

Report on the Radio Testing
For
Research Instruments Limited
on
Sperm Preparation Reader
Report no. TRA-056643-45-02B
22nd July 2024

Report Number: TRA-056643-45-02B
Issue: B

REPORT ON THE RADIO TESTING OF A
Research Instruments Limited
Sperm Preparation Reader
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 2022-02-03 to 2022-03-02

Tested by: A Longley & I Broadwell

Written by: 

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Date: 22nd July 2024

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	29th March 2022	Original
B	22nd July 2024	Updated FCC ID Added antenna details

2 Summary

TEST REPORT NUMBER: TRA-056643-45-02B

WORKS ORDER NUMBER: TRA-056643-01

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: 47CFR15.225

EQUIPMENT UNDER TEST (EUT): Sperm Preparation Reader

FCC IDENTIFIER: 2ACOO-670854V9

EUT SERIAL NUMBER: 01033

MANUFACTURER/AGENT: Research Instruments Limited

ADDRESS: Bickland Ind. Park
Falmouth
Cornwall
TR11 4TA
United Kingdom

CLIENT CONTACT: Tim Stanhope
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ORDER NUMBER: PO112430

TEST DATE: 2022-02-03 to 2022-03-02

TESTED BY: A Longley & I Broadwell
Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated spurious emissions, below 30 MHz	15.225(d)	☒	PASS
Radiated spurious emissions	15.209	☒	PASS
AC power line conducted emissions	15.207	☒	PASS
Occupied bandwidth	15.215(c)	☒	PASS
Field strength of fundamental	15.225(a), (b) and (c)	☒	PASS
Frequency stability	15.225(e)	☒	PASS

General 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-056643-45-02B presents the results of the Radio testing on a Research Instruments Limited, Sperm Preparation Reader to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Research Instruments Limited 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 following US-UK MRA, Designation numbers.

Element Hull	UK2007
Element Skelmersdale	UK2020

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

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.
- KDB 174176 D01 Line Conducted FAQ v01r01 - AC Power-Line Conducted Emissions Frequently Asked Questions

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 (now ISED)
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: Sperm Preparation Reader
- Serial Number: 01033
- Model Number: 6-70-854
- Software Revision: Firmware Version 1.01
- 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.

PC connected to the EUT.

7.3 EUT Mode of Operation

The EUT was transmitting at 13.56 MHz.

7.4 EUT Radio Parameters

Frequency of operation:	13.56 MHz
3 Loop antennas, part numbers:	6-70-809
Nominal supply voltage:	120 Vac
EUT Modulation and Duty:	81% ASK

7.5 Antenna Details

Antenna Type:	Loop Antenna
Left/Right Shoulder Antenna dimensions:	125 X 126 mm
Rear Antenna dimensions:	192 X 109 mm
Base Antenna dimensions:	210 X 150 mm
Turns:	3

7.6 EUT Description

The EUT is a Sperm Prep Reader with a 13.56 MHz RFID reader. The sperm preparation reader includes 3 loop antennas which are part of the device construction

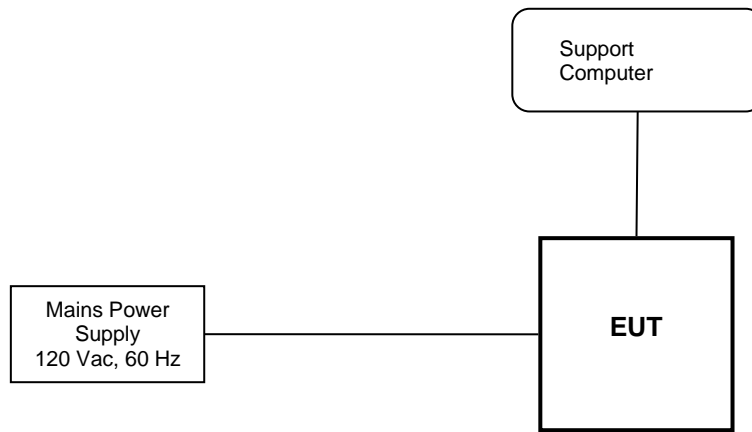
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

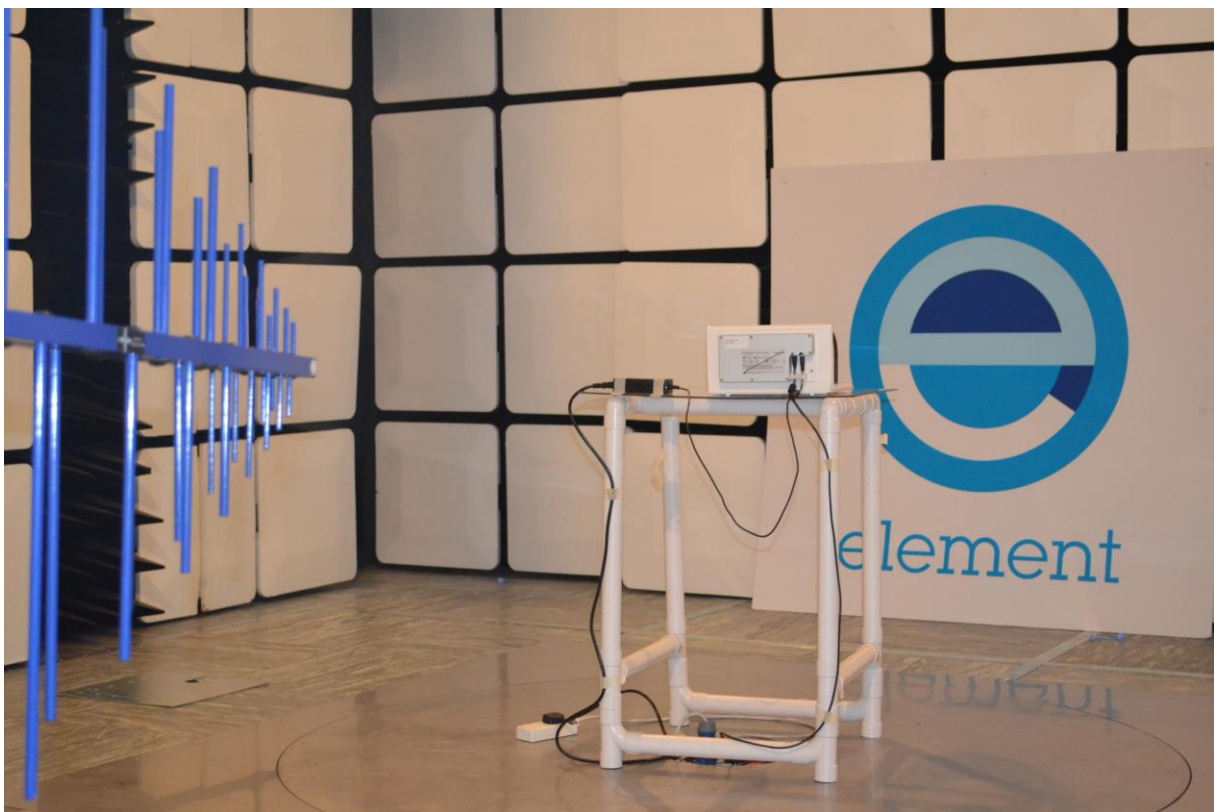
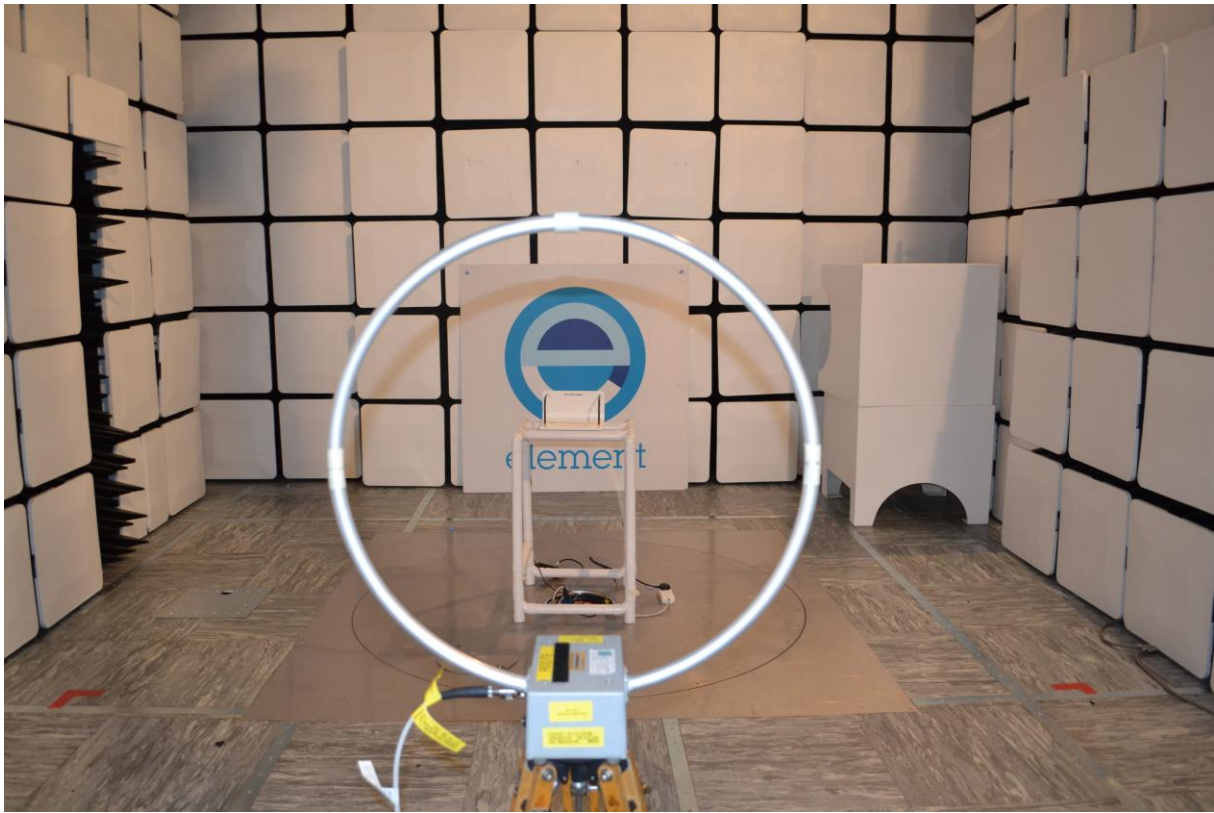
9.1 Block Diagram

The following diagram shows basic EUT interconnections:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9.3 Measurement software

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5 (See Note)

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

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 120 Vac, 60 Hz, from the mains.

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:

	Category	Variation
<input checked="" type="checkbox"/>	Standard	-20 to +50 C in 10 degree steps
<input type="checkbox"/>	Extended	N/A

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:

	Category	Nominal	Variation
<input checked="" type="checkbox"/>	Mains	120 Vac +/-2 %	85 % and 115 %
<input type="checkbox"/>	Battery	New battery	N/A

11 Radiated emissions below 30 MHz

11.1 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.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
EUT Height:	0.8 m
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: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	120 V ac \pm 10 % (as declared)

11.3 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</i>	<i>Measurement Distance (m)</i>
9 to 490	$2,400 / f$ (μ V/m)	300
490 to 1,750	$24,000 / f$ (μ V/m)	30
1,750 to 30,000	30 (μ V/m)	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.

11.4 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 $\mu\text{V}/\text{m}$ at the regulatory distance, using:

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

Where,

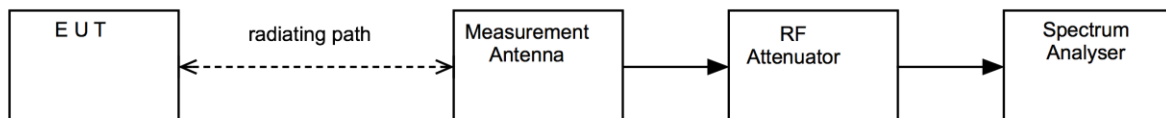
PR is the power recorded on the receiver / spectrum analyzer in $\text{dB}\mu\text{V}$ and includes any cable loss, antenna factor and pre-amplifier gain;

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 i Test Setup



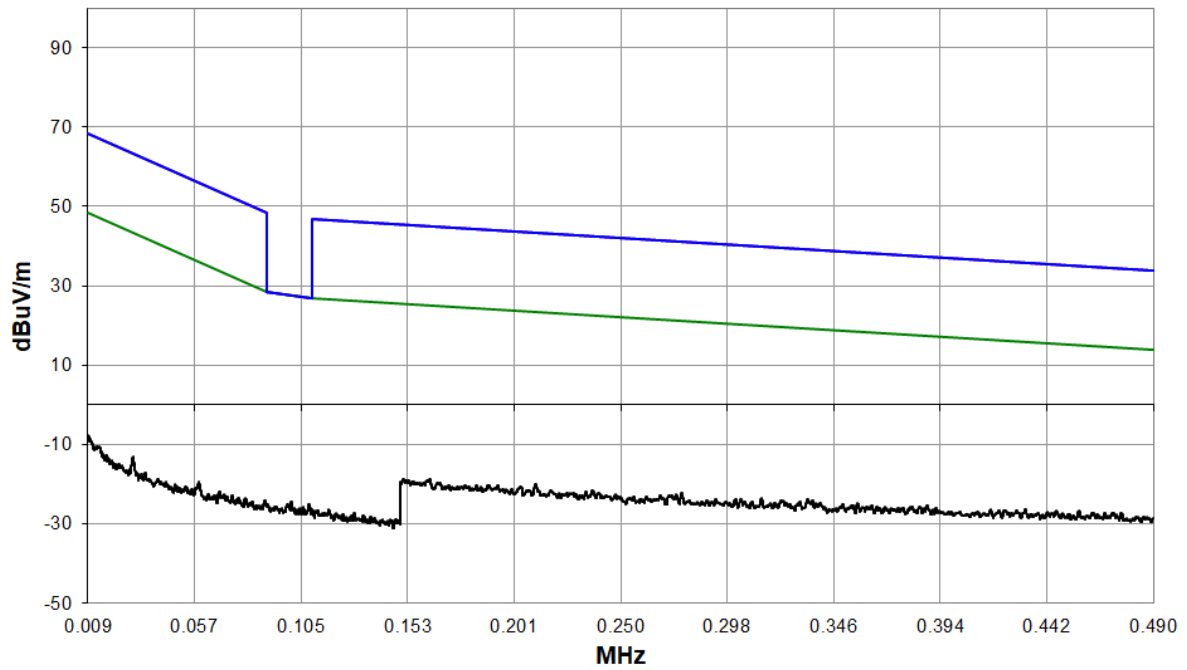
11.5 Test Equipment

<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
EMI Test Receiver	R&S	ESW26	REF2235	2022-10-05
Active Loop Antenna	EMCO	6502	R0079	2023-06-16
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

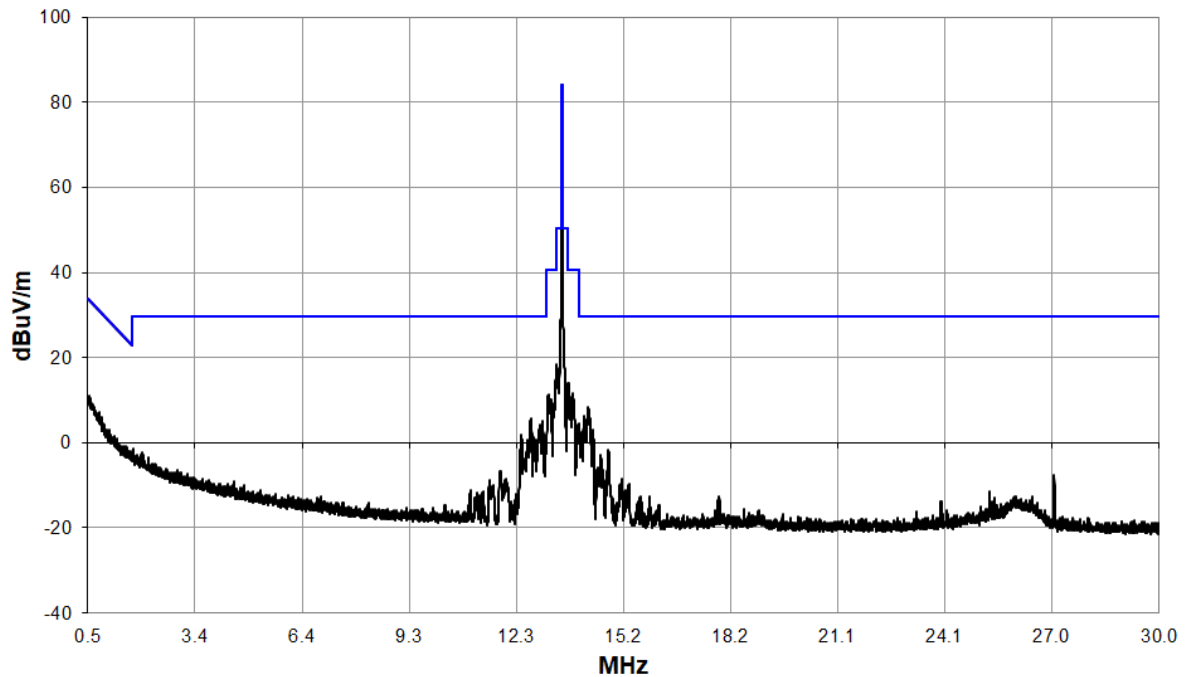
11.6 Test Results

13.56 MHz RFID active reading						
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 limit.						

9 kHz – 490 kHz



490 kHz – 30 MHz



12 Radiated emissions

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 Standard and Clause:	ANSI C63.10-2013, Clause 6.5
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1000 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	120 Vac ±10 % (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 above 30 MHz

<i>Frequency (MHz)</i>	<i>Field Strength (μV/m at 3 m)</i>
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

12.4 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 dB μ V/m at the regulatory distance, using:

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

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

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB μ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

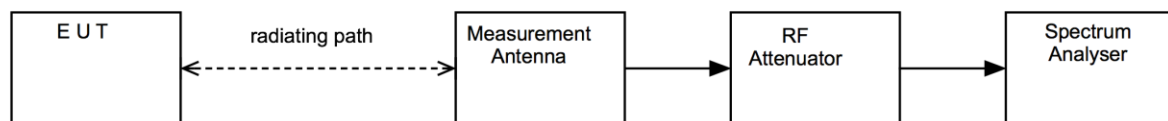
PA is the pre-amplifier gain in dB (where used);

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



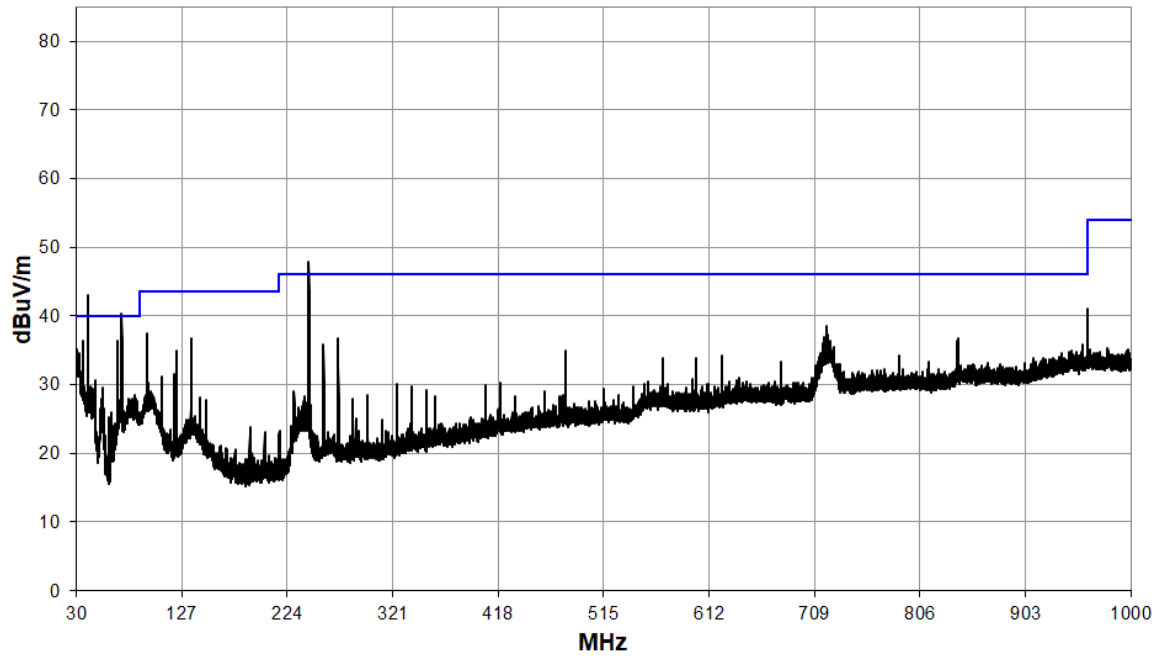
12.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
ESW26	R&S	EMI Test Receiver	REF2235	2022-10-05
-	Rainford	Ferrite Lined Chamber	REF2259	2022-08-03
CBL6111B	Chase	Bilog Antenna	REF2233	2022-09-15
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

12.6 Test Results

<i>Detector</i>	<i>Frequency (MHz)</i>	<i>Measured Emission (dBμV)</i>	<i>Factors (dB)</i>	<i>Field Strength (dBμV/m)</i>	<i>Field Strength (μV/m)</i>	<i>Limit (μV/m)</i>	<i>Result</i>
Quasi-Peak	30.1	-1.3	26.7	25.4	18.6	100.0	PASS
Quasi-Peak	33.4	0.4	24.0	24.4	16.6	100.0	PASS
Quasi-Peak	36.0	10.2	22.8	33.0	44.7	100.0	PASS
Quasi-Peak	40.7	19.8	20.1	39.9	98.9	100.0	PASS
Quasi-Peak	45.0	2.5	17.6	20.1	10.1	100.0	PASS
Quasi-Peak	48.0	14.7	16.0	30.7	34.3	100.0	PASS
Quasi-Peak	67.8	19.8	13.2	33.0	44.7	100.0	PASS
Quasi-Peak	72.0	21.8	13.6	35.4	58.9	100.0	PASS
Quasi-Peak	94.9	17.6	16.7	34.3	51.9	150.0	PASS
Quasi-Peak	122.1	19.8	19.5	39.3	92.3	150.0	PASS
Quasi-Peak	135.6	16.2	19.6	35.8	61.7	150.0	PASS
Quasi-Peak	244.1	26.1	19.8	45.9	197.2	200.0	PASS
Quasi-Peak	257.7	13.8	21.7	35.5	59.6	200.0	PASS
Quasi-Peak	271.2	15.2	21.1	36.3	65.3	200.0	PASS
Quasi-Peak	720.1	-0.9	31.0	30.1	32.0	200.0	PASS
Quasi-Peak	840.7	0.7	32.8	33.5	47.3	200.0	PASS

30 MHz – 1 GHz



13 AC power-line conducted emissions

13.1 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.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	EMC Lab 7
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 31 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	120 Vac ±10 % (as declared)

13.3 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

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average**
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.

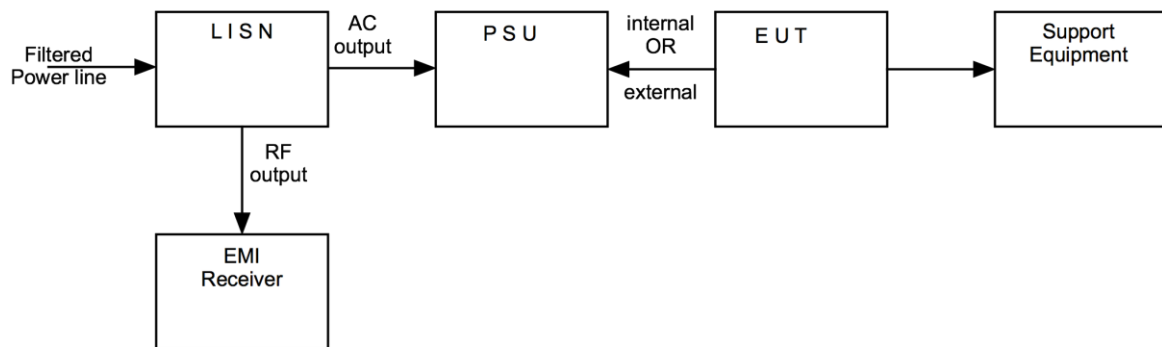
13.4 Test Method

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



13.5 Test Set-up Photograph



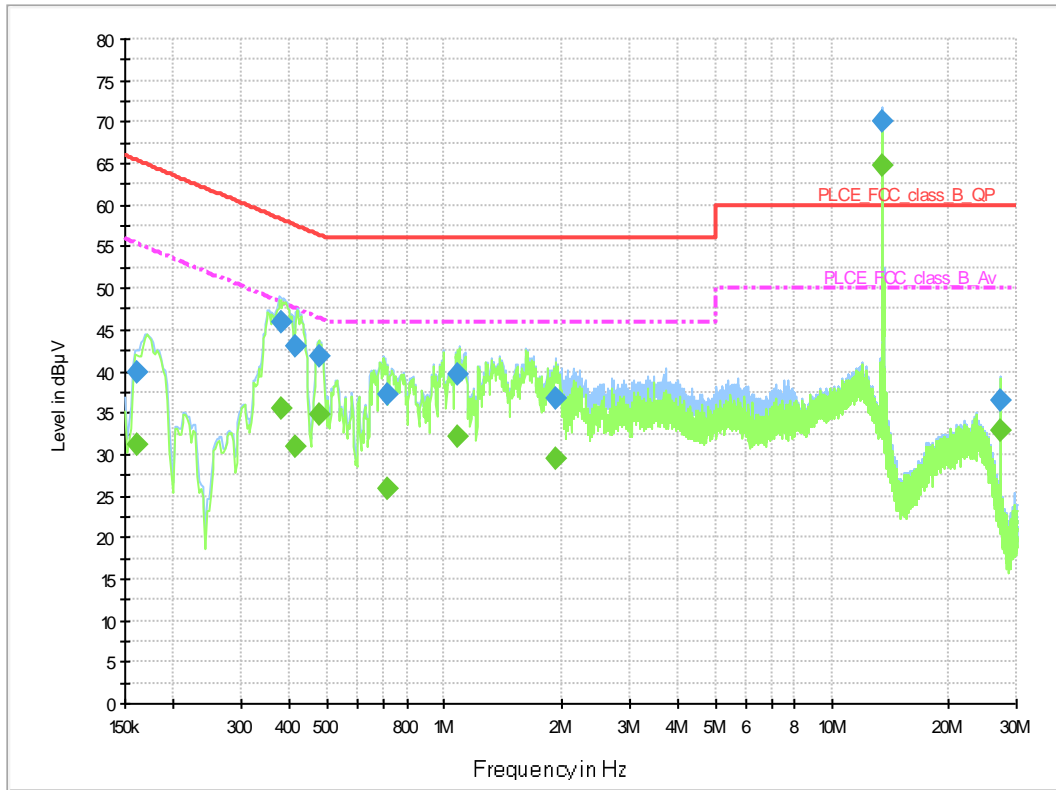
13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Measuring Receiver	R&S	ESC17	RFG715	2022-03-29
Pulse Limiter	R&S	ESH3-Z2	RFG674	2022-05-04
LISN	R&S	ESH3-Z5	RFG189	2023-07-26

13.7 Test Results – Antenna

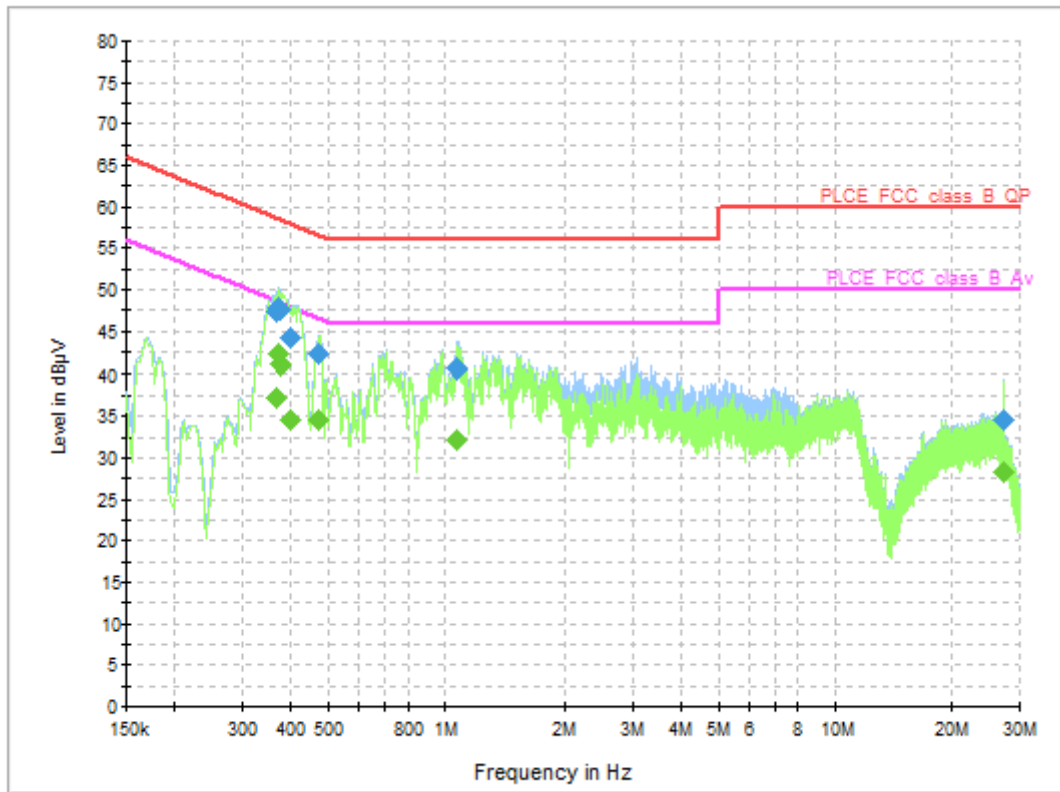
<i>AC power-line conducted emissions, Transmit mode</i>						
<i>Results measured using the average detector</i>						
<i>Reference Number</i>	<i>Frequency (MHz)</i>	<i>Conductor</i>	<i>Result (dBuV)</i>	<i>Specification Limit (dBuV)</i>	<i>Margin (dB)</i>	<i>Result Summary</i>
1	0.163	L1	31.2	55.4	24.2	PASS
2	0.379	L1	35.6	48.3	12.8	PASS
3	0.413	L1	31.0	47.6	16.6	PASS
4	0.477	L1	34.7	46.4	11.7	PASS
5	0.713	L1	25.7	46.0	20.3	PASS
6	1.084	L1	32.2	46.0	13.8	PASS
7	1.946	L1	29.5	46.0	16.5	PASS
8	13.561	L1	64.9	50.0	-14.9	FAIL
9	27.121	L1	32.8	50.0	17.2	PASS
<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	0.163	L1	39.9	65.4	25.4	PASS
2	0.379	L1	46.0	58.3	12.3	PASS
3	0.413	L1	43.1	57.6	14.5	PASS
4	0.477	L1	41.8	56.4	14.6	PASS
5	0.713	L1	37.3	56.0	18.7	PASS
6	1.084	L1	39.7	56.0	16.3	PASS
7	1.946	L1	36.6	56.0	19.4	PASS
8	13.561	L1	70.1	60.0	-10.1	FAIL
9	27.121	L1	36.5	60.0	23.5	PASS

Note * Fail emission is the fundamental frequency. See plots with antenna replaced by load.



13.8 Test Results – Antenna Replaced with Load

AC power-line conducted emissions, Transmit mode						
Results measured using the average detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.366	L1	37.2	48.6	11.4	PASS
2	0.372	L1	42.2	48.4	6.3	PASS
3	0.373	L1	41.2	48.4	7.2	PASS
4	0.399	L1	34.6	47.9	13.2	PASS
5	0.468	L1	34.7	46.5	11.9	PASS
6	1.070	L1	32.2	46.0	13.8	PASS
7	27.121	L1	28.3	50.0	21.7	PASS
Results measured using the quasi-peak detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.366	L1	47.3	58.6	11.3	PASS
2	0.372	L1	47.8	58.4	10.6	PASS
3	0.373	L1	47.7	58.4	10.7	PASS
4	0.399	L1	44.3	57.9	13.6	PASS
5	0.468	L1	42.2	56.5	14.3	PASS
6	1.070	L1	40.6	56.0	15.4	PASS
7	27.121	L1	34.6	60.0	25.4	PASS



14 Occupied Bandwidth

14.1 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.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels / Frequencies 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: 29 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	120 Vac ±10 % (as declared)

14.3 Test Limit

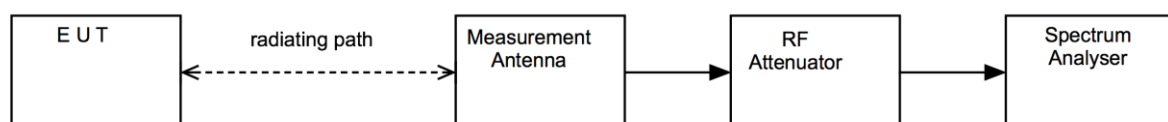
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific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

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the bandwidth of the EUT was measured on a spectrum analyser.

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.

Figure iv Test Setup

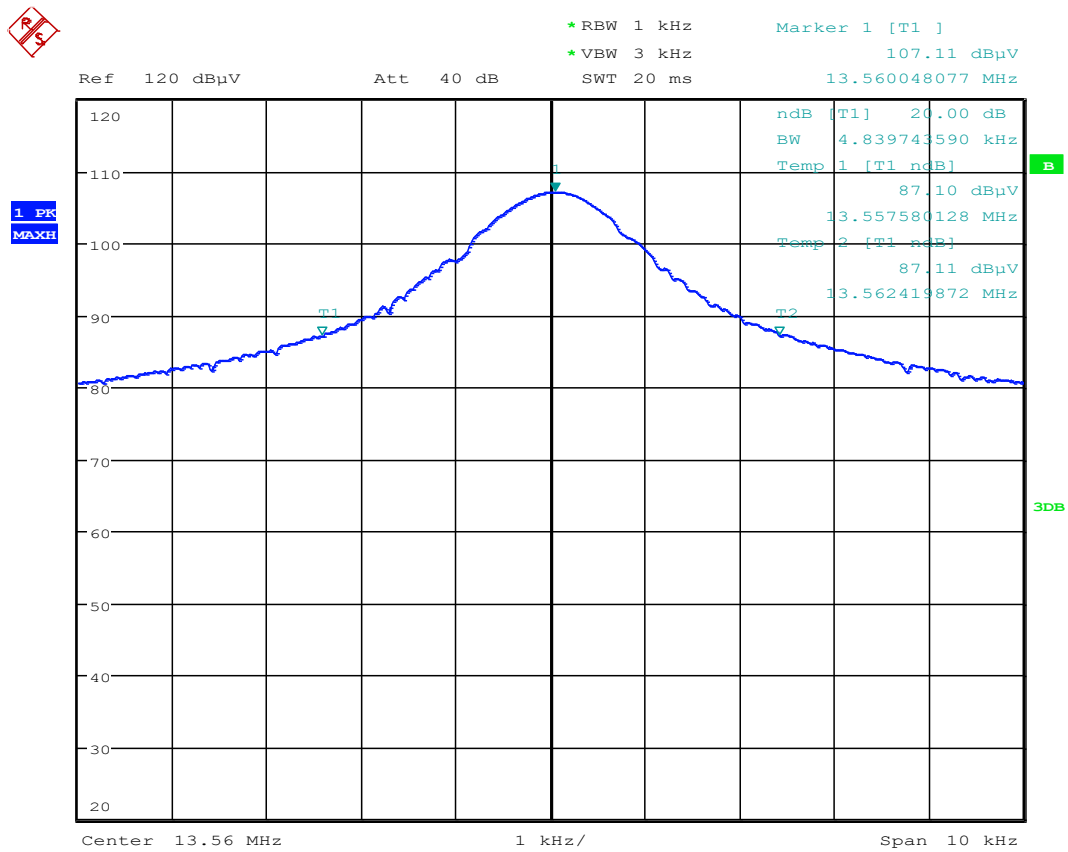


14.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	2022-07-22

14.6 Test Results

20 dB Bandwidth			
Frequency (MHz)	F_L (MHz)	F_H (MHz)	Bandwidth (kHz)
13.56	13.557580	13.562420	4.840



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15 Transmitter output power (fundamental radiated emission)

15.1 Definition

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

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Antenna:	Active 60cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)

15.3 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 30m)</i>	<i>Field strength (dBμV/m at 30m)</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

15.4 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 $\mu\text{V}/\text{m}$ at the regulatory distance, using:

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

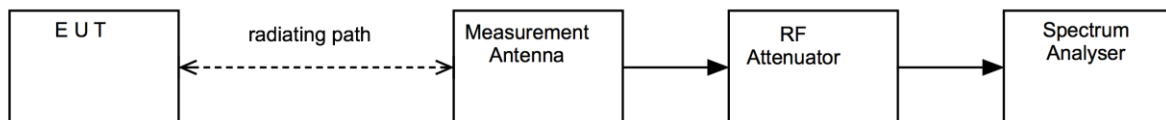
Where,

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

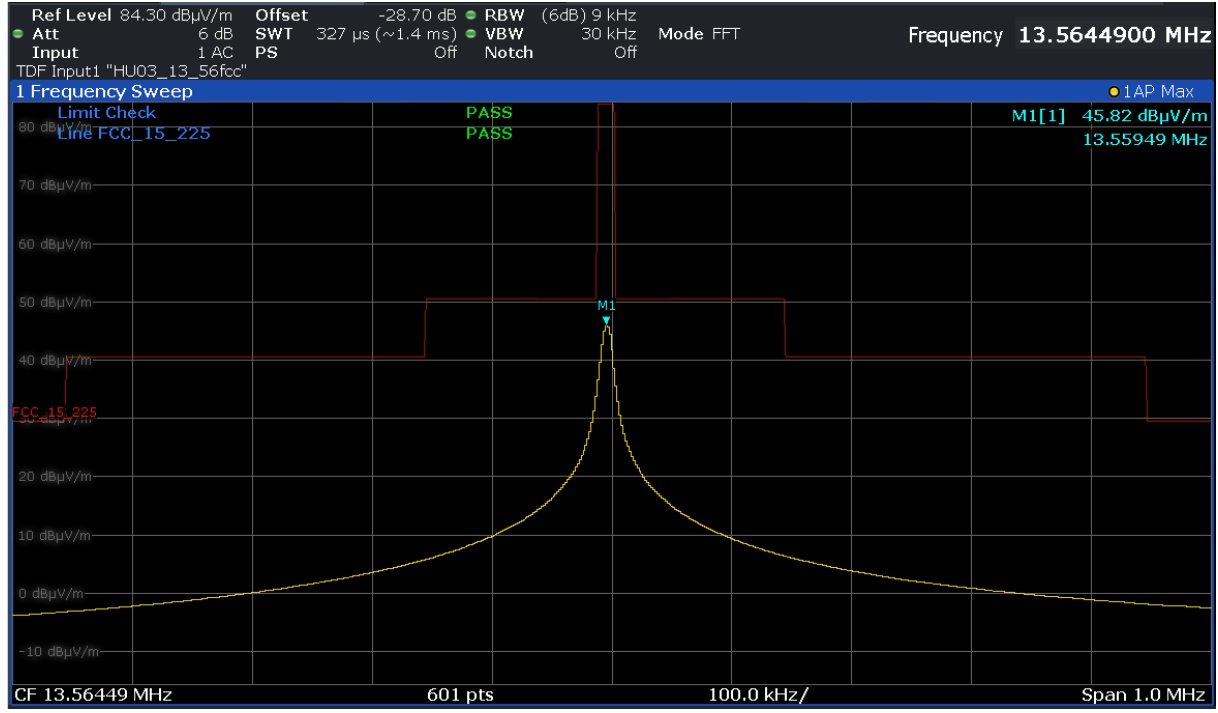


15.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	-	REF2259	2022-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2022-10-05
Active Loop Antenna	EMCO	6502	R0079	2023-06-16
Spectrum Analyser	R&S	FSU26	REF909	2022-07-22
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

15.6 Test Results

Channel Freq. (MHz)	Receiver Level (dBμV)	Factor (dB/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field strength (dBμV/m)	Field Strength (μV/m)	Result
13.56	76.1	9.7	3.0	30.0	40.0	45.8	195.0	PASS



16 Frequency stability

16.1 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.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Channels / Frequencies Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	EUT was left ON for the duration of the test.
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	Mains Power = $\pm 15\%$ of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 24 °C	Standard Requirement: +20 °C
Humidity: 29 %RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

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

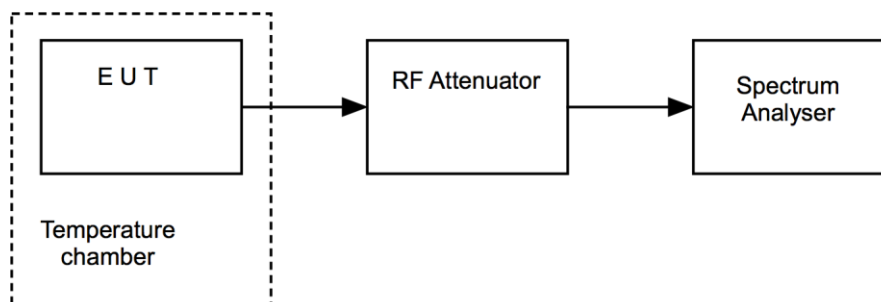
16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the frequency was measured under varying conditions of temperature and supply voltage.

The measurements were performed with EUT set in a CW mode of operation.

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

Figure v Test Setup



16.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU26	REF909	2022-07-22
Temperature Chamber	JTS	ETC/JTS/2/01	RFG365	Cal with REF2110
Thermometer	Fluke	53 II B	REF2110	2022-08-31
Variable Voltage Control	Zenith	VVC	REF1270	Cal with REF887
Multimeter	Agilent	34405A	REF887	2022-10-12

16.6 Test Results

EUT Frequency: 13.56 MHz					
Test Environment		Measured Frequency (MHz)	Frequency error (kHz)	Frequency error (%)	Result
-20 C	V _{nominal}	13.5601259	-0.0340	-0.00025073	PASS
-10 C	V _{nominal}	13.5601212	-0.0387	-0.00028539	PASS
0 C	V _{nominal}	13.5601011	-0.0588	-0.00043362	PASS
+10 C	V _{nominal}	13.5600689	-0.0910	-0.00067108	PASS
+20 C	V _{minimum}	13.5600389	-0.121	-0.00089232	PASS
	V _{nominal}	13.5601599	N/A	N/A	N/A
	V _{maximum}	13.5600392	-0.1207	-0.00089011	PASS
+30 C	V _{nominal}	13.5600147	-0.1452	-0.00107078	PASS
+40 C	V _{nominal}	13.5601054	-0.0545	-0.00040191	PASS
+50 C	V _{nominal}	13.5600263	-0.1336	-0.00098524	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.

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connector) Dare RPR3006W Power Head	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	0.9 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions	MU4041	0.9 dB
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	2.4 dB
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	2.5 dB
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	2.4 dB
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	3.7 dB
Effective Radiated Power	MU4021	4.7 dB
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	5.3 dB
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	5.1 dB
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	2.7 dB
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	2.7 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	4.7 dB
Radiated Spurious Emissions 1-18 GHz	MU4032	4.5 dB
E Field Emissions 18GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB
Frequency Measurements		
Frequency Deviation	MU4022	0.316 kHz
Frequency error using CMTA test set	MU4023	113.441 Hz
Frequency error using GPS locked frequency source	MU4045	0.0413 ppm
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	3.87 %
Transmitter Mask Amplitude	MU4039	1.3 dB
Transmitter Mask Frequency	MU4040	2.59 %
Time Domain Measurements		
Transmission Time	MU4038	4.40 %
Dynamic Frequency Selection (DFS) Parameters		
DFS Analyser - Measurement Time	MU4006	679 µs
DFS Generator - Frequency Error	MU4007	92 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	1.1 dB
EN301893 Receiver Blocking	MU4011	1.1 dB
EN303340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN303340 Overloading	MU4013	1.1 dB
EN303340 Receiver Blocking	MU4014	1.1 dB
EN303340 Receiver Sensitivity	MU4015	0.9 dB
EN303372-1 Image Rejection	MU4016	1.4 dB
EN303372-1 Receiver Blocking	MU4017	1.1 dB
EN303372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN303372-2 Dynamic Range	MU4019	0.9 dB
Receiver Blocking Talk Mode Conducted	MU4033	1.2 dB
Receiver Blocking Talk Mode- radiated	MU4034	3.4 dB
Rx Blocking, listen mode, blocking level	MU4035	3.2 dB
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	3.4 dB
Adjacent Sub Band Selectivity	MU4003	4.2 dB