

Report on the Radio Testing
For
Buddi Limited
on
SmartTag Location Quad
Report no. TRA-021068-13-47-00A
27th January 2017

RF922 2.0



Report Number: TRA-021068-13-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
Buddi Limited
SmartTag Location Quad
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.249 & IC RSS-210 Annex 2.9

TEST DATE: 17th - 18th January 2017

Written by: D Winstanley

D Winstanley
Radio Senior Test Engineer

Approved by:

J Charters
Department Manger - Radio

Date: 27th January 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

RF922 2.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	27th January 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-021068-13-47-00A
WORKS ORDER NUMBER	TRA-021068-11
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. Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radio communication Act and 21(1) of the Radio communication Regulations.
TEST SPECIFICATION(S):	47CFR15.249 & RSS-210 Annex 2.9
EQUIPMENT UNDER TEST (EUT):	SmartTag Location Quad
FCC IDENTIFIER:	ZDLST3
IC NUMBER:	20371-ST3
EUT SERIAL NUMBER:	Not Available
MANUFACTURER/AGENT:	Buddi Limited
ADDRESS:	Talbot House 17 Church Street Rickmansworth Hertfordshire WD3 1DE
CLIENT CONTACT:	Charles Lewinton   charles@buddi.co.uk
TEST DATE:	17th - 18th January 2017
TESTED BY:	D Winstanley Element

2.1 Test Summary

Test Method and Description	Requirement Clause		Applicable to this equipment	Result / Note
	RSS	47CFR15		
Radiated spurious emissions	210, A2.9(b)	15.249(d)	☒	Pass
AC power line conducted emissions	Gen, 8.8	15.207	☒	Note 1
Occupied bandwidth	Gen, 6.6	15.215(c)	☒	Note 1
Field strength of fundamental	210, A2.9(a)	15.249(a)	☒	Pass
Calculation of duty correction ¹	-	15.35(c)	☒	N/A

Notes:

Note 1

Limited radio testing of Colorado Smart Tag, 915 MHz Radio; to determine whether there have been any changes to the radio parameters previously reported on.

Scope of Work:

Radiated Spurious Emissions only;

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
7.3.1	Transmission.....	10
7.3.2	Reception.....	10
7.4	EUT Radio Parameters.....	11
7.4.1	General	11
7.4.2	Antennas.....	11
7.5	EUT Description	11
8	Modifications.....	12
9	EUT Test Setup	13
9.1	Block Diagram.....	13
9.2	General Set-up Photograph	14
10	General Technical Parameters.....	15
10.1	Normal Conditions.....	15
10.2	Varying Test Conditions	15
11	Radiated emissions.....	16
11.1	Definitions	16
11.2	Test Parameters.....	16
11.3	Test Limit.....	16
11.4	Test Method	17
11.5	Test Set-up Photograph	18
11.6	Test Equipment.....	18
11.7	Test Results	19
12	Transmitter output power (fundamental radiated emission)	23
12.1	Definition	23
12.2	Test Parameters.....	23
12.3	Test Limit.....	23
12.4	Test Method	24
12.5	Test Equipment.....	24
12.6	Test Results	24
13	Duty Cycle.....	25
13.1	Definition	25
13.2	Test Parameters.....	25
13.3	Test Limit.....	25
13.4	Test Method	26
13.5	Test Equipment.....	26
13.6	Test Results	26
14	Measurement Uncertainty.....	27

4 Introduction

This report TRA-021068-13-47-00A presents the results of the Radio testing on a Buddi Limited, SmartTag Location Quad 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 Buddi 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.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

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

IC Registration Number(s):

Element North West 3930B

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
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: SmartTag Location Quad
- Serial Number: Not Available
- Model Number: S1-BUD-B-TE2RA-WIQD
- Firmware Revision: 1.11.0
- Build Level / Revision Number: Not Stated

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.

Type Of Equipment: on body charger
Part Number: T5-SMS-OBCHBK-D

Type Of Equipment: Power Supply for on body charger

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows...

Transmitting a modulated carrier on top and bottom operating frequencies at 100 % duty cycle.
Transmitting in normal operation for duty cycle measurements.

7.3.2 Reception

Not Applicable. Standby mode only.

7.4 EUT Radio Parameters

7.4.1 General

Frequencies of operation:	914.5 MHz and 921.0 MHz
Modulation type(s):	FSK
Occupied channel bandwidth(s):	70kHz
Channel spacing:	Not Applicable, Wideband
ITU emission designator(s):	70k0F1D
Nominal Supply Voltage:	3.7Vdc
Duty cycle:	5.75%

7.4.2 Antennas

Type:	Integral PCB
Frequency range:	914.5 MHz – 921.0 MHz
Impedance:	50Ohms
Polarisation:	Omni directional
Connector type:	Integral – Not Applicable

7.5 EUT Description

The EUT is Offender monitoring tag.

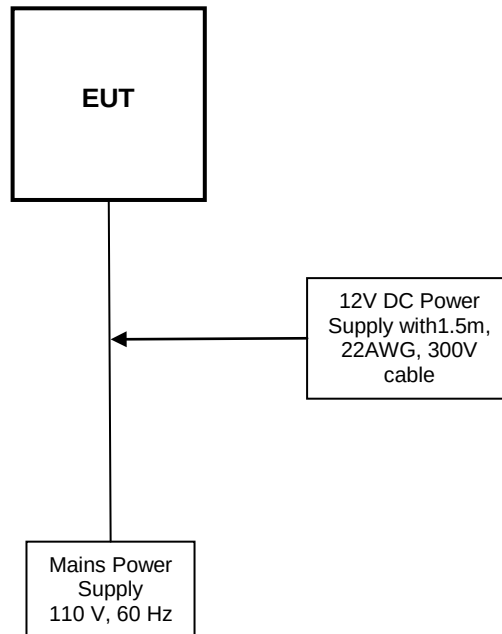
8 Modifications

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 batteries and power supply with charger to connect to 110 V ac, 60 Hz, from the mains.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

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

	Category	Nominal	Variation
☐	Mains	110 V ac +/- 2 %	85 % and 115 %
☒	Battery	Fully Charged	N/A

11 Radiated emissions

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:	Radio Chamber (REF940)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	914.5 MHz and 921
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)

11.3 Test Limit

Except for harmonics, out-of-band emissions shall be attenuated by at least 50 dB below the level of the fundamental or to the general field strength limits listed in FCC 47CFR15.209 / RSS-Gen {see table below}, whichever is less stringent.

Harmonics shall be limited to a maximum level of 0.5 mV/m measured at 3 metres.

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

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

n.b. per FCC 47CFR15.35(b) / RSS-Gen 8.1, peak limit is 20 dB above average.

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, 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;

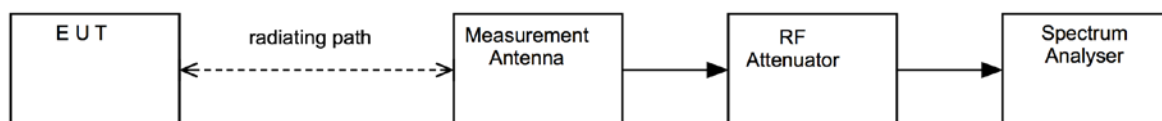
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

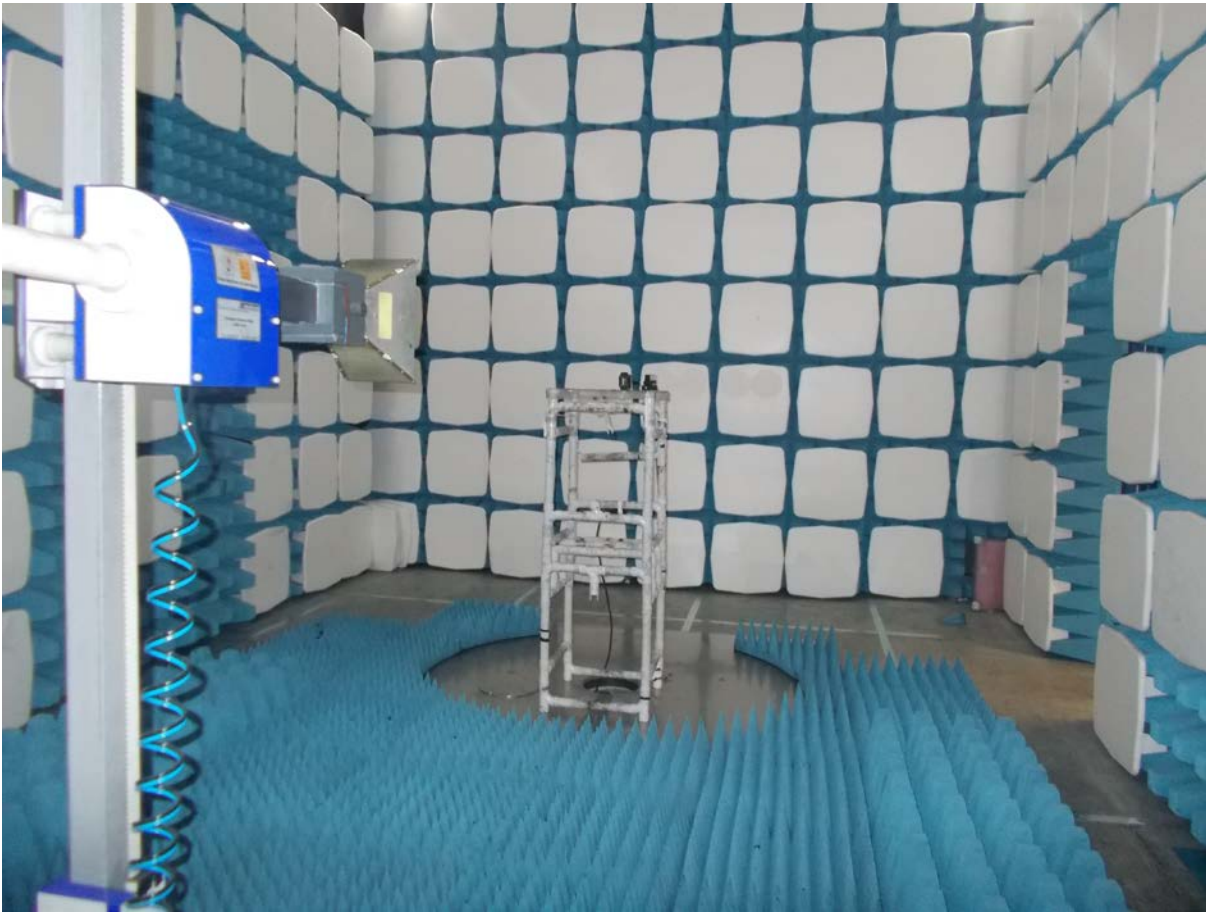
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



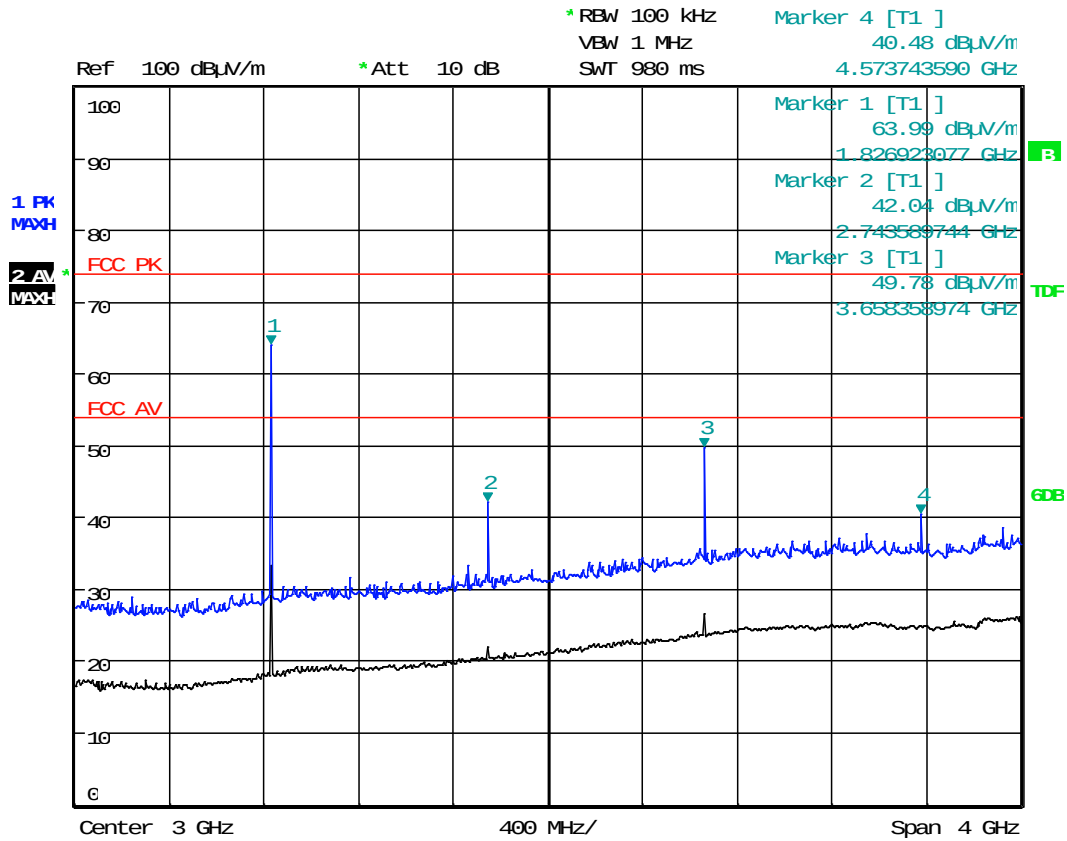
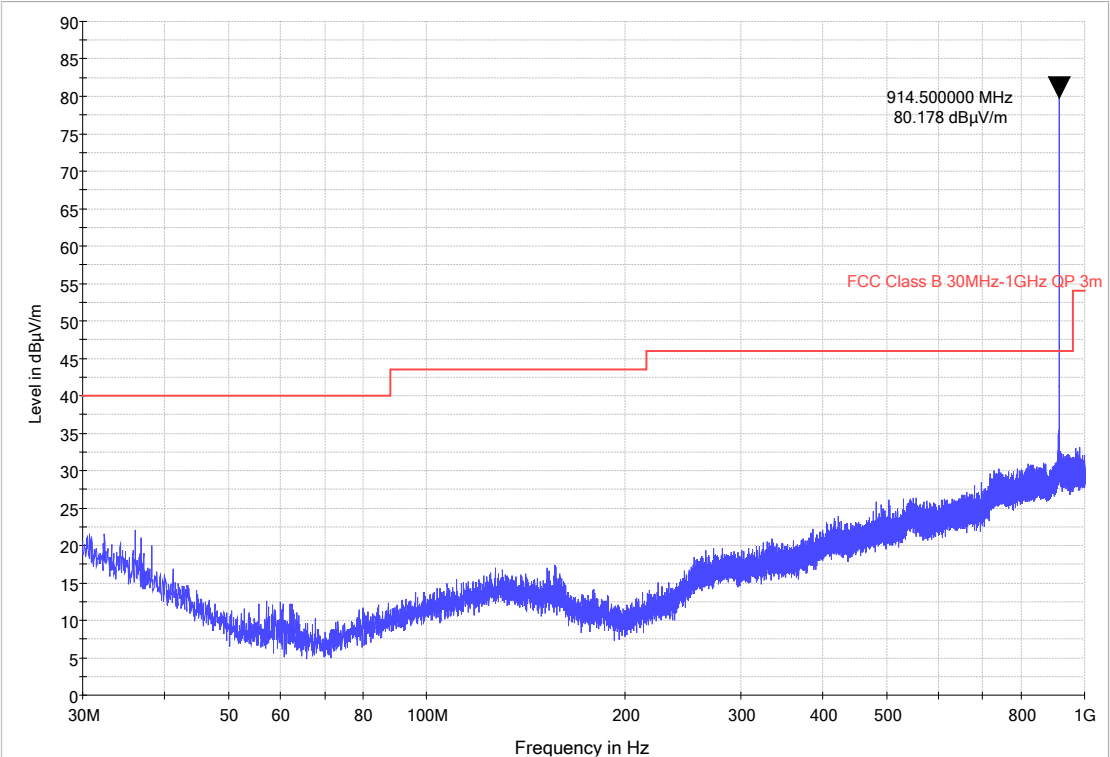
11.5 Test Set-up Photograph

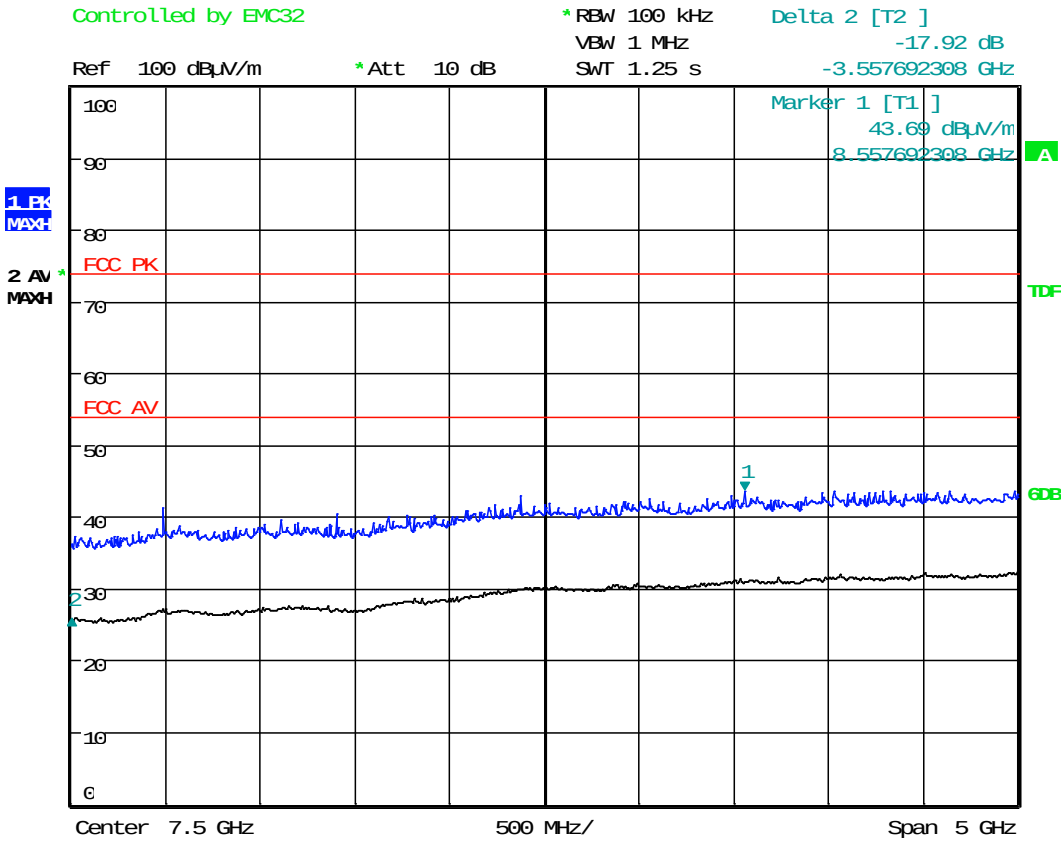


11.6 Test Equipment

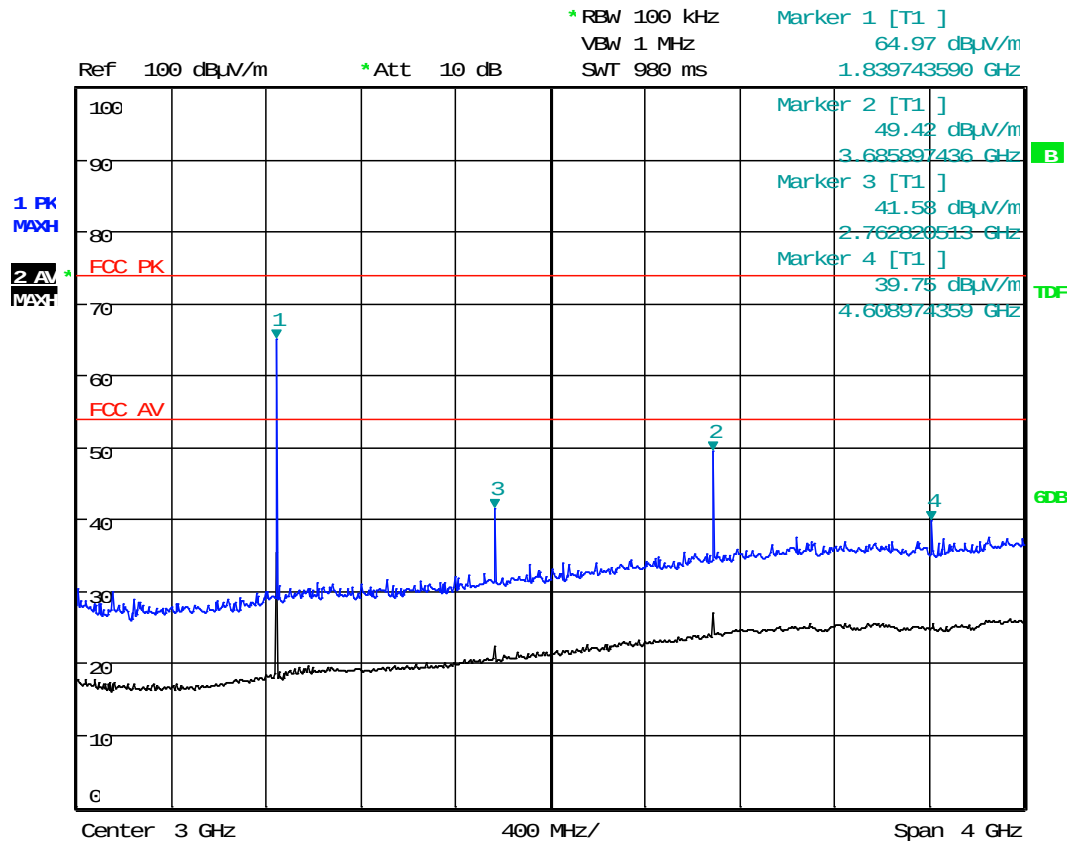
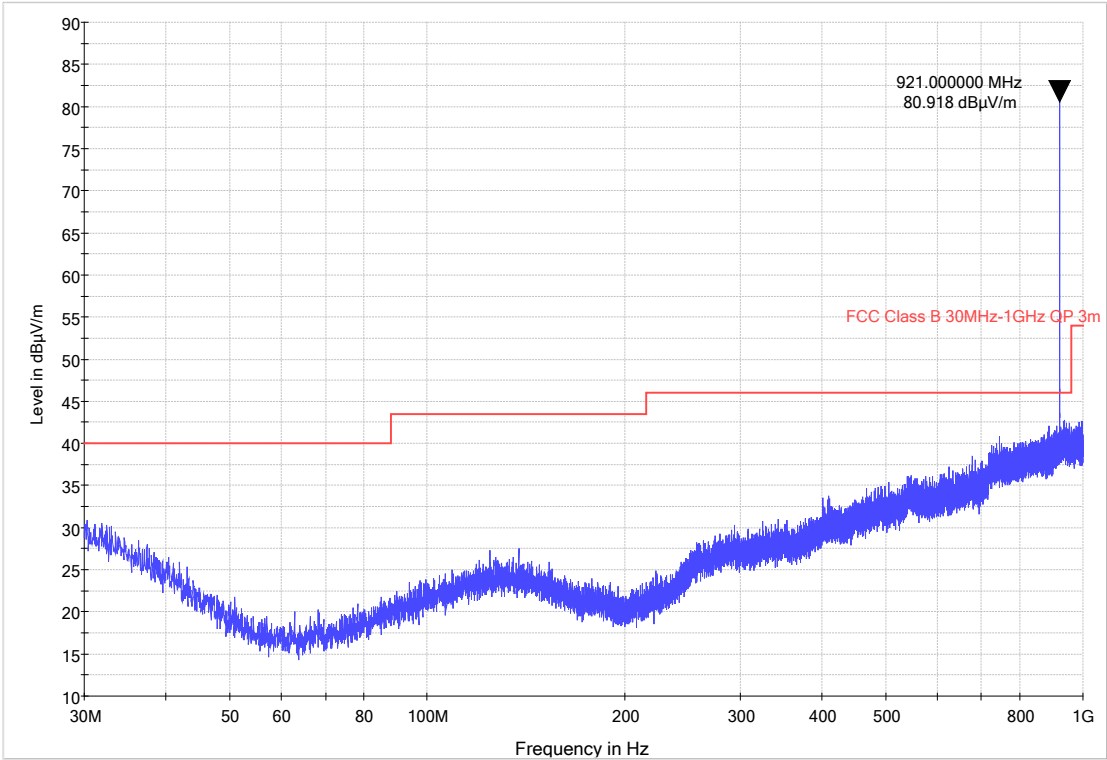
<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Bilog	Chase	CBL611/A	UH191	26/02/2017	24
ESVS10	R&S	ESVS10	L352	07/08/2016	12
Spectrum Analyser	R&S	FSU46	U281	07/06/2017	12
Horn Antenna	EMCO	3115	TRL139	20/09/2015	24
Pre-Amplifier	Agilent	8449B	TRL572	10/02/2016	12

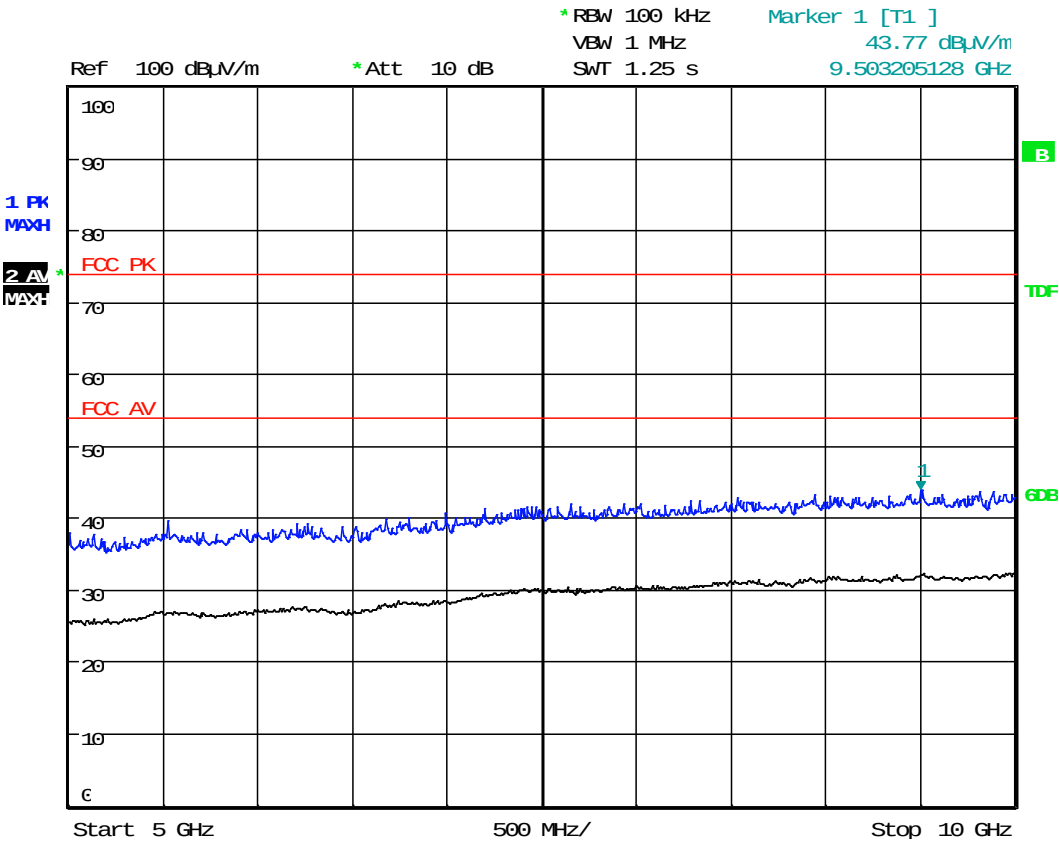
11.7 Test Results





High Power; Channel: 914.5 MHz										
DET	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)
Pk	1828.99	71.23	3.00	27.10	36.08	0.00	0.00	65.25	1830.21	5012
Av	1828.99	71.23	3.00	27.10	36.08	-24.81	0.00	40.44	105.24	500
Pk	2743.49	52.05	3.70	29.00	36.06	0.00	0.00	48.69	271.96	5012
Av	2743.49	52.05	3.70	29.00	36.06	-24.81	0.00	23.88	15.64	500
Pk	3657.99	57.20	4.20	31.70	35.71	0.00	0.00	57.39	740.46	5012
Av	3657.99	57.20	4.20	31.70	35.71	-24.81	0.00	32.58	42.58	500
Pk	4572.48	48.62	4.90	32.50	35.75	0.00	0.00	50.27	326.21	5012
Av	4572.48	48.62	4.90	32.50	35.75	-24.81	0.00	25.46	18.76	500





High Power; Channel: 921 MHz										
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)
Pk	1842.08	71.43	3.00	27.20	36.08	0.00	0.00	65.55	1894.52	5012
Av	1842.08	71.43	3.00	27.20	36.08	-24.81	0.00	40.74	108.94	500
Pk	2763.02	51.54	3.70	29.10	36.07	0.00	0.00	48.27	259.12	5012
Av	2763.02	51.54	3.70	29.10	36.07	-24.81	0.00	23.46	14.90	500
Pk	3683.70	56.04	4.30	31.70	35.70	0.00	0.00	56.34	656.15	5012
Av	3683.70	56.04	4.30	31.70	35.70	-24.81	0.00	31.53	37.73	500
Pk	4604.95	48.00	4.90	32.60	35.77	0.00	0.00	49.73	306.55	5012
Av	4604.95	48.00	4.90	32.60	35.77	-24.81	0.00	24.92	17.63	500

12 Transmitter output power (fundamental radiated emission)

12.1 Definition

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

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber (REF940)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	914.5 MHz and 921.0 MHz
Deviations From Standard:	None
Measurement BW:	120 kHz
Measurement Detector:	Up to 1 GHz: Quasi-peak
Voltage Extreme Environment Test Range:	Battery Power = Fully Charged

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

The field strength measured at 3 metres shall not exceed the limits in the following table:

Field Strength Limits for License-Exempt Transmitters for Any Application

<i>Fundamental frequency (MHz)</i>	<i>Field strength (mV/m at 3 m)</i>	<i>Detector</i>
902 to 928	50	Quasi-Peak

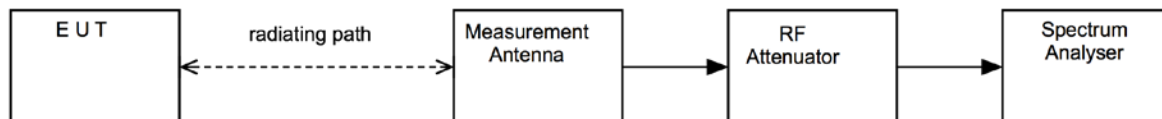
n.b. per FCC 47CFR15.249(e) / RSS-Gen 8.1, peak limit is 20 dB above average.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, 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.

Figure iv Test Setup



12.5 Test Equipment

Type of Equipment	Maker/Supplier	Model Number	Element Number	Calibration Due Date	Calibration Interval
Bilog	Chase	CBL611/A	UH191	26/02/2017	24
ESVS10	R&S	ESVS10	L352	07/08/2016	12

12.6 Test Results

Channel Frequency (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Field Strength (dBuV/m)	Distance Extrap'n Factor (dB)	Field Strength (mV/m)
914.50	58.90	4.10	23.43	N/A	86.43	-	20.9
921.00	59.20	4.10	23.65	N/A	86.95	-	22.3

13 Duty Cycle

13.1 Definition

The ratio of the sum of all pulse durations to the total period, during a specified period of operation. The duty cycle is determined on the basis of one complete pulse train for pulse trains not exceeding 100 milliseconds. Where the pulse train exceeds 100 milliseconds, the duty cycle is determined on the basis of the 100 millisecond interval with the highest average value of emission.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	914.5 MHz and 921.0 MHz
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 25 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

N/A.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, the duty of the EUT was calculated from the sum of total on and off times over the observation period.

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

[1] Single antenna output devices

Duty was measured at the antenna port / at a distance of 3 m.

[2] Multiple antenna output devices

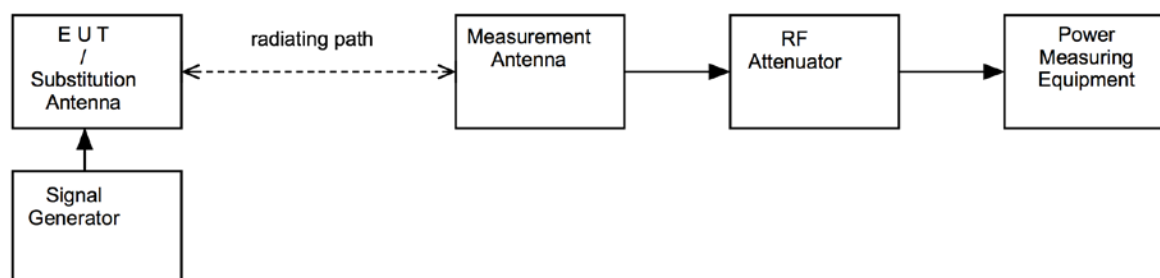
Duty was measured as the combination of all ports simultaneously / at a distance of 3 m.

The duty cycle correction factor, DC, is used to adjust peak emissions (voltage) to give an average value and is calculated by:

$$DC = 20 \log (\text{duty ratio})$$

Where, duty ratio is total on-time divided by total off-time in the worst-case pulse train or 100 ms, whichever is longer.

Figure vii Test Setup



13.5 Test Equipment

Type of Equipment	Maker/Supplier	Model Number	Element Number	Calibration Due Date	Calibration Interval
Spectrum Analyser	R&S	FSU46	U281	07/06/2017	12

13.6 Test Results

Test Environment		Single Channel TxOn time (ms)	Total TxOn time (ms)	Observation period (ms)	Duty (%)	Calculated Factor (dB)
V _{nominal}	T _{nominal}	5.75	5.75	100	5.75	24.44

14 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] Carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

Uncertainty in test result (Spectrum Analyser) = **2.48 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**

[6] Duty cycle

Uncertainty in test result = **7.98 %**