Report on the Radio Testing

For

AGD Systems Limited

on

AGD 326

Report no. TRA-043537-47-01A

2020-05-13

Report Number: TRA-043537-47-01A
Issue: A

REPORT ON THE RADIO TESTING OF A
AGD Systems Limited
AGD 326
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & RSS-247

TEST DATE: 2020-04-29 to 2020-04-30

Written by:	Steve Garwell cn=Steve Garwell, o=Element Material Technology, ou, email=steve.garwell@element.com, c=GB I am the author of this document 2020.05.13 16:18:35 +01'00'	Steven Garwell Radio Test Engineer
Approved by:	Digitally signed by John Charters DN: cn=John Charters, o, ou=Element Materials Technology Ltd., email=john.charters@element.com, c=GB Reason: I have reviewed this document Date: 2020.05.13 16:13:21 +01'00'	John Charters Department Manager - Radio
Date:	2020-05-13	

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2020-05-13	Original

2 Summary

TEST REPORT NUMBER:	TRA-043537-47-01A
WORKS ORDER NUMBER:	TRA-043537-02
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. 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:	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	AGD 326
FCC IDENTIFIER: ISED IDENTIFIER:	WH3326505 7907A-326505
EUT SERIAL NUMBER:	114856-0023
MANUFACTURER/AGENT:	AGD Systems Limited
ADDRESS:	White Lion House Gloucester Road Staverton Cheltenham Gloucestershire GL1 0TF United Kingdom
CLIENT CONTACT:	Richard Ellis ☎ 01452854212 ✉ richard.ellis@agd-systems.com
ORDER NUMBER:	406193
TEST DATE:	2020-04-29 to 2020-04-30
TESTED BY:	Steven Garwell Element

2.1 Test Summary

Test Method and Description		*Requirement Clause*			*Result / Note*
		RSS	*47CFR15*		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	☒	*PASS*
AC power line conducted emissions		Gen, 8.8	15.207	☐	*Note 1*
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	☐	*Note 1*
Radiated carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	☒	*PASS*
	Max.			☐	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	☐	*Note 1*
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	☐	*Note 1*
Calculation of duty correction		-	15.35(c)	☐	*Customer Declaration*

Notes:

Note1: Limited testing to confirm radiated carrier power and transmitter radiated spurious emissions only as required for pre-approved module integration requirements, this report covers the testing of Wi-Fi module only.

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

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

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

3 Contents

4 Introduction

This report TRA-043537-47-01A presents the results of the Radio testing on a AGD Systems Limited, AGD 326 to specifications 47CFR15 radio frequency devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for AGD Systems Limited by Element, at the address 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.

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 2, February 2017 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 5, March 2019 – General Requirements for Compliance of Radio Apparatus

5.2 Deviations from Test Standards

Limited testing to confirm radiated carrier power and transmitter radiated spurious emissions only as required for pre-approved module integration requirements, this report covers the testing of Wi-Fi module only.

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: AGD 326
- Serial Number: 114856-0023-TBD
- Model Number: 326
- Software Revision: MI-197 Ver 4
- Build Level / Revision Number: Prototype

Integrated Module details

Type: 2.4 GHz Wi-Fi
Manufacture: ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD
Model Number: ESP-WROOM-02
FCCID: 2AC7Z-ESPWROOM02
ISED ID: 21098 -ESPWROOM02

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 transmit tests was as follows:-

The EUT was set to transmit permanently on top, middle or bottom channels as indicated.

7.4 EUT Radio Parameters

7.4.1 General

Frequencies of operation:	2412 MHz – 2462 MHz
Modulation types:	DSSS / OFDM
Occupied channel bandwidth:	20 MHz
Channel spacing:	5 MHz
Declared output power:	18 dBm
Nominal Supply Voltage:	24 Vdc

7.4.2 Antennas

Type:	Patch antenna
Frequency range:	2412 MHz – 2462 MHz

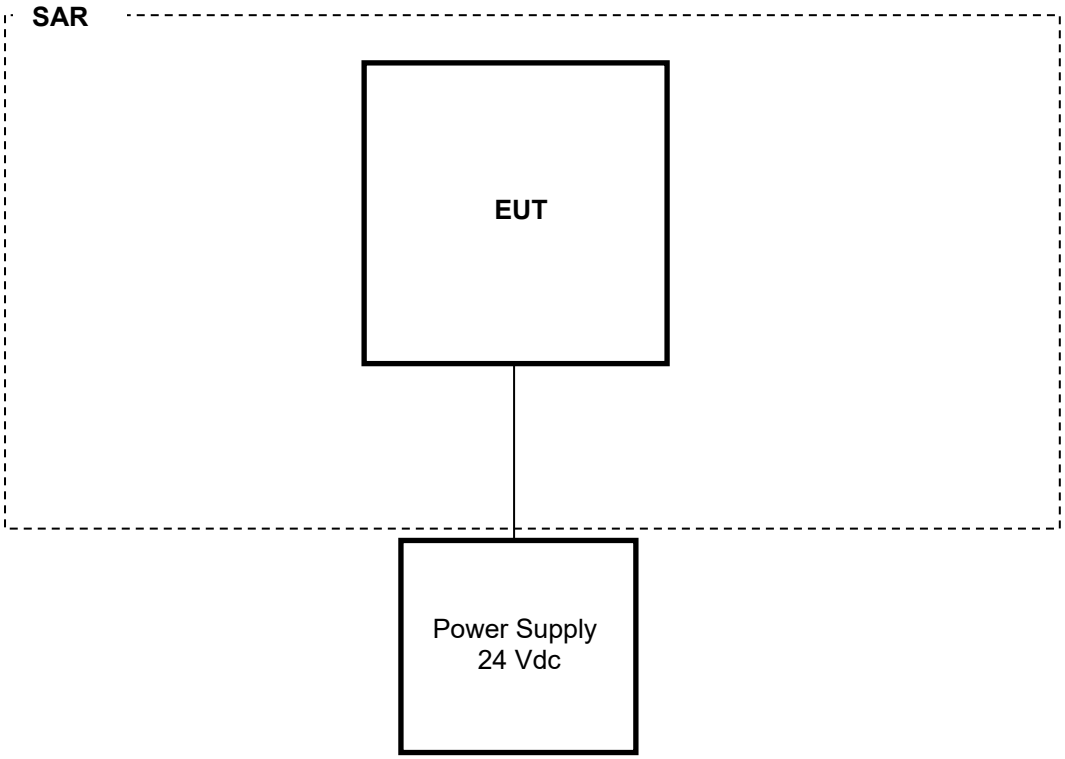
7.5 EUT Description

The EUT is a Pedestrian radar using 2.4 GHz Wi-Fi module and 24 GHz radar.
This report covers requirements for integration of the pre-approved Wi-Fi Module.

8 EUT Test Setup

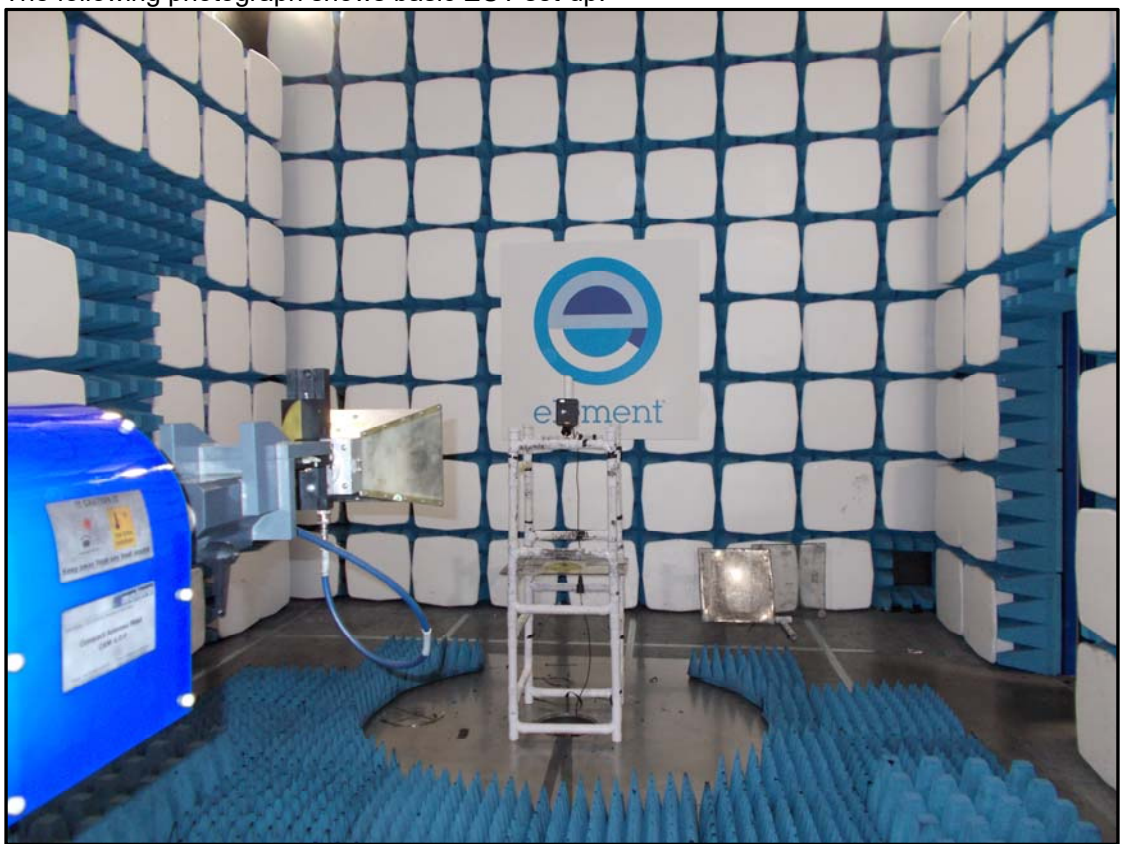
8.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



8.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



8.3 Measurement software

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5 (See Note)
Element Transmitter Bench Test (See Note)
ETS Lindgren EMPower V1.0.4.2

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

9 General Technical Parameters

9.1 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 24 Vdc from an external power supply.

9.2 Varying Test Conditions

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

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

	Category	***Nominal***	***Variation***
☐	Mains	110 V ac +/-2 %	85 % and 115 %
☐	Battery	New battery	N/A

Note: No voltage variation testing was carried out.

10 Radiated emissions

10.1 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.

10.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber SK03
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2412 MHz, 2437 MHz, 2462 MHz
EUT Channel Bandwidth:	20 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	24 Vdc (as declared)

10.3 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

10.4 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:

$$FS = PR + CL + AF – PA + DC – CF$$

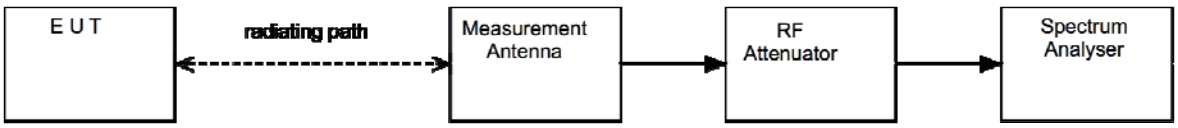
$$Factor = CL + AF - PA$$

Where,

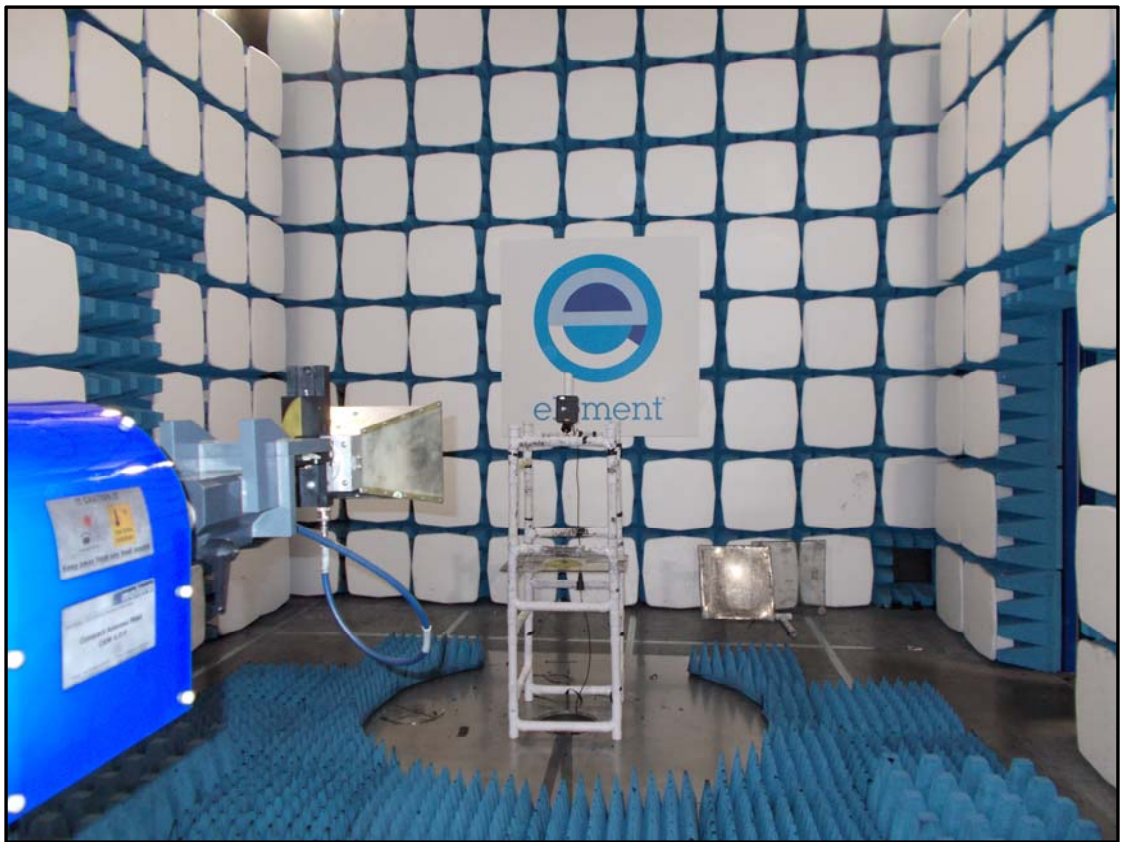
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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

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

Figure i Test Setup



10.5 Test Set-up Photograph

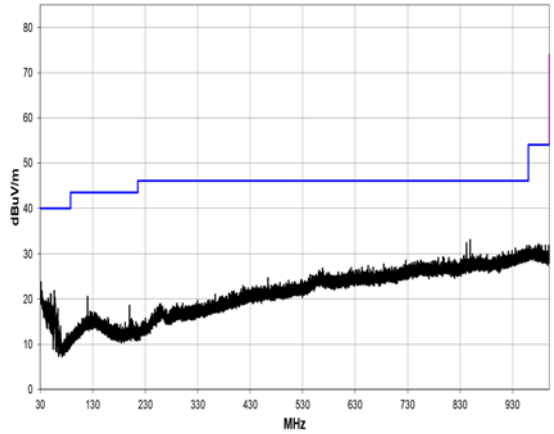


10.6 Test Equipment

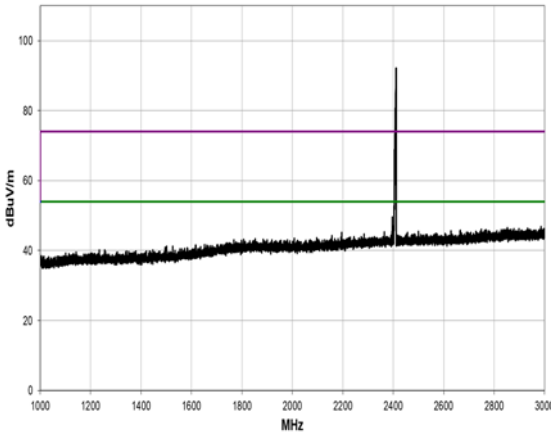
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2020-10-17
Bilog	Chase	CBL611/A	U573	2021-09-19
Log Periodic Ant	Chase	UPA6108	L203	2020-06-11
Pre Amp	Watkins Johnson	6201-69	U372	2021-02-26
Pre Amp	Agilent	8449	L572	2020-10-15
1-18GHz Horn	EMCO	3115	L139	2021-07-16
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2022-04-23
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

10.7 Test Results

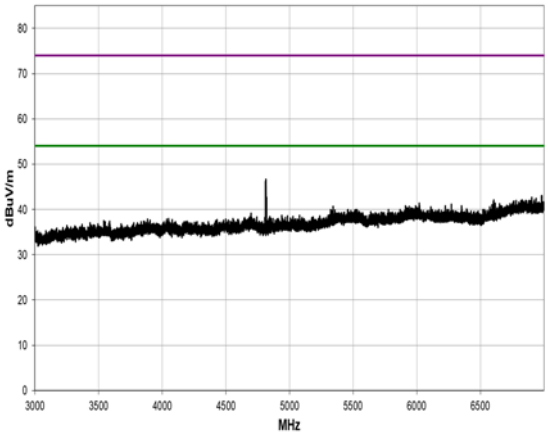
Bottom channel: 2412 MHz



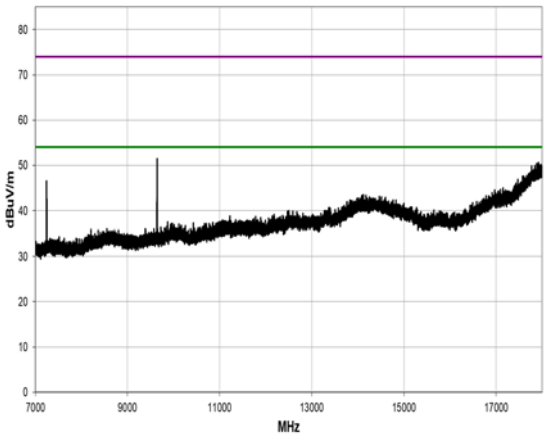
30 MHz to 1 GHz



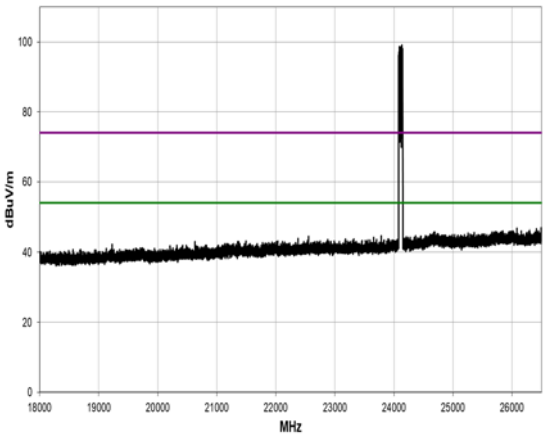
1 GHz to 3 GHz



3 GHz to 7 GHz



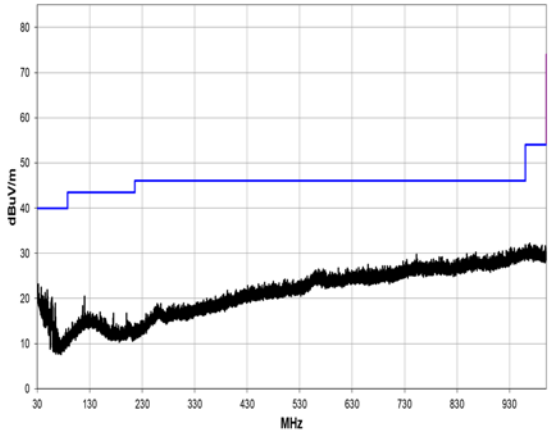
7 GHz to 18 GHz



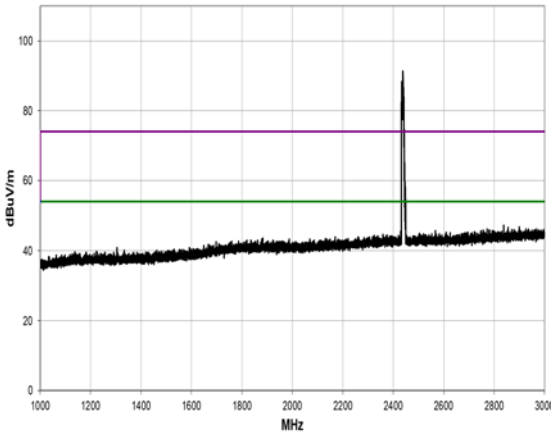
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4824.183	64.7	3.5	1.64	-0.1	3.0	0.0	Horz	PK	0.0	68.2	74.0	-5.8
4823.967	43.6	3.5	1.64	-0.1	3.0	0.0	Horz	AV	0.0	47.1	54.0	-6.9
4824.108	59.8	3.5	1.5	315.0	3.0	0.0	Vert	PK	0.0	63.3	74.0	-10.7
4824.192	38.2	3.5	1.5	315.0	3.0	0.0	Vert	AV	0.0	41.7	54.0	-12.3

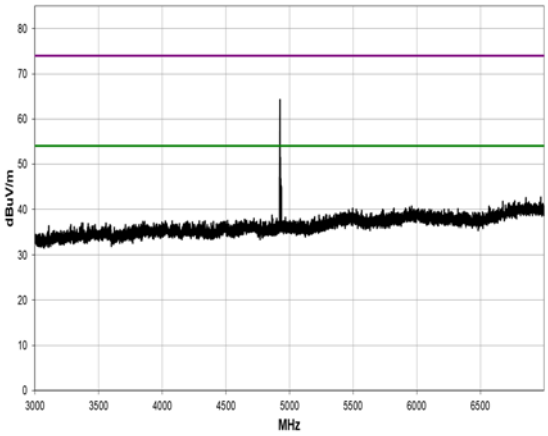
Middle channel: 2437 MHz



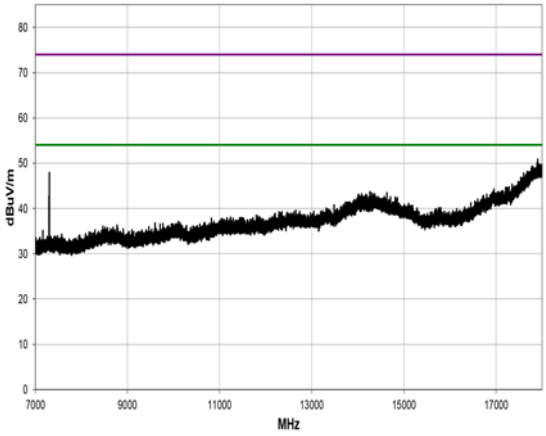
30 MHz to 1 GHz



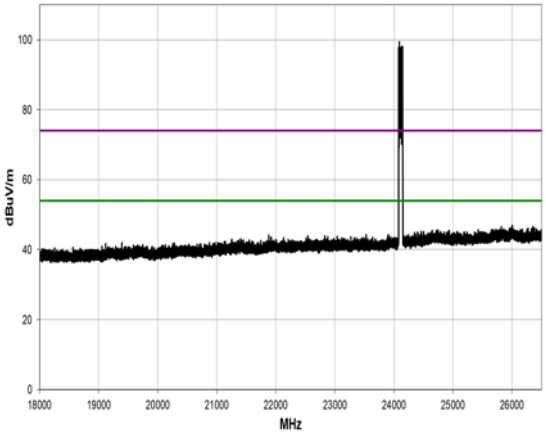
1 GHz to 3 GHz



3 GHz to 7 GHz



7 GHz to 18 GHz

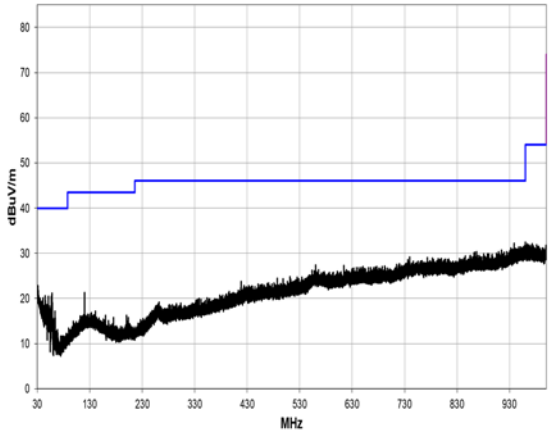


18 GHz to 26.5 GHz

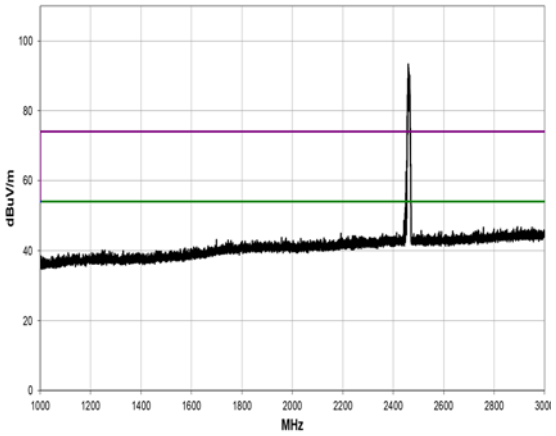
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4874.017	64.7	3.8	1.5	360.1	3.0	0.0	Horz	PK	0.0	68.5	74.0	-5.5
4873.825	41.8	3.8	1.5	360.1	3.0	0.0	Horz	AV	0.0	45.6	54.0	-8.4
4874.025	61.0	3.8	1.5	315.1	3.0	0.0	Vert	PK	0.0	64.8	74.0	-9.2
4873.992	39.7	3.8	1.5	315.1	3.0	0.0	Vert	AV	0.0	43.5	54.0	-10.5

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
7309.567	71.9	8.0	1.5	248.0	1.0	0.0	Vert	PK	-9.5	70.4	74.0	-3.6
7312.317	71.7	8.0	1.45	314.9	1.0	0.0	Horz	PK	-9.5	70.2	74.0	-3.8
7311.867	44.3	8.0	1.5	248.0	1.0	0.0	Vert	AV	-9.5	42.8	54.0	-11.2
7312.300	42.9	8.0	1.45	314.9	1.0	0.0	Horz	AV	-9.5	41.4	54.0	-12.6

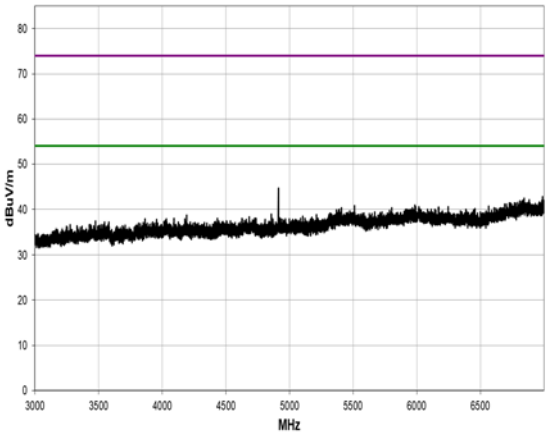
Top channel: 2462 MHz



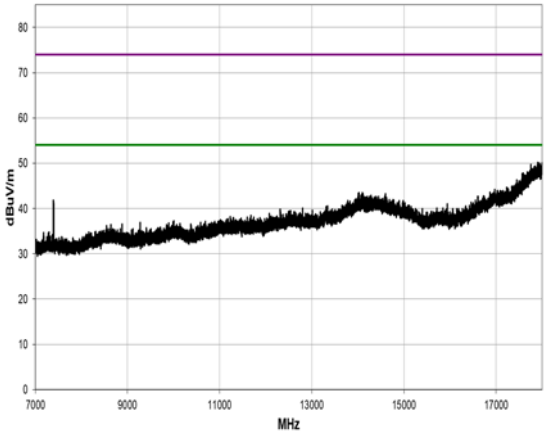
30 MHz to 1 GHz



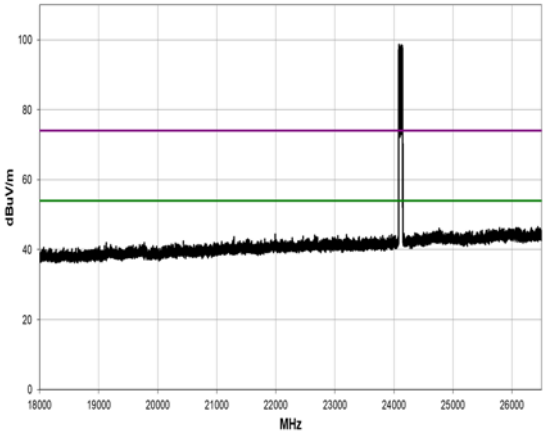
1 GHz to 3 GHz



3 GHz to 7 GHz



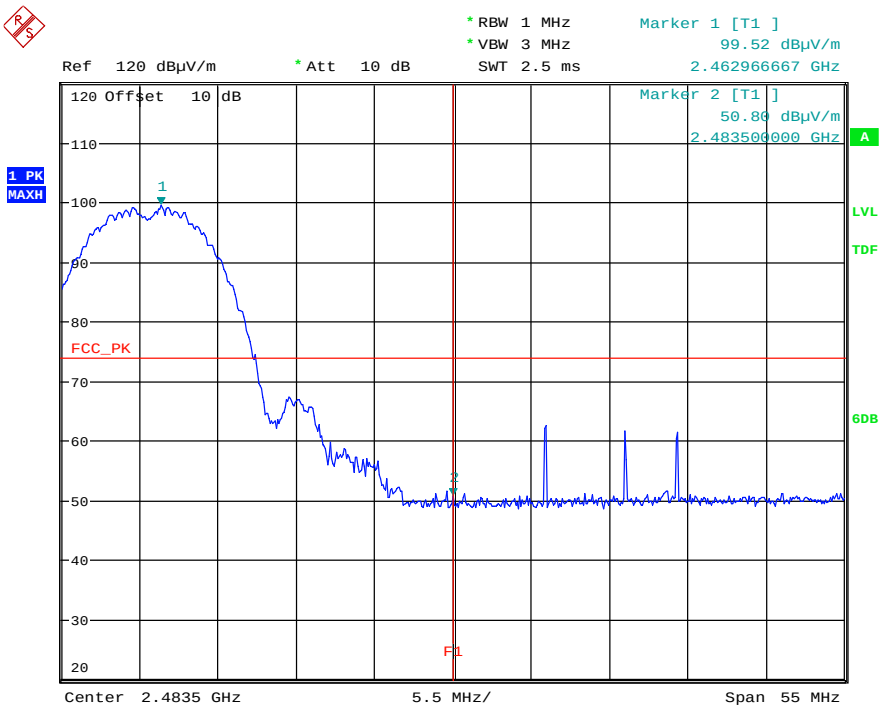
7 GHz to 18 GHz



18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4923.942	65.7	3.9	1.5	360.0	3.0	0.0	Horz	PK	0.0	69.6	74.0	-4.4
4923.967	44.2	3.9	1.5	360.0	3.0	0.0	Horz	AV	0.0	48.1	54.0	-5.9
4923.950	61.5	3.9	1.5	282.0	3.0	0.0	Vert	PK	0.0	65.4	74.0	-8.6
4923.850	38.9	3.9	1.5	282.0	3.0	0.0	Vert	AV	0.0	42.8	54.0	-11.2

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
7386.850	74.6	8.0	1.4	191.0	1.0	0.0	Horz	PK	-9.5	73.1	74.0	-0.9
7386.017	72.4	8.0	1.5	90.0	1.0	0.0	Vert	PK	-9.5	70.9	74.0	-3.1
7385.117	46.7	8.0	1.4	191.0	1.0	0.0	Horz	AV	-9.5	45.2	54.0	-8.8
7386.700	44.9	8.0	1.5	90.0	1.0	0.0	Vert	AV	-9.5	43.4	54.0	-10.6



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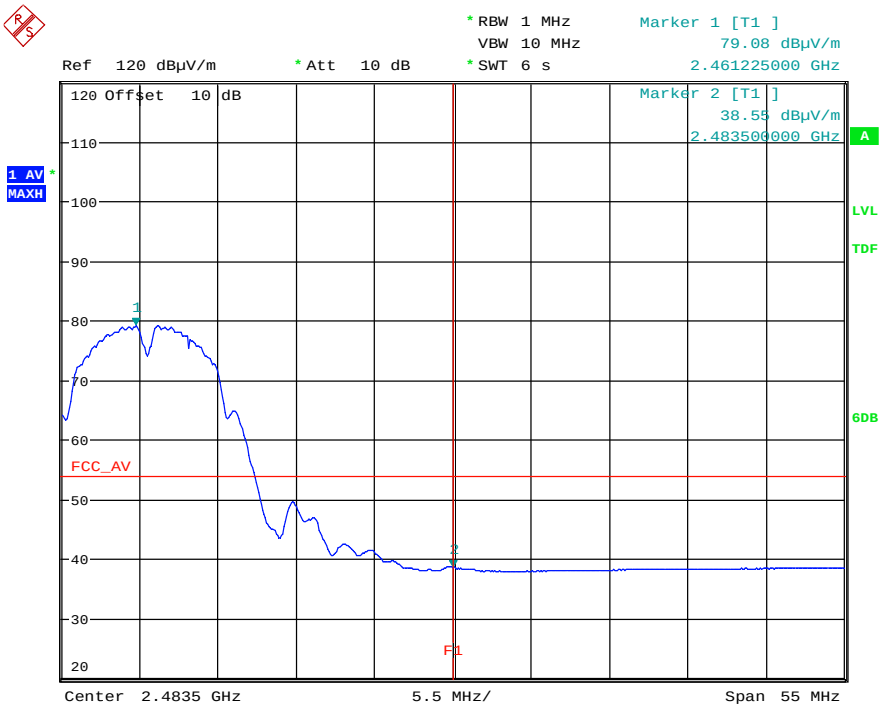
Upper Radiated Band Edge – Peak



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Upper Radiated Band Edge - Average

11 Maximum peak conducted output power

11.1 Definition

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

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber SK03
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 / 6.6
EUT Frequency Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz
Deviations From Standard:	None
Measurement BW:	20 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 MHz
Measurement Detector:	Up to 1 GHz: Quasi-peak; Above 1 GHz: Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)

11.3 Test Limit

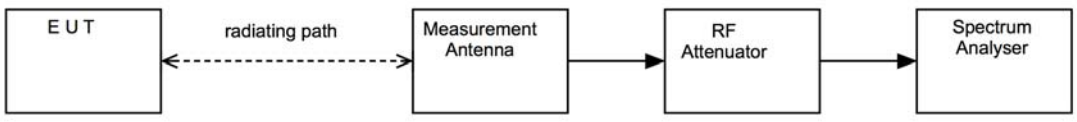
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak output power shall not exceed 1 W conducted or with antenna gain not greater than 6 dBi shall not exceed 4W radiated.

11.4 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



11.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2020-10-17
Pre Amp	Watkins Johnson	6201-69	U372	2021-02-26
1-18GHz Horn	EMCO	3115	L139	2021-07-16
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

11.6 Test Results

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

Modulation: DSSS / OFDM; Power setting: default					
Channel Frequency (MHz)	***Peak Field Strength (dBµV/m)***	***Distance (m)***	***Antenna Gain (dBi)***	***Max. Power (W)***	***Result***
2412	112.1	3	0	0.049	PASS
2437	111.7	3	0	0.044	PASS
2462	110.5	3	0	0.034	PASS

12 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**