DFS TEST REPORT

Part 15 Subpart E 15.407

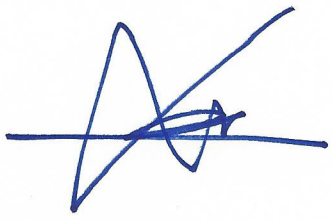
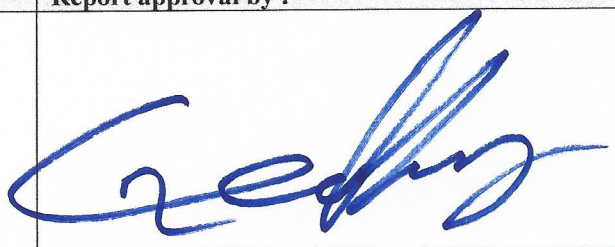
Equipment under test	WiFi Module
Model name	SWL-Q93T
Derivative Model	SWL-CQ93
FCC ID	NLMSWLQ93T
Applicant	Hanwha Techwin Co., Ltd.
Manufacturer	Hanwha Techwin Co., Ltd.
Date of test(s)	2015.11.16 ~2015.12.15
Date of issue	2015.12.17

Issued to

Hanwha Techwin Co., Ltd.
1204, Changwon-daero, Seongsan-gu, Changwon-si
Gyeongsangnam-do, South Korea
Tel: +82-70-7147-8361 / Fax: +82-31-8108-3717

Issued by

KES Co., Ltd.
C-3701, Simin-daero 365-40, Dongan-gu, Anyang-si, Gyeonggi-do,431-716, Korea
473-29, Gayeo-ro, Yeoju-si, Gyeonggi-do, 12658, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	Report approval by :
	
Kwon-se Kim / Test engineer	Jeff Do / Technical manager

Revision history

Revision	Date of issue	Test report No.	Description
-	2015.12.17	KES-RF-15T0095	Initial

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1. General information

Applicant:	Hanwha Techwin Co., Ltd.
Applicant address:	1204, Changwon-daero, Seongsan-gu, Changwon-si Gyeongsangnam-do, South Korea
Test site:	KES Co., Ltd.
Test site address:	C-3701, Simin-daero 365-40, Dongan-gu, Anyang-si, Gyeonggi-do,14057, Korea 473-29, Gayeo-ro, Yeoju-si, Gyeonggi-do, 12658, Korea
Rule part(s):	15.407
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering
Application purpose:	☒ Original grant ☐ Class I permissive change ☐ Class II permissive change

1.1. EUT description

Equipment under test	WiFi Module
Frequency range	5 260 ㎒ ~ 5 320 ㎒(802.11a/n_HT20), 5 270 ㎒ ~ 5 310 ㎒(802.11n_HT40) 5 500 ㎒ ~ 5 700 ㎒(802.11a/n_HT20), 5 510 ㎒ ~ 5 670 ㎒(802.11n_HT40)
Model:	SWL-Q93T(Basic), SWL-CQ93(Derivative model)
Modulation technique	DSSS, OFDM
Number of channels	5 260 ㎒ ~ 5 320 ㎒(802.11a/n_HT20) : 4ch 5 270 ㎒ ~ 5 310 ㎒(802.11n_HT40) : 2ch 5 500 ㎒ ~ 5 700 ㎒(802.11a/n_HT20) : 11ch 5 510 ㎒ ~ 5 670 ㎒(802.11n_HT40) : 5ch
Antenna specification	Antenna type: FIPA Antenna
Power source	DC 5 V

1.2. Frequency/channel operations

Band2A

Ch.	Frequency (㎒)	Mode
52	5 260	11a/n_HT20
. .	. .	. .
60	5 300	11a/n_HT20
. .	. .	. .
64	5 320	11a/n_HT20

Ch.	Frequency (㎒)	Mode
54	5 270	11n_HT40
. .	. .	. .
62	5 310	11n_HT40

Band2C

Ch.	Frequency (㎒)	Mode
100	5 500	11a/n_HT20
. .	. .	. .
116	5 580	11a/n_HT20
. .	. .	. .
140	5 700	11a/n_HT20

Ch.	Frequency (㎒)	Mode
102	5 510	11n_HT40
. .	. .	. .
110	5 550	11n_HT40
. .	. .	. .
134	5 670	11n_HT40

1.3 Information about derivative model

This is to notify that SWL-CQ93 are same Hardware, Software and components.

2. Description of dynamic frequency selection test

2.1 Applicability

The following table from KDB 905462 D02 v01r02 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 2.1. DFS Applicability

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
Non-Occupancy Period	NA/Yes	Yes

Additional requirements for devices with multiple	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 2.2. DFS Applicability During normal operaion

2.2 Requirements

KDB 905462 D02 v01r02 the following are the requirements for 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

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 U-NII 99% transmission power bandwidth. See Note3.
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 (and 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 the used. For each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.	

Table 2.3. DFS Response Requirement Values

2.3 DFS Detection Thresholds

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 respons. **Note 3:** EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01	

Table 2.4. DFS Detection Thresholds for Master Devices and Client Devices With Radar Detection

2.4 Parameters of DFS Test Signals

As the EUT is a Client Device with no Radar Detection only Zero 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.

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Mnimum Number of Trials
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup: {(1/360)*(19*10 ^{6} PRI μsec)}	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 2.5. Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	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

Table 2.6. Short Pulse Radar Test Waveforms

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	0.333	300	70%	30

Table 2.7. Frequency Hopping Radar Test Waveform

3. Summary of tests

Reference	Parameter	Test results
15.407(h)(iii)(iv)	Channel Move Time	Pass
	Channel Closing Transmission Time	Pass
	Non-Occupancy Period	Pass

Test procedures;
The guidance provided in KDB 905462 D02 v01r02 were used in the measurement of the EUT.

4. DFS (Dynamic Frequency Selection)

Test setup

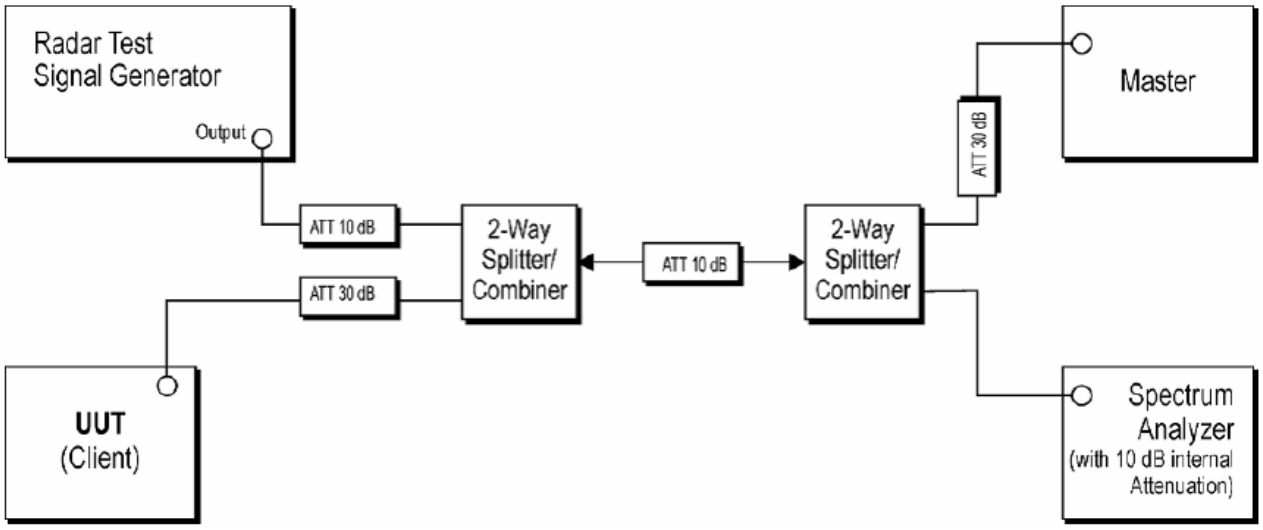


Figure 1: Conducted Test Setup for DFS

Test procedure

KDB 905462 D02 v01r02 describes a radiated test setup and a conducted test setup. The conducted test setup was used for this testing. Figure 1 shows the typical test setup.

In Band 2A, one channel selected between 5260 and 5350 ㎒ is chosen for the testing.

In Band 2C, one channel selected between 5500 and 5720 ㎒ was chosen for testing.

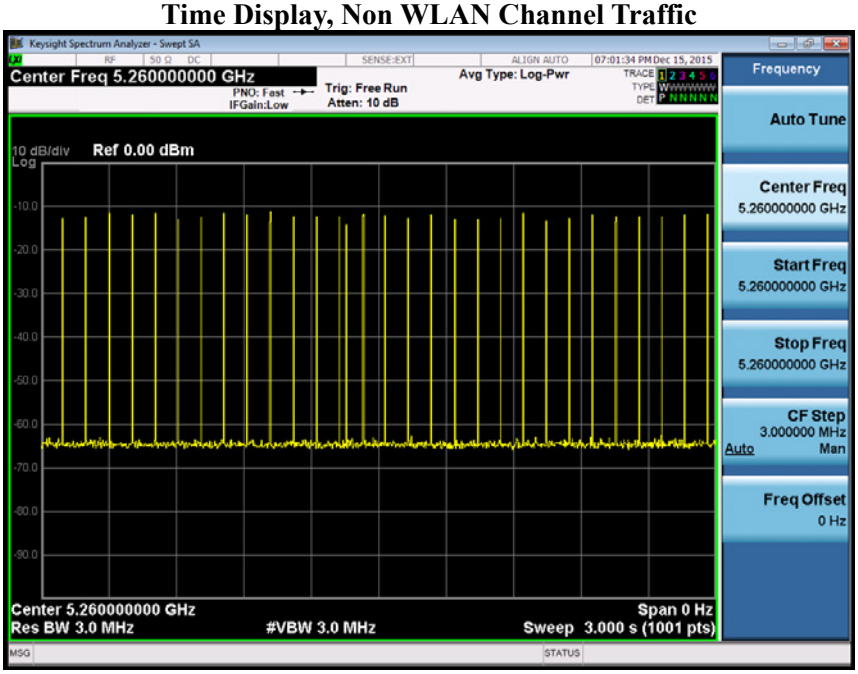
1. The Client Device (EUT) is setup per the diagram in Firure1 and communications between the Master device and the Client is established.
2. An MPEG or data file that is typical for the device is streamed from the Master to the Client to properly load the network.

4.1 Test results

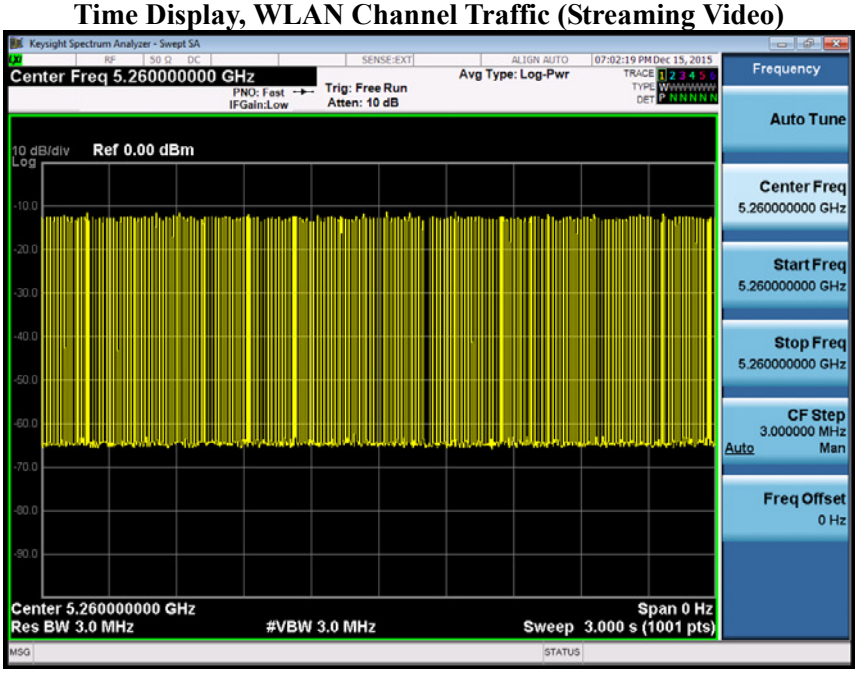
4.1.1 Traffic load

Mode:	802.11 a (Band2A)
Operating frequency:	5 260 ㎒

Time Display, Non WLAN Channel Traffic



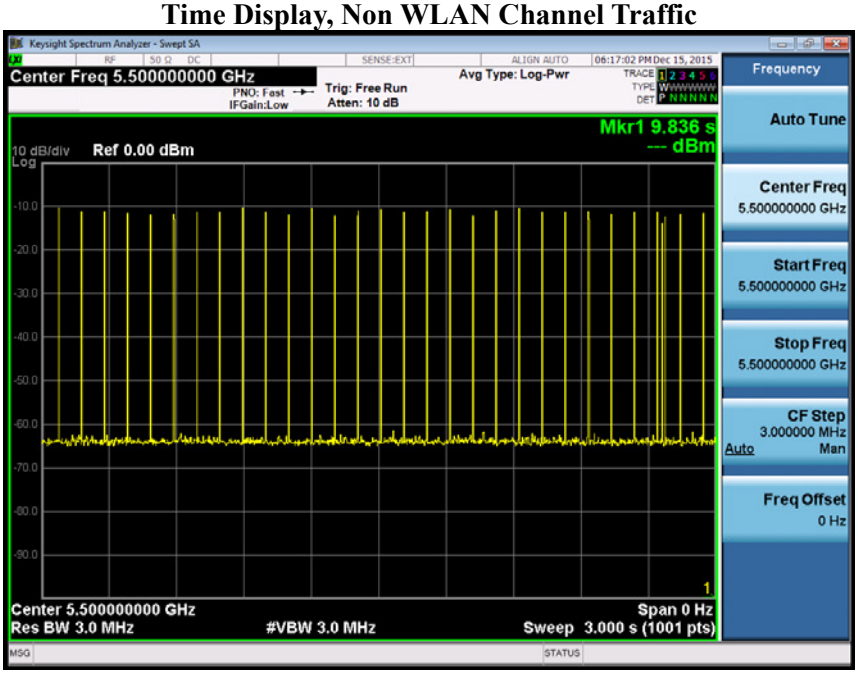
Time Display, WLAN Channel Traffic (Streaming Video)



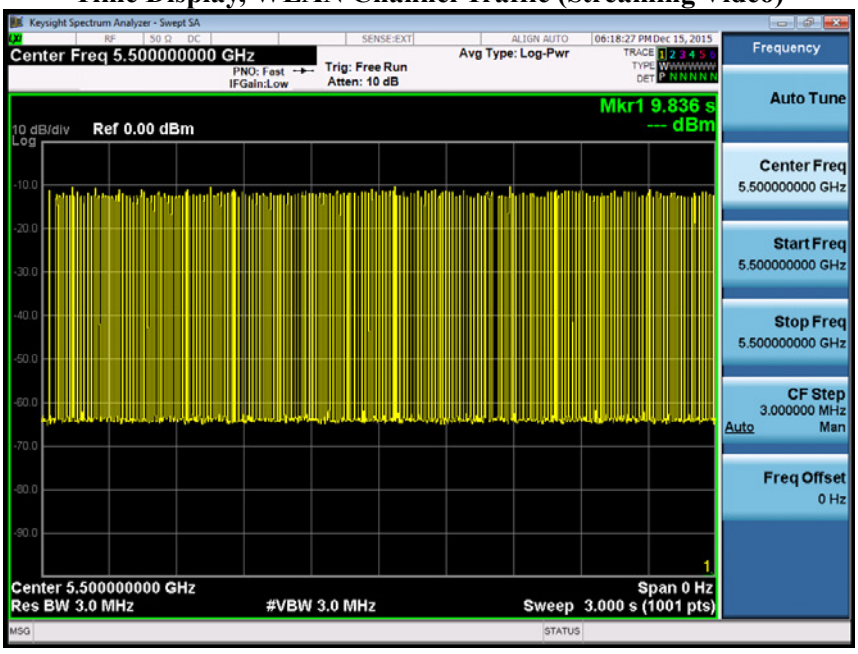
Mode: 802.11 a (Band2C)

Operating frequency: 5 500 ㎒

Time Display, Non WLAN Channel Traffic



Time Display, WLAN Channel Traffic (Streaming Video)



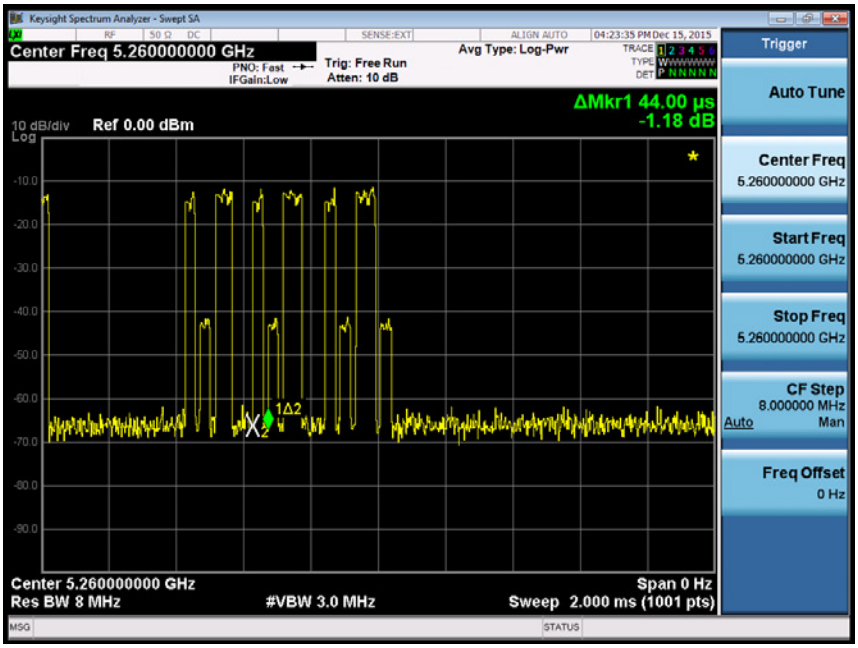
4.1.2 Channel Loading

Mode: 802.11 a (Band2A)

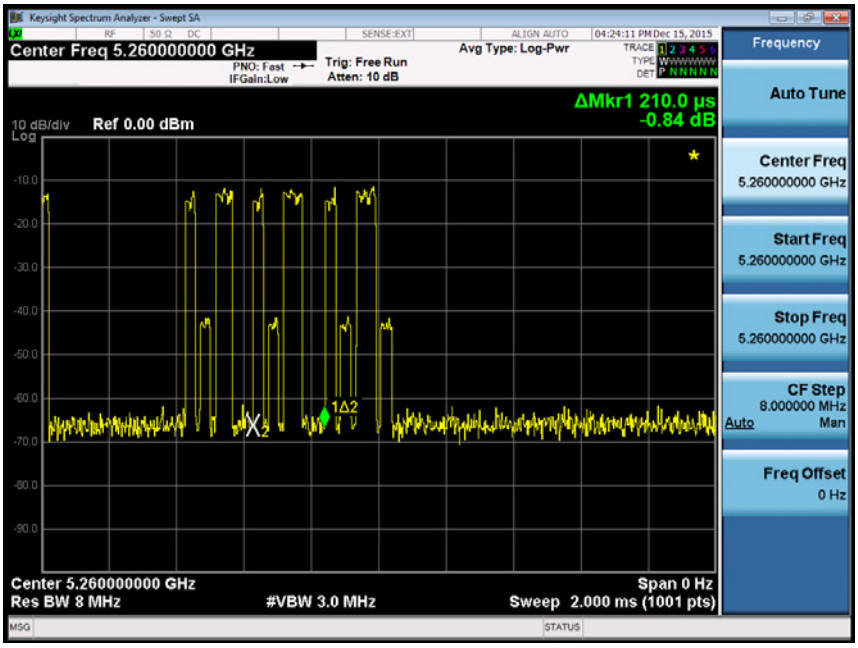
Operating frequency: 5 260 ㎒

Channel Loading = Pulse Width / Period = 44μs / 210 μs = 20.95%

Pulse Width



Period

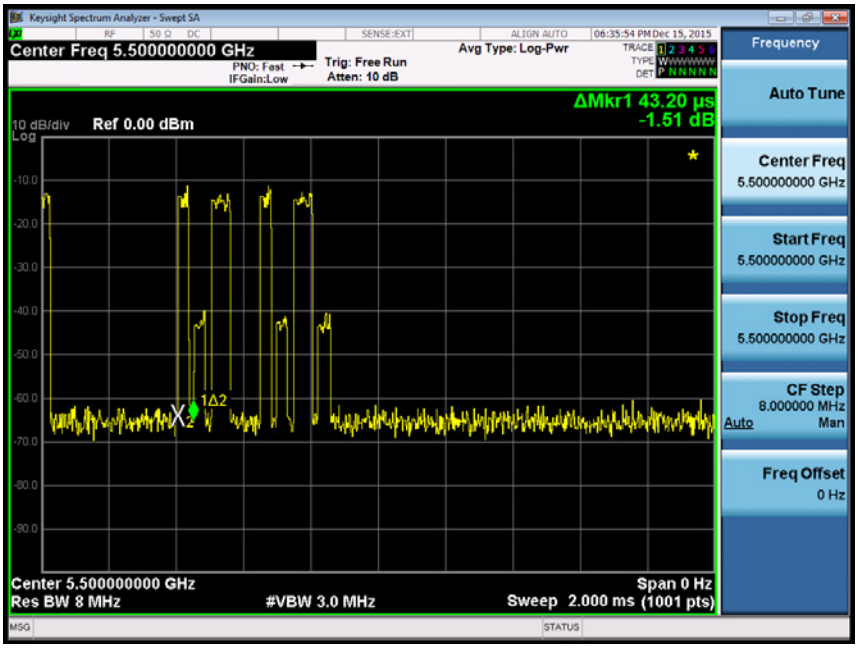


Mode: 802.11 a (Band2C)

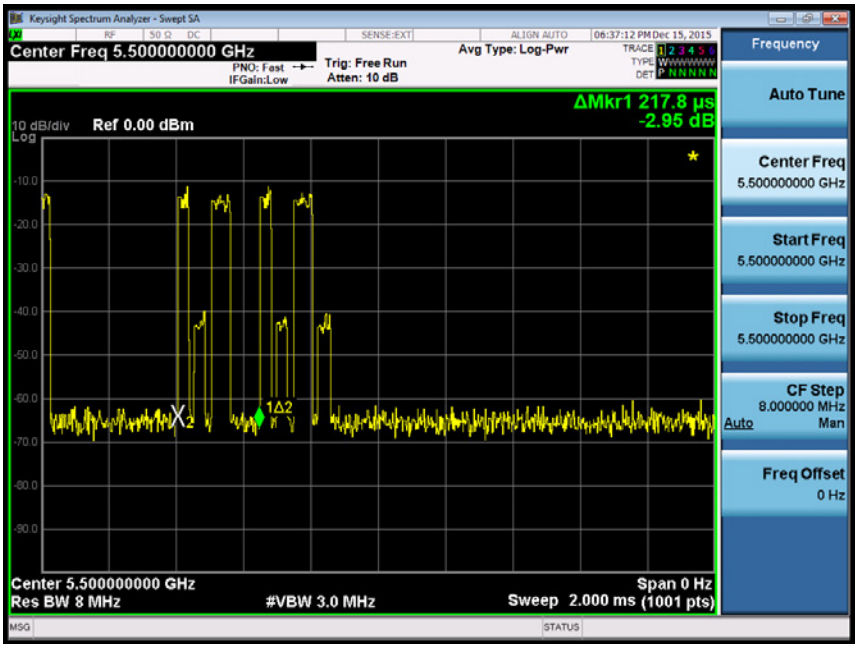
Operating frequency: 5 500 ㎒

Channel Loading = Pulse Width / Period = 43.2μs / 217.8 μs = 19.83%

Pulse Width



Period

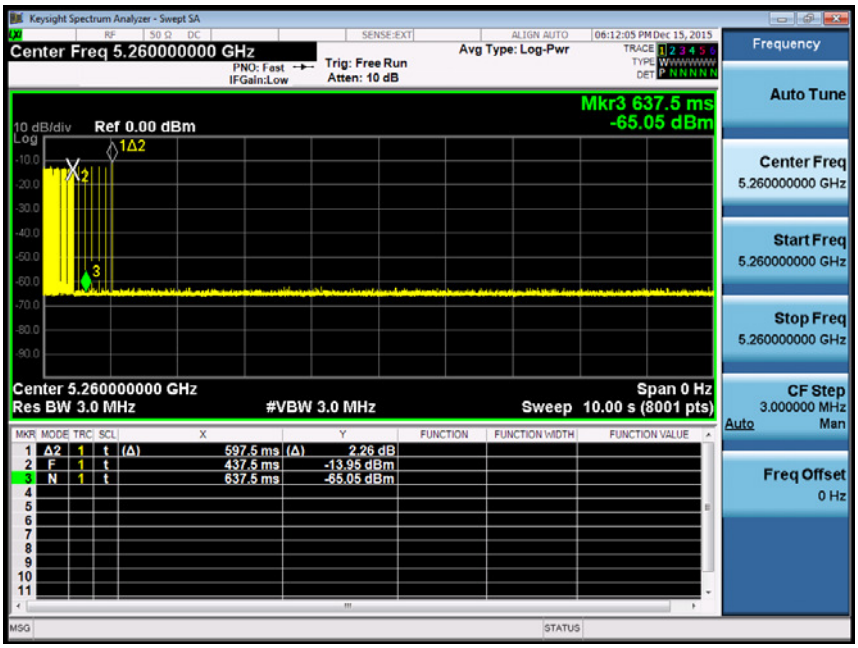


Notes: Per KDB 905462 D02 v01, timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater. For example, you can zero span the spectrum analyzer and approximate the transmission time.

4.1.3 Channel move time & aggregate channel closing transmission time

Mode: 802.11 a (Band2A)

Operating frequency: 5 260 ㎒



Channel closing transmission time calculated	Test results
Sweep time[S] sec	10
Sampling bins[B]	8001
Number of sampling bins in 10 sec[N]	2
Closing transmission time [C] ms	2.49

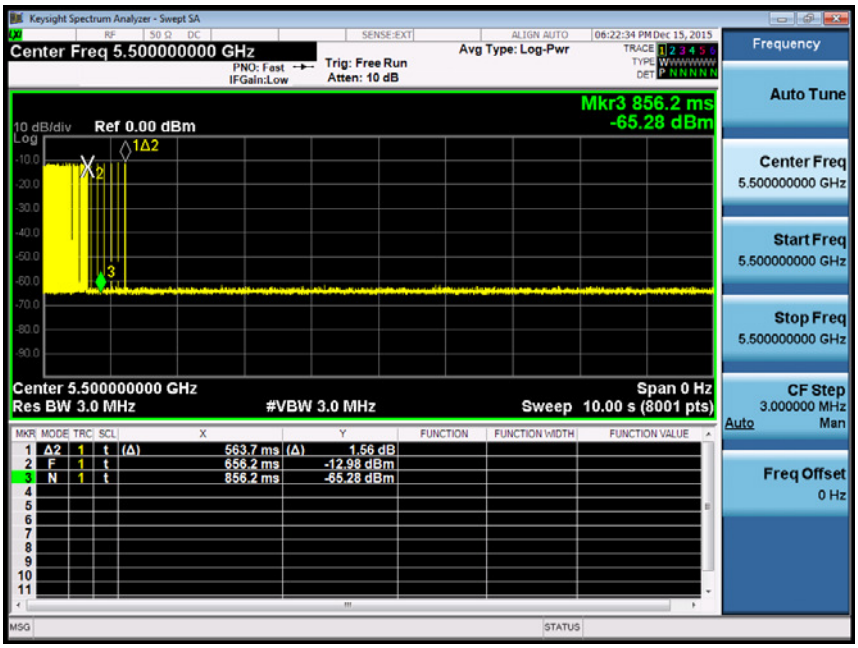
Note:
Dwell = S/B;
Where **dwell** is the dwell time per spectrum analyzer sampling bin, **S** is the sweep time and **B** is the number of spectrum analyzer sampling bins.

An upper bound of the aggregate duration of the channel closing transmission time is calculated by:
C = N × Dwell;
Where **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] = 10 / 8001 = 0.00124
Closing Transmission Time[C] = [N] × [Dwell] = 2 × 0.00124 = 0.00248 s = 2.49 ms
Channel Move Time : 0.5975 s

Mode: 802.11 a (Band2C)

Operating frequency: 5 500 ㎒



Channel closing transmission time calculated	Test results
Sweep time[S] sec	10
Sampling bins[B]	8001
Number of sampling bins in 10 sec[N]	2
Closing transmission time [C] ms	2.49

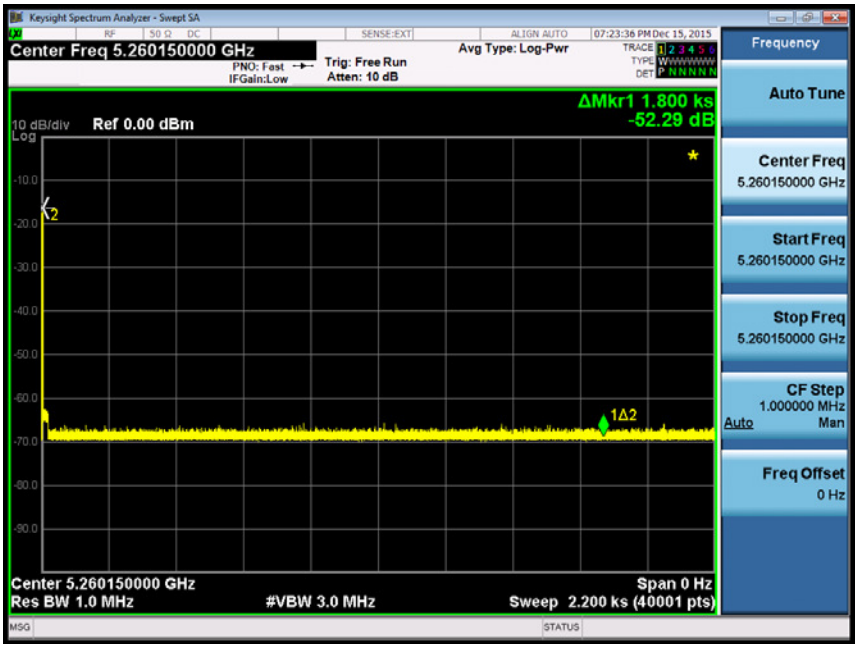
Note:
Dwell = S/B;
Where **dwell** is the dwell time per spectrum analyzer sampling bin, **S** is the sweep time and **B** is the number of spectrum analyzer sampling bins.

An upper bound of the aggregate duration of the channel closing transmission time is calculated by:
C = N × Dwell;
Where **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] = 10 / 8001 = 0.00124
Closing Transmission Time[C] = [N] × [Dwell] = 2 × 0.00124 = 0.00248 s = 2.49 ms
Channel Move Time : 0.5637 s

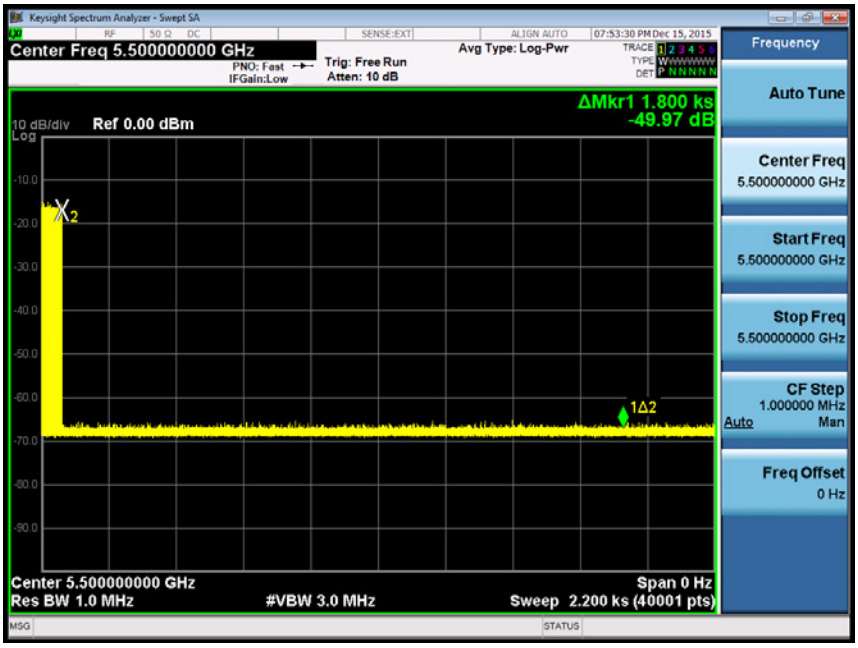
4.1.4 Non-occupancy period

Mode:	802.11 a (Band2A)
Operating frequency:	5 260 ㎒



Mode: 802.11 a (Band2C)

Operating frequency: 5 500 ㎒



Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum Analyzer	Agilent	N9010A	MY51440103	1 year	2016.01.26
Vector Signal Generator	R&S	SMBV100A	1407.6004K02	1 year	2016.07.23
Attenuator	HP	8493C	08961	1 year	2016.07.24
Attenuator	HP	8493C	09304	1 year	2016.07.24
Attenuator	Anritsu	8493C	51401	1 year	2016.07.24
Attenuator	Anritsu	8493C	78799	1 year	2016.07.24
Attenuator	KEYSIGHT	8493C	82506	1 year	2016.04.02
Attenuator	KEYSIGHT	8493C	82507	1 year	2016.04.02
Splitter	MINI-CIRCUITS	ZFSC-2-10G+	F679501347-1	1 year	2016.07.24
Splitter	MINI-CIRCUITS	ZFSC-2-10G+	F679501347-2	1 year	2016.07.24

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
-	-	-	-