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Test Report for the Testing of the Communicator to FCC Rule 47CFR 15.247 and ISED RSS-247 For Lumi holdings ltd

Test Report number 13511TR3

Project number C5342

Author: .....
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Checked: .....
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Approved: .....
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Principal Engineer

Issue	Description						Issue by	Date
3	*Copy 1*		*Copy 2*		*PDF*		*E Warren*	*20th April 2020*

1574

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Registered in England and Wales
Company Reg. No. 6048589
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Test Report Change History

Issue	Date	Modification Details
1	31 March 2020	Original issue of test report
2	2nd April 2020	Reissue with new radiated emission results.
3	20th April 2020	Reissue with radiated band edge measurements
4		
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7		
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10		

Section 1 Test Location

All testing was performed at;

Eurofins York Ltd	Unit 5
	Speedwell Road
	Castleford
	WF10 5PY
	-
Tested by	M Render, Senior Test Engineer
Tel:	01977 731173
	-
Website	http://www.yorkemc.co.uk
UKAS Testing No.	1574

1.1 UKAS Accreditation

Tests marked "Not UKAS Accredited" in this report are not included in the UKAS Accreditation Schedule for our laboratory.

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

York EMC Services latest accreditation schedule can be found at:

http://www.ukas.org/testing/lab_detail.asp?lab_id=989&location_id=&vMenuOption=3

FCC Recognition

Eurofins York Castleford Laboratory is an Accredited facility recognised by the Federal Communications Commission (FCC) for certification testing. The appropriate FCC Designation Number is number UK0022, dated 5th September 2017

ISED Recognition

Eurofins York Castleford Laboratory is an Accredited facility recognised by the Innovation, Science and Economic Development Canada (ISED) for certification testing. The appropriate ISED number is 22959

Section 2 Customer Information

Company name	Lumi holdings ltd
Address	Armoury House
	Ordnance Business Park,
	Midhurst Road,
	Liphook
	Hampshire,
	GU30 7ZA
Tel:	-
Contact	-
Customer Representative(s) present during testing	Not present.

Section 3 Equipment Details

3.1 Equipment Under Test (EUT)

Date received:	31st January 2020
EUT name:	Communicator
FCCID	In progress
EUT description:	Handheld wireless communication device for audience voting and feedback
Hardware version	PRDV06a
Firmware version	B2.11.0R
Transmission	Frequency Hopping Spread Spectrum (FHSS)
Modulation	GMSK modulation

No of units tested:	One
EUT power:	Battery operation
Highest internal frequency:	2480MHz
Highest frequency to test to for emissions (	24.8350GHz (tenth harmonic of the highest fundamental)
Number of channels to test	Three, one near the bottom, middle and top
Mode/s of operation	Transmitting on channel 2403.56MHz Transmitting on channel 2436.45MHz Transmitting on channel 2479.68MHz Frequency hopping enabled
Modifications incorporated during testing:	None

3.2 EUT Photos

Photographs of the apparatus and test set ups are provided separately.

3.3 Configuration of EUT

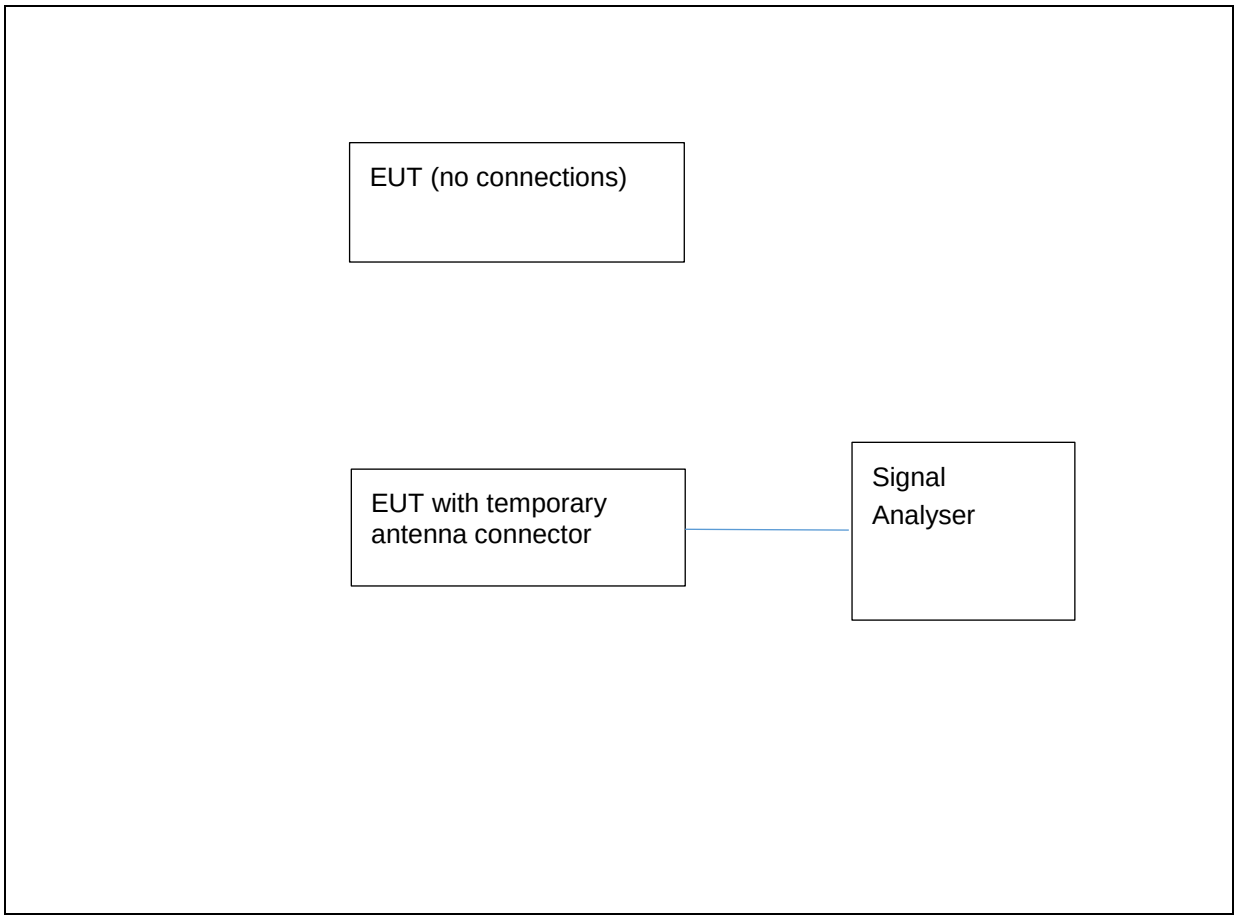

Figure 1: Diagram of EUT

3.4 EUT Monitoring/Auxiliary Equipment

None.

Section 4 Test Specifications

The tests were performed in accordance with Eurofins York Quotation QuC3881

FCC Requirements

FCC Rule	47 CFR Part 15 Radio Frequency Devices; Subpart C Intentional Radiators
Test standard	ANSI C63.10-2013

Test description	Rule Part	Result Summary
Intentional emission, band occupancy, 20dB bandwidth	47 CFR 15.215(C) 47 CFR 15.247 (a)(1)(i)	Pass
FHSS Requirements	Number of hopping channels 47CFR15.247(a)(1)(i)	Pass
	Channel separation 47CFR15.247(a)(1)(i)	Pass
	Hopping channel occupancy time 47CFR15.247(a)(1)(i)	Pass
	Hopping sequence 47CFR15.247(a)(1)(i)	Pass
Peak power output (conducted)	47 CFR 15.247 b (2)	Pass
Maximum antenna gain	47 CFR 15.247 b(4)	Pass
Radiated spurious emissions* 30MHz to 10GHz	15.247(d)	Pass
Restricted band compliance	47CFR15.247(d) and 45CFR15.205 and 47CFR15.209	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 – battery powered	Not applicable

Note 1 :All testing was carried out at a test distance of 3m and the limits adjusted accordingly. This is a deviation from the standard as Class A limits are specified at 10m test distance.

Note 2: Applies to carrier current systems see reference 47CFR Part 15Clause 15.109(e).

ISED Requirements

Test description	RSS Reference	Result Summary
Intentional emission, band occupancy	-	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
Maximum antenna gain	-	Pass (declaration)
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
AC power line conducted emissions	RSS-247 Section 3.1 RSS Gen Section 8.8 Applicable when powered via USB	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 Communicator as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

Section 5 Maximum Conducted Output Power

FCC Rule Part	47CFR15.247(b)(2)
ISED	RSS-247 Issue 2 Section 5.4(a)
Standard	ANSI C63.10:2013
Measurement Uncertainty	The reported uncertainty of measurement y ± U, where expanded 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 ±1.5dB

5.1.1 Date of Test

3rd March 2020

5.1.2 Test Area

Laboratory 4

5.1.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short cable.

5.1.4 Maximum Peak Conducted Power Limit

47CFR15.247(b)(1)

For frequency hopping systems operating in the 2400MHz to 24835MHz band: 1 watt (30dBm) for systems employing at least 50 hopping channels.

5.1.5 Test Results

Frequency (MHz)	Measured Power (mW)	Measured Power (dBm)	Cable loss (dB)	Conducted power (dBm)	Limit (dBm)	Margin (dB)	Result Summary
2403.56	193.67	22.87	0.5	23.37	30.0	-6.63	Pass
2436.45	166.14	22.20	0.5	22.7	30.0	-7.3	Pass
2479.68	104.33	20.2	0.5	20.7	30.0	-9.3	Pass

Note:

10dBm = 0.01W

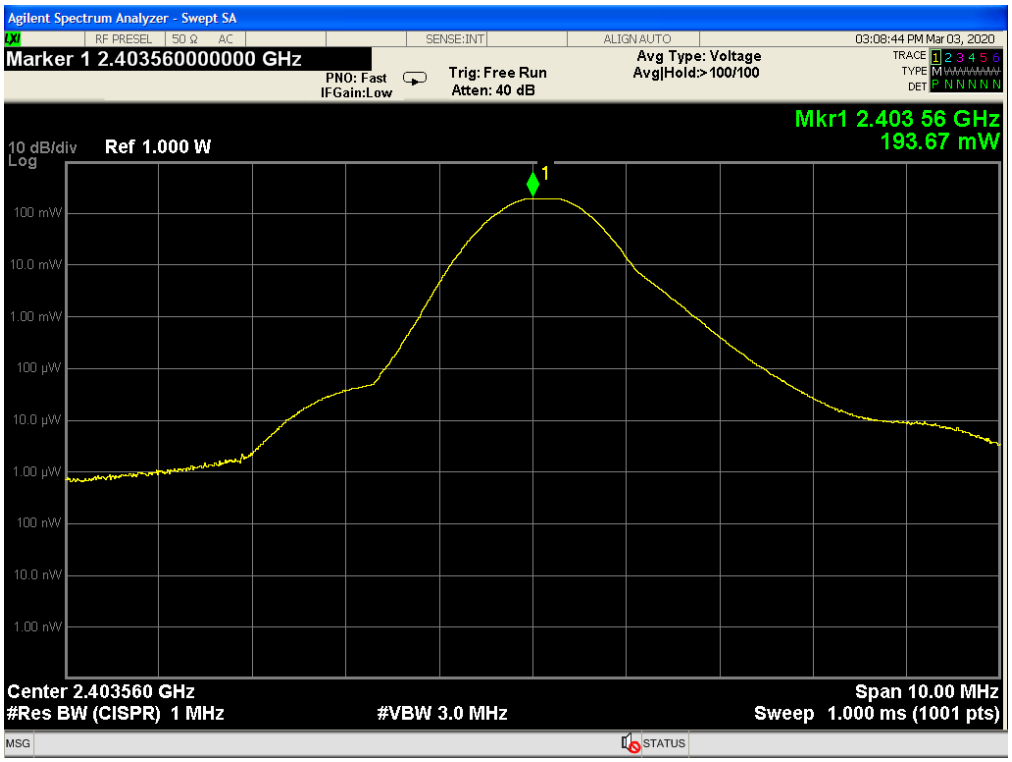

Figure 2: Peak output power – Bottom Channel 2403.56MHz

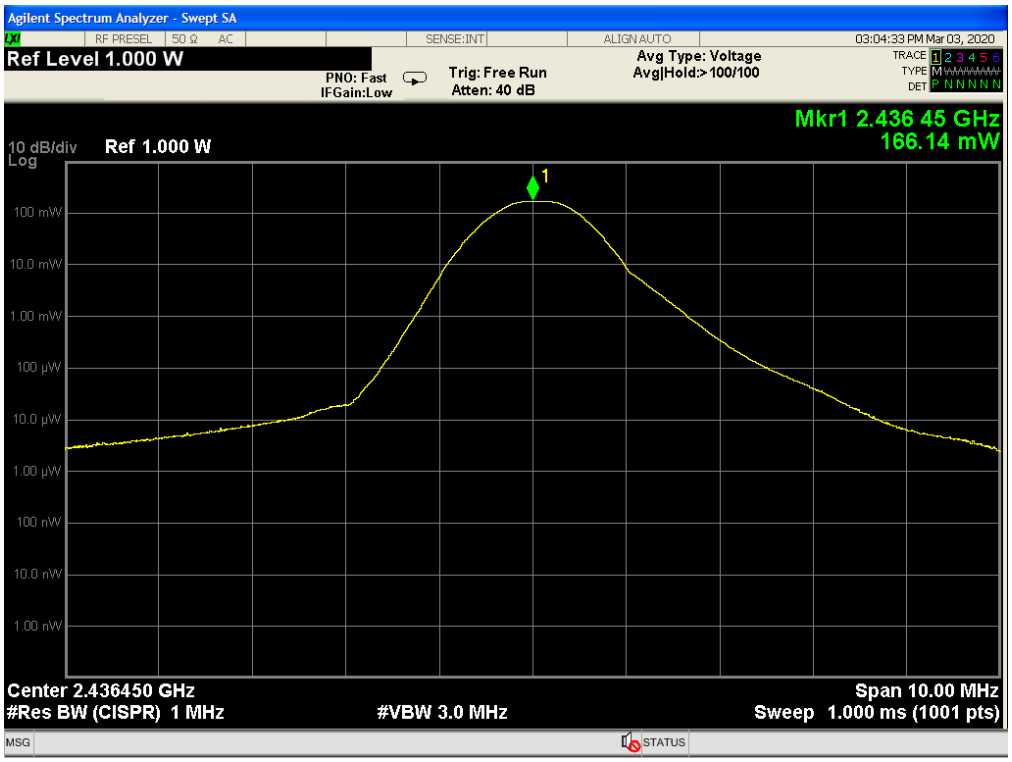

Figure 3: Peak output power – Middle Channel 2436.45MHz

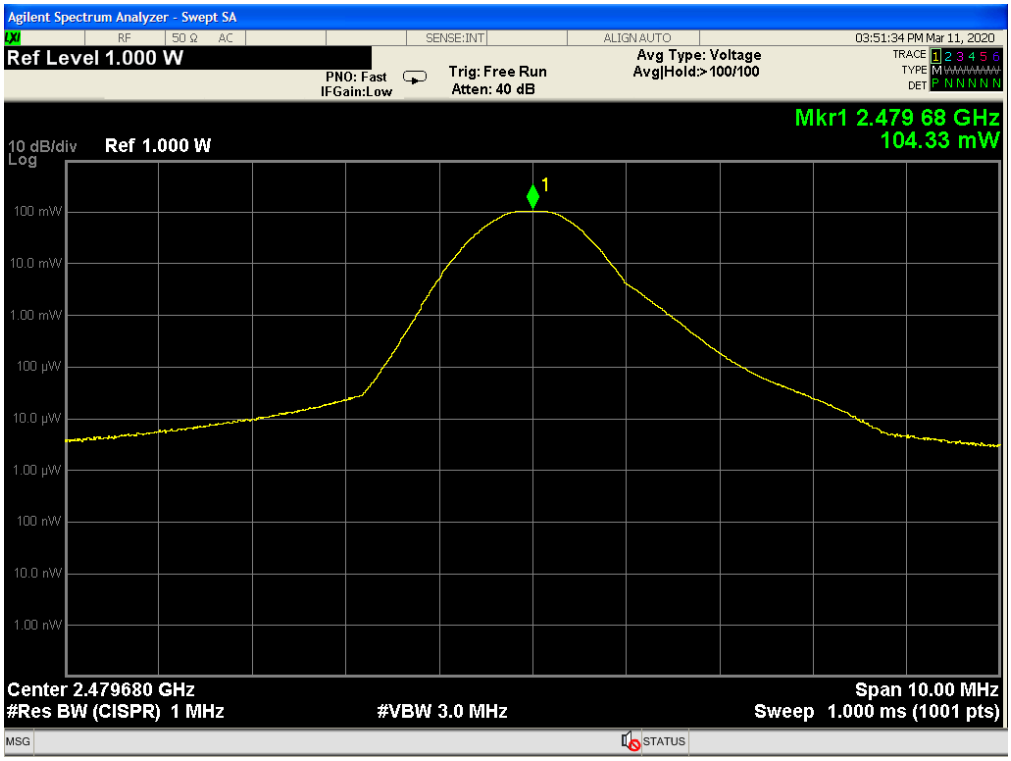

Figure 4: Peak output power – Top Channel 2479.68MHz

Section 6 Conducted Spurious Emission Results

FCC Rule Part	47CFR15.247(d)
ISED	RSS-247 Issue 2
Standard	ANSI C63.10:2013
Measurement Uncertainty	The reported uncertainty of measurement y ± U, where expanded 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 ±1.5dB

6.1.1 Date of Test

3rd March 2020

6.1.2 Test Area

Laboratory 1

6.1.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short (30cm) low loss coaxial cable

6.1.4 Maximum Peak Conducted Spurious Power Limit

47CFR15.247(d)

The unwanted 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

Emissions within the restricted bands must comply with the radiated emission limits of 47CFR 15.209.

6.1.5 Test Results

The measurements were taken with the equipment transmitting on the top, middle and bottom channels.

In the spectrum analyser displays the green display line is positioned 40dB below the peak carrier. All disturbances are greater than 40dB below the carrier in all cases.

Disturbance within the restricted bands were measured radiated.

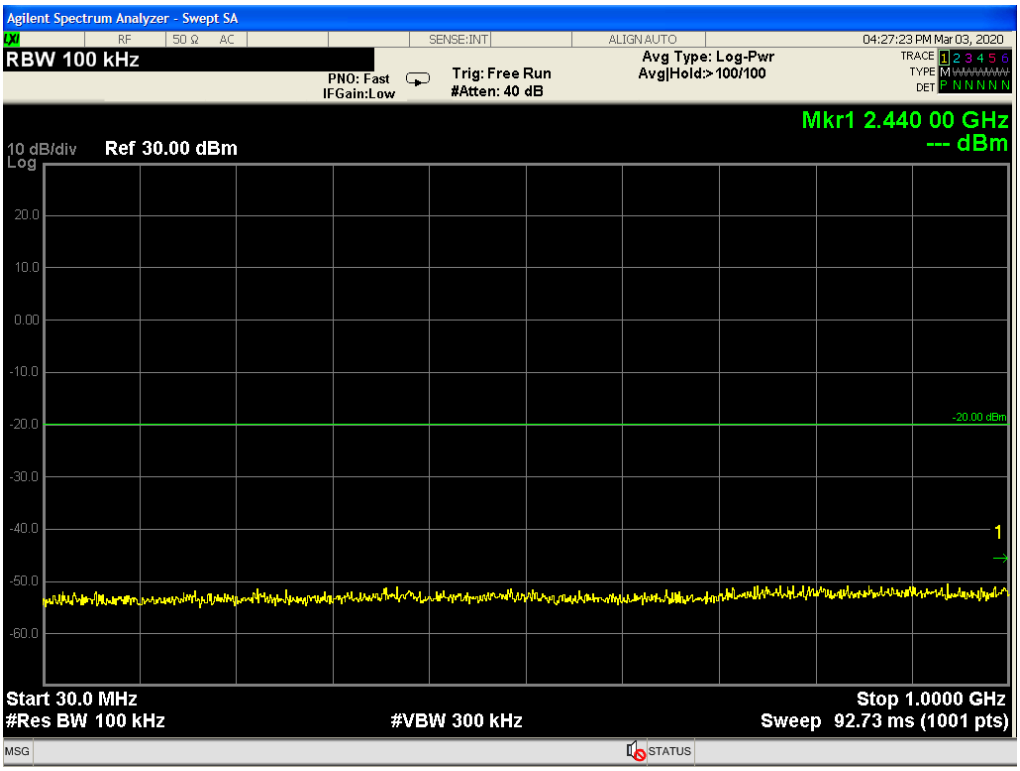

Figure 5: Conducted emissions bottom channel 30MHz to 1GHz

Figure 6: Conducted emissions bottom channel 1GHz to 10GHz

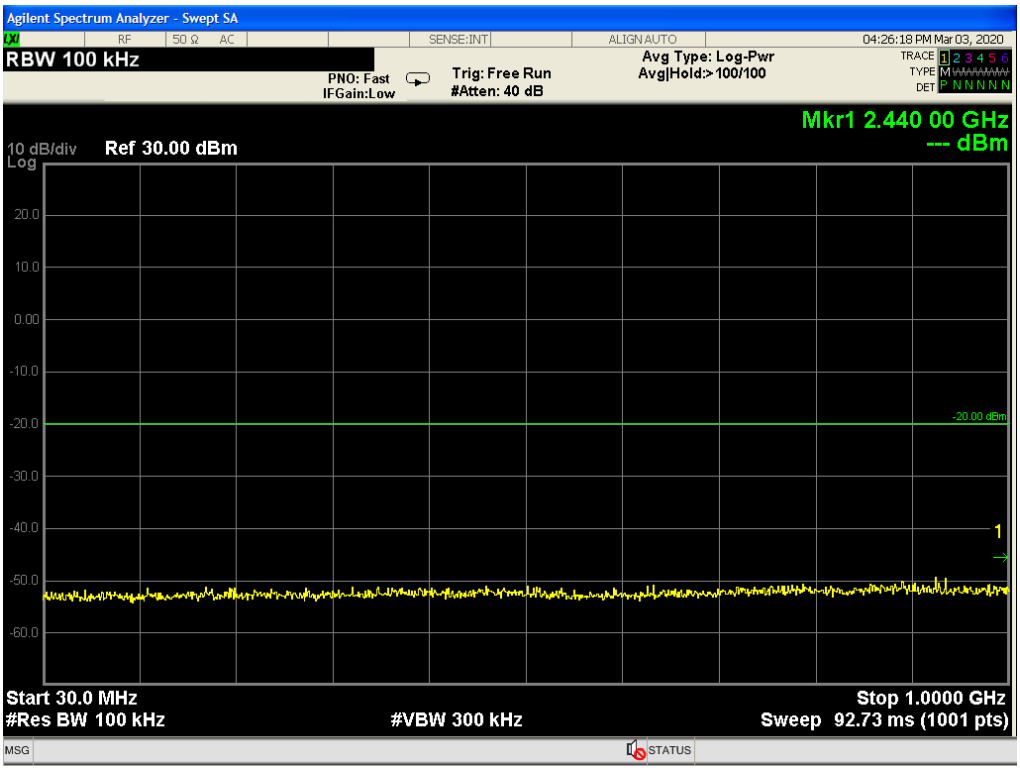

Figure 7: Conducted emissions middle Channel 30MHz to 1GHz

Figure 8: Conducted emissions middle channel 1GHz to 25GHz

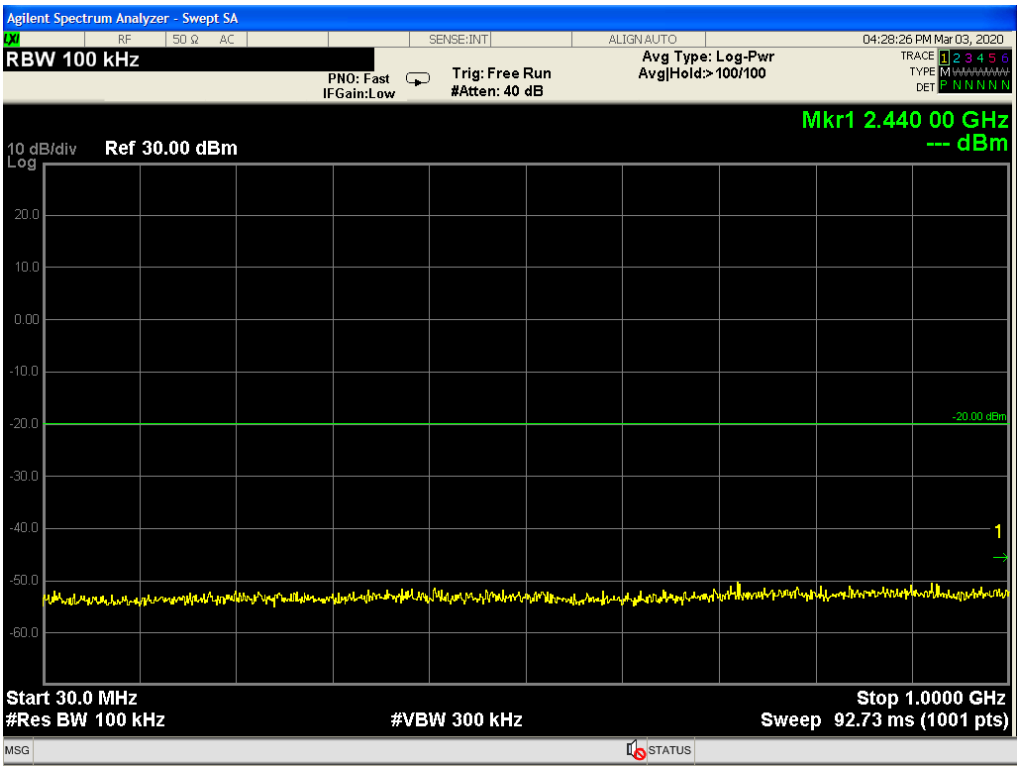

Figure 9: Conducted emissions top channel 30MHz to 1GHz

Figure 10: Conducted emissions top channel 1GHz to 25GHz

Section 7 Radiated Emission Results

7.1 Test Specification

FCC Rule Part	47CFR15.247(d) and 47CFR15.209
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 +/- 4.27dB for the frequency range from 9kHz to 30MHz +/- 5.81dB 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 +/- 4.77dB for the frequency range from 18GHz to 40GHz

7.2 Procedure and Test Software Version

Eurofins York Test procedure (9kHz to 30MHz)	CEP22 Issue 2
Eurofins York test procedure (30MHz to 1GHz)	CEP23b Issue 2
Eurofins York test procedure (1GHz to 40GHz)	CEP64b Issue 2
Test software	Radimation Version 2018.2.8

7.2.1 Electric Field Strength Limits

The electric field strength limits are defined in 47CFR15.209. The radiated limits apply to any disturbance within the restricted bands defined section 47CFR15.205. All other emissions must comply with the conducted emission requirement of 47CFR15.247(d).

Frequency (MHz)	Quasi Peak (dBμV/m)
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 specifies test limits at 3m.

7.2.2 Receiver Settings

Receiver Parameters	Setting
Detector Function for spectrum analyser swept measurements	Peak hold
Detector Function for final measurements	Quasi Peak
Start Frequency	30MHz
Stop Frequency	1000MHz
Resolution Bandwidth	120kHz
Video Bandwidth	Auto

7.2.3 Emissions measurements

7.2.4 Date of Test

4th February 2020

7.2.5 Test Area

Laboratory 1

7.2.6 Test Setup

The EUT was configured in the Semi-Anechoic Chamber (SAC) on an 80cm high table.

The measurement was performed with an antenna to EUT separation distance of 3m. The Quasi peak limits are therefore increased by 10dB (from the 10m values), to allow for the reduction in the measurement distance.

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

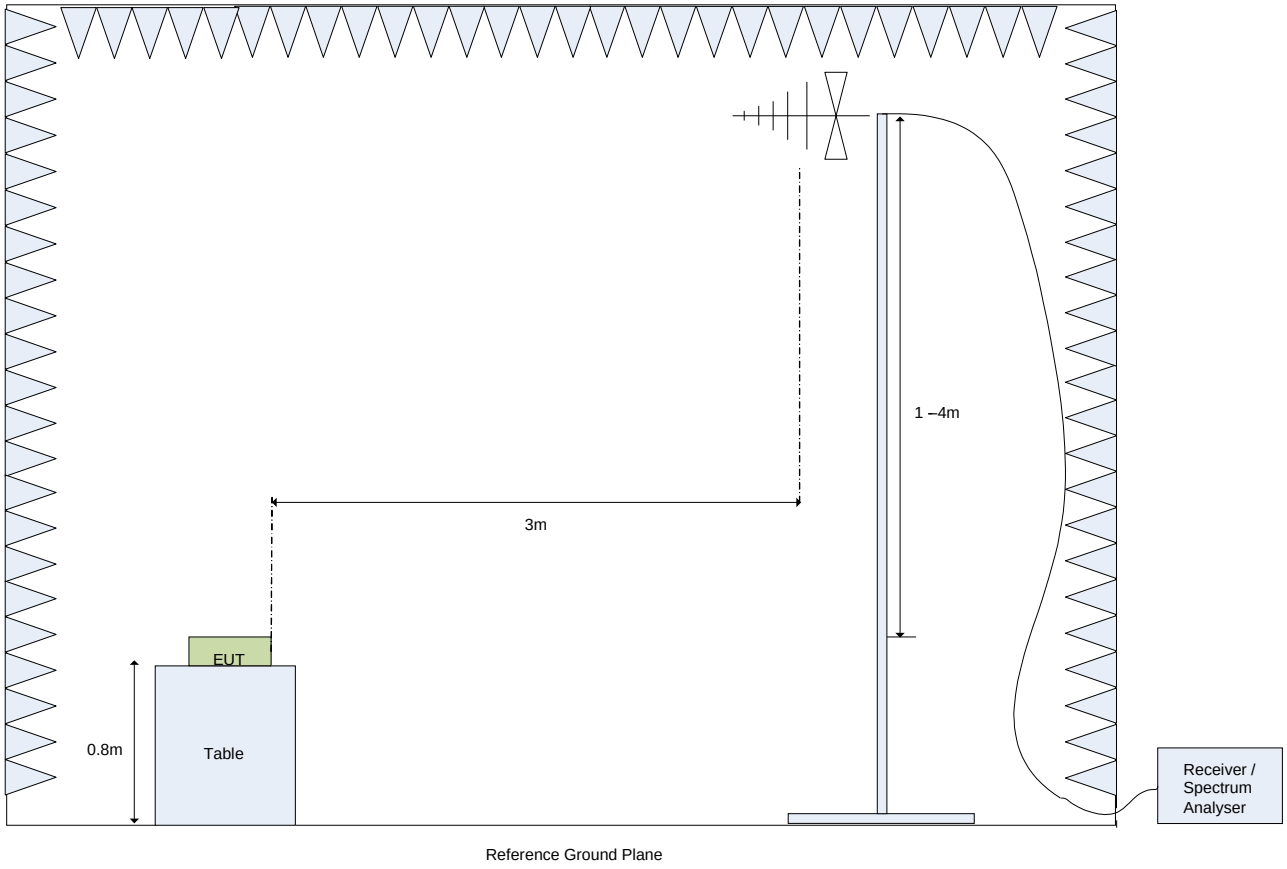

Figure 11: Arrangement for radiated electric field emissions 30MHz to 1GHz

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.

EUT Orientation

The device was tested in all three orientations as per C63.10 clause 5.10.1.

7.2.7 Radiated Electric field emissions, 30MHz to 1GHz

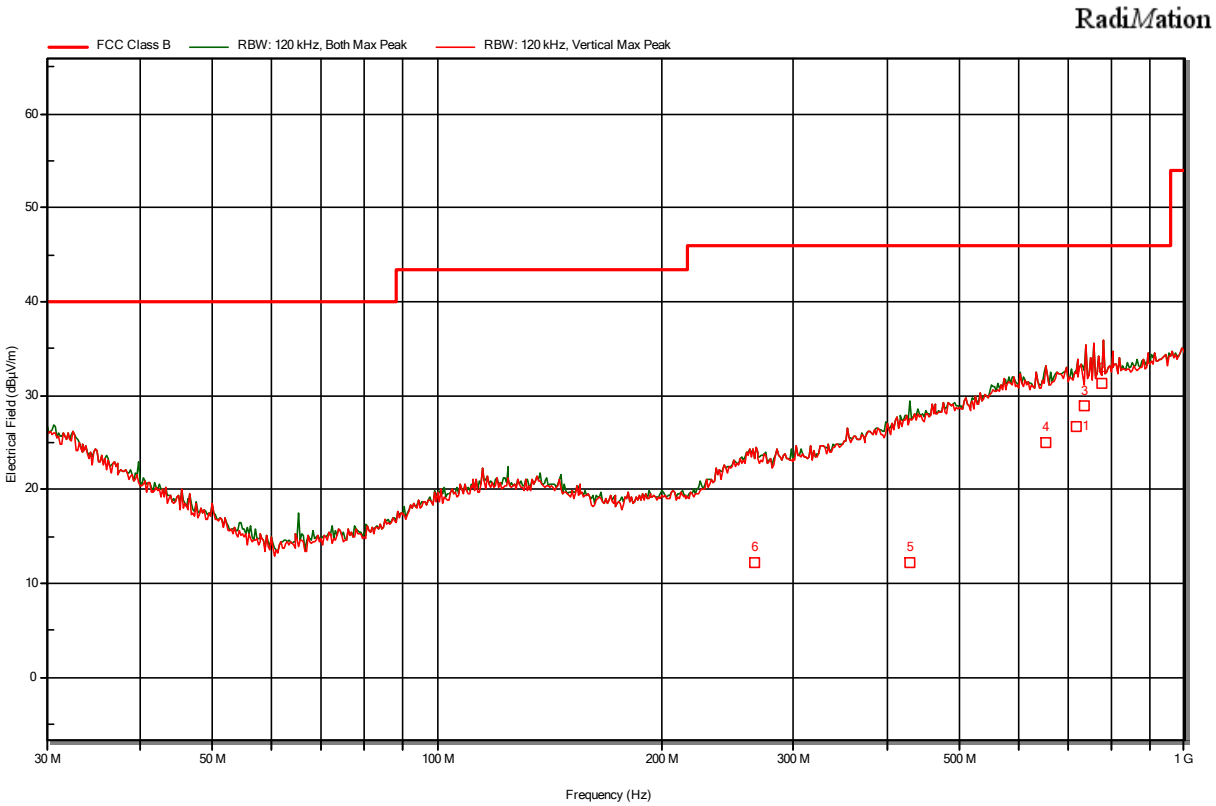

Figure 12: Radiated electric field emissions bottom channel

Frequency (MHz)	Quasi-Peak (dBµV/m)	Quasi-Peak Limit (dBµV/m)	Quasi-Peak Difference (dB)	Quasi-Peak Status	Angle (degree)	Height (m)	Polarization
266.46	12.3	46	-33.7	Pass	325	1.5	Vertical
428.22	12.3	46	-33.7	Pass	195	1.8	Horizontal
653.16	25	46	-21	Pass	15	1.5	Vertical
715.38	26.6	46	-19.4	Pass	360	1.5	Vertical
736.14	29	46	-17	Pass	360	1.4	Vertical
777.6	31.3	46	-14.7	Pass	10	1.3	Vertical

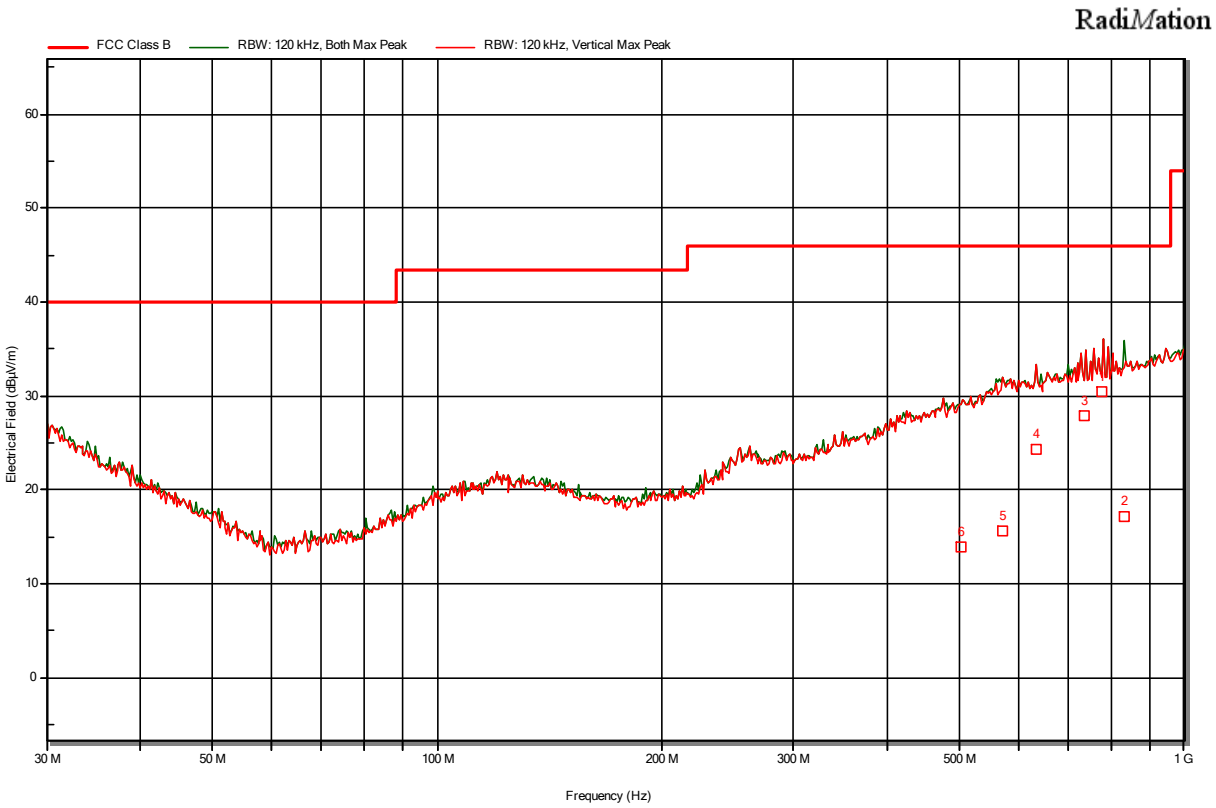

Figure 13 Radiated electric field emissions middle channel

Frequency (MHz)	Quasi-Peak (dBµV/m)	Quasi-Peak Limit (dBµV/m)	Quasi-Peak Difference (dB)	Quasi-Peak Status	Angle (degree)	Height (m)	Polarization
502.14	14	46	-28.8	Pass	150	3.4 m	Vertical
570.24	15.6	46	-18.1	Pass	345	1 m	Vertical
632.46	24.3	46	-21.7	Pass	270	1.3 m	Horizontal
736.14	27.9	46	-30.4	Pass	45	1.4 m	Vertical
777.6	30.4	46	-32	Pass	5	1.3 m	Vertical
829.14	17.2	46	-15.6	Pass	75	3 m	Horizontal

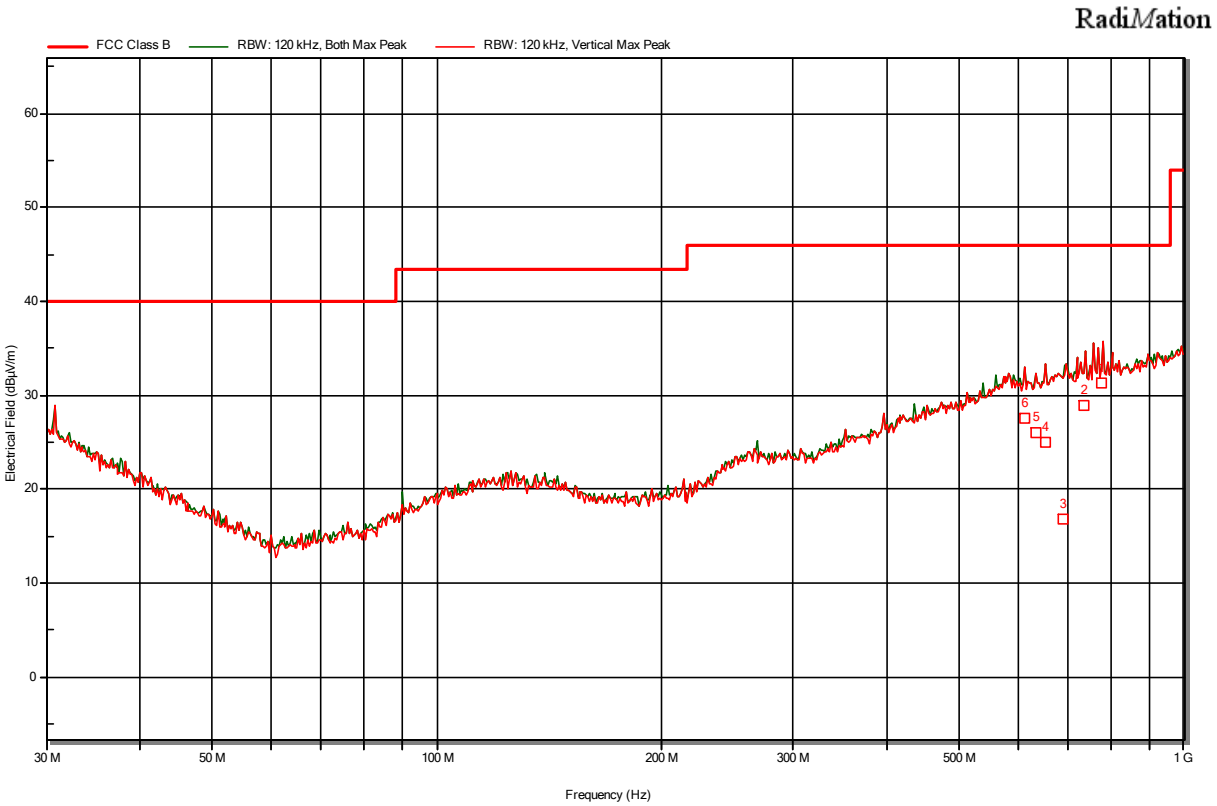

Figure 14: Radiated electric field emissions top channel

Frequency (MHz)	Quasi-Peak (dBmV/m)	Quasi-Peak Limit (dBmV/m)	Quasi-Peak Difference (dB)	Quasi-Peak Status	Angle (degree)	Height (m)	Polarization
777.6	31.3	46	-14.7	Pass	360	1.3 m	Vertical
736.14	29	46	-17	Pass	360	1.4 m	Vertical
690.36	16.9	46	-29.1	Pass	65	2.1 m	Horizontal
653.16	25.1	46	-20.9	Pass	20	1.5 m	Vertical
632.46	26	46	-20	Pass	360	1.6 m	Vertical
611.7	27.6	46	-18.4	Pass	355	1 m	Vertical

7.2.8 Quasi Peak correction factors

The reported field strength consists of Indicated signal level (receiver voltage reading), Antenna factor (AF) and Cable loss (CL).

Field strength (FS) is calculated as follows:

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

7.2.9 Sample Data

The Quasi-Peak level at 777.6MHz – top channel

FS (dBµV/m) = 3.2dBµV(indicated signal level)
+ 25.69dB/m (antenna factor)
+ 2.46dB = dBµV/m
= 31.3dBµV/m

7.3 Radiated electric field emissions 1GHz to 26GHz

7.3.1 Limits

Frequency (GHz)	Average (dBμV/m)	Peak (dBμV/m)
1-26	54	74

7.3.2 Receiver Settings

Receiver Parameters	Setting
Detector Function for spectrum analyser swept measurements	Peak hold
Detector Function for final measurements	Average
Start Frequency	1GHz
Stop Frequency	25GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

7.3.3 Emissions measurements

7.3.4 Date of Test

5th February 2020

7.3.5 Test Area

Laboratory 1

7.3.6 Test Setup

The EUT was configured in the SAC on an 1.5m high polystyrene support.

Exploratory measurements on the EUT were carried out to identify suspect frequencies and worst case orientations, see Section 7.3.7.

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.

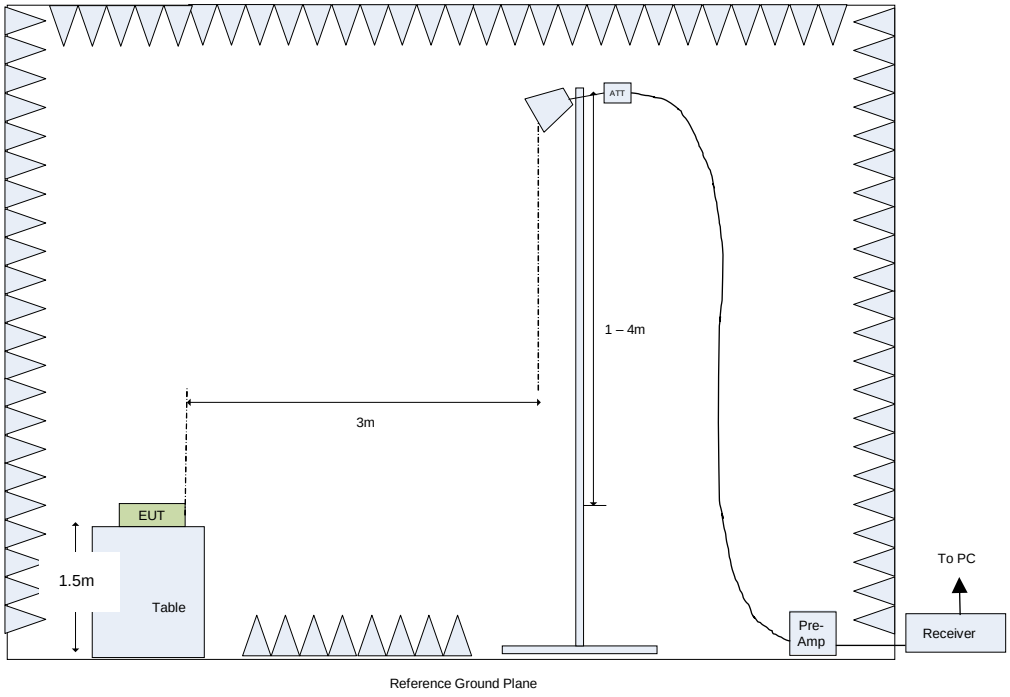

Figure 15: Test Setup for Final E-Field Measurements from 1GHz to 25GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.10 2013 Clause 6.6.4.1.

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.

7.3.7 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.

No additional signals were investigated during investigative measurements.

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

7.3.8 Electric field emissions, 1GHz to 18GHz

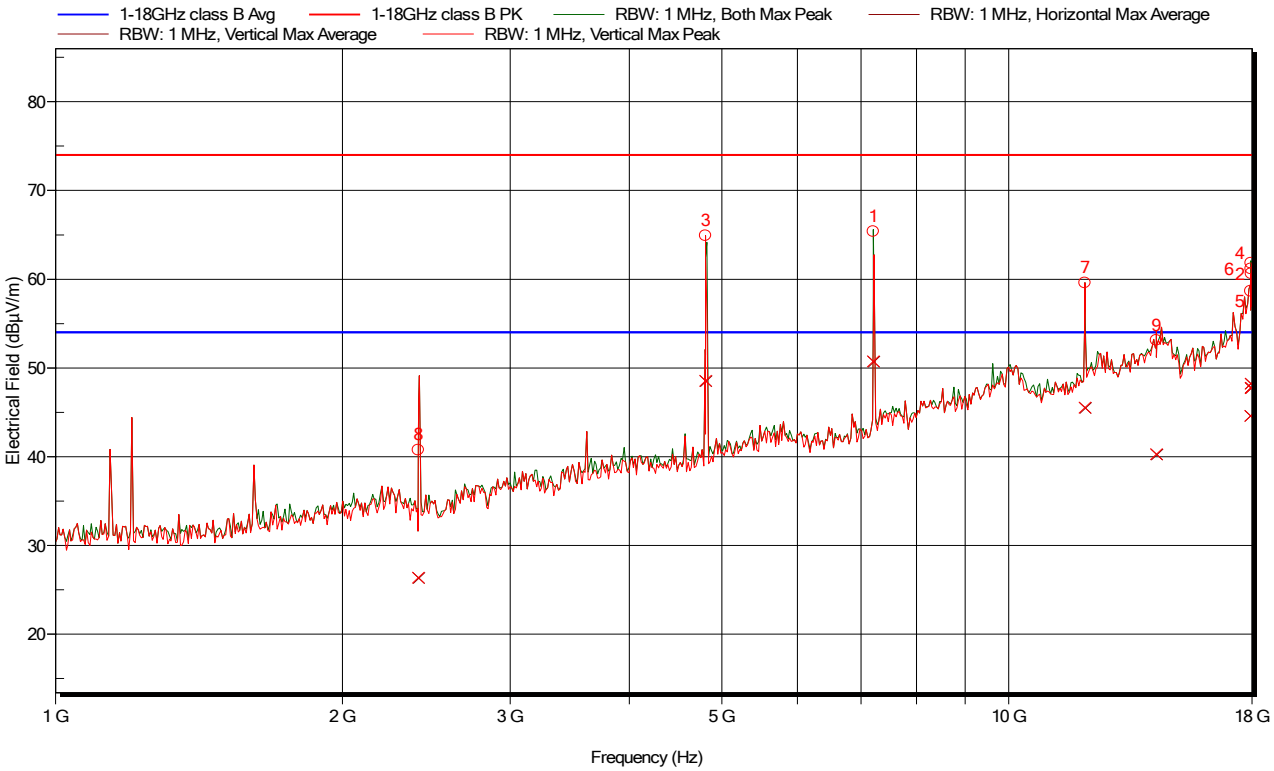

Figure 16: Electric field emissions bottom channel, 1GHz to 18GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle	Height (m)	Polarization
2.403	40.76	74	-33.24	Pass	350	1	Vertical
4.807	64.9	74	-9.1	Pass	205	1.6	Vertical
7.211	65.39	74	-8.61	Pass	125	1	Horizontal
12.019	59.59	74	-14.41	Pass	210	1	Vertical
14.285	53.12	74	-20.88	Pass	150	2.5	Vertical
17.93	58.64	74	-15.36	Pass	230	1.6	Vertical
17.942	61.18	74	-12.82	Pass	295	1.8	Horizontal
17.946	61.83	74	-12.17	Pass	180	1.1	Horizontal
17.956	60.62	74	-13.38	Pass	210	4	Vertical

Frequency (GHz)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Difference (dB)	Average Status	Angle	Height (m)	Polarization
2.403	26.37	54	-27.63	Pass	350	1	Vertical
4.807	48.55	54	-5.45	Pass	205	1.6	Vertical
7.211	50.74	54	-3.26	Pass	125	1	Horizontal
12.019	45.52	54	-8.48	Pass	210	1	Vertical
14.285	40.28	54	-13.72	Pass	150	2.5	Vertical
17.93	44.58	54	-9.42	Pass	230	1.6	Vertical
17.942	47.77	54	-6.23	Pass	295	1.8	Horizontal
17.946	48.23	54	-5.77	Pass	180	1.1	Horizontal
17.956	47.74	54	-6.26	Pass	210	4	Vertical

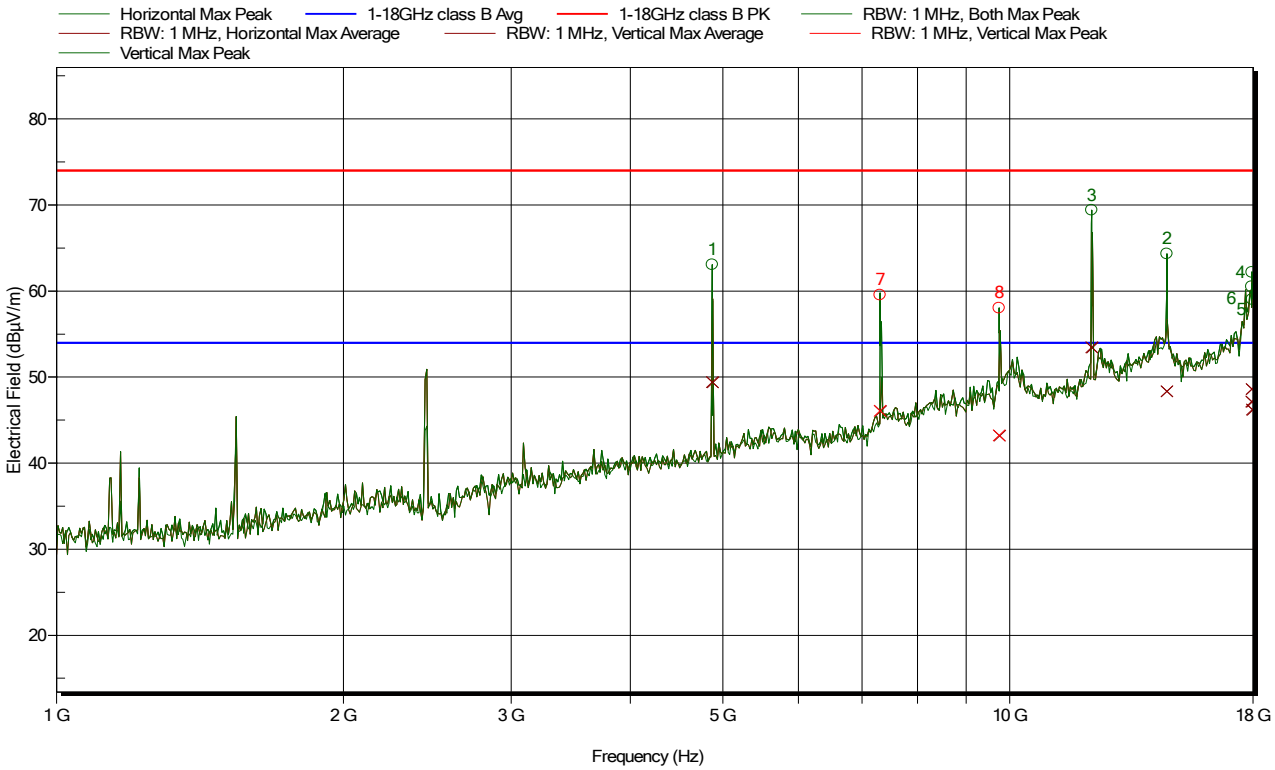

Figure 17: Electric field emissions Middle channel, 1GHz to 18GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle (degree)	Height (m)	Polarization
4.873	63.06	74	-10.94	Pass	20	3.9	Horizontal
7.309	59.53	74	-14.47	Pass	305	1	Horizontal
9.746	58.04	74	-15.96	Pass	110	2	Horizontal
12.184	69.4	74	-4.6	Pass	125	3.1	Horizontal
14.62	64.34	74	-9.66	Pass	115	1	Horizontal
17.939	60.52	74	-13.48	Pass	5	1.7	Vertical
17.949	62.17	74	-11.83	Pass	110	3.7	Horizontal
17.969	59.01	74	-14.99	Pass	285	3.1	Vertical

Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Difference (dB)	Average Status	Angle	Height	Polarization
4.873	49.41	54	-4.59	Pass	20	3.9 m	Horizontal
7.309	46.09	54	-7.91	Pass	305	1 m	Horizontal
9.746	43.22	54	-10.78	Pass	110	2 m	Horizontal
12.184	53.48	54	-0.52	Pass	125	3.1 m	Horizontal
14.62	48.34	54	-5.66	Pass	115	1 m	Horizontal
17.939	47.16	54	-6.84	Pass	5	1.7 m	Vertical
17.949	48.62	54	-5.38	Pass	110	3.7 m	Horizontal
17.969	46.24	54	-7.76	Pass	285	3.1 m	Vertical

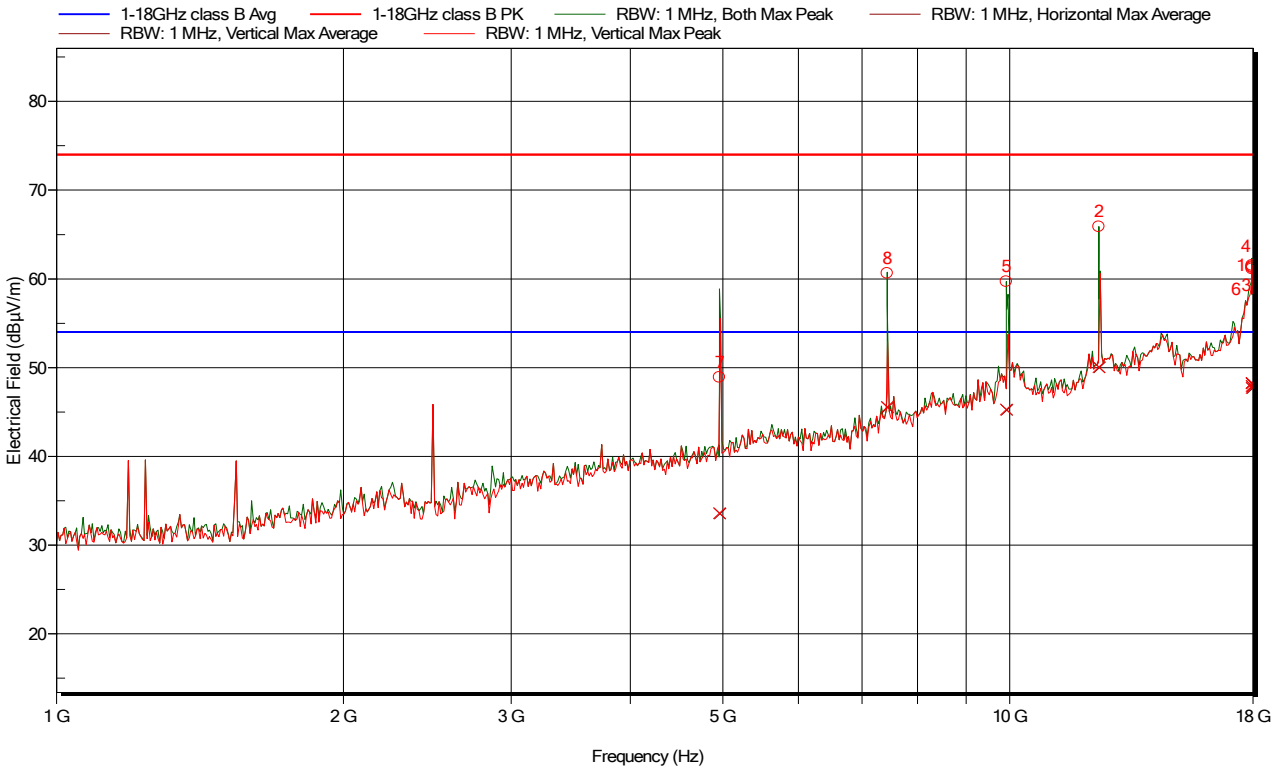

Figure 18: Electric field emissions top channel 1GHz to 18GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle	Height (m)	Polarization
4.958	48.92	74	-25.08	Pass	105	1.3	Horizontal
7.439	60.62	74	-13.38	Pass	120	3.1	Horizontal
9.919	59.68	74	-14.32	Pass	245	1	Horizontal
12.4	65.89	74	-8.11	Pass	135	3	Horizontal
17.942	61.14	74	-12.86	Pass	305	3.5	Vertical
17.946	61.52	74	-12.48	Pass	45	2.5	Horizontal
17.951	61.39	74	-12.61	Pass	225	3.5	Horizontal
17.954	61.27	74	-12.73	Pass	210	4	Vertical

Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Difference (dB)	Average Status	Angle	Height	Polarization
4.958	33.58	54	-20.42	Pass	105	1.3	Horizontal
7.439	45.58	54	-8.42	Pass	120	3.1	Horizontal
9.919	45.29	54	-8.71	Pass	245	1	Horizontal
12.4	50.08	54	-3.92	Pass	135	3	Horizontal
17.942	47.72	54	-6.28	Pass	305	3.5	Vertical
17.946	48.22	54	-5.78	Pass	45	2.5	Horizontal
17.951	48.26	54	-5.74	Pass	225	3.5	Horizontal
17.954	47.94	54	-6.06	Pass	210	4	Vertical

7.3.9 Electric field emissions, 18G to 26GHz

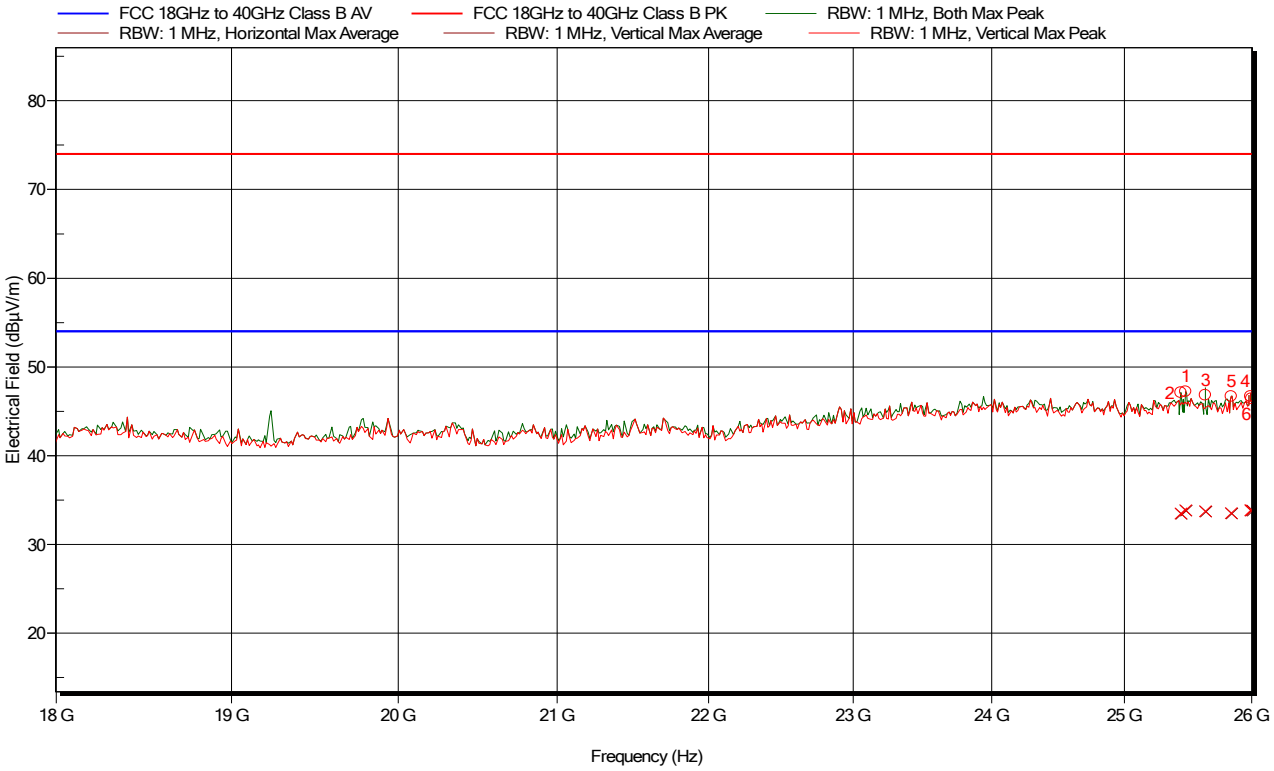

Figure 19: Electric field emissions bottom channel 18GHz to 26GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle (degrees)	Height (m)	Polarization
25.436	47.1	74	-26.9	Pass	125	1.3	Horizontal
25.474	47.21	74	-26.79	Pass	135	1.7	Horizontal
25.628	46.84	74	-27.16	Pass	175	3.1	Horizontal
25.833	46.68	74	-27.32	Pass	285	1.9	Vertical
25.987	46.7	74	-27.3	Pass	185	3.3	Vertical
26	46.43	74	-27.57	Pass	295	2.2	Horizontal

Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Difference (dB)	Average Status	Angle (degrees)	Height	Polarization
25.436	33.48	54	-20.52	Pass	125	1.3	Horizontal
25.474	33.82	54	-20.18	Pass	135	1.7	Horizontal
25.628	33.74	54	-20.26	Pass	175	3.1	Horizontal
25.833	33.54	54	-20.46	Pass	285	1.9	Vertical
25.987	33.85	54	-20.15	Pass	185	3.3	Vertical
26.000	33.83	54	-20.17	Pass	295	2.2	Horizontal

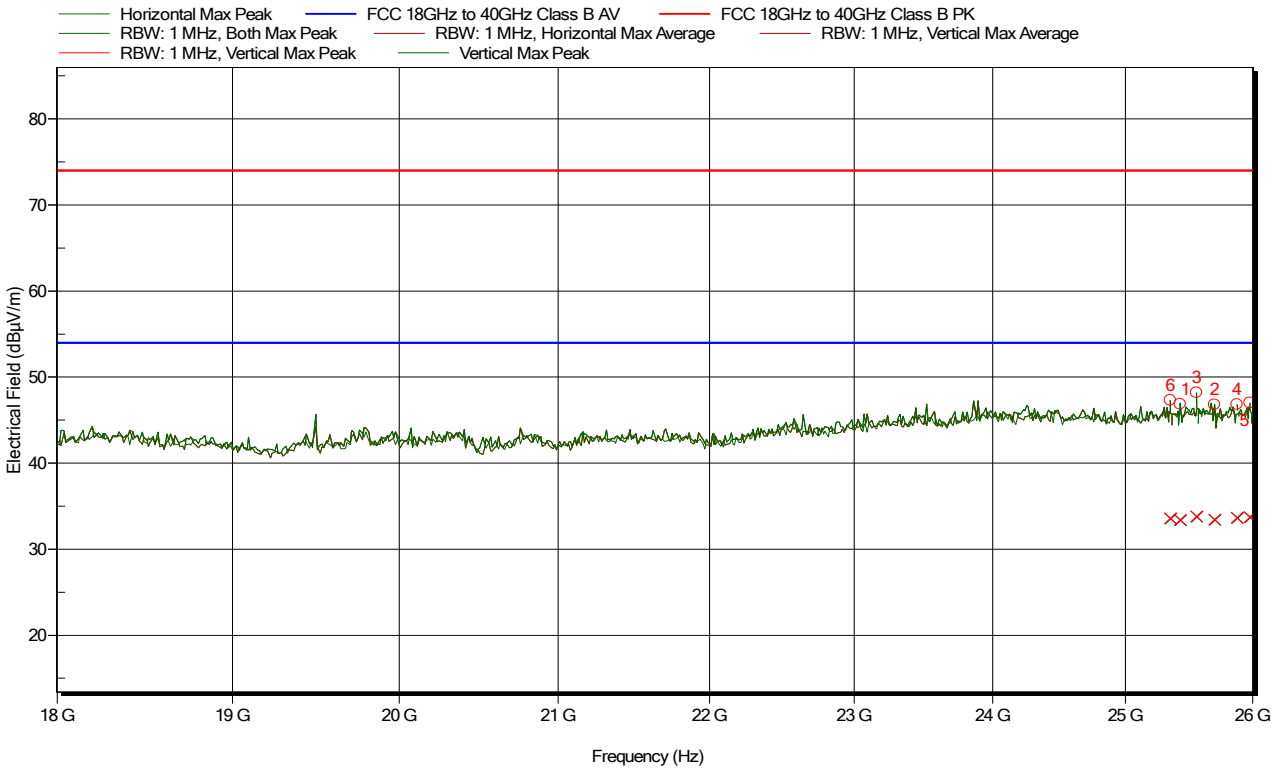

Figure 20: Electric field emissions middle channel 18GHz to 26GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle	Height (m)	Polarization
25.346	47.3	74	-26.7	Pass	280	3.1	Vertical
25.423	46.87	74	-27.13	Pass	80	1	Horizontal
25.551	48.19	74	-25.81	Pass	170	3.5	Horizontal
25.692	46.8	74	-27.2	Pass	185	2.9	Vertical
25.872	46.84	74	-27.16	Pass	215	2	Horizontal
25.974	47	74	-27	Pass	250	1.6	Horizontal

Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Difference (dB)	Average Status	Angle	Height	Polarization
25.346	33.58	54	-20.42	Pass	280	3.1	Vertical
25.423	33.39	54	-20.61	Pass	80	1	Horizontal
25.551	33.8	54	-20.2	Pass	170	3.5	Horizontal
25.692	33.42	54	-20.58	Pass	185	2.9	Vertical
25.872	33.65	54	-20.35	Pass	215	2	Horizontal
25.974	33.75	54	-20.25	Pass	250	1.6	Horizontal

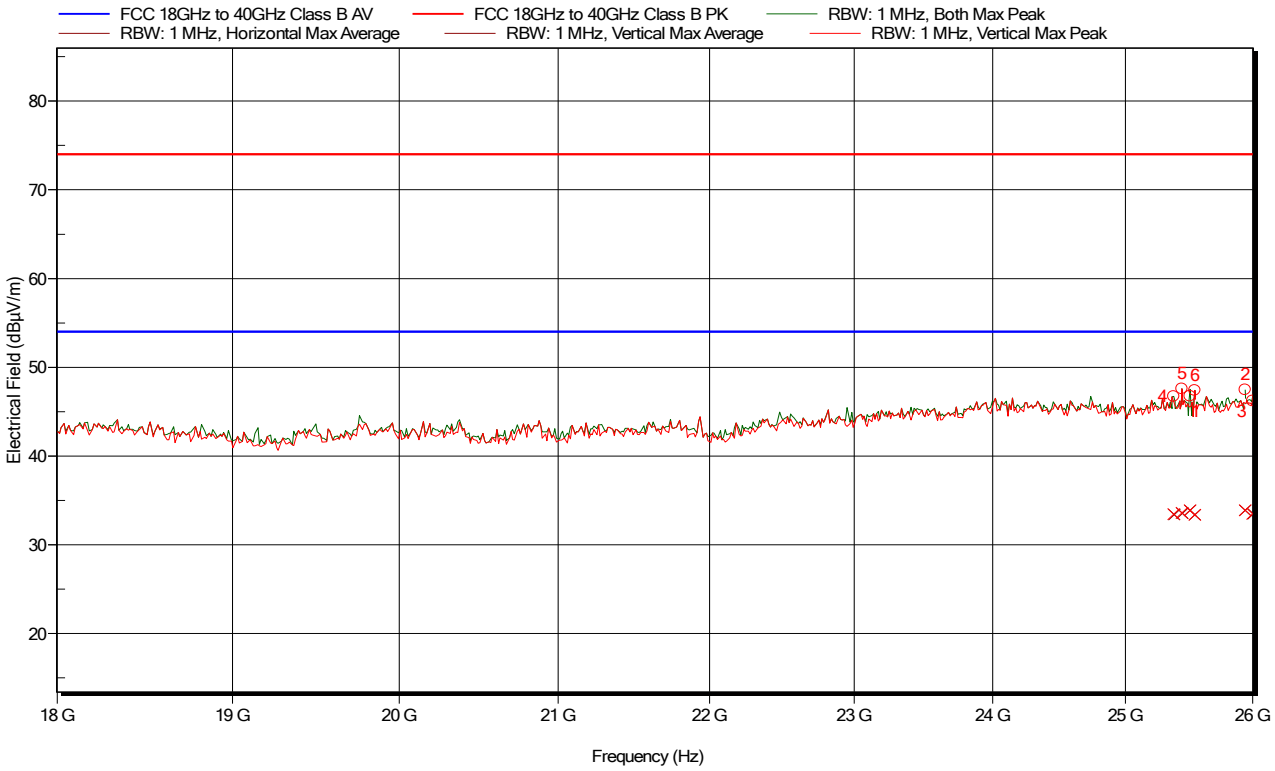

Figure 21: Electric field emissions top channel 18GHz to 26GHz

Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	-Peak Difference (dB)	-Peak Status	Angle	Height (m)	Polarization
25.372	46.7	74	-27.3	Pass	215	3.5	Horizontal
25.436	47.57	74	-26.43	Pass	255	3.4	Vertical
25.5	46.76	74	-27.24	Pass	360	1.9	Horizontal
25.538	47.41	74	-26.59	Pass	280	1.1	Vertical
25.936	47.47	74	-26.53	Pass	70	3.2	Horizontal
26.000	46.21	74	-27.79	Pass	80	1.2	Vertical

Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Difference (dB)	Average Status	Angle	Height	Polarization
25.372	33.44	54	-20.56	Pass	215	3.5 m	Horizontal
25.436	33.59	54	-20.41	Pass	255	3.4 m	Vertical
25.5	33.89	54	-20.11	Pass	360	1.9 m	Horizontal
25.538	33.36	54	-20.64	Pass	280	1.1 m	Vertical
25.936	33.87	54	-20.13	Pass	70	3.2 m	Horizontal
26	33.48	54	-20.52	Pass	80	1.2 m	Vertical

7.3.10 Contributing calibration factors

The reported field strength consists of Indicated signal level (receiver voltage reading) Preamplifier gain (PG), Antenna factor (AF) and Cable loss (CL).

Field strength (FS) is calculated as follows:

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

7.3.11 Sample Data

The Average level at (top channel)

FS (dBµV/m) =
67.6dBµV (receiver voltage level)
-51.9 dB (pre-amplifier gain)
+ 36.3dB/m (antenna factor)
+8.6dB (cable loss)
=60.6dBµV/m

Section 8 20dB Bandwidth

FCC Rule Part	47CFR15.247(a)(1)(i)
ISED	RSS Gen Clause 6.7
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 Frequency: $\pm 10^{-8}$

8.1.1 Date of Test

11th March 2020

8.1.2 Test Area

Laboratory 4

8.1.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short (30cm)

8.1.4 20dB Bandwidth Requirement

The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping. stopped.

The 20dB bandwidth must remain with the frequency allocation.

8.1.5 Test Results

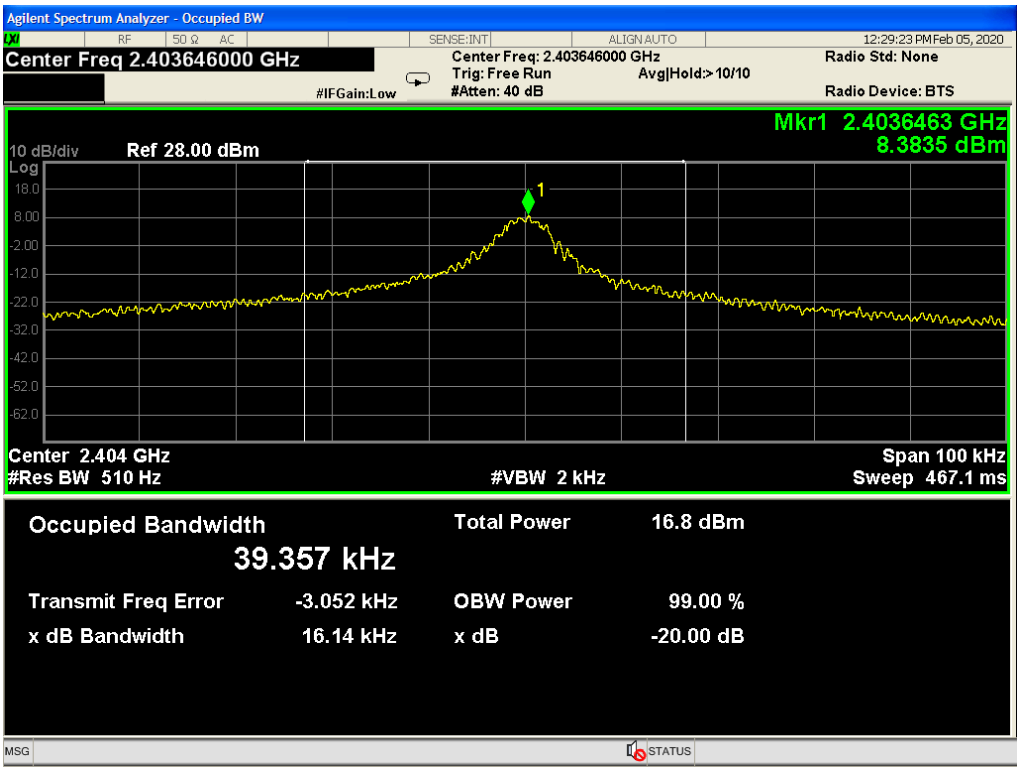

Figure 22: 20dB Bandwidth bottom channel 2403.656MHz

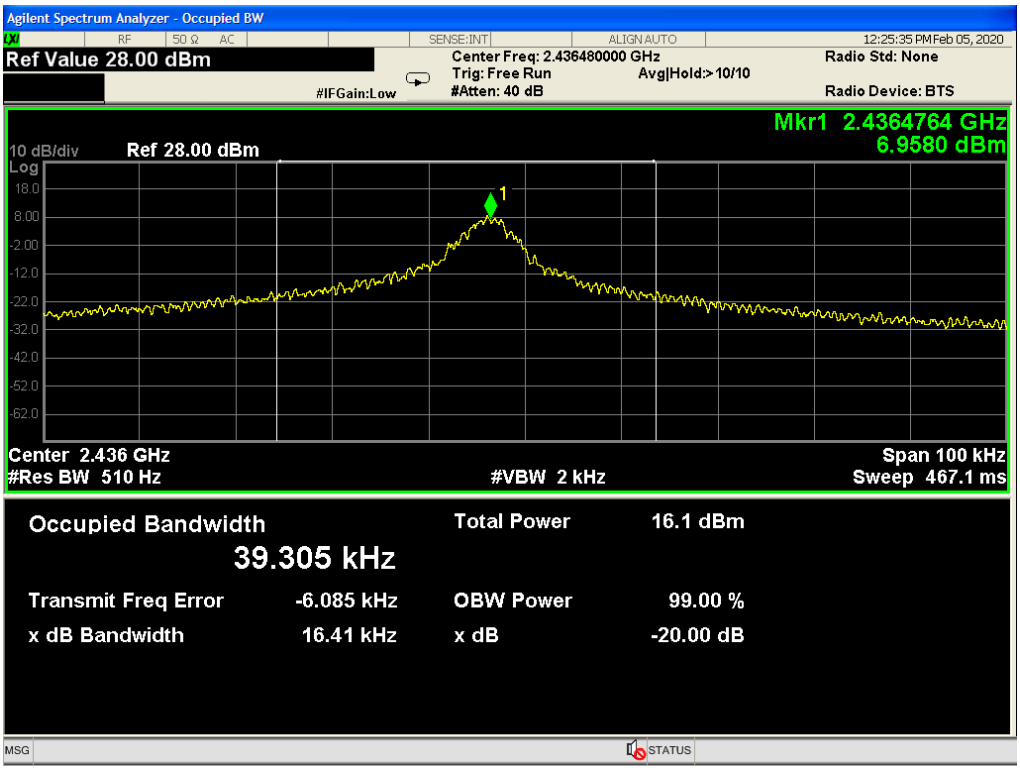

Figure 23: 20dB Bandwidth middle channel 2436.484MHz

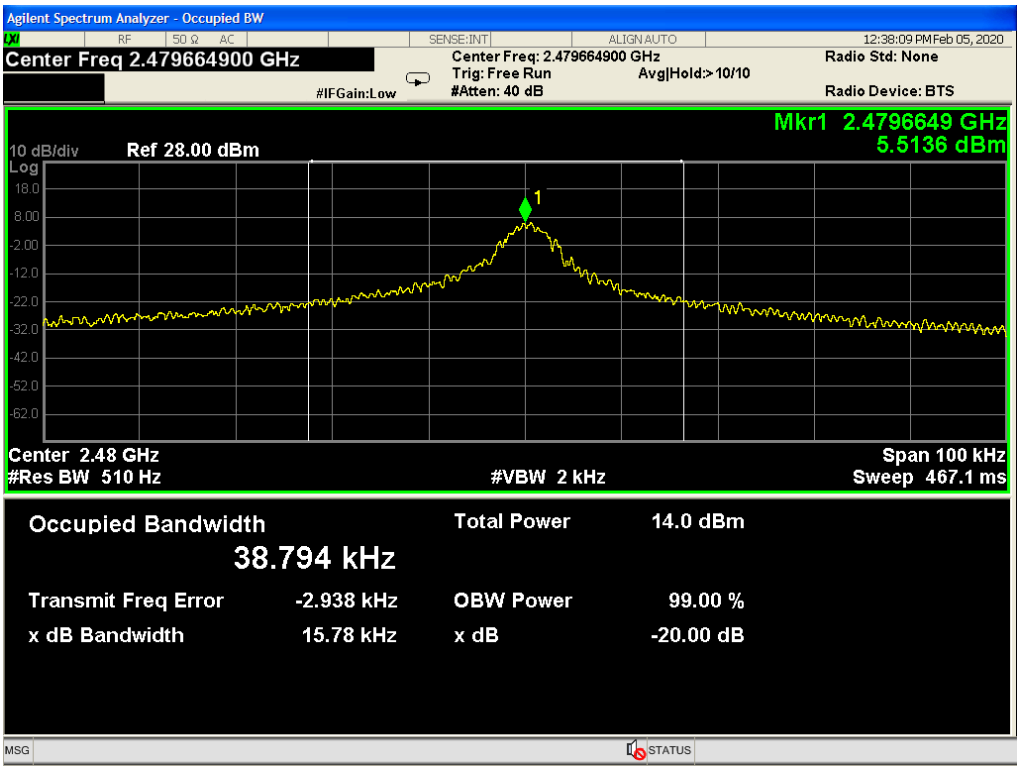

Figure 24: 20dB Bandwidth top channel 2479.68MHz

Section 9 Frequency Hopping Spread Spectrum Requirements

9.1 Number of Hopping Frequencies

FCC Rule Part	47CFR15.247(a)(1)(iii)
ISED	RSS-247 Issue 2 Section 5.1
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 Not applicable

9.1.1 Date of Test

31st January 2020

9.1.2 Test Area

Laboratory 1

9.1.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short (<30cm) coaxial cable.

9.1.4 Requirement

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.

9.1.5 Test Results

The results show that 89 hopping channels were utilised. The analyser screen displays show the 89 hopping channels, split into four subranges:

Overall requirement of at least 15 channels was met.

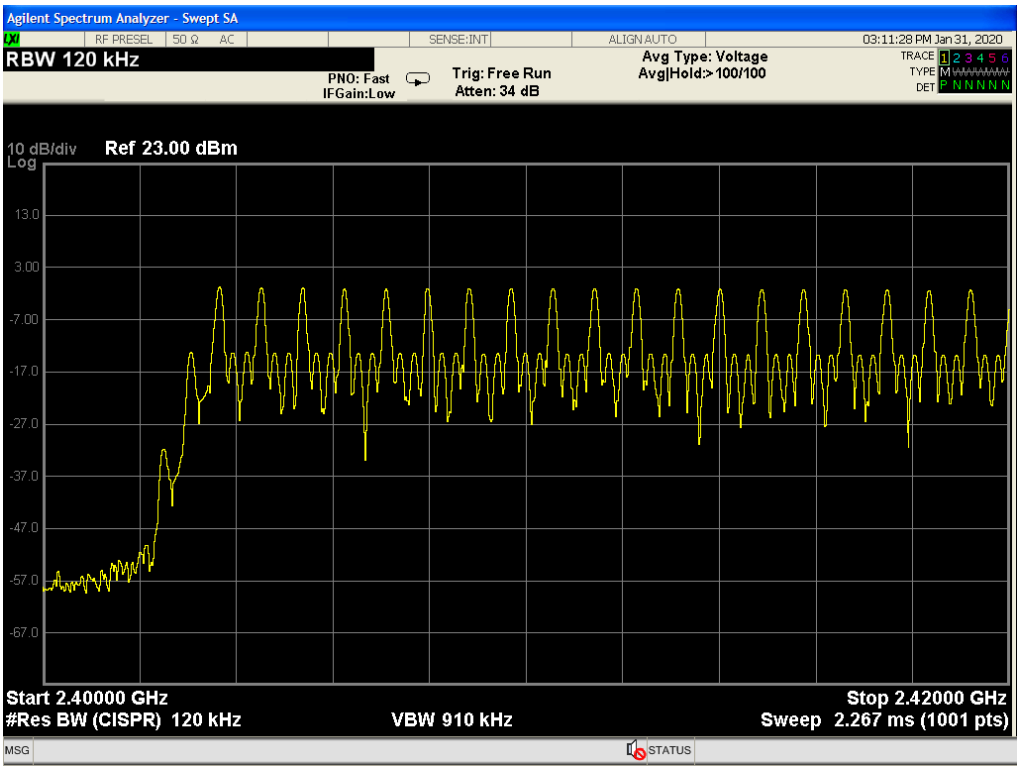

Figure 25: Number of hopping frequencies

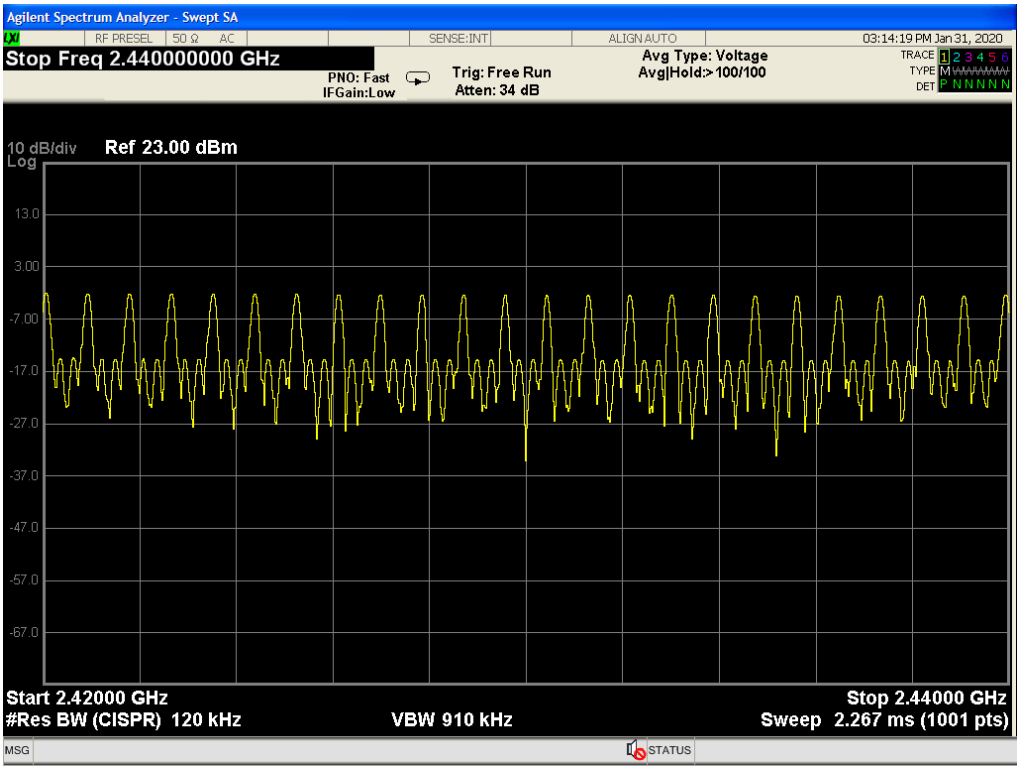

Figure 26: Number of hopping frequencies

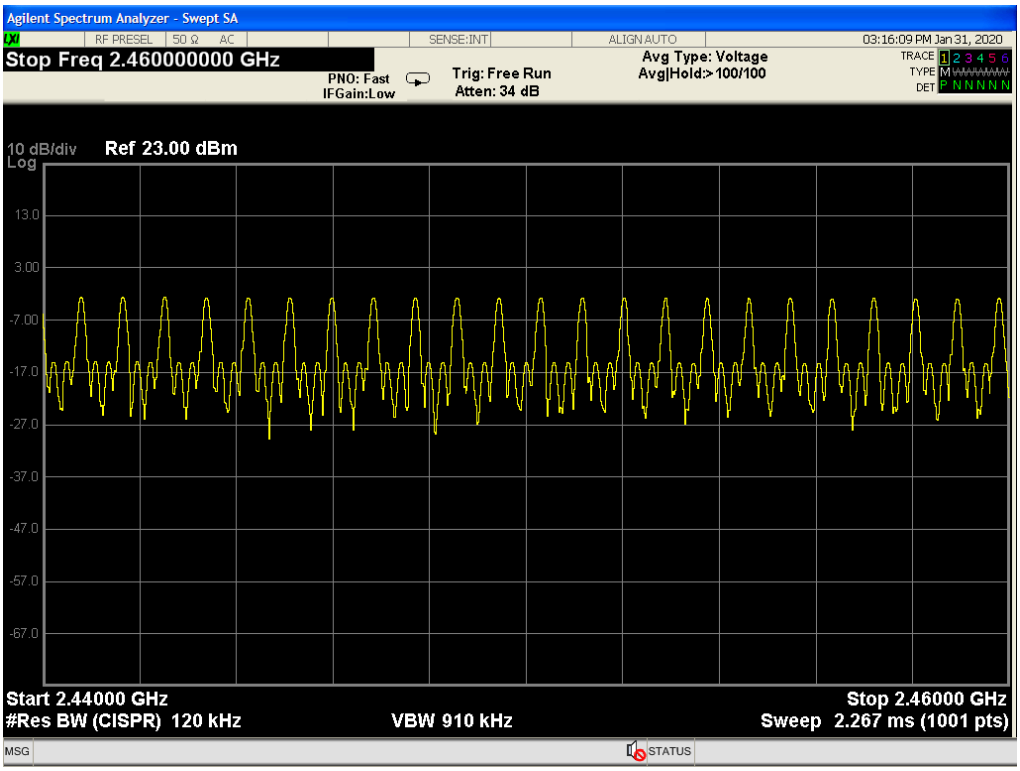

Figure 27: Number of hopping frequencies

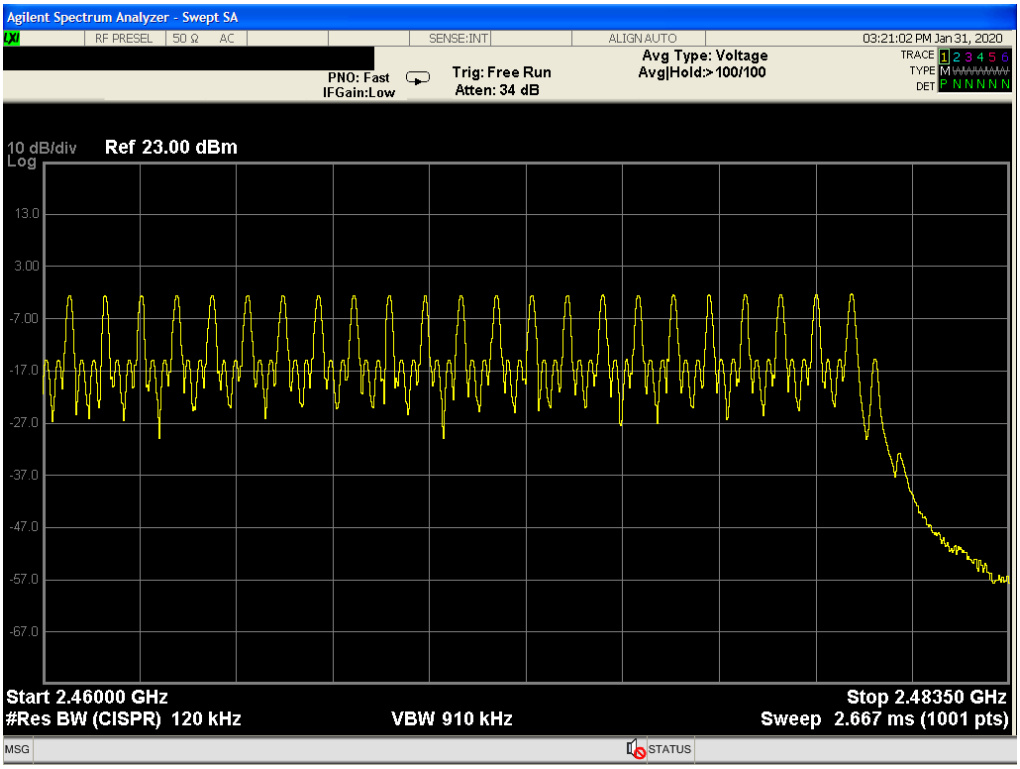

Figure 28: Number of hopping frequencies

9.2 Frequency Hopping Channel Separation

FCC Rule Part	47CFR15.247(a)(1)
ISED	RSS-247 Issue 2 Section 5.1
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 Frequency: $\pm 10^{-8}$

9.2.1 Date of Test

31st January 2020

9.2.2 Test Area

Laboratory 1

9.2.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short (<30cm) coaxial cable.

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

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Since 25kHz is greater than the measured 20dB bandwidth, the carrier frequency separation shall be > 25kHz.

9.2.5 Procedure

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

9.2.6 Test Results

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

Measured Separation (kHz)	Limit (kHz)	Result
871.10	>25kHz	Pass

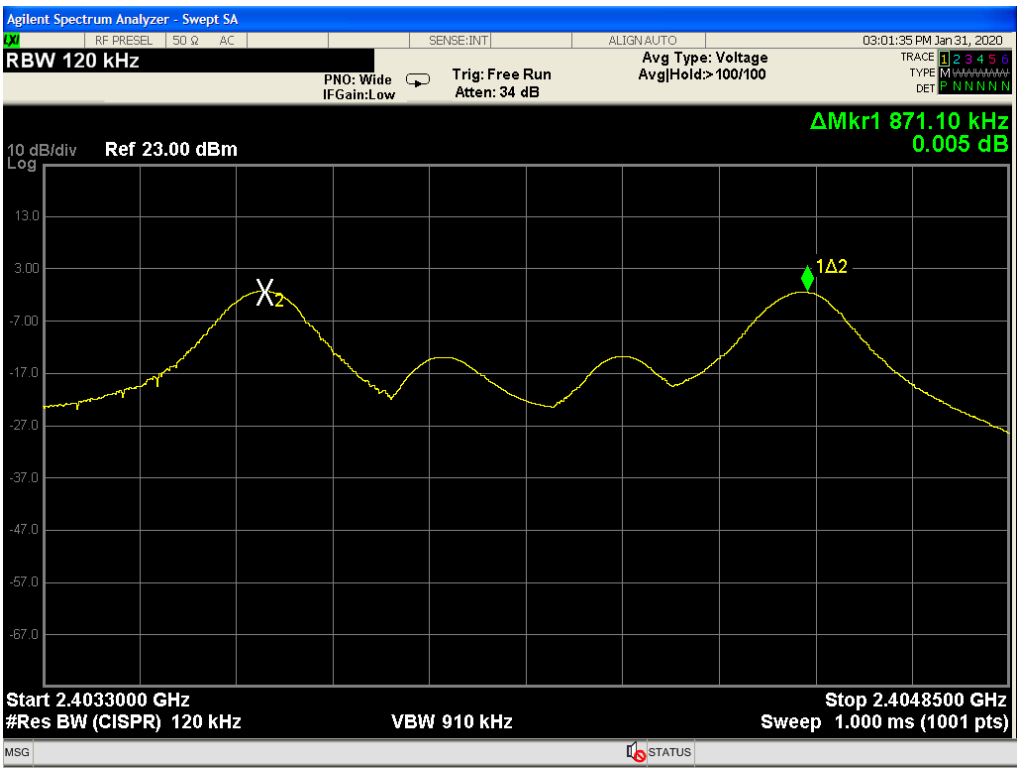

Figure 29: Carrier frequency separation

9.3 Hopping Channel Occupancy Time

FCC Rule Part	47CFR15.247(a)(1)(i)
ISED	RSS-247 Issue 2 Section 5.1
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 Frequency: $\pm 10^{-8}$

9.3.1 Date of Test

4th February 2020

9.3.2 Test Area

LAB 4 bench area.

9.3.3 Test Setup

The equipment under test was provided with an SMA antenna connector and connected directly to the spectrum analyser using a short (30cm) coaxial cable.

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

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

9.3.5 Procedure

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

9.3.6 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 (s)
lowest frequency	10	12	89	35.6	42.72	3.87×10^{-04}	0.4	0.016533
centre frequency	10	12	89	35.6	42.72	3.87×10^{-04}	0.4	0.016533
Highest frequency	10	12	89	35.6	42.72	3.87×10^{-04}	0.4	0.016533

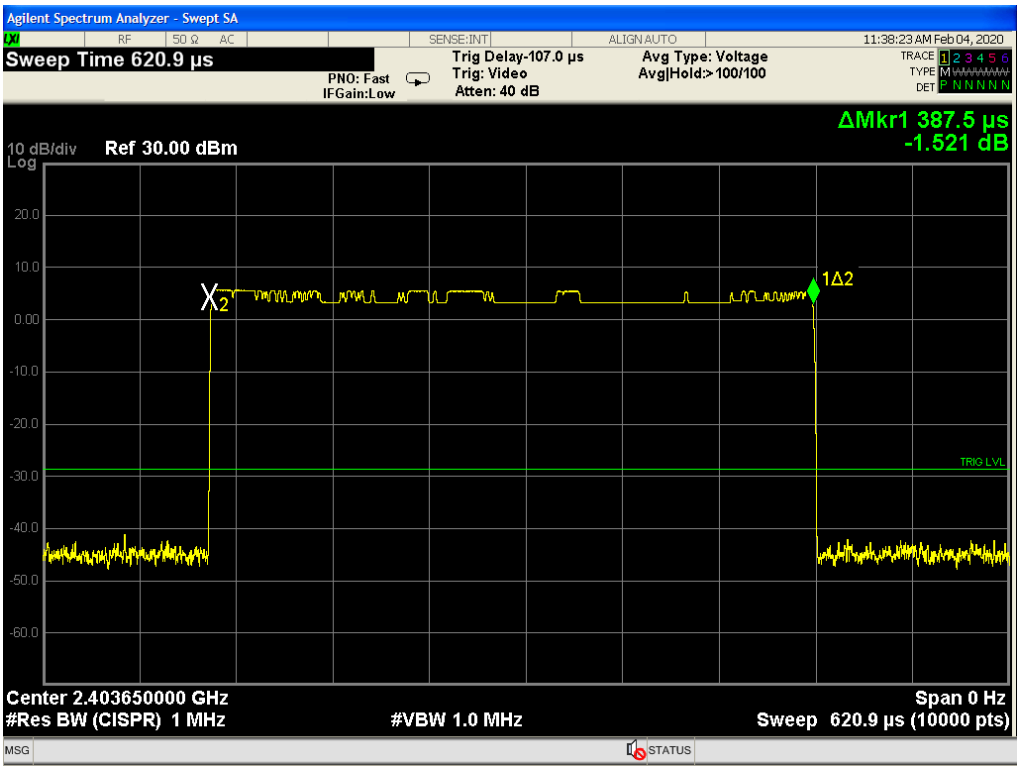

Figure 30: Bottom channel, transmit time per hop

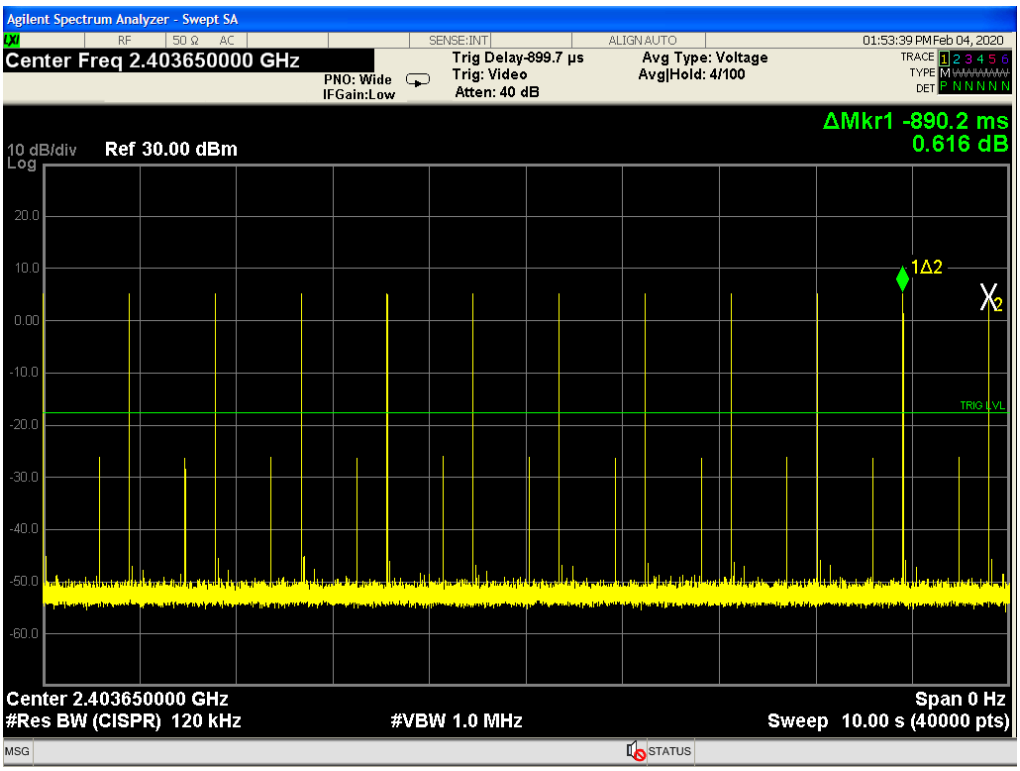

Figure 31: Bottom channel, number of hops in specified period

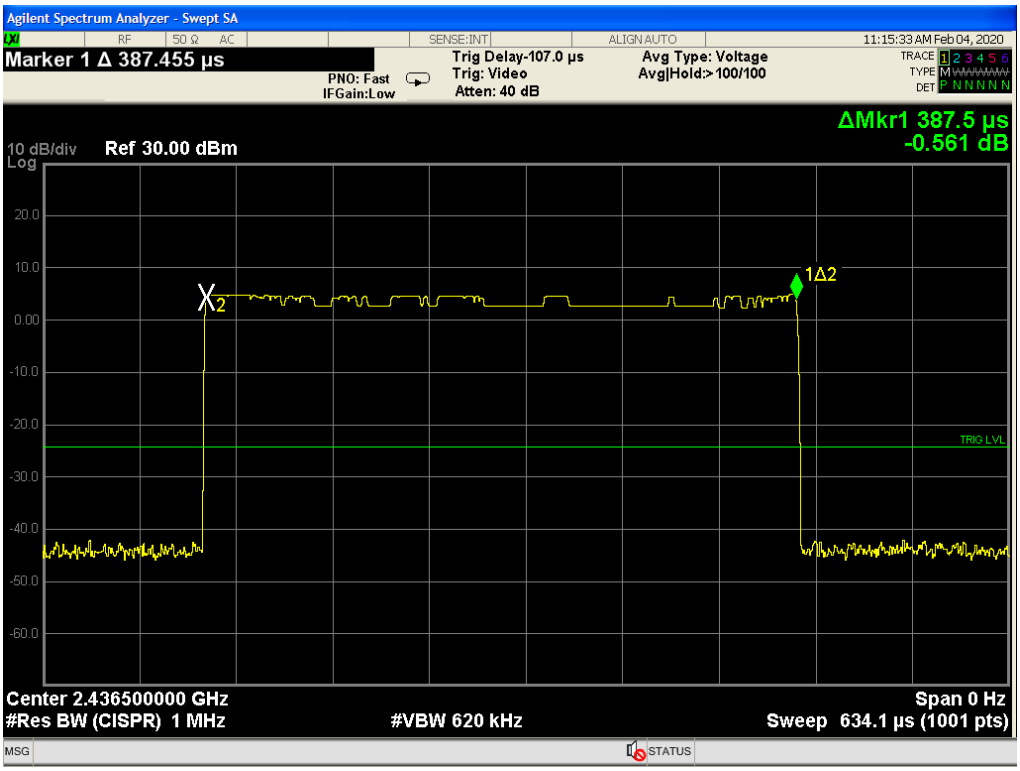

Figure 32: Centre channel, transmit time per hop

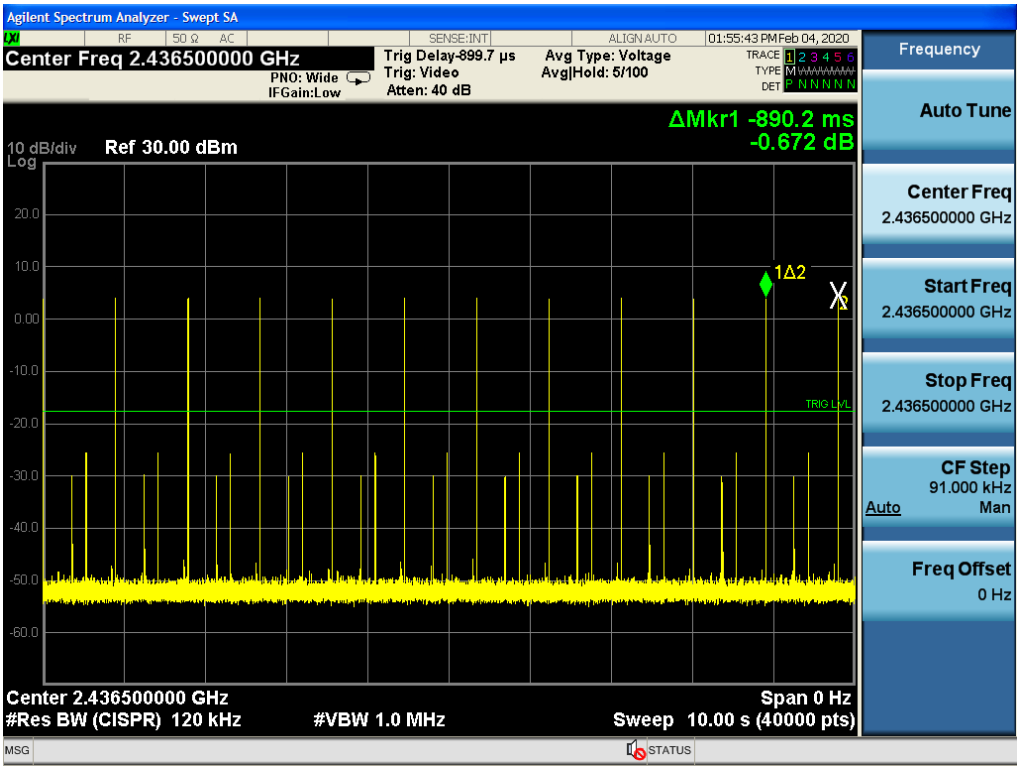

Figure 33: Centre channel, number of hops in specified period

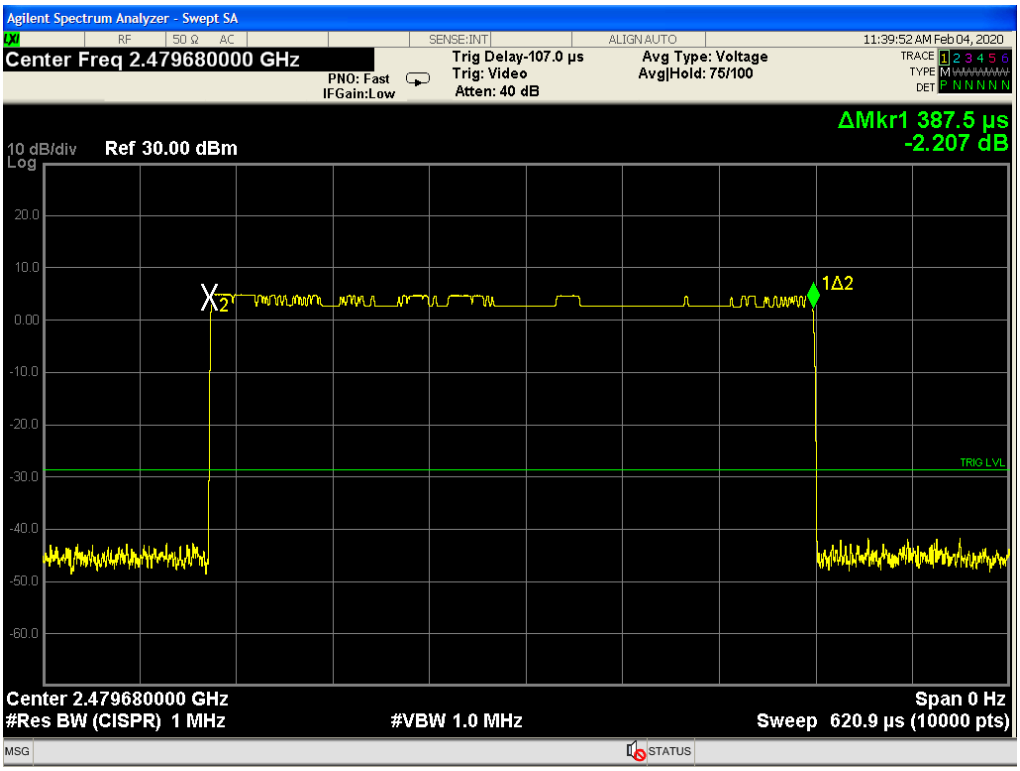

Figure 34: Top channel, transmit time per hop

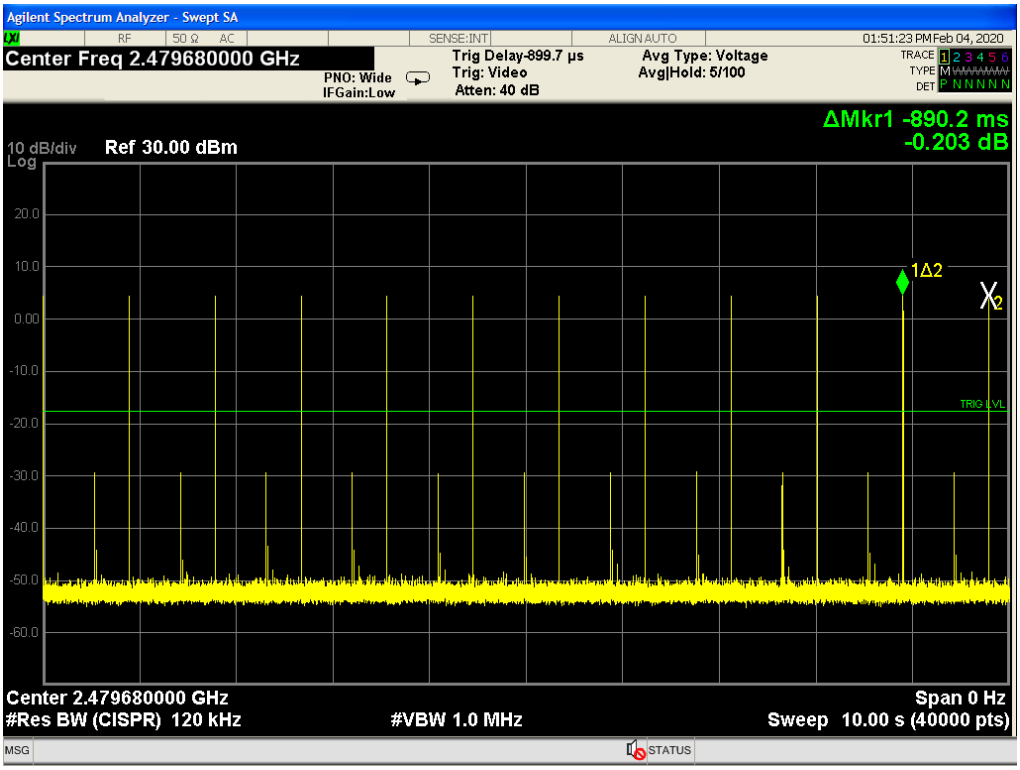

Figure 35: Top channel, number of hops in specified period

Section 10 Band Edge Compliance

FCC Rule Part	47CFR15.247(a)(1)
ISED	RSS-247 Issue 2 Sections 3.3 and 5.5 RSS-Gen Issue 5 Section 8.10
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 Frequency: $\pm 10^{-8}$

10.1.1 Date of Test

16th April 2020

10.1.2 Test Area

Laboratory 1

10.1.3 Test Setup

The test method used was radiated. The EUT was positioned on a 1.5m polystyrene support. The measurement distance used was 3m.

10.1.4 Requirement 47CFR15 / RSS-GEN.

For a 2400MHz to 2483.5MHz device, there are restricted bands at:

2310 to 2390MHz

and

2483.5 to 2500MHz

For FHSS apparatus, frequency hopping was turned off according to ANSI C63.10-2013 Clause 6.10.5.2 a).

10.1.5 Procedure

The procedure described in ANSI C63.10-2013 Clause 6.10.5 “Restricted Band Edge Measurements”.

10.1.6 Results

The following radiated band edge measurements were measured and recorded as follows:

Pol	Detector	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E(dBuV/m)	Limit (dBuV/m)	Margin (dB)	
v	PK	2483.5	87.76	50.47	2.55	28.5	68.34	74	-5.66	Pass
v	Av	2483.5	53.45	50.49	2.57	28.81	34.34	54	-19.66	Pass
h	Pk	2483.5	73.96	50.47	2.55	28.5	54.54	74	-19.46	Pass
h	Av	2483.5	51.16	50.47	2.55	28.5	31.74	54	-22.26	Pass
V	Pk	2390	76.61	50.46	2.53	28.36	57.04	74	-16.96	Pass
v	Av	2390	53.52	50.46	2.53	28.36	33.95	54	-20.05	Pass
h	Pk	2390	67.87	50.46	2.53	28.36	48.3	74	-25.7	Pass
h	Av	2390	51.49	50.46	2.53	28.36	31.92	54	-22.08	Pass

Pk = Peak detector
Av = Linear average detector

.

10.1.7 Analyser Displays

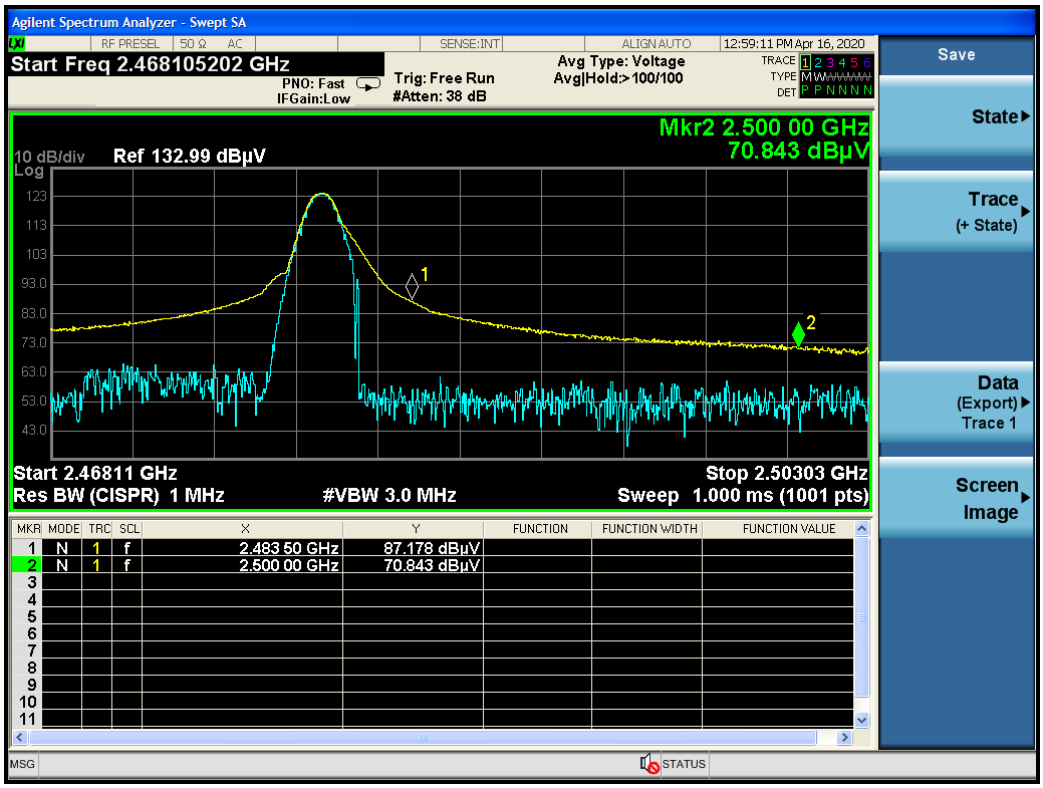

Figure 36: Upper and edge – vertical polarity

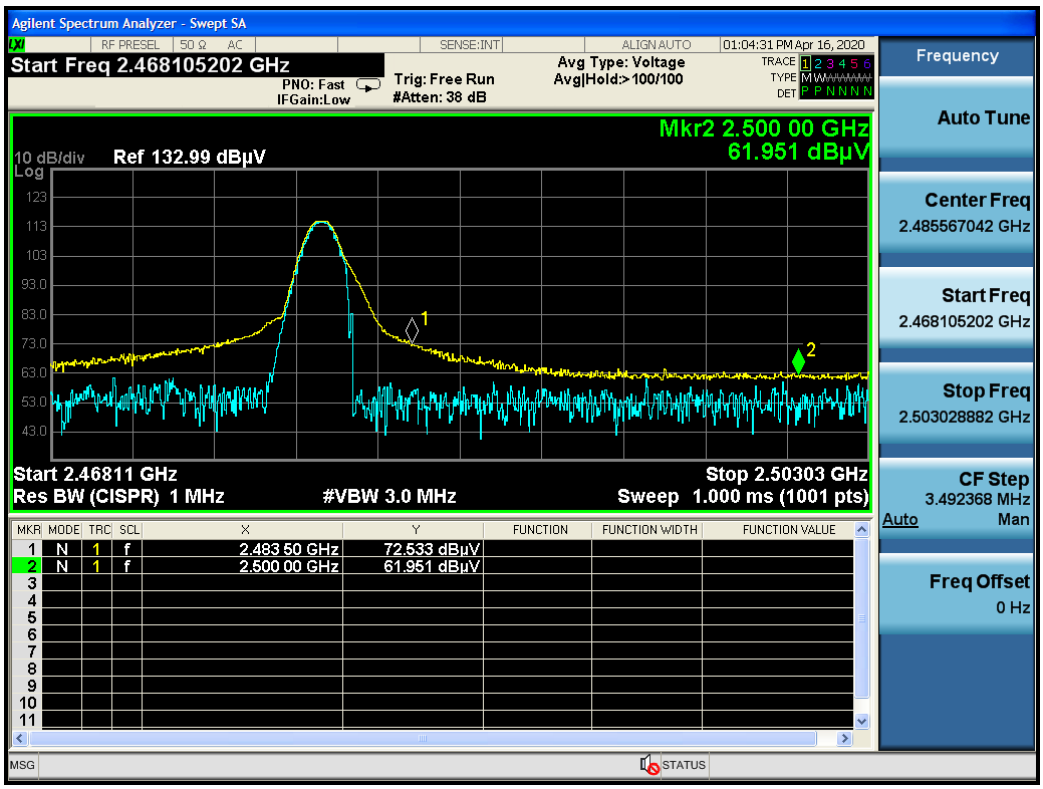

Figure 37: Upper band edge – horizontal polarity

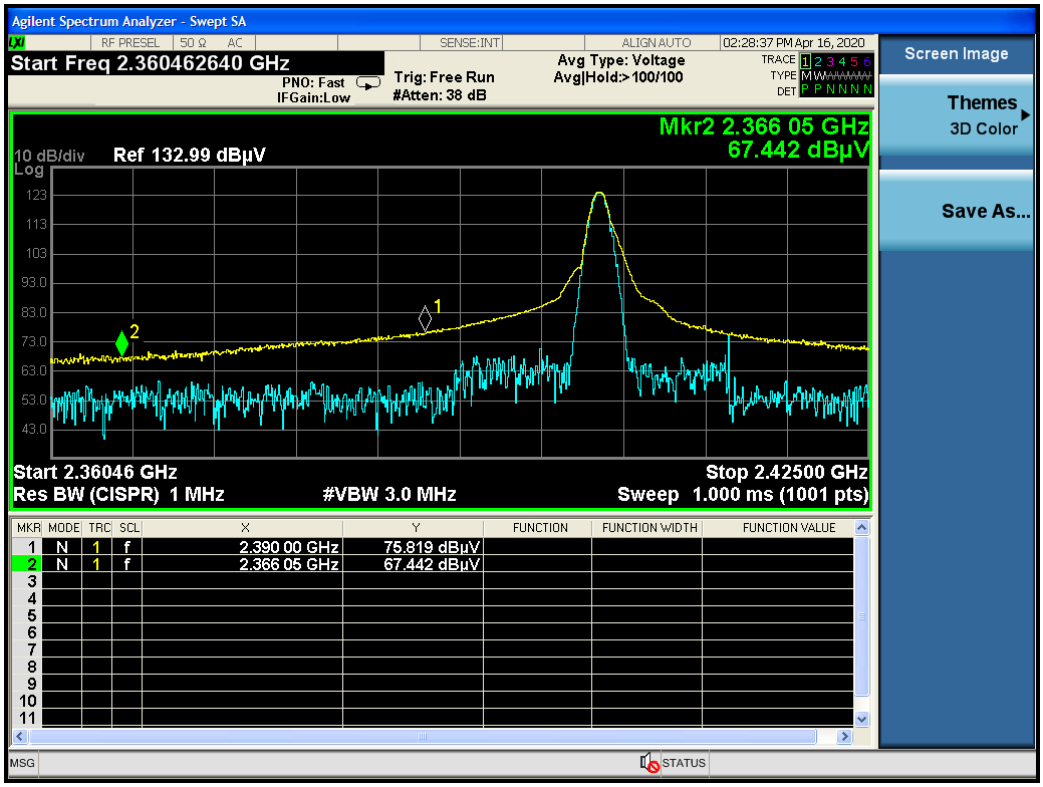

Figure 38: Lower band edge vertical polarity

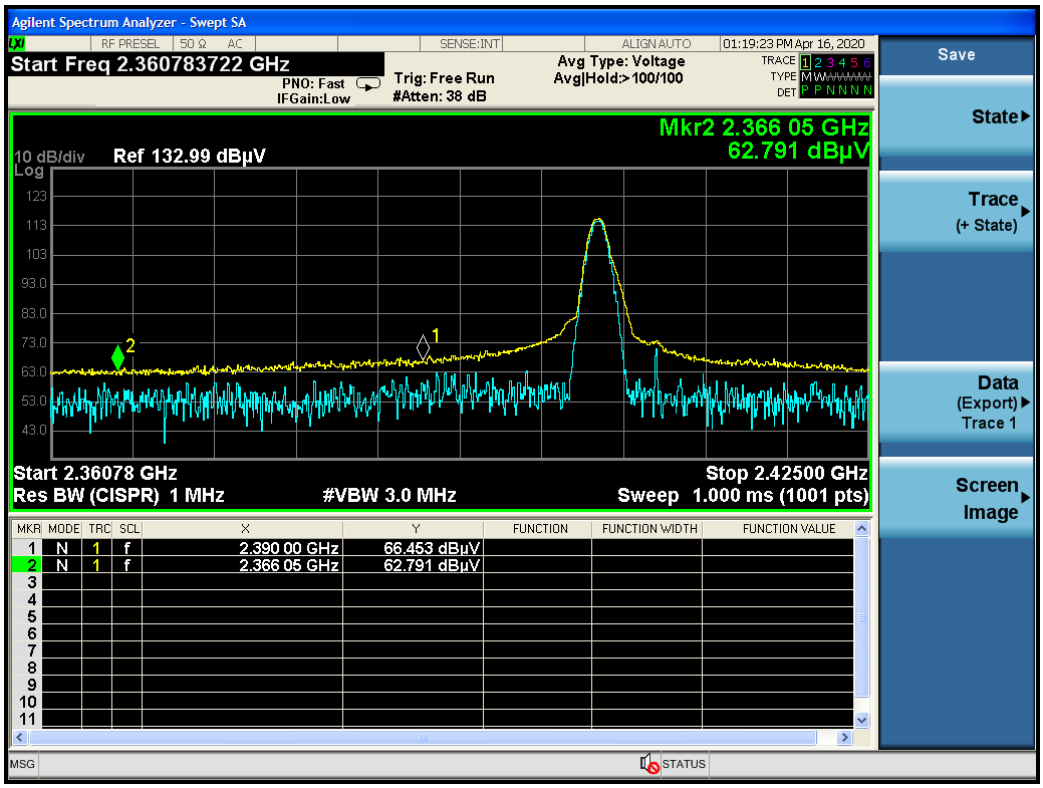

Figure 39: Lower band edge horizontal polarity

Appendix A EUT Test Photos

Photographs are supplied separately.

Appendix B Test Equipment List

Radiated and conducted antenna port emissions Equipment

Item	Serial No.	Last Calibration Date	Calibration Interval
Laboratory 1 Semi-Anechoic Chamber	Lab 1	5th November 2019	24 Months
ETS Lindgren 2017B Mast (1 – 4m) with tilting mechanism	--	N/A	N/A
HF18 Cable (For use from 9kHz to 18GHz)	167004-001	January 2020	12 Months
Keysight PXA EMI Receiver / signal analyser	MY54170531	4th May 2018	24 Months
Teseq CBL6112D Bilog Antenna	49040	15th August 2018	18 Months
6dB Attenuator (For use with Bilog Antenna)	78708B	15th August 2018	18 Months
HF14 Cable (For use from 9kHz to 18GHz)	167003-001	January 2020	12 Months
HF17 Cable (For use from 9kHz to 18GHz)	167002-001	January 2020	12 Months
EMCO 3115 1-18GHz Horn Antenna	9712-5380	2nd May 2018	24 Months
BONN BLMA 0118-5A Preamplifier	149759	3rd February 2020	12 Months
ETS Lindgren 18-40GHz horn antenna	3116C-PA	17th October 2019	36 Months