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Test Report for the FCC and ISED Testing of a Varjo VR-3 Headset for Varjo Technologies Oy

Test Report number: 14127TR4

Project number: C6062

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Issue	Description						Issue by	Date
4	Copy 1		Copy 2		PDF	x	DB	4th November 2021

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Test Report Change History

Issue	Date	Modification Details
1	29th April 2021	First Issue
2	13th September 2021	Photographs removed and supplied separately.
3	14th October 2021	Response to comments from TCB review
4	4th November 2021	Response to comments from TCB review
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 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	Varjo Technologies Oy
Address	Vuorikatu 20
	00100 Helsinki
	Finland
Contact	Martti Timonen
Email	Martti@varjo.com

2.1 Purpose of testing

To support a Class 2 Permissive Change to certified equipment.

Section 3Equipment Details

3.1 Equipment Under Test (EUT)

EUT name:	Varjo VR-3 Mixed Reality Headset		
PMN:	VR-3		
HVIN:	HS-6		
FVIN:	0.11.0.372		
FCC ID:	2AROD-004		
ISED number:	IC: 24483-004		
Serial no/s:	V0022CC15AE1200009 and V0022CC15AE1200005		
EUT description:	The VR-3 is a photorealistic Virtual reality headset. The headset has forward hand tracking IR cameras and two internal Bluetooth modules, with integral antennas, operating at 2.4 GHz. The headset is powered by 12 V DC from two pre-approved power supplies. The power supplies power two adapter units which in turn interface with a control PC and the headset via USB.		
Antenna	Integral Manufacturer: PulseLarsen Antennas Type: W3008 featuring 2400-2483.5MHz.		
Transmission	Proprietary Digital Transmission System (DTS) Channelisation declared by manufacturer		
Modulation scheme	GFSK		
Number of antennas	Varjo headsets can connect two SteamVR supported controllers through integrated SteamVR radio sub-systems, using Steam proprietary protocol. One radio sub-system exists for each controller, thereby there are also two antennas in Varjo headsets.		
Operating frequency band	2400MHz to 2483.5MHz		
No of units tested:	Three		
EUT power:	100 -240 V, 50 – 60 Hz mains supply		
Highest internal frequency:	2.480GHz		
Size of EUT (m)	Width: 200 mm	Depth: 290 mm	Height: 170 mm
Mode/s of operation	Continuous transmit of packetised data at top, middle and bottom channels. For spurious emissions testing, both antennas transmitted simultaneously at the same frequency. Channels used: 2402MHz, 2440MHz and 2480MHz		
Modifications incorporated during testing:	None		

Ports and Cables	Cable Length	Screened/ unscreened	Connected to
USB-C to Focus adapter	4m	unscreened	Focus adapter
USB-C to CNTXT adapter	4m	unscreened	CNTXT adapter
Focus USB-A	1m	unscreened	PC
CNTXT USB-A	1m	unscreened	PC
Focus display cable	1m	unscreened	PC
CNTXT display cable	1m	unscreened	PC

3.2 Configuration of EUT

The apparatus was supplied in one single possible configuration.

3.3 EUT Monitoring/Auxiliary Equipment

None.

3.4 Monitoring Software

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

Section 4 Test 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)	Test not performed (Class 2 permissive change)	N/A
Maximum peak conducted power	FCC § 15.247(b)(3)	Test not performed (Class 2 permissive change)	N/A
Power spectral density	FCC § 15.247(e)	Test not performed (Class 2 permissive change)	N/A
AC power line conducted emissions	FCC § 15.207	Test not performed (Class 2 permissive change)	N/A
Band edge compliance	FCC § 15.247(d)	Applies	Pass
Conducted spurious emissions	FCC § 15.247(d)	Test not performed (Class 2 permissive change)	N/A
Transmitter radiated spurious emissions	FCC § 15.247(d) FCC § 15.209	Applies	Pass

Note 1: The above testing was performed of a class 2 permissive change. Therefore, only radiated emission testing was performed.

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 2nd 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
Occupied Bandwidth	RSS-Gen 6.6	Test not performed (Class 2 permissive change)	N/A
6 dB Bandwidth	ISED RSS-247 § 5.2	Test not performed (Class 2 permissive change)	N/A
Maximum peak conducted power	ISED RSS-247 § 5.4	Test not performed (Class 2 permissive change)	N/A
Power spectral density	ISED RSS-247 § 5.2	Test not performed (Class 2 permissive change)	N/A
AC power line conducted emissions	ISED RSS-247 § 3.1	Test not performed (Class 2 permissive change)	N/A
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	Test not performed	N/A
Transmitter radiated spurious emissions	ISED RSS-GEN § 8.9	Applies	Pass

Receiver radiated spurious emissions	ISED RSS-247 § 3.1	Test not performed	N/A

Note 1: The above testing was performed of a class 2 permissive change. Therefore only radiated emission testing was performed.

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 Varjo VR-3 Headset, as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

4.3 Decision Rule

The Decision Rule for determining compliance is applied on the basis of the requirements of the following:

Wireless testing - ETSI TR 102 273 and ETSI TR 100 028

These standards provide guidance on how to calculate and apply measurement uncertainty whilst providing maximum uncertainties allowance. In all cases due consideration will be given to JCGM 106:2012, ILAC-G8:09/2019 and LAB 48.

This laboratory has demonstrated by calibrating its equipment and facilities, and calculating its own uncertainties, that it complies with the above requirements and therefore no allowance of uncertainties has been given to the tolerances.

Where a result is considered marginal in respect of its proximity to the limit line, for example, the customer would be made aware of situation so that they can make an informed decision on how to proceed.

Section 5 Spurious Emission Results – Radiated

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

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)	Limit (dBµV/m)
	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

22nd March 2021

5.3.4 Test Area

LAB 1 (SAC)

5.3.5 Tested by

M Render

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.

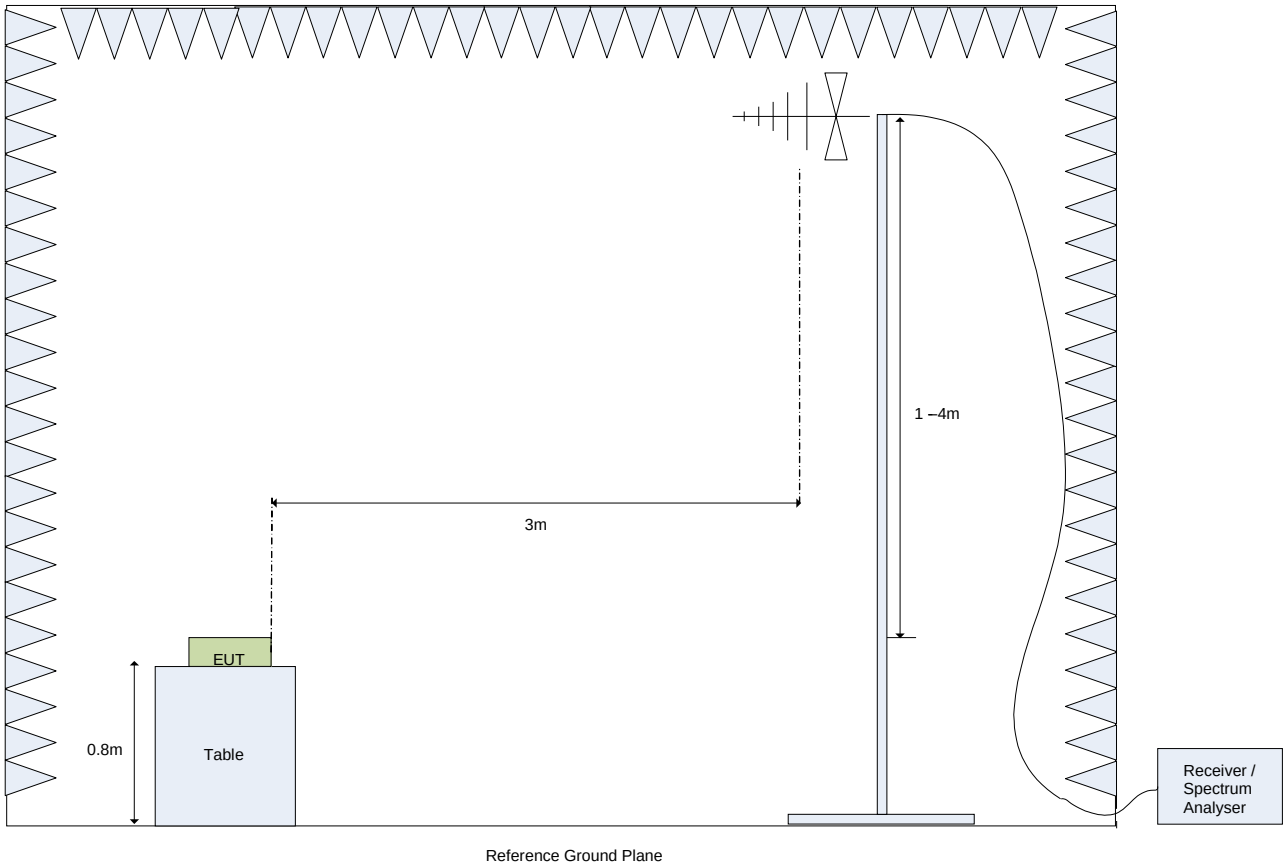


Figure 5.3.6.1: Test Setup for E-Field Measurements from 30MHz to 1GHz

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 both antennas were set to transmit at the same frequency on the following channels: 2402MHz, 2440MHz and 2480MHz.

5.3.7 Electric field emissions, 30MHz to 1GHz

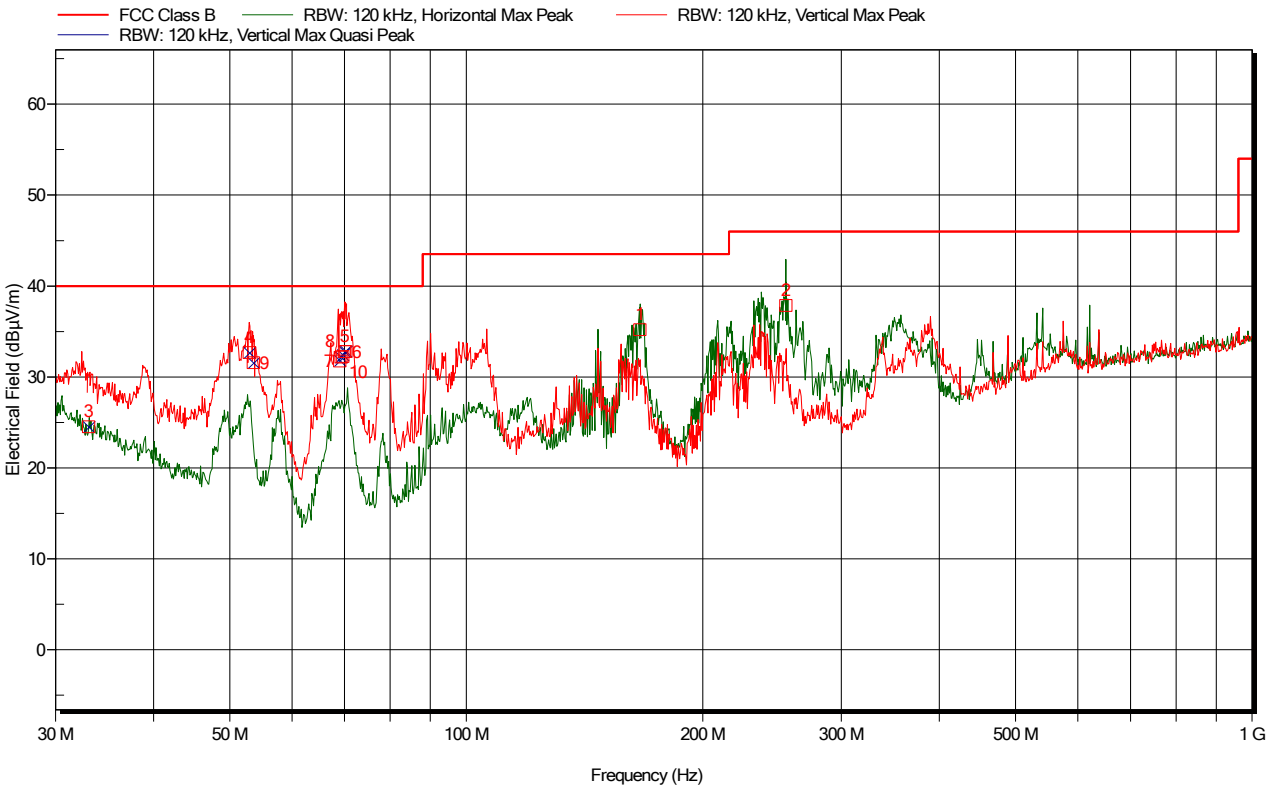


Figure 5.3.7.1: Electric field emissions Plot, 30MHz to 1GHz, Operation on 2480MHz

Frequency	Quasi-Peak	Quasi Peak Limit	Quasi-Peak Difference	Quasi-Peak Status	Angle	Height	Polarization
MHz	dBµV/m	dBµV/m	dB		degrees	m	
33.060	24.5	40	-15.5	Pass	275	1.0	Vertical
52.920	32.7	40	-7.3	Pass	225	1.0	Vertical
53.580	31.6	40	-8.4	Pass	315	1.0	Vertical
69.000	31.8	40	-8.2	Pass	45	1.8	Vertical
69.300	32.2	40	-7.8	Pass	359	1.8	Vertical
69.600	32.3	40	-7.7	Pass	10	1.7	Vertical
69.960	32.8	40	-7.2	Pass	205	1.5	Vertical
70.260	32.8	40	-7.2	Pass	200	1.2	Vertical
166.344	35.2	43.5	-8.3	Pass	40	1.8	Horizontal
254.988	37.9	46	-8.1	Pass	180	1.6	Horizontal

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

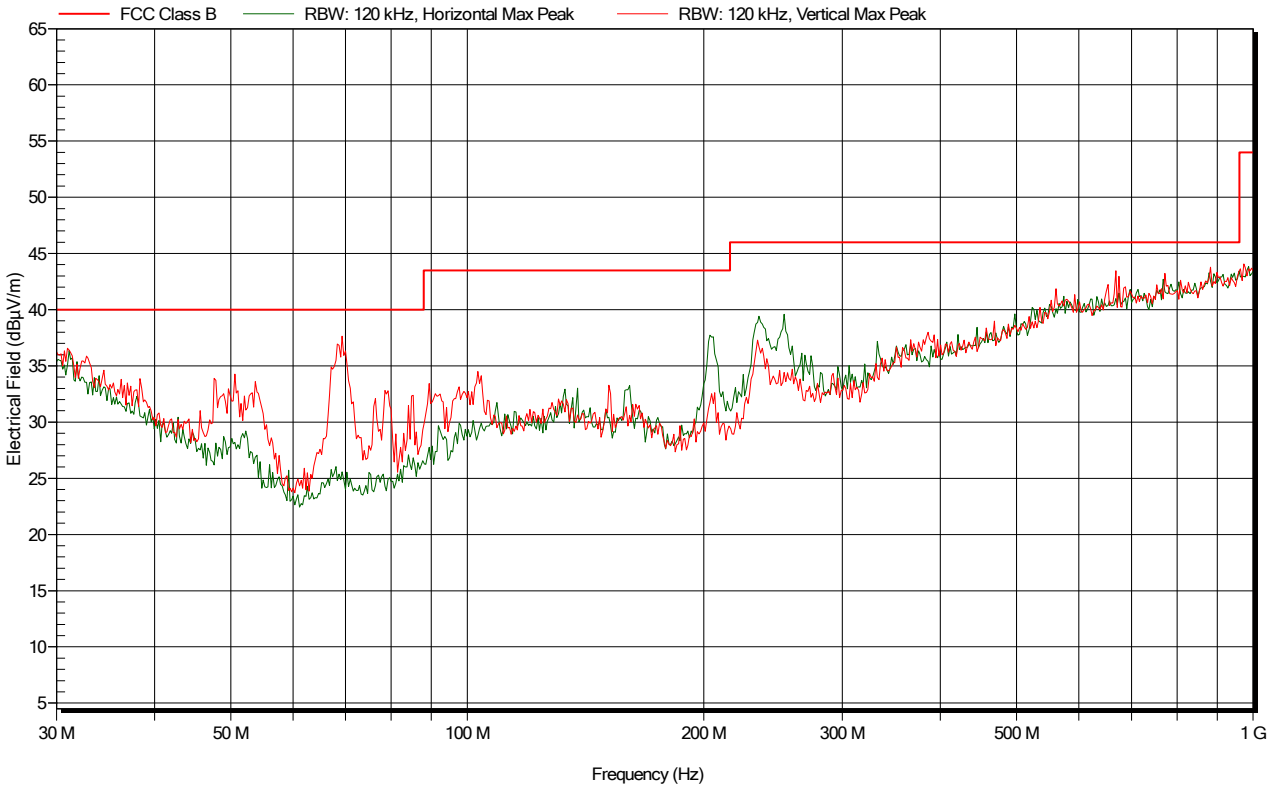


Figure 5.3.7.2: Electric field emissions Peak Detector Plot, 30MHz to 1GHz Operation on 2440MHz

Figure 5.3.7.3: Electric field emissions Peak Detector Plot, 30MHz to 1GHz Operation on 2402MHz

5.3.8 Example field strength calculation

Field strength (FS) is calculated as follows:

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

5.3.9 Sample Data

From Figure 5.3.7.1, and associated tabulated data, the Quasi-Peak level at MHz is calculated as follows:

Emission at 69.960MHz:

FS (dBµV/m) = 19.3(dBµV) + 12.6(dB/m) + 0.9 (dB) = 32.8 dBµV/m

5.3.10 Test set-up photograph

Supplied separately.

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

23rd March 2021

5.4.5 Test Area

LAB 1 (SAC)

5.4.6 Tested by

M Render

5.4.7 Test Setup

The EUT was configured in the SAC on an 1.5m high polystyrene 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 1m.

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.

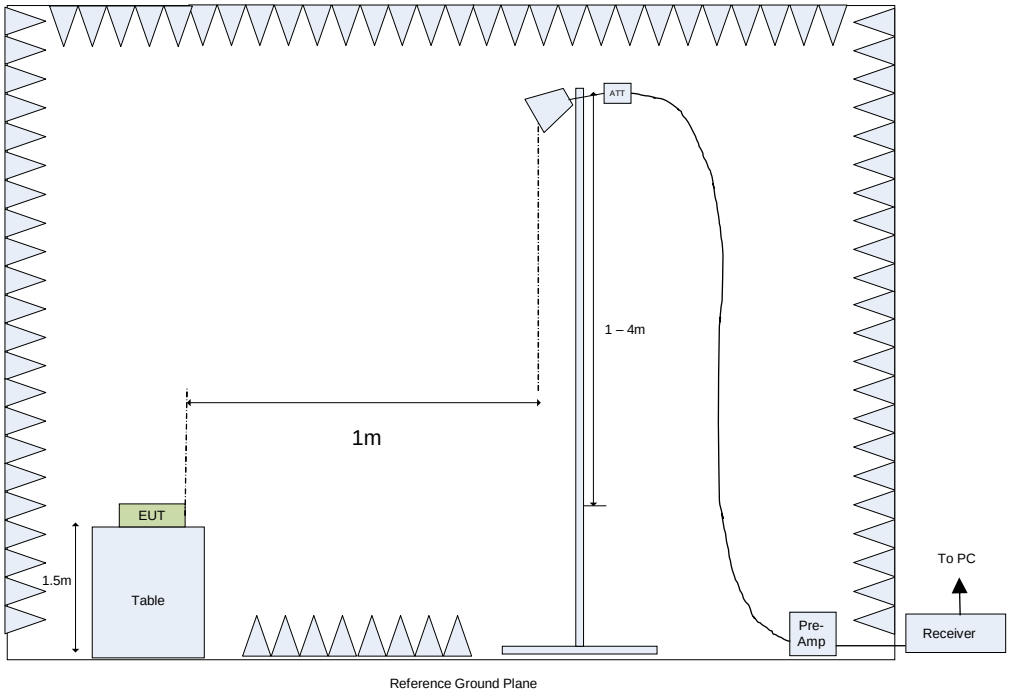


Figure 5.4.7.1: Test Setup for Final E-Field Measurements from 1GHz to 18GHz

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

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.

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
None	Transmitting on channel 2402MHz	-	-	-	-
None	Transmitting on channel 2440MHz	-	-	-	-
None	Transmitting on channel 2480MHz	-	-	-	-

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 channel 2480MHz.

Please note that a 2.4GHz band reject filter (notch filter, Microtronics BRM50702) was inserted beterrn the output of the measurement antenna and the input of the pre-amplifier used. This attenuated the carrier signal to the noise floor.

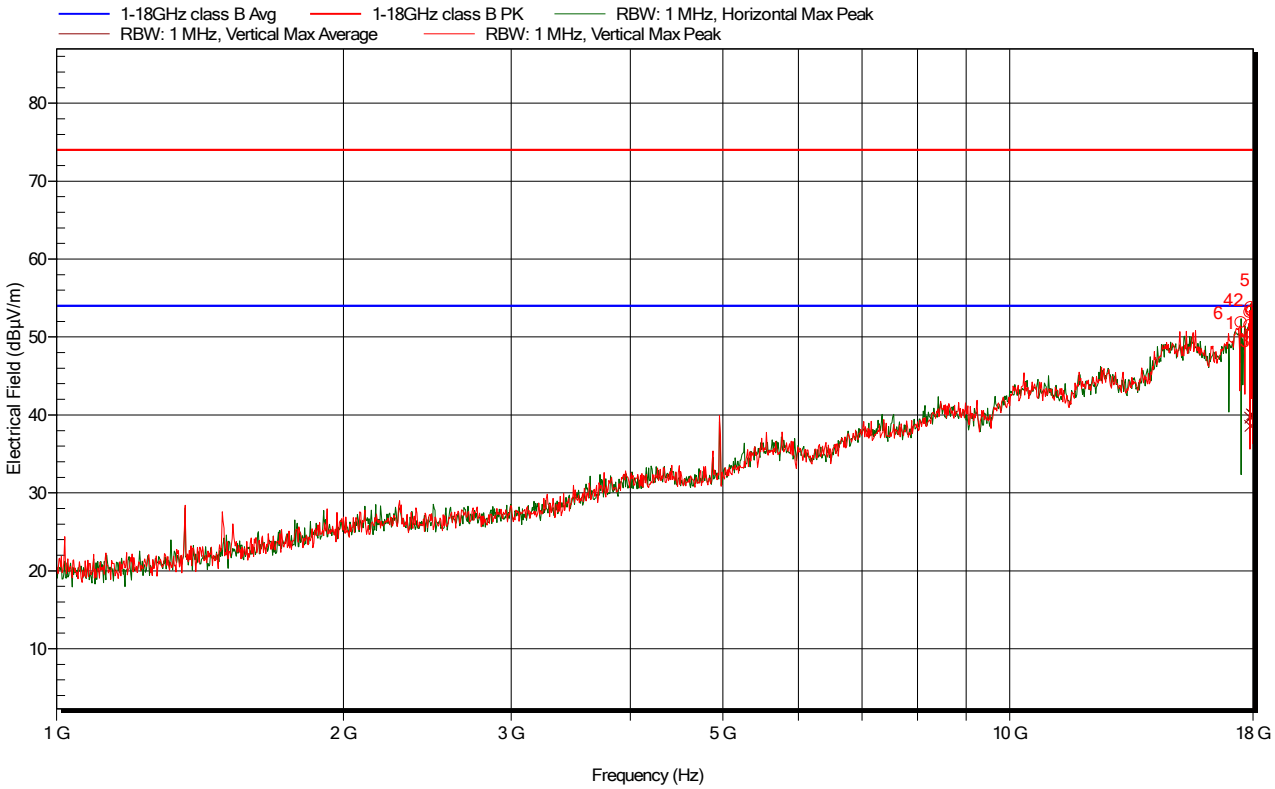


Figure 5.4.9.1: Electric field emissions Plot, 1GHz to 18GHz. Operation on 2480MHz

Frequency	Average	Average Limit	Average Difference	Average Status	Angle	Height	Polarization
GHz	dBµV/m	dBµV/m	dB		degrees	m	
17.490	38.58	54	-15.42	Pass	35	2.1	Horizontal
17.855	38.63	54	-15.37	Pass	160	1.3	Vertical
17.864	39.69	54	-14.31	Pass	340	1.0	Vertical
17.907	40.48	54	-13.52	Pass	235	2.3	Horizontal
17.932	40.11	54	-13.89	Pass	225	3.1	Vertical
17.985	40.02	54	-13.98	Pass	90	3.5	Vertical

Table 5: Electric Field Emissions Peaks, 1GHz to 18GHz – Operation on 2480MHz

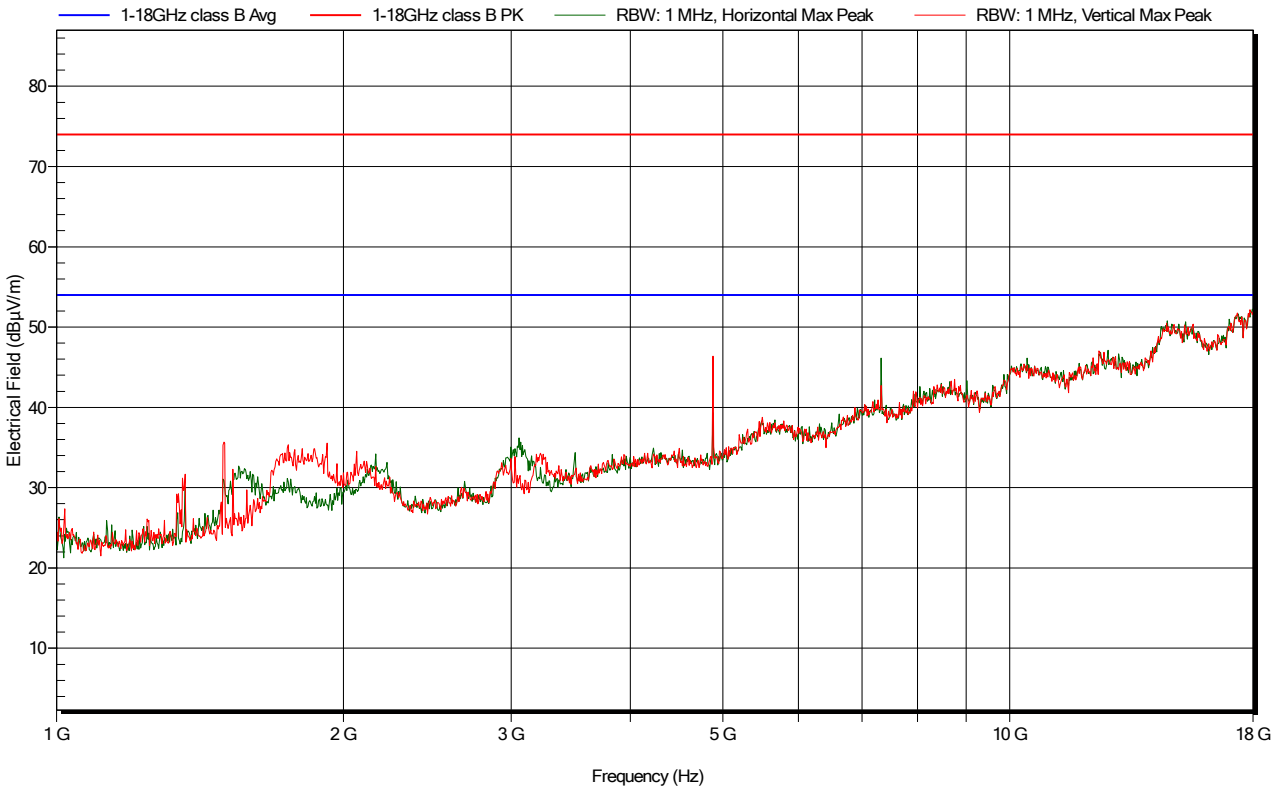


Figure 5.4.9.2: Electric field emissions Plot, 1GHz to 18GHz, Operation on 2440MHz - Peak detector scan

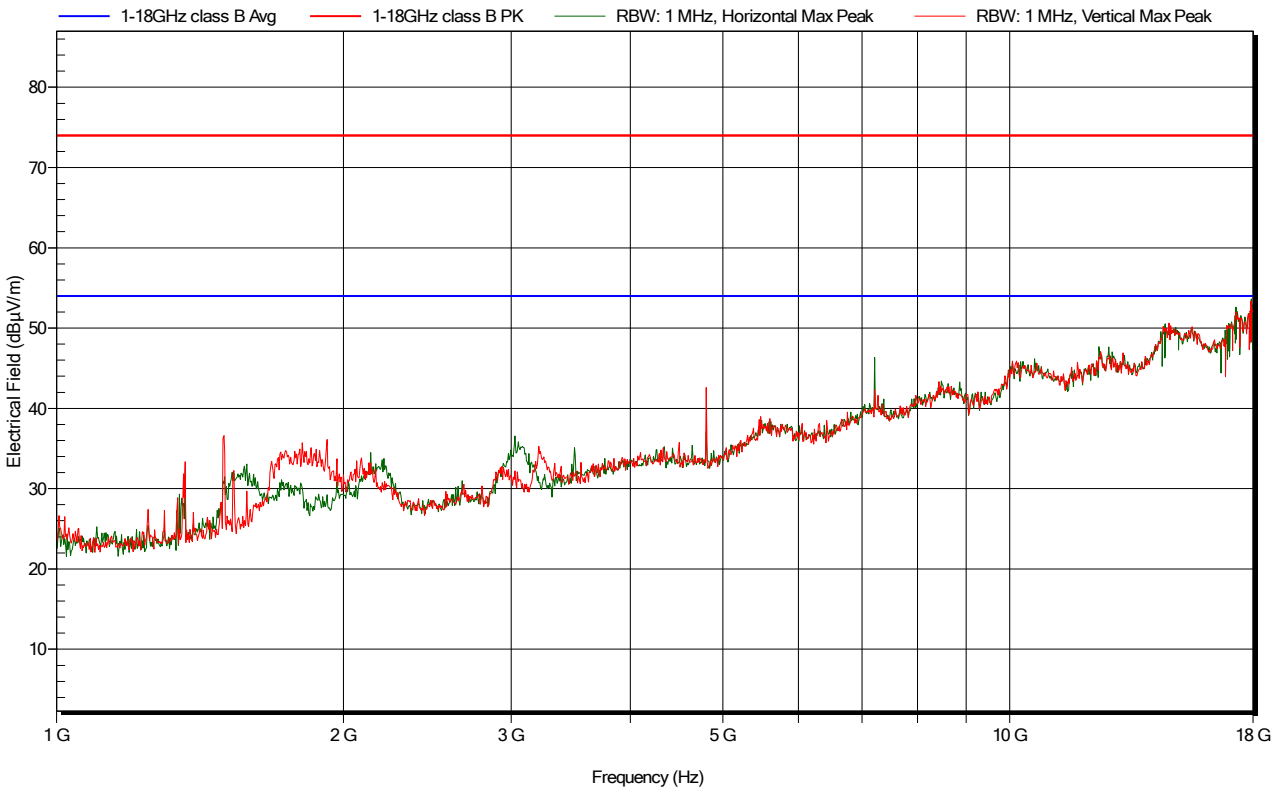


Figure 5.4.9.3: Electric field emissions Plot, 1GHz to 18GHz, Operation on 2402MHz Peak detector scan

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); Attenuator loss (AL) and Cable loss (CL).

Field strength (FS) is calculated as follows:

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

5.4.11 Sample Data

From Figure 5.4.9.1 and associated tabulated data, The Average level at 17.932GHz is calculated as follows:

FS (dBµV/m) = 20.73(dBµV) – 49.67(dB) + 47.75(dB/m) + 21.3(dB) = 40.11dBµV/m

5.4.12 Set-up photograph

Supplied separately.

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

24th February 2021

5.5.5 Test Area

LAB 1 (SAC)

5.5.6 Tested by

M Render

5.5.7 Test Setup

This is the same as for the 1-18GHz range for final measurements, with a measurement distance of 1m. The antenna used was an ETS Lindgren 18GHz to 40GHz horn antenna. Model 3116B.

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°.

5.5.9 Electric field emissions, 18GHz to 26GHz

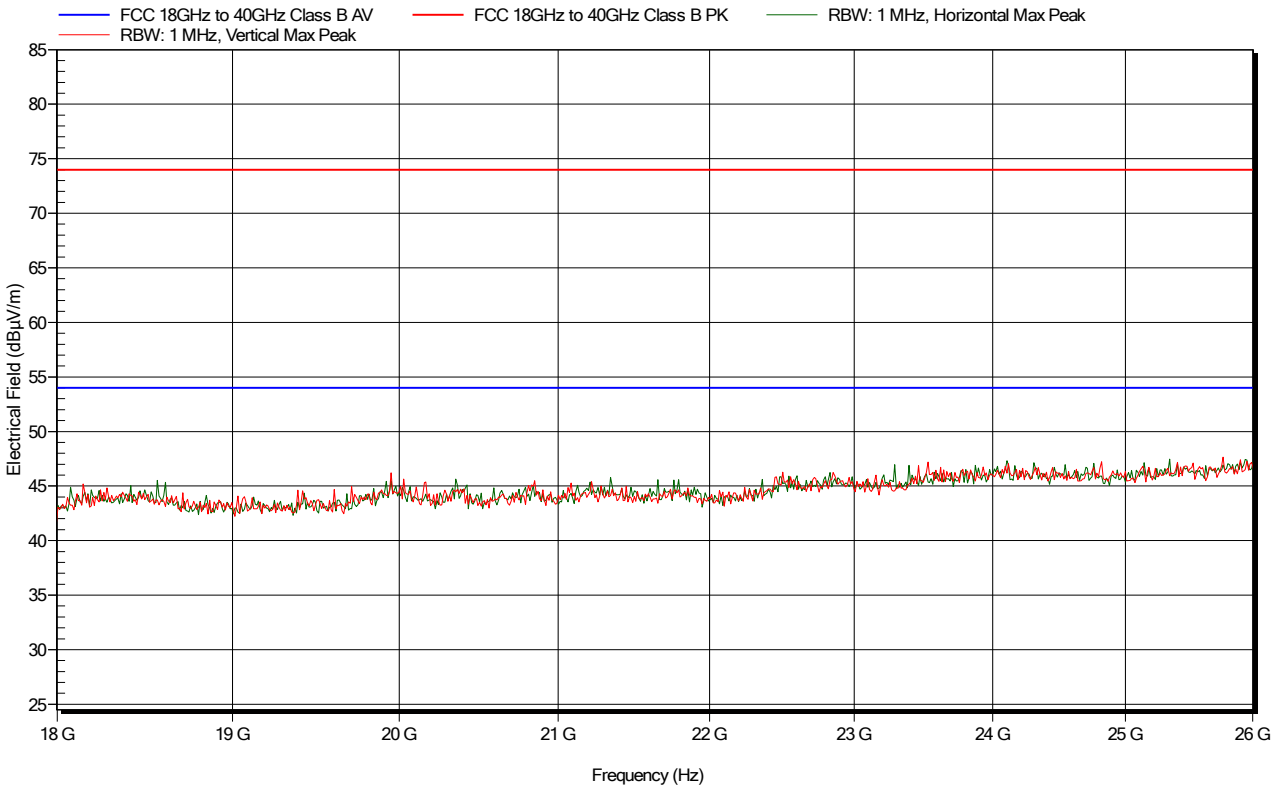


Figure 5.5.8.1 –Operating on channel 2480MHz

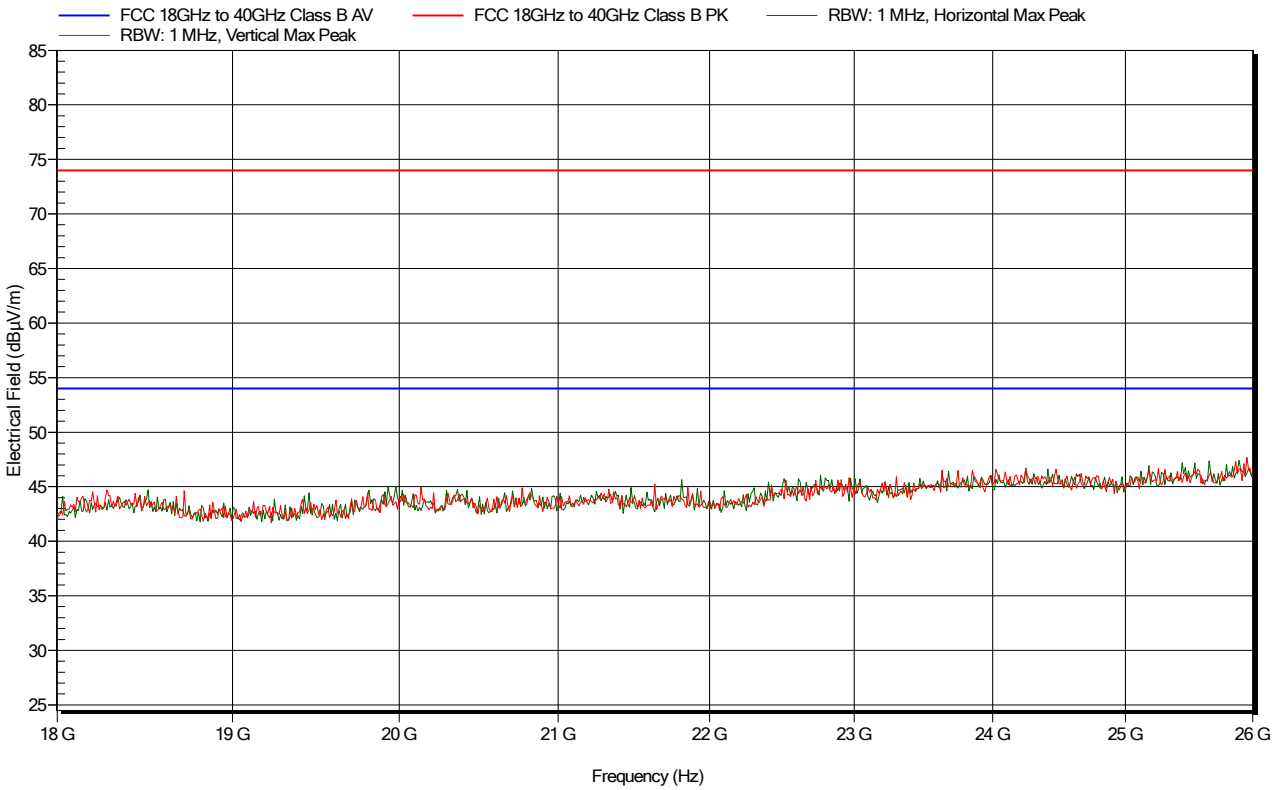


Figure 5.5.8.2 – Operating on channel 2440MHz

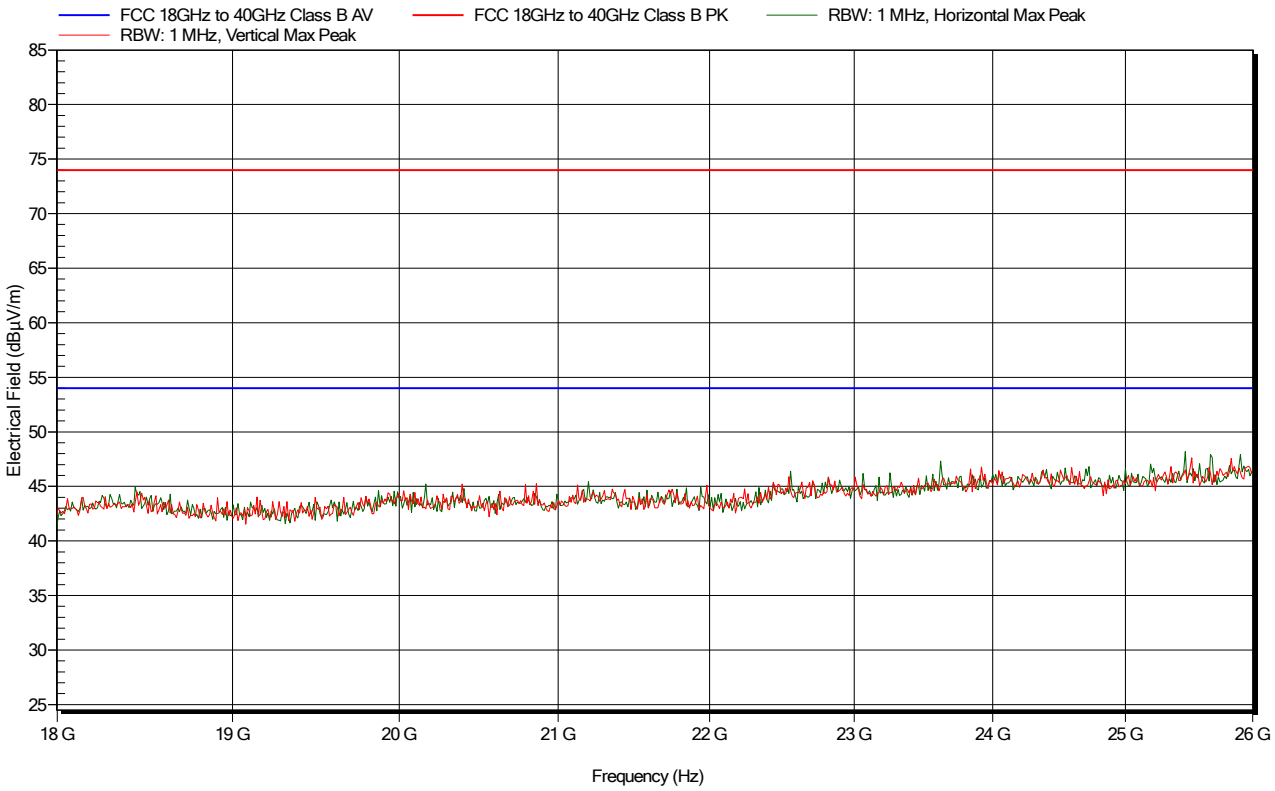


Figure 5.5.8.2 – Operating on channel 2402MHz

5.5.10 Test Set-up photograph

Supplied separately.

Section 6 Band Edge Compliance

6.1 Test Specification

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

6.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	Clause 6.10.4 Authorised band-edge measurements
Test software	Keysight Connection Expert

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

6.2.1 Emissions measurements

6.2.2 Date of Test

24th March 2021

6.2.3 Test Area

LAB 1

6.2.4 Tested by

M Render

6.2.5 Test Setup

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

6.2.6 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	73.20	50.99	4.77	29.89	56.87	74	-17.13
V	2483.5	80.32	50.99	4.77	29.89	63.99	74	-10.01

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	48.12	50.99	4.77	29.89	31.79	54	-22.21
V	2483.5	53.95	50.99	4.77	29.89	37.62	54	-16.38

Operation on Channel 2480MHz, average detector measurements

Lower band edge

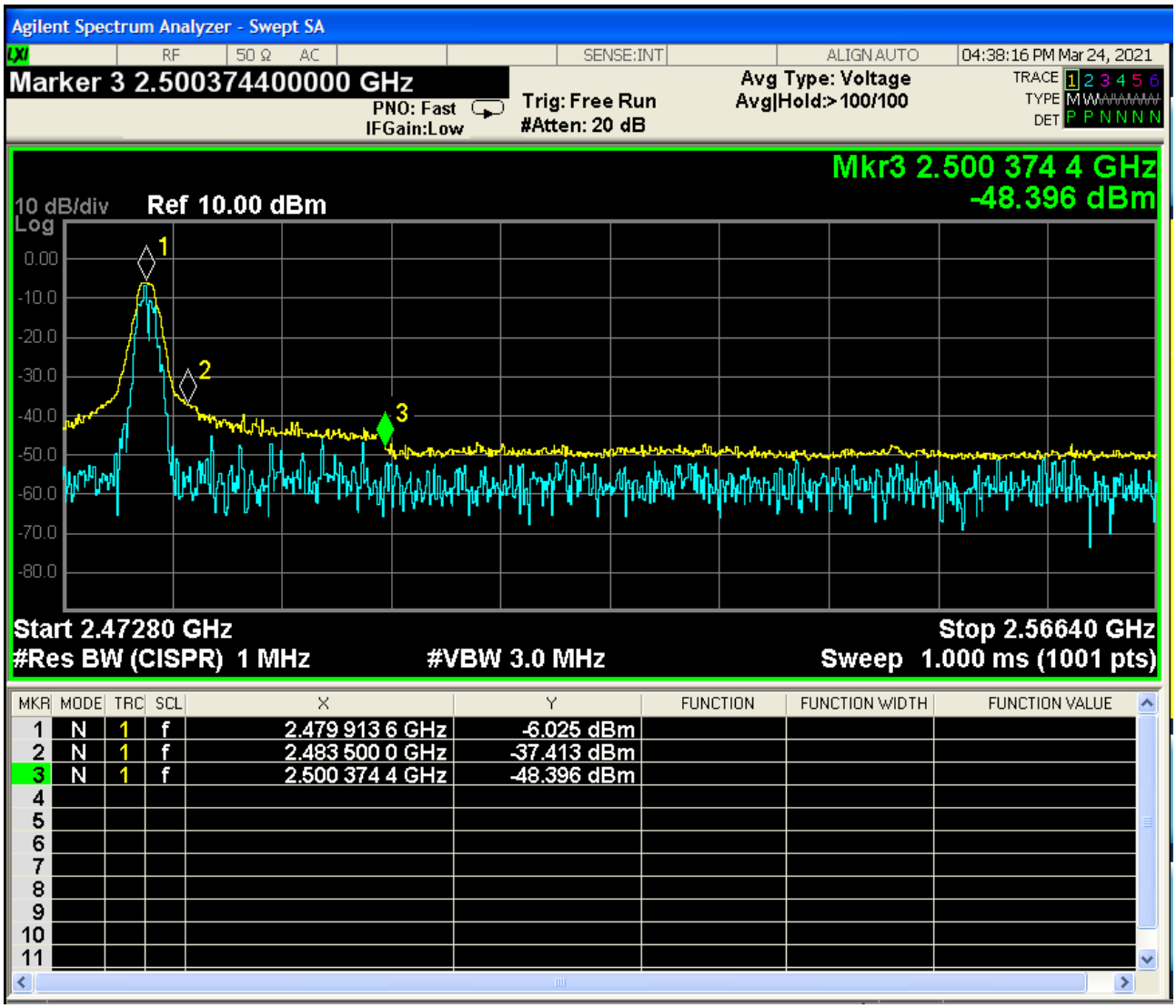
Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E dBuV/m	Limit (dBuV/m)	Margin (dB)
H	2400	79.66	50.97	4.64	29.67	63.00	74	-11.00
V	2400	80.32	50.97	4.64	29.67	63.66	74	-10.34

Operation on 2402MHz Peak detector measurements

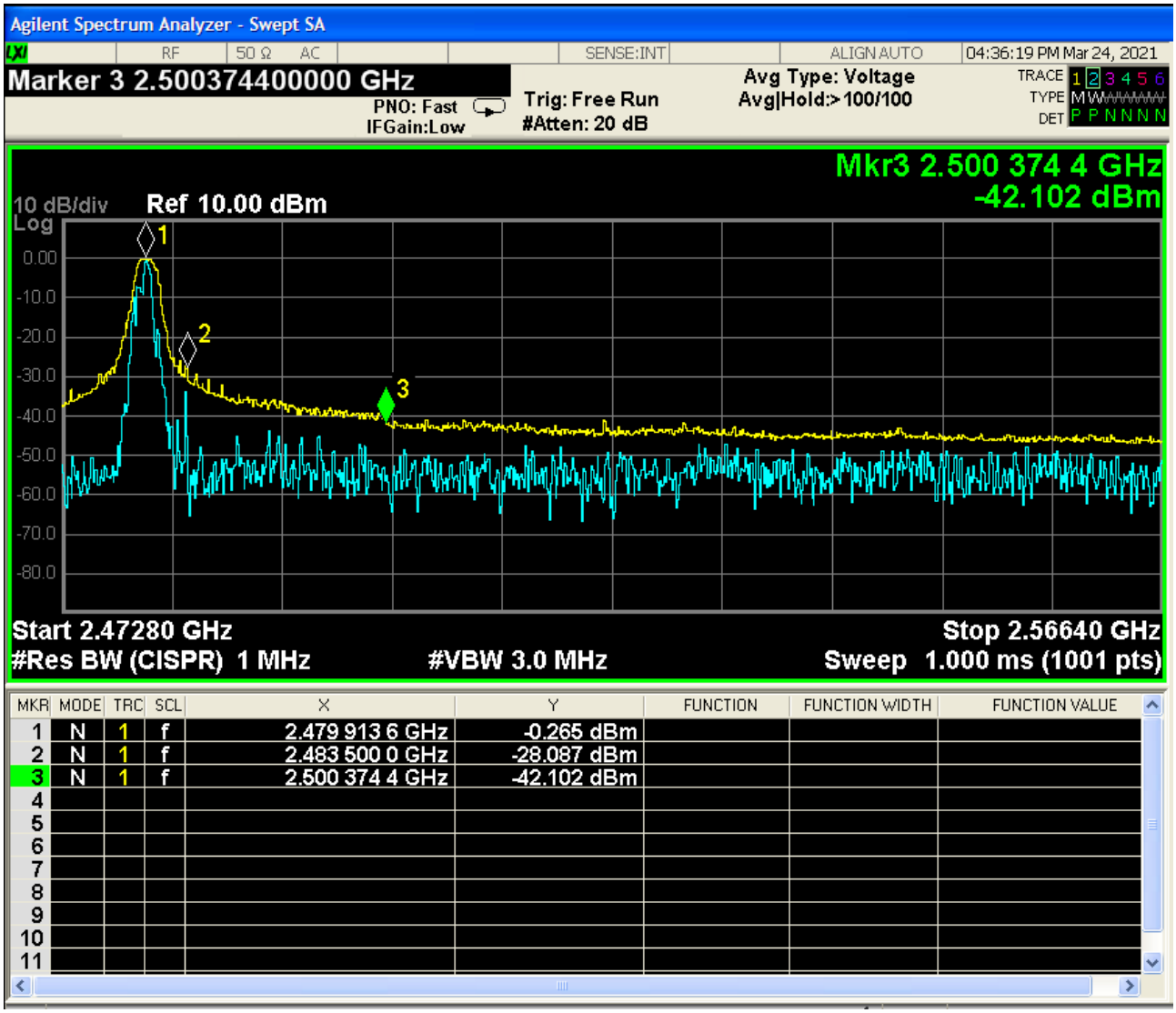
Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E dBuV/m	Limit (dBuV/m)	Margin (dB)
H	2400	56.02	50.97	4.64	29.67	39.36	54	-14.64
V	2400	56.02	50.97	4.64	29.67	39.36	54	-14.64

Operation on 2402MHz average detector measurements

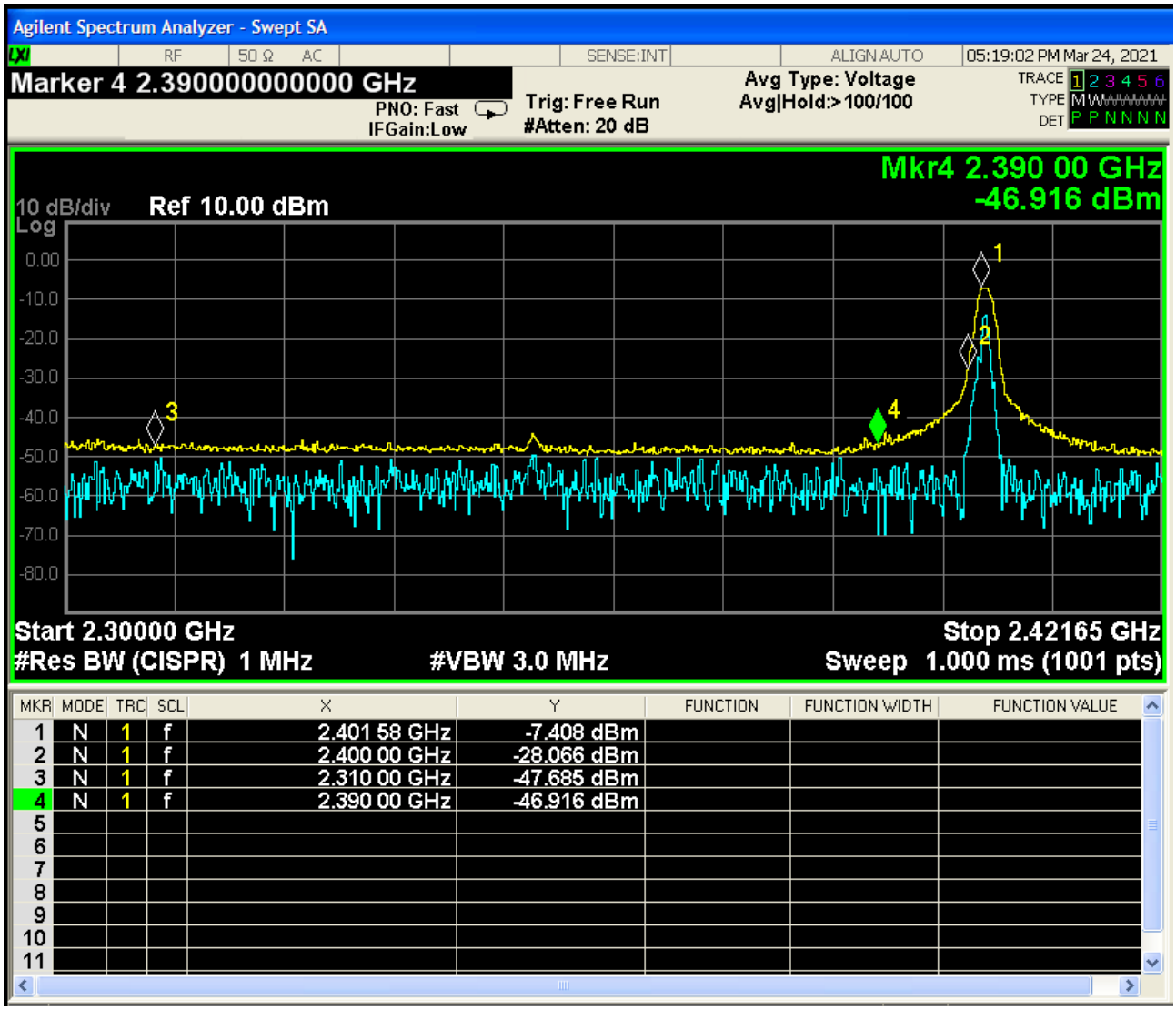
Spectrum analyser displays



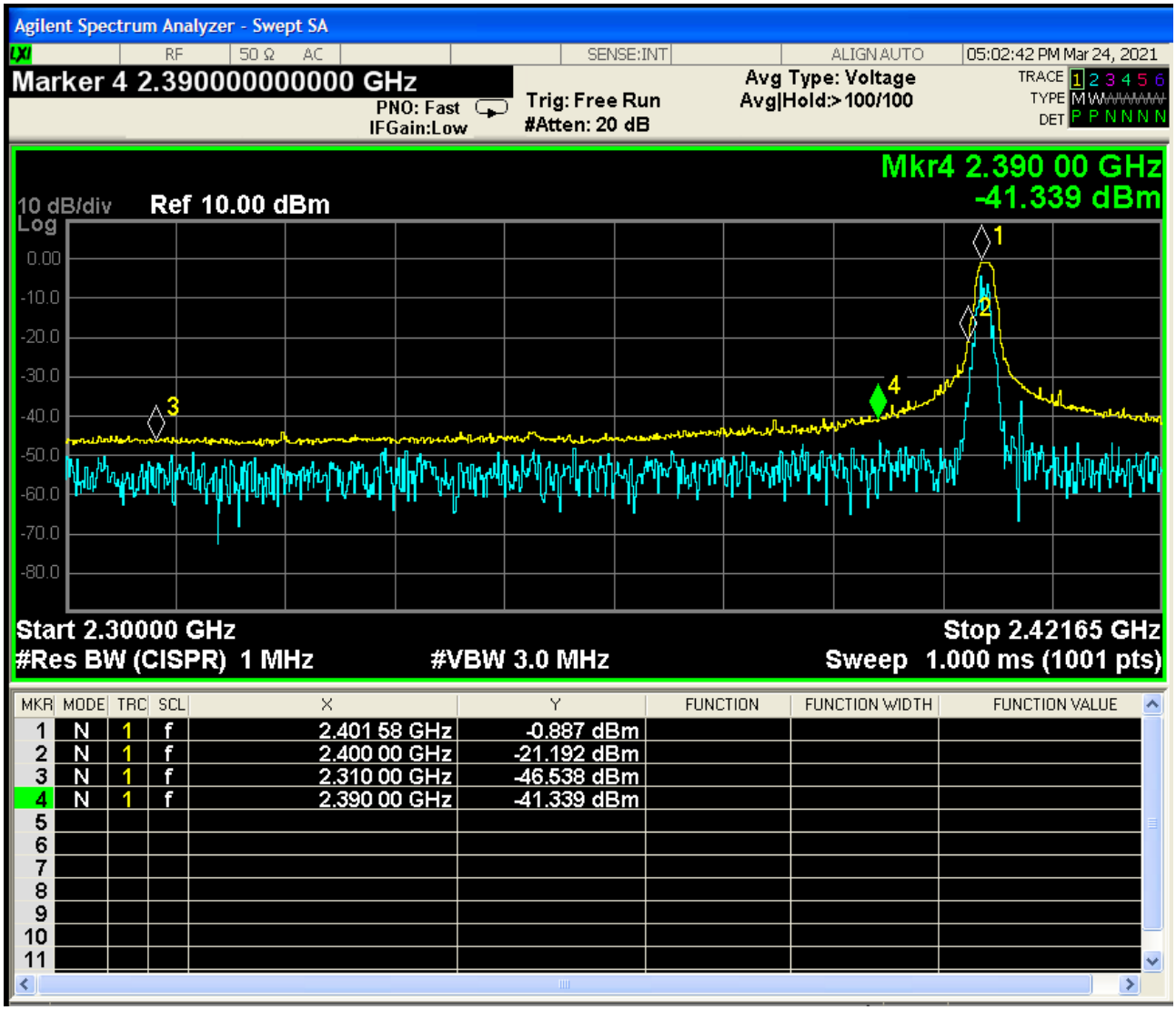
Band Edge Measurement – upper band edge - horizontal polarity



Band Edge Measurement – upper band edge - vertical polarity



Band Edge Measurement – lower band edge - horizontal polarity



Band Edge Measurement – lower band edge - vertical polarity

Appendix A Test Equipment List

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 ESR		26th March 2020	12 Months
Chase CBL6112B Bilog Antenna, 78167	1503	13th December 2019	36 Months
6dB Attenuator (For use with Bilog Antenna)	78708B	13th December 2019	36 Months
HF26 Cable	167003-001	25th January 2021	12 Months
HF17 Cable	167002-001	25th January 2021	12 Months
HF27 Cable	-	25th January 2021	12 Months
EMCO 3115 Horn Antenna 78347	9712-5380	25th May 2020	24 Months
ETS Lindgren 18GHz to 40GHz horn antenna. Model 3116B	00130537	29th October 2020	24 Months
BONN BLMA 0118-5A Preamplifier	149759	9th March 2021	12 Months
Micro-Tronics 2.4GHz Band Reject Filter	BRM50702	5th January 2021	12 Months