

Report on the Radio Testing

For

CMR Surgical Limited

on

MA-0382 J8 to J9-11 Assembly

Report no. TRA-044411-45-00B

27 March 2019

RF914 5.0



Report Number: TRA-044411-45-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
CMR Surgical Limited
MA-0382 J8 to J9-11 Assembly
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 2018-03-04 to 2018-03-05

Tested by: A Tosif & D Garvey

Written by: 

A Tosif
Radio Test Engineer

Approved by:

Date: 27 March 2019

J Charters
Department Manager - Radio

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	7 March 2019	Original
B	27 March 2019	EUT name and section 15.6 updated

2 Summary

TEST REPORT NUMBER: TRA-044411-45-00B

WORKS ORDER NUMBER: TRA-044411-01

PURPOSE OF TEST: Certification

TEST SPECIFICATION: 47CFR15.225

EQUIPMENT UNDER TEST (EUT): MA-0382 J8 to J9-11 Assembly

FCC IDENTIFIER: 2ASDBMA-0382

EUT SERIAL NUMBER: not applicable

MANUFACTURER/AGENT: CMR Surgical Limited

ADDRESS: Unit 2, Crome Lea Business Park,
Madingley Road,
Cambridge,
CB23 7PH

CLIENT CONTACT: Andrew Thompson
☎ +44 (0)7864 922474
✉ andrew.thompson@cmrsurgical.com

ORDER NUMBER: PO-7769v1.0

TEST DATE: 2018-03-04 to 2018-03-05

TESTED BY: A Tosif & D Garvey
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>
Radiated spurious emissions, below 30 MHz	15.225(d)	<input checked="" type="checkbox"/>	Pass
Radiated spurious emissions	15.209	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions	15.207	<input checked="" type="checkbox"/>	Pass
Occupied bandwidth	15.215(c)	<input checked="" type="checkbox"/>	Pass
Field strength of fundamental	15.225(a), (b) and (c)	<input checked="" type="checkbox"/>	Pass
Frequency stability	15.225(e)	<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).

3 Contents

1	Revision Record	3
2	Summary	4
2.1	Test Summary	5
3	Contents	6
4	Introduction	7
5	Test Specifications	8
5.1	Normative References	8
5.2	Deviations from Test Standards	8
6	Glossary of Terms	9
7	Equipment under Test	10
7.1	EUT Identification	10
7.2	System Equipment	10
7.3	EUT Mode of Operation	10
7.4	EUT Radio Parameters	10
7.5	EUT Description	10
8	Modifications	11
9	EUT Test Setup Photographs	12
10	General Technical Parameters	13
10.1	Normal Conditions	13
10.2	Varying Test Conditions	13
11	Radiated emissions below 30 MHz	14
11.1	Definitions	14
11.2	Test Parameters	14
11.3	Test Limit	14
11.4	Test Method	15
11.5	Test Equipment	15
11.6	Test Results	16
12	Radiated emissions	17
12.1	Definitions	17
12.2	Test Parameters	17
12.3	Test Limit	17
12.4	Test Method	18
12.5	Test Equipment	18
12.6	Test Results	19
13	Occupied Bandwidth	20
13.1	Definition	20
13.2	Test Parameters	20
13.3	Test Limit	20
13.4	Test Method	20
13.5	Test Equipment	21
13.6	Test Results	21
14	Transmitter output power (fundamental radiated emission)	22
14.1	Definition	22
14.2	Test Parameters	22
14.3	Test Limit	22
14.4	Test Method	22
14.5	Test Equipment	23
14.6	Test Results	23
15	Frequency stability	24
15.1	Definition	24
15.2	Test Parameters	24
15.3	Test Limit	24
15.4	Test Method	24
15.5	Test Equipment	25
15.6	Test Results	25
16	AC power-line conducted emissions	26
16.1	Definition	26
16.2	Test Parameters	26
16.3	Test Limit	26
16.4	Test Method	26
16.5	Test Set-up Photograph	27
16.6	Test Equipment	27
16.7	Test Results	28
17	Measurement Uncertainty	29

4 Introduction

This report TRA-044411-45-00B presents the results of the Radio testing on a CMR Surgical Limited, MA-0382 J8 to J9-11 Assembly to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for CMR Surgical Limited by Element, at the address detailed below.

<input checked="" type="checkbox"/> Element Hull	<input type="checkbox"/> Element Skelmersdale
Unit E	Unit 1
South Orbital Trading Park	Pendle Place
Hedon Road	Skelmersdale
Hull	West Lancashire
HU9 1NJ	WN8 9PN
UK	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:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

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
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: MA-0382 J8 to J9-11 Assembly
- Model Number: MA-0382
- 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.

Not Applicable – No support/monitoring equipment required.

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
Nominal Supply Voltage:	20 Vdc
Location of notice for license exempt use:	User manual
Antenna type:	PCB Antenna

7.5 EUT Description

The EUT is a section of medical robot containing 13.56 MHz RFID reader. This report covers modular approval of this section only, and not the whole robot.

8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup Photographs



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 20 Vdc.

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:

	<i>Nominal</i>	<i>Variation</i>
☒	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:

	<i>Nominal</i>	<i>Variation</i>
☒	20 Vdc	17 Vdc and 23 Vdc

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 Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Distance:	3 m
EUT Height:	0.8 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: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 20 Vdc	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 (μ V/m)	Measurement Distance (m)
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.

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:

$$FS = 10 \frac{(PR - CF)}{20}$$

Where,

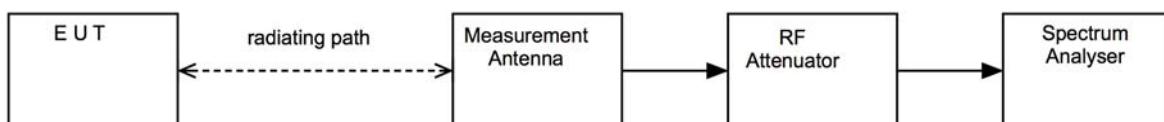
PR is the power recorded on the receiver / spectrum analyzer in $\text{dB}\mu\text{V}$ and includes any cable loss, antenna factor and pre-amplifier gain;

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

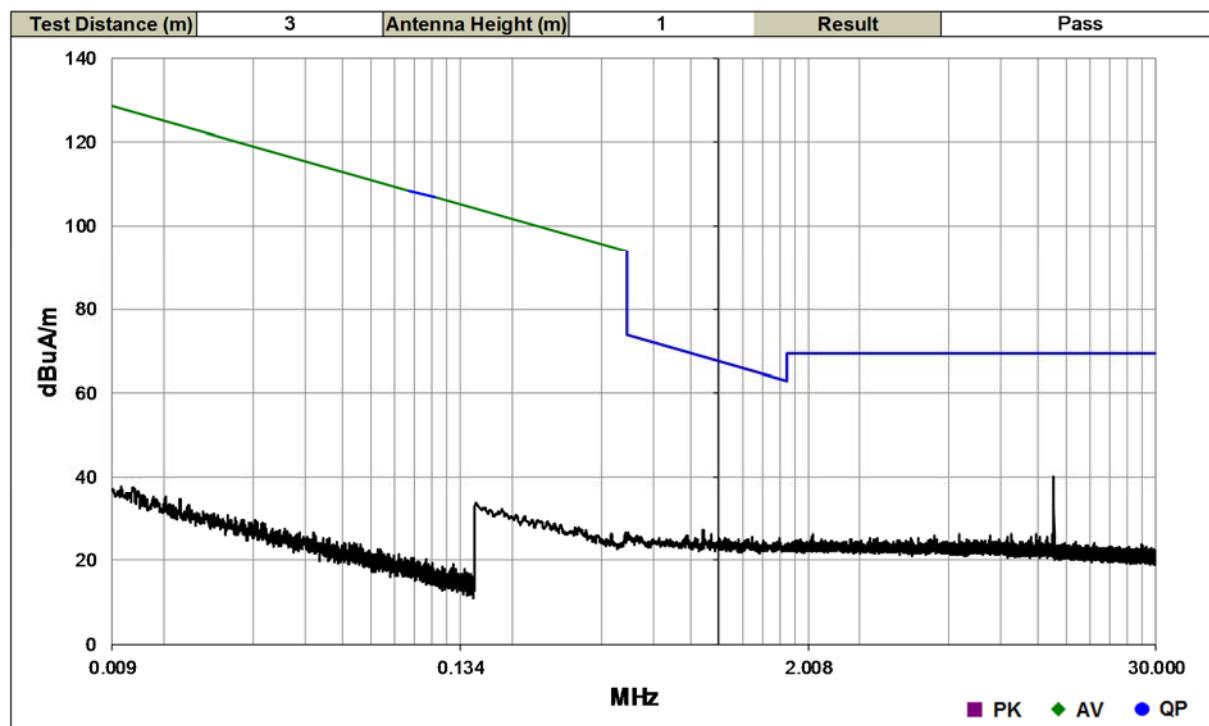


11.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2019-07-23
6502	EMCO	Active Loop Antenna	R0079	2019-05-24
hfh2	R&S	Loop Antenna	L007	2019-05-10

11.6 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 10 dB of the limit						



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 Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 20 Vdc	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 dB μ V/m at the regulatory distance, using:

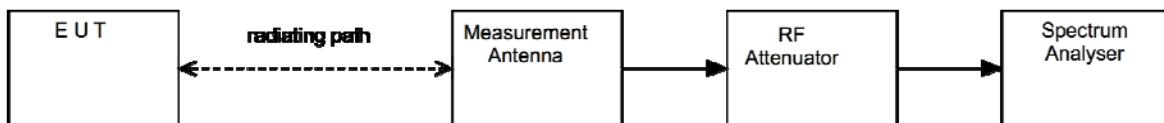
$$FS = PR + CL + AF - PA + DC - CF$$

Where,

- PR is the power recorded on the receiver / spectrum analyzer in 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

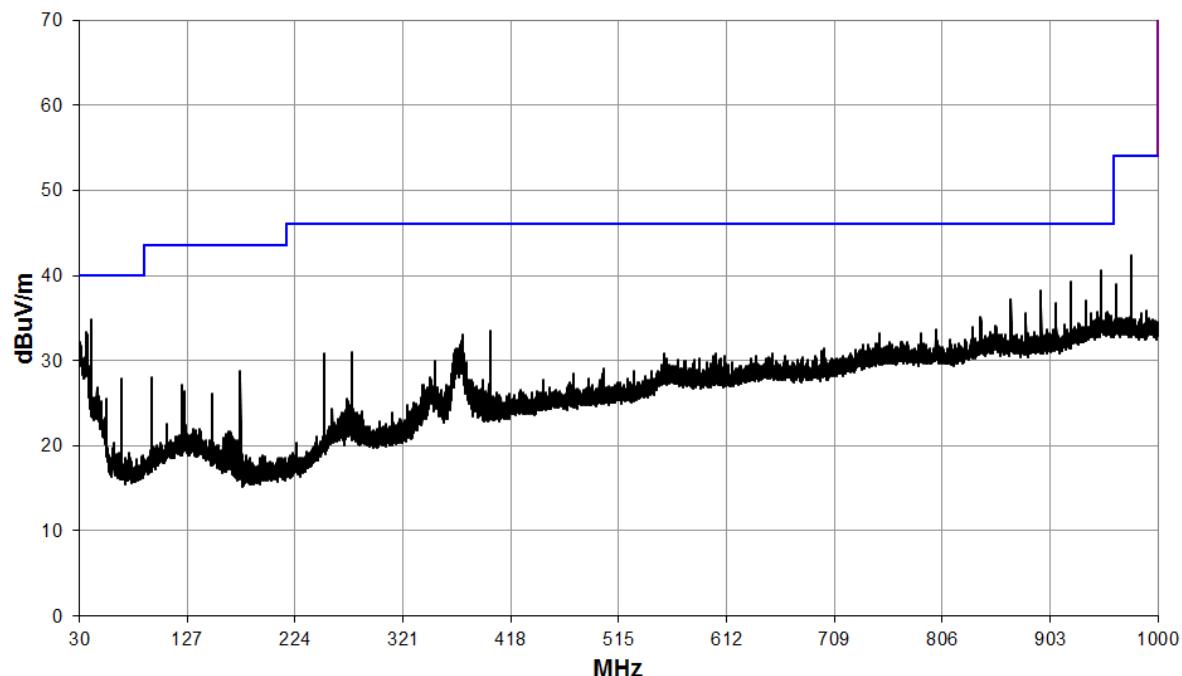


12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2019-07-23
Bilog Antenna	Chase	CBL6111B	REF2218	2019-11-06

12.6 Test Results

Detector	Frequency (MHz)	Measured Emission (dB μ V)	Factors (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
Quasi-peak	30.0	0.1	25.0	25.1	18.0	100.0
Quasi-peak	37.2	3.9	21.7	25.6	19.1	100.0
Quasi-peak	40.7	13.6	19.8	33.4	46.8	100.0
Quasi-peak	250.0	8.2	20.9	29.1	28.5	200.0
Quasi-peak	275.0	6.2	21.1	27.3	23.2	200.0
Quasi-peak	375.0	5.3	23.7	29.0	28.2	200.0
Quasi-peak	400.0	5.4	24.5	29.9	31.3	200.0
Quasi-peak	867.8	1.4	33.3	34.7	54.3	200.0
Quasi-peak	881.4	-0.2	33.3	33.1	45.2	200.0
Quasi-peak	895.0	2.2	33.3	35.5	59.6	200.0
Quasi-peak	908.5	-0.9	33.5	32.6	42.7	200.0
Quasi-peak	922.1	2.3	33.8	36.1	63.8	200.0
Quasi-peak	935.6	-0.3	34.7	34.4	52.5	200.0
Quasi-peak	949.2	3.5	35.2	38.7	86.1	200.0
Quasi-peak	976.3	4.4	35.1	39.5	94.4	500.0



13 Occupied Bandwidth

13.1 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.

13.2 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 BW:	10 kHz
Spectrum Analyzer Video BW:	30 kHz
Measurement Span:	50 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 20 V dc	As declared

13.3 Test Limit

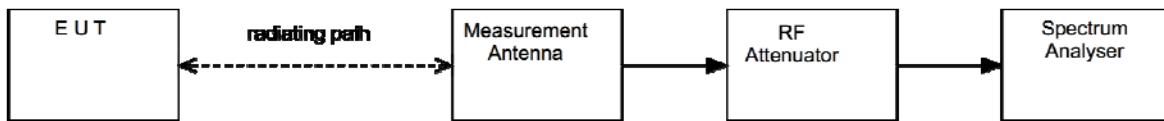
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific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

13.4 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

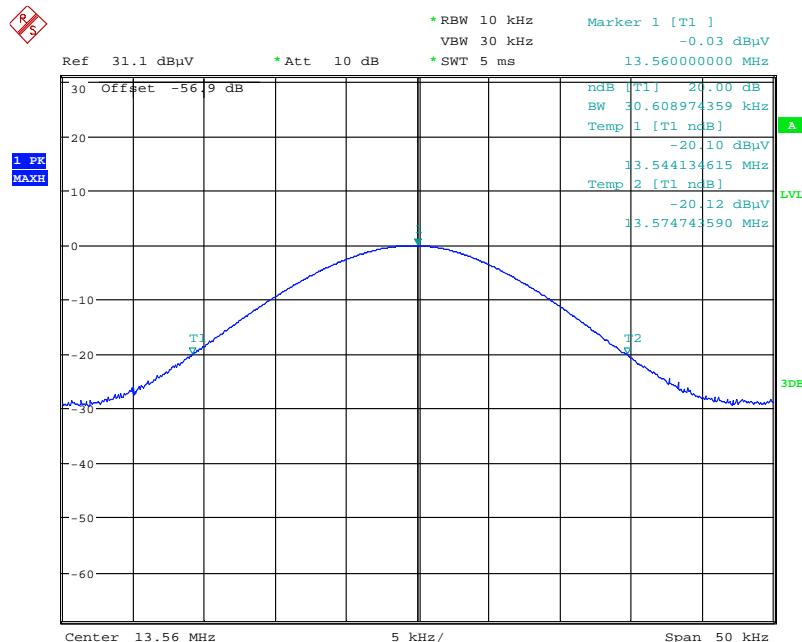


13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	U281	2019-11-20
7429-1	Solar Electronics	Loop Antenna	RFG408	Calibrate before use

13.6 Test Results

Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	20 dB Bandwidth (kHz)
13.56	13.54413	13.57474	30.609



14 Transmitter output power (fundamental radiated emission)

14.1 Definition

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

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1 & 3
Test Antenna:	Active 60 cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
EUT Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Detector:	Quasi-peak
Voltage Extreme Environment Test Range:	17 Vdc – 23 Vdc

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 20 Vdc	As declared

14.3 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

14.4 Test Method

With the EUT 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,

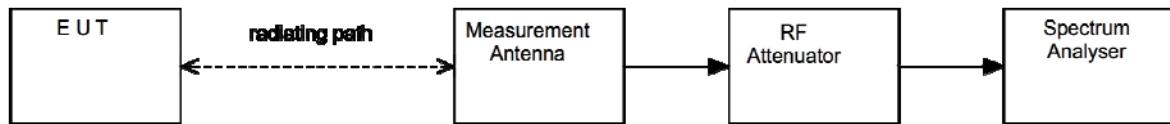
PR is the power recorded on the receiver / spectrum analyzer in dBµV and includes any cable loss, antenna factor and pre-amplifier gain;

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

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

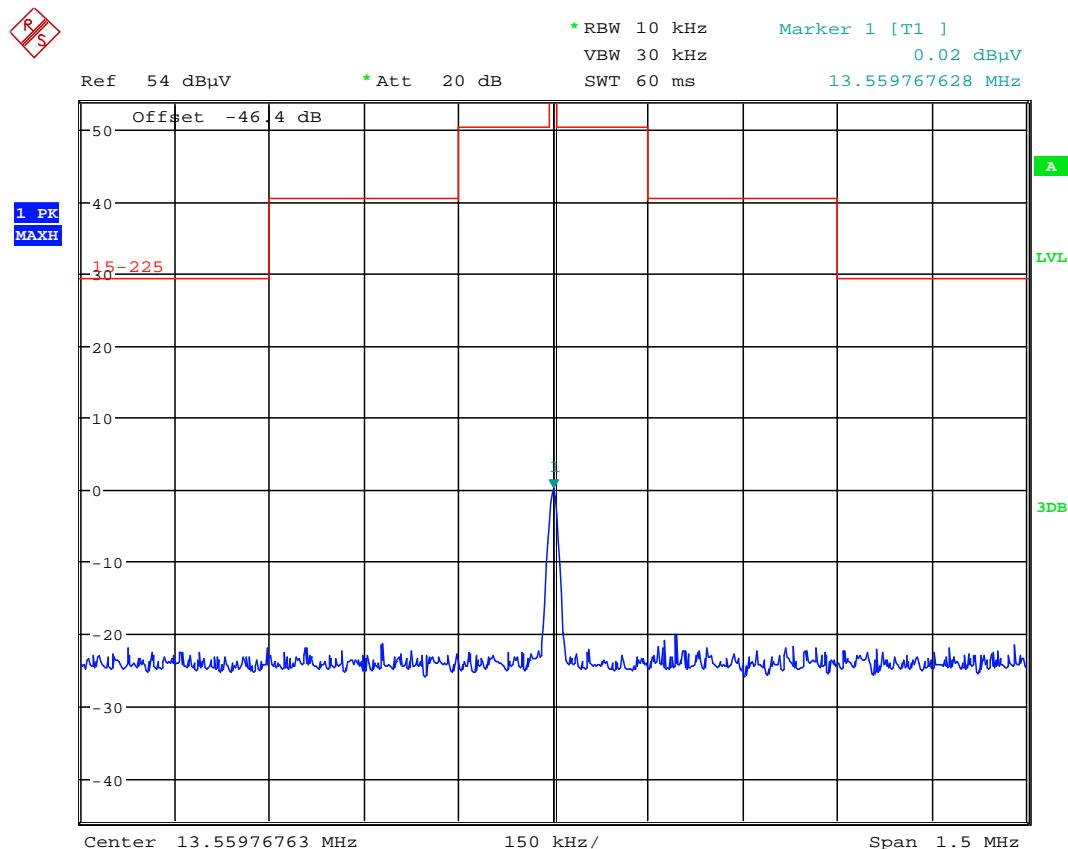


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2019-07-23
FSU46	R&S	Spectrum Analyser	U281	2019-11-20
6502	EMCO	Active Loop Antenna	R0079	2019-05-24
7429-1	Solar Electronics	Loop Antenna	RFG408	Calibrate before use

14.6 Test Results

Channel Frequency (MHz)	Receiver Level (dB μ V/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Result
13.56	40.0	3	30	40.0	0.0	1.0	PASS



15 Frequency stability

15.1 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.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequency Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	17 Vdc - 23 Vdc

Environmental Conditions (Normal Environment)

Temperature: 21 °C	Standard Requirement: +20 °C
Humidity: 40 %RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

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

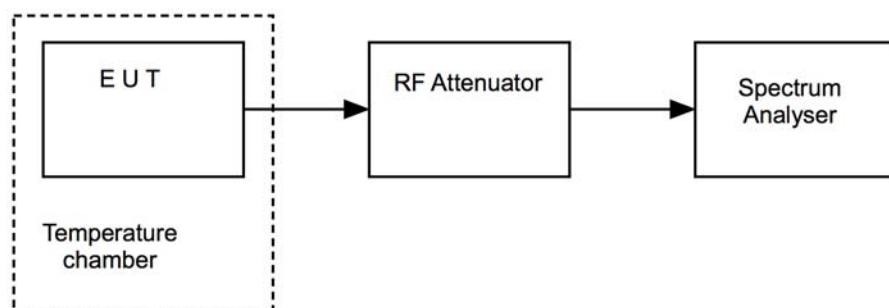
15.4 Test Method

With the EUT 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



15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	U281	2019-11-20
7429-1	Solar Electronics	Loop Antenna	RFG408	Calibrate before use

15.6 Test Results

EUT Frequency: 13.56 MHz					
Test Environment		Measured Frequency (MHz)	Frequency error (kHz)	Limit (kHz)	Result
-20 C	V _{nominal}	13.559770	-0.230	± 1.356	PASS
-10 C	V _{nominal}	13.559711	-0.289	± 1.356	PASS
0 C	V _{nominal}	13.559650	-0.350	± 1.356	PASS
+10 C	V _{nominal}	13.559625	-0.375	± 1.356	PASS
+20 C	V _{minimum}	13.559583	-0.417	± 1.356	PASS
	V _{nominal}	13.559582	-0.418	± 1.356	PASS
	V _{maximum}	13.559582	-0.418	± 1.356	PASS
+30 C	V _{nominal}	13.559552	-0.448	± 1.356	PASS
+40 C	V _{nominal}	13.559543	-0.457	± 1.356	PASS
+50 C	V _{nominal}	13.559500	-0.500	± 1.356	PASS

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: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 29 % 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

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.

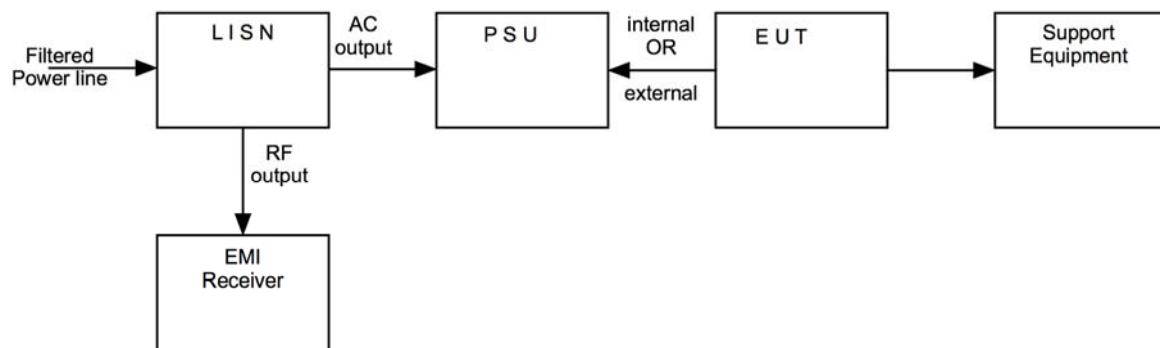
**A linear average detector is required.

16.4 Test Method

With the EUT setup in a screened room, and connected as per Figure ii, 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.

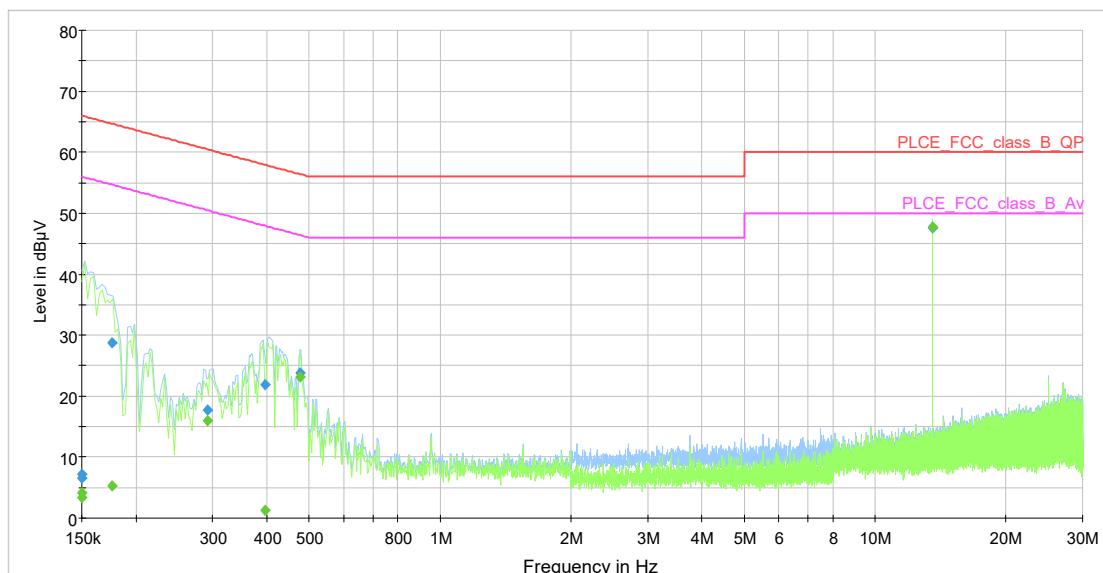
Figure ii Test Setup**16.5 Test Set-up Photograph****16.6 Test Equipment**

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Measuring Receiver	R&S	ESCI7	RFG715	2019-11-16
LISN	R&S	ESH3-Z5	RFG732	2019-05-22
Pulse Limiter	R&S	ESH3-Z2	RFG674	2019-04-06

16.7 Test Results

Results measured using the average detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.150	L1	4.2	56.0	51.8	PASS
2	0.150	N	3.3	56.0	52.7	PASS
3	0.176	N	5.2	54.7	49.5	PASS
4	0.291	N	16.0	50.5	34.5	PASS
5	0.396	L1	1.3	47.9	46.6	PASS
6	0.477	L1	23.1	46.4	23.3	PASS
7	13.562	N	47.8	50.0	2.2	PASS

Results measured using the quasi-peak detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.150	L1	7.3	66.0	58.7	PASS
2	0.150	N	6.5	66.0	59.5	PASS
3	0.176	N	28.8	64.7	35.9	PASS
4	0.291	N	17.8	60.5	42.7	PASS
5	0.396	L1	21.9	57.9	36.0	PASS
6	0.477	L1	23.8	56.4	32.6	PASS
7	13.562	N	47.6	60.0	12.4	PASS



17 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated emissions below 30 MHz

Uncertainty in test result (9 kHz to 30 MHz) = **2.3 dB**

[2] Spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[3] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[4] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[5] Maximum frequency error

Uncertainty in test result (Power Meter) = **0.113 ppm**
Uncertainty in test result (Spectrum Analyser) = **0.265 ppm**