



A Smarter Vision®

**Technical Report to the FCC and Industry Canada Regarding  
Gentex Corporation - Homelink© 5**

**Model: UAHL5A  
FCC ID: NZLUAHL5A  
IC: 4112- UAHL5A**

**Emission Designator: 234KF7D  
12/17/15**

A report concerning approval for Gentex Corporation Homelink® model UAHL5A  
Please issue grant immediately upon review.

Measurements Made by:

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## 1. General Information

### 1.1. Product Description

The Gentex Corporation HomeLink® HL5 Universal Garage Door Opener is a low-power transceiver OEM device that is installed into an overhead area of the automobile. The installation is provided by trained technicians during the course of the manufacture of the automobile. It is powered by the 12 Volt system of the automobile.

This Universal Garage Door Opener has the capability to

1. Learn the frequency and bit code format of the user's existing garage door remote control devices
2. Transmit and receive frequency hopping spread spectrum in the 902 to 928 MHz band using an internal antenna as per Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15.247

The unit is designed for the periodic operation of a control signal, which typically activates a garage door opener receiver.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a typical assembly and 2-conductor cable harness were used to power to the unit.

The three-button HomeLink® unit replaces up to three hand-held transmitters. In addition to the typical operation of the garage door, the unit will learn the radio frequency codes of other transmitter types to activate entry door locks, estate gates, security systems, and home or office lighting.

The antenna system is an integral part of the unit. It cannot be altered nor replaced by the user. Service of this system is only available from the Automobile Manufacturer's Dealerships and Gentex Corporation.

### 1.2. Related Grants

This device will have functionality that is covered under CFR 47 15.231. The device will have a FCC ID # of NZLUAHL5A and an IC ID # of 4112A-UAHL5A under both rule parts. A separate report is submitted for functionality covered under CFR 47 15.231.

### 1.3. Test Methodology

Radiated Emissions testing was performed according to ANSI C63.10-2013. The power source for this product is a 12V automotive vehicle battery.

Conducted measurements were performed using a power supply.

Measurements were performed per FCC OET KDB 867751 and DA 00-0705.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a 2-conductor cable harness was used to interface to the unit. The unit ground is provided through the negative terminal of the harness.

## 1.4. Test Facility

The Open Area Test Site where these measurements were taken, is located on the grounds of Gentex Corporation's Technical Campus, in the city of Holland, county of Ottawa, state of Michigan, United States of America.

The site is a fully enclosed 10m weather-protected OATS. All structure materials above the conducting ground-plane are non-metallic and consist of wood, laminated lumber, fiberglass, glue, plastic, or fiberglass reinforced plastic. For radiated measurements above 1 GHz, a 2.4m x 2.4m area of RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4-2009 Section 5.5.

The site contains a 15-foot diameter turntable capable of supporting large cars and light trucks under test. Tabletop testing was conducted on a smaller 3m turntable described in the site recertification report. The test site has been fully described in a reports filled with the FCC and Industry Canada. The report filed with the FCC is dated February 11, 2015, was accepted by the FCC in a letter dated April 08, 2015. The report filled with Industry Canada, dated February 11, 2015, was accepted via a letter dated February 11, 2015. Our OATS is registered with the IC under file number IC# 4112A, and accredited to ANSI C63.4 (2009).

### Corporate Mailing/Shipping Address

Gentex Corporation  
600 N. Centennial Street  
Zeeland, MI 49464

### Site Address

Gentex Corporation  
864 E. 24<sup>th</sup> Street  
Holland, MI 49423

## 1.5. Accreditation

The Gentex Corporate EMC Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA). Our laboratory scope and accreditation certificate #2529.01 are available from their web site [www.a2la.org](http://www.a2la.org). Our scope of accreditation covers ANSI C63.4-2009 Radiated Emissions at 3m, FCC 47 CFR Part 15, IC RSS-210, and IC RSS-247.

## 2. Product Labeling

### 2.1. Identifiers

The FCC Identifier assigned is FCC ID: NZLUAHL5A. The Industry Canada certification number is 4112A-UAHL5A. These identifiers will be labeled on the product housing.

The label will be placed on the exterior of the HL housing using laser etching that will permanently affix the label.

Because of the small size of the device and because the installation is inside a portion of the automobile, the following statements will appear in the user's manual. Refer to attachment "Users Manual.pdf" for the entire text of the user's manual.

"This device complies with FCC rules Part 15 and with Industry Canada RSS-247 Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference,
- (2) This device must accept any interference that may be received including interference that may cause undesired operation.

WARNING: The transmitter has been tested and complies with FCC and Industry Canada rules. Changes or modifications not expressly approved by the party responsible for the compliance could void the user's authority to operate the device."

The term "IC:" before the certification/registration number only signifies that Industry Canada technical specifications were met.

IC: 4112A-UAHL5A

FCC ID: NZLUAHL5A

MODEL: UAHL5A

## **2.2. Label Drawing and Location on Product**

The label drawing and location of the label on the assembly is included in the "Label Location.pdf" attachment.

## **3. Test Configuration**

Radiated Emission measurements presented in the report were made in accordance with ANSI C63.10-2013. The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane for measurements below 1GHz and elevated to 1.5m for measurements above 1GHz. The harness was run straight down from the center of the turntable to a power supply sitting at the base of the table.

For radiated measurements above 1 GHz, a 2.4m x 2.4m area of RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4-2009 Section 5.5.

For conducted measurements, a non-metallic table approximately 80cm x 90cm, 85cm above the floor was used.

## **4. Block Diagram**

For system block diagram please refer to attachment named "HLV Block Diagram.pdf"

## **5. Powerline Conducted Emissions Measurements**

Powerline Conducted Measurements are not required for this product as the part is powered via 12V battery.

## 6. Emissions Data

### 6.1. Summary of Results (Part 15.247)

| Measurement                           |                                | Margin  | Frequency  |
|---------------------------------------|--------------------------------|---------|------------|
| Worst Case Spurious Emission          | 73.19dBuV/m                    | 0.81    | 2744.25MHz |
| Worst Case Receiver Spurious Emission | 33.36dBuV/m                    | 12.64dB | 926.75Mhz  |
| Maximum 20dB BW                       | 234kHz                         | 256kHz  | -          |
| Maximum 99% BW                        | 203kHz                         | 289kHz  | -          |
| Maximum Carrier Frequency Separation  | 503kHz                         | 264kHz  | -          |
| Number of Hopping Frequencies         | 50                             | -       | -          |
| Peak Output Power                     | 3.57dBm                        | 26.43dB | 902.25MHz  |
| Time of Occupancy                     | 4.3ms multiplied by 80= 0.344s | 0.056s  | -          |

- Band Edge Measurement Requirement:** Per section 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

Emissions are at least **40dB** below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. Emissions are over **60dB** below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.

- Duty Cycle Factor Corrections:** Since the frequency hopping is turned off for the radiated measurements, a duty cycle factor is used to correct the average readings based on the dwell time. This factor is computed from the time domain trace of the dwell time in any 100 ms period. The duty cycle is calculated as the (dwell time/100ms) where the dwell time is limited to 100ms. The duty cycle factor is  $20 \cdot \log(\text{duty cycle})$ . The duty cycle factor is calculated as **-27.3dB**. ( $-27.3\text{dB} = 20 \cdot \log(4.3\text{ms}/100\text{ms})$ ).

## 6.2. Test Equipment Setup and Procedure

### 6.2.1. Test Equipment Used for Conducted Measurement

| Description                | Model #        | ID Number | Last Cal Date | Cal Due |
|----------------------------|----------------|-----------|---------------|---------|
| Agilent Spectrum Analyzer  | E4407B         | H7968     | 5/12/15       | 6/12/16 |
| Tensolite Work Horse Cable | WHU18-1818-048 | CBL 66    | 4/28/15       | 4/30/16 |

### 6.2.2. Test Equipment Used for Radiated Measurement Equipment

| Description                                   | Model # | ID Number                                     | Last Cal Date | Cal Due |
|---|---------|---|---------------|---------|
| EMCO Biconical Antenna [20-300 MHz]           | 3110B   | H6189   | 3/27/15       | 3/27/16 |
| EMCO LPA Antenna [200-2000MHz]                | 3148    | H6193   | 3/27/15       | 3/27/16 |
| Electro-metrics Double Ridged Guide [1-18GHz] | RGA-60  | H8132   | 9/5/13        | 9/5/16  |
| Rohde & Schwarz EMI Receiver                  | ESR26   | 6595  | 5/13/15       | 6/13/16 |
| Cables, attenuator and port feed through      | various | 3M Port Combo (CBL 63, CBL 64, CBL 71, EL459) | 4/30/15       | 4/30/16 |

### 6.2.3. Test Equipment Setup and Procedure

EMI Receiver Settings Emissions:

Detector Function :Peak  
Resolution Bandwidth :120kHz (below 1GHz)  
:1MHz (above 1GHz)  
Video Bandwidth: :300kHz (below 1GHz)  
:3MHz (above 1GHz)

EMI Receiver (in Spectrum Analyzer mode) Settings Occupied Bandwidth:

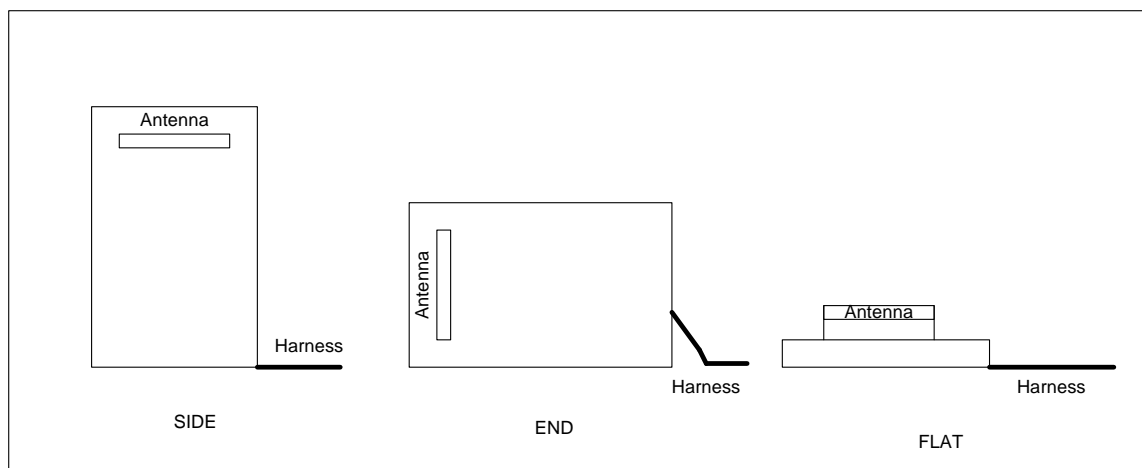
Detector :Peak  
Resolution Bandwidth :3 MHz ( to determine peak level)  
:10 kHz (to determine occupied bandwidth)  
Video Bandwidth :3 MHz ( to determine peak level)  
:30 kHz (to determine occupied bandwidth)

Spectrum Analyzer Settings for Conducted measurements:

Detector Function :Peak  
Resolution Bandwidth :120kHz (below 1GHz)  
:1MHz (above 1GHz)  
Video Bandwidth: :300kHz (below 1GHz)  
:3MHz (above 1GHz)

For the testing, the EUT was placed at the center of a non-conducting table 80cm above the ground plane pursuant to ANSI C63.10-2013 for stand-alone equipment. The 2-conductor harness was run straight down from the center of the turntable to a power supply sitting at the base of the table.

Equipment is placed in one of the three orthogonal orientations, End, Side, and Flat. These orientations are described below in Figure 6.2.3



**Figure 6.2.3 EUT Orthogonal Orientations**

While in the prescribed orientation, the vertical antenna positioner sweeps in elevation from 1 to 4m in height until the operator finds the peak. The 3m turntable is then rotated through 360 degrees until a peak is found. The table is stopped at the peak location and the peak in elevation re-verified. Procedure is repeated for applicable orientations/measurement antenna polarizations.

### **6.3. Measured Data – See Appendix A**

## **7. Formulas and Sample Calculations**

### **7.1. Adjustment to account for duty cycle**

To calculate the duty cycle correction factor for the average measurement, the following calculation was performed.

3.5ms while in Wireless Diagnostic mode was used for the on time, as this was the worst case.

Duty cycle Correction Factor =  $20 \cdot \log(\text{On Time}(\text{ms}) / 100\text{ms})$ .

$-27.3\text{dB} = 20 \cdot \log(4.3\text{ms}/100\text{ms})$

### **7.2. Calculation of IC Limits from RSS-247 and 47 CFR Part 15.247**

The Peak Tx Spurious Emissions limit for the fundamental is given by:

Limit dBuV/m =  $1W \text{ ERP} = 127.38 \text{ dBuV/m}$ , which is the fundamental limit.

The Rx Spurious Emissions limit for the fundamental is given by:

Limit dBuV/m =  $20 \cdot \log(200\text{uV/m}) = 46.0 \text{ dBuV/m}$

The Rx Spurious Emissions limit for the harmonics is given by:

Limit dBuV/m =  $20 \cdot \log(500\text{uV/m}) = 54.0 \text{ dBuV/m}$

## **8. Other Attachments and Description**

### **8.1. User Manual**

Please refer to attachment "User\_Manual\_English.pdf" and "User\_Manual\_French.pdf".

### **8.2. Schematics/ Tuning Information**

For schematics please refer to attachment "Schematic.pdf".

### **8.3. Theory of Operation**

Please refer to attachment "HL5 Operation FCC 231\_247.pdf"



#### **8.4. Label Drawing and Location on Complete Assembly**

For a drawing of the label and position of the label on the finished assembly refer to "Label Location.pdf".

#### **8.5. Photos**

For exterior photos, refer to exhibit "exterior photographs.pdf".

For interior photos, refer to exhibit "interior photographs.pdf".

For test setup photos, refer to exhibit "test setup photographs.pdf".

## Appendix A

### A. Radiated (Tx) Measurements

Note: The Duty Cycle Correction factors are worst case based on a 4.3ms dwell time.

#### 1. DUT Transmitting at 902.25MHz (Fundamental)

**Peak Measurement**  
**902.25 MHz**

| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Measurement (dBuV/m) | Peak Limit (dBuV/m) | Margin (dB) |
|-----------------|-----------------------------|--------------------------------|----------------------|---------------------|-------------|
| 902.25          | Side                        | H                              | 94.64                | 127.3               | 32.66       |
| 1804.5          | Side                        | H                              | 61.22                | 74.6                | 13.42       |
| 2706.75         | Side                        | H                              | 71.8                 | 74.0                | 2.20        |
| 3609            | Side                        | H                              | 63.11                | 74.0                | 10.89       |
| 4511.25         | Side                        | V                              | 54.38                | 74.0                | 19.62       |
| 5413.5          | Side                        | V                              | 59.03                | 74.0                | 14.97       |
| 6315.75         | Side                        | H                              | 56.37                | 74.6                | 18.27       |
| 7218            | Side                        | H                              | 59.34                | 74.0                | 14.66       |
| 8120.25         | End                         | H                              | 60.38                | 74.0                | 13.62       |
| 9022.5          | End                         | V                              | 59.73                | 74.0                | 14.27       |

**Average Measurement  
902.25 MHz**

| Frequency<br>(MHz) | Orientation<br>(Flat/End/Side) | Measurement<br>Polarization<br>(H/V) | Measurement<br>(dBuV/m) | Duty<br>Cycle<br>Correction<br>(dB) | Average<br>Level<br>(dBuV/m) | Average<br>Limit<br>(dBuV/m) | Margin<br>(dB) |
|--------------------|--------------------------------|--------------------------------------|-------------------------|-------------------------------------|------------------------------|------------------------------|----------------|
| 1804.5             | Side                           | H                                    | 61.22                   | -27.3                               | 33.9                         | 54.6                         | 20.7           |
| 2706.75            | Side                           | H                                    | 71.8                    | -27.3                               | 44.5                         | 54.0                         | 9.5            |
| 3609               | Side                           | H                                    | 63.11                   | -27.3                               | 35.8                         | 54.0                         | 18.2           |
| 4511.25            | Side                           | H                                    | 54.38                   | -27.3                               | 27.1                         | 54.0                         | 26.9           |
| 5413.5             | Side                           | V                                    | 59.03                   | -27.3                               | 31.7                         | 54.0                         | 22.3           |
| 6315.75            | Side                           | V                                    | 56.37                   | -27.3                               | 29.1                         | 54.6                         | 25.6           |
| 7218               | Side                           | H                                    | 59.34                   | -27.3                               | 32.0                         | 54.0                         | 22.0           |
| 8120.25            | Side                           | H                                    | 60.38                   | -27.3                               | 33.1                         | 54.0                         | 20.9           |
| 9022.5             | End                            | H                                    | 59.73                   | -27.3                               | 32.4                         | 54.0                         | 21.6           |

## 2. DUT Transmitting at 914.75MHz (Fundamental) – FCC 15.247

### Peak Measurement 914.75 MHz

| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Measurement (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|-----------------|-----------------------------|--------------------------------|----------------------|--------------------|-------------|
| 914.75          | Side                        | H                              | 94.33                | 127.3              | 32.97       |
| 1829.5          | Side                        | H                              | 60.1                 | 74.3               | 14.23       |
| 2744.25         | Side                        | H                              | 73.19                | 74.0               | 0.81        |
| 3659            | Side                        | H                              | 63.33                | 74.0               | 10.67       |
| 4573.75         | Flat                        | V                              | 58.74                | 74.0               | 15.26       |
| 5488.5          | Side                        | H                              | 59.6                 | 74.0               | 14.40       |
| 6403.25         | Side                        | V                              | 60.21                | 74.3               | 14.12       |
| 7318            | Side                        | V                              | 61.92                | 74.0               | 12.08       |
| 8232.75         | Side                        | V                              | 60.44                | 74.0               | 13.56       |
| 9147.5          | Side                        | H                              | 60.36                | 74.0               | 13.64       |

### Average Measurement 914.75 MHz

| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Measurement (dBuV/m) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|-----------------|-----------------------------|--------------------------------|----------------------|----------------------------|------------------------|--------------------|-------------|
| 1829.5          | Side                        | H                              | 60.1                 | -27.3                      | 32.8                   | 54.3               | 21.5        |
| 2744.25         | Side                        | H                              | 73.19                | -27.3                      | 45.9                   | 54.0               | 8.1         |
| 3659            | Side                        | H                              | 63.33                | -27.3                      | 36.0                   | 54.0               | 18.0        |
| 4573.75         | Side                        | H                              | 58.74                | -27.3                      | 31.4                   | 54.0               | 22.6        |
| 5488.5          | Flat                        | V                              | 59.6                 | -27.3                      | 32.3                   | 54.0               | 21.7        |
| 6403.25         | Side                        | H                              | 60.21                | -27.3                      | 32.9                   | 54.3               | 21.4        |
| 7318            | Side                        | V                              | 61.92                | -27.3                      | 34.6                   | 54.0               | 19.4        |
| 8232.75         | Side                        | V                              | 60.44                | -27.3                      | 33.1                   | 54.0               | 20.9        |
| 9147.5          | Side                        | V                              | 60.36                | -27.3                      | 33.1                   | 54.0               | 20.9        |

### 3. DUT Transmitting at 926.75MHz (Fundamental) – FCC 15.247

**Peak Measurement**  
926.75 MHz

| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Measurement (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|-----------------|-----------------------------|--------------------------------|----------------------|--------------------|-------------|
| 926.75          | Side                        | H                              | 94.52                | 127.3              | 32.78       |
| 1853.5          | Side                        | H                              | 61.25                | 74.5               | 13.27       |
| 2780.25         | Side                        | H                              | 71.69                | 74.0               | 2.31        |
| 3707            | Side                        | H                              | 64.35                | 74.0               | 9.65        |
| 4633.75         | Side                        | V                              | 54.96                | 74.0               | 19.04       |
| 5560.5          | End                         | V                              | 58.43                | 74.0               | 15.57       |
| 6487.25         | Side                        | H                              | 59.65                | 74.5               | 14.87       |
| 7414            | Side                        | H                              | 61.09                | 74.0               | 12.91       |
| 8340.75         | Flat                        | H                              | 60.49                | 74.0               | 13.51       |
| 9267.5          | Flat                        | H                              | 61.8                 | 74.0               | 12.20       |

**Average Measurement**  
926.75 MHz

| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Measurement (dBuV/m) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|-----------------|-----------------------------|--------------------------------|----------------------|----------------------------|------------------------|--------------------|-------------|
| 1853.5          | Side                        | H                              | 61.25                | -27.3                      | 34.0                   | 54.5               | 20.6        |
| 2780.25         | Side                        | H                              | 71.69                | -27.3                      | 44.4                   | 54.0               | 9.6         |
| 3707            | Side                        | H                              | 64.35                | -27.3                      | 37.1                   | 54.0               | 17.0        |
| 4633.75         | Side                        | H                              | 54.96                | -27.3                      | 27.7                   | 54.0               | 26.3        |
| 5560.5          | Side                        | V                              | 58.43                | -27.3                      | 31.1                   | 54.0               | 22.9        |
| 6487.25         | End                         | V                              | 59.65                | -27.3                      | 32.4                   | 54.5               | 22.2        |
| 7414            | Side                        | H                              | 61.09                | -27.3                      | 33.8                   | 54.0               | 20.2        |
| 8340.75         | Side                        | H                              | 60.49                | -27.3                      | 33.2                   | 54.0               | 20.8        |
| 9267.5          | Flat                        | H                              | 61.8                 | -27.3                      | 34.5                   | 54.0               | 19.5        |

## 4. Radiated Rx Spurious Emissions

The receiver circuit spurious emissions were measured in accordance to Industry Canada RSS-GEN Issue 3 Section 6 and ANSI C63.4-2009.

The FHSS operational band low, mid and high frequencies over which the receiver is designed to operate are 902.25, 914.75 and 926.75MHz. The HomeLink is supplied with commands to place it into diagnostic / manufacturing mode, and tune the receiver to these frequencies.

Worst case results are provided in the tables below. The low band has a minimum margin of 14.74dB, the mid band has a minimum margin of 13.67dB, and the high frequency band has a minimum margin of 12.64dB.

| Frequency (MHz) | DUT Orientation | Antenna Polarization | Field Strength (dBuV/m) | Limit (dBuV/m) | Margin (dB)   |
|-----------------|-----------------|----------------------|-------------------------|----------------|---------------|
| 901.25          | Side            | V                    | 31.26                   | 46             | <b>-14.74</b> |
| 1802.6          | Side            | V                    | 31.22                   | 54             | -22.78        |
| 2703.9          | Side            | H                    | 34.59                   | 54             | -19.41        |
| 3605.2          | Side            | H                    | 38.56                   | 54             | -15.44        |
| 4506.5          | Side            | H                    | 38.56                   | 54             | -15.44        |
| 914.75          | Flat            | H                    | 32.33                   | 46             | <b>-13.67</b> |
| 1829.5          | Flat            | V                    | 34.26                   | 54             | -19.74        |
| 2744.25         | Flat            | V                    | 36.56                   | 54             | -17.44        |
| 3659            | Side            | H                    | 38.15                   | 54             | -15.85        |
| 4573.75         | Side            | H                    | 38.25                   | 54             | -15.75        |
| 926.75          | End             | V                    | 33.36                   | 46             | <b>-12.64</b> |
| 1853.5          | Flat            | H                    | 32.47                   | 54             | -21.53        |
| 2780.25         | End             | H                    | 38.56                   | 54             | -15.44        |
| 3707            | End             | V                    | 38.52                   | 54             | -15.48        |
| 4633.75         | End             | V                    | 38.67                   | 54             | -15.33        |

## 5. Conducted Measurements

### a. Occupied Bandwidth Measurement (FCC Part 15.247)

**20dB Bandwidth Requirement:** Per 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Per section 15.247(a) (1) (i), for frequency hopping systems operating in the 902-928 MHz band, the 20dB bandwidth shall be measured for determination of the carrier frequency separation limits and must not exceed 500 kHz. In this design, the 20dB bandwidth of the hopping channel is less than 250 kHz, so the system shall use at least 50 hopping channels.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

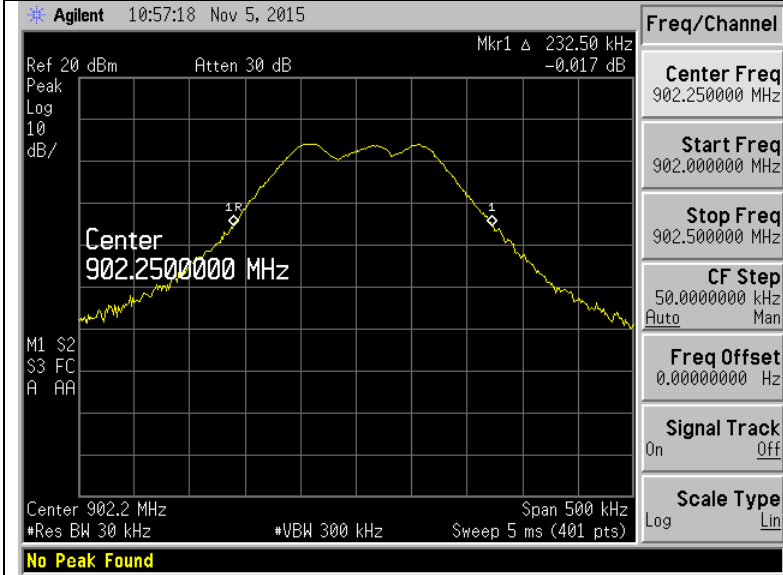
In measurement of the 20dB bandwidth, the transmit frequency was set to low, middle and high hopping channels. The resolution bandwidth (RBW) was set to > than 1% of the 20dB bandwidth. The span was set to approximately 2 to 3 times the 20dB bandwidth.

The plots show that the maximum 20dB bandwidth was 234 kHz, which is within limit. The 99% bandwidth was measured to be 203 kHz.

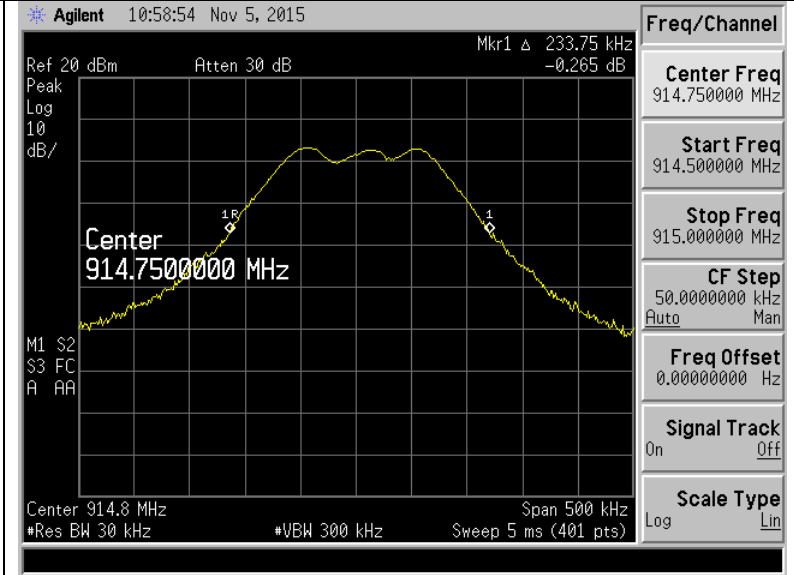
**20dB BW Results**

| Frequency (MHz) | 20dB Bandwidth (kHz) | Limit (kHz) |
|-----------------|----------------------|-------------|
| 902.25          | 233                  | 500         |
| 914.75          | 234                  |             |
| 926.75          | 233                  |             |

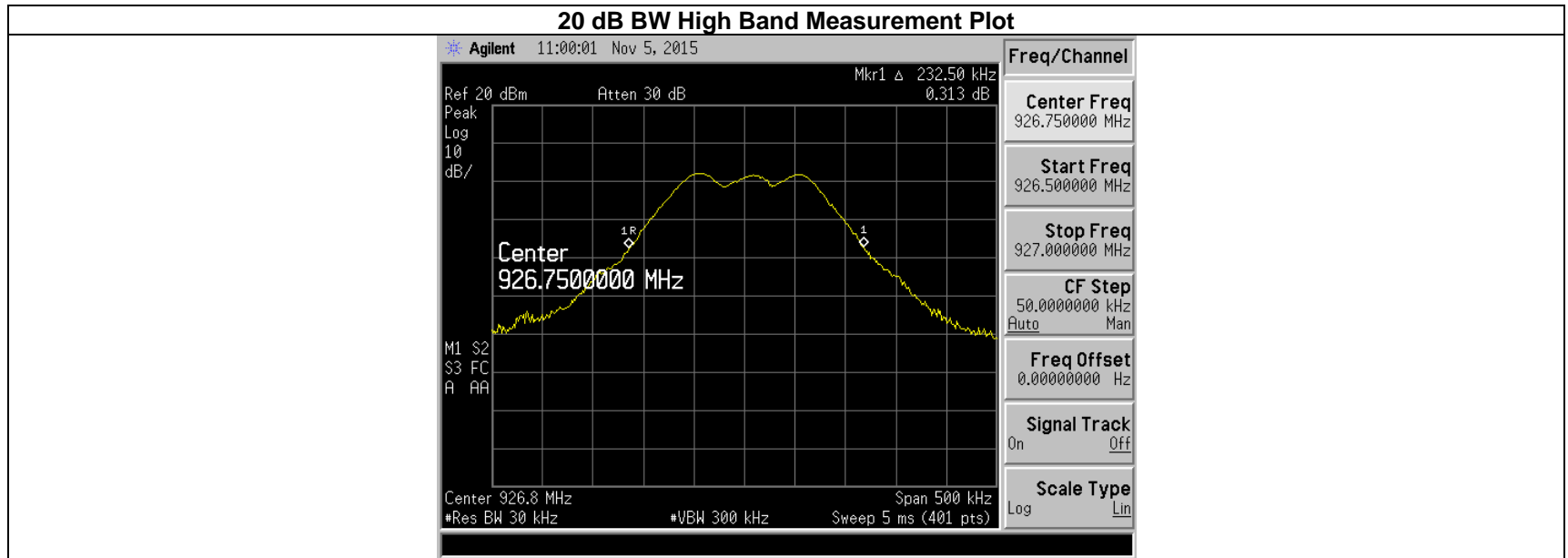
### 20 dB BW Low Band Measurement Plot



### 20 dB BW Mid Band Measurement Plot



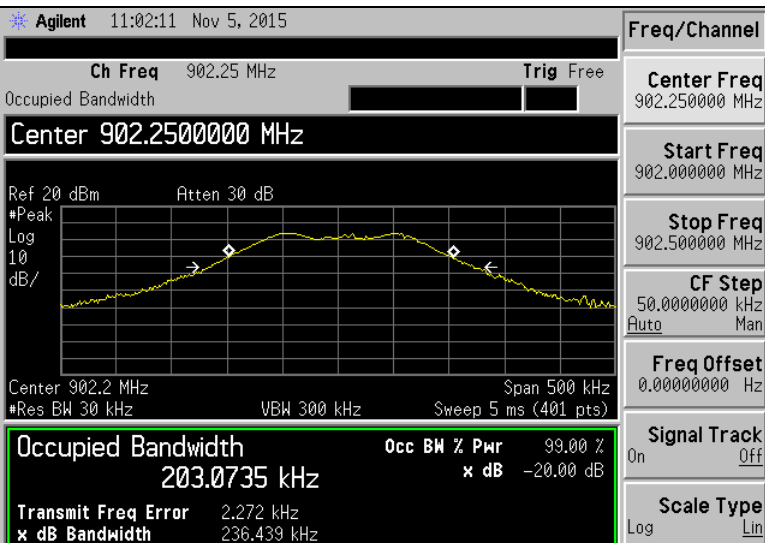




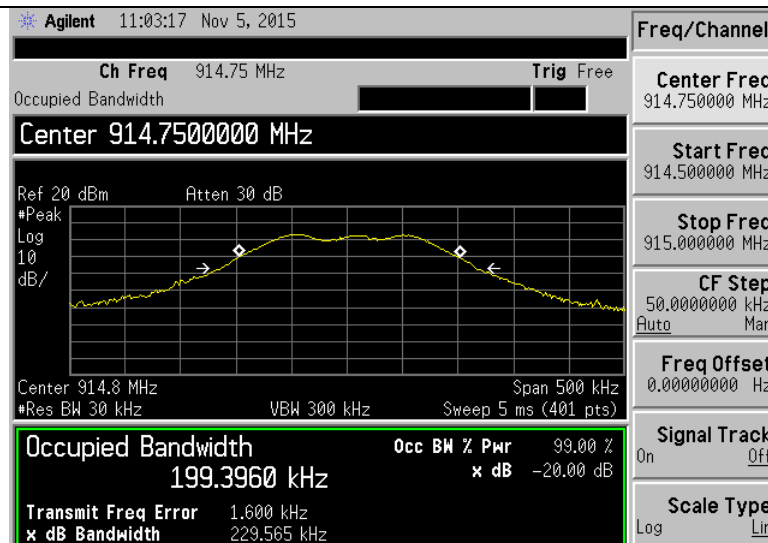
#### 99% BW Results

| Frequency (MHz) | 99% Bandwidth (kHz) | Limit (kHz) |
|-----------------|---------------------|-------------|
| 902.25          | 203                 | 500         |
| 914.75          | 199                 |             |
| 926.75          | 198                 |             |

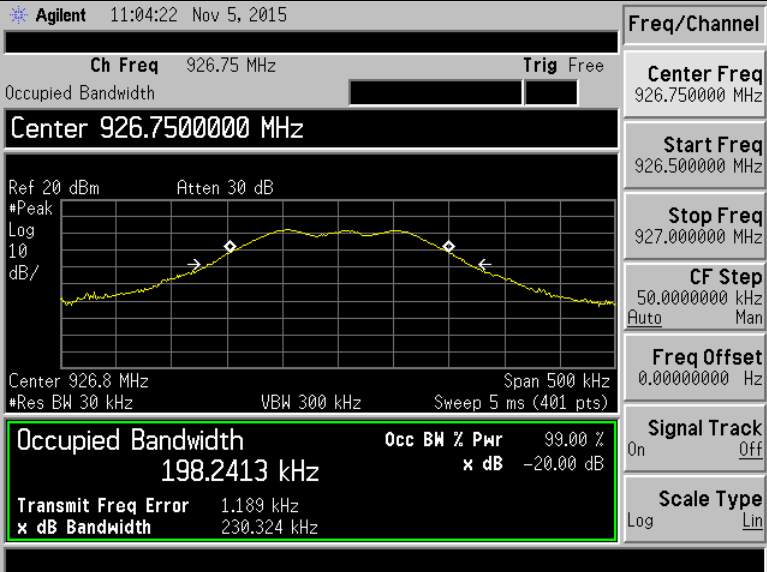
### 99% BW Low Band Measurement Plot



### 99% BW Mid Band Measurement Plot



### 99% BW High Band Measurement Plot



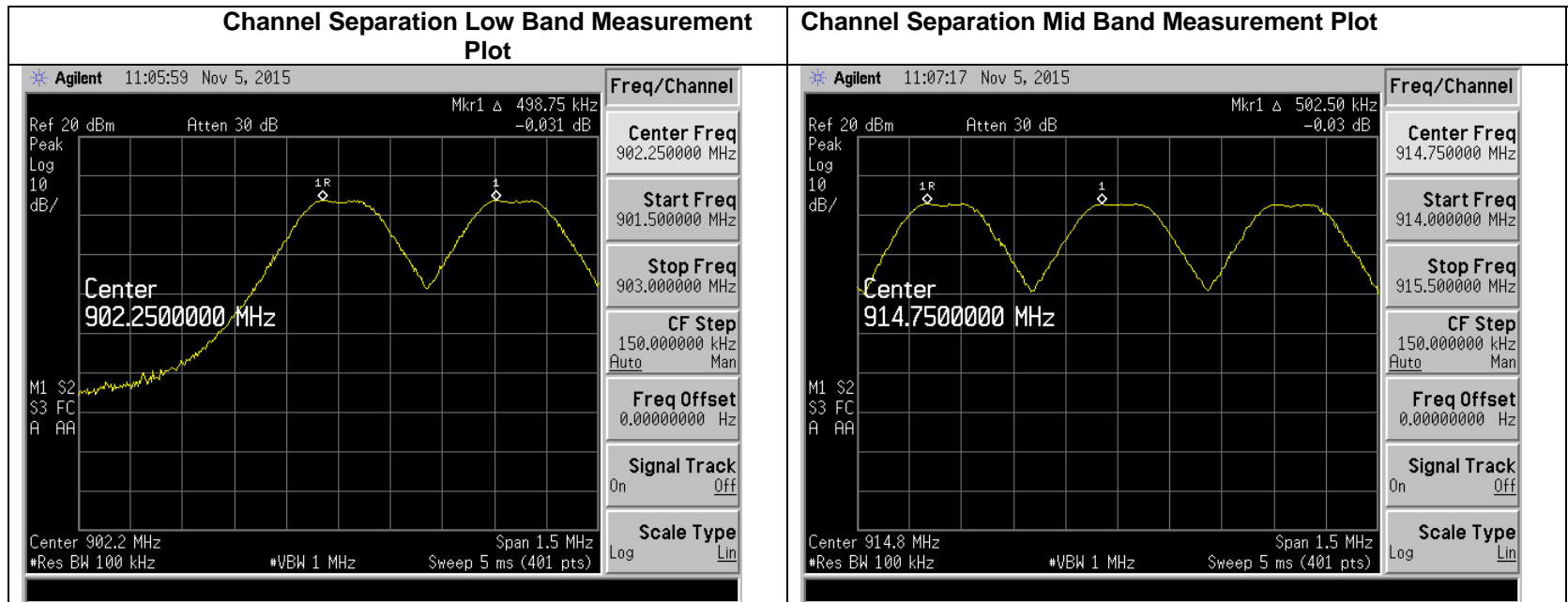
## 6. Carrier Frequency Separation Measurement (FCC Part 15.247)

**Carrier Frequency Separation Requirement:** Per 15.247(a)(1), Frequency Hopping Systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

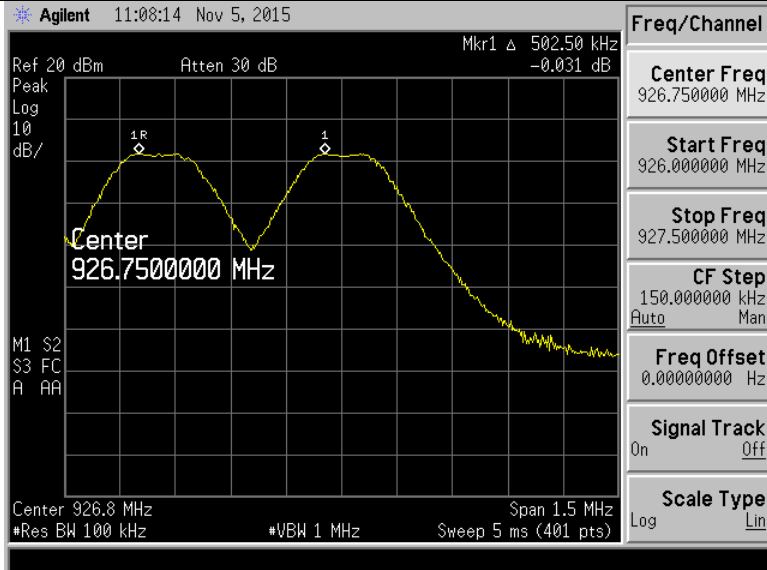
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

In measurement of the Carrier Frequency Separation, the RBW was set to > than 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the peaks of at least two adjacent channels. When the trace stabilizes after multiple scans, the marker-delta function is used to determine the separation between the adjacent channels. Measurements were made for low, mid and high channels.

The plot shows that the maximum carrier frequency separation is measured as **503.00 kHz**, which is greater than the 20dB bandwidth measurement (**234.00 kHz**).



### Channel Separation High Band Measurement Plot



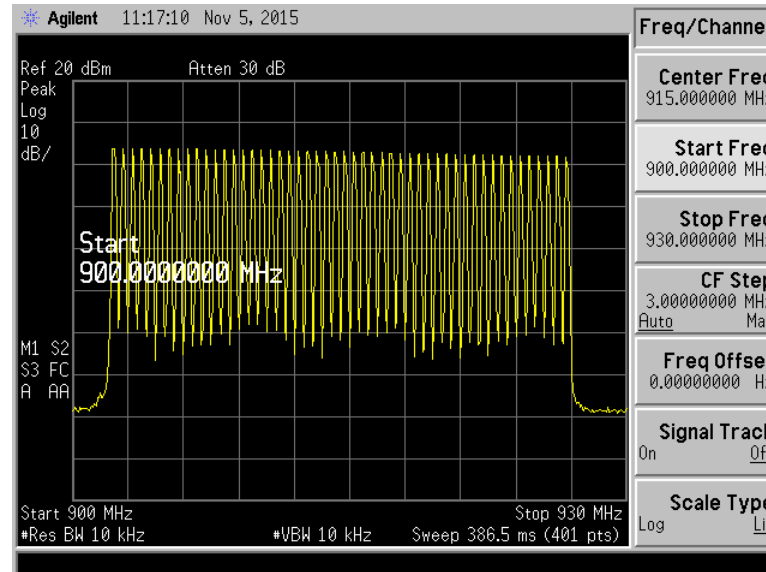
## 7. Number of Hopping Frequencies Measurement (FCC Part 15.247)

**Number of Hopping Frequencies Requirement:** Per section 15.247(a) (1) (i), for frequency hopping systems operating in the 902-928 MHz band, the 20dB bandwidth shall be measured for determination of the carrier frequency separation limits and must not exceed 500 kHz. In this design, the 20dB bandwidth of the hopping channel is less than 250 kHz, so the system shall use at least 50 hopping channels.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

In measurement of the number of hopping frequencies, the DUT was allowed to continuously transmit. The RBW was set to < than 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the entire frequency band of operation. When the trace stabilizes after multiple scans, the number of hopping frequencies is counted.

The plot, shows the number of hopping frequencies equals 50, which meets the requirements.



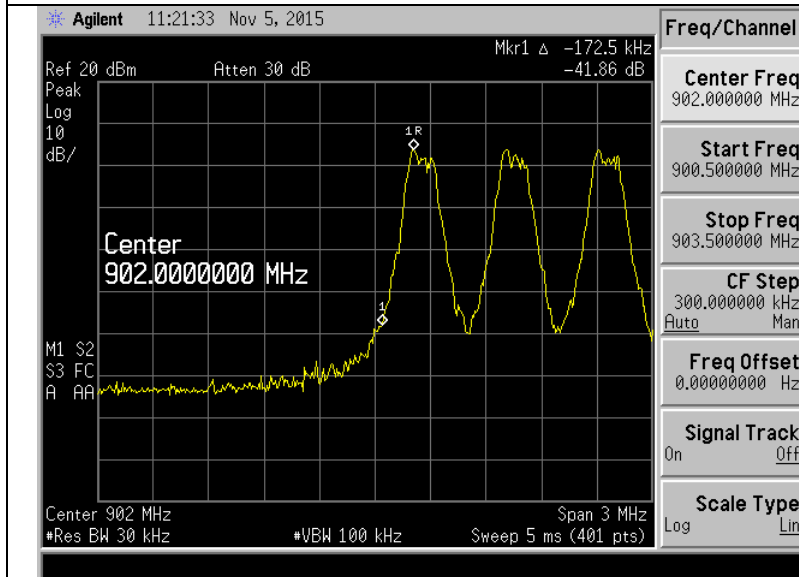
## 8. Band Edge Measurement (FCC Part 15.247)

Per section 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

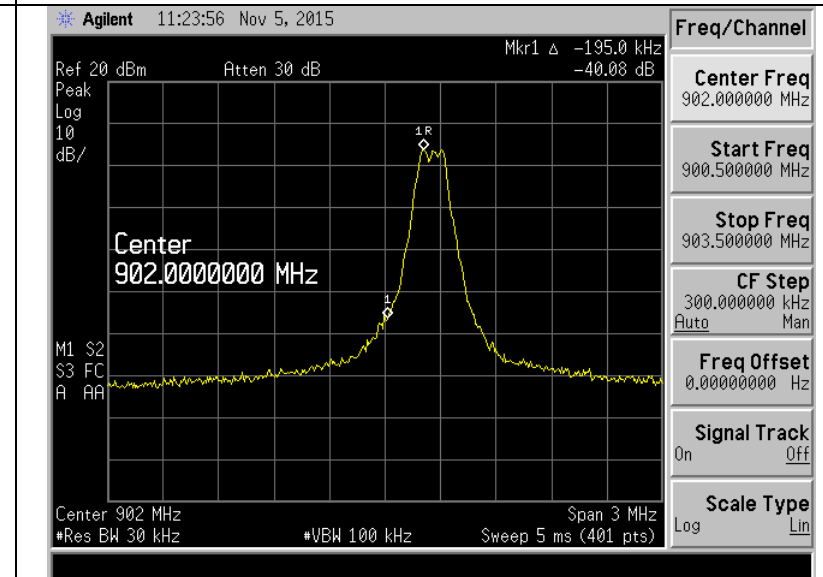
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT. The measurements are also performed without hopping on multiple channels.

For the Low Frequency Band Edge, emissions are at least 40dB below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. For the High Frequency Band Edge, emissions are over 59dB below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.

### Hopping Low Frequency Band Edge

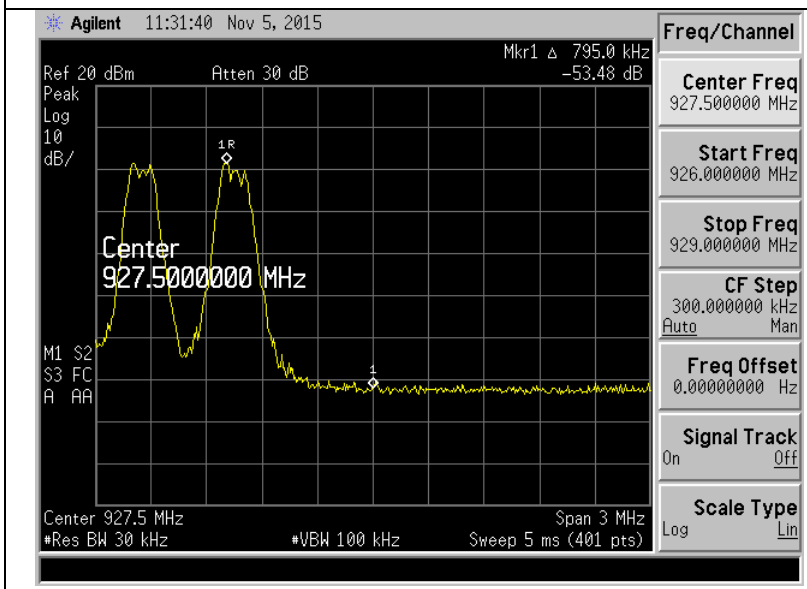


### Non - Hopping Low Frequency Band Edge

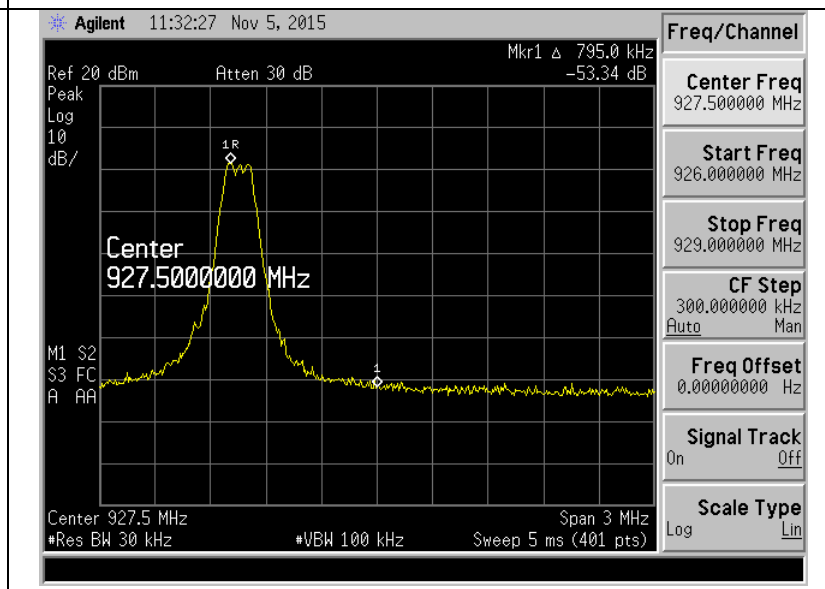




### Hopping High Frequency Band Edge



### Non - Hopping High Frequency Band Edge

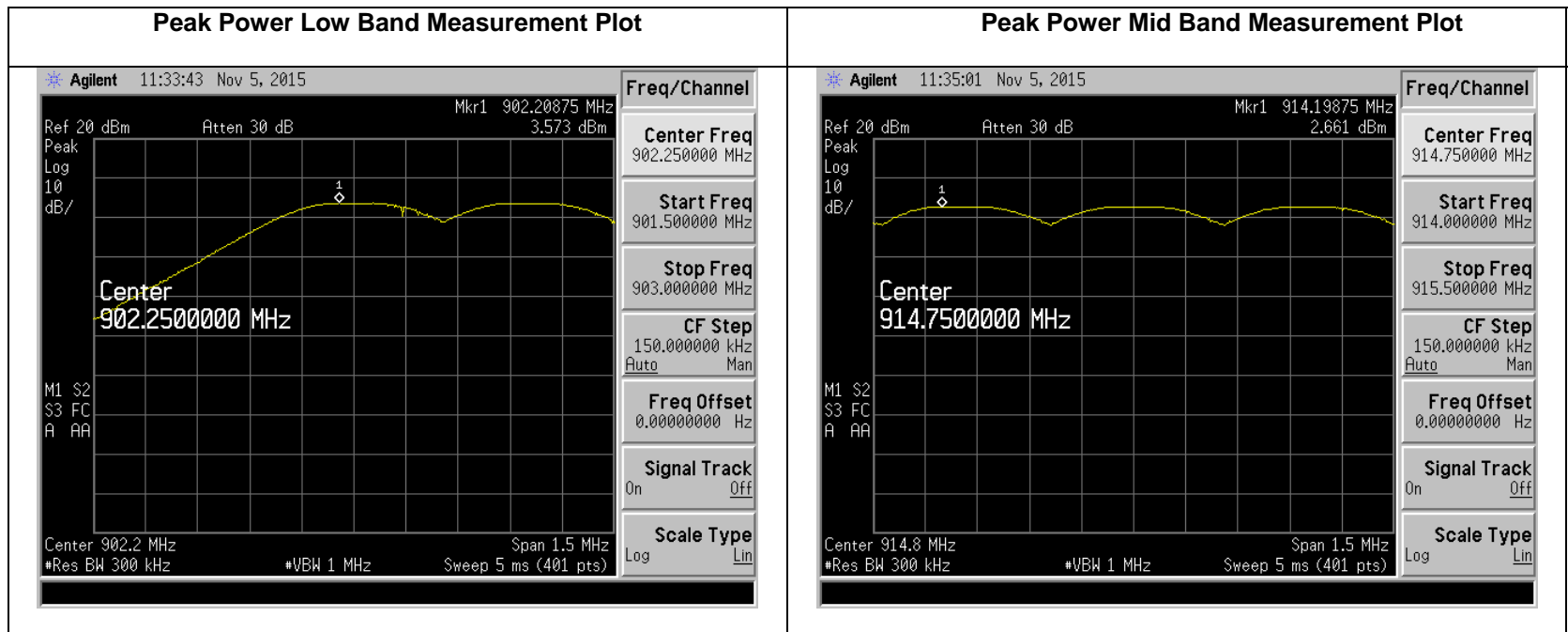


## 9. Peak Power (FCC Part 15.247)

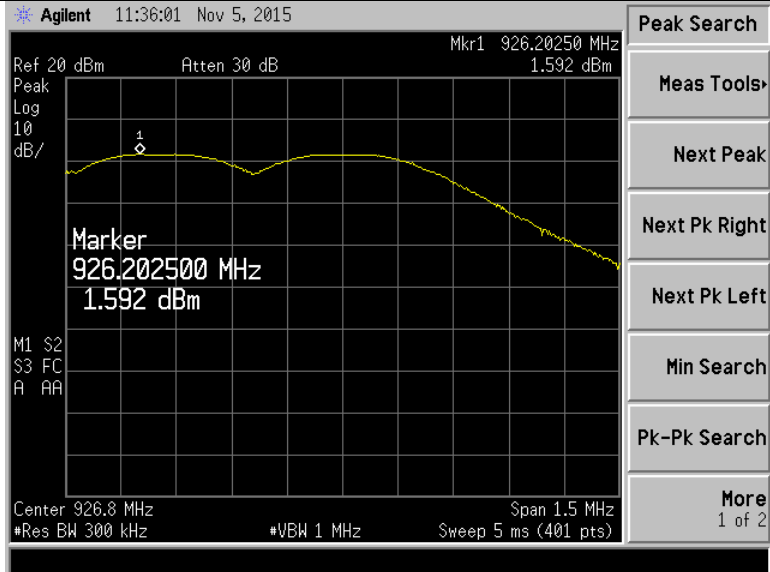
Per section 15.247(b)(2), for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels, the maximum peak output power shall not be greater than 1W (30dBm).

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

Peak power was measured with the transmitter set separately at 902.25MHz, 914.75MHz, and also 926.75MHz. For each of the frequencies, the peak power was less than 30dBm. At 902.25 the peak power was 3.573dBm, at 914.75 the peak power was 2.661dBm, and at 926.75 the peak power was 1.592dBm, as shown in the plots below.



### Peak Power High Band Measurement Plot



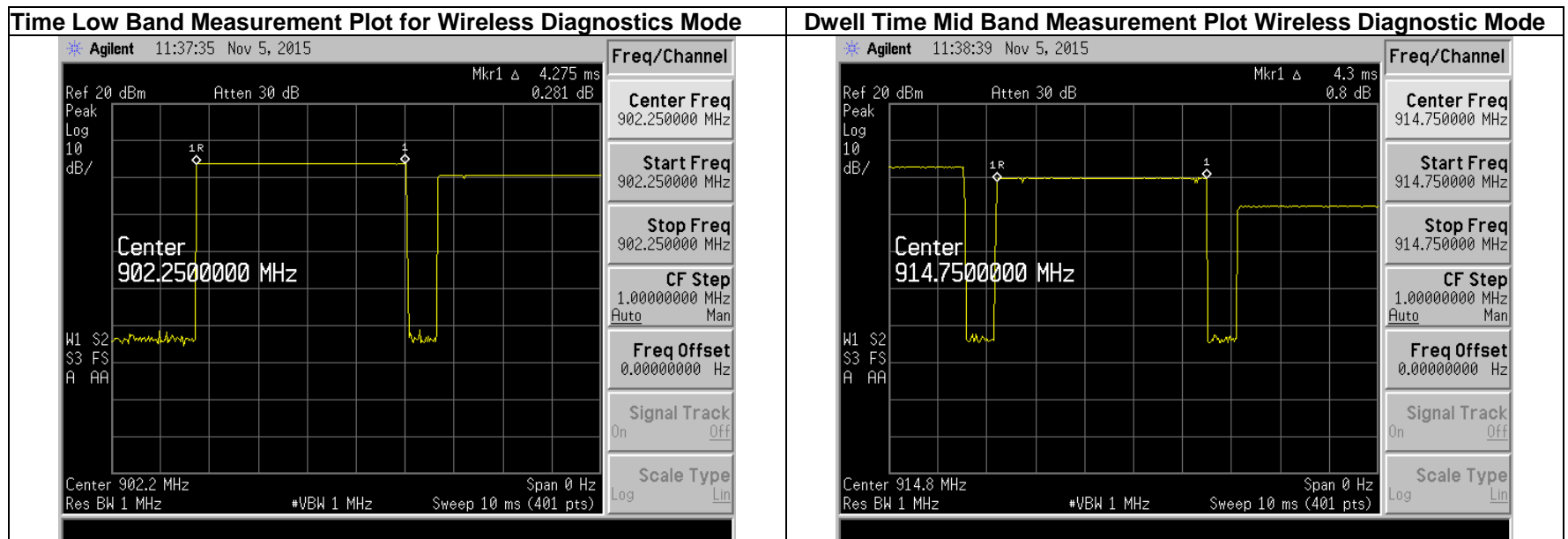
## 10. Time of Occupancy (FCC Part 15.247)

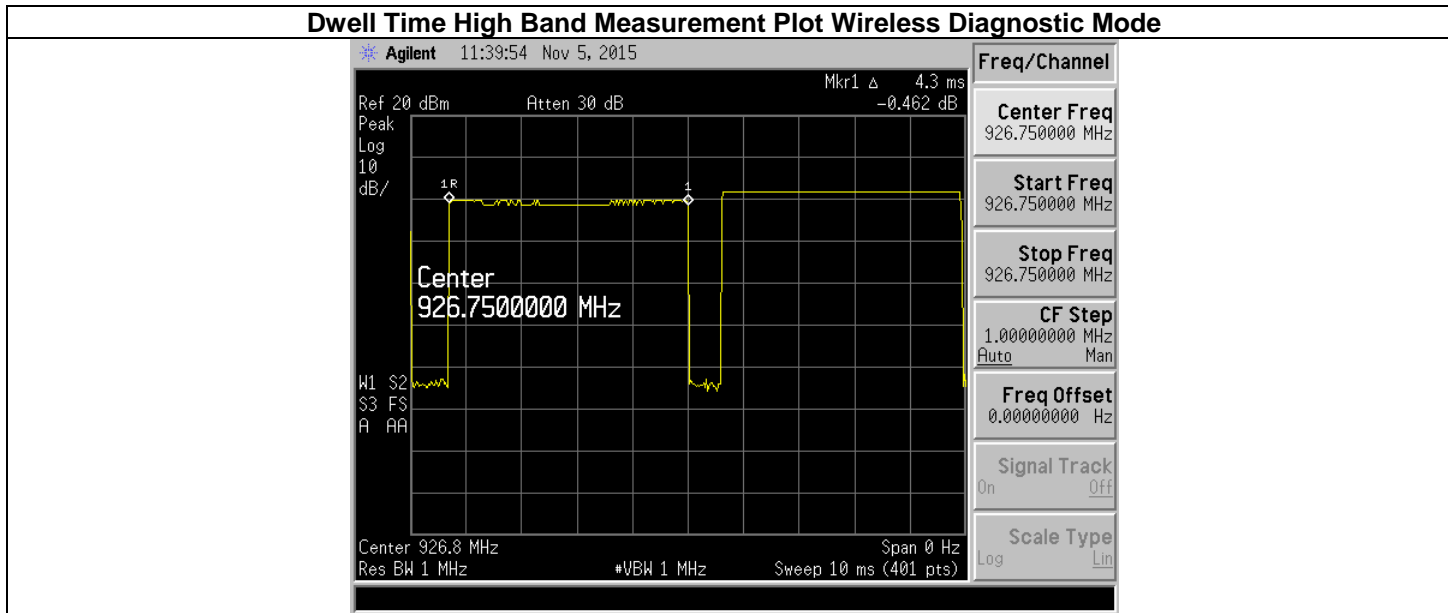
Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, if the 20dB bandwidth of the hopping channel is less than 250kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT. The part was placed in Wireless Diagnostics mode with the "Hop" message as it produced the worst case total dwell times. Within Wireless diagnostic mode, the "Info" message produced longer individual on times, but did not have as many transmissions in a 20s period.

In measurement of the time of occupancy, the RBW was set to 1MHz. The peak detector and 'Max-Hold' function were engaged. With the span set to 0Hz, the sweep time was adjusted to capture a single event in order to measure the dwell time per hop.

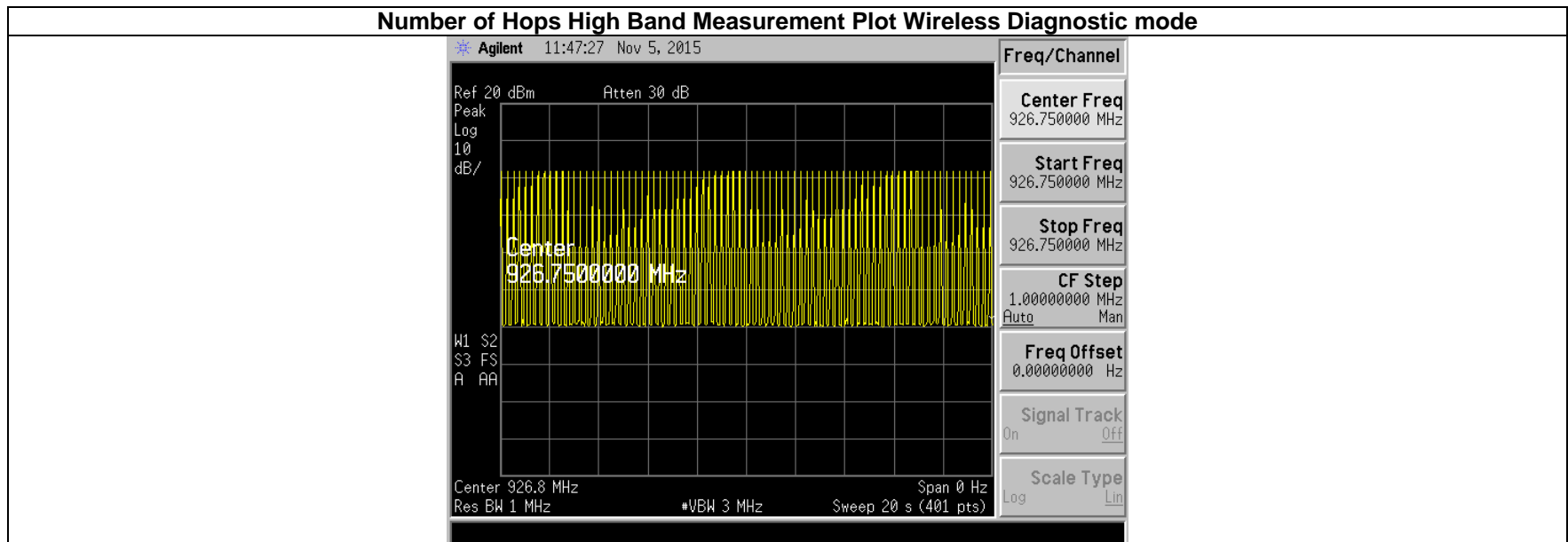
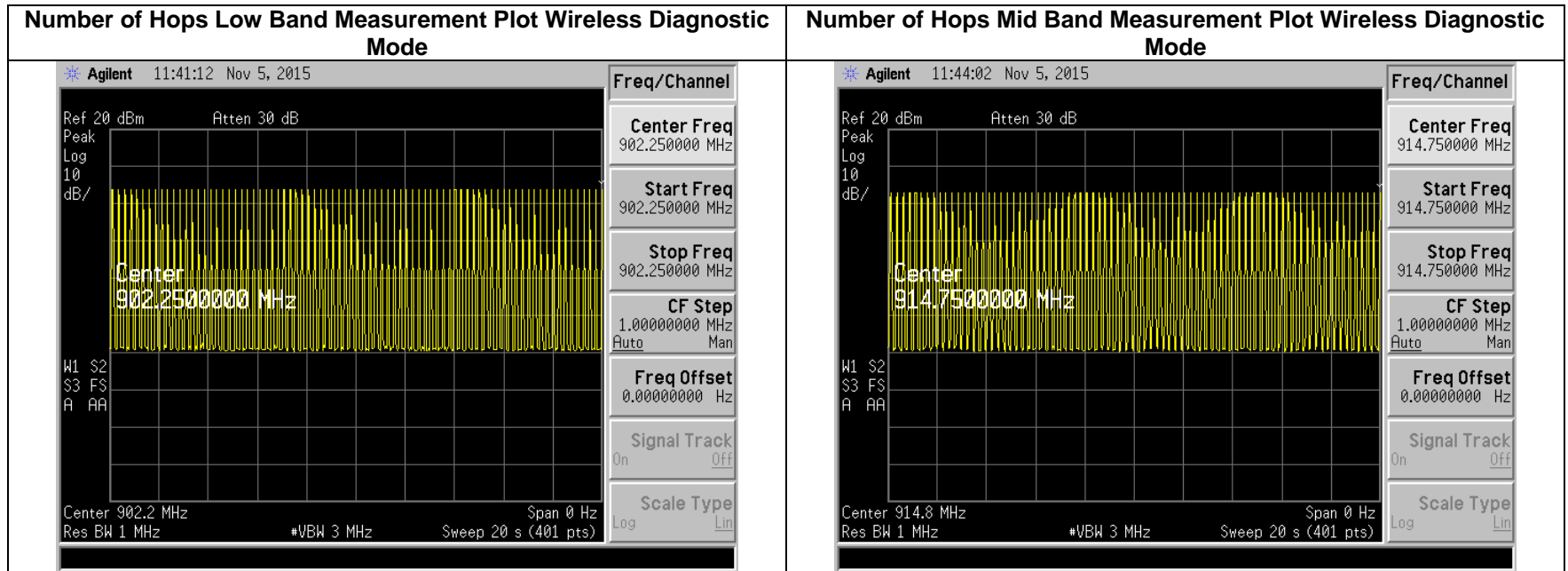
The figures below show the hop dwell time for each band





Dwell time per frequency =  $4.3/250$  per cycle = 1.72% or 172msec in 10 seconds or 344msec in 20 seconds, where the limit is 0.4 seconds leaving a margin of 0.056seconds.

Then the sweep time was expanded to 20 seconds to capture the number of hops in the appropriate sweep time. A single sweep is made for each band, shown in the plots below.



# 11. Duty Cycle Correction Measurements (FCC Part 15.247)

