
Report on the Intermodulation Testing

For

AGD Systems Limited

on

AGD 326

Report no. TRA-043537-47-00A

2020-05-13

RF915 4.0

Report Number: TRA-043537-47-00A
Issue: A

REPORT ON THE INTERMODULATION TESTING OF A
AGD Systems Limited
AGD 326
WITH RESPECT TO SPECIFICATIONS
47CFR15.247 / RSS-247 & 47CFR15.245 / RSS-210
INTERMODULATION EMISSIONS INVESTIGATION

TEST DATE: 2020-04-23 to 2020-04-24

Written by:

Steven Garwell
Radio Test Engineer

Approved by:

John Charters
Department Manager- Radio

Date:

2020-05-13

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

RF915 4.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2020-05-13	Original

2 Summary

TEST REPORT NUMBER: TRA-043537-47-00A

WORKS ORDER NUMBER: TRA-043537-02

PURPOSE OF TEST: Intermodulation emissions investigation

TEST SPECIFICATION(S): 47CFR15.247 /RSS-247 & 47CFR15.245 / RSS-210

EQUIPMENT UNDER TEST (EUT): AGD 326

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: 2020-04-23 to 2020-04-23

TESTED BY: Steven Garwell
Element

2.1 Test Summary

Test Method and Description	Requirement Clause		Applicable to this equipment	Result / Note
	RSS	47CFR		
Intermodulation spurious emissions	Gen, 8.10	Part 15	<input checked="" type="checkbox"/>	PASS

Notes:

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

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

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

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4 Introduction

This report TRA-043537-47-00A presents the results of the intermodulation investigation testing on an AGD Systems Limited, AGD 326.

The AGD 326 contains a pre-approved Wi-Fi module and 24 GHz radar that are able to operate simultaneously.

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

<input type="checkbox"/> Element Hull	<input checked="" type="checkbox"/> Element Skelmersdale
Unit E	Unit 1
South Orbital Trading Park	Pendle Place
Hedon Road	Skelmersdale
Hull	West Lancashire
HU9 1NJ	WN8 9PN
UK	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-210 Issue 10, December 2019 – Licence-Exempt Radio Apparatus: Category I Equipment
- Industry Canada RSS-Gen, Issue 5, March 2019 – General Requirements for Compliance of Radio Apparatus

5.2 *Deviations from Test Standards*

Limited testing to investigate if any intermodulation spurious emissions products are generated by simultaneous operation radios.

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

24 GHz Radar:

Manufacturer: AGD Systems Limited
 Model Number: Innocent IVS-922
 FCC ID: WH3326505
 ISED ID: 7907A-326505

2.4 GHz Wi-Fi

Manufacturer: 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 transmitter tests was as follows:

Radios were set to transmit permanently in various combinations, the spectrum was checked to determine if any intermodulation products were generated due to multiple radios operating simultaneously. The worst case emission plots are shown in this document.

EUT was operated with worst case modes of operation for each radio device.

7.4 EUT Description

The EUT is a Pedestrian radar using 2.4 GHz Wi-Fi module and 24 GHz radar.

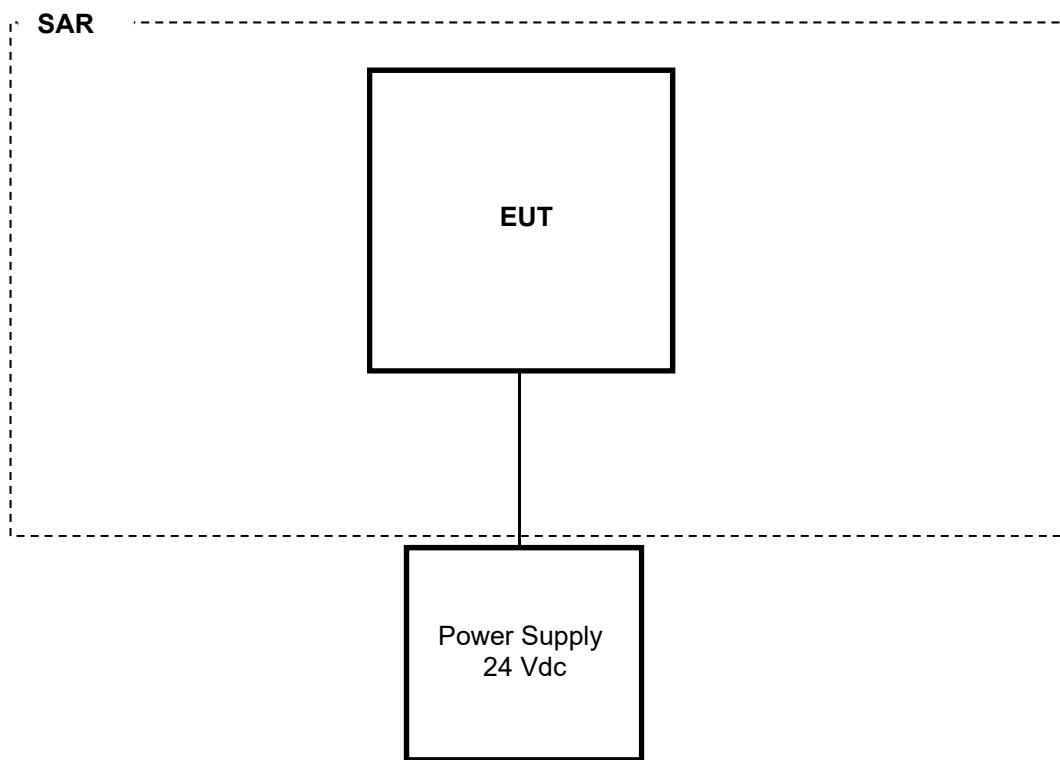
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

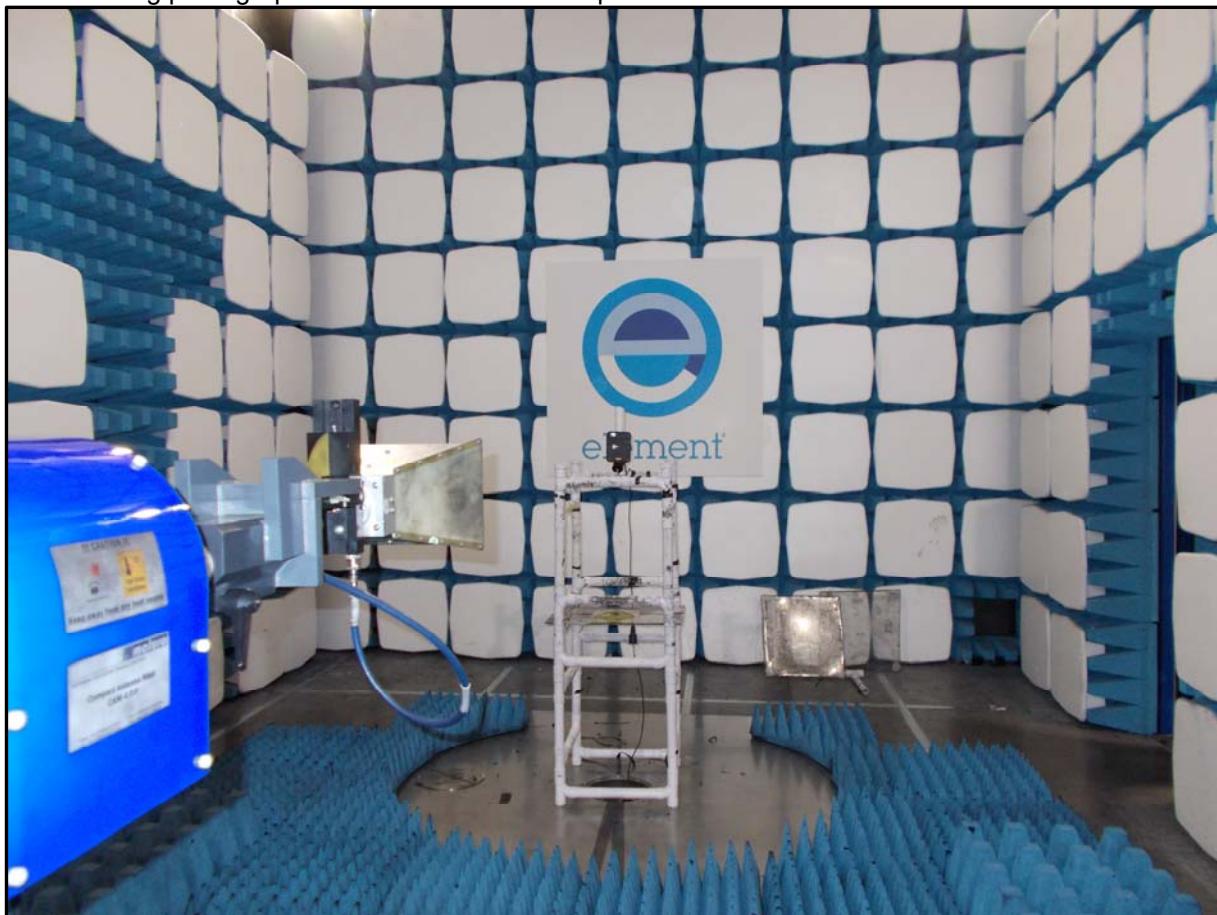
9.1 *Block Diagram*

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



9.2 General Set-up Photograph

The following photographs shows basic EUT set-up:



10 General Technical Parameters

10.1 Normal Conditions

The AGD 326 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.

<i>Modes of operation:</i>	Wi-Fi	Radar
<i>Frequencies of operation:</i>	2412 MHz to 2462 MHz	24.075 GHz to 24.150 GHz
<i>Declared output power(s):</i>	18 dBm	20 dBm
<i>Antenna type(s):</i>	Patch antenna	IVS-922
<i>Modulation type(s):</i>	DSSS / OFDM	FMCW
<i>Nominal Supply Voltage:</i>	24 Vdc	24 Vdc

11 Radiated emissions, intermodulation products

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.

Intermodulation products

Emissions of two or more electromagnetic waves transmitted simultaneously through a nonlinear electronic system.

11.2 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
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: 33% RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	24 Vdc (as declared)

11.3 Test Limits

CFR47 Part 15.247 / RSS-247

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

CFR47 Part 15.245 / RSS-210

The average field strength of emissions measured at 3 m shall not exceed:

- (a) 2500 mV/m for fundamental emission; and
- (b) 25 mV/m for harmonic emissions for devices operating in the 24.075 GHz - 24.175 GHz band

Harmonic emissions falling into restricted bands which are at and above 17.7 GHz shall not exceed the following strength limits measured at a distance of 3 m:

- (a) 25 mV/m for the second and third harmonic emissions of devices operating in the band 24.075-24.175 GHz; and
- (b) 7.5 mV/m for all other devices.

Emissions radiated outside of these specified operating frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits specified, whichever is less stringent.

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

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

n.b. peak limit is 20 dB above average.

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dB μ V/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

$$\text{Factor} = CL + AF - PA$$

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;

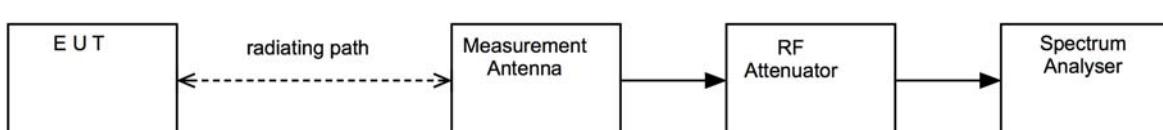
PA is the pre-amplifier gain in dB (where used);

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

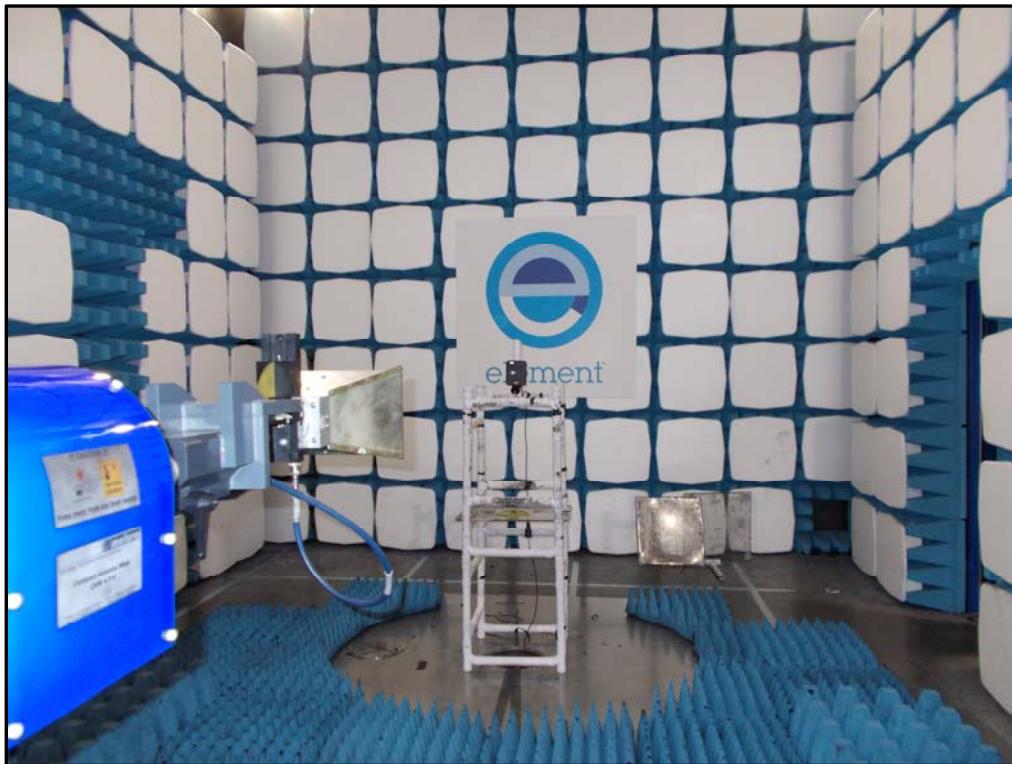
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph

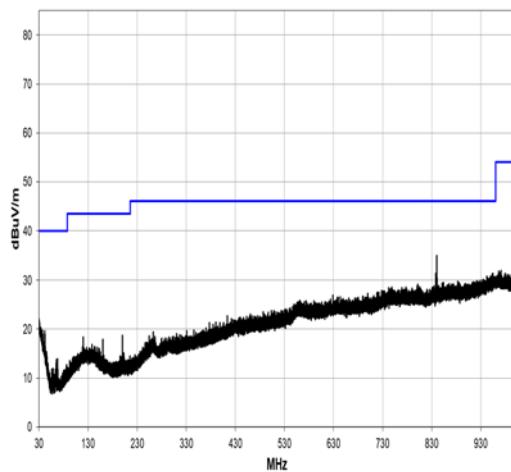


11.6 Test Equipment

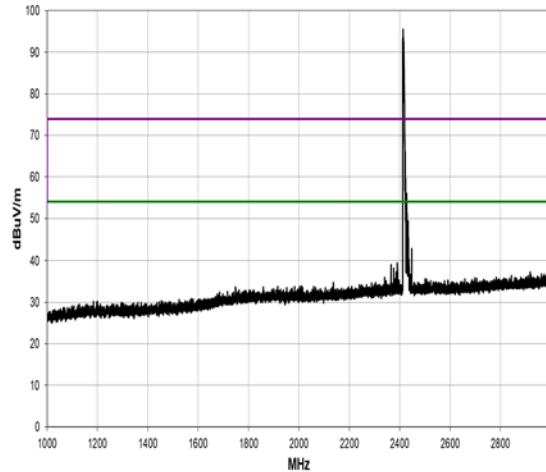
Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	2020-10-17
Spectrum Analyser	Agilent	N9030A	REF2167	2020-08-12
Bilog	Chase	CBL611/A	U573	2021-09-19
Log Periodic Ant	Chase	UPA6108	L203	2020-06-11
Pre Amp	Watkins Johnson	6201-69	U372	2021-02-26
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
Standard Gain Horn 26-40	Flann	22240-20	L301	2020-08-10
Harmonic Mixer (33-50)	Agilent	11970Q	U365	2022-05-06
Harmonic Mixer (50-75)	Agilent	11970V	U366	2022-05-06
Harmonic Mixer (75-110)	Agilent	11970W	U367	2022-05-17
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

11.7 Results

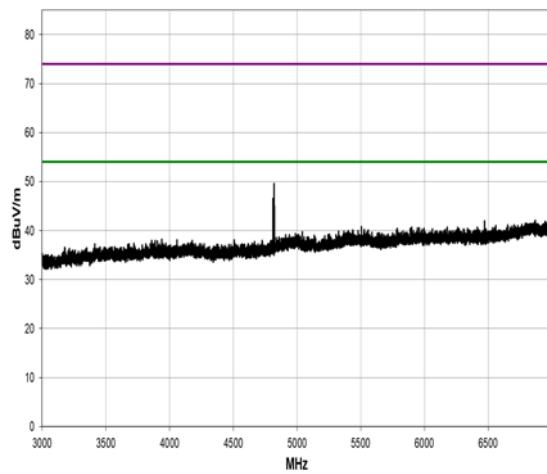
Wi-Fi: Bottom channel / Radar: Bottom channel



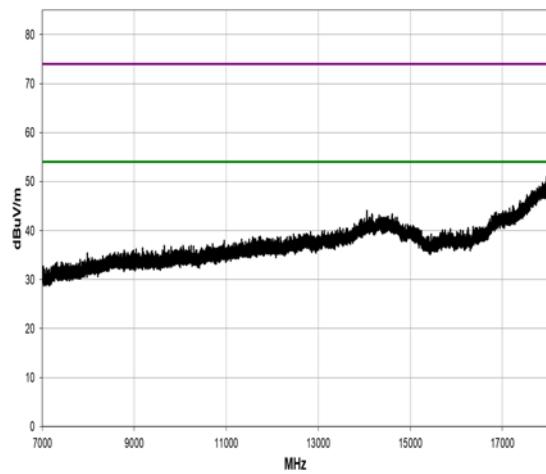
30 MHz to 1 GHz



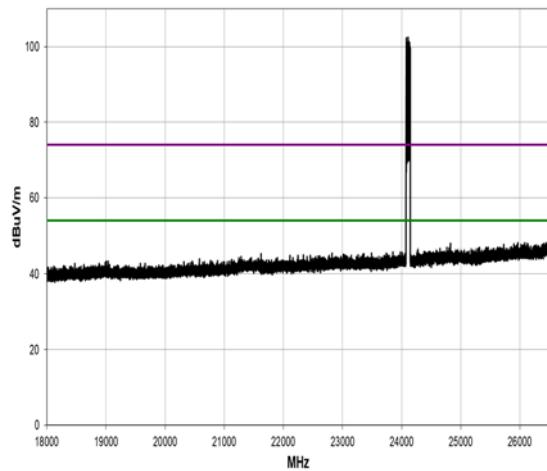
1 GHz to 3 GHz



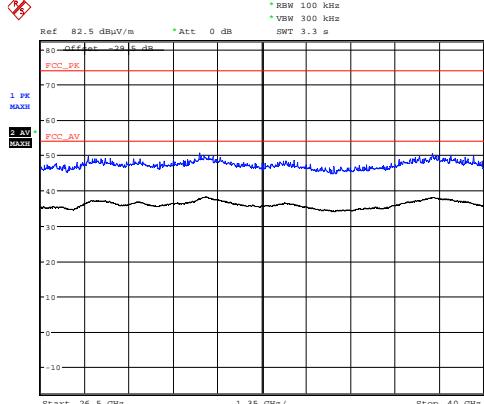
3 GHz to 7 GHz



7 GHz to 18 GHz



18 GHz to 26.5 GHz

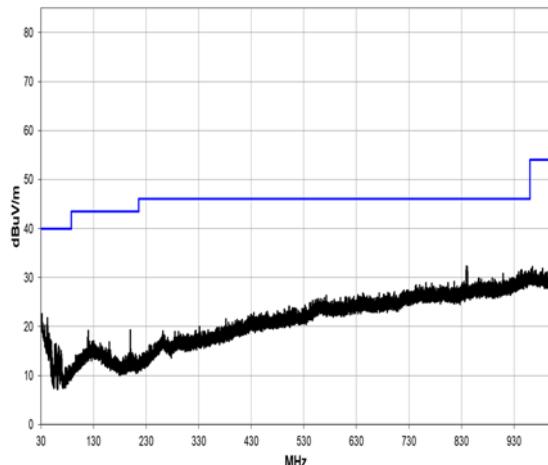


26.5 GHz to 40 GHz

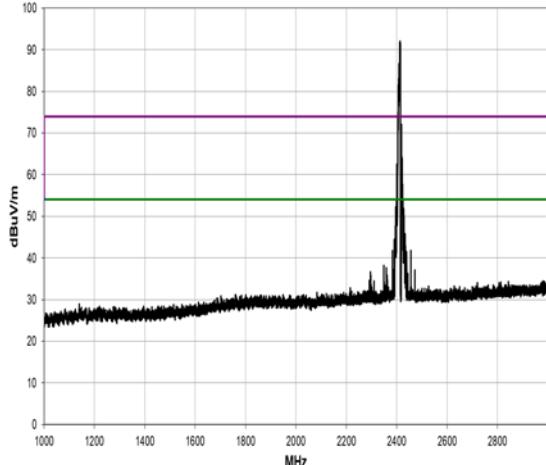
Frequency Range 40 GHz to 110 GHz					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
Emission Checked up to 110GHz No inter-modulation products found				PASS	

All emissions on graphs are related to either the Wi-Fi or Radar operation and are not inter-modulation products

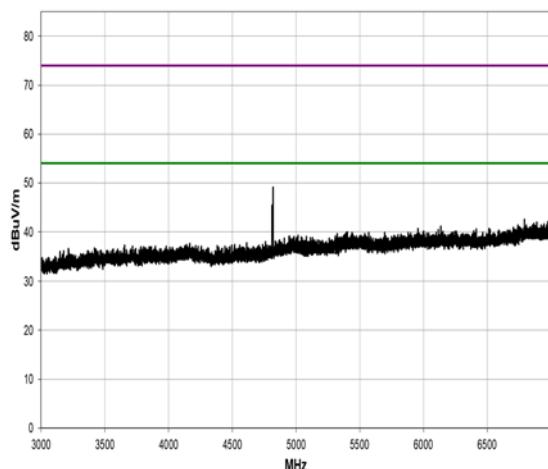
Wi-Fi: Bottom channel / Radar: Top channel



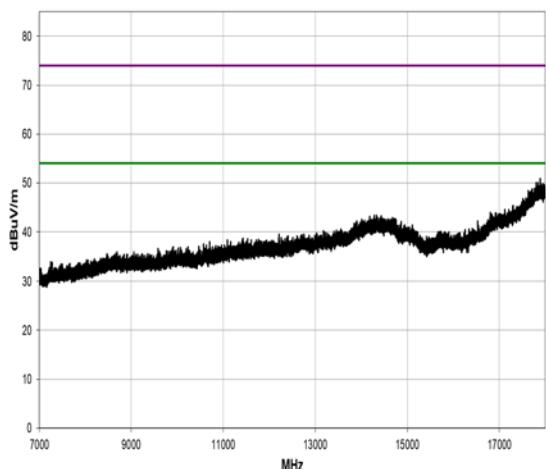
30 MHz to 1 GHz



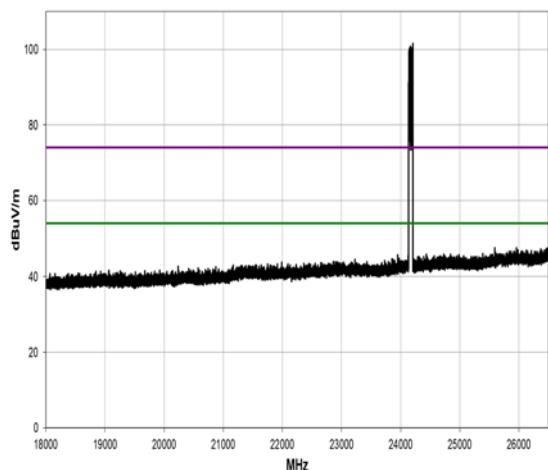
1 GHz to 3 GHz



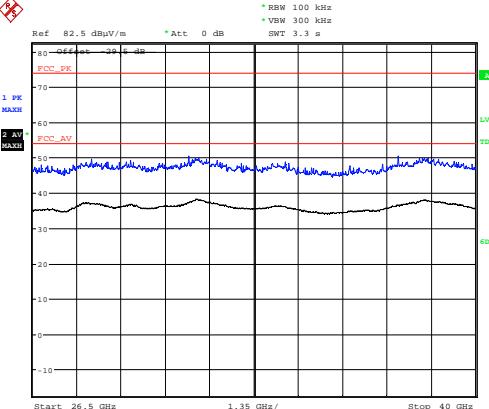
3 GHz to 7 GHz



7 GHz to 18 GHz



18 GHz to 26.5 GHz



26.5 GHz to 40 GHz

Frequency Range 40 GHz to 110 GHz					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
Emission Checked up to 110GHz No inter-modulation products found					PASS

All emissions on graphs are related to either the Wi-Fi or Radar operation and are not inter-modulation products

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) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**