

Report on the Radio Testing
For
MacDonald Humfrey Automation Ltd.
on
HF RFID Handheld Scanner
Report no. TRA-033116-01-45-00A
14th March 2017

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



RF914 4.0

Report Number: TRA-033116-01-45-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
MacDonald Humfrey Automation Ltd.
HF RFID Handheld Scanner
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225 & IC RSS-210 Annex 2.6

TEST DATE: From 17-1-2017 to 23-1-2017

Tested by: A Wong

Alan Wong
Atif Tosif
Adam Longley
Radio Test Engineers

Approved by:

John Charters
Department Manager - Radio

Date:

14th March 2017

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

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

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	14 th March 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-033116-01-45-00A
WORKS ORDER NUMBER	TRA-033116-01
PURPOSE OF TEST:	<p>USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.</p> <p>Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.</p>
TEST SPECIFICATION(S):	47CFR15.225 & RSS-210 Annex 2.6
EQUIPMENT UNDER TEST (EUT):	HF RFID Handheld Scanner
FCC IDENTIFIER:	2AKLH
ISED CERTIFICATION NUMBER:	22275
EUT SERIAL NUMBER:	00000145
MANUFACTURER:	MacDonald Humfrey Automation Ltd.
ADDRESS:	<p>29-35 Bolton Road Luton Bedfordshire LU1 3HY United Kingdom</p>
CLIENT CONTACT:	<p>Gordon Matthews  0044 (0)1582 405741  gordon.matthews@mhaltd.co.uk</p>
ORDER NUMBER:	057452
TEST DATE:	From 17-1-2017 to 23-1-2017
TESTED BY:	<p>Alan Wong Element</p>

2.1 Test Summary

Test Method and Description	Requirement Clause		Applicable to this equipment	Result / Note
	RSS	47CFR15		
Radiated spurious emissions, below 30 MHz	210, A2.6(d)	15.225(d)	<input checked="" type="checkbox"/>	PASS
Radiated spurious emissions	Gen, 6.13	15.209	<input checked="" type="checkbox"/>	PASS
AC power line conducted emissions	Gen, 8.8	15.207	<input checked="" type="checkbox"/>	PASS
Occupied bandwidth	Gen, 6.6	15.215(c)	<input checked="" type="checkbox"/>	PASS
Field strength of fundamental	210, A2.6(a), (b) and (c)	15.225(a), (b) and (c)	<input checked="" type="checkbox"/>	PASS
Frequency stability	210, A2.6	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.....	8
5	Test Specifications.....	9
5.1	Normative References.....	9
5.2	Deviations from Test Standards	9
6	Glossary of Terms	10
7	Equipment Under Test.....	11
7.1	EUT Identification	11
7.2	System Equipment.....	11
7.3	EUT Mode of Operation.....	11
7.3.1	Transmission	11
7.3.2	Reception	11
7.4	EUT Radio Parameters.....	12
7.4.1	General.....	12
7.4.2	Antennas	12
7.5	EUT Description.....	13
8	Modifications.....	13
9	EUT Test Setup	14
9.1	Block Diagram	14
9.2	General Set-up Photograph.....	15
10	General Technical Parameters	16
10.1	Normal Conditions	16
10.2	Varying Test Conditions.....	16
11	Radiated emissions below 30 MHz.....	17
11.1	Definitions.....	17
11.2	Test Parameters	17
11.3	Test Limit.....	18
11.4	Test Method.....	18
11.5	Test Set-up Photograph.....	19
11.6	Test Equipment.....	20
11.7	Test Results.....	20
12	Radiated emissions	22
12.1	Definitions.....	22
12.2	Test Parameters	22
12.3	Test Limit.....	22
12.4	Test Method.....	23
12.5	Test Set-up Photograph.....	24
12.6	Test Equipment.....	25
12.7	Test Results.....	25
13	Occupied Bandwidth.....	27
13.1	Definition.....	27
13.2	Test Parameters	27
13.3	Test Limit.....	27
13.4	Test Method.....	28
13.5	Test Equipment.....	28
13.6	Test Results.....	29
14	Transmitter output power (fundamental radiated emission).....	31
14.1	Definition.....	31
14.2	Test Parameters	31
14.3	Test Limit.....	31
14.4	Test Method.....	32
14.5	Test Equipment.....	32
14.6	Test Results.....	33
15	Frequency stability.....	35
15.1	Definition.....	35
15.2	Test Parameters	35
15.3	Test Limit.....	35
15.4	Test Method.....	36
15.5	Test Equipment.....	36
15.6	Test Results.....	37
16	Measurement Uncertainty.....	38
17	RF Exposure.....	39
18	AC power-line conducted emissions.....	42

18.1	Definition.....	42
18.2	Test Parameters	42
18.3	Test Limit	42
18.4	Test Method.....	43
18.5	Test Set-up Photographs.....	44
18.6	Test Equipment.....	45
18.7	Test Results.....	46

4 Introduction

This report TRA-033116-01-45-00A presents the results of the Radio testing on a MacDonald Humfrey Automation Ltd., HF RFID Handheld Scanner, 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 MacDonald Humfrey Automation Ltd. by Element, at the address(es) 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.

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.
- Industry Canada RSS-210, Issue 8, December 2010 – Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

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: HF RFID Handheld Scanner
- Serial Number: 00000145
- Model Number: MHA 00025505
- Software Revision: 2.6
- Build Level / Revision Number: Production

7.2 System Equipment

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The two test modes of operation for Tx tests could be obtained as follows:

When the EUT is connected to a USB port on a computer, it will boot into a test mode, transmitting continuous wave at 13.56 MHz, with unmodulated signal for the relevant tests. To obtain continuous modulated signal, hold the trigger button before plugging the EUT to a USB port on a computer. Once connected, wait for booting up and release the button, EUT will then transmit a modulated signal with centre frequency at 13.56 MHz.

7.3.2 Reception

'Receiver only' test mode is not applicable. The EUT cannot operate in 'receiver only' mode, because RFID tags need to be energised by transmitter in a scanner, before sending signals to the scanner.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Modulation type(s):	ASK, 100%
Occupied channel bandwidth(s):	26.48 kHz
Channel spacing:	n/a (single channel)
ITU emission designator(s):	13M5H1DXN
Declared output power(s):	20 dBm
Warning against use of alternative antennas in user manual (yes/no):	Not applicable - Integral, non-replaceable antenna
Nominal Supply Voltage:	5V
Frequency stability:	+/-10ppm (based on crystal used)
Location of notice for license exempt use:	Label / user manual / both.
Method of prevention of use on non-US / non-Canadian frequencies:	Implicit within component selection
Duty cycle:	100%

7.4.2 Antennas

Type:	Printed loop
Frequency range:	Pre-tuned to operating frequency
Impedance:	27 Ω.
SWR:	Not Applicable - fixed antenna
Gain:	Not applicable as this is by direct induction
Polarisation:	Non polarised, will work in either orientation
Beam width:	200mm
Connector type:	n/a
Length / diameter:	64 x 39 mm
Weight:	7 grams
Environmental limits:	-40 to +85 °C (Industrial spec)
Mounting:	Internal, PCB

7.5 *EUT Description*

MacDonald Humfrey's Hand held HF Hand Held Tag Reader is for the identification of single preprogrammed RFID tags, this product has been designed to be used in conjunction with the MachSecure product range.

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 regulated 5 V dc from a USB socket on a computer.

10.2 Varying Test Conditions

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

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

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

	Category	Nominal	Variation
<input type="checkbox"/>	Mains		85 % and 115 %
<input type="checkbox"/>	Battery	New battery	N/A
<input checked="" type="checkbox"/>	USB socket on computer	5V	N/A

11 Radiated emissions below 30 MHz

11.1 Definitions

Out-of-band emissions

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

Spurious emissions

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

Restricted bands

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

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
EUT Channels / Frequencies Measured:	13.56 MHz
EUT Channel Bandwidths:	26.48 kHz
Deviations From Standard:	None
Measurement Distance and Site	3m SAR with 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: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	Regulated 5V in USB socket on computer

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 (μ A/m) 2,400 / f (μ V/m)	300
490 to 1,750	24,000 / 377. f (μ A/m) 24,000 / f (μ V/m)	30
1,750 to 30,000	30 (μ V/m)	30

n.b. Devices operated pursuant to §15.225 / 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 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 μ V/m at the regulatory distance, using:

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

Where,

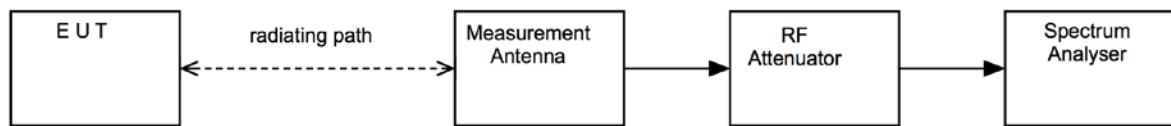
PR is the power recorded on the receiver / spectrum analyzer in $\text{dB}\mu\text{V}$ and includes any cable loss, antenna factor and pre-amplifier gain;

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

Per FCC 47CFR15.31(f)(2) / 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



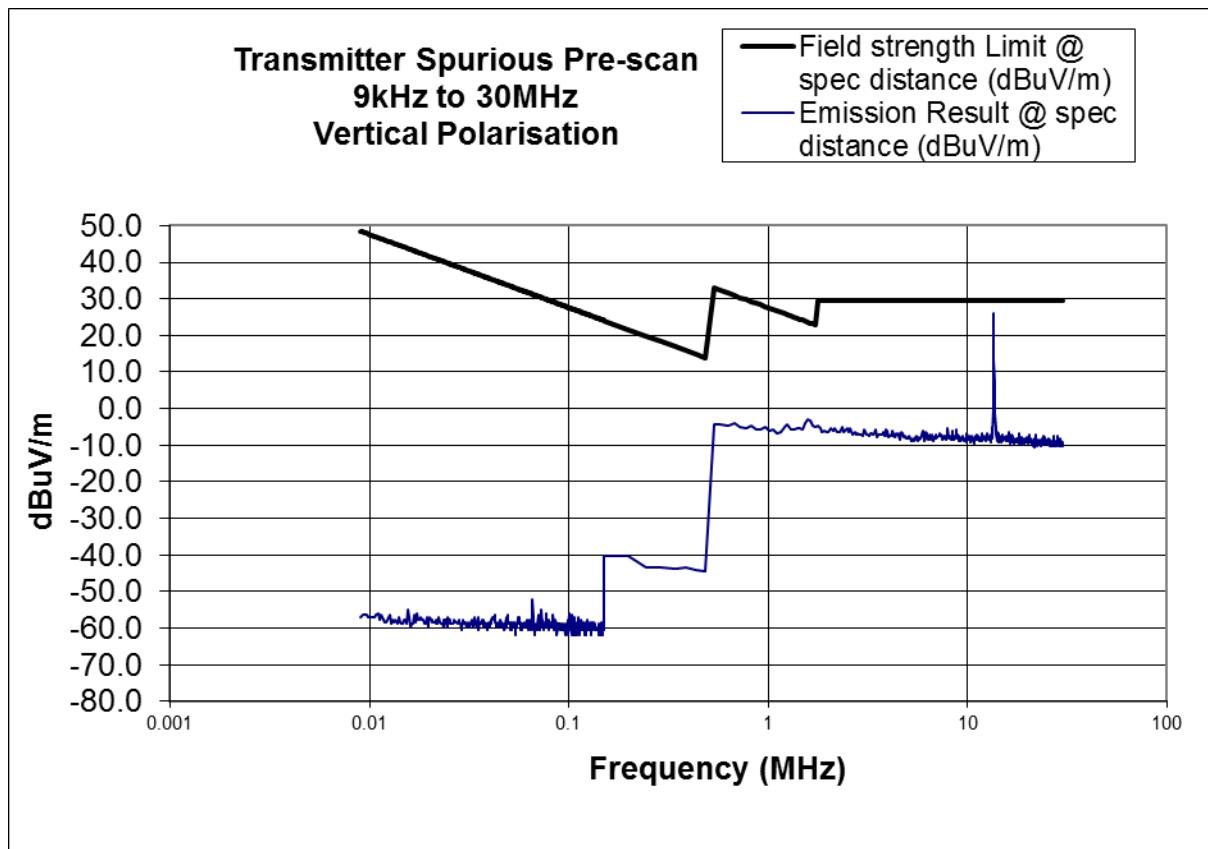
11.5 Test Set-up Photograph



11.6 Test Equipment

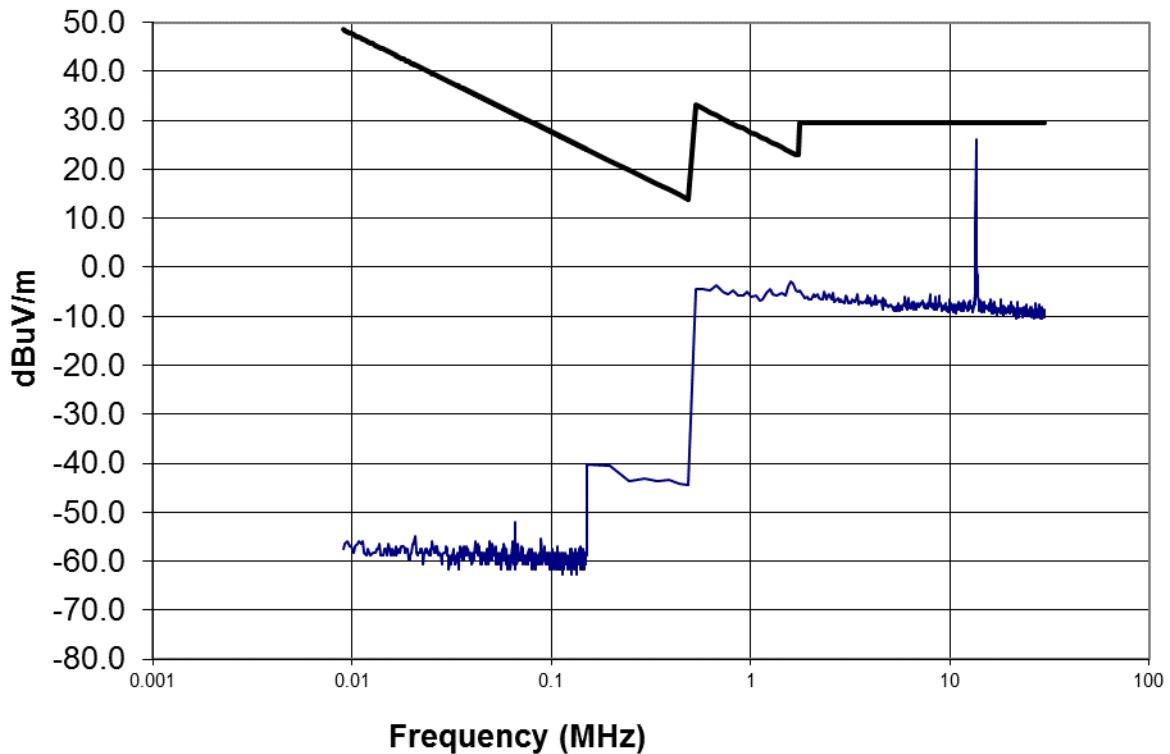
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/2017
Amplifier	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
Cable	Unknown	N-Type RF coaxial cable	REF884	05/12/2017
Cable	AtlanTec	Short SMA RF Cable	REF2165	09/12/2017
Antenna	EMCO	Biconical Antenna	RFG095	17/05/2019
Antenna	EMCO	Log Periodic Antenna	RFG191	17/05/2019

11.7 Test Results



Transmitter Spurious Pre-scan
9kHz to 30MHz
Horizontal Polarisation

— Field strength Limit @ spec distance (dB μ V/m)
 — Emission Result @ spec distance (dB μ V/m)



Modulation: RFID; Data rate: RFID; Power setting: Normal

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 significant spurious emissions detected						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. Clause 15.205 (d)(4) exempts the EUT from the requirements of Clause 15.205.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab16
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
EUT Channels / Frequencies Measured:	13.56 MHz
EUT Channel Bandwidths:	26.48 kHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 300 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	Regulated 5V in USB socket on computer

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;

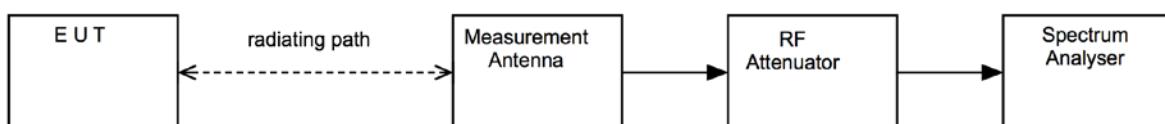
PA is the pre-amplifier gain in dB (where used);

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



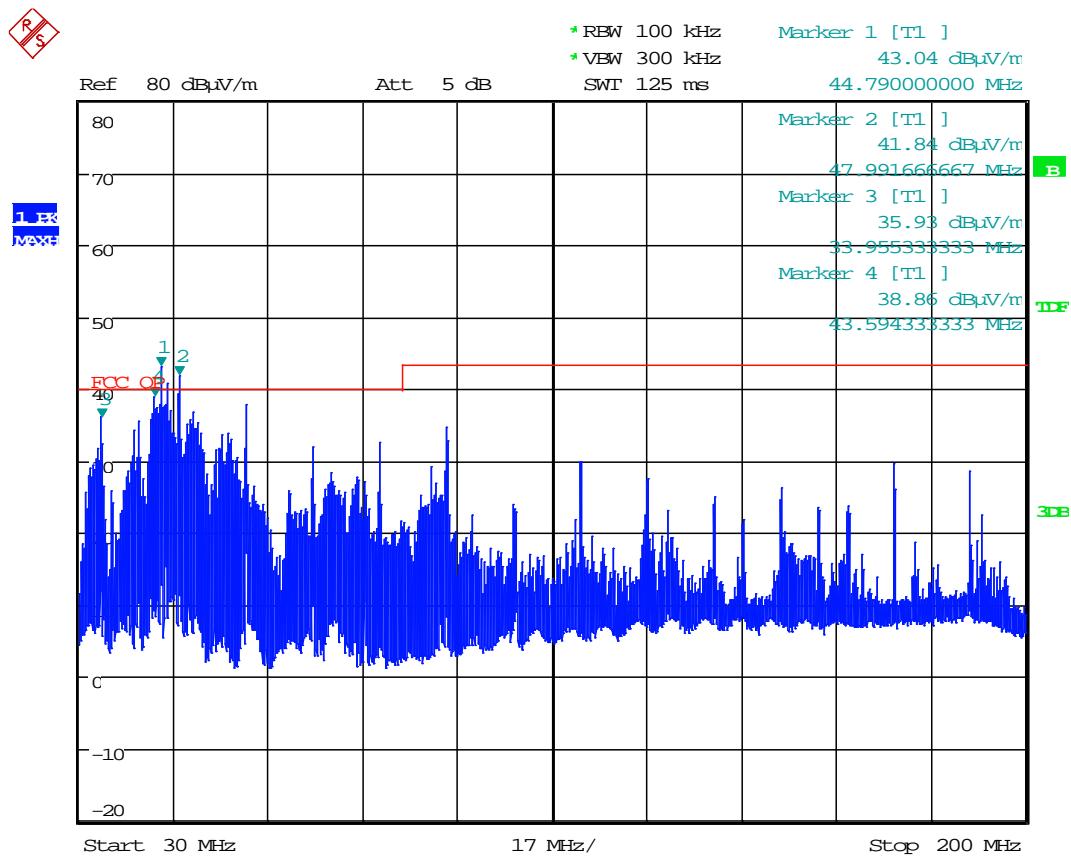
12.5 Test Set-up Photograph



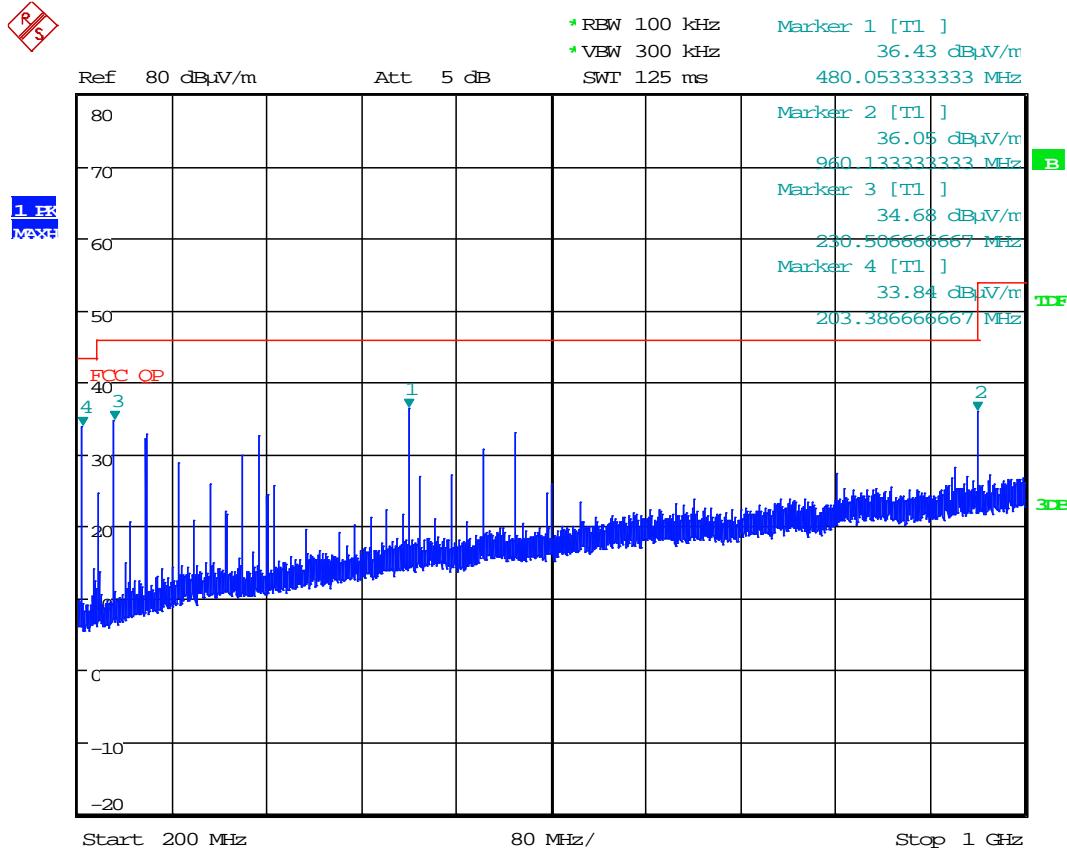
12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/2017
Amplifier	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
Cable	Unknown	N-Type RF coaxial cable	REF884	05/12/2017
Antenna	EMCO	Biconical Antenna	RFG095	17/05/2019
Antenna	EMCO	Log Periodic Antenna	RFG191	17/05/2019
ESVS20	R&S	EMI Test Receiver	RFG126	23/05/2017

12.7 Test Results



Date: 17.JAN.2017 12:02:54

R
S

Date: 17.JAN.2017 14:15:46

Nominal Operating Power; Single Channel: 13.56 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dB μ V)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
Quasi Peak	40.677	57.8	0.7	11.4	31.6	N/A	0	38.3	82.2	150
Quasi Peak	48.005	59.4	0.7	10.2	31.6	N/A	0	38.7	86.1	150
Quasi Peak	48.031	57.9	0.7	10.2	31.6	N/A	0	37.2	72.4	150
Quasi Peak	54.240	20.1	0.6	9.1	31.6	N/A	0	29.8	30.9	150
Quasi Peak	54.251	56.5	0.6	9.0	31.6	N/A	0	34.5	53.09	150
Quasi Peak	71.509	44.6	0.8	9.0	31.6	N/A	0	22.8	13.8	150
Quasi Peak	203.402	21.8	1.5	10.7	31.5	N/A	0	34.0	50.1	150
Quasi Peak	480.050	10.7	2.8	17.2	31.6	N/A	0	30.7	34.3	200
Quasi Peak	960.105	6.4	4.0	23.1	30.2	N/A	0	33.5	47.3	500

13 Occupied Bandwidth

13.1 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.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Frequency Measured:	13.56 MHz
EUT Channel Bandwidth:	26.48 kHz
EUT Test Modulation:	ASK
Deviations From Standard:	None
Measurement BW: (requirement: 1% to 5% OBW)	5.1 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	20 kHz
Measurement Span: (requirement 2 to 5 times OBW)	2 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	Regulated 5V in USB socket on computer

13.3 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:

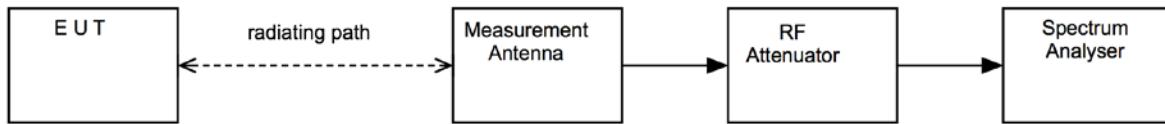
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific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

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

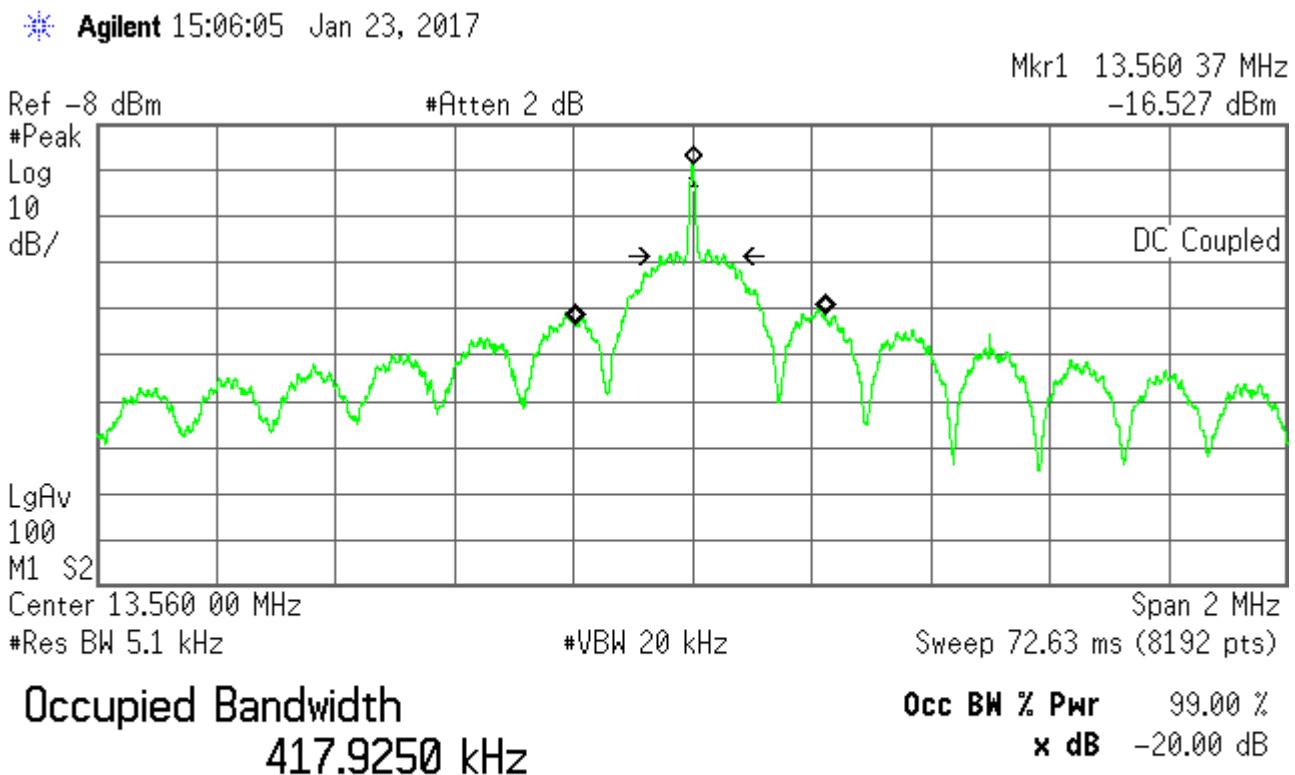


13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
E4440A	Agilent	Spectrum Analyser	REF837	22/06/2017
Antenna	Solar Electronics	Loop Antenna	RFG408	N/A
Power supply	HP	DC power supply	RFG464	N/A
34405A	Agilent	Multimeter	REF887	22/09/2017

13.6 Test Results

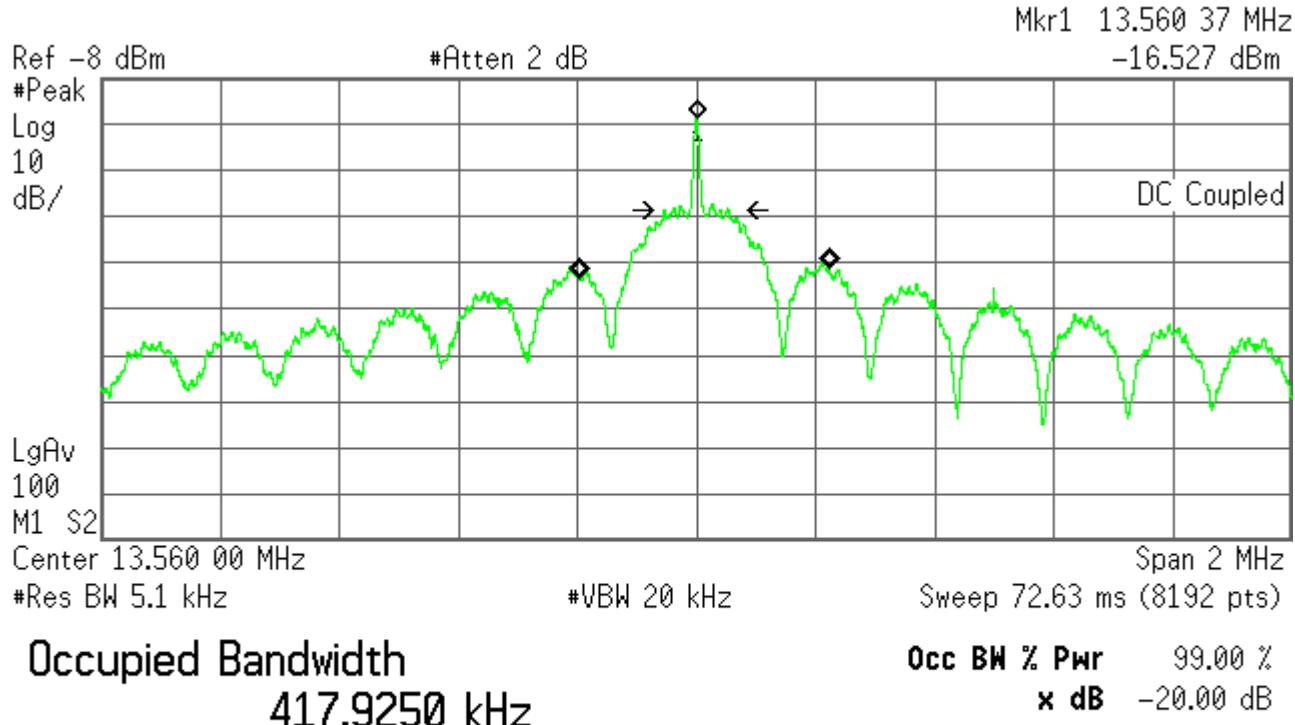
RSS-210. Modulation: RFID; Power setting: -71.25 dBm			
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	99 % Bandwidth (kHz)
13.56	13.3510375	13.7689625	417.9250



Transmit Freq Error 13.799 kHz
 x dB Bandwidth 93.206 kHz

15.225. Modulation: RFID; Power setting: -71.25 dBm			
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	20 dB Bandwidth (kHz)
13.56	13.513397	13.606603	93.206

Agilent 15:06:05 Jan 23, 2017



Transmit Freq Error 13.799 kHz
 x dB Bandwidth 93.206 kHz

Occupied Bandwidth Upper / Lower Limits				
Min. F_L (MHz)	F_{drift} (kHz)	$F_L - F_{drift}$ (MHz)	Limit (MHz)	Result
15.36	0.070	13.560046	13.110,000	PASS
Max. F_H (MHz)	F_{drift} (kHz)	$F_H + F_{drift}$ (MHz)	Limit (MHz)	Result
13.56	-0.082	13.560199	14.010,000	PASS

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:	Lab4
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
EUT Channel Bandwidths:	26.48 kHz
Deviations From Standard:	None
Measurement BW:	9 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 kHz
Measurement Detector:	Average
Voltage Extreme Environment Test Range:	N/A (Regulated USB power output from computer only)

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (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 (μ V/m at 30m)	Field strength ($dB\mu$ V/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 setup as per section 9 of this report and connected as per Figure v, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

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

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

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

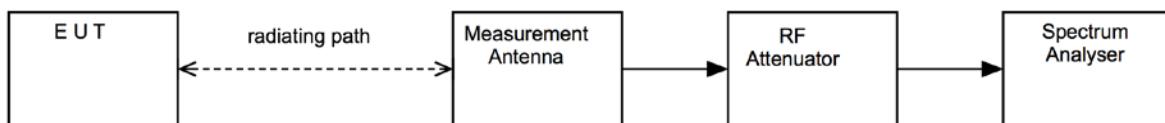
Where,

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) / 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 v Test Setup

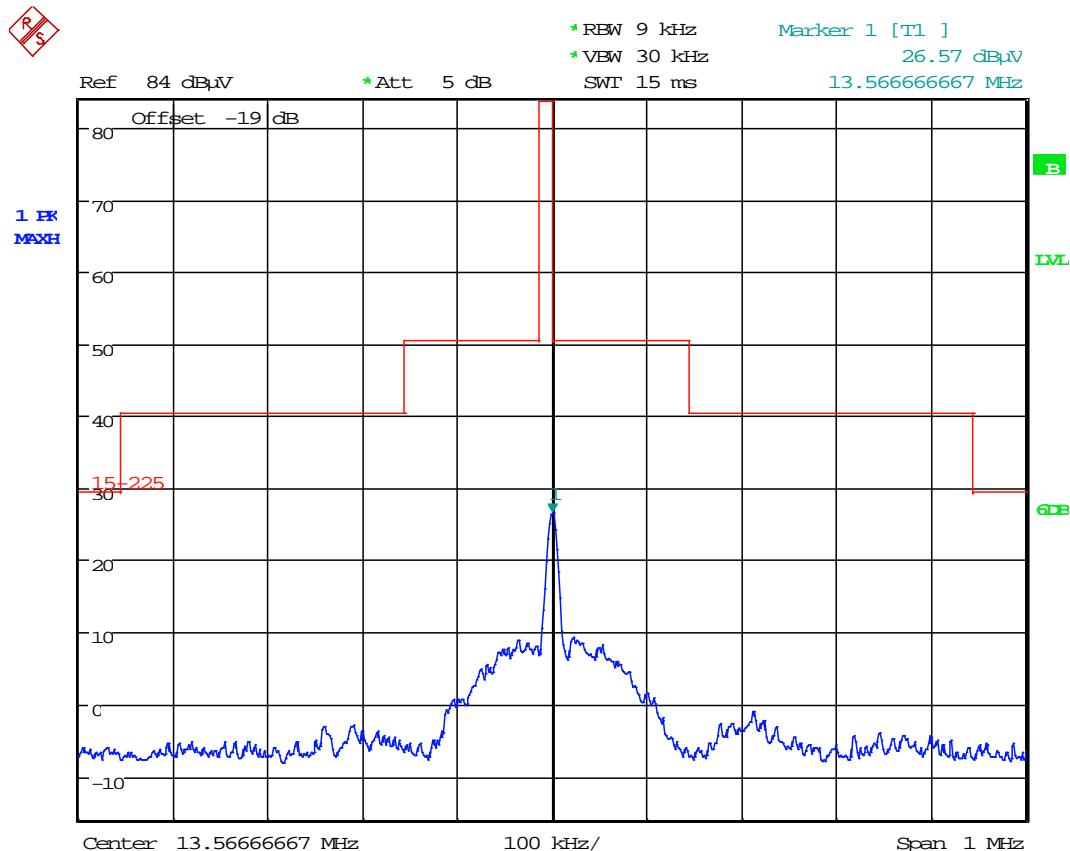


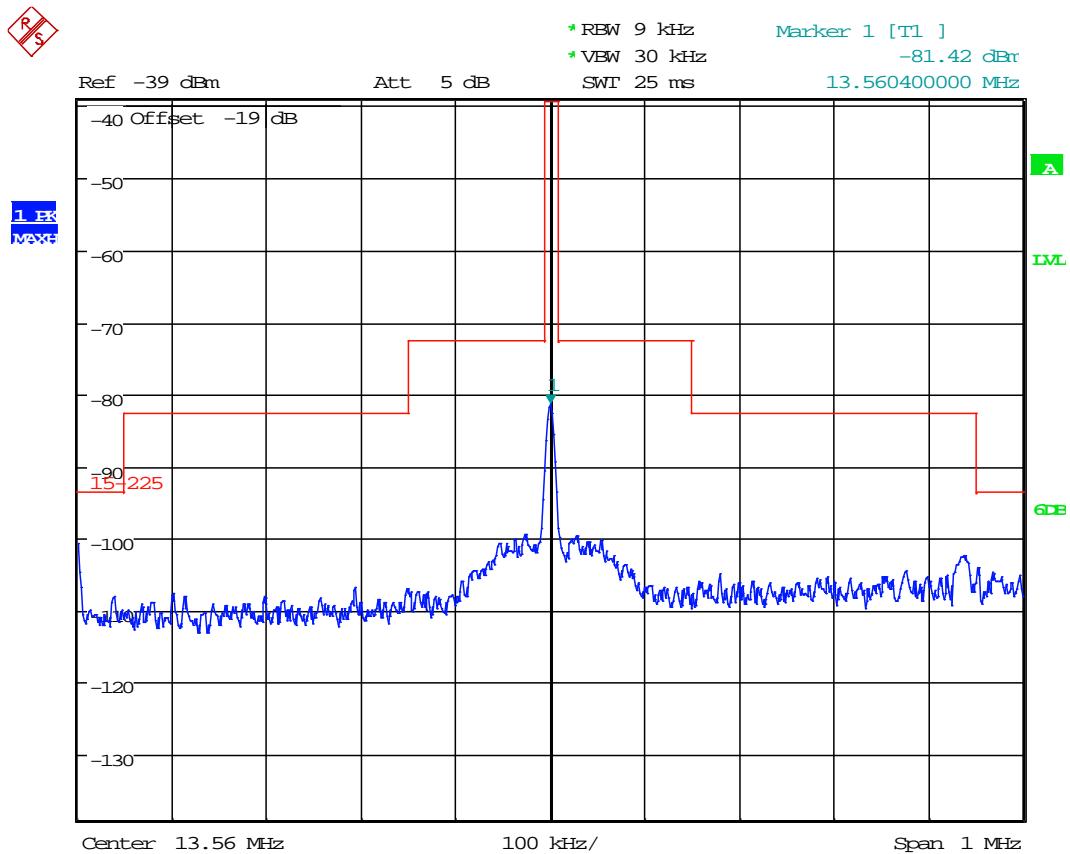
14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017
HFH2-Z2	R&S	Active Loop Antenna	RFG023	26/11/2017
Cable	Unknown	N-Type RF coaxial cable	REF884	05/12/2017

14.6 Test Results

Modulation: RFID; Data rate: RFID; Power setting: 20 dBm						
Channel Frequency (MHz)	Receiver Level (dB μ V/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (μ V/m)	Result
13.56	46.03	3	30	-40	26.13	PASS





Date: 16.FEB.2017 08:33:08

The above test result was obtained from measurement carried out on an open area test site (OATS)

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:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequency Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	EUT was left ON for the duration of the test.
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	Regulated 5V in USB socket on computer

Environmental Conditions (Normal Environment)

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

15.3 Test Limit

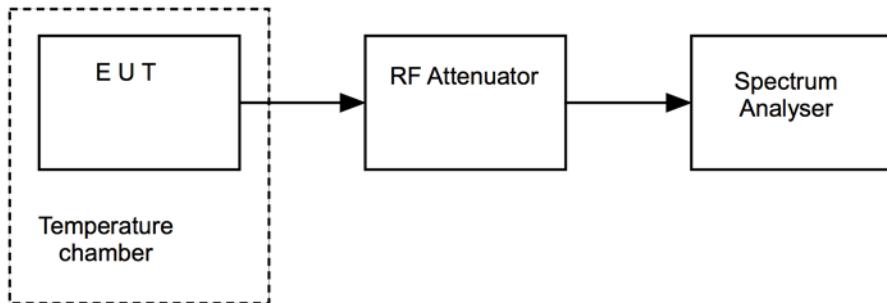
Carrier frequency stability shall be maintained to $\pm 0.01\%$ (± 100 ppm).

15.4 Test Method

With the EUT 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



15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
5385A	HP	Frequency Counter	RFG011	16/05/2017
53 II B	Fluke	Thermometer	REF2110	03/05/2017
Cable	Unknown	Low Loss SMA RF Cable	REF2145	16/02/2017
Antenna	Solar Electronics	Loop Antenna	RFG408	N/A
ETC/JTS/2/01	JTS	Temperature Chamber	RFG365	Cal with REF2110

15.6 Test Results

EUT Frequency: 13.56 MHz					
Test Environment		Measured Frequency (MHz)	Frequency error (kHz)	Frequency error (%)	Result
-20 °C	V _{nominal}	13.560182	-0.065	-0.00048	PASS
-10 °C	V _{nominal}	13.560199	-0.082	-0.00060	PASS
0 °C	V _{nominal}	13.560189	-0.072	-0.00053	PASS
+10 °C	V _{nominal}	13.560166	-0.049	-0.00036	PASS
+20 °C	V _{nominal}	13.560117	N/A	N/A	N/A
+30 °C	V _{nominal}	13.560081	0.036	0.00027	PASS
+40 °C	V _{nominal}	13.560052	0.065	0.00048	PASS
+50 °C	V _{nominal}	13.560046	0.070	0.00052	PASS

16 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**

17 RF Exposure

FCC KDB 447498 D01 General RF Exposure Guidance v06 Clause 4.3 General SAR test exclusion guidance

4.3.1 (c) For frequencies below 100 MHz, the following may be considered for SAR test exclusion (also illustrated in Appendix C): 33

1) For test separation distances > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by $[1 + \log(100/f(\text{MHz}))]$

4.3.1(b) For 100 MHz to 6 GHz and test separation distances > 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following (also illustrated in Appendix B): 32 1)
 $\{[\text{Power allowed at numeric threshold for } 50 \text{ mm in step a}]) + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(\text{MHz})/150)]\} \text{ mW, for } 100 \text{ MHz to } 1500 \text{ MHz}$

2) For test separation distances ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by $\frac{1}{2}$

3) SAR measurement procedures are not established below 100 MHz

Operating Frequency 13.56 MHz

Step 1:

From the table in Appendix B of KDB 447498, the power threshold is 474 mW for 100 MHz at 50 mm. Thus, by substituting the values into the variables in equation 4.3.1(b), the calculated SAR test Exclusion Threshold (SARET) level is...

$$\text{SARET} = \{474 + [(50-50) \cdot (100/150)]\} = 474 \text{ mW}$$

Step 2:

Multiply the value of SARET in Step 1 by 0.5, the result is 237 mW

Results

Channel Frequency (MHz)	Declared EIRP (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
13.56	100	237	Exempted

The maximum EIRP output power declared by the manufacturer is 20 dBm, which is 100 mW and it is well below the SARET value of 237 mW (Calculated value in the above, which is the same value as in the table of Appendix C), thus it is exempted for SAR Evaluation.

RADIO FREQUENCY RADIATION EXPOSURE

RSS-102 Issue 5

Radio frequency radiation exposure evaluation.

Devices that have a radiating element normally operating at or below 6 GHz, with a separation distance of up to 20 cm between the user and/or bystander and the device, shall undergo a SAR evaluation. Devices that have a radiating element normally operating at or below 6 GHz, with a separation distance greater than 20 cm between the user and/or bystander and the device shall undergo an RF exposure evaluation. However, a SAR evaluation may be performed in lieu of an RF exposure evaluation for devices operating below 6 GHz with a separation distance of greater than 20 cm between the user and/or bystander and the device. Devices operating above 6 GHz regardless of the separation distance shall undergo an RF exposure evaluation.

RSS-102 Issue 5 Limits

IC RSS102 Issue 5	
Frequency Range (MHz)	Power Density, S (W/m ²)
0.003-10	N/A
1-10	-
1.1-10	-
10-20	2
20-48	8.944/ f ^{0.5}
48-300	1.291
300-6000	0.02619*f ^{0.6834}
6000-15000	10
15000-150000	10
150000-300000	6.67x10 ⁻⁵ f

Prediction of MPE limit at a given distance

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

where:

S = power density in W/m² for MPE Level

R = distance to the centre of radiation of the antenna in m

EIRP = EUT Maximum power in W

Results

RSS-102 i5		
Evaluation Frequency	13.56	MHz
Section 2.5 Exemption limits	71	Watts
Radiated Carrier Power	46.03	dB μ V/m
Measurement Distance	3	meters
EIRP	12	μ W
Evaluation Required / Exempt		
R =	0.005	Meters
MPE Level =	0.004	W/m ²
IC Limit =	2	W/m ²

EIRP Calculated From Field Strength as Per ANSI C63.10

The MPE level is well below the IC limit, so it meets the exemption limit, hence it does not require a complete SAR or RF exposure evaluation.

18 AC power-line conducted emissions

18.1 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.

18.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	13.56 MHz
EUT Channel Bandwidths:	26.48 kHz
EUT Modulation:	ASK
Deviations From Standard:	None
Measurement BW:	9 kHz
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	USB socket on computer

18.3 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.

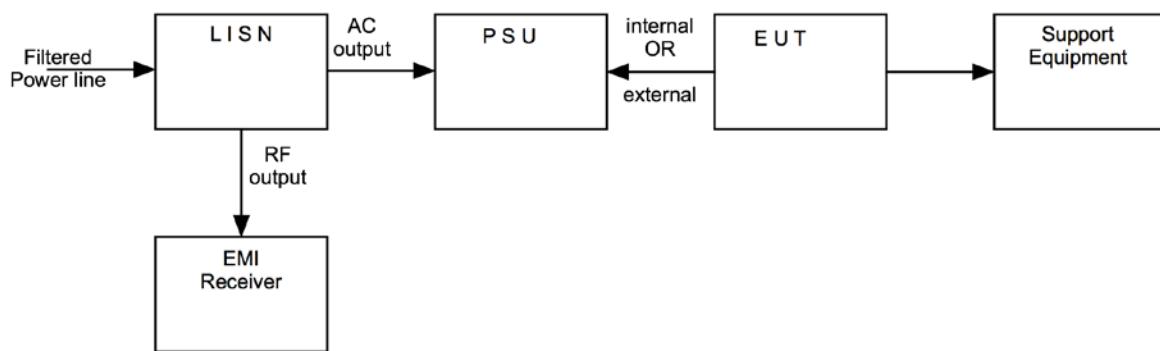
18.4 Test Method

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



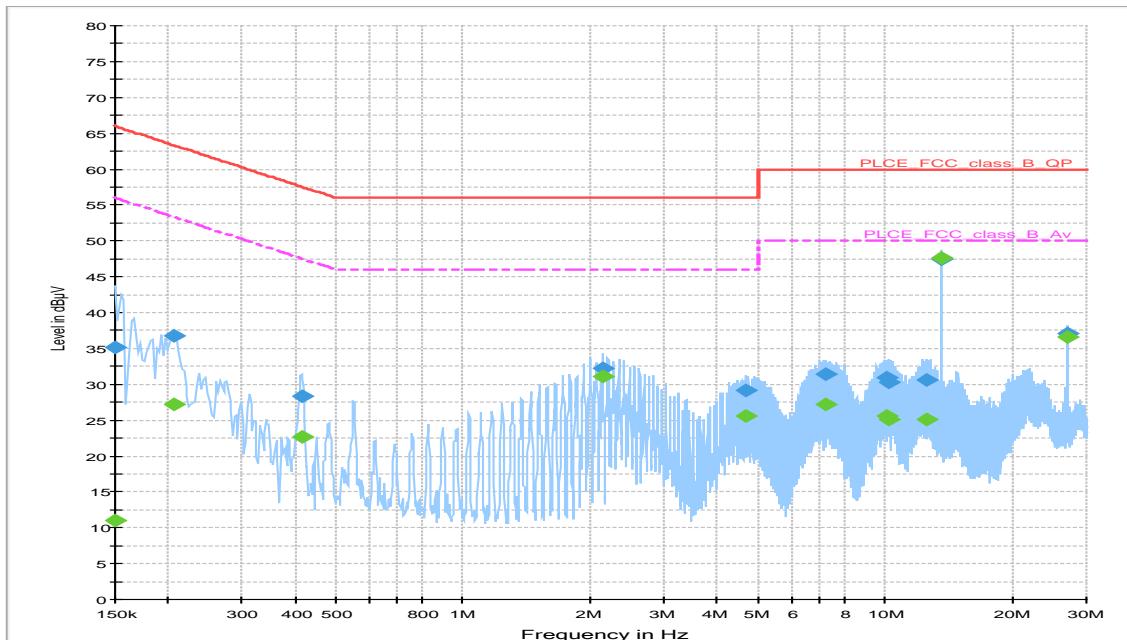
18.5 Test Set-up Photographs



18.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESCI7	R&S	Measuring Receiver	RFG715	06/10/2017
Cable	Unknown	BNC cable	RFG299	12/02/2017
ESH3-Z2	R&S	Pulse Limiter	RFG674	11/04/2017
Transformer	8559 Frequency Converter 500VA	Frequency converter	RFG109	N / A
Screened Room	Unknown	EMC chamber	RFG205	N / A
Cable	Unknown	BNC coaxial cable	RFG296	12/02/2017

18.7 Test Results



Final Result 1

Frequency (MHz)	QuasiPeak (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	35.1	15000.0	0.200	GND	L1	10.2	30.9	66.0
0.207275	36.7	15000.0	9.000	GND	L1	10.2	26.6	63.3
0.415825	28.4	15000.0	9.000	GND	L1	10.3	29.1	57.5
2.137575	32.2	15000.0	9.000	GND	L1	10.5	23.8	56.0
4.692675	29.1	15000.0	9.000	GND	N	10.6	26.9	56.0
7.243000	31.5	15000.0	9.000	GND	N	10.8	28.5	60.0
10.146000	30.9	15000.0	9.000	GND	N	11.0	29.1	60.0
10.217500	30.3	15000.0	9.000	GND	N	11.0	29.7	60.0
12.558500	30.5	15000.0	9.000	GND	N	11.2	29.5	60.0

Final Result 2

Frequency (MHz)	Average (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	11.0	15000.0	9.000	GND	L1	10.2	45.0	56.0
0.207275	27.3	15000.0	9.000	GND	L1	10.2	26.0	53.3
0.415825	22.7	15000.0	9.000	GND	L1	10.3	24.8	47.5
2.137575	31.0	15000.0	9.000	GND	L1	10.5	15.0	46.0
4.692675	25.6	15000.0	9.000	GND	N	10.6	20.4	46.0
7.243000	27.3	15000.0	9.000	GND	N	10.8	22.7	50.0
10.146000	25.6	15000.0	9.000	GND	N	11.0	24.4	50.0
10.217500	25.1	15000.0	9.000	GND	N	11.0	24.9	50.0
12.558500	25.0	15000.0	9.000	GND	N	11.2	25.0	50.0