PCTEST
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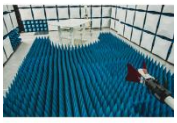

MEASUREMENT REPORT
FCC PART 15.407 / ISED RSS-247 DFS

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
06/12/2020-07/23/2020
Test Site/Location:
PCTEST. Morgan Hill, CA, USA
Test Report Serial No.:
1C2004270015-06.BCG

FCC ID:	**BCG-A2291**
IC:	**579C-A2291**
APPLICANT:	**Apple Inc.**

Application Type:	Certification
Mode/HVIN:	A2291
EUT Type:	Client Only Device, No Radar Detection Capability
Max. RF Output Power:	44.668 mW (16.50 dBm) Conducted (802.11n UNII Band 2A) 44.259 mW (16.46 dBm) Conducted (802.11n UNII Band 2C)
Frequency Range:	5250 – 5350 MHz (UNII-2A Band) 5470 – 5725 MHz (UNII-2C Band)
FCC Classification:	Unlicensed National Information Infrastructure (UNII)
FCC Rule Part(s):	Part 15 Subpart E (15.407)
ISED Specification:	RSS-247 Issue 2
Test Procedure(s):	KDB 905462 D02 v02

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in KDB 905462 D02 v02 Compliance Measurement Procedures for Unlicensed-National Information Infrastructure Devices Operating in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz Bands Incorporating Dynamic Frequency Selection. Test results reported herein relate only to the item(s) tested.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Randy Ortanez
President

ACCREDITED
CERT #2041.02

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Scope

This report has been prepared to demonstrate compliance with the requirements for Dynamic Frequency Selection (DFS) as stated in KDB 905462 D02 v02. As of July 20, 2007, all devices operating in the 5250 – 5350 MHz and/or the 5470 – 5725 MHz bands (excluding 5600-5650MHz for ISED Canada) must comply with the DFS requirements.

1.2 PCTEST Test Location

These measurement tests were conducted at the PCTEST facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at PCTEST located in Morgan Hill, CA 95037, U.S.A.

- PCTEST is an ISO 17025-2005 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 for Specific Absorption Rate (SAR), Hearing Aid Compatibility (HAC) testing, where applicable, and Electromagnetic Compatibility (EMC) testing for FCC and Innovation, Science, and Economic Development Canada rules.

- PCTEST TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC 17065-2012 by A2LA (Certificate number 2041.03) in all scopes of FCC Rules and ISED Standards (RSS).

- PCTEST facility is a registered (22831) test laboratory with the site description on file with ISED.

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Watch FCC ID: BCG-A2291**. The test data contained in this report pertains only to the emissions due to the EUT's UNII transmitter. As the EUT does not have radar detection capability it was evaluated as a Client Only Device. All test results reported herein are applicable to the sample selected for testing.

Mode of Operation:

Master Device	☐
Client Device (No radar detection)	☒
Client Device with Radar Detection	☐

Test Device Serial No.: GY6CN0A7Q5YJ

2.2 Device Capabilities

This device contains the following capabilities:

802.11b/g/n WLAN, Bluetooth (1x, EDR, HDR4, HDR8, LE), NFC, 802.11a/n UNII, UWB

Band 1		Band 2A		Band 2C		Band 3	
Ch.	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**
36	5180	52	5260	100	5500	149	5745
:	:	:	:	:	:	:	:
42	5210	56	5280	116	5580	157	5785
:	:	:	:	:	:	:	:
48	5240	64	5320	144	5720	165	5825

Table 2-1. 802.11a / 802.11n (20MHz) Frequency / Channel Operations

2.3 Antenna Description

Following antenna was used for the testing.

Frequency [GHz]	Antenna Gain (dBi)
	FCM
5.150 – 5.250	-2.3
5.250 – 5.350	-2.9
5.470 – 5.725	-5.3
5.725 – 5.850	-4.1

Table 2-2. Highest Antenna Gain

2.4 Test Support Equipment

The following equipment was used in support of the DFS testing.

Device	Manufacturer	Model	Description	S/N:	FCC ID:
Master	Apple	A1521	Access Point	C86L3BA8FJ1R	BCGA1521
		MacBook	Controller	C02P41RZG086	QDS-BRCM1072
Client	Apple	MacBook	Controller	C02P41RZG086	QDS-BRCM1072
		Kanzi	Lightning Cable	2092FC	N/A

Table 2-3. Test Support Equipment List

2.5 Master Parameters

Parameters of Master:	
Minimum Antenna Gain	1.4 dBi
EIRP Level:	>23 dBm
Access Point Software Version	7.7.9

Table 2-4. Parameters of Master

2.6 Software and Firmware

The test was done with firmware version wOS 7.0. installed on the EUT.

2.7 EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and/or no modifications were made during testing.

3.0 DESCRIPTION OF TESTS

3.1 Evaluation Procedure

The measurement procedures described in KDB 905462 D02 v02 were used in the measurement of the EUT**.** Radiated test methodology was used for the DFS evaluation procedure of the EUT. No deviations to the test procedure and test methods occurred during the evaluation of the EUT.

Deviation from measurement procedure……..…….....None

3.2 Environmental Conditions

The temperature is controlled within range of 15ºC to 35ºC. The relative humidity is controlled within range of 10% to 75%. The atmospheric pressure is monitored within the range 86-106kPa (860-1060mbar).

4.0 ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules/Regulations:
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

- The antennas of the EUT are **permanently attached.**
- There are no provisions for connection to an external antenna.

Conclusion:

The EUT complies with the requirement of §15.203.

5.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty
Time	± 0.02%

6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). Measurements antennas used during testing were calibrated in accordance to the requirements of ANSI C63.5-2017.

Manufacturer	Model	Description	Cal. Date	Cal. Interval	Cal. Due Date	Serial No.
Aeroflex	3025C	PXI RF Synthesizer	7/25/2018	Biennial	7/25/2020	302570726
Aeroflex	3035C	PXI RF Digitizer	7/25/2018	Biennial	7/25/2020	303570427
ETS-Lindgren	3117	Double Ridged Guide Antenna	04/21/2020	Annual	04/21/2021	205956
Rohde & Schwarz	ESW44	EMI Test Receiver	9/13/2019	Annual	9/13/2020	101570
Rohde & Schwarz	TC-TA18	Cross Polarized Vivaldi Antenna	11/14/2019	Annual	11/14/2020	101057

Table 6-1. Test Equipment List

Note:

For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.

7.0 DESCRIPTION OF DYNAMIC FREQUENCY SELECTION TEST

7.1 Applicability

The following table from KDB 905462 D02 v02 lists the applicable requirements for the DFS testing. The device evaluated in this report is considered a client device without radar detection capability.

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

Table 7-1. DFS Applicability

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

Table 7-2. DFS Applicability During Normal Operation

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.		

Table 7-3. Additional Requirement for Devices with Multiple Bandwidth Modes

Per KDB 905462 D02 v02 the operational behavior and individual DFS requirements associated with these modes are as follows:

7.1.1 Master Devices:

a) The Master Device will use DFS in order to detect Radar Waveforms with received signal strength above the DFS Detection Threshold in the 5250 − 5350 MHz and 5470 − 5725 MHz bands. DFS is not required in the 5150 − 5250 MHz or 5725 – 5850 MHz bands.

b) Before initiating a network on a Channel, the Master Device will perform a Channel Availability Check for a specified time duration (Channel Availability Check Time) to ensure that there is no radar system operating on the Channel, using DFS described under subsection a) above.

c) The Master Device initiates a U-NII network by transmitting control signals that will enable other U-NII devices to Associate with the Master Device.

d) During normal operation, the Master Device will monitor the Channel (In-Service Monitoring) to ensure that there is no radar system operating on the Channel, using DFS described under a).

e) If the Master Device has detected a Radar Waveform during In-Service Monitoring as described under d), the Operating Channel of the U-NII network is no longer an Available Channel. The Master Device will instruct all associated Client Device(s) to stop transmitting on this Channel within the Channel Move Time. The transmissions during the Channel Move Time will be limited to the Channel Closing Transmission Time.

f) Once the Master Device has detected a Radar Waveform it will not utilize the Channel for the duration of the Non-Occupancy Period.

g) If the Master Device delegates the In-Service Monitoring to a Client Device, then the combination will be tested to the requirements described under d) through f) above.

7.1.2 Client Devices:

a) A Client Device will not transmit before having received appropriate control signals from a Master Device.

b) A Client Device will stop all its transmissions whenever instructed by a Master Device to which it is associated and will meet the Channel Move Time and Channel Closing Transmission Time requirements. The Client Device will not resume any transmissions until it has again received control signals from a Master Device.

c) If a Client Device is performing In-Service Monitoring and detects a Radar Waveform above the DFS Detection Threshold, it will inform the Master Device. This is equivalent to the Master Device detecting the Radar Waveform and d) through f) of section 5.1.1 apply.

d) Irrespective of Client Device or Master Device detection the Channel Move Time and Channel Closing Transmission Time requirements remain the same.

e) The client test frequency must be monitored to ensure no transmission of any type has occurred for 30 minutes. Note: If the client moves with the master, the device is considered compliant if nothing appears in the client non-occupancy period test. For devices that shutdown (rather than moving channels), no beacons should appear.

7.2 DFS Detection Threshold Values

The DFS detection thresholds are defined for Master devices and Client Devices with In-service monitoring. These detection thresholds are listed in the following table.

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.

Table 7-4: Detection Thresholds for Master Devices and Client Devices with Radar Detection

7.3 DFS Response Requirements

DFS response requirements for Master and Client Devices are listed in the following table.

Parameter	Value
Non-occupancy period	Minimum 30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds See Note1
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Note 1 and 2.
U-NII Detection Bandwidth	Minimum 100% of the U- NII 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 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. frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.	

Table 7-5: DFS Response Requirements

7.5 Parameters of DFS Test Signals

As the EUT is a Client Device with no Radar Detection only one type radar pulse is required for the testing. Radar Pulse type 0 was used in the evaluation of the Client device for the purpose of measuring the Channel Move Time and the Channel Closing Transmission Time. Table 7-6 lists the parameters for the Short Pulse Radar Waveforms. A plot of the Radar Pulse Type 0 used for testing is included in Section 7.7 of this report.

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum 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 $\left\{\frac{1}{360}\cdot\frac{19.10^6}{PRI_{\mu sec}}\right\}$	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.					

Table 7-6: Parameters for Short Pulse Radar Waveforms

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

Table 7-7. Parameters for Long Pulse Radar Waveforms

Radar Type	Pulse Width (µsec)	PRI (µsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Number of Trials
6	1	333	9	0.333	300	70%	30

Table 7-8. Parameters for Frequency Hopping Radar Waveforms

7.6 System Overview and Procedure

DFS Test Setup per KDB 905462 D02 V02:

Radiated DFS Test Setup	☒
Conducted DFS Test Setup	☐

KDB 905462 D02 v02 describes a radiated test setup and a conducted test setup. DFS testing was performed using radiated test setup, as seen in Figure 7-1 below. One channel was selected in Band UNII-2C, between 5470-5725 MHz, for testing.

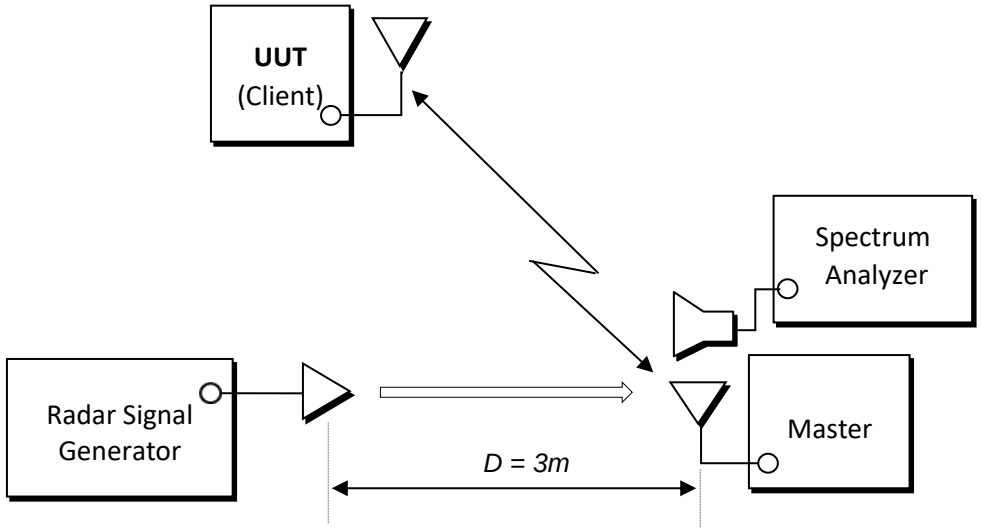

Figure 7-1. Radiated Test Setup for DFS

1. The "Aeroflex PXI DFS Radar Simulator and Analyzer Test Suite" is setup to provide a simulated radar pulse at the frequency that the Master and Client are operating. A Type 0 radar pulse was used.
2. The Client Device (EUT) is set up per the diagram in Figure 7-1 and communications between the Master device and the Client is established.
3. Client (EUT) is connected to Master (AP) via WLAN network. Additional data traffic was sent from the EUT (Client) to AP (Server) using iPerf to properly load the network.
4. The "Aeroflex PXI DFS Radar Simulator and Analyzer Test Suite" is set to record and display 12 seconds of time, starting from where the simulated radar is generated. This time domain plot captures any transmissions occurring up to and after 10 seconds. Aggregate time is computed to ensure compliance. (Note: the channel may be different since the Master and Client have changed channels due to the detection of the initial radar pulse.)
5. After the initial radar burst the channel is monitored for 30 minutes to ensure no transmissions or beacons occur. A second monitoring setup is used to verify that the Master and Client have both moved to different channels.

7.7 System Calibration:

The following equipment setup was used to calibrate the 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. The spectrum analyzer resolution bandwidth (RBW) and video bandwidth (VBW) were set to 3 MHz.

The signal generator amplitude is adjusted so that the power level measured at the spectrum analyzer is equal to the DFS detection threshold -64 dBm. The required radiated threshold at the antenna port is -64dBm + 0dBi + 1dB = -63 dBm (Section 7.2).

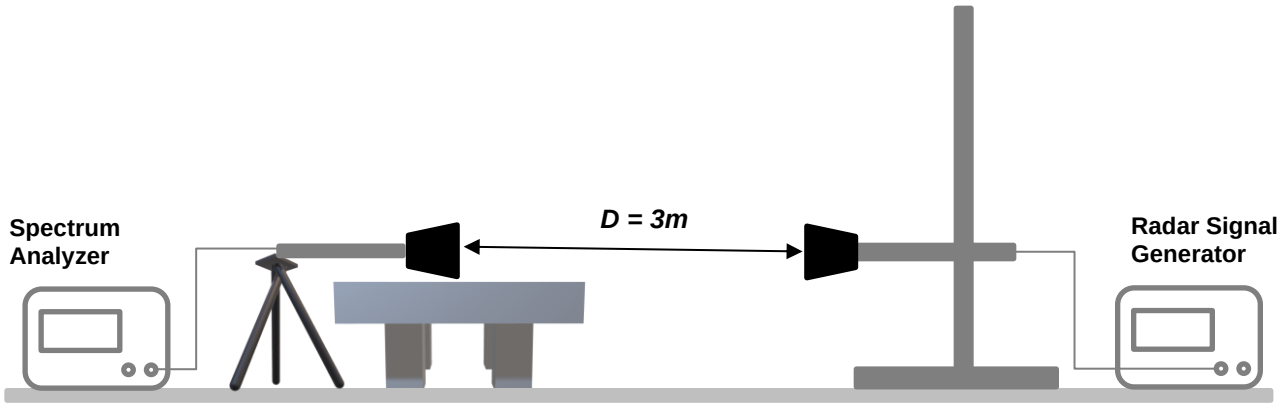

Figure 7-2. Radar Waveform Calibration

Radar Waveform Calibration Plot:

The radiated plot of the Radar Pulse Signals (Type 0) is given below after performing the system calibration as described in Section 7.7.

Short Pulse Radar Type 0:

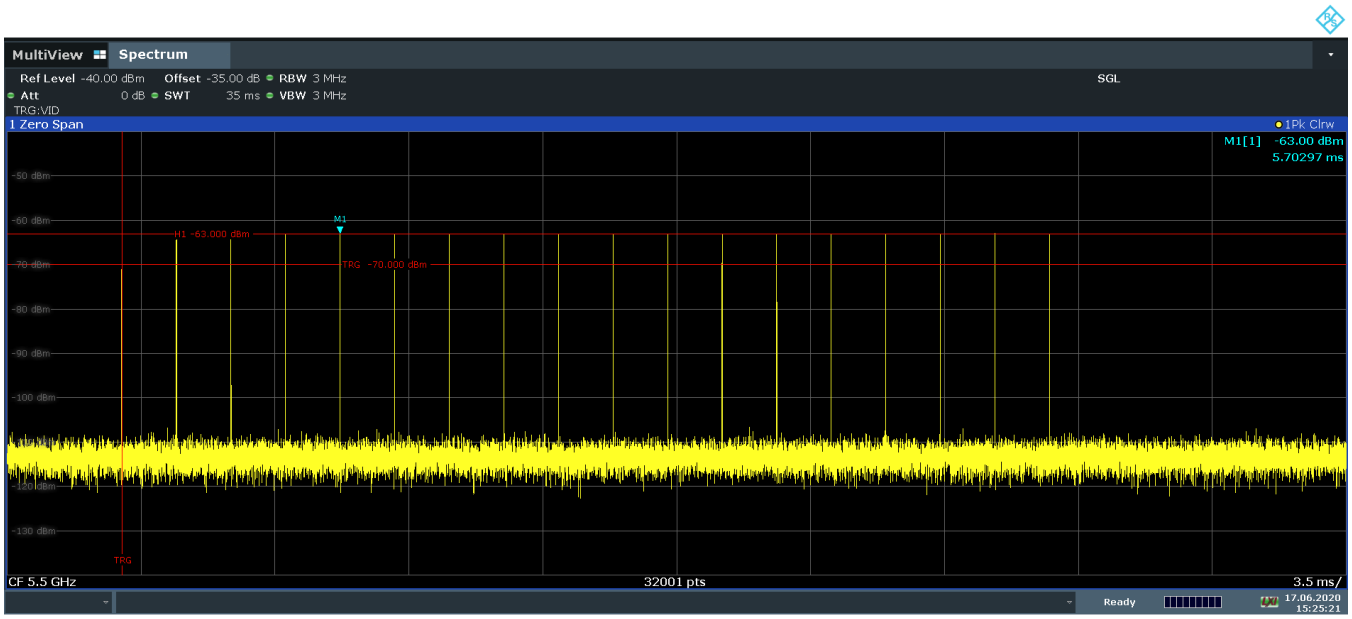

Figure 7-3. 5500MHz – Radar Pulse Type 0 (20MHz)

8.0 EUT TEST SETUP

Client (EUT) is connected to Master (AP) via WLAN network. Additional data traffic was sent from the EUT (Client) to AP (Server) using iPerf to properly load the network. The Vivaldi antenna is adjusted so that the WLAN traffic level, as displayed on the spectrum analyzer, is at lower amplitude than the radar detection threshold.

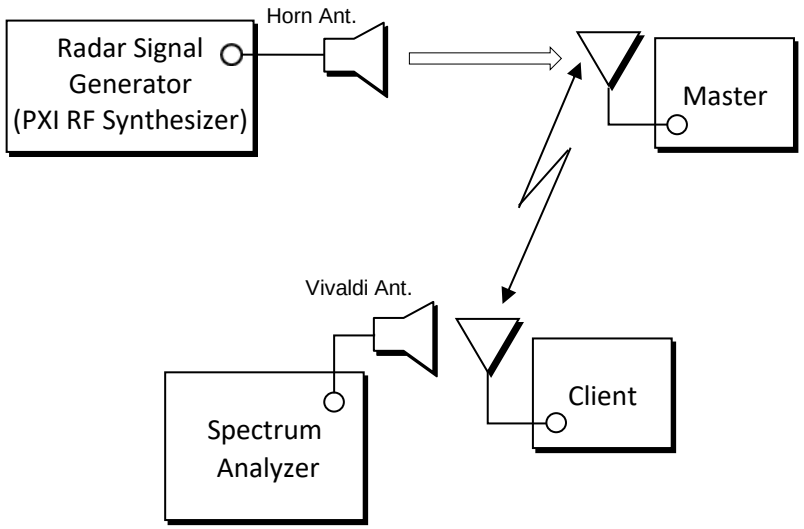

Figure 8-1. Radiated DFS Test Setup

9.0 TEST RESULTS

9.1 Summary

Company Name: Apple Inc.
FCC ID: BCG-A2291
FCC Classification: Unlicensed National Information Infrastructure (UNII)

	Parameter	Measured	Limit	Result
		20MHz Bandwidth		
5470 – 5725 MHz (excluding 5600-5650MHz for ISED Canada) UNII – 2C Band	Channel Move Time	4.138 s	10 seconds	Pass
	Channel Closing Transmission Time	< 200ms + 17.930 ms (aggregate)	200 ms + aggregate of 60ms over remaining 10 second period	Pass
	Non-Occupancy Period	Monitored for 30 minutes with no client transmission	30 Minutes	Pass

Table 9-1. Summary of Test Results

Notes:

1) The EUT was found to be compliant with the requirements for DFS as required for a Client Device per Part 15.407(h), RSS-247 and KDB 905462 D02 v02.
2) Automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance. The list is given below,
   - DFS threshold count v1.1
   - DFS Radar Simulator and Analyzer v2.8 (Aeroflex Inc.)
   - iPerf Software

9.2 Channel Loading

Channel Loading Notes:

Per KDB 905462 D02 v02, timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater. Channel loading can be estimated by setting the spectrum analyzer to zero span and approximate the transmission time.

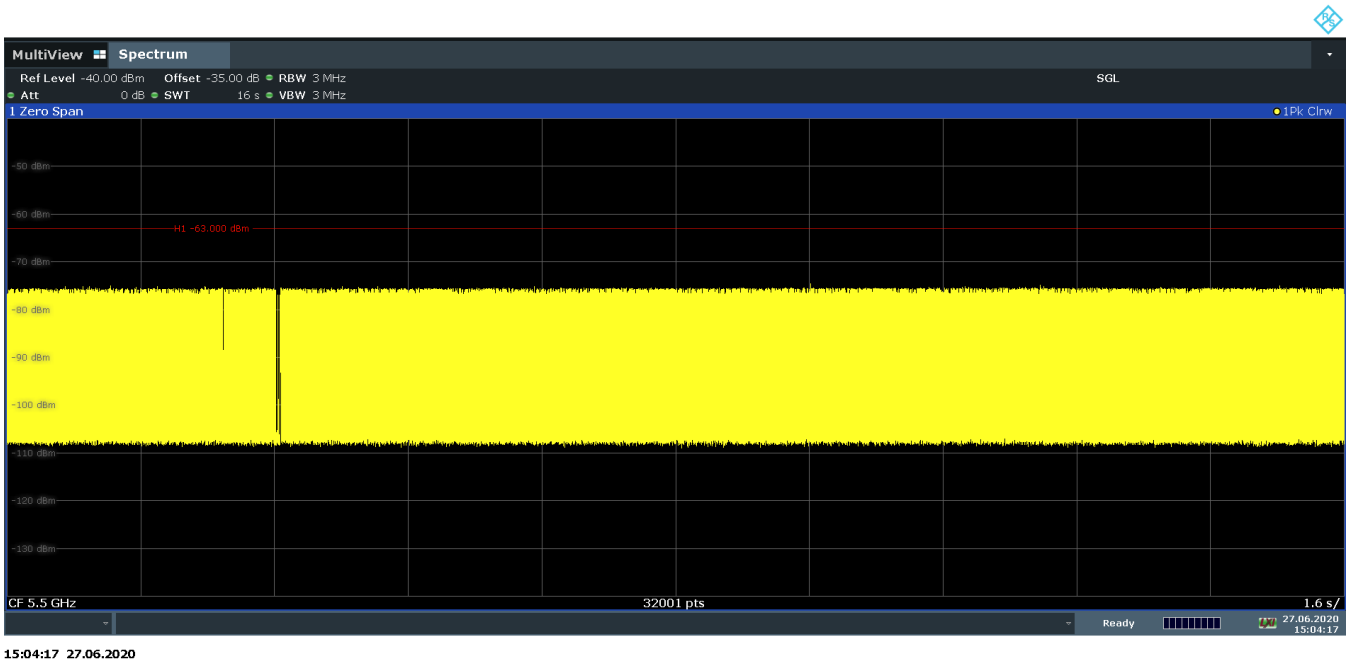

Figure 9-1. 5500MHz - Channel Loading - (20MHz)

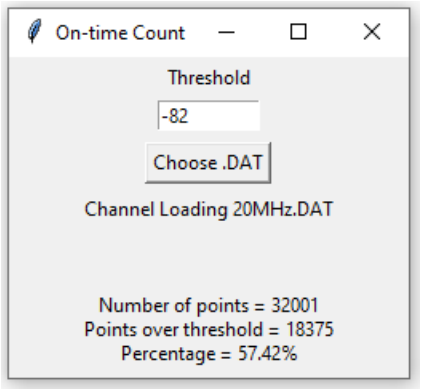

Figure 9-2. 5500MHz - Channel Loading Calculation - (20MHz)

9.3 Channel Move/ Closing Transmission Time

Result

Parameter	Measured	Limit
	20MHz Bandwidth	
Channel Move Time	4.138 s	10 seconds
Channel Closing Transmission Time	< 200ms + 17.930 ms (aggregate)	200 ms + aggregate of 60ms over remaining 10 second period

Notes:

1. The pulses shown in the plots below have been determined to be from the Master AP.
2. Marker Info and Aggregate time results are shown on the right side of the plots below.

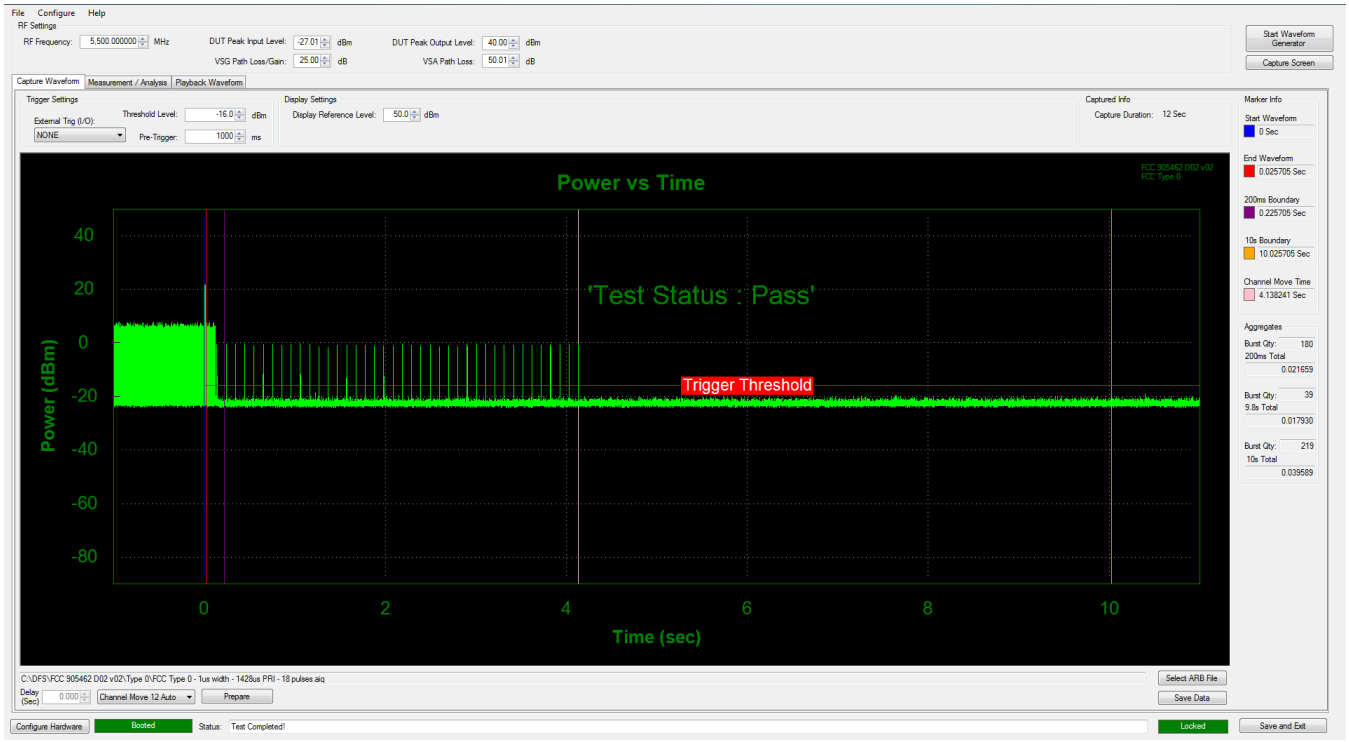

Figure 9-3. 5500MHz - Channel Move/ Closing Transmission Time - (20 MHz)

9.4 Non-Occupancy Period

Notes:

1. No frequency transmission detected during the Non-Occupancy Period of 30 minutes monitoring.

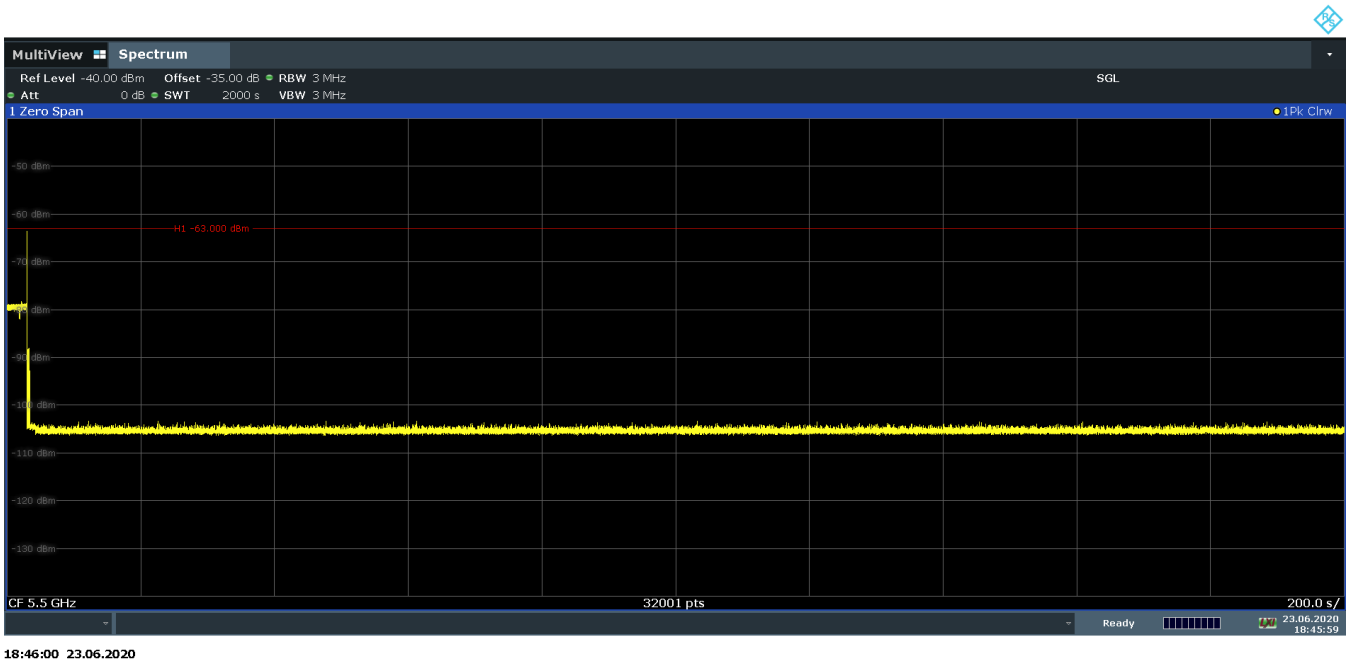

Figure 9-4. 5500MHz - Non-Occupancy Period (30 Minutes) - (20MHz)

10.0 CONCLUSION

The data collected relate only to the item(s) tested and show that the **Apple Watch FCC ID: BCG-A2291** is in compliance with the DFS requirements for a Client Device without radar detection in accordance with Part 15.407 of the FCC Rules and RSS-247 of the Innovation, Science and Economic Development Canada Rules.