TEST REPORT

Test Report No. : UL-RPT-RP11624992JD06C V2.0

Customer	:	Apple Inc.
Model No.	:	A1842
FCC ID	:	BCGA1842
Technology	:	WLAN (802.11 a/n/ac)
Test Standard(s)	:	FCC Part 15.407(h)(2)

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 2.0 supersedes all previous versions.

Date of Issue: 22 August 2017

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Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	01/08/2017	Initial Version	Ian Watch
2.0	22/08/2017	Removed ISED Canada references Removed test setup photos from Appendix 1 Changed Model No. to A1842	Ian Watch

Table of Contents

1. Attestation of Test Results

1.1. Description of EUT

The device is an interactive digital media player which plays content onto a screen through an HDMI port. It incorporates Wi-Fi and Bluetooth radios.

1.2. General Information

FCC Specification Reference:	47CFR15.407
FCC Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart E (Unlicensed National Information Infrastructure Devices) - Section 15.407
Test Dates:	19 June 2017 to 29 June 2017

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.407(h)(2)(iii)	Channel Closing Transmission Time and Channel Move Time	Complied
Part 15.407(h)(2)(iv)	Non-Occupancy Period	Complied

Note(s):

1. There are two vendors of the WiFi/*Bluetooth* radio modules, Vendor 1 and Vendor 2.
2. The WiFi/*Bluetooth* radio modules have the same mechanical outline (i.e. the same packaging dimension and pin layout), use the same on-board antenna matching circuit, have an identical antenna structure and are built and tested to conform to the same specification and to operate within the same tolerances.

   Baseline testing was performed on the two vendors to determine the worst case.

1.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations or exclusions from the test specification identified above.

2. Summary of Testing

2.1. Facilities and Accreditation

The test site and measurement facilities used to collect data are located at Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom.

UL VS LTD is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

2.2. Methods and Procedures

Reference:	FCC KDB 905462 D02 U-NII DFS Compliance Procedures New Rules v02 (April 8, 2016)
Title:	Compliance Measurement Procedures for Unlicensed-National Information Infrastructure Devices Operating in the 5250-5350 MHz and 5470-5725 MHz Bands Incorporating Dynamic Frequency Selection

2.3. Calibration and Uncertainty

Measuring Instrument Calibration

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

Measurement Uncertainty

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value measured (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

Measurement Type	Confidence Level (%)	Calculated Uncertainty
DFS Channel Shutdown Timing	95%	± 450 µs
DFS Non-Occupancy Timing	95%	± 79.25 ms
DFS Radar Amplitude	95%	± 2.17 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

2.4. Test and Measurement Equipment

Test Equipment Used

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	22 Feb 2018	12
M1631	DFS Test System	Aeroflex	PXI 3000	300110/291	09 Jul 2017	24
M1886	Test Receiver	Rohde & Schwarz	ESU26	100554	04 Apr 2018	12
A163	Step Attenuator	Narda	743-80	01344	Calibrated Before Use	-
A1065	Step Attenuator	Hewlett Packard	8494B	3308A38165	Calibrated Before Use	-
A463	Step Attenuator	Hewlett Packard	8495B	2814A12326	Calibrated Before Use	-
A2180	Coaxial Circulator	AtlanTecRF	ACC-20130-SF-SF-SF	120409233	Calibrated Before Use	-
A2181	Coaxial Circulator	AtlanTecRF	ACC-20130-SF-SF-SF	120409229	Calibrated Before Use	-
A2944	10 dB Attenuator	AtlanTecRF	AN18W5-10	208149#1	Calibrated before use	-
A2121	Power Splitter	Mini-Circuits	ZN4PD1-63-S+	SUU12701203	Calibrated before use	-
A2994	50Ω Termination	Unknown	Unknown	Not Marked or Stated	Calibrated Before Use	-
A2494	50Ω Termination	AtlanTecRF	TA06W5-F	082013#2	Calibrated Before Use	-

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model No.:	A1842
Test Sample Serial Number:	C07TK00WJ4CM
Hardware Version:	EVT
Software Version:	15J42500h
FCC ID:	BCGA1842

3.2. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3. Description of Available Antennas

The radio utilizes two integrated antennas of 50 Ω impedance. Maximum gains are shown below:

Frequency Band (MHz)	$G_{Antenna\ 1}$ (dBi)	$G_{Antenna\ 2}$ (dBi)
5150 to 5250	1.9	1.7
5250 to 5350	2.0	1.9
5470 to 5725	0.7	1.2
5725 to 5850	-0.1	1.6

Frequency Band (MHz)	Directional Antenna Gain for Power Measurements (dBi)
5150 to 5250	1.9
5250 to 5350	2.0
5470 to 5725	1.2
5725 to 5850	1.6

3.4. Additional Information Related to Testing

Technology Tested:	WLAN (IEEE 802.11a,n,ac) / U-NII	
Type of Unit:	Transceiver	
Modulation:	BPSK, QPSK, 16QAM, 64QAM & 256QAM	
Data rates:	802.11a	6, 9, 12, 18, 24, 36 ,48 & 54 Mbit/s
	802.11n HT20	MCS0 to MCS7 (1 spatial stream) with or without CDD / (SISO, or MIMO with CDD/STBC) MCS8 to MCS15 (2 spatial streams) (MIMO SDM)
	802.11n HT40	MCS0 to MCS7 with or without CDD / (SISO, or MIMO with CDD/STBC) MCS8 to MCS15 (MIMO SDM)
	802.11ac VHT20	MCS0 to MCS8 (1 spatial stream) with or without CDD / (SISO, or MIMO with CDD/STBC) MCS0 to MCS8 (2 spatial streams) (MIMO SDM)
	802.11ac VHT40	MCS0 to MCS9 (1 spatial stream) with or without CDD / (SISO, or MIMO with CDD/STBC) MCS0 to MCS9 (2 spatial streams) (MIMO SDM)
	802.11ac VHT80	MCS0 to MCS9 (1 spatial stream) with or without CDD / (SISO, or MIMO with CDD/STBC) MCS0 to MCS9 (2 spatial streams) (MIMO SDM)
Power Supply Requirement(s):	Nominal	120 VAC 60 Hz
Maximum Conducted Output Power:	20 MHz	23.5 dBm
	40 MHz	22.3 dBm
	80 MHz	23.8 dBm

3.5. Support Equipment

The following support equipment was used to exercise the EUT during testing:

Description:	Wireless Dual Band Router (DFS Master)
Brand Name:	Cisco
Model Name or Number:	AIR-CAP3702E-A-K9 V04
FCC ID:	LDK102087
Serial Number:	FJC1938F3G6

Description:	Companion Client Device (for Client-to-Client Testing)
Brand Name:	Apple
Model Name or Number:	AA1601
Serial Number:	C39TQ04KJ6KP

Description:	Laptop PC
Brand Name:	Apple
Model Name or Number:	MacBook Pro A1398
Serial Number:	C2QQN40SG8WP

Description:	Laptop PC
Brand Name:	Lenovo
Model Name or Number:	L440
Serial Number:	R9-019EA0 14/04

Operating Modes

The EUT was tested in the following operating modes:

- As a client without radar detection device, being sent UDP test data from the associated DFS Master access point. The EUT was tested with a fixed 802.11ac MCS0x1 modulation.
- As a client without radar detection device, receiving a video stream from another client without radar detection device in client-to-client mode using Apple's AirPlay streaming protocol. Both devices were connected to a supervising DFS Master access point. Both clients were set to single spatial stream auto data rate.
- The EUT test data and rate used gave >17% channel loading as required by KDB 905462 D02 Section 7.7.2.

Configuration and Peripherals

The EUT was tested in the following configuration(s):

- All measurements were made using a conducted link.
- The EUT operational parameters were adjusted via its UI, with additional settings to fix data rate or select active transmit chains performed via a laptop PC via a terminal application. The laptop PC was connected to the EUT via special USB to Ethernet test cable.
- Further details of the conducted test network and set-up can be found in Appendix 1 of this test report.
- The DFS detection threshold of -62 dBm was used throughout, as the maximum transmit power was <200 mW and the power spectral density was < 10 dBm/MHz.
- The DFS Master test access point was set to use a 0 dBi antenna gain. Since the test is performed conducted, any additional gain which would normally be present in the incoming signal path is added to the radar test level. The EUT and client device for client-to-client modes do not have radar detection, so their antenna gains are irrelevant to the test method. The radar level to be presented at the antenna ports was calculated as:
    - -62 dBm +0 dBi antenna gain +1 dB to account for variations = -61.0 dBm radar level at antenna ports.

KDB 905462 D02 Table 3: DFS Detection Thresholds for Master Devices and Client Devices With Radar Detection

Maximum Transmit Power	**Value (See Notes 1, 2, and 3)**
EIRP ≥ 200 milliwatt	-64 dBm
EIRP < 200 milliwatt and power spectral density < 10 dBm/MHz	-62 dBm
EIRP < 200 milliwatt that do not meet the power spectral density 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 3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.	

4. Measurements, Examinations and Derived Results

4.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section* 6 *Measurement Uncertainty* for details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

4.2. Test Results

4.2.1. Channel Closing Transmission Time and Channel Move Time

Test Summary:

Test Engineer:	Philip Harrison	**Test Dates:**	19 June 2017 to 29 June 2017
Test Sample Serial Number:	C07TK00WJ4CM		

FCC Reference:	Part 15.407(h)(2)(iii)
Test Method Used:	KDB 905462 D02 Section 7.8.3

Environmental Conditions:

Temperature (°C):	22 to 26
Relative Humidity (%):	46 to 58

Notes:

1. In accordance with KDB 905462 D02 Table 2, the Initial Channel Availability Check test was performed on the widest channel bandwidth. It was therefore tested only on an 80 MHz channel bandwidth.
2. For the client-to-client mode the EUT streamed a video from an AA1601 companion device using Apple's Airplay streaming protocol.
3. Tests were performed using a type 0 radar and the radar detection threshold calculated in Section 3.5 of this test report.
4. The total channel closing time limit was 200 ms + 60 ms = 260 ms (from KDB 905462 D02 Table 4).
5. Radar burst type 0 was detected and channel move occurred within the channel move and channel closing time limits, for both Master and Client and Client to Client modes. Therefore the EUT complied.
6. The channel loading requirement of >17% in KDB 905462 D02 Section 7.7(c) was met. See Appendix 5 for further details.

Results: 80 MHz EUT to Master - Channel Move Time

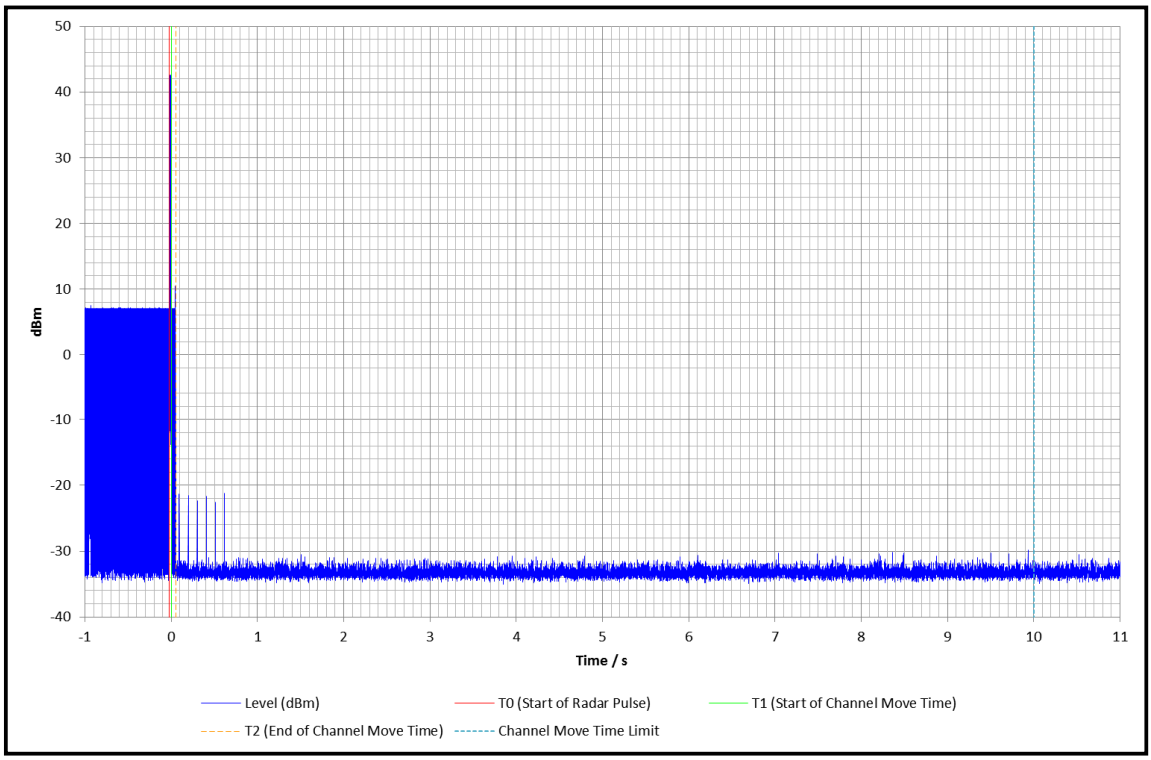
Channel (MHz)	Move Time (ms)	Limit (ms)	Margin (ms)	Detected
5290	50.6	10000	9949.4	Yes

Results: 80 MHz EUT to Master - Channel Closing Transmission Time

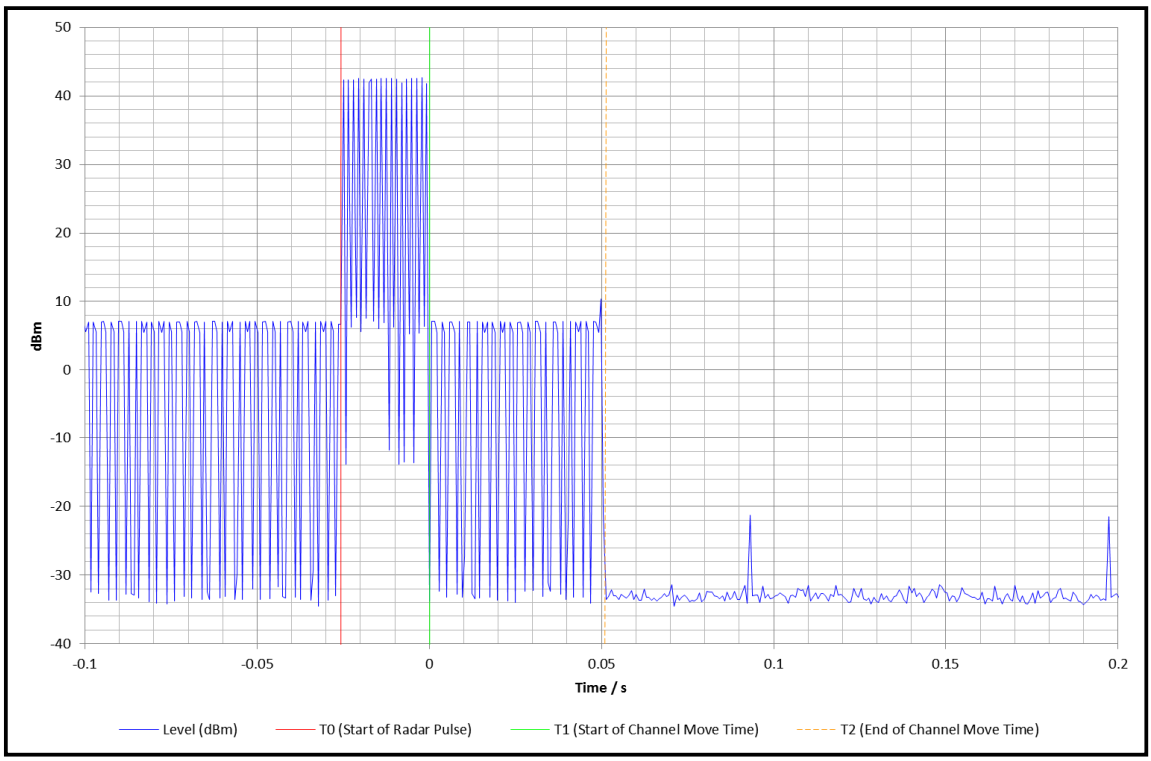
Channel (MHz)	Total Aggregate Tx Time (ms)	Limit (ms)	Margin (ms)	Tx Time >200 ms after end of radar (ms)	Limit (ms)	Margin (ms)
5290	33.0	260	227.0	0.0	60	60.0

Channel Closing Transmission Time and Channel Move Time (continued)

Results: 80 MHz EUT to Master



Plot showing the full 10 second shutdown limit



Zoomed plot showing the first 200 ms after the end of the type 0 radar burst

Channel Closing Transmission Time and Channel Move Time (continued)

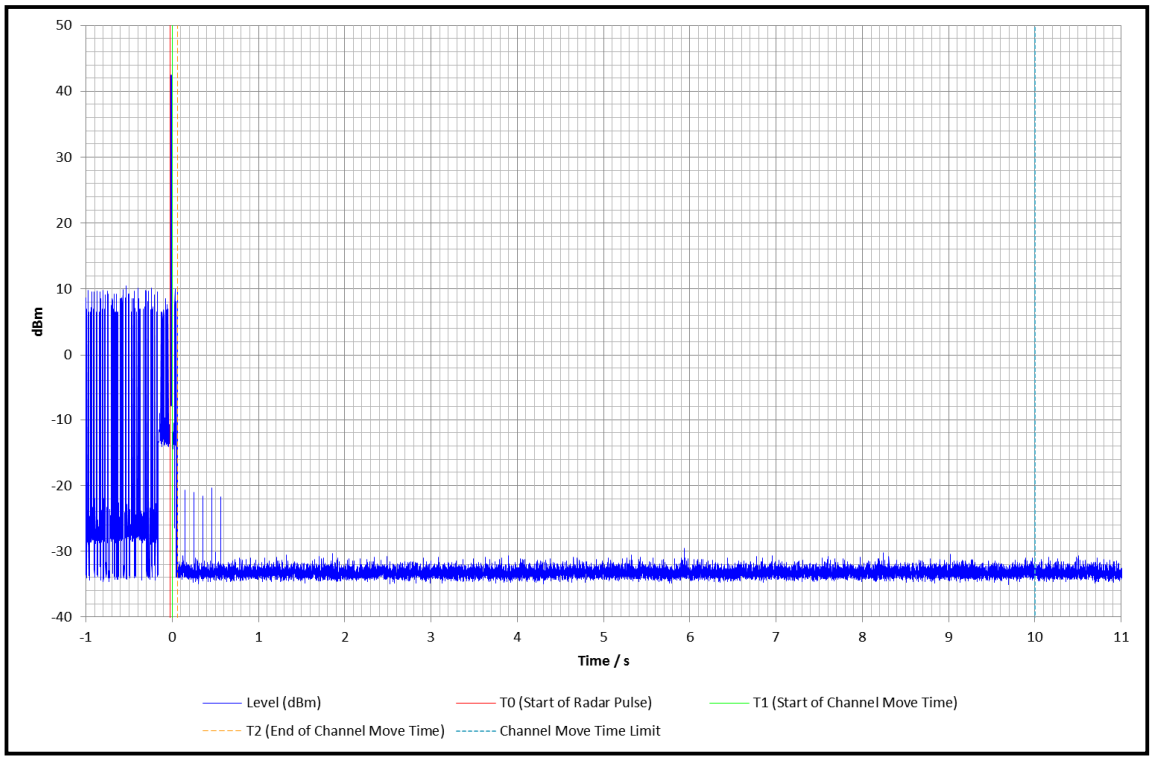
Results: 80 MHz Client-to-Client, Radar at Master – Channel Move Time

Channel (MHz)	Move Time (ms)	Limit (ms)	Margin (ms)	Detected
5290	58.7	10000	9941.3	Yes

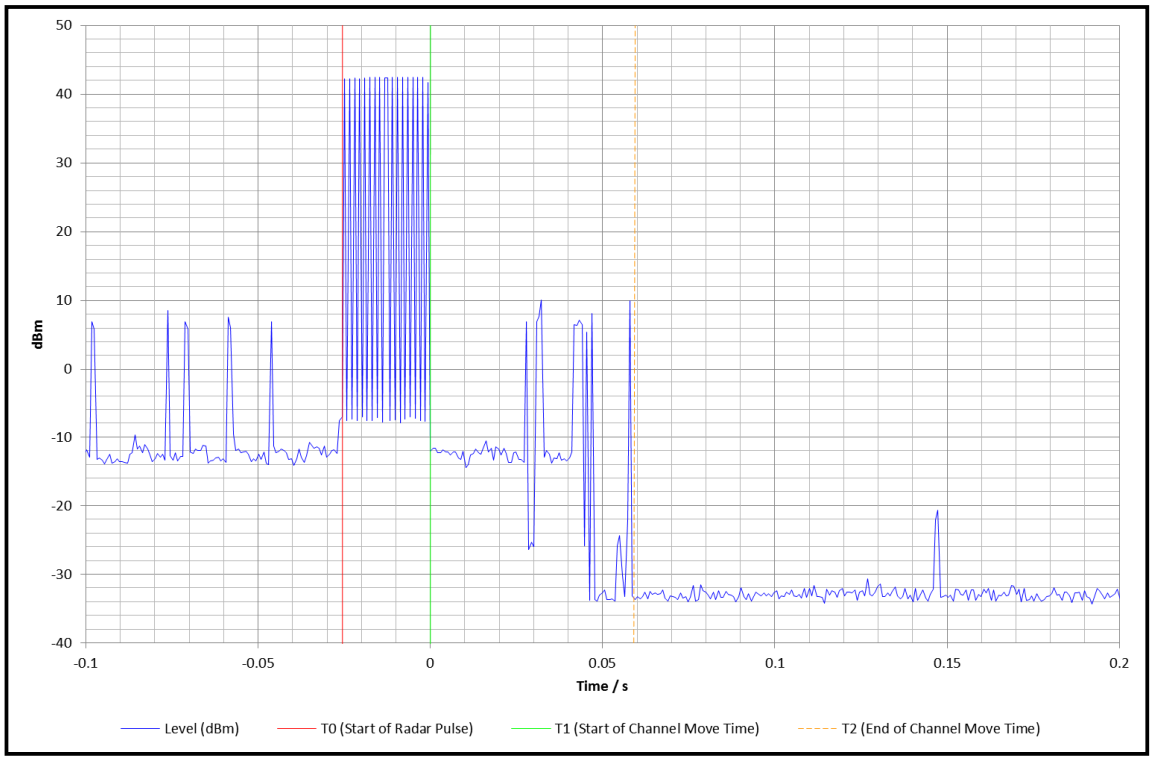
Results: 80 MHz Client-to-Client, Radar at Master – Channel Closing Transmission Time

Channel (MHz)	Total Aggregate Tx Time (ms)	Limit (ms)	Margin (ms)	Tx Time >200 ms after end of radar (ms)	Limit (ms)	Margin (ms)
5290	8.1	260	251.9	0.0	60	60.0

Channel Closing Transmission Time and Channel Move Time (continued)



Plot showing the full 10 second shutdown limit



Zoomed plot showing the first 200 ms after the end of the type 0 radar burst

Channel Closing Transmission Time and Channel Move Time (continued)

Limits:

Part 15.407(h)(2)(iii)

After a radar's presence is detected, all transmissions shall cease on the operating channel within 10 seconds. Transmissions during this period shall consist of normal traffic for a maximum of 200 ms after detection of the radar signal. In addition, intermittent management and control signals can be sent during the remaining time to facilitate vacating the operating channel.

KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
Channel Move Time	10 seconds See Note 1.
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 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 milliseconds 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 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.	

4.2.2. Non-occupancy Period

Test Summary:

Test Engineer:	Philip Harrison	**Test Dates:**	28 June 2017 & 29 June 2017
Test Sample Serial Number:	C07TK00WJ4CM		

FCC Reference:	Part 15.407(h)(iv)
Test Method Used:	KDB 905462 D02 Section 7.8.3

Environmental Conditions:

Temperature (°C):	22 to 26
Relative Humidity (%):	46 to 58

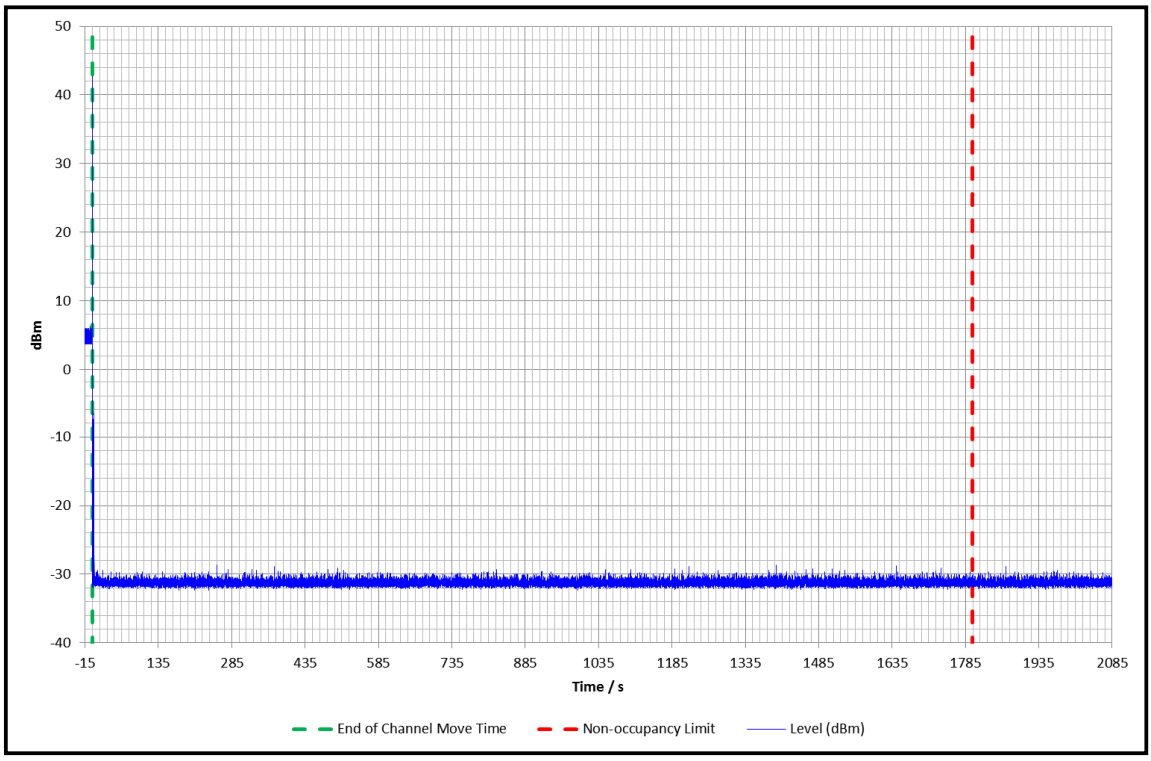
Notes:

1. KDB 905462 D03 point 6 states a non-occupancy plot is required for clients without radar detection. Since KDB 905462 D02 Table 2 says the test is not applicable it was therefore tested on the widest 80 MHz channel bandwidth since this is the given requirement for Channel Closing Transmission Time and Channel Move Time, and tested using the non-occupancy test method from KDB 905462 D02.
2. Tests were performed using a type 0 radar and the radar detection threshold calculated in Section 3.5 of this test report.
3. Radar burst type 0 was detected and the channel was vacated for >1800 seconds, meeting the 30 minute (1800 second) non-occupancy period. During this period all emissions remained below the -27 dBm/MHz spurious limit. Therefore the EUT complied.
4. The channel loading requirement of >17% in KDB 905462 D02 Section 7.7(c) was met. See Appendix 5 for further details.

Non-occupancy Period (continued)

Results: 80 MHz Client Mode

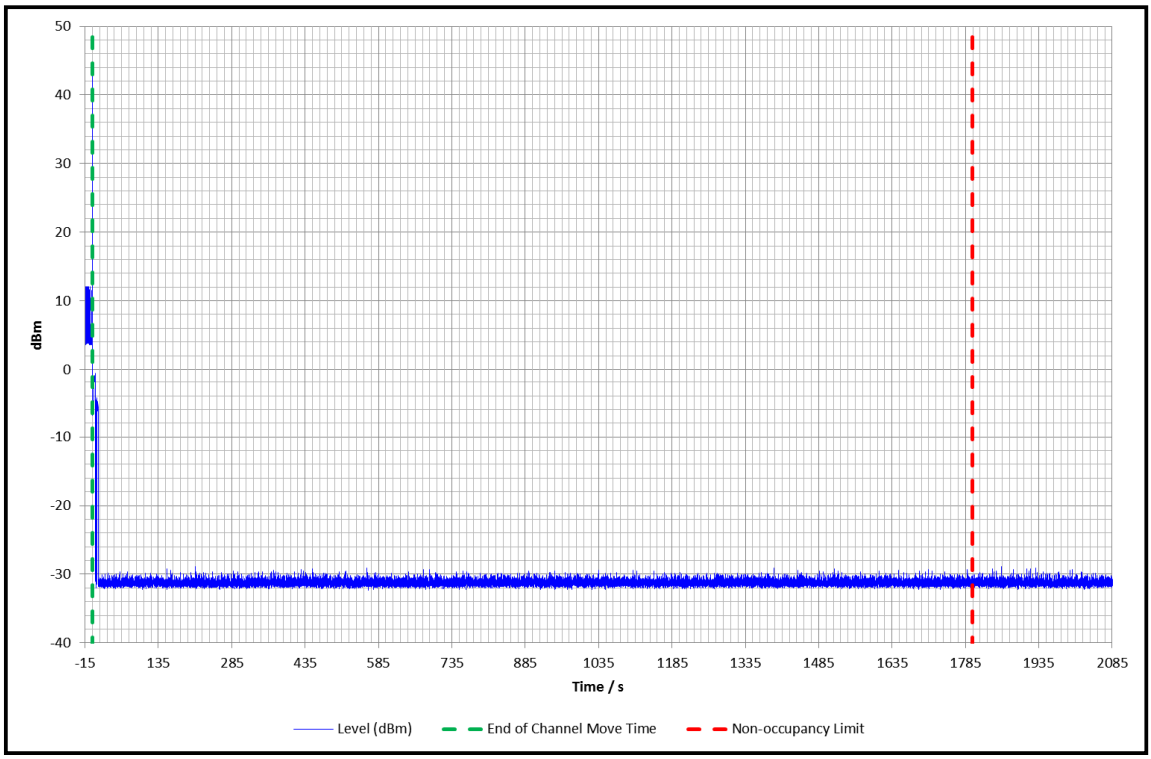
Channel (MHz)	Trial	Non-Occ (min)	Limit (min)	Margin (min)	Result
5290	1	>34.7	30	>4.7	Complied



Non-occupancy Period (continued)

Results: 80 MHz Client-to-Client Mode

Channel (MHz)	Trial	Non-Occ (min)	Limit (min)	Margin (min)	Result
5290	1	>34.8	30	>4.8	Complied



Limits:

Part 15.407(h)(2)(iv)

A channel that has been flagged as containing a radar system, either by a channel availability check or in-service monitoring, is subject to a non-occupancy period of at least 30 minutes. The non-occupancy period starts at the time when the radar system is detected.

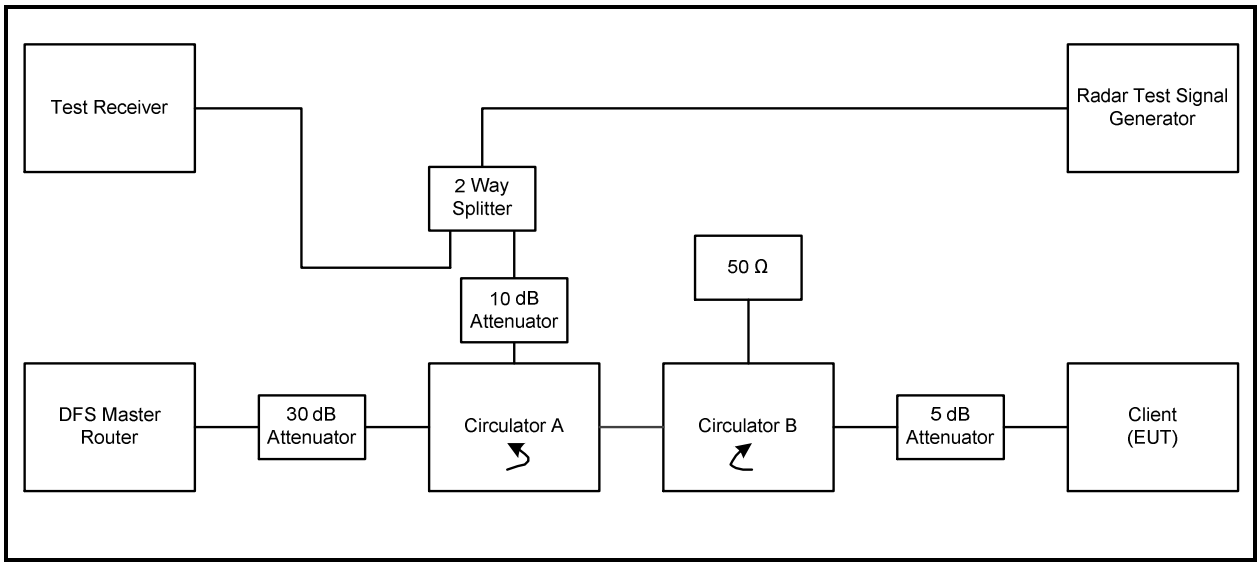
KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
Non-occupancy period	Minimum 30 minutes

Appendix 1. Monitoring Methods Diagrams

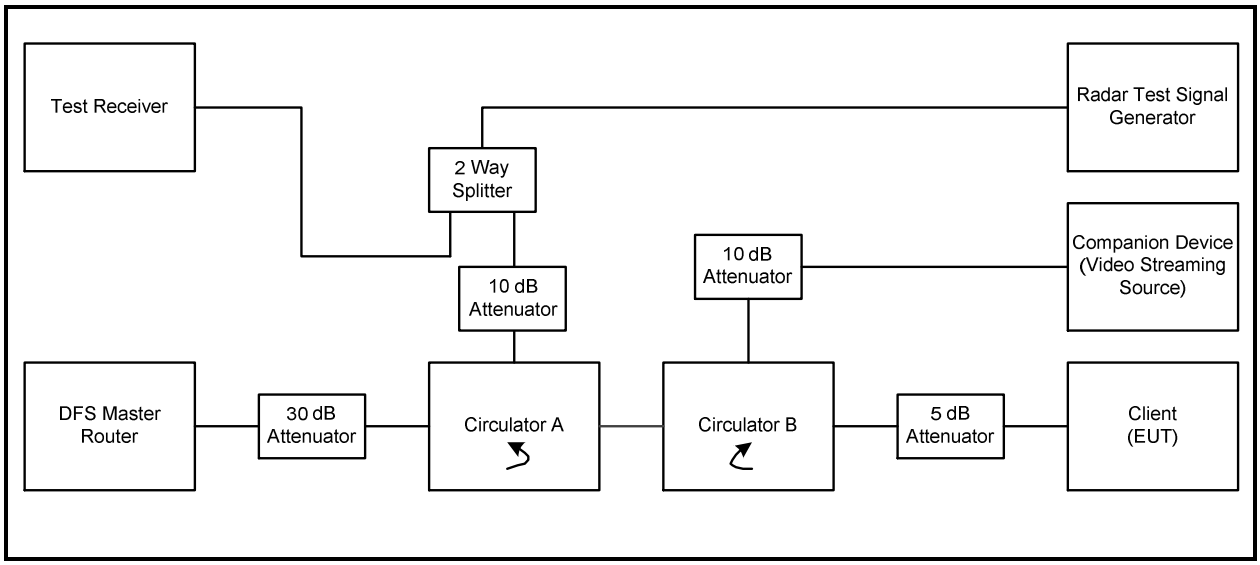
All tests were performed as conducted measurements using the setups as shown below. The detecting device always receives the radar via a direct (non-isolated) port of any circulator or splitter to ensure impedance variations do not affect the radar amplitude in accordance with KDB 905462 D02 Section 7.2, point (2).

Setup Diagram – EUT as Client with Radar Injection at Master



Note: Circulator A directs the radar pulse towards the DFS Master. Circulator B provides the same transmit path loss in both directions between the Master and Client devices. The EUT will appear larger than the ancillary device, and smaller than the radar at the Spectrum Analyser. The radar will be larger at the Master than at the EUT.

Setup Diagram – EUT in Client-to-Client Mode with Radar Injection at Master



Note: Similarly to the set-up above, circulator A again directs the radar towards the radar detecting device. Circulator B provides the same transmit path loss in both directions between the Master and Client devices whilst also attenuating any radar heading in the direction of the EUT. Due to the attenuation settings the levels on the Spectrum Analyser will show the Radar will appear largest, with the EUT (Client) then next largest, then the companion device, with the Master device smallest.

Appendix 2. Radar Type 0 Calibration and Verification Data

All radar types were generated and produced by an Aeroflex DFS test system. The radar pulse generation of this system has previously been verified by the FCC (see Appendix 3 of this test report).

The radar amplitude was calibrated using the setup diagram shown below. The spectrum analyser was replaced by a 50Ω load. The EUT was replaced by a spectrum analyser. The Aeroflex DFS test system was then set to transmit a CW signal used to calibrate the radar level. The output level was adjusted to give the correct level into the EUT, as calculated in Section 3.5 of this report, before the tests were performed.

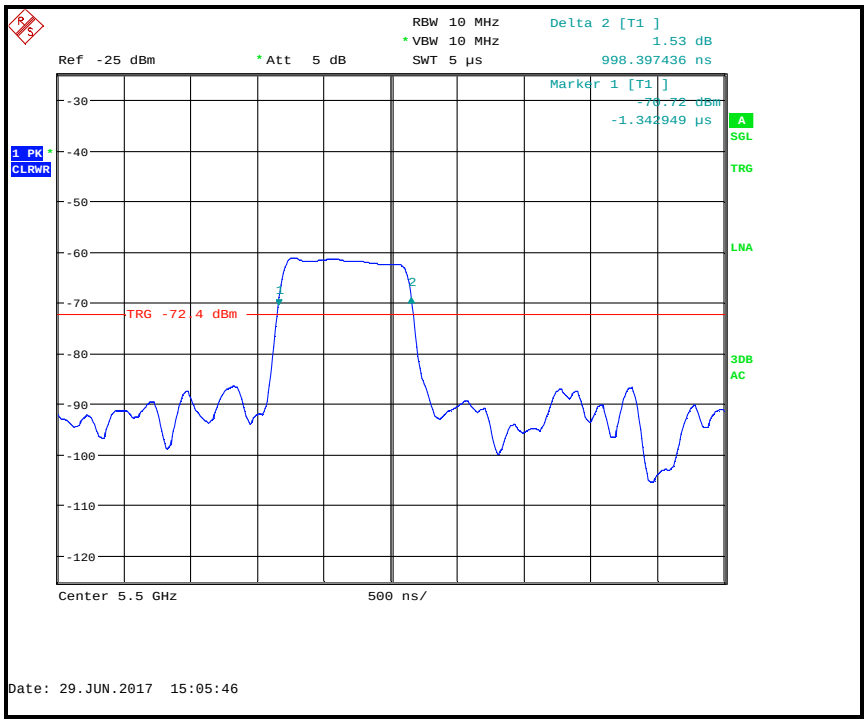
An additional check was then made using the above calibrated level and a 1 µs pulse of a type 0 radar. Maximum spectrum analyser RBW/VBW setting was used for this to avoid pulse desensitisation effects of the very short burst time. This level was then used for all radar types during testing.

For radar calibration the equipment was set up as for testing shown in Appendix 1, but with the spectrum analyser cable terminated with a 50 Ω load, and the DFS master replaced by the spectrum analyser to measure the radar parameters.

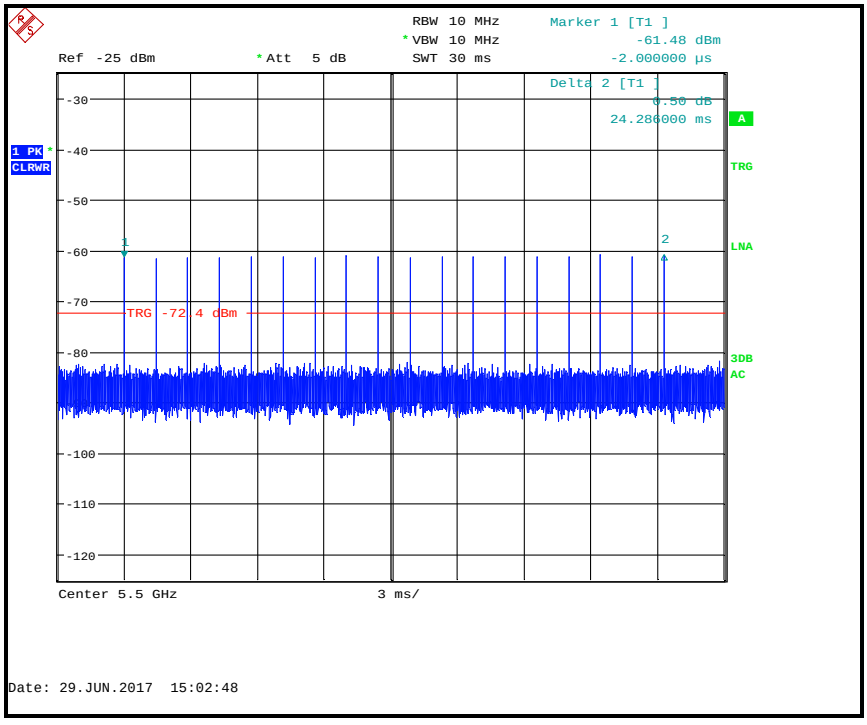
Radar Verification

The test system and its waveform generation has been validated by the FCC as an ‘approved’ device (see Appendix 3 of this test report), therefore full analysis of each radar is not necessary. However, below are sample plots for each of the radar types. Note the full timing plots of all the pulses in the waveform may give slightly inaccurate amplitudes. They are therefore accurate only as timing plots for an example radar overview.

Radar Type 0



Radar Type 0 – single 1 µs pulse



Radar Type 0 – full 18 pulse waveform

Appendix 3. Test platform confirmation email

From: Andrew Leimer [mailto:Andrew.Leimer@fcc.gov]
Sent: Friday, September 23, 2011 4:24 PM
To: Chisham, Steve
Cc: Carey, Tim; Hack, Barry; Rashmi Doshi; Joe Dichoso
Subject: RE: Certification for Aeroflex DFS solution

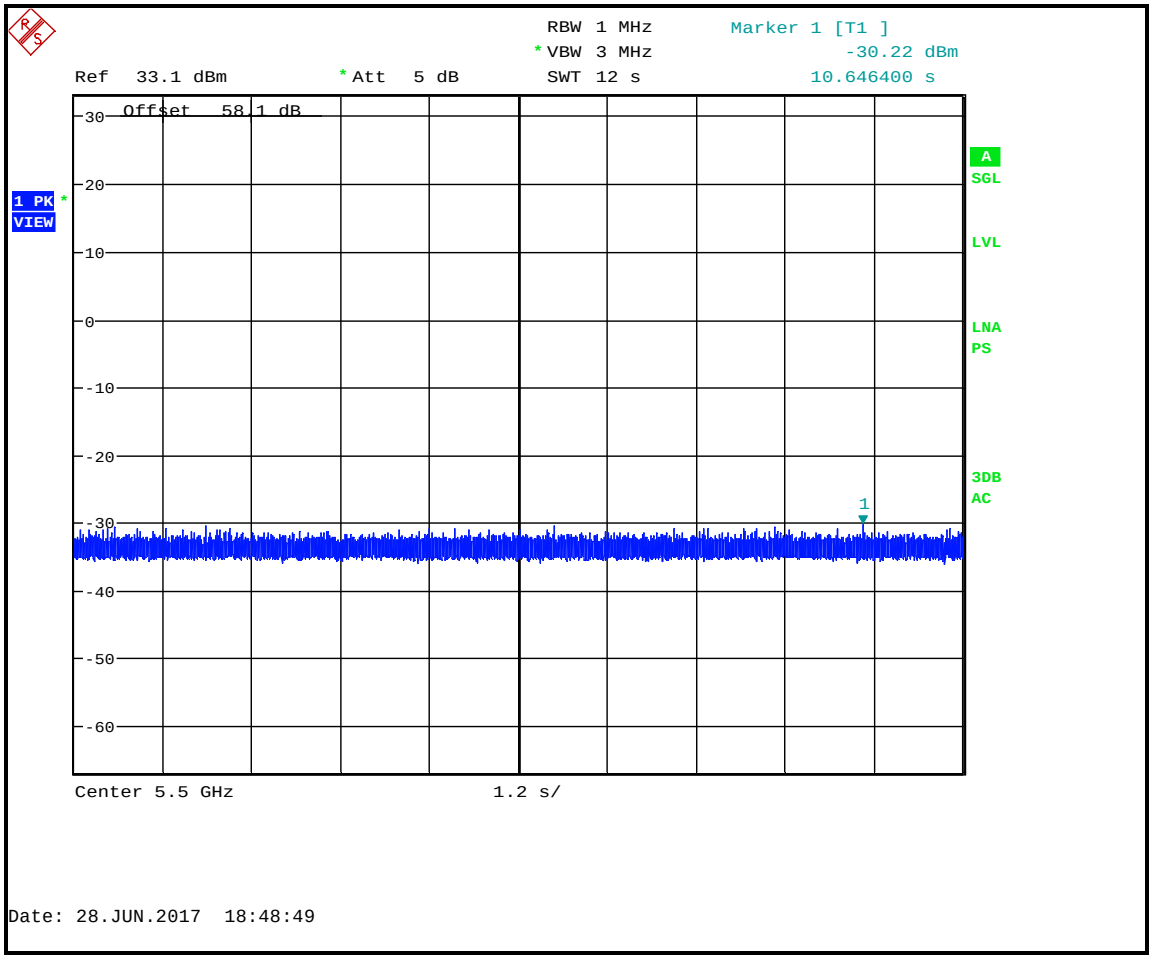
Hello Steve,
The Aeroflex "DXI based DFS test solution" system used for DFS alternative radar signal generation has been approved by the FCC and NTIA.
This approval permits the system to be used by labs in the testing of DFS devices for equipment authorization Certification. It is recommended that applicants that use your system for testing include a statement in the Test Report or a Letter Exhibit stating that the system has FCC and NTIA approval. This E-mail is your record of this approval.
Note that the appropriate term for your system is Approved as the term Certification is reserved for devices gaining equipment authorization through the FCC or a TCB.

Regards,
Andy Leimer

FCC/OET/EACB

Appendix 4. System Noise Floor Reference Plots

As required by Section 8.3(d)(3) of KDB 905462 D02, the following plot shows the reference noise floor of the system used during measurement. It also shows compliance when the path loss of the coupling network shown in Appendix 1 of this Test Report (*Configuration and Peripherals)* is added to the noise floor as a reference level offset.

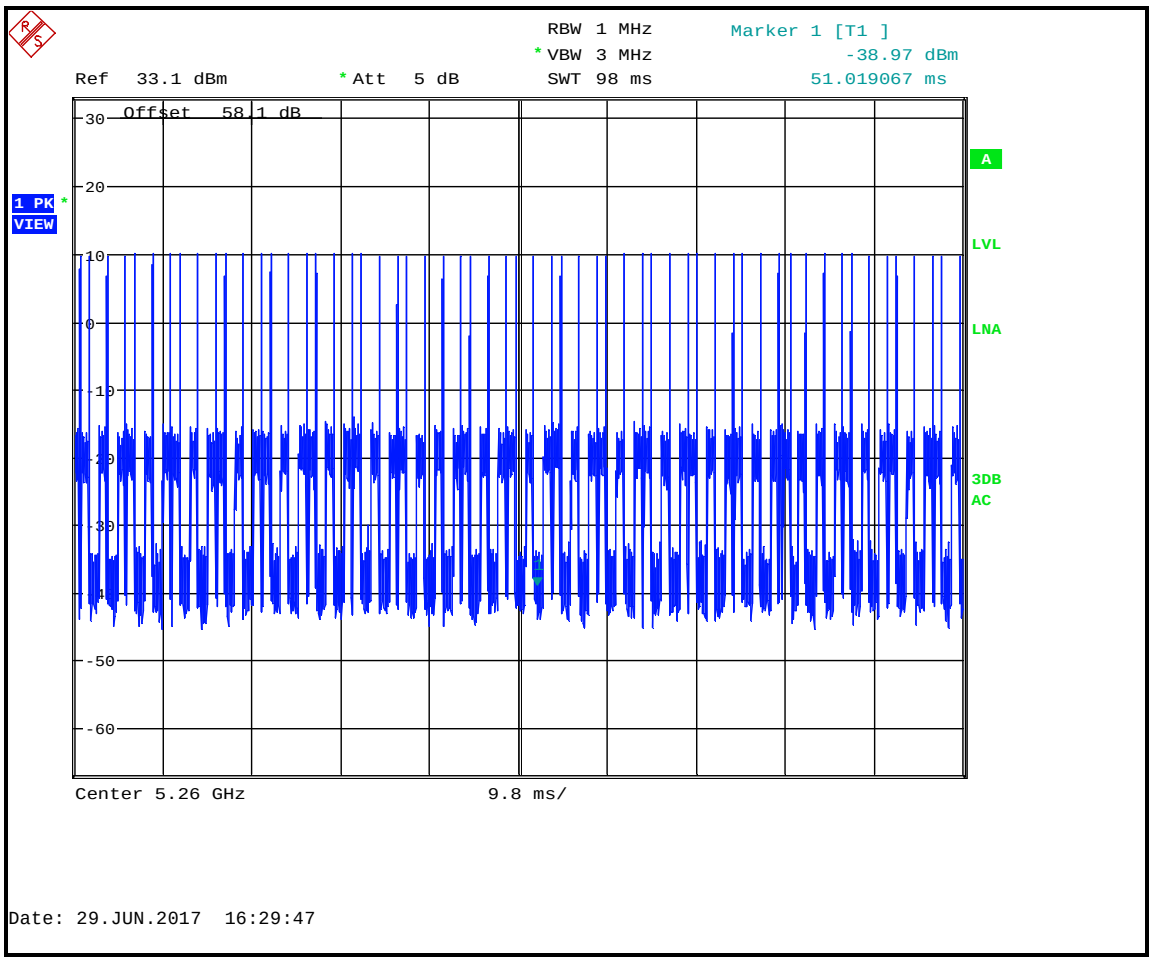


Noise Floor of Spectrum Analyser

Appendix 5. Channel Loading

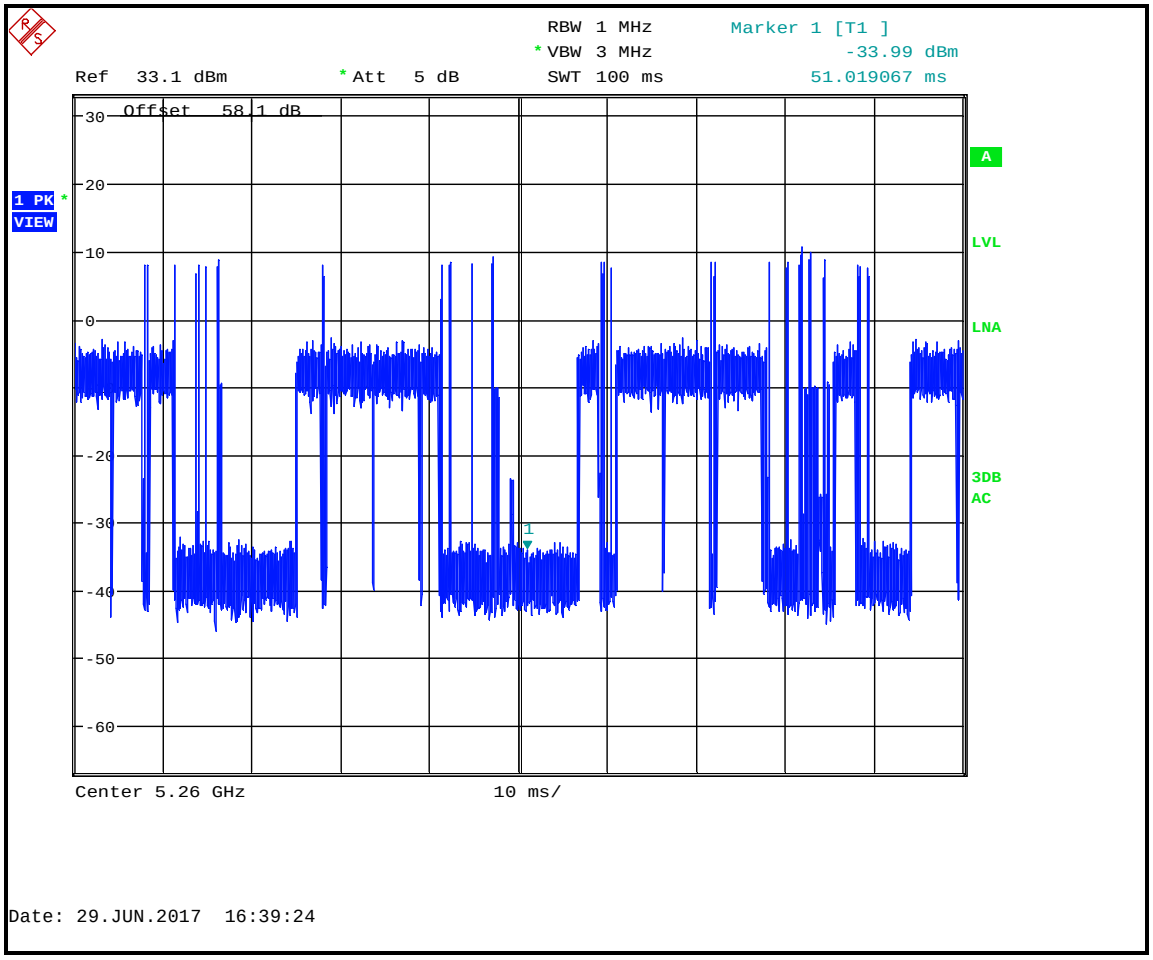
UDP data was transmitted from the EUT to the companion device. 100 ms of transmissions showing both the EUT and companion device were then captured on a spectrum analyser in the time domain. The spectrum analyser was set to 30,001 sweep points giving a sample size accuracy of 3.333 µs. The data points were then exported as an ASCII file and each sample determined to be either transmissions from the EUT or companion device (channel loading) or idle. The duty cycle was then calculated from this ratio.

Included below are spectrum analyser plots from which the raw data was extracted to calculate the channel loading.



54.6% Channel Loading at 80 MHz Bandwidth – Fixed Rate MCS0x1 with 10 Mbit/s Throughput

Channel Loading (continued)



57.1% Channel Loading at 80 MHz Bandwidth – Client-to-Client Video Streaming

Appendix 6. Channel/Frequency plan

Wi-Fi Supported Channels			
Country	**Channels**		
	20 MHz	40 MHz	80 MHz
United States Canada	1 - 13 36 - 48 52 – 64 100 – 144 149 - 165	38 – 46 54 – 62 102 – 142 151 - 159	42 – 58 106 -138 155

Note(s):

1. Channels 120 – 128: Only used if DFS Master allows
2. Channels 36 – 64: Set to Indoor use only for Canada
3. The following channels are set to Active/Passive in FCC domain:

2.4 GHz Band
Channels 1 – 11: Active
Channels 12 – 13: Passive

5 GHz Band
Channels 36 – 48: Active
Channels 52 – 144: Passive DFS
Channels 149 – 165: Active

--- END OF REPORT ---