


Test Report for the FCC Radio Testing of a HAVwear Module To 47CFR 15.225 For Reactec Ltd

Test Report number: 14139TR1

Project number: C5667

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Issue	Description						Issue by	Date
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Test Report Change History

Issue	Date	Modification Details
1	26 th May 2021	Original issue of test report
2		
3		
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Section 1 Test Location

All testing was performed at;

Eurofins York Ltd	Unit 5
	Speedwell Road
	Castleford
	WF10 5PY
Tel:	01977 731173
Website	https://www.yorkemc.com
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.

Eurofins York, Castleford latest accreditation schedule can be found at:

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

Eurofins York, is a recognised test facility with the Federal Communications Commission (FCC). The appropriate FCC recognition number is UK2013, recognition date 1st March 2021.

Section 2 Customer Information

Company name	Reactec Ltd
Address	Vantage Point
	3 Cultins Road
	Edinburgh
	EH11 4DF
Tel:	44 (0)131 221 0930
Contact	Mr P Gillespie
Email	PeterGillespie@reactec.com
Customer Representative(s) present during testing	Testing was not witnessed

Section 3 Equipment Details**3.1 Equipment Under Test (EUT)**

Date received:	7 th December 2020					
EUT name:	HAVwear Module with BLE					
Type/Part no:	HVW-002, HVW-004					
FCC ID	2AYGFHVW001					
EUT description:	Device which monitors Hand Arm Vibration (HAV) exposure of the user or Social Distance between users. The operating mode used is configured by the end user within the Reactec Analytics system.					
No of units tested:	One					
EUT power:	4.1V \pm 0.1V DC					
Cables:	None, enclosure only					
Size of EUT (mm)	L: -	40	W: -	37	H: -	14
Tested as	Body worn					
Mode/s of operation	RFID active operating at 13.56MHz					
Client modification statement:	Not applicable					
Modifications incorporated during testing:	None.					

3.2 EUT Photos

Photographs are supplied separately.

3.3 Configuration of EUT

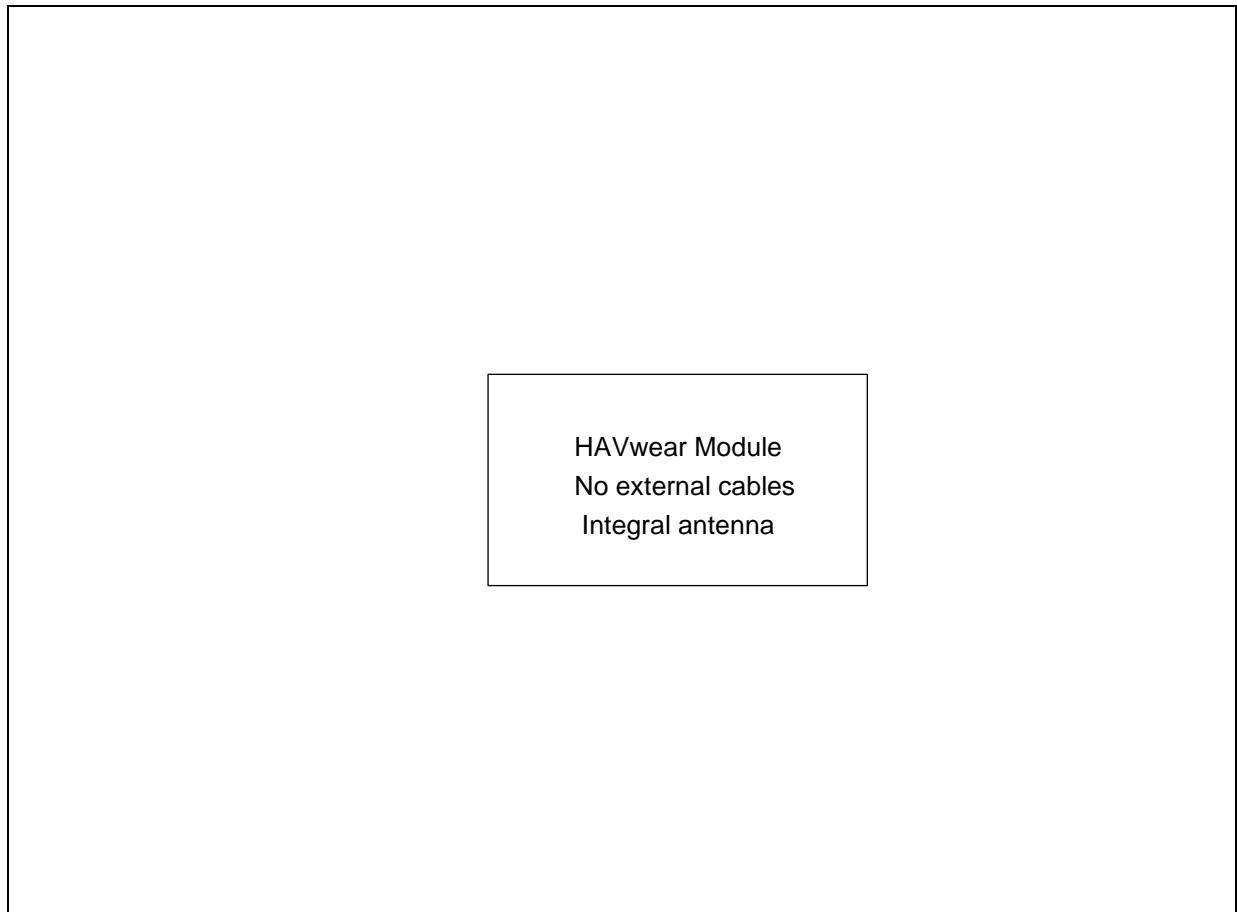


Figure 1: Diagram of EUT

3.4 EUT Monitoring/Auxiliary Equipment

None.

3.5 Monitoring Software

Monitoring software was not used.

Section 4 Test Specifications

The tests were performed in accordance with Eurofins York Ltd Quotation QuC5667.

47CFR Part 15, Sub Part C Intentional Radiators Section 15.225 Operation within the band 13.110-14.010MHz. Section 15.215 Additional provisions to the general radiated emission limitations. Section (C) 20dB bandwidth.			
Which references the following test standard 47CFR 15.38 (G) (3): -			
ANSI C63-10: 2013 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.			
Test	Method	Levels	Result
Conducted Emissions (0.15 – 30MHz)	ANSI C63.10 2013	47CFR15.207	Not applicable
Radiated Emissions Magnetic Field Measurements (Expressed as electric field) (9kHz to 30MHz) And Electric Field Measurements (30MHz – 1000MHz)	ANSI C63.10: 2013	(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters. (b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters. (c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters. (d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209.	Pass
Section 15.225 (e) – Frequency tolerance of the carrier signal	ANSI C63.10: 2013	The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to $+ 50$ degrees C at normal supply voltage	Pass
Section 15.215(C)	ANSI C63.10:2013	20dB bandwidth must remain within assigned frequency band	Pass

Note 1 :All testing was carried out at a test distance of 3m and the data adjusted accordingly.

4.1 Knowledge Database References

The following KDBs were referenced during the testing of the HAVwear Module

The latest knowledge database references are available via the FCC KDB website at:

<https://apps.fcc.gov/kdb>

4.1.1 Conducted Emissions

Publication Number	Keyword	Publication Date
174176	Section 15.107, 15.207, 18.307, C63.4, C63.10, Suitable Dummy Load, AC Power Line Conducted Measurement	03/06/2015
640677	Radio Frequency LED Lighting	17/06/2016
892282	Exclusions, Transportation, Electric Vehicle Battery Charge	21/01/2012
657217	Test procedures for Notebook Computers	01/10/2008

4.1.2 Radiated Emissions (9kHz to 30MHz)

Publication Number	Keyword	Publication Date
937606	Test Site Requirements for Part 15 and 18 Devices Operating Below 30 MHz	10/10/2014
460108	Radiated emission measurements below 30 MHz	06/15/2015

4.1.3 Radiated Emissions (30MHz to 1000MHz)

Publication Number	Keyword	Publication Date
746324	CE Mark and use of CISPR 22 limits	06/12/2015
640677	Radio Frequency LED Lighting	17/06/2016
657217	Test procedures for Notebook Computers	01/10/2008
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017

4.1.4 Radiated Emissions (1GHz to 40GHz)

Publication Number	Keyword	Publication Date
746324	CE Mark and use of CISPR 22 limits	12/06/2015
714737	15B, Average Detector for Unintentional Radiator	30/11/2010
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

4.1.5 Radiated Emissions - Apparatus Containing a Modular Transmitter

Publication Number	Keyword	Publication Date
996369	Modular Transmitter Integration Guide – Guidance for Host Product Manufacturers, Frequency Spectrum to be Investigated	01/02/2019

4.2 Compliance Statement

The HAVwear Module as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

Section 5 Conducted Emission Results

This test was not applicable.

Section 6 Radiated Emission Results

6.1 Test Specification

Standard	ANSI C63.10:2013
Measurement Uncertainty	<p>The reported uncertainty of measurement $y \pm U$, 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</p> <p>+/- 5.01dB for the frequency range from 9kHz to 30MHz</p> <p>+/- 6.23dB for the frequency range 30MHz to 1GHz</p> <p>+/- 5.04dB for the frequency range from 1GHz to 6GHz</p> <p>+/- 5.35dB for the frequency range from 6GHz to 18GHz</p> <p>+/- 4.81dB for the frequency range from 18GHz to 40GHz</p>

6.2 Procedure and Test Software Version

Eurofins York test procedure (9kHz to 30MHz)	CEP22 Issue 5
Eurofins York test procedure (30MHz to 1GHz)	CEP23 Issue 5
Eurofins York test procedure (1GHz to 40GHz)	CEP64 Issue 6
Test software	Keysight Connect

6.3 Magnetic Field Radiated Emissions (9kHz to 30MHz)**6.3.1 Limits**

Frequency	Limits (µV/m)
9kHz to 490kHz	2400/F(kHz) at 300m
490kHz to 1.705MHz	24000/F(kHz) at 30m
1,705MHz to 30MHz	30 at 30m

Note 1: * The limit decreases linearly with the logarithm of the frequency in the range

Note 2: FCC 47 CFR Part 15 Section 15.209 has different test limits from 300m to 30m depending upon the measurement frequency range. The limits have been adjusted for a measurement distance of 3m.

Distance Correction Factor = $40\log(\text{test distance} / \text{specific distance})$.

6.3.2 Analyser Settings Outside of the 13.110-14.010 MHz band

Receiver Parameters	Setting
Detector Function	Peak – for initial investigation
Start Frequency	9kHz
Stop Frequency	150kHz
Resolution Bandwidth	200Hz
Video Bandwidth	620Hz

Receiver Parameters	Setting
Detector Function	Peak – for initial investigation
Start Frequency	150kHz
Stop Frequency	30MHz
Resolution Bandwidth	10kHz
Video Bandwidth	30kHz

Spectrum Mask: Analyser Settings within the bands,

13.553-13.567 MHz, 13.410-13.553 MHz, 13.567-13.710 MHz, 13.110-13.410 MHz and 13.710-14.010 MHz

Receiver Parameters	Setting
Detector Function	Peak – for initial investigation
Start Frequency	13.110MHz
Stop Frequency	14.010MHz
Resolution Bandwidth	10kHz
Video Bandwidth	30kHz

6.3.3 Emissions measurements

6.3.4 Date of Test

18th January 2021

6.3.5 Test Area

LAB 5 (Anechoic
chamber)

6.3.6 Tested by

M Render

6.3.7 Anechoic Test Setup

The EUT was configured in the chamber on an 80cm high table (polystyrene block)

The measurement was then performed with an antenna to EUT separation distance of 3m within the anechoic chamber based upon the highest emissions results recorded on the outside test site.

The centre of the loop antenna was 1m above the ground and results were obtained with it parallel to the EUT and then perpendicular to the EUT.

The results are maximised in orientation 0-360 degrees.

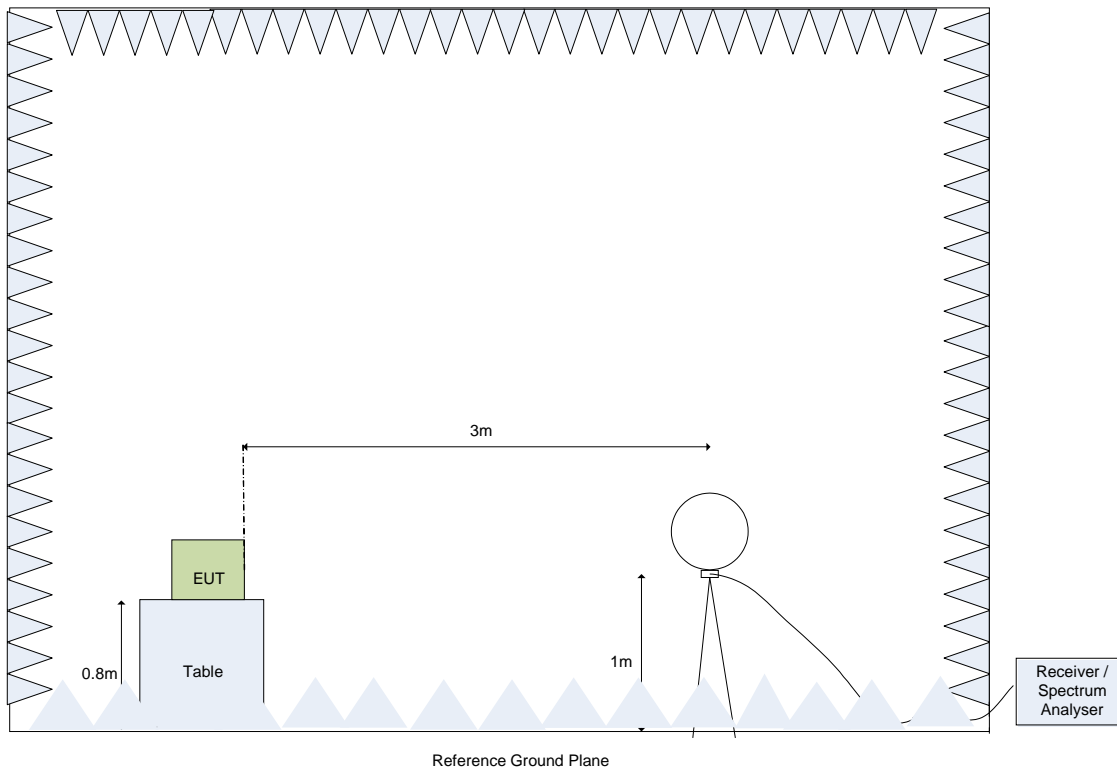


Figure 2: Test Setup for H-Field Measurements from 9kHz to 30MHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement

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.

6.3.8 Magnetic Field Emissions Results, 9kHz to 30MHz

Measurements were made in an anechoic chamber at a 3m measurement distance. There were no reflective surfaces, since the wall, floor and ceiling were lined with radio absorbent material.

The results present data measured with a PEAK detector.

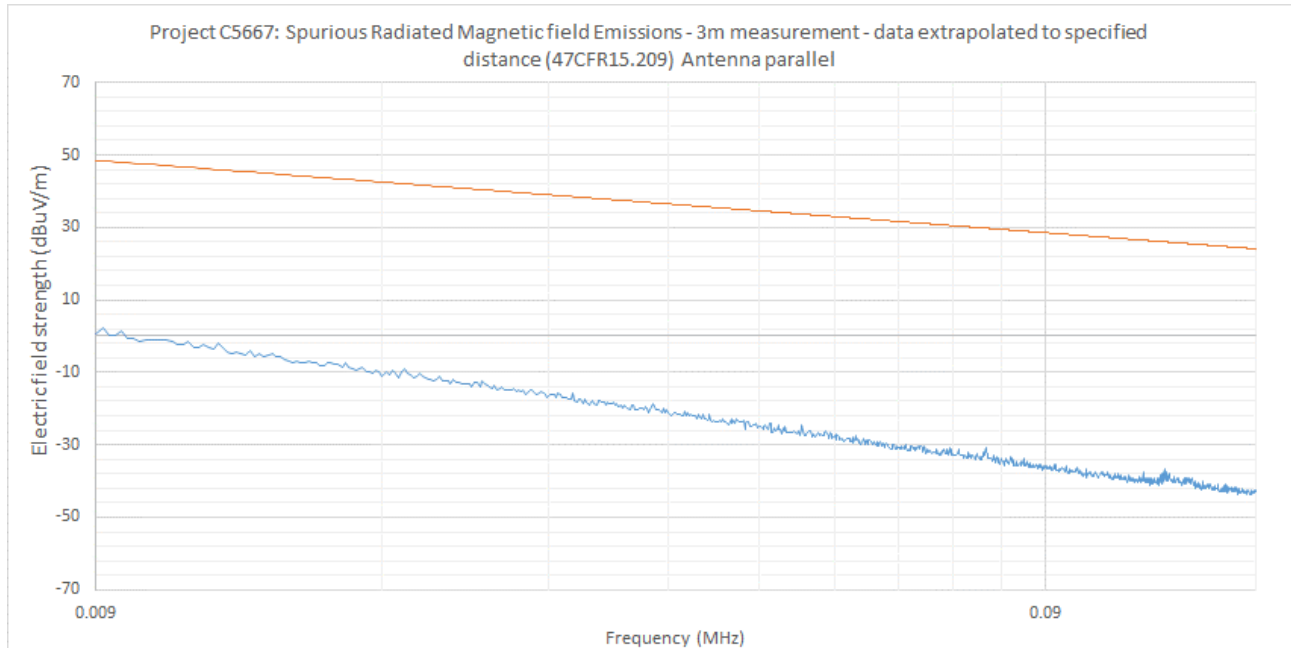


Figure 3: Magnetic field emissions Plot, 9kHz to 150kHz Parallel

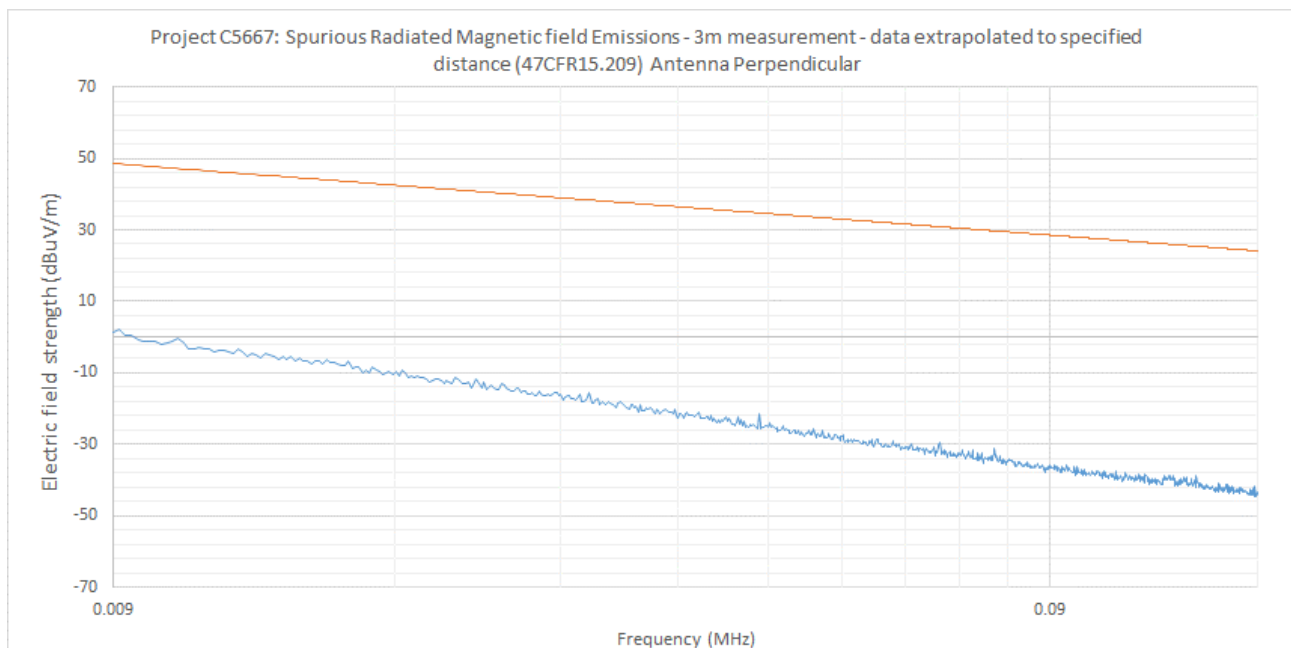


Figure 4: Magnetic field emissions Plot, 9kHz to 150kHz Perpendicular

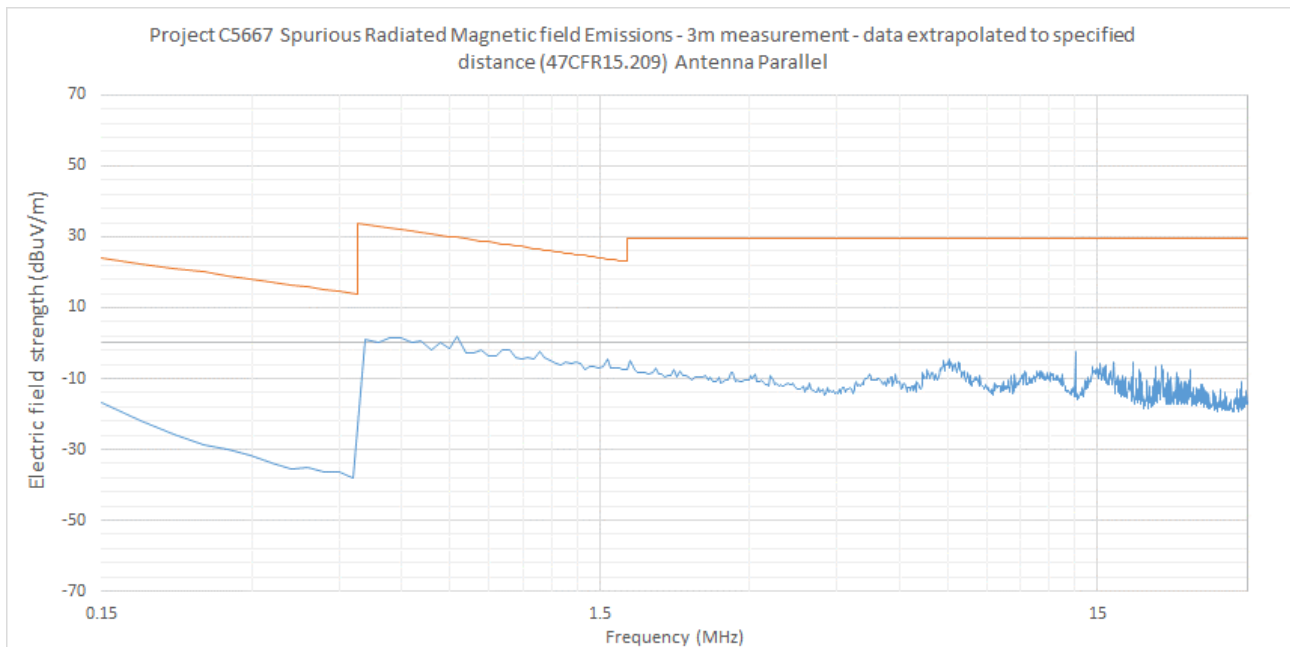


Figure 5: Magnetic field emissions Plot, 150kHz to 30MHz Parallel

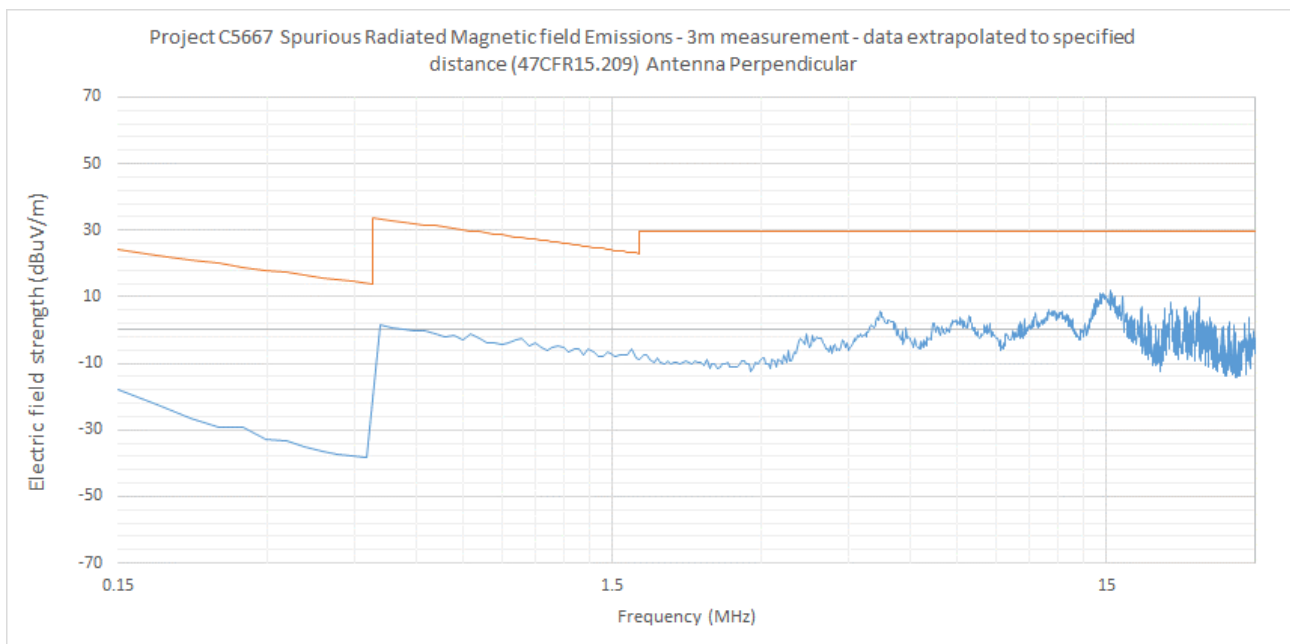


Figure 6: Magnetic field emissions Plot, 150kHz to 30MHz Perpendicular

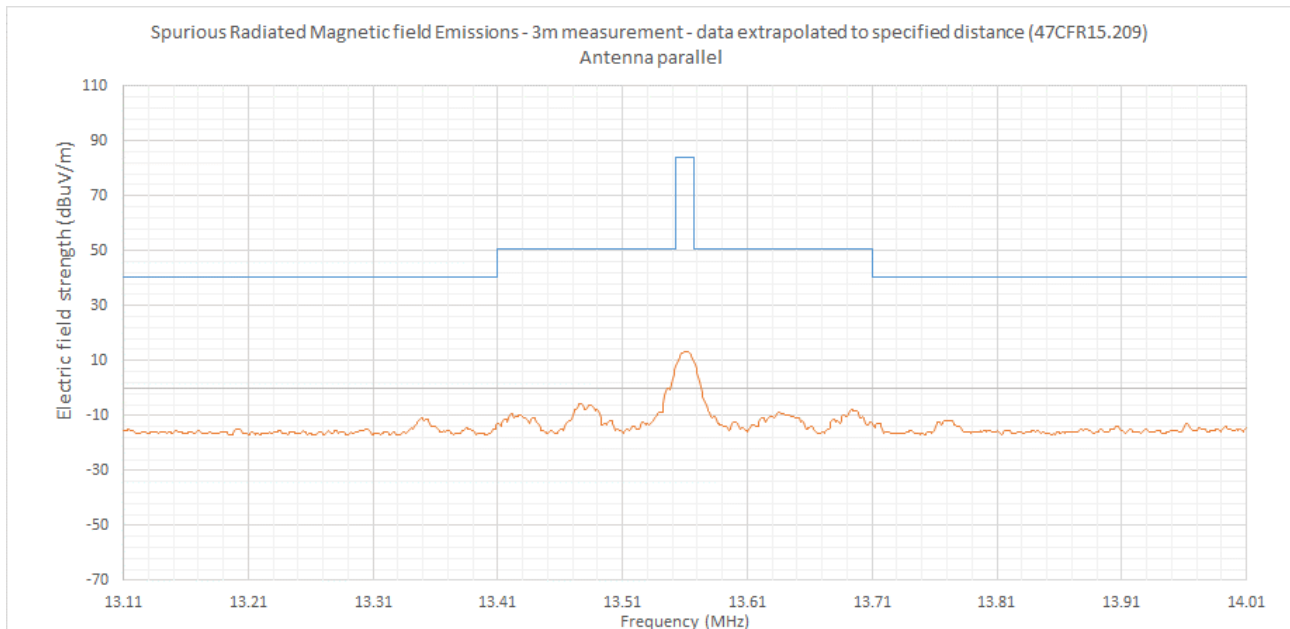


Figure 7: Magnetic field emissions Plot, 13.11MHz to 14.01MHz – Spectrum Mask – antenna Parallel

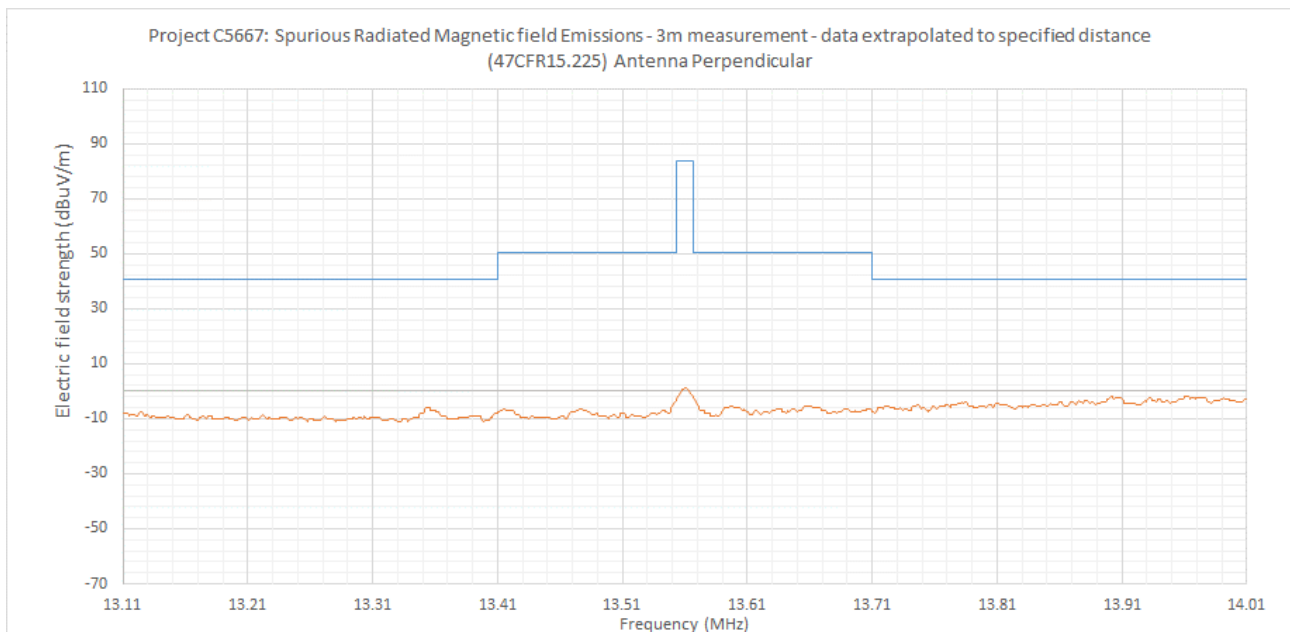


Figure 8: Magnetic field emissions Plot, 13.11MHz to 14.01MHz – Spectrum Mask – antenna Perpendicular

6.3.9 Calculation of result

Field strength (FS) is calculated as follows from the receiver reading, Antenna factor (AF) in dB/m; Cable loss (CL) and pre-amplifier gain (G).

$$FS \text{ (dB}\mu\text{V/m)} = \text{Indicated Signal Level (dB}\mu\text{V)} + AF(\text{dB/m}) - G(\text{dB}) + CL \text{ (dB)}$$

Cable loss was considered to have no influence on the measurement result in this case.

Freq (MHz)	Rx (dBμV)	Preamp gain G (dB)	Antenna factor (dB/m)	Result at 3m (dBμV/m)	Distance correction factor (40dB/decade)	Result at 30m (dBμV/m)	Limit At 30m (dBμV/m)	Margin (dB)	Result
13.56	37.47	29.16	32.70	41.01	-40	1.01	84	-82.99	Below limit

13.56MHz result calculation – measurement antenna perpendicular

Freq (MHz)	Rx (dBμV)	Preamp gain G (dB)	Antenna factor (dB/m)	Result at 3m (dBμV/m)	Distance correction factor (40dB/decade)	Result at 30m (dBμV/m)	Limit At 30m (dBμV/m)	Margin (dB)	Result
13.56	45.99	29.16	32.74	45.57	-40	9.57	84	-74.43	Below limit

13.56MHz result calculation – measurement antenna parallel

6.3.10 Data Extrapolation

Measurements were made at a 3m measurement distance since the NFC 13.56MHz signal was not detected at 10m. The data was extrapolated to the required specified distance as follows:

Between 9kHz and 490kHz the measurement distance according to 47CFR15.209 (a) is 300m:

$$\text{measurement at 300m} = \text{measurement at 3m} + 40\log\left(\frac{3}{300}\right)$$

$$\text{measurement at 300m} = \text{measurement at 3m} - 80\text{dB}$$

Between 490kHz and 30MHz the measurement distance according to 47CFR15.209 (a) is 30m:

$$\text{measurement at 30m} = \text{measurement at 3m} + 40\log\left(\frac{3}{30}\right)$$

$$\text{measurement at 30m} = \text{measurement at 3m} - 40\text{dB}$$

6.3.11 Measurement Summary

No further emissions were identified as being within 20dB of the specification limit using a peak detector. No further measurements were taken.

6.4 Radiated Emissions (30MHz to 1GHz)**6.4.1 Limits at 3m**

Frequency (MHz)	47CFR15.209 (a) (dB μ V/m)
	Quasi Peak
30 - 88	40.0
88 -216	43.5
216 - 960	46.0
960- 1000	54.0

47CFR 15.209 specifies limits at a 3m measurement distance.

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

6.4.2 Emissions measurements**6.4.3 Date of Test**

19th January 2021

6.4.4 Test Area

LAB 1 (SAC)

6.4.5 Tested by

M Render

6.4.6 Test Setup

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

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.

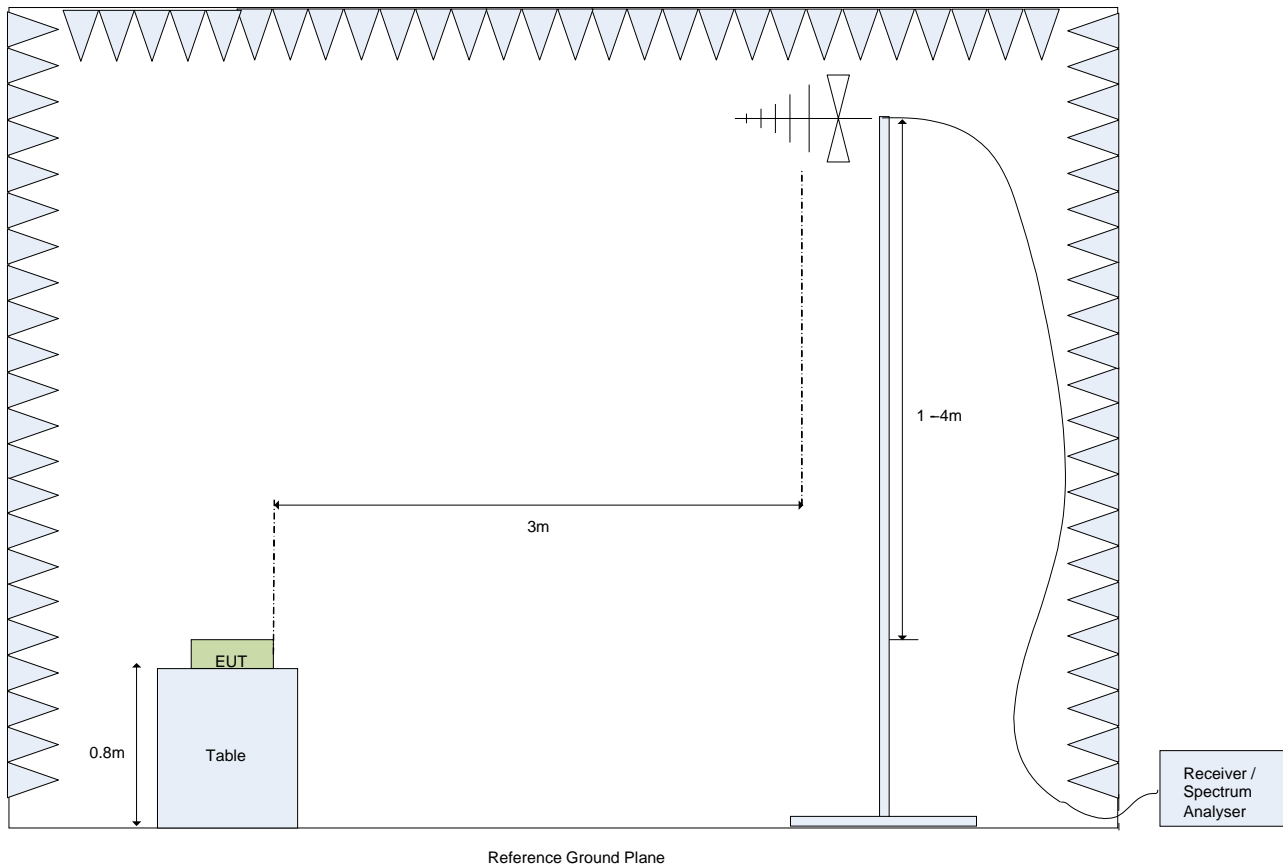


Figure 2: Test Setup for E-Field Measurements from 30MHz to 1GHz

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

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.

6.4.7 Electric field emissions, 30MHz to 1GHz

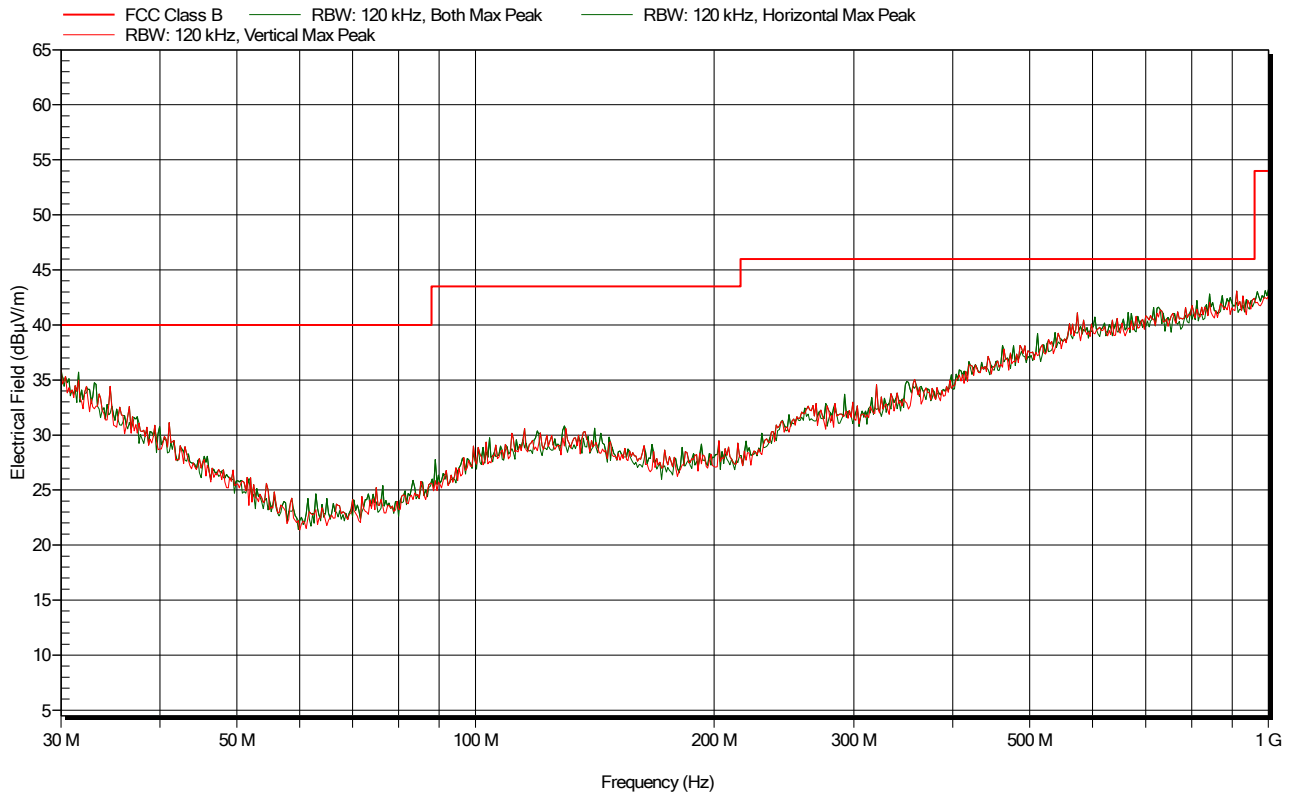


Figure 9: Electric field emissions Plot, 30MHz to 1GHz. Resting on back, display facing the ceiling. Spectrum analyser plot

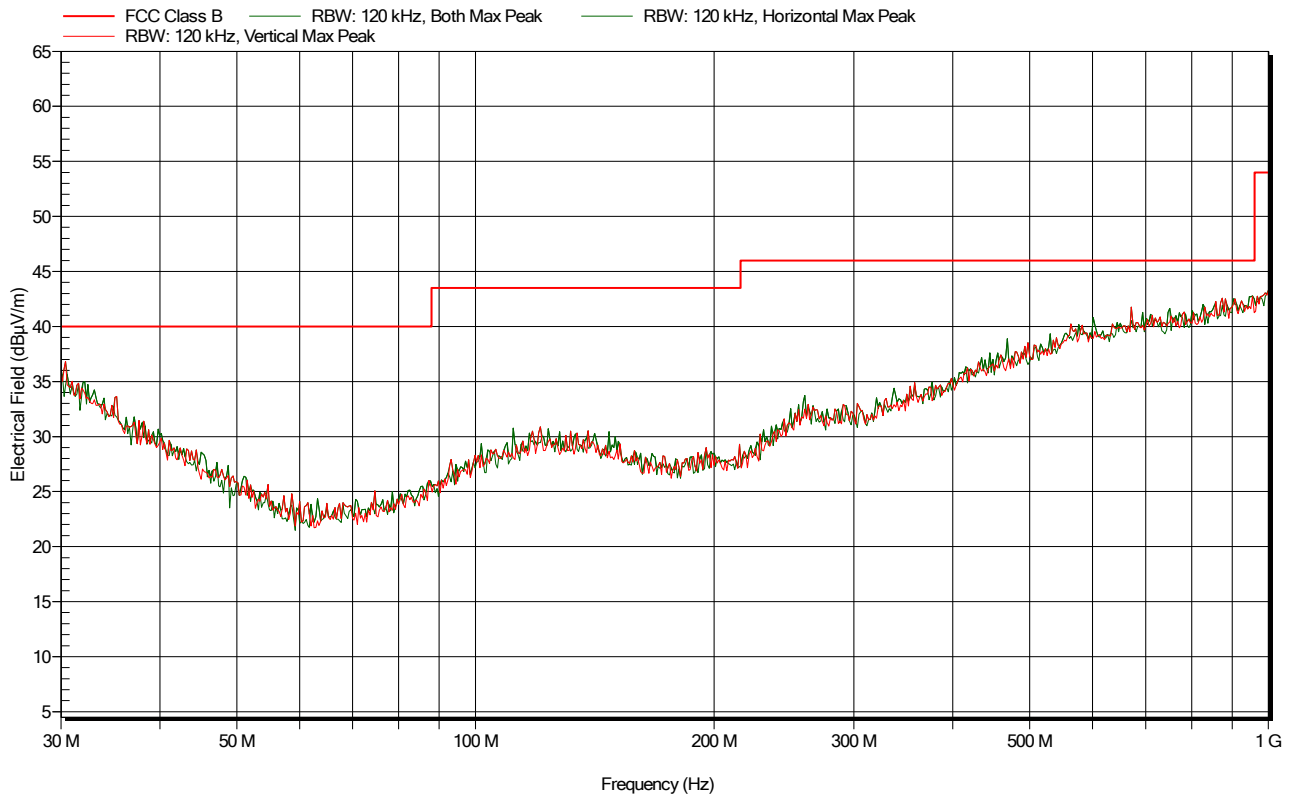
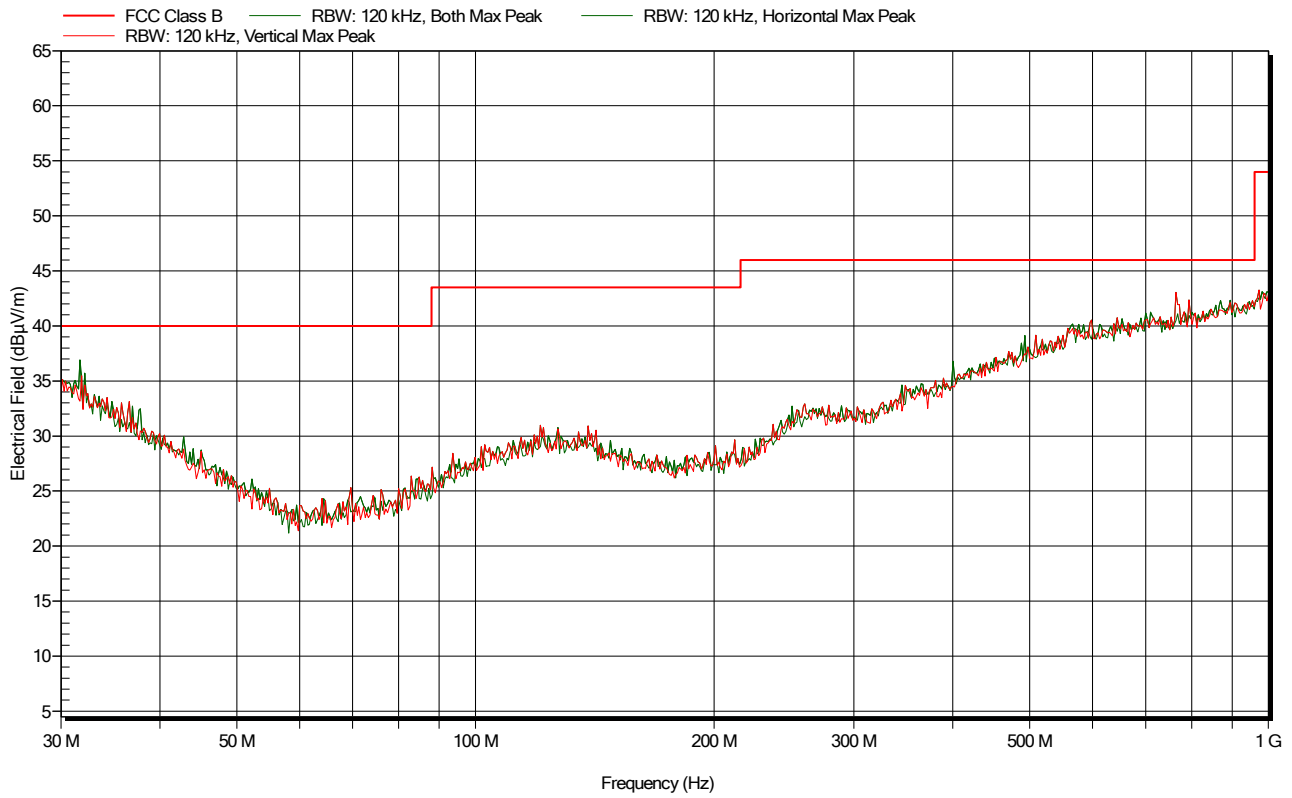
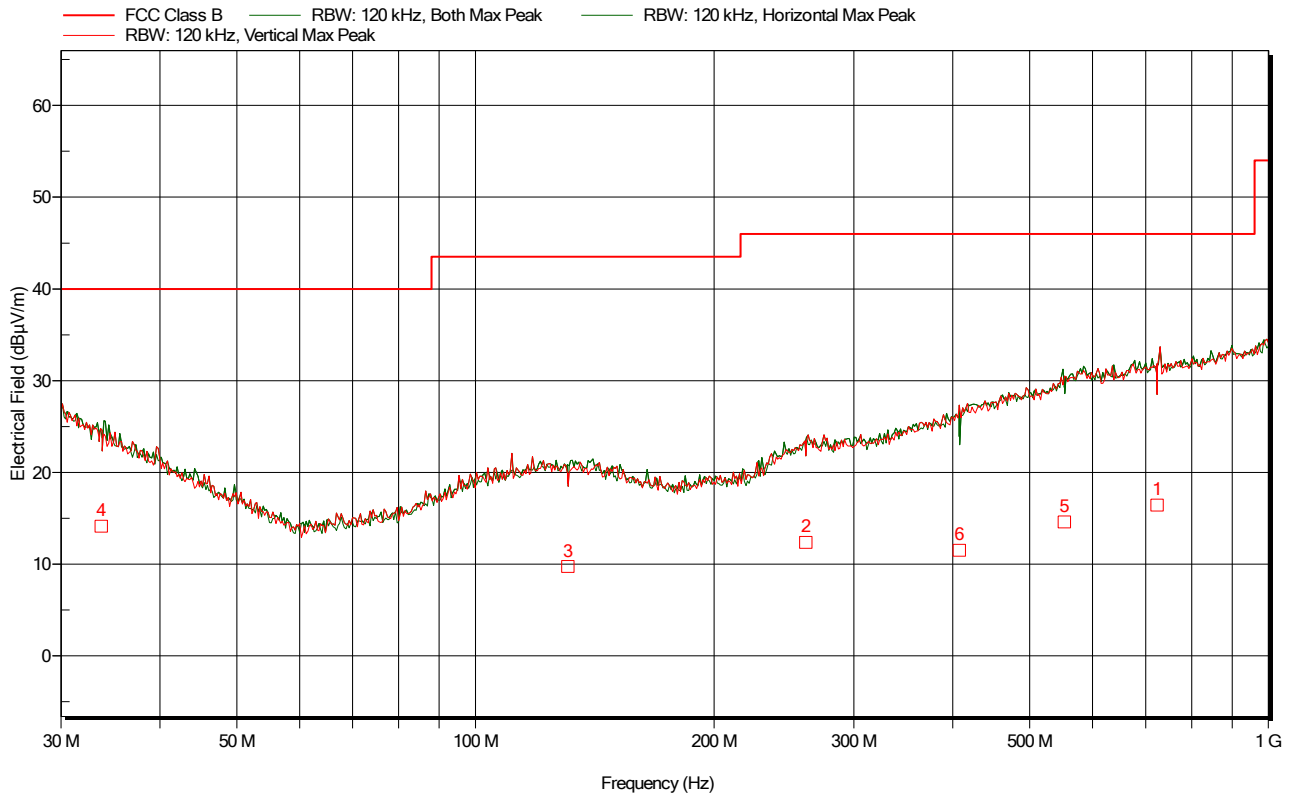


Figure 10: Electric field emissions Plot, 30MHz to 1GHz. Resting on back, Stood upright on long side. Spectrum analyser plot



**Figure 11: Electric field emissions Plot, 30MHz to 1GHz. Resting on back, Stood on end.
Spectrum analyser plot**



**Figure 12: Electric field emissions Plot, 30MHz to 1GHz. Resting on back, Stood on end.
Final measurement**

Frequency MHz	Measured QP dBμV/m	Limit dBμV/m	Margin dB	Polarity	Height (m)	Comment
33.720	14.1	40.0	-25.9	Vertical	1.0	Pass
130.740	9.8	43.5	-33.7	Vertical	1.0	Pass
261.000	12.4	46.0	-33.6	Vertical	2.1	Pass
407.580	11.5	46.0	-34.5	Horizontal	3.9	Pass
553.080	14.6	46.0	-31.4	Horizontal	2.5	Pass
723.377	16.4	46.0	-29.6	Vertical	3.0	Pass

Final quasi-peak detector measurements

6.4.8 Quasi Peak correction factors

The quasi peak correction is shown in the above table. This correction figure consists of Antenna factor (AF); and Cable loss (CL).

Field strength (FS) is calculated as follows:

$$\text{FS (dB}\mu\text{V/m)} = \text{Indicated Signal Level (dB}\mu\text{V)} + \text{AF (dB)} + \text{CL (dB)}$$

6.4.9 Sample Data

The Quasi-Peak level at 723.377MHz

$$\text{FS (dB}\mu\text{V/m)} = 16.36 \text{ dB}\mu\text{V/m} = -11.30\text{dB}\mu\text{V} + 25.06\text{dB} + 2.60\text{dB}$$

Section 7 Frequency Stability

7.1.1 Limits

FCC Rule Part	Test Standard	Requirement
Section 15.225 (e) – Frequency tolerance of the carrier signal	ANSI C63.10: 2013	The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to $+ 50$ degrees C at normal supply voltage

7.1.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average
Centre Frequency	13.56MHz
Span	500kHz
Resolution Bandwidth	10kHz
Video Bandwidth	30kHz

7.1.3 Frequency stability measurements

7.1.4 Date of Test

21st January 2021

7.1.5 Test Area

LAB 7 (temperature chambers)

7.1.6 Tested by

M Render

7.1.7 Test Setup

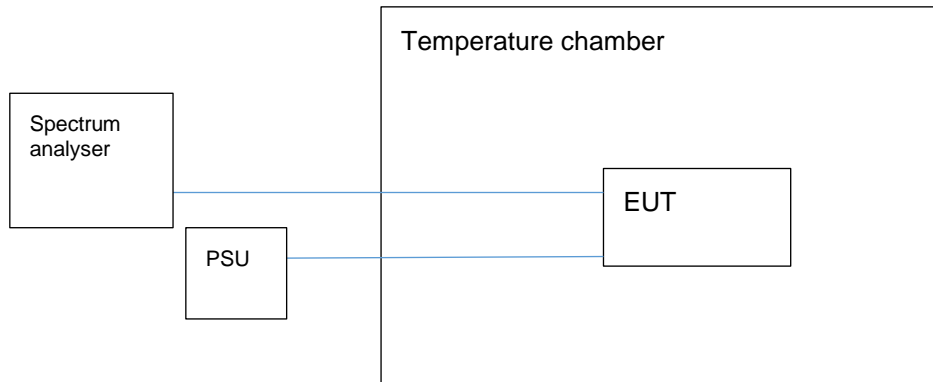


Figure 13: Test arrangement for frequency stability testing.

For this test, a temporary SMA antenna connector was fitted for direct connection to the spectrum analyser.

7.1.8 Frequency stability test results

Temp. C		Frequency (MHz)	Nominal (MHz)	Deviation %	Limit 47CFR15.225 (e) %	Result
50	Startup	13.56022725	13.56	0.00242663	0.01	Within limit
	2min	13.56028187	13.56	0.00240047	0.01	Within limit
	5min	13.56022589	13.56	0.0022725	0.01	Within limit
	10min	13.56022545	13.56	0.00223966	0.01	Within limit
40	Startup	13.56023833	13.56	0.00175753	0.01	Within limit
	2min	13.56023255	13.56	0.00171494	0.01	Within limit
	5min	13.56025718	13.56	0.00189658	0.01	Within limit
	10min	13.56023159	13.56	0.00170785	0.01	Within limit
30	Startup	13.56025942	13.56	0.00191312	0.01	Within limit
	2min	13.56025458	13.56	0.0018774	0.01	Within limit
	5min	13.56027904	13.56	0.0020578	0.01	Within limit
	10min	13.56022837	13.56	0.00168408	0.01	Within limit
20	Startup	13.56027692	13.56	0.00204217	0.01	Within limit
	2min	13.56028557	13.56	0.00210593	0.01	Within limit
	5min	13.56028414	13.56	0.00209537	0.01	Within limit
	10min	13.56028334	13.56	0.00208946	0.01	Within limit
10	Startup	13.56034218	13.56	0.00252335	0.01	Within limit
	2min	13.56033955	13.56	0.00250396	0.01	Within limit
	5min	13.56033786	13.56	0.00249152	0.01	Within limit
	10min	13.56033723	13.56	0.00248685	0.01	Within limit
0	Startup	13.56031541	13.56	0.00232596	0.01	Within limit
	2min	13.56033965	13.56	0.00250472	0.01	Within limit
	5min	13.56033977	13.56	0.00250562	0.01	Within limit
	10min	13.56033981	13.56	0.00250588	0.01	Within limit
-10	Startup	13.56032442	13.56	0.00239244	0.01	Within limit
	2min	13.56032552	13.56	0.00240053	0.01	Within limit
	5min	13.56032648	13.56	0.00240763	0.01	Within limit
	10min	13.56032812	13.56	0.00241972	0.01	Within limit
-20	Startup	13.56032906	13.56	0.00242663	0.01	Within limit
	2min	13.56032551	13.56	0.00240047	0.01	Within limit
	5min	13.56030816	13.56	0.0022725	0.01	Within limit
	10min	13.56030371	13.56	0.00223966	0.01	Within limit

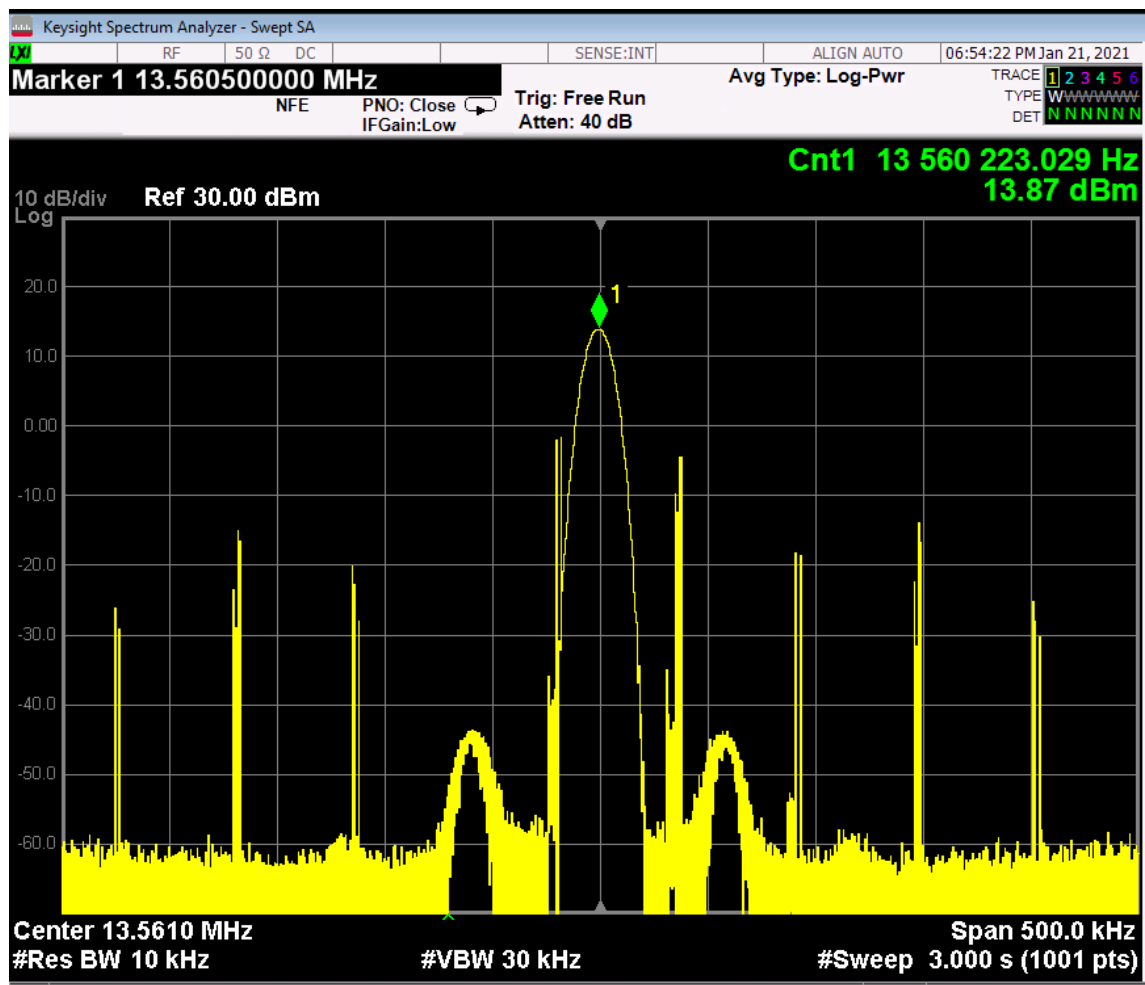


Figure 14: Example measurement of frequency stability

Section 8 20dB Bandwidth Results

8.1.1 Limits

FCC Rule Part	Test Standard	Requirement
Section 15.215(C)	ANSI C63.10:2013	20dB bandwidth must remain within assigned frequency band

8.1.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average
Centre Frequency	13.56MHz
Stop Frequency	4MHz
Resolution Bandwidth	24kHz
Video Bandwidth	75KHz

8.1.3 20dB Bandwidth

8.1.4 Date of Test

19th January 2021

8.1.5 Test Area

LAB 5

8.1.6 Tested by

M Render

8.1.7 20dB Bandwidth Results

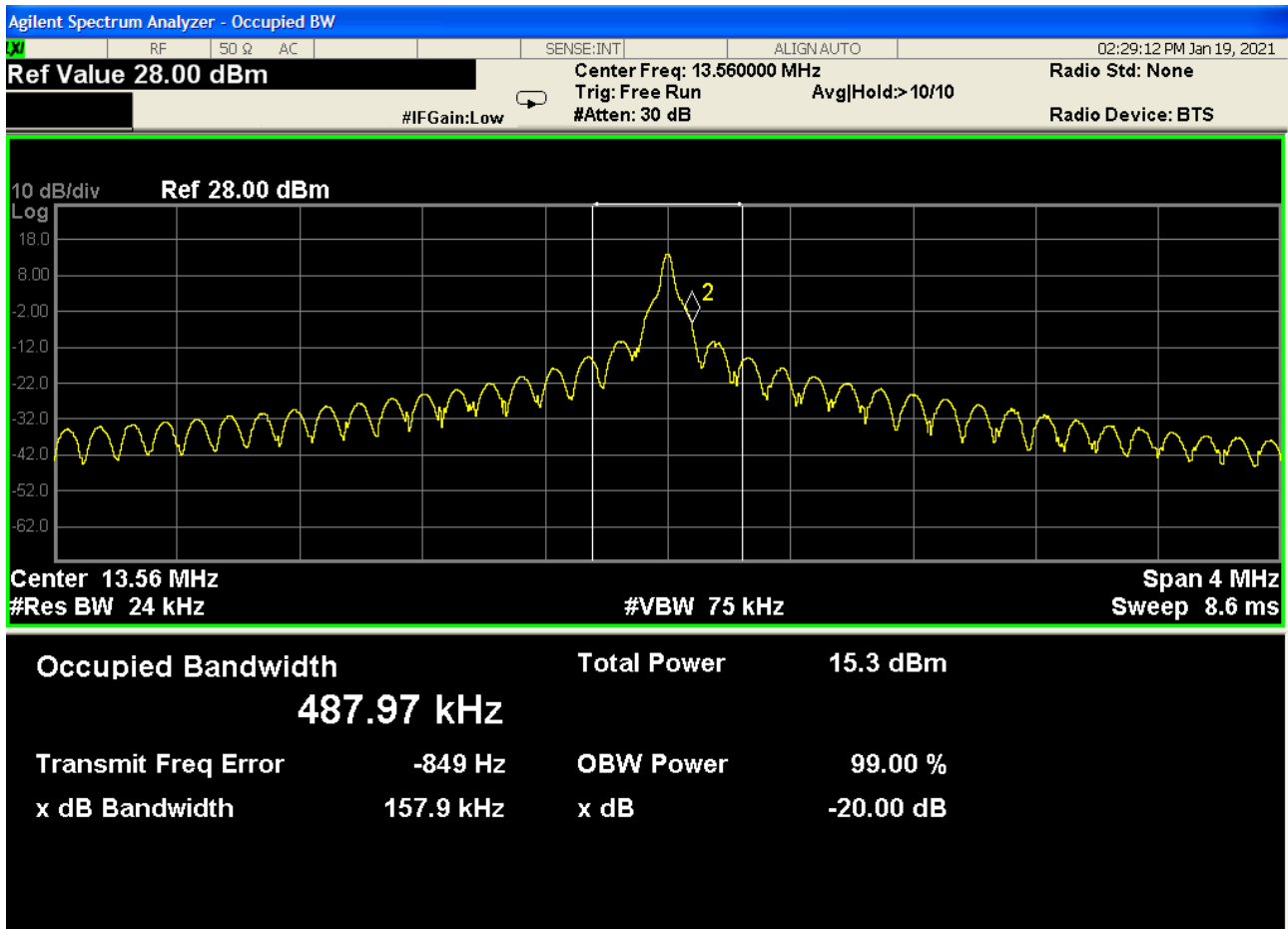


Figure 15: 20dB Bandwidth Measurement

Note: The whole of the emission is below the limit for general radiated emissions of 47CFR15.209 as shown by figures 7 and 8 and contained within the band 13.110-14.010 MHz

Appendix A EUT Test Photos

Photographs are supplied separately.

Appendix B Test Equipment List

Radiated Emissions Equipment

Item	Serial No.	Last Calibration Date	Calibration Interval
Laboratory 1 Semi-Anechoic Chamber	Lab 1	04/11/2019 (NSA) 28/01/2020 (Svswr)	36 Months
ETS Lindgren 2017B Mast (1 – 4m) with tilting mechanism	--	N/A	N/A
Laboratory 5 fully anechoic chamber for 9kHz to 30MHz	-	N/A	N/A
EMCO Loop antenna 6512	00148043	2/06/2020	24 Months
Rohde & Schwarz ESR 26	101464	10/11/2020	12 Months
Rohde & Schwarz ESR 7	101930	26/01/2021	12 Months
Teseq CBL6112D Bilog Antenna	49040	15/08/2018	36 Months
6dB Attenuator (For use with Bilog Antenna)	C0506B	15/08/2018	36 Months
HF 26 Cable	19148_06_13_001	5/01/2021	12 Months
HF 27 Cable	19149.03.13.004	5/01/2021	12 Months
HF17 Cable	167002-001	5/01/2021	12 Months
Keysight PXA EMI Receiver	MY54170531	03/04/20	20 Months