Report on the Radio Testing

For

Ocado Innovation Limited

on

RCOM Bot Communications Module

Report no. TRA-059223-47-04B

20th July 2023

Report Number: TRA-059223-47-04B
Issue: B

REPORT ON THE RADIO TESTING OF A
Ocado Innovation Limited
RCOM Bot Communications Module
WITH RESPECT TO SPECIFICATION
FCC 47CFR Subpart E

TEST DATE: 3rd - 11th May 2023

Tested by: D Winstanley, S Hodgkinson, S lung Sui

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J Charters
Lab Manager

Date: 20th July 2023

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	28th June 2023	Original
B	20th July 2023	Typographical Corrections addition of non-occupancy plot

2 Summary

TEST REPORT NUMBER:	TRA-059223-47-04B
WORKS ORDER NUMBER:	TRA-059223-07
PURPOSE OF TEST:	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:	47CFR15 Subpart E
EQUIPMENT UNDER TEST (EUT):	RCOM Bot Communications Module
FCC IDENTIFIER:	2AGHF-RCOMBCM003
EUT SERIAL NUMBER:	OCAG00118
MANUFACTURER/AGENT:	Ocado Innovation Limited
ADDRESS:	Trident Place, Hatfield Business Park Mosquito Way, Hatfield Hertfordshire AL10 9UL United Kingdom
CLIENT CONTACT:	Ed Briggs ☎ 07557 860903 ✉ Ed.Briggs@Ocado.com
TEST DATE:	3rd - 11th May 2023
TESTED BY:	D Winstanley, S Hodgkinson, S lung Sui 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	☒	*Pass*
AC power line conducted emissions		15.207	☒	*Pass*
Occupied bandwidth		15.407(e)	☒	*Pass*
Output power	Conducted	15.407(a)	☒	*Pass*
	PSD		☒	
	RPE		☐	
Conducted / radiated RF power out-of-band		15.407(b)	☒	*Pass*
Duty cycle		15.35(c)	☒	*Pass*
TPC and DFS		15.407(h)	☒	*Pass*
U-NII detection bandwidth		15.407(h)(2)	☐	*Note 1*
CAC		15.407(h)(2)(ii)	☐	*Note 1*
In-service monitoring		15.407(h)(2)(iii) & 15.407(h)(2)(iv)	☒	*Pass*
Statistical performance check		-	☐	*Note 1*

Notes:

1. This test is not applicable to a client device without radar detection.

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).

General notes

The decision rule for compliance is not inherent within this specification and compliance is based on the customer requesting a simple acceptance rule based on understanding and acceptance of Elements Measurement Uncertainty values.

3 Contents

4 Introduction

This report TRA-059223-47-04B presents the results of the Radio testing on a Ocado Innovation Limited, RCOM Bot Communications Module to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Ocado Innovation 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 Skelmersdale West Lancashire WN8 9PN UK	☐	Element Surrey Hills Unit 15 B Henley Business Park Pirbright Road Normandy Guildford GU3 2DX UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

FCC Site Listing:
The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Hull	UK2007
Element Skelmersdale	UK2020

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.
- FCC KDB Publication 905462 D02 v01r02 – Compliance measurement procedures for unlicensed-national information infrastructure devices operating in the 5250-5350 MHz and 5470-5725 MHz bands incorporating dynamic frequency selection.
- 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
CAC	Channel Availability Check
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DFS	Dynamic Frequency Selection
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 (now ISED)
ISED	Innovation, Science and Economic Development Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
LE-LAN	Licence-Exempt Local Area Network
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
PSD	Power Spectral Density
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
TPC	Transmitter Power Control
Tx	transmitter
UKAS	United Kingdom Accreditation Service
U-NII	Unlicensed-National Information Infrastructure
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: RCOM Bot Communications Module
- Serial Number: OCAG00118
- Model Number: RCOM BCM
- Software Revision: v12.0.18
- Build Level / Revision Number: 20058850 Rev 1.00

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.

Customer supplied Laptop
RCOM Base Station

7.3 EUT Mode of Operation

7.3.1 Transmission

The EUT was set to transmit on the required channel in a communication link with a companion device (Base Station). A Laptop Supplied by the manufacturer containing Engineering Test Interface (ETIF) software, this software is used to select the region the EUT test scenario / operating mode and operating channel

7.4 EUT Radio Frequency Parameters

7.4.1 General

Frequency of operation:	5470 MHz – 5725 MHz
Modulation type(s):	OFDMA
Occupied channel bandwidth(s):	10 MHz
Channel spacing:	10 MHz
Declared output power(s):	21 dBm EIRP
Nominal Supply Voltage:	24 Vdc

7.4.2 Antennas

Frequency range:	5470 MHz – 5725 MHz
Impedance:	50 Ohms
Antenna Assembly Gain:	+5 dBi (with 1 dB cable loss) (Antenna Assembly Gain including cable = 4 dBi)
Polarisation:	Linear
Connector type:	RP-SMA
Environmental limits:	-30 ºC to + 45 ºC
Mounting:	External

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	Single Transmit, Receive Diversity
Fixed pt-pt operations (yes/no):	No

DFS Parameters:	
Highest and lowest EIRP:	21 dBm EIRP
Antenna used for testing:	None (pulses applied to both antenna A&B Simultaneously)
Antenna port impedance:	50 ohms
Channel loading / test file:	Master Device used in test Loaded to 47.5 %
TPC description:	EUT at Full Power (TPC N/A <500mW)
Clients: Radar detection Master U-NII Device FCC ID	2AGHF-RCOMBS003

7.5 EUT Description

The EUT is part of a point to multipoint short range radio communications system, identified as RCOM, which operates in the frequency band 5470MHz to 5725MHz. The wireless part of this system comprises of two parts, the BS – Base Station (EUT) and the BCM – Bot Communications Module. One Base Station can be connected to many BCMs at any one time. The purpose of this radio system is to provide a low data rate, bi-directional, wireless connection to a large number of low speed factory floor machines which transport goods, in a controlled manner, around the facility. These machines are unmanned and the purpose of the wireless connection is to issue commands to the machines and relay status information back, from each of the machines, to a central point in the factory.

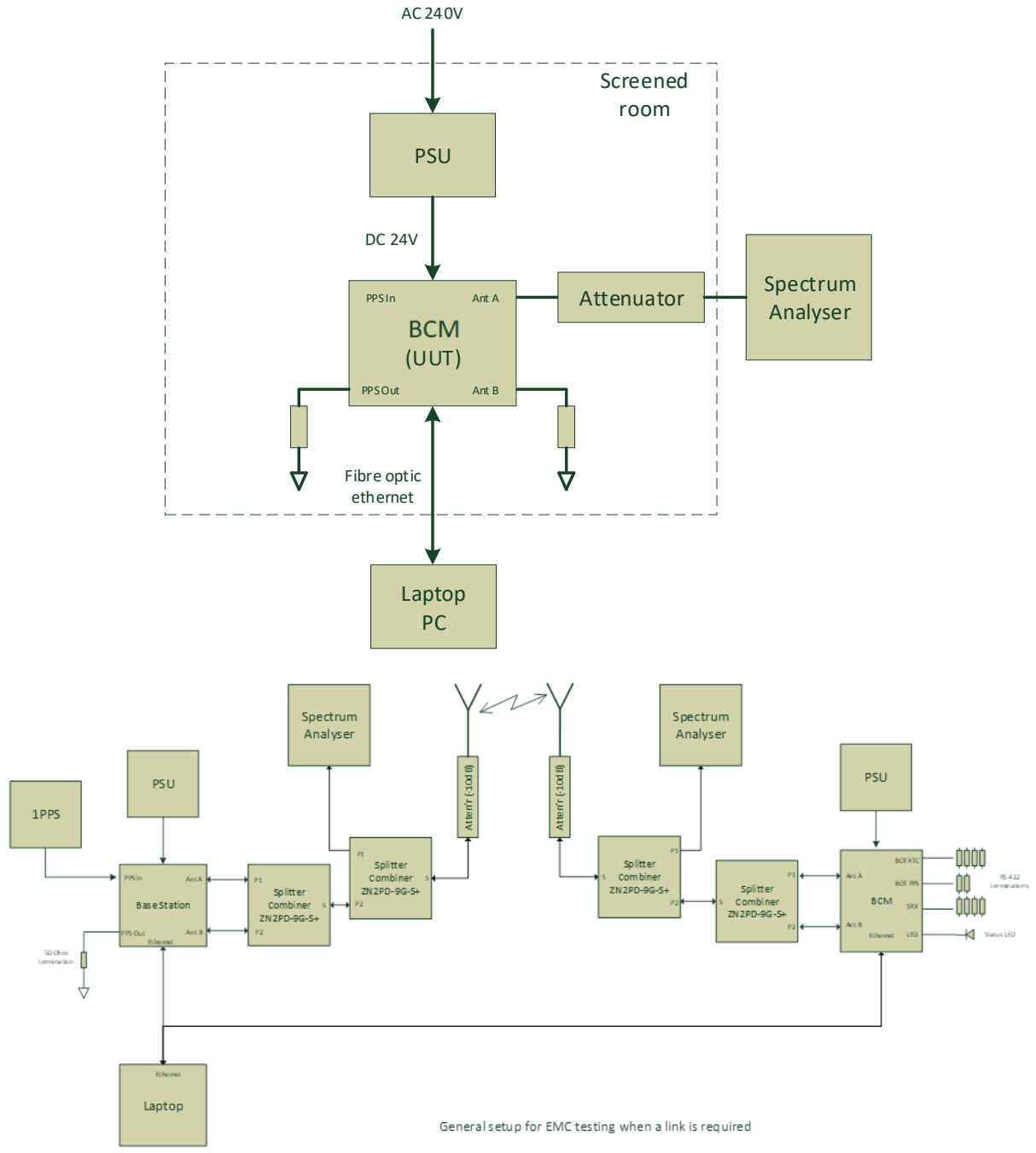
8 Modifications

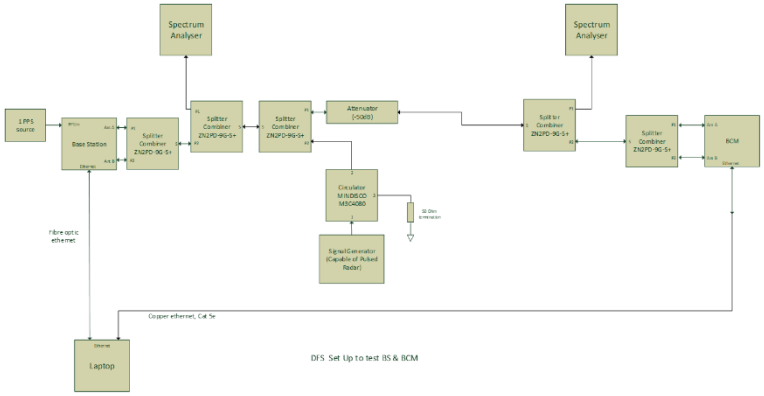
No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections:



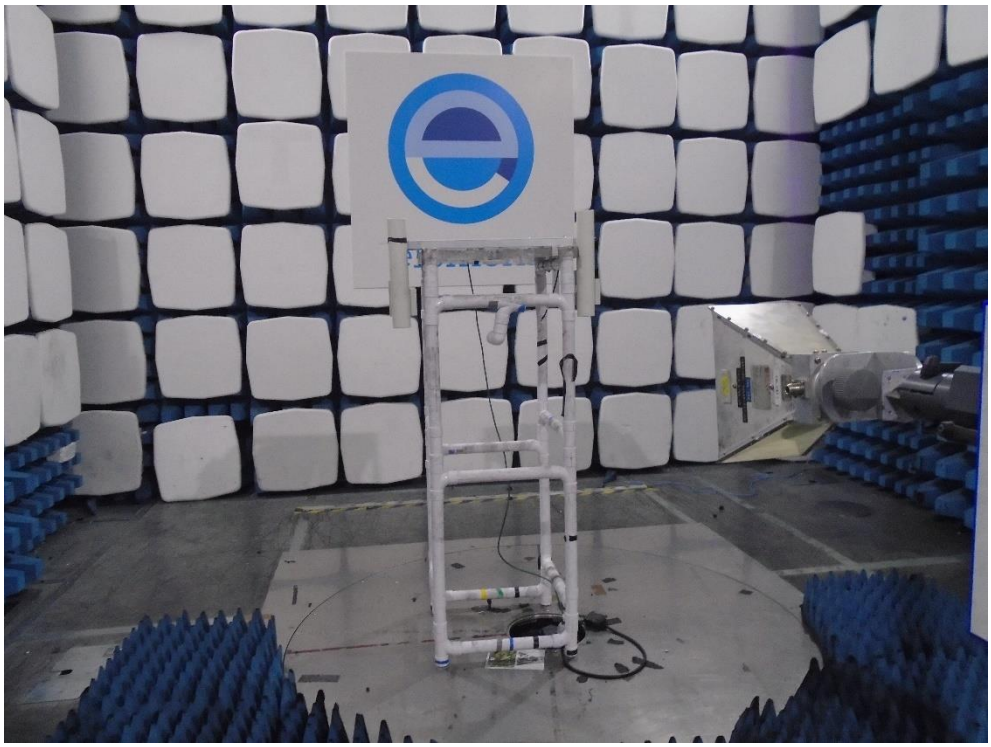


DFS Set Up to test BS & BCM

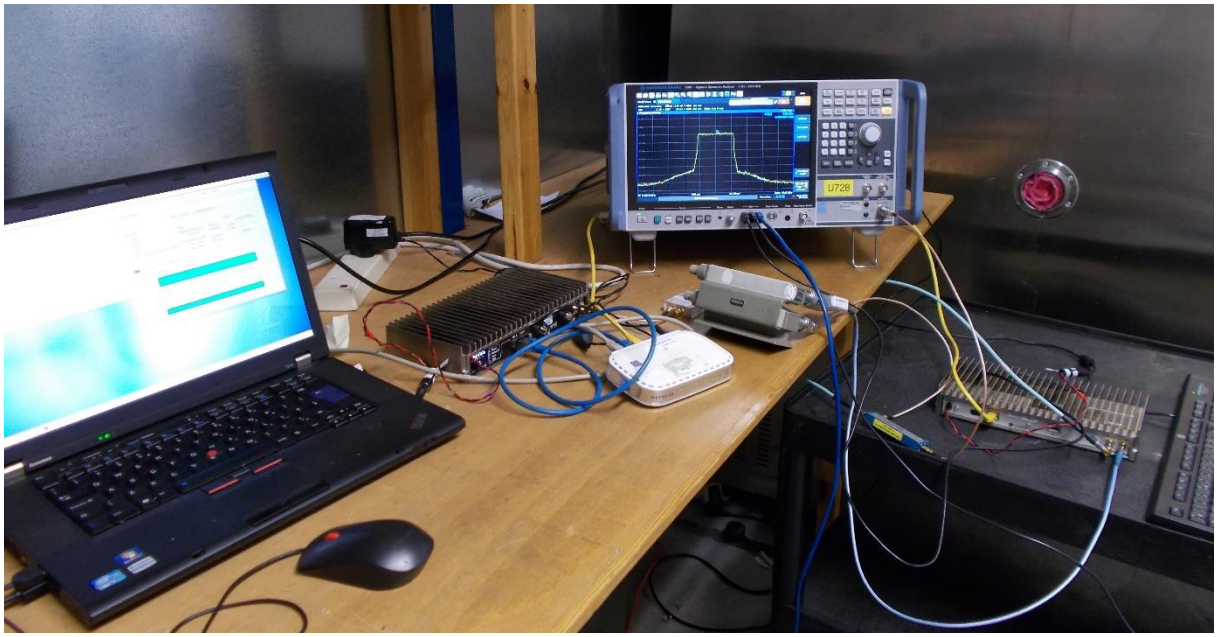
9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:

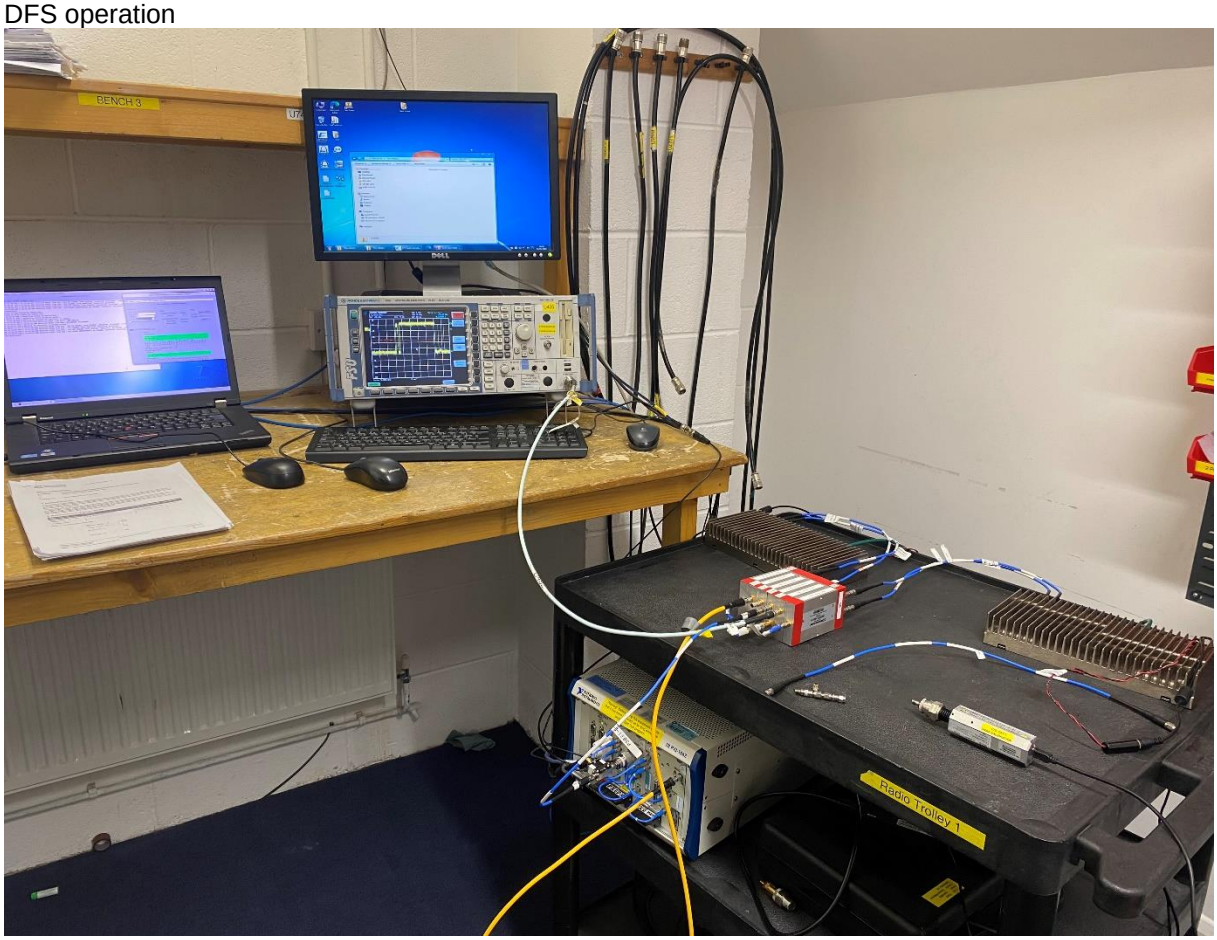
Radiated Emissions:



Conducted Bench Test



DFS operation



9.3 *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.

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 24 V dc from a mains adaptor.

10.2 Varying Test Conditions

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

	Category	***Nominal***	***Variation***
☐	Mains	110V ac +/-2%	85% and 115%
☐	Battery	New battery	N/A
☒	Other	24 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 Skelmersdale
Test Chamber:	Radio Chamber / EMC chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	5482.5MHz & 5712.5MHz
EUT Channel Bandwidths:	10MHz
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: 45 %RH	20%RH to 75%RH (as declared)

Test Limits
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 3m)***
30-88	100
88-216	150
216-960	200
Above 960	500

11.3 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 100kHz 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:

$$FS = PR + CL + AF – PA + DC – CF$$

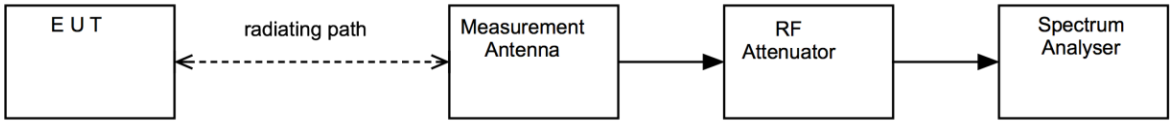
$$Factor = CL + AF – PA$$

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. where average detector on pulsed harmonic understates the power);
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



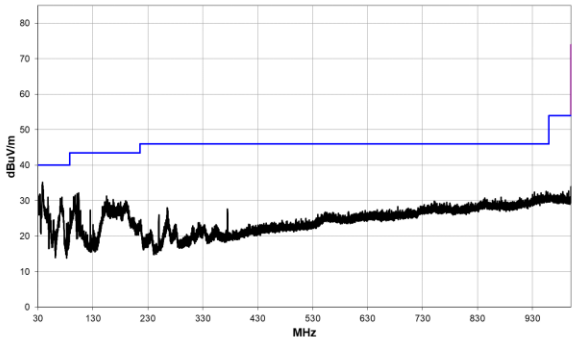
11.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
PreAmp	Watkins Johnson	6201-69	U372	2023-03-01	1 Year	2024-03-07
2.4G Band Stop Filter	BSC	SN 4478	U543	2023-02-03	1 Year	2024-02-08
Bilog	Chase	CBL611/A	U191	2020-11-10	2 Year	2025-02-23
Horn Antenna	EMCO	3115	L138	2022-05-23	1 Year	2024-05-23
Spectrum Analyser	R&S	FSU46	REF910	2022-12-22	1 Year	2024-01-10
Pre Amp	Agilent	8449B	L572	2022-10-24	1 Year	2023-10-24
EMI Receiver	R&S	ESR26	U489	2021-03-04	1 Year	2023-09-30
PreAmp	Com-power	PAM-840A	REF2390	2021-09-02	1 Year	2023-09-02
PreAmp	Watkins Johnson	6201-69	U372	2023-03-01	1 Year	2024-03-07

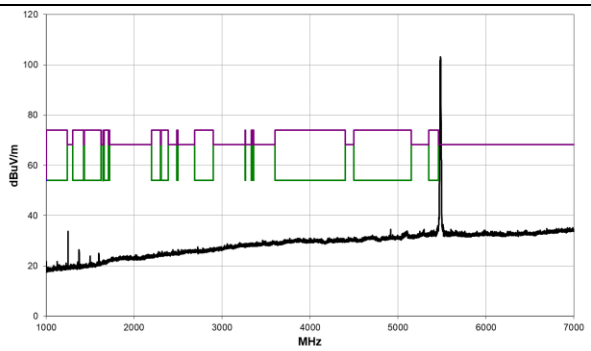
11.5 Test Results

Common Emissions								
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Factor***	***Duty Cycle Corr'n (dB)***	***Field Strength (dBµV/m)***	***Distance Extrap'n Factor (dB)***	***Limit (dBuV/m)***	***Margin (µV/m)***
QP	38.106	39.1	-8.0	0	31.1	0	40.0	-8.9
QP	71.375	42.2	-15.7	0	26.5	0	40.0	-13.5
QP	33.620	31.6	-5.6	0	26.0	0	40.0	-14.0
QP	48.551	39.8	-13.8	0	26.0	0	40.0	-14.0
QP	31.703	30.1	-4.6	0	25.5	0	40.0	-14.5

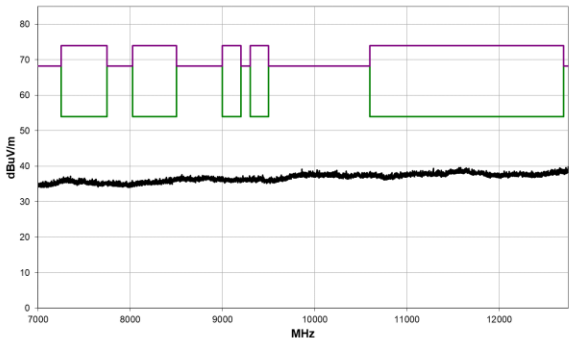
Channel: 5482.5 MHz, Wideband Mode								
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Factor***	***Duty Cycle Corr'n (dB)***	***Field Strength (dBµV/m)***	***Distance Extrap'n Factor (dB)***	***Limit (dBuV/m)***	***Margin (µV/m)***
No Emission within 20dB of the limits								



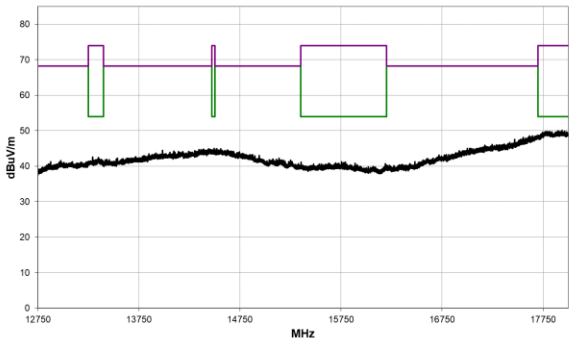
30MHz – 1GHz



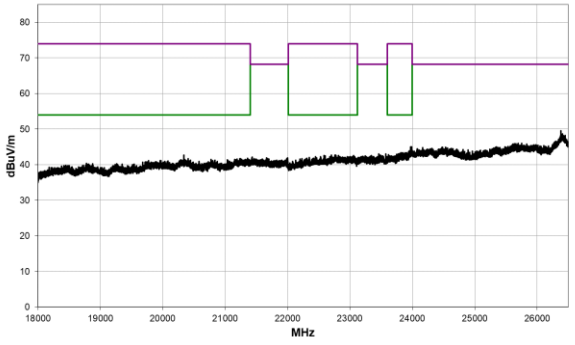
1GHz – 7GHz



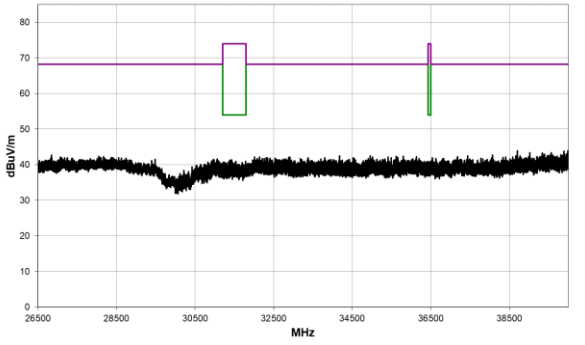
7GHz – 12.75GHz



12.75GHz – 18GHz

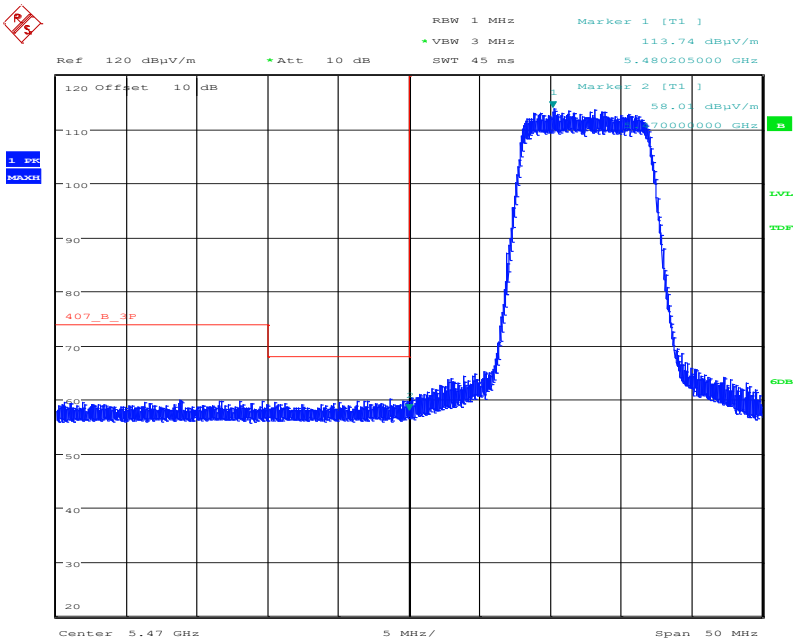


18GHz – 26.5GHz



26.5GHz – 40GHz

Band Edge Peak Limit:



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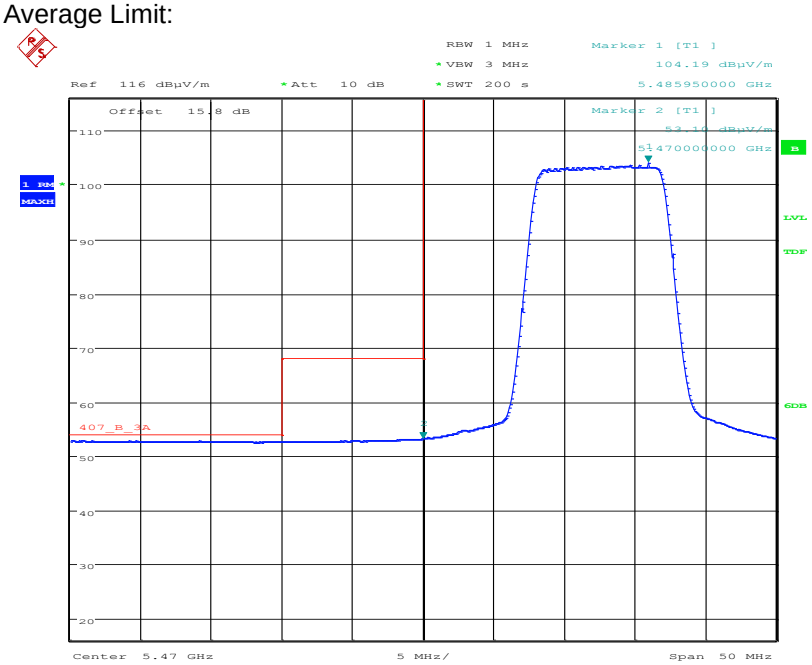
Band Edge Average Limit:



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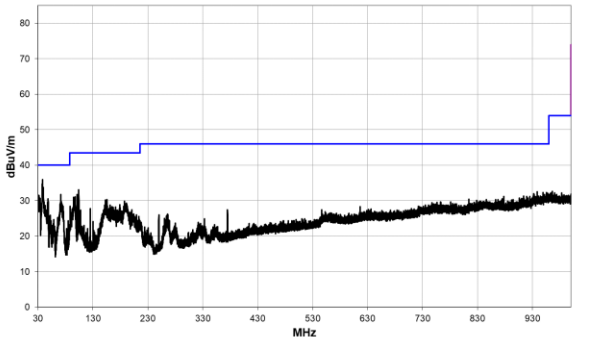
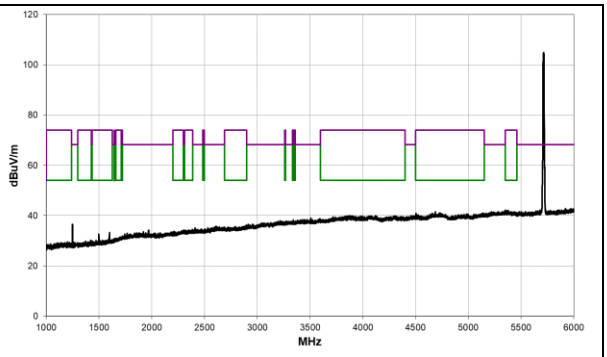
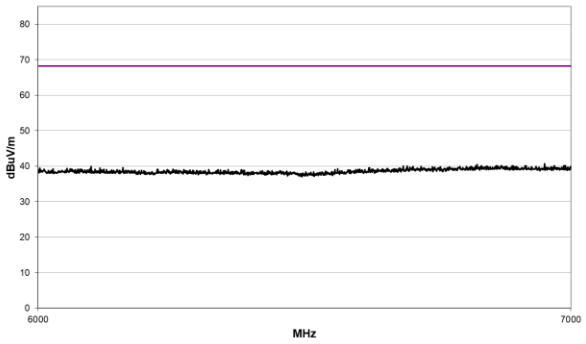
Channel: 5712.5 MHz, Wideband Mode								
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Factor***	***Duty Cycle Corr'n (dB)***	***Field Strength (dBµV/m)***	***Distance Extrap'n Factor (dB)***	***Limit (dBuV/m)***	***Margin (µV/m)***
No Emission within 20dB of the limits								



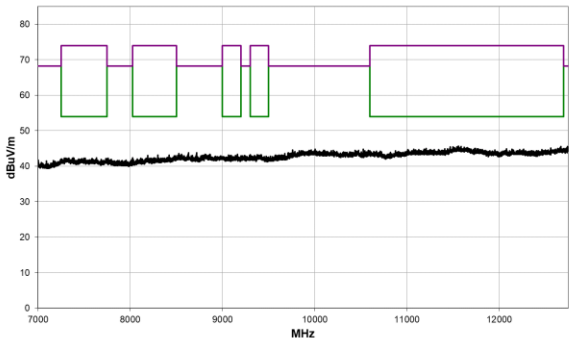
30MHz – 1GHz



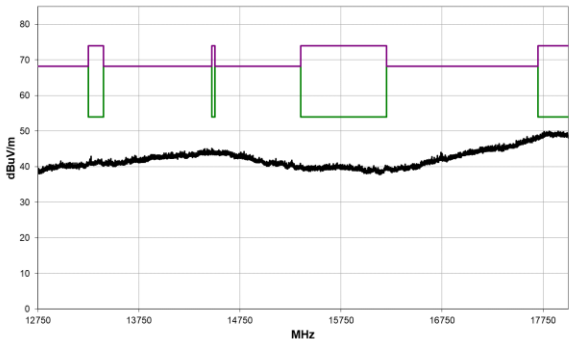
1GHz – 6GHz



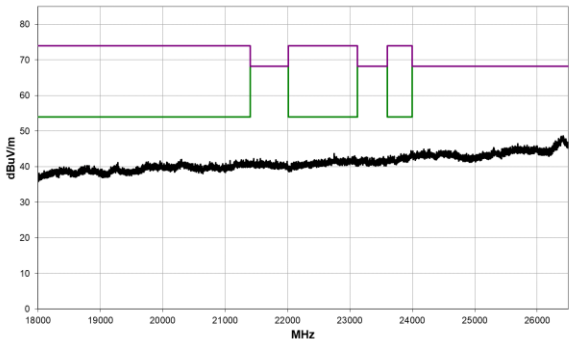
6GHz – 7GHz



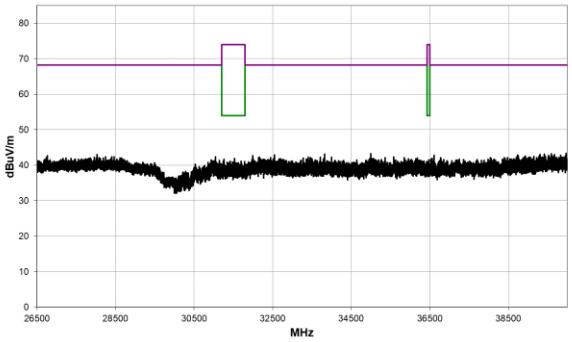
7GHz – 12.75GHz



12.75GHz – 18GHz

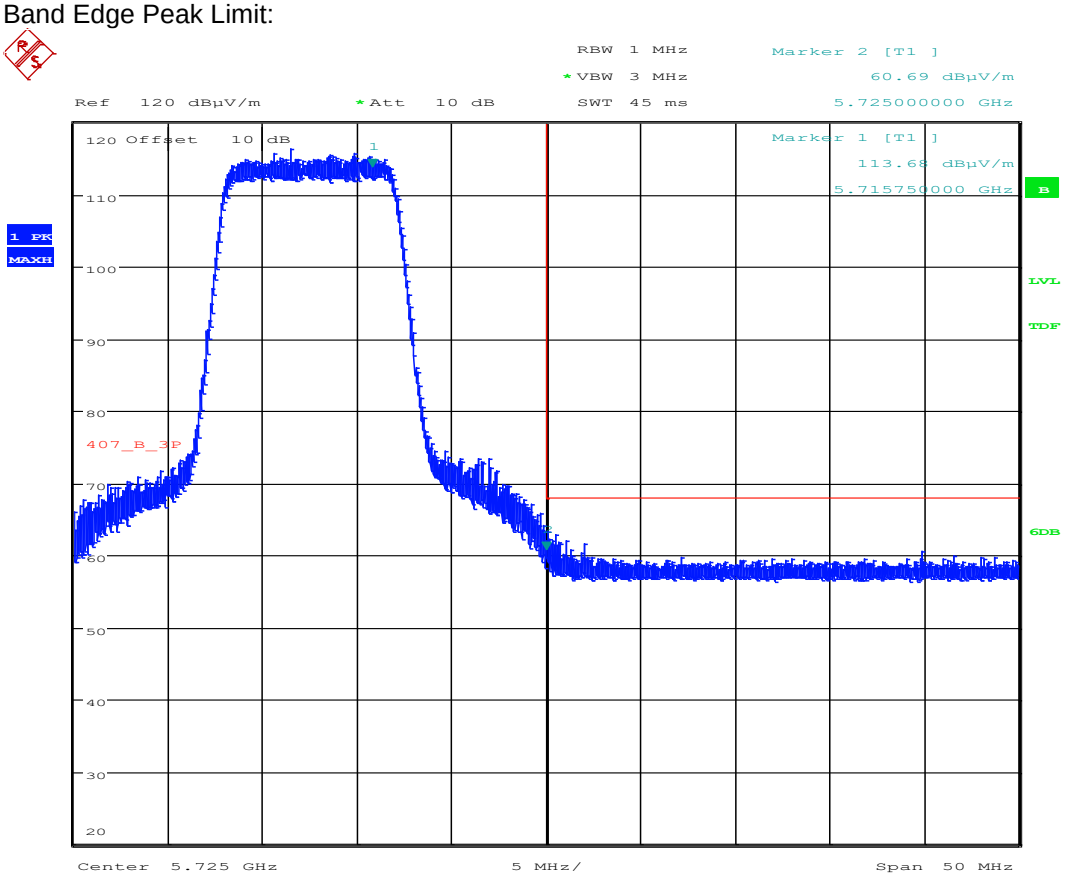


18GHz – 26.5GHz



26.5GHz – 40GHz

Band Edge Peak Limit:



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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 Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	Mid
EUT Channel Bandwidths:	10 MHz
EUT Modulation:	OFDM
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: 42 %RH	20%RH to 75%RH (as declared)

Test Limits

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-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 – 0.5	66 to 56*	56 to 46*
0.5 – 5.0	56	46
5.0 – 30.0	60	50

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

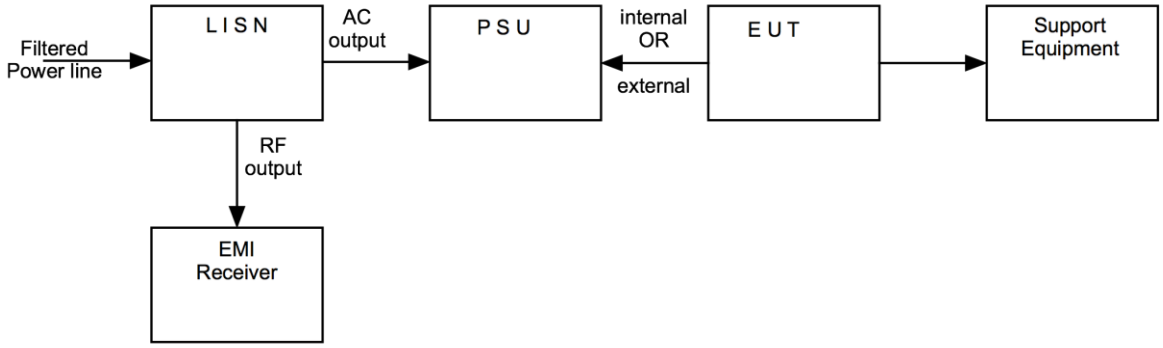
12.3 Test Method

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

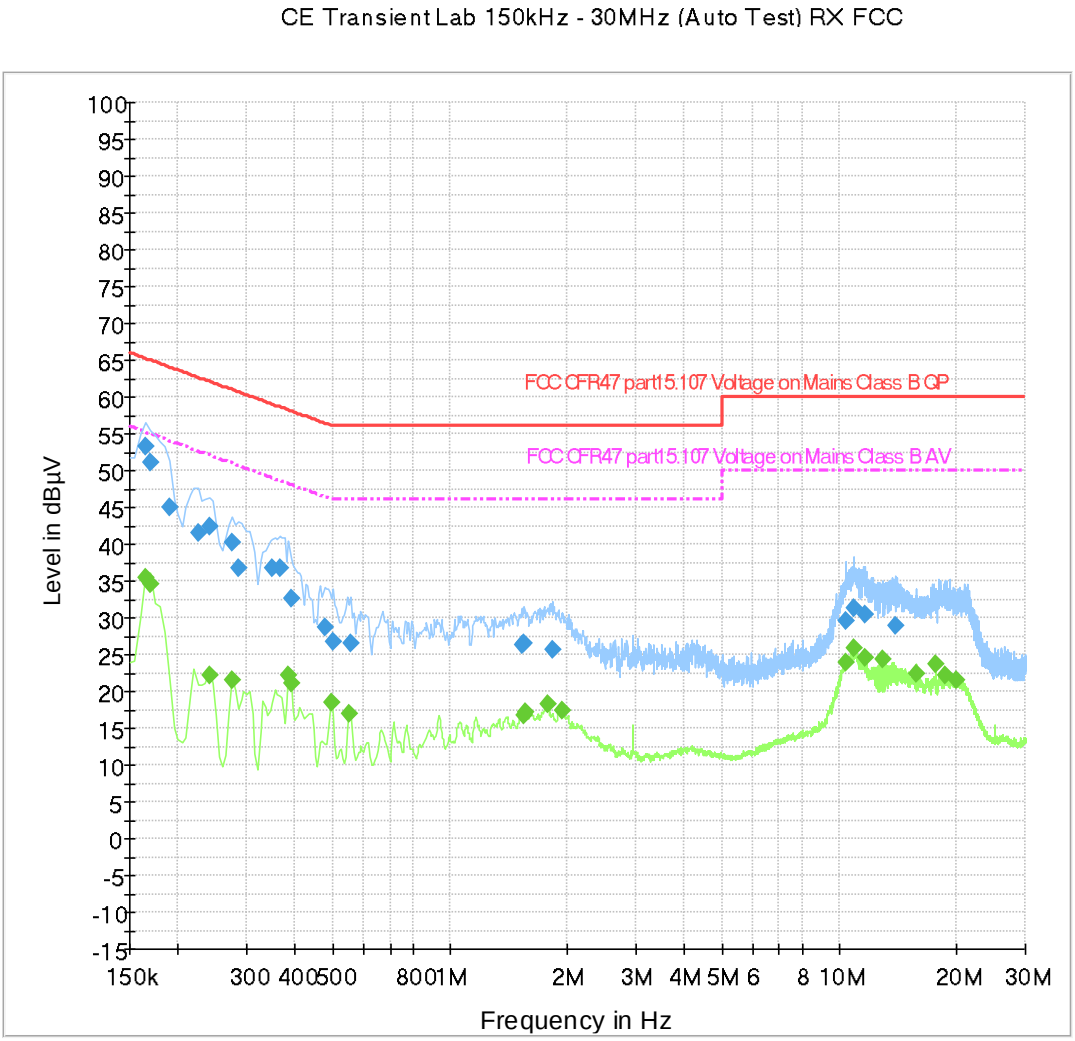


Test Setup Photograph(s)

12.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Receiver	R&S	ESHS10	U003	2023-02-14	12	2024-02-14
Lisn	R&S	ENV216	U396	2022-05-23	12	2023-05-23

12.5 Test Results



Results measured using the quasi-peak detector								
Frequency (MHz)	**QuasiPeak (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**Filter**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**
0.165000	53.3	2000.0	10.000	Off	L1	19.5	11.9	65.2
0.170000	51.0	2000.0	10.000	Off	N	19.5	13.9	65.0
0.190000	44.9	2000.0	10.000	Off	N	19.5	19.1	64.0
0.225000	41.5	2000.0	10.000	Off	N	19.5	21.1	62.6
0.240000	42.4	2000.0	10.000	Off	L1	19.5	19.7	62.1
0.275000	40.2	2000.0	10.000	Off	N	19.6	20.8	61.0
0.285000	36.8	2000.0	10.000	Off	L1	19.6	23.8	60.7
0.350000	36.7	2000.0	10.000	Off	L1	19.6	22.3	59.0
0.365000	36.7	2000.0	10.000	Off	L1	19.6	21.9	58.6
0.390000	32.5	2000.0	10.000	Off	L1	19.6	25.5	58.1
0.475000	28.6	2000.0	10.000	Off	L1	19.6	27.8	56.4
0.500000	26.7	2000.0	10.000	Off	L1	19.6	29.4	56.0
0.555000	26.5	2000.0	10.000	Off	L1	19.6	29.5	56.0
1.525000	26.2	2000.0	10.000	Off	N	19.6	29.8	56.0
1.550000	26.5	2000.0	10.000	Off	L1	19.6	29.5	56.0
1.830000	25.7	2000.0	10.000	Off	N	19.6	30.3	56.0
10.375000	29.5	2000.0	10.000	Off	N	19.9	30.5	60.0
10.910000	31.3	2000.0	10.000	Off	N	19.9	28.7	60.0
11.585000	30.4	2000.0	10.000	Off	L1	19.9	29.6	60.0
13.925000	29.0	2000.0	10.000	Off	L1	19.9	31.0	60.0

Results measured using the average detector								
Frequency (MHz)	**Average (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**Filter**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**
0.165000	35.4	2000.0	10.000	Off	L1	19.5	19.8	55.2
0.170000	34.5	2000.0	10.000	Off	N	19.5	20.4	55.0
0.240000	22.2	2000.0	10.000	Off	N	19.5	29.9	52.1
0.275000	21.4	2000.0	10.000	Off	L1	19.6	29.5	51.0
0.385000	22.2	2000.0	10.000	Off	N	19.6	26.0	48.2
0.390000	21.0	2000.0	10.000	Off	N	19.6	27.1	48.1
0.495000	18.5	2000.0	10.000	Off	N	19.6	27.6	46.1
0.550000	17.1	2000.0	10.000	Off	L1	19.6	28.9	46.0
1.540000	16.8	2000.0	10.000	Off	N	19.6	29.2	46.0
1.555000	17.1	2000.0	10.000	Off	N	19.6	28.9	46.0
1.780000	18.2	2000.0	10.000	Off	L1	19.6	27.8	46.0
1.945000	17.4	2000.0	10.000	Off	L1	19.6	28.6	46.0
10.370000	23.9	2000.0	10.000	Off	L1	19.9	26.1	50.0
10.890000	25.9	2000.0	10.000	Off	N	19.9	24.1	50.0
11.585000	24.6	2000.0	10.000	Off	L1	19.9	25.4	50.0
12.920000	24.3	2000.0	10.000	Off	L1	19.9	25.7	50.0
15.690000	22.5	2000.0	10.000	Off	N	19.9	27.5	50.0
17.575000	23.8	2000.0	10.000	Off	N	19.9	26.2	50.0
18.635000	22.1	2000.0	10.000	Off	N	19.9	27.9	50.0
19.915000	21.5	2000.0	10.000	Off	N	19.9	28.5	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 6.9
Frequencies Measured:	5482.5 MHz, 5592.5 MHz,& 5712.5 MHz
EUT Channel Bandwidths:	10 MHz
EUT Test Modulations:	OFDM
Deviations from Standard:	None
Measurement BW: (FCC requirement: 100 kHz)	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	20 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 33 %RH	20%RH to 75%RH (as declared)
Supply: 24 Vdc	(as declared)

Test Limits

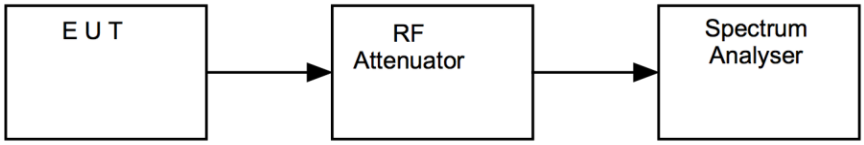
Within the 5.725–5.85 GHz band, the minimum 6 dB bandwidth of U–NII devices shall be at least 500 kHz.

There are no requirements outside of this band, the results were taken for the calculation of the power limits.

13.3 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

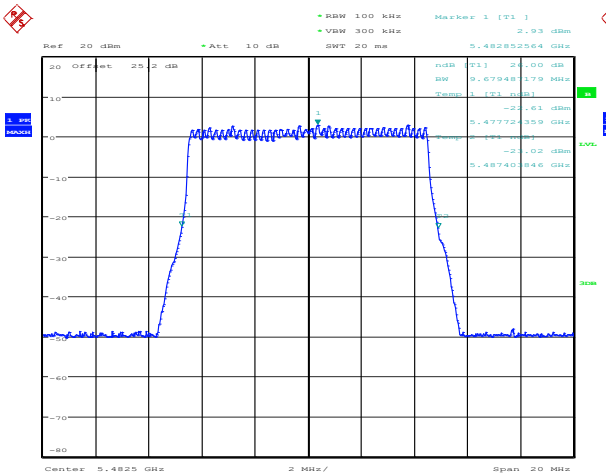


13.4 Test Equipment

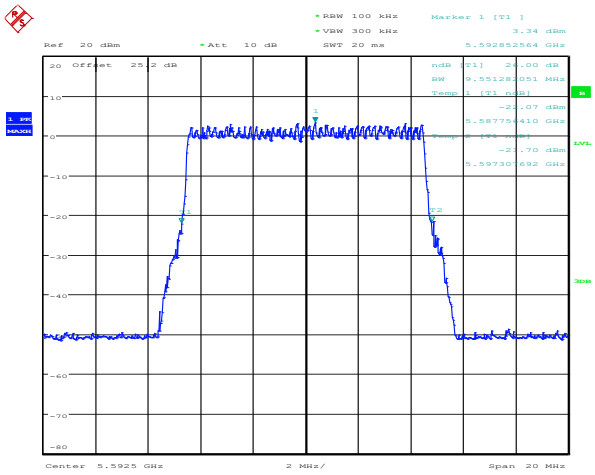
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU50	U544	2022-11-18	12	2023-11-18
20dB SMA attenuator	Atlantec	AA18-20H	U631	Calibrate in use		

13.5 Test Results

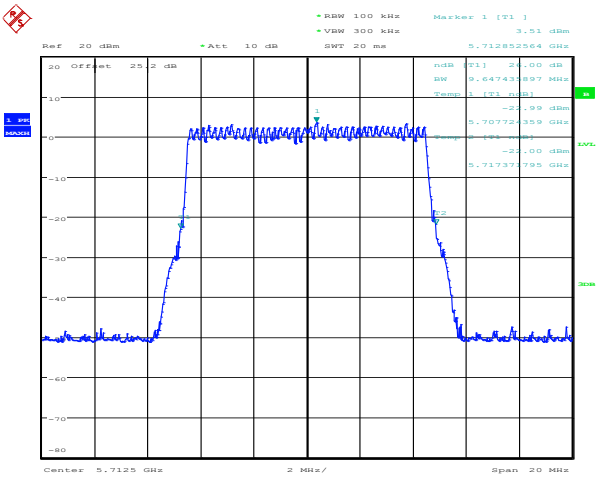
Mode Of Operation; Narrowband: Modulation: OFDM				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***26dB Bandwidth (kHz)***	***Result***
5482.5	5477.724359	5487.403846	9679.487	PASS
5592.5	5587.756410	5597.307692	9551.282	PASS
5712.5	5707.724359	5717.371795	9647.436	PASS



5482.5 MHz

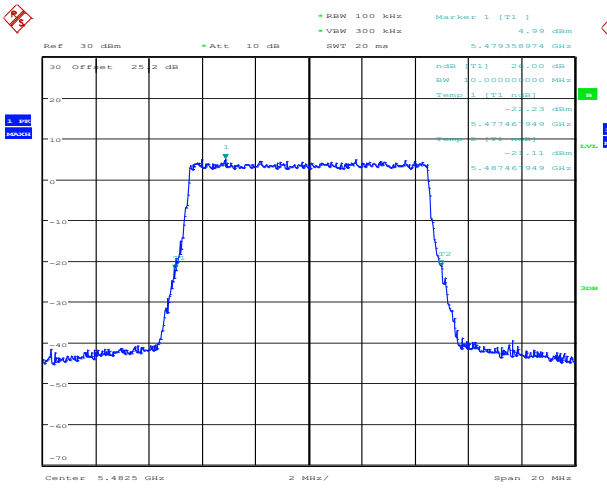


5592.5 MHz

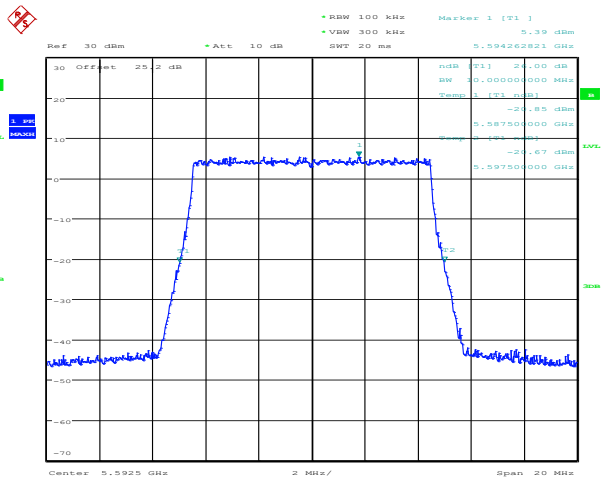


5712.5 MHz

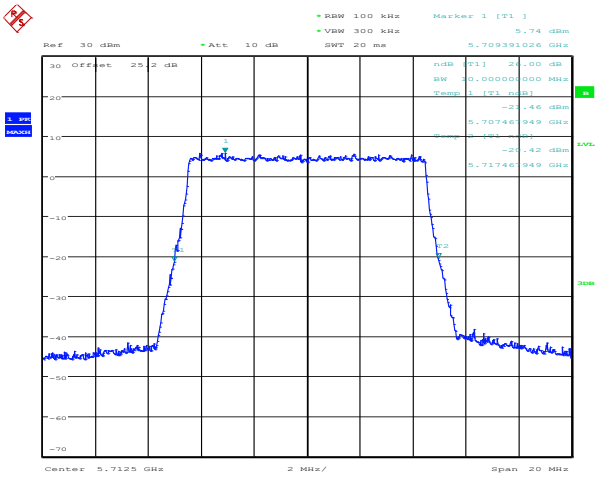
Mode Of Operation; Wideband: Modulation: OFDM				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**26dB Bandwidth (kHz)**	**Result**
5482.5	5477.467949	5487.467949	10000.0	PASS
5592.5	5587.500000	5597.500000	10000.0	PASS
5712.5	5707.467949	5717.467949	10000.0	PASS



5482.5 MHz

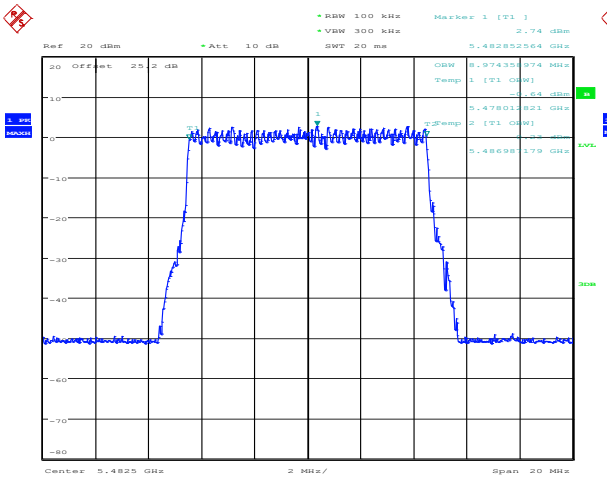


5592.5 MHz

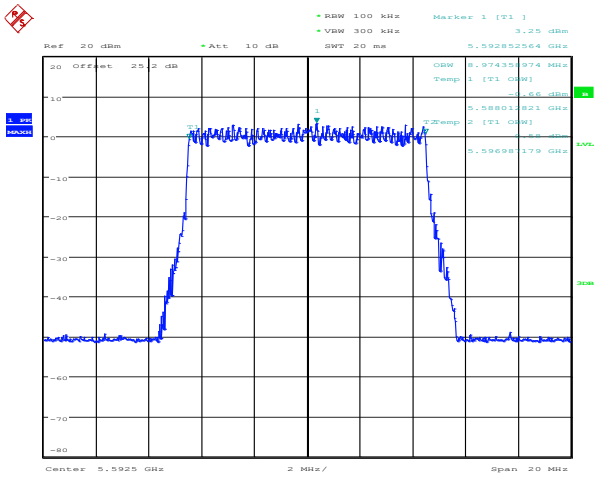


5712.5 MHz

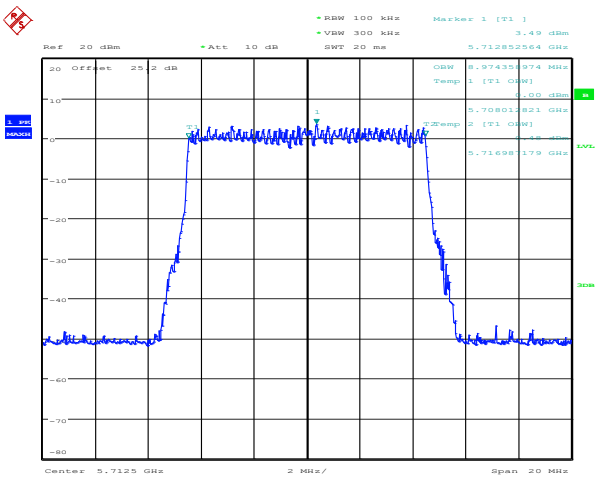
Mode Of Operation; Narrowband: Modulation: OFDM				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**99% Bandwidth (kHz)**	**Result**
5482.5	5478.012821	5486.987179	8974.358	N/A
5592.5	5588.012821	5596.987179	8974.358	N/A
5712.5	5708.012821	5716.987179	8974.358	N/A



5482.5 MHz

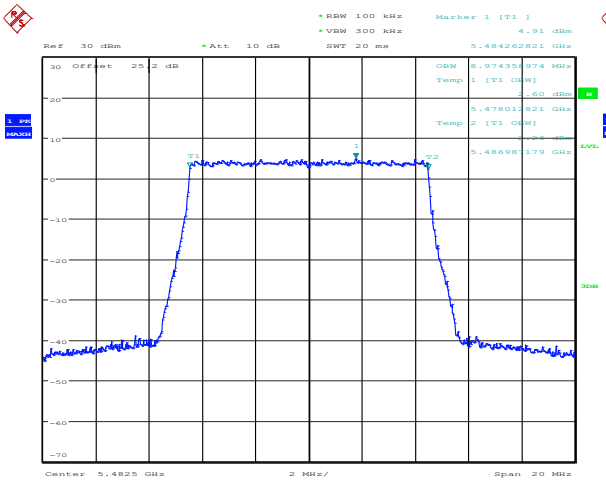


5592.5 MHz

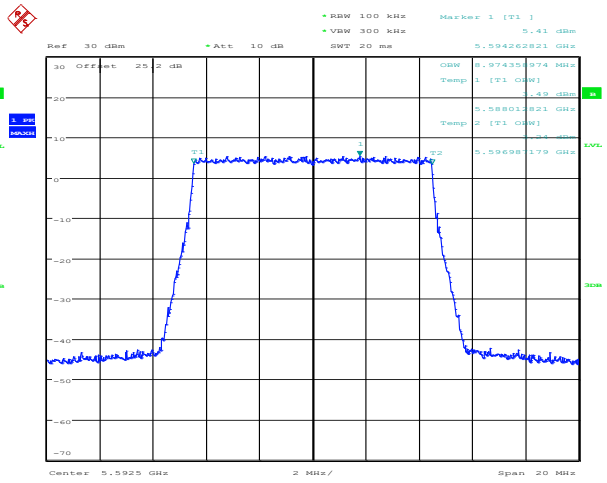


5712.5 MHz

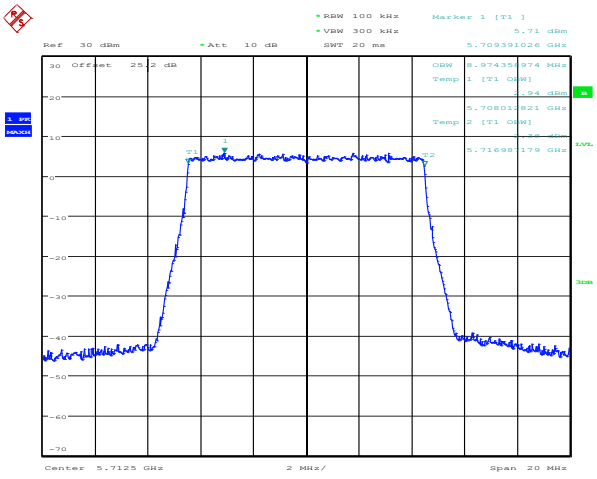
Mode Of Operation; Wideband: Modulation: OFDM				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**99% Bandwidth (kHz)**	**Result**
5482.5	5478.012821	5486.987179	8974.358	N/A
5592.5	5588.012821	5596.987179	8974.358	N/A
5712.5	5708.012821	5716.987179	8974.358	N/A



5482.5 MHz



5592.5 MHz



5712.5 MHz

14 Maximum conducted output power

14.1 Definition

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 12.3
Frequencies Measured:	5482.5 MHz, 5592.5 MHz, 5712.5 MHz
EUT Occupied Bandwidths:	9.63 MHz
EUT Duty Cycle:	0.5 % for Narrowband & 10.5% for Wideband
Deviations From Standard:	None
Measurement BW:	Wideband power meter
Measurement Span:	Wideband power meter
Measurement Points:	Wideband power meter
Measurement Detector:	RMS
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 33 %RH	20%RH to 75%RH (as declared)

Test Limits

For an access point operating in the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W.
For mobile and portable client devices in the 5.15–5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW.
For the 5.25–5.35 GHz and 5.47–5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz.
For the band 5.725–5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W.

If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Fixed point-to-point U–NII devices operating in the band 5.725-5.85 GHz may employ antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power.
Fixed point-to-point U-NII devices operating in other bands may employ antennas with directional gain up to 23dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi.

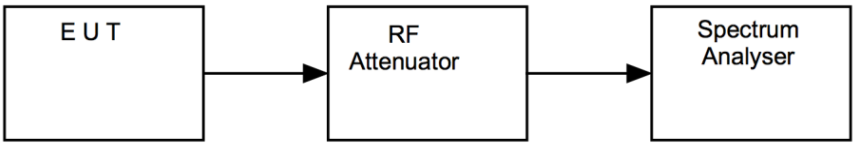
Maximum Conducted Output Power Limit							
Mode of Operation	***Band Of Operation (GHz)***	***Minimum 26 dB BW (MHz)***	***11 dBm + 10 log B (mW)***	***Fixed Limit (mW)***	****Applicable Limit***	***Antenna Assembly Gain (dBi)***	***Maximum Conducted Output Power Limit (mW)***
Narrowband	5.47–5.725	9.5	120.2	250	120.2	4	120.2
Wideband	5.47–5.725	10.0	125.9	250	125.9	4	125.9

*the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz

14.3 Test Method

The EUT was setup as per section 9 of this report and, as per Figure iv, the wideband power meter was used to measure at the antenna output port, having taken account of all path losses.
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



14.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Power Meter	Dare	RPR3006W	REF2223	2023-03-03	12	2024-03-03
20dB SMA attenuator	Atlantec	AA18-20H	U631	Calibrate In Use		

14.5 Test Results

Mode Of Operation; Narrowband: Modulation: OFDM						
Channel Frequency (MHz)	*Power Meter Level (dBm)*	*Cable loss (dB)*	*Maximum conducted output power (mW)*	*Antenna gain (dBi)*	*E.I.R.P. (mW)*	*Result*
5482.5	-23.30	25.20	1.55	4	3.89	PASS
5592.5	-23.10	25.20	1.62	4	4.07	PASS
5712.5	-23.10	25.15	1.60	4	4.03	PASS

Mode Of Operation; Wideband: Modulation: OFDM						
Channel Frequency (MHz)	*Power Meter Level (dBm)*	*Cable loss (dB)*	*Maximum conducted output power (mW)*	*Antenna gain (dBi)*	*E.I.R.P. (mW)*	*Result*
5482.5	-9.80	25.20	34.67	4	87.10	PASS
5592.5	-9.40	25.20	38.02	4	95.50	PASS
5712.5	-9.40	25.15	37.58	4	94.41	PASS

As can be seen from the output powers results above, the output power levels fall below that required for the use of TPC.

TPC is not required < 500 mW (27 dBm).

15 Power spectral density

15.1 Definition

The power spectral density is the total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its maximum level, divided by the total duration of the pulses.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 12.5
Frequencies Measured:	5482.5 MHz, 5592.5 MHz, and 5712.5 MHz
EUT Channel Bandwidths:	10 MHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Span:	10 MHz
Measurement Detector:	RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 31 %RH	20%RH to 75%RH (as declared)
Supply: 24 Vdc	(as declared)

Test Limits

For an access point operating in the band 5.15–5.25 GHz the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band.
For mobile and portable client devices in the 5.15–5.25 GHz band, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band.
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band.
For the band 5.725–5.85 GHz, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band.

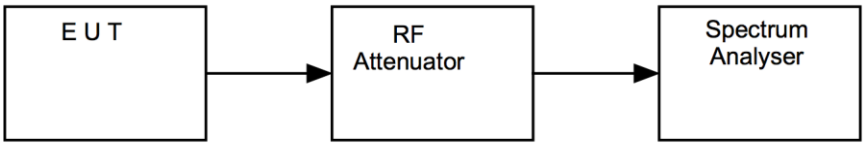
If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Fixed point- to-point U–NII devices may employ antennas with directional gain up to 23dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi.

15.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, 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 v Test Setup

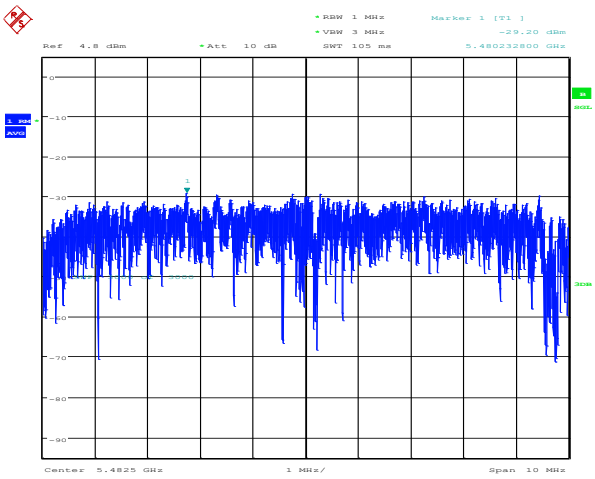


15.4 Test Equipment

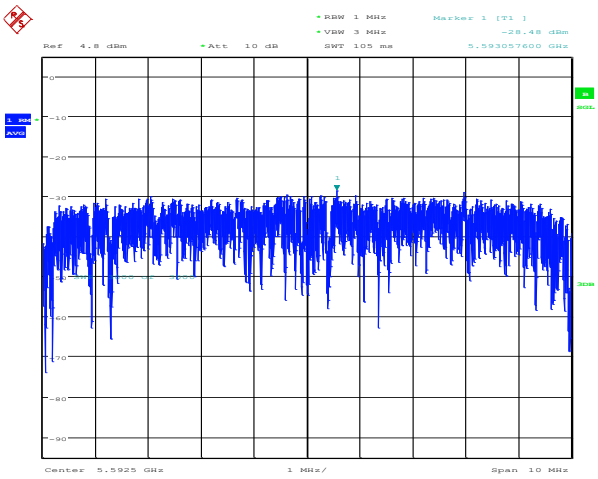
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU50	U544	2022-11-18	12	2023-11-18
20dB SMA attenuator	Atlantec	AA18-20H	U631	Calibrate in use		

15.5 Test Results

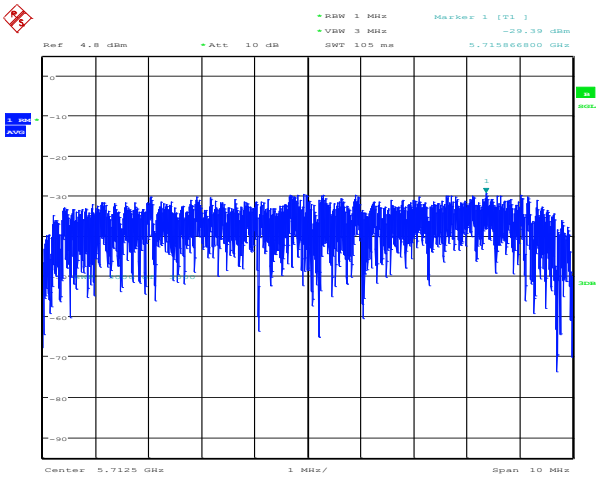
Operating Mode: Narrowband; Modulation: OFDM; Power setting: Maximum						
Measurement Bandwidth (MHz)	***Channel Frequency (MHz)***	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Duty Cycle (dB)***	***PSD (dBm/MHz)***	***Result***
1.0	5482.5	-29.2	5.2	23.0	-1.0	PASS
1.0	5592.5	-28.5	5.2	23.0	-0.3	PASS
1.0	5712.5	-29.4	5.2	23.0	-1.2	PASS



5482.5 MHz

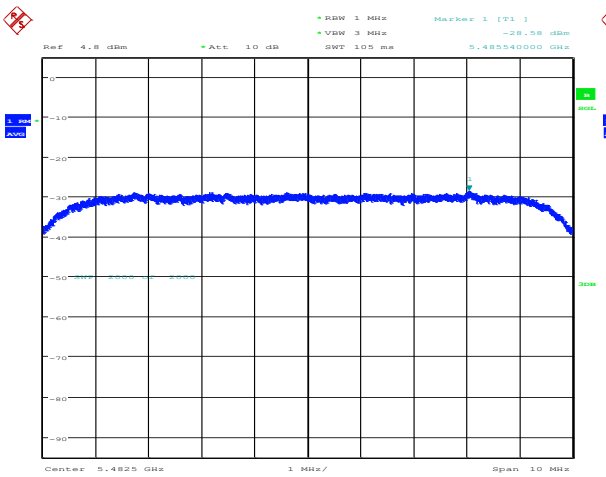


5592.5 MHz

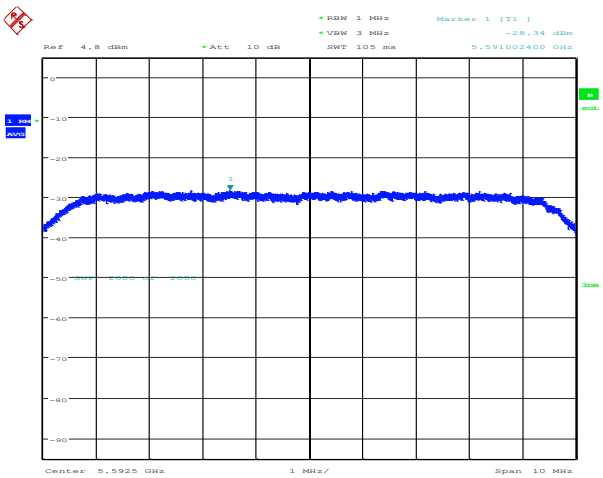


5712.5 MHz

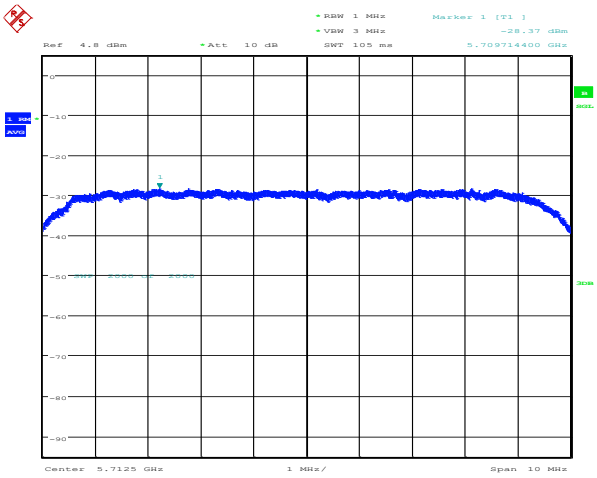
Operating Mode: Wideband; Modulation: OFDM; Power setting: Maximum						
Measurement Bandwidth (MHz)	***Channel Frequency (MHz)***	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Duty Cycle (dB)***	***PSD (dBm/MHz)***	***Result***
1.0	5482.5	-28.6	25.2	9.8	6.4	PASS
1.0	5592.5	-28.3	25.2	9.8	6.6	PASS
1.0	5712.5	-28.4	25.2	9.8	6.6	PASS



5482.5 MHz



5592.5 MHz



5712.5 MHz

16 Out-of-band spurious emissions

16.1 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.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber / EMC chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 12.7.3
EUT Channels / Frequencies Measured: (requirement as close to upper and lower frequency band edges as the design of the equipment permits).	5482.5MHz & 5712.5MHz
EUT Channel Bandwidths:	10 MHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Detector:	Peak
Measurement Range:	1 GHz to 40 GHz
Antenna Gain: (required if conducted measurement made)	N/A Radiated Measurements

Environmental Conditions (Normal Environment)

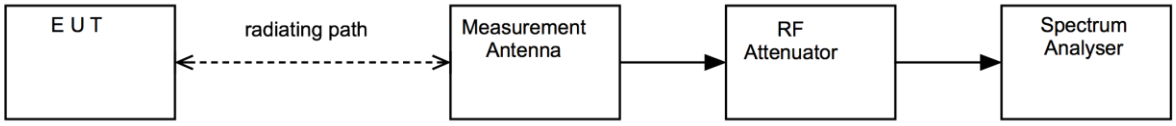
Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 50 %RH	20%RH to 75%RH (as declared)

Test Limits
15.407(b):
(1) For transmitters operating in the 5.15–5.25 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
(2) For transmitters operating in the 5.25–5.35 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
(3) For transmitters operating in the 5.47–5.725 GHz band: All emissions outside of the 5.47–5.725 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
(4) For transmitters operating in the 5.725–5.85 GHz band: All emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of -17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an e.i.r.p. of -27 dBm/MHz.

16.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, 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 vii Test Setup



16.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
PreAmp	Watkins Johnson	6201-69	U372	2023-03-01	1 Year	2024-03-07
2.4G Band Stop Filter	BSC	SN 4478	U543	2023-02-03	1 Year	2024-02-08
Bilog	Chase	CBL611/A	U191	2020-11-10	2 Year	2025-02-23
Horn Antenna	EMCO	3115	L138	2022-05-23	1 Year	2024-05-23
Spectrum Analyser	R&S	FSU46	REF910	2022-12-22	1 Year	2024-01-10
Pre Amp	Agilent	8449B	L572	2022-10-24	1 Year	2023-10-24
EMI Receiver	R&S	ESR26	U489	2021-03-04	1 Year	2023-09-30
PreAmp	Com-power	PAM-840A	REF2390	2021-09-02	1 Year	2023-09-02

16.5 Test Results

Channel: 5482.5 MHz; Modulation: OFDM Wideband Mode						
Emission Frequency (MHz)	***Peak Field Strength (dBµV/m)***	***Distance (m)***	***Power (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant Emissions Within 20 dB of Limit						PASS

Channel: 5712.5 MHz; Modulation: OFDM Wideband Mode						
Emission Frequency (MHz)	***Peak Field Strength (dBµV/m)***	***Distance (m)***	***Power, eirp (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant Emissions Within 20 dB of Limit						PASS

See Section 11 for out of band emissions plots.

Conversion from field strength to eirp is as follows:

$$EIRP = E + 20\log(d) - 104.77, \text{ where}$$

EIRP is the equivalent isotropically radiated power in dBm;
E is field strength in dBµV/m;
d is the measurement distance in meters.

17 Duty Cycle

17.1 Definition

Duty cycle (x), as used in this clause, refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level.

17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 12.2
Frequencies Measured:	5482.5 MHz, 5592.5 MHz, and 5712.5 MHz
EUT modulation:	OFDM
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 33 %RH	20%RH to 75%RH (as declared)
Supply: 24.0 Vdc	(as declared)

Test Limits
N/A.

17.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure viii, the duty of the EUT was calculated from the sum of total on and off times over the observation period.
The measurements were performed with EUT set at its maximum duty. All modulation schemes, bandwidths, data rates and power settings were used to completely characterise the system.

[1] Single antenna output devices

Duty was measured at the antenna port / at a distance of 3m.

[2] Multiple antenna output devices

Duty was measured as the combination of all ports simultaneously / at a distance of 3m.

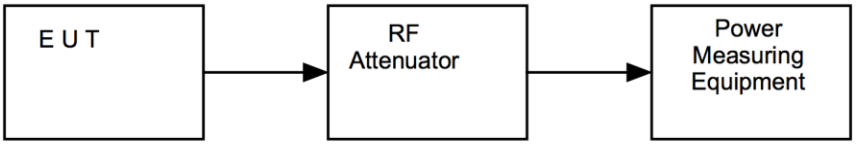
The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

1) If power averaging (rms) mode was used in step f), then the applicable correction factor is [10 log (1 / *D*)], where *D* is the duty cycle.

2) If linear voltage averaging mode was used in step f), then the applicable correction factor is [20 log (1 / *D*)], where *D* is the duty cycle.

3) If a specific emission is demonstrated to be continuous (*D* ≥ 98%) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Figure viii Test Setup

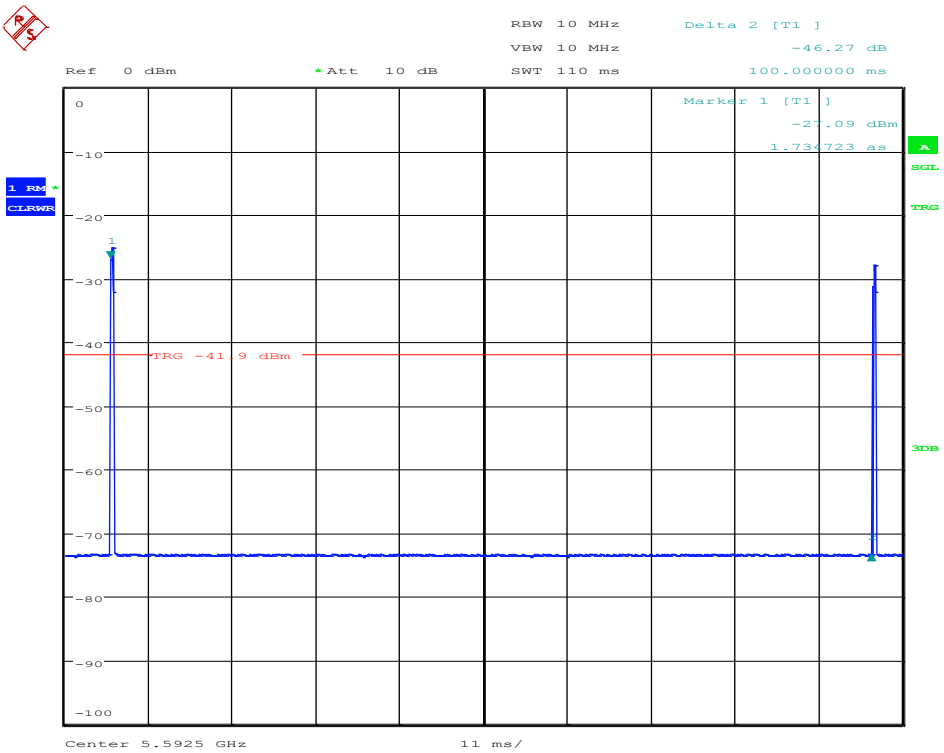


17.4 Test Equipment

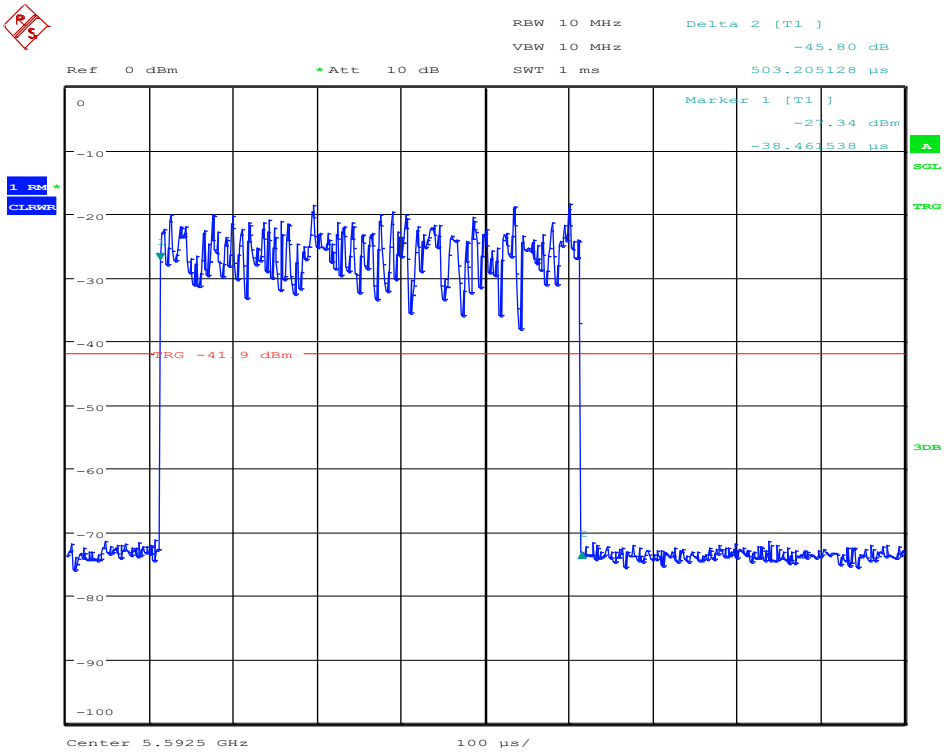
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU50	U544	2022-11-18	12	2023-11-18
20dB SMA attenuator	Atlantec	AA18-20H	U631	Calibrate in use		

17.5 Test Results

Mode Of Operation; Narrowband; Frequency: 5482.5 MHz; Modulation: OFDM					
Single Channel TxOn time (ms)	Total TxOn time (ms)	Observation period (ms)	Duty (%)	Calculated Factor (dB)	
				RMS Detector	Average Detector
0.5	0.5	100	0.50	23.0	46.0



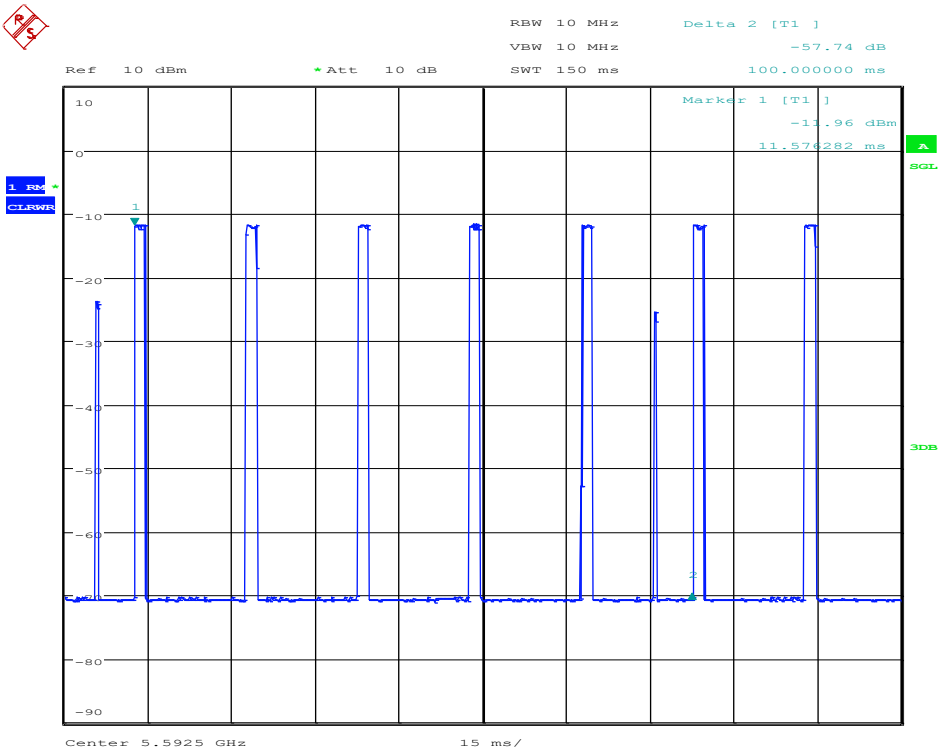
Observation Period



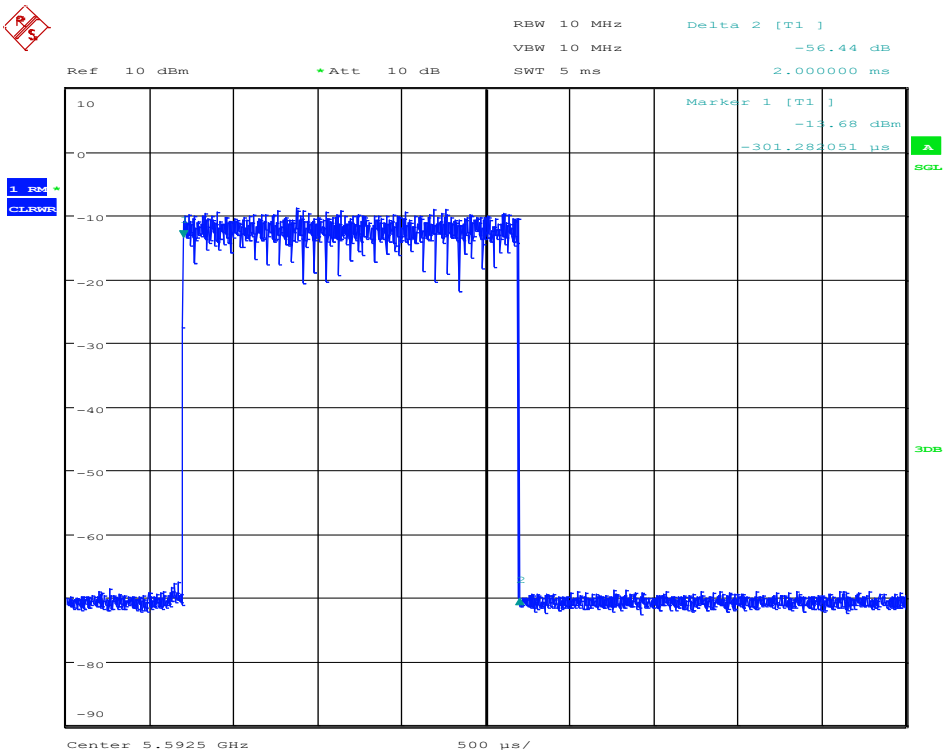
Single Channel on Time

Mode Of Operation; Wideband; Frequency: 5482.5 MHz; Modulation: OFDM						
TxOn time (ms)		Total TxOn time (ms)	Observation period (ms)	Duty (%)	Calculated Factor (dB)	
Ton 1	Ton 2*				RMS Detector	Average Detector
0.5	2.0	10.5	100	10.50	9.8	19.6

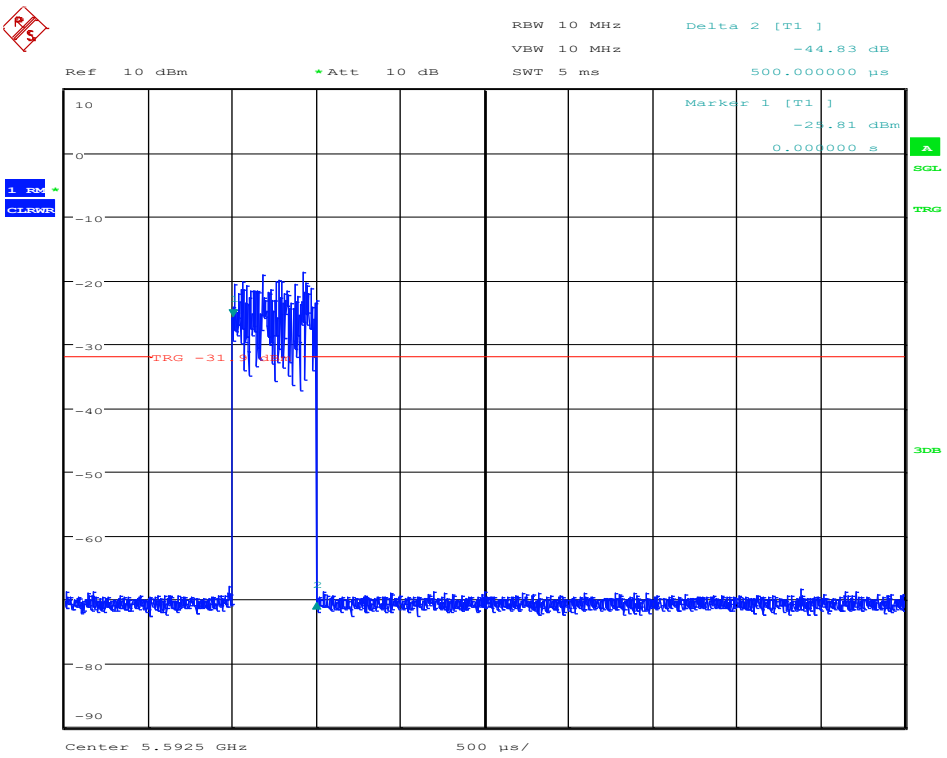
* Five Occurrences in observation period



Observation Period



Ton 1 on Time (One Occurrence in Observation Period)



Ton 2 on Time (Five Occurrence in Observation Period)

18 Dynamic Frequency Selection (DFS)

18.1 General

An U-NII network will employ a Dynamic Frequency Selection (DFS) function to detect interference from radar systems (radar detection) and to avoid co-channel operation with these systems.
Within the context of the operation of the DFS function, a U-NII device will operate in either *Master Mode* or *Client Mode*. U-NII devices operating in *Client Mode* can only operate in a network controlled by a U-NII device operating in *Master Mode.*

18.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 905462 D02, Clause 7.8
EUT Tested Channel Bandwidths:	10 MHz
EUT Test Channel Loading:	Internal data pattern repeated every 20ms, 10.5% duty.
EUT Output Power Setting:	Max.
EUT Tested Modes:	Slave without Radar Detection
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 22 °C	Usually: +15 ºC to +35 ºC
Humidity: 38 %RH	Usually: 20%RH to 75%RH

Test Limits

Refer to individual tests for applicable tables, as defined below.

Table 3: Interference threshold values

Maximum Transmit Power	*Value (see notes 1, 2 and 3)*
EIRP ≥ 200 mW	-64 dBm
EIRP < 200 mW and PSD < 10 dBm/MHz	-62 dBm
EIRP < 200 mW that do not meet the PSD requirement	-64 dBm
NOTE 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna.	
NOTE 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.	
NOTE 2: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.	

Table 4: DFS requirement values

Parameter	*Value*
Non-Occupancy Period	Min. 30 minutes
Channel Availability Check Time	60 s
Channel Move Time	10 s (see note 1).
Channel Closing Transmission Time	200 ms + an aggregate of 60 ms over remaining 10 s period (see notes 1 & 2).
U-NII Detection Bandwidth	Min. 100 % of the U-NII 99% transmission power bandwidth (see note 3).
Maximum Off-Channel CAC Time	4 hours (see note 2)
NOTE 1: *Channel Move Time* and the *Channel Closing Transmission Time* should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst.	
NOTE 2: The *Channel Closing Transmission Time* is comprised of 200 ms starting at the beginning of the *Channel Move Time* plus any additional intermittent control signals required to facilitate a channel move (an aggregate of 60 ms) during the remainder of the 10 s period. The aggregate duration of control signals will not count quiet periods in-between transmissions.	
NOTE 3: During the *U-NII Detection Bandwidth* detection test, radar type 0 should be used. For each frequency step the minimum percentage of detection is 90 %. Measurements are performed with no data traffic.	

Table 5: Short pulse radar test signals

Radar type	*Pulse width (µs)*	*PRI (µs)*	*Number of pulses*	*Min. % of successful detection*	*Min. number of trials*
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup: 1/360 x 19.10^6/PRI	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 µs, with a minimum increment of 1 µs, excluding PRI values selected in Test A			
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120
NOTE 1: Short pulse radar type 0 should be used for detection bandwidth test, channel move time and channel closing time tests.					

Table 5a: Pulse repetition intervals for test A

Pulse repetition frequency number	*Pulse repetition frequency (pulses / s)*	*Pulse repetition interval (µs)*
1	1930.5	518
2	1858.7	538
3	1792.1	558
4	1730.1	578
5	1672.2	598
6	1618.1	618
7	1567.4	638
8	1519.8	658
9	1474.9	678
10	1432.7	698
11	1392.8	718
12	1355	738
13	1319.3	758
14	1285.3	778
15	1253.1	798
16	1222.5	818
17	1193.3	838
18	1165.6	858
19	1139	878
20	1113.6	898
21	1089.3	918
22	1066.1	938
23	326.2	3066

Table 6: Long pulse radar test signal

Radar type	*Pulse width (µs)*	*Chirp width (MHz)*	*PRI (µs)*	*Number of pulses per burst*	*Number of bursts*	*Min. % of successful detection*	*Min. number of trials*
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

Table 7: Frequency hopping radar test signal

Radar type	*Pulse width (µs)*	*PRI (µs)*	*Pulses per hop*	*Hopping rate (kHz)*	*Hopping sequence length (ms)*	*Min. % of successful detection*	*Min. number of trials*
6	1	333	9	0.333	300	70%	30

18.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure ix, the wanted signal (Gen A) was set to establish a reliable link (approx. 10 dB above receiver threshold). The interfering signal (Gen B) was then introduced at the specified Radar Detection Threshold level, plus 1dB.

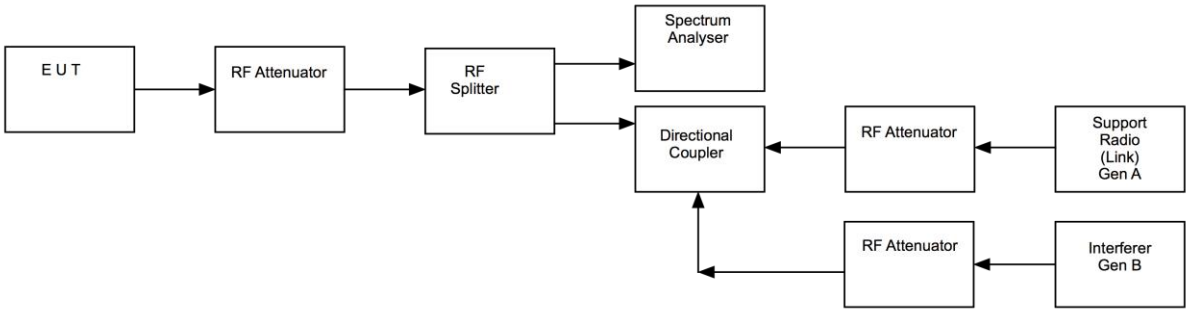
[1] Conducted method

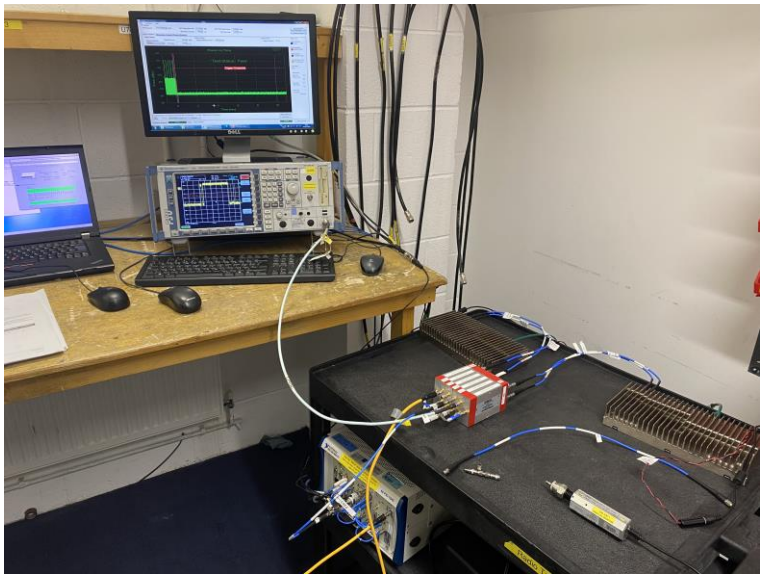
Received power was measured at the antenna port. For multiple port devices, equal splitting was employed to ensure the same level was received at each antenna port.

[2] Radiated method

Received power was measured at the centre of the EUT.

Figure ix Test Setup





18.4 Calibration

Antenna Gain
Declared antenna gain = 14.0 dBi (including loss of antenna assembly cable) Based on signals applied to the master device (BS).

DFS Radar Waveforms
The RF attenuator nearest the EUT was set to provide sufficient attenuation not to overload the analyser whilst the EUT was at maximum power. The RF attenuator nearest the support radio was then set by increasing to the point where the EUT could no longer receive the signal (receiver threshold), then backing off 10dB. The RF attenuator nearest the signal generator was then set to provide sufficient isolation between the generator and the support radio.

The interferer (Gen B) was set to the centre of the test channel, Ch_r, in CW mode. The EUT was replaced with the spectrum analyser, whilst the analyser was replaced with a 50 ohm load. The level of the generator was adjusted to find the appropriate DFS threshold +1dB, adjusted for min. antenna gain 14.0dB, measured on the spectrum analyser. The analyser and EUT were then returned to position and an offset added to the analyser to read the same level as measured at the EUT.

Each radar signal required was then observed on the spectrum analyser in a 3MHz RBW with peak detector.

19 In-Service Monitoring

19.1 Definition

19.1.1 Channel Closing

The *Channel Closing* is defined as the process initiated by the U-NII device on an *Operating Channel* after a radar signal has been detected during the *In-Service Monitoring* on that channel.

The master device shall instruct all associated slave devices to stop transmitting on this channel, which they shall do within the *Channel Move Time*.

Slave devices with a Radar Interference Detection function, shall stop their own transmissions on an *Operating Channel* within the *Channel Move Time* upon detecting a radar signal within this channel.

The aggregate duration of all transmissions of the U-NII device on this channel during the *Channel Move Time* shall be limited to the *Channel Closing Transmission Time.* The aggregate duration of all transmissions shall not include quiet periods in-between transmissions.

For equipment having simultaneous transmissions on multiple (adjacent or non-adjacent) operating channels, only the channel(s) containing the frequency on which radar was detected is subject to the *Channel Closing* requirement. The equipment is allowed to continue transmissions on other *Operating Channels*.

19.1.2 Non-Occupancy Period

The *Non-Occupancy Period* is defined as the time during which the U-NII device shall not make any transmissions on a channel after a radar signal was detected on that channel.

For equipment having simultaneous transmissions on multiple (adjacent or non-adjacent) operating channels, only the channel(s) containing the frequency on which radar was detected is subject to the *Non-Occupancy Period* requirement. The equipment is allowed to continue transmissions on other *Operating Channels*.

After the *Non-Occupancy Period*, the channel needs to be identified again as an *Available Channel* before the U-NII device may start transmitting again on this channel.

19.2 Additional Test Parameters

EUT Test Channels, Ch_r.	5482.5 MHz
EUT Operating Channels / Bandwidths:	10 MHz
Master Uniform Spreading:	Disabled

Test Limits

The *Channel Move Time* shall not exceed the limit defined in table 4.

The *Channel Closing Transmission Time* shall not exceed the limit defined in table 4.

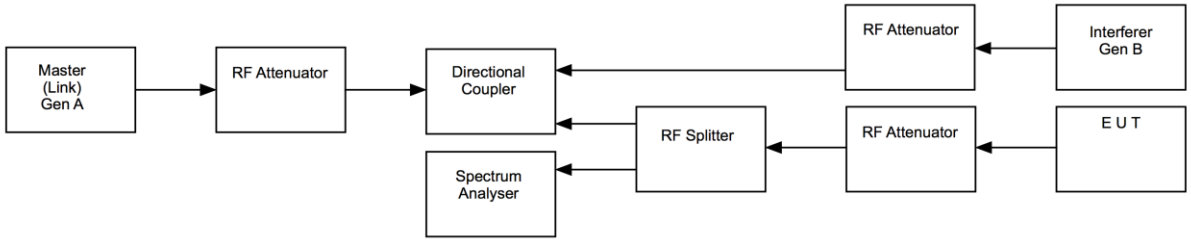
The *Non-Occupancy Period* shall not be less than the value defined in table 4.

19.3 Test Method

The EUT channel for both data and control signals, Ch_r, was selected, then transmissions to the paired device commenced. The interferer (Gen B) was set to the same frequency, Ch_r, and a radar test signal of table 5 (to appear at the Master at the threshold level + 1dB) then muted. The spectrum analyser was set to time domain (zero span) with sufficient bandwidth to capture all intentional emissions from the EUT. The analyser was then synchronised to the switching of the interferer – the interferer (Gen B) level was unmuted for a single burst. Transmissions from the EUT continued to be observed for a further 30 min.

Note, the set-up of figure x was required to test slave mode, where the master is not the EUT.

Figure x Test Setup

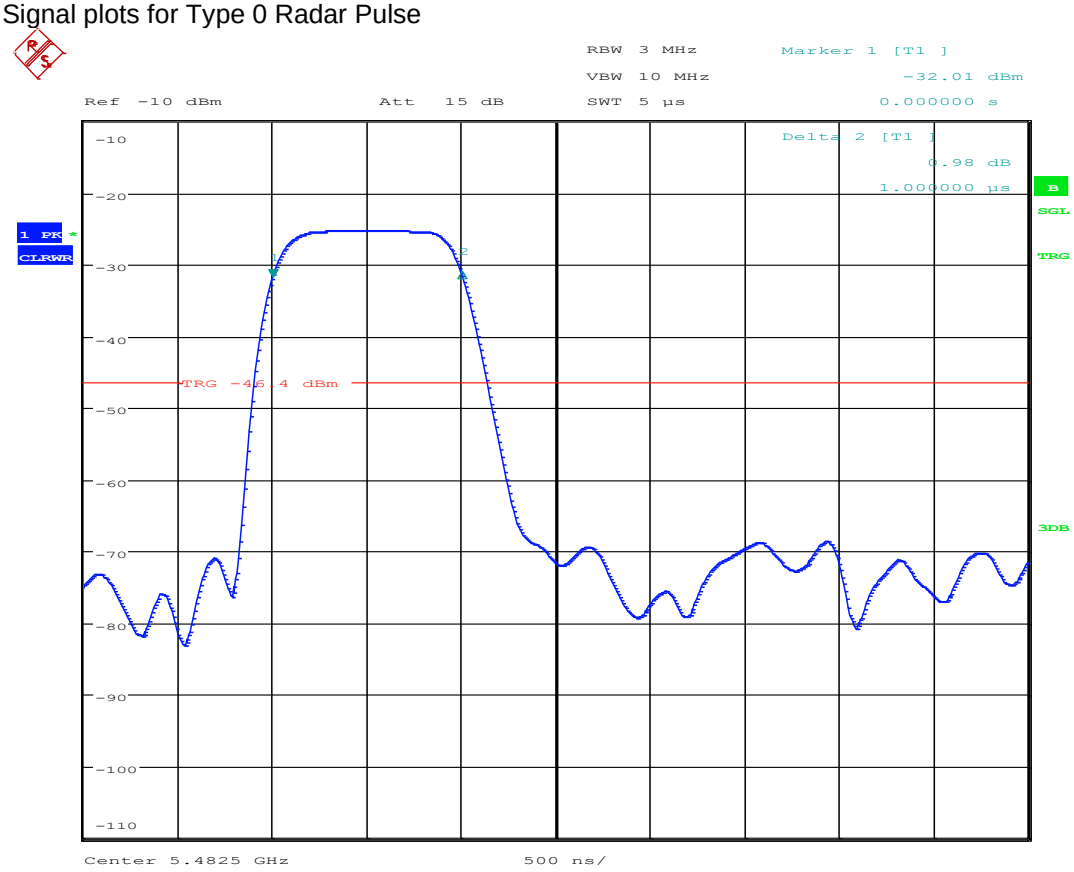


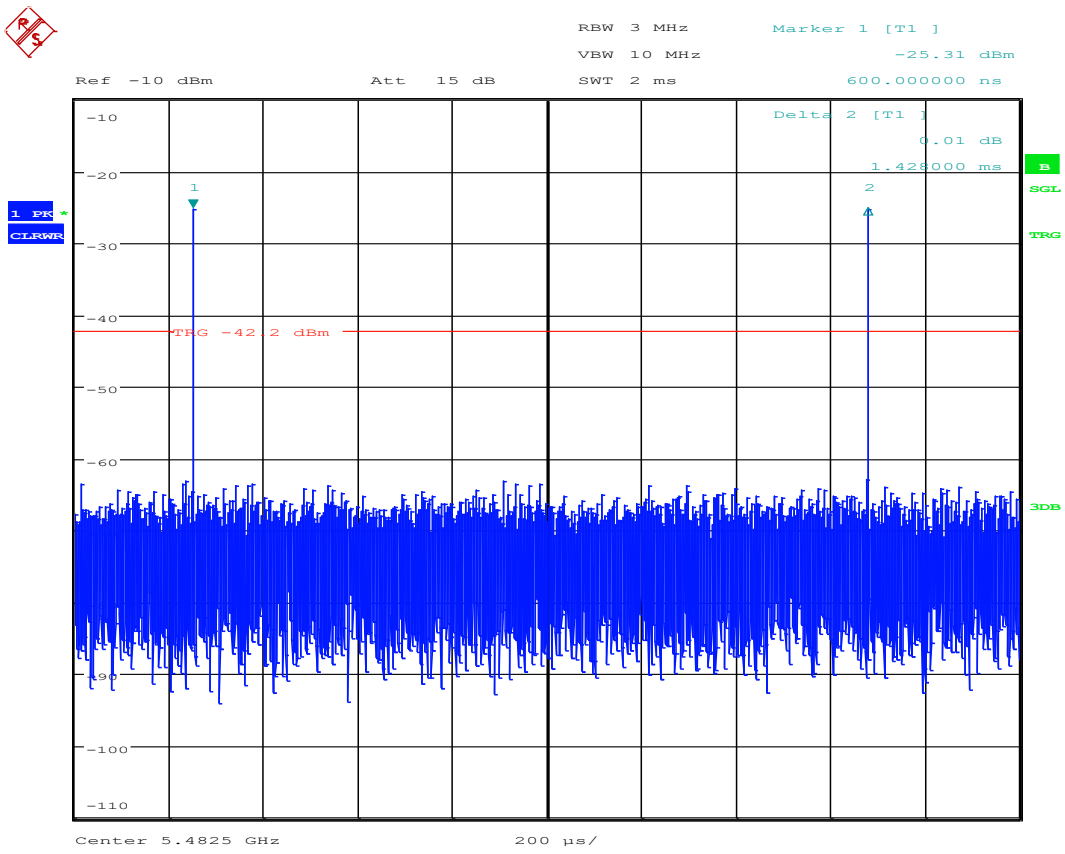
19.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
DFS Test System	Aeroflex	PXI-1042	REF2152	Calibrate in Use		
Spectrum Analyser	R&S	FSU26	U405	2022-04-21	12	2023-04-21

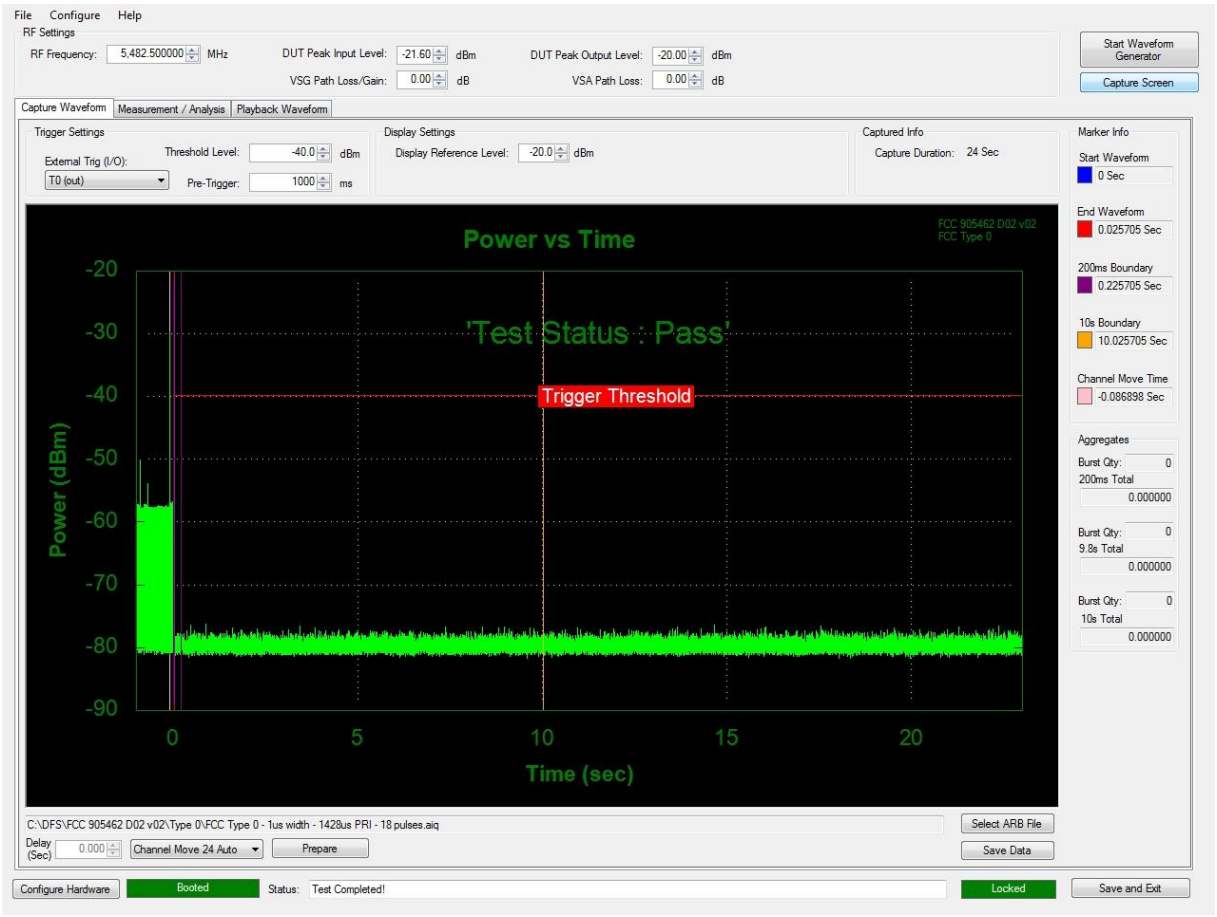
19.5 Test Results

Test Signal plots for Type 0 Radar Pulse

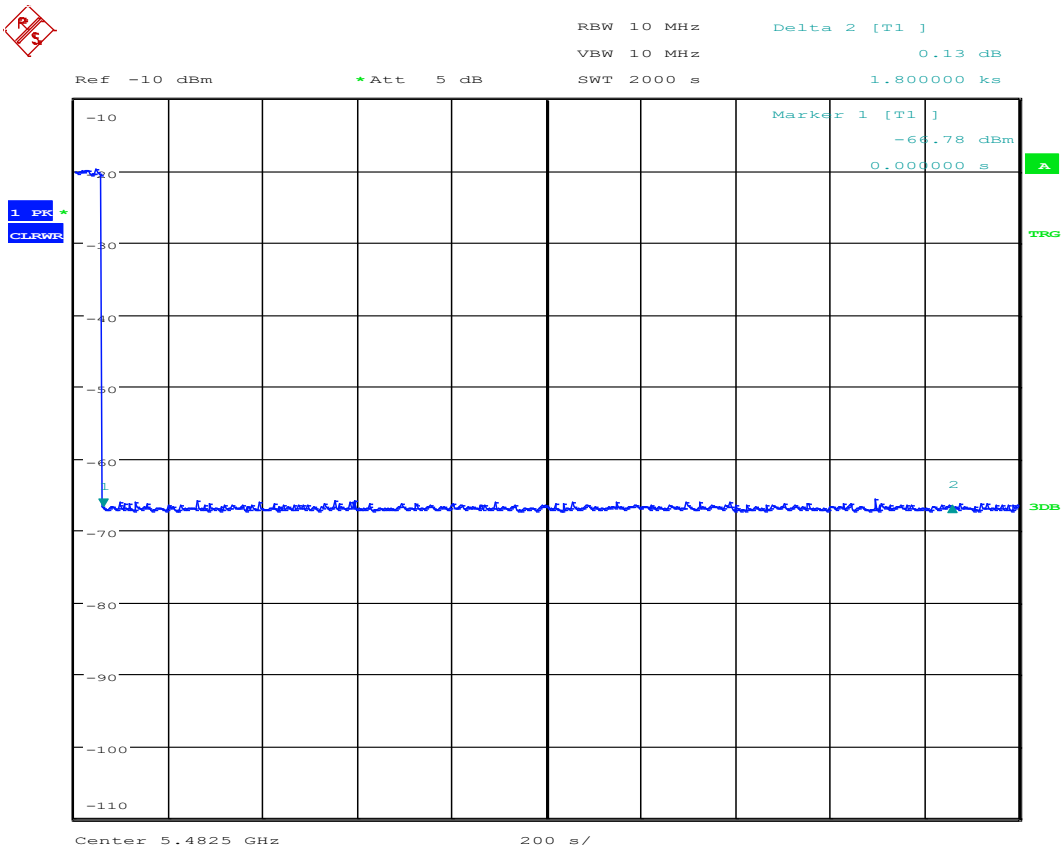




Bandwidth: 10 MHz					
Channel (MHz)	***Interference level (dBm)***	***Channel move time (s)***	***Channel Closing Transmission Time (ms)***	***Transmissions during non-occupancy period***	***Result***
5482.5	-48.5	-0.086898	0.0	None	PASS



Non-occupancy period



20 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connecter) Dare RPR3006W Power Head	MU4001	**0.9 dB**
Carrier Power and PSD - Spectrum Analysers	MU4004	**0.9 dB**
Adjacent Channel Power	MU4002	**1.9 dB**
Transmitter conducted spurious emissions	MU4041	**0.9 dB**
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	**2.4 dB**
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	**2.5 dB**
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	**2.4 dB**
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	**3.7 dB**
Effective Radiated Power	MU4021	**4.7 dB**
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	**5.3 dB**
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	**5.1 dB**
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	**2.7 dB**
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	**2.7 dB**
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	**4.7 dB**
Radiated Spurious Emissions 1-18 GHz	MU4032	**4.5 dB**
E Field Emissions 18GHz to 26 GHz	MU4024	**3.2 dB**
E Field Emissions 26GHz to 40 GHz	MU4025	**3.3 dB**
E Field Emissions 40GHz to 50 GHz	MU4026	**3.5 dB**
E Field Emissions 50GHz to 75 GHz	MU4027	**3.6 dB**
E Field Emissions 75GHz to 110 GHz	MU4028	**3.6 dB**
Radiated Magnetic Field Emissions	MU4031	**2.3 dB**
Frequency Measurements		
Frequency Deviation	MU4022	**0.316 kHz**
Frequency error using CMTA test set	MU4023	**113.441 Hz**
Frequency error using GPS locked frequency source	MU4045	**0.0413 ppm**
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	**3.87 %**
Transmitter Mask Amplitude	MU4039	**1.3 dB**
Transmitter Mask Frequency	MU4040	**2.59 %**
Time Domain Measurements		
Transmission Time	MU4038	**4.40 %**
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	**679 µs**
DFS Generator - Frequency Error	MU4007	**92 Hz**
DFS Threshold Conducted	MU4008	**1.3 dB**
DFS Threshold Radiated	MU4009	**3.2 dB**

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	**1.1 dB**
EN301893 Receiver Blocking	MU4011	**1.1 dB**
EN303340 Adjacent Channel Selectivity	MU4012	**1.1 dB**
EN303340 Overloading	MU4013	**1.1 dB**
EN303340 Receiver Blocking	MU4014	**1.1 dB**
EN303340 Receiver Sensitivity	MU4015	**0.9 dB**
EN303372-1 Image Rejection	MU4016	**1.4 dB**
EN303372-1 Receiver Blocking	MU4017	**1.1 dB**
EN303372-2 Adjacent Channel Selectivity	MU4018	**1.1 dB**
EN303372-2 Dynamic Range	MU4019	**0.9 dB**
Receiver Blocking Talk Mode Conducted	MU4033	**1.2 dB**
Receiver Blocking Talk Mode- radiated	MU4034	**3.4 dB**
Rx Blocking, listen mode, blocking level	MU4035	**3.2 dB**
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	**3.4 dB**
Adjacent Sub Band Selectivity	MU4003	**4.2 dB**

21 RF Exposure

U-NII devices are subject to the radio frequency radiation exposure requirements specified in §1.1307(b), §2.1091 and §2.1093 of chapter 47 of the CFR, as appropriate. All equipment shall be considered to operate in a ‘‘general population/uncontrolled’’ environment. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. Technical information showing the basis for this statement must be submitted to the Commission upon request.

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20 cm separation specified under FCC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit, as required under FCC rules.

Equation from IEEE C95.1

$$S = \frac{EIRP}{4\pi R^2} \quad \text{re-arranged } R = \sqrt{\frac{EIRP}{S4\pi}}$$

Where:

S = power density
R = distance to the centre of radiation of the antenna
EIRP = EUT Maximum power

Result

Operating Band (MHz)	***EIRP (mW)***	***Power density limit (S) (mW/cm^2)***	***Distance (R) cm required to be less than the power density limit***
5470 - 5725	95.5	1.0	2.8