Report on the Radio Testing

For

Silent Herdsman Ltd

on

Base Station

Report no. TRA-027735-47-00B

20th November 2015

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

Report Number: TRA-027735-47-00B
Issue: A

REPORT ON THE RADIO TESTING OF A
Silent Herdsman Ltd
Base Station
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-210 Annex 8

TEST DATE: 24th - 28th September 2015

Written by:	D Winstanley	D Winstanley Radio Senior Test Engineer
Approved by:	John Charters Digitally signed by John Charters DN: cn=John Charters, o=Element Materials Technology, ou, email=john.charters@element.com, c=GB Date: 2015.11.20 14:54:45 Z	J Charters Department Manager - Radio
Date:	20th November 2015	

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1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	20th November 2015	Original

2 Summary

TEST REPORT NUMBER:	TRA-027735-47-00B
WORKS ORDER NUMBER	TRA-027735-03
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):	Base Station
FCC IDENTIFIER:	2ABHT2110013
EUT SERIAL NUMBER:	not applicable
MANUFACTURER/AGENT:	Silent Herdsman Ltd
ADDRESS:	Unit 9000 Academy Park 51 Gower Street Glasgow G51 1PR United Kingdom
CLIENT CONTACT:	Dave Evans ☎ 0141 255 2930 ✉ devans@silentherdsman.com
ORDER NUMBER:	Not Applicable
TEST DATE:	24th - 28th September 2015
TESTED BY:	D Winstanley Element

2.1 Test Summary

Test Method and Description		*47CFR15*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	*Pass*
AC power line conducted emissions		15.207	☒	*Pass*
Occupied bandwidth		15.247(a)(2)	☒	*Pass*
Conducted carrier power	Peak	15.247(b)(3)	☒	*Pass*
	Max.		☐	
Conducted / radiated RF power out-of-band		15.247(d)	☒	*Pass*
Power spectral density, conducted		15.247(e)	☒	*Pass*
Calculation of duty correction		15.35(c)	☐	*N/A*

Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

3 Contents

4 Introduction

This report TRA-027735-47-00B presents the results of the Radio testing on a Silent Herdsman Ltd, Base Station to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Silent Herdsman Ltd 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
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.

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-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: Base Station
- Serial Number: not applicable
- Model Number: V2.2
- 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.

	Desription	***Make***	***Model***	***Serial Number***
1	POE Injector	Planet	POE-151 (V2)	N/A
2	POE Injector Power Supply	Powertron Electronics Corp	PA1024-480HBB050	AF00103901774
3	Internet Broadband Router	Planet	XRT-401F	B400112400872(166)

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows:-
EUT was set to transmit a permanently modulated carrier on bottom middle and top frequencies

7.3.2 Reception

The mode of operation for Rx tests was as follows:-
EUT was set to permanent receive mode on bottom middle and top frequencies

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2455 MHZ – 2475 MHz
Modulation type(s):	DSSS
Occupied channel bandwidth(s):	5MHz
Channel spacing:	5MHz
Declared output power(s):	+2.4 dBm
Warning against use of alternative antennas in user manual (yes/no):	Yes
Nominal Supply Voltage:	48Vdc POE

7.4.2 Antennas

Type:	N-Type omni directional
Part number:	NET-WL-ANT-009NPLG
Frequency range:	2400 – 2483.5
Impedance:	50 ohm
Gain:	9 dBi
Polarisation:	N/A
Beam width:	N/A
Connector type:	N-Type

Type:	N-Type omni directional
Part number:	NET-WL-ANT-015ON
Frequency range:	2400 – 2500
Impedance:	50 ohm
Gain:	15 dBi
Polarisation:	N/A
Beam width:	N/A
Connector type:	N-Type

7.4.3 Product specific declarations

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

7.5 EUT Description

The EUT is a base station operating in the 2.4 GHz band.

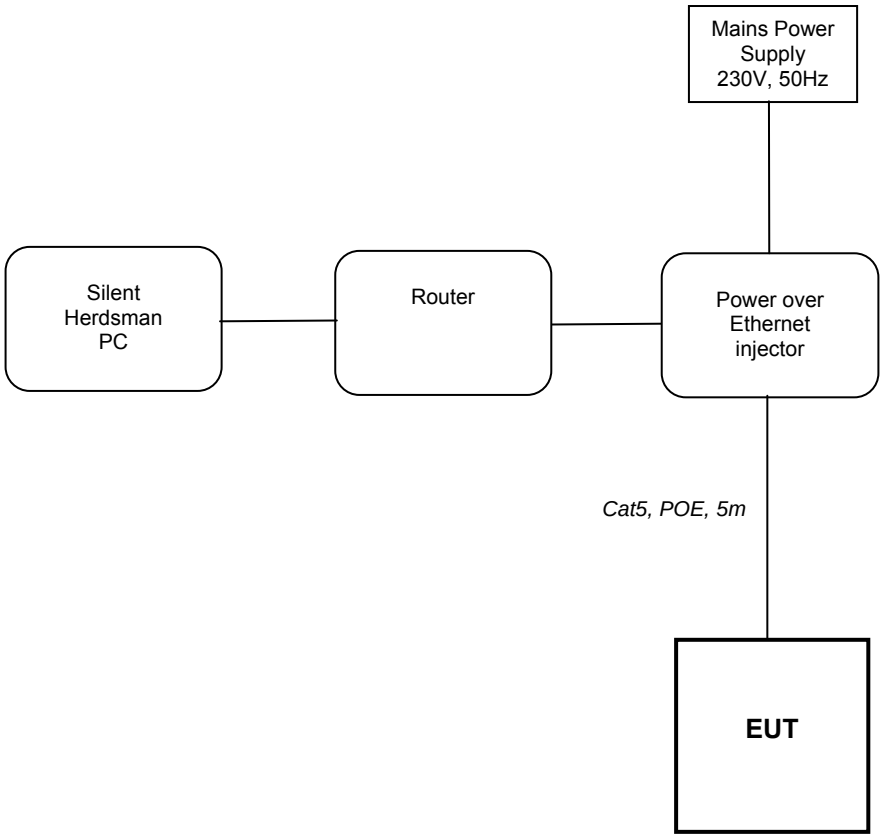
8 Modifications

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. 5 V dc from the adaptor / 3V dc from alkaline batteries / 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.

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	New battery	N/A
☐	Other	N/A	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 REF940
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	2455 MHz / 2465 MHz / 2475 MHz
EUT Channel Bandwidths:	5MHz
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: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)
Supply: 48 V dc POE	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

Frequency (MHz)	*Field Strength (µV/m at 3 m)*
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 dBµV/m at the regulatory distance, using:

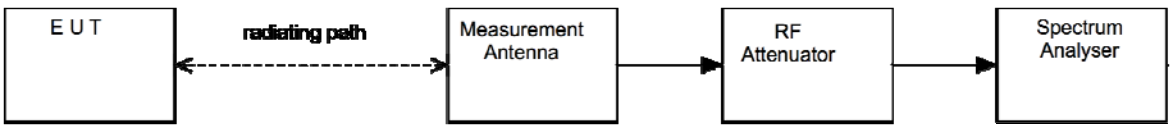
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

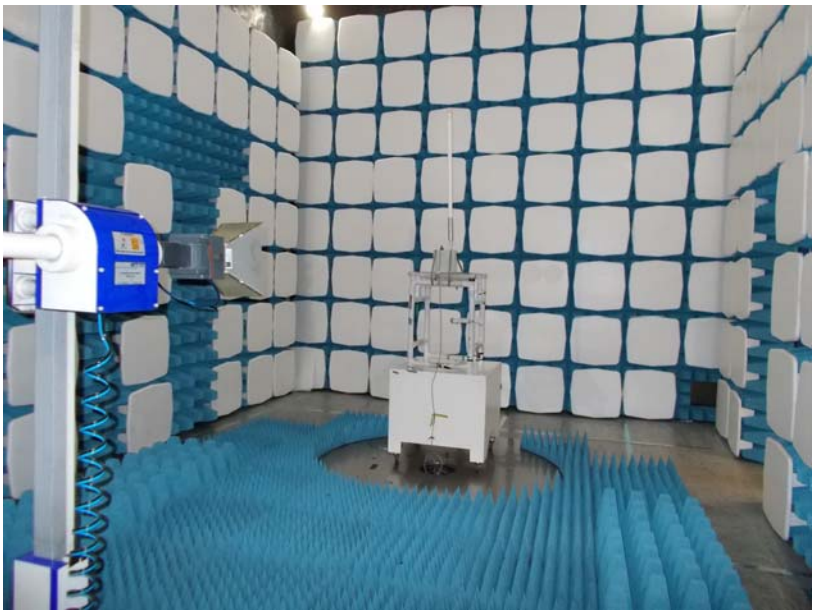
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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

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

Figure i Test Setup



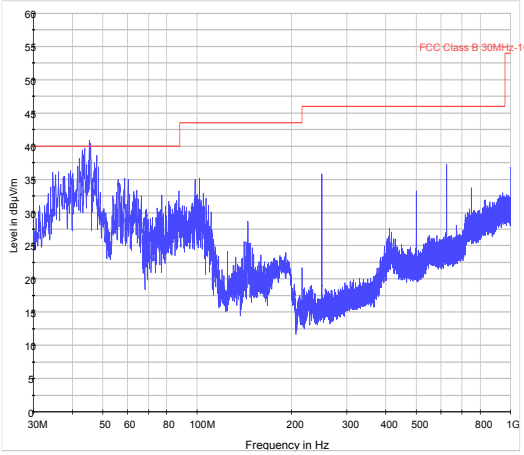
11.5 Test Set-up Photograph



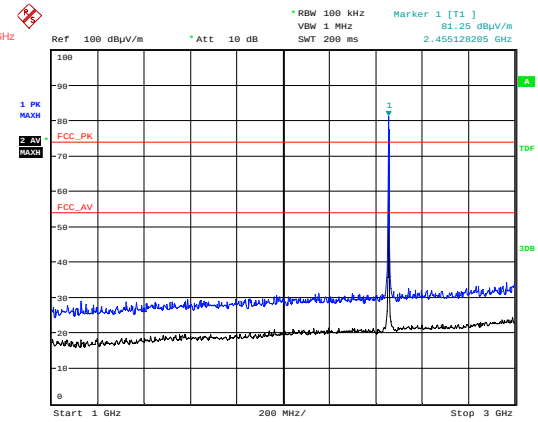
11.6 Test Equipment

Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*
EMI Receiver	R&S	ESVS10	TRL352	07/08/2016
Bilog Antenna	Chase	CBL6111/A	UH191	26/02/2017
Spectrum Analyser	R&S	FSU46	UH281	24/04/2016
Horn Antenna	Emco	3115	TRL138	17/10/2015
Horn Antenna	Flann	20240-20	TRL300	10/02/2016
Pre Amplifier	Agilent	8449A	TRL572	10/02/2016

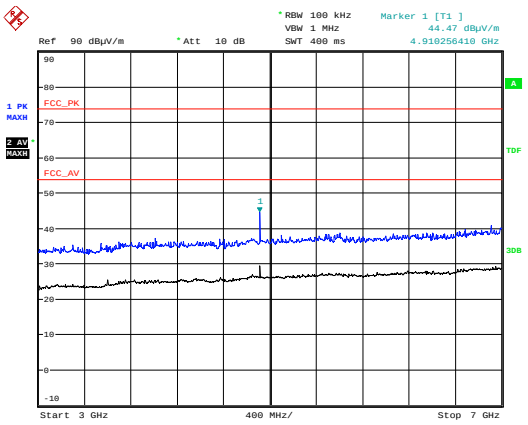
2455 MHz



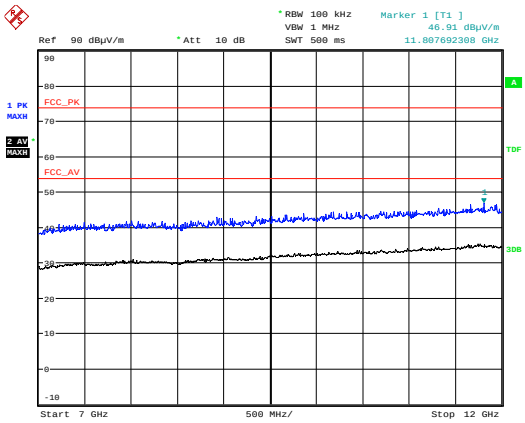
30 MH – 1 GHz



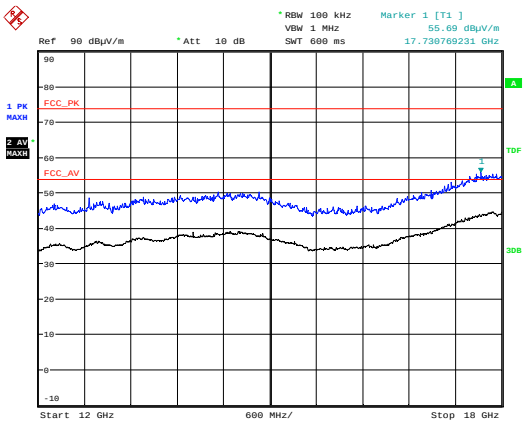
1 GHz – 3 GHz



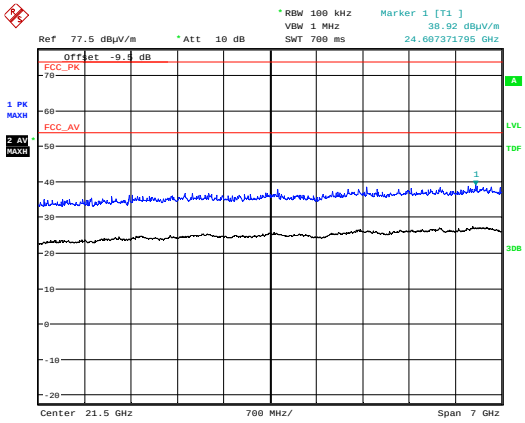
3 GHz – 7 GHz



7 GHz – 12 GHz

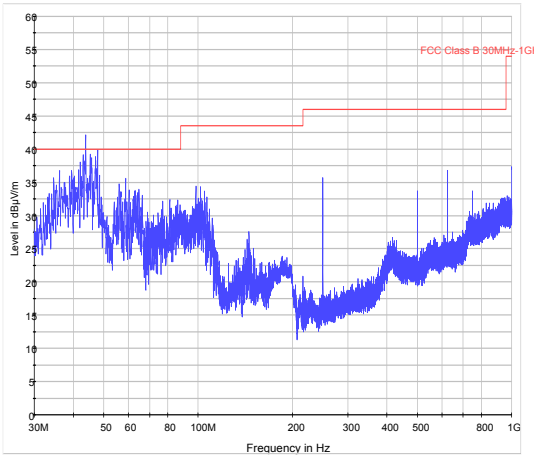


12 GHz – 18 GHz

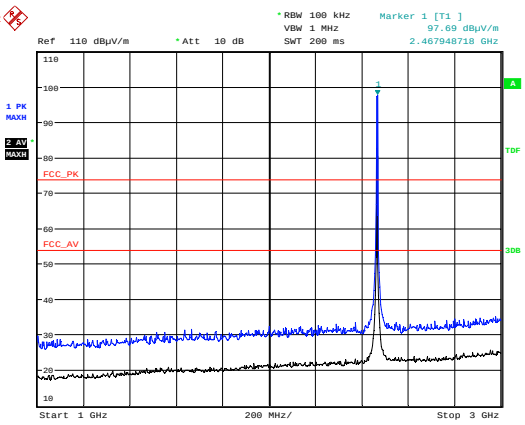


18 GHz – 25 GHz

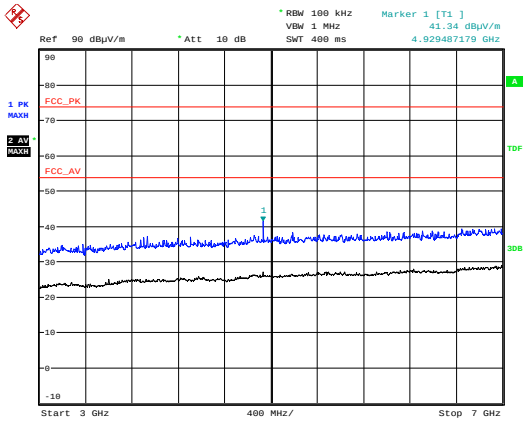
2465 MHz



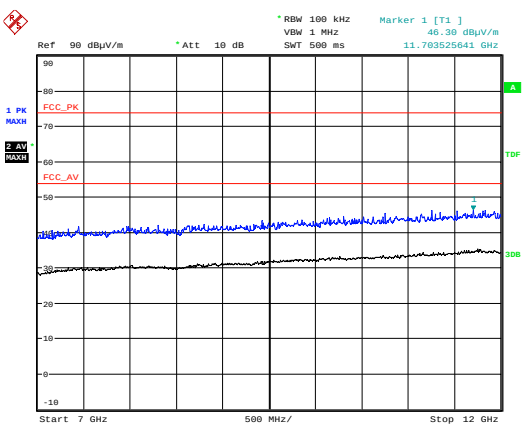
30 MH –1 GHz



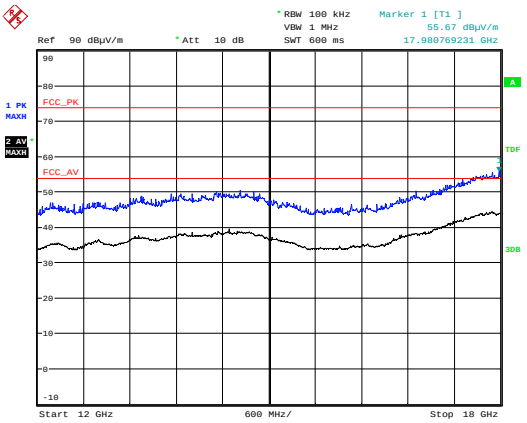
1 GHz – 3 GHz



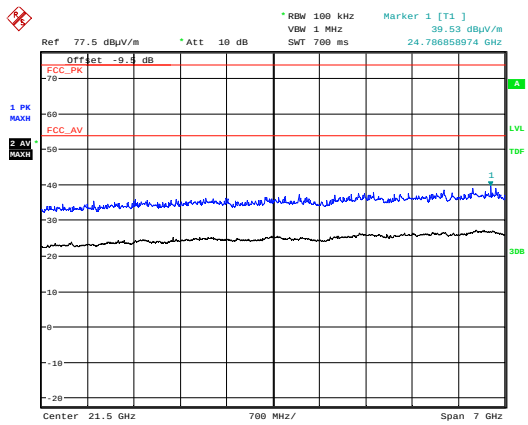
3 GHz – 7 GHz



7 GHz – 12 GHz

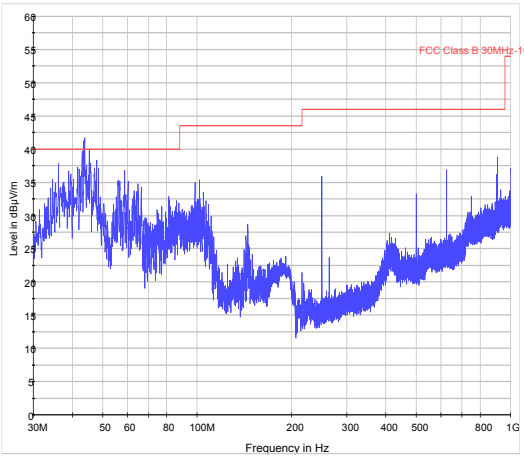


12 GHz – 18 GHz

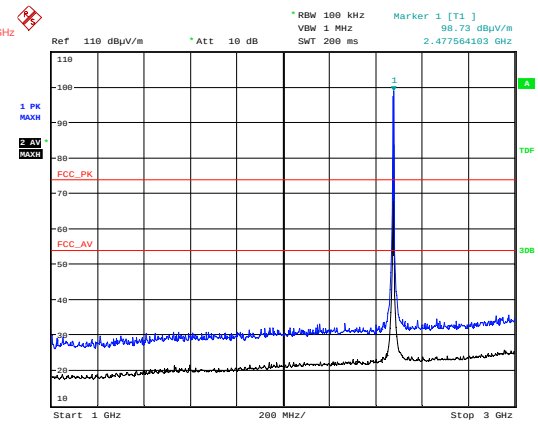


18 GHz – 25 GHz

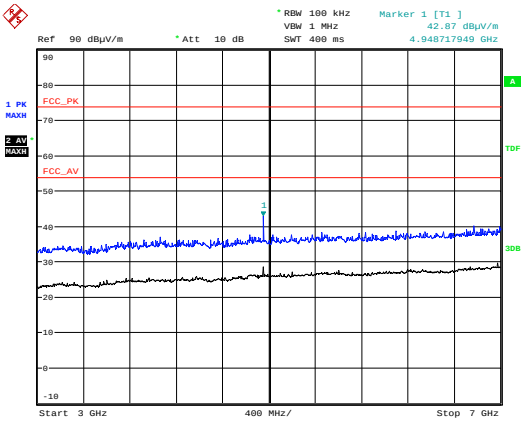
2475 MHz



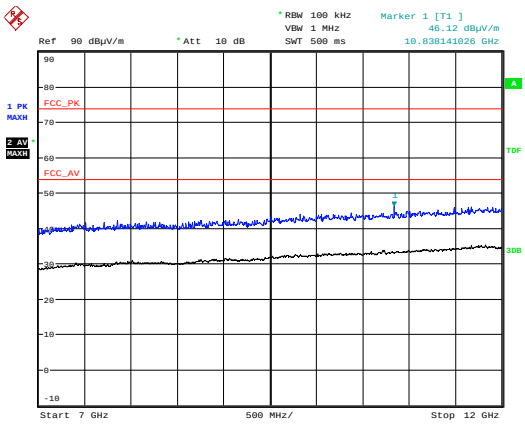
30 MH – 1GHz



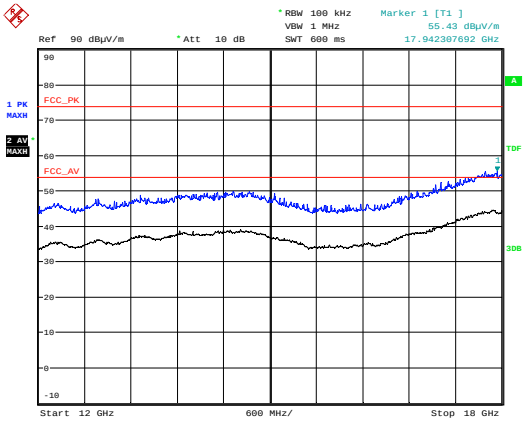
1GHz – 3GHz



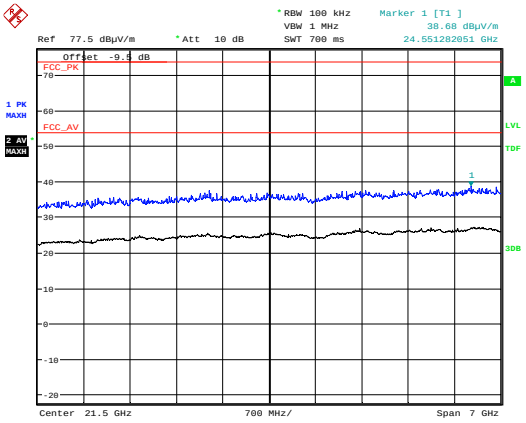
3 GHz – 7 GHz



7 GHz – 12 GHz



12 GHz – 18 GHz



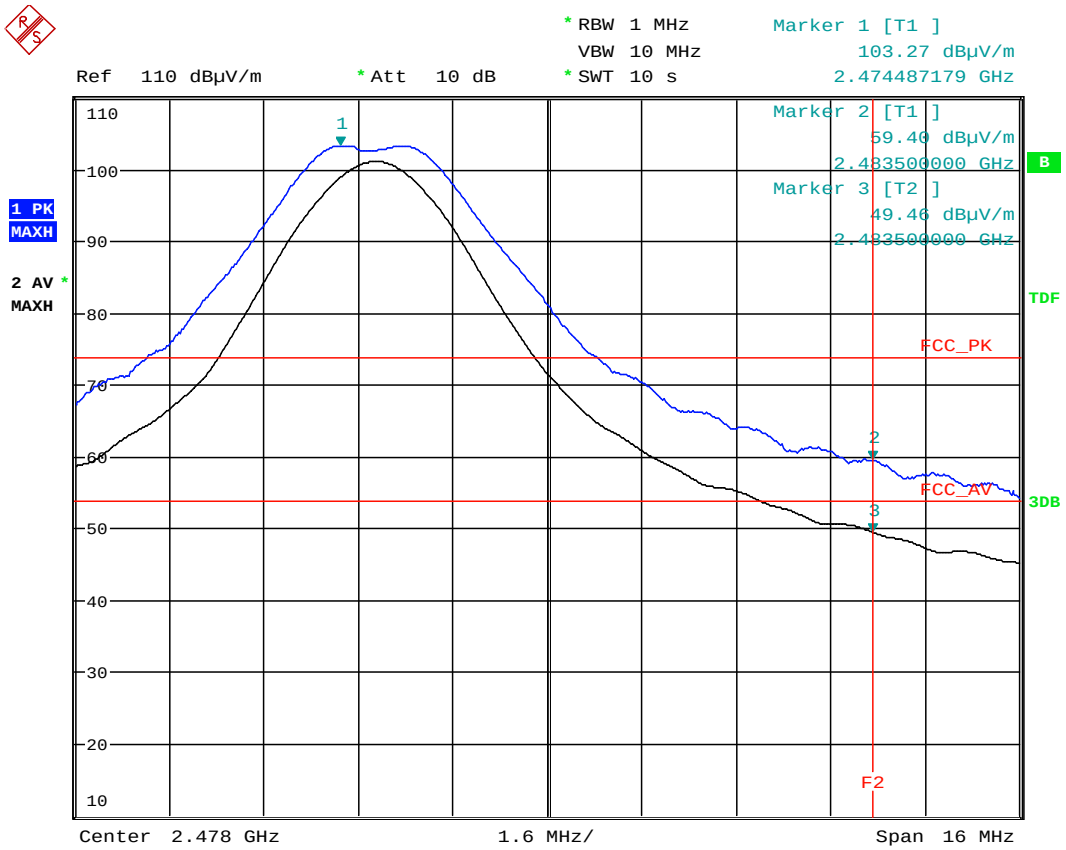
18 GHz – 25 GHz

11.7 Test Results

High Power; Channel: 2455 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)*
Pk	4911.09	52.26	5.3	33.1	35.9	0.00	0.00	54.8	547.65	5012
Av	4911.09	42.24	5.3	33.1	35.9	0.00	0.00	44.8	172.78	500

High Power; Channel: mid 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)*
Pk	4931.04	53.16	5.3	33.2	35.9	0.00	0.00	55.8	614.47	5012
Av	4931.04	42.67	5.3	33.2	35.9	0.00	0.00	45.3	183.65	500

High Power; Channel: high 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)*
Pk	4950.99	52.02	5.3	33.2	35.9	0.00	0.00	54.6	538.89	5012
Av	4950.99	42.75	5.3	33.2	35.9	0.00	0.00	45.4	185.35	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:	Transient Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	2465
EUT Channel Bandwidths:	5 MHz
EUT Modulation:	DSSS
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 18 °C	+15 ºC to +35 ºC (as declared)
Humidity: xx % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110Vac power to POE adaptor powering EUT

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 (dBµV)***	
	Quasi-Peak	***Average***
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.
**A linear average detector is required.

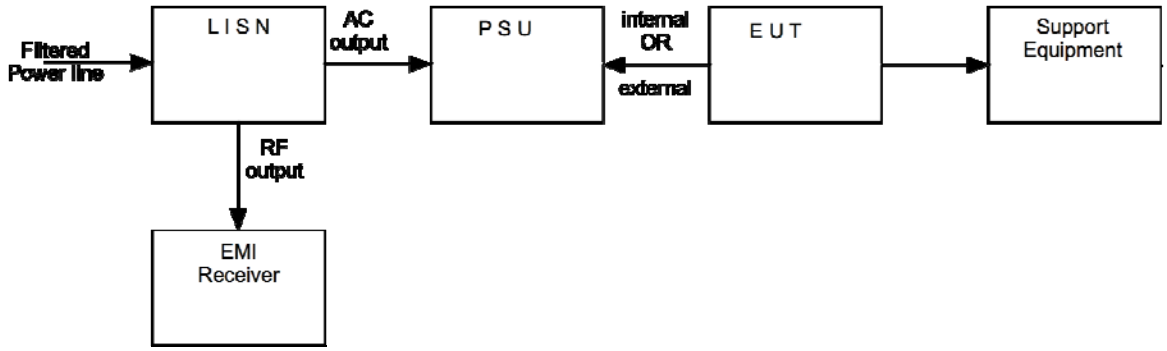
12.4 Test Method

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.

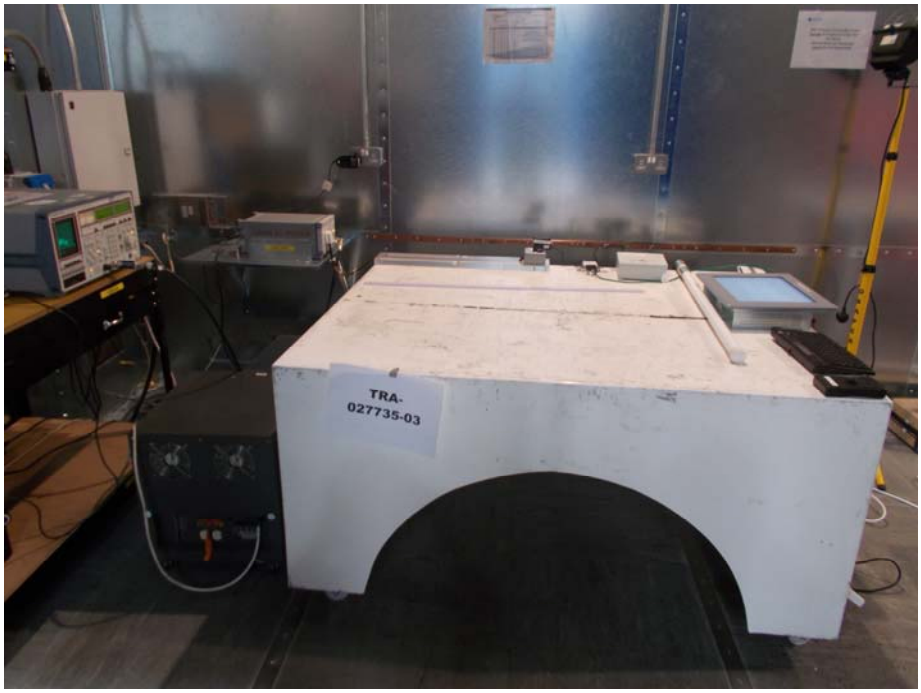
AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

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

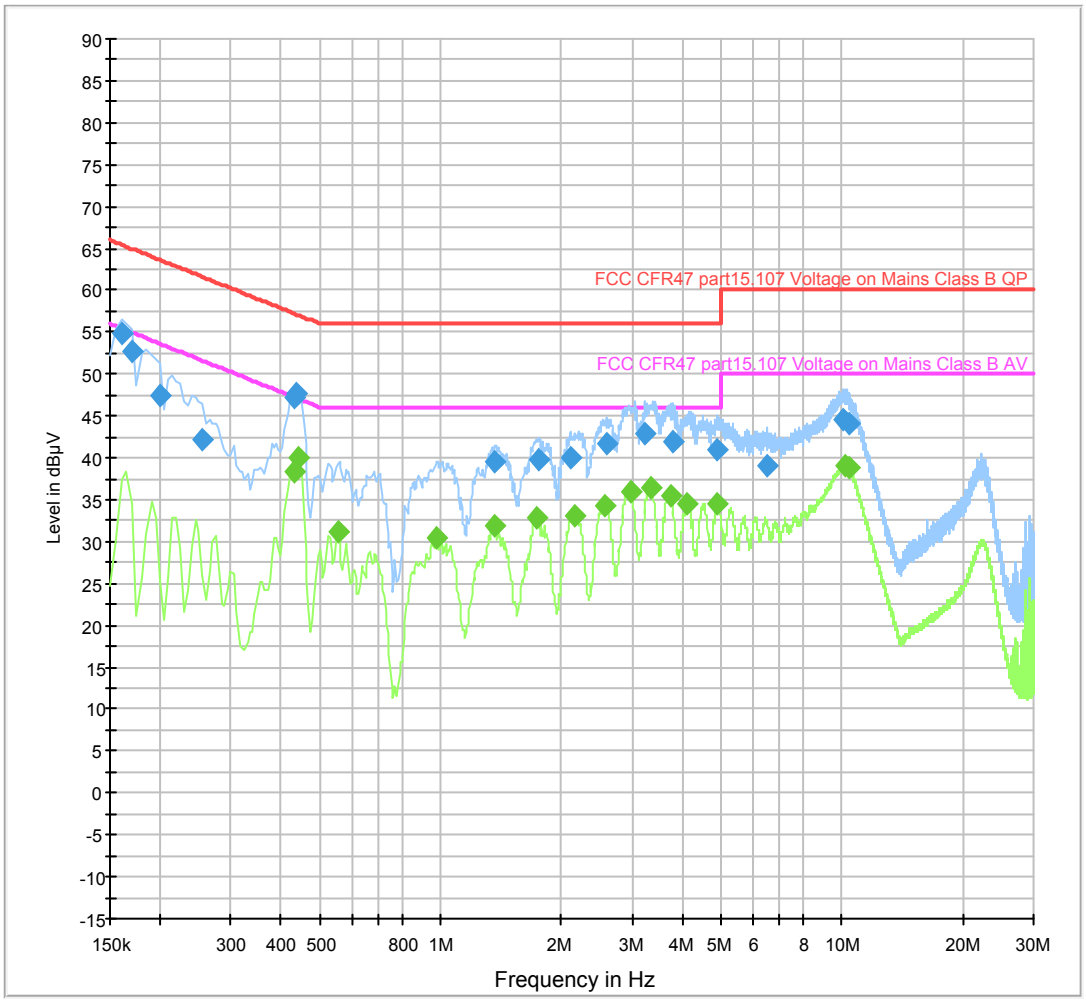


12.6 Test Equipment

Type of Equipment	Maker/Supplier	Model Number	Element Number	Calibration Due Date
EMI Receiver	R&S	EHSH30	N/A	12/01/2016
LISN	R&S	ESH3-Z-3	UH195	04/06/15

12.7 Test Results

Conducted emissions on Mains 9kHz-30MHz ESHS 30 + UH195 Rx prescans



Results measured using the average detector								
Frequency (MHz)	**Average (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**PE**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**
0.430000	**38.2**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**9.0**	**47.3**
0.440000	**40.1**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**7.0**	**47.1**
0.555000	**31.1**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**14.9**	**46.0**
0.975000	**30.4**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**15.6**	**46.0**
1.370000	**32.0**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**14.0**	**46.0**
1.735000	**32.9**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**13.1**	**46.0**
2.150000	**33.0**	**2000.0**	**10.000**	**GND**	**L1**	**10.3**	**13.0**	**46.0**
2.550000	**34.4**	**2000.0**	**10.000**	**GND**	**L1**	**10.3**	**11.6**	**46.0**
2.970000	**35.9**	**2000.0**	**10.000**	**GND**	**N**	**10.3**	**10.1**	**46.0**
3.330000	**36.5**	**2000.0**	**10.000**	**GND**	**N**	**10.3**	**9.5**	**46.0**
3.735000	**35.5**	**2000.0**	**10.000**	**GND**	**N**	**10.4**	**10.5**	**46.0**
4.120000	**34.6**	**2000.0**	**10.000**	**GND**	**N**	**10.4**	**11.4**	**46.0**
4.895000	**34.6**	**2000.0**	**10.000**	**GND**	**N**	**10.5**	**11.4**	**46.0**
10.200000	**39.0**	**2000.0**	**10.000**	**GND**	**N**	**10.7**	**11.0**	**50.0**
10.400000	**38.8**	**2000.0**	**10.000**	**GND**	**N**	**10.7**	**11.2**	**50.0**

Results measured using the quasi-peak detector								
Frequency (MHz)	**QuasiPeak (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**PE**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**
0.160000	**54.9**	**2000.0**	**10.000**	**GND**	**N**	**10.1**	**10.6**	**65.5**
0.170000	**52.7**	**2000.0**	**10.000**	**GND**	**N**	**10.1**	**12.3**	**65.0**
0.200000	**47.3**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**16.3**	**63.6**
0.255000	**42.2**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**19.4**	**61.6**
0.430000	**47.3**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**10.0**	**57.3**
0.435000	**47.7**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**9.5**	**57.2**
1.365000	**39.6**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**16.4**	**56.0**
1.760000	**39.7**	**2000.0**	**10.000**	**GND**	**L1**	**10.2**	**16.3**	**56.0**
2.100000	**40.1**	**2000.0**	**10.000**	**GND**	**L1**	**10.3**	**15.9**	**56.0**
2.580000	**41.6**	**2000.0**	**10.000**	**GND**	**L1**	**10.3**	**14.4**	**56.0**
3.245000	**42.9**	**2000.0**	**10.000**	**GND**	**N**	**10.3**	**13.1**	**56.0**
3.790000	**42.0**	**2000.0**	**10.000**	**GND**	**N**	**10.4**	**14.0**	**56.0**
4.885000	**40.9**	**2000.0**	**10.000**	**GND**	**N**	**10.4**	**15.1**	**56.0**
6.530000	**39.1**	**2000.0**	**10.000**	**GND**	**N**	**10.6**	**20.9**	**60.0**
10.090000	**44.5**	**2000.0**	**10.000**	**GND**	**N**	**10.7**	**15.5**	**60.0**
10.405000	**44.2**	**2000.0**	**10.000**	**GND**	**N**	**10.7**	**15.8**	**60.0**

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 Lab
Test Standard and Clause:	FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	2455MHz / 2465MHz / 2475MHz
EUT Channel Bandwidths:	5MHz
EUT Test Modulations:	DSSS
Deviations From Standard:	None
Measurement BW: (FCC requirement: 100 kHz)	100kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300kHz
Measurement Span: (requirement 2 to 5 times OBW)	10MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)
Supply: +48Vdc POE	as declared

13.3 Test Limit

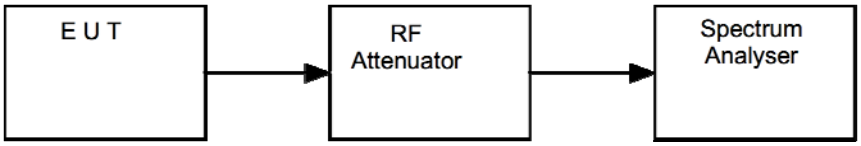
The minimum -6 dB bandwidth shall be at least 500 kHz.

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

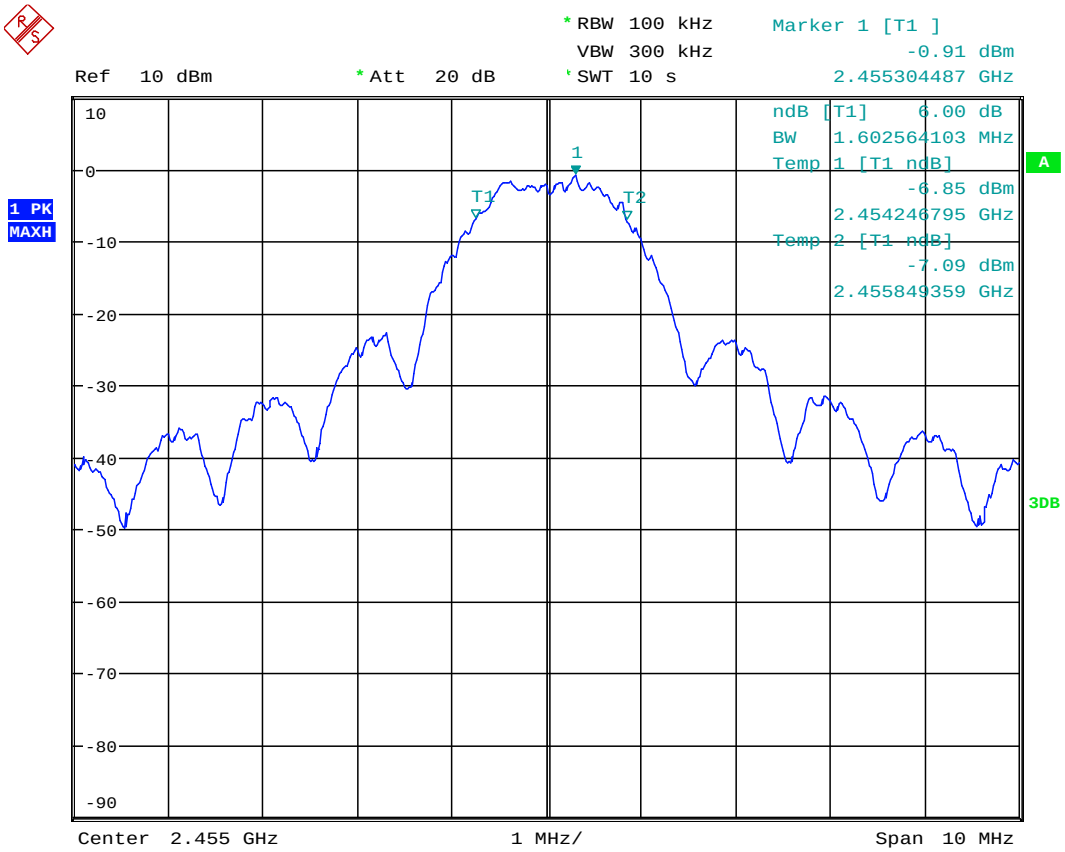


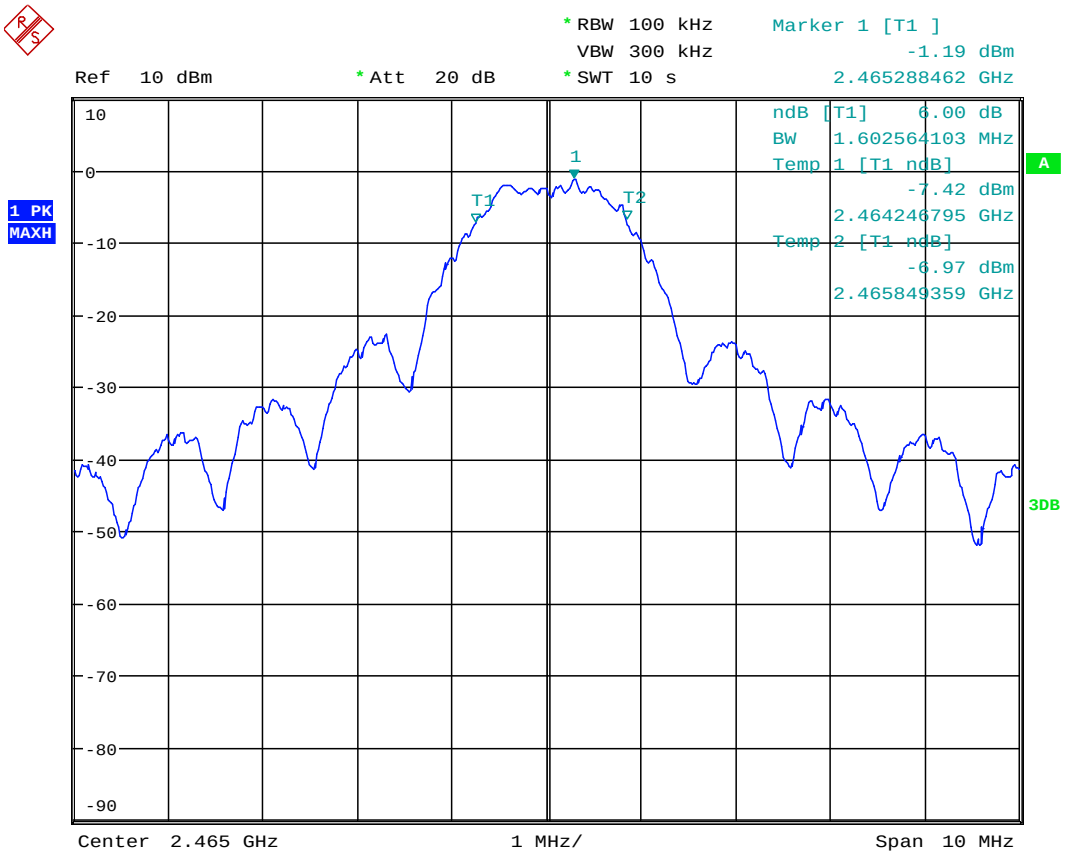
13.5 Test Equipment

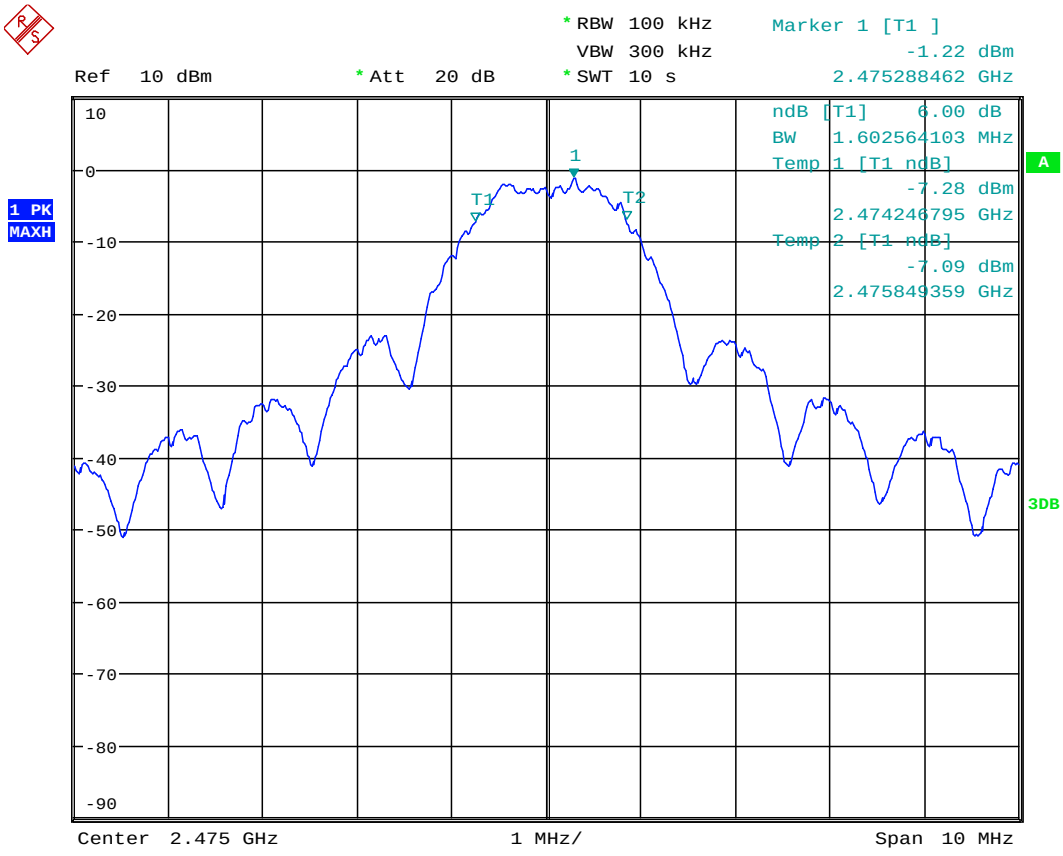
Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016

13.6 Test Results

Channel Frequency (MHz)	*F_L (MHz)*	*F_H (MHz)*	*6dB Bandwidth (kHz)*	*Result*
2455	2454.246795	2455.849359	1602.564	PASS
2465	2464.246795	2465.849359	1602.564	PASS
2475	2474.246795	2475.849359	1602.564	PASS


*RBW 100 kHz
VBW 300 kHz
Ref 10 dBm
*Att 20 dB
*SWT 10 s
Marker 1 [T1]
-0.91 dBm
2.455304487 GHz
ndB [T1] 6.00 dB
BW 1.602564103 MHz
Temp 1 [T1 ndB]
-6.85 dBm
2.454246795 GHz
Temp 2 [T1 ndB]
-7.09 dBm
2.455849359 GHz
1 PK
MAXH
A
3DB
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Center 2.455 GHz
1 MHz/
Span 10 MHz


*RBW 100 kHz
VBW 300 kHz
Ref 10 dBm
*Att 20 dB
*SWT 10 s
Marker 1 [T1]
-1.19 dBm
2.465288462 GHz
ndB [T1] 6.00 dB
BW 1.602564103 MHz
Temp 1 [T1 ndB]
-7.42 dBm
2.464246795 GHz
Temp 2 [T1 ndB]
-6.97 dBm
2.465849359 GHz
1 PK
MAXH
A
3DB
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Center 2.465 GHz
1 MHz/
Span 10 MHz


*RBW 100 kHz
VBW 300 kHz
*SWT 10 s
Marker 1 [T1]
-1.22 dBm
2.475288462 GHz
Ref 10 dBm
*Att 20 dB
ndB [T1] 6.00 dB
BW 1.602564103 MHz
Temp 1 [T1 ndB]
-7.28 dBm
2.474246795 GHz
Temp 2 [T1 ndB]
-7.09 dBm
2.475849359 GHz
1 PK
MAXH
A
3DB
T1
T2
1
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Center 2.475 GHz
1 MHz/
Span 10 MHz

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 Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	2455MHz / 2465MHz / 2475MHz
EUT Channel Bandwidths:	5 MHz
Deviations From Standard:	None
Measurement BW:	3MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 % 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 per 15.247(b)(4) the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. To show compliance the limit is reduced.

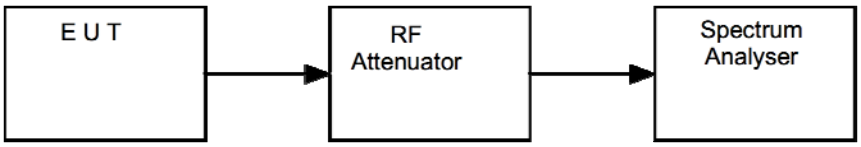
Power Limit	Maximum Antenna Gain	Exceeds 6 dBi by	Corrected Limit
1 W	15 dBi	9 dB	125.9 mW

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

Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016

14.6

14.7 Test Results

Channel Frequency (MHz)	*Analyzer Level (dBm)*	*Cable loss (dB)*	*Power (mW)*	*Result*
2455	2.13	0.00	1.63	PASS
2465	1.99	0.00	1.58	PASS
2475	1.85	0.00	1.53	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 Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	2455MHz / 2465MHz / 2475MHz
EUT Channel Bandwidths:	5 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)
Supply: 48 V dc POE	230 V ac ±10 % (as declared)

15.3 Test Limit

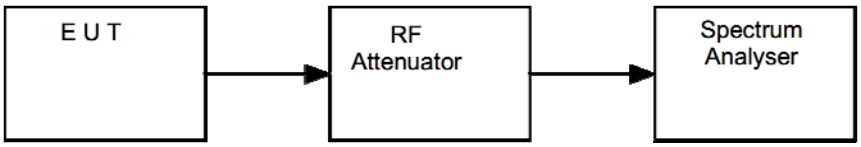
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

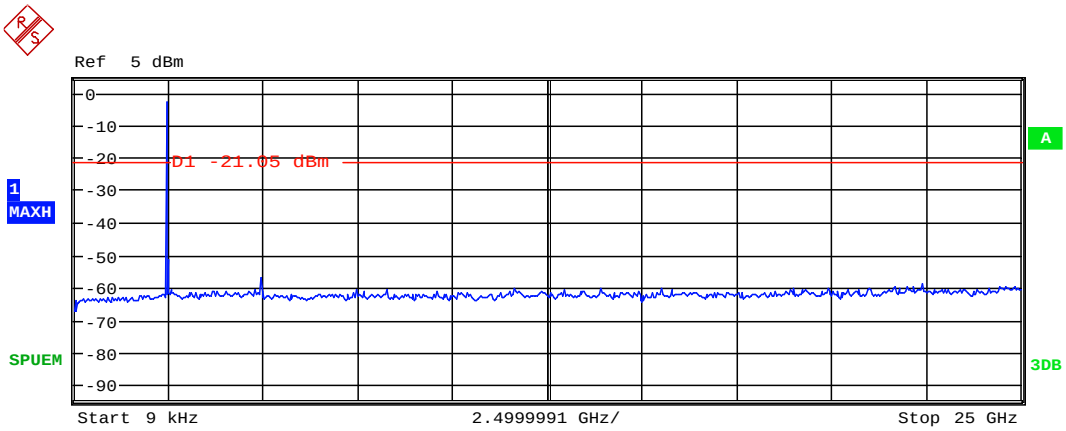
Figure v Test Setup



15.5 Test Equipment

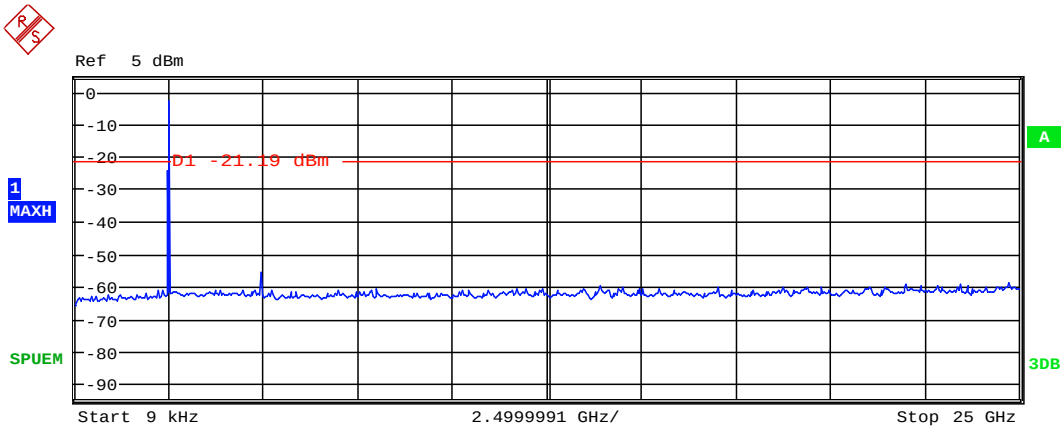
Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016

15.6 Test Results



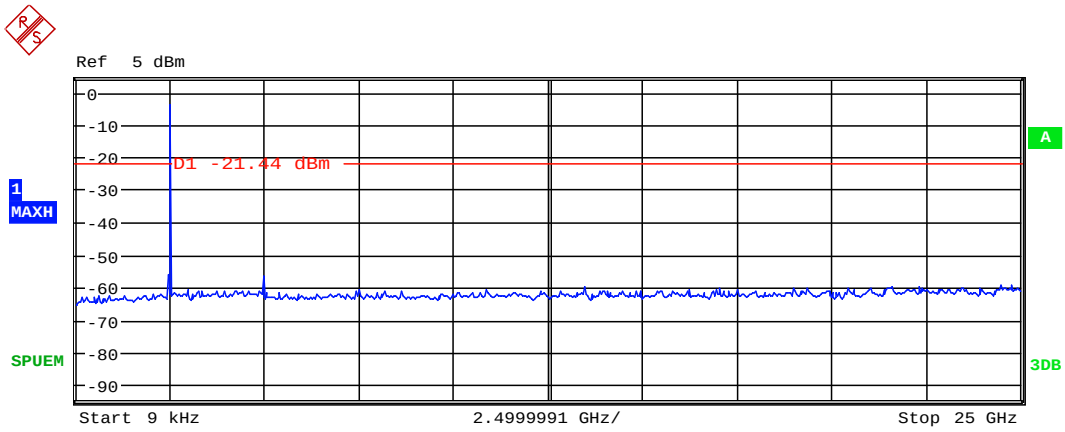
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	14.875000 k	-68.32	-200.00
150.000 k	30.000 M	10.00 k	158.955000 k	-67.58	-200.00
30.000 M	1.000 G	100.00 k	879.817000 M	-63.54	-200.00
1.000 G	5.000 G	100.00 k	2.454800 G	-2.64	-200.00
5.000 G	10.000 G	100.00 k	7.462000 G	-60.79	-200.00
10.000 G	15.000 G	100.00 k	11.622500 G	-60.41	-200.00
15.000 G	20.000 G	100.00 k	15.518500 G	-60.52	-200.00
20.000 G	25.000 G	100.00 k	22.401000 G	-59.26	-200.00

2455 MHz



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	66.168269 k	-68.46	-200.00
150.000 k	30.000 M	10.00 k	161.940000 k	-66.31	-200.00
30.000 M	1.000 G	100.00 k	898.247000 M	-63.00	-200.00
1.000 G	5.000 G	100.00 k	2.464800 G	-2.51	-200.00
5.000 G	10.000 G	100.00 k	7.974500 G	-61.04	-200.00
10.000 G	15.000 G	100.00 k	13.914000 G	-60.02	-200.00
15.000 G	20.000 G	100.00 k	17.018500 G	-60.26	-200.00
20.000 G	25.000 G	100.00 k	24.712000 G	-59.25	-200.00

2465 MHz



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	66.168269 k	-67.89	-200.00
150.000 k	30.000 M	10.00 k	150.000000 k	-65.54	-200.00
30.000 M	1.000 G	100.00 k	599.584000 M	-62.70	-200.00
1.000 G	5.000 G	100.00 k	2.475200 G	-3.89	-200.00
5.000 G	10.000 G	100.00 k	7.489500 G	-61.20	-200.00
10.000 G	15.000 G	100.00 k	13.456500 G	-59.83	-200.00
15.000 G	20.000 G	100.00 k	19.363500 G	-60.35	-200.00
20.000 G	25.000 G	100.00 k	24.755000 G	-59.41	-200.00

2475 MHz

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2455MHz / 2465MHz / 2475MHz
EUT Channel Bandwidths:	5MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 1.5 times Channel BW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)
Supply: 48 V dc POE	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.

As per 15.247(e) the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. To show compliance the limit is reduced.

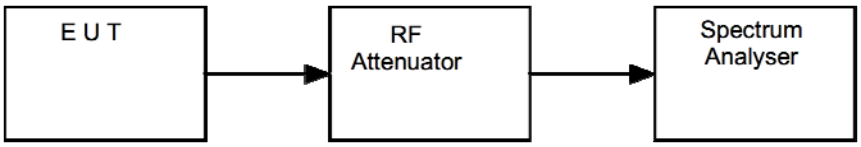
PSD Limit	Maximum Antenna Gain	Exceeds 6 dBi by	Corrected Limit
8 dBm	15 dBi	9 dB	-1 dBm

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

Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016

16.6 Test Results

Channel Frequency (MHz)	*Analyzer Level (dBm)*	*Cable loss (dB)*	*Power (dBm)*	*Result*
2455	-1.05	0.00	-1.05	PASS
2465	-1.19	0.00	-1.19	PASS
2475	-1.44	0.00	-1.44	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**

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 in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

NT = [(MP/TSDA) * √ fGHz]

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)
TSDA = 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 x TSDA) / √ fGHz]

For Distances Greater than 50 mm Step 2 applies

Step 2

(TSDB – 50mm) * 10}

Where:
TSDB = Min Test separation Distance (mm) = 50

Operating Frequency 2.455 GHz

SARET = [(3.0 x 50) / √2.412] + { (50 – 50) * 10 }
SARET = [150 / 1.55] + (0 * 10 }
SARET = 96.77mW

Operating Frequency 2.465 GHz

SARET = [(3.0 x 50) / √2.437] + { (50 – 50) * 10 }
SARET = [150 / 1.56] + (0 * 10 }
SARET = 96.15mW

Operating Frequency 2.475 GHz

SARET = [(3.0 x 50) / √2.462] + { (50 – 50) * 10 }
SARET = [150 / 1.57] + (0 * 10 }
SARET = 95.54mW

Channel Frequency (MHz)	Conducted Carrier Power (dBm)	Maximum Antenna Gain (dBi)	EIRP (mW)	SAR Exclusion Threshold	SAR Evaluation
2455	2.13	15	51.64	96.77	Not Required
2465	1.99	15	50.00	96.15	Not Required
2475	1.85	15	48.42	95.54	Not Required

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