Technical Report to the FCC and Industry Canada Regarding Johnson Controls Interiors, L.L.C. Homelink© 5
Model: SAHL5C
FCC ID: CB2SAHL5C
IC: 279B-SAHL5C
Title 47, Part 15.247
12/9/2012

A report concerning approval for Johnson Controls Homelink® model SAHL5C

Measurements Made by:

Bolay Bun (Radiated Measurements)
RF Test Site Technician and
Edward Thomsen (Conducted Measurements)
Test / EMC Engineer
Johnson Controls Interiors, LLC.

Measurements Reviewed by:

Edward Thomsen
Test / EMC Engineer
Johnson Controls Interiors, LLC.

Report and Application Prepared by:

Edward Thomsen
Test / EMC Engineer
Johnson Controls Interiors, LLC.

Report Submitted by:

Edward Thomsen
Test / EMC Engineer
Johnson Controls Interiors, LLC.

1. General Information

1.1. Product Description:

The Johnson Controls Interiors 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 Johnson Controls Interiors, LLC.

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 CB2SAHL5C and an IC ID # of 279B-SAHL5C 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 C63.4-2003. The power source for this product is a 12V automotive vehicle battery.

Conducted measurements were performed using a power supply.

Measurements were performed per KDB 867751.

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 Johnson Controls Automotive Interiors System's Edgar D. Prince 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. 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 December 20, 2011, was accepted by the FCC in a letter dated January 10, 2012. The report filled with Industry Canada, dated June 7, 2011, was accepted via a letter dated June 7, 2011. Our OATS is registered with the IC under file number IC# 279B-1.

Conducted Measurements were performed inside an approximately 7'x7'x8' copper screened Faraday cage.

1.5. Accreditation

The Johnson Controls, Inc. - Electronics Validation Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA). Our laboratory scope and accreditation certificate (#1425.02) are available from their web site www.a2la.org. Our scope of accreditation covers ANSI C63.4 Radiated Emissions at 3m, FCC 47 CFR Part 15, and IC RSS-210.

2. Product Labeling

The FCC Identifier assigned is FCC ID: CB2SAHL5C. The Industry Canada certification number is 279B-SAHL5C. These identifiers will be labeled on the product housing.

The label will be placed on the exterior of the HL housing using an acrylic adhesive 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-210. 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: 279B-SAHL5C JCI MODEL/FCC ID: CB2SAHL5C

2.1. Label Drawing and Location on Product.

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

3. Test Configuration

Radiated Emission measurements presented in the report were made in accordance with ANSI C63.4 Figure 9(c). The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane. The harness was run to the long edge of the table and dropped to a power supply sitting at base of the table.

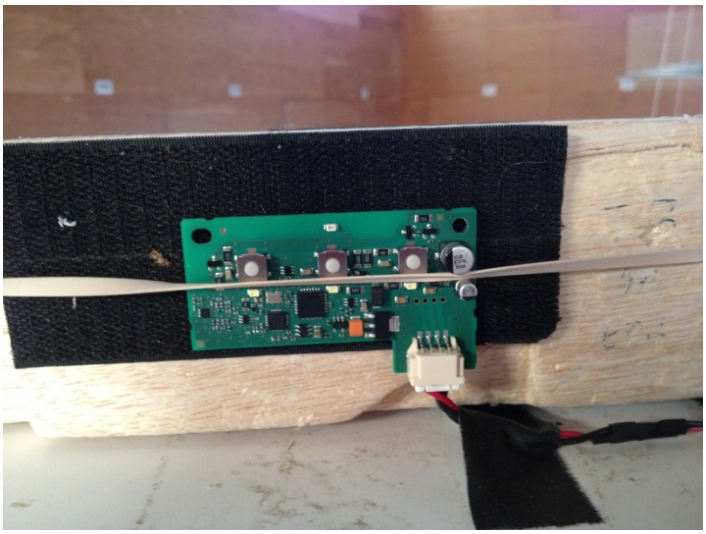
Conducted measurements were performed on a non-metallic table approximately 80cm x 90cm, 85cm above the floor.

4. Block Diagram

For system block diagram please refer to attachment named "HLV Block Diagram 12FEB11.pdf"

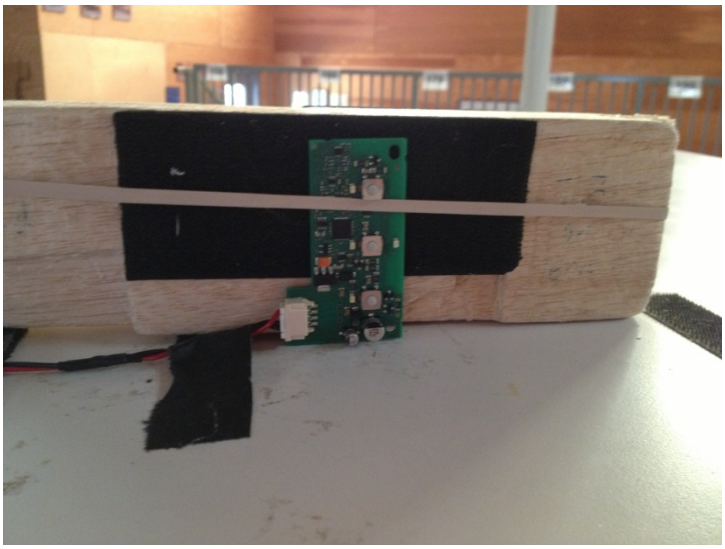
5. Test Setup Photographs

Radiated Emissions Photos (Setup for Tx and Rx)



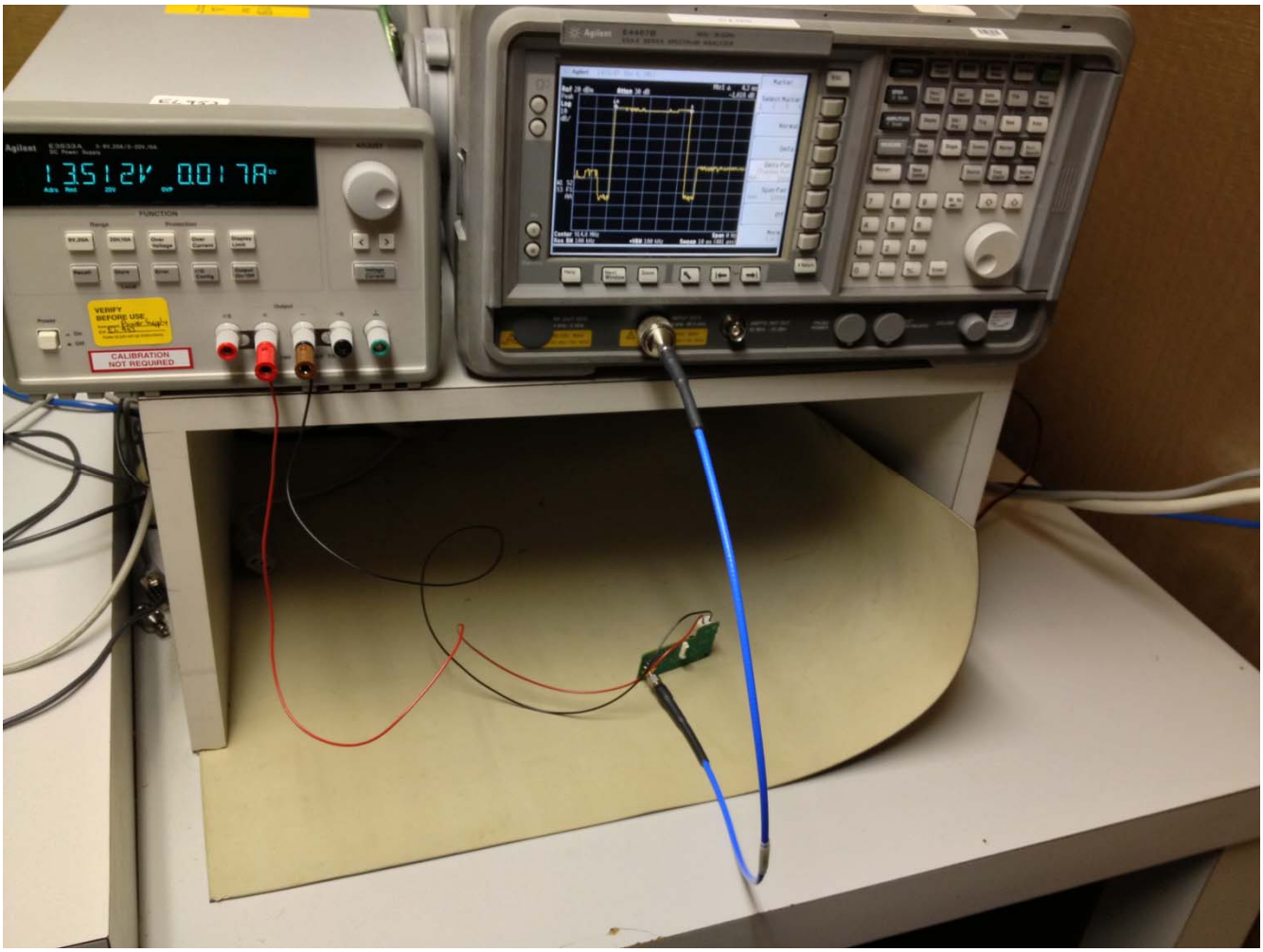
Test Setup Side

Test Setup Flat

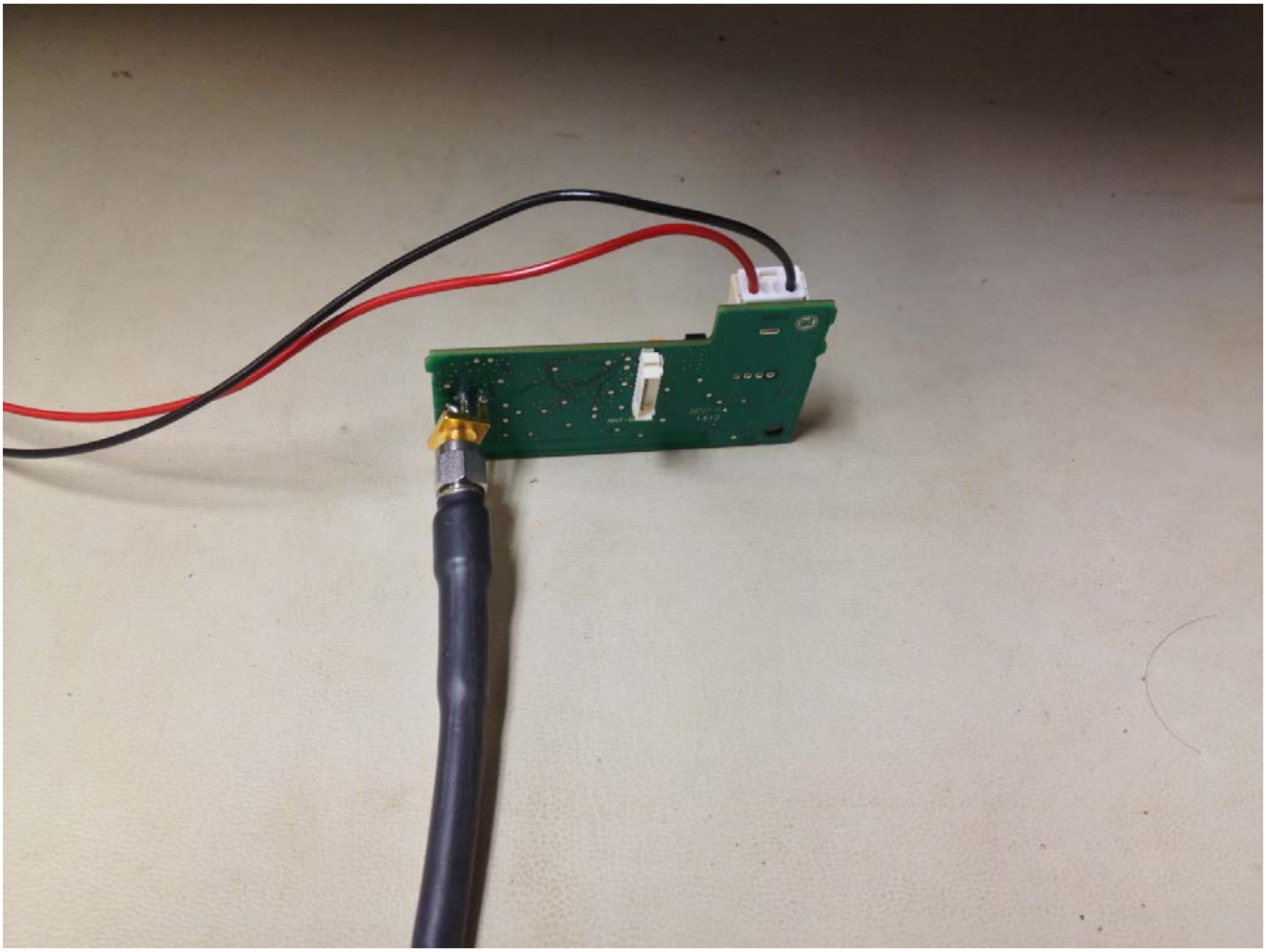


Test Set Up End

Conducted Measurement Setup Photo



Device Close-Up Conducted Measurement Photo



6. Powerline Conducted Emissions Measurements

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

7. Test Data

7.1. Summary of Results (Part 15.247)

- **20dB Bandwidth Requirement**: The plots, show that the maximum 20dB bandwidth was **235.00kHz**, which is within limit. The 99% bandwidth was measured to be **197.13kHz**.
- **Carrier Frequency Separation Requirement**: The plot, shows that the maximum carrier frequency separation is measured as **502.50kHz**, which is greater than the 20dB bandwidth measurement (**235.00kHz**).
- **Number of Hopping Frequencies Requirement**: The plot, shows the number of hopping frequencies equals **50**, which meets the requirements.
- **Time of Occupancy Requirement**: The time of occupancy can be determined by **4.3ms** multiplied by **80**. This calculated value is equal to **0.344s** which is less than the 0.4s maximum allowed.
- **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 **59dB** below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.
- **Peak Output Power Requirement**: 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). Measurements of the transmit output field strength were taken with the DUT trained to 902.25, 914.75, and 926.75MHz. A **worst-case emission of 12.06 dBm** occurred at 902.205MHz remained **17.94dBm below the FCC and IC limits** for this type of device.
- **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*Log(duty cycle). The duty cycle factor is calculated as **-27.3dB**. (-27.3dB = 20*Log(4.3ms/100ms)).

- **Radiated Spurious Emissions (Transmitter) Requirement:** See the tables in section 7.4.1 for limits. All measurements were below the prescribed limits. The low band has a minimum margin of **4.18dB** for the peak measurement and **14.6dB** for the average measurement, the mid band has a minimum margin of **5.53dB** for the peak measurement and **11.5dB** for the average measurement, the mid band has a minimum margin of **1.74dB** for the peak measurement and 9.1dB for the average measurement, and the high frequency band has a minimum margin of **2.29dB** for the peak measurement and **9.6dB** for the average measurement.
- **Radiated Spurious Emissions (Receiver) Requirement**: See the tables in section 7.4.1 for limits. All measurements were below the prescribed limits. The low band has a minimum margin of **17.4dB**, the mid band has a minimum margin of **20.7dB**, and the high frequency band has a minimum margin of **15.4dB**.

7.2. Test Equipment Used

7.2.1 Conducted Measurement Equipment

Description	Model #	Serial Number	Last Cal Date	Cal Due
Power Supply	E3633A	MY40008208	N/A	N/A
Agilent E-series EMC Analyzer	E4407B	US41192569	5/5/12	5/5/13
Fluke Digital Multimeter	77III	74730552	10/12/11	10/12/13
Agilent EXA Spectrum Analyzer	N9010A	MY51250400	10/20/11	10/20/13

7.2.2 Radiated Measurement Equipment

Description	Model #	Serial Number	Last Cal Date	Cal Due
EMCO Biconical Antenna [20-300 MHz]	3110B	9906-3309	1/26/12	11/26/14
EMCO LPA Antenna [200-2000MHz]	3148	9908-1076	11/26/12	11/26/14
Electro-metrics Double Ridged	RGA-60	6147	01/02/11	01/02/13

Guide [1-18GHz]				
Agilent E-series EMC Analyzer	**E4407B**	**US41192569**	**10/16/12**	**10/16/13**

7.3. Test Equipment Setup and Procedure

Spectrum Analyzer Settings Emissions:

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

Spectrum Analyzer 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)

For the testing, the EUT was placed at the center of a non-conducting table 80cm above the ground plane pursuant to ANSI C63.4 for stand-alone equipment. The 2-conductor cable harness was routed to the edge of the long side of the table then down to the power supply located on the turntable base.

Equipment is placed in one of the three orthogonal orientations, End, Side, and Flat. These orientations are described below in Figure 7.3.1.

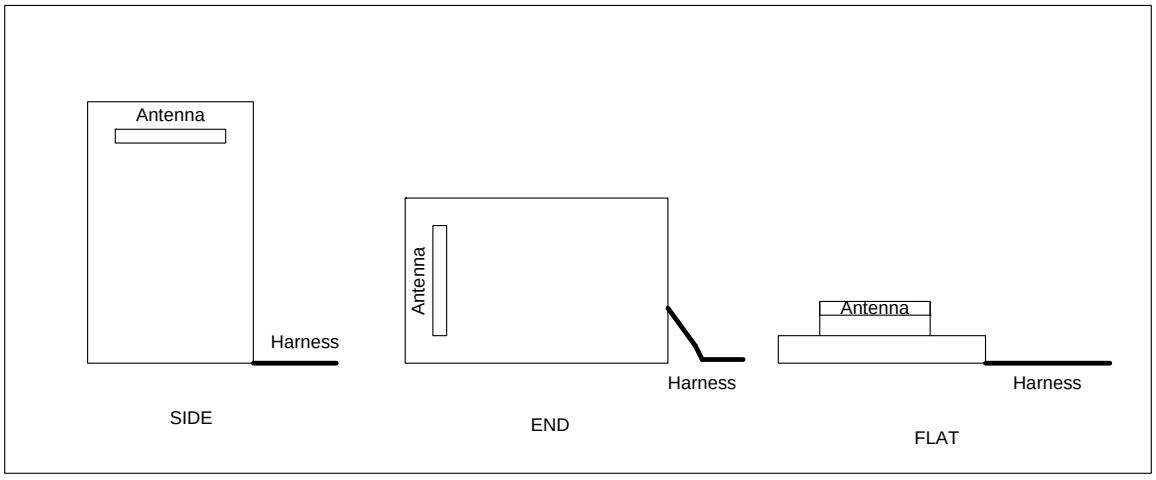


Figure 7.3.1 EUT Orthogonal Orientations

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.

7.4. Measured Data

7.4.1 Radiated (Tx) Measurements

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

7.4.1.1 DUT Transmitting at 902.25MHz (Fundamental) – FCC 15.247

Peak Measurement 902.25MHz

	Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
1	902.25	End	H	99.74	137.0	37.25
2	1804.5	Flat	H	73.03	79.7	6.71
3	2706.75	Flat	H	69.82	74.0	4.16
4	3609	End	H	68.91	74.0	5.07
5	4511.25	End	H	58.23	74.0	15.75
6	5413.5	Side	V	60.99	74.0	12.99
7	6315.75	Side	H	62.73	79.7	17.01
8	7218	End	H	62.01	79.7	17.73
9	8120.25	Side	H	65.15	74.0	8.83
10	9022.5	Side	H	66.63	74.0	7.35

Average Measurement 902.25MHz

	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)
3	2706.75	Flat	H	69.82	-27.3306	42.5	54.0	11.5
4	3609	End	H	68.91	-27.3306	41.6	54.0	12.4
5	4511.25	End	H	58.23	-27.3306	30.9	54.0	23.1

6	5413.5	Side	V	60.99	-27.3306	33.7	54.0	20.3
9	8120.25	Side	H	65.15	-27.3306	37.8	54.0	16.2
10	9022.5	Side	H	66.63	-27.3306	39.3	54.0	14.7

7.4.1.2 DUT Transmitting at 914.75MHz (Fundamental) – FCC 15.247

Peak
Measurement
914.75MHz

	Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
1	914.75	End	H	98.74	137.0	38.25
2	1829.5	Flat	H	73.6	78.7	5.14
3	2744.25	Flat	H	72.24	74.0	1.74
4	3659	End	V	68.34	74.0	5.64
5	4573.75	End	V	60.24	74.0	13.74
6	5488.5	End	V	60.73	74.0	13.25
7	6403.25	Side	V	61.48	78.7	17.26
8	7318	Side	V	64.42	78.7	14.32
9	8232.75	Side	H	66.5	74.0	7.48
10	9147.5	Side	V	66.76	74.0	7.22

Average
Measurement
914.75MHz

	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)
3	2744.25	Flat	H	72.24	-27.3306	44.9	54.0	9.1
4	3659	End	V	68.34	-27.3306	41.0	54.0	13.0
5	4573.75	End	V	60.24	-27.3306	32.9	54.0	21.1
6	5488.5	End	V	60.73	-27.3306	33.4	54.0	20.6
9	8232.75	Side	H	66.5	-27.3306	39.2	54.0	14.8
10	9147.5	Side	V	66.76	-27.3306	39.4	54.0	14.6

7.4.1.3 DUT Transmitting at 926.75MHz (Fundamental) – FCC 15.247

Peak
Measurement
926.75MHz

	Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
1	926.75	End	H	102.2	137.0	34.79
2	1853.5	Flat	H	79.48	82.2	2.72
3	2780.25	Flat	H	71.69	74.0	2.29
4	3707	End	H	69.45	74.0	4.53
5	4633.75	End	H	59.78	74.0	14.20
6	5560.5	End	V	61.28	82.2	20.92
7	6487.25	End	H	62.49	82.2	19.71
8	7414	Side	H	63.38	82.2	18.82
9	8340.75	End	H	65.6	74.0	8.38
10	9267.5	Flat	H	65.53	74.0	8.45

Average
Measurement
926.75MHz

	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)
3	2780.25	Flat	H	71.69	-27.3306	44.4	54.0	9.6
4	3707	End	H	69.45	-27.3306	42.1	54.0	11.9
5	4633.75	End	H	59.78	-27.3306	32.4	54.0	21.5
6	5560.5	End	V	61.28	-27.3306	33.9	54.0	20.0
9	8340.75	End	H	65.6	-27.3306	38.3	54.0	15.7
10	9267.5	Flat	H	65.53	-27.3306	38.2	54.0	15.8

7.4.2 Conducted Measurements

7.4.2.1 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 250kHz, 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.

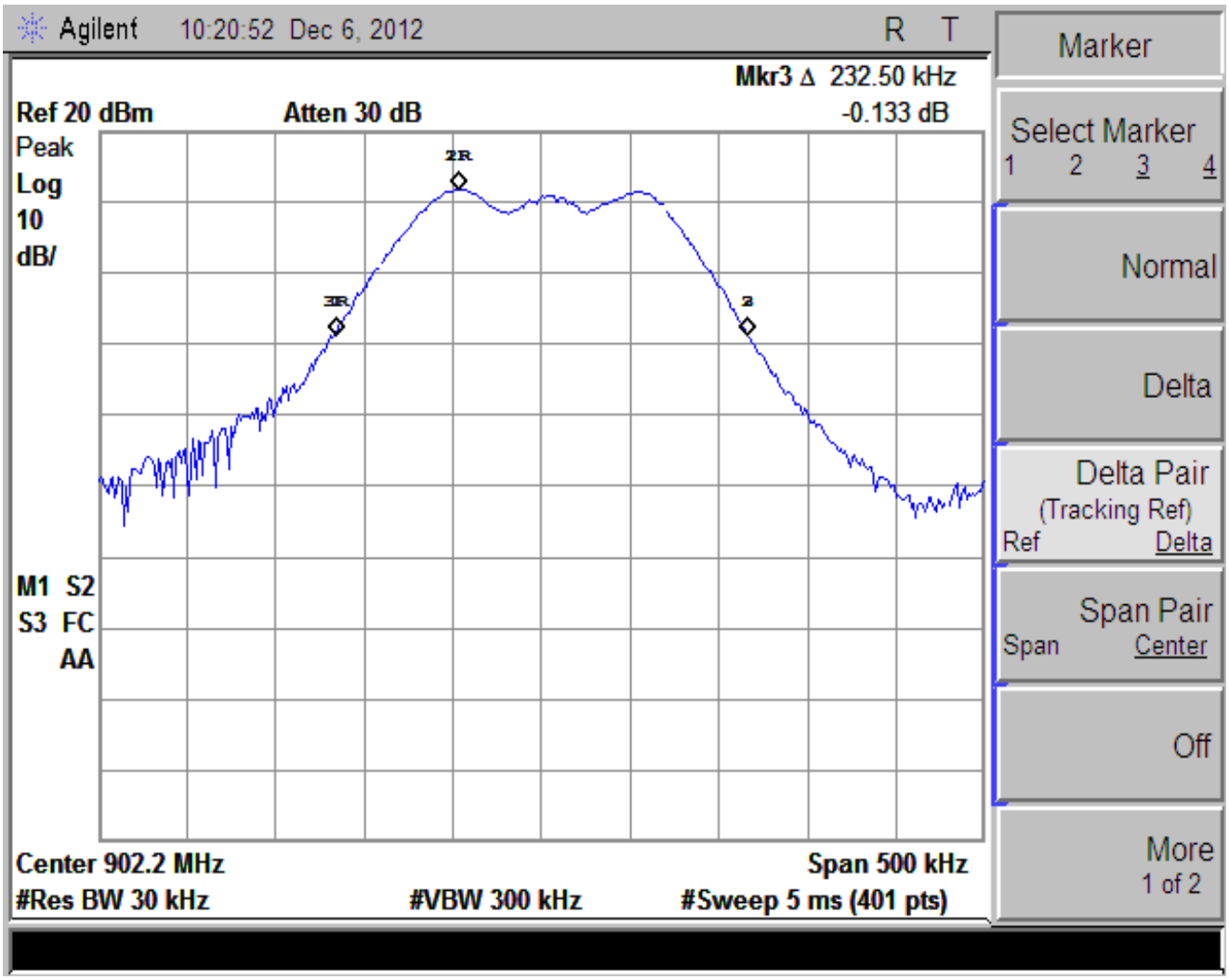
In measurement of the 20dB bandwidth, the transmit frequency was set to low, middle and high hopping channels. The resolution band width (RBW) was set to > than 1% of the 20dB bandwidth. The span was set to approximately 2 to 3 times the 20dB bandwidth.

The plots, show that the maximum 20dB bandwidth was 235.00kHz, which is within limit. The 99% bandwidth was measured to be 197.13kHz.

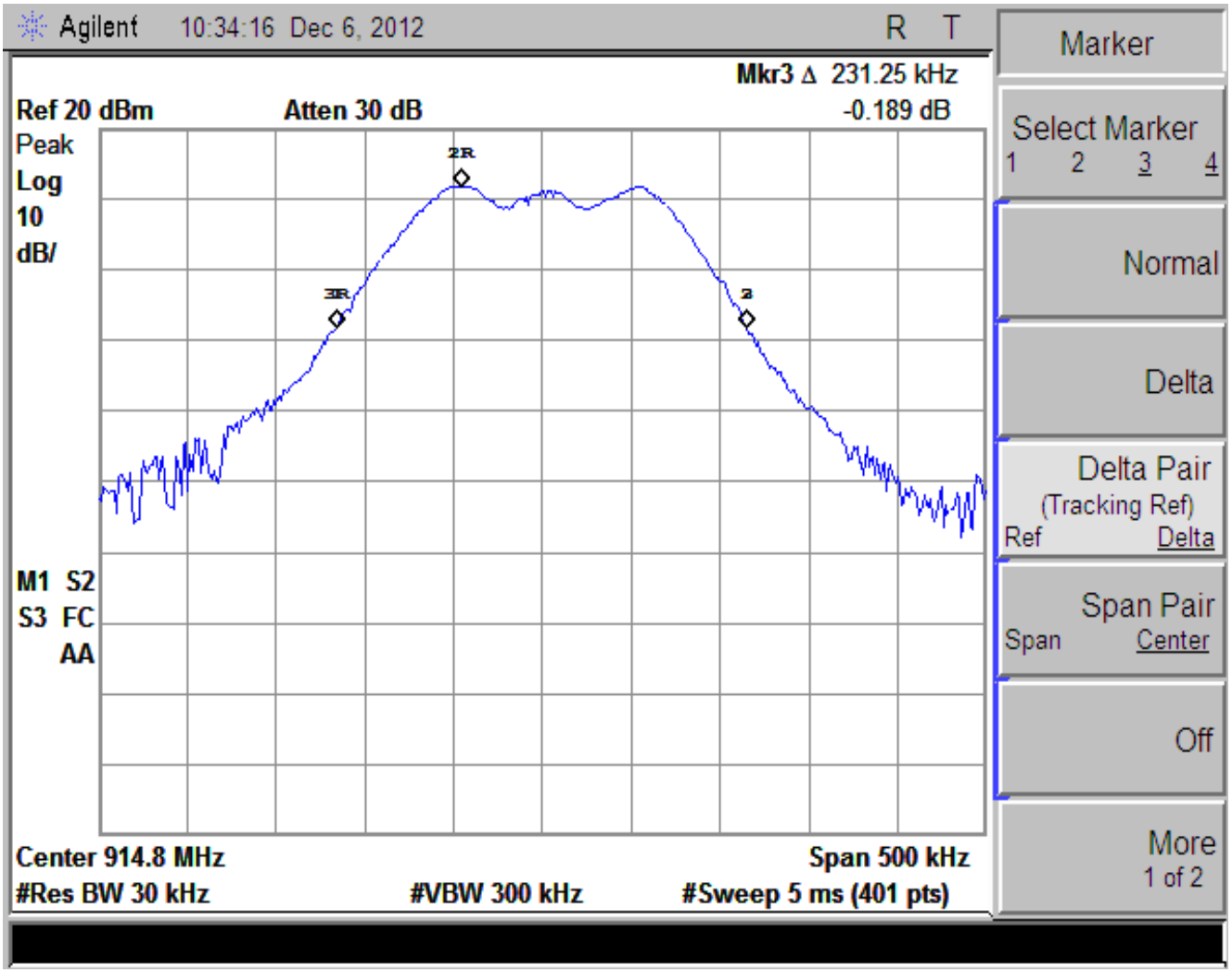
20dB BW Results

Frequency (MHz)	20dB Bandwidth (kHz)	Limit (kHz)
902.25	232.50	500
914.75	231.25	
926.75	235.00	

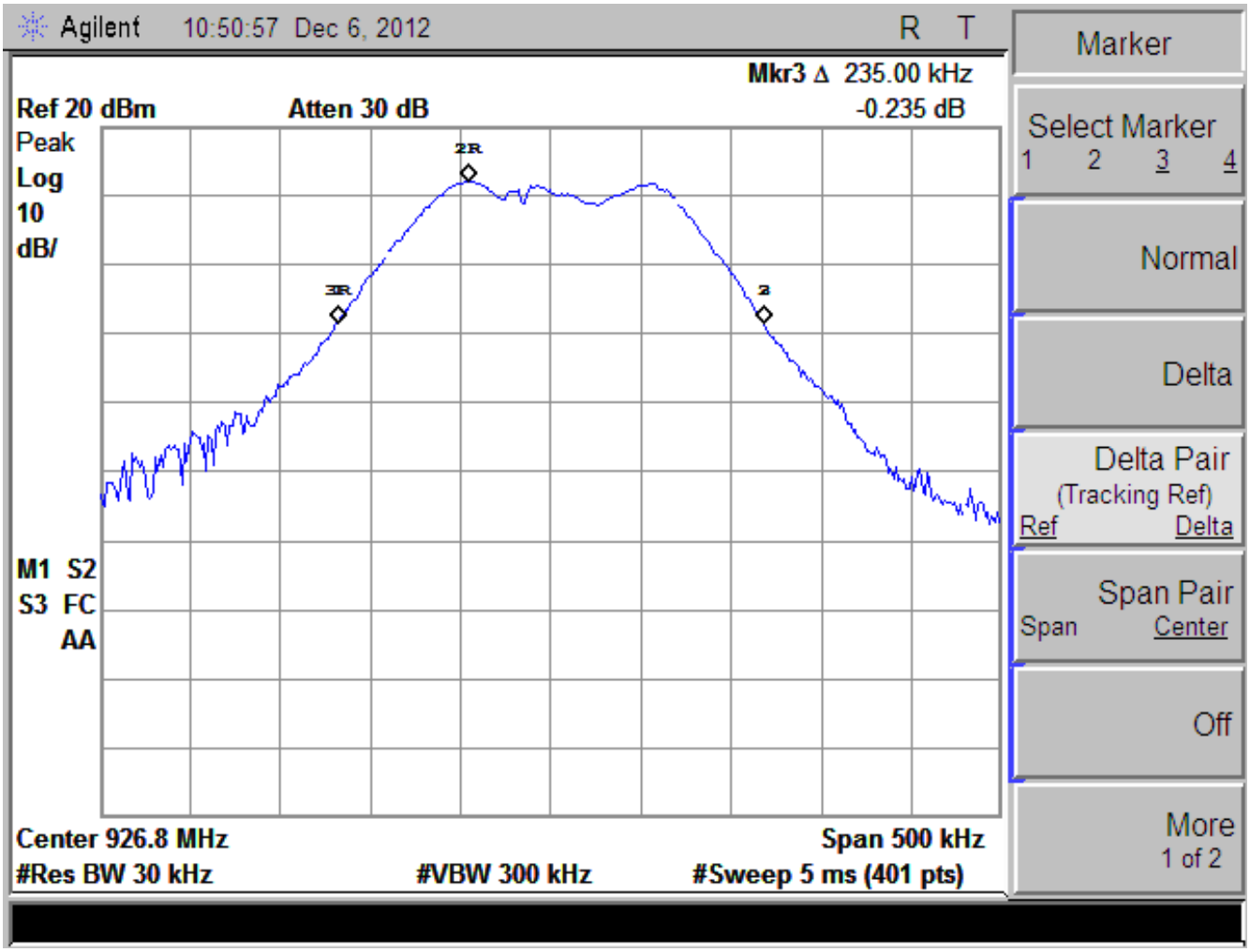
20 dB BW Low Band Measurement Plot



20 dB BW Mid Band Measurement Plot



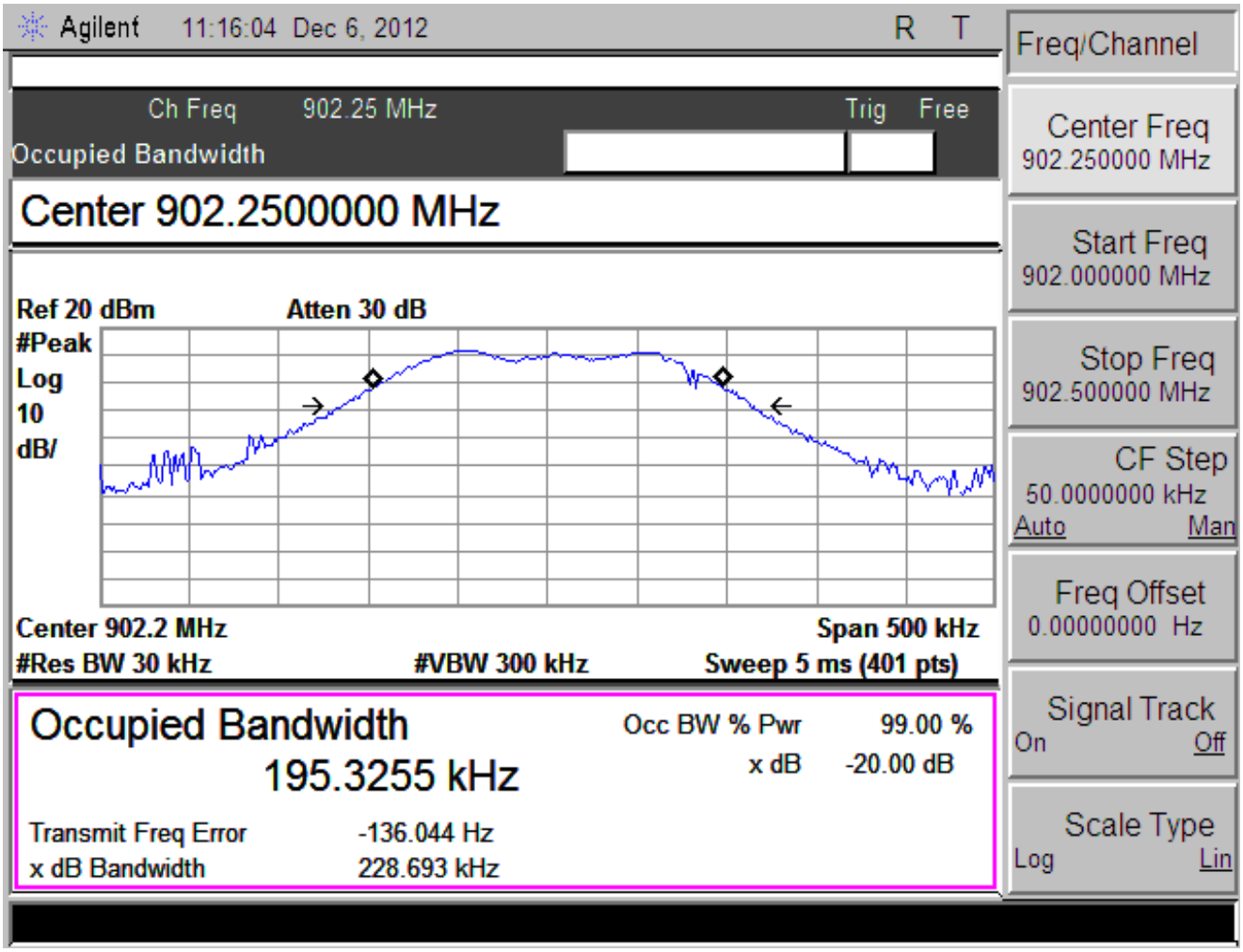
20 dB BW High Band Measurement Plot



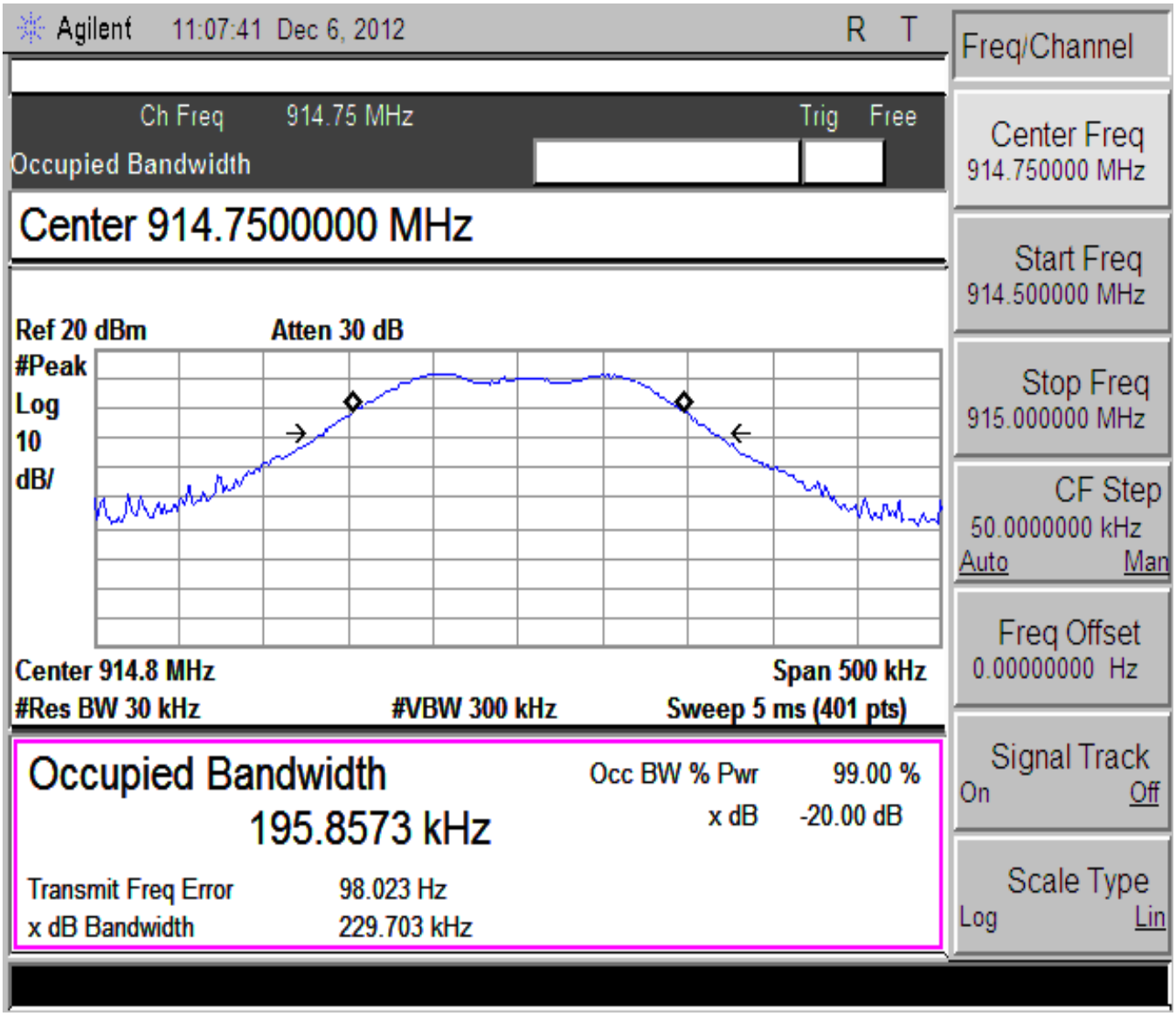
99% BW Results

Frequency (MHz)	99% Bandwidth (kHz)	Limit (kHz)
902.25	195.33	500
914.75	195.86	
926.75	197.13	

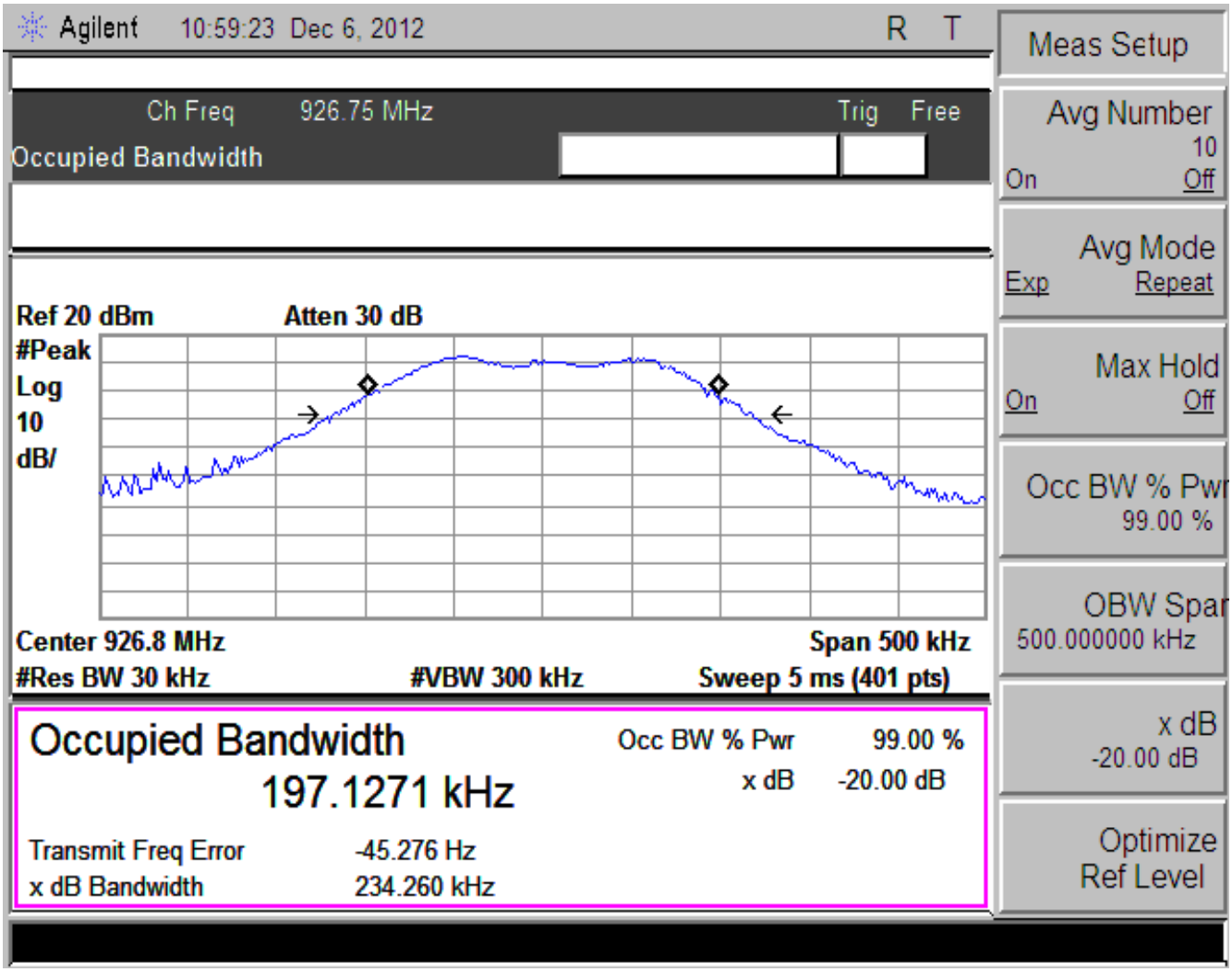
99% BW Low Band Measurement Plot



99% BW Mid Band Measurement Plot



99% BW High Band Measurement Plot



7.4.2.2 Carrier Frequency Separation Measurement (FCC Part 15.247)

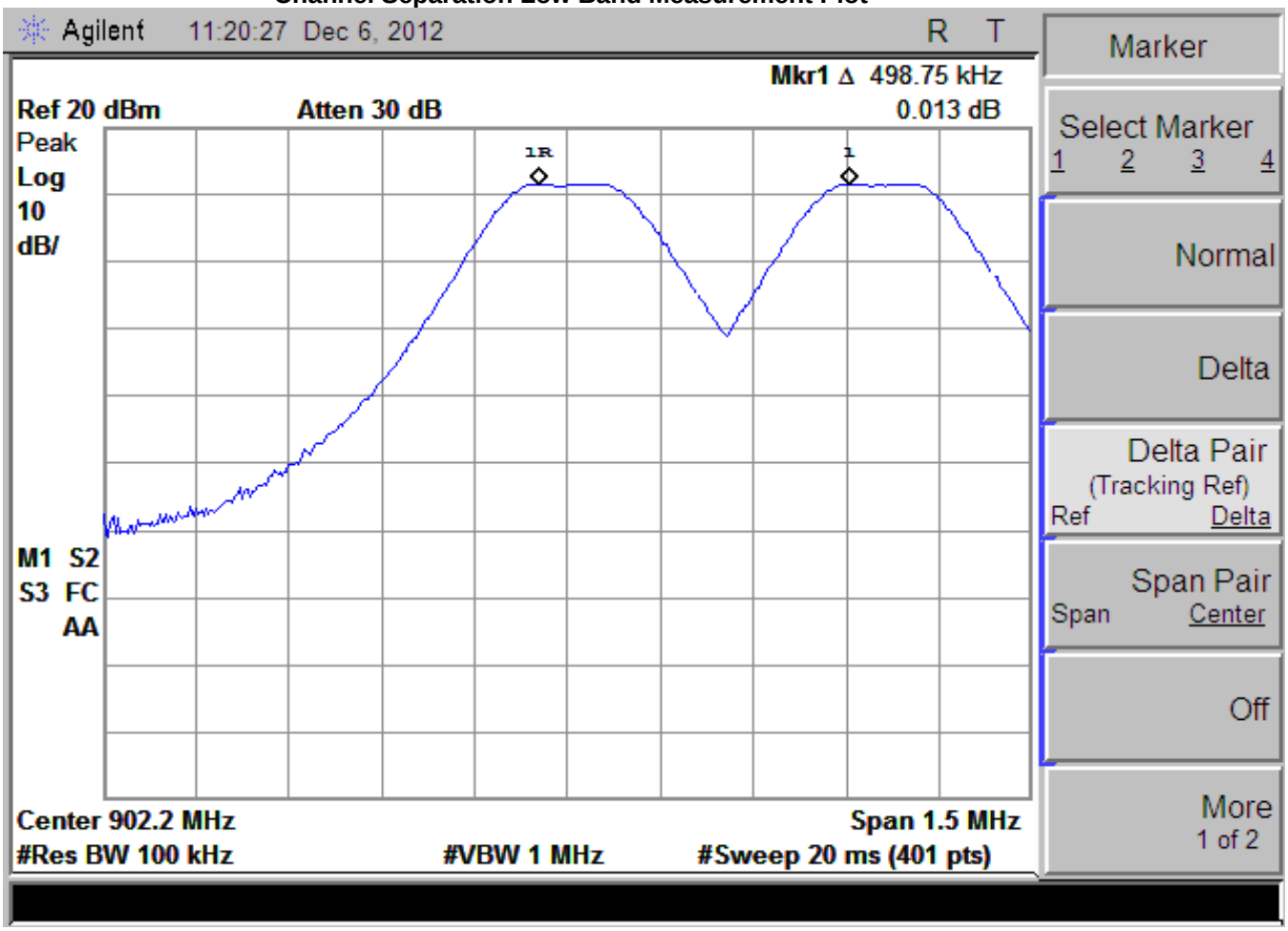
Carrier Frequency Separation Requirement: Per 15.247(a)(1), Frequency Hopping Systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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.

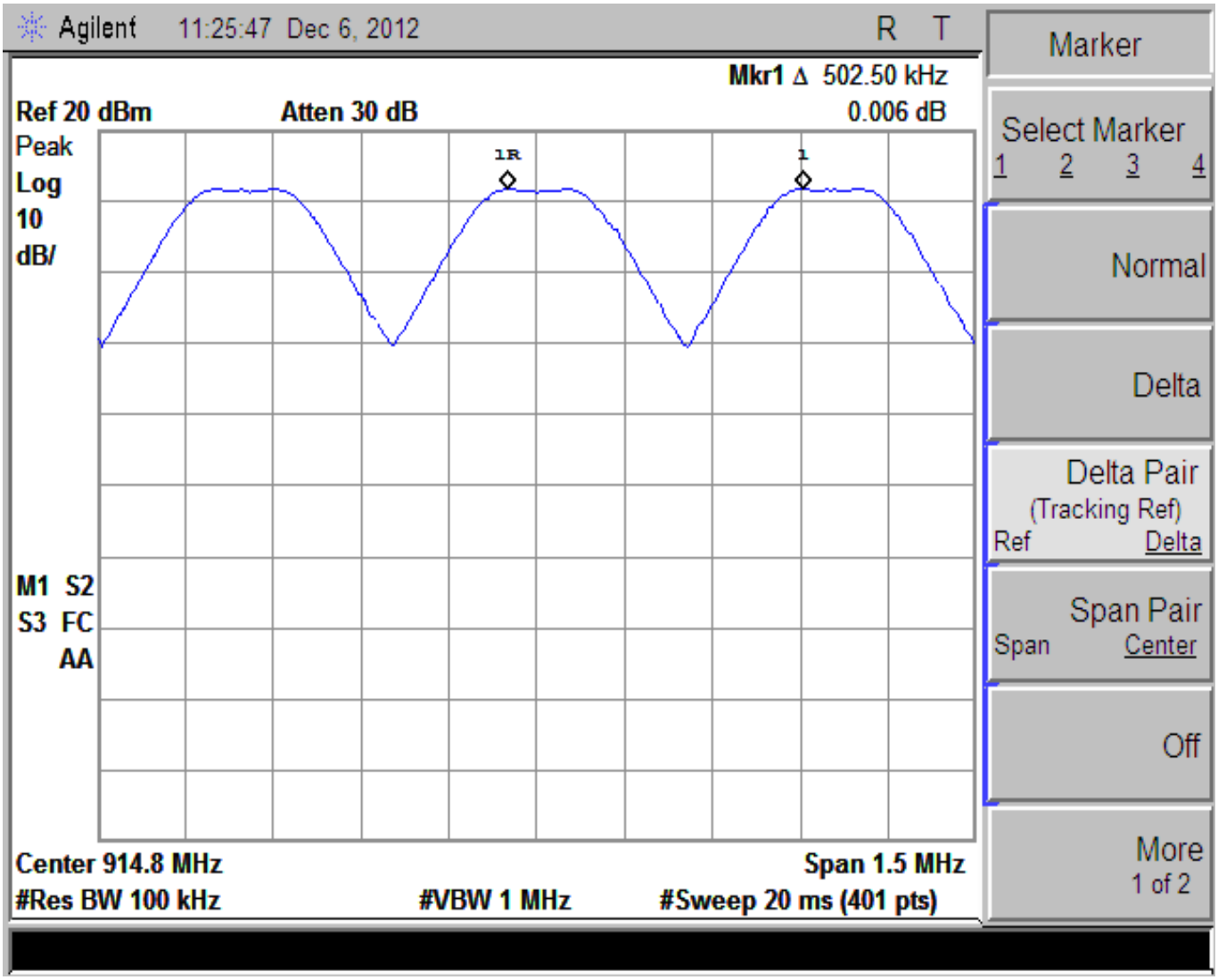
In measurement of the Carrier Frequency Separation, the RBW was set to > than 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the peaks of at least two adjacent channels. When the trace stabilizes after multiple scans, the marker-delta function 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 502.50kHz, which is greater than the 20dB bandwidth measurement (235.00kHz).

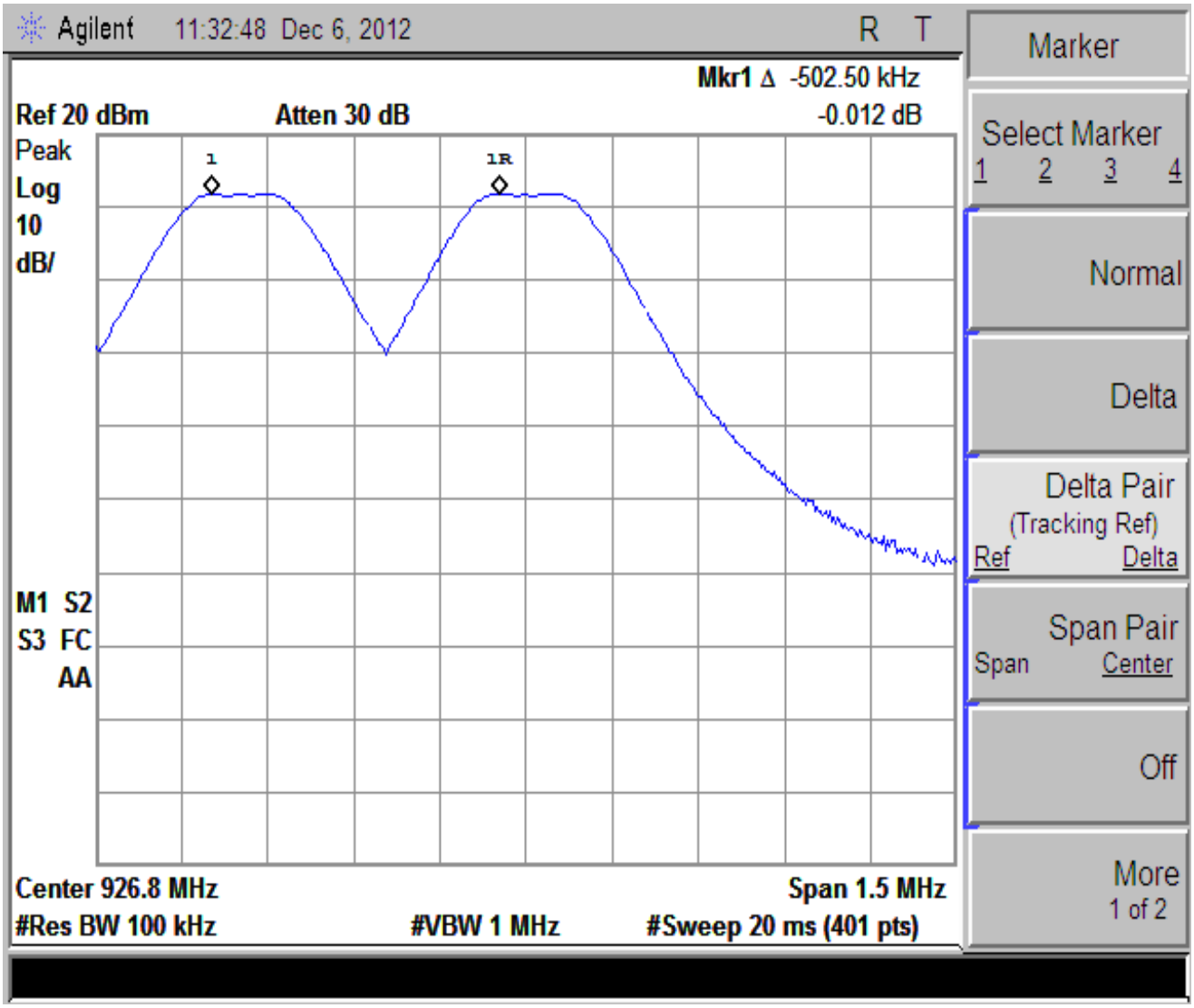
Channel Separation Low Band Measurement Plot



Channel Separation Mid Band Measurement Plot



Channel Separation High Band Measurement Plot



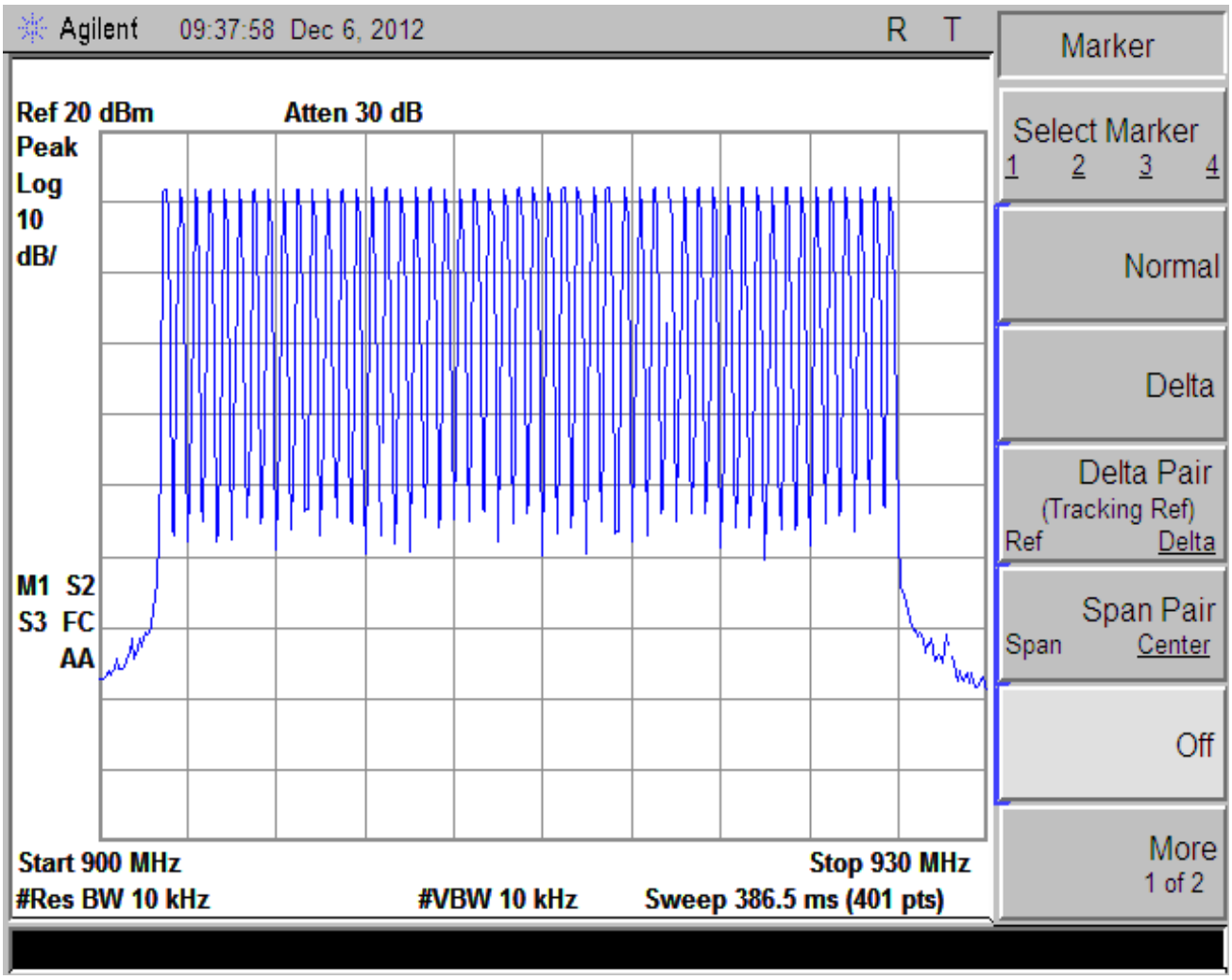
7.4.2.3 Number of Hopping Frequencies Measurement (FCC Part 15.247)

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 250kHz, 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.



7.4.2.3 Band Edge Measurement (FCC Part 15.247)

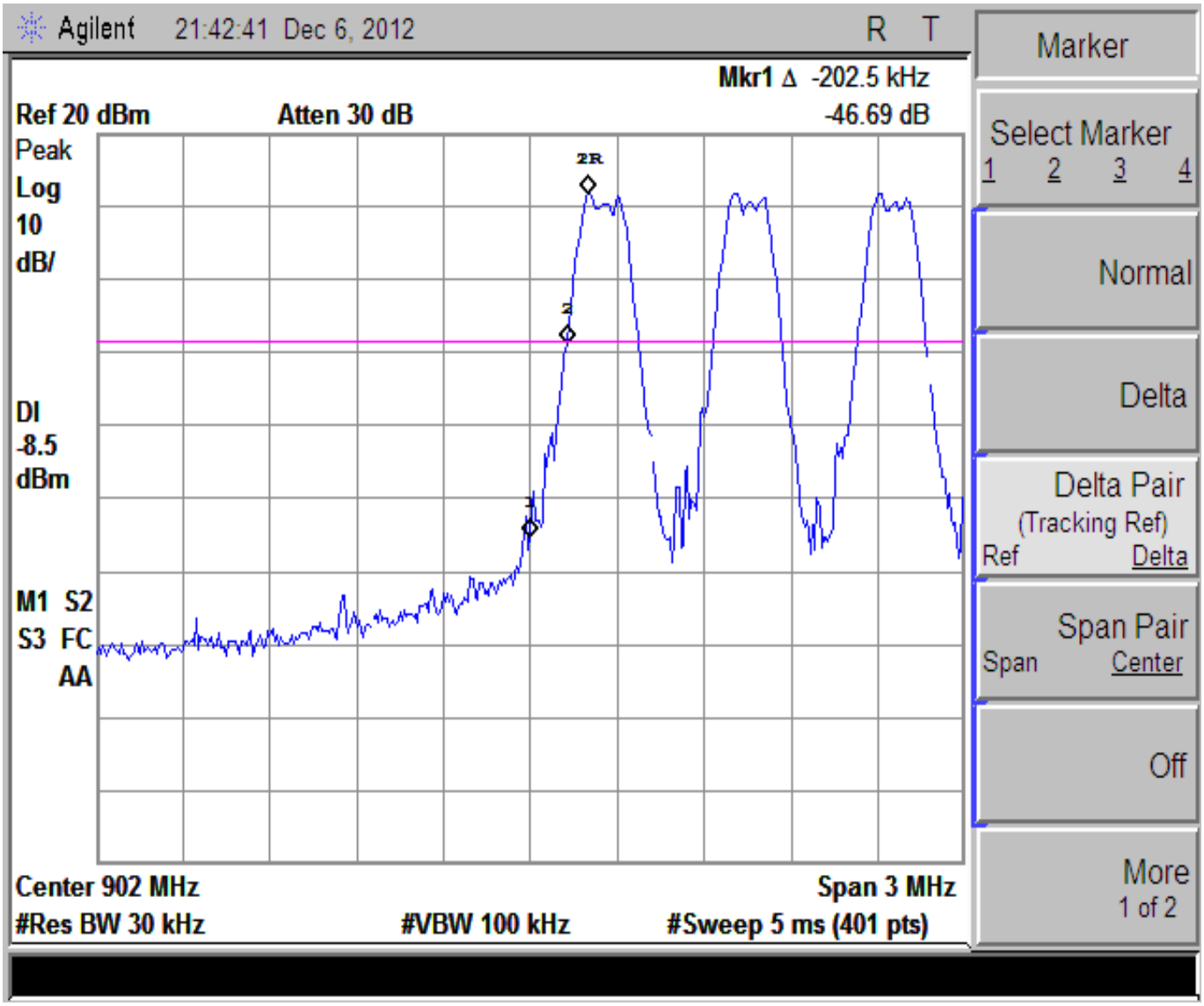
Per section 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the 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

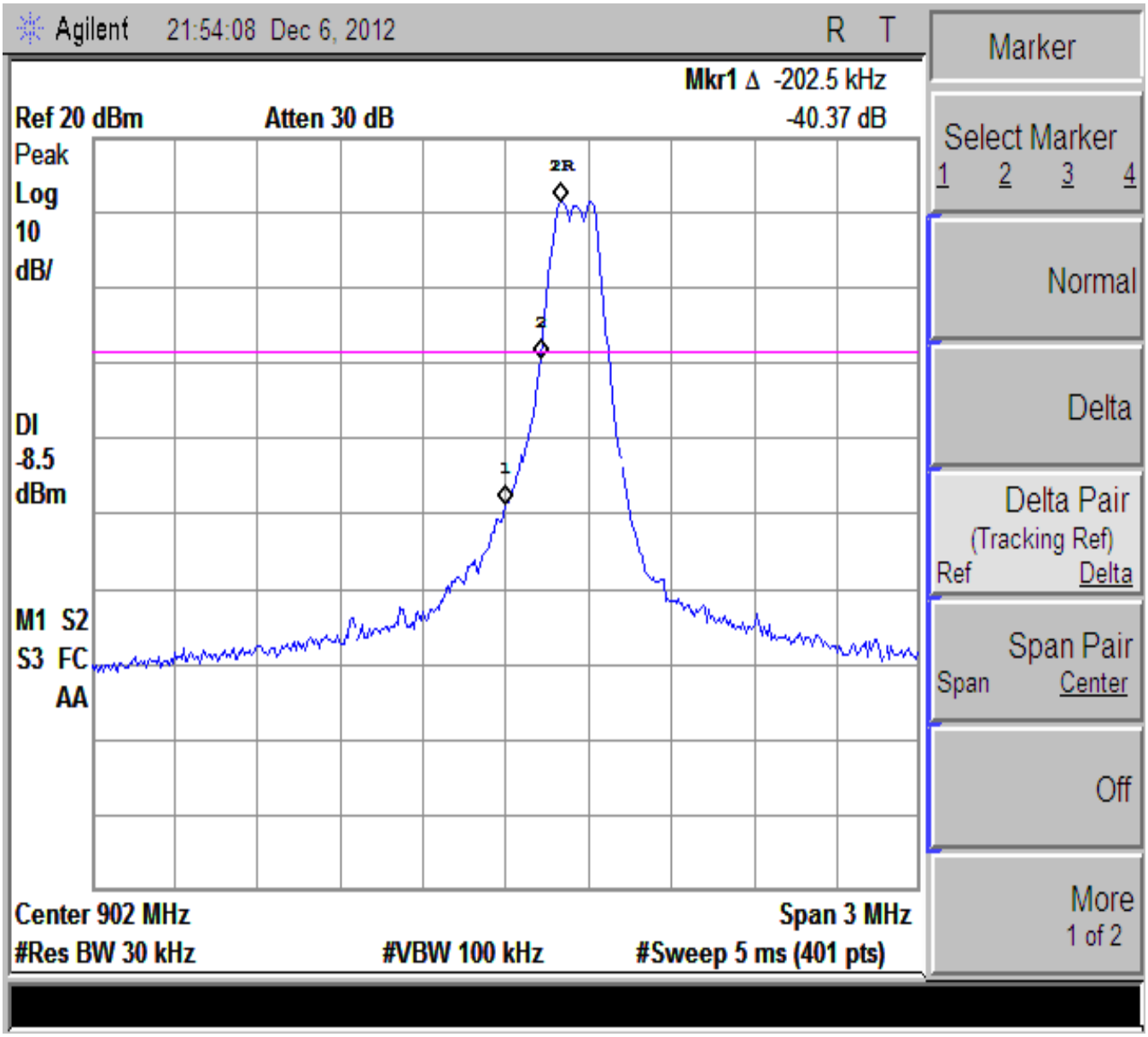
to the EUT. The measurements are also performed without hopping on multiple channels.

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.

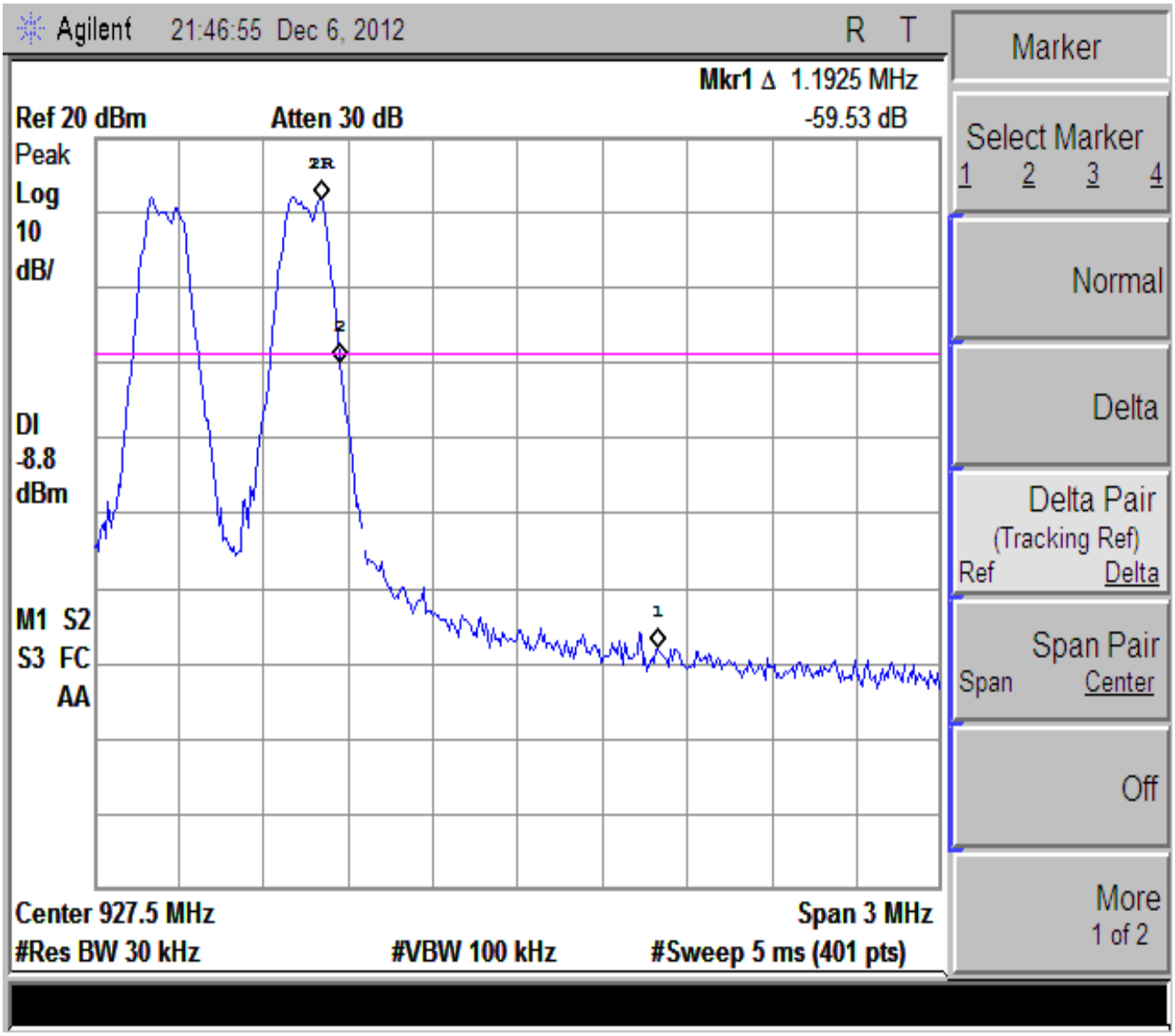
Hopping Low Frequency Band Edge


Agilent 21:42:41 Dec 6, 2012
R T
Mkr1 Δ -202.5 kHz
-46.69 dB
Ref 20 dBm
Atten 30 dB
Peak
Log
10
dB/
Dl
-8.5
dBm
M1 S2
S3 FC
AA
2R
Center 902 MHz
Span 3 MHz
#Res BW 30 kHz
#VBW 100 kHz
#Sweep 5 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2

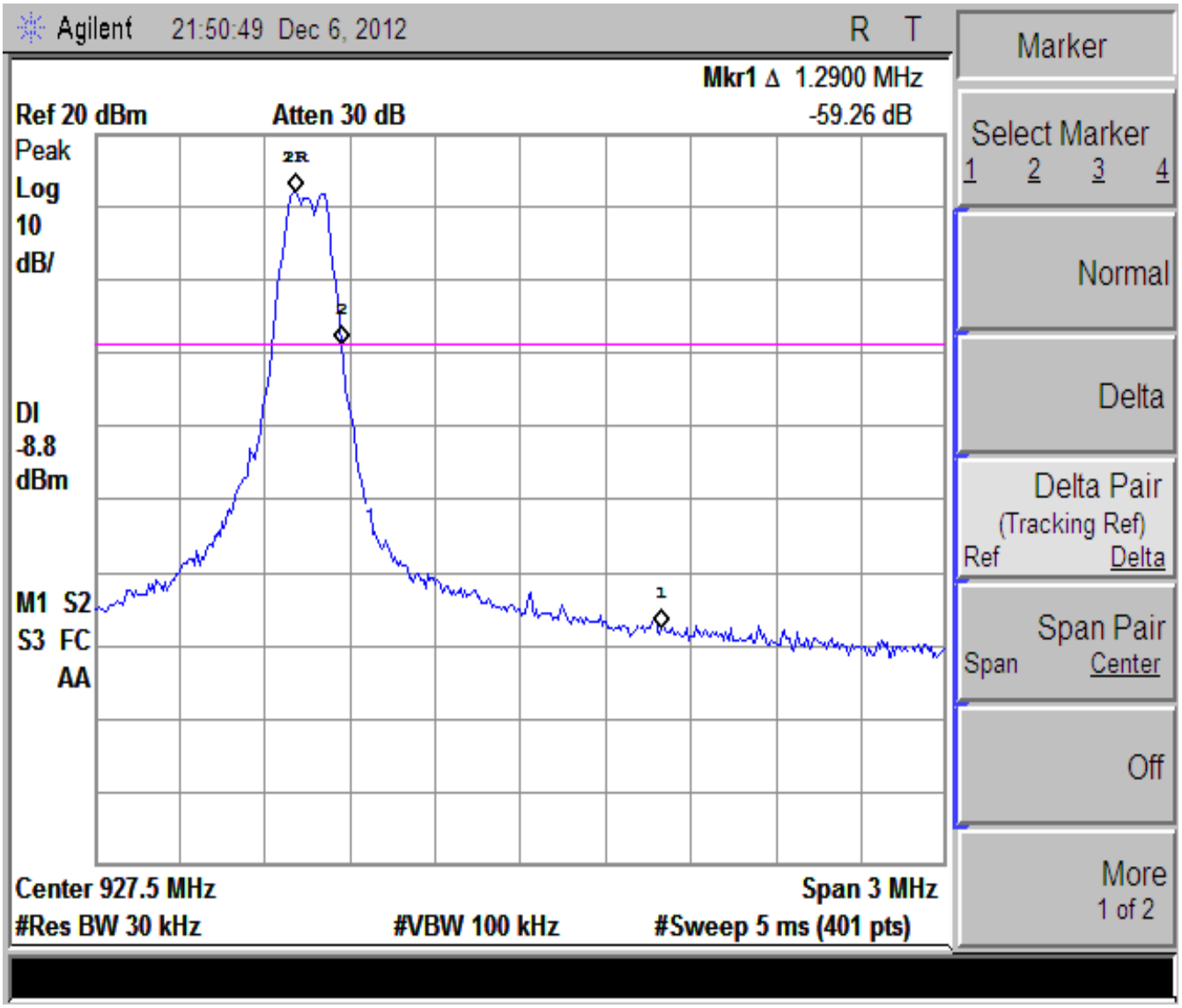
Non - Hopping Low Frequency Band Edge



Hopping High Frequency Band Edge


Agilent 21:46:55 Dec 6, 2012
R T
Mkr1 Δ 1.1925 MHz
Ref 20 dBm
Atten 30 dB
-59.53 dB
Peak
Log
10
dB/
2R
2
1
DI
-8.8
dBm
M1 S2
S3 FC
AA
Center 927.5 MHz
Span 3 MHz
#Res BW 30 kHz
#VBW 100 kHz
#Sweep 5 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2

Non - Hopping High Frequency Band Edge



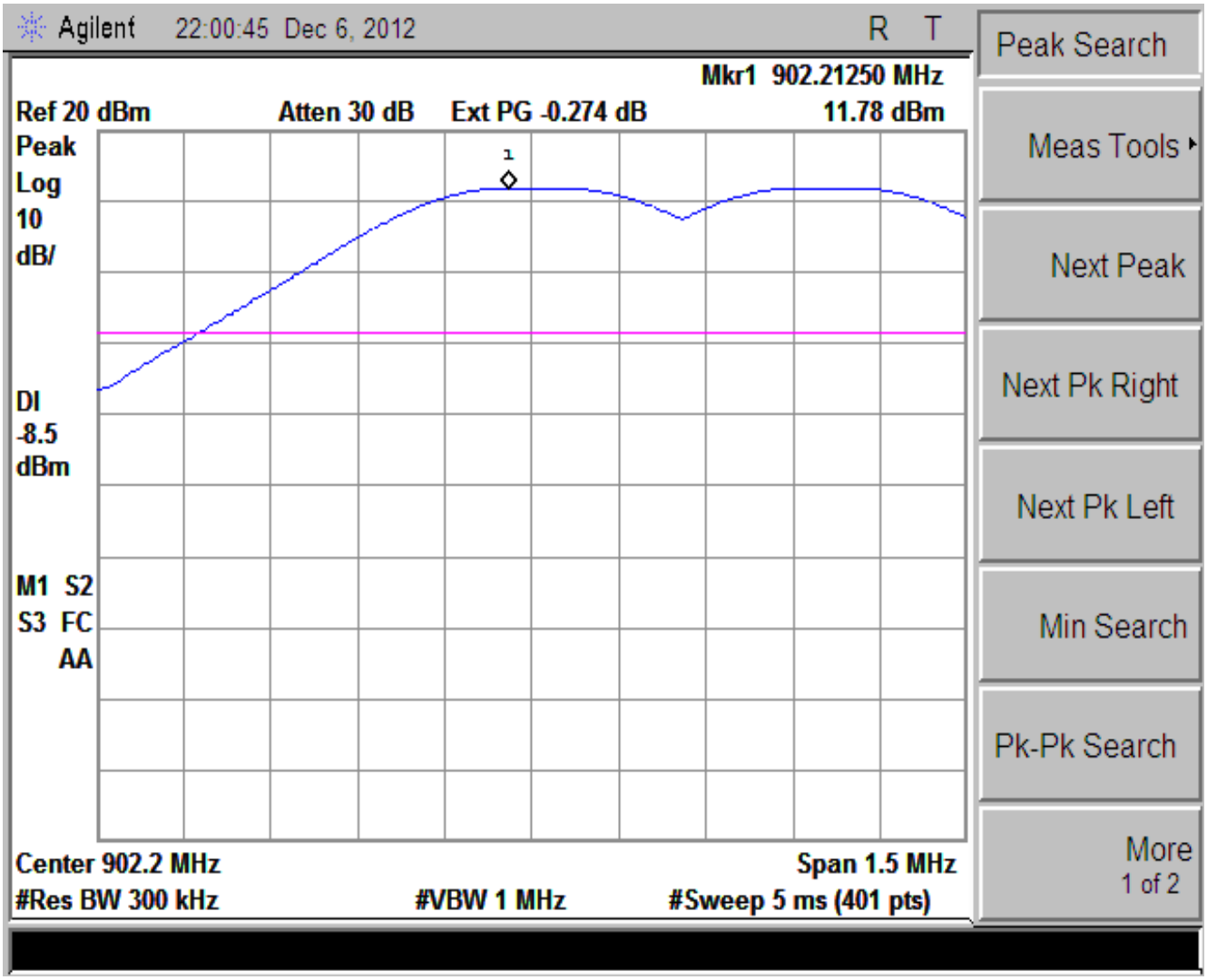
7.4.2.4 Peak Power (FCC Part 15.247)

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).

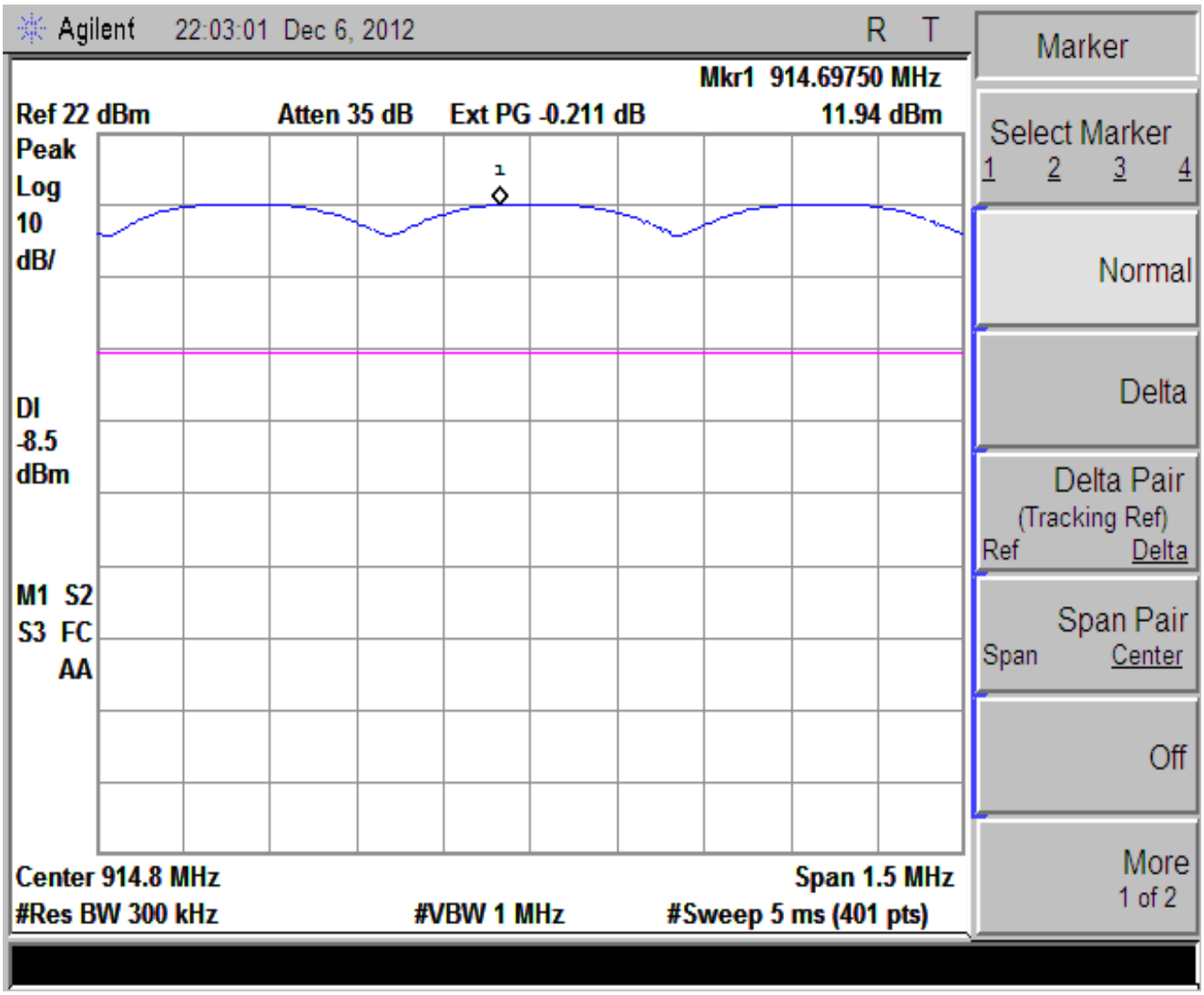
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

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 11.78dBm, at 914.75 the peak power was 11.94dBm, and at 926.75 the peak power was 12.06dBm, as shown in the plots below.

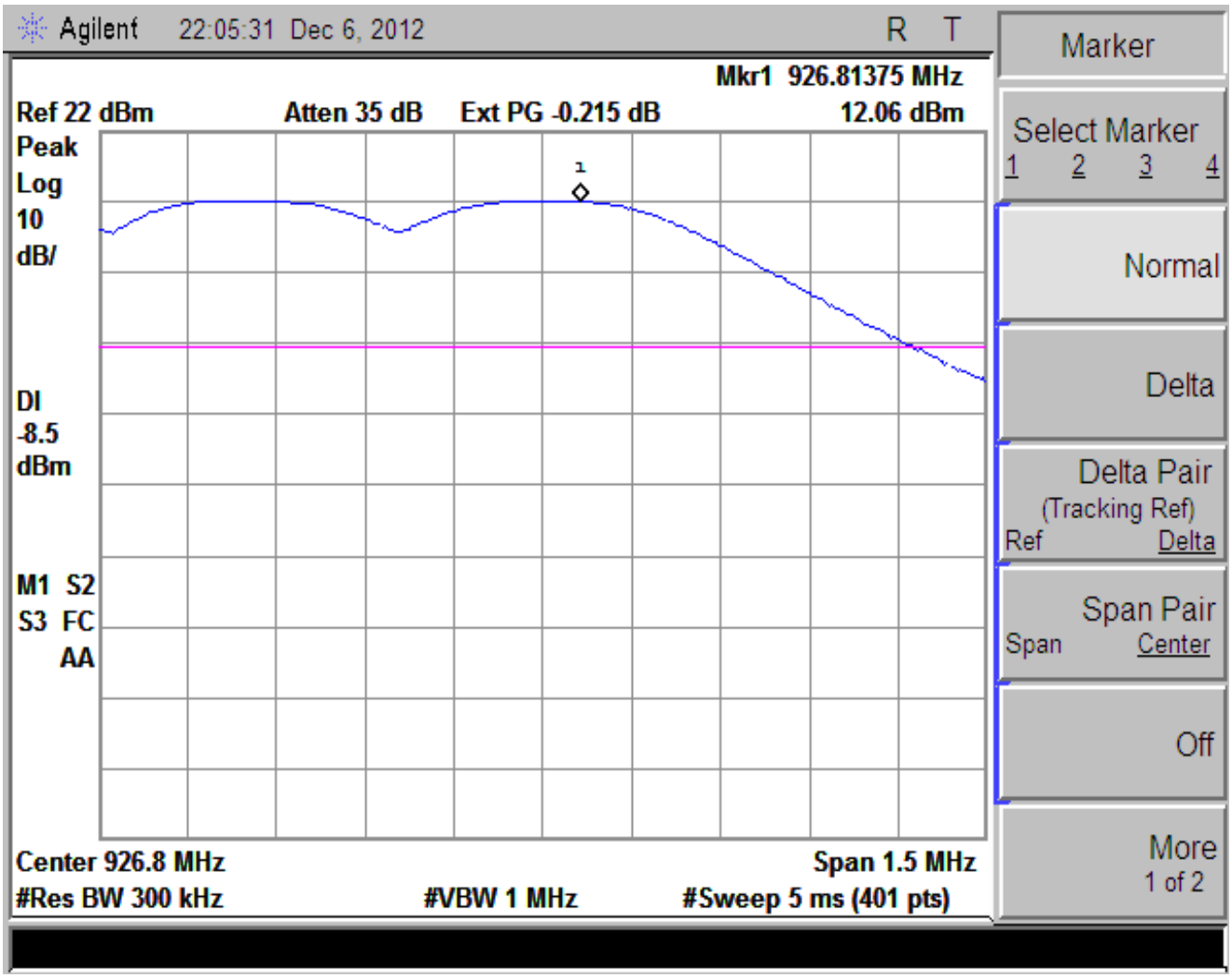
Peak Power Low Band Measurement Plot



Peak Power Mid Band Measurement Plot



Peak Power High Band Measurement Plot



7.4.2.5 Time of Occupancy (FCC Part 15.247)

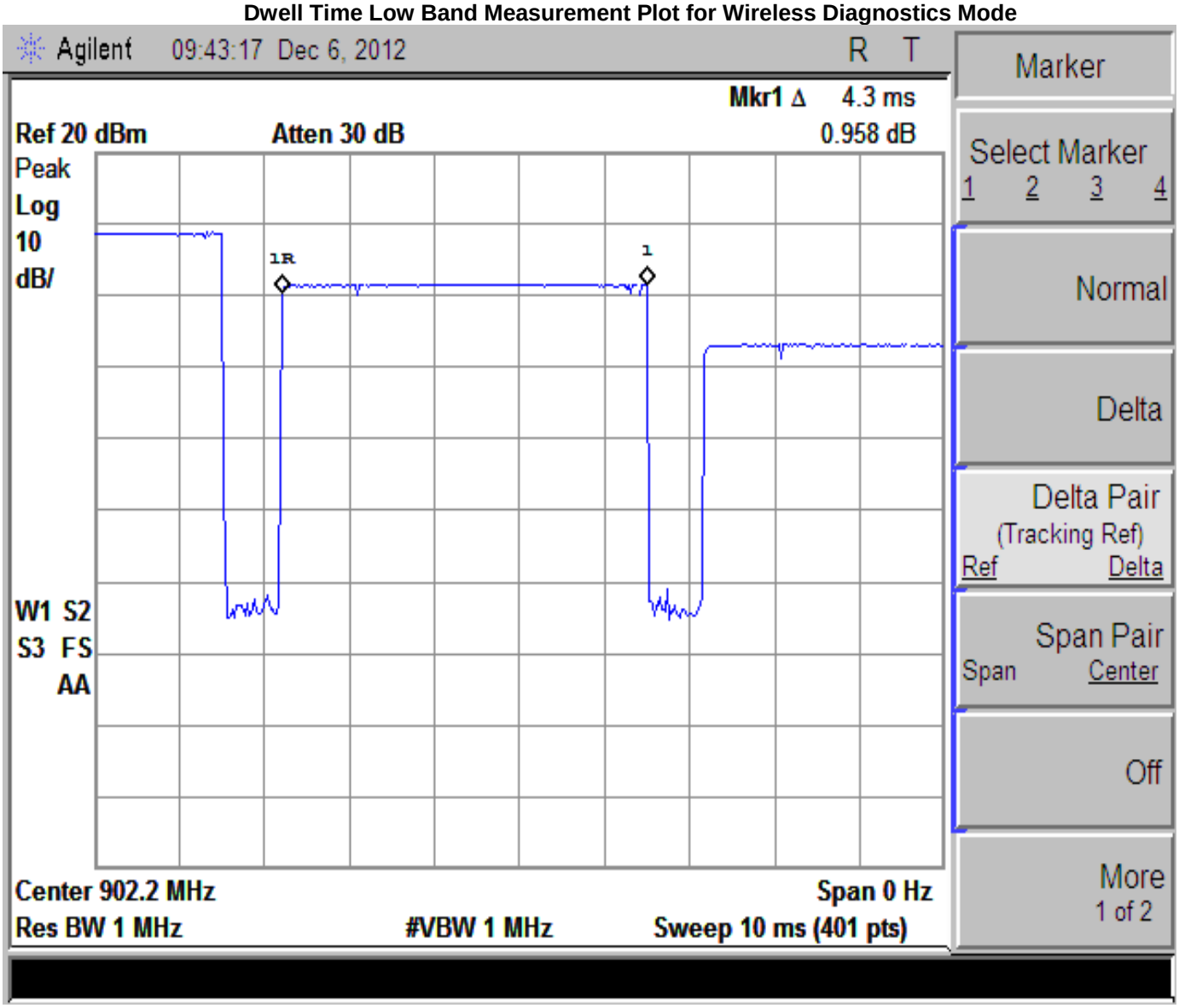
Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, if the 20dB bandwidth of the hopping channel is less than 250kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds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

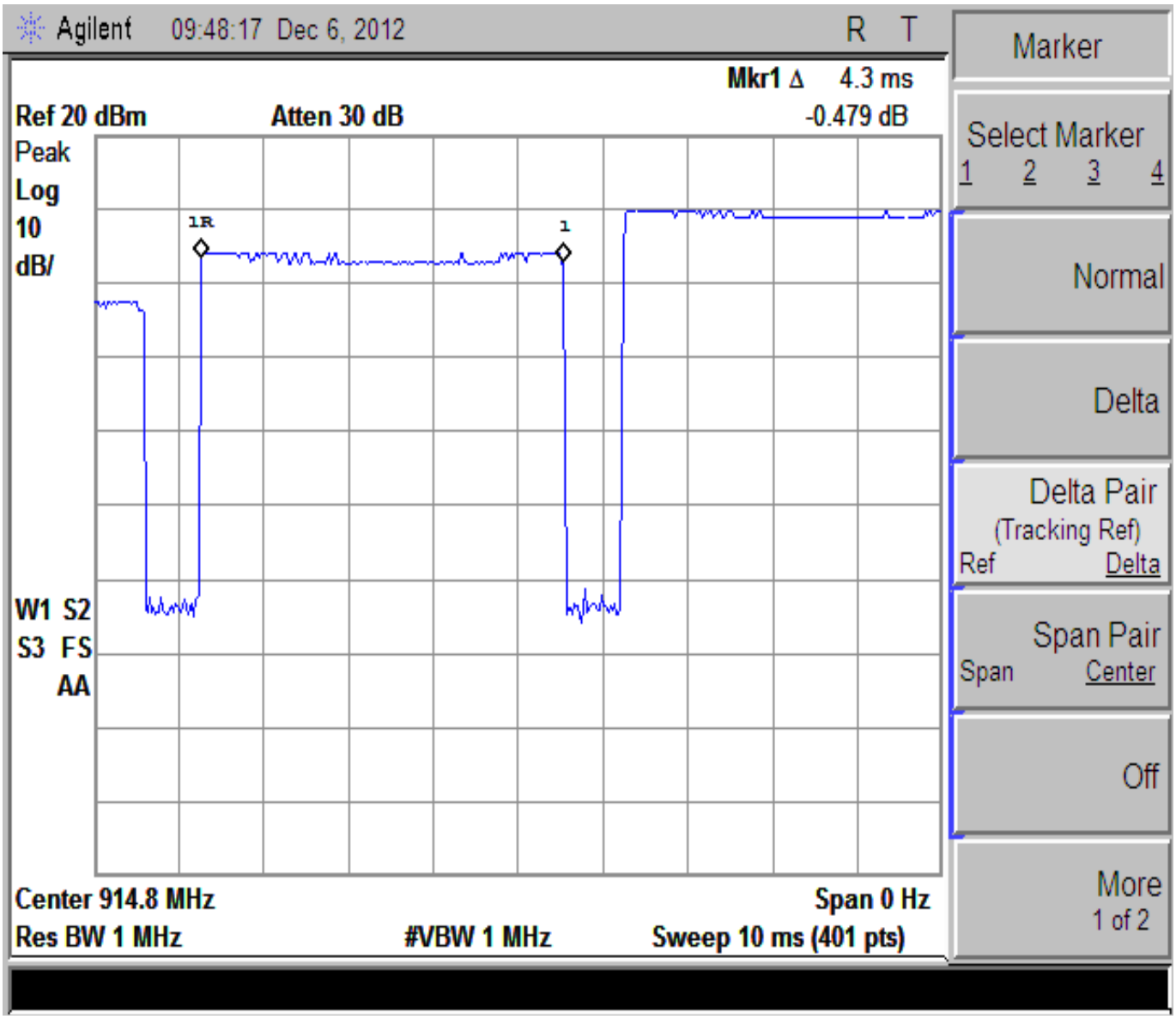
In measurement of the time of occupancy, the RBW was set to 1MHz. The peak detector and 'Max-Hold' function were engaged. With the span set to 0Hz, the sweep time was adjusted to capture a single event in order to measure the dwell time per hop.

The figures below show the hop dwell time for each band

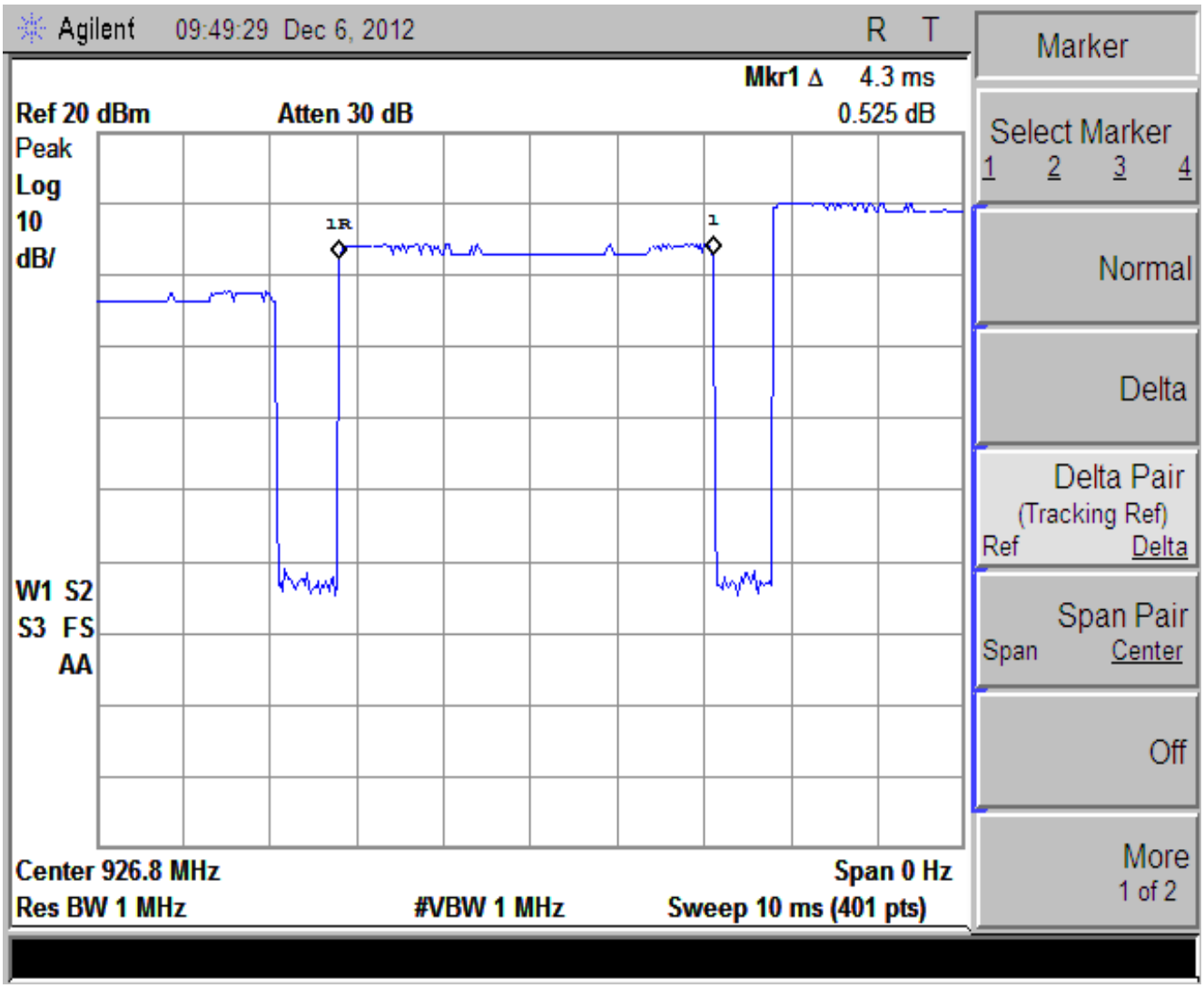
Dwell Time Low Band Measurement Plot for Wireless Diagnostics Mode



Dwell Time Mid Band Measurement Plot Wireless Diagnostic Mode

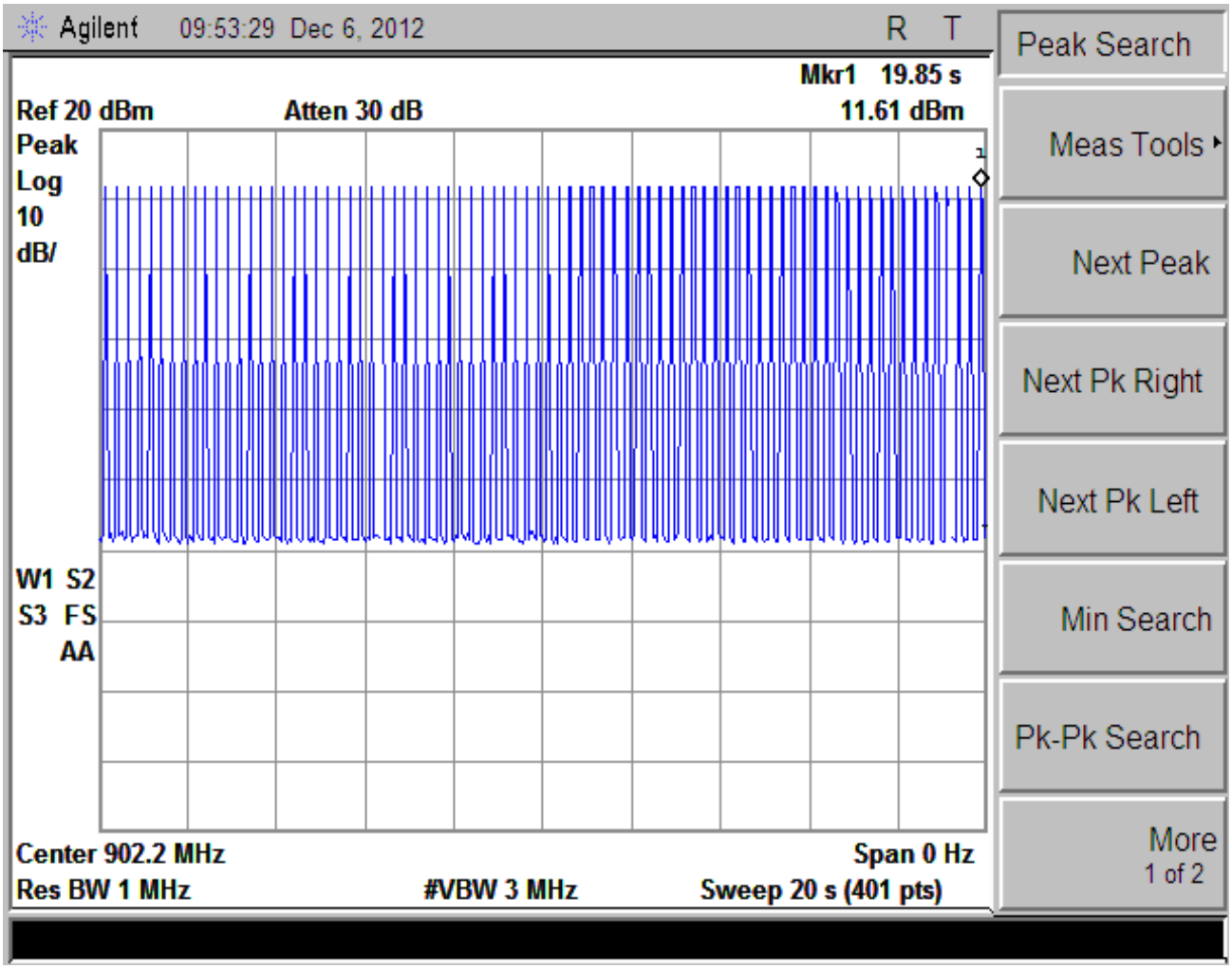


Dwell Time High Band Measurement Plot Wireless Diagnostic Mode

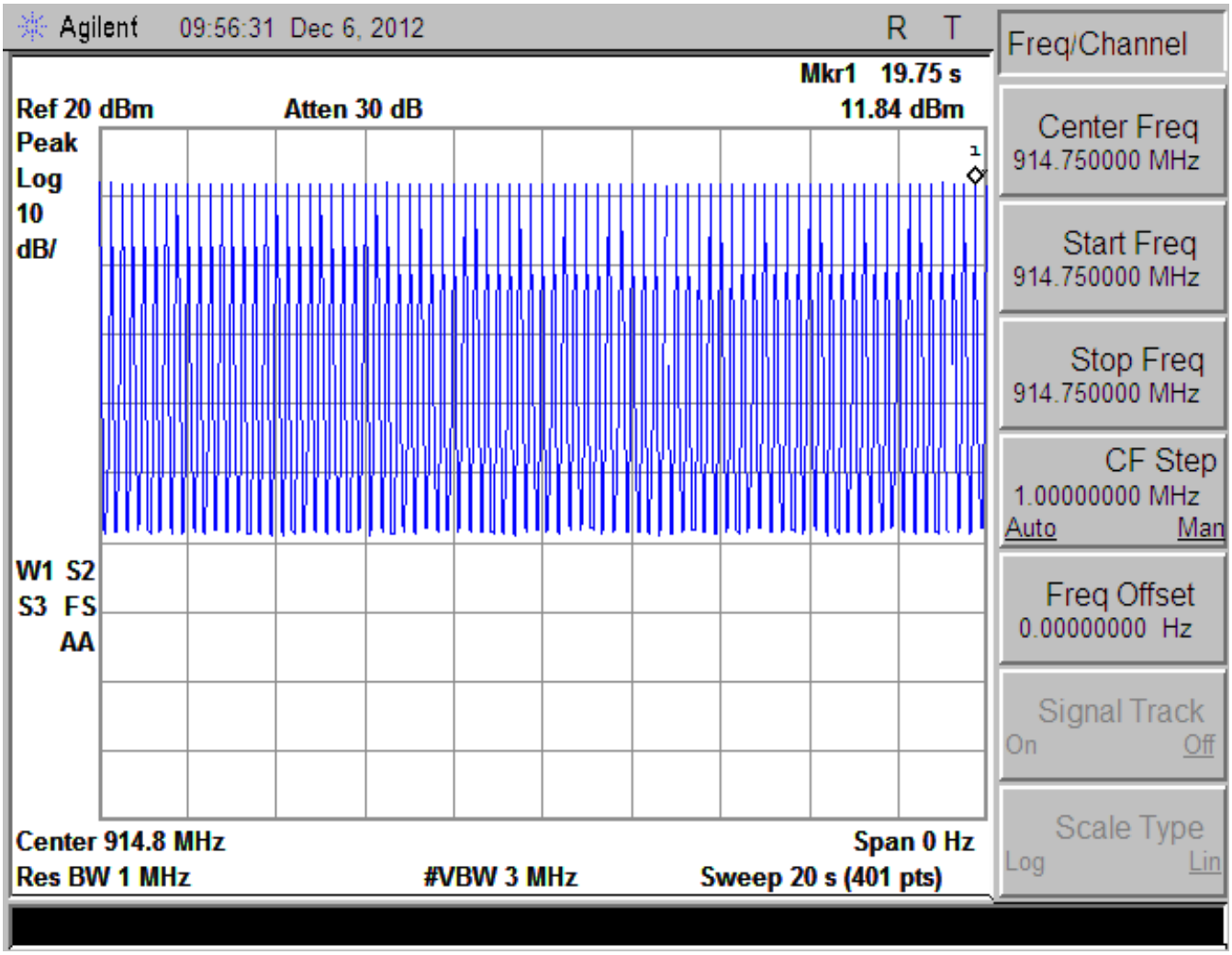


Then the sweep time was expanded to 20 seconds to capture the number of hops in the appropriate sweep time. A single sweep is made for each band, shown in the plots below.

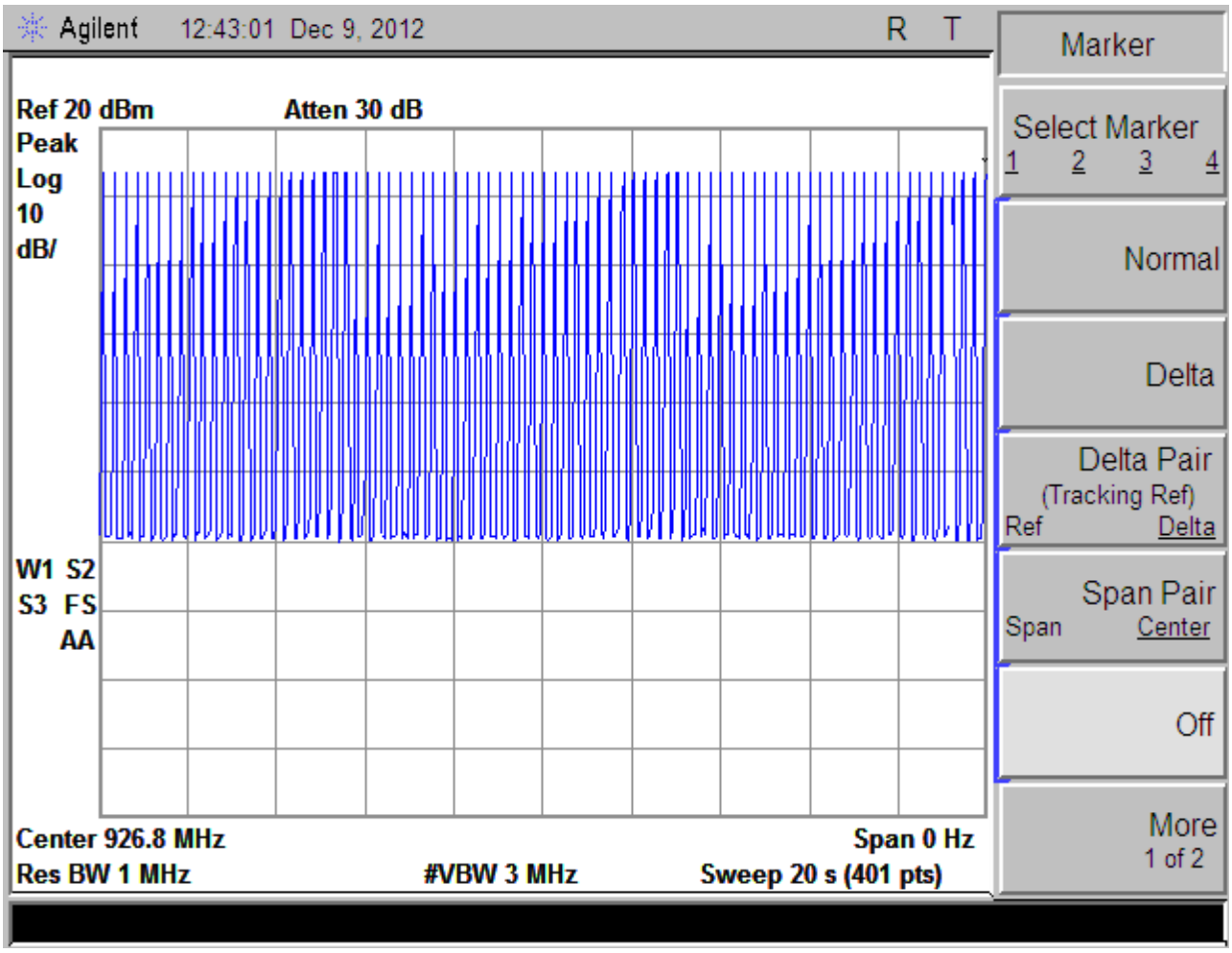
Number of Hops Low Band Measurement Plot Wireless Diagnostic Mode



Number of Hops Mid Band Measurement Plot Wireless Diagnostic Mode



Number of Hops High Band Measurement Plot Wireless Diagnostic Mode

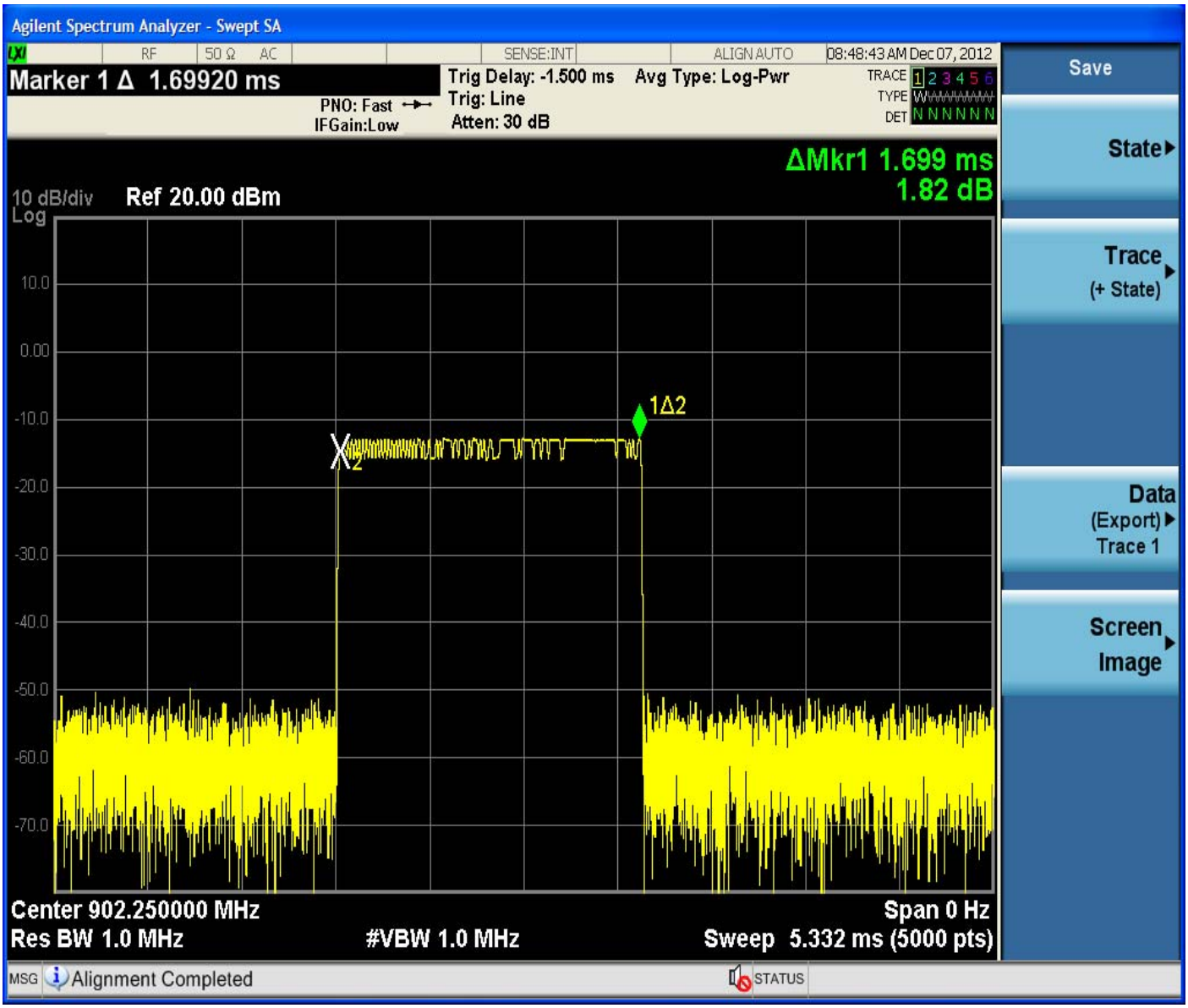


The dwell time in the specified time period was then calculated from dwell time per hop multiplied by the number of hops in the specified time period. As can be seen by the table below, the maximum time of occupancy can be determined by 4.3ms multiplied by 80. This calculated value is equal to 0.344 seconds which is less than the 0.4 seconds maximum allowed.

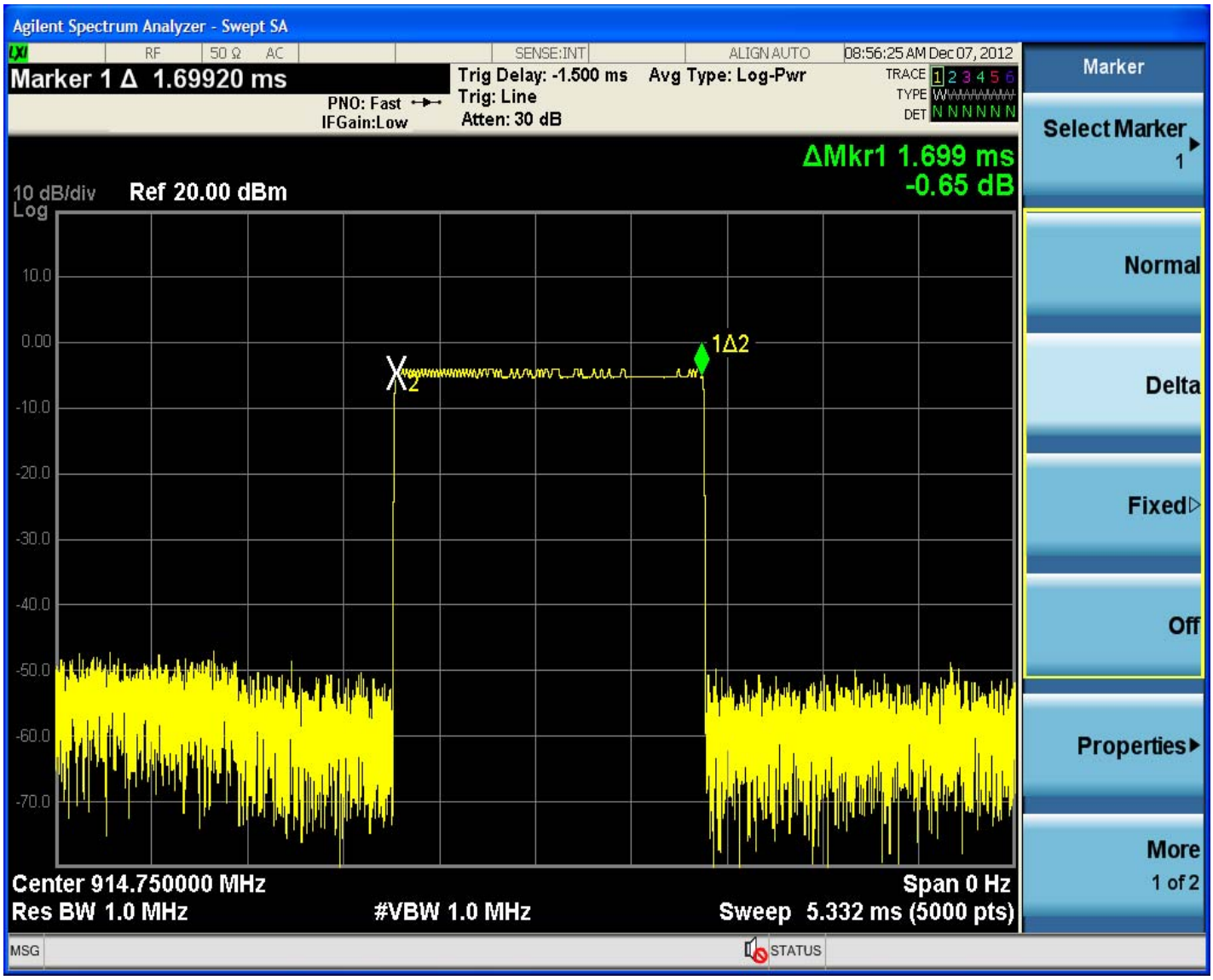
Total Dwell Time Wireless Diagnostic Mode

Frequency (MHz)	Dwell Time/Hop (ms)	Number of Hops	Total Dwell Time (s)
902.25	4.3	80	0.344
914.75	4.3	80	0.344
926.75	4.3	80	0.344

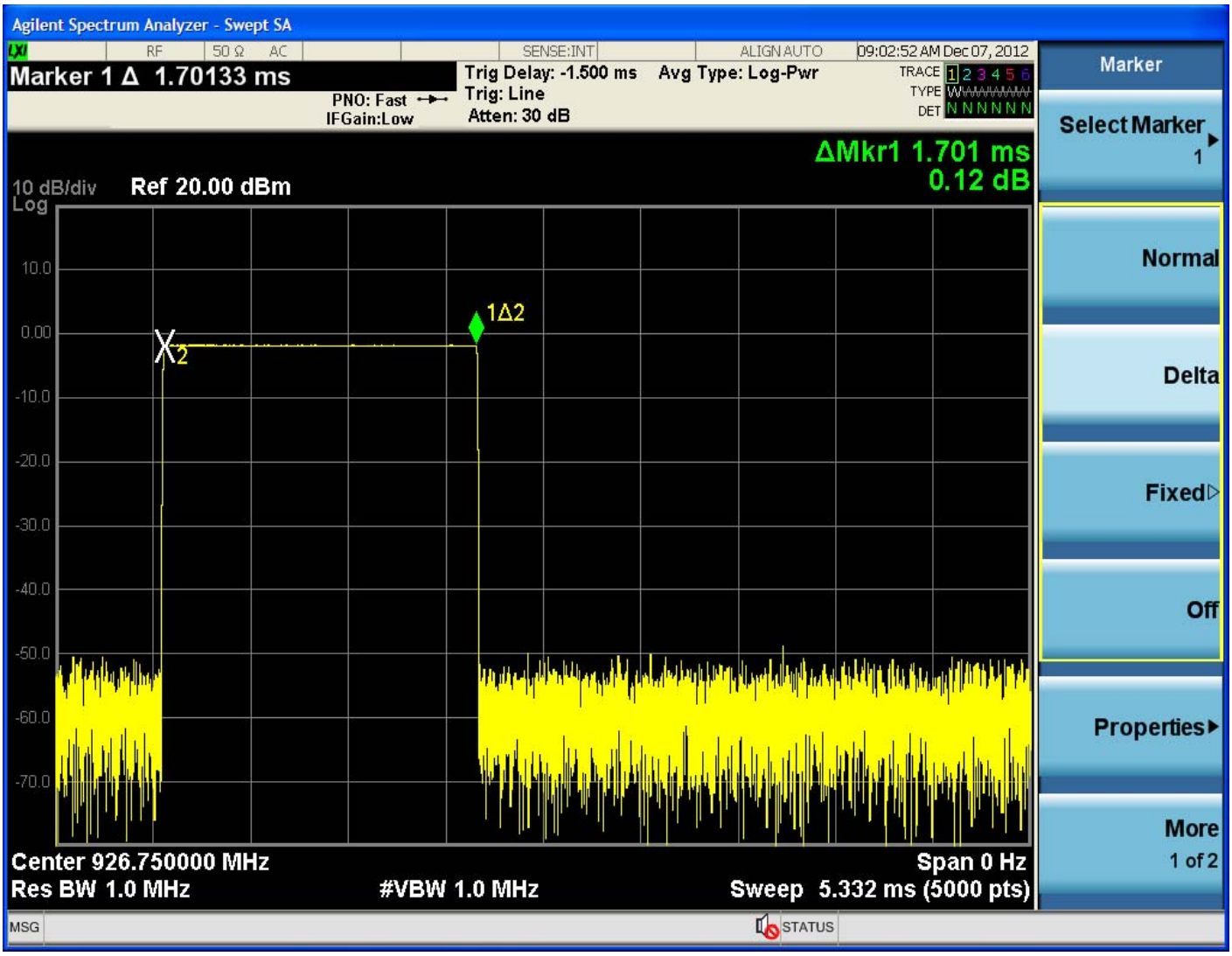
Dwell Time Low Band Measurement Plot for Reflash Mode



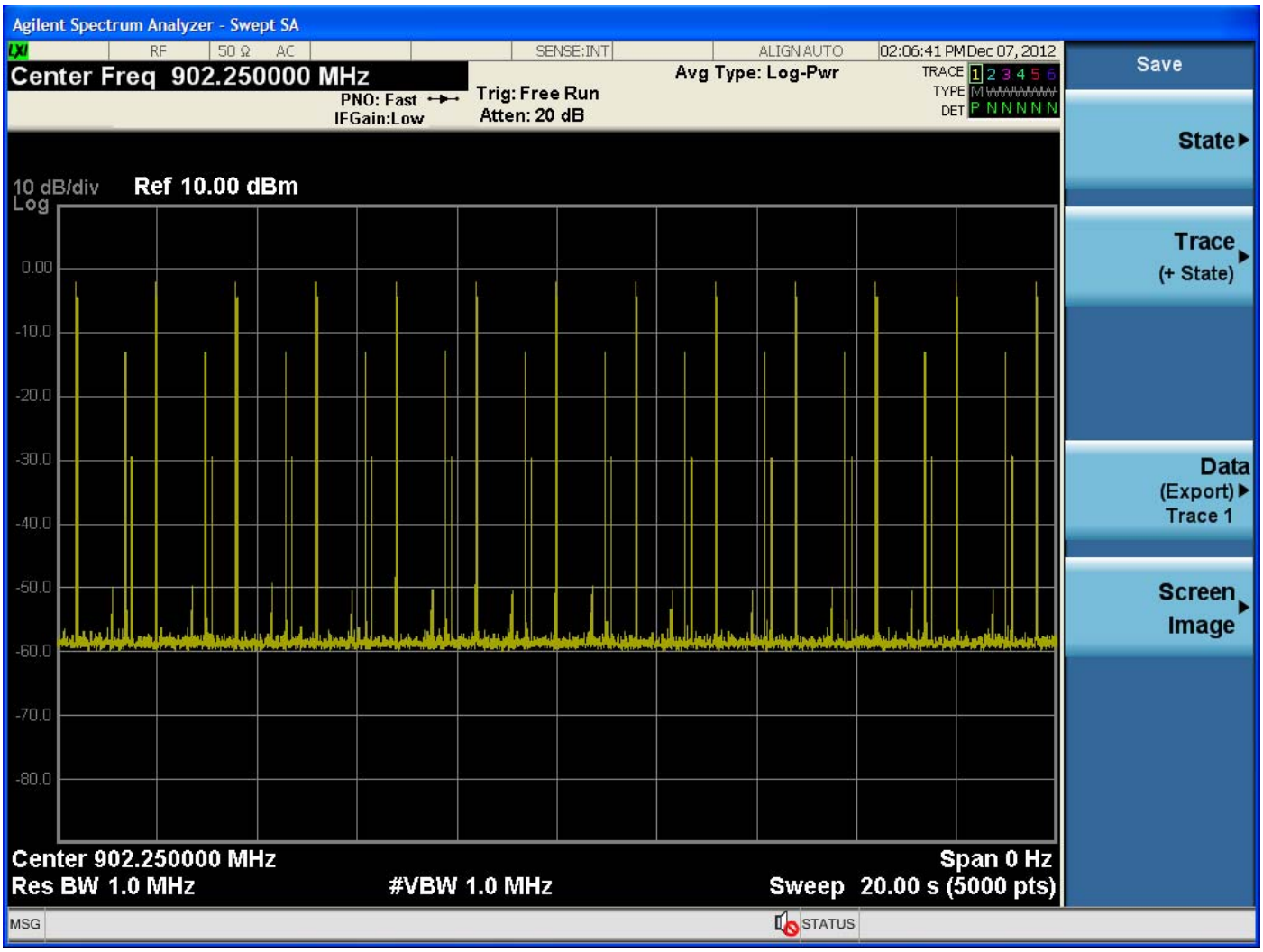
Dwell Time Mid Band Measurement Plot for Reflash Mode



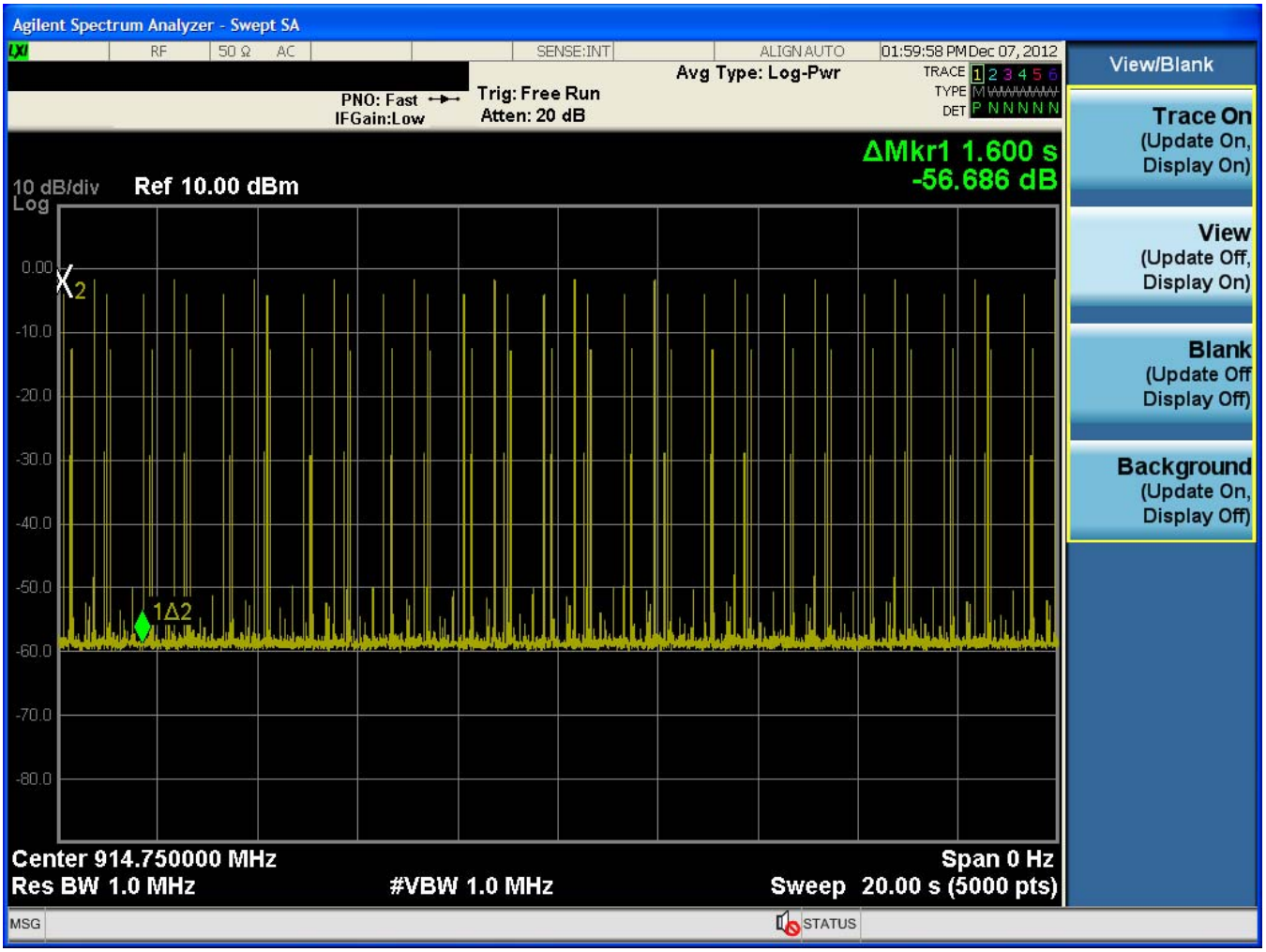
Dwell Time High Band Measurement Plot for Reflash Mode



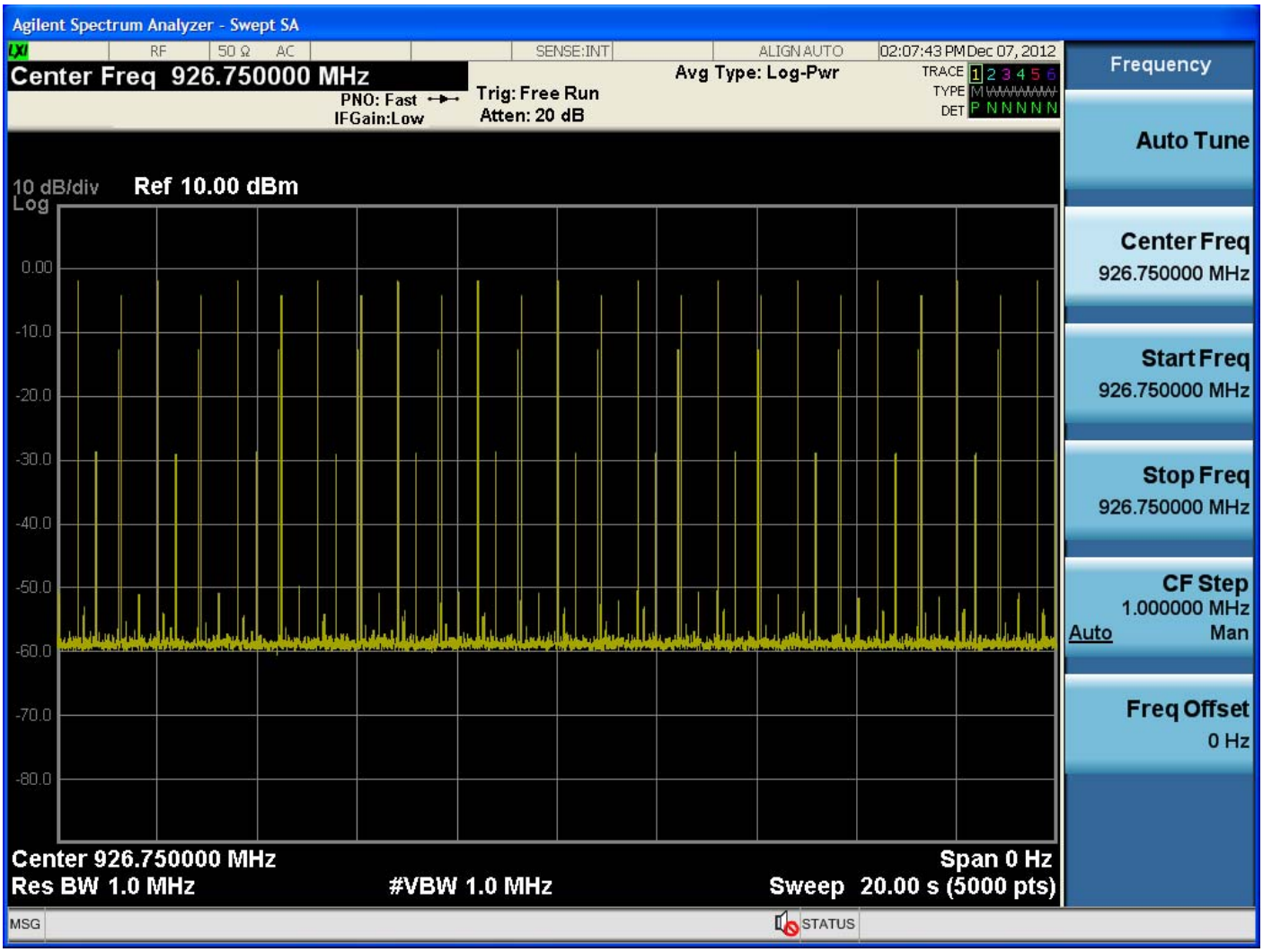
Number of Hops Low Band Measurement Plot for Reflash Mode


Agilent Spectrum Analyzer - Swept SA
RF
50 Ω AC
SENSE:INT
ALIGN AUTO
02:06:41 PM Dec 07, 2012
Center Freq 902.250000 MHz
PNO: Fast
IFGain:Low
Trig: Free Run
Atten: 20 dB
Avg Type: Log-Pwr
TRACE 1 2 3 4 5 6
TYPE M
DET P N N N N N
10 dB/div
Log
Ref 10.00 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Center 902.250000 MHz
Res BW 1.0 MHz
#VBW 1.0 MHz
Span 0 Hz
Sweep 20.00 s (5000 pts)
MSG
STATUS
Save
State
Trace
(+ State)
Data
(Export)
Trace 1
Screen
Image

Number of Hops Mid Band Measurement Plot for Reflash Mode



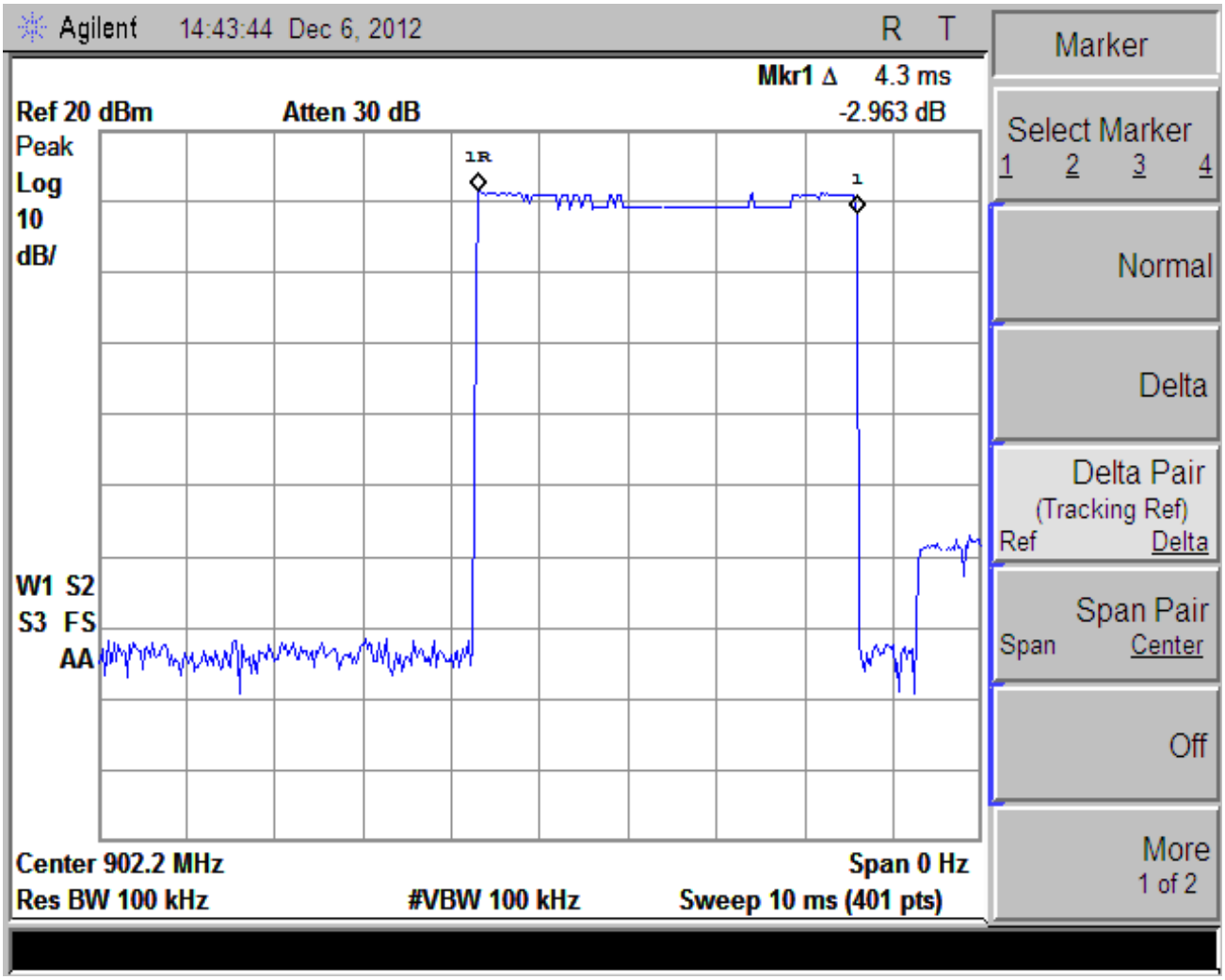
Number of Hops High Band Measurement Plot for Reflash Mode

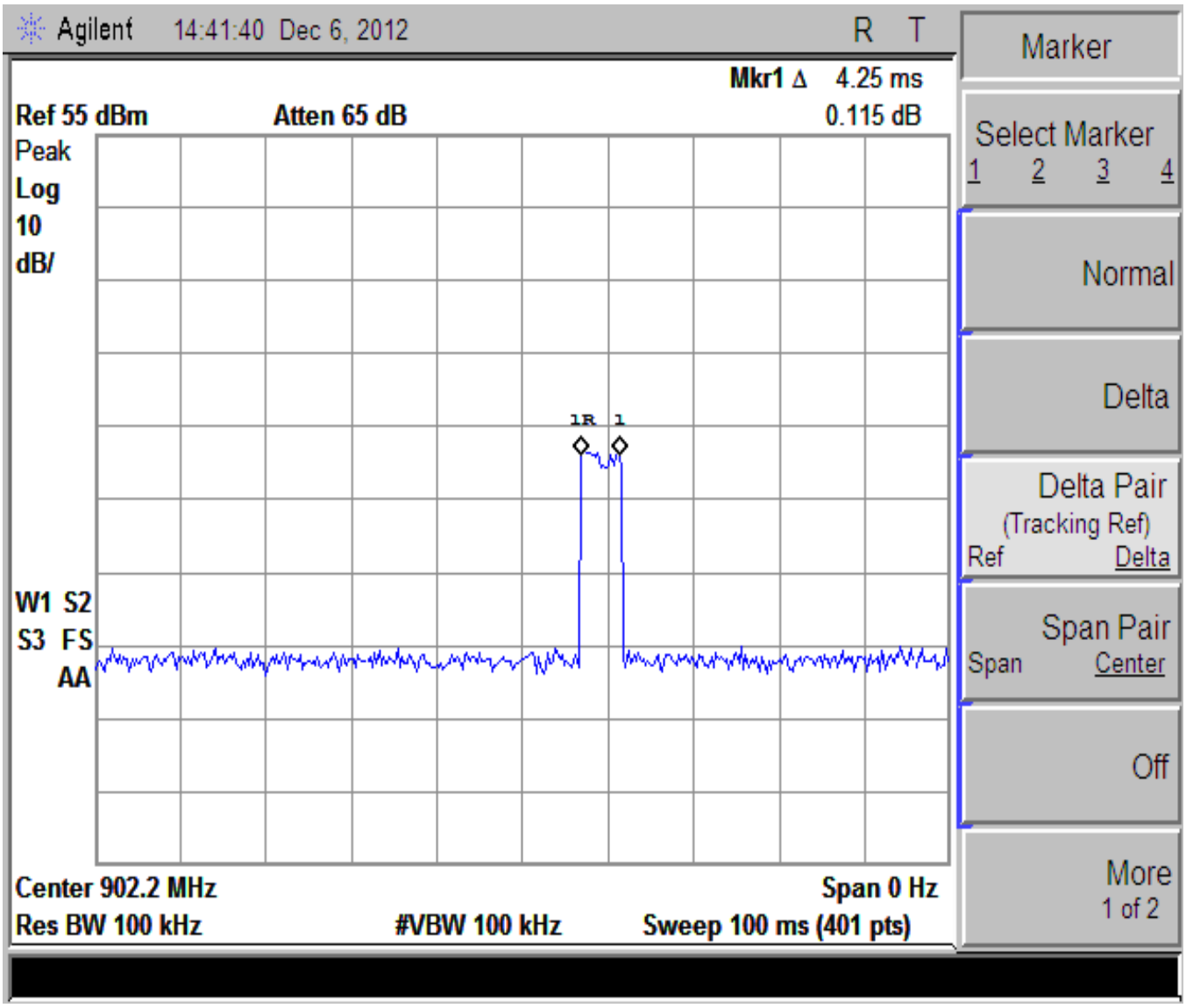


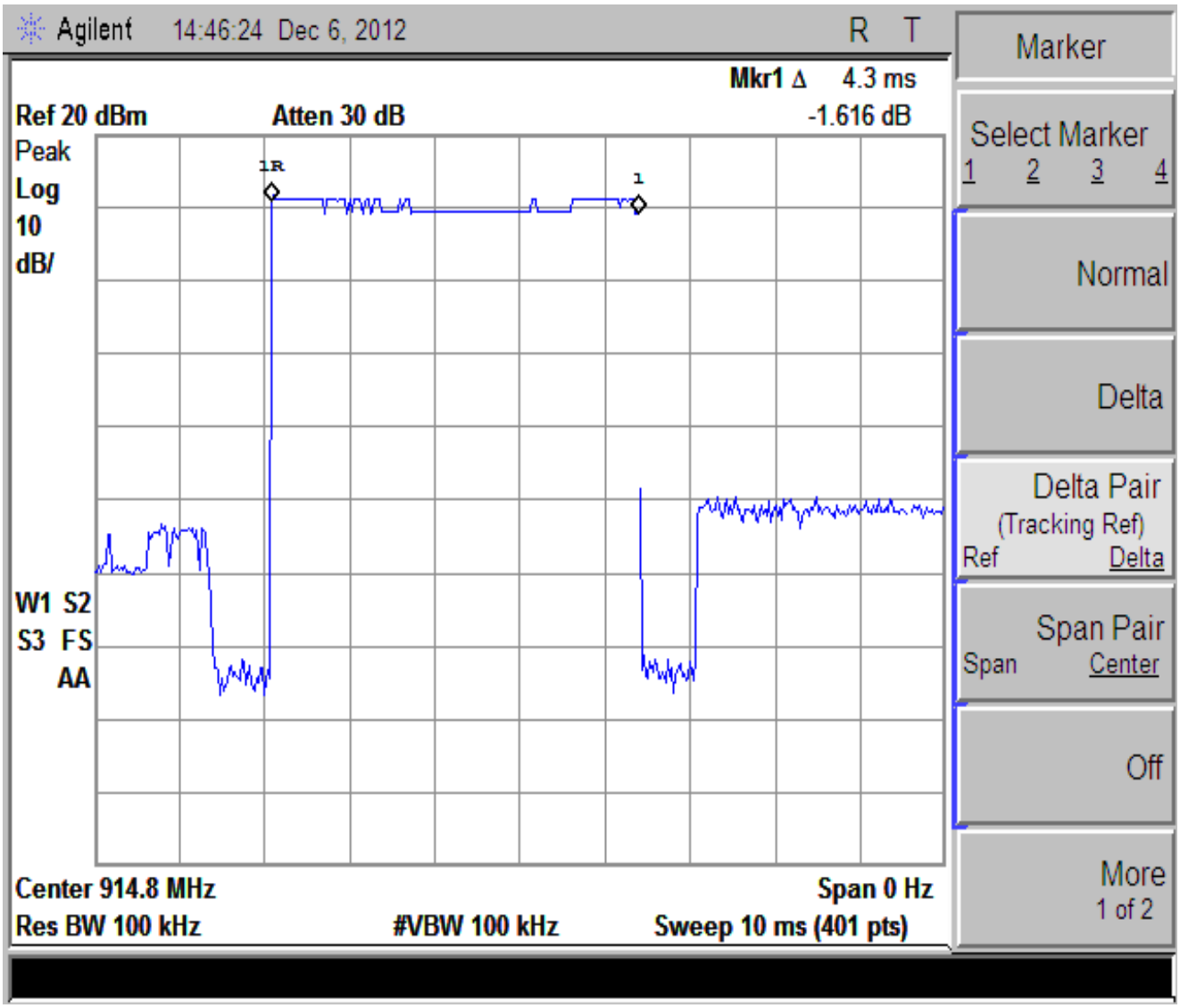
Total Dwell Time for Reflash Mode

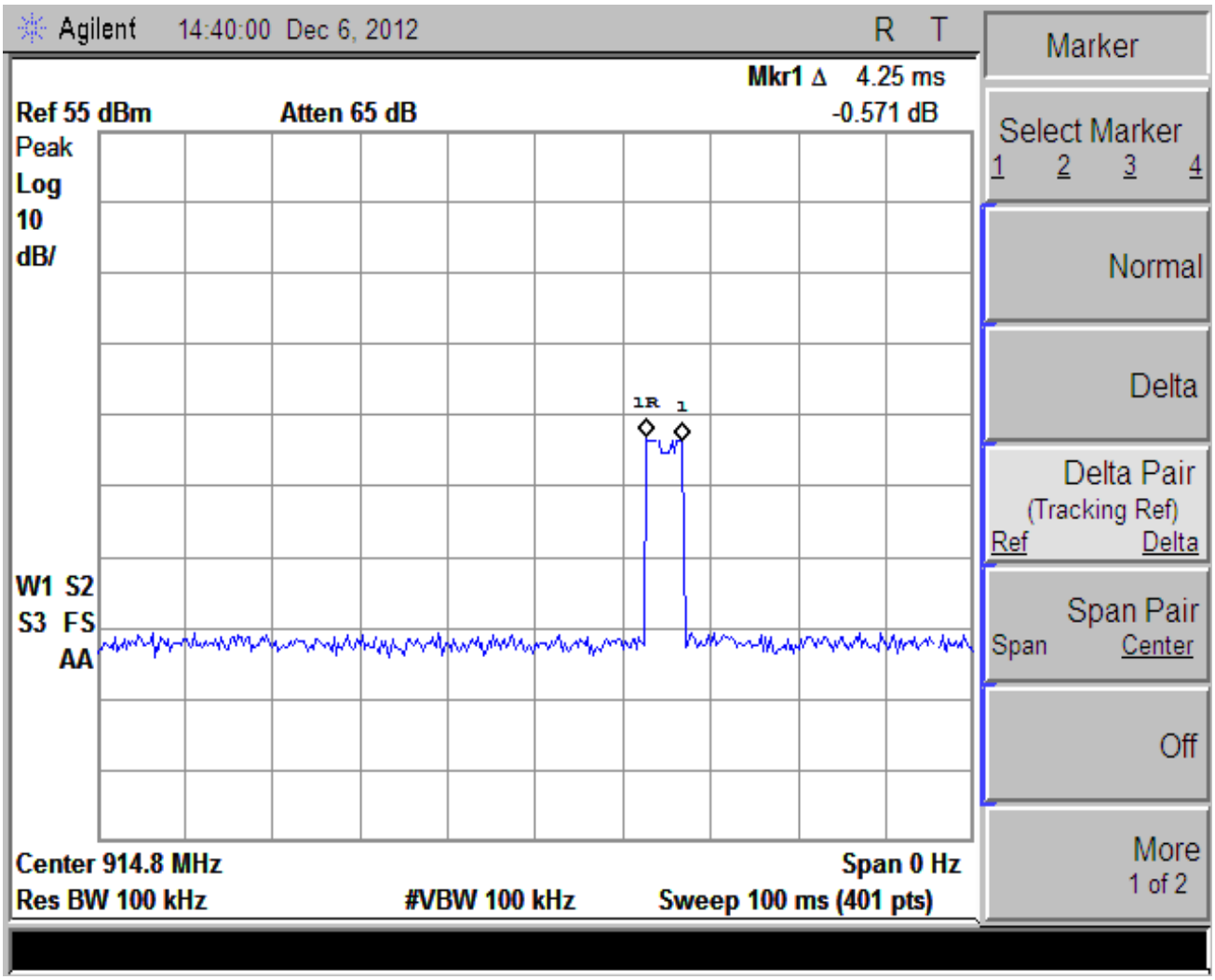
Frequency (MHz)	Dwell Time/Hop (ms)	Number of Hops	Total Dwell Time (s)
902.25	1.699	13	0.02209
914.75	1.699	13	0.02209
926.75	1.701	13	0.02211

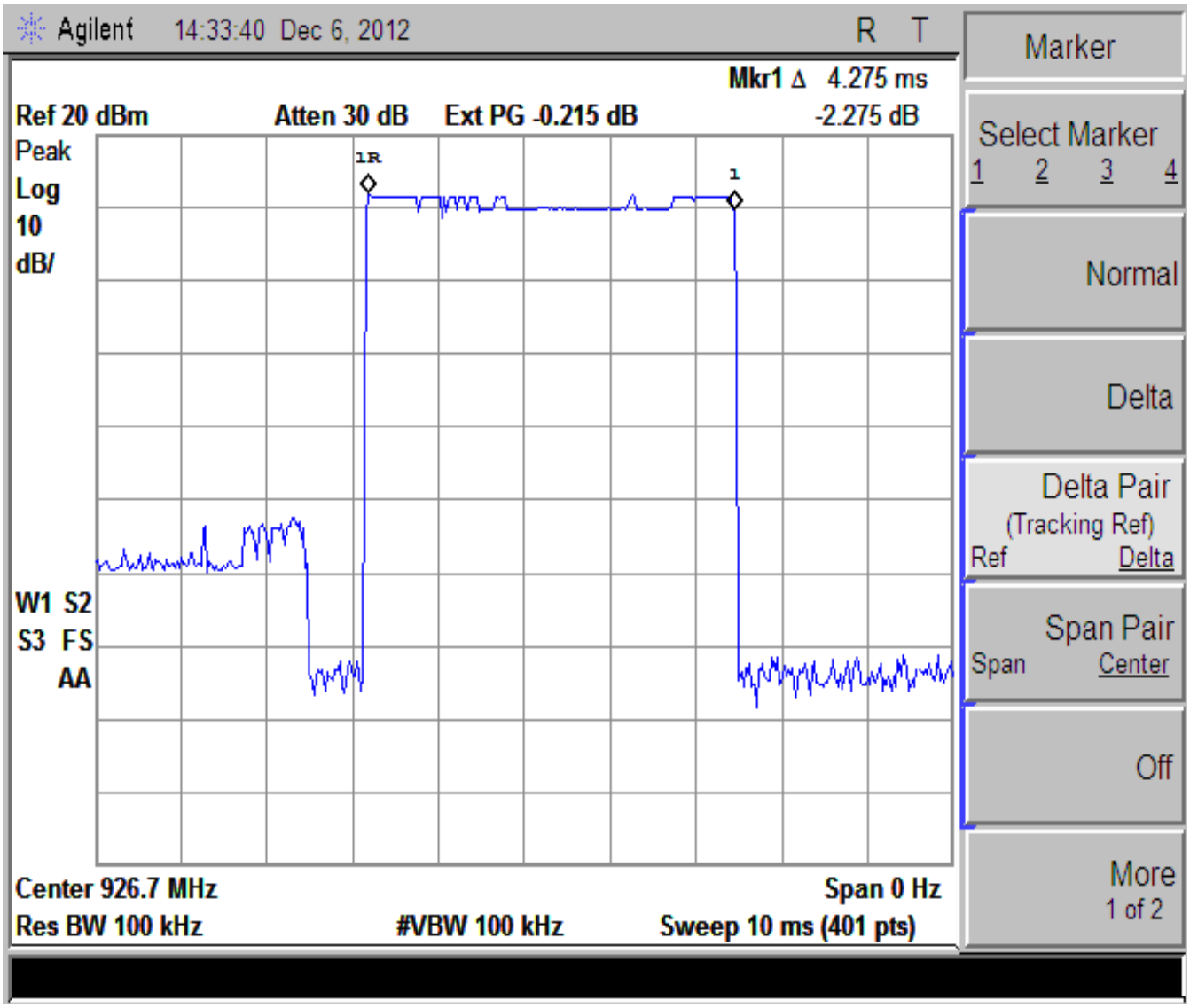
7.4.2.6 Duty Cycle Correction Measurements (FCC Part 15.247)

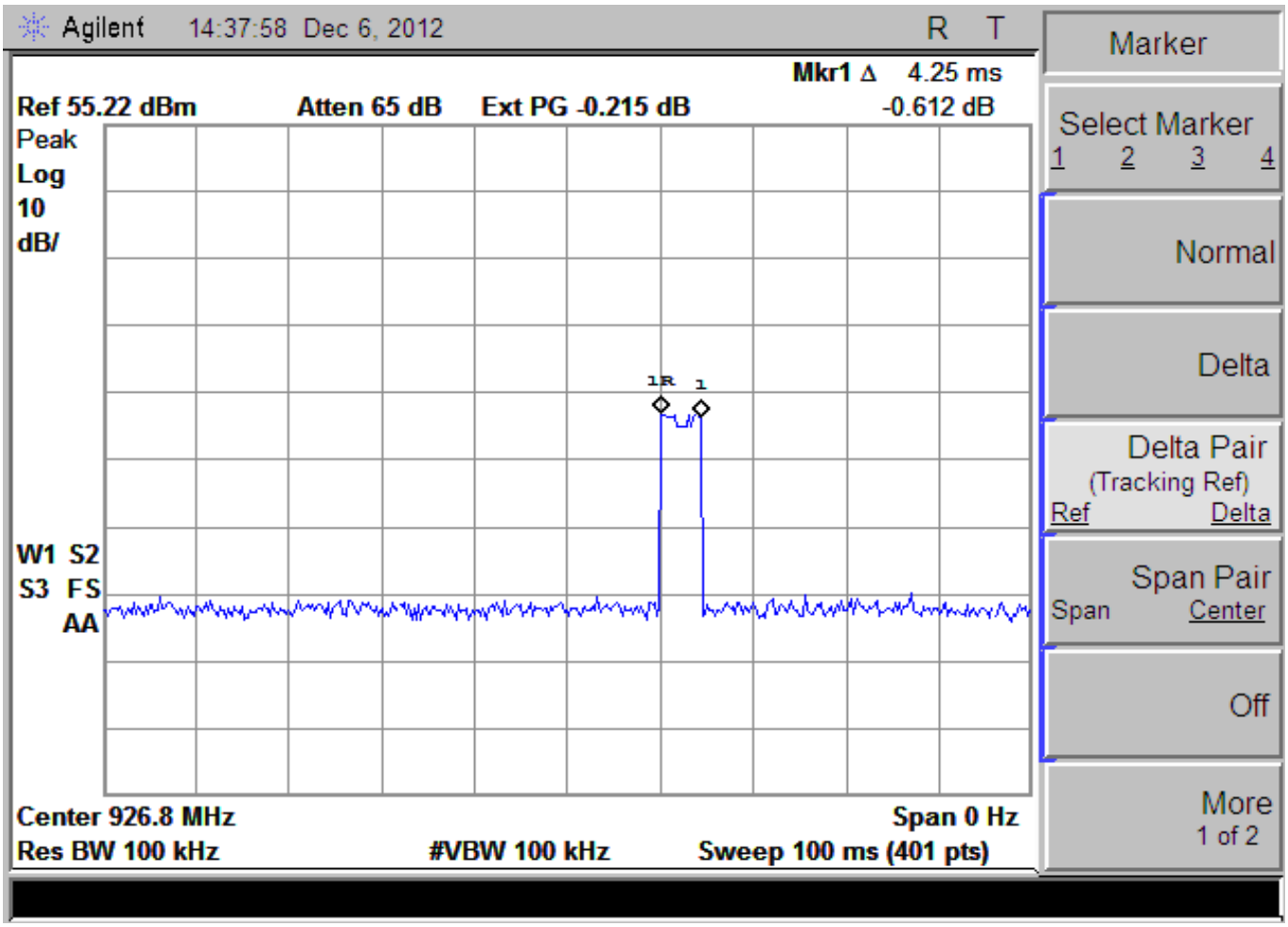



Agilent 14:41:40 Dec 6, 2012
R T
Mkr1 Δ 4.25 ms
0.115 dB
Ref 55 dBm
Atten 65 dB
Peak
Log
10
dB/
1R 1
W1 S2
S3 FS
AA
Center 902.2 MHz
Span 0 Hz
Res BW 100 kHz
#VBW 100 kHz
Sweep 100 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2


Agilent 14:46:24 Dec 6, 2012
R T
Mkr1 Δ 4.3 ms
-1.616 dB
Ref 20 dBm
Atten 30 dB
Peak
Log
10
dB/
1R
1
W1 S2
S3 FS
AA
Center 914.8 MHz
Span 0 Hz
Res BW 100 kHz
#VBW 100 kHz
Sweep 10 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2


Agilent 14:40:00 Dec 6, 2012
R T
Mkr1 Δ 4.25 ms
Ref 55 dBm
Atten 65 dB
-0.571 dB
Peak
Log
10
dB/
1R 1
W1 S2
S3 FS
AA
Center 914.8 MHz
Span 0 Hz
Res BW 100 kHz
#VBW 100 kHz
Sweep 100 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2


Agilent 14:33:40 Dec 6, 2012
R T
Mkr1 Δ 4.275 ms
-2.275 dB
Ref 20 dBm
Atten 30 dB
Ext PG -0.215 dB
Peak
Log
10
dB/
1R
1
W1 S2
S3 FS
AA
Center 926.7 MHz
Span 0 Hz
Res BW 100 kHz
#VBW 100 kHz
Sweep 10 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2



7.4.3 Radiated Rx Spurious Emissions

The receiver circuit spurious emissions were measured in accordance to Industry Canada RSS-GEN Issue 3 Section 6 and ANSI C63.4-2003.

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 24.8dB, the mid band has a minimum margin of 26.0dB, and the high frequency band has a minimum margin of 14.9dB.

7.4.3.1 Setup Photograph for Receiver spurious emissions

	Freq	Position	Power Reading (dBuV/m) H	V	Lim	Amt Over (dB) H	V
Fundamental	901.3	Flat		28.56	46.0		-17.4
	901.3	Side			46.0		
	901.3	End			46.0		
2nd Harmonic	1802.6	Flat		26.54	*54.0*		-27.5
	1802.6	Side			*54.0*		
	1802.6	End			*54.0*		
3rd Harmonic	2703.9	Flat	29.65		*54.0*	-24.3	
	2703.9	Side			*54.0*		
	2703.9	End			*54.0*		
4th Harmonic	3605.2	Flat	31.22		*54.0*	-22.8	
	3605.2	Side			*54.0*		
	3605.2	End			*54.0*		
5th Harmonic	4506.5	Flat	32.41		*54.0*	-21.6	
	4506.5	Side			*54.0*		
	4506.5	End			*54.0*		

	Freq	Position	Power Reading (dBuV/m) H	V	Lim	Amt Over (dB) H	V
Fundamental	913.8	Flat	25.36		46.0	-20.7	
	913.8	Side			46.0		
	913.8	End			46.0		
2nd Harmonic	1827.6	Flat	30.24		*54.0*	-23.7	
	1827.6	Side			*54.0*		
	1827.6	End			*54.0*		
3rd Harmonic	2741.4	Flat	31.02		*54.0*	-23.0	
	2741.4	Side			*54.0*		
	2741.4	End			*54.0*		
4th Harmonic	3655.2	Flat			*54.0*		
	3655.2	Side	32.25		*54.0*	-21.7	
	3655.2	End			*54.0*		
5th Harmonic	4569	Flat	33.26		*54.0*	-20.7	
	4569	Side			*54.0*		
	4569	End			*54.0*		

	Freq	Position	Power Reading (dBuV/m) H	V	Lim	Amt Over (dB) H	V
Fundamental	925.8	Flat		22.45	46.0		-23.6
	925.8	Side			46.0		

	925.8	End			46.0		
2nd Harmonic	1851.6	Flat			*54.0*		
	1851.6	Side		29.65	*54.0*		-24.4
	1851.6	End			*54.0*		
3rd Harmonic	2777.4	Flat			*54.0*		
	2777.4	Side	28.54		*54.0*	-25.4	
	2777.4	End			*54.0*		
4th Harmonic	3703.2	Flat		38.54	*54.0*		-15.5
	3703.2	Side			*54.0*		
	3703.2	End			*54.0*		
5th Harmonic	4629	Flat		38.56	*54.0*		-15.4
	4629	Side			*54.0*		
	4629	End			*54.0*		

7.5 Formulas and Sample Calculations

7.5.1 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*Log(On Time(ms) /100ms).

-27.3dB = 20*Log(4.3ms/100ms)

7.5.2 Calculation of IC Limits from RSS-210 and 47 CFR Part 15.247.

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

Limit dBuV/m= 20*Log(7071mV/m*1000)=137dBuV/m

where 7071mV/m=1W, which is the fundamental limit.

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

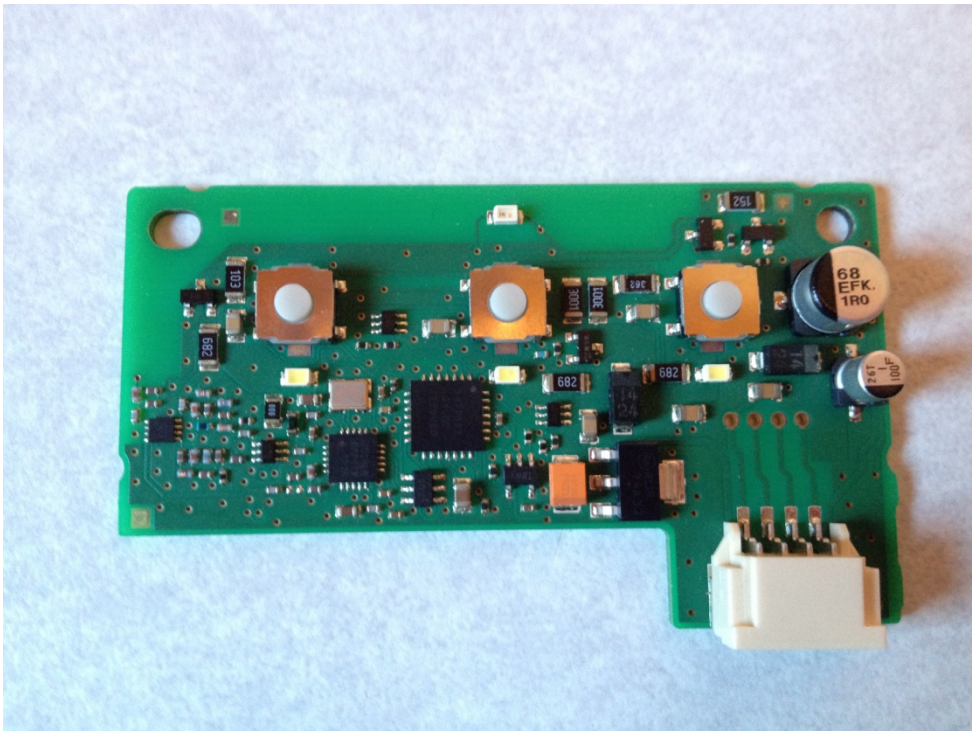
Limit dBuV/m= 20*Log(200uV/m)=46.0dBuV/m

while the Rx Spurious Emissions limit for the harmonics is given by

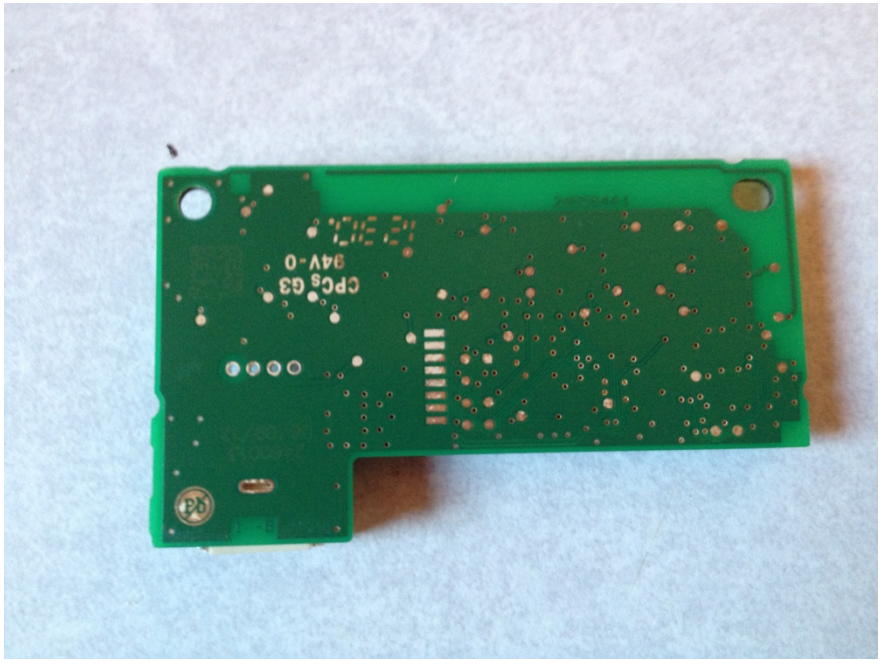
Limit dBuV/m= 20*Log(500uV/m)=54.0dBuV/m

Photos of Product Tested

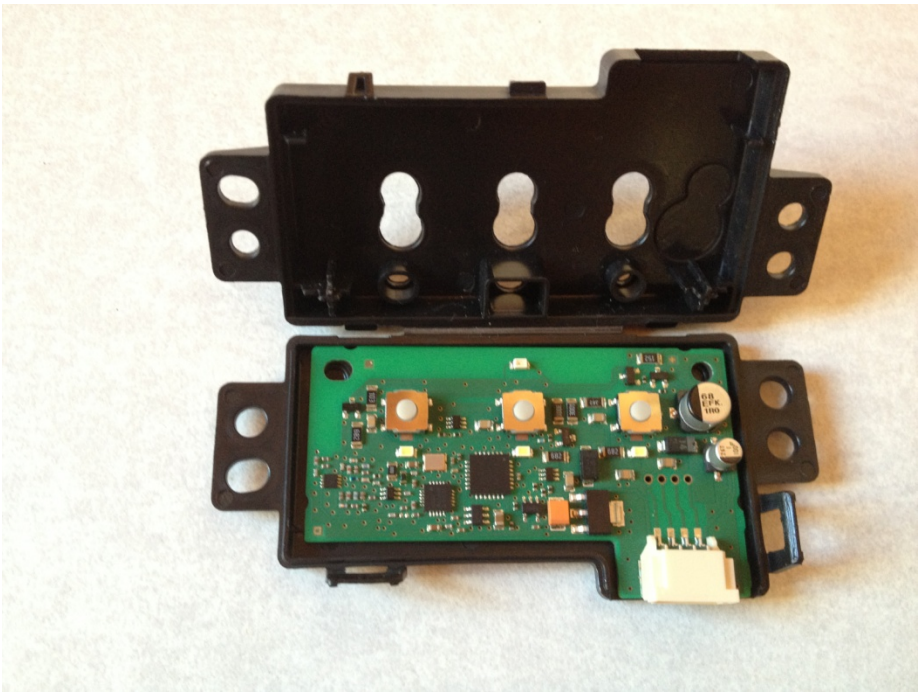
8.1.1 Front View – Printed Circuit Board

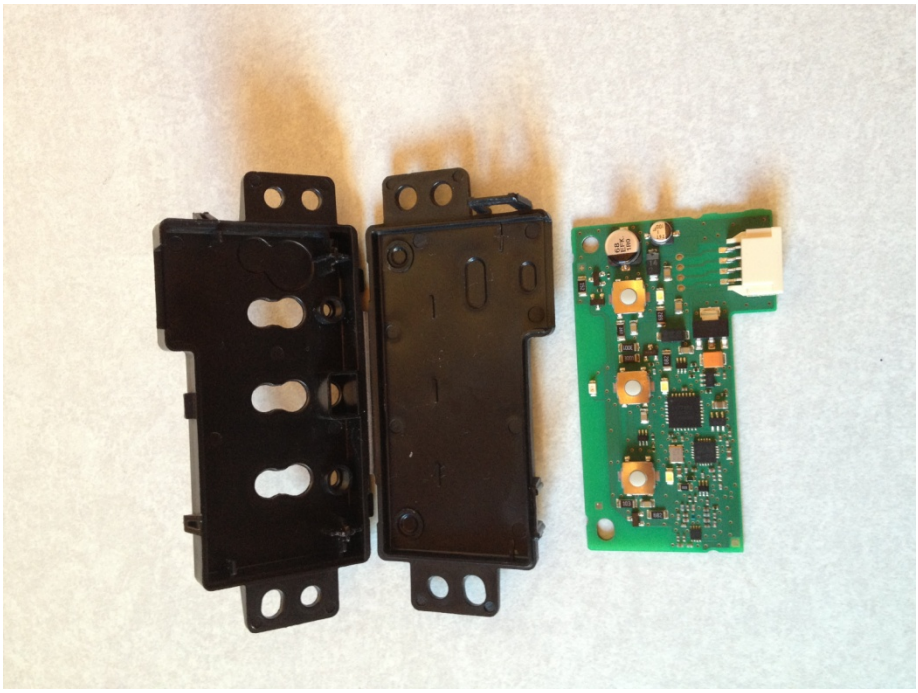


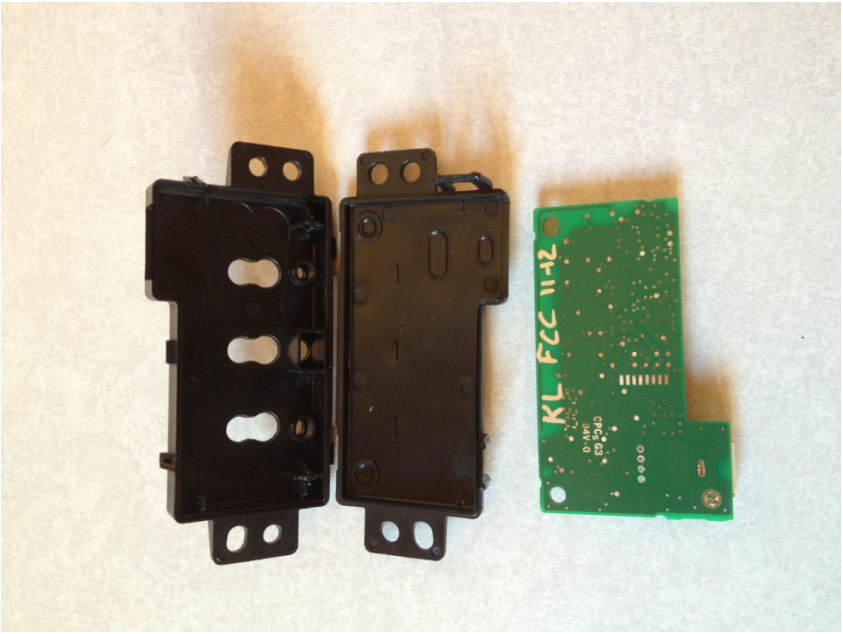
8.1.2 Rear View – Printed Circuit Board.



8.1.3 Unit Disassembled

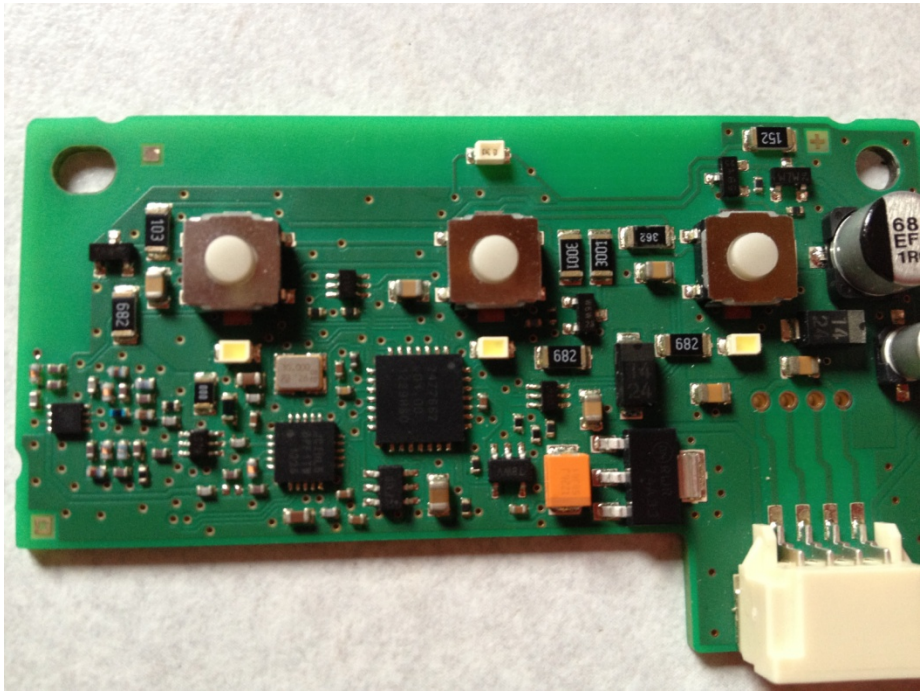






8.2 Housing & PCB Board Internal View

8.3 Close-up of Homelink RF Section.



9 Other Attachments and Description

9.1 User Manual

Please refer to attachment “User_Manual_English.pdf” and “User_Manual_French.pdf”.

9.2 Schematics/ Tuning Information

For schematics please refer to attachment “Schematic.pdf”.

9.3 Theory of Operation

Please refer to attachment “HL5 Operation FCC 231_247.pdf”

9.4 Label Drawing and Location on Complete Assembly.

For a drawing of the label, refer to attachment “Label Drawing_Label Location.pdf.”

For a drawing of the position of the label on the finished assembly refer to

“Label Drawing_Label Location.pdf”.