

Report on the Radio Testing
For
DOT Origin Ltd.
on
VTAP100
Report no. TRA-051169-45-00A
21st October 2021

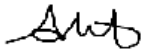
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Report Number: TRA-051169-45-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
DOT Origin Ltd.
VTAP100
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 2021-09-14 to 2021-09-17

Tested by: 

A Tosif
Radio Test Engineer

Approved by:

D Winstanley
Radio Senior Test Engineer

Date: 21st October 2021

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	21st October 2021	Original

2 Summary

TEST REPORT NUMBER:	TRA-051169-45-00A
WORKS ORDER NUMBER:	TRA-051169-01
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION(S):	47CFR15.225
EQUIPMENT UNDER TEST (EUT):	VTAP100
FCC IDENTIFIER:	2A282-VTAP100
EUT SERIAL NUMBER:	SQ100042 / 40059
MANUFACTURER/AGENT:	DOT Origin Ltd.
ADDRESS:	Unit 7 Coopers Place Combe Lane Wormley GU8 5SZ United Kingdom
CLIENT CONTACT:	Dan Isaaman ☎ 44 (0) 7785 265 265 ✉ dan.isaaman@dotorigin.com
ORDER NUMBER:	P1956
TEST DATE:	2021-09-14 to 2021-09-17
TESTED BY:	A Tosif Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause, 47CFR15</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Field strength of fundamental	15.225 (a)	<input checked="" type="checkbox"/>	PASS
Radiated spurious emissions	15.225 (b), (c) & (d)	<input checked="" type="checkbox"/>	PASS
Frequency stability	15.225 (e)	<input checked="" type="checkbox"/>	PASS
Occupied bandwidth	15.215 (c)	<input checked="" type="checkbox"/>	PASS
AC power line conducted emissions	15.207	<input checked="" type="checkbox"/>	PASS

Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-051169-45-00A presents the results of the Radio testing on a DOT Origin Ltd., VTAP100 to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for DOT Origin Ltd. by Element, at the address detailed below.

<input checked="" type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

FCC Site Listing:

The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Hull UK2007
Element Skelmersdale UK2020

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada (nowISED)
ISED	Innovation, Science and Economic Development Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: VTAP100
- Serial Number: SQ100042 / 40059
- Model Number: N/A
- Software Revision: v1.1.0.6
- Build Level / Revision Number: production

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Apple A1399 USB Mains Adaptor

7.3 EUT Mode of Operation

The EUT was transmitting continuously with and without modulation, as required.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Nominal supply voltage:	5 Vdc
Antenna type:	Integral

7.5 EUT Description

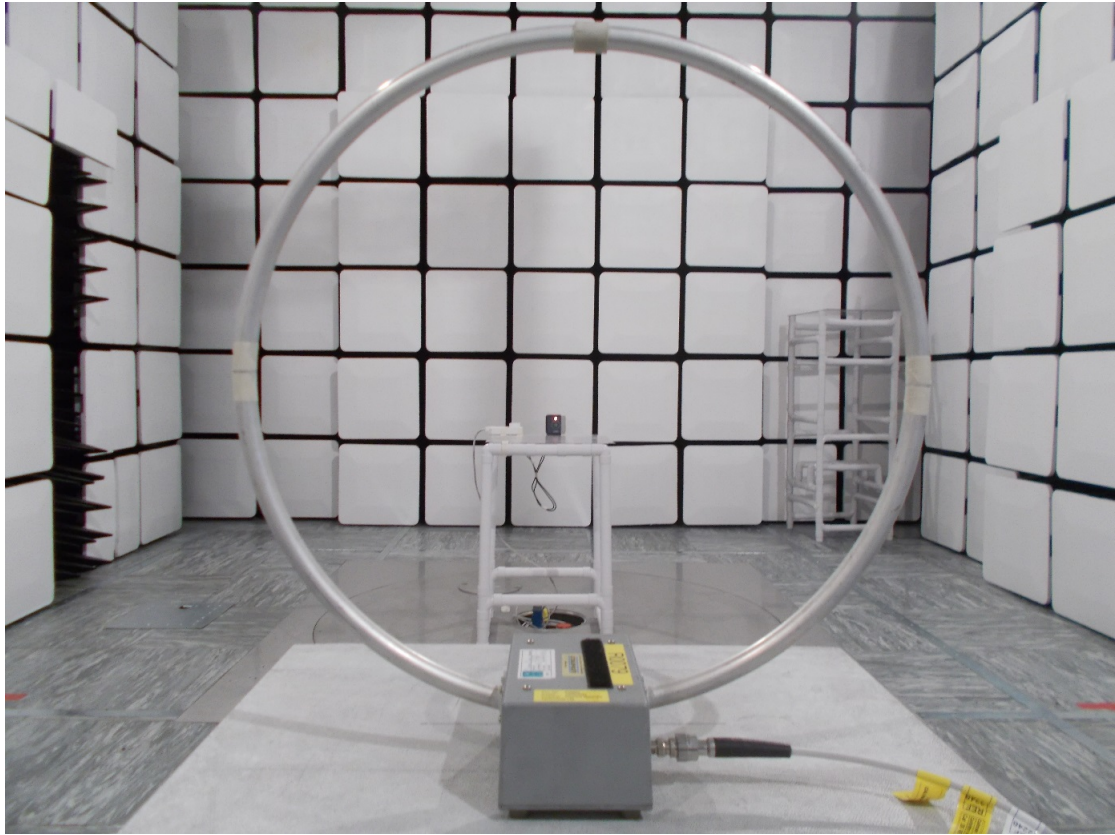
The EUT is a mobile wallet reader designed to enable iPhone and Android based passes to be read via NFC and transferred to other systems.

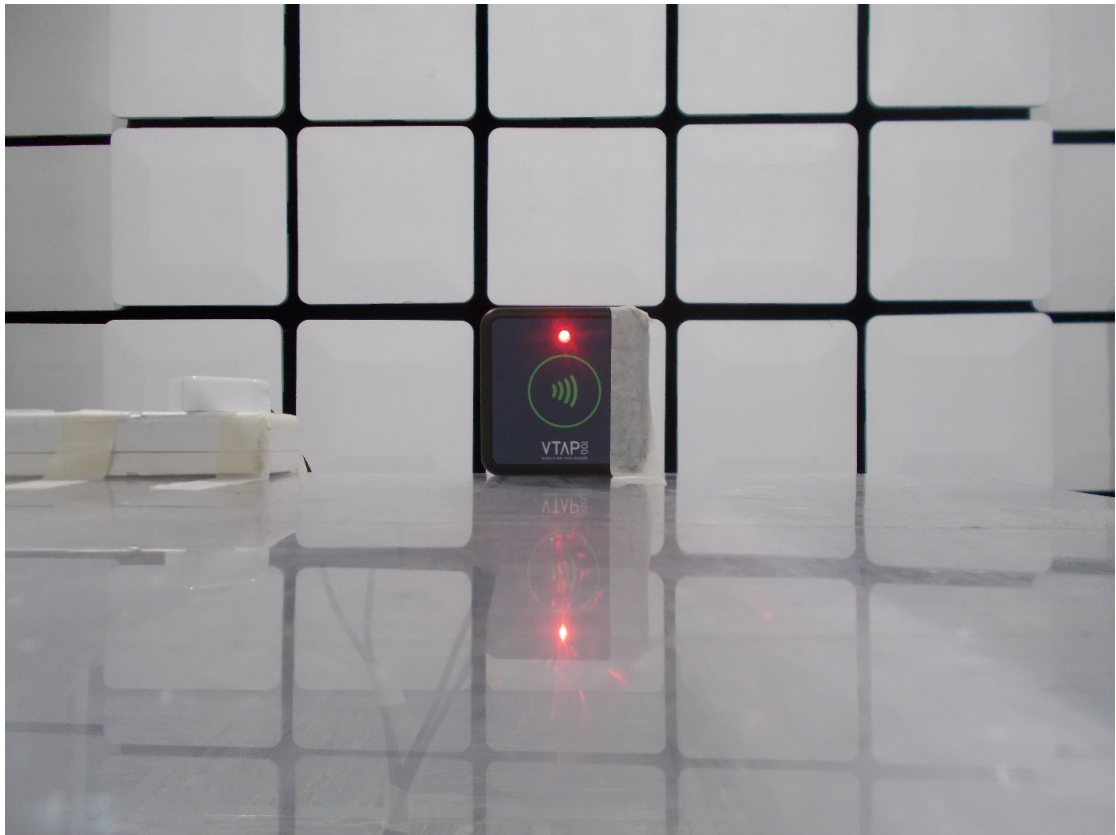
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup Photographs

The following photographs show basic EUT radiated set-up:





10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 5 Vdc from the USB adaptor.

10.2 Varying Test Conditions

Variation of temperature is required to ensure stability of the declared fundamental frequency. During frequency error testing the following variations were made:

	Nominal	Variation
☒	20 °C	-20 °C to +50 °C in 10 degree steps

Variation of supply voltage is required to ensure stability of the declared output power and frequency. During carrier power and frequency error testing the following variations were made:

	Nominal	Variation
☒	5 Vdc	4.25 Vdc and 5.75 Vdc

11 Transmitter output power (fundamental radiated emission)

11.1 Definition

The RF power dissipated in the standard output termination when operating under the rated duty cycle selected by the applicant for approval.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Antenna:	Active loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)

11.3 Test Limit

The field strength measured at 30 m shall not exceed the limits in the following table:

Field Strength Limits for License-Exempt Transmitters for Any Application

<i>Frequency range (MHz)</i>	<i>Field strength (μV/m at 30 m)</i>	<i>Field strength (dBμV/m at 30 m)</i>
13.110 – 13.410	106	40.5
13.410 – 13.553	334	50.5
13.553 – 13.567	15,848	84.0
13.567 – 13.710	334	50.5
13.710 – 14.010	106	40.5

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in $\mu\text{V/m}$ at the regulatory distance, using:

$$FS = 10^{(PR - CF) / 20}$$

Where,

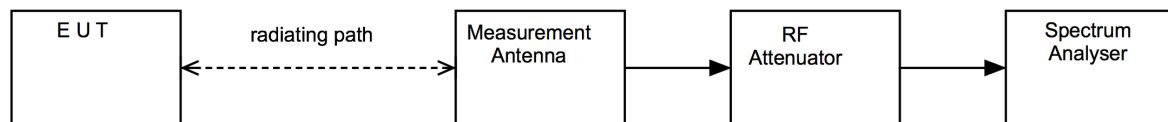
PR is the power recorded on the receiver / spectrum analyzer in $\text{dB}\mu\text{V}$ and includes any cable loss, antenna factor and pre-amplifier gain;

CF is the distance extrapolation factor in dB (where measurement distance different to limit distance);

Per FCC 47CFR15.31(f)(2), an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

This field strength value is then compared with the regulatory limit.

Figure v Test Setup

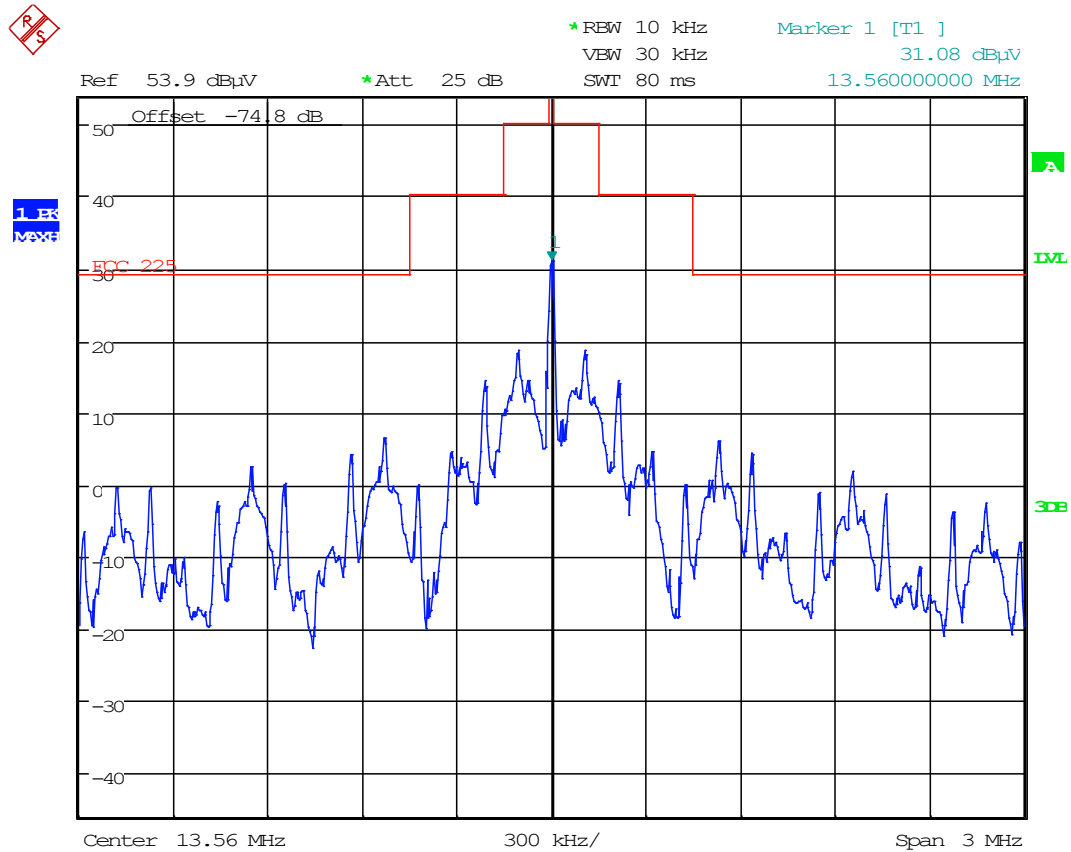


11.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Ferrite Lined Chamber	Rainford	-	REF2259	2022-08-03
Spectrum Analyser	R&S	FSU50	U544	2022-06-22
Active Loop Antenna	EMCO	6502	R0079	2023-06-16
Multimeter	Agilent	34405A	REF887	2021-10-12
Power Supply	Farnell	LT30-2	RFG035	Cal with REF887
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

11.6 Test Results

Frequency (MHz)	Receiver Level (dBμV/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Result
13.56	71.1	3.0	30.0	40.0	31.1	35.9	PASS



12 Radiated emissions below 30 MHz

12.1 Definitions

Out-of-band emissions

Emissions on a frequency or frequencies immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

Spurious emissions

Emissions on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Antenna:	Active loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	9 kHz to 150 kHz: 200 Hz; 150 kHz to 30 MHz: 9 kHz
Measurement Detector:	9 kHz to 90 kHz and 110 kHz to 490 kHz: Average, RMS Other frequencies below 30 MHz: Quasi-peak.

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

Emissions from license-exempt transmitters shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

**General Field Strength Limits for License-Exempt Transmitters
at Frequencies below 30 MHz**

<i>Frequency, f (kHz)</i>	<i>Field Strength (μV/m)</i>	<i>Measurement Distance (m)</i>
9 to 490	2,400 / f	300
490 to 1,750	24,000 / f	30
1,750 to 30,000	30	30

n.b. Devices operated pursuant to §15.225 are exempt from complying with the restricted band requirements for the 13.36 – 13.41 MHz band only.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the EUT fundamental frequency was maximised by rotating the EUT through 360°, in three orthogonal planes, and adjusting the measurement antenna azimuth.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 9 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 9 kHz and 30 MHz are measured using a calibrated 60cm active loop antenna. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in $\mu\text{V/m}$ at the regulatory distance, using:

$$FS = 10^{(PR - CF) / 20}$$

Where,

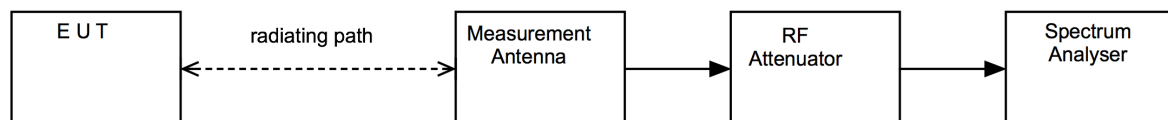
PR is the power recorded on the receiver / spectrum analyzer in dB μV and includes any cable loss, antenna factor and pre-amplifier gain;

CF is the distance extrapolation factor in dB (where measurement distance different to limit distance);

Per FCC 47CFR15.31(f)(2), an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



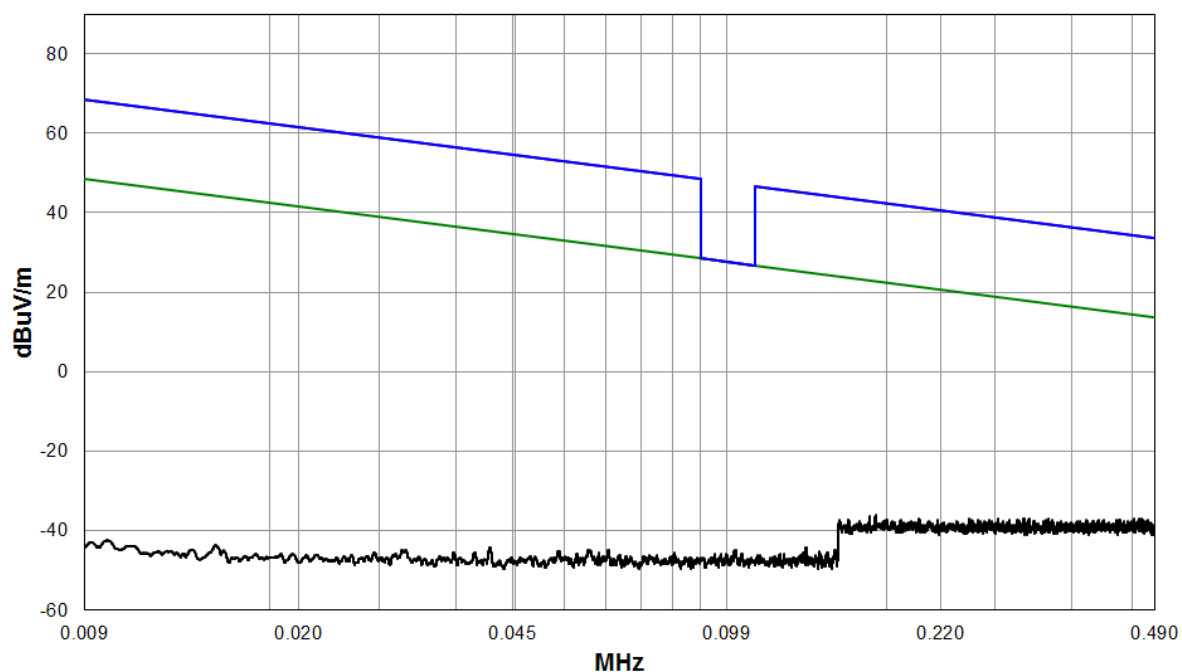
12.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Ferrite Lined Chamber	Rainford	-	REF2259	2022-08-03
Spectrum Analyser	R&S	FSU50	U544	2022-06-22
Active Loop Antenna	EMCO	6502	R0079	2023-06-16

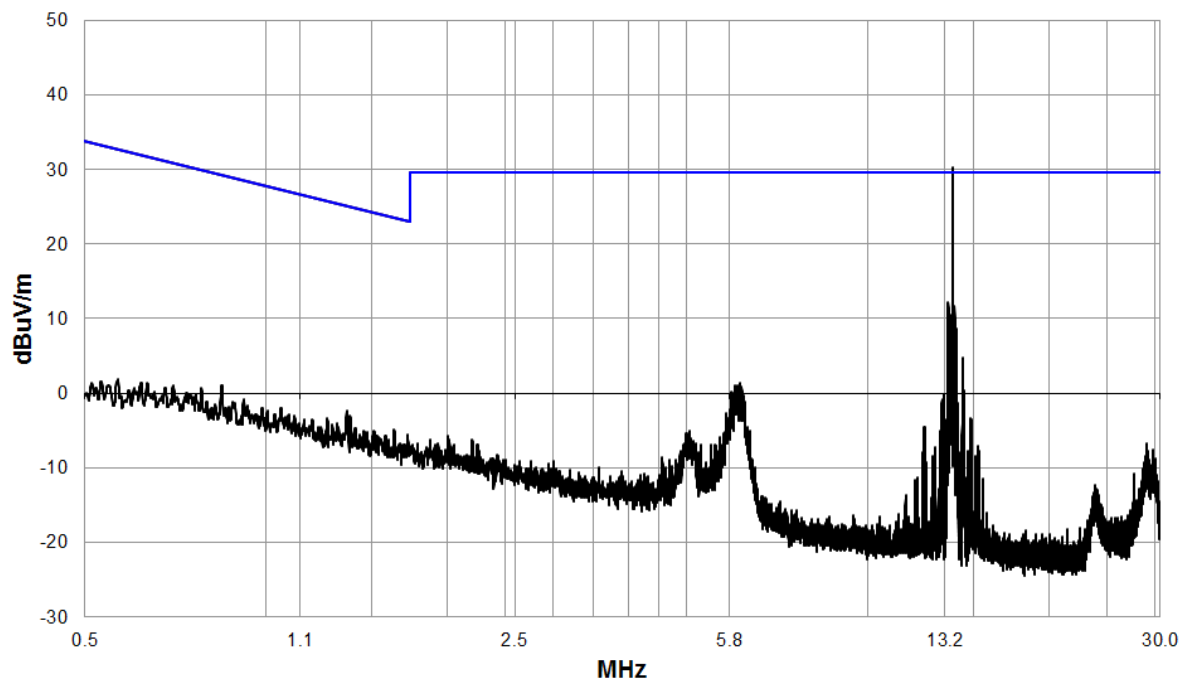
12.6 Test Results

Emission Frequency (MHz)	Receiver Level (dB μ V/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (μ V/m)	Result
No emissions were detected within 20 dB of the limit						

9 kHz – 490 kHz



490 kHz – 30 MHz



13 Radiated emissions

13.1 Definitions

Out-of-band emissions

Emissions on a frequency or frequencies immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

Spurious emissions

Emissions on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

Emissions from license-exempt transmitters shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

**General Field Strength Limits for License-Exempt Transmitters
at Frequencies above 30 MHz**

Frequency (MHz)	Field Strength (μV/m at 3 m)	Field Strength (dBμV/m at 3 m)
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure ii, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where

applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBμV/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

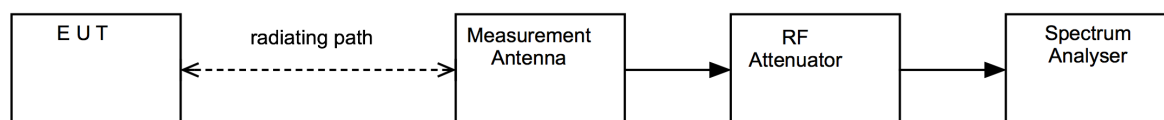
$$\text{Factors} = CL + AF - PA$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBμV;
 CL is the cable loss in dB;
 AF is the test antenna factor in dB/m;
 PA is the pre-amplifier gain in dB (where used);
 DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
 CF is the distance factor in dB (where measurement distance is different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure ii Test Setup



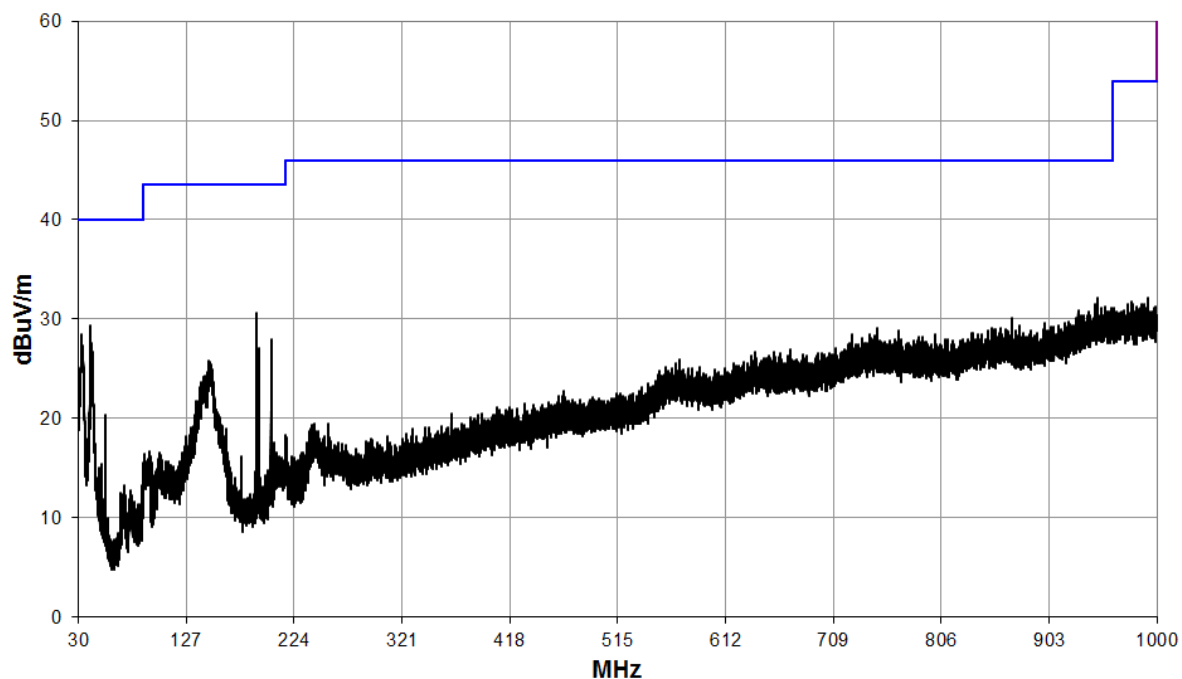
13.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Ferrite Lined Chamber	Rainford	-	REF2259	2022-08-03
Spectrum Analyser	R&S	FSU50	U544	2022-06-22
Bilog Antenna	Chase	CBL6111B	REF2218	2021-10-23
Pre-Amp (9 kHz - 1 GHz)	Sonoma	310	REF927	2022-07-15
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

13.6 Test Results

Detector	Frequency (MHz)	Measured Emission (dB μ V)	Factors (dB)	Field Strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
Quasi-Peak	33.0	33.9	-9.0	24.9	40.0	-15.1	PASS
Quasi-Peak	40.7	40.6	-12.6	28.0	40.0	-12.0	PASS
Quasi-Peak	189.9	45.3	-15.4	29.9	43.5	-13.6	PASS
Quasi-Peak	203.4	41.4	-15.1	26.3	43.5	-17.2	PASS

30 MHz – 1000 MHz



14 Frequency stability

14.1 Definition

Frequency stability is a measure of frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
EUT Frequency Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 °C to +50 °C
Voltage Extreme Environment Test Range:	4.25 Vdc to 5.75 Vdc

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

Carrier frequency stability shall be maintained to $\pm 0.01\%$ (± 100 ppm).

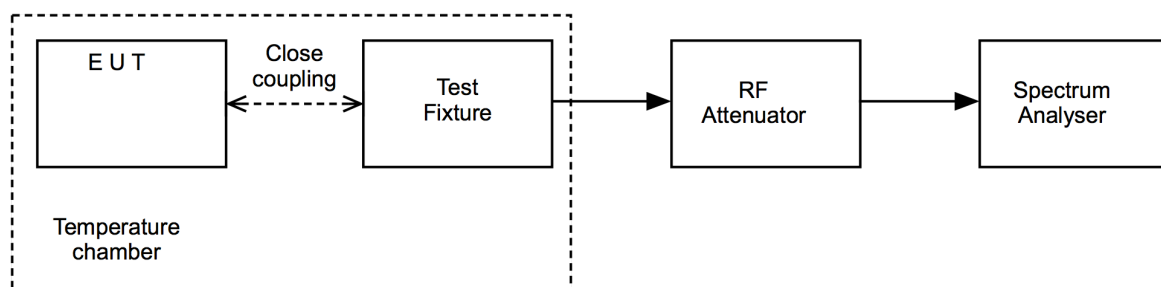
14.4 Test Method

With the EUT setup connected as per Figure v, the frequency was measured under varying conditions of temperature and supply voltage.

Measurements were made once temperature stability was achieved at each temperature.

Per ANSI C63.4, measurements were made, once temperature stabilisation was reached at intervals of zero, two, five and ten minutes after switching on the EUT. Only the worst case results are given.

Figure v Test Setup



14.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	2022-06-22
Thermometer	Fluke	53 II B	REF2110	2022-08-31
Multimeter	Agilent	34405A	REF887	2021-10-12
Temperature Chamber	JTS	ETC/JTS/2/01	RFG365	Cal with REF2110
Power Supply	Farnell	LT30-2	RFG035	Cal with REF887

14.6 Test Results

Test Environment		Measured Frequency (MHz)	Frequency error (kHz)	Frequency error (%)	Result
-20 C	V _{nominal}	13.560755	0.074	0.000546	PASS
-10 C	V _{nominal}	13.560757	0.076	0.000560	PASS
0 C	V _{nominal}	13.560758	0.077	0.000568	PASS
+10 C	V _{nominal}	13.560761	0.080	0.000590	PASS
+20 C	V _{minimum}	13.560679	-0.002	-0.000015	PASS
	V _{nominal}	13.560681	0.000	0.000000	PASS
	V _{maximum}	13.560679	-0.002	-0.000015	PASS
+30 C	V _{nominal}	13.560677	-0.004	-0.000029	PASS
+40 C	V _{nominal}	13.560680	-0.001	-0.000007	PASS
+50 C	V _{nominal}	13.560699	0.018	0.000133	PASS

15 Occupied Bandwidth

15.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 55 % RH	20 % RH to 75 % RH (as declared)

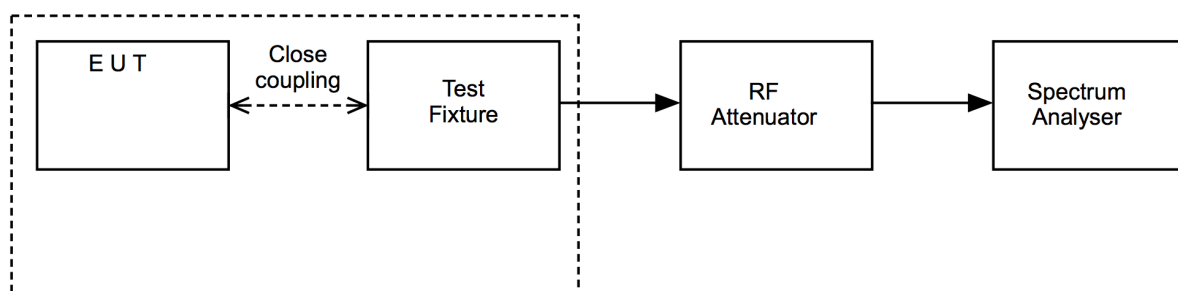
15.3 Test Limit

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated.

15.4 Test Method

With the EUT connected as per Figure iv, the bandwidth of the EUT was measured on a spectrum analyser.

Figure iv Test Setup

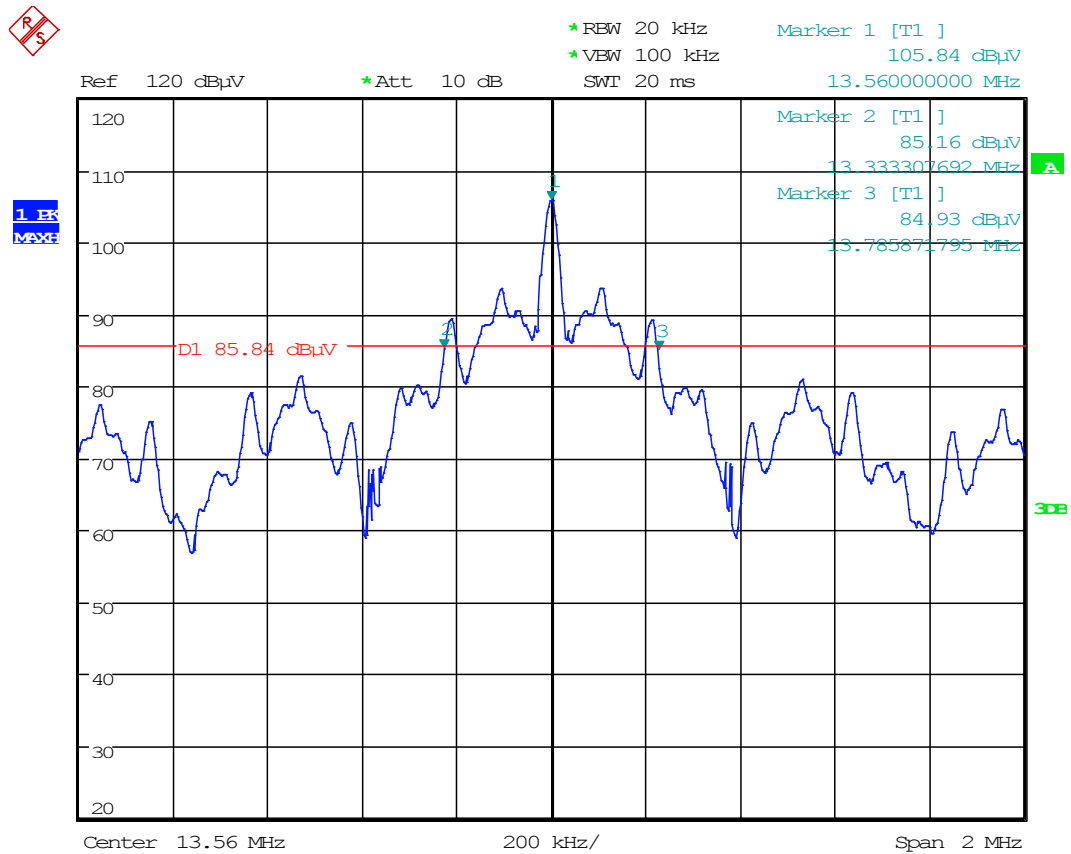


15.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU50	U544	2022-06-22

15.6 Test Results

20 dB Bandwidth			
Frequency (MHz)	F_L (MHz)	F_H (MHz)	Bandwidth (kHz)
13.56	13.333308	13.785872	452.564



16 AC power-line conducted emissions

16.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Screen Room 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 56 % RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

<i>Frequency (MHz)</i>	<i>Conducted limit (dBμV)</i>	
	<i>Quasi-Peak</i>	<i>Average**</i>
0.15 to 0.5	66 to 56 [*]	56 to 46 [*]
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

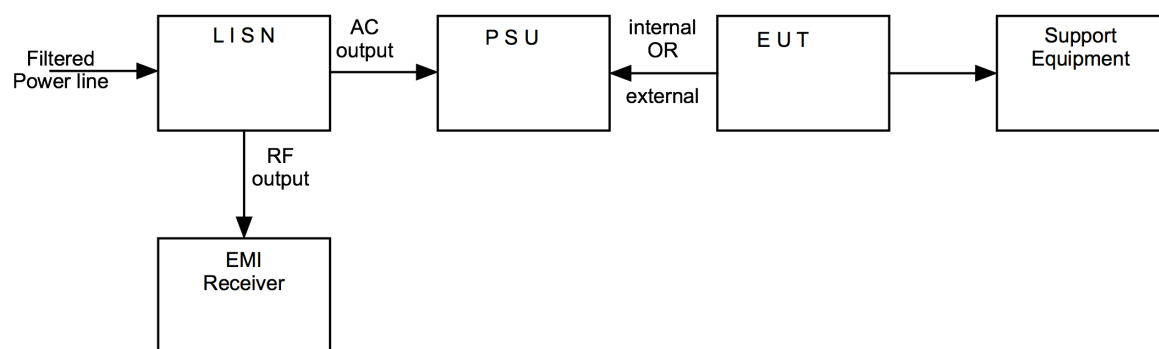
16.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure iii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure iii Test Setup



16.5 Test Set-up Photograph



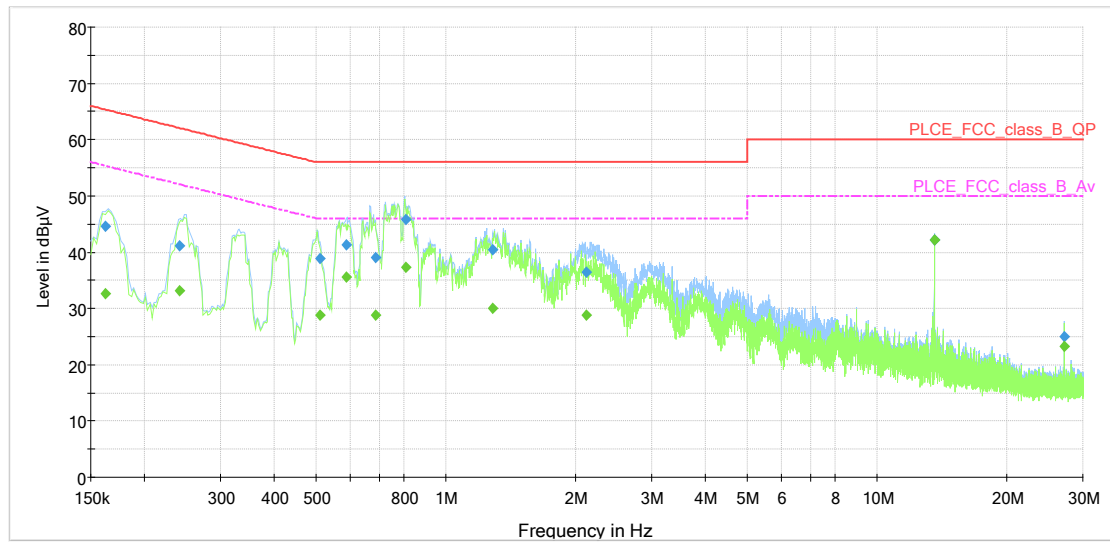
16.6 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Measuring Receiver	R&S	ESC17	RFG715	2022-03-29
Pulse Limiter	R&S	ESH3-Z2	RFG674	2022-05-04
LISN	R&S	ESH3-Z5	RFG732	2022-05-18

16.7 Test Results

<i>Results measured using the quasi-peak detector</i>						
<i>Reference Number</i>	<i>Frequency (MHz)</i>	<i>Conductor</i>	<i>Result (dBUV)</i>	<i>Specification Limit (dBUV)</i>	<i>Margin (dB)</i>	<i>Result Summary</i>
1	0.162	L1	44.6	65.4	20.8	PASS
2	0.241	L1	41.1	62.1	21.0	PASS
3	0.511	L1	38.9	56.0	17.1	PASS
4	0.587	L1	41.3	56.0	14.7	PASS
5	0.688	N	39.1	56.0	16.9	PASS
6	0.806	L1	45.7	56.0	10.3	PASS
7	1.280	L1	40.4	56.0	15.6	PASS
8	2.116	L1	36.5	56.0	19.5	PASS
9	13.562	N	42.1	60.0	17.9	PASS
10	27.120	N	25.0	60.0	35.0	PASS

<i>Results measured using the average detector</i>						
<i>Reference Number</i>	<i>Frequency (MHz)</i>	<i>Conductor</i>	<i>Result (dBUV)</i>	<i>Specification Limit (dBUV)</i>	<i>Margin (dB)</i>	<i>Result Summary</i>
1	0.162	L1	32.6	55.4	22.8	PASS
2	0.241	L1	33.2	52.1	18.9	PASS
3	0.511	L1	28.8	46.0	17.2	PASS
4	0.587	L1	35.7	46.0	10.3	PASS
5	0.688	N	28.8	46.0	17.2	PASS
6	0.806	L1	37.3	46.0	8.7	PASS
7	1.280	L1	30.1	46.0	15.9	PASS
8	2.116	L1	28.8	46.0	17.2	PASS
9	13.562	N	42.2	50.0	7.8	PASS
10	27.120	N	23.2	50.0	26.8	PASS



17 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Reference No.	Parameter	Description	Value	Unit
1	Adjacent Channel Power	Uncertainty in test result	1.86	dB
2	Carrier Power	Uncertainty in test result (Power Meter)	0.070	dB
		Uncertainty in test result (Spectrum Analyser)	3.11	
3	Effective Radiated Power	Uncertainty in test result	4.71	dB
4	Radiated Spurious Emissions	Uncertainty in test result 30 MHz to 1 GHz	4.75	dB
		1 GHz to 18 GHz	4.46	
5	Maximum Frequency Error	Uncertainty in test result (CMTA)	113.441	Hz
6	Radiated Emissions, Field Strength OATS 9 kHz – 110 GHz Electric Field	Uncertainty in test result (9 kHz – 30 MHz)	2.3	dB
		Uncertainty in test result (30 MHz – 1 GHz)	4.75	
		Uncertainty in test result (1 GHz – 18 GHz)	4.46	
		Uncertainty in test result (18 GHz – 26 GHz)	3.2	
		Uncertainty in test result (26 GHz – 40 GHz)	3.3	
		Uncertainty in test result (40 GHz – 50 GHz)	3.5	
		Uncertainty in test result (50 GHz – 75 GHz)	3.6	
		Uncertainty in test result (75 GHz – 110 GHz)	3.6	
7	Frequency Deviation	Uncertainty in test result	3.7	%
8	Magnetic Field Emissions	Uncertainty in test result	2.3	dB
9	Conducted Spurious	Uncertainty in test result Up to 26 GHz	0.921	dB
10	Channel Bandwidth	Uncertainty in test result	15.71	%

Reference No.	Parameter	Description	Value	Unit
11	Spectrum Mask Measurements	Uncertainty in test result (frequency)	2.59	%
		Uncertainty in test result (amplitude)	1.32	dB
12	Adjacent Sub Band Selectivity	Uncertainty in test result	1.24	dB
13	Receiver Blocking – Listen Mode, Radiated	Uncertainty in test result	3.23	dB
14	Receiver Blocking – Talk Mode, Radiated	Uncertainty in test result	3.36	dB
15	Receiver Blocking – Talk Mode, Conducted	Uncertainty in test result	1.24	dB
16	Receiver Threshold	Uncertainty in test result	3.42	dB
17	Transmission Time Measurement	Uncertainty in test result	4.40	%