# DFS TEST REPORT

# Part 15 Subpart E 15.407

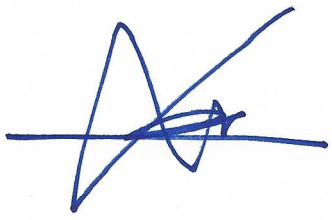
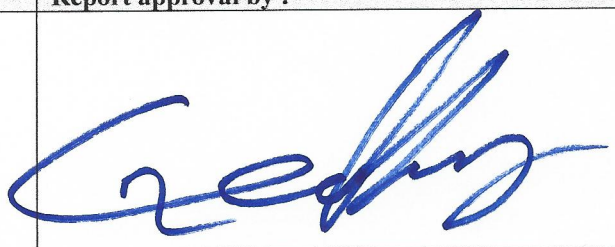
| | |
|---|---|
| **Equipment under test** | WiFi Module |
| **Model name** | SWL-Q93T |
| **Derivative Model** | SWL-CQ93 |
| **FCC ID** | NLMSWLQ93T |
| **Applicant** | Hanwha Techwin Co., Ltd. |
| **Manufacturer** | Hanwha Techwin Co., Ltd. |
| **Date of test(s)** | 2015.11.16 ~2015.12.15 |
| **Date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

# TABLE OF CONTENTS

## 1. General information

| | |
|---|---|
| Applicant: | Hanwha Techwin Co., Ltd. |
| Applicant address: | 1204, Changwon-daero, Seongsan-gu, Changwon-si<br>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<br>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)<br>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<br>5 270 ㎒ ~ 5 310 ㎒(802.11n_HT40) : 2ch<br>5 500 ㎒ ~ 5 700 ㎒(802.11a/n_HT20) : 11ch<br>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<br>See Note 1. |
| Channel Closing Transmission Time | 200 milliseconds + an<br>Aggregate of 60 milliseconds over remaining 10 second period.<br>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.<br>**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.<br>**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<br>(See Notes 1, 2, and 3) |
|---|---|
| EIRP ≥ 200 milliwatt | -64 dBm |
| EIRP< 200 milliwatt and<br>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.<br>**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.<br>**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**

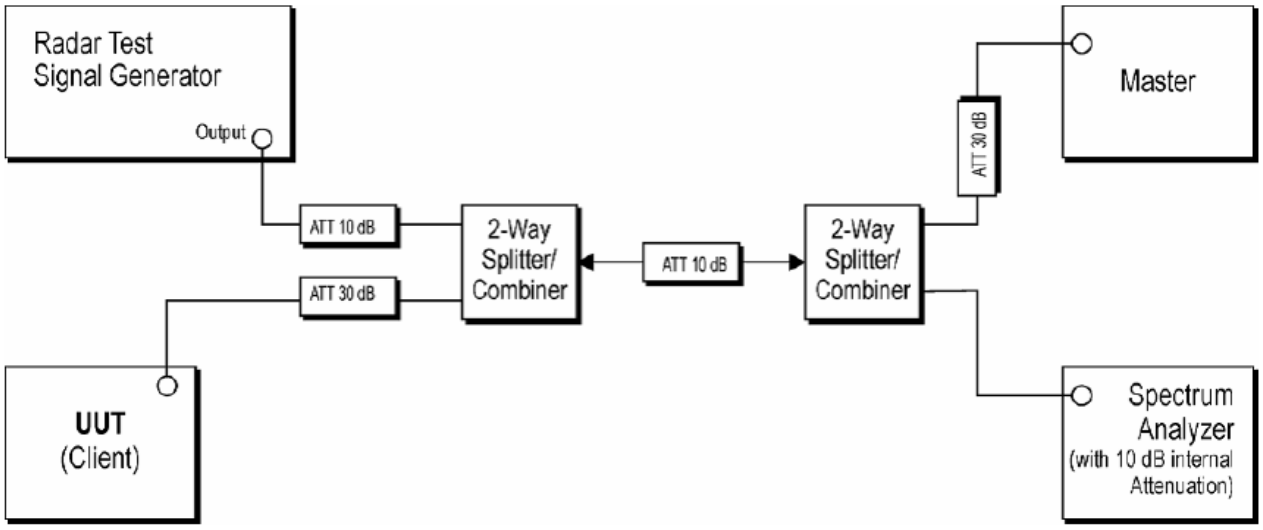



Figure 1: Conducted Test Setup for DFS

**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.

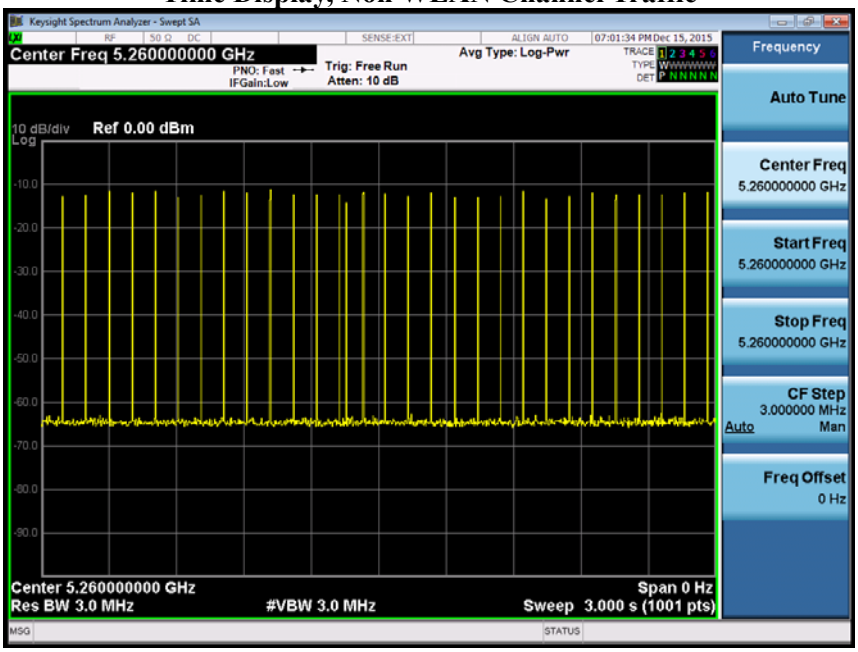
1. The Client Device (EUT) is setup per the diagram in Firure1 and communications between the Master device and the Client is established.
2. An MPEG or data file that is typical for the device is streamed from the Master to the Client to properly load the network.

## 4.1 Test results

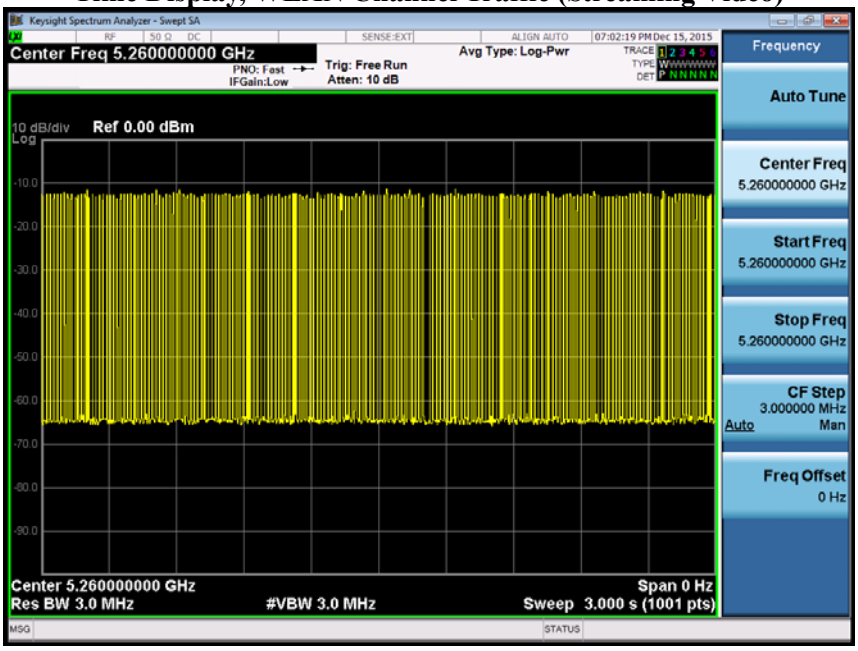
### 4.1.1 Traffic load

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

**Time Display, Non WLAN Channel Traffic**



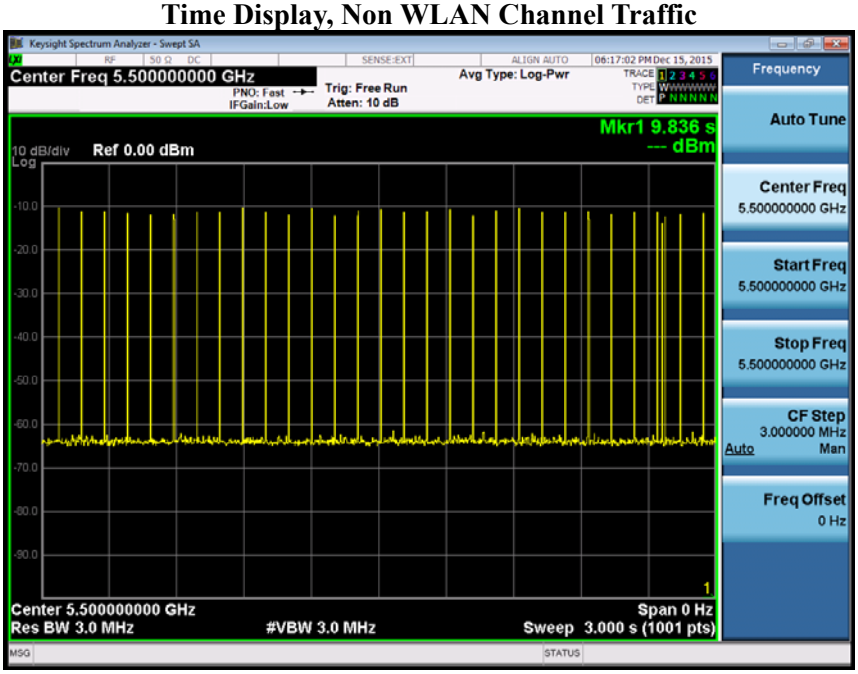

**Time Display, WLAN Channel Traffic (Streaming Video)**



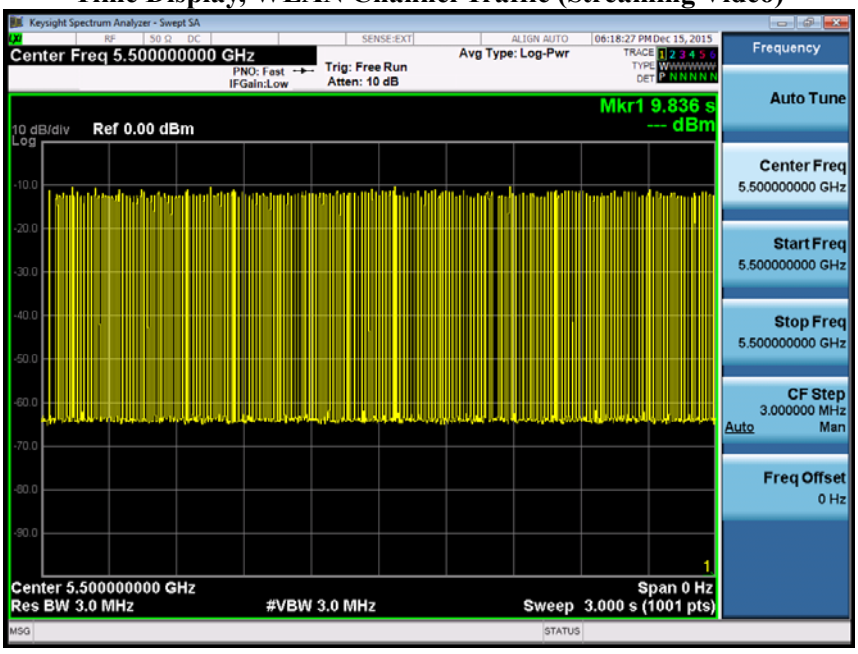
Mode: 802.11 a (Band2C)

Operating frequency: 5 500 ㎒

**Time Display, Non WLAN Channel Traffic**




**Time Display, WLAN Channel Traffic (Streaming Video)**



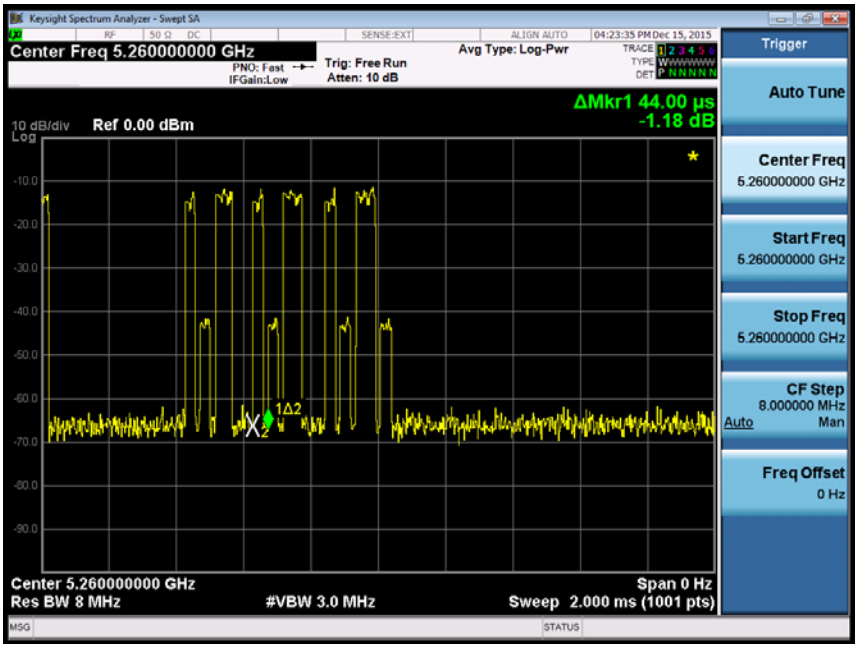
### 4.1.2 Channel Loading

Mode: 802.11 a (Band2A)

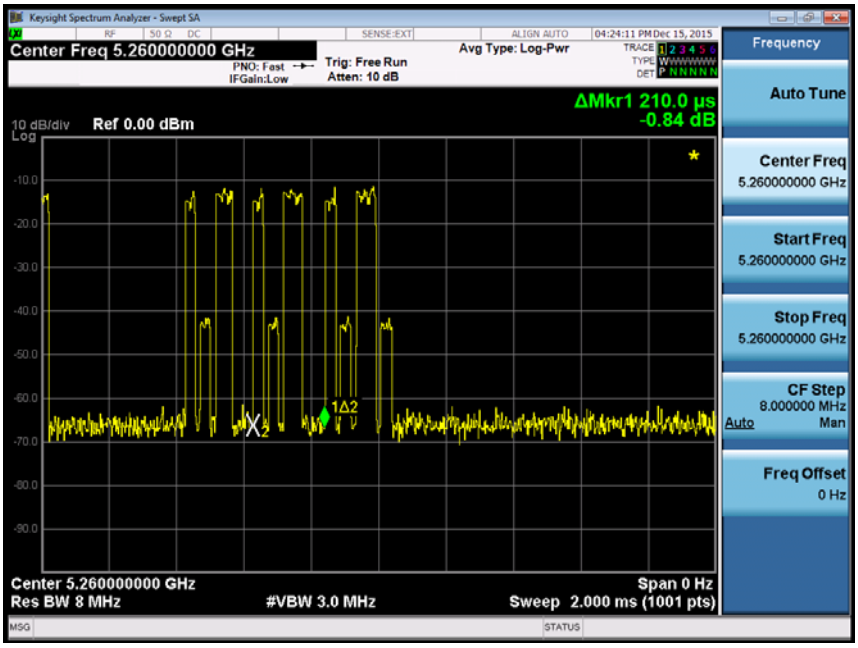
Operating frequency: 5 260 ㎒

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

**Pulse Width**




**Period**

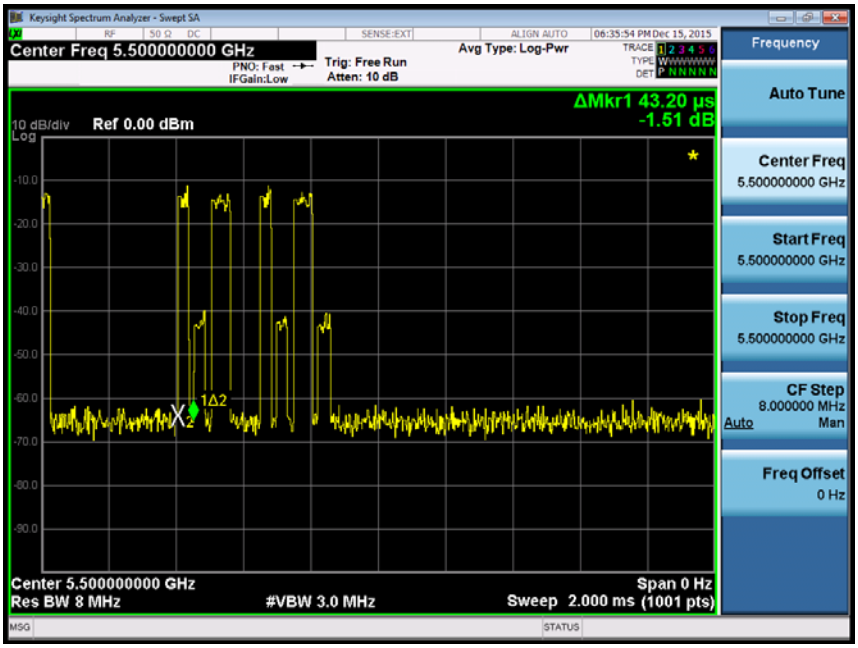


Mode: 802.11 a (Band2C)

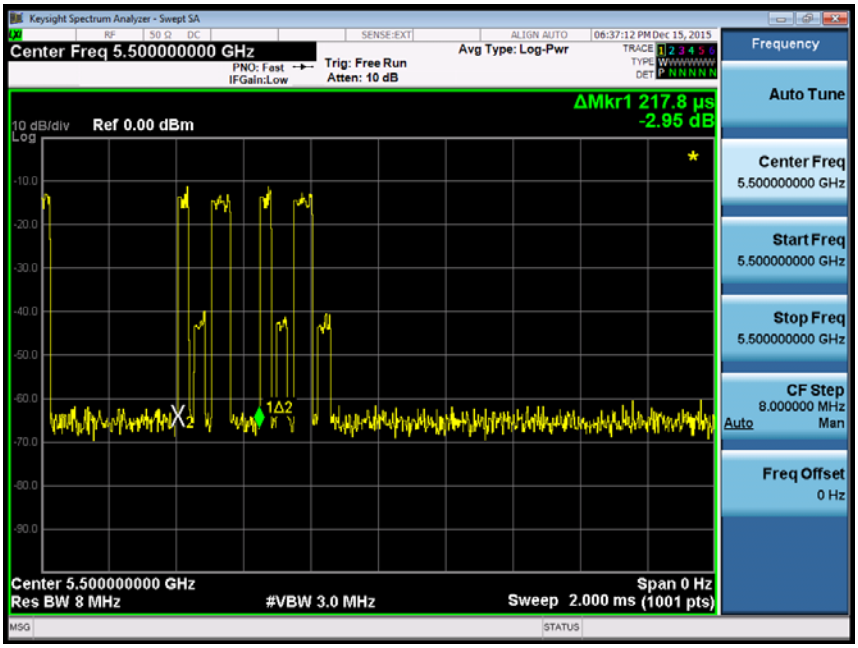
Operating frequency: 5 500 ㎒

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

**Pulse Width**




**Period**

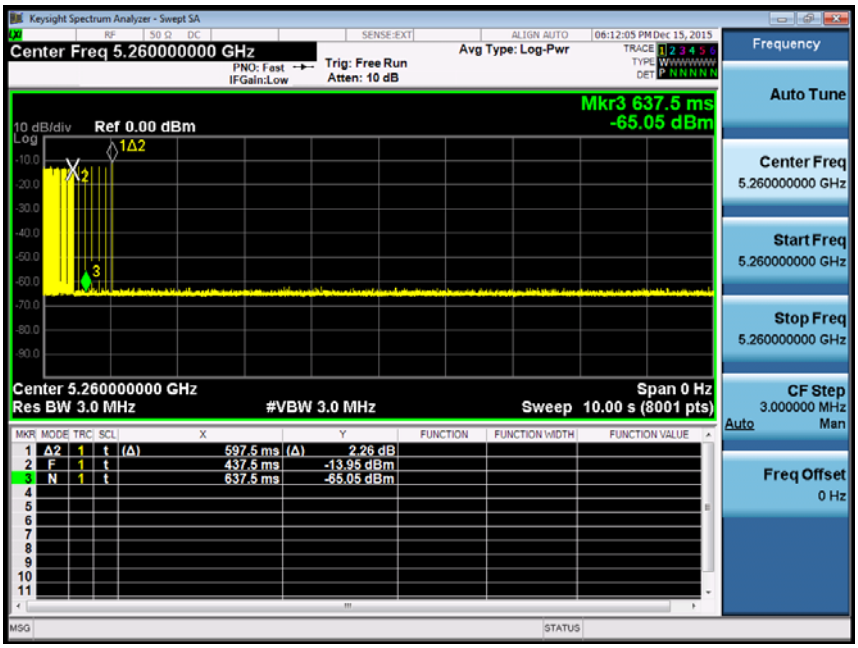



Notes: Per KDB 905462 D02 v01, timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater. For example, you can zero span the spectrum analyzer and approximate the transmission time.

### 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 |

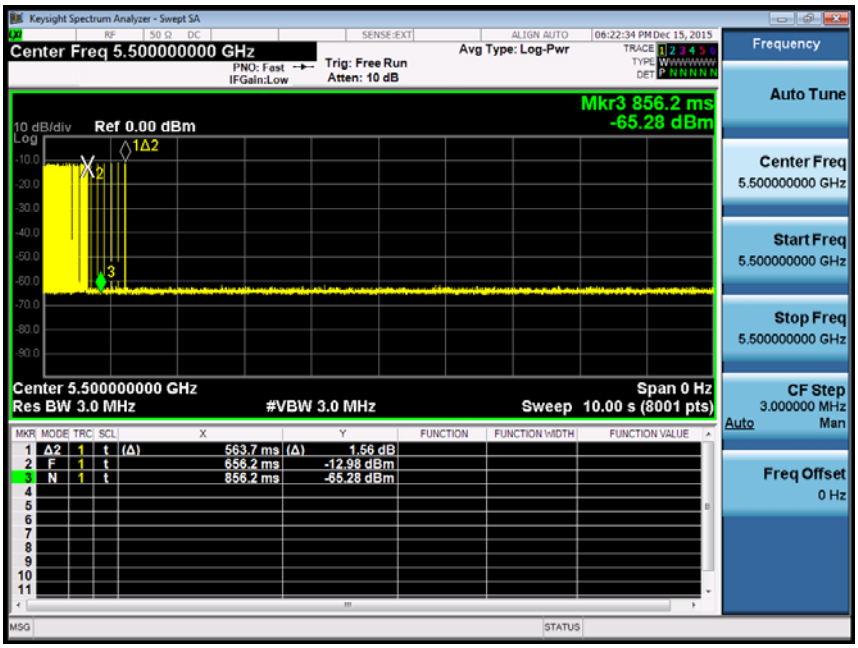
Note:
**Dwell = S/B**;
Where **dwell** is the dwell time per spectrum analyzer sampling bin, **S** is the sweep time and **B** is the number of spectrum analyzer sampling bins.

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 |

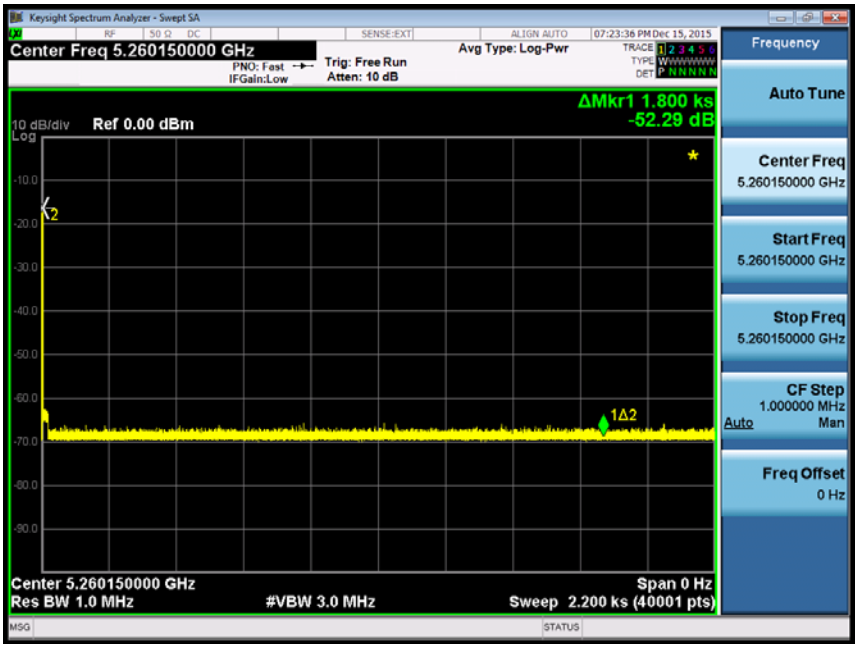
Note:
**Dwell = S/B**;
Where **dwell** is the dwell time per spectrum analyzer sampling bin, **S** is the sweep time and **B** is the number of spectrum analyzer sampling bins.

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**

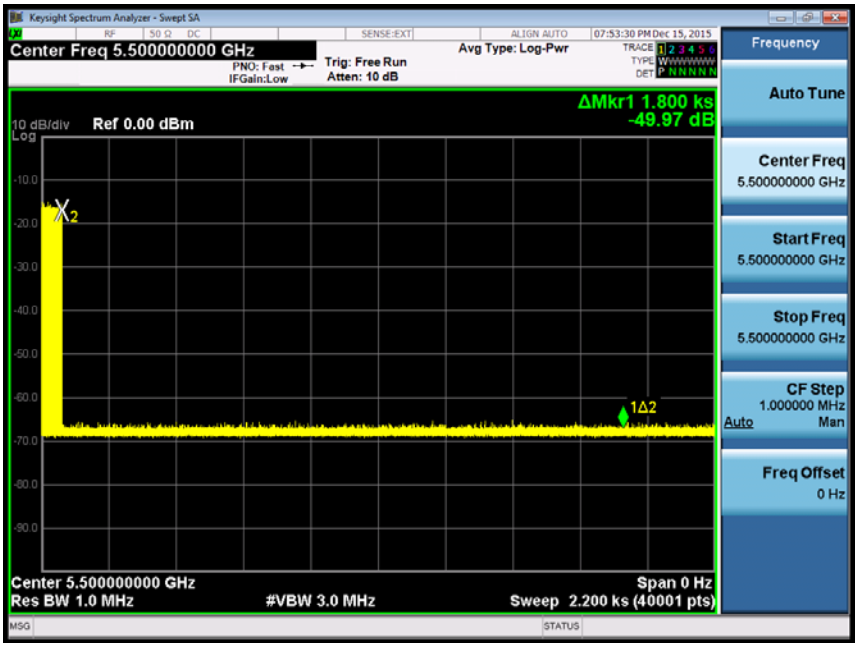
### 4.1.4 Non-occupancy period

| | |
|---|---|
| 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. |
|---|---|---|---|
| - | - | - | - |