FCC & Industry Canada Certification Test Report
For the
Axiometric, LLC
MS2E

FCC ID: VE4-MS2E
IC ID: TBD

WLL JOB# **12006**
June 16, 2011

Prepared for:

Axiometric, LLC
10718 Vista Road
Columbia, MD 21044

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ACLASS ACCREDITED TESTING

Testing Certificate AT-1448

Certificates and reports shall not be reproduced except in full, without the written permission of Washington Laboratories, Limited

FCC & Industry Canada Certification Test Report
for the
Axiometric, LLC
MS2E
FCC ID: VE4-MS2E
IC ID: TBD

June 16, 2011

WLL JOB# 12006

Prepared by:

Steven Dovell
Compliance Engineer

Reviewed by:

Steven D. Koster
EMC Operations Manager

© 2011 Washington Laboratories, Ltd.

Abstract

This report has been prepared on behalf of Axiometric, LLC to support the attached Application for Equipment Authorization. The test report and application are submitted for a Frequency Hopping Spread Spectrum Transmitter under Part 15.247 (10/2009) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Axiometric, LLC MS2E.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

The Axiometric, LLC MS2E complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 and Industry Canada RSS-210.

Revision History	Description of Change	Date
Rev 0	Initial Release	June 16, 2011

 © 2011 Washington Laboratories, Ltd.

Table of Contents

List of Tables

© 2011 Washington Laboratories, Ltd.

List of Figures

© 2011 Washington Laboratories, Ltd.

© 2011 Washington Laboratories, Ltd.

1 Introduction

1.1 Compliance Statement

The Axiometric, LLC MS2E FHSS Module complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 and Industry Canada RSS-210.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with FCC Public Notice DA 00-705. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Axiometric, LLC 10718 Vista Road Columbia, MD 21044
Quotation Number:	66226

1.4 Test Dates

Testing was performed on the following date(s):	6/1/11 – 6/2/11

1.5 Test and Support Personnel

Washington Laboratories, LTD	Steven Dovell
Client Representative	Frank Moody

 © 2011 Washington Laboratories, Ltd.

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**ere**s**
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**c**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**m**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

© 2011 Washington Laboratories, Ltd.

2 Equipment Under Test

2.1 EUT Identification & Description

The Axiometric, LLC MS2E Module is a small (60mm x 68mm) module. The 100 pin connector on the bottom of the board allow the module to be plugged into devices with appropriate sockets. The module may be plugged directly into a third-party product and connected to an approved antenna (approved type modular approval grant) to enable the product to participate in an Axiometric wireless mesh network. The module specifically includes:

- AX_RFM_250 transceiver module

  (Axiometric has developed an RF transceiver module (AX_RFM_250) that is used in all Axiometric mesh products and contains all of the RF circuitry excluding the antenna system and power supply)

- ARM7 micro-controller
- 3.3vdc linear voltage regulator (regulates power to transceiver)
- Reverse SMA antenna connector

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Axiometric LLC
FCC ID Number	VE4-MS2E
IC ID Number	TBD
EUT Name:	MS2E RF Module
Model:	MS2E
FCC Rule Parts:	15.247
Frequency Range:	902.5-927MHz
Maximum Output Power:	414mW (26.17dBm)
Modulation:	FHSS FSK
20dB Bandwidth:	157.1 kHz for mesh mode, 316.5 kHz for drive-by mode
Maximum Transmit Spurious Emission	8235 MHz @ 447.5 uV/m (3m) Margin= -1dB (limit=500uV/m)
Maximum Receiver Spurious Emission	144MHz @ 110.2 uV/m (3m) Margin= -2.7dB (limit=150uV/m)
Keying:	Automatic
Type of Information:	Data
Number of Channels:	50
Power Output Level	Fixed
Antenna Type	Tested with a 8dBi whip antenna
Interface :	100 pins for data and DC power, 8 pin programing port, RF reverse SMA RF port
Power Source & Voltage:	3.6-6VDC
Manufacturer:	Axiometric LLC

 © 2011 Washington Laboratories, Ltd.

2.2 Test Configuration

The MS2E module was tested as a stand-alone device, only using the mother board to route the communication lines and power. The module was powered with a 5VDC power provided directly to the EUT from a 120VAC to 5 VDC PRS AC/DC adaptor. The EUT was connected to a support laptop for RF control via USB maintenance port on the motherboard. The motherboard was not powered nor operating. The RF radiated tests were performed with an 8dBi whip antenna connected to the EUT.

2.3 Testing Algorithm

The MS2E was programmed via the USB port on the EUT from the support laptop. The support laptop used a proprietary control program to command the EUT to transmit on the lowest, center, and highest channels. Commands were also sent to allow the unit to transmit in a hopping fashion. The unit was preloaded with a typical data payload to transmit.

Worst case emission levels are provided in the test results data.

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 Methods of Measurement of Radio Noise from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

KDB558074: “Measurement of Digital Transmission Systems operating under Section 15.247.”

2.5.2 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

 © 2011 Washington Laboratories, Ltd.

Equation 1: Standard Uncertainty

$$\boxed{u_c = \pm\sqrt{\frac{a^2}{div_a^{\;2}} + \frac{b^2}{div_b^{\;2}} + \frac{c^2}{div_c^{\;2}} + \ldots\ldots}}$$

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a,\,b,\,c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$\boxed{U = ku_c}$$

Where U = expanded uncertainty

k = coverage factor

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 2 below.

Table 2: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	4.55 dB

 © 2011 Washington Laboratories, Ltd.

3 Test Equipment

Table 3 shows a list of the test equipment used for measurements along with the calibration information.

Table 3: Test Equipment List

Equipment List- Conducted Antenna Port Tests

Test Name:	**Conducted Antenna Port Test**	Test Date:	**06/02/2011**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
528	AGILENT - E4446A	ANALYZER SPECTRUM	9/27/2011
728	AGILENT - 8564EC	SPECTRUM ANALYZER 30HZ - 40GHZ	4/28/2012

Equipment List- Radiated Emissions Tests

Test Name:	**Radiated Emissions**	Test Date:	**06/01/2011**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	2/15/2013
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	1/12/2012
68	HP - 85650A	ADAPTER QP	6/22/2011
72	HP - 8568B	ANALYZER SPECTRUM	6/22/2011
70	HP - 85685A	PRESELECTOR RF W/OPT 8ZE	6/22/2011
528	AGILENT - E4446A	ANALYZER SPECTRUM	9/27/2011
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/4/2012
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHZ	3/24/2012

© 2011 Washington Laboratories, Ltd.

Equipment List- Conducted AC power line Emissions Tests

Test Name: Conducted Emissions Voltage		Test Date: 06/01/2011	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
125	SOLAR - 8028-50-TS-24-BNC	LISN	7/10/2011
126	SOLAR - 8028-50-TS-24-BNC	LISN	7/10/2011
68	HP - 85650A	ADAPTER QP	6/22/2011
72	HP - 8568B	ANALYZER SPECTRUM	6/22/2011

4 Test Summary

The Table Below shows the results of testing for compliance with a Digital Transmission System in accordance with FCC Part 15.247:2007 and RSS210e issue 7. Full results are shown in section 5.

Table 4: Test Summary Table

TX Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (a)(1)(iii)	RSS-210 [A8. 1]	20dB Bandwidth	Pass
15.247 (b)(1)	RSS-210 [A8.4 (2)]	Transmit Output Power	Pass
15.247 (a)(1)	RSS-210 [A8.1 (2)]	Channel Separation	Pass
15.247 (a)(1)(iii)	RSS-210 [A8. 1 (4)]	Number of Channels =50 Minimum	Pass
15.247 (a)(1)(iii)	RSS-210 [A8. 1 (4)]	Time of Occupancy	Pass
15.247 (d)	RSS-210 [A8. 5]	Occupied BW / Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-210 [A8. 5]	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	Pass
RX/Digital Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	Pass
15.209	RSS-Gen [7.2.3.2]	General Field Strength Limits (Restricted Bands & RE Limits)	Pass

© 2011 Washington Laboratories, Ltd.

5 Test Results

5.1 Duty Cycle Correction

In accordance with the FCC Public Notice the spurious radiated emissions measurements may be adjusted by using a duty cycle correction factor if the dwell time per channel of the hopping signal is less than 100 ms.

The duty cycle correction factor is calculated by:

20 x LOG (dwell time/100 ms)

The following figure shows the plot of the dwell time for the transmitter. Based on this plot, the dwell time per hop is 176.2ms for 'Mesh Mode' and 66.29ms for 'Drive-by mode'. The unit makes a single hop transmission every 6 seconds. FCC part 15.247 also requires that for hopping signals with an occupied bandwidth of greater than 250kHz the total transmit dwell time must be no more than 0.4 seconds per 10 seconds . For signals less than 250 kHz the limit is 0.4 seconds per 20 seconds. As the 'Mesh mode bandwidth is less than 250kHz and the 'Drive-by' mode is more than 250kHz both modes were tested and complied.

Even though the drive-by mode is 66.29ms no duty cycle correction was applied as the normal mode of operation 'Mesh mode' is over 100ms.

 © 2011 Washington Laboratories, Ltd.

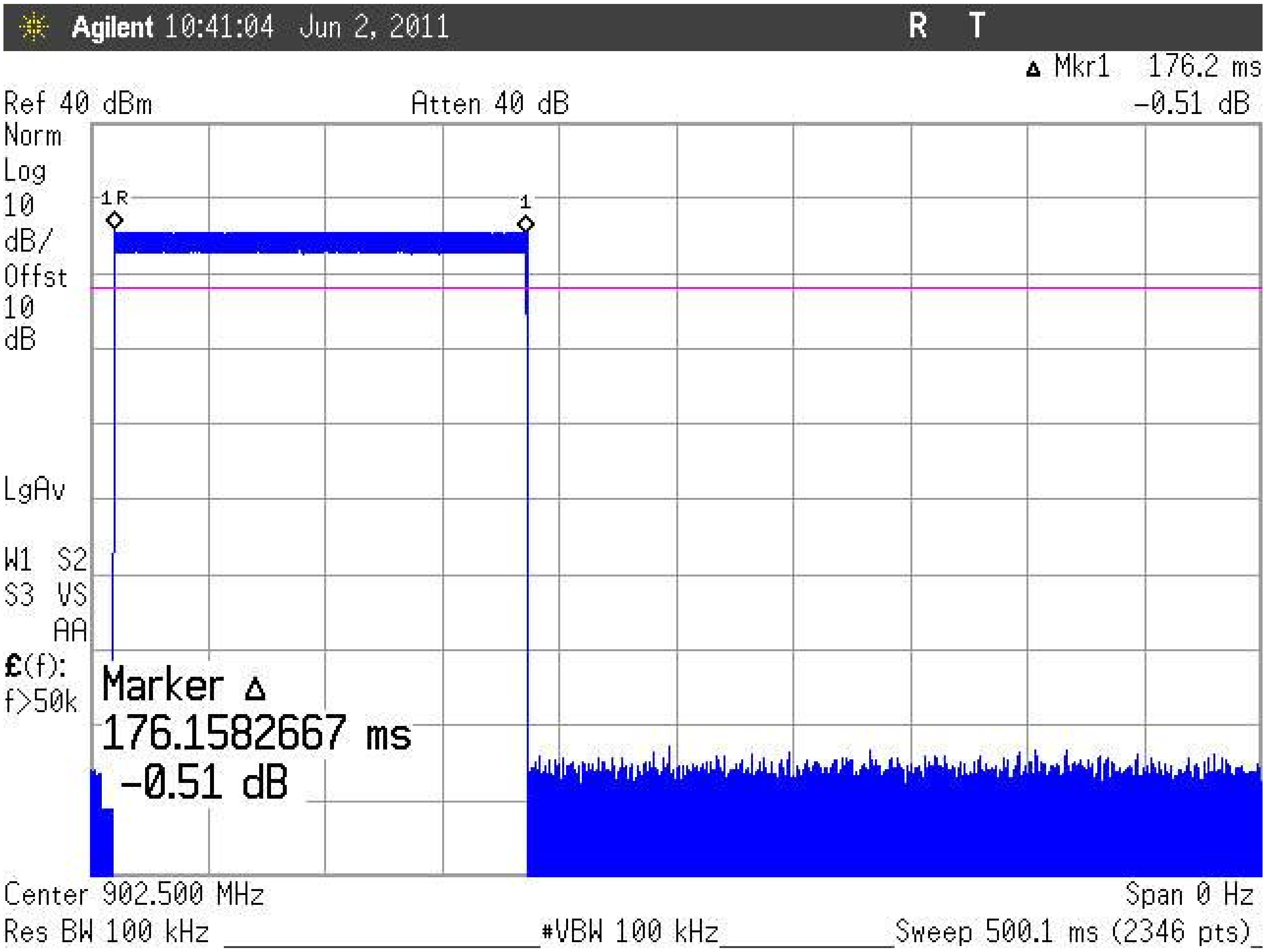

Figure 1. Dwell Time Per Hop, Mesh Mode

 © 2011 Washington Laboratories, Ltd.

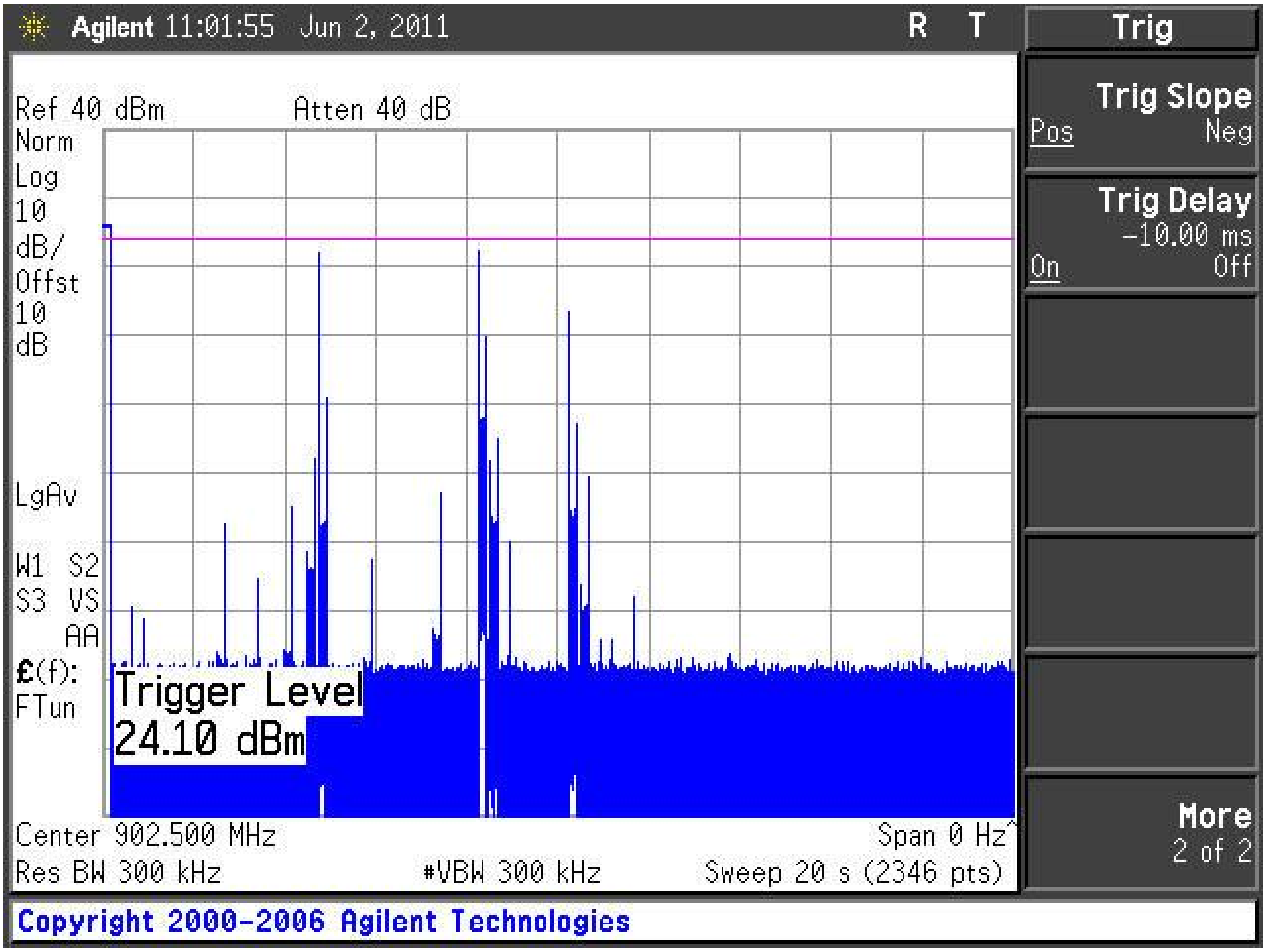

Figure 2. Time of Occupancy per 20 seconds, Mesh Mode

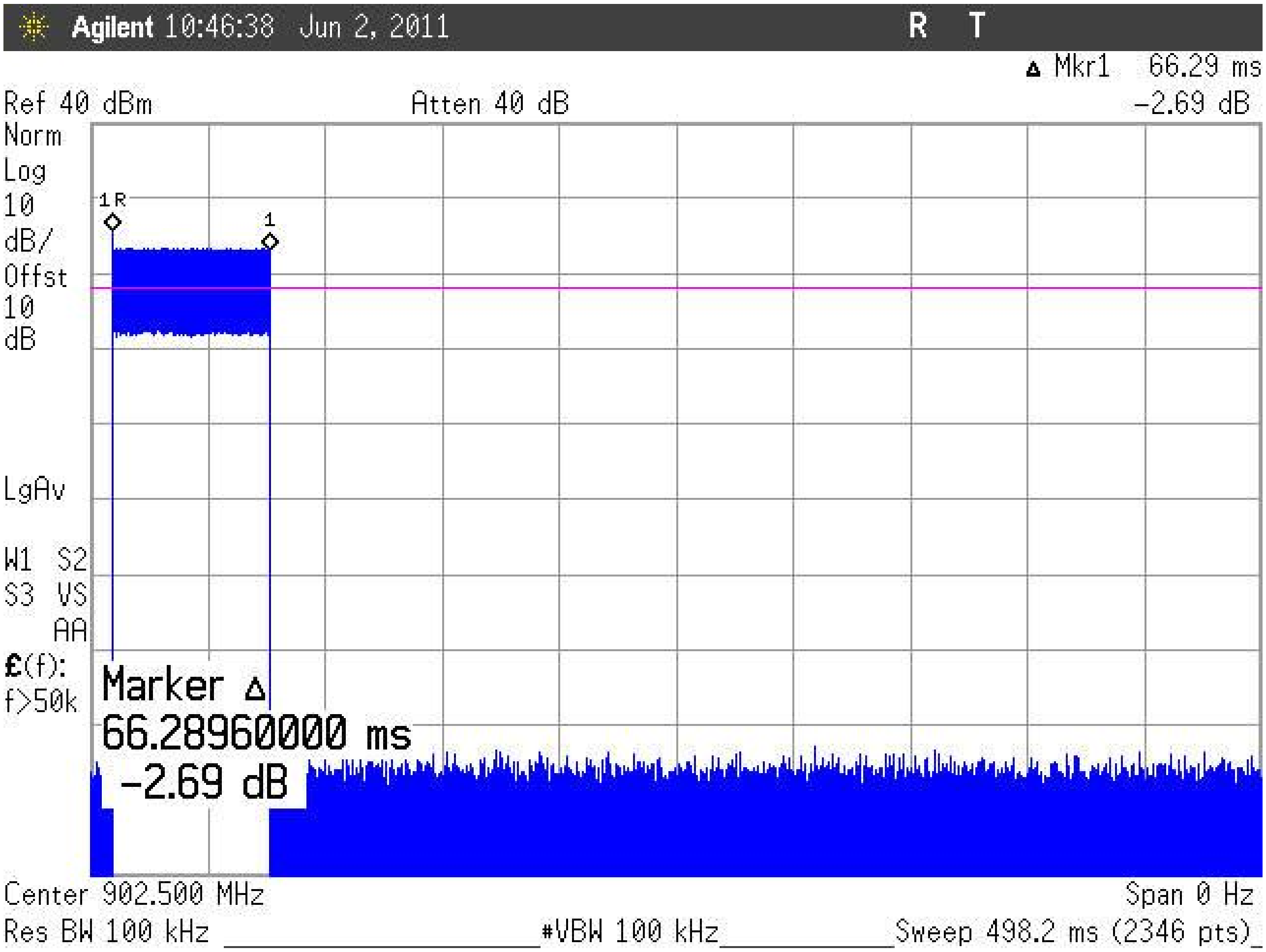

Figure 3. Dwell Time Per Hop, Drive-by Mode

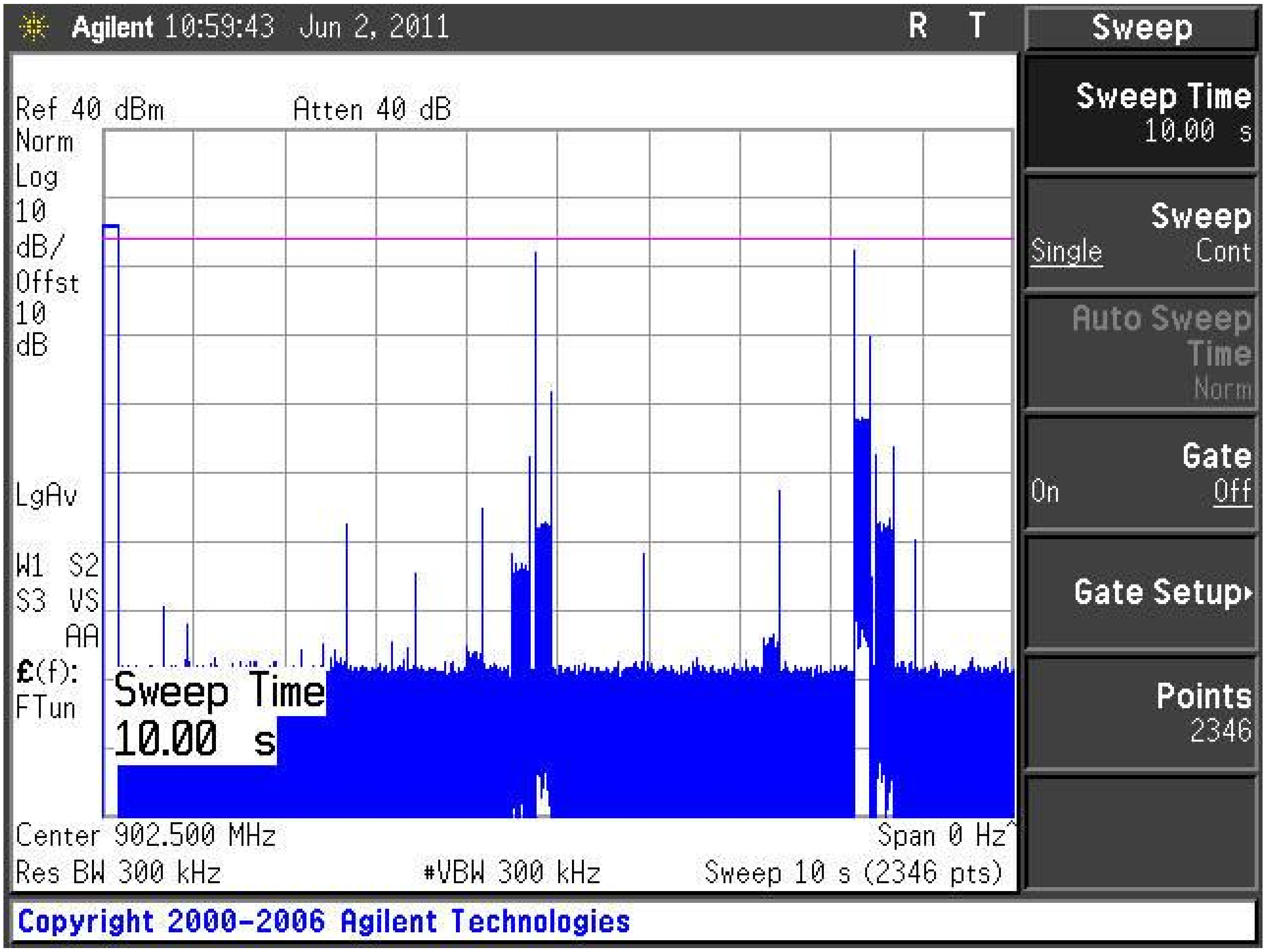

Figure 4. Time of Occupancy per 10 seconds, drive-by Mode

5.2 RF Power Output: (FCC Part §2.1046)

To measure the output power the hopping sequence was stopped while the frequency dwelled on a low, high and middle channel. The output from the transmitter was connected to an attenuator and then to the input of the RF Spectrum Analyzer. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system.

2 modes of operation were available: a narrow bandwidth 'Mesh Mode' and a wider bandwidth 'Drive-by' mode.

Table 5: RF Power Output

Mode Tested	Frequency	Level	Limit	Pass/Fail
Mesh Mode	Low Channel: 902.5MHz	25.94 dBm	30 dBm	Pass
Mesh Mode	Center Channel: 915MHz	25.90 dBm	30 dBm	Pass
Mesh Mode	High Channel: 927MHz	26.16 dBm	30 dBm	Pass
Drive-by Mode	Low Channel: 902.5MHz	25.91 dBm	30 dBm	Pass
Drive-by Mode	Center Channel: 915MHz	25.89 dBm	30 dBm	Pass
Drive-by mode	High Channel: 927MHz	26.17 dBm	30 dBm	Pass

 © 2011 Washington Laboratories, Ltd.

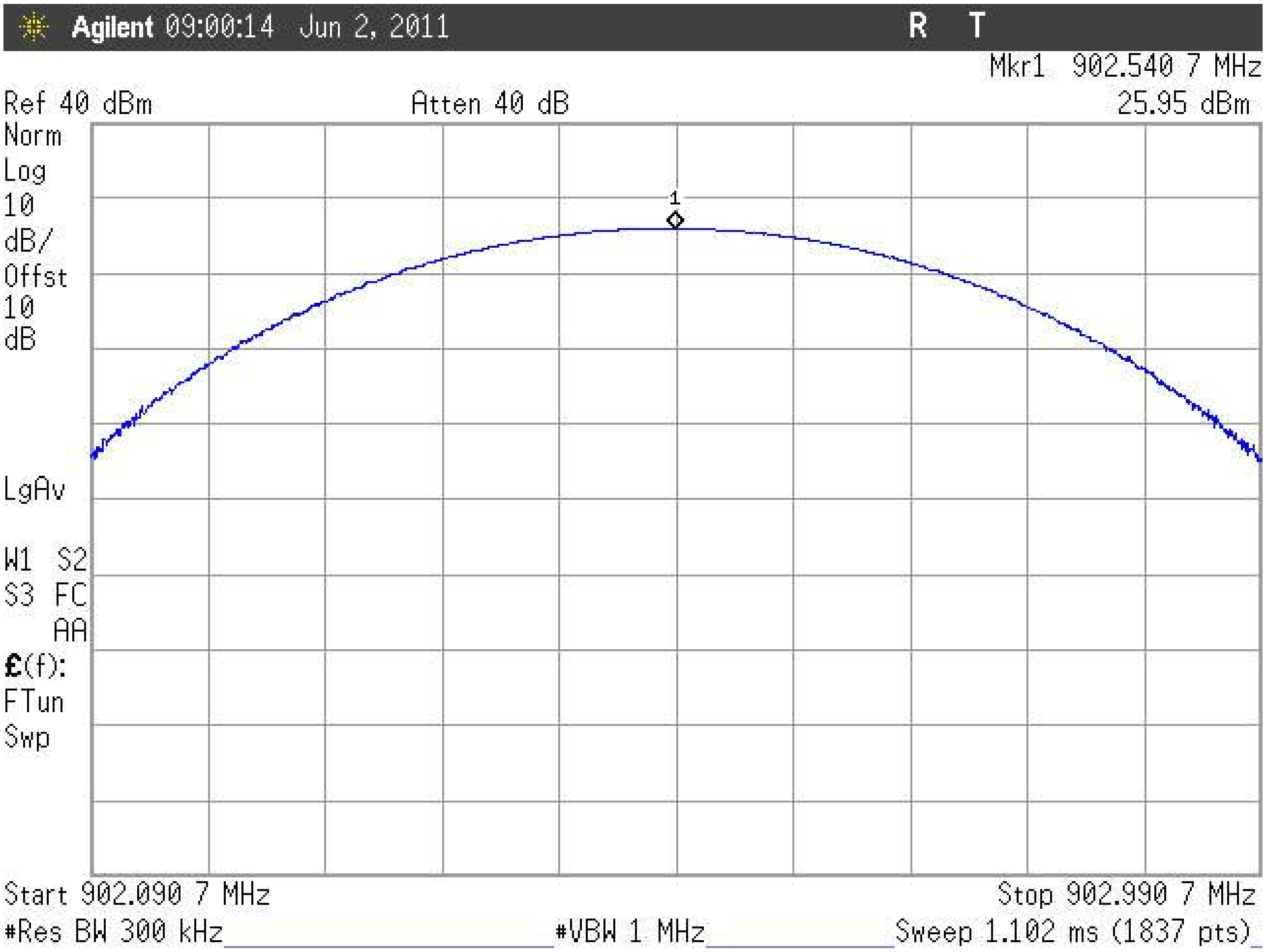

Figure 5. RF Peak Power, Mesh Mode, Low Channel

 © 2011 Washington Laboratories, Ltd.

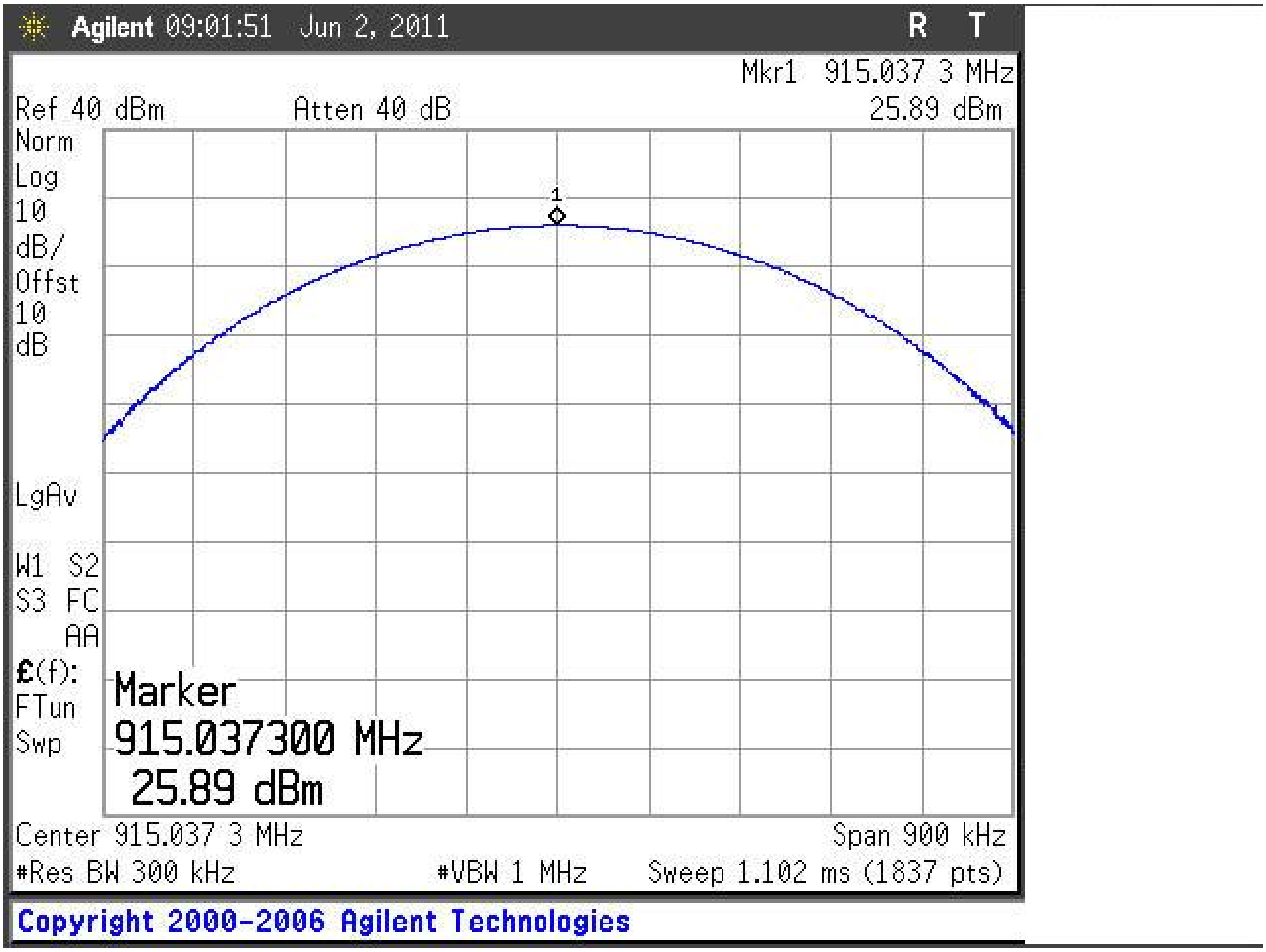

Figure 6. RF Peak Power, Mesh Mode, Center Channel

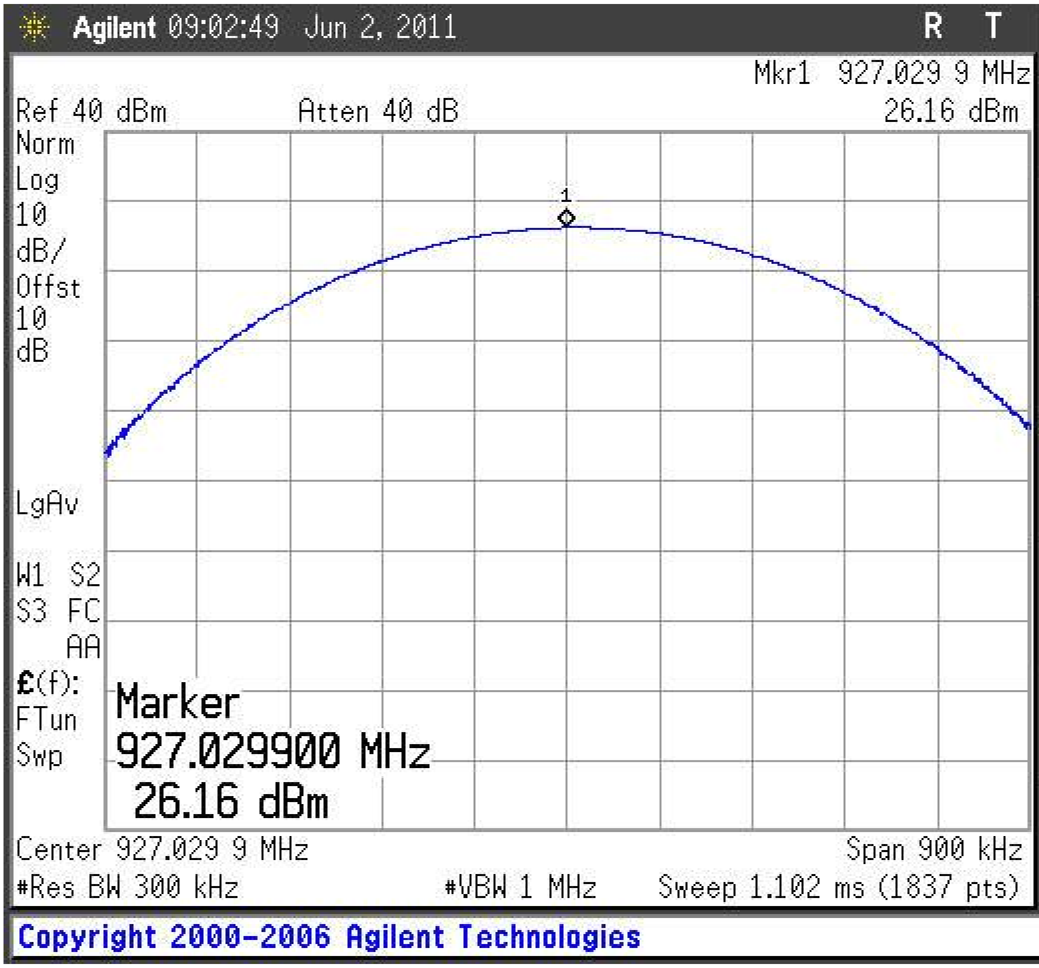

Figure 7. RF Peak Power, Mesh Mode, High Channel

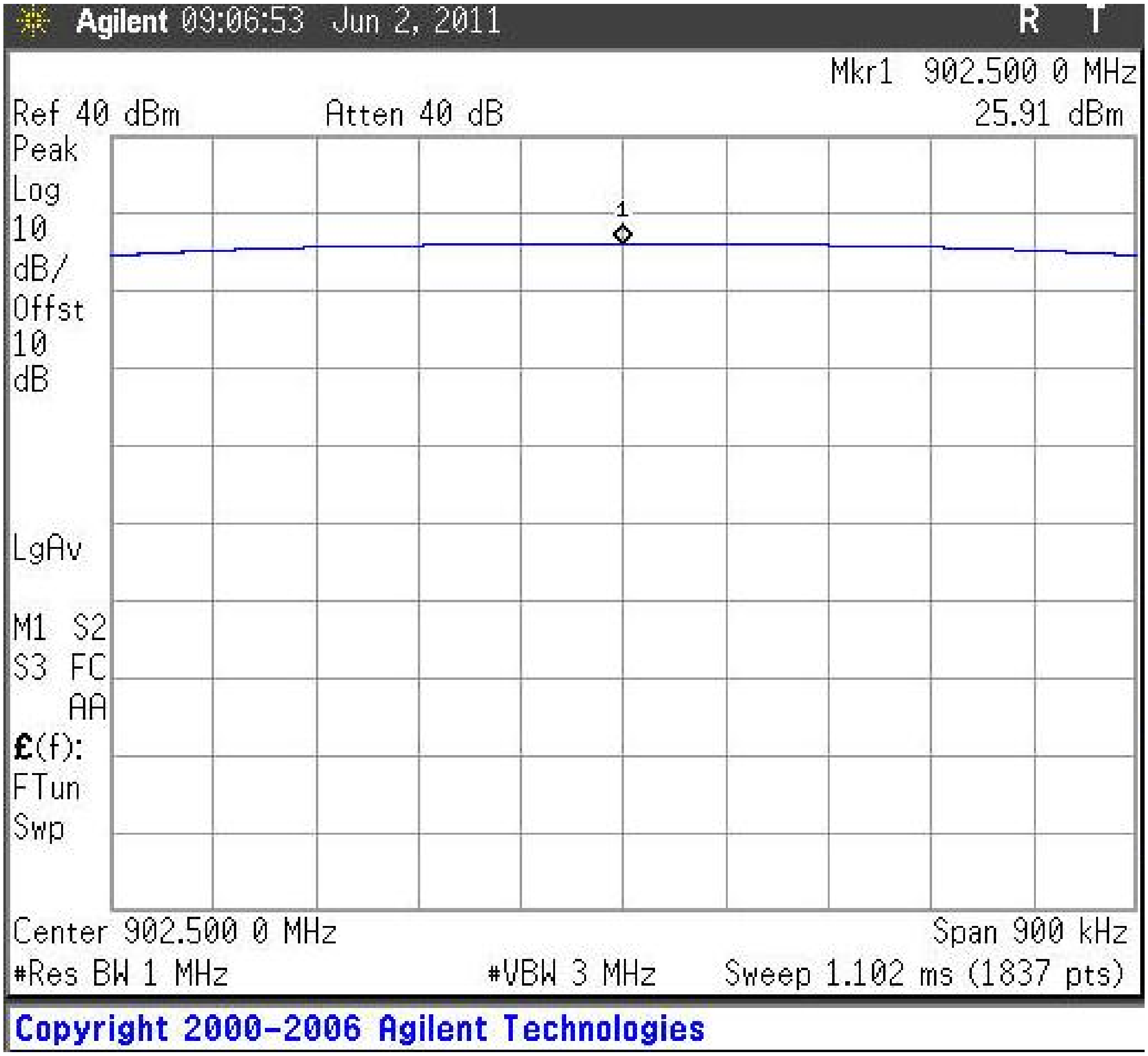

Figure 8. RF Peak Power, Drive-by Mode, Low Channel

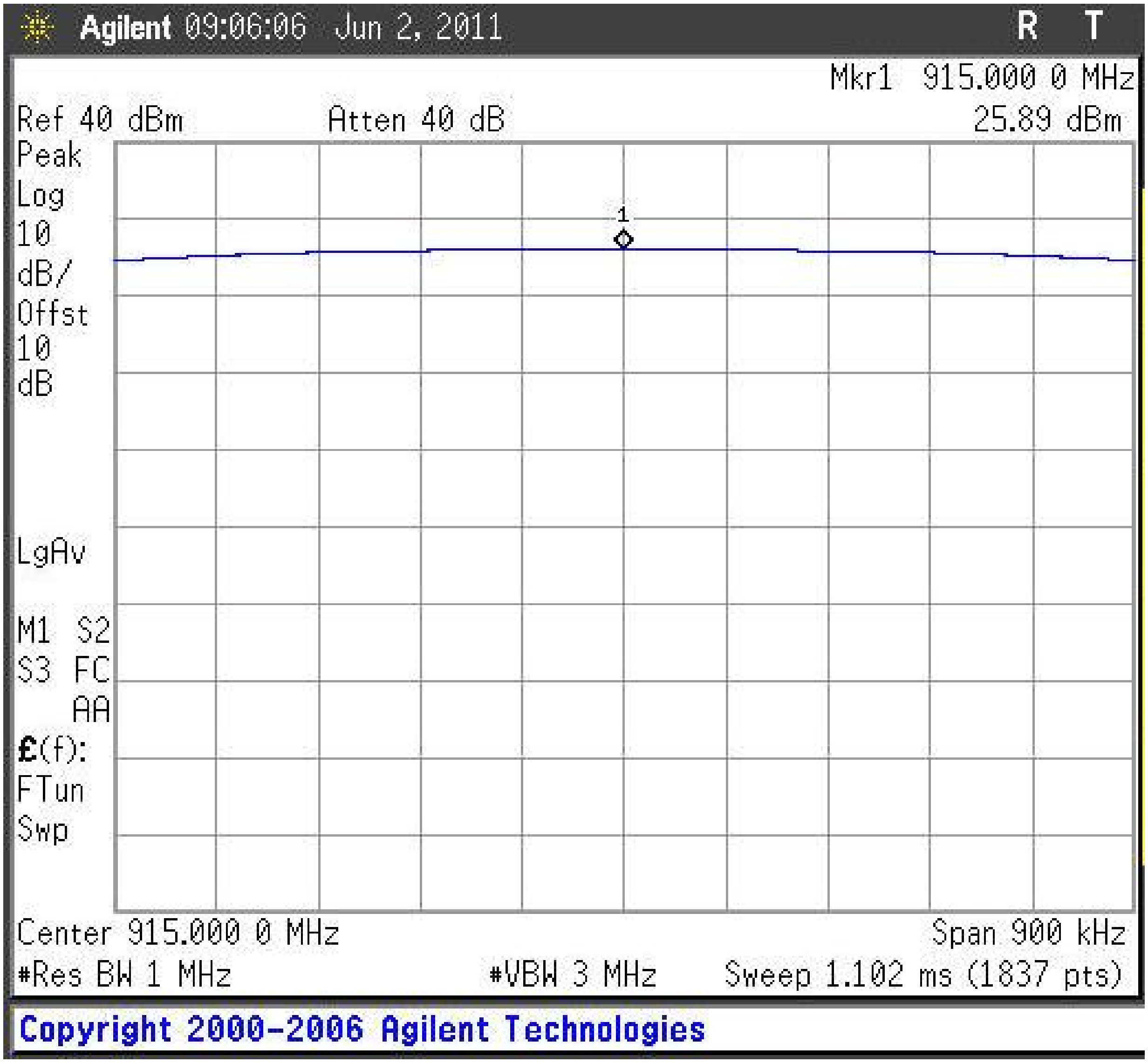

Figure 9. RF Peak Power, Drive-by Mode, Center Channel

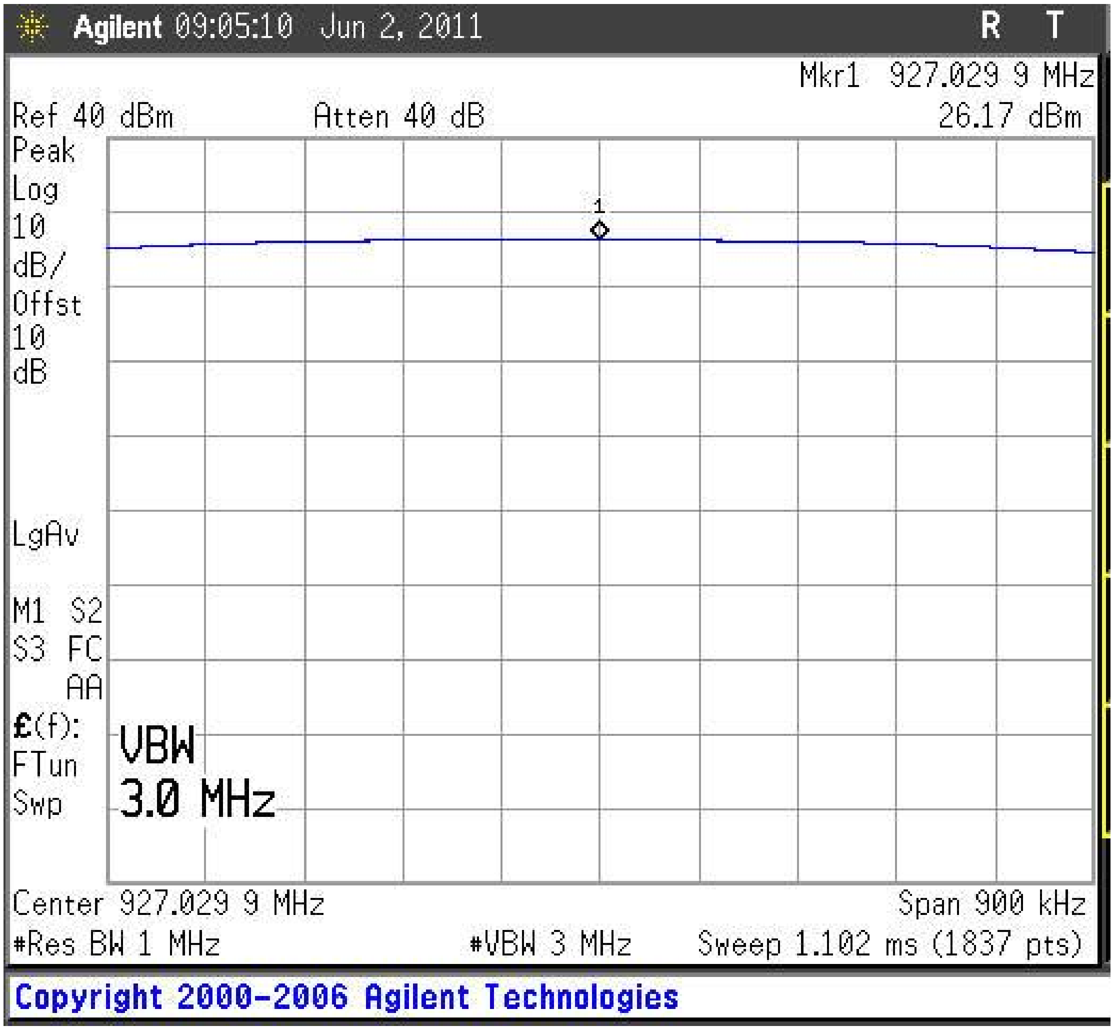

Figure 10. RF Peak Power, Drive-by Mode, High Channel

5.3 Occupied Bandwidth: (FCC Part §2.1049)

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

For Frequency Hopping Spread Spectrum Systems, FCC Part 15.247 requires the maximum 20 dB bandwidth not exceed 500 kHz.

Two modes of operation were available: a narrow bandwidth 'Mesh Mode' and a wider bandwidth 'Drive-by' mode, the occupied bandwidth was measured as shown:

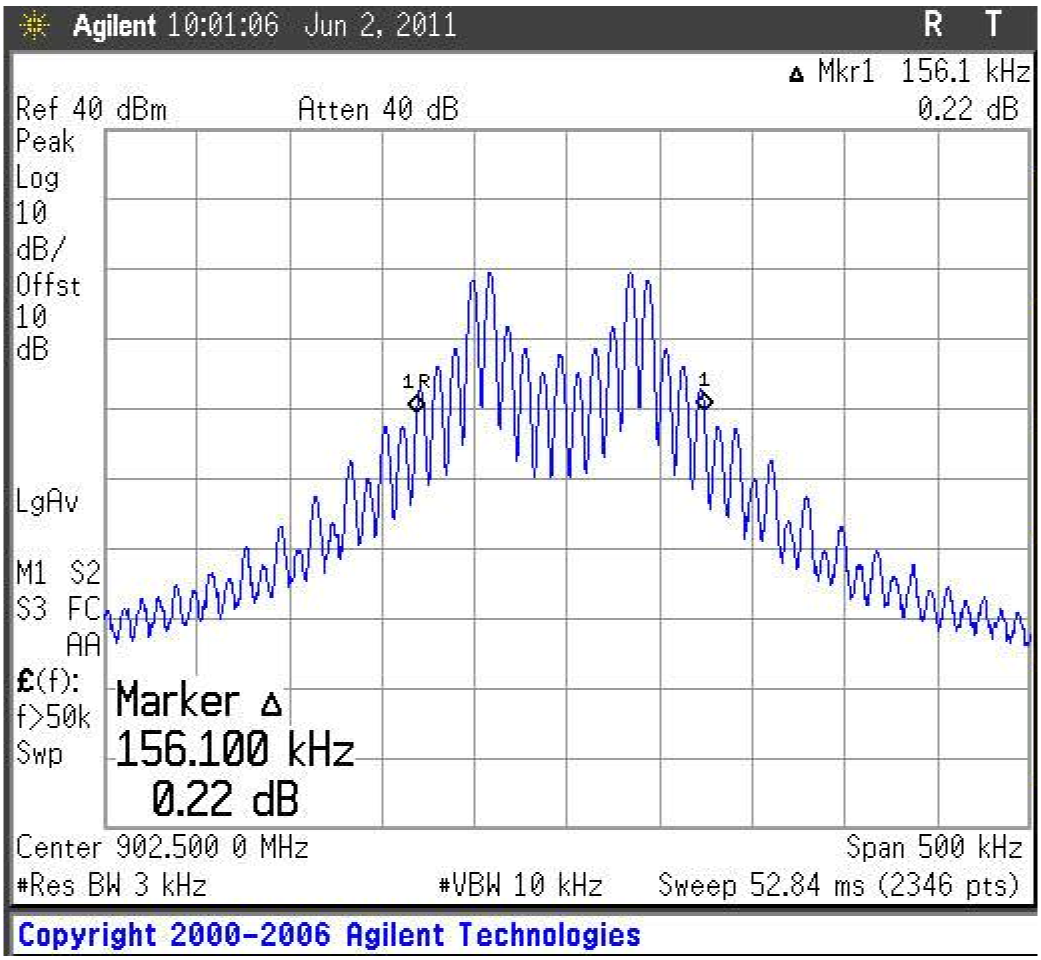

Figure 11. Occupied Bandwidth, Mesh Mode, Low Channel

 © 2011 Washington Laboratories, Ltd.

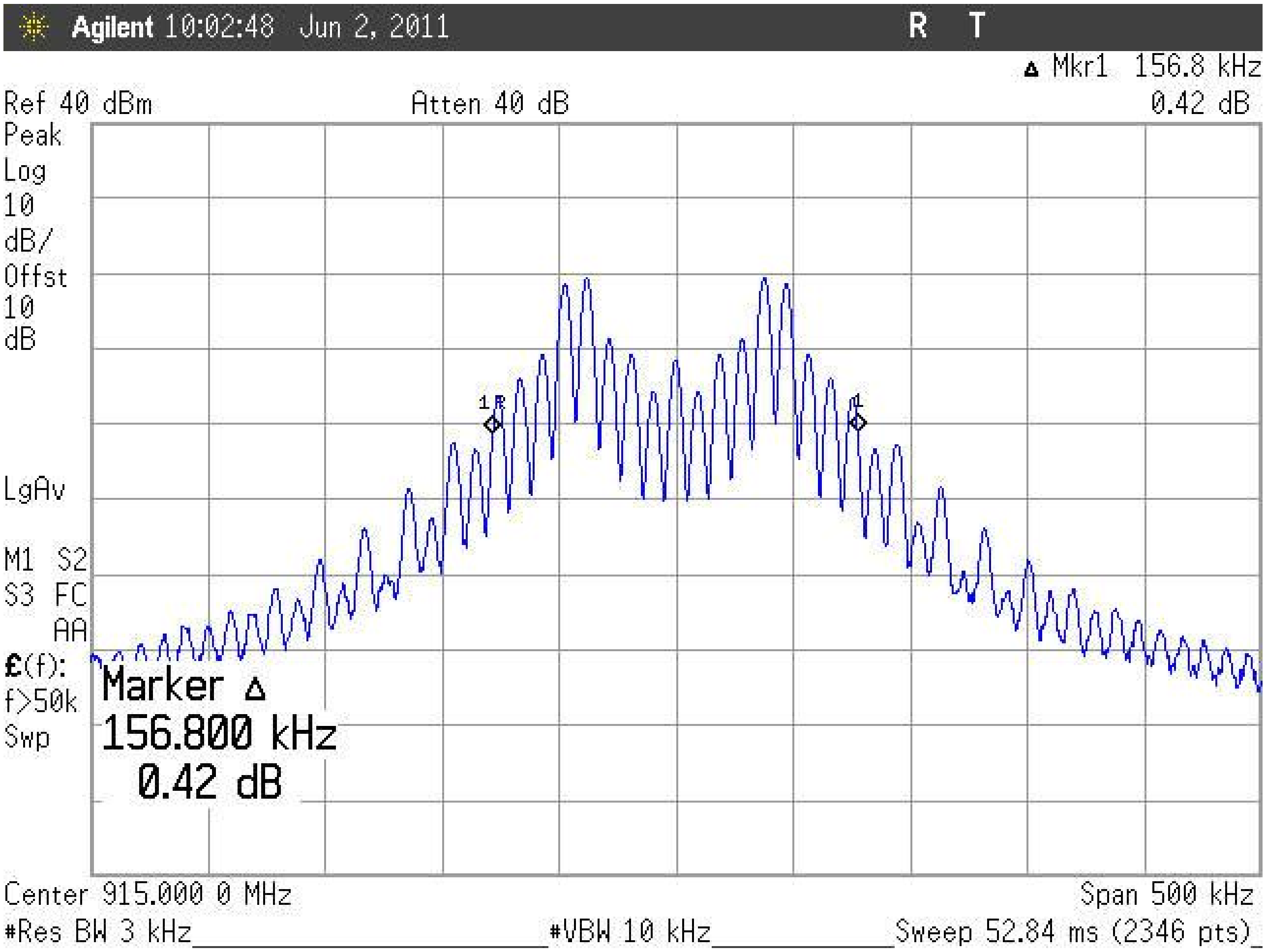

Figure 12. Occupied Bandwidth, Mesh Mode, Center Channel

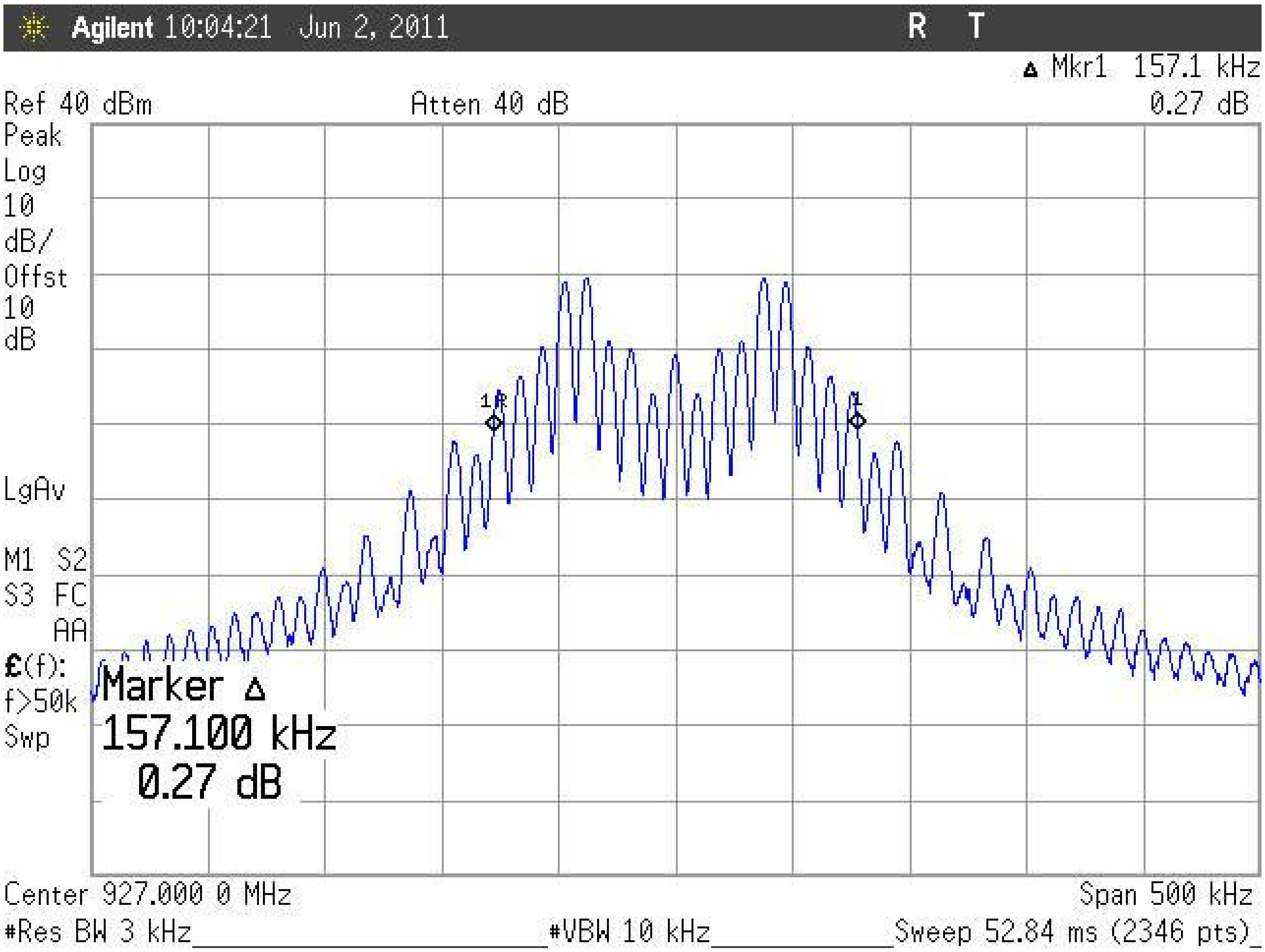

Figure 13. Occupied Bandwidth, Mesh Mode, High Channel

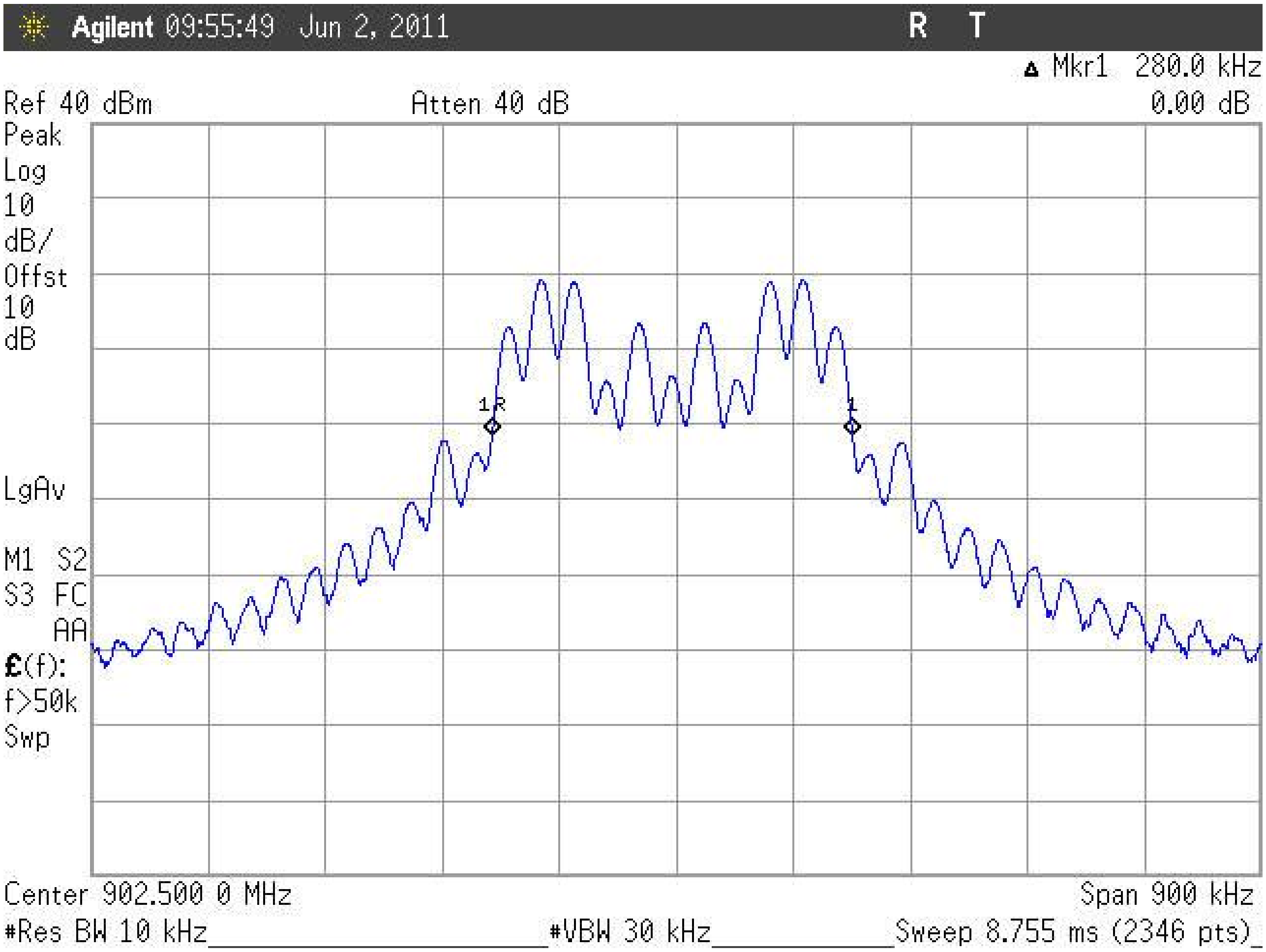

Figure 14. Occupied Bandwidth, Drive-by Mode, Low Channel

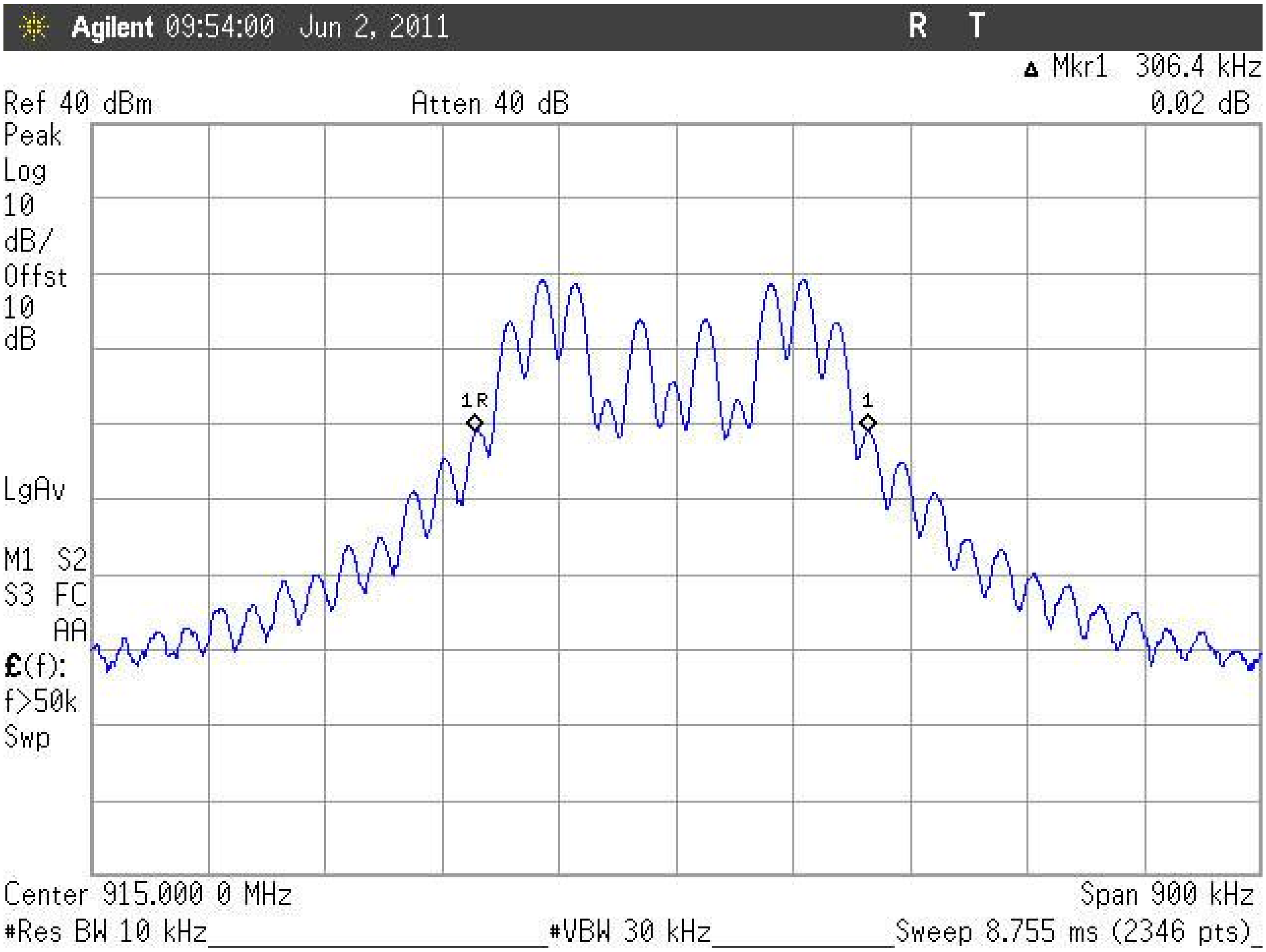

Figure 15. Occupied Bandwidth, Drive-by Mode, Center Channel

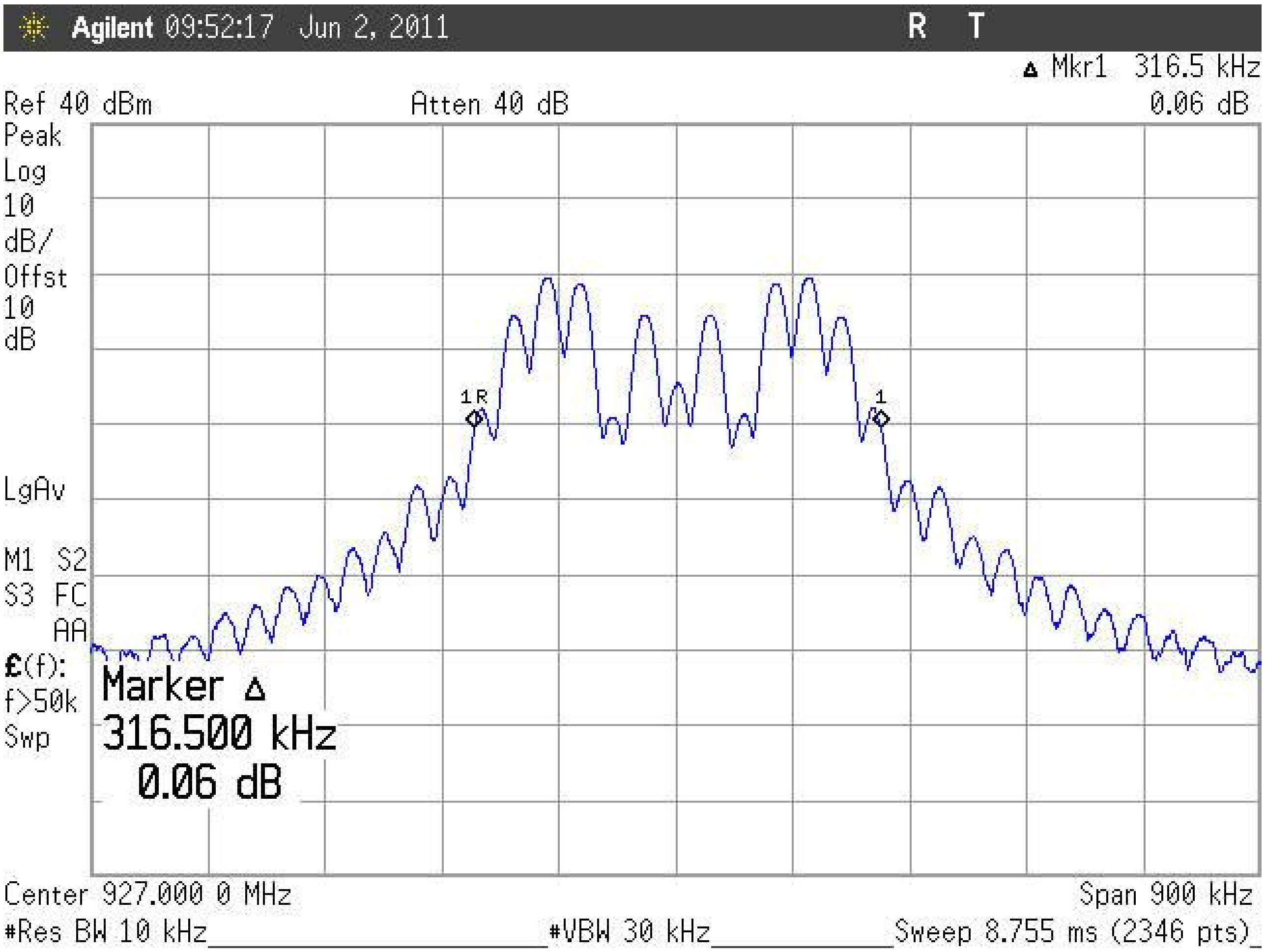

Figure 16. Occupied Bandwidth, Drive-by Mode, High Channel

Table 6 provides a summary of the Occupied Bandwidth Results.

Table 6: Occupied Bandwidth Results

Mode Tested	Frequency	Bandwidth	Limit	Pass/Fail
Mesh Mode	Low Channel: 902.5MHz	156.1 kHz	500 kHz	Pass
Mesh Mode	Center Channel: 915MHz	156.8 kHz	500 kHz	Pass
Mesh Mode	High Channel: 927MHz	157.1 kHz	500 kHz	Pass
Drive-by Mode	Low Channel: 902.5MHz	280.0 kHz	500 kHz	Pass
Drive-by Mode	Center Channel: 915MHz	306.4 kHz	500 kHz	Pass
Drive-by mode	High Channel: 927MHz	316.5kHz	500 kHz	Pass

© 2011 Washington Laboratories, Ltd.

5.4 Carrier Frequency Separation and Number of Hop Channels (FCC Part §15247(a)(1)

Per the FCC requirements, frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20 dB bandwidth, whichever is greater. The maximum 20dB bandwidth measured is 157.1 kHz (mesh) so the channel spacing must be more than 157.1 kHz for mesh mode and 316.5 kHz for drive-by mode. In addition, the number of hopping channels is 50 or more for a system with an occupied bandwidth greater than 250kHz.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to greater than 1% of the span and the video bandwidth was set greater than the RBW. The channel spacing of 2 adjacent channels was measured using a spectrum analyzer span setting of 1.5MHz. Also, the number of hopping channels was measured from 902 to 928MHz (to encompass the passband).

The following are plots of the channel spacing and number of hopping channels data. The channel spacing was measured to be 500kHz in both Mesh and Drive-by Modes and the number of channels used is 50 in both modes.

 © 2011 Washington Laboratories, Ltd.

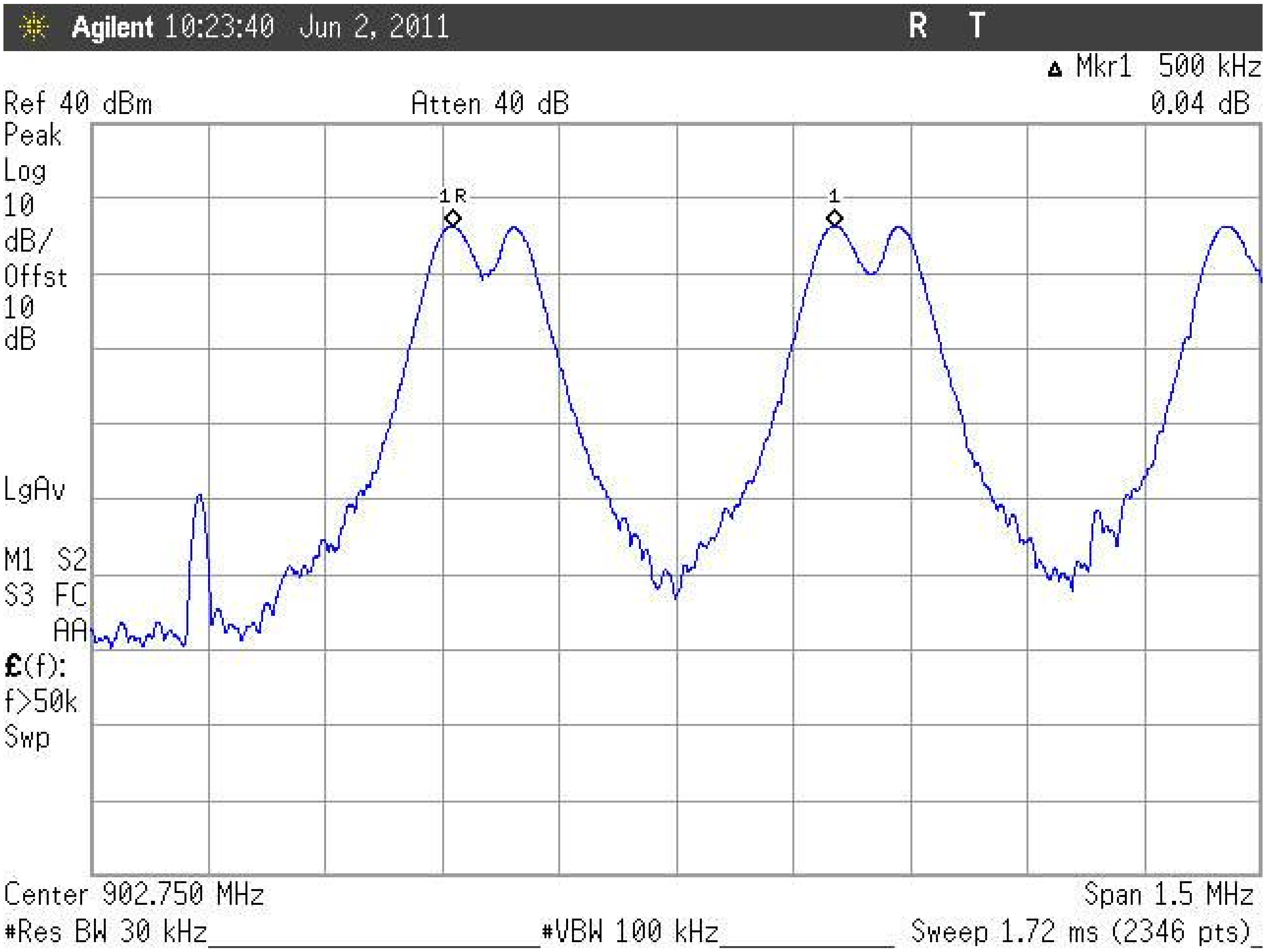

Figure 17, Channel Spacing, Mesh Mode

 © 2011 Washington Laboratories, Ltd.

Figure 18, Channel Spacing, Drive-by Mode

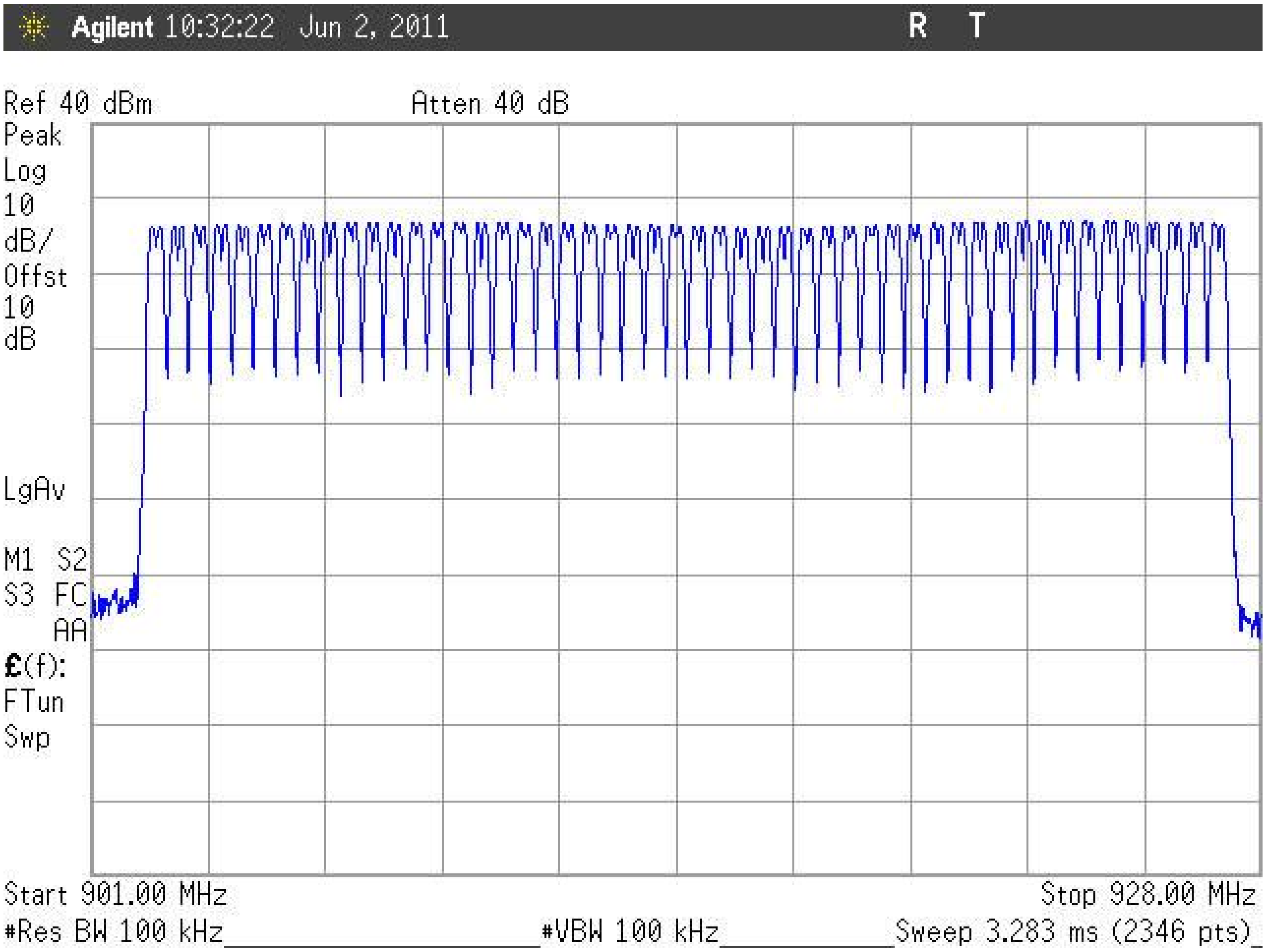

Figure 19, Number of Channels

 © 2011 Washington Laboratories, Ltd.

5.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §2.1051)

The EUT must comply with requirements for spurious emissions at antenna terminals. Per §15.247(c) all spurious emissions in any 100 kHz bandwidth outside the frequency band in which the spread spectrum device is operating shall be attenuated 20 dB below the highest power level in a 100 kHz bandwidth within the band containing the highest level of the desired power.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 30 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 100 kHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit (20 dB below the carrier frequency amplitude). The emissions outside of the allocated frequency band were then scanned from 30 MHz up to the tenth harmonic of the carrier.

The following are plots of the conducted spurious emissions data.

© 2011 Washington Laboratories, Ltd.

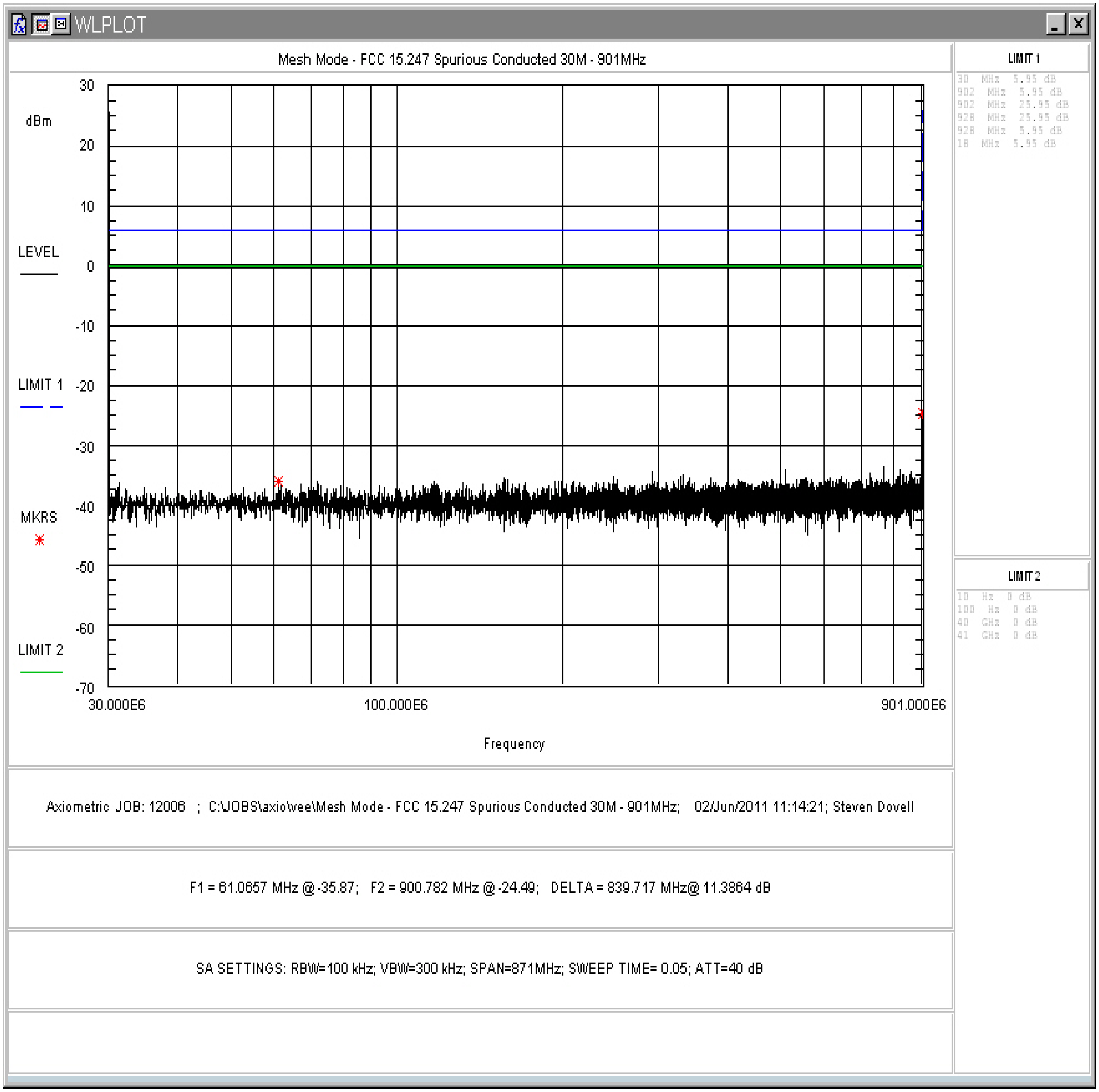

Figure 20. Conducted, Spurious Emissions, Mesh Mode, Low Channel 30 - 901MHz

 © 2011 Washington Laboratories, Ltd.

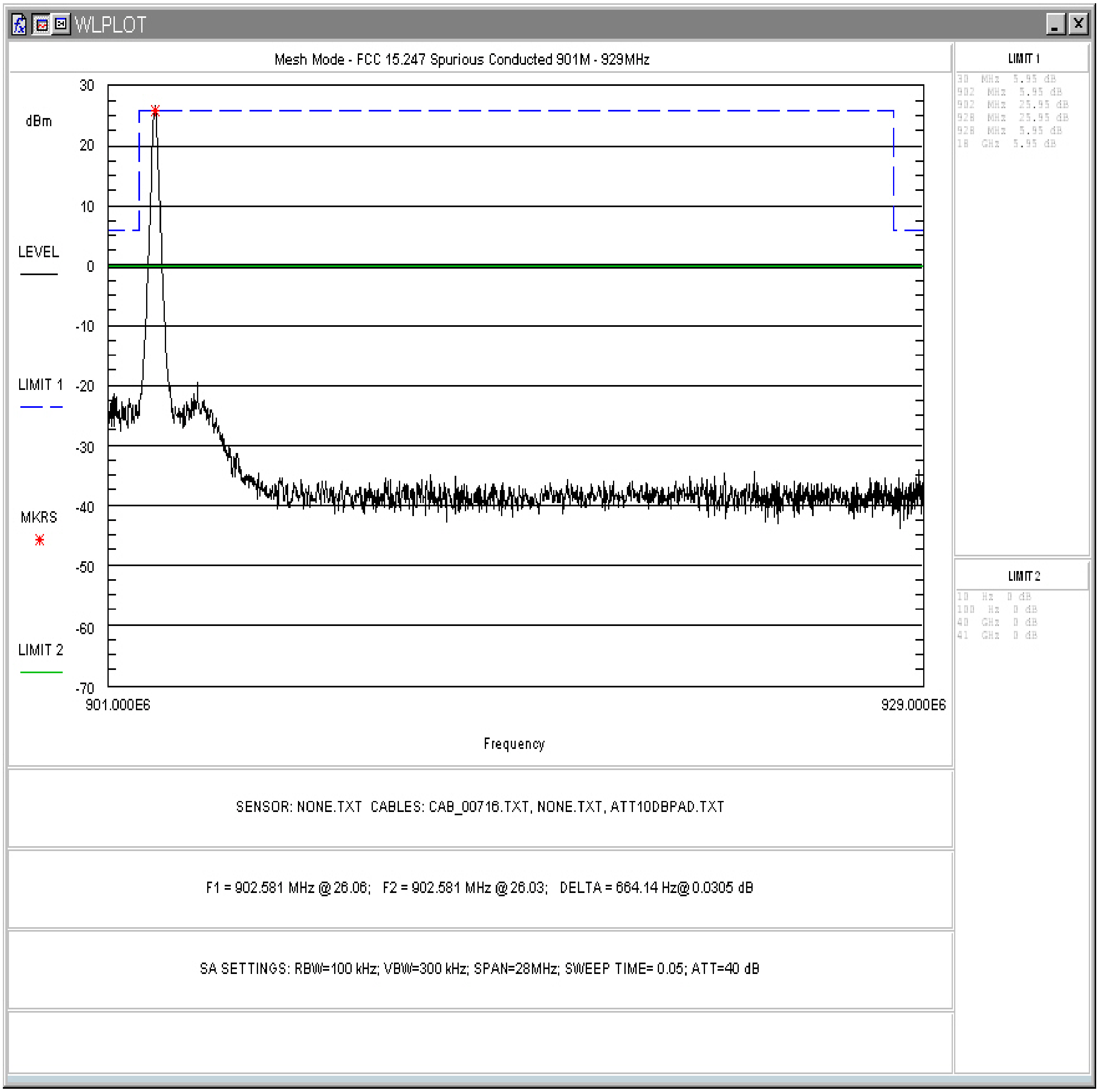

Figure 21. Conducted, Spurious Emissions, Mesh Mode, Low Channel 901 – 929MHz

 © 2011 Washington Laboratories, Ltd.

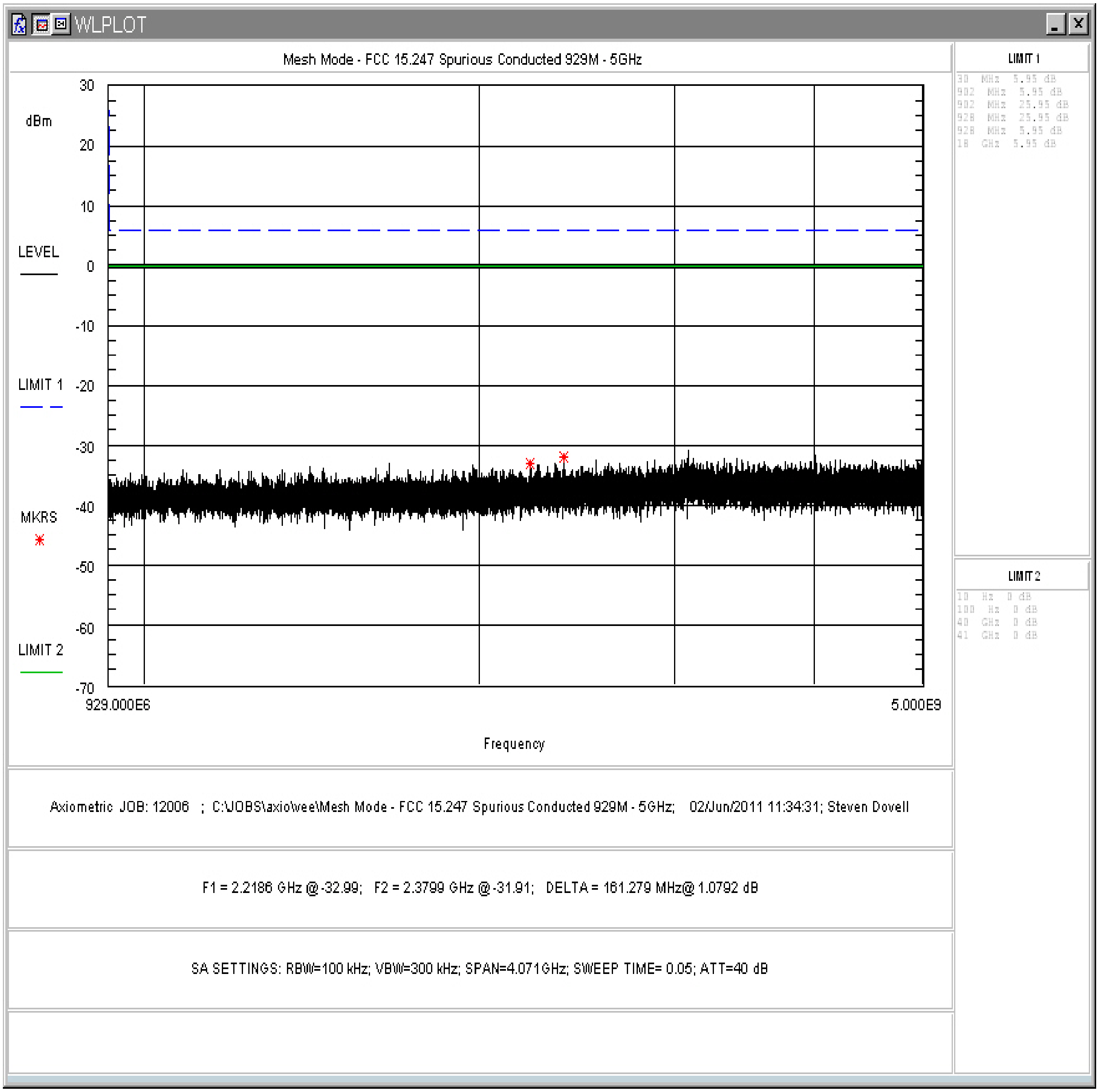

Figure 22. Conducted, Spurious Emissions, Mesh Mode, Low Channel 929-5000MHz

 © 2011 Washington Laboratories, Ltd.

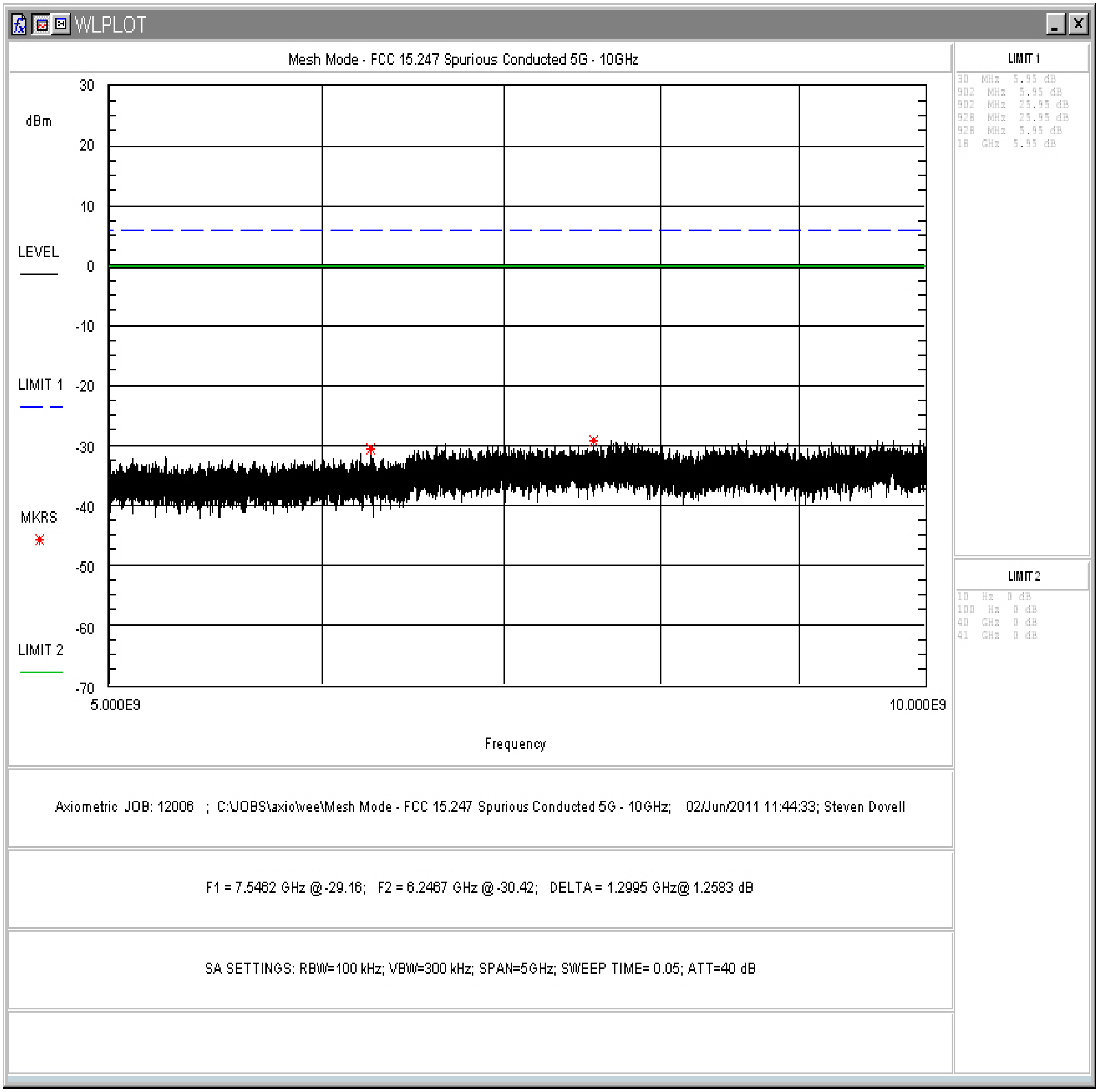

Figure 23. Conducted, Spurious Emissions, Mesh Mode, Low Channel 5- 10GHz