ENGINEERING TEST REPORT # TR 316356 D (DFS)
LSR Job #: C-2602

Compliance Testing of:
Sterling LWB5

Test Date(s):
April 27, 2017

Prepared For:
Laird Technologies, Inc.
Attn: Bill Steinike
W66N220 Commerce Ct.
Cedarburg, WI 53012

This Test Report is issued under the Authority of:

Signature: Date: 5/9/17

Test Report Reviewed by:
Adam Alger, Quality Systems Engineer
Signature: Date: 5/9/2017

Report by:

Signature: Date: 4/27/17

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Laird Technologies Test Services in Review

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01
Scope of accreditation includes all test methods listed herein, unless otherwise noted

Federal Communications Commission (FCC) – USA

Accredited recognition of two 3 meter Semi-Anechoic chambers
Accredited Test Firm Registration Number: 953492

Innovation, Science and Economics Development Canada

ISED Site Listing of two 3 meter Semi-Anechoic Chambers based on RSS-GEN-Issue 4
File Number: IC 3088A-2
File Number: IC 3088A-3

1.0 Summary of Test Report

On April 27th 2017 the EUT, Sterling LWB5, as supplied by Laird Technologies, Inc. was tested and was found to MEET the following requirements:

Operation in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz bands

FCC Rule Part	IC Standard	Test Description	Measurement Procedure	Test Result
15.407 (h)(2)	RSS-247 Section 6.3	Dynamic Frequency Selection	FCC KDB 905462 D02	Pass*
15.407 (h)(2)(ii)	RSS-247 Section 6.3	Channel Availability Check Time	FCC KDB 905462 D02	N/A*
15.407 (h)(2)(iii)	RSS-247 Section 6.3	Channel Move Time	FCC KDB 905462 D02	Pass
15.407 (h)(2)(iv)	RSS-247 Section 6.3	Non-Occupancy period	FCC KDB 905462 D02	Pass

* The EUT is a client only device

2.0 Test Facilities

All testing was performed at:

Laird Technologies Test Services
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA

3.0 Client Information

Manufacturer Name:	Laird Technologies, Inc.
Address:	W66N220 Commerce Ct. Cedarburg, WI 53012
Contact Person:	Bill Steinike

3.1 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Sterling-LWB5 Module
Model Number:	Sterling-LWB5
Serial Number:	Engineering sample

3.2 Product Description

The Sterling-LWB5 is a multi-standard module with support for WLAN (802.11 a/b/g/n/ac), Bluetooth 2.1+EDR, Bluetooth 3.0, and Bluetooth 4.1 (Bluetooth Low Energy) with multiple antenna options.

Chip Antenna: Johanson Part # 2450AD14A5500 peak gain 1.0 dBi (2.4 GHz) / 4.0 dBi (5.5 GHz)

U.FL Antenna port utilizes the following antenna options:

LSR Part #001-0009 2.4 GHz Dipole Antenna peak gain 2.0 dBi (2.4 GHz & 5.5 GHz)

LSR Part #001-0016 2.4 GHz FlexPIFA peak gain 2.5 dBi (2.4 GHz) / 3.0 dBi (5.5 GHz)

3.3 Modifications Incorporated In the EUT for Compliance Purposes

None noted at time of test

3.4 Deviations & Exclusions from Test Specifications

None noted at time of test

3.5 Additional Information

During testing, EUT was paired up with a CISCO AIR-AP2802E-B-K9 (MAC: 0081C46C96E6), FCC ID: LDK102099, IC ID: 2461B-102099, and SN: FJC2052M291. Data streaming between the EUT (client) and AP was achieved using 'iperf'. The link established used a communication bandwidth of 80MHz with a center frequency at 5530MHz.

4.0 Conditions of Test

Environmental:

Temperature: 20-25º C
Relative Humidity: 30-60%
Atmospheric Pressure: 86-106 kPa

Mains Voltage: 120 VAC 60 Hz

5.0 Test Equipment

All test equipment is calibrated by a calibration laboratory accredited by A2LA to the requirements of ISO 17025. For a complete list of test equipment and calibration dates, see Appendix A. Unless otherwise noted, resolution bandwidth of measuring instrument used during testing for given frequency range, see below.

Frequency Range	Resolution Bandwidth
9 kHz – 150 kHz	200 Hz
150 kHz – 30 MHz	9 kHz
30 MHz – 1000 MHz	120 kHz
Above 1000 MHz	1 MHz

6.0 Conformance Summary

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Subpart E Part and RSS-247 DFS requirements.

<u>If some emissions are seen to be within 3 dB of their respective limits</u>:
As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

Laird Technologies, Inc. certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

Appendix A – Test Equipment

LSR
a Laird Business

Date : 6-Feb-2017 Type Test : 5 GHz WLAN DFS Job # : C-2602

Prepared By: Aidi Customer : LSR Quote #: 316356

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration
2	CC 000314C	Vector Signal Generator	Agilent	E4438C	US 41469143	4/29/2015	4/28/2017	Active Calibration
3	CC 000710C	Oscilloscope	Agilent	MSO8104A	MY45001068	11/22/2016	11/22/2017	Active Calibration
4	CC 000259C	Function / Arbitrary Waveform Generator	Agilent	33250A	US40000583	11/21/2016	11/21/2017	Active Calibration

Project Engineer: Kimberly Bay Quality Assurance: Adam Alger

Appendix B – Test Data
B.1 – DFS

Manufacturer	Laird Technologies, Inc.
Test Location	Laird Technologies Test Services
Rule Part	FCC Subpart E IC RSS-247
General Measurement Procedure	Client without Radar Detection Requirements Prior to Use of a Channel 1. Non-Occupancy Period minimum 30 minutes Client without Radar Detection Requirements During Normal Operation 1. Channel Closing Time 200 ms + an aggregate of 60 ms over remaining 10 second period using Radar Type 0 starting at beginning of Channel move time plus any additional control signals not counting quiet periods during the remaining 10 second period. 2. Channel Move Time 10 seconds using Radar Type 0 Radar Type 0 Pulse width = 1 µsec PRI = 1428 µsec Number of Pulses = 18
General Description of Measurement	Conducted Setup for Client with injection at the Master (Section 7.2.2) (see setup photo exhibit) Radar Test Signal Generator = Arbitrary Waveform Generator + Signal Generator with Ext pulse input EUT Setup to connect to CISCO AIR-AP28025-B-K9 AP and perform data streaming using 'I-Perf'. The streaming link was over an 802.11ac 80MHz channel on 5530MHz. Channel loading was shown to be greater than 17%.

7.2.2 Setup for Client with injection at the Master

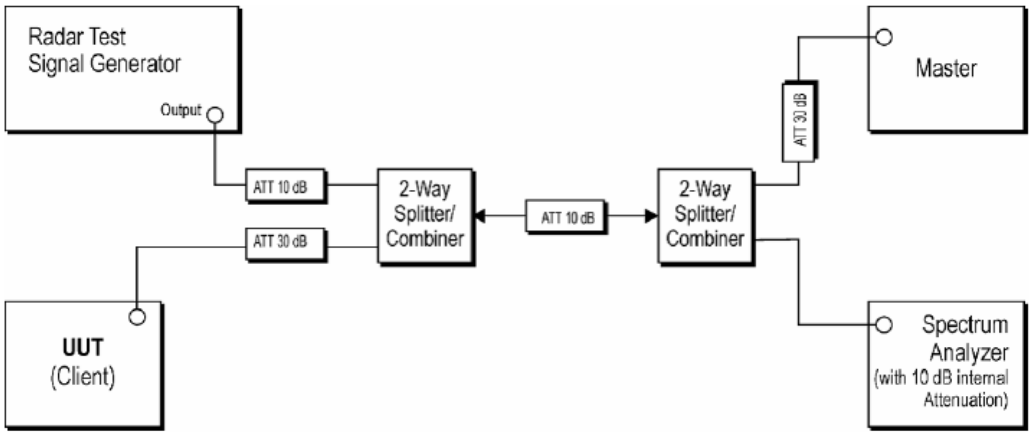
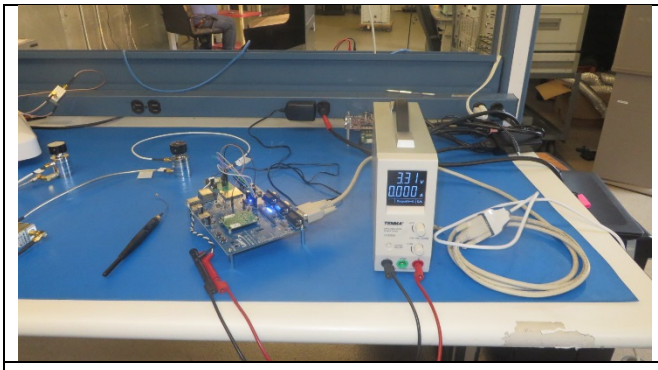
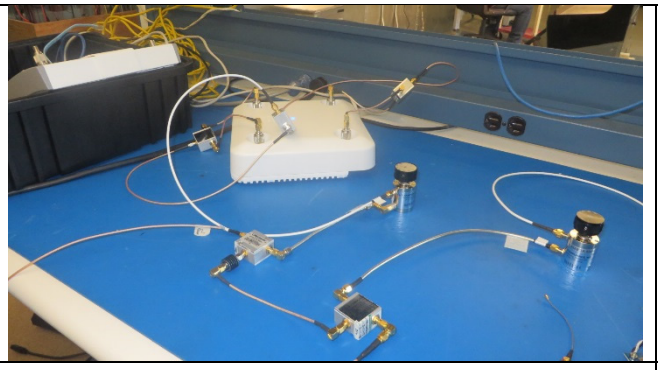
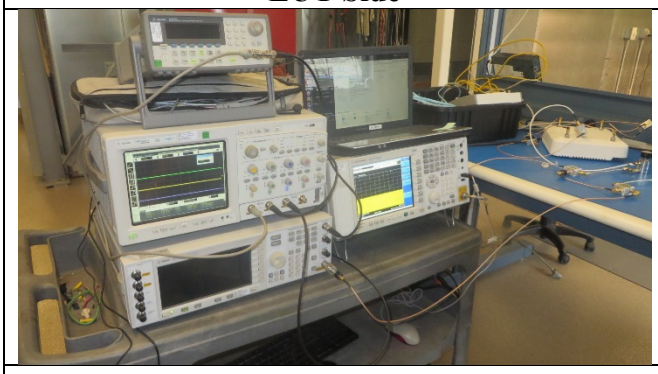
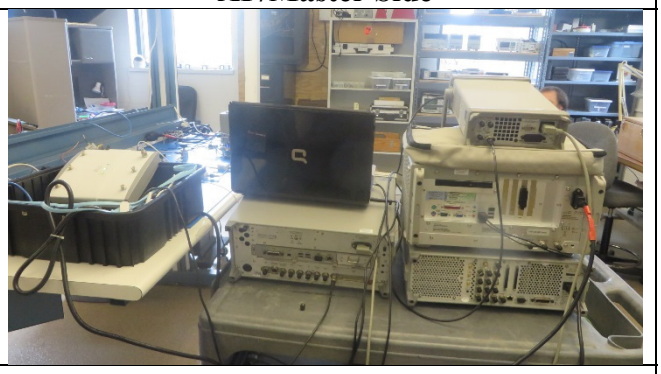
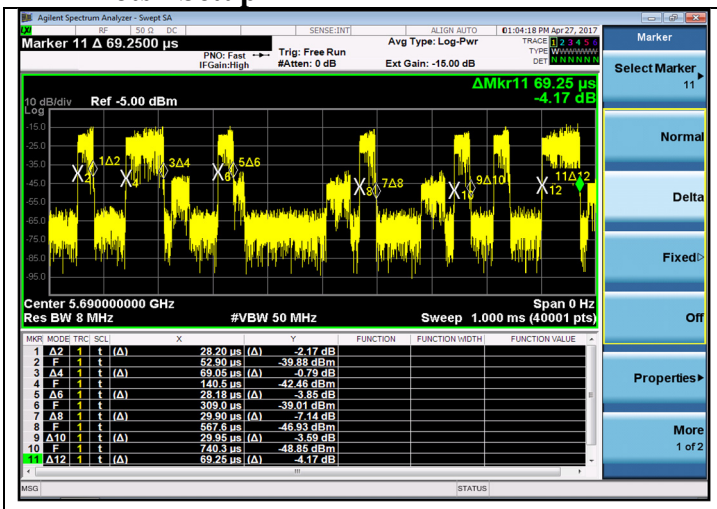


Figure 3: Example Conducted Setup where UUT is a Client and Radar Test Waveforms are injected into the Master

EUT Test Setup

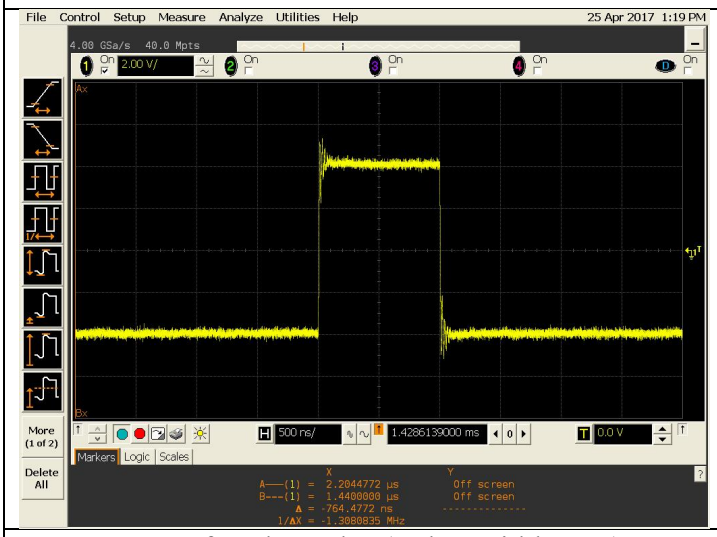
<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>EUT Side</td><td>AP/Master Side</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Radar pulse and monitoring Equipment</td><td>Radar pulse and monitoring Equipment</td></tr>
</table>

Plots - Setup



Channel loading = 28.8% > 17%

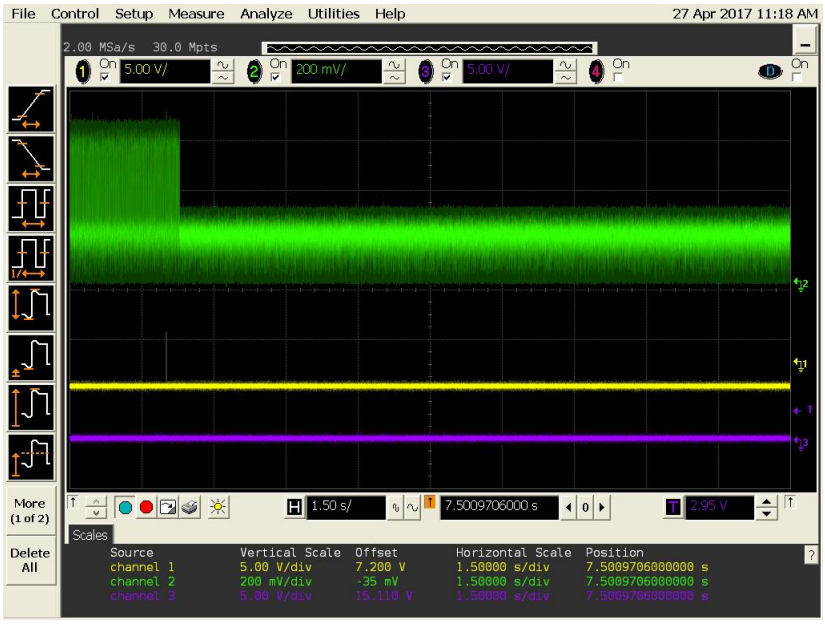
Setup of Radar Pulse (18 Pulses)



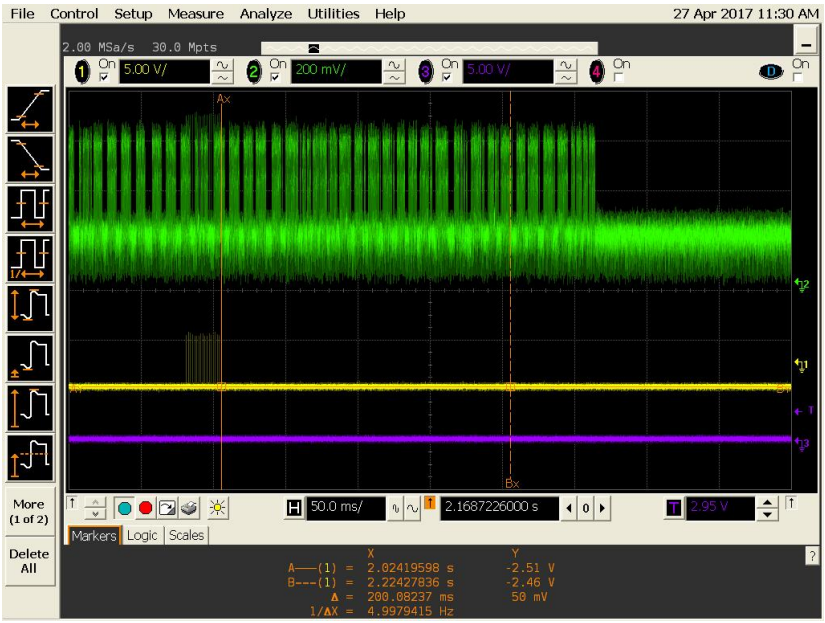
Setup of Radar Pulse (Pulse Width 1 µs)

Setup of Radar Pulse (PRI 1.428 ms)

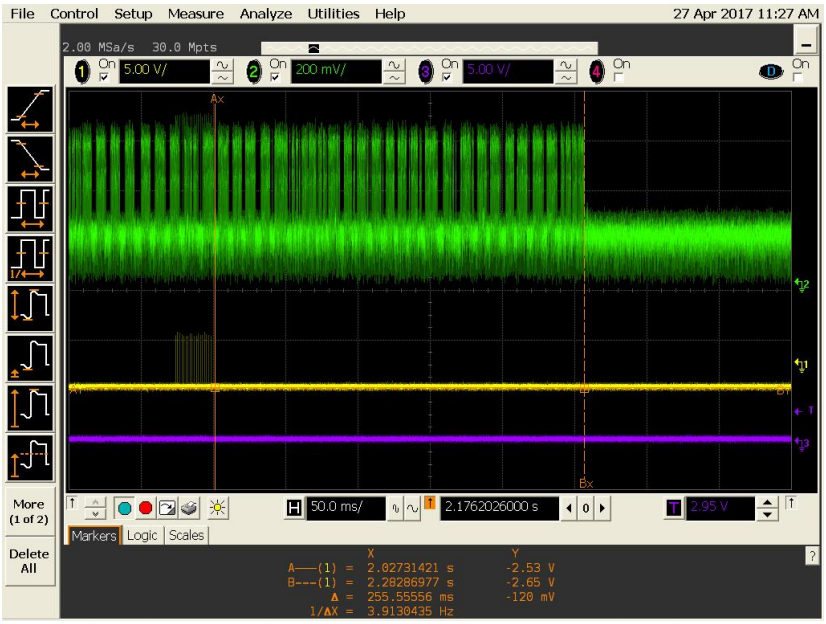
Plots - Performing the test



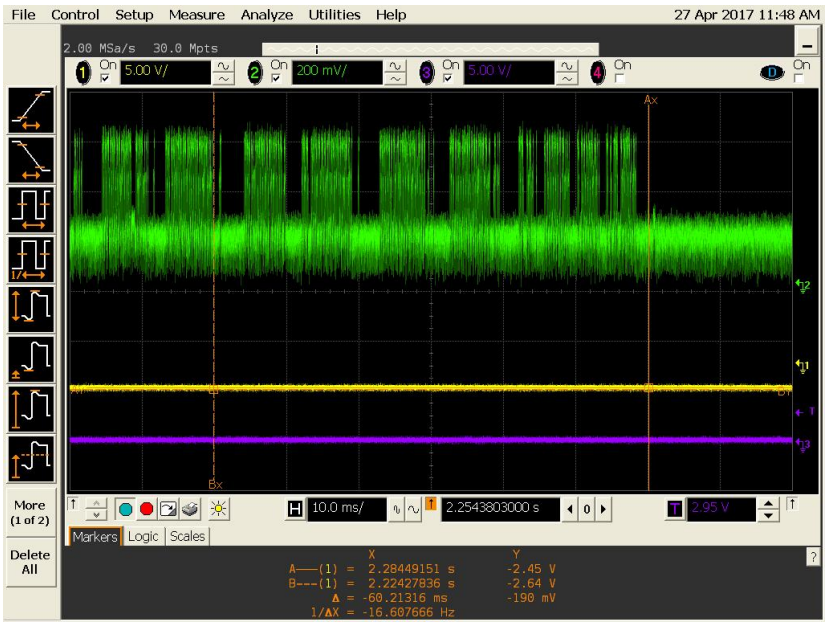
Radar pulse introduced at 2 seconds mark and extends beyond 10 seconds. Note the radar pulse in the yellow trace.



Plot showing start of closing time (Marker A)

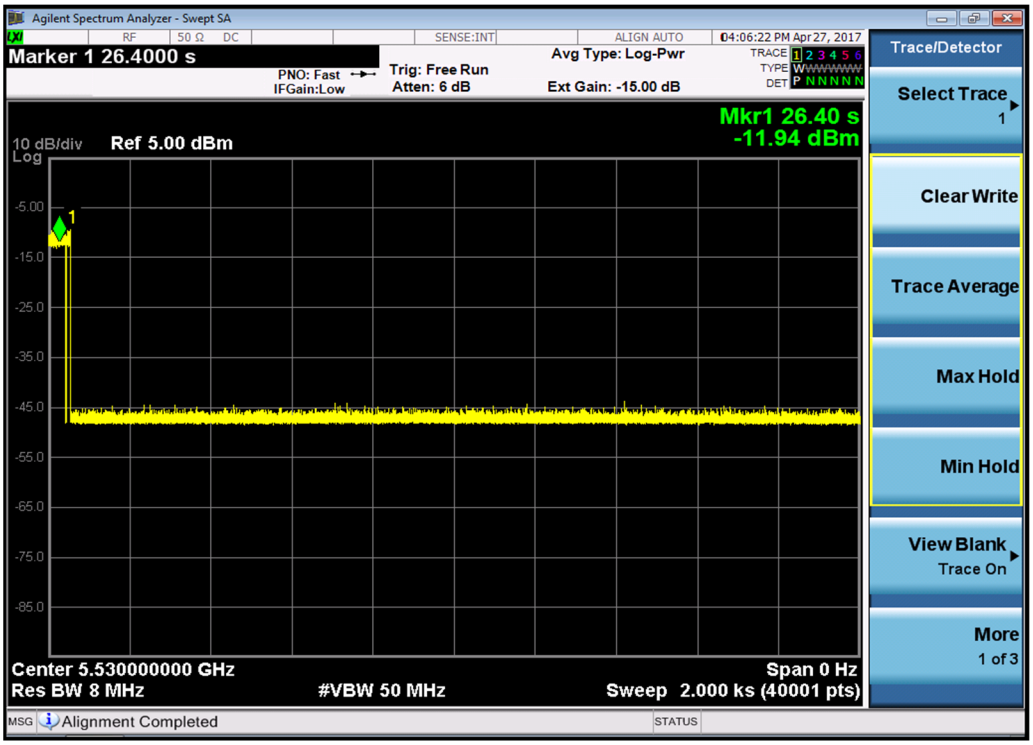


Plot showing that all forms of transmissions are concluded in 255ms



Plot showing that transmissions after the first 200ms is less than 60ms. Refer to the delta between marker A and B.

Non-Occupancy Period



Plot above shows that there are no transmissions on the channel for more than 30 minutes after radar had been detected.

Information as required by KDB 905462 D02 Section 8:

Section 8.1:

8.1 Complete description of the U-NII device	
a) The operating frequency range(s) of the equipment.	5260MHz - 5320MHz, 5500MHz-5700MHz
b) The operating modes (Master and/or Client) of the U-NII device. Bridge modes and MESH modes, as applicable, must be included in the description.	Client with no radar detection capability
c) For Client devices, indicate whether or not it has radar detection capability and indicate the FCC identifier for the Master U-NII Device that is used with it for DFS testing.	Client with no radar detection capability. Master used with testing, FCCID LDK102099.
d) List the highest and the lowest possible power level (equivalent isotropic radiated power (EIRP)) of the equipment.	Highest EIRP = 13.8dBm + 4.0dBi = 17.8dBm Lowest EIRP = 7.7dBm + 4.0dBi = 11.7dBm
e) List all antenna assemblies and their corresponding gains.	Refer to section 3.2 of this report
1) If radiated tests are to be performed, the U-NII Device should be tested with the lowest gain antenna assembly (regardless of antenna type). The report should indicate which antenna assembly was used for the tests. For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.	Not Applicable
2) If conducted tests are to be performed, indicate which antenna port/connection was used for the tests and the antenna assembly gain that was used to set the DFS Detection Threshold level during calibration of the test setup.	Not Applicable- EUT Client only
i) Indicate the calibrated conducted DFS Detection Threshold level.	Not Applicable- EUT Client only
ii) For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.	No adjustable power. Maximum EIRP = 17.8dBm
iii) Indicate the antenna connector impedance. Ensure that the measurement instruments match (usually 50 Ohms) or use a minimum loss pad and take into account the conversion loss.	50 ohms
3) Antenna gain measurement verification for tested antenna.	Not Applicable- EUT Client only
i) Describe procedure	Not Applicable- EUT Client only
ii) Describe the antenna configuration and how it is mounted	Not Applicable- EUT Client only
iii) If an antenna cable is supplied with the device, cable loss needs to be taken into account. Indicate the maximum cable length and either measure the gain with this cable or adjust the measured gain accordingly. State the cable loss.	Antenna cable was accounted in te gain measurement.
f) Test sequences or messages that should be used for communication between Master and Client Devices, which are used for Channel load	EUT and Master running 'Iperf' to stream data
1) Stream the test file from the Master Device to the Client Device for IP based systems or frame based systems which dynamically allocate the talk/listen ratio.	EUT and Master running 'Iperf' to stream data
2) For frame based systems with fixed talk/listen ratio, set the ratio to the worst case (maximum) that is user configurable during this test as specified by the manufacturer and stream the test file from the Master to the Client.	Not applicable
3) For other system architectures, supply appropriate Channel loading methodology.	Not applicable
g) Transmit Power Control description—Provide a description.	Not Applicable
h) System architectures, data rates, U-NII Channel bandwidths — Indicate the type(s) of system architecture (e.g. IP based or Frame based) that the U-NII device employs. Each type of unique architecture must be tested.	Channel bandwidths: 20MHz, 40MHz and 80MHz. Data rates: 6MBPS - MCS9
i) The time required for the Master Device and/or Client Device to complete its power-on cycle.	Client device takes less than 10 seconds to boot up
j) Manufacturer statement confirming that information regarding the parameters of the detected Radar Waveforms is not available to the end user.	See Software security exhibit
k) The manufacturer is permitted to select the first channel either manually or randomly. The manufacturer may also block DFS channels from use.	Not applicable-EUT client device only

Section 8.2

8.2 Complete description of the Radar Waveform calibration	
a) Description of calibration setup—Block diagram of equipment setup, clearly identifying if a radiated or conducted method was used.	Not Applicable- EUT client device only
b) Description of calibration procedure	Not Applicable- EUT client device only
1) Verify DFS Detection Threshold levels	Not Applicable- EUT client device only
i) Indicate DFS Detection Threshold levels used.	Not Applicable- EUT client device only
ii) Consider output power range and antenna gain.	Not Applicable- EUT client device only
2) For the Short Pulse Radar Types, spectrum analyzer plots of the burst of pulses on the Channel frequency should be provided.	Supplied in this report
3) For the Long Pulse Radar Type, spectrum analyzer plot of a single burst (1-3 pulses) on the Channel frequency should be provided.	Not Applicable- EUT client device only
4) Describe method used to generate frequency hopping signal.	Not Applicable- EUT client device only
5) The U-NII Detection Bandwidth	Not Applicable- EUT client device only
6) For the Frequency Hopping waveform, a spectrum analyzer plot showing 9 pulses on one frequency within the U-NII Detection Bandwidth should be provided.	Not Applicable- EUT client device only
7) Verify use of vertical polarization for testing when using a radiated test method.	Not applicable- testing performed conducted
c) When testing a Client Device with radar detection capability, verify that the Client Device is responding independently based on the Client Device's self-detection rather than responding to the Master Device. If required, provide a description of the method used to isolate the client from the transmissions from the Master Device to ensure Client Device self-detection of the Radar Waveform.	Not Applicable- EUT client device only without radar detection capability

Section 8.2

8.3 Complete description of test procedure	
a) Description of deviations to the procedures or equipment described in this document.	No deviations during test
b) Description of DFS test procedure and test setup used to monitor the U-NII device and Radar Waveform transmissions. Provide a block diagram of the signal monitoring equipment setup.	Provided in this report
1) List of equipment	See Appendix A of this report
2) Test setup photos	See Appendix B of this report
c) Description of DFS test procedure and test setup used to generate the Radar Waveforms.	See Appendix B of this report
1) Block diagram of equipment setup	See Appendix B of this report
2) List of equipment	See Appendix A of this report
3) Test setup photos	See Appendix B of this report
4) For each of the waveforms that were used for each signal type, supply the characteristics (pulse width, pulse repetition interval, number of pulses per burst, modulation).	Radar type 0 in KDB905462 D02
5) For selecting the waveform parameters from within the bounds of the signal type, describe how they were selected (i.e., manually or randomly).	Manually using arbitrary waveform generator and signal generator
6) Channel loading description including data type, timing plots, percentage of channel loading calculation, and protocol.	Plots supplied. See appendix B
d) The DFS tests are to be performed on U-NII Channel(s). Refer to Table 2 for additional requirements for devices with multiple bandwidth modes.	Testing performed on UNII channel with 80MHz bandwidth
1) List each Channel frequency that was used for the tests.	5530 MHz (center frequency). 80MHz bandwidth which combines 5500MHz to 5560MHz channels.
2) Data Sheet showing the U-NII Detection Bandwidth for the Channel(s) used during the test.	Not Applicable-EUT client device only
3) Plot of RF measurement system showing its nominal noise floor in the same bandwidth which is used to perform the Channel Availability Check, initial radar bursts, In-Service Monitoring, and 30 minute Non-Occupancy Period tests.	Not Applicable-EUT client device only
e) Timing plot(s) showing compliance with the Channel Availability Check Time requirement of 60 seconds at start up.	Not Applicable-EUT client device only
1) The plot should show the Initial Tpower-up time.	Not Applicable-EUT client device only
2) The plot should include the Initial Tpower-up period in addition to 60 second period.	Not Applicable-EUT client device only
f) Timing plot(s) showing compliance with the Initial DFS radar detection requirements during the 60 second initial Channel Availability Check at start up.	Not Applicable-EUT client device only
1) Plot for DFS radar detection for Radar Waveforms applied 6 seconds after the Initial Tpower-up time period. The minimum length of the plot should be 1.5 minutes after the Tpower-up time period. The plot should show the radar burst at the appropriate time. This test is only required once and Radar Type 0 should be used for the test.	Not Applicable-EUT client device only
2) Plot for DFS radar detection for Radar Waveforms applied 6 seconds before end of the 60 second Channel Availability Check Time. The minimum length of the plot should be 1.5 minutes after the Tpower-up time period. The plot should show the radar burst at the appropriate time. This test is only required once and Radar Types 0 should be used for the test.	Not Applicable-EUT client device only
3) The minimum time resolution of the plots should be sufficient to show the Radar Waveform bursts (overall, not individual pulses within the burst).	Plots provided in Appendix B
g) Verification that when the device is "off" that the RF energy emitted is below the FCC rules for unintentional radiators:	Verified
For the plots of U-NII RF activity versus time, the device is considered to be "off" or not transmitting when intentional U-NII signals (beacons, data packets or transmissions, or control signals) are below the FCC rules for unintentional radiation due to device leakage, oscillator noise, clocks, and other unintentional RF generators.	
h) Spectrum Analyzer, VSA, or some other data gathering Instrument plots showing compliance with the Channel Move Time requirements during in the In-Service Monitoring. The plots need to show U-NII device transmissions on the Channel in the form of RF activity on the vertical axis versus time on the horizontal axis. Only one 10 second plot needs to be reported for Radar Type 0. The plot for the Short Pulse Radar Types should start at the end of the radar burst. The Channel Move Time will be calculated based on the plot of Radar Type 0. The plots need to show U-NII device transmissions on the Channel in the form of RF activity on the vertical axis versus time on the horizontal axis. Sufficient resolution should be used.	Provided in Appendix B
1) The plots and/or data must show the U-NII Device's compliance with the 200 milliseconds limit on data transmission and compliance with the 60 millisecond aggregate limit found in Table 4.	Provided in Appendix B
2) Indicate the total number of times the test was performed.	Not Applicable-EUT client device only
3) Indicate a detect/not detect for each waveform within a signal type and the number of failures and the number of successful radar detection times within the time limit. Sample data sheets are shown in Tables 8-11.	Not Applicable-EUT client device only
4) Verify compliance with the minimum percentage of successful detection requirements found in Tables 5-7.	Not Applicable-EUT client device only
i) Spectrum Analyzer plot(s) showing compliance with the 30 minute Non-Occupancy Period requirement. Only one plot is required. This is a separate test that is performed in addition to the other In-Service Monitoring tests.	Provided in Appendix B

Appendix C - References

Publication	Year	Title
FCC CFR Parts 0-15	2017	Code of Federal Regulations – Telecommunications
RSS-247 Issue 2	2017	Digital Transmissions Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN Issue 4	2014	General Requirements and Information for the Certification of Radio Apparatus
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.
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing Unlicensed Wireless Devices
FCC KDB 905462 D02 v02	2016	UNII DFS Compliance Procedures New Rules v01r02

END OF REPORT

Date	Version	Comments	Person
4/28/17	V0	Initial Draft Release	KB
5/9/17	V1	Final	KB