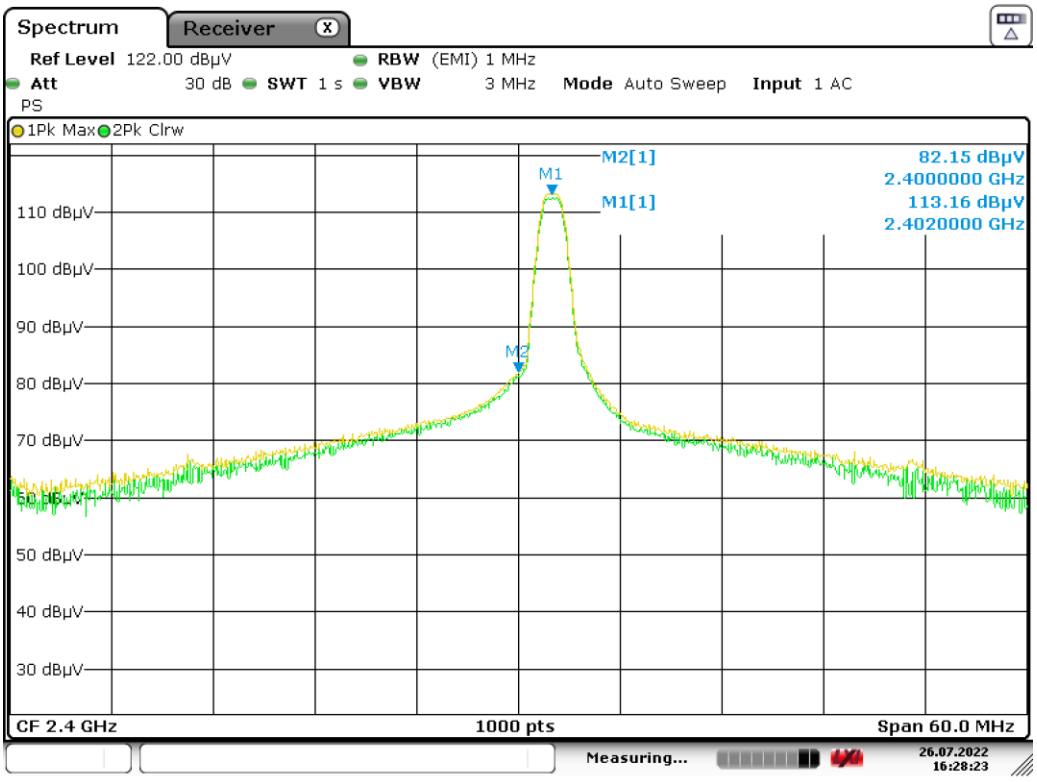
Date: 26.JUL.2022 17:11:31

Figure 28 Band Edge Measurement – upper band edge - vertical polarity



Date: 26.JUL.2022 17:11:31

Figure 29 Band Edge Measurement – lower band edge - horizontal polarity



Date: 26.JUL.2022 16:28:22

Figure 30 Band Edge Measurement – lower band edge - vertical polarity

Section 10 Mains Conducted Emissions

10.1 Test Specification

FCC rule part	47CFR 15.207
Standard	ANSI C63.10:2013
Measurement Uncertainty	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 +/- 3.45dB

10.2 Power Line Emission Limits

Frequency (MHz)	Limit (dBµV)	
	Quasi Peak	Average
0.15 – 0.5	66 – 56*	56 – 46*
0.5 – 5.0	56.0	46.0
5.0 - 30	60.0	50.0

Note: * The limit decreases linearly with the logarithm of the frequency in the range

10.3 Receiver Settings

Receiver Parameters	Setting
Detector Function	Quasi Peak and Average
Start Frequency	150kHz
Stop Frequency	30MHz
Resolution Bandwidth	10kHz
Video Bandwidth	Auto

10.4 Procedure and Test Software Version

Eurofins York test procedure	CEP19 Issue 8
Test software	RadiMation Version 2016.1.6

10.4.1 Date of Test

22nd July 2022

10.4.2 Test Area

LAB 2

10.4.3 Tested by

J Beevers

10.4.4 Test Setup

This test was applied to the EUT's Live and Neutral lines. The EUT was configured in the screened room on an 80cm high table and was positioned 40cm from the room wall.

The EUT was then powered from the mains supply via a Line Impedance Stabilisation Network (LISN).

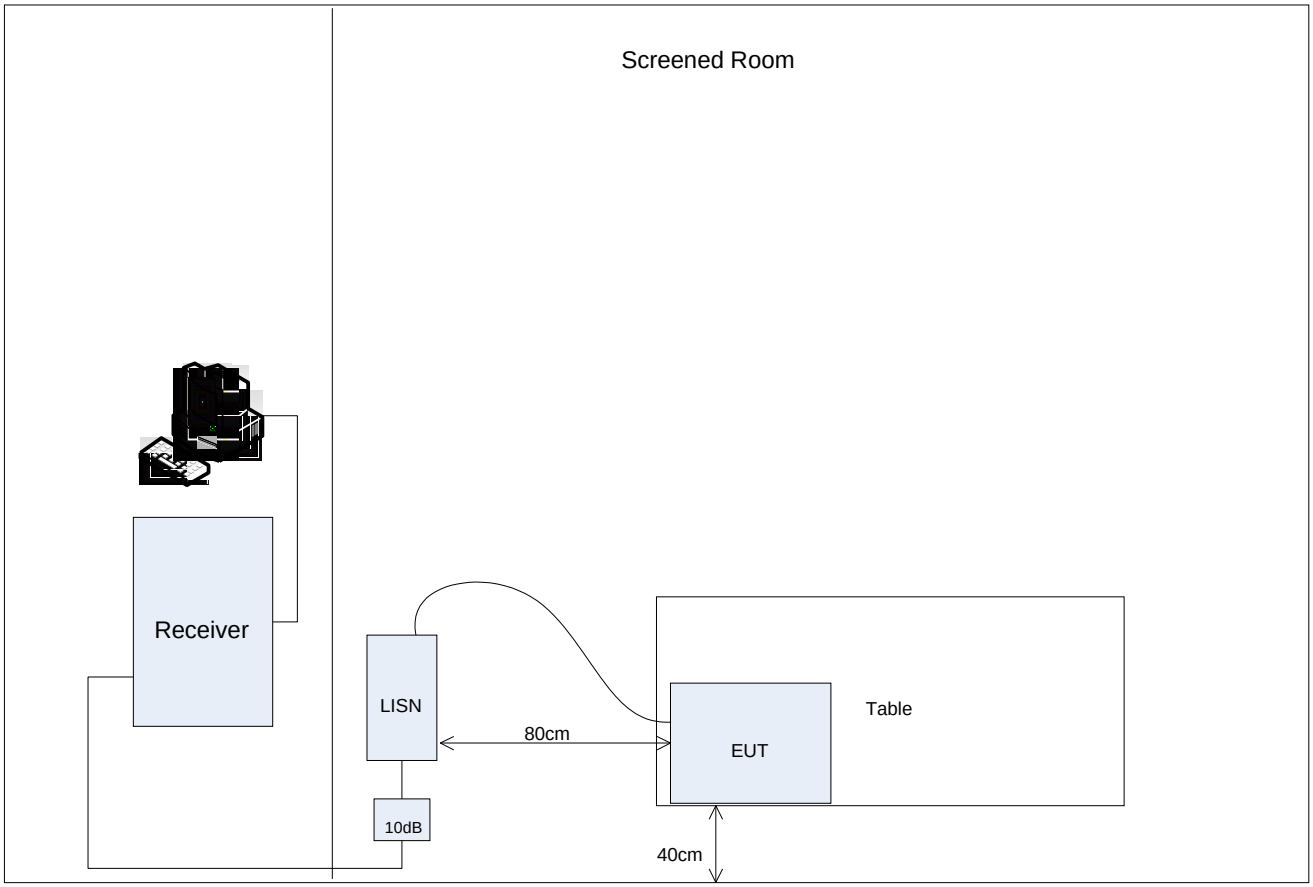


Figure 31: Test setup for Conducted Emissions on the AC power port

The screened room provides an environment that ensures valid, repeatable measurement results that meet the requirements of Clause 5.2 of ANSI C63.4-2014.

10.4.5 Mains Conducted Emissions Results

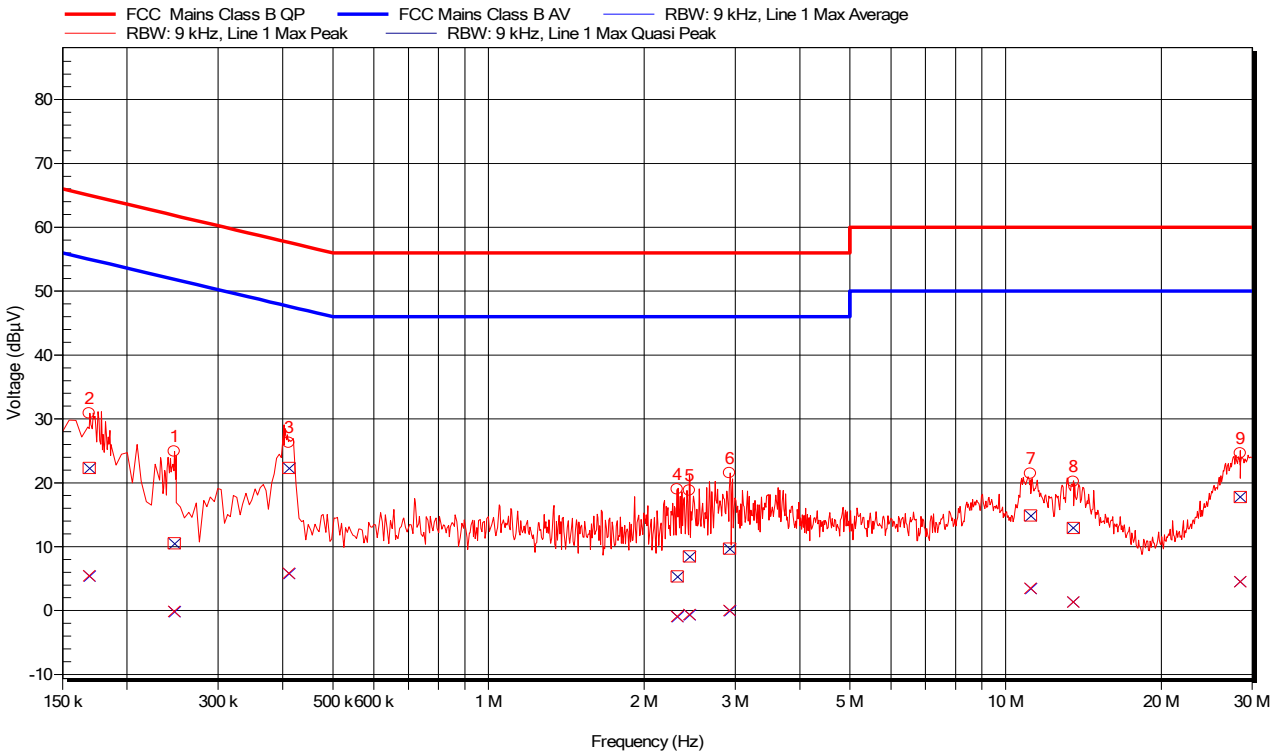


Figure 32: Mains Conducted Emissions Plot - channel 2402MHz - Input Power 120V 60Hz Live

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
246.75 kHz	-0.1	51.9	-52.01	9.8	Pass	10.5	61.9	-51.34	9.8	Pass	Pass
168.90 kHz	5.5	55.0	-49.54	10.0	Pass	22.3	65.0	-42.68	10.0	Pass	Pass
411.00 kHz	5.8	47.6	-41.78	9.9	Pass	22.4	57.6	-35.28	9.9	Pass	Pass
2.318 MHz	-0.9	46.0	-46.90	10.0	Pass	5.3	56.0	-50.65	10.0	Pass	Pass
2.444 MHz	-0.6	46.0	-46.63	10.0	Pass	8.5	56.0	-47.51	10.0	Pass	Pass
2.924 MHz	0.0	46.0	-45.97	10.0	Pass	9.7	56.0	-46.30	10.0	Pass	Pass
11.175 MHz	3.5	50.0	-46.51	10.9	Pass	14.9	60.0	-45.09	10.9	Pass	Pass
13.524 MHz	1.3	50.0	-48.65	11.0	Pass	12.9	60.0	-47.05	11.0	Pass	Pass
28.433 MHz	4.5	50.0	-45.50	11.3	Pass	17.8	60.0	-42.20	11.3	Pass	Pass

Table 12: Input Power Live Conducted Emissions Peaks - Operation on channel 2402MHz

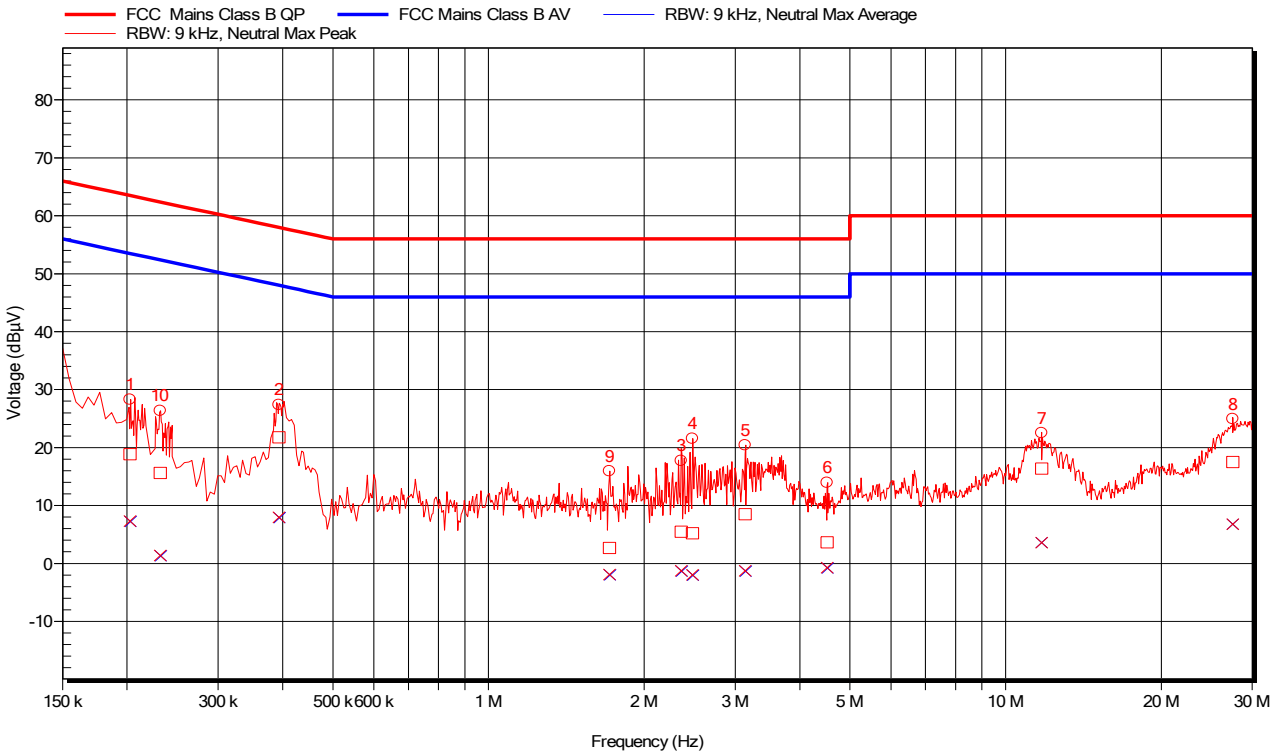


Figure 33: Mains conducted Emissions Plot - channel 2402MHz - Input Power 120V 60Hz Neutral

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
202.65 kHz	7.3	53.5	-46.17	9.9	Pass	18.9	63.5	-44.64	9.9	Pass	Pass
393.45 kHz	8.0	48.0	-40.03	9.8	Pass	21.8	58.0	-36.23	9.8	Pass	Pass
2.359 MHz	-1.3	46.0	-47.29	10.0	Pass	5.5	56.0	-50.52	10.0	Pass	Pass
2.478 MHz	-2.0	46.0	-47.97	10.0	Pass	5.2	56.0	-50.79	10.0	Pass	Pass
3.134 MHz	-1.3	46.0	-47.28	10.1	Pass	8.5	56.0	-47.50	10.1	Pass	Pass
4.519 MHz	-0.7	46.0	-46.74	10.2	Pass	3.6	56.0	-52.38	10.2	Pass	Pass
11.733 MHz	3.6	50.0	-46.42	10.9	Pass	16.4	60.0	-43.60	10.9	Pass	Pass
27.501 MHz	6.8	50.0	-43.23	11.3	Pass	17.5	60.0	-42.47	11.3	Pass	Pass
1.714 MHz	-1.9	46.0	-47.91	10.0	Pass	2.7	56.0	-53.32	10.0	Pass	Pass
231.90 kHz	1.4	52.4	-51.02	9.8	Pass	15.6	62.4	-46.75	9.8	Pass	Pass

Table 13: Input Power Neutral Conducted Emissions Peaks - Operation on channel 2402MHz

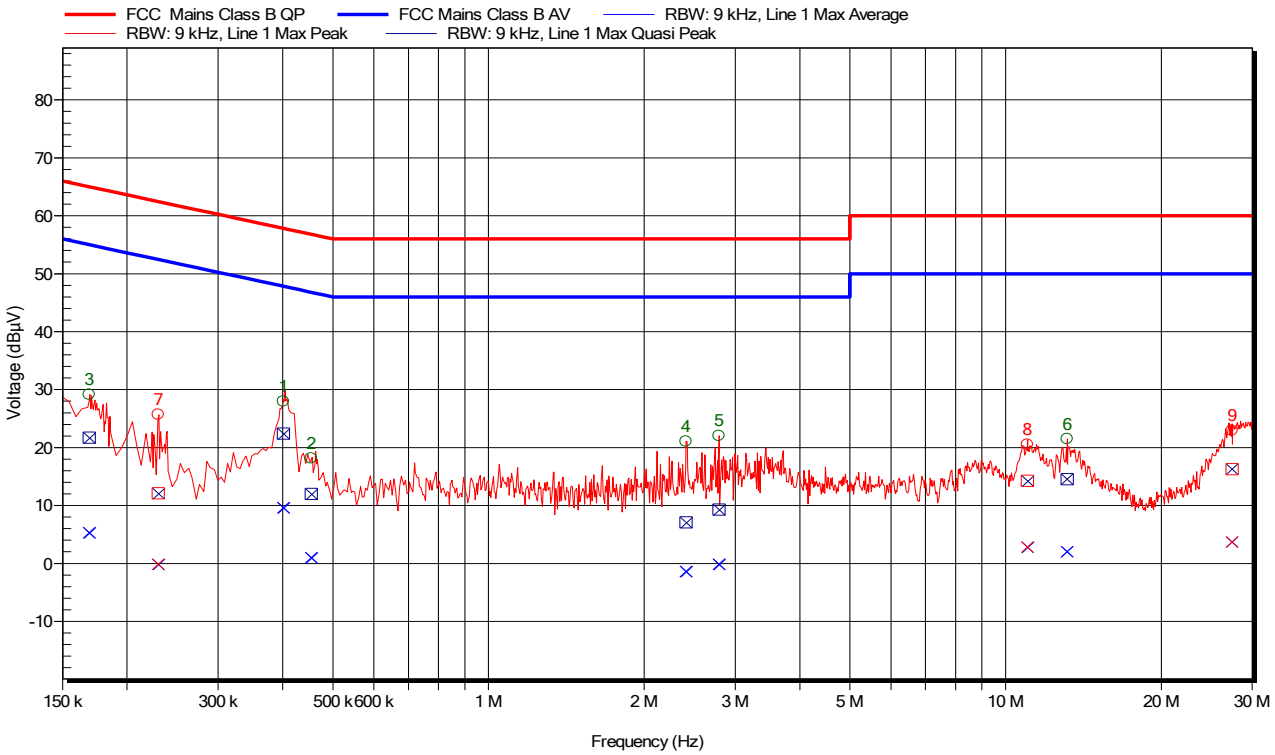


Figure 34: Mains Conducted Emissions Plot - channel 2440MHz - Input Power 120V 60Hz Live

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
401.1 kHz	9.6	47.8	-38.22	9.9	Pass	22.4	57.8	-35.44	9.9	Pass	Pass
454.2 kHz	1.0	46.8	-45.80	9.9	Pass	12.0	56.8	-44.77	9.9	Pass	Pass
168.9 kHz	5.3	55.0	-49.70	10.0	Pass	21.7	65.0	-43.30	10.0	Pass	Pass
2.409 MHz	-1.3	46.0	-47.35	10.0	Pass	7.1	56.0	-48.90	10.0	Pass	Pass
2.790 MHz	-0.1	46.0	-46.15	10.0	Pass	9.3	56.0	-46.72	10.0	Pass	Pass
13.155 MHz	2.0	50.0	-47.96	11.0	Pass	14.6	60.0	-45.44	11.0	Pass	Pass
229.650 kHz	-0.1	52.5	-52.59	9.8	Pass	12.1	62.5	-50.33	9.8	Pass	Pass
11.022 MHz	2.8	50.0	-47.17	10.8	Pass	14.3	60.0	-45.73	10.8	Pass	Pass
27.426 MHz	3.7	50.0	-46.29	11.3	Pass	16.3	60.0	-43.71	11.3	Pass	Pass

Table 14: Input Power Live Conducted Emissions Peaks - Operation on channel 2440MHz

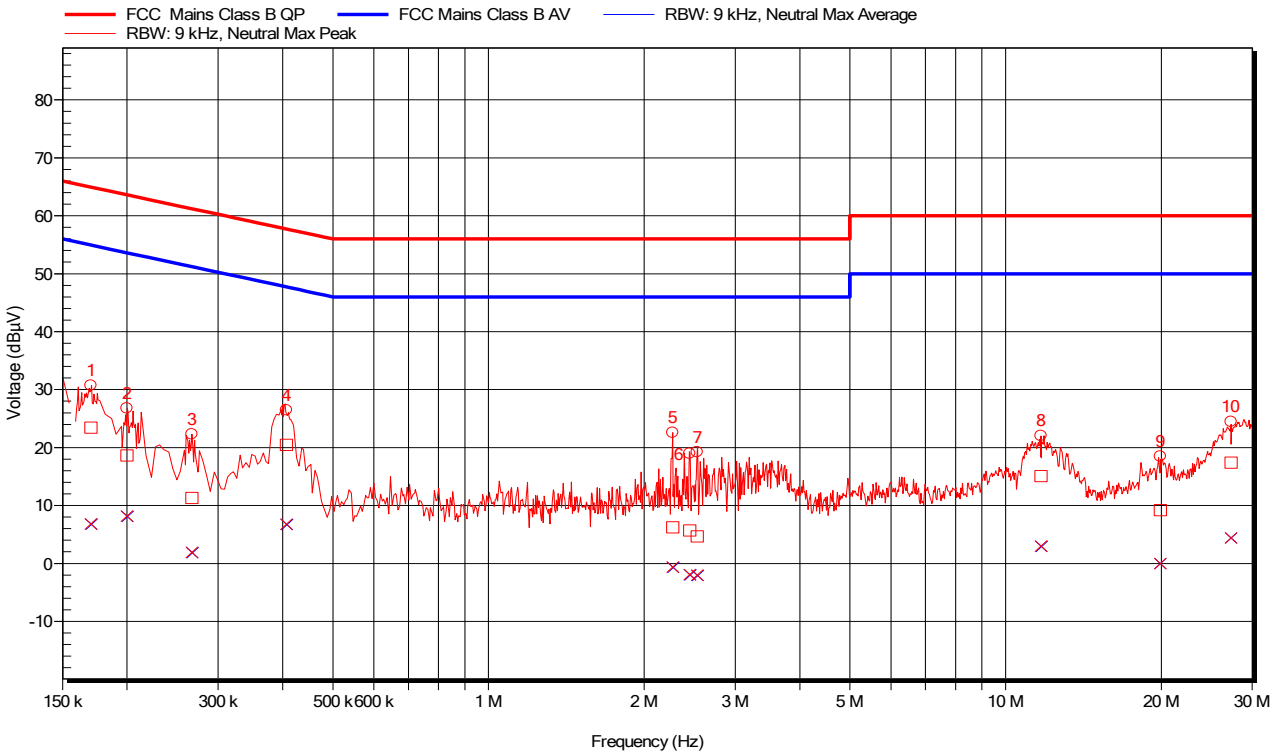


Figure 35: Mains conducted Emissions Plot - channel 2440MHz - Input Power 120V 60Hz Neutral

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
170.25 kHz	6.8	54.9	-48.15	10.0	Pass	23.5	64.9	-41.50	10.0	Pass	Pass
199.95 kHz	8.2	53.6	-45.42	9.9	Pass	18.6	63.6	-44.99	9.9	Pass	Pass
267.00 kHz	1.9	51.2	-49.27	9.7	Pass	11.3	61.2	-49.92	9.7	Pass	Pass
406.50 kHz	6.8	47.7	-40.95	9.9	Pass	20.5	57.7	-37.23	9.9	Pass	Pass
2.269 MHz	-0.6	46.0	-46.64	10.0	Pass	6.2	56.0	-49.75	10.0	Pass	Pass
2.448 MHz	-1.9	46.0	-47.90	10.0	Pass	5.7	56.0	-50.31	10.0	Pass	Pass
2.533 MHz	-2.0	46.0	-47.99	10.0	Pass	4.7	56.0	-51.33	10.0	Pass	Pass
11.702 MHz	3.0	50.0	-46.99	10.9	Pass	15.1	60.0	-44.95	10.9	Pass	Pass
19.932 MHz	0.0	50.0	-50.05	11.0	Pass	9.2	60.0	-50.81	11.0	Pass	Pass
27.308 MHz	4.4	50	-45.60	11.3	Pass	17.4	60.0	-42.58	11.3	Pass	Pass

Table 15: Input Power Neutral Conducted Emissions Peaks - Operation on channel 2440MHz

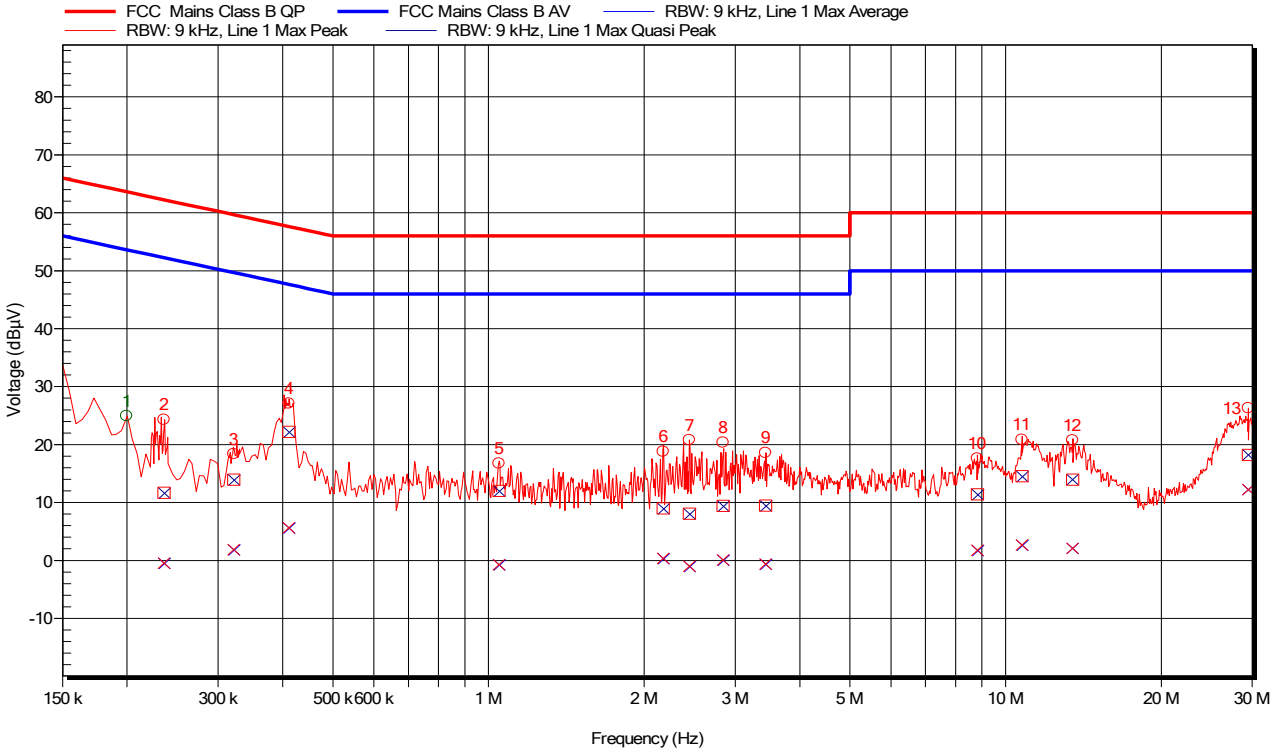


Figure 36: Mains Conducted Emissions Plot - channel 2480MHz - Input Power 120V 60Hz Live

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
235.79 kHz	-0.4	52.2	-52.68	9.8	Pass	11.7	62.2	-50.54	9.8	Pass	Pass
321.45 kHz	1.9	49.7	-47.80	9.7	Pass	13.9	59.7	-45.74	9.7	Pass	Pass
411.00 kHz	5.6	47.6	-42.00	9.9	Pass	22.2	57.6	-35.45	9.9	Pass	Pass
1.047 MHz	-0.7	46.0	-46.72	10.0	Pass	12.0	56.0	-43.99	10.0	Pass	Pass
2.175 MHz	0.3	46.0	-45.67	10.0	Pass	9.0	56.0	-47.00	10.0	Pass	Pass
2.445 MHz	-1.0	46.0	-46.99	10.0	Pass	8.1	56.0	-47.91	10.0	Pass	Pass
2.841 MHz	0.1	46.0	-45.90	10.0	Pass	9.4	56.0	-46.59	10.0	Pass	Pass
3.432 MHz	-0.6	46.0	-46.62	10.1	Pass	9.5	56.0	-46.53	10.1	Pass	Pass
8.817 MHz	1.8	50.0	-48.24	10.7	Pass	11.4	60.0	-48.58	10.7	Pass	Pass
10.757 MHz	2.7	50.0	-47.33	10.8	Pass	14.6	60.0	-45.45	10.8	Pass	Pass
13.479 MHz	2.1	50.0	-47.93	11.0	Pass	14.0	60.0	-46.05	11.0	Pass	Pass
29.466 MHz	12.2	50.0	-37.76	11.4	Pass	18.2	60.0	-41.81	11.4	Pass	Pass

Table 16: Input Power Live Conducted Emissions Peaks - Operation on channel 2480MHz

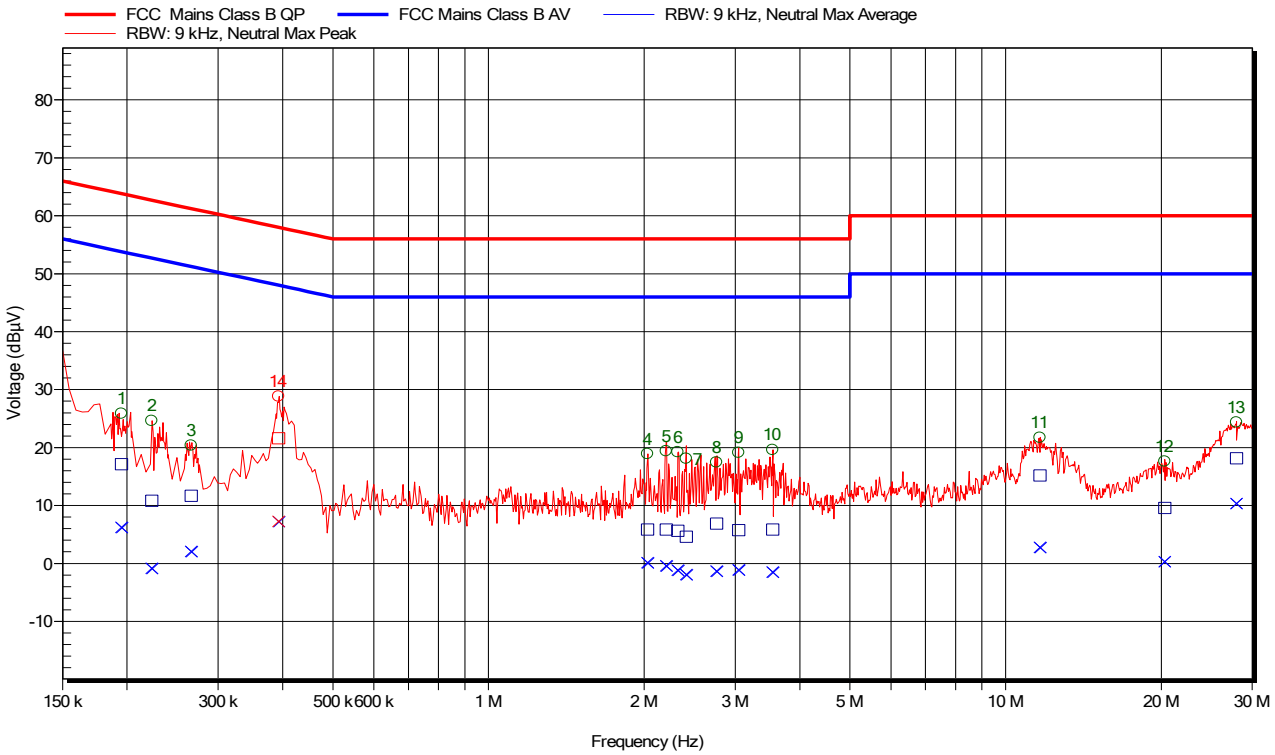


Figure 37: Mains conducted Emissions Plot - channel 2480MHz - Input Power 120V 60Hz Neutral

Frequency	Average dBµV	Average Limit dBµV	Average Difference dB	Average Correction dB	Average Status dB	Quasi-Peak dBµV	Quasi-Peak Limit dBµV	Quasi-Peak Difference dB	Quasi-Peak Correction dB	Quasi-Peak Status	Overall Status
195.00 kHz	6.2	53.8	-47.59	9.9	Pass	17.2	63.8	-46.67	9.9	Pass	Pass
223.35 kHz	-0.9	52.7	-53.54	9.8	Pass	10.8	62.7	-51.86	9.8	Pass	Pass
266.10 kHz	2.1	51.2	-49.13	9.7	Pass	11.7	61.2	-49.57	9.7	Pass	Pass
2.031 MHz	0.1	46.0	-45.87	10.0	Pass	5.8	56.0	-50.17	10.0	Pass	Pass
2.206 MHz	-0.4	46.0	-46.42	10.0	Pass	5.9	56.0	-50.15	10.0	Pass	Pass
2.324 MHz	-1.2	46.0	-47.16	10.0	Pass	5.7	56.0	-50.35	10.0	Pass	Pass
2.413 MHz	-1.9	46.0	-47.91	10.0	Pass	4.6	56.0	-51.36	10.0	Pass	Pass
2.759 MHz	-1.3	46.0	-47.32	10.0	Pass	6.9	56.0	-49.13	10.0	Pass	Pass
3.048 MHz	-1.1	46.0	-47.13	10.1	Pass	5.8	56.0	-50.24	10.1	Pass	Pass
3.543 MHz	-1.5	46.0	-47.46	10.1	Pass	5.8	56.0	-50.15	10.1	Pass	Pass
11.657 MHz	2.8	50.0	-47.20	10.9	Pass	15.2	60.0	-44.83	10.9	Pass	Pass
20.319 MHz	0.3	50.0	-49.68	11.0	Pass	9.6	60.0	-50.41	11.0	Pass	Pass
27.965 MHz	10.3	50.0	-39.66	11.3	Pass	18.1	60.0	-41.87	11.3	Pass	Pass
392.55 kHz	7.3	48.0	-40.73	9.8	Pass	21.6	58.0	-36.40	9.8	Pass	Pass

Table 17: Input Power Neutral Conducted Emissions Peaks - Operation on channel 2480MHz

10.4.6 Correction factors

The quasi-peak correction and average correction are shown in the above table. This correction figure consists of LISN Insertion loss (IL), Cable loss (CL) and Transient Limiter Loss (TL)

The Actual Signal Level (ASL) is calculated as follows:

ASL (dBµV) = Indicated Signal Level (dBµV) + IL (dB) + CL (dB) + TL (dB)

10.4.7 Sample Data

The Quasi-Peak level at 27.965 MHz

ASL (dBµV) = 10.3dBµV = -1.4dBµV + 1.2dB + 0.1dB + 10.4dB

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 22	January 2022	12 Months
R & S ESR7	C0499	3rd February 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
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