Report on the Radio Testing

For

Cambridge Design Partnership LLP

on

Ooka Sense Station

Report no. TRA-056868-47-00A

18th October to 26th October 2022

Report Number: TRA-056868-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
Cambridge Design Partnership LLP
Ooka Sense Station
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 18th October to 26th October 2022

Tested by: Digitally signed by Steven Hodgkinson DN: cn=Steven Hodgkinson, o, ou=Element Materials Technology Ltd, email=steven.hodgkinson@element.com, c=GB Date: 2023.03.23 09:55:12 Z — S Hodgkinson, Radio Test Engineer

Approved by: Digitally signed by John Charters Date: 2023.03.23 11:16:15 Z — J Charters, Laboratory Manager

Date: 14th November 2022

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	14 November 2022	Original

1.1 Summary

TEST REPORT NUMBER:	TRA-056868-47-00A
WORKS ORDER NUMBER:	TRA-056868-02
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):	Ooka Sense Station
FCC IDENTIFIER:	2A9JT-AIR-A001
EUT SERIAL NUMBER:	220307EJ0175
MANUFACTURER/AGENT:	Cambridge Design Partnership LLP
ADDRESS:	The Long Barn Church Road Toft Cambridge Cambridgeshire CB23 2RF
CLIENT CONTACT:	Jonathan Stafford ☎ 01223 264428 ✉ jonathan.stafford@cambridge-design.com
TEST DATE:	18th October to 26th October 2022
TESTED BY:	S Hodgkinson Element

2 Test Summary

Test Method and Description	*Requirement Clause* *47CFR15*	*Applicable to this equipment*	*Result / Note*
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*

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).

3 Contents

4 Introduction

This report TRA-056868-47-00A presents the results of the Radio testing on a Cambridge Design Partnership LLP, Ooka Sense Station to specification 47CFR15 Radio Frequency Devices and RSS-210 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Cambridge Design Partnership LLP by Element, at the address detailed below.

☐ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☒ Element Skelmersdale
Unit 1
Pendle Place
Skelmersdale
West Lancashire
WN8 9PN
UK

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 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.

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: Ooka Sense Station
- Model Number: A001
- Software Revision: V3.00 (Test)
- Build Production (MCU Board - rev H, NFC Board - rev D1, UX Flexi - rev D, Button Board - rev E1)

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.

Lenovo Thinkpad

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows: the client supplied test GUI enabled the 13.56 MHz RFID into a continuous modulated test mode.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Modulation type(s):	ASK
Antenna type(s) and gain(s):	Integral Loop
Nominal Supply Voltage:	14.4 Vdc

7.4.2 Antennas

Type:	Molex 146236-2102
Frequency range:	13.56 MHz
Antenna Thickness:	0.17±0.05 mm
Loop Height:	15 mm
Loop Width:	25 mm
Turns:	8
Maximum Output Power Level:	30 dBm
Environmental limits:	-40°C to + 85°C
Mounting:	Peel and Stick

7.5 EUT Description

The Ooka Sense Station is a device for heating up flavoured pods, for smoking, and makes use of 13.56 MHz RFID

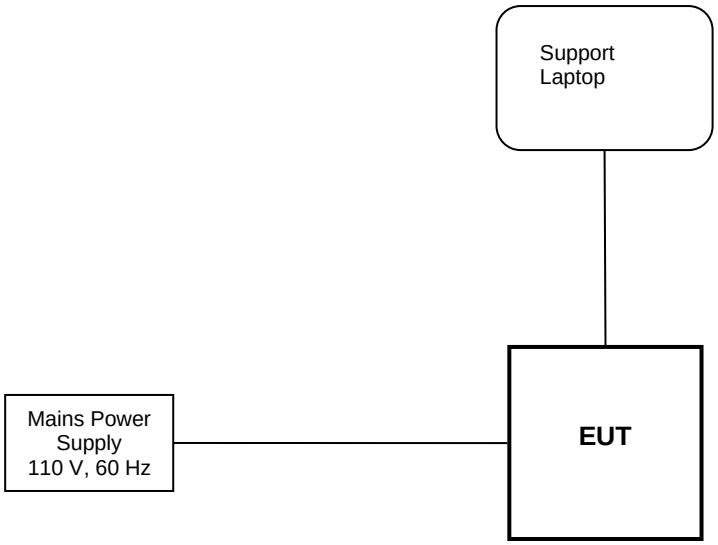
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

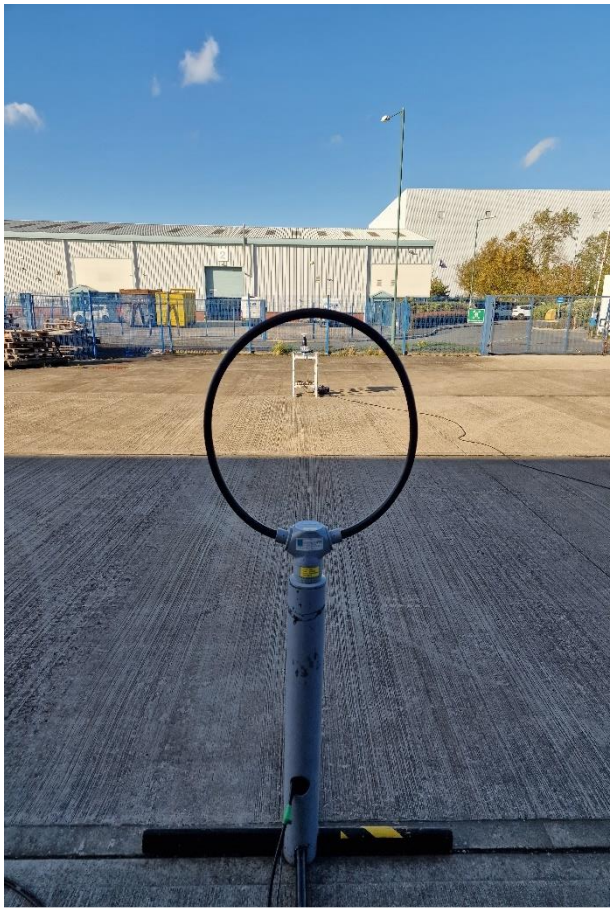
9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



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)
Element Transmitter Bench Test (See Note)
ETS Lindgren EMPower V1.0.4.2

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 Ooka Sense Station was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 14.4 Vdc, from the Lithium Batteries. The Ooka Sense Station can also operate whilst connected to the 110 Vac Mains whilst charging the batteries.

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***
☒	Standard	-20 to +50 C in 10 degree steps
☐	Extended	

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***
☐	Mains		85 % and 115 %
☒	Battery	14.4 Vdc	85 % and 115 %

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 Skelmersdale
Test Chamber:	Chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
Frequencies Measured:	13.56 MHz
Deviations from Standard:	None
Measurement Distance and Site:	10 m, OATS without ground plane.
EUT Height:	1 m
Measurement Antenna and Height:	60 cm shielded loop; 1 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: 17 °C	+15 ºC to +35 ºC (as declared)
Humidity: 57 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	(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

Frequency, f (kHz)	*Field Strength*	*Measurement Distance (m)*
9 to 490	2,400 / 377.f (µA/m) 2,400 / f (µV/m)	300
490 to 1,750	24,000 / 377.f (µA/m) 24,000 / f (µV/m)	30
1,750 to 30,000	30 (µV/m)	30

n.b. Devices operated pursuant to §15.225 / RSS-210 A2.6 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 360º, 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 µV/m at the regulatory distance, using:

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

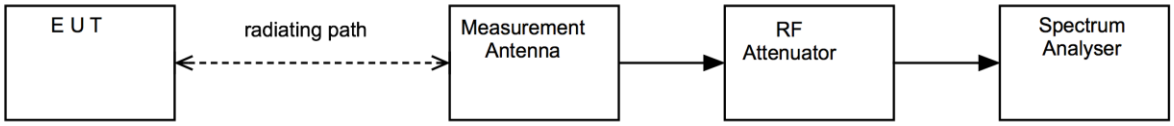
Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV 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) / RSS-Gen 6.4, 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



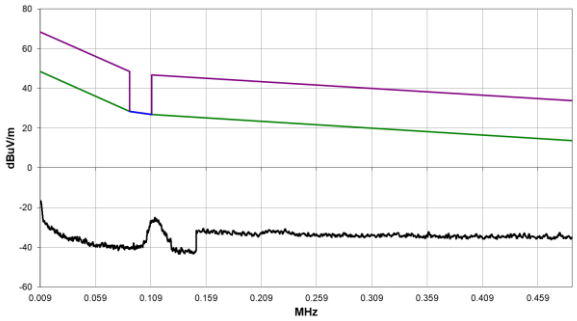
11.5 Test Set-up Photograph

11.6 Test Equipment

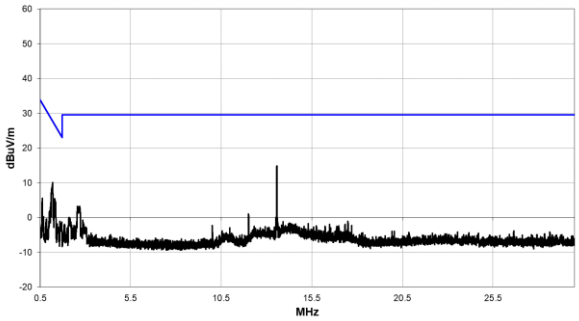
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required
EMI Receiver	R&S	ESR26	U489	2023-03-04
Loop Antenna	R&S	hfh2	L007	2023-09-09

11.7 Test Results

13.56 MHz



9 kHz to 490 kHz



490 kHz to 30 MHz

13.56 MHz						
Emission Frequency (MHz)	*Receiver Level (dBµV/m)*	*Measurement Distance (m)*	*Limit Distance (m)*	*Extrapolation Factor (dB)*	*Field Strength (µV/m)*	*Result*
No significant emissions within 10 dB of the limit.						PASS

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 Skelmersdale
Test Chamber:	Chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
Frequencies Measured:	13.56 MHz
Deviations from Standard:	None
Measurement BW:	30 MHz to 300 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 18 °C	+15 ºC to +35 ºC (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	(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

Frequency (MHz)	***Field Strength (µV/m at 3 m)***
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 dBµV/m at the regulatory distance, using:

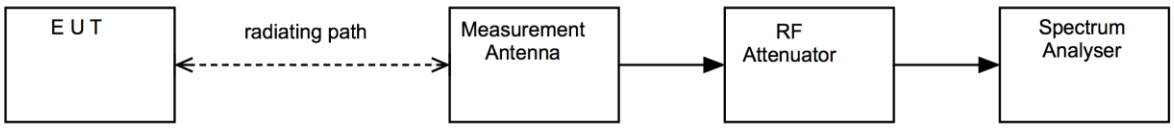
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

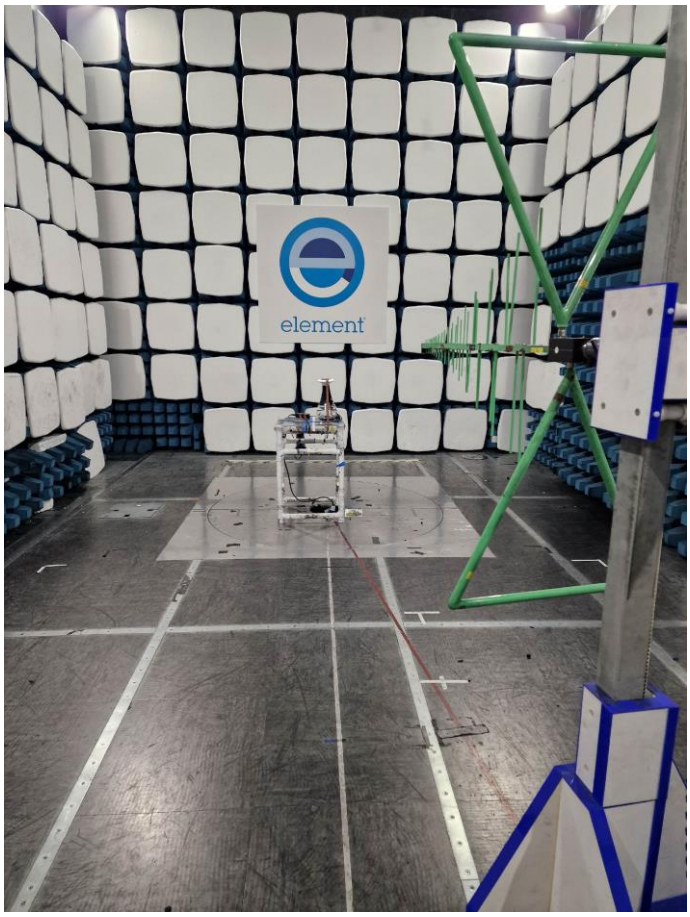
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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



12.5 Test Set-up Photograph

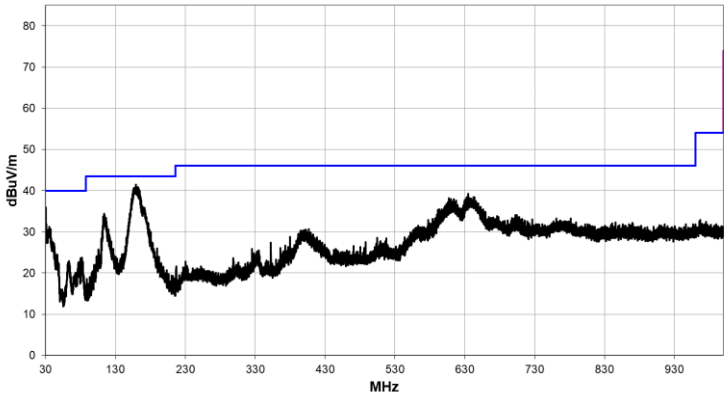


12.6 Test Equipment

Equipment Description	***Manufacturer***	***Equipment Type***	***Element No***	***Due For Calibration***
Radiated Test Software	Element	Emissions R5 2022.07.06.0	REF9000	Cal not required
Chamber 1	Rainford EMC	ATS	U387	2023-10-24
PreAmp	Watkins Johnson	6201-69	U372	2023-03-01
Bilog	Chase	CBL6112	U420	2023-01-28
EMI Receiver	R&S	ESR26	U489	2023-03-04

12.7 Test Results

13.56 MHz



30 MHz to 1 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
159.006	49.5	-11.3	1.0	243.2	3.0	0.0	Vert	QP	0.0	38.2	43.5	-5.3
30.377	35.5	-4.3	3.8	352.8	3.0	0.0	Horz	QP	0.0	31.2	40.0	-8.8
30.621	33.7	-4.5	3.8	22.1	3.0	0.0	Horz	QP	0.0	29.2	40.0	-10.8
635.242	34.8	-0.2	1.5	172.9	3.0	0.0	Vert	QP	0.0	34.6	46.0	-11.4
607.756	34.1	-0.6	1.65	148.0	3.0	0.0	Vert	QP	0.0	33.5	46.0	-12.5
113.807	40.8	-9.8	1.0	166.9	3.0	0.0	Vert	QP	0.0	31.0	43.5	-12.5
613.891	33.6	-0.4	1.5	141.8	3.0	0.0	Vert	QP	0.0	33.2	46.0	-12.8
35.571	34.0	-7.1	1.0	322.2	3.0	0.0	Vert	QP	0.0	26.9	40.0	-13.1

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 Skelmersdale
Test Chamber:	Transient Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
Frequencies Measured:	13.56 MHz
EUT Modulation:	ASK
Deviations from Standard:	None
Measurement BW:	10.0 kHz
Measurement Detectors:	Quasi-Peak and Average,

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	

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 (dBµV)***	
	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.

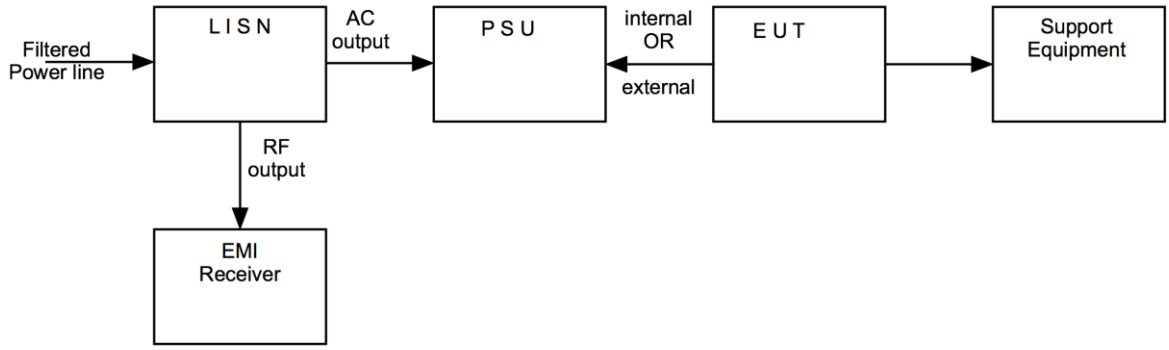
13.4 Test Method

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.

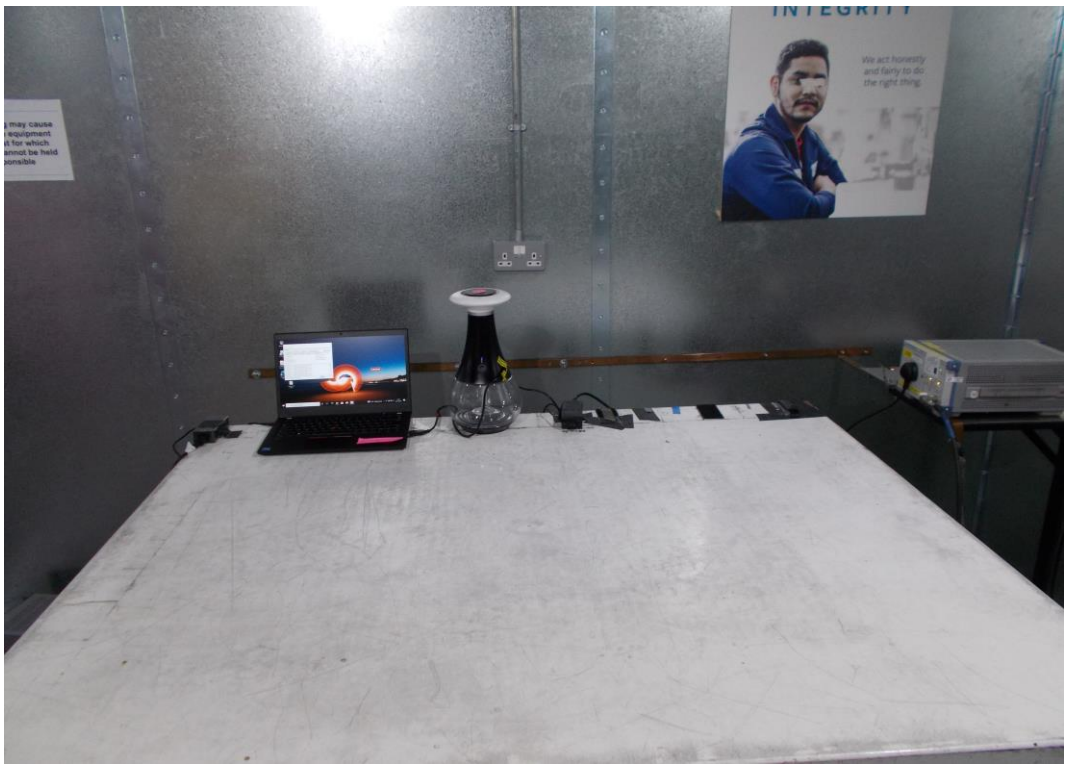
AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

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



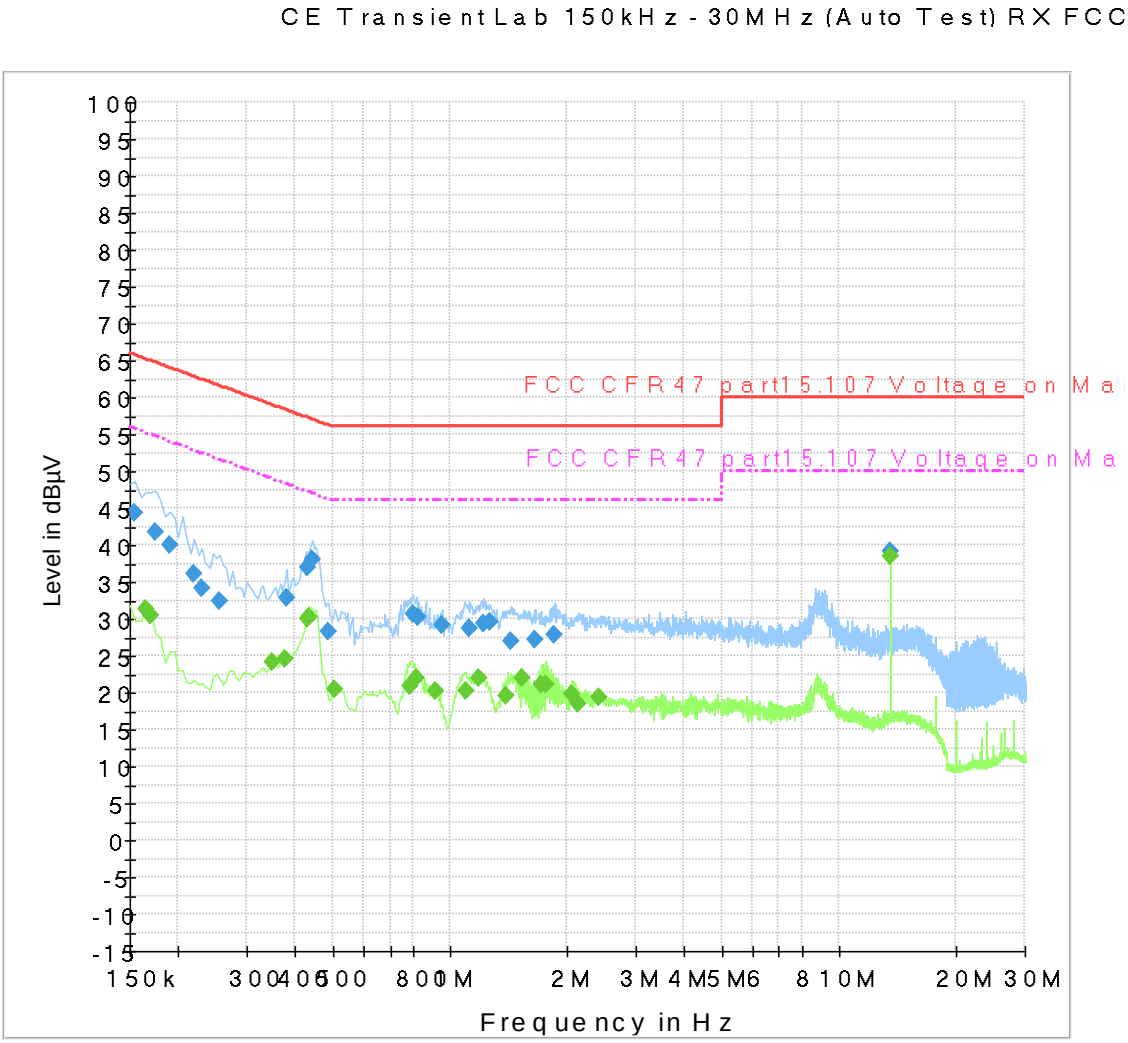
13.5 Test Set-up Photograph



13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ENV216	R&S	Lisn	U396	2022-09-30
ESHS10	R&S	Receiver	U003	2024-02-4

13.7 Test Results



Quasi Peak

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.155000	44.4	2000.0	10.000	Off	L1	19.7	21.3	65.7	Pass
0.175000	41.7	2000.0	10.000	Off	N	19.6	23.0	64.7	Pass
0.190000	40.1	2000.0	10.000	Off	L1	19.7	24.0	64.0	Pass
0.220000	36.1	2000.0	10.000	Off	L1	19.7	26.7	62.8	Pass
0.230000	34.1	2000.0	10.000	Off	N	19.6	28.4	62.4	Pass
0.255000	32.4	2000.0	10.000	Off	L1	19.7	29.1	61.6	Pass
0.380000	32.9	2000.0	10.000	Off	N	19.7	25.4	58.3	Pass
0.430000	36.9	2000.0	10.000	Off	L1	19.8	20.3	57.3	Pass
0.440000	38.1	2000.0	10.000	Off	L1	19.8	18.9	57.1	Pass
0.485000	28.4	2000.0	10.000	Off	L1	19.8	27.9	56.3	Pass
0.800000	30.7	2000.0	10.000	Off	L1	19.8	25.3	56.0	Pass
0.830000	30.2	2000.0	10.000	Off	L1	19.8	25.8	56.0	Pass
0.955000	29.1	2000.0	10.000	Off	N	19.8	26.9	56.0	Pass
1.120000	28.7	2000.0	10.000	Off	L1	19.8	27.3	56.0	Pass
1.220000	29.4	2000.0	10.000	Off	L1	19.8	26.6	56.0	Pass
1.260000	29.7	2000.0	10.000	Off	N	19.8	26.3	56.0	Pass
1.435000	26.9	2000.0	10.000	Off	L1	19.8	29.1	56.0	Pass
1.645000	27.1	2000.0	10.000	Off	N	19.8	28.9	56.0	Pass
1.855000	27.8	2000.0	10.000	Off	L1	19.8	28.2	56.0	Pass
13.560000	39.2	2000.0	10.000	Off	L1	20.6	20.8	60.0	Pass

Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.165000	31.4	2000.0	10.000	Off	N	19.6	23.9	55.2	Pass
0.170000	30.4	2000.0	10.000	Off	L1	19.7	24.6	55.0	Pass
0.350000	24.2	2000.0	10.000	Off	L1	19.8	24.7	49.0	Pass
0.375000	24.5	2000.0	10.000	Off	N	19.7	23.9	48.4	Pass
0.430000	29.9	2000.0	10.000	Off	L1	19.8	17.4	47.3	Pass
0.435000	30.2	2000.0	10.000	Off	L1	19.8	17.0	47.2	Pass
0.505000	20.4	2000.0	10.000	Off	N	19.7	25.6	46.0	Pass
0.785000	20.8	2000.0	10.000	Off	L1	19.8	25.2	46.0	Pass
0.820000	21.9	2000.0	10.000	Off	N	19.8	24.1	46.0	Pass
0.915000	20.2	2000.0	10.000	Off	N	19.8	25.8	46.0	Pass
1.095000	20.2	2000.0	10.000	Off	L1	19.8	25.8	46.0	Pass
1.180000	21.9	2000.0	10.000	Off	L1	19.8	24.1	46.0	Pass
1.385000	19.6	2000.0	10.000	Off	L1	19.8	26.4	46.0	Pass
1.530000	22.0	2000.0	10.000	Off	N	19.8	24.0	46.0	Pass
1.710000	21.0	2000.0	10.000	Off	L1	19.8	25.0	46.0	Pass
1.760000	21.2	2000.0	10.000	Off	L1	19.8	24.8	46.0	Pass
2.050000	19.9	2000.0	10.000	Off	L1	19.8	26.1	46.0	Pass
2.125000	18.6	2000.0	10.000	Off	L1	19.8	27.4	46.0	Pass
2.410000	19.3	2000.0	10.000	Off	L1	19.9	26.7	46.0	Pass
13.560000	38.5	2000.0	10.000	Off	L1	20.6	11.5	50.0	Pass

14 Occupied Bandwidth

14.1 Definition

Occupied bandwidth

20 dB bandwidth
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 Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
Frequencies Measured:	13.56 MHz
EUT Test Modulations:	ASK
Deviations from Standard:	None
Measurement BW: (Irequirement: 1% to 5% OBW)	See Note:
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	See Note
Measurement Span: (requirement 2 to 5 times OBW)	See Note
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)
Supply: 14.4 Vdc	

Note: The modulation type used by the Ooka Sense Station is ASK. ANSI C63-10 clause 6.9.3, the requirement for calculating the required resolution bandwidth, based upon the occupied bandwidth, as per the calculation does not function correctly, as the bandwidth and the resolution bandwidth continually decrease using the formula stated in ANSI C63-10, and does not result in a meaningful measurement.
It was determined to use a resolution bandwidth of 1 kHz for the 20 dB occupied bandwidth.

14.3 Test Limit

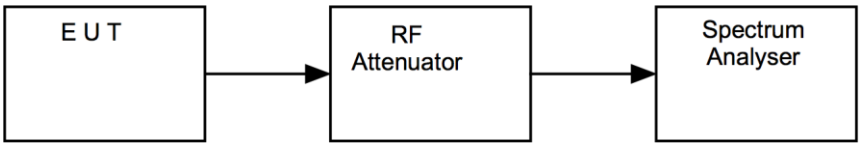
Federal Communications Commission:
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise 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

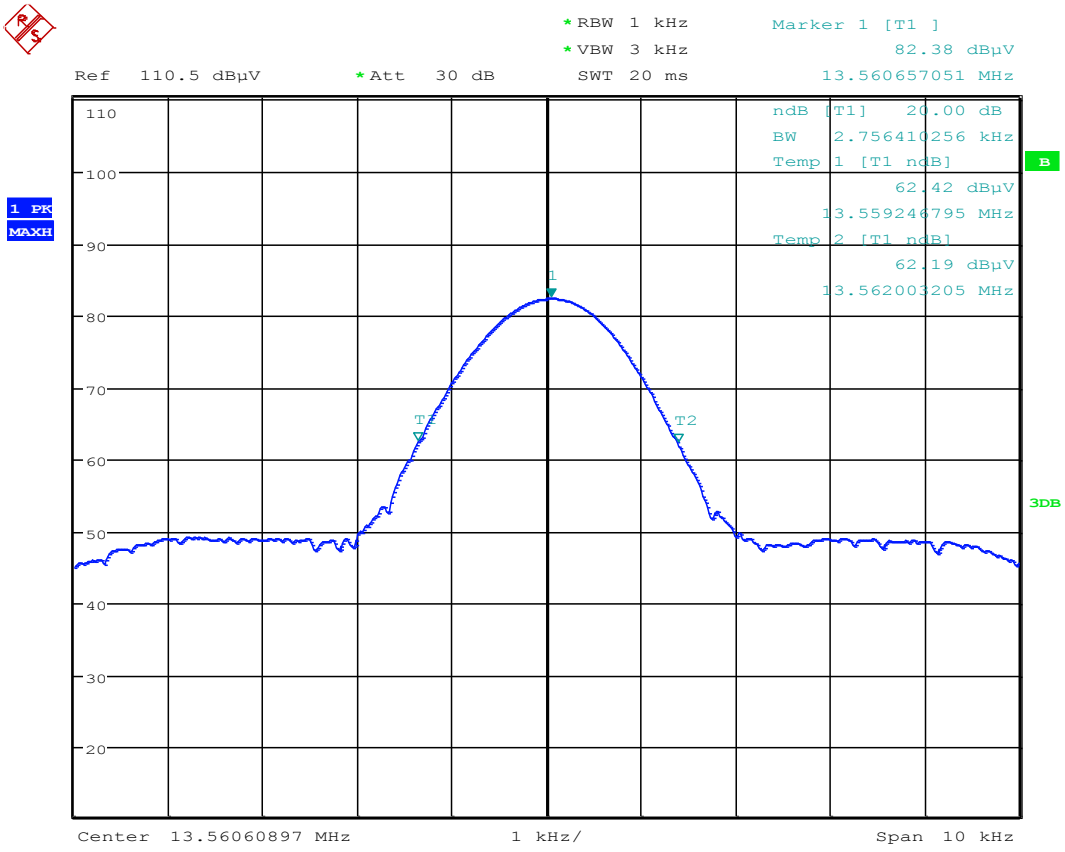


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	U405	2023-04-21

14.6 Test Results

15.225. Modulation: ASK			
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**20 dB Bandwidth (kHz)**
13.56	13.559246	13.562003	2.76



Date: 1.NOV.2022 17:13:32

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 Skelmersdale
Test Chamber:	OATS
Test Antenna:	Active 60cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
Frequencies Measured:	13.56 MHz
Deviations from Standard:	None
Measurement BW:	10 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 kHz
Measurement Detector:	Quasi-peak
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal (FCC only requirement);

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 53 % 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

Frequency range (MHz)	*Field strength (µV/m at 30m)*	*Field strength (dBµV/m at 30m)*
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 µV/m at the regulatory distance, using:

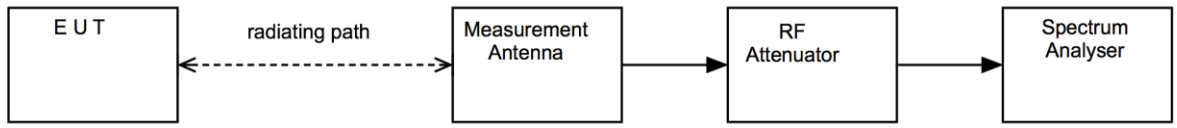
$$FS = 10^{(PR - CF) / 20}$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV 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);

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

Figure v Test Setup

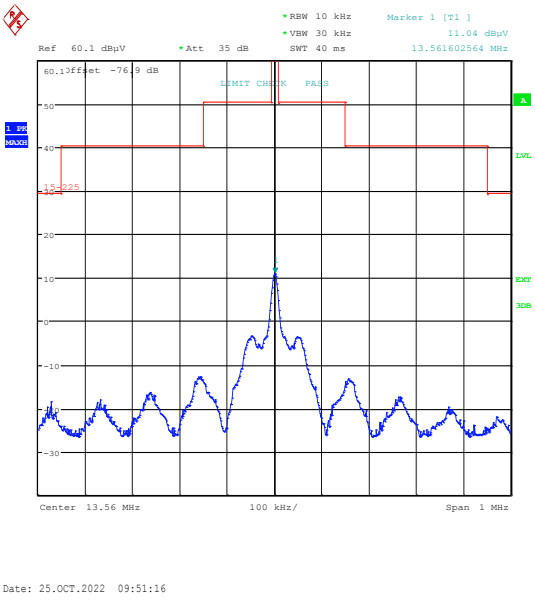


15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
hfh2	R&S	Loop Antenna	L007	2023-09-09
ESR26	R&S	EMI Receiver	U489	2023-03-04

15.6 Test Results

13.56MHz						
Channel Frequency (MHz)	***Receiver Level (dBµV/m)***	***Measurement Distance (m)***	***Limit Distance (m)***	***Extrapolation Factor (dB)***	***Field Strength (µV/m)***	***Result***
13.56	70.50	1	30	59.50	3.548	PASS
13.56	51.00	3	30	40.00	3.548	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 Skelmersdale
Test Chamber:	Radio laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequencies Measured:	13.56
Modulation:	0n
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:	Battery = ±15% of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 19 °C	Standard Requirement: +20 ºC
Humidity: 53 %RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

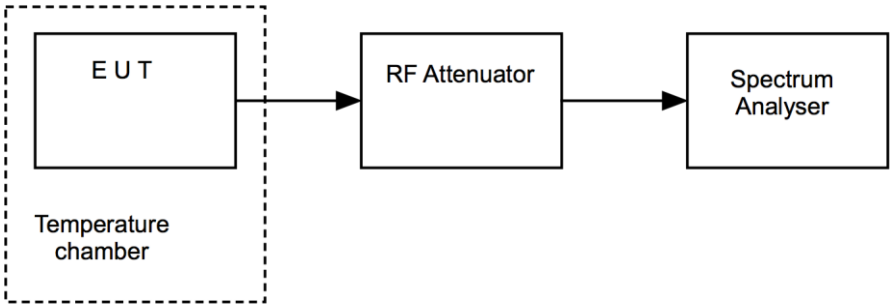
Carrier frequency stability shall be maintained to ±0.01% (±100 ppm).

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.

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	U405	2023-04-21
Temperature Chamber	Votsch	VT 4002	U521	Use L426 or U720
Multimeter	Agilent	34405a	REF976	2022-12-21
Power Supply	ISO-Tech	IPS 303A	U747	Use REF976
Temperature Indicator	Digitron	2000T	U720	2023-05-09

16.6 Test Results

Vnom (Vdc)	Temperature (°C)	Frequency (MHz)	Result (kHz)	Limit = ± 0.01%= 1.3562kHz
14.4	+50 ºC	13.560641	0.0260	Pass
14.4	+40 ºC	13.560620	0.0050	Pass
14.4	+30 ºC	13.560613	-0.0020	Pass
14.4	+20 ºC	13.560615	0.0000	Pass
14.4	+10 ºC	13.560634	0.0190	Pass
14.4	0 ºC	13.560647	0.0320	Pass
14.4	-10 ºC	13.560646	0.0310	Pass
14.4	-20 ºC	13.560631	0.0160	Pass
Voltage (Vdc) 85% - 115%	Temperature (°C)	Frequency (MHz)	Result	Limit = ± 0.01%= 1.3562kHz
16.56	+20 ºC	13.560608	-0.0070	Pass
12.24	+20 ºC	13.560608	-0.0070	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 connecter) 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**