FCC/ISED DFS CLIENT TEST REPORT

Vista Labs
TEST • CERTIFY • COMPLY

Test Report Number……	**WAP-19091821-LC-FCC-IC-DFS**
Applicant……	**Ford Motor Company**
Applicant Address……	**Building 5, 20300 Rotunda Dr., Dearborn, Michigan, United States 48124**
Product Name……	Vehicle Telematics Control Unit
Model Number……	FB5-TCU-NA
Family Product/Model……	N/A
FCC ID……	KMH-14H074-NA1
ISED ID……	1422A-14H074NA1
Date of EUT received……	09/27/2019
Date of Test……	09/27/2019 – 11/25/2019
Report Issue Date……	12/02/2019
Test Standards……	**47CFR Part 15.407** **RSS-247 Issue 2.0: Feb 2017** **RSS-Gen Issue 5: Apr 2018**
Test Result……	Pass

Issued By:

Vista Laboratories

1261 Puerta Del Sol, San Clemente, CA 92673 USA

www.vista-compliance.com

Tested by:	**Approved By:**
Bruce Li	
Bruce Li/Test Engineer	**David Zhang/Technical Manager**

Laboratory Introduction

Vista Labs is an A2LA accredited 17025 compliant regulatory compliance testing laboratories (Cert. number: 4848-01) strategically located in Orange County, providing services in the electrical and telecommunication industries. Vista labs is also recognized testing facility for Australia (ACMA), Chinese Taipei (BSMI), Chinese Taipei (NCC), Hong Kong (OFCA), Israel (MOC), Korea (RRA), Singapore (IMDA), Vietnam (MIC), etc.

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for technical competence in the field of

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Presented this 21st day of June 2018.

President and CEO
For the Accreditation Council
Certificate Number 4848.01
Valid to July 31, 2020

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17025 Product Testing Accreditation Certificate

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A2LA has accredited

VISTA LABORATORIES, INC.

San Clemente, CA

This product certification body is accredited in accordance with the recognized International Standard ISO/IEC 17065:2012 *Requirements for bodies certifying products, processes and services*. This product certification body also meets the A2LA R308 – Specific Requirements – ISO-IEC 17065 – Telecommunication Certification Body Accreditation Program and R322 – Specific Requirements – Notified Body Accreditation Requirements. This accreditation demonstrates technical competence for a defined scope and the operation of a management system.

Presented this 1st day of October 2018.

President and CEO
For the Accreditation Council
Certificate Number 4848.02
Valid to July 31, 2020

For the product certification schemes to which this accreditation applies, please refer to the organization's Product Certification Scope of Accreditation.

17065 Product Certification Accreditation Certificate

TABLE OF CONTENTS

REVISION HISTORY

Revision	Issue Date	Description	Note
Original	12/02/2019	Original release	N/A

1 General Information

1.1 Applicant

Applicant:	Ford Motor Company
Applicant address:	Building 5, 20300 Rotunda Dr., Dearborn, Michigan, United States 48124
Manufacturer:	Ford Motor Company
Manufacturer Address:	Building 5, 20300 Rotunda Dr., Dearborn, Michigan, United States 48124

1.2 Product information

Product Name	Vehicle Infotainment System
Model Number	MUST-14H074-NAC
Family Model Number	N/A
Serial Number	ENMHF19050112411, ENMHF19050112546 (Conducted)
Frequency Band	BT BDR/EDR: 2402-2480MHz BLE: 2402-2480MHz 802.11b/g/n-20MHz: 2412-2462MHz 802.11n-40MHz: 2422-2452MHz 802.11a/n-20MHz: 5500-5580MHz, 5660-5720, 5725-5825MHz 802.11n-40MHz: 5510-5550MHz, 5630-5710, 5755-5795MHz 802.11ac: 5530, 5690MHz, 5775MHz WCDMA Band 2: 1852.4- 1907.6MHz WCDMA Band 4: 1712.4- 1752.6MHz WCDMA Band 5: 826.4- 846.6MHz LTE Band 2: 1850.7-1909.3MHz LTE Band 4: 1710.7-1754.3MHz LTE Band 5: 824.7-848.3MHz LTE Band 12: 699.7-713.5MHz LTE Band 17: 706.5-784.5 MHz LTE Band 66: 1710.7-1779.3MHz
Type of modulation	BT BDR/EDR: GFSK, π/4DQPSK, 8DPSK BLE: GFSK 802.11b: DSSS (CCK, DQPSK, DBPSK) 802.11g: OFDM-CCK (BPSK, QPSK, 16QAM, 64QAM) 802.11a/n/ac: OFDM (BPSK, QPSK, 16QAM, 64QAM, 256QAM) WCDMA: QPSK LTE: QPSK, 16QAM
Equipment Class/ Category	DSS, DTS, UNII, PCB
Maximum output power	See test result

Antenna Information	**Internal PCB trace antenna** Peak Gain: - Antenna1: 3.40 dBi @2.4GHz WiFi/Bluetooth, 8.00 dBi @5GHz WiFi - Antenna2: 3.39 dBi @2.4GHz WiFi/Bluetooth, 6.17 dBi @5GHz WiFi **External Antenna** Peak Gain: - Antenna3: 9.74 dBi @2.4GHz WiFi/Bluetooth **Cellular main and diversity antennas:** Peak Gain: 4.32 dBi @ 698-850MHz 5.53 dBi @ 1700-1910MHz For 2.4GHz Wi-Fi, it has total 3 antennas that can transmit simultaneously (Internal antenna 1 &2, and external antenna). For 5GHz Wi-Fi, it has total 2 antennas that can transmit simultaneously (Internal antenna 1 &2). The directional gain is calculated per KDB 662911 D01 Multiple Transmitter Output v02r01, Directional Gain: - 12.59 dBi @2.4GHz - 10.143 dBi @5GHz
Clock Frequencies	N/A
Port/Connectors	Micro USB, CAN bus
Input Power	Vehicle Battery powered: 12VDC
Power Adapter Manu/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	BT/BLE, WLAN and cellular radio can transmit simultaneously
Additional Info	This device is original equipment (OEM) devices, which will be installed in vehicles by vehicles manufacturers. The operation in band 5600-5650MHz is not allowed per ISED rules. This device does not operate as DFS master, nor as client device with DFS detection capability.

1.3 Test standard and method

Test standard	47CFR Part 15.407 RSS-247 Issue 2.0: Feb 2017 RSS-Gen Issue 5: Apr 2018
Test method	ANSI C63.10: 2013 905462 D02 UNII DFS Compliance Procedures New Rules v02 905462 D03 UNII Clients Without Radar Detection New Rules v01r02

1.4 Test Purpose and statement

The purpose of this test report is intended to demonstrate the compliance of product listed in section 1.2, received from company listed in section 1.1, to the requirements of standard and method listed in section 1.3. Based on our test results, we conclude that the product tested complies with the requirements of the standards indicated.

2 Test site information

Lab performing tests	**Vista Laboratories**
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www. Vista-compliance.com

Test condition	Test Engineer	Test Environment	Test Date
DFS Testing	Bruce Li	23.5°C / 58.2%/996 mbar	09/27/2019–11/25/2019

3 Modification of EUT

The EUT is an engineering test sample loaded with test firmware to simulate the operation when the vehicle is in parking mode in order to activate the Wi-Fi normal operation mode.

4 Test configuration and operation

4.1 EUT test configuration

EUT is powered by external DC power supply for testing purpose. EUT's RF antenna port is connected to spectrum analyzer through RF test cable for measurement. EUT is associated with the DFS master device and established the communication.

4.2 EUT test mode

Radio	Frequency
802.11n	5500MHz
802.11ac	5530MHz

4.3 Supporting Equipment

Index	Description	Model	S/N	Brand	Remark
1	WLAN AP	EA8300	21P10C67818280	Linksys	DFS master
2	Notebook	W520	427638U	Lenovo	N/A
3	AC/DC Adapter	HA45NM140	00285K	DELL	-
4	AC/DC Adapter	GST60A12-P1J	EB74Q81066	MEAN WELL	-

4.4 EUT operation

EUT is associated with the DFS master device and established the communication.

4.5 Test software

Index	Description	Remark
1	Keysight N7607B Signal Studio	DFS signal generation for ETSI/FCC

5 Test Summary

FCC Rules	ISED Rules	Test Item	Section	Verdict
§15.407(h)	RSS-247 §6.3	Channel Closing Transmission Time- Measurement	7.3	Pass
§15.407(h)	RSS-247 §6.3	In-Service Monitoring for Channel Move Time	7.3	Pass
§15.407(h)	RSS-247 §6.3	Non-Occupancy Period	7.3	Pass

6 Uncertainly of Measurement

Test item	Measurement Uncertainty (dB)
Dynamic frequency selection (DFS) Conducted Measurement	±1.5dB

7 Test summary and result

7.1 Dynamic Frequency Selection (DFS) Introduction

7.1.1 Requirement

Interference Threshold values, Master or Client incorporating In-Service Monitoring

Maximum Transmit Power	Value (see note)
≥ 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 spectra 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. Note3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.	

DFS Response requirement values

Parameter	Value
Non-occupancy period	Minimum 30 minutes
Channel Availability Check Time	60 seconds
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.
U-NII Detection Bandwidth	Minimum 100% of the UNII 99% transmission power bandwidth See Note 3.
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 facilitating 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. 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 percent. Measurements are performed with no data traffic.	

7.1.2 Radar type and test waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance. Step intervals of 0.1 microsecond for Pulse Width, 1 microsecond for PRI, 1 MHz for chirp width and 1 for the number of pulses will be utilized for the random determination of specific test waveforms

Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (µsec)	PRI (µsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum 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) * (19*10^6/ PRI_{usec}	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 µsec, with a minimum increment of 1 µsec, 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 the detection bandwidth test, channel move time, and channel closing time tests.					

Long Pulse Radar Test Waveform

Radar Type	Pulse Width (µsec)	Chirp Width (MHz)	PRI (µsec)	Number of Pulses per *Burst*	Number of *Bursts*	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

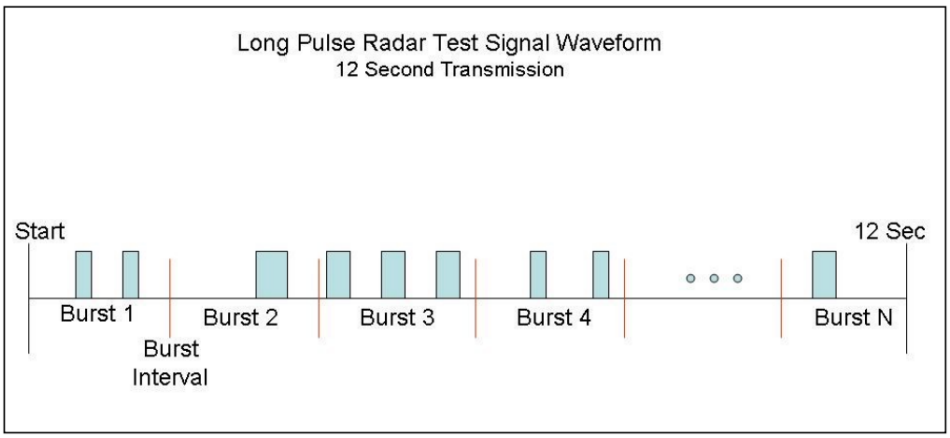
The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse radar test signal. If more than 30 waveforms are used for the Long Pulse radar test signal, then each additional waveform must also be unique and not repeated from the previous waveforms.

Each waveform is defined as follows:

1) The transmission period for the Long Pulse Radar test signal is 12 seconds.
2) There are a total of 8 to 20 Bursts in the 12 second period, with the number of Bursts being randomly chosen. This number is Burst Count.
3) Each Burst consists of 1 to 3 pulses, with the number of pulses being randomly chosen. Each Burst within the 12 second sequence may have a different number of pulses.
4) The pulse width is between 50 and 100 microseconds, with the pulse width being randomly chosen. Each pulse within a Burst will have the same pulse width. Pulses in different Bursts may have different pulse widths.
5) Each pulse has a linear FM chirp between 5 and 20 MHz, with the chirp width being randomly chosen. Each pulse within a Burst will have the same chirp width. Pulses in different Bursts may have different chirp widths. The chirp is centered on the pulse. For example, with a radar frequency of 5300 MHz and a 20 MHz chirped signal, the chirp starts at 5290 MHz and ends at 5310 MHz
6) If more than one pulse is present in a Burst, the time between the pulses will be between 1000 and 2000 microseconds, with the time being randomly chosen. If three pulses are present in a Burst, the time between the first and second pulses is chosen independently of the time between the second and third pulses.
7) The 12 second transmission period is divided into even intervals. The number of intervals is equal to Burst Count. Each interval is of length (12,000,000 / Burst Count) microseconds. Each interval contains one Burst. The start time for the Burst, relative to the beginning of the interval, is between 1 and [(12,000,000 / Burst Count) – (Total Burst Length) + (One Random PRI Interval)] microseconds, with the start time being randomly chosen. The step interval for the start time is 1 microsecond. The s9tart time for each Burst is chosen independently.

A representative example of a Long Pulse radar test waveform:

1) The total test signal length is 12 seconds.
2) 8 Bursts are randomly generated for the Burst Count.
3) Burst 1 has 2 randomly generated pulses.
4) The pulse width (for both pulses) is randomly selected to be 75 microseconds.
5) The PRI is randomly selected to be at 1213 microseconds.
6) Bursts 2 through 8 are generated using steps 3 – 5.
7) Each Burst is contained in even intervals of 1,500,000 microseconds. The starting location for Pulse 1, Burst 1 is randomly generated (1 to 1,500,000 minus the total Burst 1 length + 1 random PRI interval) at the 325,001 microsecond step. Bursts 2 through 8 randomly fall in successive 1,500,000 microsecond intervals (i.e. Burst 2 falls in the 1,500,001 – 3,000,000 microsecond range).



Frequency Hopping Radar Type

Radar Type	Pulse Width (µsec)	PRI (µsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	9	.333	300	70%	30

For the Frequency Hopping Radar Type, the same Burst parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected 1 from the hopping sequence defined by the following algorithm:

The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set. For selection of a random frequency, the frequencies remaining within the group are always treated as equally likely.

7.2 Dynamic Frequency Selection (DFS) Applicability

7.2.1 Requirement

A U-NII network will employ a DFS function to detect signals from radar systems and to avoid co-channel operation with these systems. This applies to the 5250-5350 MHz and/or 5470-5725 MHz bands.1

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 UNII device operating in Master Mode.

Following tables shown below summarize the DFS testing applicability.

Applicability of DFS Requirements Prior to Use of a Channel

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
Non-Occupancy Period	Yes	Not required	Yes
DFS Detection Threshold	Yes	Not required	Yes
Channel Availability Check Time	Yes	Not required	Not required
U-NII Detection Bandwidth	Yes	Not required	Yes

Applicability of DFS requirements during normal operation

Requirement	Operational Mode	
	Master Device or Client with Radar Detection	Client Without Radar Detection
DFS Detection Threshold	Yes	Not required
Channel Closing Transmission Time	Yes	Yes
Channel Move Time	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required

Additional requirements for devices with multiple bandwidth modes	Master Device or Client with Radar Detection	Client Without Radar Detection
U-NII Detection Bandwidth and Statistical Performance Check	All BW modes must be tested	Not required
Channel Move Time and Channel Closing Transmission Time	Test using widest BW mode available	Test using the widest BW mode available for the link
All other tests	Any single BW mode	Not required
Note: Frequencies selected for statistical performance check (Section 7.8.4) should include several frequencies within the radar detection bandwidth and frequencies near the edge of the radar detection bandwidth. For 802.11 devices it is suggested to select frequencies in each of the bonded 20 MHz channels and the channel center frequency.		

7.2.2 Conclusion

EUT is client device without radar detection function. Only the Channel Closing Transmission Time and Channel Move time testing are required. The testing shall be done using the widest BW mode.

7.3 Dynamic Frequency Selection (DFS) Testing

7.3.1 Requirement

Channel Closing Transmission Time

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.

The channel closing transmission time shall be less than (200 milliseconds + an aggregate of 60 milliseconds) over remaining 10 second period

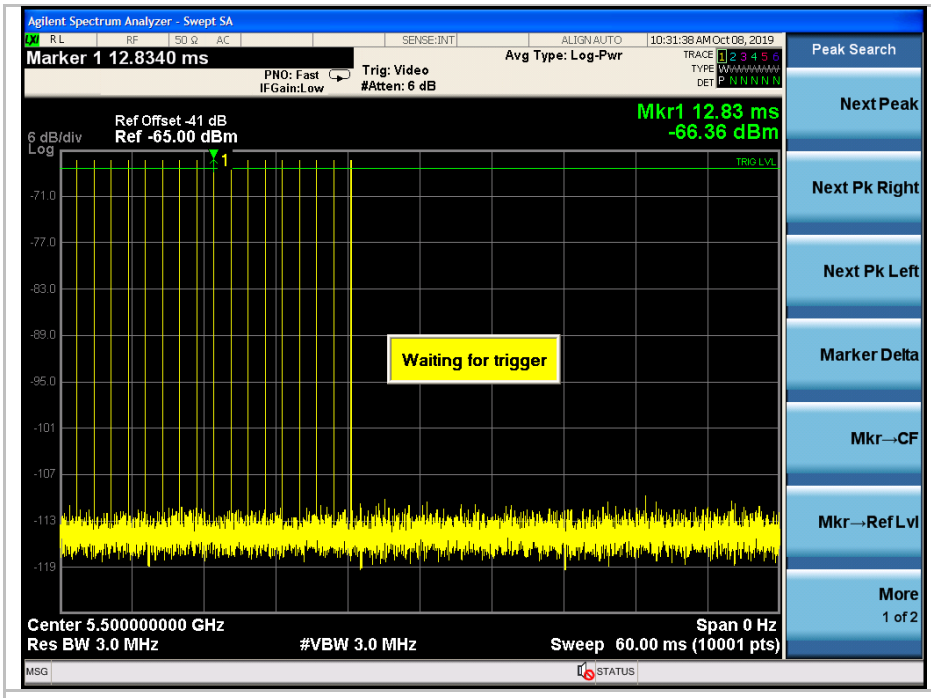
Channel Move Time

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.

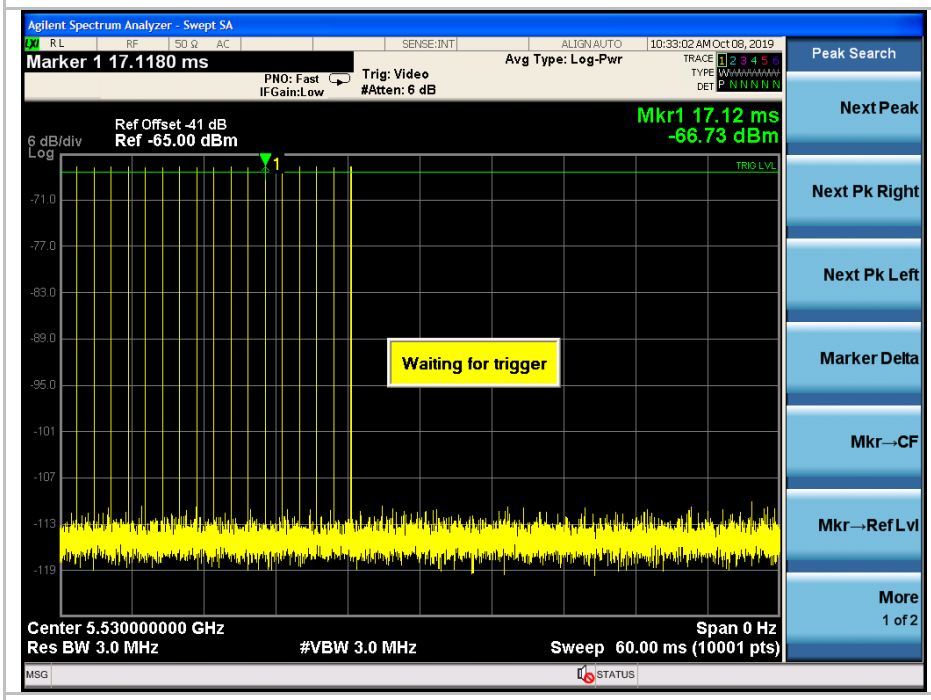
7.3.2 Radar Waveform Calibration

The following equipment setup was used to calibrate the conducted Radar Waveform. A spectrum analyzer was used to establish the test signal level for each radar type. During this process there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) mode at the frequency of the Radar Waveform generator. Peak detection was utilized.

Calibration Test Plots



5470MHz to 5725MHz bands – Radar Type 1 @ 5500MHz



5470MHz to 5725MHz bands – Radar Type 0 @ 5530MHz

7.3.3 DFS Test Procedure

In-Service Monitoring for Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period

These tests define how the following DFS parameters are verified during In-Service Monitoring; Channel Closing Transmission Time, Channel Move Time, and Non-Occupancy Period.

The steps below define the procedure to determine the above mentioned parameters when a radar Burst with a level equal to the DFS Detection Threshold + 1dB is generated on the Operating Channel of the U-NII device.

UUT operating as a Client Device will associate with the (Master) at Mid Channel. DFS testing while the System testing was performed with the designated MPEG test file that streams full motion video at 30 frames per second from the Master to the Client IP based system

At time T0 the Radar Waveform generator sends a Burst of pulses for each of the radar types.

Observe the transmissions of the UUT at the end of the radar Burst on the Operating Channel for duration greater than 10 seconds. Measure and record the transmissions from the UUT during the observation time (Channel Move Time). Compare the Channel Move Time and Channel Closing Transmission Time results to the limits defined in the DFS Response requirement values table.

Channel Closing Transmission Time- Measurement

A type 1 waveform was introduced to the EUT and the Spectrum Analyzer sweep time was set to 1s for monitoring and capturing the plot. A LabVIEW program was created to collect trace data and capturing the plot. The program will calculate the channel closing time base on the spectrum analyzer result. The result will be calculated based on FCC procedure.

C= N*Dwell

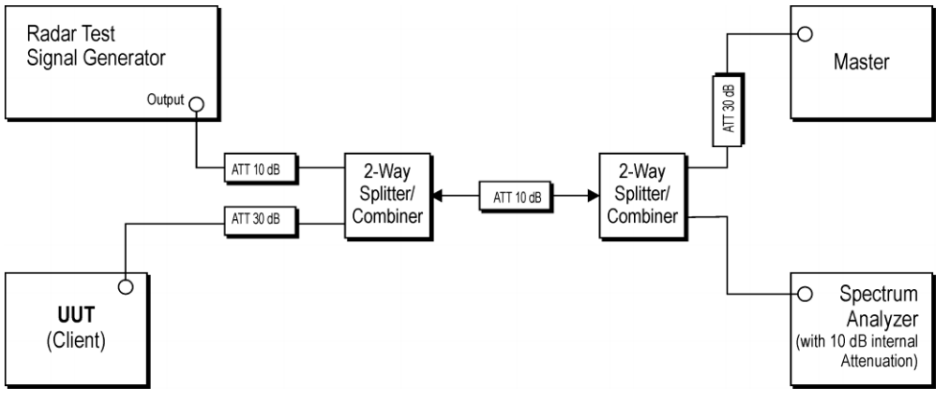
C is the closing time, N is the number of spectrum analyzer sampling bins showing a U-NII transmission and dwell is the dwell time per bin.

Dwell= S/B

Where Dwell is the dwell time per spectrum analyzer sampling bin, S is the sweep time and B is the number 0f spectrum analyzer sampling bins.

7.3.4 DFS Test Setup

Test Setup Block Diagram



The radio was set at the center channel frequency of tested Channel.
A FCC approved Master device – (FCC ID: Q87-EA8300) AP was used to link with DUT device.

The master device provides, on aggregate, uniform loading of the spectrum across all devices by selecting an operating channel among the available channels using a random algorithm.

The rated output power of the Master unit is > 23 dBm (EIRP). Therefore, the required interference threshold is – 64 dBm. After correction for procedural adjustment, the required radiated threshold at the antenna port is -64 + 1 = -63 dBm.

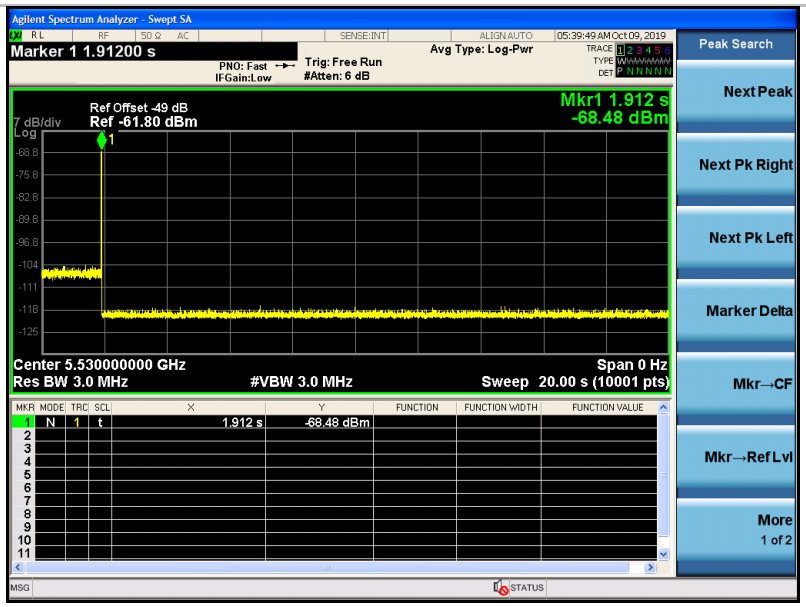
The calibrated radiated DFS detection threshold level is set to -64 dBm. The tested level is lower than the required level hence it provides margining to the limit.

7.3.5 DFS Test Results

BW / Channel	Test Item	Test Result	Limit	Verdict
11ac-5530MHz	Channel Move Time	< 10s	< 10s	Pass
11ac-5530MHz	Channel Closing Transmission Time	0ms	< 260ms	Pass
11n-5500MHz	Non-Occupancy Period	≥ 30min	≥ 30 min	Pass

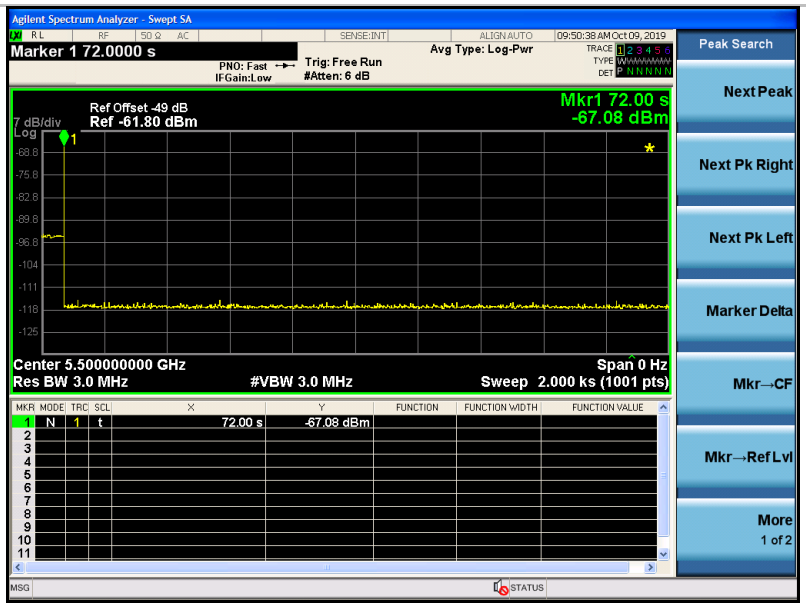
7.3.6 DFS Test Plots

Plots for Channel closing time and Channel Move Time



CH Closing time - 802.11ac-5530MHz

Plots for non-occupancy period



Non-occupancy Period - 802.11n-20MHz-5500MHz

8 Test instrument list

Equipment	Manufacturer	Model	Serial Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	5/11/2019	5/11/2020
Spectrum Analyzer	Keysight	N9020A	MY50110074	5/4/2019	5/4/2020
Agilent Signal Generator	MXG N5182A	MY47071065	US47080548	5/2/2019	5/2/2020
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	5/2/2019	5/2/2020
Horn Antenna (1-18GHz)	FT-RF	HA-07M18G-NF	180010HA	5/2/2019	5/2/2020
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/9/2019	5/9/2020
RF Attenuator	Pasternack	PE7005-3	VL061	5/10/2019	5/10/2020
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	5/10/2019	5/10/2020
RE test cable (>18GHz)	Sucoflex	104	344903/4	5/10/2019	5/10/2020
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL052	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL053	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL054	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL055	N/A	N/A