Report on the Radio Testing

For

Controlled Electronic Management Systems Limited

on

S700 Access Control Reader

Report no. TRA-032043-47-04A

15th March 2017

Report Number: TRA-032043-47-04A
Issue: A

REPORT ON THE RADIO TESTING OF A
Controlled Electronic Management Systems Limited
S700 Access Control Reader
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 6th - 10th March 2017

Tested by: D Winstanley — D Winstanley, Senior Radio Test Engineer

Approved by: Digitally signed by John Charters
DN: cn=John Charters, o=Element Materials Technology, ou, email=john.charters@element.com, c=GB
Date: 2017.03.15 11:40:56 Z — J Charters, Department Manager - Radio

Date: 15th March 2017

Element Materials Technology Warwick Ltd.
Registered in England and Wales. Registered Office: 5 Fleet Place, London, EC4M 7RD
Company Reg No. 02536659

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	15th March 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-032043-47-04A
WORKS ORDER NUMBER	TRA-032034-16
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):	S700 Access Control Reader
FCC IDENTIFIER:	QABS700V1-00
EUT SERIAL NUMBER:	#004
MANUFACTURER/AGENT:	Controlled Electronic Management Systems Limited
ADDRESS:	Accounts Payable Mailpoint 1006 PO Box 3572 Stone ST15 9DX United Kingdom
CLIENT CONTACT:	Tim Harrison ☎ 9078 8027 ✉ tiharrison@tycoint.com
ORDER NUMBER:	Not Applicable
TEST DATE:	6th - 10th March 2017
TESTED BY:	D Winstanley Element

2.1 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-032043-47-04A presents the results of the Radio testing on a Controlled Electronic Management Systems Limited, S700 Access Control Reader to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Controlled Electronic Management Systems Limited by Element, at the address(es) 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:
Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

ISED Registration Number(s):

Element Skelmersdale	3930B
Element Hull	3483A

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: S700 Access Control Reader
- Serial Number: #004
- Model Number: S700
- Software Revision: MCP V0.3.3 / KEYPAD V2.5.1

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.

	Description	***Make***	***Model***	***Serial Number***
1	Laptop	Dell	Lattitude E5440	7F3KK12
2	Ethernet Switch	NETGEAR	FS105V2	1D52253X000C2
3	Door Simulator	CEM	Ver 1	N/A
4	Magnetic Lock	Generic	Generic	N/A

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows…

Test	Description of Operating Mode
All tests detailed in this report	EUT actively transmitting either waiting for a tag to be presented or reading a tag as required.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Antenna:	Integral
Nominal Supply Voltage:	12 Vdc

7.5 EUT Description

The EUT is a Multifunction IP Access Terminal. It contains a 13.56 MHz RFID Reader

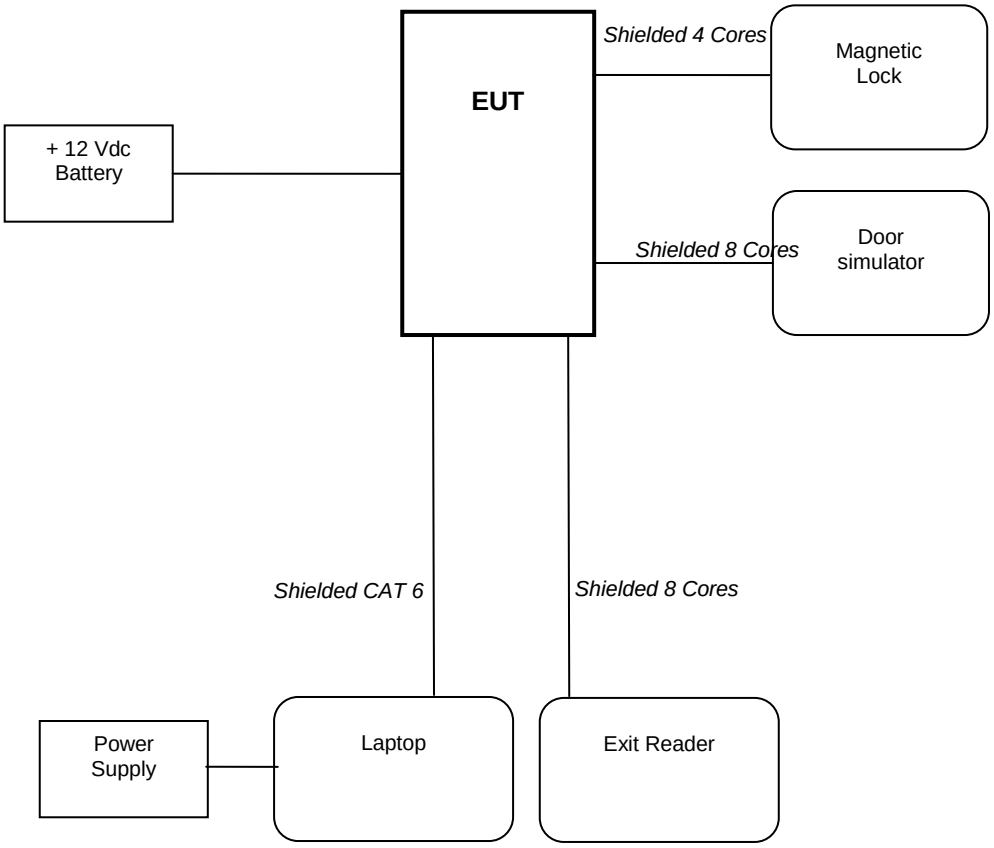
8 Modifications

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:

10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 12 V dc from a battery.

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	110 V ac +/-2 %	85 % and 115 %
☒	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 Skelmersdale
Test Chamber:	Chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Distance and Site	3m Alternative test sites (for preview) 10 m, OATS without ground plane (for Formals)
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: 15 °C	+15 ºC to +35 ºC (as declared)
Humidity: 39 % RH	20 % RH to 75 % RH (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:

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

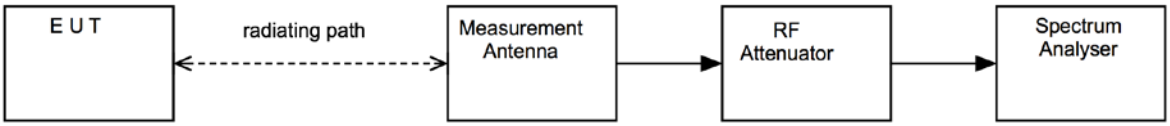
Where,

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);

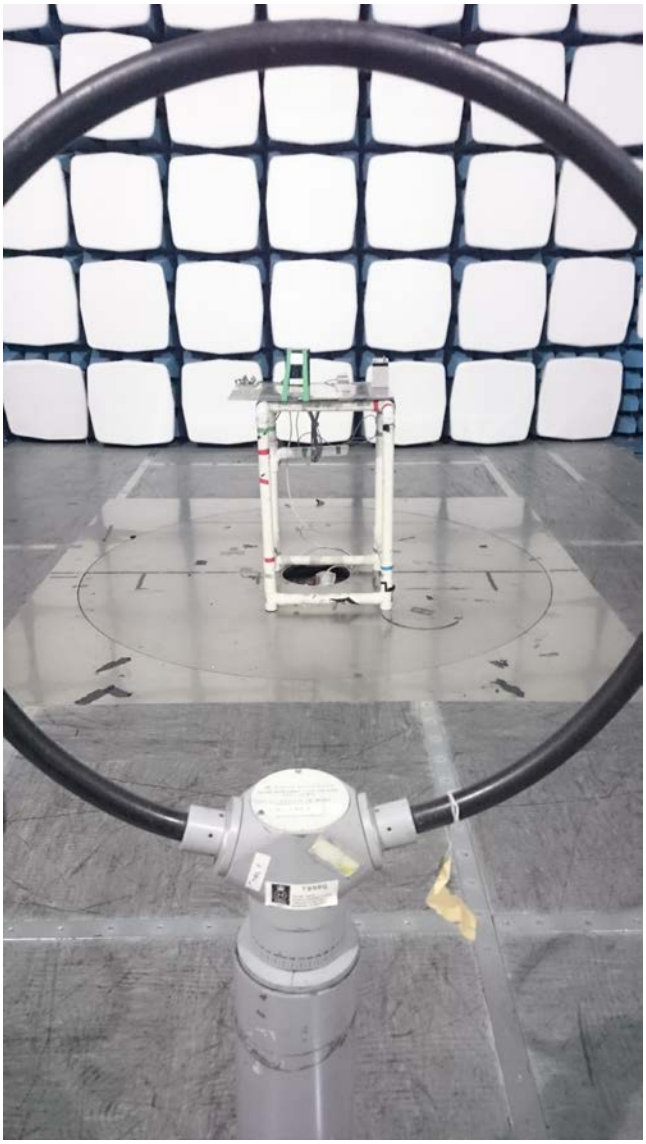
Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

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

Figure i Test Setup



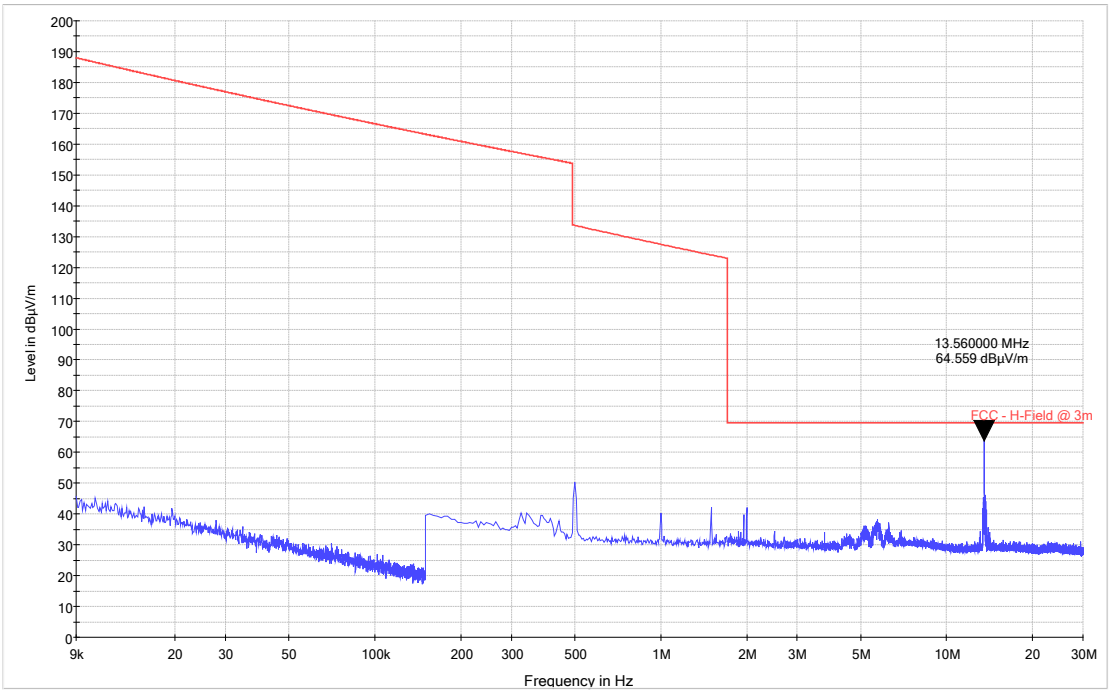
11.5 Test Set-up Photograph



11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESR7	R&S	EMI Receiver	U456	03/09/2016
hfh2	R&S	Loop Antenna	L007	10/04/2017

11.7 Test Results



Emission Frequency (MHz)	*Receiver Level (dBµV/m)*	*Measurement Distance (m)*	*Limit Distance (m)*	*Extrapolation Factor (dB)*	*Field Strength (µV/m)*	*Result*
No Significant Emissions						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:	Radio Chamber
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 300 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 24 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

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

General Field Strength Limits for License-Exempt Transmitters at Frequencies 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:

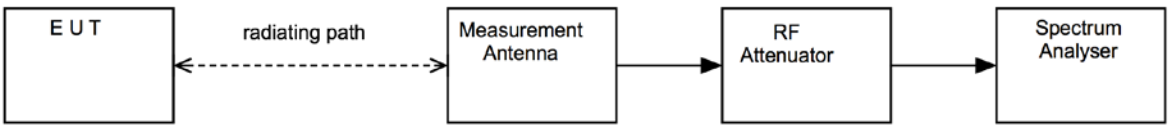
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

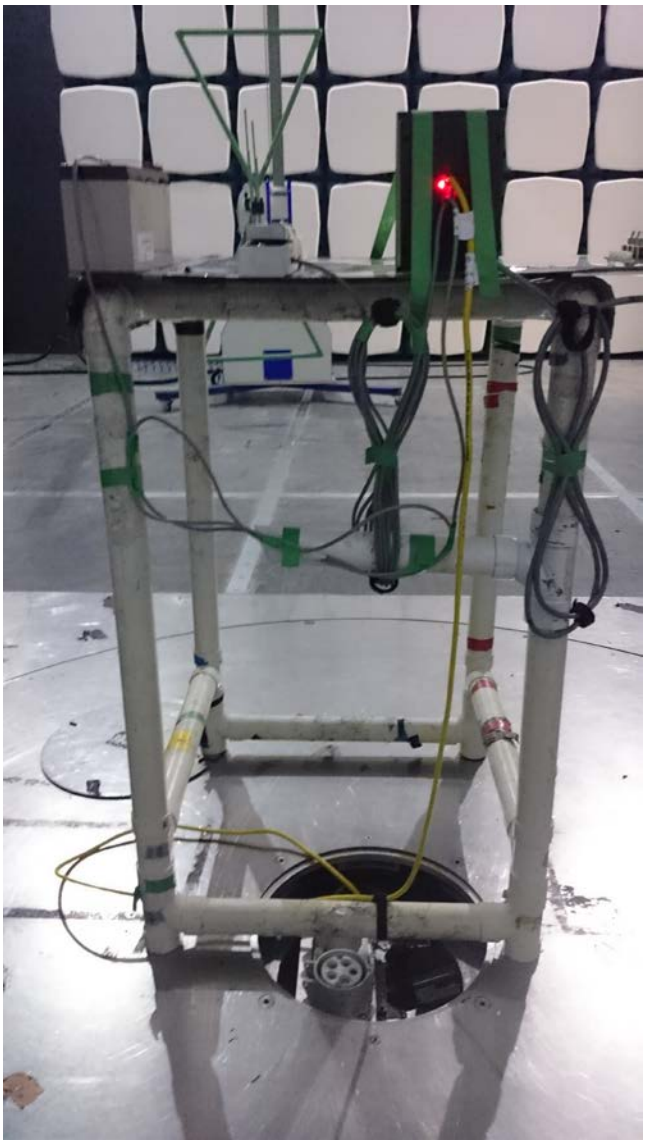
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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



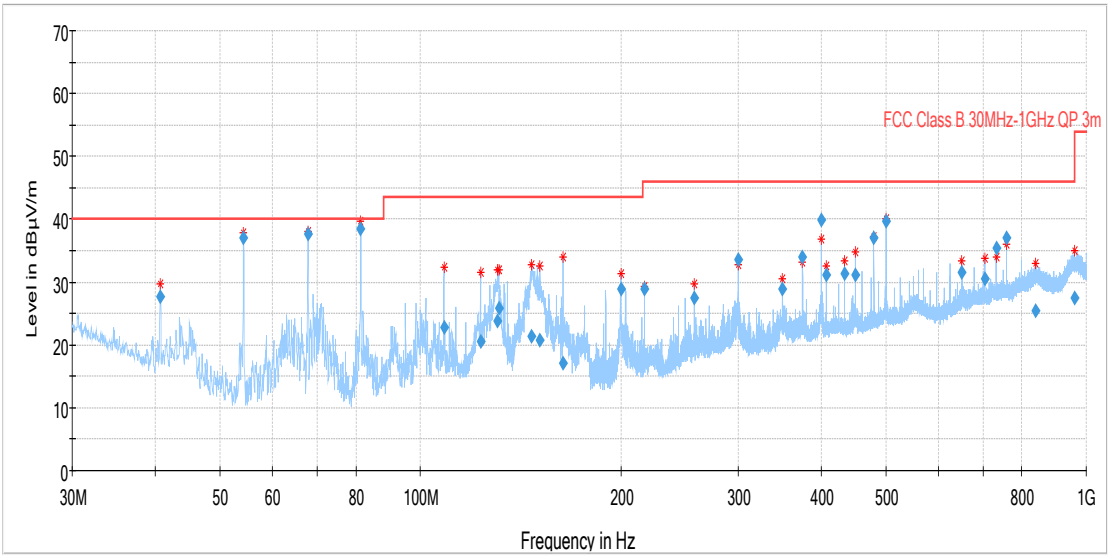
12.5 Test Set-up Photograph



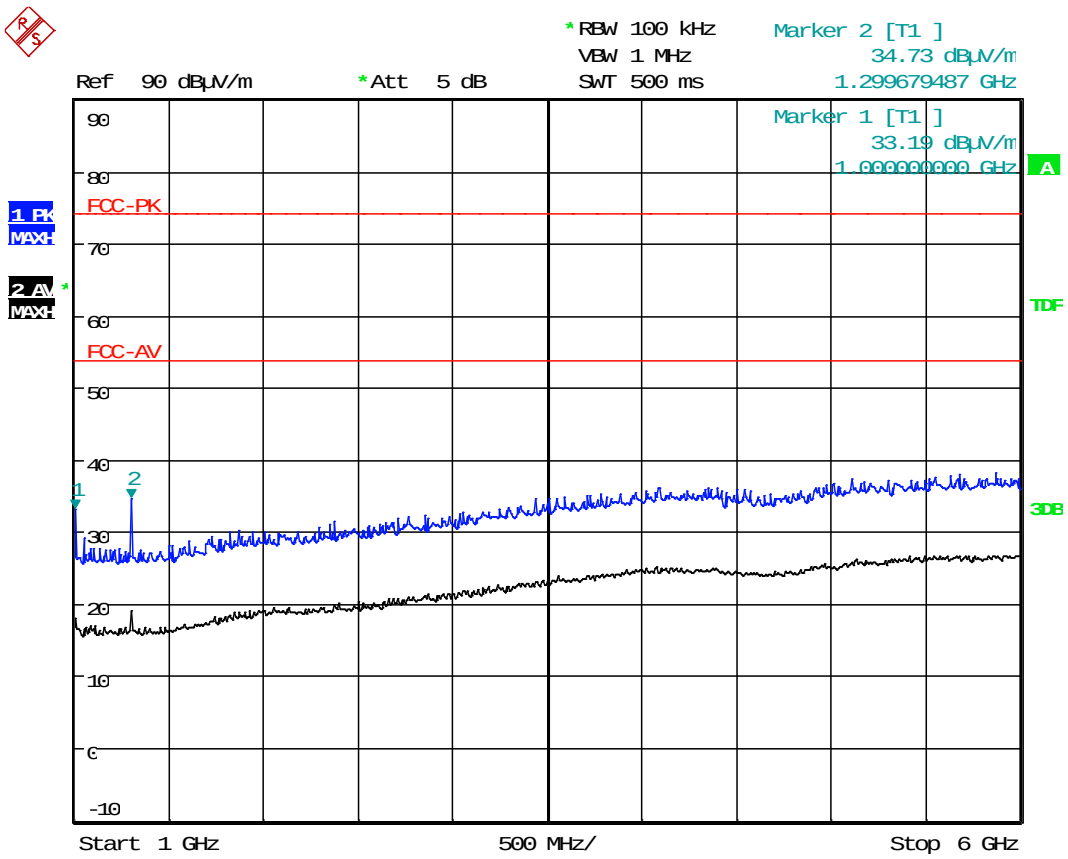
12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	L290	08/12/2018
ESVS10	R&S	Receiver	L317	11/03/2017
8449B	Agilent	Pre Amp	L572	07/02/2018
3115	EMCO	1-18GHz Horn	L139	25/09/2017
FSU46	R&S	Spectrum Analyser	U281	07/06/2017

12.7 Test Results



Det	Freq. (MHz)	Meas'd Emission (dBµV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
QP	40.70	13.66	1.00	13.45	N/A	0.00	0.00	28.11	25.44	100
QP	54.25	29.31	1.20	7.08	N/A	0.00	0.00	37.59	75.77	100
QP	67.80	31.11	1.30	6.18	N/A	0.00	0.00	38.59	85.02	100
QP	81.35	30.48	1.30	7.87	N/A	0.00	0.00	39.65	96.05	100
QP	200.00	17.65	2.00	8.20	N/A	0.00	0.00	27.85	24.69	150
QP	217.00	17.23	2.10	9.20	N/A	0.00	0.00	28.53	26.70	200
QP	257.65	12.52	2.20	13.17	N/A	0.00	0.00	27.89	24.80	200
QP	300.00	18.86	2.33	12.70	N/A	0.00	0.00	33.89	49.49	200
QP	375.00	16.35	2.60	14.65	N/A	0.00	0.00	33.60	47.86	200
QP	400.00	21.58	2.72	15.50	N/A	0.00	0.00	39.80	97.72	200
QP	406.80	12.61	2.79	15.94	N/A	0.00	0.00	31.34	36.90	200
QP	433.95	12.45	2.90	16.10	N/A	0.00	0.00	31.45	37.37	200
QP	450.00	12.13	2.90	16.50	N/A	0.00	0.00	31.53	37.71	200
QP	480.00	17.55	3.03	17.00	N/A	0.00	0.00	37.58	75.68	200
QP	500.00	18.89	3.12	17.60	N/A	0.00	0.00	39.61	95.61	200
QP	650.90	8.26	3.43	19.60	N/A	0.00	0.00	31.29	36.69	200
QP	705.15	6.23	3.54	20.12	N/A	0.00	0.00	29.89	31.22	200
QP	732.30	11.29	3.70	21.52	N/A	0.00	0.00	36.51	66.91	200
QP	759.40	12.70	3.70	21.40	N/A	0.00	0.00	37.80	77.62	200
QP	839.95	-1.38	3.88	22.00	N/A	0.00	0.00	24.50	16.79	200
QP	959.70	-1.83	4.15	24.50	N/A	0.00	0.00	26.82	21.93	200


*RBW 100 kHz
VBW 1 MHz
SWT 500 ms
Marker 2 [T1]
34.73 dBµV/m
1.299679487 GHz
Marker 1 [T1]
33.19 dBµV/m
1.000000000 GHz
Ref 90 dBµV/m
*Att 5 dB
1 PK MAXH
2 AV MAXH
FCC-PK
FCC-AV
A
TDF
3DB
Start 1 GHz
500 MHz/
Stop 6 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 Skelmersdale
Test Chamber:	Transient Lab (U390)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (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 (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.

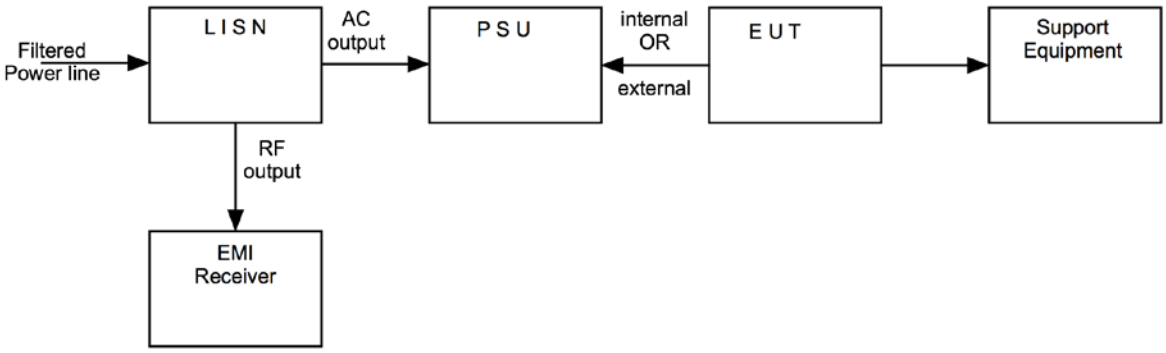
13.4 Test Method

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

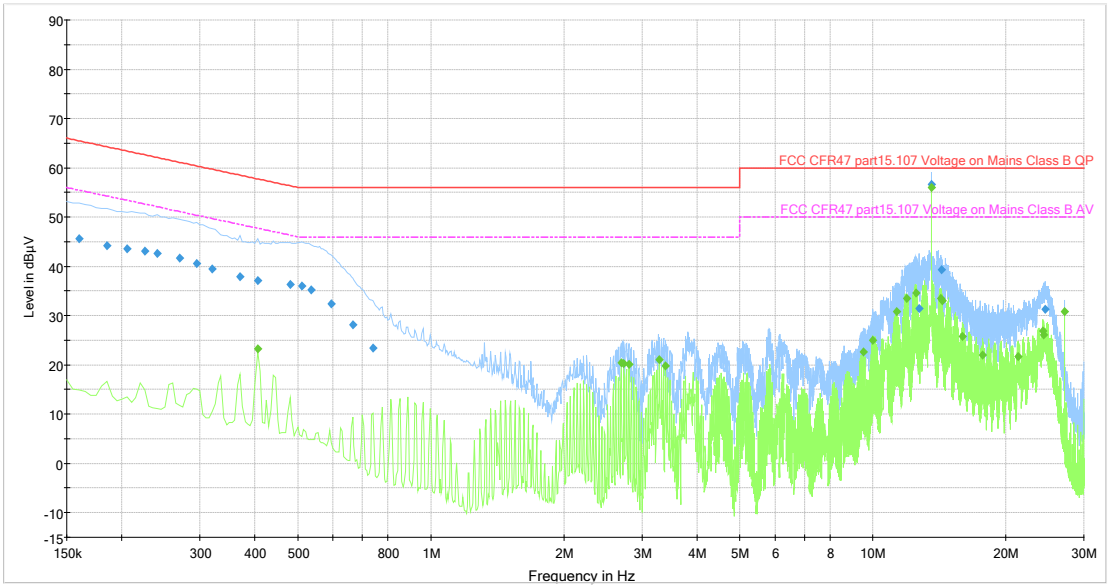


13.5 Test Set-up Photograph

13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Receiver	U003	25/06/2017
ESH3-Z5.831.5	R&S	Lisn	U195	25/05/2017
ESH3-Z2	R&S	Pulse Limiter	U559	28/07/2017

13.7 Test Results



QuasiPeak Detector								
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.160000	45.6	2000.0	10.000	GND	N	10.1	19.9	65.5
0.185000	44.2	2000.0	10.000	GND	N	10.1	20.0	64.3
0.205000	43.5	2000.0	10.000	GND	N	10.1	19.9	63.4
0.225000	43.0	2000.0	10.000	GND	N	10.1	19.6	62.6
0.240000	42.6	2000.0	10.000	GND	N	10.1	19.5	62.1
0.270000	41.7	2000.0	10.000	GND	N	10.1	19.4	61.1
0.295000	40.6	2000.0	10.000	GND	N	10.1	19.7	60.4
0.320000	39.5	2000.0	10.000	GND	N	10.1	20.2	59.7
0.370000	37.9	2000.0	10.000	GND	L1	10.1	20.6	58.5
0.405000	37.2	2000.0	10.000	GND	N	10.1	20.6	57.8
0.480000	36.3	2000.0	10.000	GND	N	10.1	20.0	56.3
0.510000	35.9	2000.0	10.000	GND	N	10.1	20.1	56.0
0.535000	35.3	2000.0	10.000	GND	N	10.2	20.7	56.0
0.595000	32.4	2000.0	10.000	GND	N	10.2	23.6	56.0
0.665000	28.1	2000.0	10.000	GND	L1	10.2	27.9	56.0
0.740000	23.4	2000.0	10.000	GND	N	10.2	32.6	56.0
12.715000	31.4	2000.0	10.000	GND	L1	10.8	28.6	60.0
13.560000	56.6	2000.0	10.000	GND	L1	10.8	3.4	60.0
14.290000	39.4	2000.0	10.000	GND	L1	10.9	20.6	60.0
24.535000	31.2	2000.0	10.000	GND	L1	11.6	28.8	60.0

QuasiPeak Detector Antenna Replaced with Load								
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
13.560000	57.3	2000.0	10.000	GND	N	10.8	2.7	60.0

Average Detector								
Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.405000	23.2	2000.0	10.000	GND	N	10.1	24.5	47.8
2.695000	20.4	2000.0	10.000	GND	N	10.3	25.6	46.0
2.730000	20.3	2000.0	10.000	GND	N	10.3	25.7	46.0
2.805000	20.1	2000.0	10.000	GND	N	10.2	25.9	46.0
3.285000	21.0	2000.0	10.000	GND	N	10.3	25.0	46.0
3.395000	19.8	2000.0	10.000	GND	N	10.3	26.2	46.0
9.525000	22.6	2000.0	10.000	GND	L1	10.6	27.4	50.0
10.005000	25.0	2000.0	10.000	GND	L1	10.6	25.0	50.0
11.335000	30.8	2000.0	10.000	GND	L1	10.7	19.2	50.0
11.925000	33.5	2000.0	10.000	GND	L1	10.7	16.5	50.0
12.515000	34.7	2000.0	10.000	GND	L1	10.8	15.3	50.0
13.560000	56.0	2000.0	10.000	GND	L1	10.8	-6.0	50.0
14.215000	33.5	2000.0	10.000	GND	L1	10.9	16.5	50.0
14.325000	33.0	2000.0	10.000	GND	L1	10.9	17.0	50.0
15.950000	25.8	2000.0	10.000	GND	L1	11.0	24.2	50.0
17.685000	21.9	2000.0	10.000	GND	L1	11.1	28.1	50.0
21.305000	21.7	2000.0	10.000	GND	L1	11.3	28.3	50.0
24.260000	26.9	2000.0	10.000	GND	L1	11.6	23.1	50.0
24.295000	26.0	2000.0	10.000	GND	L1	11.6	24.0	50.0
27.120000	30.8	2000.0	10.000	GND	L1	11.6	19.2	50.0

Average Detector Antenna Replaced with Load								
Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
13.560000	43.2	2000.0	10.000	GND	N	10.8	6.8	50.0

14 Occupied Bandwidth

14.1 Definition

Occupied bandwidth
The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5 % of the emitted power. This is also known as the *99 % emission bandwidth*. For transmitters in which there are multiple carriers, contiguous or non-contiguous in frequency, the occupied bandwidth is to be the sum of the occupied bandwidths of the individual carriers.

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 Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels / Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	10 kHz
Spectrum Analyzer Video BW:	30 kHz
Measurement Span:	2 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 23 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	12 V dc ±15 % (as declared)

14.3 Test Limit

Industry Canada:
When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99 % emission bandwidth, as calculated or measured.

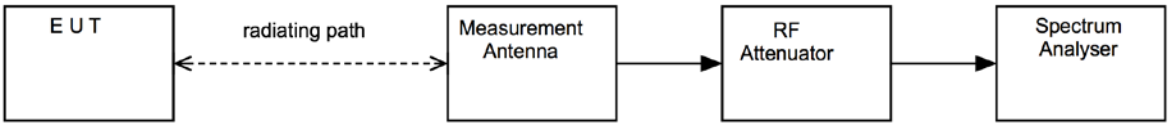
Federal Communications Commission:
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise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

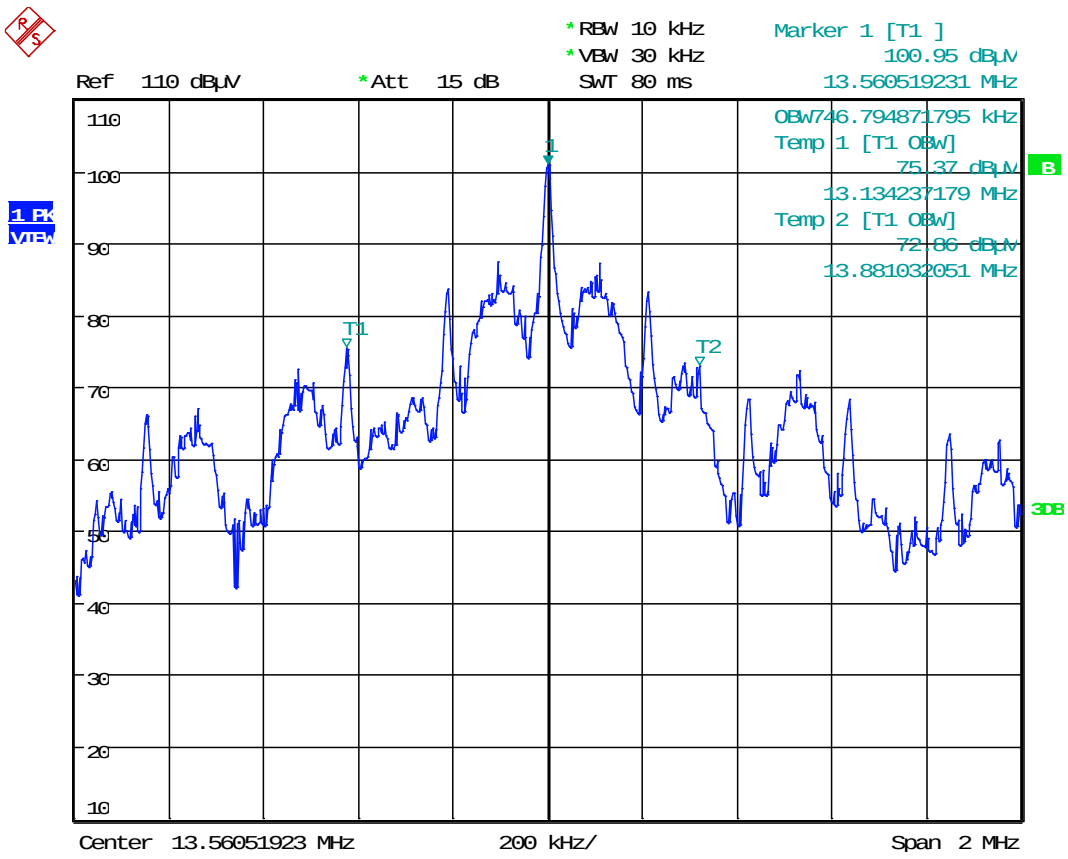


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	16/03/2017

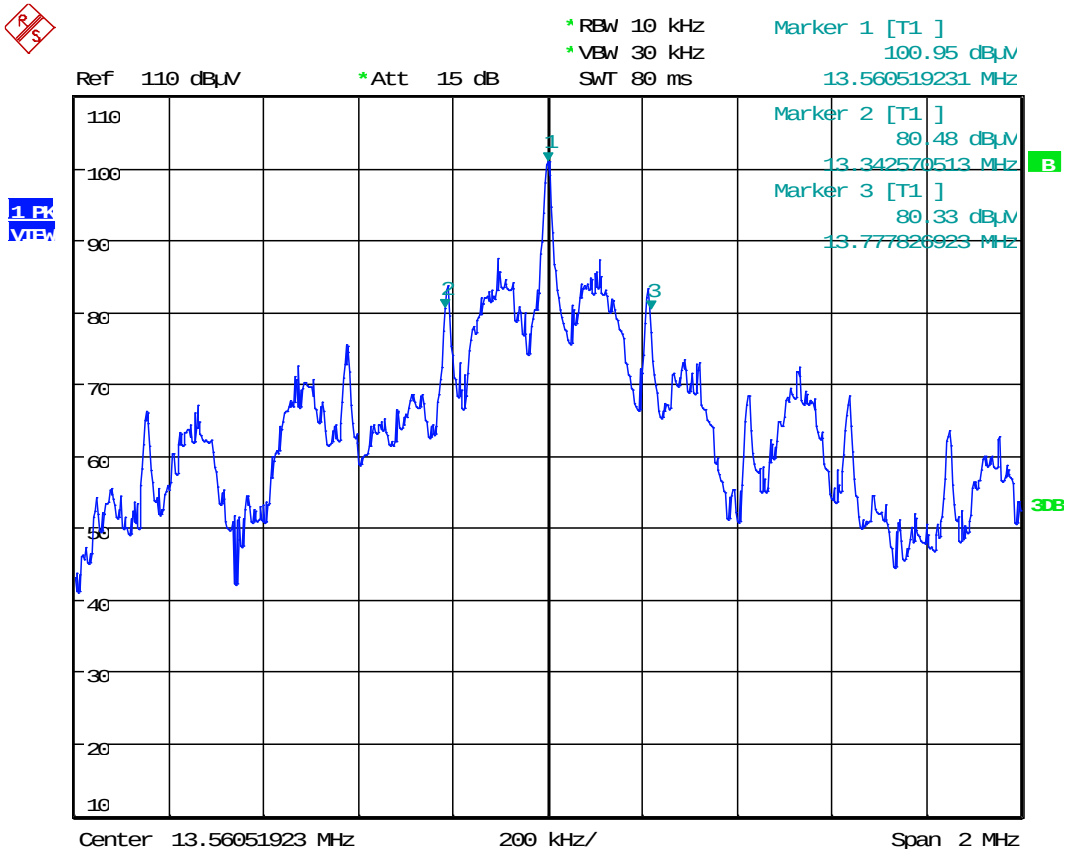
14.6 Test Results

RSS-210.			
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***99 % Bandwidth (kHz)***
13.56	13.13423717	13.88103205	746.794881



Date: 10.MAR.2017 15:07:54

15.225			
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***20 dB Bandwidth (kHz)***
13.56	13.34257051	13.77782692	435.2564093



Date: 10.MAR.2017 15:09:57

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:	Radio Chamber - Outdoor test site
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
Measurement BW:	9 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 12 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % 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,

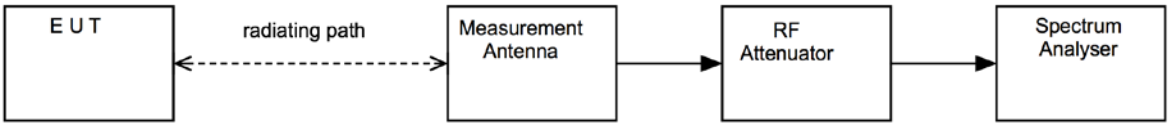
PR is the power recorded on the receiver / spectrum analyzer in dBµV and includes any cable loss, antenna factor and pre-amplifier gain;
CF is the distance extrapolation factor in dB (where measurement distance different to limit distance);

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. Giving a factor or 19.08 dB between 10 meters and 30 meters

Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor of 18 dB was determined from measurements at 3 and 10 metres. Giving an extrapolation of 37 .08 between 3 meters and 30 meters

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

Figure v Test Setup

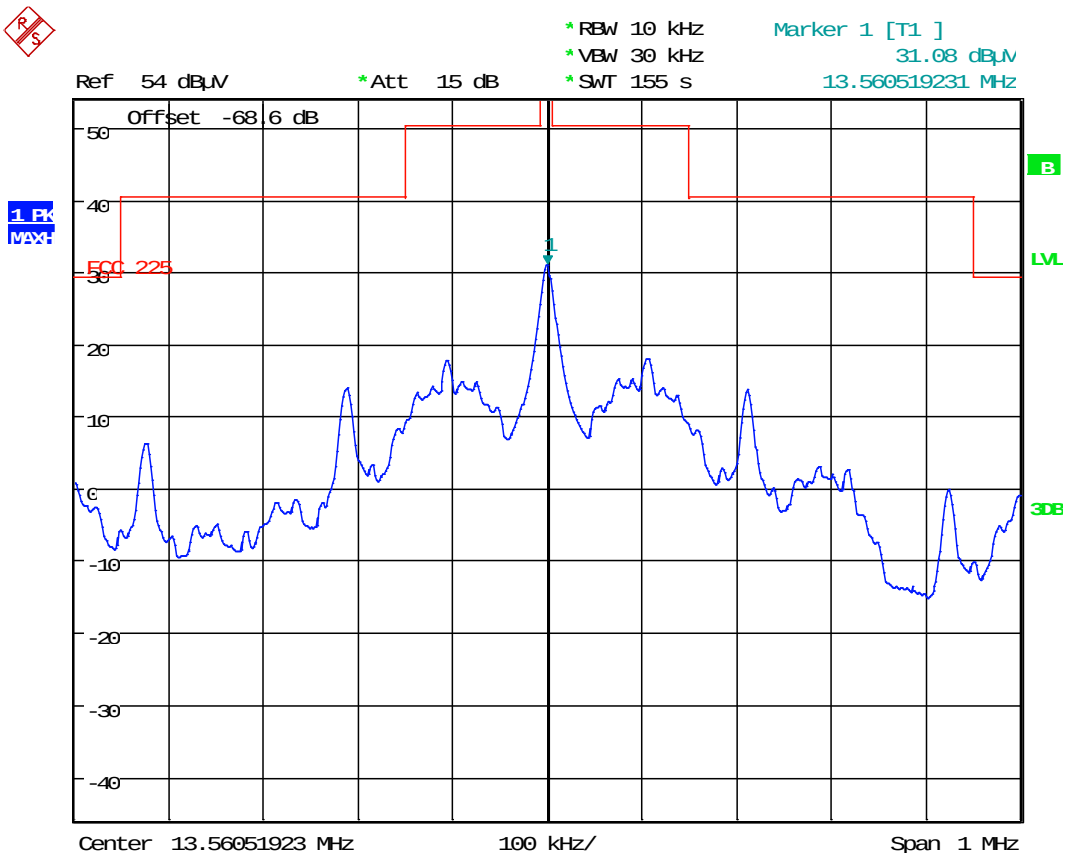


15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Receiver	U187	25/10/2017
hfh2	R&S	Loop Antenna	L007	10/04/2017

15.6 Test Results

Channel Frequency (MHz)	Receiver Level (dBµV/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (µV/m)	Result
13.56	68.1	3	30	36.88	**36.329**	PASS
13.56	50.3	10	30	19.08	**36.329**	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 Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Channels / Frequencies Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	Mains Power = ±15% of Nominal; IC: Battery: nominal and end point; FCC: Battery: new battery.

Environmental Conditions (Normal Environment)

Temperature: 22 °C	Standard Requirement: +20 ºC
Humidity: 42 %RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

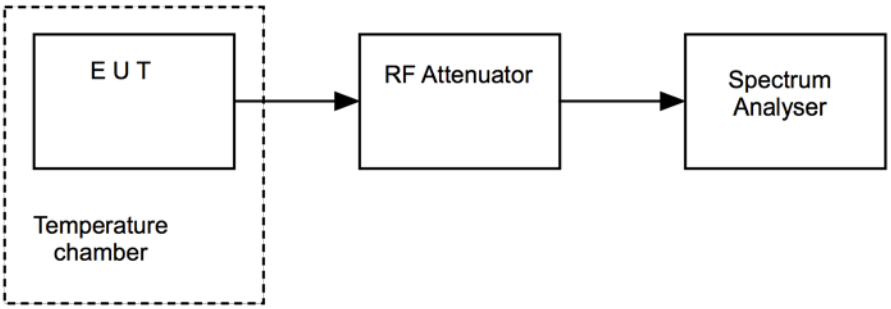
Carrier frequency stability shall be maintained to ±0.01% (±100 ppm).

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.

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 Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	16/03/2017
VT 4002	Votsch	Temperature Chamber	U521	Use L426
52 Series II	Fluke	Temperature Indicator	L426	02/06/2017
IPS-303DD	ISO-Tech	Power Supply	U515	Use REF976
34405a	Agilent	Multimeter	REF976	31/05/2017

16.6 Test Results

Test Environment		*Measured Frequency (MHz)*	*Frequency error (kHz)*	*Frequency error (%)*	*Result*
-20 C	$V_{nominal}$	13.56057933	0.579327	0.004272	PASS
-10 C	$V_{nominal}$	13.56057692	0.576923	0.004255	PASS
0 C	$V_{nominal}$	13.56055529	0.555288	0.004095	PASS
+10 C	$V_{nominal}$	13.56052885	0.528846	0.003900	PASS
+20 C	$V_{minimum}$	13.56049680	0.496795	0.003664	PASS
	$V_{nominal}$	13.56049519	N/A	N/A	N/A
	$V_{maximum}$	13.56049519	0.495192	0.003652	PASS
+30 C	$V_{nominal}$	13.56046555	0.465545	0.003433	PASS
+40 C	$V_{nominal}$	13.56043830	0.438301	0.003232	PASS
+50 C	$V_{nominal}$	13.56042388	0.423878	0.003126	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**

18 RF Exposure

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.
The SAR Test Exclusion Threshold for frequency range below 100 MHz will be determined as follows.

SAR Exclusion Threshold (SARET) = (Step 1 + Step 2) * Step 3

Step 1

$$NT = [(MP/TSD^{A}) * \sqrt{f_{GHz}}]$$

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)
MP = Max Power of channel (mW) (including tune-up tolerance)
TSD^{A} = Min Test separation Distance or 50mm (whichever is lower) = 5mm (in this case)

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

$$= [(NT \times TSD^{A}) / \sqrt{f_{GHz}}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2 $(TSD^{B} – 50mm) * 10$

Where:

TSD^{B} = Min Test separation Distance (mm) = 50

Note: Step 2 doesn't apply here as the TSD^{A} is less than 50 mm

Step 3

a) the power threshold at the corresponding test separation distance at 100 MHz in step 2 is multiplied by [1 + log (100/ f_{MHz}))] for test separation distances > 50 mm and < 200 mm

b) the power threshold determined by the equation in steps 1 for 50 mm and 100 MHz is multiplied by ½ for test separation distances ≤ 50 mm

$$SARET = [(NT \times TSD^{A}) / \sqrt{f_{GHz}}] * ½$$
$$SARET = [(3.0 \times 50) / \sqrt{0.1}] * ½$$
SARET = 474.34 mW

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
13.56	3.71×10^{-5}	474.34	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

Prediction of MPE limit at a given distance

$$S = \frac{EIRP}{4\pi R^2} \quad \text{re-arranged } R = \sqrt{\frac{EIRP}{S4\pi}}$$

Where:

S = power density
R = distance to the centre of radiation of the antenna
EIRP = EUT Maximum power

Result

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/cm^2)	Distance (R) cm required to be less than 0.98 mW/cm^2
13.56	3.71×10^{-5}	0.98	0.0018

Note: EIRP calculated from maximum radiated field strength