

Report on the Radio Testing

For

EkkoSense Ltd

on

EkkoHub

Report no. TRA-036043-47-00A

13 October 2018

RF915 6.0



Report Number: TRA-036043-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
EkkoSense Ltd
EkkoHub
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 22nd August - 11th September 2018

Written by:

D Garvey
TelecomsTest Engineer

Approved by:

J Charters
Department Manager - Radio

Date: 13 October 2018

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	13 October 2018	Original

2 Summary

TEST REPORT NUMBER: TRA-036043-47-00A

WORKS ORDER NUMBER: TRA-036043-02

PURPOSE OF TEST: USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.

TEST SPECIFICATION(S): 47CFR15.247

EQUIPMENT UNDER TEST (EUT): EkkoHub

FCC IDENTIFIER: 2AP4G-FS-EH-02

EUT SERIAL NUMBER: HUB 2

MANUFACTURER/AGENT: EkkoSense Ltd

ADDRESS: Sir Colin Campbell Building
University of Nottingham Innovation Park
Triumph Road
Nottingham
NG7 2TU
United Kingdom

CLIENT CONTACT: David Corder
☎ 0115 8232664
✉ david.corder@ekkosense.co.uk

TEST DATE: 22nd August - 11th September 2018

TESTED BY: D Garvey
Element

2.1 Test Summary

Test Method and Description		Requirement Clause 47CFR15	Applicable to this equipment	Result / Note
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions		15.207	<input checked="" type="checkbox"/>	Pass
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	Pass
Conducted carrier power	Peak	15.247(b)(3)	<input checked="" type="checkbox"/>	Pass
	Max.		<input type="checkbox"/>	
Conducted / radiated RF power out-of-band		15.247(d)	<input checked="" type="checkbox"/>	Pass
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	Pass
Calculation of duty correction		15.35(c)	<input type="checkbox"/>	Note 1

Notes:

1. Duty cycle is not required to be taken into account for any requirements to be met.

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
7.4	EUT Radio Parameters.....	12
7.4.1	General.....	12
7.4.2	Antennas.....	12
7.4.3	Product specific declarations.....	13
7.5	EUT Description.....	13
8	Modifications.....	14
9	EUT Test Setup.....	15
9.1	Block Diagram.....	15
9.2	General Set-up Photograph.....	16
10	General Technical Parameters.....	17
10.1	Normal Conditions.....	17
10.2	Varying Test Conditions.....	17
11	Radiated emissions.....	18
11.1	Definitions.....	18
11.2	Test Parameters.....	18
11.3	Test Limit.....	18
11.4	Test Method.....	19
11.5	Test Set-up Photograph.....	20
11.6	Test Equipment.....	20
11.7	Test Results.....	21
12	AC power-line conducted emissions.....	23
12.1	Definition.....	23
12.2	Test Parameters.....	23
12.3	Test Limit.....	23
12.4	Test Method.....	24
12.5	Test Set-up Photograph.....	24
12.6	Test Equipment.....	24
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.....	27
13.5	Test Equipment.....	28
13.6	Test Results.....	28
14	Maximum peak conducted output power.....	29
14.1	Definition.....	29
14.2	Test Parameters.....	29
14.3	Test Limit.....	29
14.4	Test Method.....	30
14.5	Test Equipment.....	30
14.6	Test Results.....	30
15	Out-of-band and conducted spurious emissions.....	31
15.1	Definition.....	31
15.2	Test Parameters.....	31
15.3	Test Limit.....	31
15.4	Test Method.....	32
15.5	Test Equipment.....	32
15.6	Test Results.....	33

16	Power spectral density	34
16.1	Definition	34
16.2	Test Parameters.....	34
16.3	Test Limit	34
16.4	Test Method	34
16.5	Test Equipment.....	35
16.6	Test Results	35
17	Measurement Uncertainty	36
18	RF Exposure	37

4 Introduction

This report TRA-036043-47-00A presents the results of the Radio testing on a EkkoSense Ltd, EkkoHub to specification 47CFR15C.

The testing was carried out for EkkoSense Ltd by Element, at the addresses detailed below.

<input checked="" 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
-------------------------------------	---	-------------------------------------	---

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.

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
POE	Power Over Ethernet
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: EkkoHub
- Serial Number: HUB 2
- Model Number: FS-EH-02
- Software Revision: Not Applicable
- 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 transmitter tests was as follows:-

The EUT was preprogrammed to produce a modulated carrier at 915.0 MHz when powered up.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	915.0 MHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	Wideband
Channel spacing:	Single channel
ITU emission designator(s):	F1D
Declared output power(s):	10 dBm
Nominal Supply Voltage:	48 Vdc (POE)
Duty cycle:	100% for test

7.4.2 Antennas

Type:	Molex 105262-0001
Frequency range:	ISM 868/915
Impedance:	50 Ohms
Gain:	1.4dBi gain
Polarisation:	Linear
Beam width:	Omni
Connector type:	MRFC
Length:	79mm (100mm Cable)
Weight:	0.690/g
Environmental limits:	-40°C to +85°C
Mounting:	Adhesive

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	Single Antenna
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	Not Applicable
Fixed pt-mpt operations (yes/no):	No
Simultaneous tx (yes/no):	No

7.5 EUT Description

The system consists of multiple battery powered temperature and humidity sensors (EkkoSensors) communicating over the RF link back to the EkkoHub which processes the received data and forwards it over the Ethernet interface to data processing software

This report covers the EkkoHub operating at 915.0 MHz

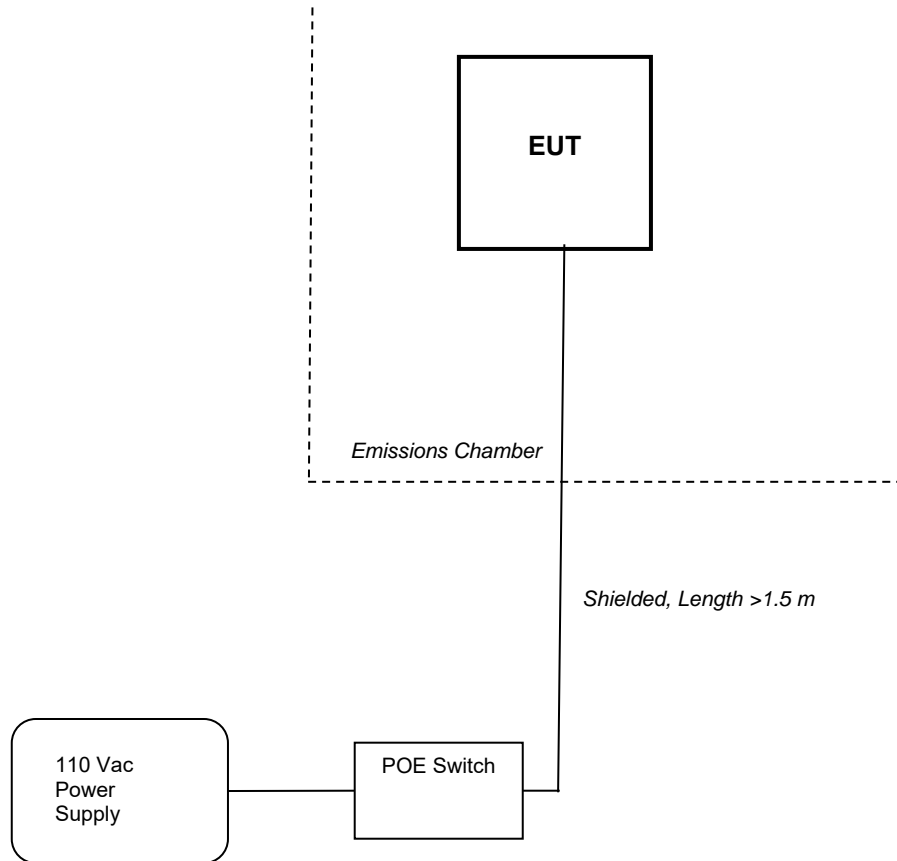
8 Modifications

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 48 Vdc from a POE device.

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 type="checkbox"/>	Battery	New battery	N/A
<input checked="" type="checkbox"/>	POE	48 Vdc	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 Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequency Measured:	915 MHz
EUT Channel Bandwidths:	1 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: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: PoE	PoE

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;

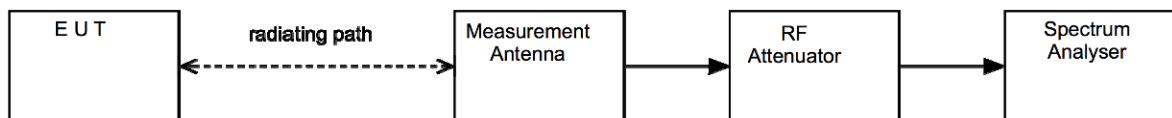
PA is the pre-amplifier gain in dB (where used);

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



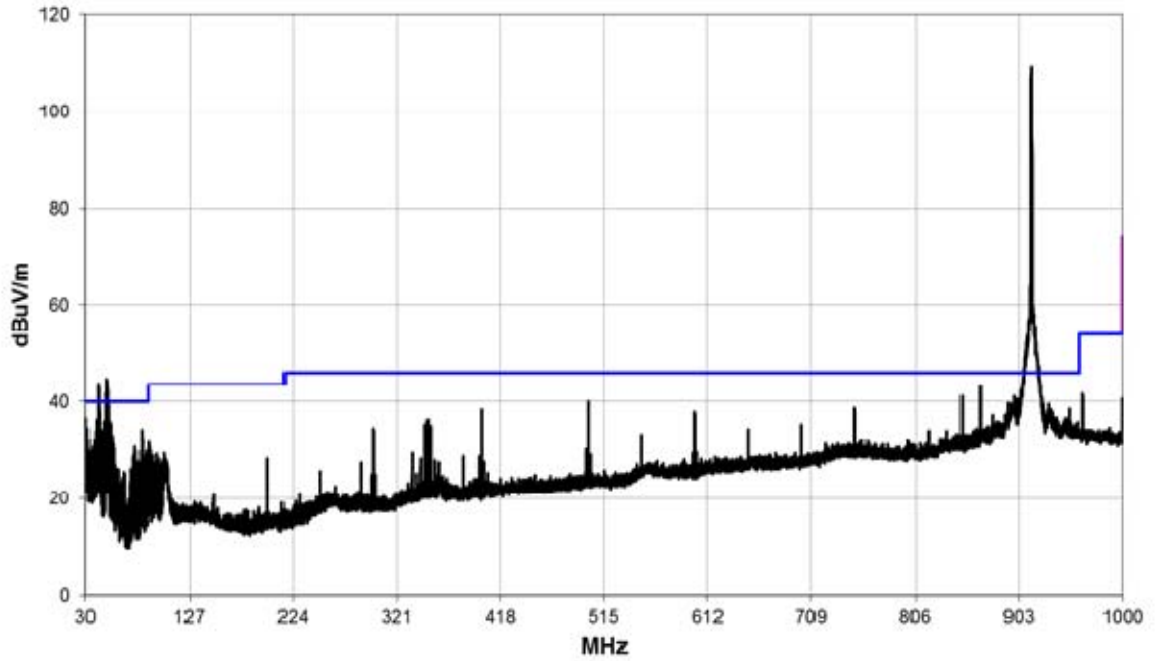
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	2019-05-22
Spectrum Analyser	R&S	FSU46	U281	2018-09-19
Bilog Antenna	Chase	CBL6111B	REF2218	2019-11-06
Ferrite Lined Chamber	Rainford	ATS	REF886	2019-07-24
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	2019-02-07
Horn Antenna	EMCO	3115	RF9129	2020-02-12

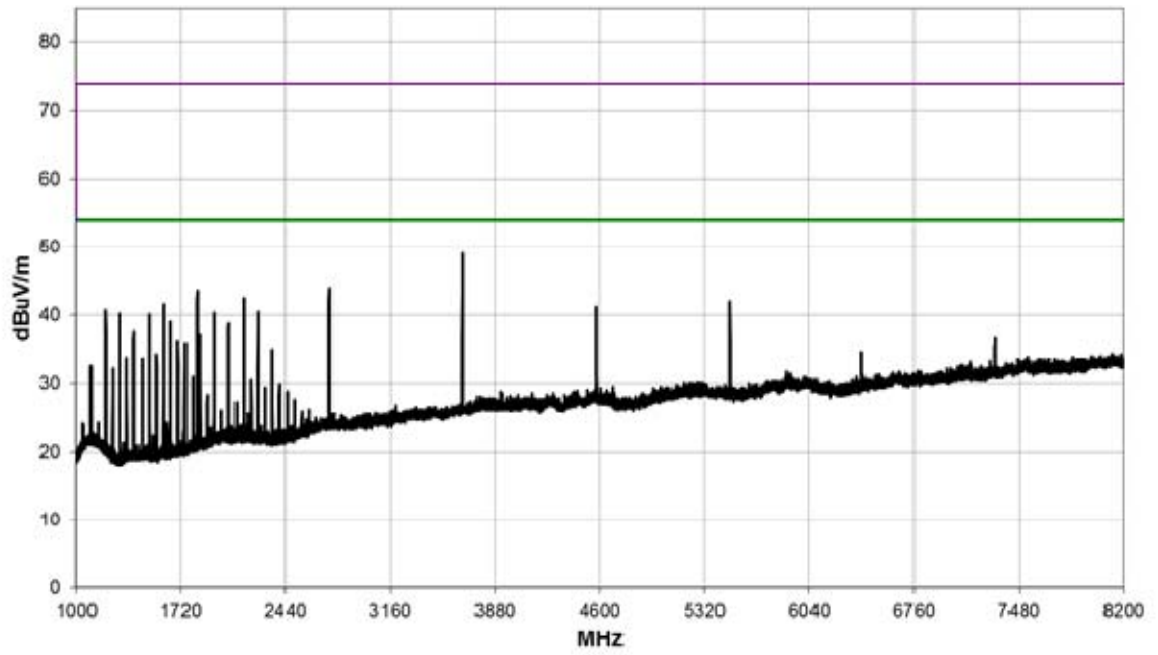
11.7 Test Results

High Power; Frequency 915 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)
PQ	38.0	43.1	0.6	20.7	32.5	0	0	31.9	39.4	100.0
PQ	400.0	47.7	1.8	21.9	32.4	0	0	39.0	89.1	200.0
AV	3660.7	54.8	4.6	31.6	35.4	0	0	46.1	201.8	500.0
PK	3660.9	61.3	4.6	31.6	35.4	0	0	52.6	426.6	5000.0

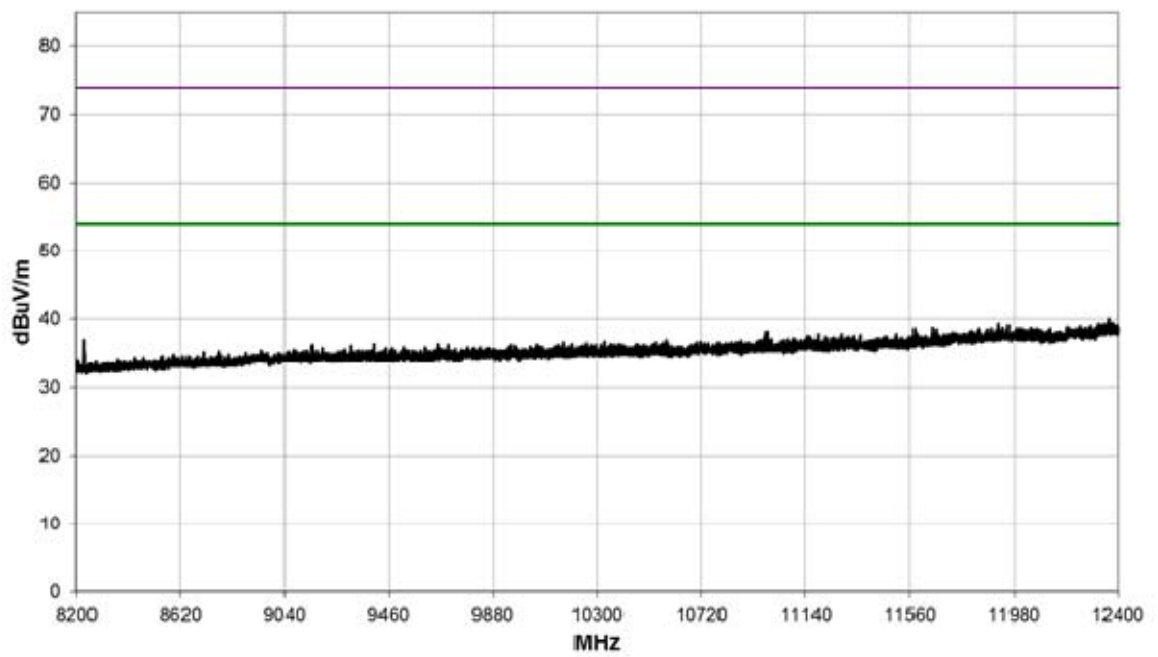
30 MHz – 1 GHz



1 – 8.2 GHz



8.2 – 12.4 GHz



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:	Transient Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Frequency Measured:	915.0 MHz
EUT Channel Bandwidths:	Wideband
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 49 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac to POE	EUT powered from POE

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.

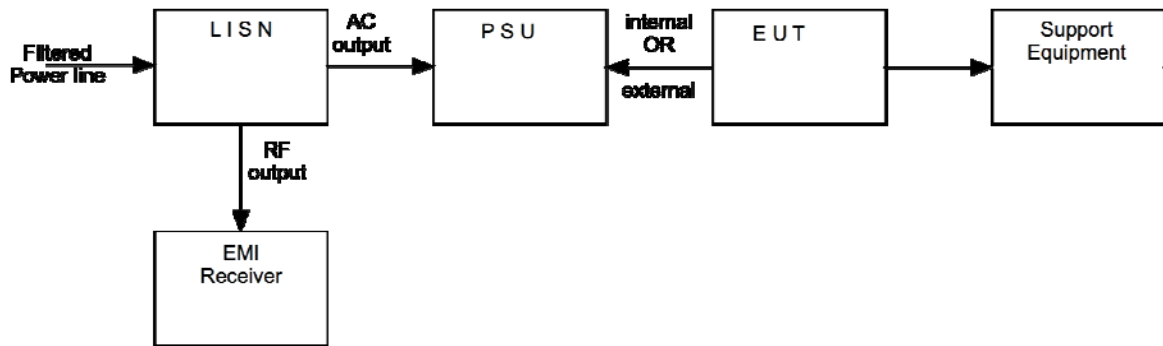
12.4 Test Method

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

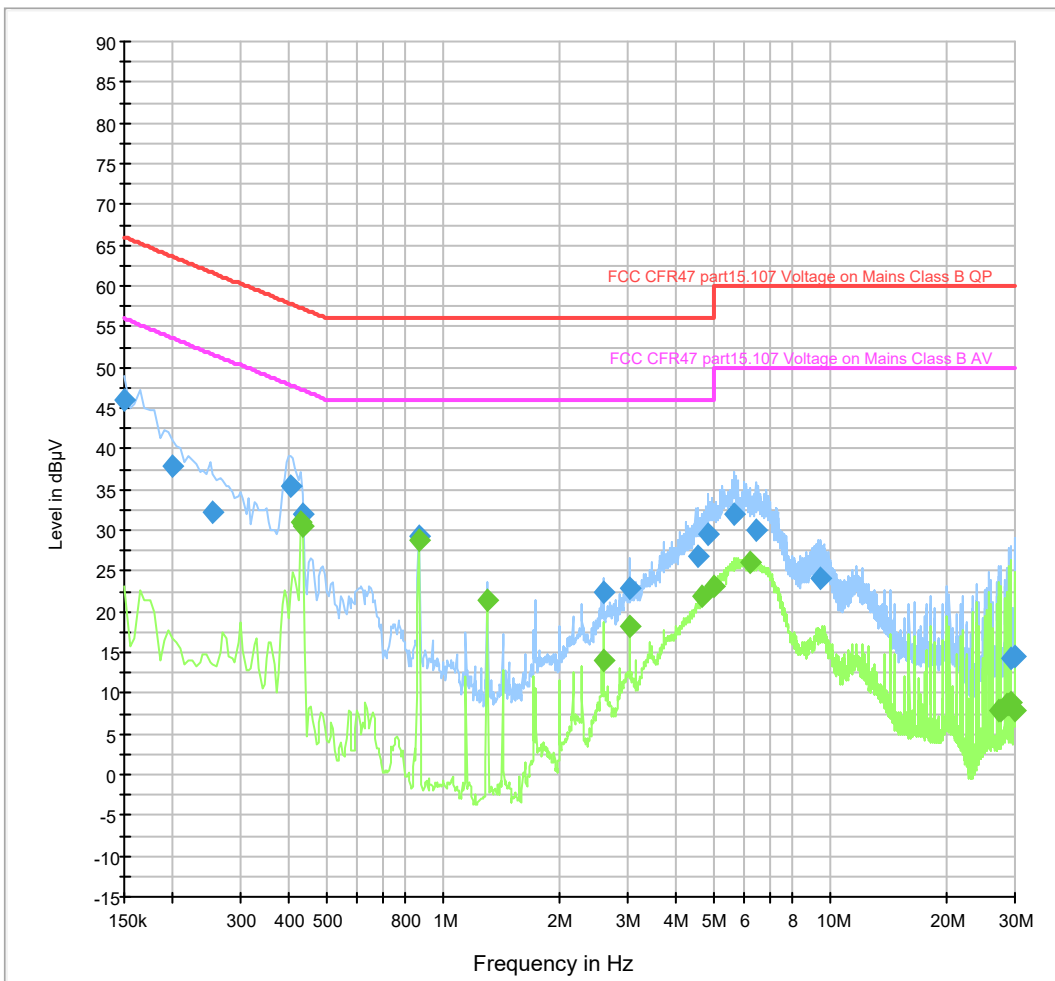


12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Receiver	U187	2018-11-09
ENV216	R&S	Lisn	U396	2018-07-05
ESH3-Z2	R&S	Pulse Limiter	U443	2018-01-29

12.7 Test Results

Conducted emissions on Mains 9kHz-30MHz ESHS10+UH396+UH443PL



Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	46.0	2000.0	10.000	On	L1	19.5	20.0	66.0
0.200000	37.9	2000.0	10.000	On	N	19.5	25.7	63.6
0.255000	32.2	2000.0	10.000	On	L1	19.6	29.4	61.6
0.405000	35.4	2000.0	10.000	On	N	19.6	22.4	57.8
0.435000	31.9	2000.0	10.000	On	N	19.6	25.2	57.2
0.865000	29.4	2000.0	10.000	On	N	19.6	26.6	56.0
2.595000	22.3	2000.0	10.000	On	N	19.6	33.7	56.0
3.030000	22.7	2000.0	10.000	On	N	19.6	33.3	56.0
4.555000	26.8	2000.0	10.000	On	N	19.7	29.2	56.0
4.855000	29.4	2000.0	10.000	On	N	19.7	26.6	56.0
5.640000	31.9	2000.0	10.000	On	L1	19.7	28.1	60.0
6.400000	30.1	2000.0	10.000	On	L1	19.7	29.9	60.0
9.380000	24.0	2000.0	10.000	On	L1	19.7	36.0	60.0
29.435000	14.3	2000.0	10.000	On	L1	19.9	45.7	60.0
29.995000	14.5	2000.0	10.000	On	L1	20.0	45.5	60.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.430000	30.9	2000.0	10.000	On	N	19.6	16.3	47.3
0.435000	30.5	2000.0	10.000	On	L1	19.6	16.6	47.2
0.865000	28.7	2000.0	10.000	On	N	19.6	17.3	46.0
1.300000	21.5	2000.0	10.000	On	L1	19.6	24.6	46.0
2.600000	14.1	2000.0	10.000	On	L1	19.6	31.9	46.0
3.030000	18.3	2000.0	10.000	On	N	19.6	27.7	46.0
4.685000	21.8	2000.0	10.000	On	L1	19.7	24.2	46.0
4.995000	23.1	2000.0	10.000	On	L1	19.7	22.9	46.0
6.215000	26.0	2000.0	10.000	On	N	19.7	24.0	50.0
27.275000	8.0	2000.0	10.000	On	L1	19.9	42.0	50.0
27.705000	7.9	2000.0	10.000	On	L1	19.9	42.1	50.0
28.570000	8.5	2000.0	10.000	On	L1	19.9	41.5	50.0
29.005000	8.5	2000.0	10.000	On	L1	19.9	41.5	50.0
29.435000	9.0	2000.0	10.000	On	L1	19.9	41.0	50.0
29.870000	7.9	2000.0	10.000	On	L1	20.0	42.1	50.0

13 Occupied Bandwidth

13.1 Definition

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

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Frequency Measured:	915.0 MHz
EUT Channel Bandwidths:	Wideband
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Span:	5 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

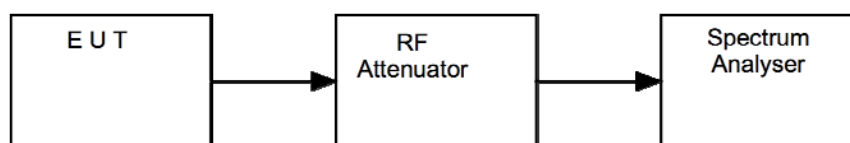
The minimum -6 dB bandwidth shall be at least 500 kHz.

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

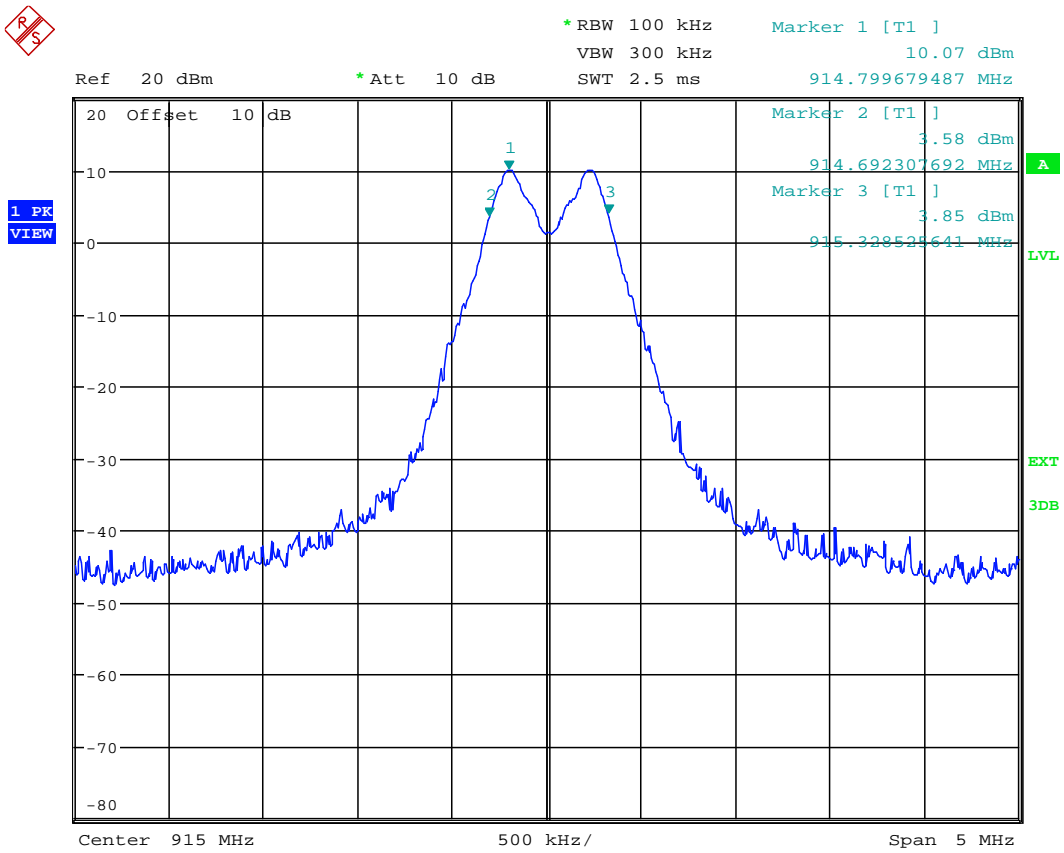


13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	U405	2018-06-06
Attenuator	AtlantecRF	10 dB	U643	In Use

13.6 Test Results

Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
915.0	914.6923077	915.3285256	636.217949	PASS



14 Maximum peak 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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Frequency Measured:	915 MHz
EUT Channel Bandwidths:	Wideband
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	PoE.

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

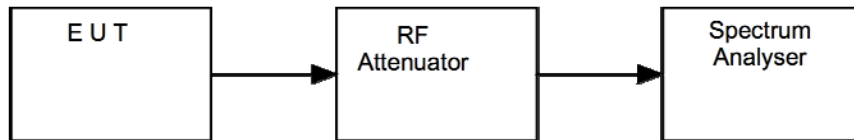
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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.

Figure iv Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	U405	2018-06-06
Attenuator	AtlantecRF	10 dB	U643	In Use

14.6 Test Results

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
915.0 MHz	0.29	10	10.69	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 Frequency Measured:	915.0 MHz
EUT Channel Bandwidths:	Wideband
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 10 GHz

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

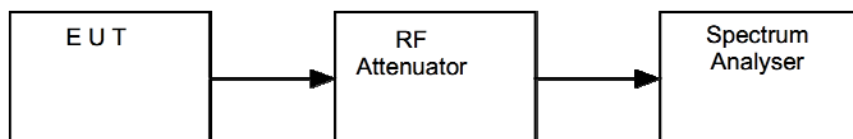
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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) 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.

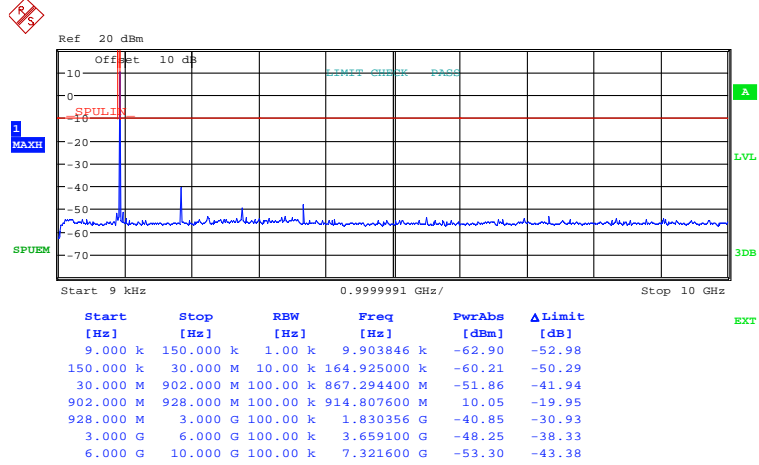
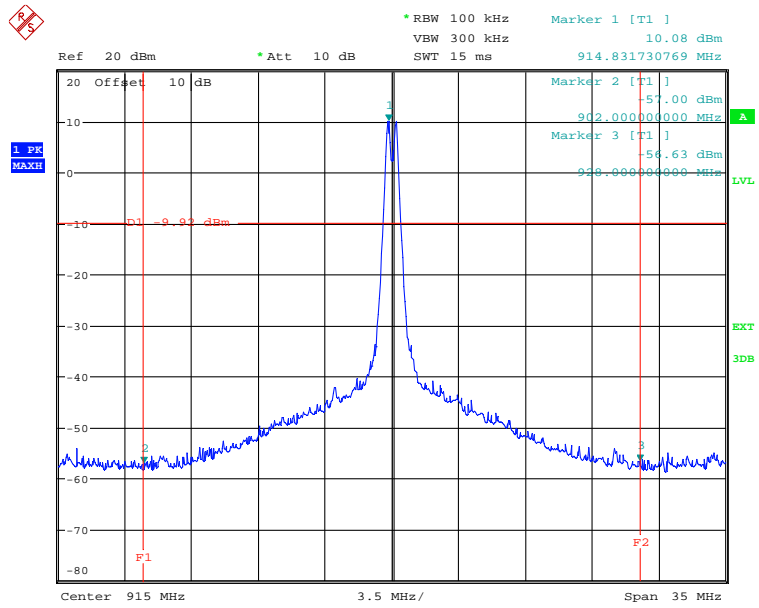
Figure v Test Setup



15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	U405	2018-06-06
Attenuator	AtlantecRF	10 dB	U643	In Use

15.6 Test Results



Channel Frequency (MHz)	Emission Frequency (MHz)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
915.0	N/A	10.08	N/A	N/A	PASS
No Significant Emissions Within 20 dB of 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 Frequency Measured:	915.0 MHz
EUT Channel Bandwidths:	Wideband
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

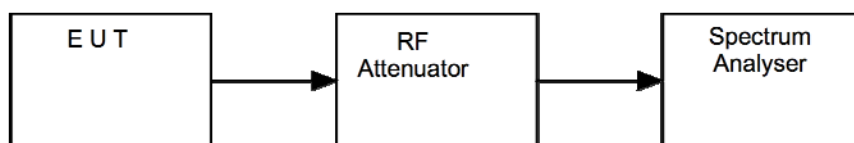
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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.

Figure vi Test Setup

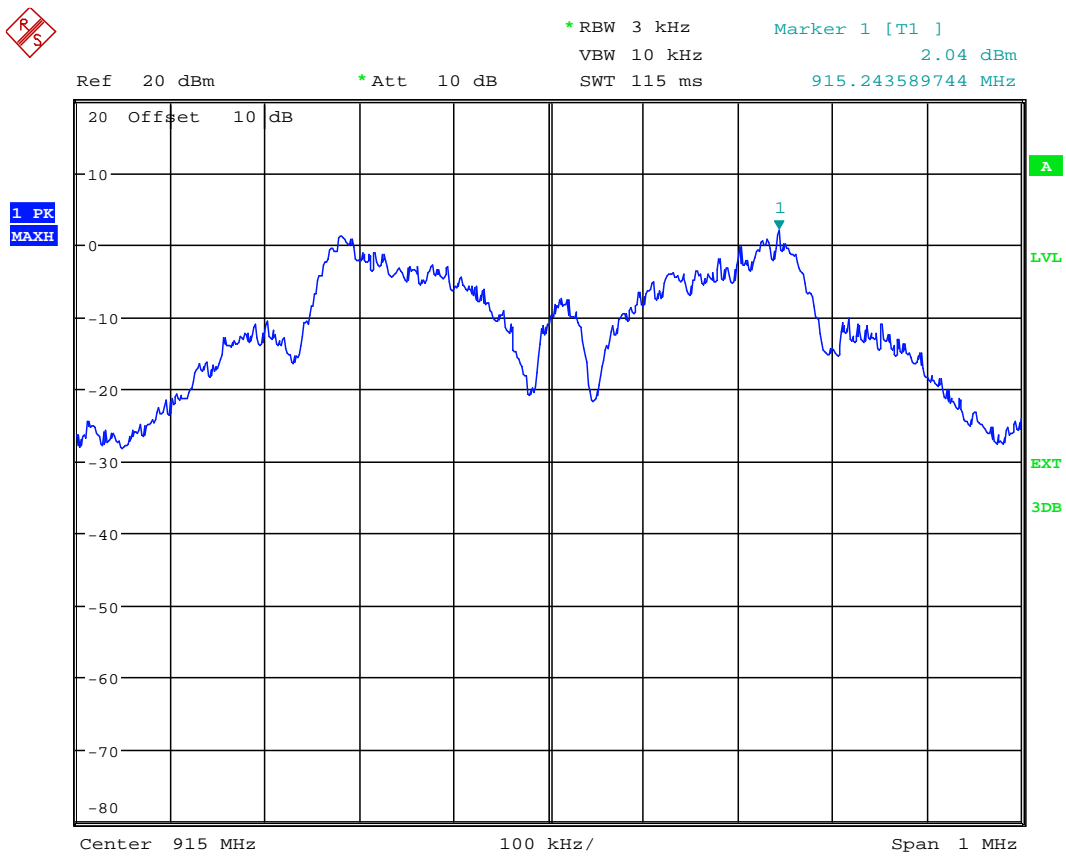


16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	U405	2018-06-06
Attenuator	AtlantecRF	10 dB	U643	In Use

16.6 Test Results

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
915.0 MHz	-7.96	10	2.04	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) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted 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**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **3.11 dB**

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**

Uncertainty in test result (Pershore OATS) = **4.26 dB**

18 RF Exposure

KDB 447498 - Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

In the frequency range below 100 MHz to 6 GHz and test separation distance of 50mm, the SAR Test Exclusion Threshold for operation at 915.0 will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

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

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

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

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

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^B - 50mm) * 10\}$$

Where:

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

Operating Frequency 915 MHz

$$\begin{aligned} MP &= [(3.0 * 50) / \sqrt{0.915}] + \{ (50 - 50) * [915/150] \} \\ MP &= [150 / \sqrt{0.915}] + \{ 0 * 6.11 \} \\ MP &= 156.8 \text{ mW} \end{aligned}$$

The calculated EIRP 11.72mW (Peak) is less than the SAR Exclusion Threshold of 156.8mW.