

Report on the Radio Testing
For
Ramtech Electronics Limited
on
WES+ 916.5MHZ Radio Module
Report no. TRA-029153-47-00C
24th October 2016

Report Number: TRA-029153-47-00C
Issue: C

REPORT ON THE RADIO TESTING OF A
Ramtech Electronics Limited
WES+ 916.5MHZ Radio Module
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: 13-04-2016 to 26-04-2016

Written by: D Winstanley

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Date: 24th October 2016

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	31 st May 2016	Original
B	13 th October 2016	Corrections and amendments
C	24 th October 2016	Additional information

2 Summary

TEST REPORT NUMBER: TRA-029153-47-00C

WORKS ORDER NUMBER: TRA-029153-04

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 Radiocommunication Act and 21(1) of the Radiocommunication Regulations.

TEST SPECIFICATION(S): 47CFR15.247 & RSS-247

EQUIPMENT UNDER TEST (EUT): WES+ 916.5MHZ Radio Module

FCC IDENTIFIER: 2AHNOW2-RDO-9X

ISED CERTIFICATION NUMBER: 21246-W2RDO9X

EUT SERIAL NUMBER: not applicable

MANUFACTURER/AGENT: Ramtech Electronics Limited

ADDRESS: Abbeyfield House
Abbeyfield Road
Nottingham
NG7 2SZ
United Kingdom

CLIENT CONTACT: Richard Fletcher
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✉ richard.fletcher@ramtech.co.uk

ORDER NUMBER: Not applicable

TEST DATE: 13-04-2016 to 26-04-2016

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 (restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions		Gen, 8.8	15.207	<input checked="" type="checkbox"/>	Pass
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	<input checked="" type="checkbox"/>	Pass
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	<input type="checkbox"/>	Pass
	Max.			<input checked="" type="checkbox"/>	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	<input checked="" type="checkbox"/>	Pass
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	<input checked="" type="checkbox"/>	Pass
Calculation of duty correction		-	15.35(c)	<input type="checkbox"/>	

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).

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4 Introduction

This report TRA-029153-47-00C presents the results of the Radio testing on a Ramtech Electronics Limited, WES+ 916.5MHZ Radio Module to specification 47CFR15 Radio Frequency Devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Ramtech Electronics Limited by Element, at the address(es) detailed below.

<input type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input checked="" type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skemersdale West Lancashire WN8 9PN UK
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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 Hull	3483A
Element North West	3930B

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

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-247, Issue 1, May 2015 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- 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: WES+ 916.5MHZ Radio Module
- Serial Number: not applicable
- Model Number: W2-RDO-9X
- Software Revision: v 2.1
- Build Level / Revision Number: Not Applicable

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows. The module was connected to a host which provide the control and power. The transmission was full time transmitting on 916.5 MHz, which is the only channel of operation on the unit.

7.3.2 Reception

The mode of operation for Rx tests was as follows. . The module was connected to a host which provide the control and power. The reception was fixed on 916.5 MHz, which is the only channel of operation on the unit.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	916.5 MHz
Modulation type(s):	2-FSK
Occupied channel bandwidth(s):	500kHz
Channel spacing:	N/A
ITU emission designator(s):	500KF1D
Declared output power(s):	25mW
Warning against use of alternative antennas in user manual (yes/no):	No – Factory fitted
Nominal Supply Voltage:	3.3V
Frequency stability:	5ppm
Location of notice for license exempt use:	User Manual
Duty cycle:	1%

7.4.2 Antennas

Type:	Whip
Frequency range:	902MHz – 928MHz
Impedance:	50Ohm
SWR:	< 1.5 : 1
Gain:	1.9dB
Polarisation:	Vertical
Beam width:	Omnidirectional
Connector type:	MCX
Length:	81mm
Weight:	14g
Mounting:	Bulkhead internally secured

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	N/A
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	No
Fixed pt-mpt operations (yes/no):	No
Simultaneous tx (yes/no):	No

7.5 EUT Description

The EUT is 916.5 MHz transceiver module connected to a host to drive and control the module on all the test modes

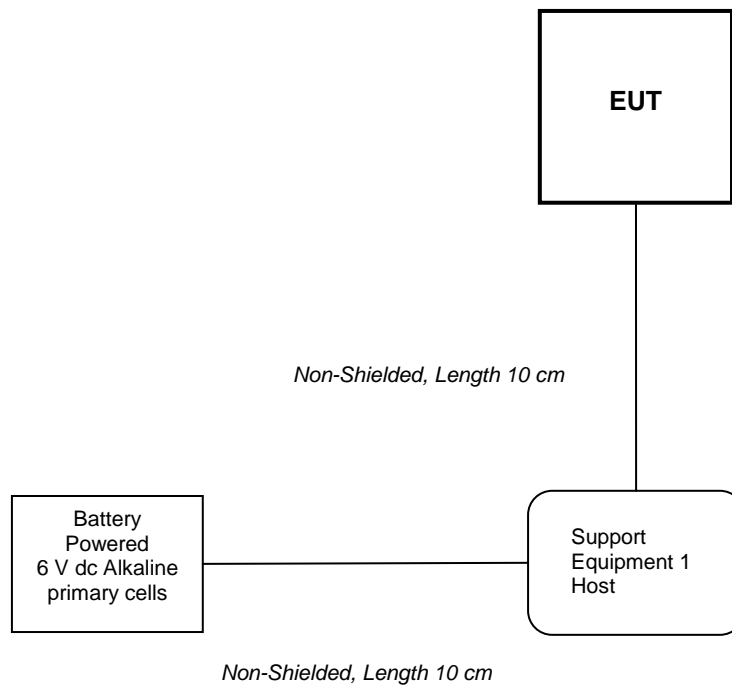
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

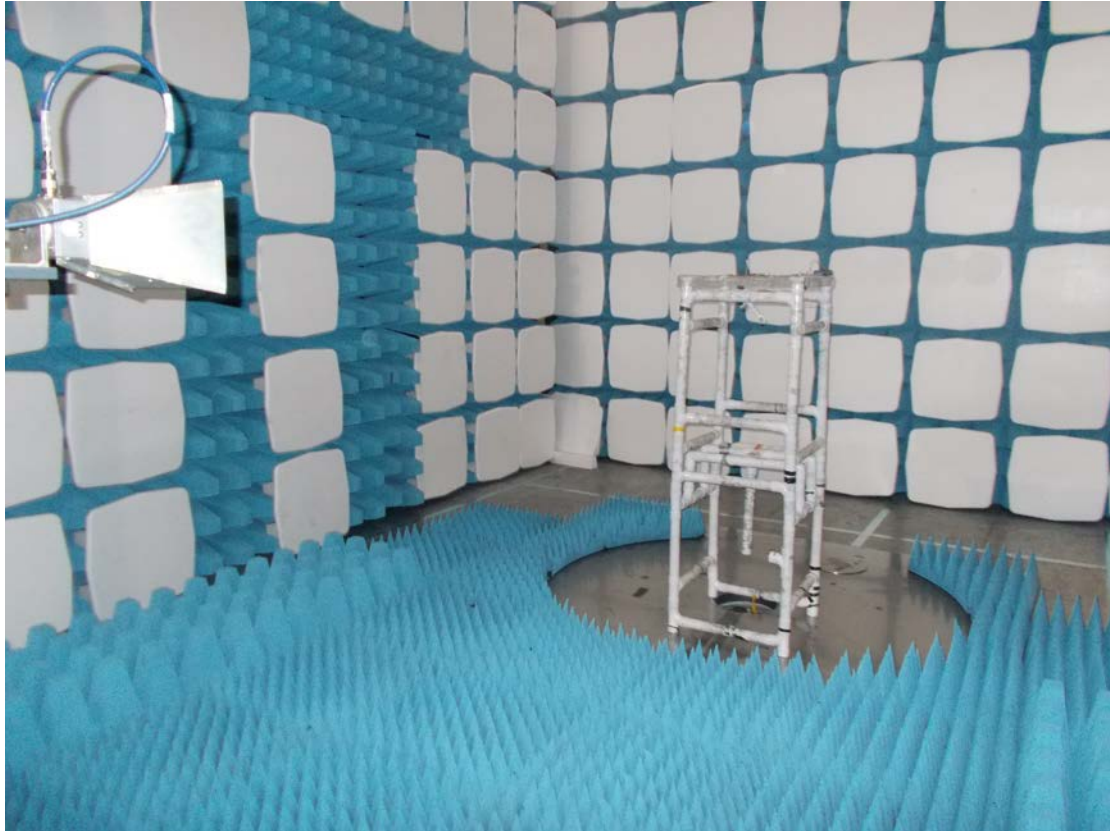
9.1 Block Diagram

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. 6V dc from alkaline batteries.

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
<input type="checkbox"/>	Mains	110 V ac +/-2 %	85 % and 115 %
<input checked="" type="checkbox"/>	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

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
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	916.5 MHz
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: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 25 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 V dc	6 V dc \pm 10 % (as declared)

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

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

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 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;

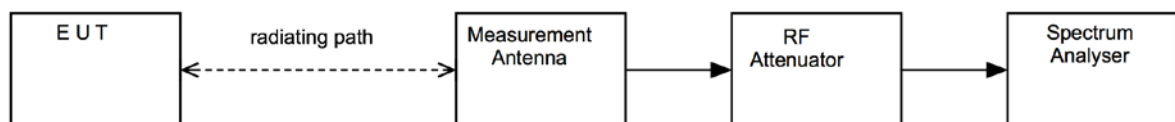
PA is the pre-amplifier gain in dB (where used);

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

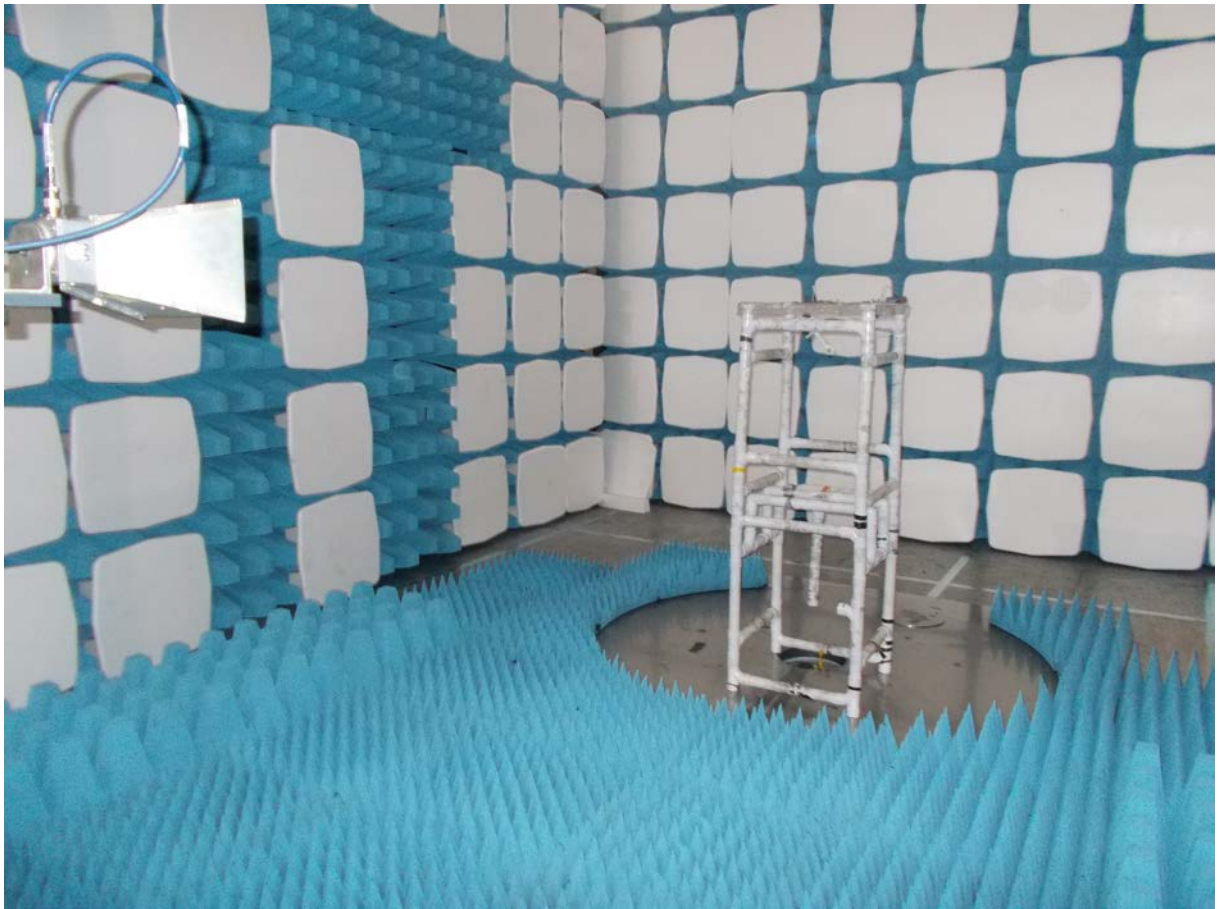
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



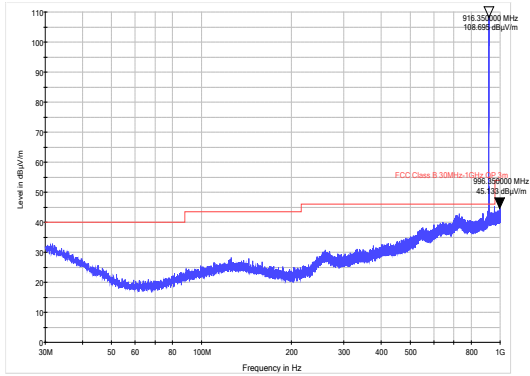
11.5 Test Set-up Photograph



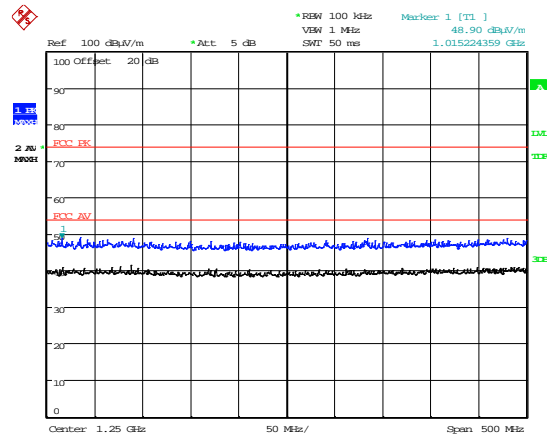
11.6 Test Equipment

<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	FSU50	U544	16/03/2017	12
Horn Antenna	EMCO	3115	TRL139	25/09/2017	24
Pre-Amplifier	Agilent	8449B	TRL572	16/02/2017	12

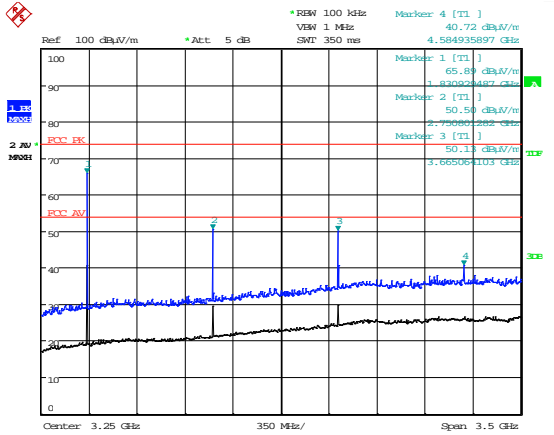
11.7 Test Results



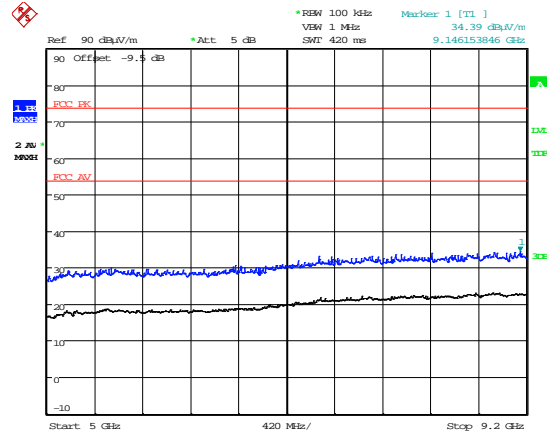
1 – 916.5 MHz (30 MHz to 1 GHz).



2 – 916.5MHz (1 GHz to 1.5 GHz).



3 – 916.5MHz (1.5 GHz to 5 GHz).



4 – 916.5MHz (5 GHz to 9.2 GHz).

Date: 25.APR.2016 16:18:57

Date: 25.APR.2016 17:43:41

High Power; Channel: 916.5 MHz										
Detector	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	960.00	15.80	4.15	24.00	N/A	0.00	0.00	43.95	157.58	200
QP	996.35	15.60	4.23	23.88	N/A	0.00	0.00	43.71	153.29	500
Qp	1000	15.10	4.24	23.90	N/A	0.00	0.00	43.24	145.21	500
Pk	2749.63	58.89	3.60	30.80	36.06	0.00	0.00	57.23	726.94	5012
Av	2749.63	52.00	3.60	30.80	36.06	0.00	0.00	50.34	328.85	500
Pk	3665.42	58.21	4.30	33.80	35.71	0.00	0.00	60.60	1071.52	5012
Av	3665.42	49.85	4.30	33.80	35.71	0.00	0.00	52.24	409.26	500
Pk	4581.79	53.76	5.40	35.30	35.76	0.00	0.00	58.70	860.99	5012
Av	4581.79	41.41	5.40	35.30	35.76	0.00	0.00	46.35	207.73	500

12 AC power-line conducted emissions

12.1 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.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Low Frequency Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	916.5 MHz
Deviations From Standard:	None
Measurement BW:	120 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 25 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 V dc	Via 110Vac unfiltered PSU dc ± 10 % (as declared)

12.3 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.

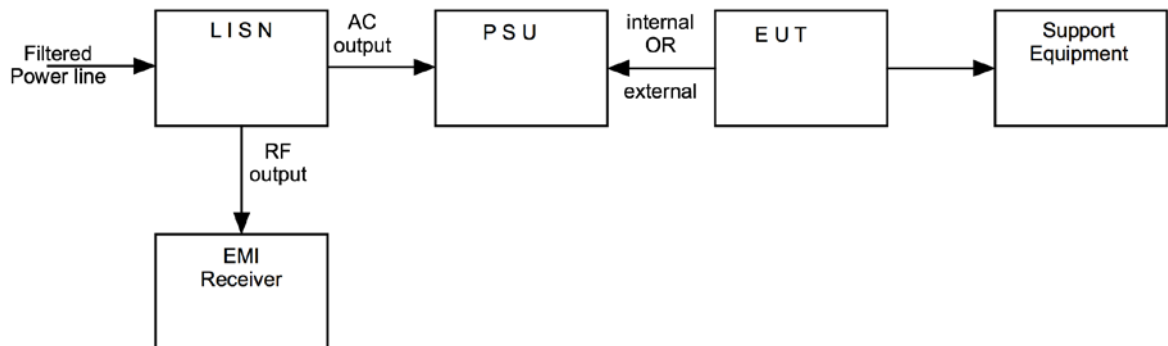
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

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

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



12.5 Test Set-up Photograph

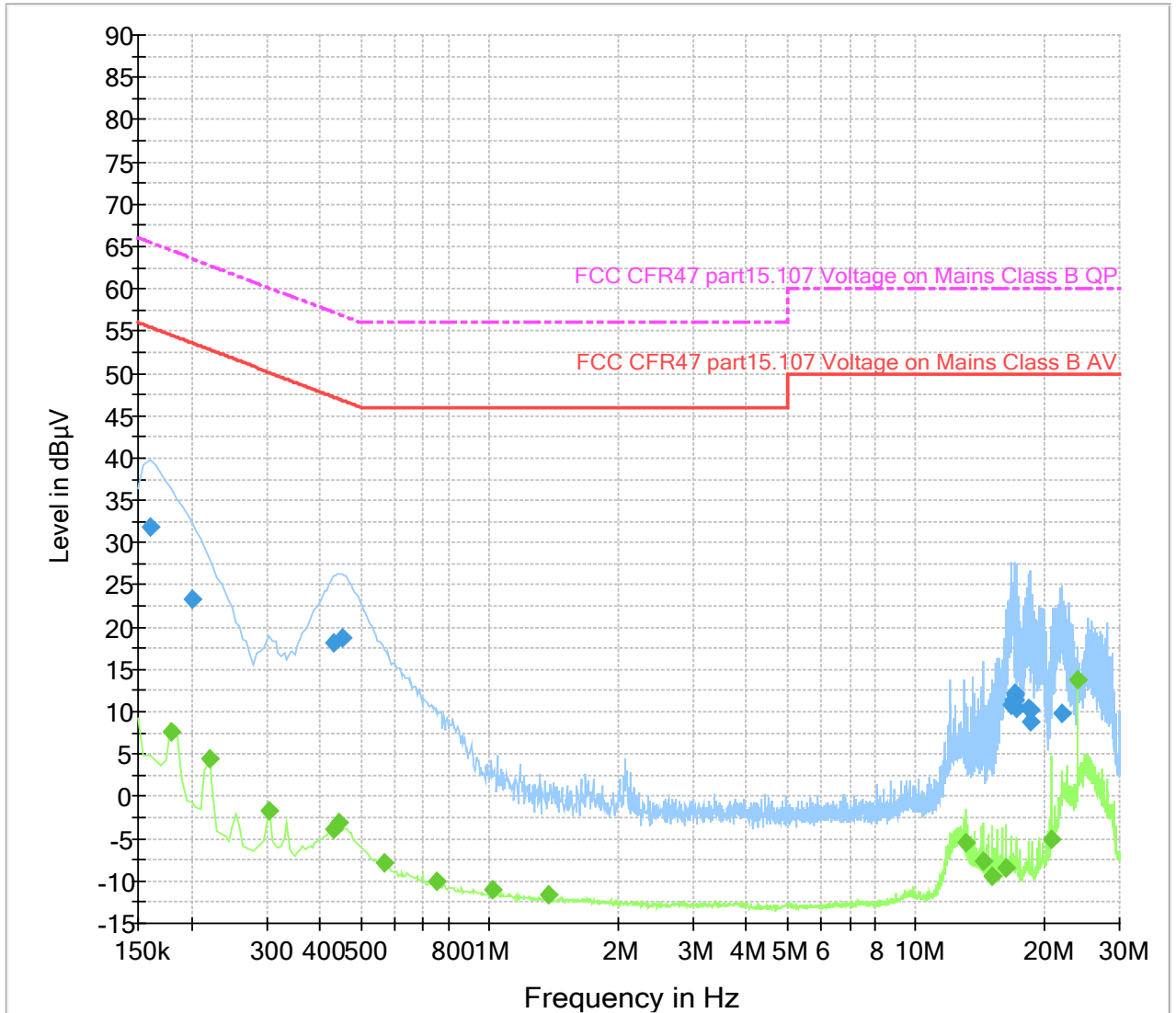


12.6 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
LISN	R&S	ESH3-Z5.831.5	U195	04/06/2016
EMI Receiver	R&S	ESHS10	U003	25/06/2016

12.7 Test Results transmit mode

Conducted emissions on Mains 9kHz-30MHz ESHS10 + UH195

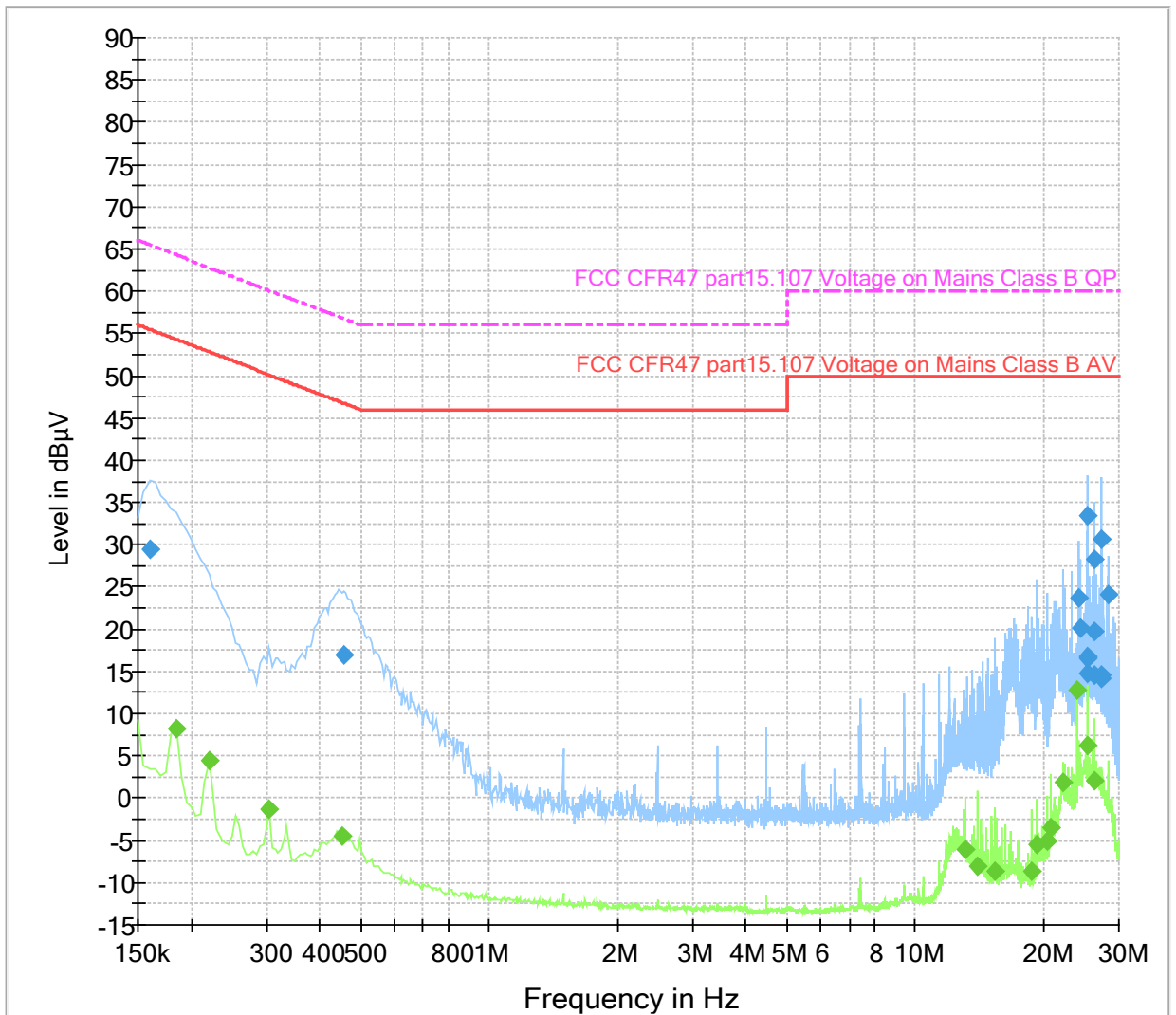


AC power-line conducted emissions, Transmit mode, QuasiPeak detector									
Frequency (MHz)	QuasiPeak (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)	Comment
0.160000	31.8	2000.0	10.000	GND	N	0.1	32.7	64.5	PASS
0.200000	23.2	2000.0	10.000	GND	N	0.1	39.6	62.8	PASS
0.430000	18.1	2000.0	10.000	GND	L1	0.1	42	60.1	PASS
0.450000	18.8	2000.0	10.000	GND	N	0.1	38.5	57.3	PASS
16.76500	10.9	2000.0	10.000	GND	N	1.3	46.1	57	PASS
16.79000	10.8	2000.0	10.000	GND	N	1.3	45.2	56	PASS
16.95000	11.4	2000.0	10.000	GND	N	1.3	44.6	56	PASS
17.01500	12.1	2000.0	10.000	GND	N	1.3	43.9	56	PASS
17.05000	11.4	2000.0	10.000	GND	N	1.3	44.6	56	PASS
17.07500	12.1	2000.0	10.000	GND	N	1.3	47.9	60	PASS
17.23000	10.5	2000.0	10.000	GND	N	1.3	49.5	60	PASS
18.30500	10.5	2000.0	10.000	GND	N	1.4	49.5	60	PASS
18.46500	8.8	2000.0	10.000	GND	N	1.5	51.2	60	PASS
18.60500	10.1	2000.0	10.000	GND	N	1.5	49.9	60	PASS
21.90000	9.9	2000.0	10.000	GND	L1	1.8	50.1	60	PASS

AC power-line conducted emissions, Transmit mode, Average detector									
Frequency (MHz)	Average (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)	Comment
0.180000	7.7	2000.0	10.000	GND	L1	0.1	47.8	55.5	PASS
0.220000	4.4	2000.0	10.000	GND	N	0.1	49.2	53.6	PASS
0.305000	-1.7	2000.0	10.000	GND	L1	0.1	49	47.3	PASS
0.430000	-3.8	2000.0	10.000	GND	L1	0.1	50.7	46.9	PASS
0.445000	-3.1	2000.0	10.000	GND	N	0.1	53.1	50	PASS
0.565000	-7.9	2000.0	10.000	GND	L1	0.1	57.9	50	PASS
0.750000	-10.0	2000.0	10.000	GND	L1	0.2	60	50	PASS
1.015000	-11.1	2000.0	10.000	GND	L1	0.2	61.1	50	PASS
1.370000	-11.7	2000.0	10.000	GND	L1	0.2	61.7	50	PASS
13.08000	-5.5	2000.0	10.000	GND	L1	1.1	55.5	50	PASS
14.43500	-7.6	2000.0	10.000	GND	L1	1.2	57.6	50	PASS
15.03000	-9.5	2000.0	10.000	GND	L1	1.3	59.5	50	PASS
16.31000	-8.4	2000.0	10.000	GND	L1	1.4	58.4	50	PASS
20.81000	-5.1	2000.0	10.000	GND	L1	1.8	55.1	50	PASS
24.01500	13.7	2000.0	10.000	GND	L1	1.9	36.3	50	PASS

12.8 Test Results receive mode

Conducted emissions on Mains 9kHz-30MHz ESHS10 + UH195



AC power-line conducted emissions, Receive mode, QuasiPeak detector									
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.160000	29.5	2000.0	10.000	GND	N	0.1	34.8	64.3	PASS
0.455000	17.0	2000.0	10.000	GND	N	0.1	45.8	62.8	PASS
24.23000	23.8	2000.0	10.000	GND	N	1.6	36.3	60.1	PASS
24.27000	20.2	2000.0	10.000	GND	L1	2.0	36.7	56.9	PASS
25.23000	16.5	2000.0	10.000	GND	L1	2.0	43.5	60	PASS
25.24000	14.8	2000.0	10.000	GND	N	1.7	45.2	60	PASS
25.25500	33.5	2000.0	10.000	GND	L1	2.0	26.5	60	PASS
25.27500	16.8	2000.0	10.000	GND	N	1.7	43.2	60	PASS
26.21000	28.2	2000.0	10.000	GND	N	1.7	31.8	60	PASS
26.22500	14.6	2000.0	10.000	GND	N	1.7	45.4	60	PASS
26.25500	19.7	2000.0	10.000	GND	L1	2.0	40.3	60	PASS
27.21000	14.1	2000.0	10.000	GND	L1	2.1	45.9	60	PASS
27.23500	30.6	2000.0	10.000	GND	L1	2.1	29.4	60	PASS
27.26000	14.6	2000.0	10.000	GND	L1	2.1	45.4	60	PASS
28.23000	24.0	2000.0	10.000	GND	N	1.7	36	60	PASS

AC power-line conducted emissions, Receive mode, Average detector									
Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.185000	8.1	2000.0	10.000	GND	N	0.1	47.4	55.5	PASS
0.220000	4.4	2000.0	10.000	GND	N	0.1	42.4	46.8	PASS
0.305000	-1.2	2000.0	10.000	GND	N	0.1	51.2	50	PASS
0.450000	-4.4	2000.0	10.000	GND	N	0.1	54.4	50	PASS
13.07500	-6.1	2000.0	10.000	GND	N	1.0	56.1	50	PASS
13.92500	-8.1	2000.0	10.000	GND	L1	1.2	58.1	50	PASS
15.37500	-8.7	2000.0	10.000	GND	N	1.2	58.7	50	PASS
18.69000	-8.7	2000.0	10.000	GND	N	1.5	58.7	50	PASS
19.31500	-5.5	2000.0	10.000	GND	N	1.5	55.5	50	PASS
20.30000	-5.1	2000.0	10.000	GND	L1	1.7	55.1	50	PASS
20.73000	-3.6	2000.0	10.000	GND	N	1.6	53.6	50	PASS
22.28000	1.8	2000.0	10.000	GND	L1	1.8	48.2	50	PASS
24.01500	12.8	2000.0	10.000	GND	N	1.6	37.2	50	PASS
25.25500	6.2	2000.0	10.000	GND	L1	2.0	43.8	50	PASS
26.21000	2.1	2000.0	10.000	GND	N	1.7	47.9	50	PASS

13 Occupied Bandwidth

13.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	916.5 MHz
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	5 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 20 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 V dc	6 V dc ±10 % (as declared)

13.3 Test Limit

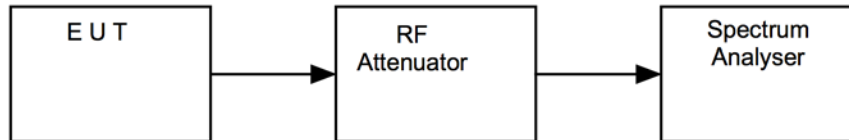
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 Test Method

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

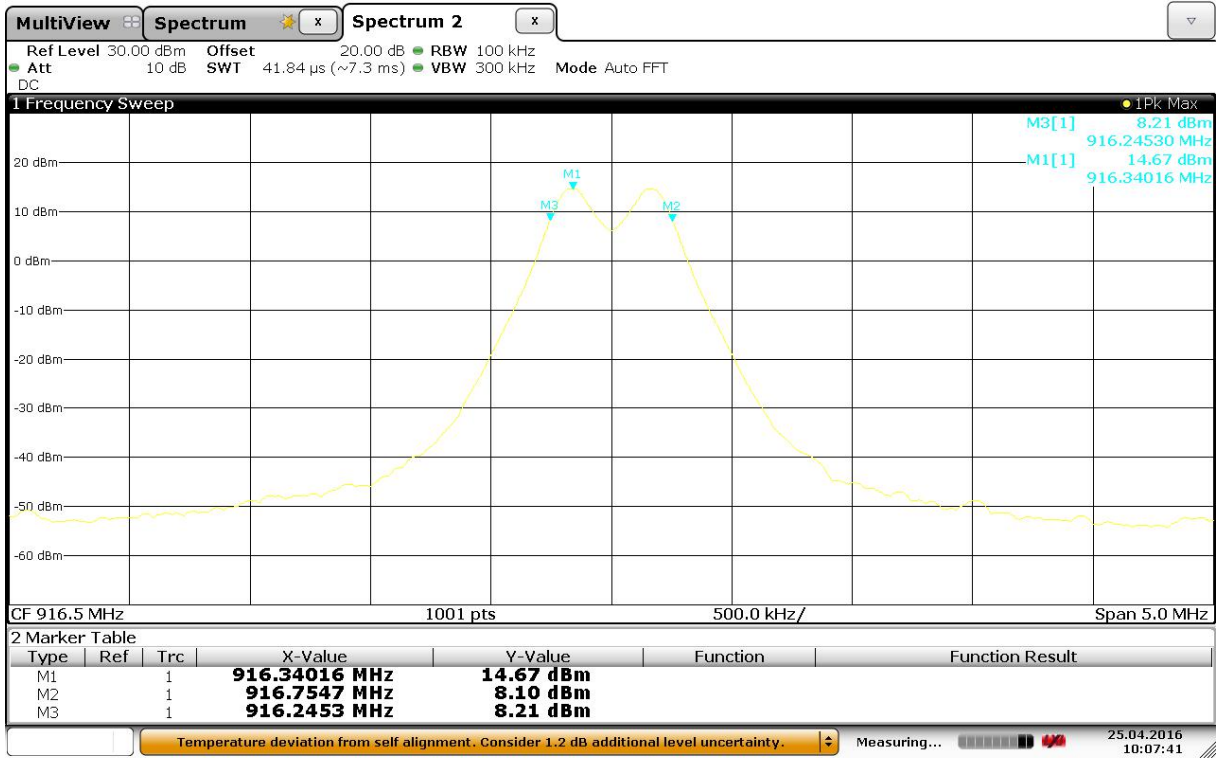
Figure iii Test Setup



13.5 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>
Spectrum analyser	R&S	FSU50	U544	16/03/2017	12

13.6 Test Results



Date: 25.APR.2016 10:07:41

Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
916.5 MHz	916.2453	916.7547	509.4	PASS

14 Maximum conducted output power

14.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

The maximum conducted (average) output power to be measured as an alternative to the maximum peak conducted output power for determining compliance to the limit.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.2.2.2
EUT Channels / Frequencies Measured:	916.5 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	RMS
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 25 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

As an alternative to a peak power measurement, compliance with the 1 W limit can be based on a measurement of the maximum conducted output power.

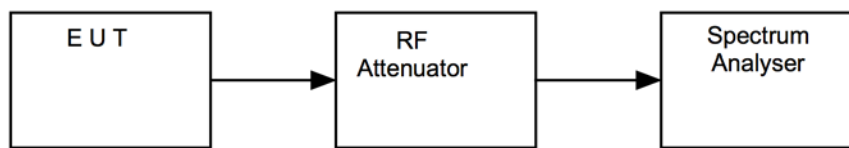
14.4 Test Method

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.

Measurements were performed in accordance with 558074 D01 DTS Meas Guidance v03r04 Clause 9.2.2.2.

Figure iv Test Setup



14.5 Test Equipment

Type of Equipment	Maker/Supplier	Model Number	Element Number	Calibration Due Date	Calibration Interval
Spectrum analyser	R&S	FSU50	U544	16/03/2017	12

14.6 Test Results

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
916.5	14.68	0.00	29.37	PASS

15 Out-of-band and conducted spurious emissions

15.1 Definition

Out-of-band emission.

Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission.

Emission on a frequency or frequencies that 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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	916.5 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 20 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 V dc	6 V dc \pm 10 % (as declared)

15.3 Test Limit

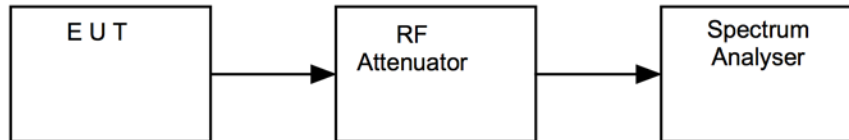
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) / RSS-Gen is not required.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were 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.

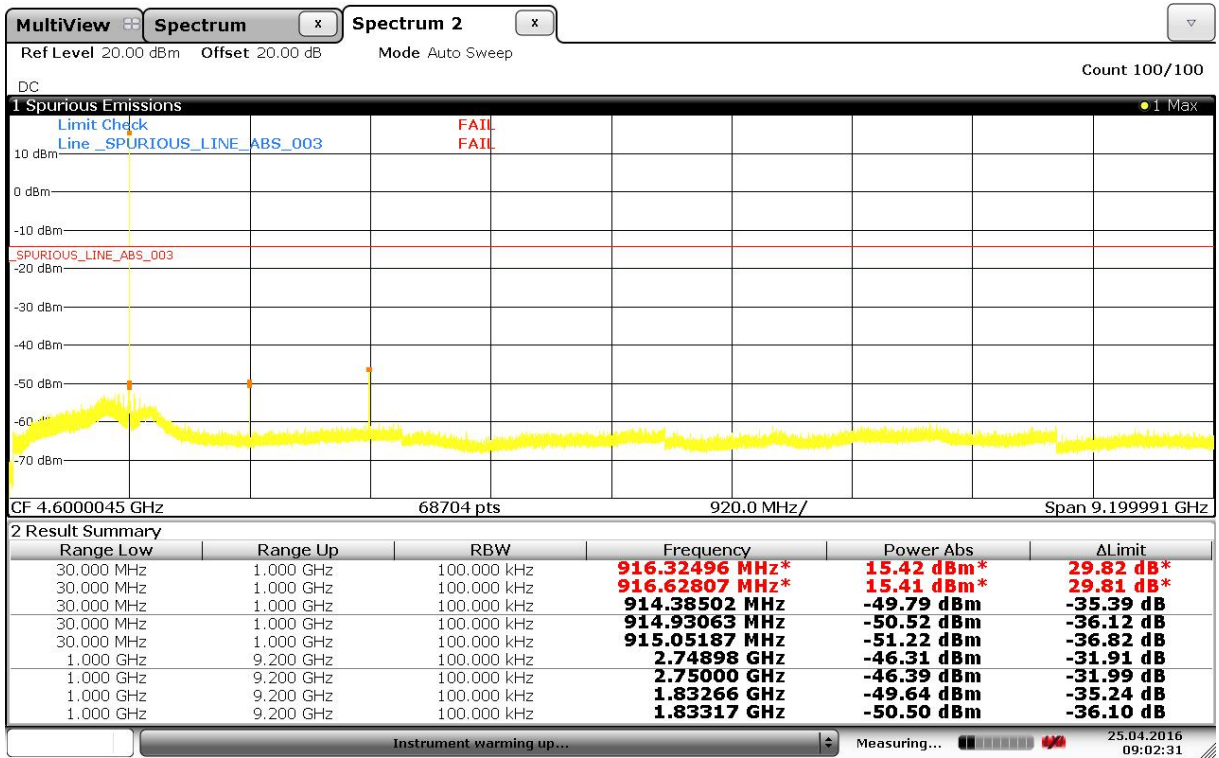
Figure v Test Setup



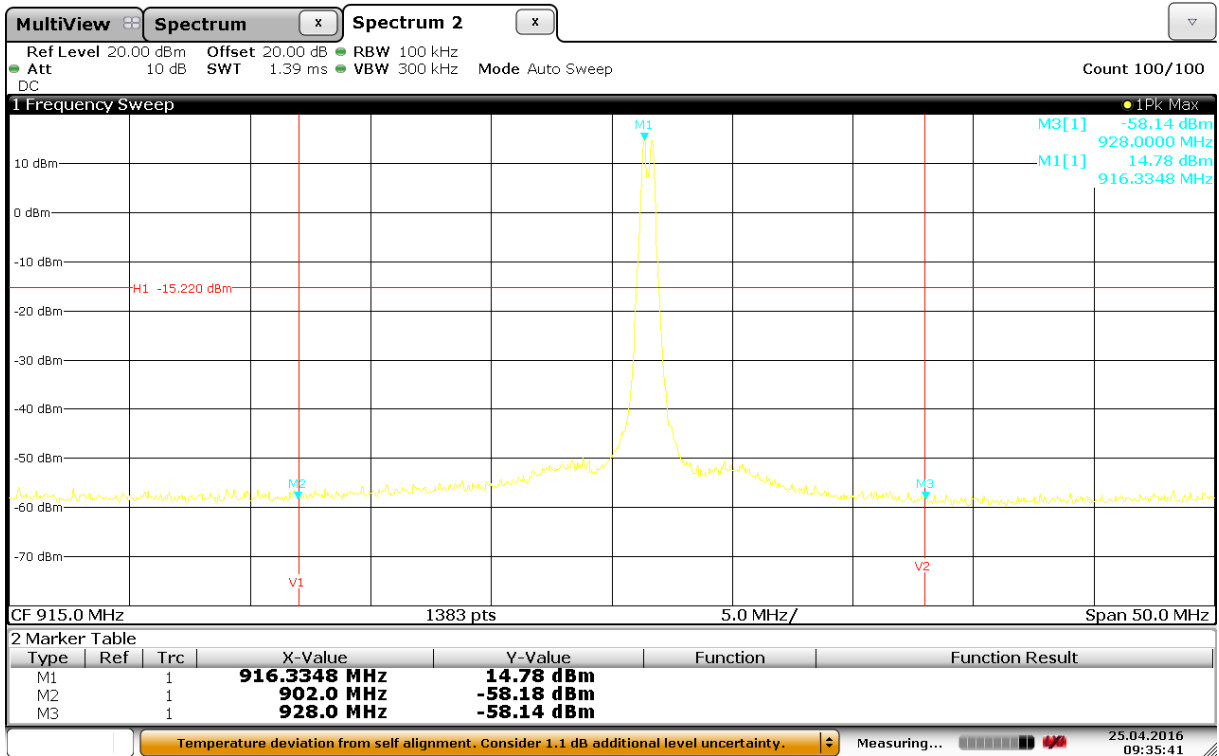
15.5 Test Equipment

<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>
Spectrum analyser	R&S	FSU50	U544	16/03/2017	12

15.6 Test Results



Date: 25.APR.2016 09:02:31



Date: 25.APR.2016 09:35:41

No emission within 20 dB to the limit

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	916.5 MHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 1.5 times Channel BW)	5 MHz
Measurement Detector:	RMS / Av

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 25 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 V dc	6 V dc \pm 10% (as declared)

16.3 Test Limit

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

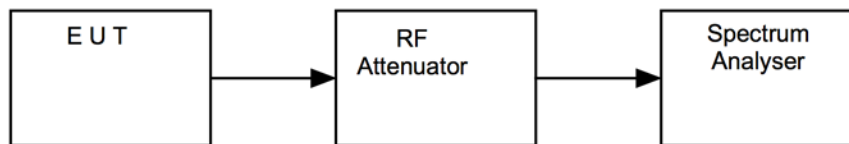
16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

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.

As Output measurements were performed in accordance with 558074 D01 DTS Meas Guidance v03r04 Clause 9.2.2.2 power spectral density is performed in accordance with clause 10.3

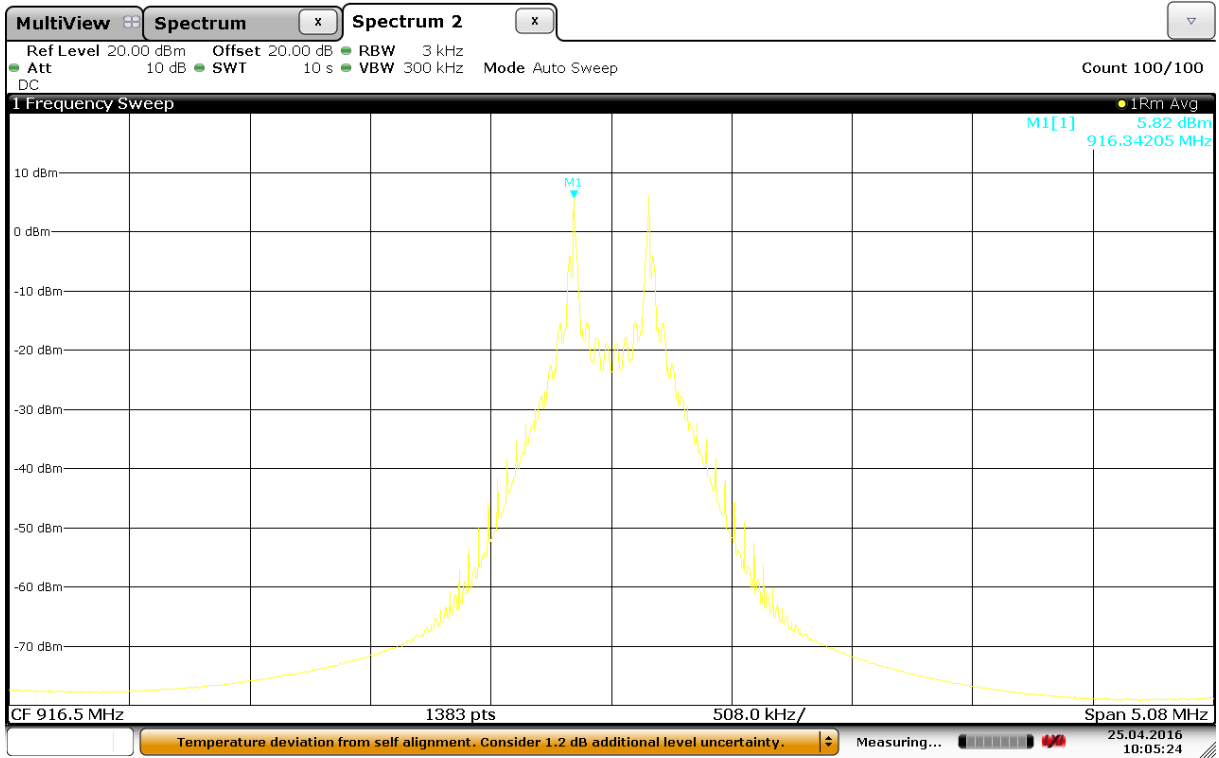
Figure vi Test Setup



16.5 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>
Spectrum analyser	R&S	FSU50	U544	16/03/2017	12

16.6 Test Results



Date: 25.APR.2016 10:05:25

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
916.5 MHz	5.82	0.00	5.82	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 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**

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

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

[5] Conducted / radiated RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**

Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

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

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

[6] Power spectral density

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