Washington Laboratories, Ltd.
www.wll.com
7560 Lindbergh Drive . Gaithersburg, MD 20879
301.216.1500 . info@wll.com

FCC & Industry Canada Certification Test Report

For the

B&B ELECTRONICS

MODEL APPN-TT551

WLAN 802.11B/G/N RADIOS

FCC ID: F4AAPPN551

IC: 3913A-APPN551

WLL REPORT # **12952-01 Rev 1**

May 21, 2013

Prepared for:

B&B Electronics
707 Dayton Rd
Ottawa, Il 61350

Prepared By:

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

Testing Certificate AT-1448

FCC & Industry Canada Certification Test Report
For the
B&B ELECTRONICS

MODEL APPN-TT551
WLAN 802.11B/G/N RADIOS
FCC ID: F4AAPPN551
IC: 3913A-APPN551

WLL REPORT # **12952-01 Rev 1**

May 21, 2013

Prepared by:

Steven Dovell
Compliance Engineer

Reviewed by:

James Ritter
EMC Laboratory Manager

Abstract

This report has been prepared on behalf of B&B Electronics to support the attached Application for Equipment Authorization. The test report and application are submitted for a Direct Sequence Spread Spectrum Transmitter under Part 15.247 (10/2010) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-210 issue 8 of Industry Canada. This Certification Test Report documents the test configuration and test results for the B&B Electronics Model APPN-TT551 Module.

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 B&B Electronics Model APPN-TT551 Module complies with the limits for a Direct Sequence Spread Spectrum Transmitter under FCC Part 15.247 and Industry Canada RSS-210.

Revision History	Description of Change	Date
Rev 0	Initial Release	May 20, 2013
Rev 1	Changed Model number	May 21, 2013

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The B&B Electronics Model APPN-TT551 Module complies with the limits for a Direct Sequence Spread Spectrum Transmitter device under FCC Part 15.247 (10/2010) and Industry Canada RSS-210 issue 8.

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 FCC97-114, Guidance on Measurements for Direct Sequence Spread Spectrum Systems & 558074 D01 DTS Meas Guidance v03r01 .The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	B&B Electronics 707 Dayton Rd Ottawa, Il 61350
Purchase Order Number:	00068907-1
Quotation Number:	67289B

1.4 Test and Support Personnel

Washington Laboratories, Ltd.	John Repella, Steven Dovell
Client Representative	Bill Keith

1.5 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

2 Equipment Under Test

2.1 EUT Identification & Description

This is a PCIe mini card form factor WiFi 802.11 b/g/n module with an MII and UART interface

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	B&B Electronics
FCC ID:	F4AAPPN551
IC:	3913A-APPN551
Model:	Model APPN-TT551
FCC Rule Parts:	§15.247
Industry Canada:	RSS210
Frequency Range:	2412 – 2462MHz
Maximum Output Power:	15.93 dBm (39.2mW) Peak
Modulation:	802.11b-DSSS, 802.11g- OFDM, 802.11n – See table 2
Occupied Bandwidth:	802.11b-13.0463MHz 802.11g- 16.4338MHz 802.11n -17.6347MHz
Maximum Spurious TX:	259.9uV/m @3m – 14.472GHz
Maximum Spurious RX:	63.6uV/m @3m - 215MHz
Emission Designator:	13M0G1D, 16M4G1D, 17M6G1D
Keying:	Automatic
Type of Information:	Data
Number of Channels:	19
Antenna Connector	SMB
Antenna Type	Dipole 3.8dBi
Power Output Level	Fixed
Interface Connector:	PCIe mini card
Power Source & Voltage:	3.3Vdc nominal, 3.135-3.465Vdc min-max.

Table 2: 802.11n Modulation

MCS index	Spatial streams	Modulation type	Coding rates	20MHz
0	1	BPSK	1/2	6.5
1	1	QPSK	1/2	13
2	1	QPSK	3/4	19.5
3	1	16-QAM	1/2	26
4	1	16-QAM	3/4	39
5	1	64-QAM	2/3	52
6	1	64-QAM	3/4	58.5
7	1	64-QAM	5/6	65

2.2 Test Configuration

The Model APPN-TT551 was mounted on a Zonda PCIe Adapter board and powered via +3.3VDC. The DC voltage was supplied with an AC/DC converter for Radiated/Conducted Emissions. The Zonda PCIe Adapter provides a SMA port for connection to measurement equipment or the supplied antenna. The adapter also provides communication ports to control the module.

2.3 Testing Algorithm

The Model APPN-TT551 Module was programmed with command line entries via a support laptop Hyperterm communications program to transmit continuously at one of three channels, 2412MHz, 2437MHz, and 2462MHz. Worst case emission levels are provided in the test results data.

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 FCC97-114, Guidance on Measurements for Direct Sequence 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.

558074 D01 DTS Meas Guidance v03r01 “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247”

2.6 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.

Equation 1: Standard Uncertainty

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

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

$$U = ku_c$$

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 3 below.

Table 3: 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

Test Equipment Table 4 shows a list of the test equipment used for measurements along with the calibration information.

Table 4: Test Equipment List

Test Name: **Conducted Emissions Voltage**		Test Date: **04/26/2013**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
125	SOLAR - 8028-50-TS-24-BNC	LISN	6/28/2013
126	SOLAR - 8028-50-TS-24-BNC	LISN	6/28/2013
68	HP - 85650A	ADAPTER QP	7/1/2013
70	HP - 85685A	PRESELECTOR RF W/OPT 8ZE	7/1/2013
72	HP - 8568B	ANALYZER SPECTRUM	7/1/2013

Test Name: **Radiated Emissions**		Test Date: **04/15/2013**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
68	HP - 85650A	ADAPTER QP	7/1/2013
72	HP - 8568B	ANALYZER SPECTRUM	7/1/2013
70	HP - 85685A	PRESELECTOR RF W/OPT 8ZE	7/1/2013
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	1/26/2014
725	B-Z TECHNOLOGIES - BZP118UD1X2	1 - 18GHZ LOW NOISE AMP	1/28/2014
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	6/11/2013
425	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	9/7/2013

Test Name: **Bench Conducted**		Test Date: **04/8/2013**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	1/26/2014

3 Test Results

3.1 Test Summary

The Table Below shows the results of testing for compliance with a Direct Sequence Spread Spectrum System in accordance with FCC Part 15.247 and Industry Canada RSS210 issue 8. Full results are shown in beginning in Section 4.2.

Table 5: Test Summary

TX Test Summary (Direct Sequence Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (2)	RSS-210 [A8. 2]	6dB Bandwidth	Pass
15.247 (2)(b)(3)	RSS-210 [A8.4]	Transmit Output Power	Pass
15.247 (e)	RSS-210 [A8.2 (b)]	Power Spectral Density	Pass
15.247 (d)	RSS-210 [A8. 5]	Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-210 Sect.2.2	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [7.2.2]	AC Conducted Emissions	Pass

3.2 Occupied Bandwidth: (FCC Part §15.247 (2))

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer. The lowest and highest data rates for each modulation type were evaluated.

For Direct Sequence Spread Spectrum Systems, FCC Part 15.247 requires the minimum 6 dB bandwidth using a 100 kHz Resolution bandwidth be greater than 500 kHz.

Table 6 provides a summary of the Occupied Bandwidth Results. D01 DTS Meas Guidance v03r01 section 8.2 Option 2 was utilized for this test method (automatic bandwidth function of analyzer).

Table 6: Occupied Bandwidth Results

Frequency	Mode	Data Rate (Mbps)	Bandwidth (MHz)	Limit (kHz)	Pass/Fail
2412MHz	802.11b	1	13.0463	>500kHz	Pass
2412MHz	802.11b	11	12.6147	>500kHz	Pass
2412MHz	802.11g	6	16.4259	>500kHz	Pass
2412MHz	802.11g	54	16.4318	>500kHz	Pass
2412MHz	802.11n	6.5	17.6238	>500kHz	Pass
2412MHz	802.11n	65	17.6232	>500kHz	Pass
2437MHz	802.11b	1	12.8826	>500kHz	Pass
2437MHz	802.11b	11	12.6235	>500kHz	Pass
2437MHz	802.11g	6	16.4338	>500kHz	Pass
2437MHz	802.11g	54	16.4333	>500kHz	Pass
2437MHz	802.11n	6.5	17.6187	>500kHz	Pass
2437MHz	802.11n	65	17.6347	>500kHz	Pass
2462MHz	802.11b	1	12.8056	>500kHz	Pass
2462MHz	802.11b	11	12.5792	>500kHz	Pass
2462MHz	802.11g	6	16.4213	>500kHz	Pass
2462MHz	802.11g	54	16.4279	>500kHz	Pass
2462MHz	802.11n	6.5	17.6160	>500kHz	Pass
2462MHz	802.11n	65	17.6288	>500kHz	Pass

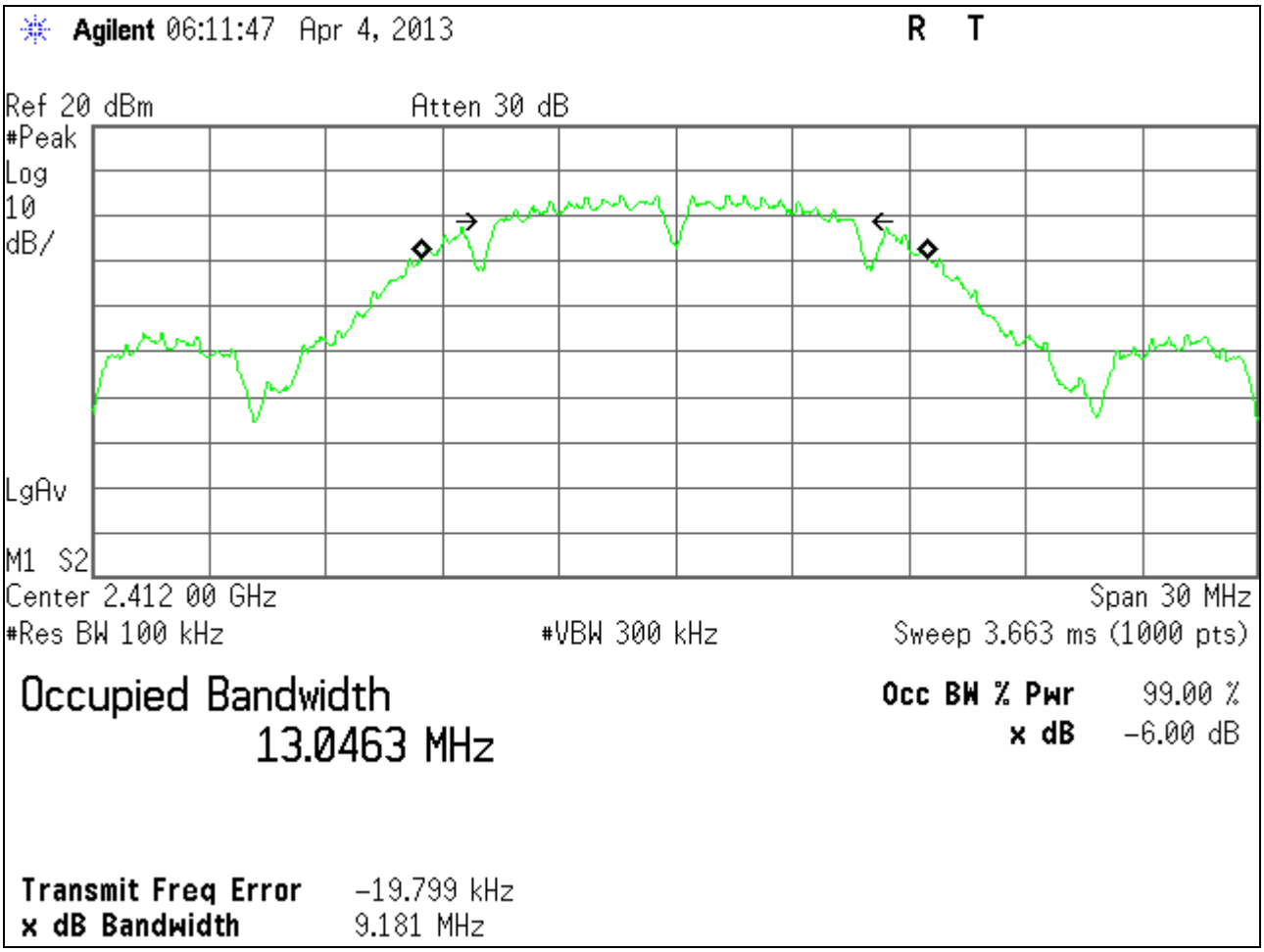

Figure 1: Occupied Bandwidth, 802.11b, 1Mbps, 2412MHz

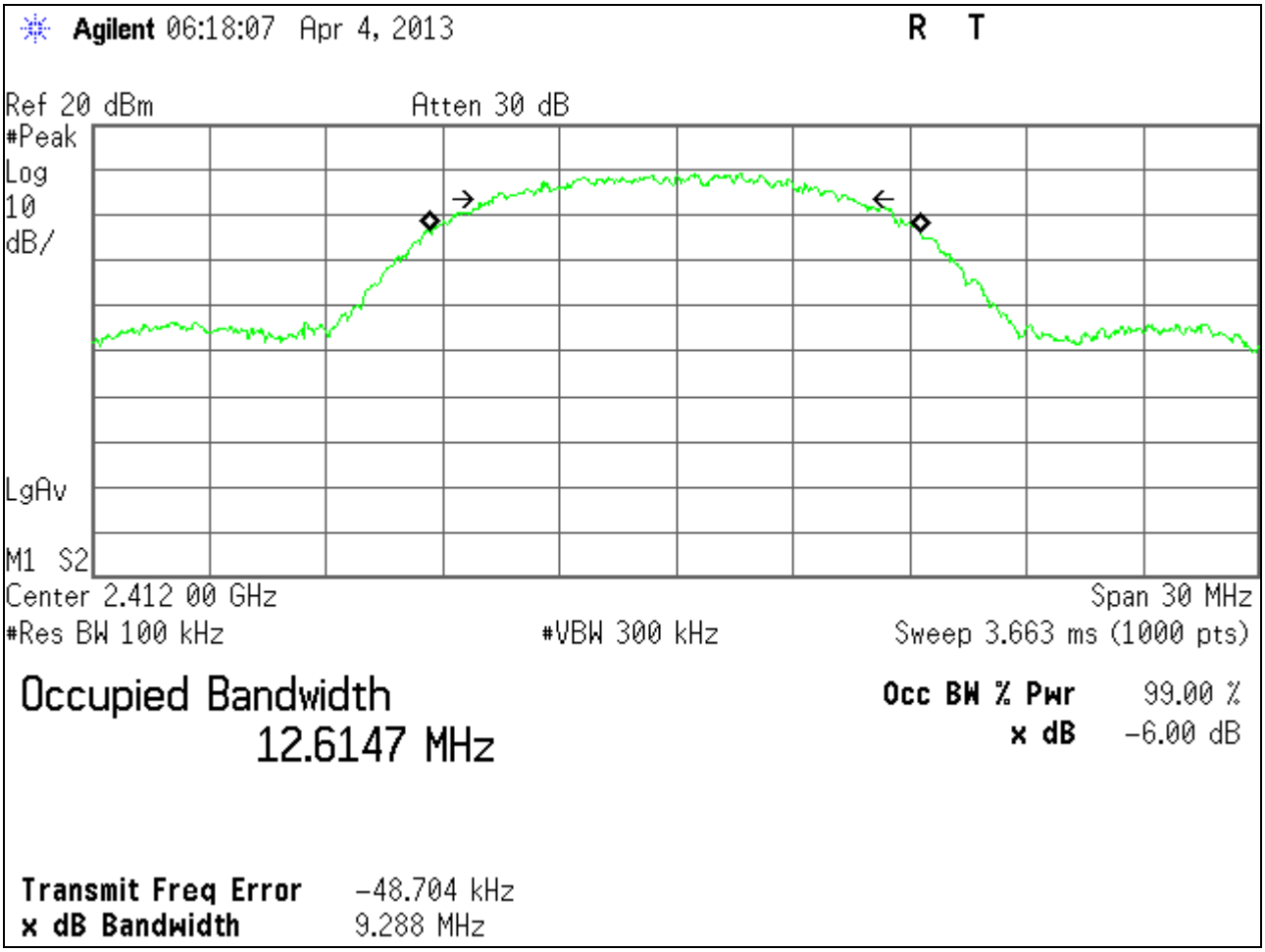

Figure 2: Occupied Bandwidth, 802.11b, 11Mbps, 2412MHz

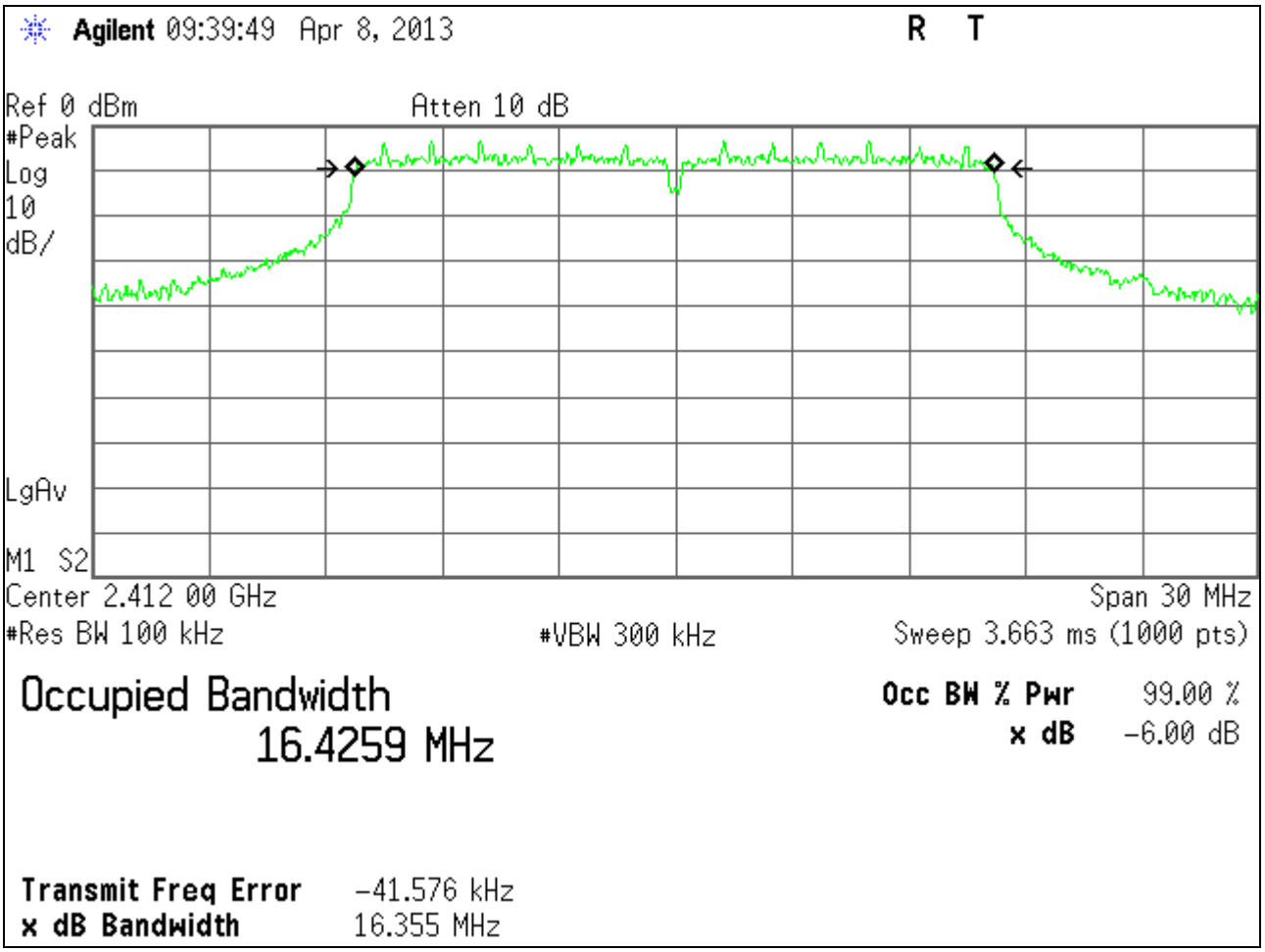

Figure 3: Occupied Bandwidth, 802.11g, 6Mbps, 2412MHz

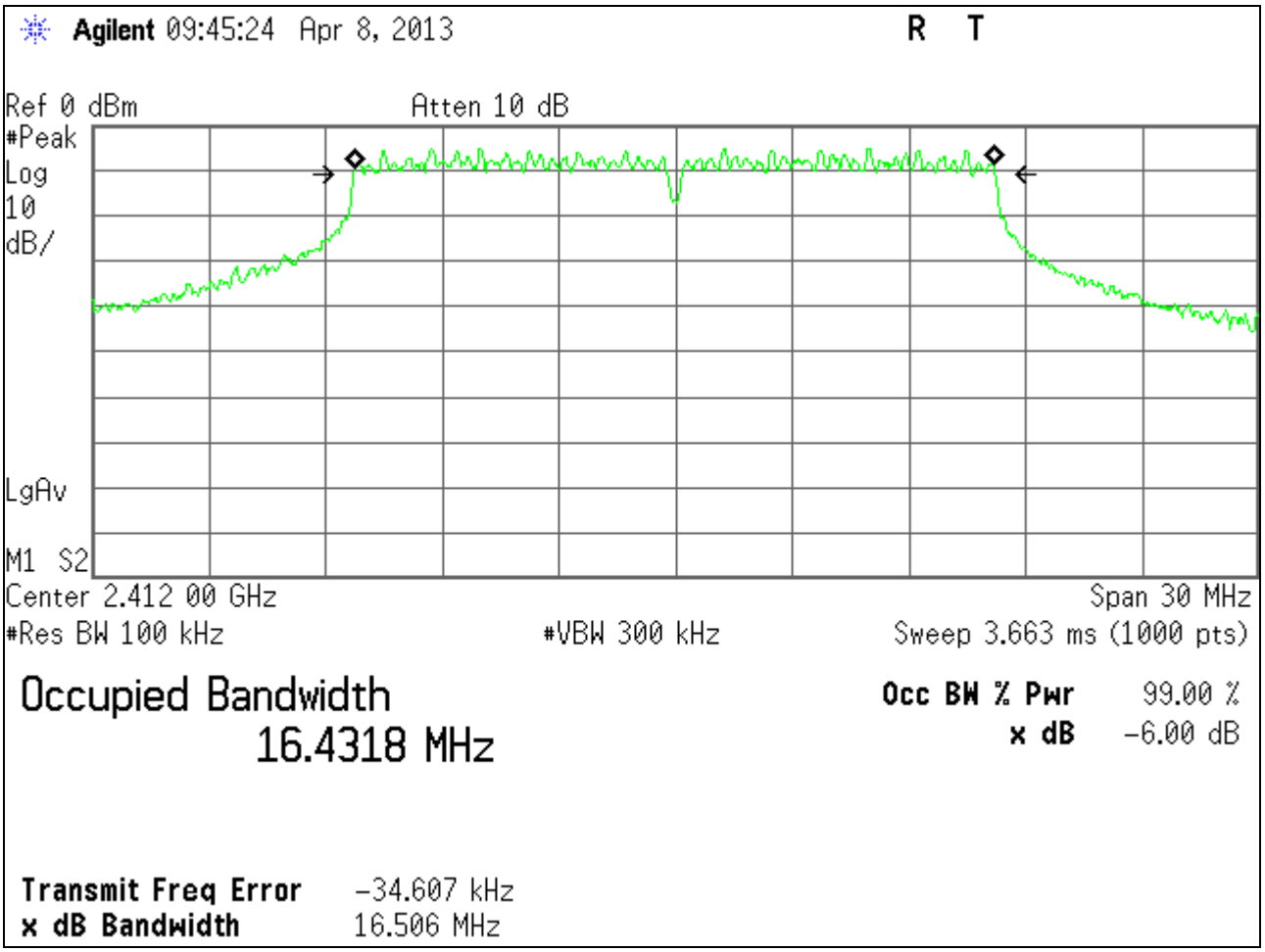

Figure 4: Occupied Bandwidth, 802.11g, 54Mbps, 2412MHz

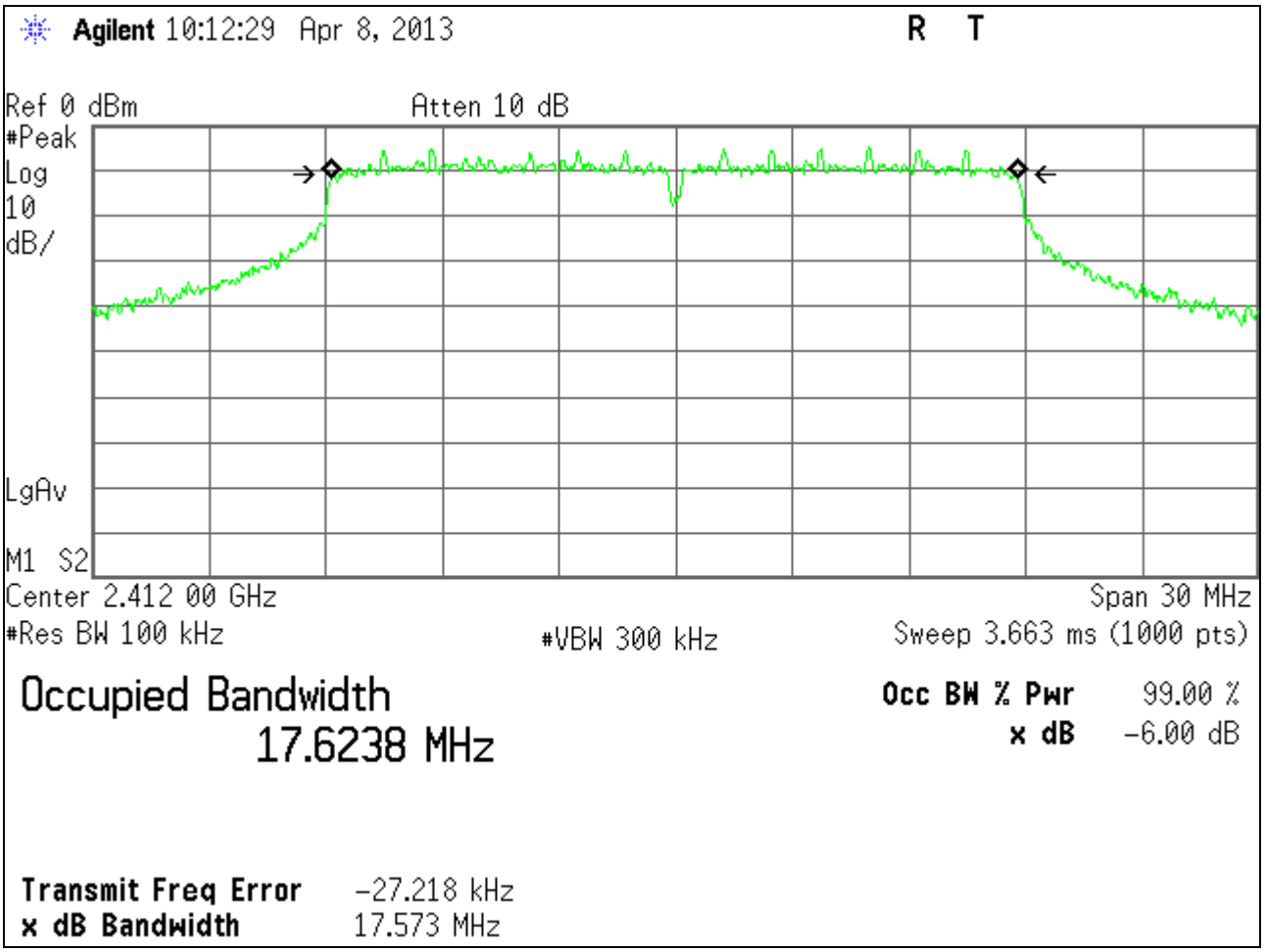

Figure 5: Occupied Bandwidth, 802.11n, 6.5Mbps, 2412MHz

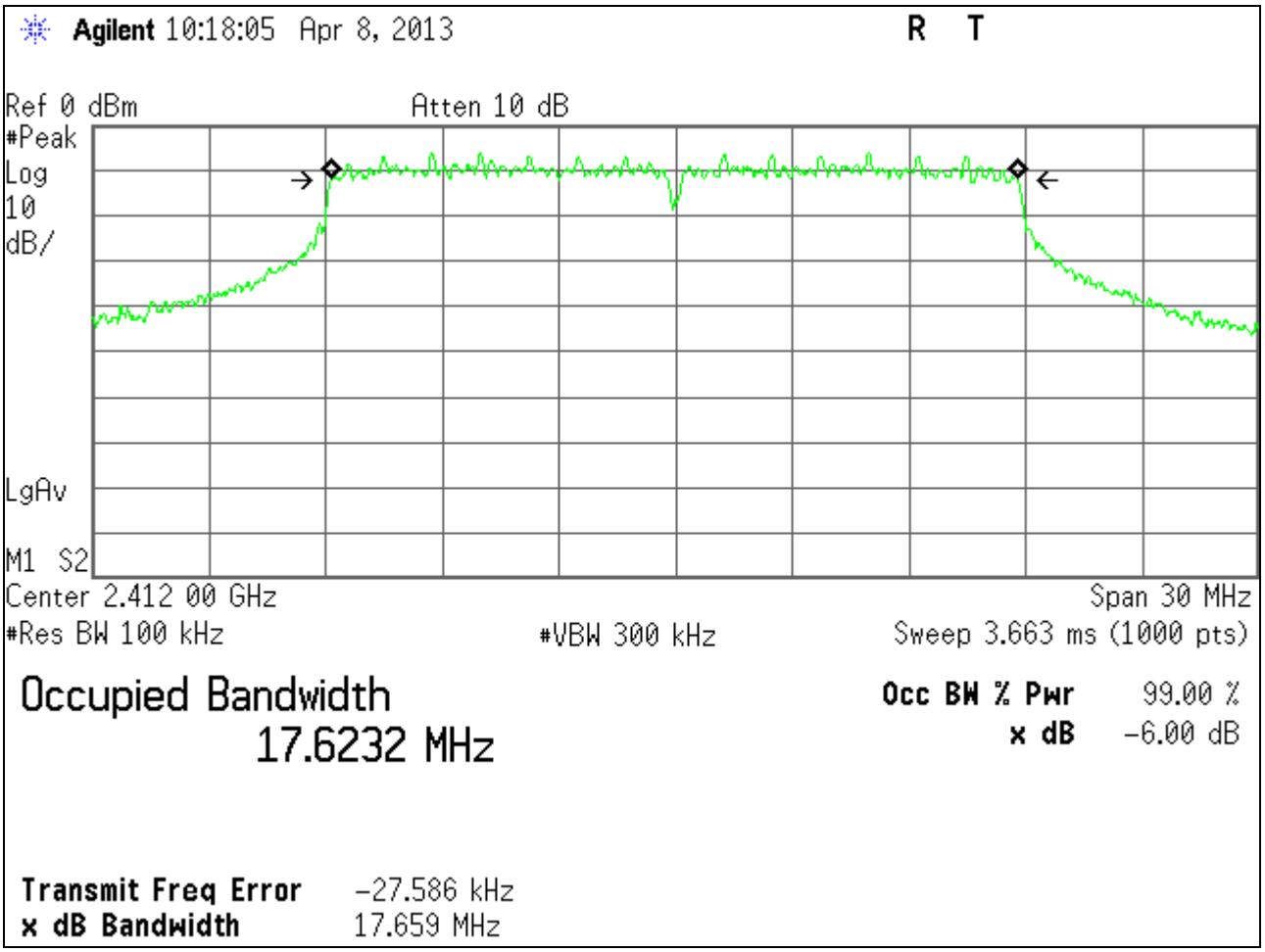

Figure 6: Occupied Bandwidth, 802.11n, 65Mbps, 2412MHz

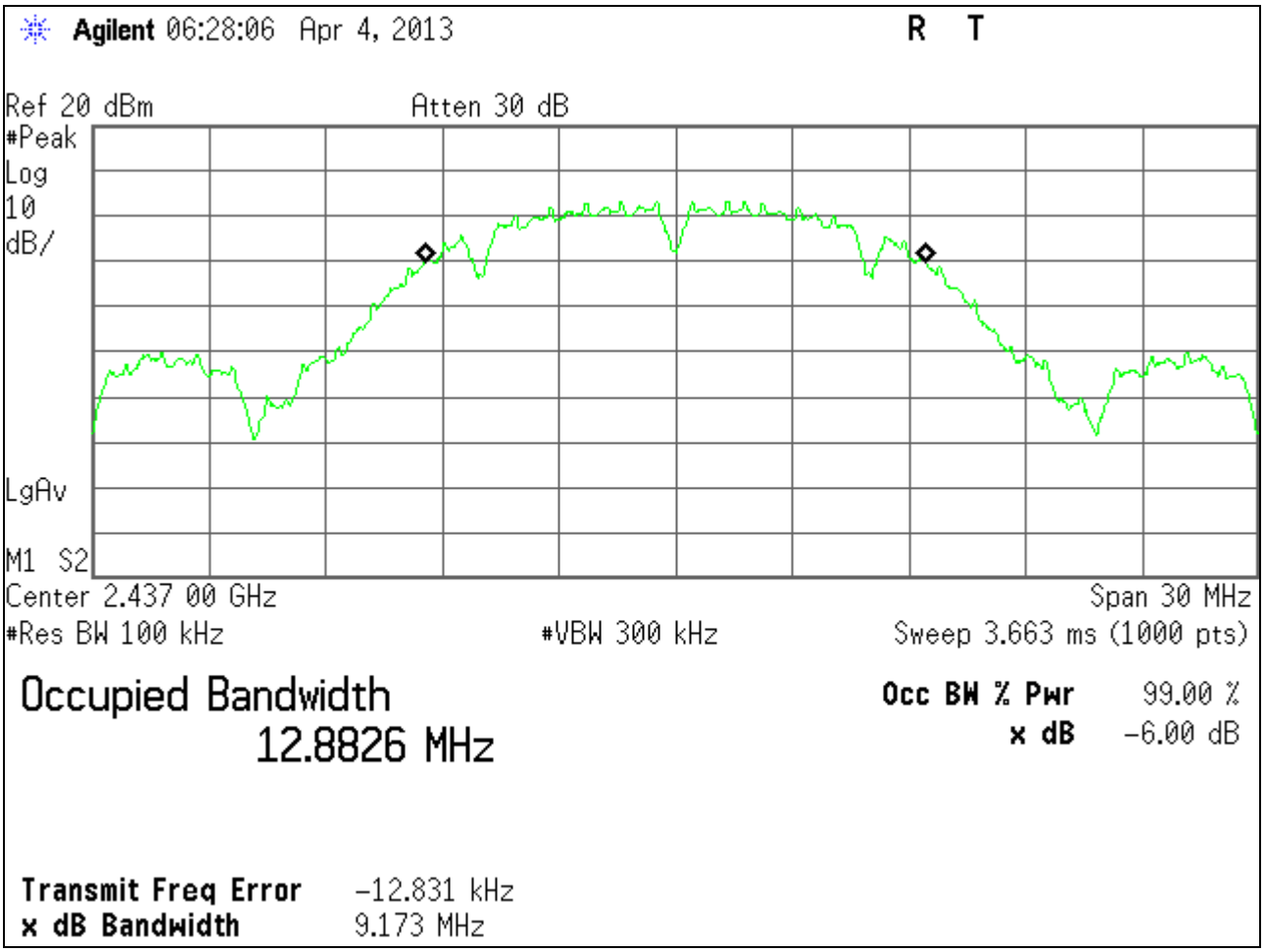

Figure 7: Occupied Bandwidth, 802.11b, 1Mbps, 2437MHz

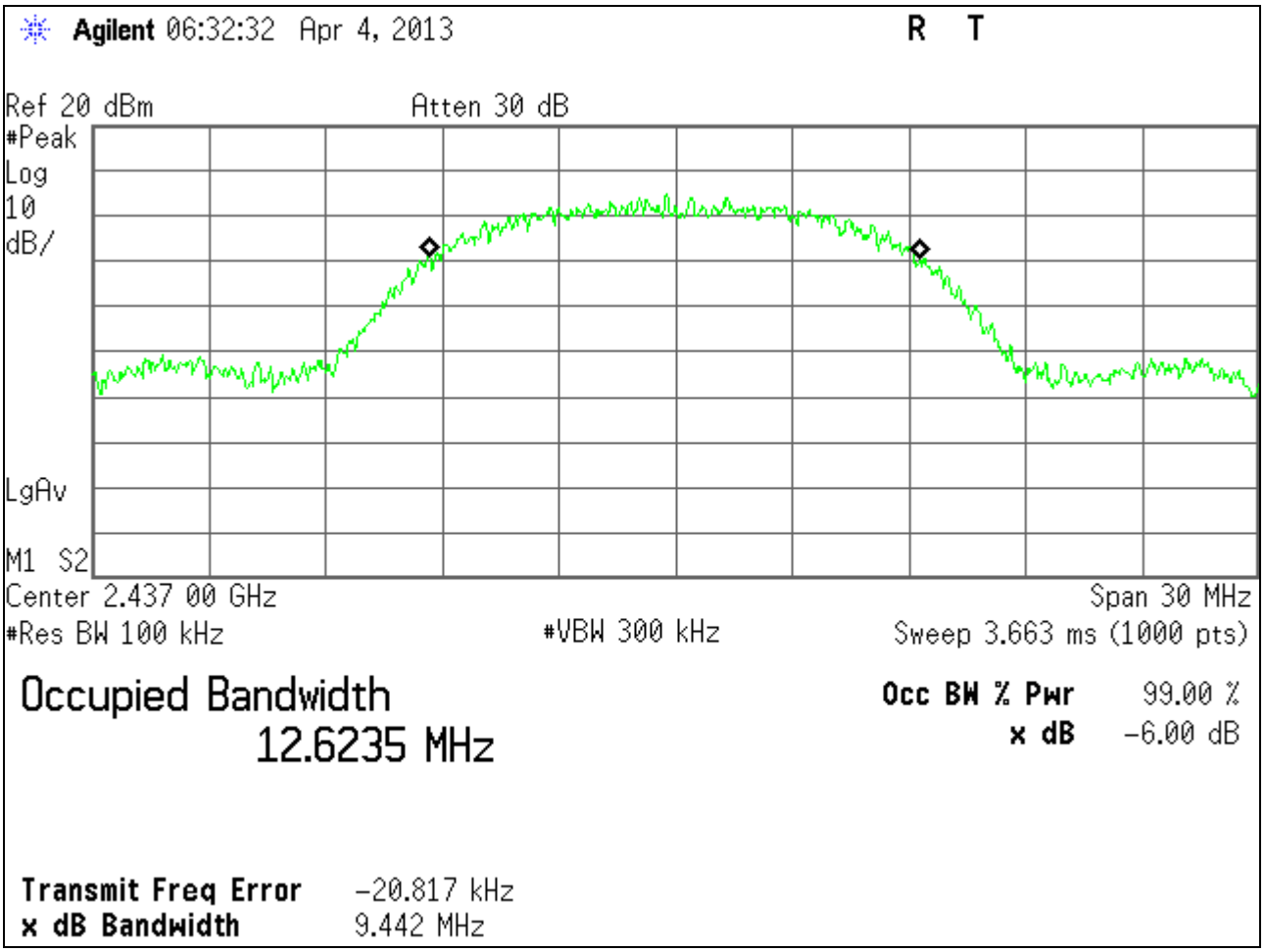

Figure 8: Occupied Bandwidth, 802.11b, 11Mbps, 2437MHz

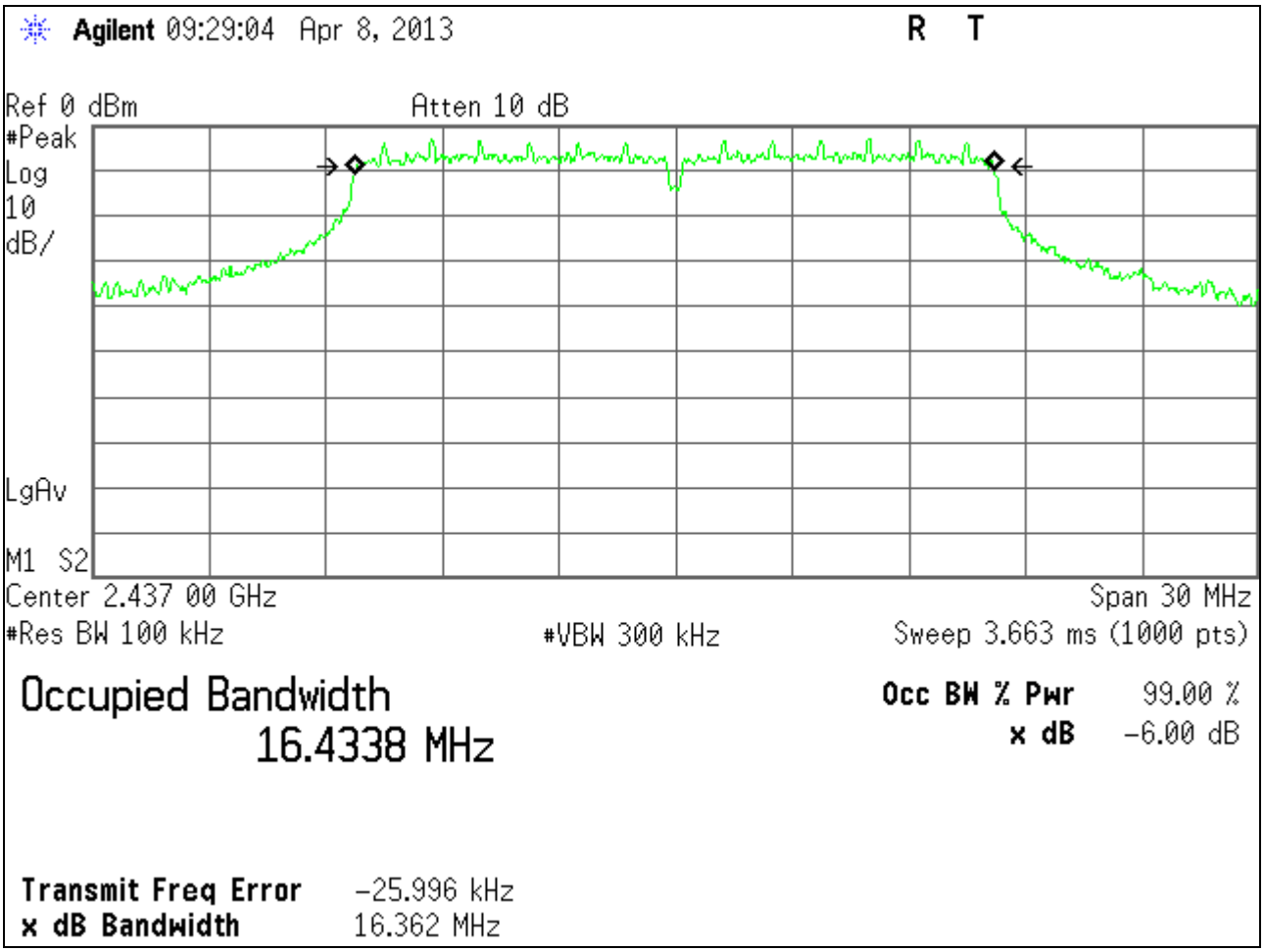

Figure 9: Occupied Bandwidth, 802.11g, 6Mbps, 2437MHz

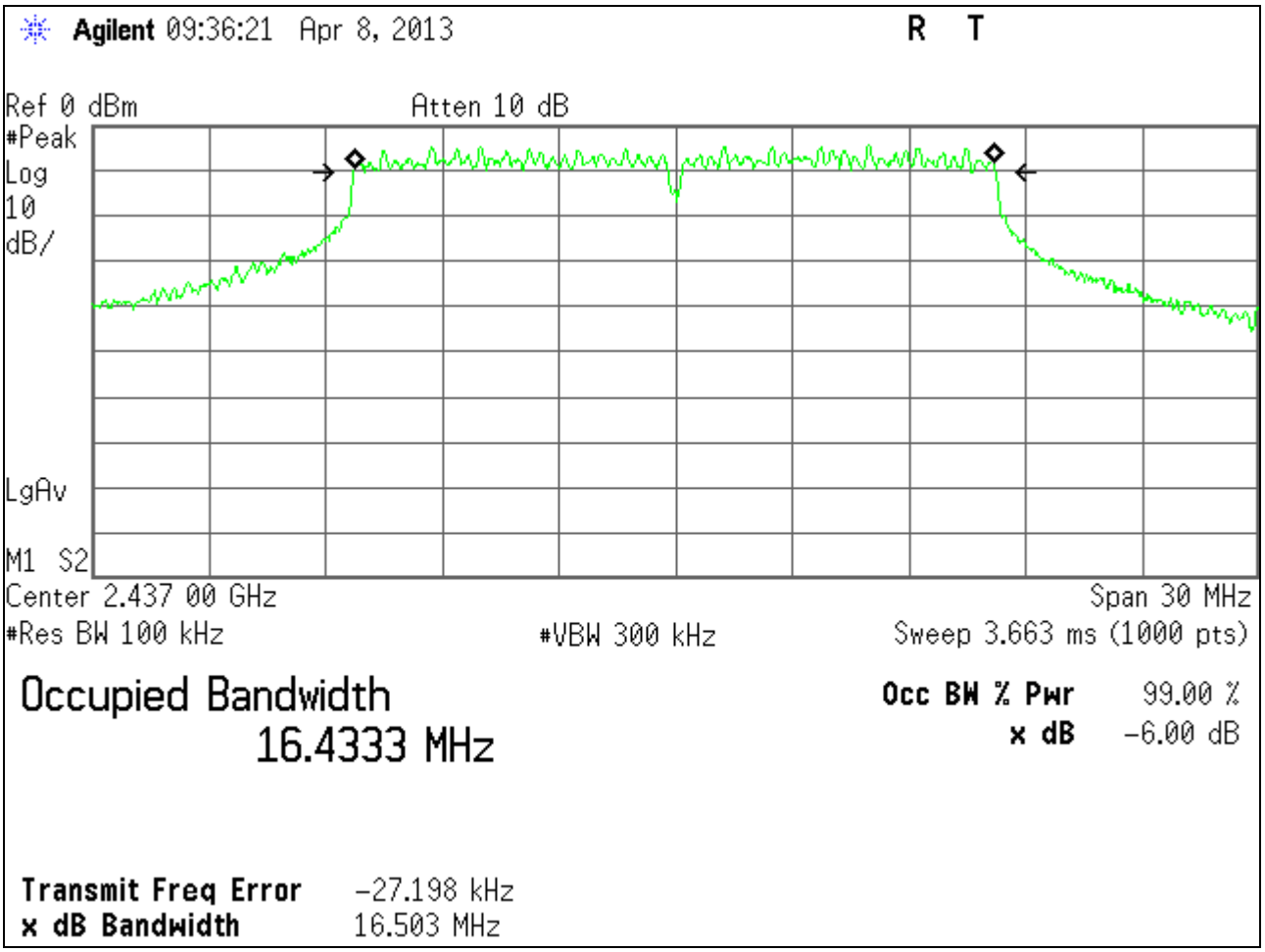

Figure 10: Occupied Bandwidth, 802.11g, 54Mbps, 2437MHz

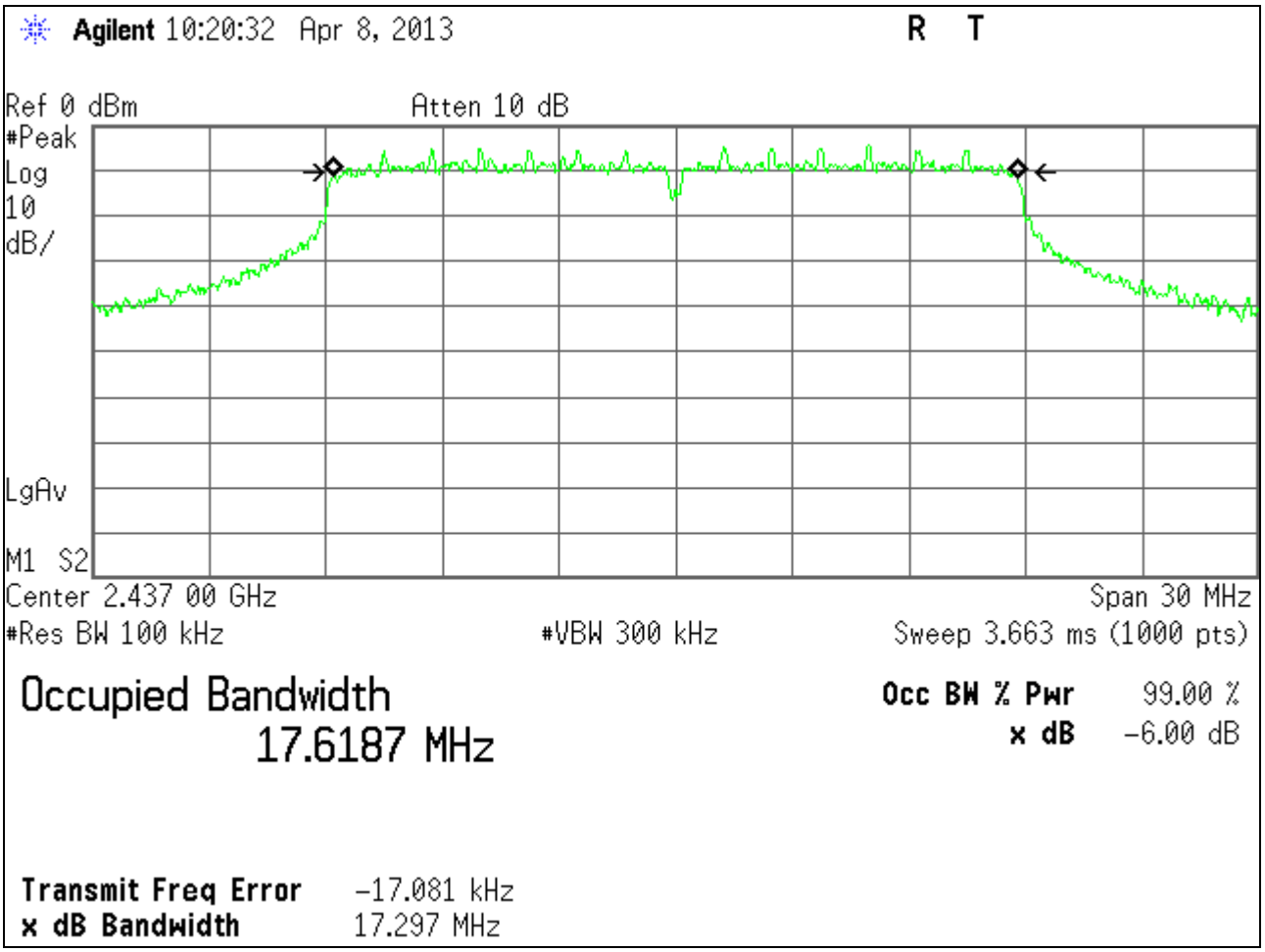

Figure 11: Occupied Bandwidth, 802.11n, 6.5Mbps, 2437MHz

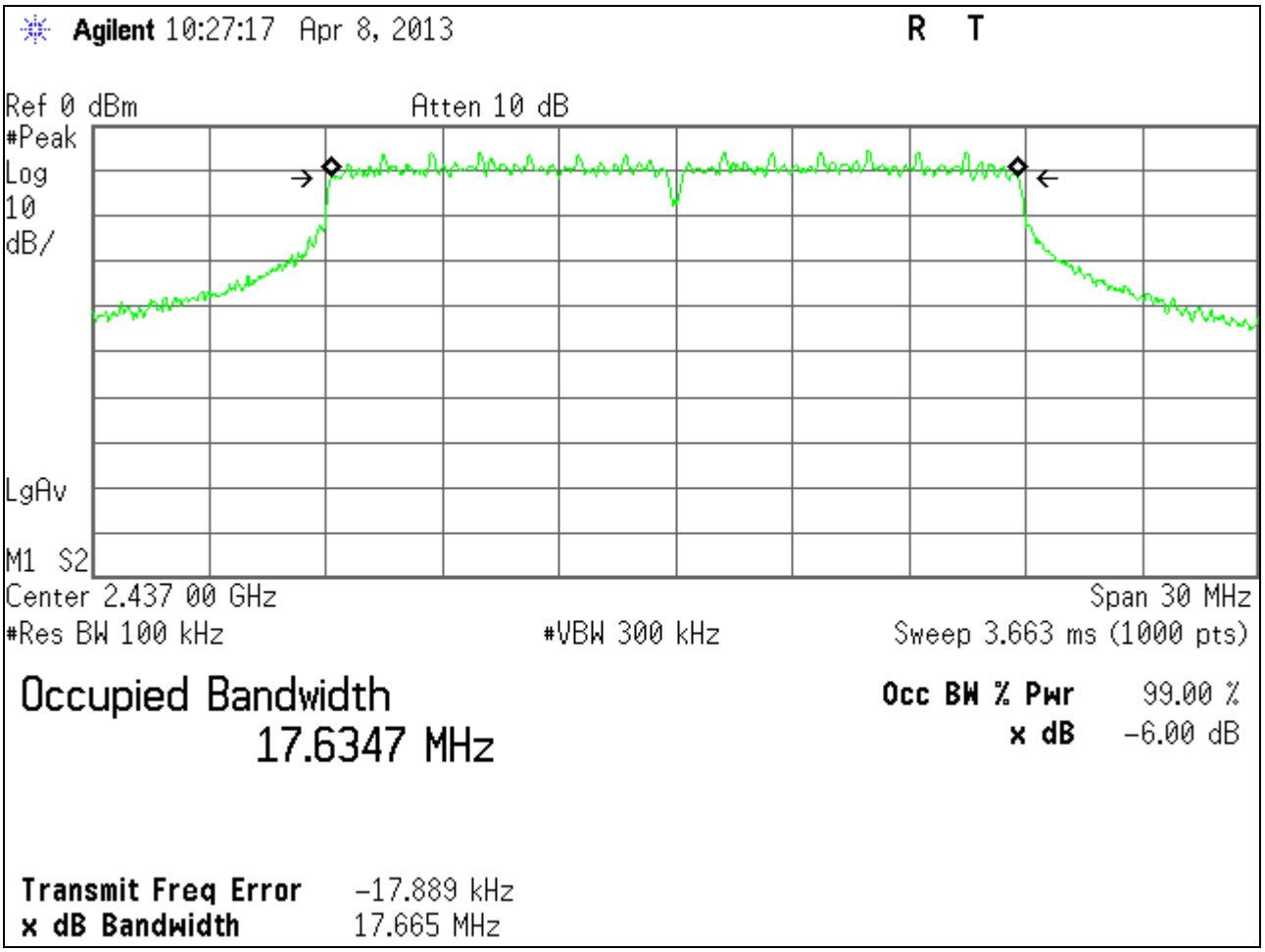

Figure 12: Occupied Bandwidth, 802.11n, 65Mbps, 2437MHz

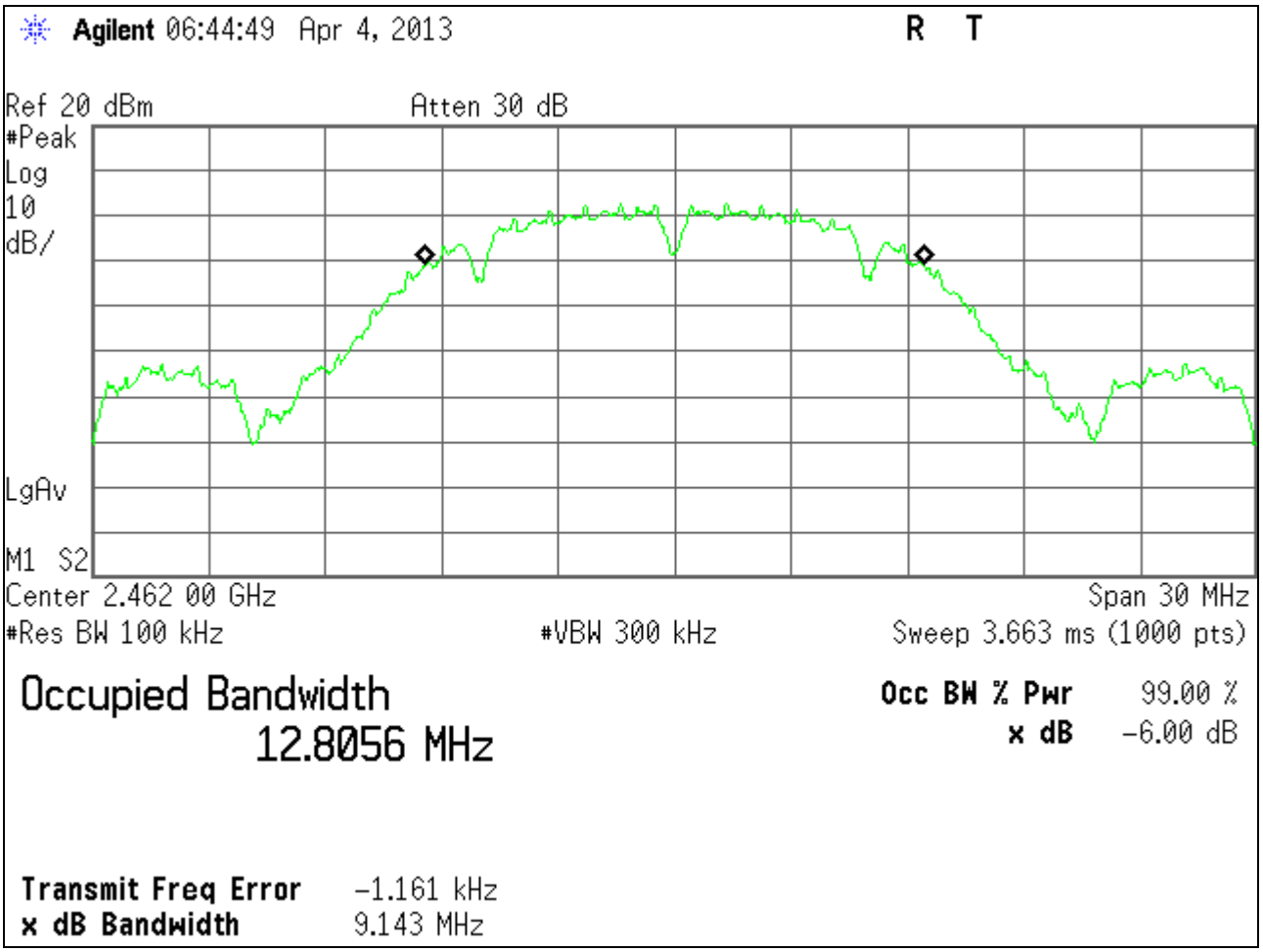

Figure 13: Occupied Bandwidth, 802.11b, 1Mbps, 2462MHz

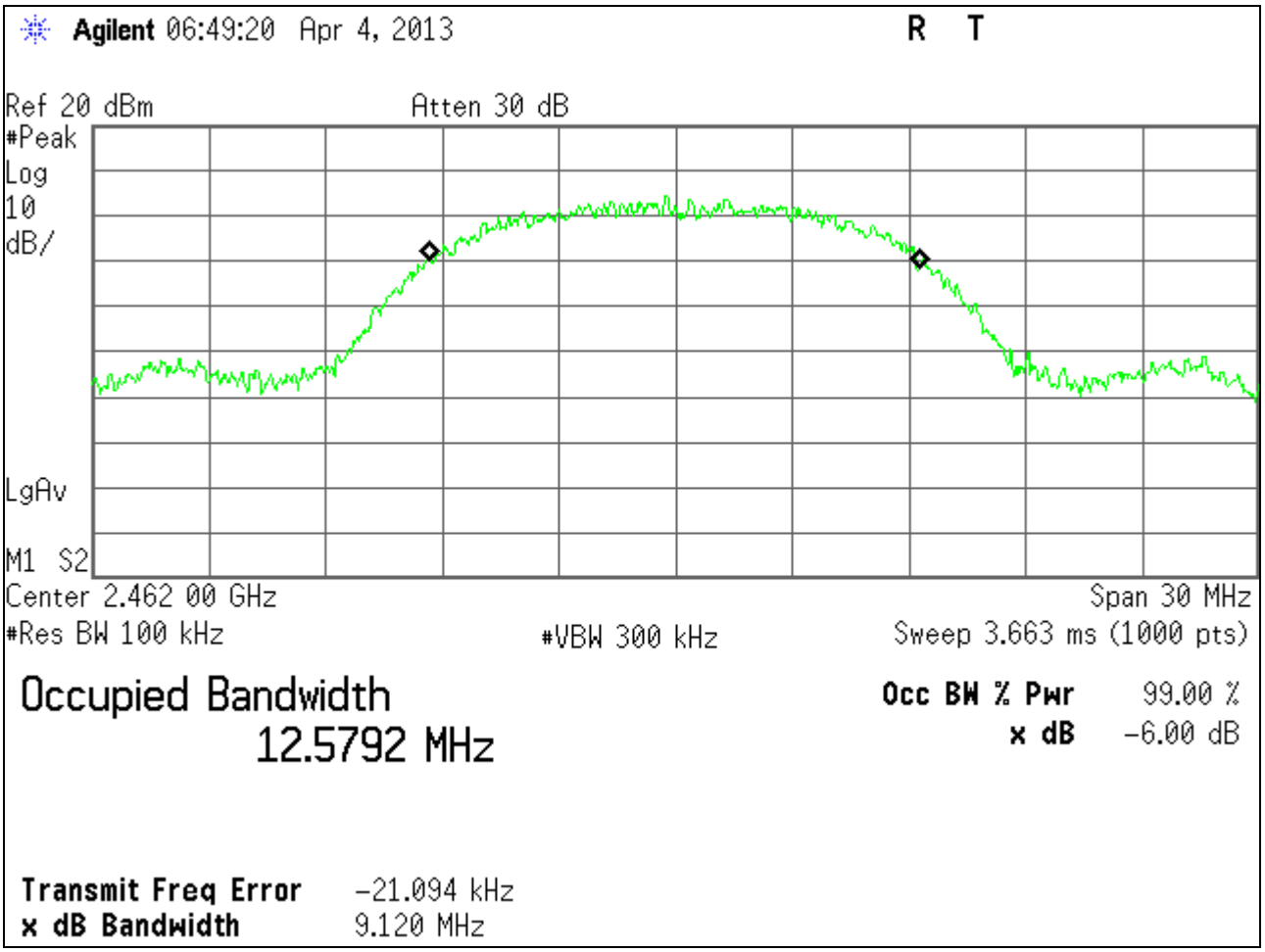

Figure 14: Occupied Bandwidth, 802.11b, 11Mbps, 2462MHz

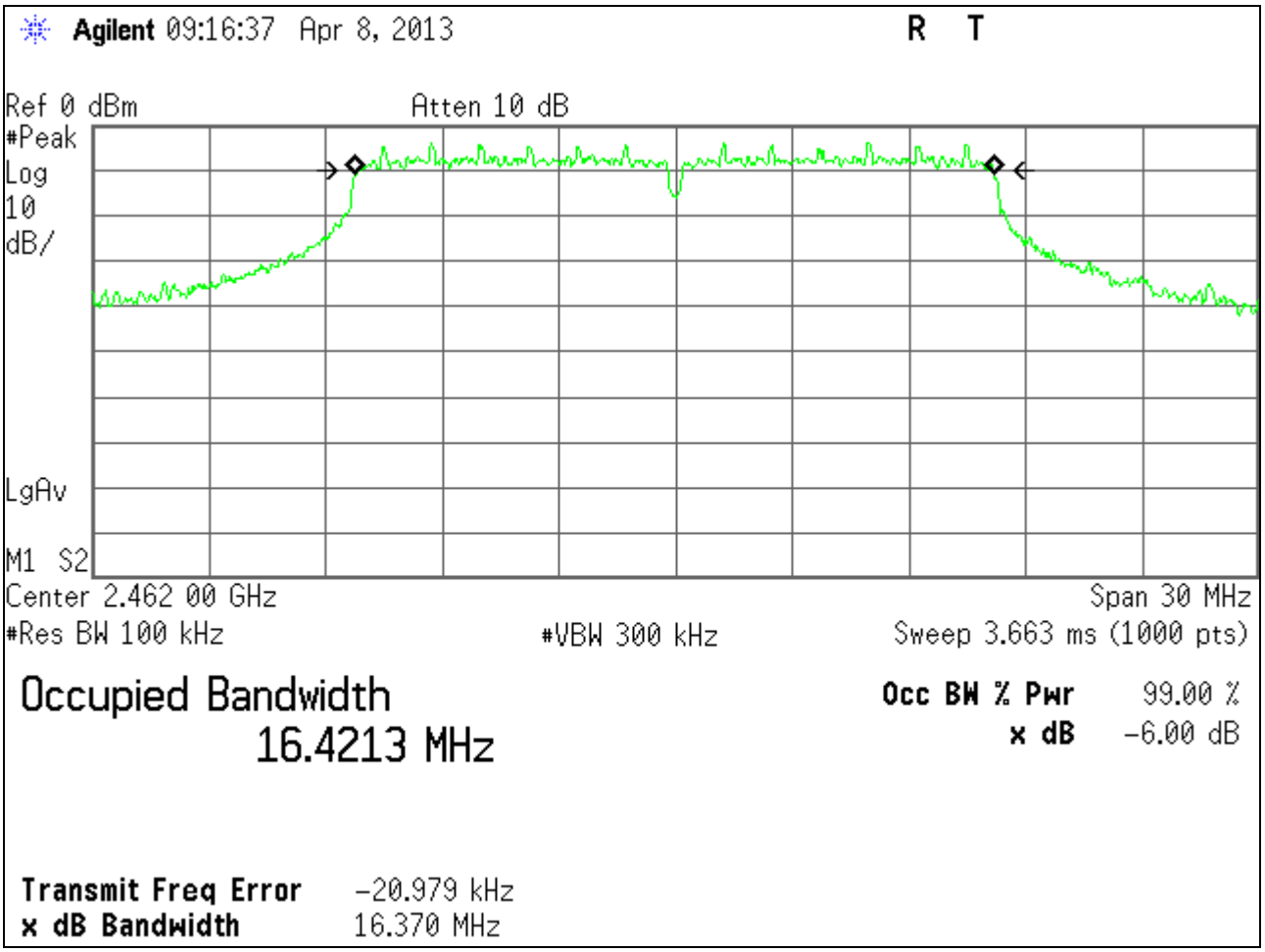

Figure 15: Occupied Bandwidth, 802.11g, 6Mbps, 2462MHz

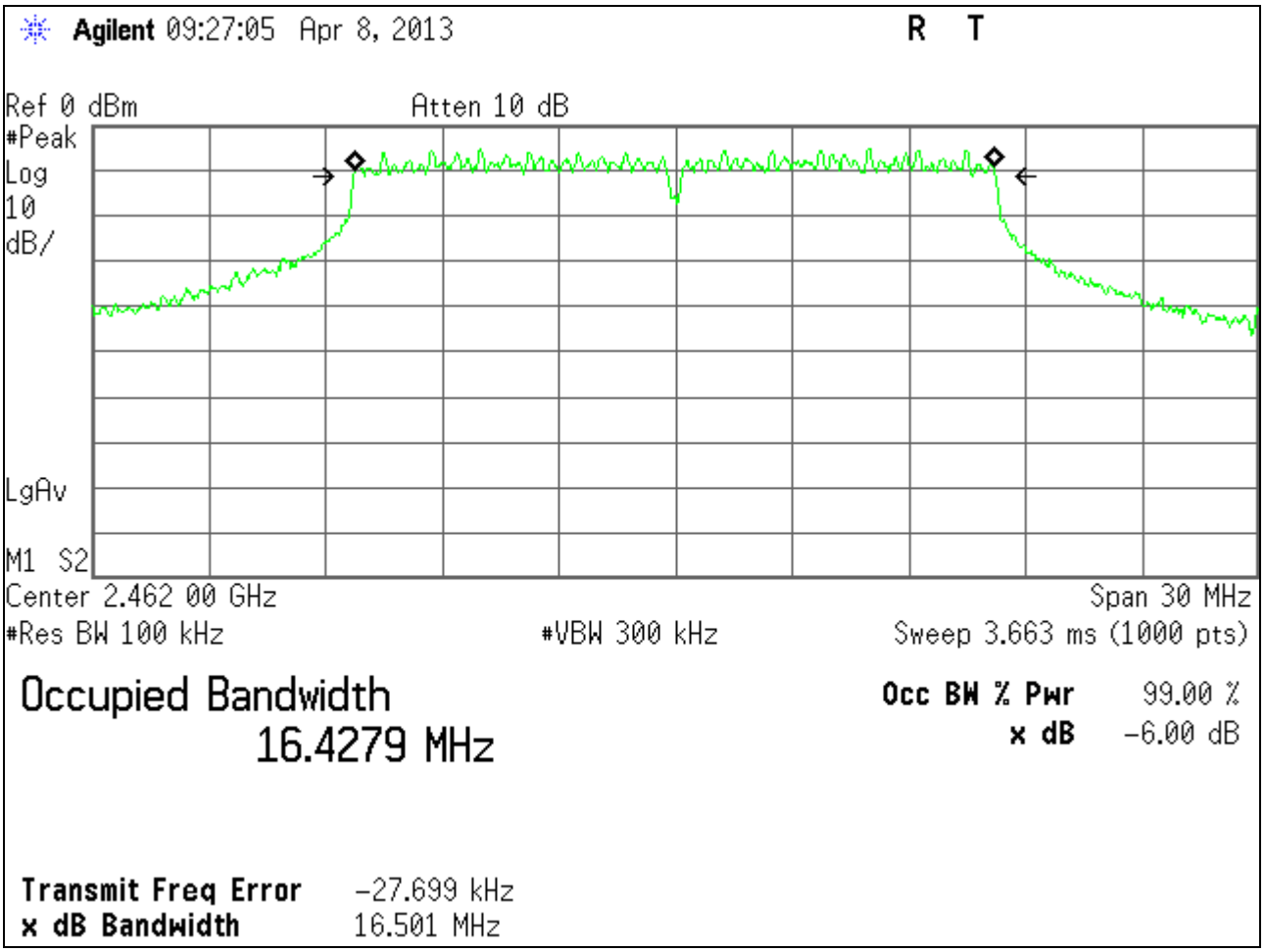

Figure 16: Occupied Bandwidth, 802.11g, 54Mbps, 2462MHz

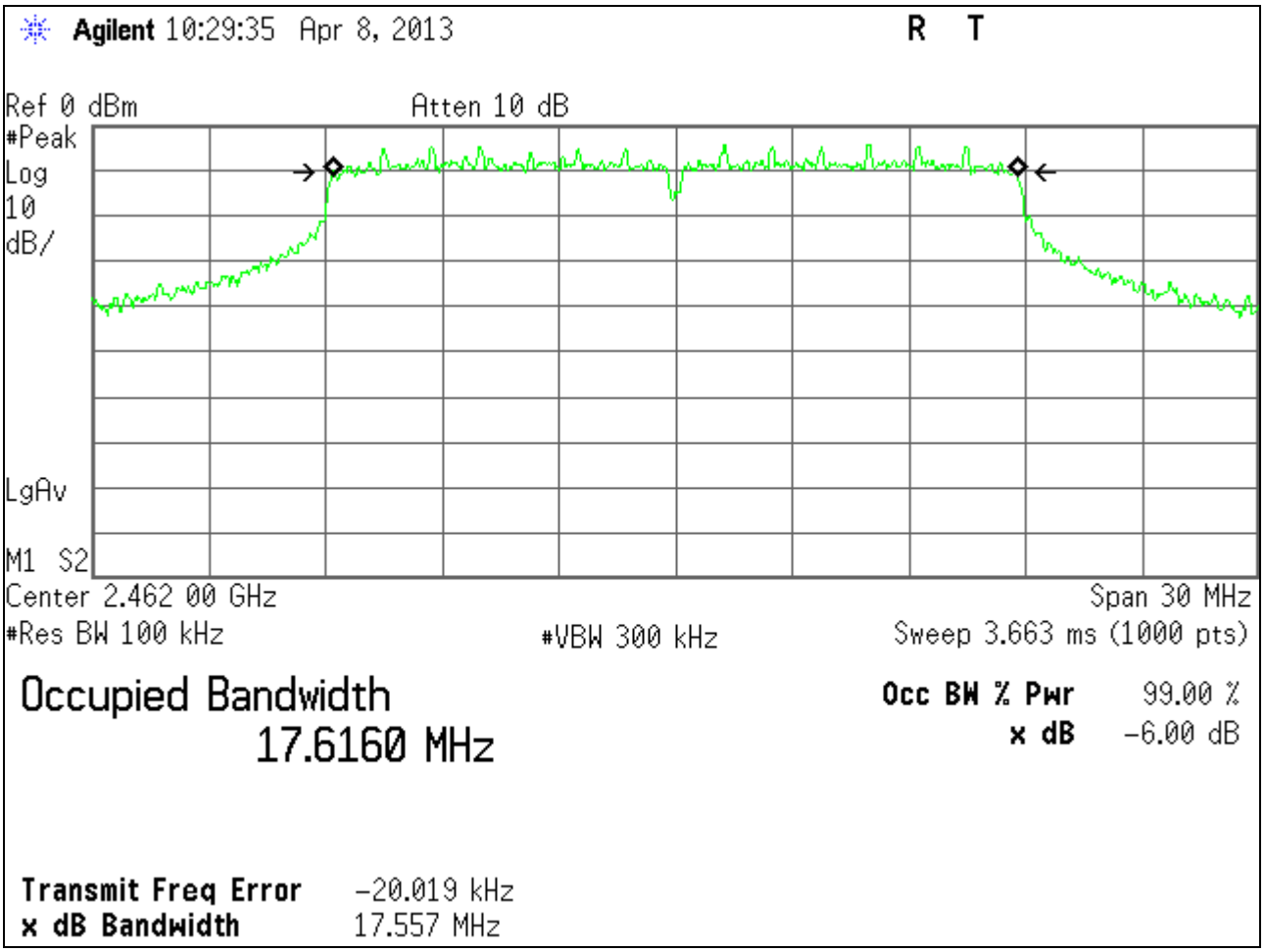

Figure 17: Occupied Bandwidth, 802.11n, 6.5Mbps, 2462MHz

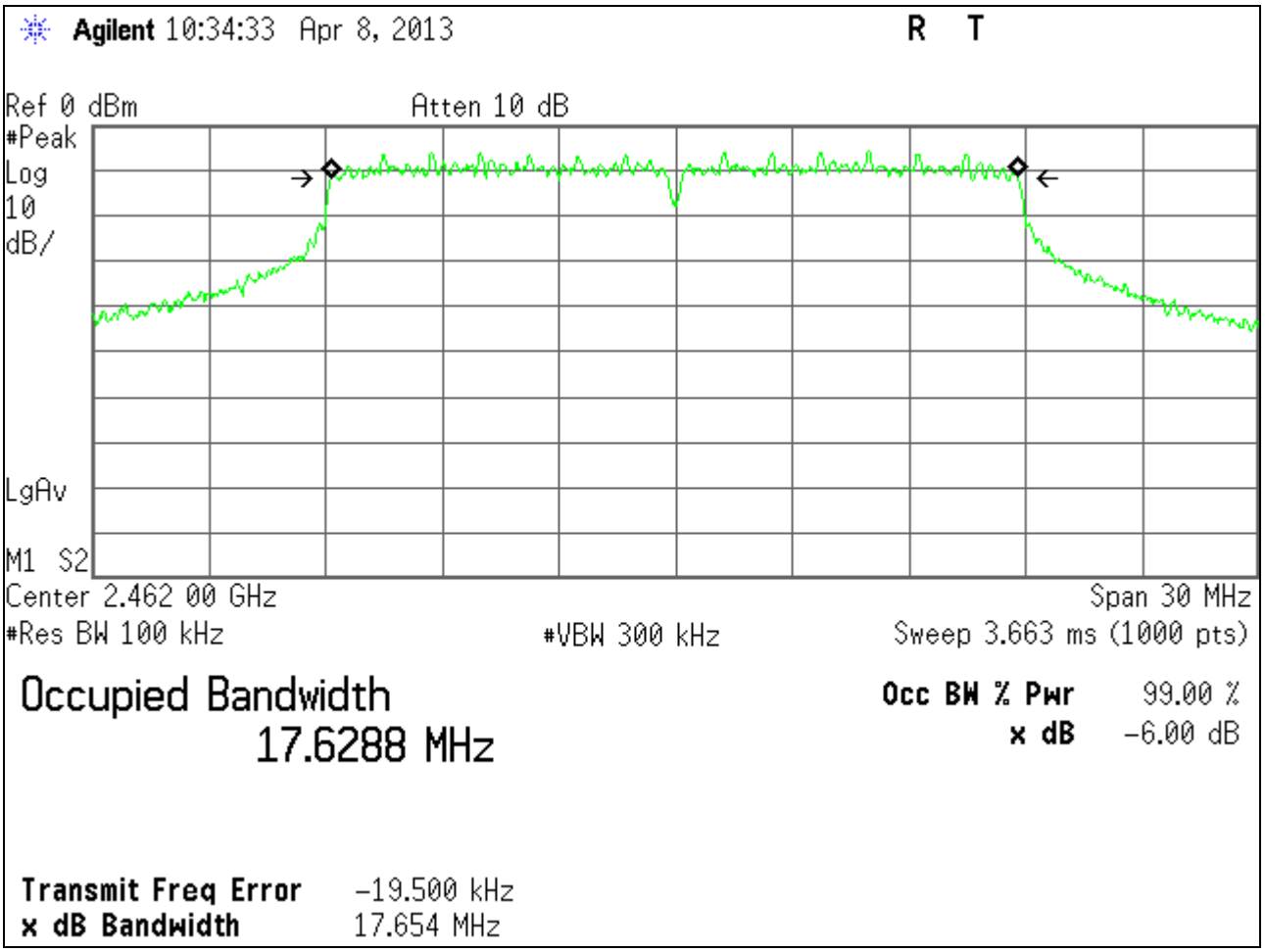

Figure 18: Occupied Bandwidth, 802.11n, 65Mbps, 2462MHz

3.3 RF Power Output: (FCC Part §15.247(b))

To measure the output power the modulation was started while the frequency dwelled on a low, center and high channels. The output from the transmitter was connected to an attenuator and then to the input of a spectrum analyzer. The spectrum analyzer offset was adjusted to compensate for the attenuator and other losses in the system. Peak Power was measured. An evaluation of each date rate was made to determine which data rate produced the highest power output. The maximum power output for each mode is presented in the Table 7.

D01 DTS Meas Guidance v03r01 section 9.1.2 Integrated band power method was utilized.

Table 7: RF Power Output

Frequency	Mode	Data Rate (Mbps)	Peak Measured Level (dBm)	Limit (dBm)	Pass/Fail
2412MHz	802.11b	1	15.93	30	Pass
2412MHz	802.11g	6	9.04	30	Pass
2412MHz	802.11n	6.5	7.55	30	Pass
2437MHz	802.11b	1	14.92	30	Pass
2437MHz	802.11g	6	9.38	30	Pass
2437MHz	802.11n	6.5	7.51	30	Pass
2462MHz	802.11b	1	14.37	30	Pass
2462MHz	802.11g	6	8.44	30	Pass
2462MHz	802.11n	6.5	7.93	30	Pass

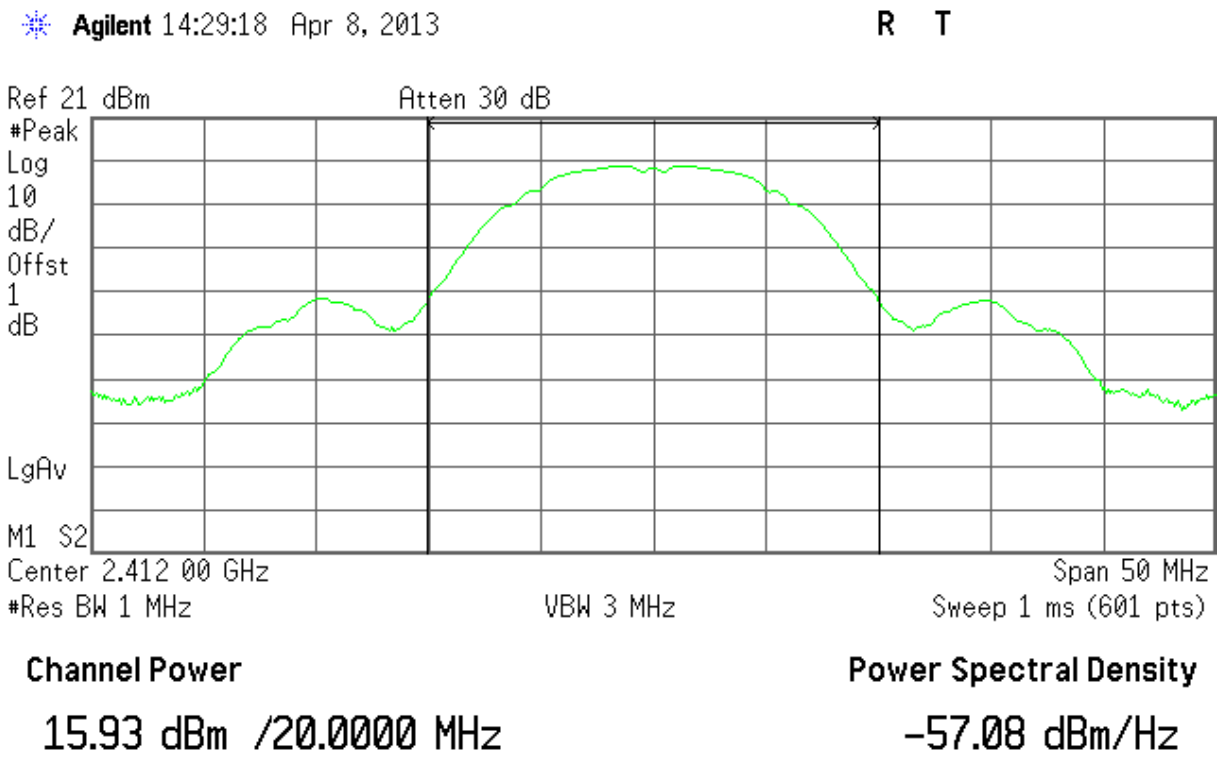

Figure 19: Power, 802.11b, 1Mbps, 2412MHz

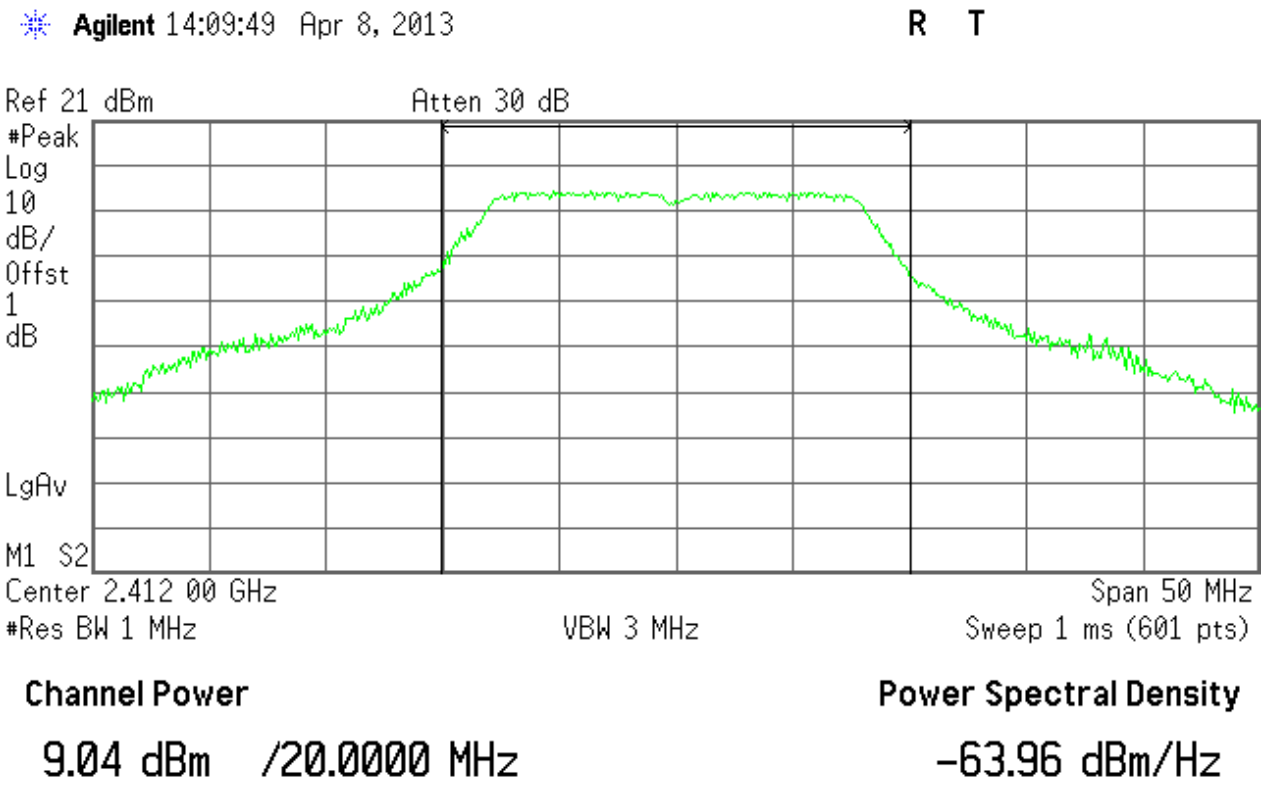

Figure 20: Power, 802.11g, 6Mbps, 2412MHz

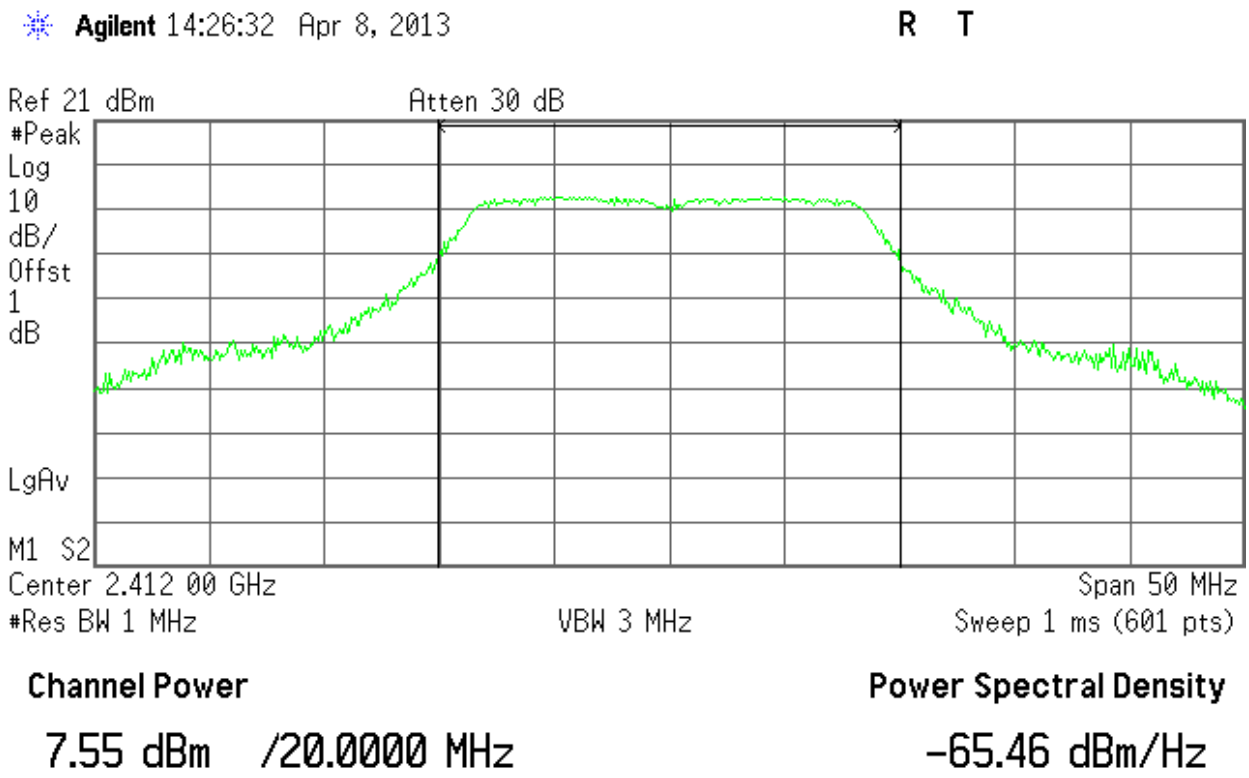

Figure 21: Power, 802.11n, 6.5Mbps, 2412MHz

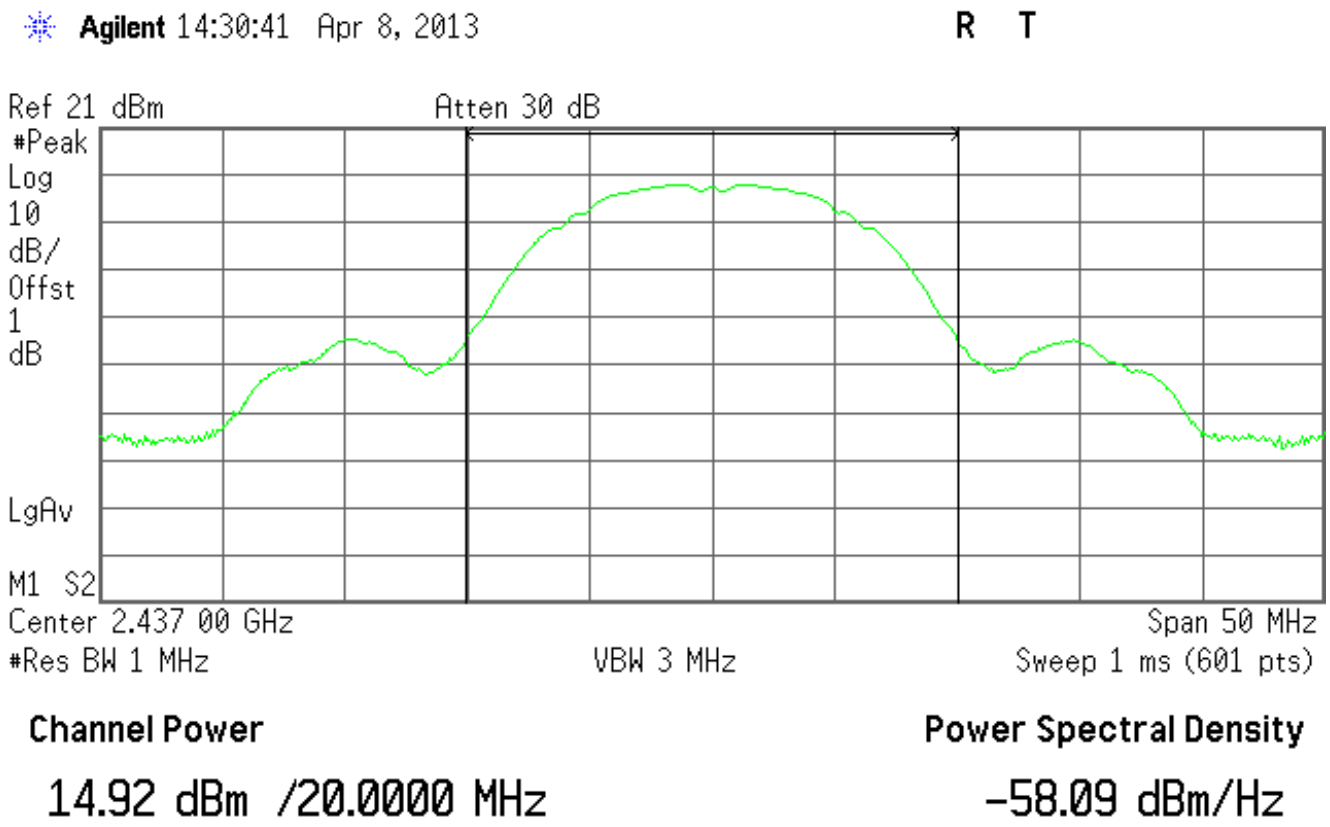

Figure 22: Power, 802.11b, 1Mbps, 2437MHz

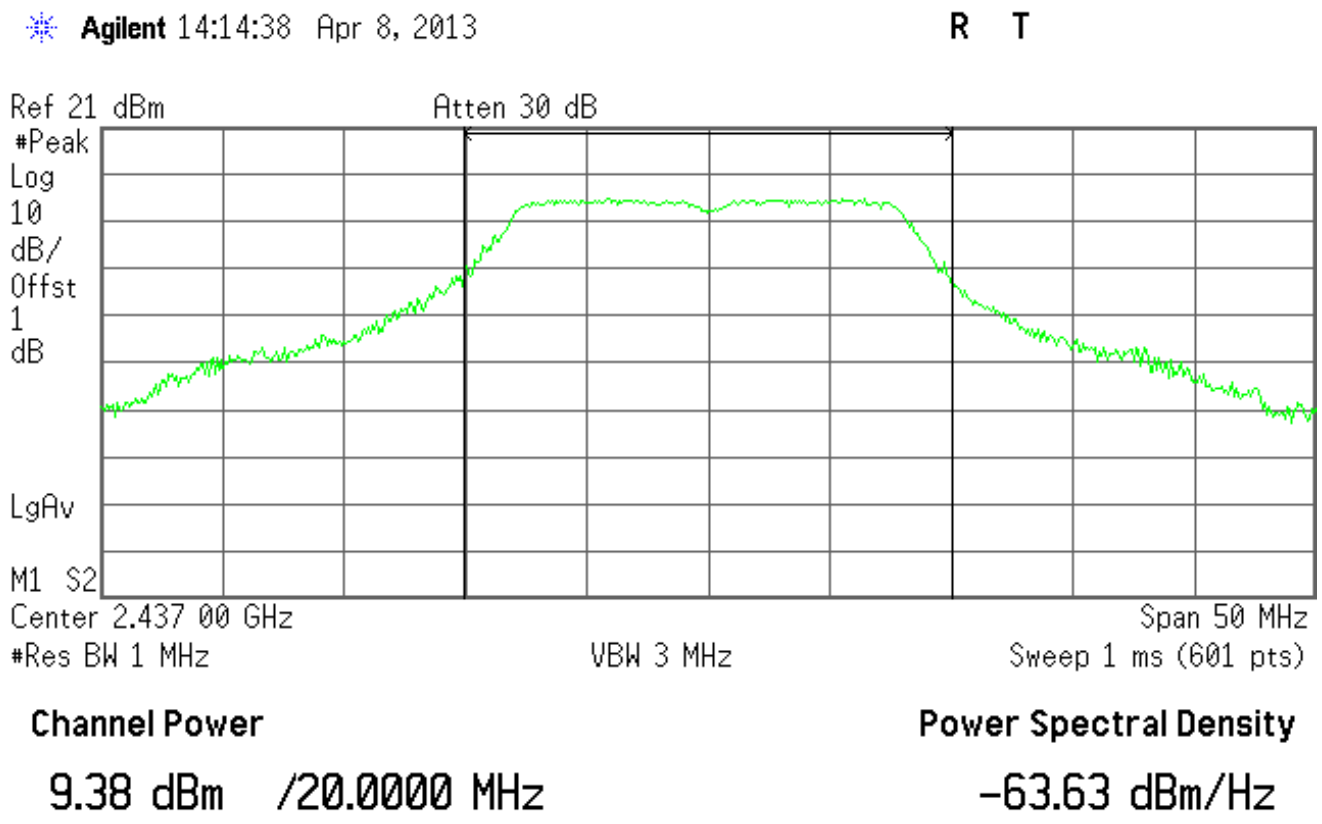

Figure 23: Power, 802.11g, 6Mbps, 2437MHz

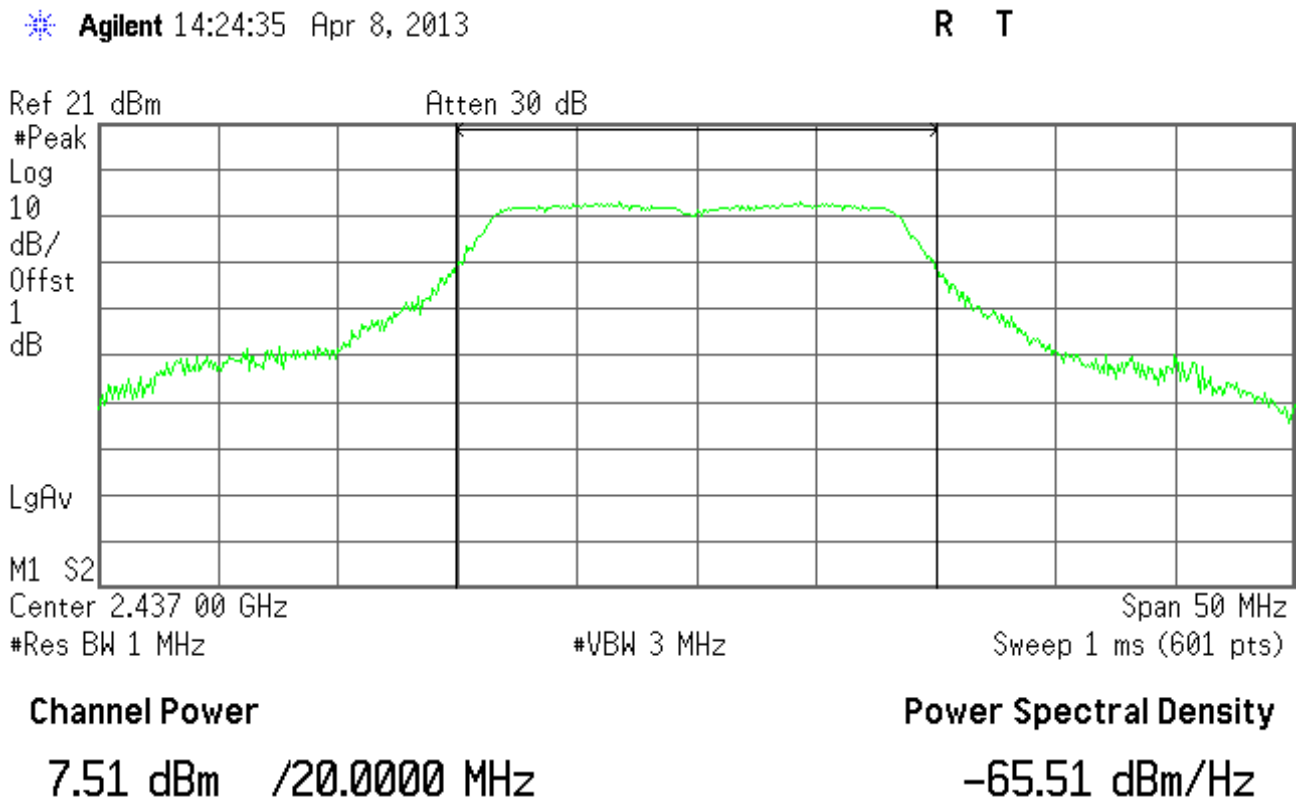

Figure 24: Power, 802.11n, 6.5Mbps, 2437MHz

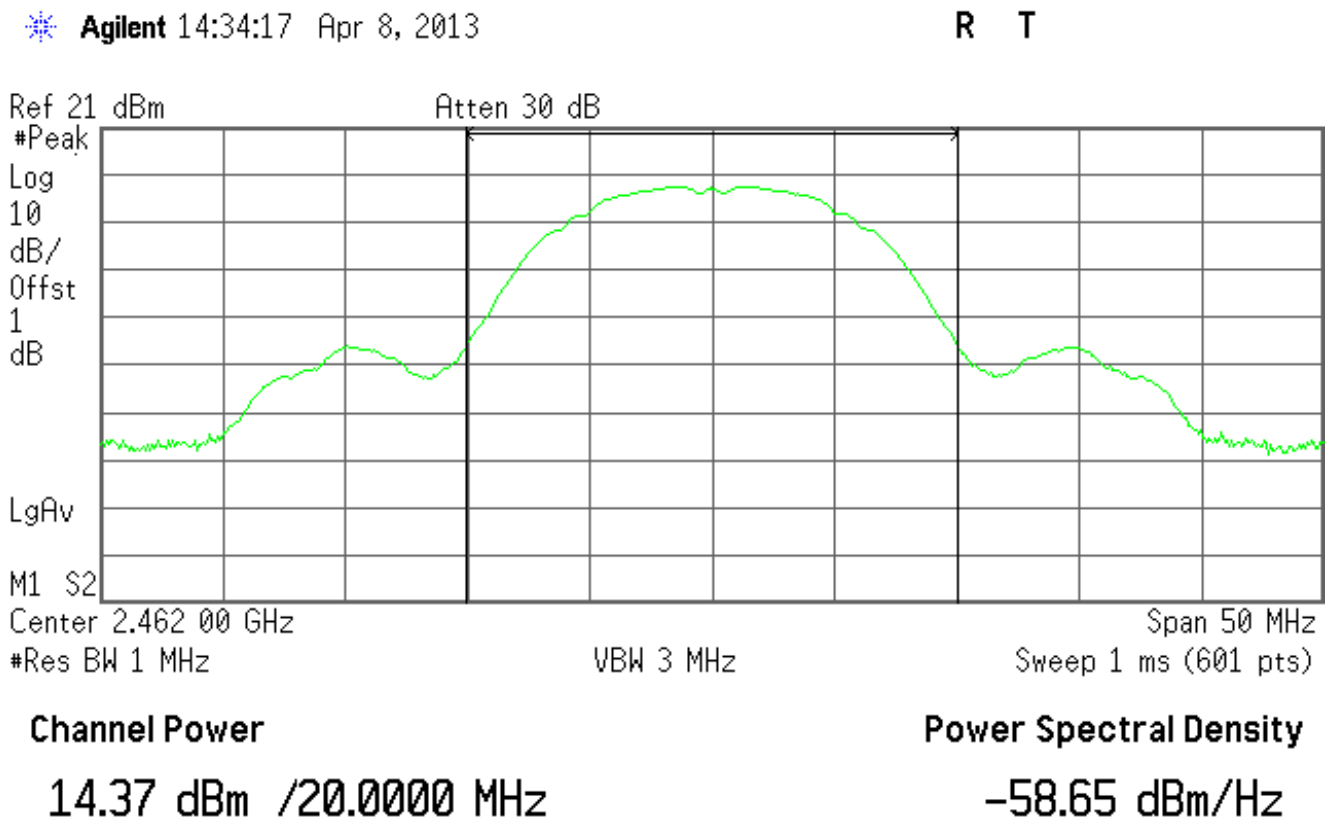

Figure 25: Power, 802.11b, 1Mbps, 2462MHz

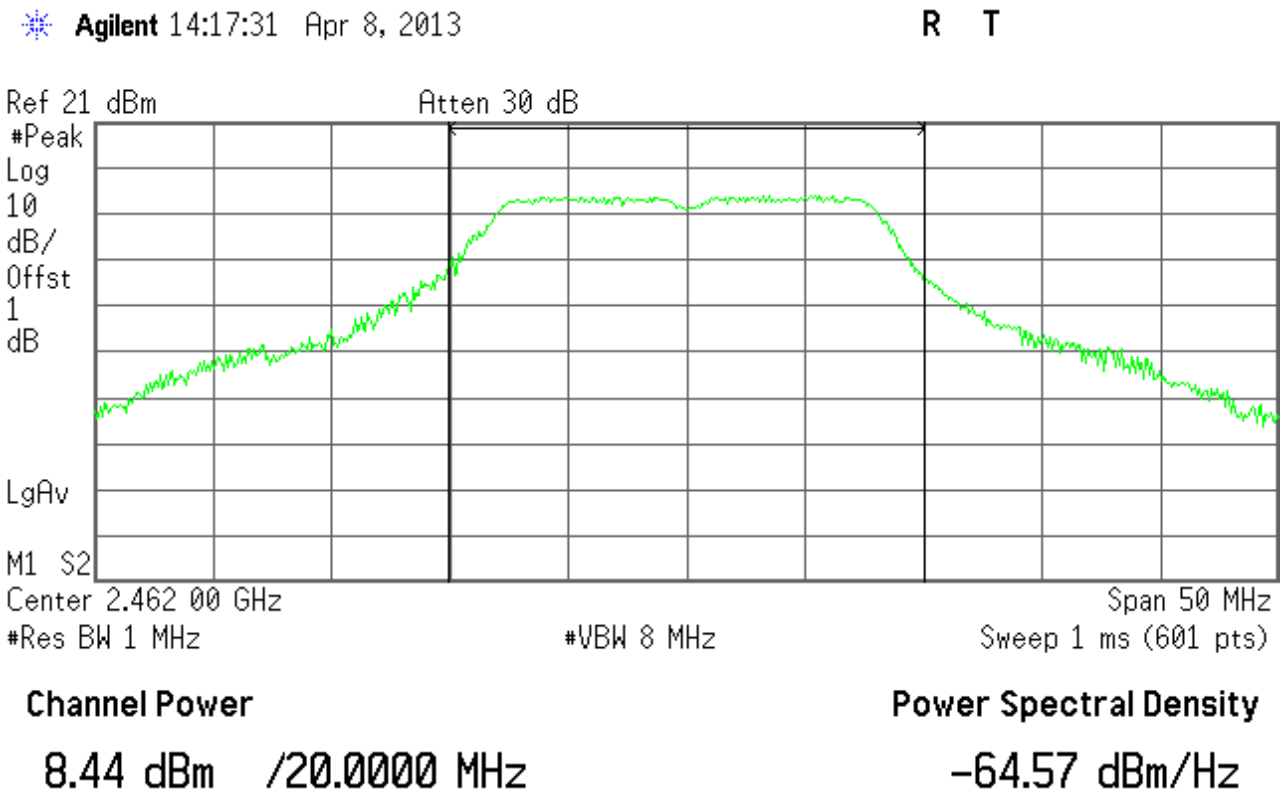

Figure 26: Power, 802.11g, 6Mbps, 2462MHz

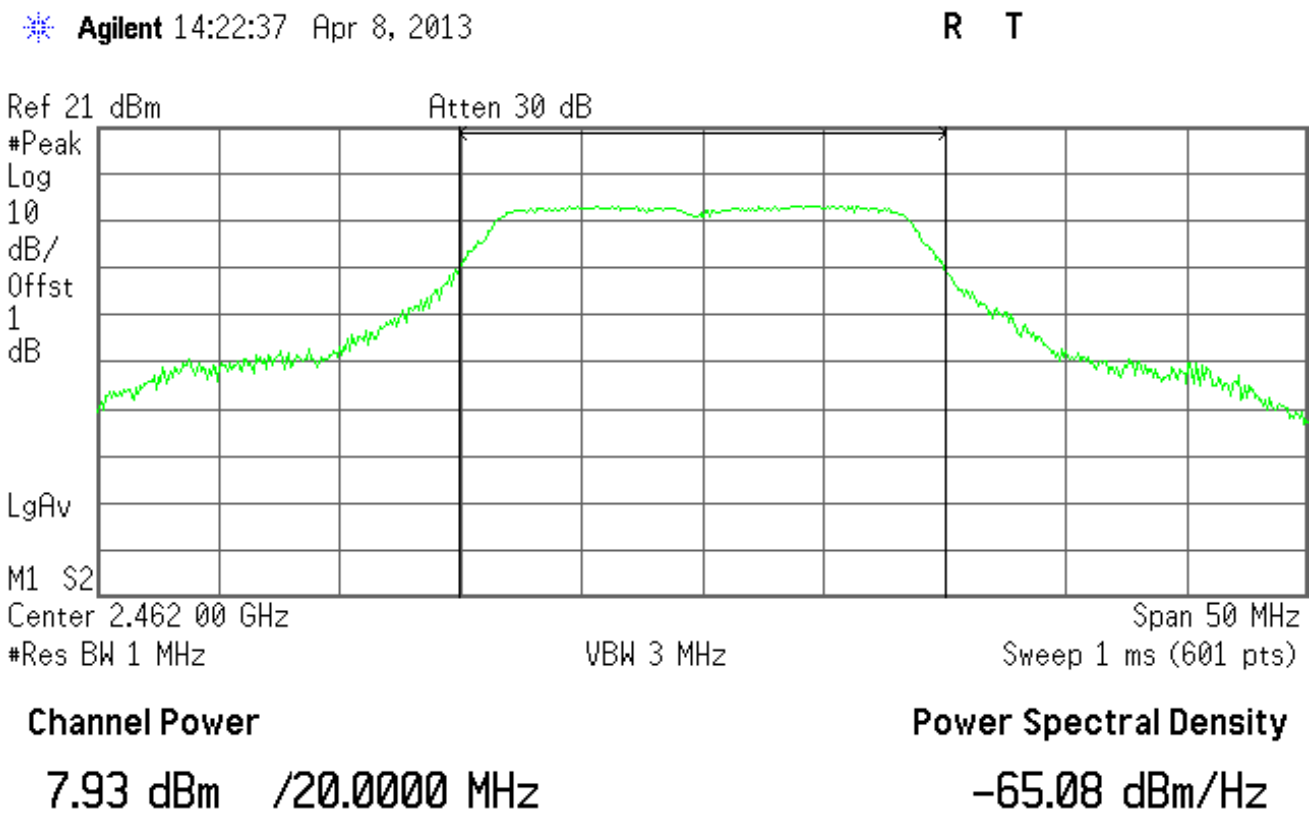

Figure 27: Power, 802.11n, 6.5Mbps, 2462MHz

3.4 Power Spectral Density (Section §15.247(e))

Measurements for power spectral density were taken in accordance with 15.247(e). The measurements were performed using 558074 D01 DTS Meas Guidance v03r01 10.2 Method PKPSD (peak PSD) , Plots show a reduced span for clarity.

The spectrum analyzer was set to peak detect mode with a RBW of 3kHz and a VBW of 10kHz. The highest level detected across any 3kHz band within the DTS bandwidth for continuous transmission was then recorded and compared to the limit 8dBm. The method used to discover the peak emission was to find the peak using a 100kHz RBW with a wide enough span to capture all peak emissions and then to zoom in on a 1.5MHz area around this point with a 3kHz RBW and a 500 second sweep. The following table and plots give the results for power spectral density testing.

Table 8: Power Spectral Density

Frequency	Mode	Data Rate (Mbps)	Spectral Density (dBm)	Limit (dBm)	Pass/Fail
2412MHz	802.11b	1	-10.5	8	Pass
2412MHz	802.11g	6	-17.26	8	Pass
2412MHz	802.11n	6.5	-16.54	8	Pass
2437MHz	802.11b	1	-11.26	8	Pass
2437MHz	802.11g	6	-16.69	8	Pass
2437MHz	802.11n	6.5	-17.28	8	Pass
2462MHz	802.11b	1	-11.61	8	Pass
2462MHz	802.11g	6	-16.44	8	Pass
2462MHz	802.11n	6.5	-15.96	8	Pass

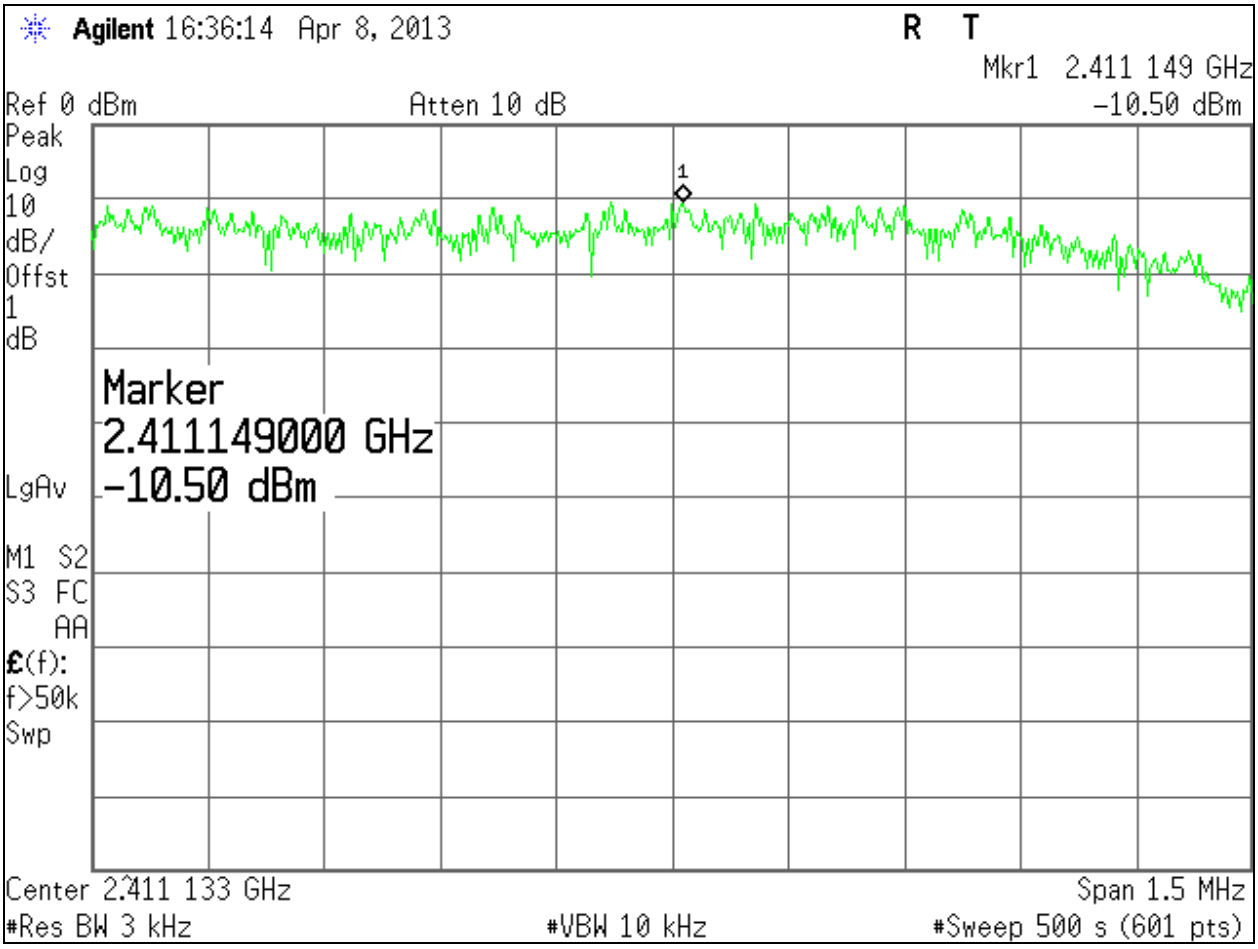

Figure 28: Power Spectral Density, 802.11b, 1Mbps, 2412MHz

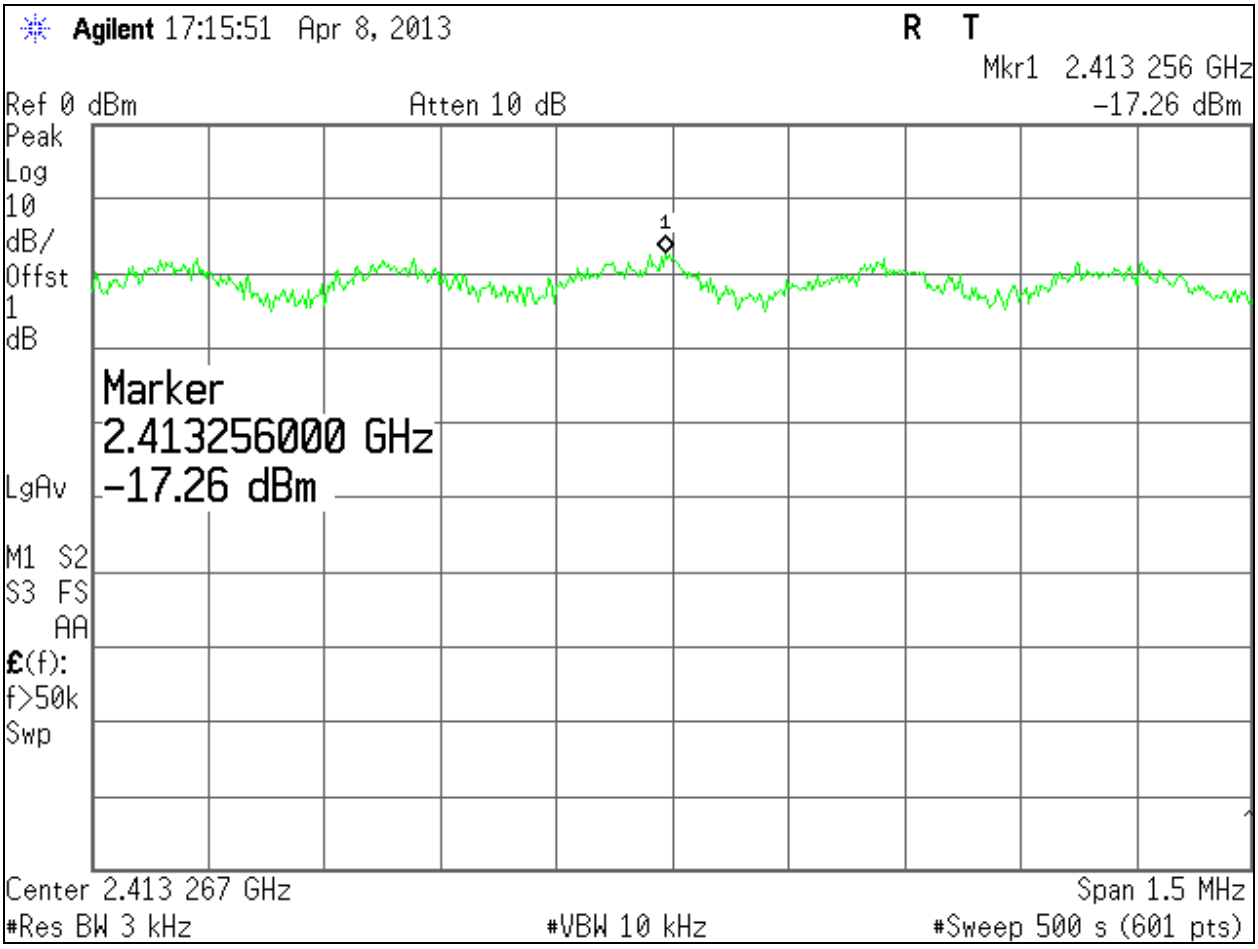

Figure 29: Power Spectral Density, 802.11g, 6Mbps, 2412MHz

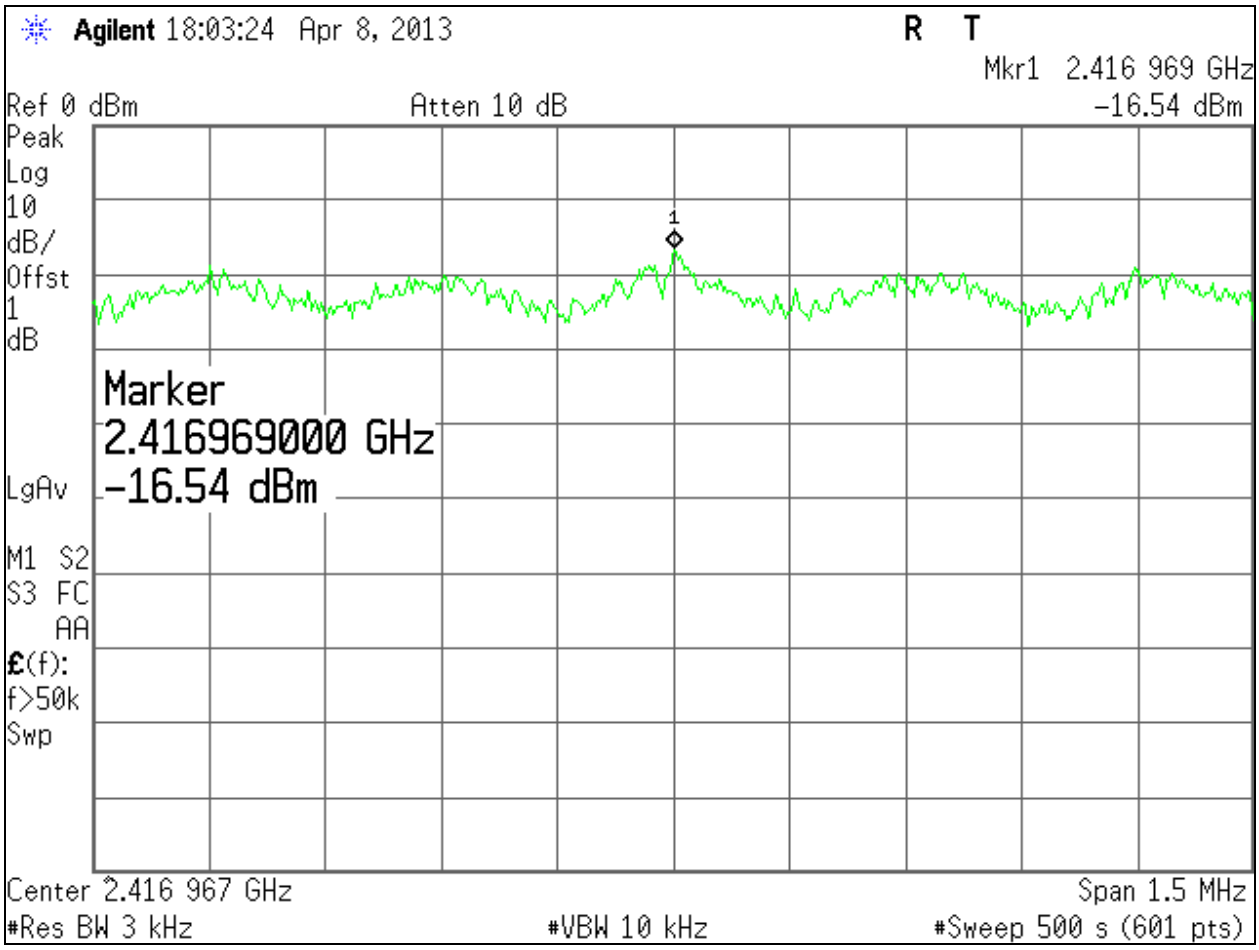

Figure 30: Power Spectral Density, 802.11n, 6.5Mbps, 2412MHz

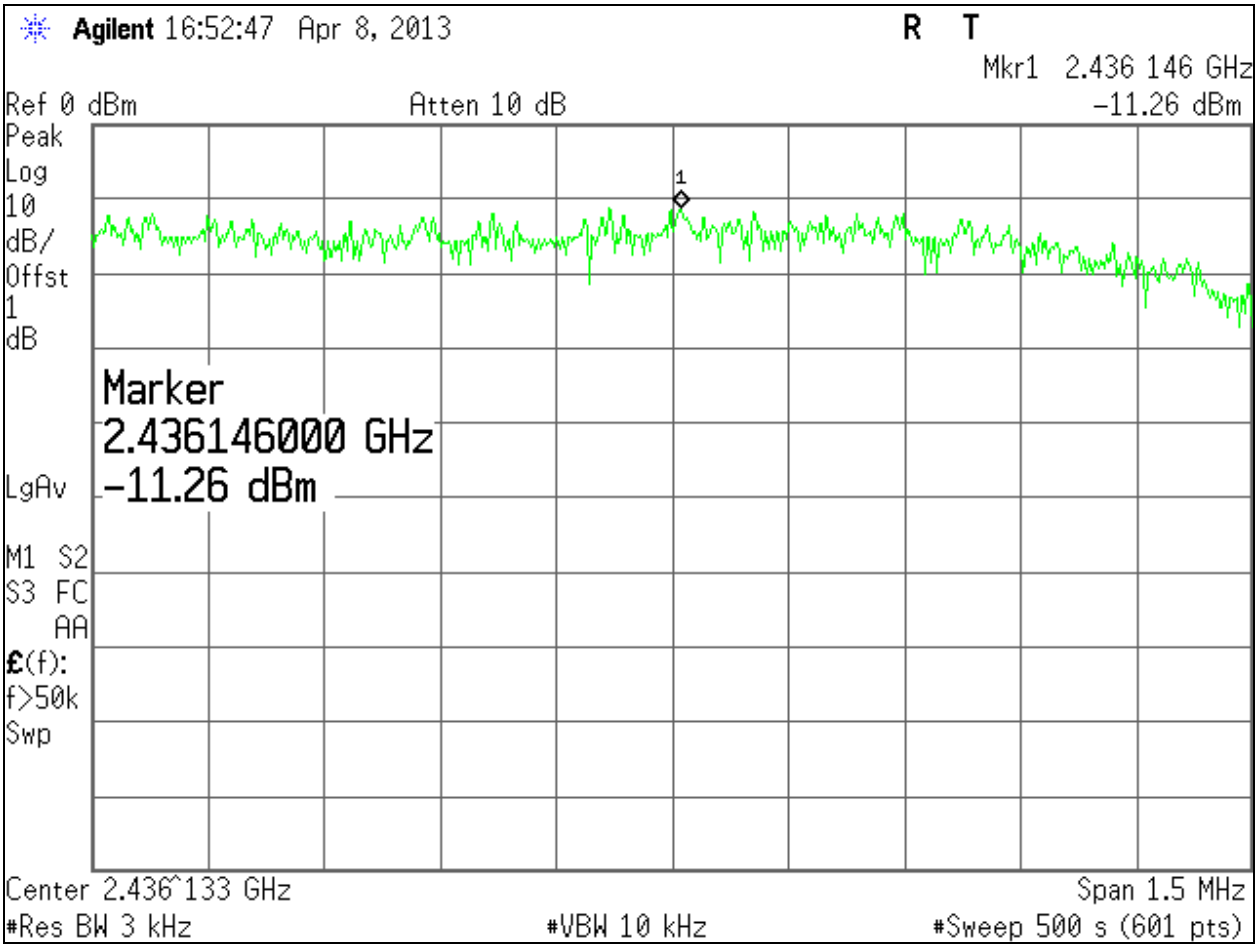

Figure 31: Power Spectral Density, 802.11b, 1Mbps, 2437MHz

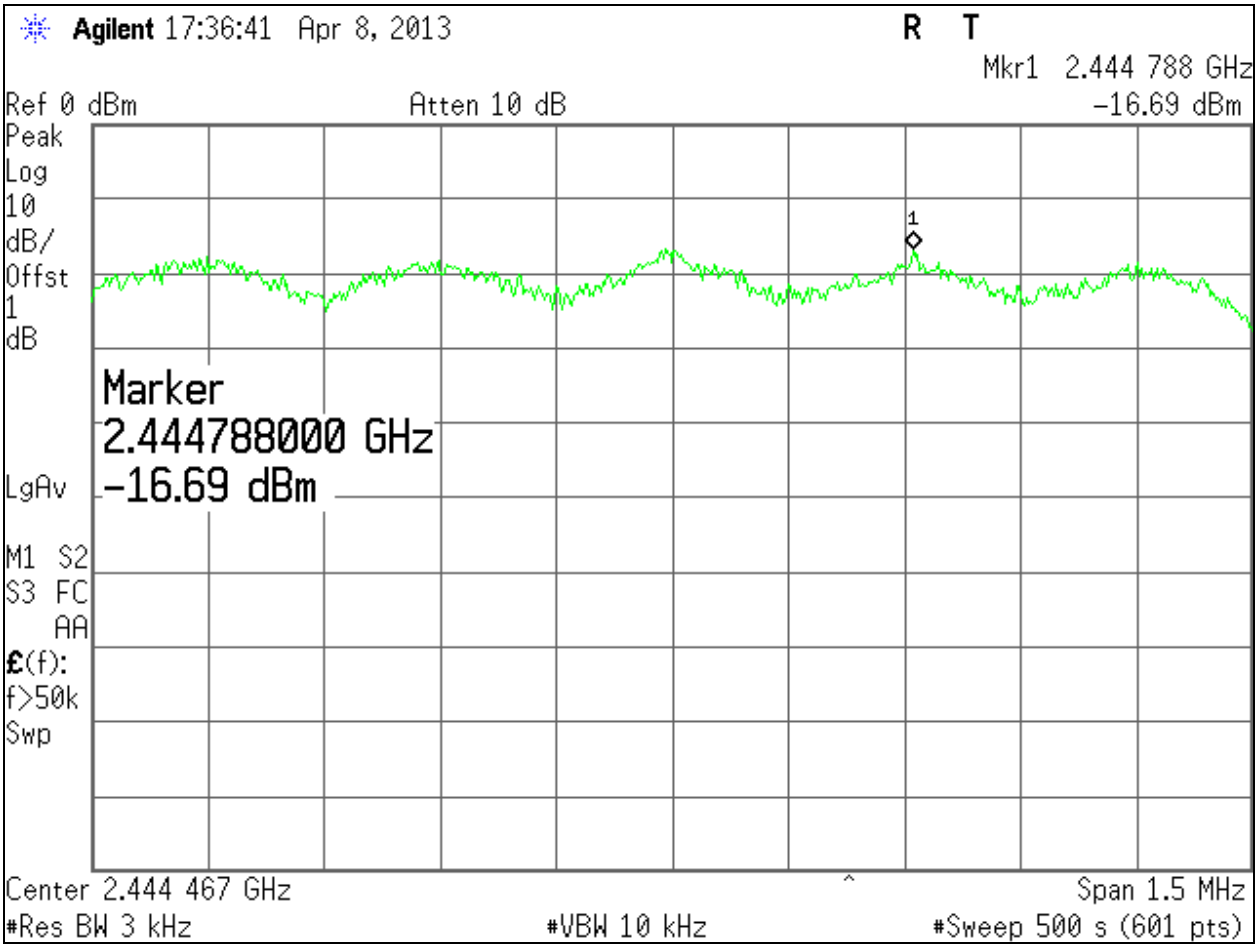

Figure 32: Power Spectral Density, 802.11g, 6Mbps, 2437MHz

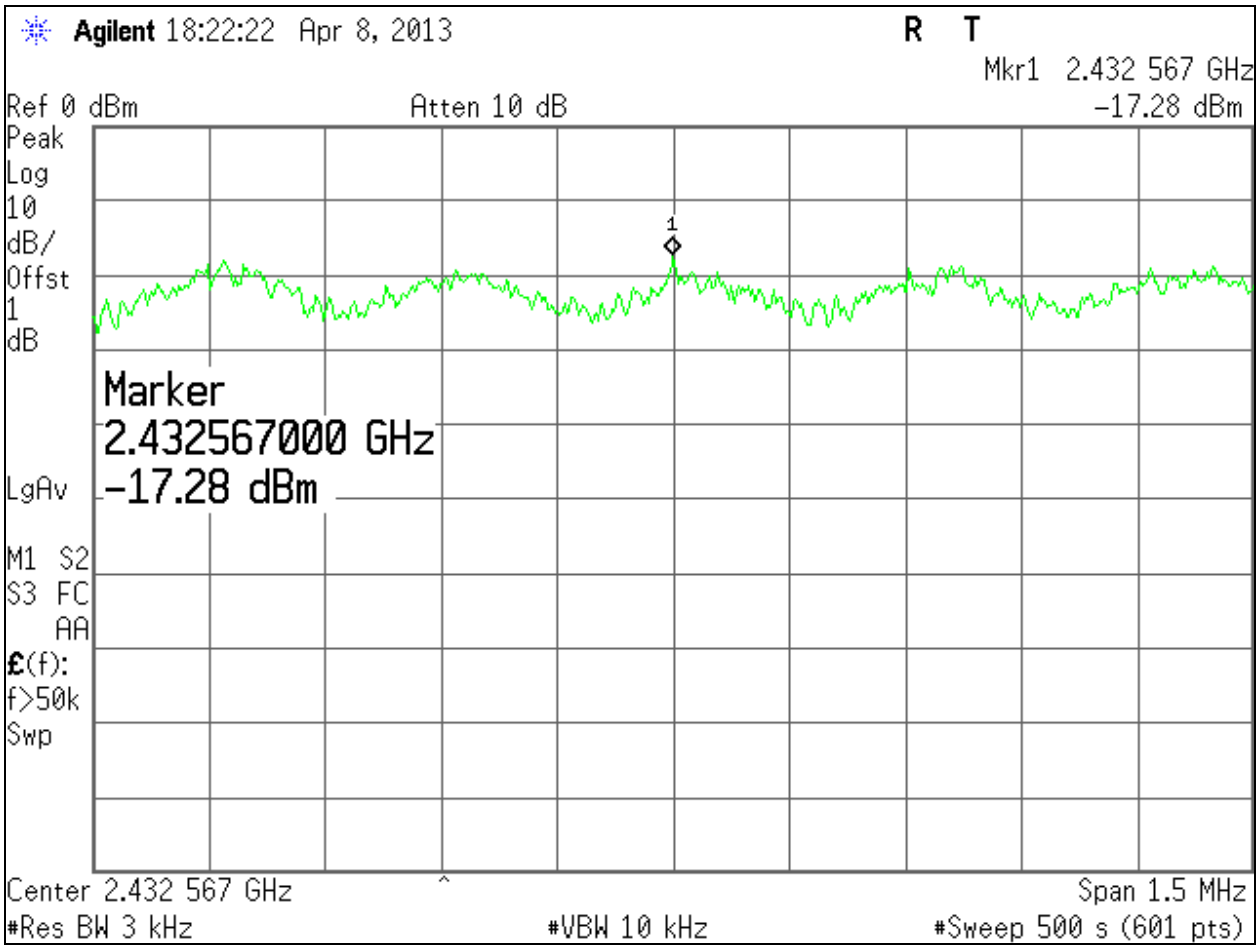

Figure 33: Power Spectral Density, 802.11n, 6.5Mbps, 2437MHz

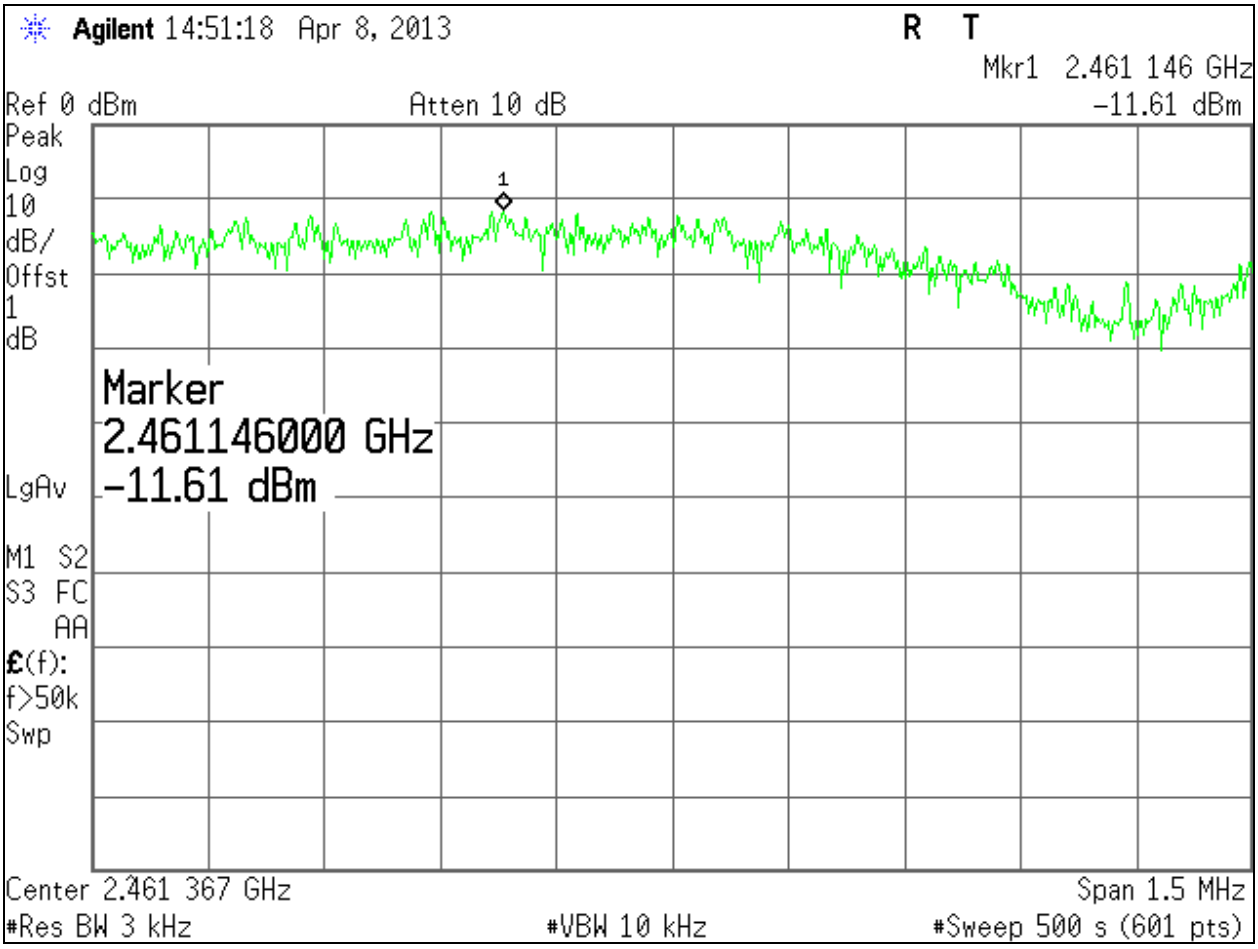

Figure 34: Power Spectral Density, 802.11b, 1Mbps, 2462MHz

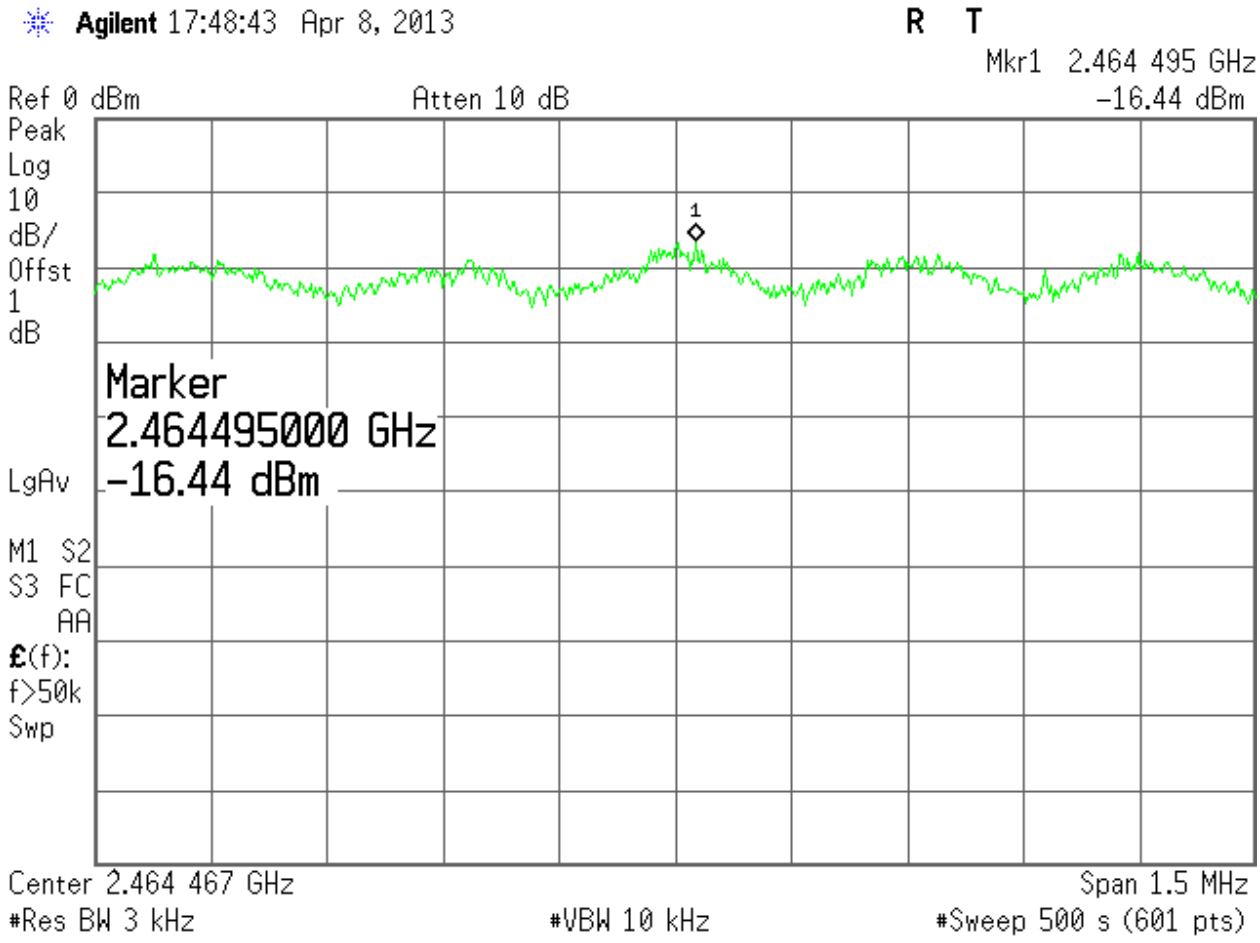

Figure 35: Power Spectral Density, 802.11g, 6Mbps, 2462MHz

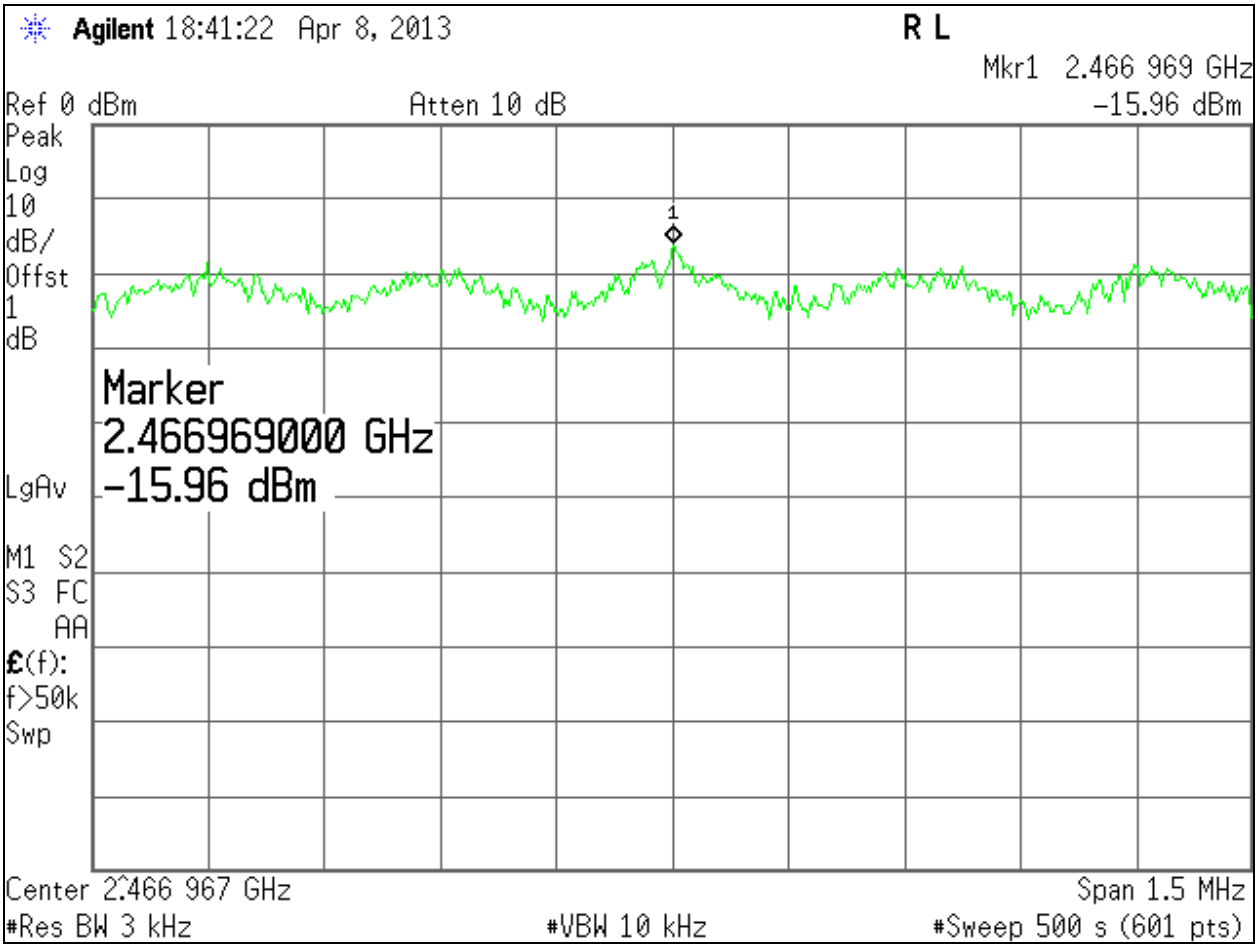

Figure 36: Power Spectral Density, 802.11n, 6.5Mbps, 2462MHz

3.5 Conducted Spurious Emissions at Antenna Terminals (FCC Part §15.247(c))

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 20 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.

These tests were conducted with the highest levels in each mode (802.11b=1Mbps & 802.11g= 6Mbps, 802.11n 6.5Mbps).

The following are plots of the conducted spurious emissions data.

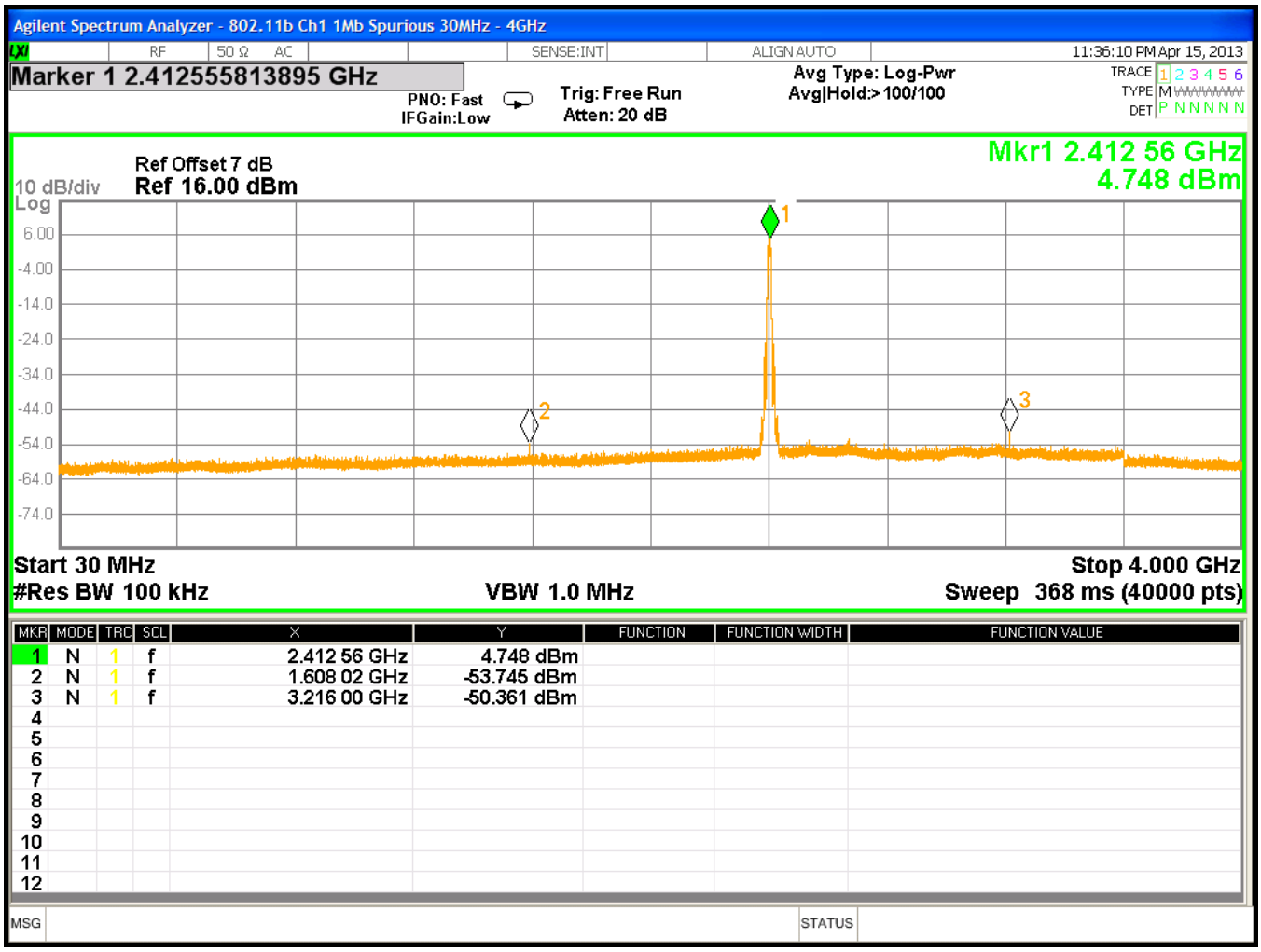

Figure 37: Conducted Spurious Emissions, 2412MHz, 1Mbps, 30MHz – 4GHz

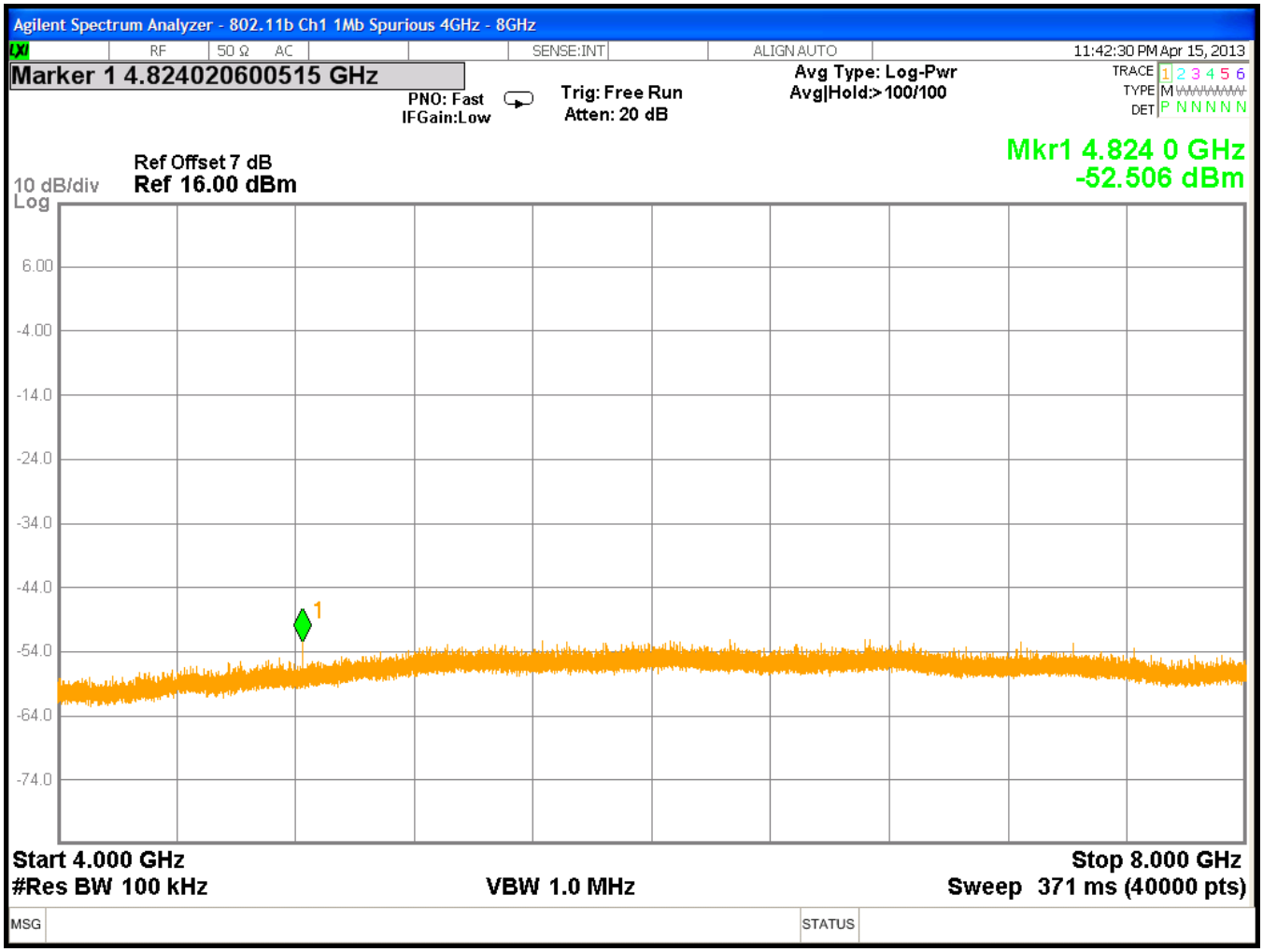

Figure 38: Conducted Spurious Emissions, 2412MHz, 1Mbps, 4 – 8GHz

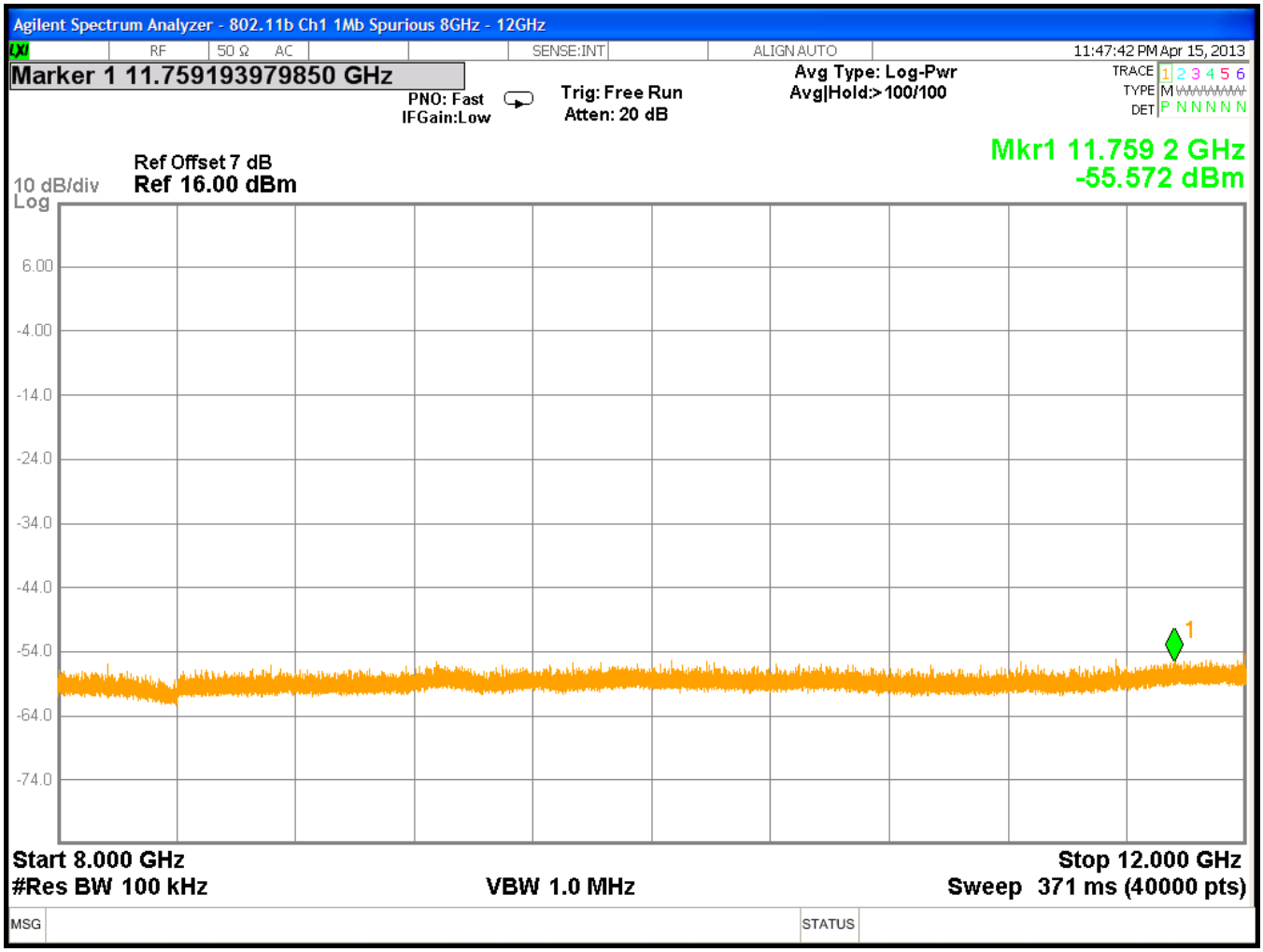

Figure 39: Conducted Spurious Emissions, 2412MHz, 1Mbps, 8 - 12GHz

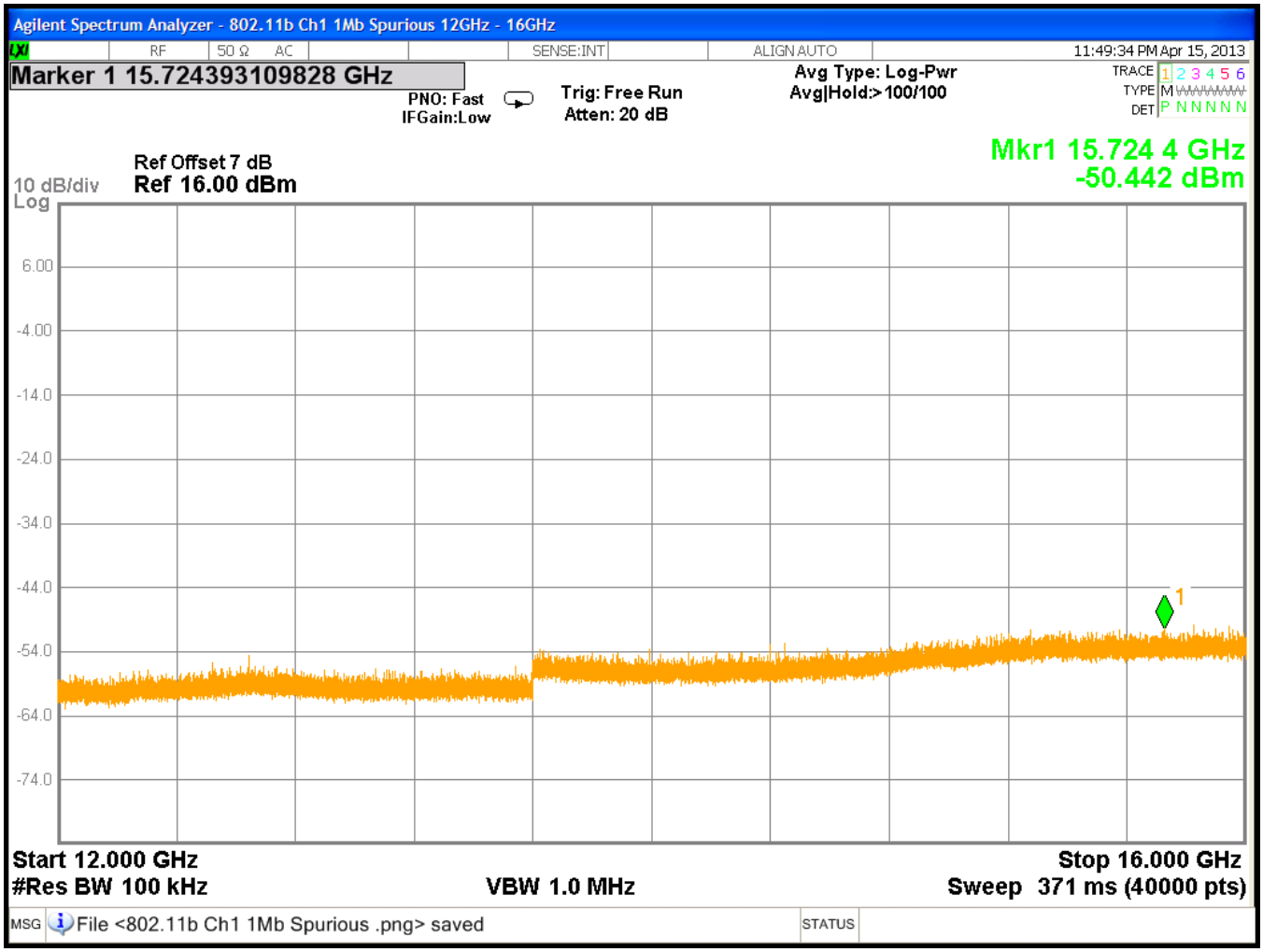

Figure 40: Conducted Spurious Emissions, 2412MHz, 1Mbps, 12 - 16GHz

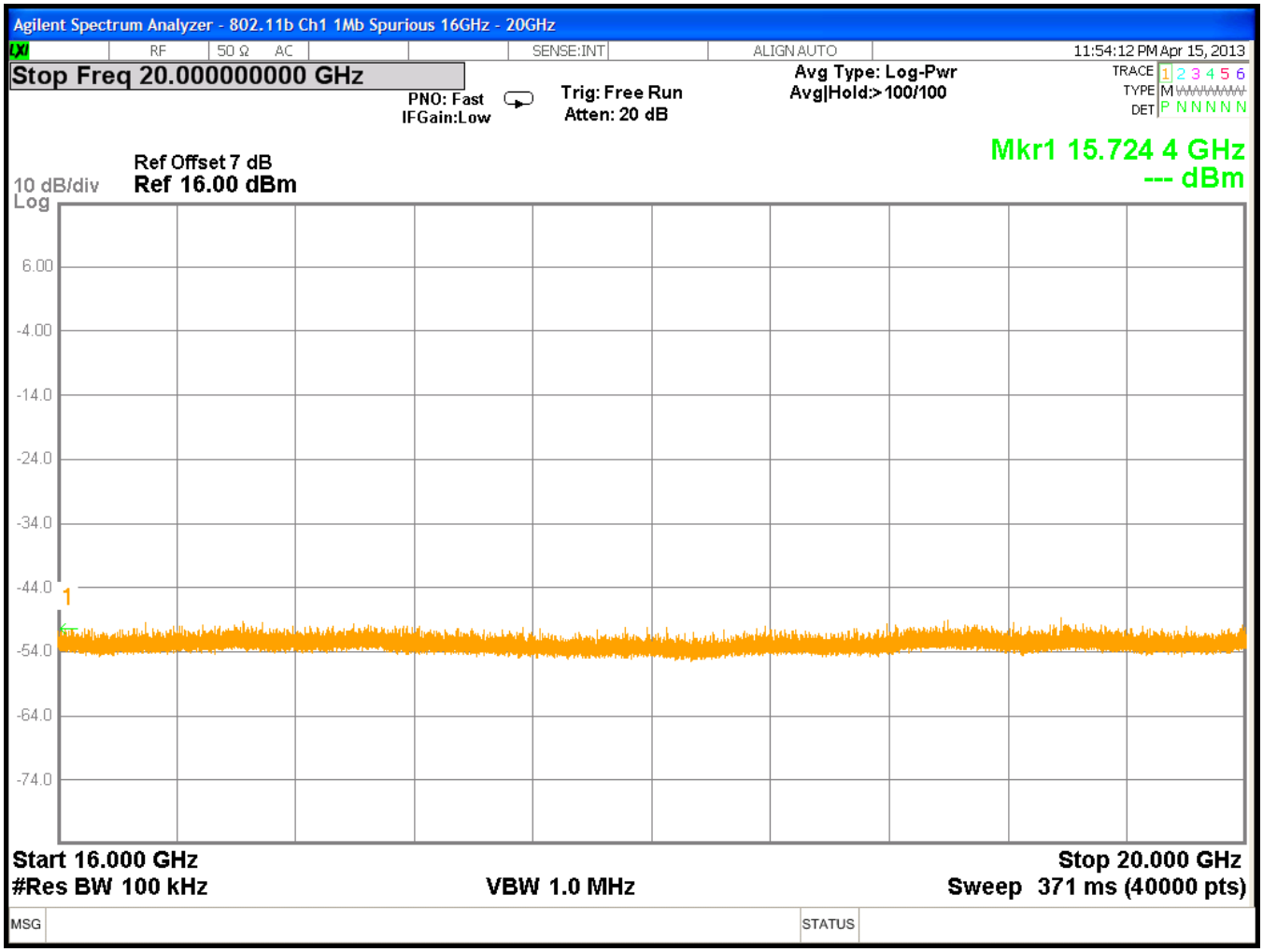

Figure 41: Conducted Spurious Emissions, 2412MHz, 1Mbps, 16 - 20GHz

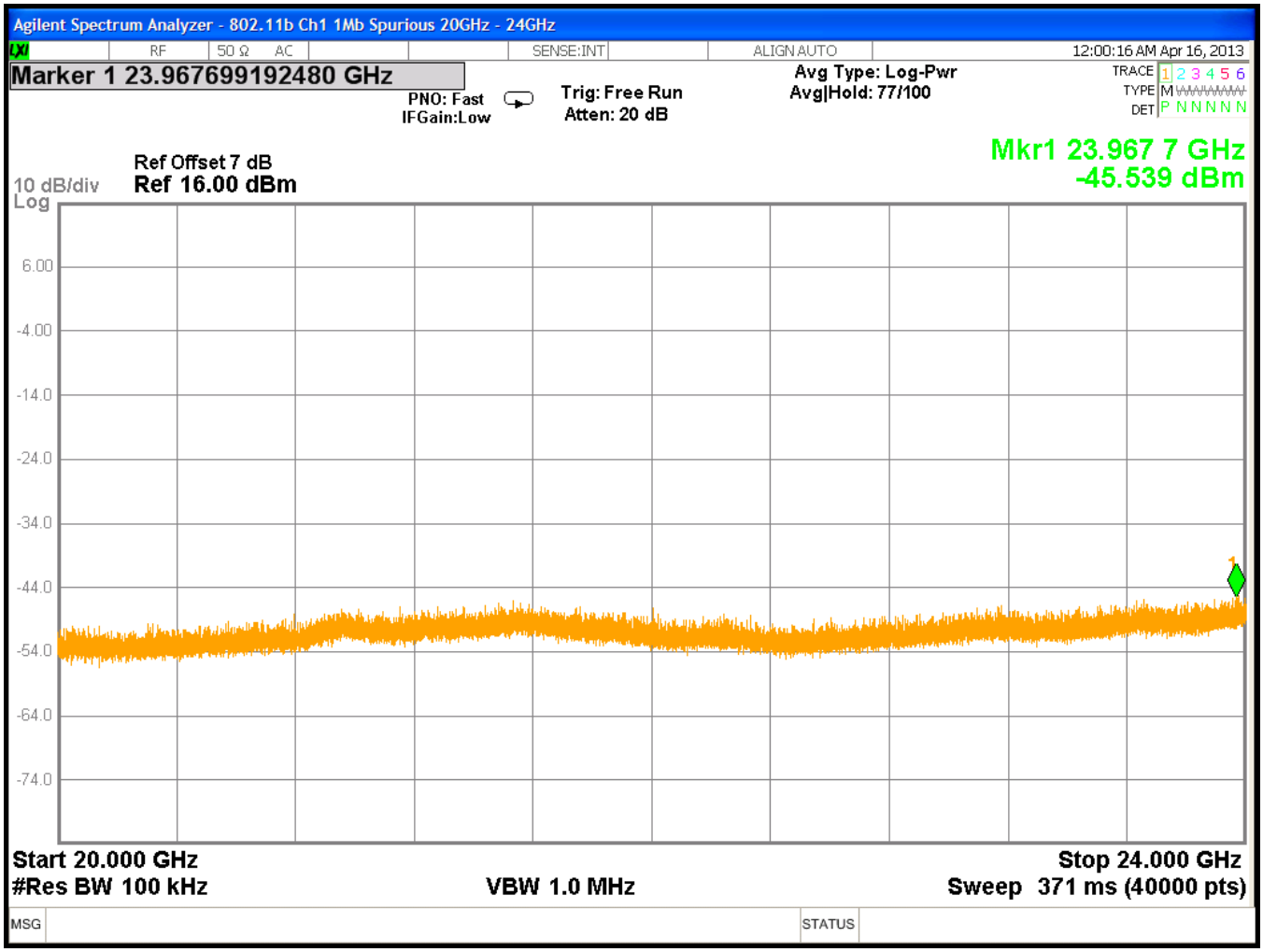

Figure 42: Conducted Spurious Emissions, 2412MHz, 1Mbps, 20 - 24GHz

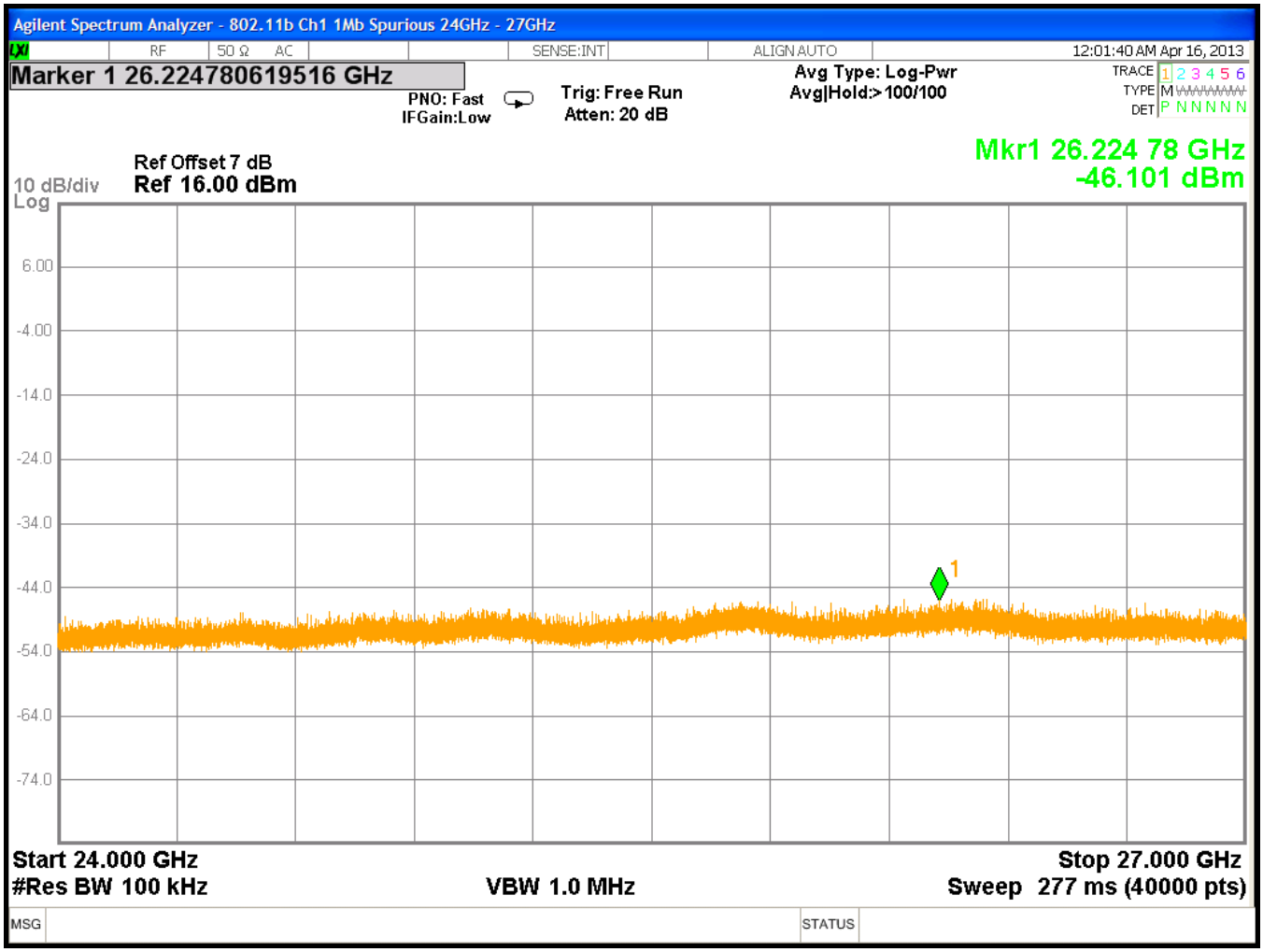

Figure 43: Conducted Spurious Emissions, 2412MHz, 1Mbps, 24 - 27GHz

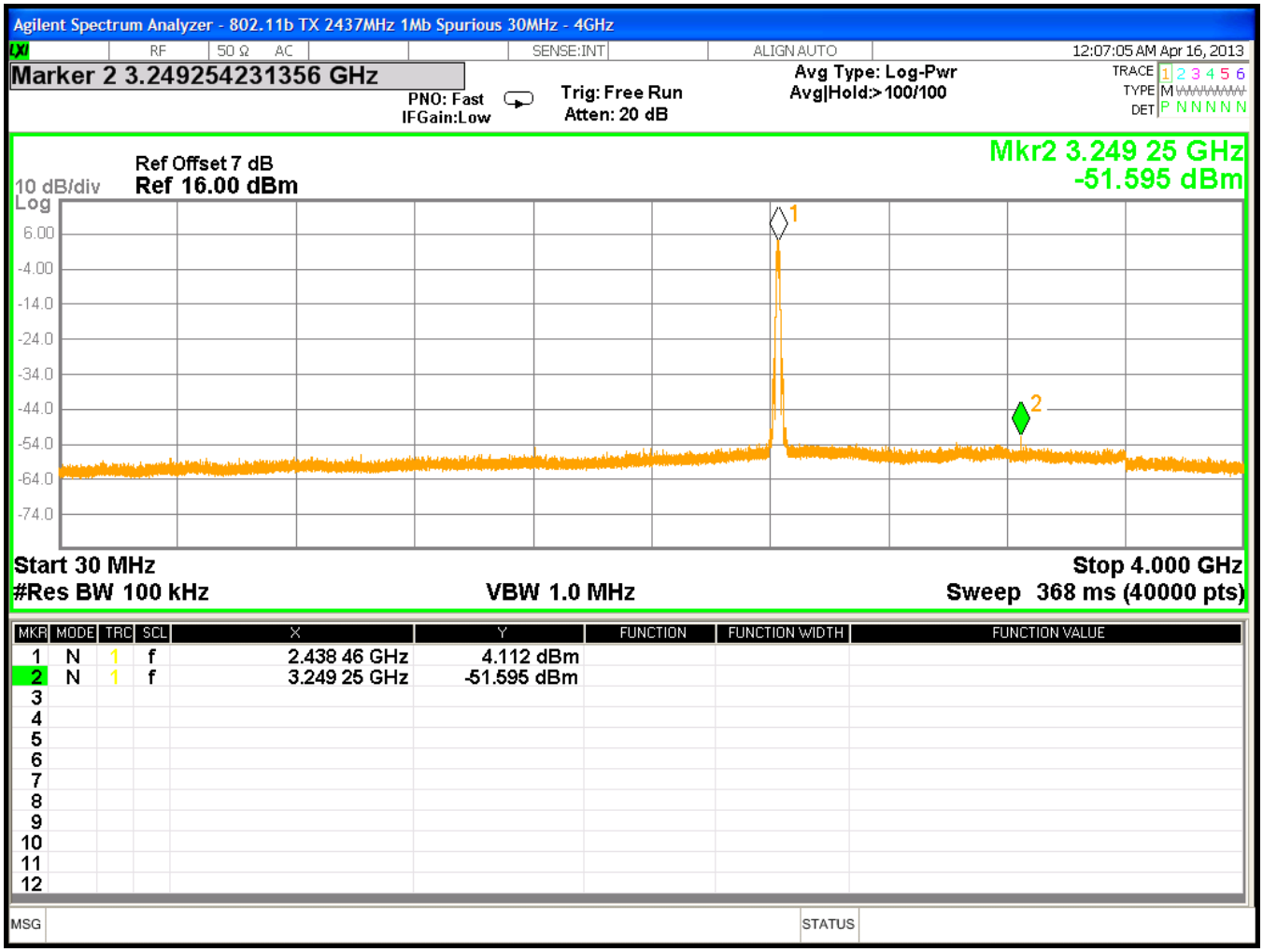

Figure 44: Conducted Spurious Emissions, 2437MHz, 1Mbps, 30MHz – 4GHz

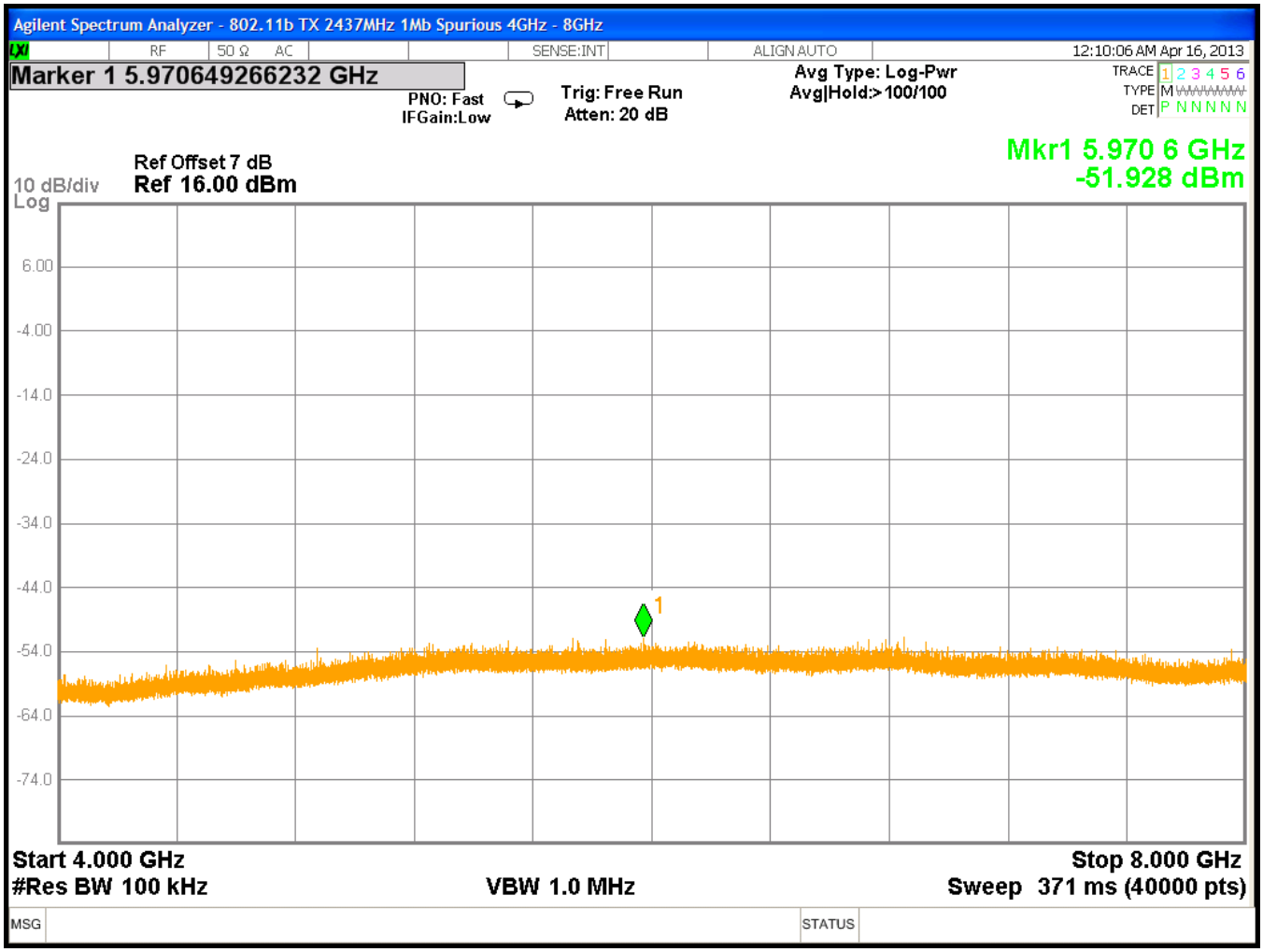

Figure 45: Conducted Spurious Emissions, 2437MHz, 1Mbps, 4 – 8GHz

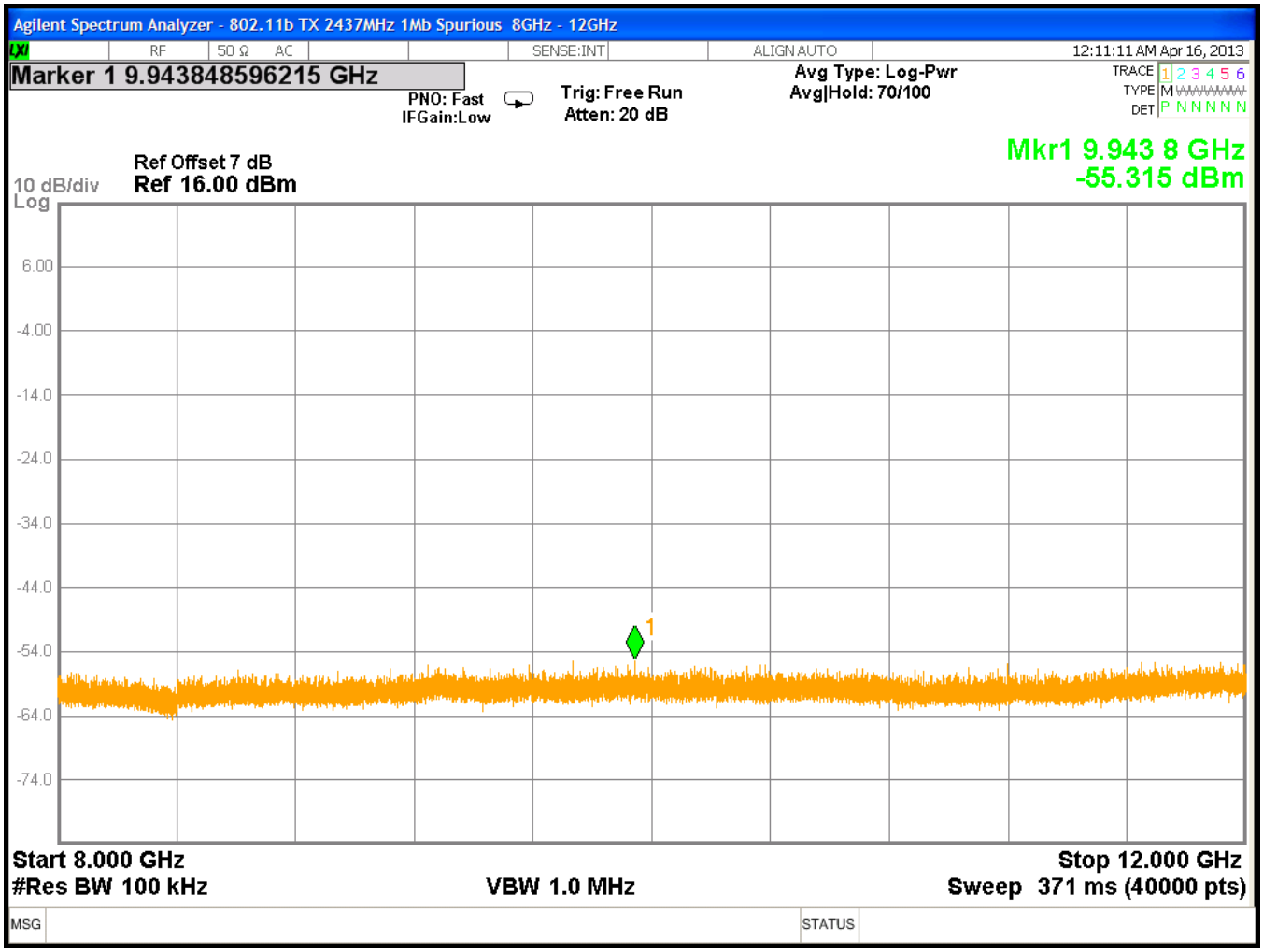

Figure 46: Conducted Spurious Emissions, 2437MHz, 1Mbps, 8 - 12GHz

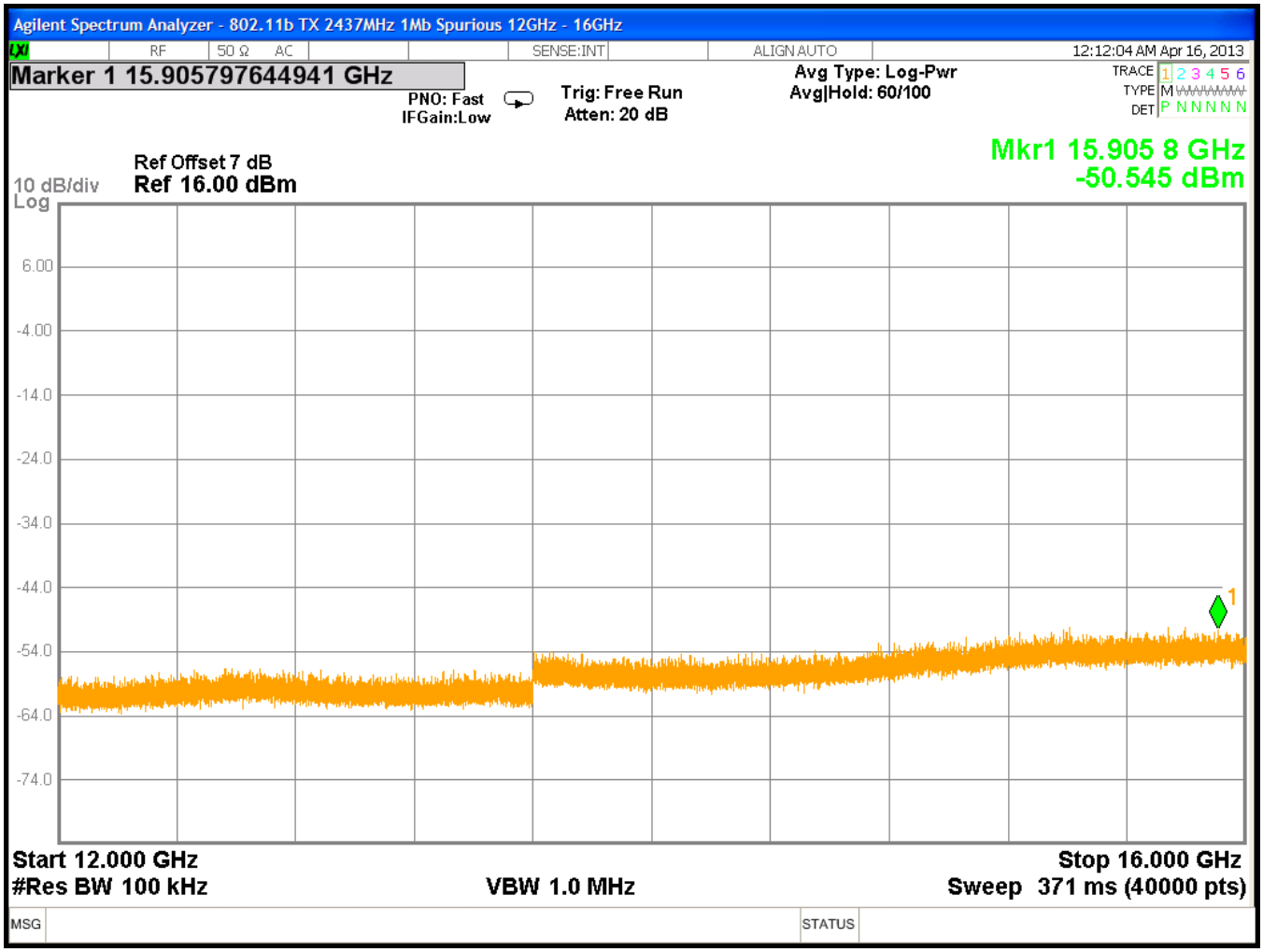

Figure 47: Conducted Spurious Emissions, 2437MHz, 1Mbps, 12 - 16GHz

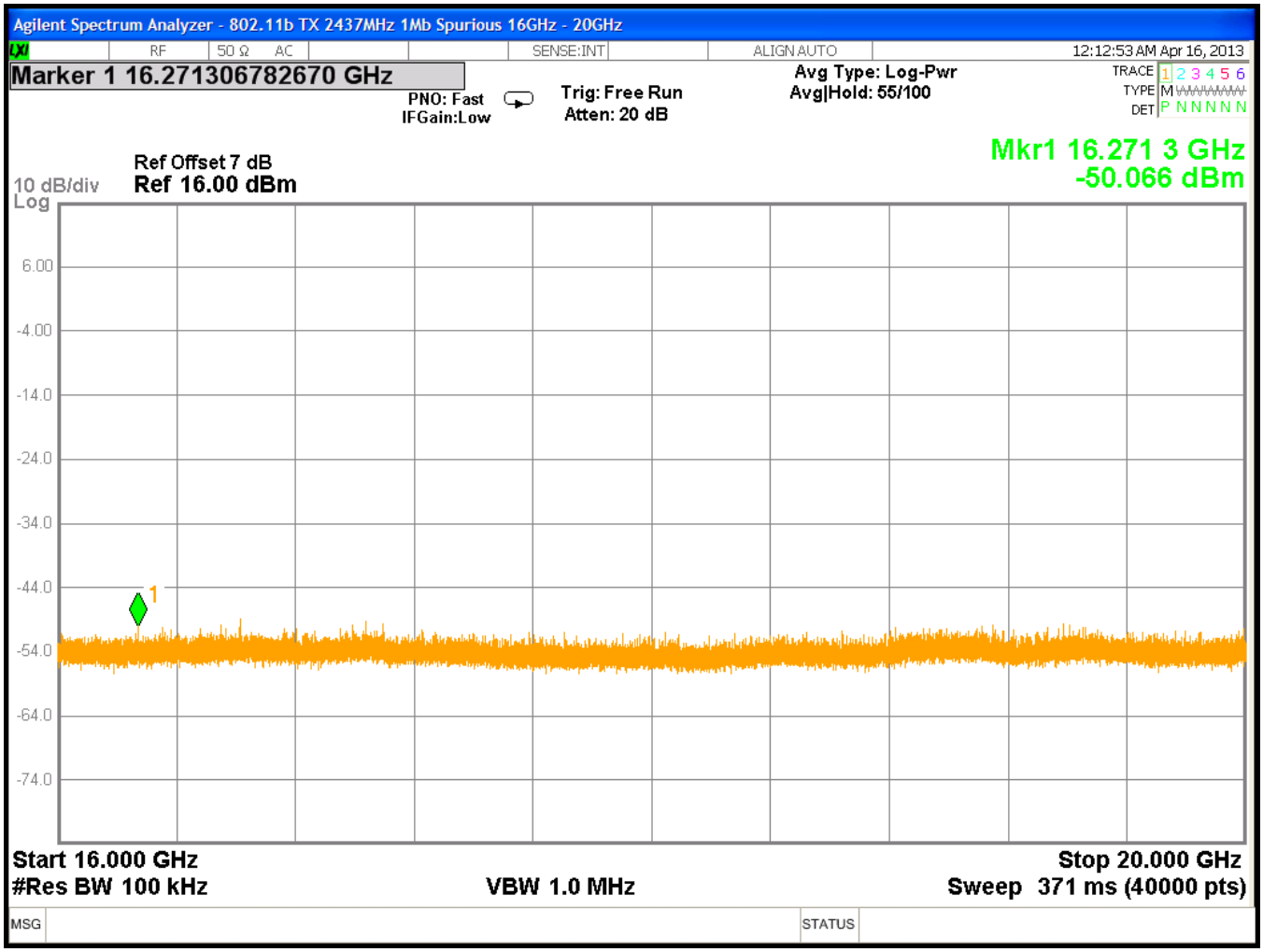

Figure 48: Conducted Spurious Emissions, 2437MHz, 1Mbps, 16 - 20GHz

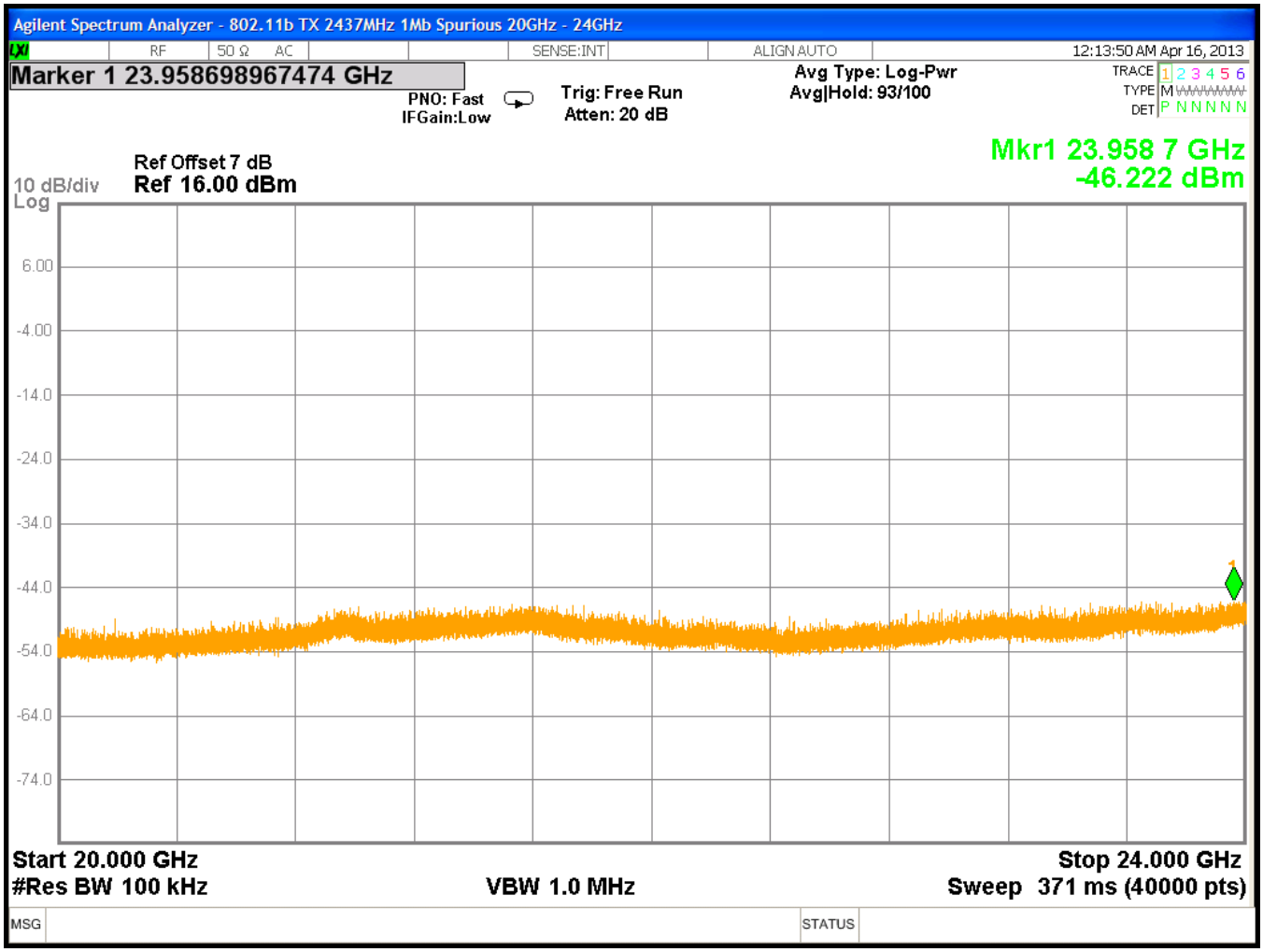

Figure 49: Conducted Spurious Emissions, 2437MHz, 1Mbps, 20 - 24GHz

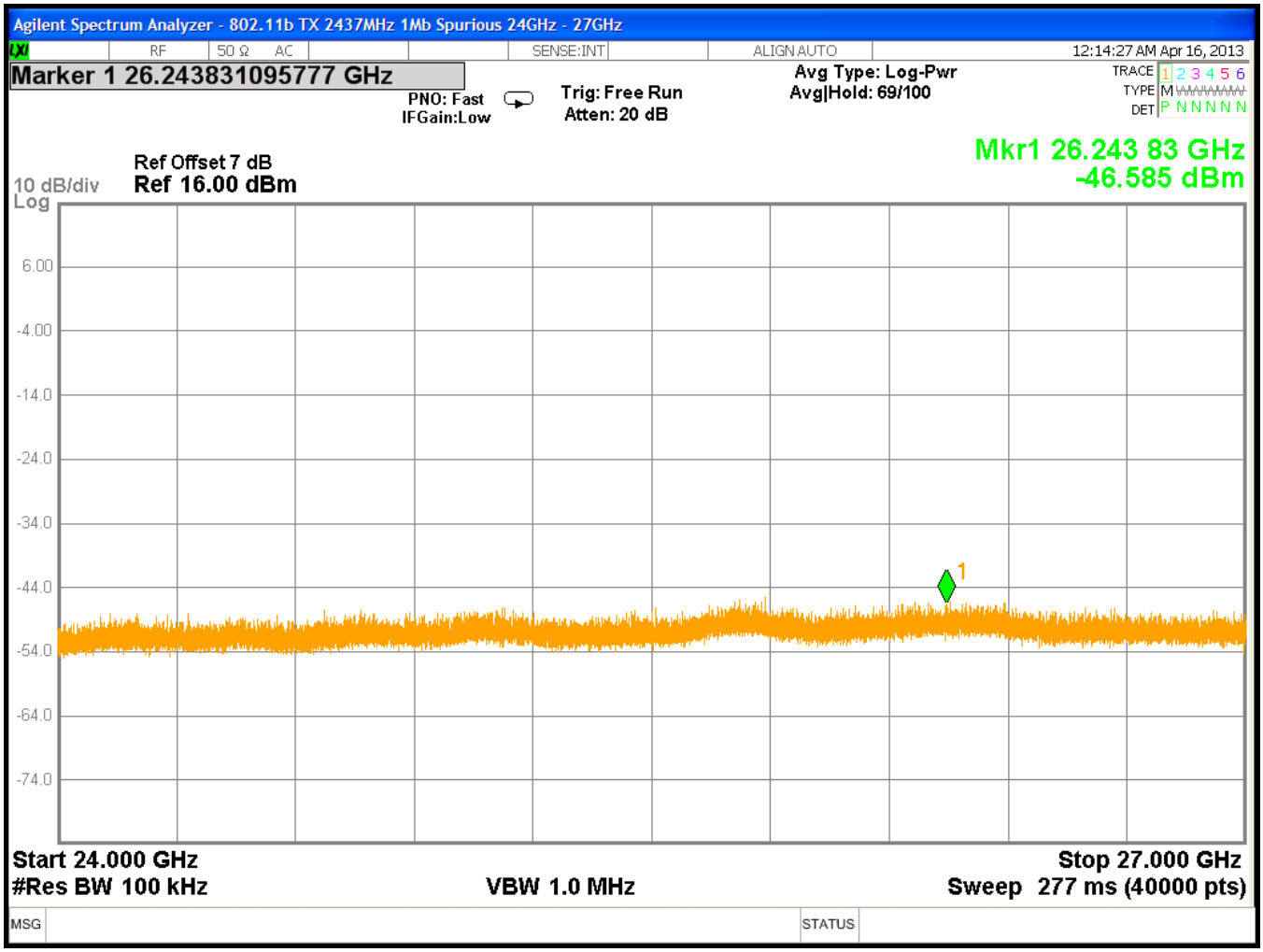

Figure 50: Conducted Spurious Emissions, 2437MHz, 1Mbps, 24 - 27GHz

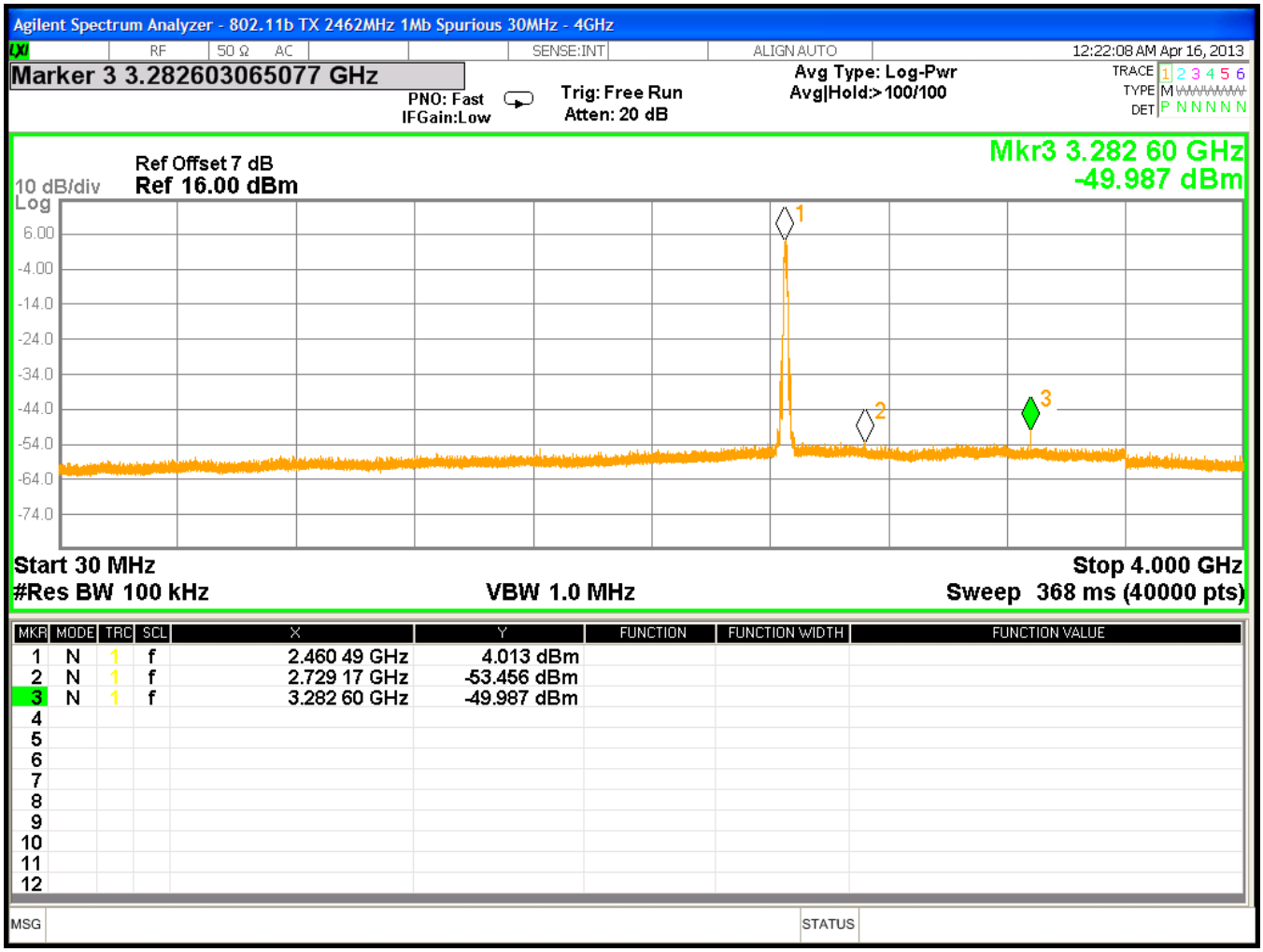

Figure 51: Conducted Spurious Emissions, 2437MHz, 1Mbps, 30MHz – 4GHz

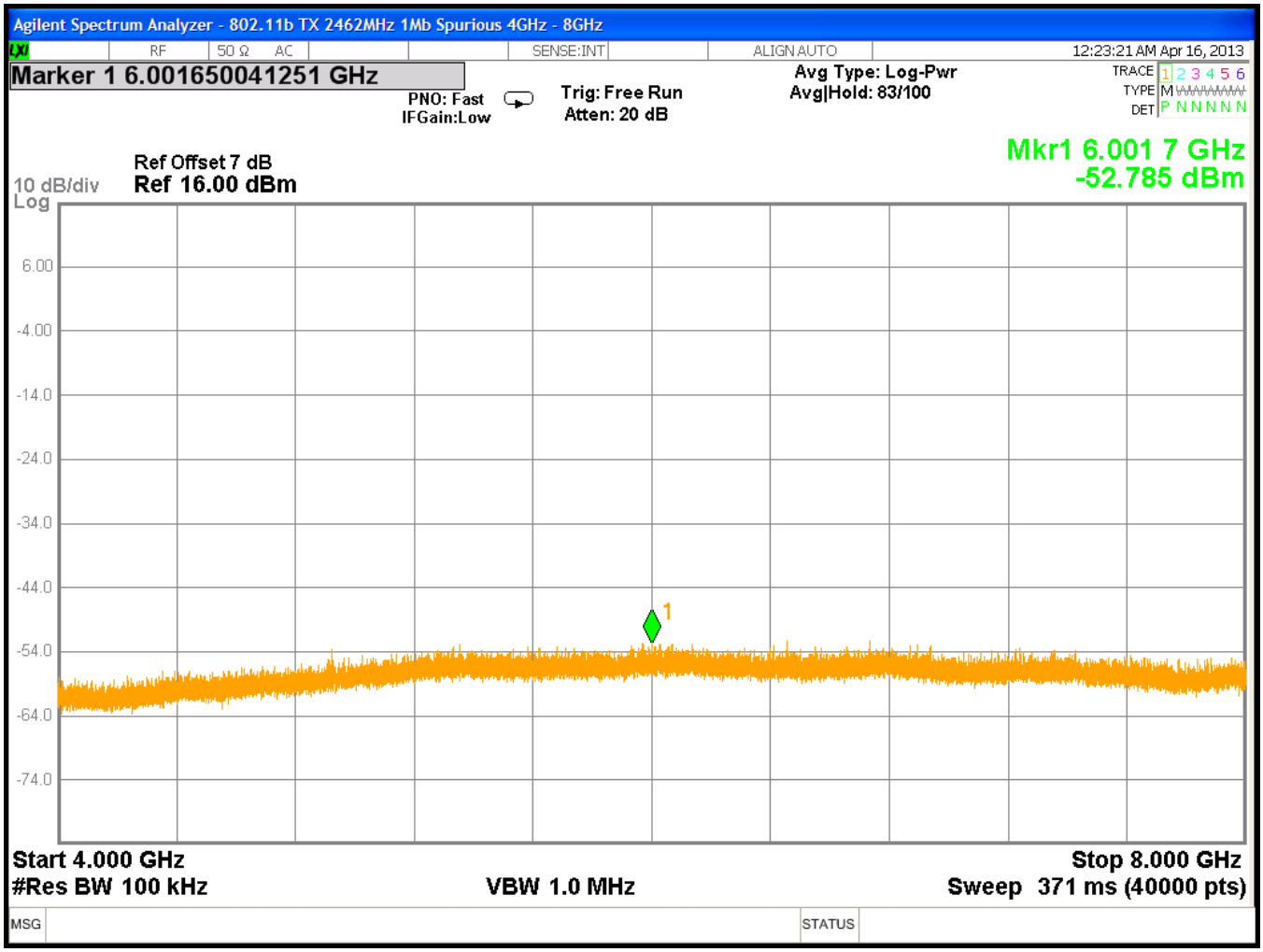

Figure 52: Conducted Spurious Emissions, 2462MHz, 1Mbps, 4 – 8GHz

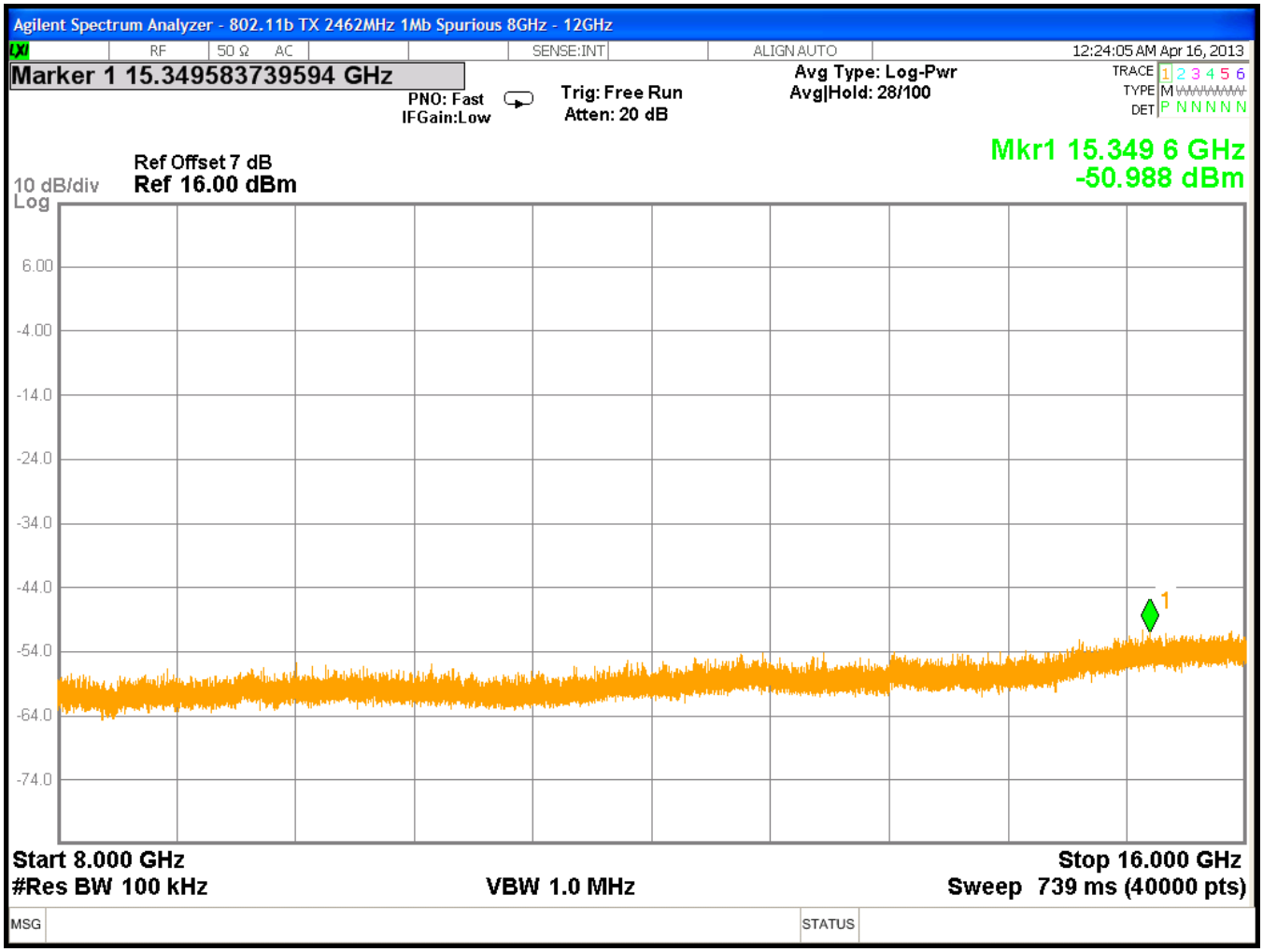

Figure 53: Conducted Spurious Emissions, 2462MHz, 1Mbps, 8 - 12GHz

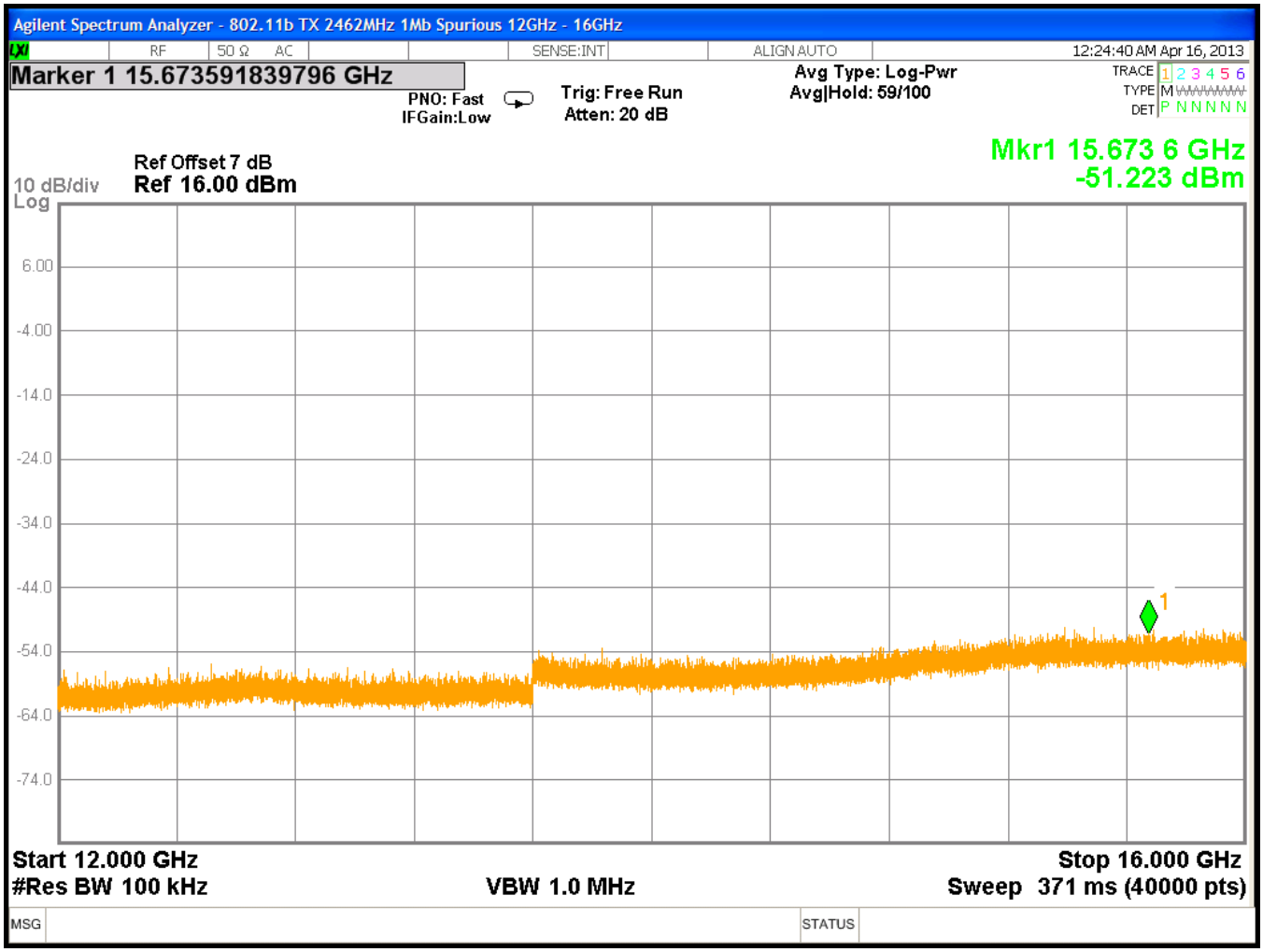

Figure 54: Conducted Spurious Emissions, 2462MHz, 1Mbps, 12 - 16GHz

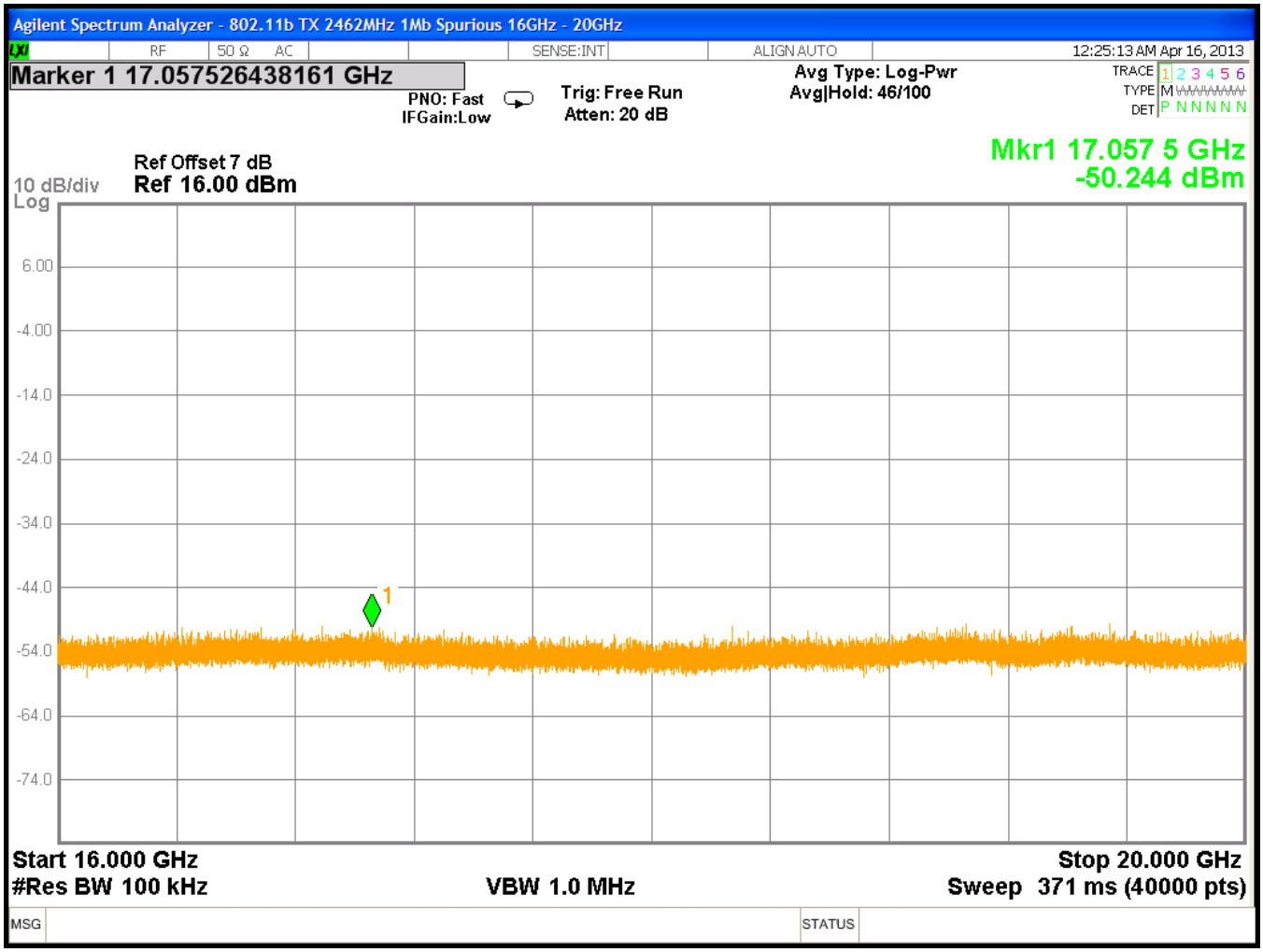

Figure 55: Conducted Spurious Emissions, 2462MHz, 1Mbps, 16 - 20GHz

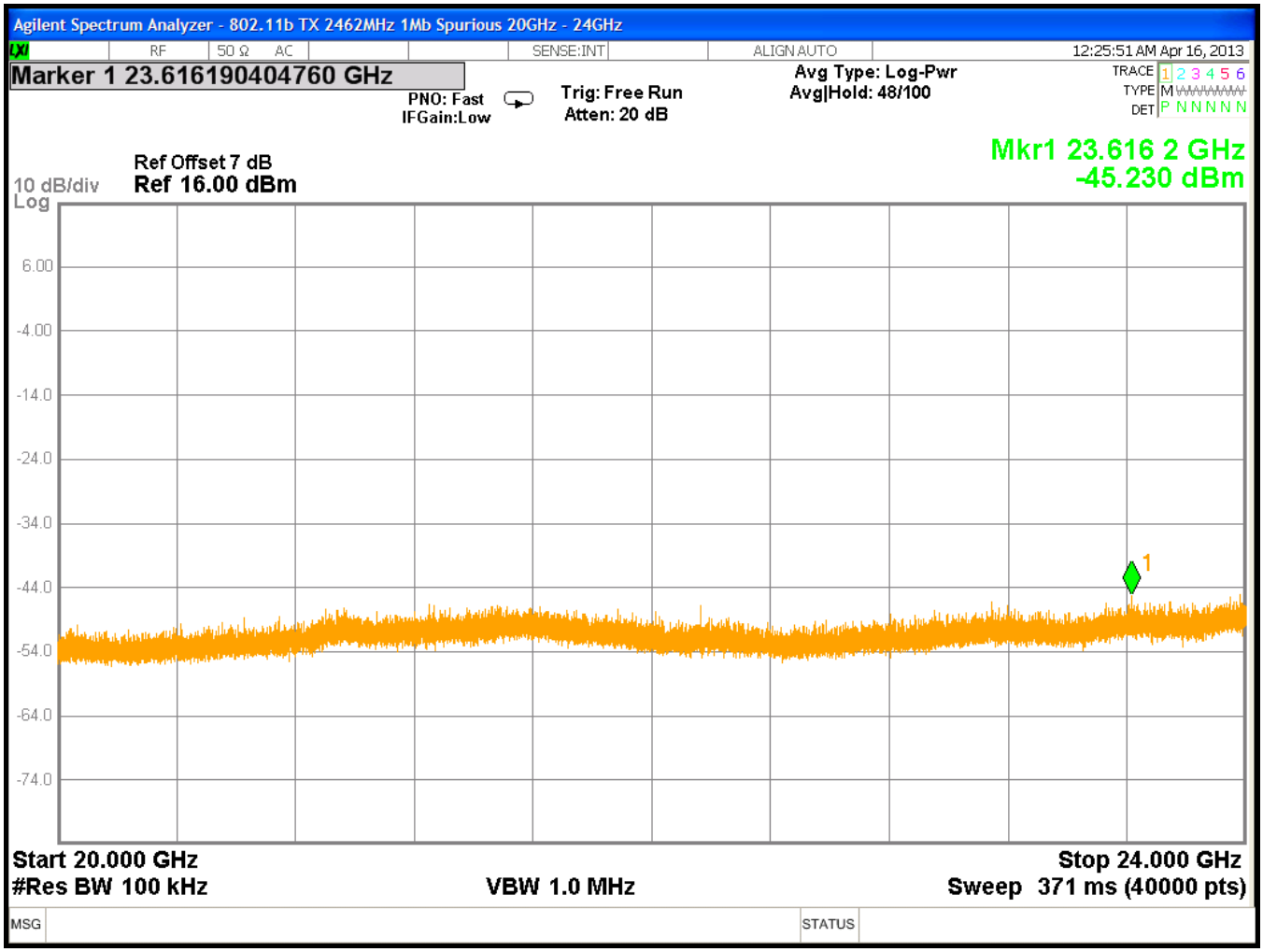

Figure 56: Conducted Spurious Emissions, 2462MHz, 1Mbps, 20 - 24GHz

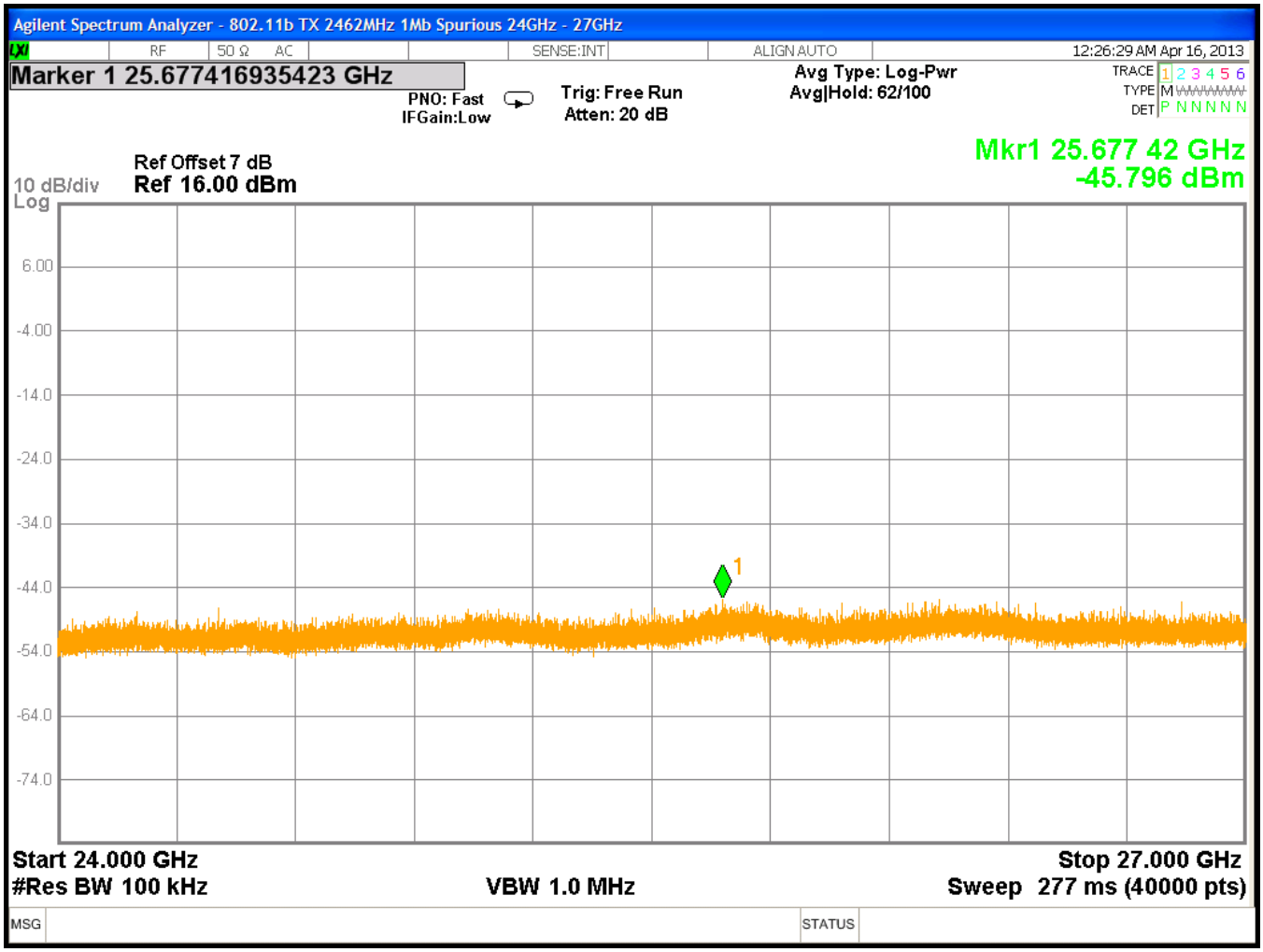

Figure 57: Conducted Spurious Emissions, 2462MHz, 1Mbps, 24 - 27GHz

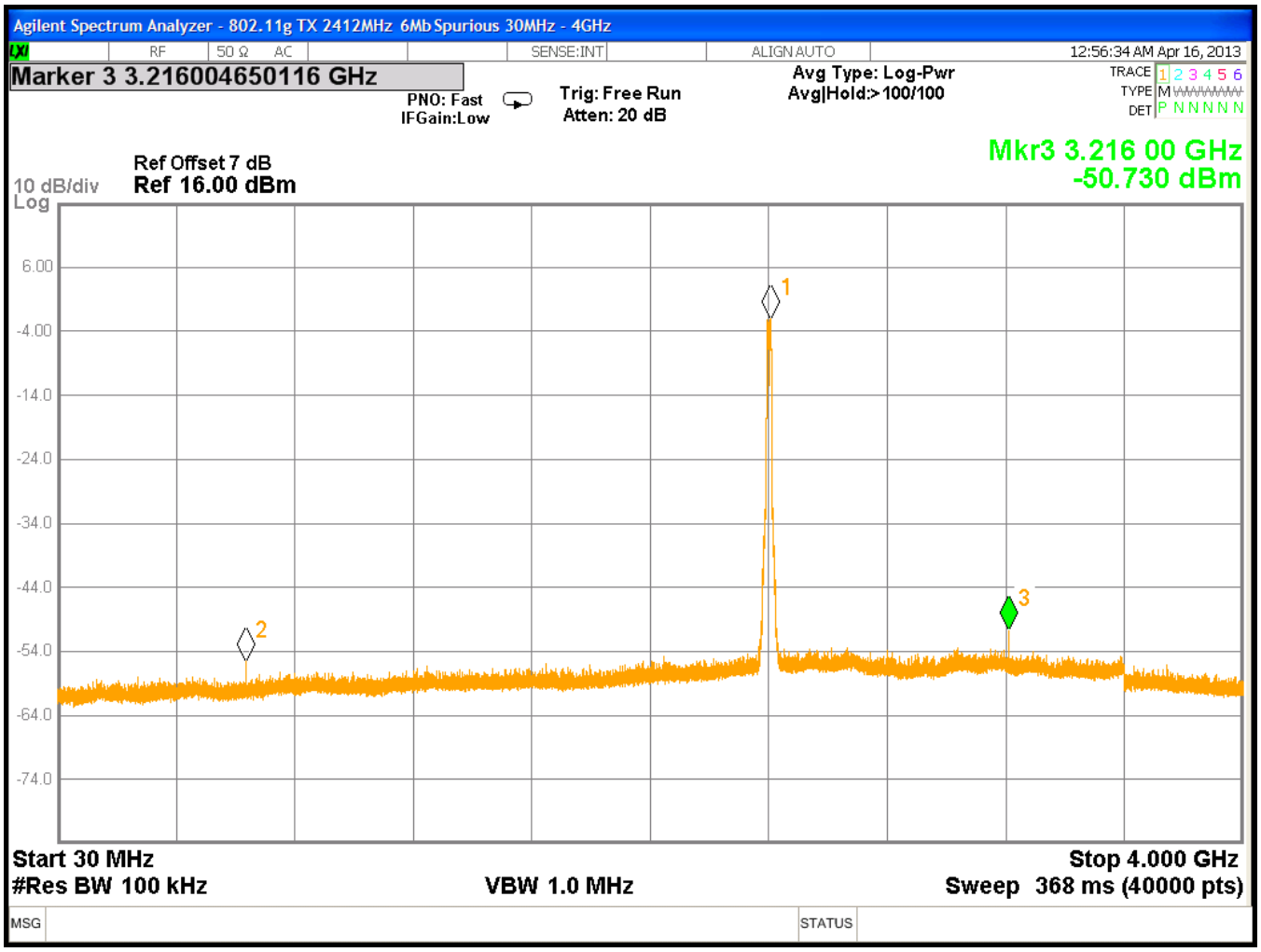

Figure 58: Conducted Spurious Emissions, 2412MHz, 6Mbps, 30MHz – 4GHz

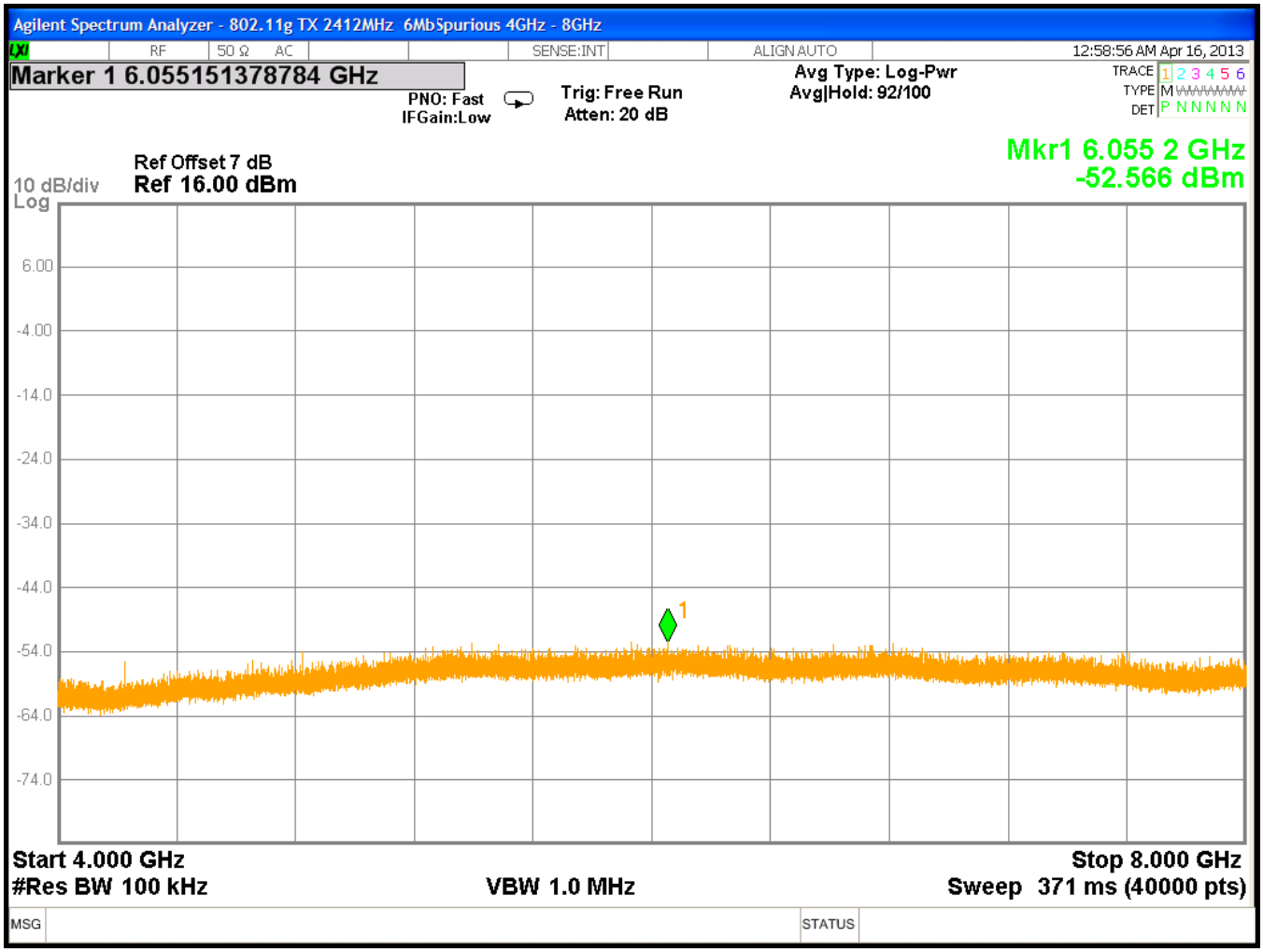

Figure 59: Conducted Spurious Emissions, 2412MHz, 6Mbps, 4 – 8GHz

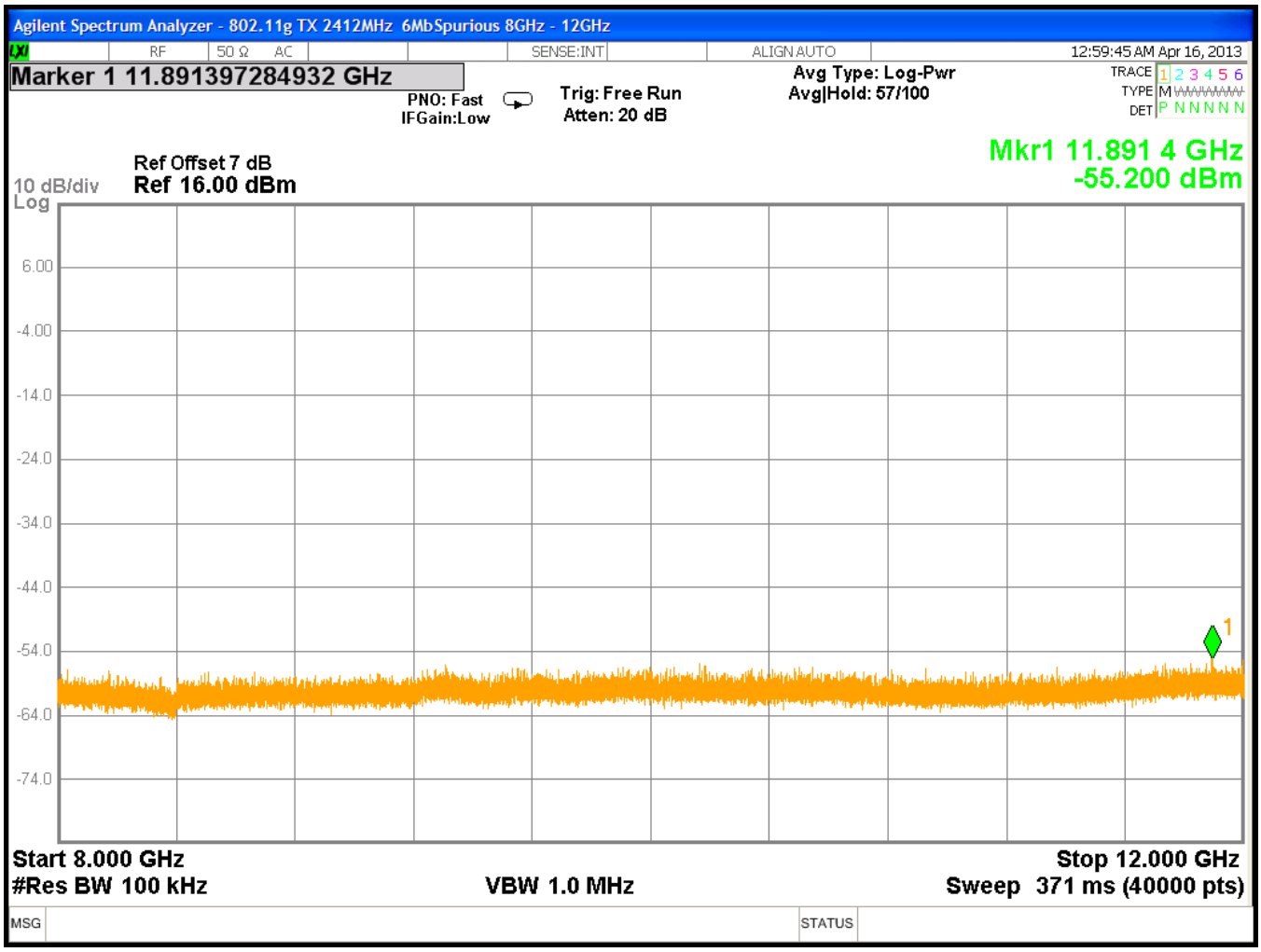

Figure 60: Conducted Spurious Emissions, 2412MHz, 6Mbps, 8 - 12GHz

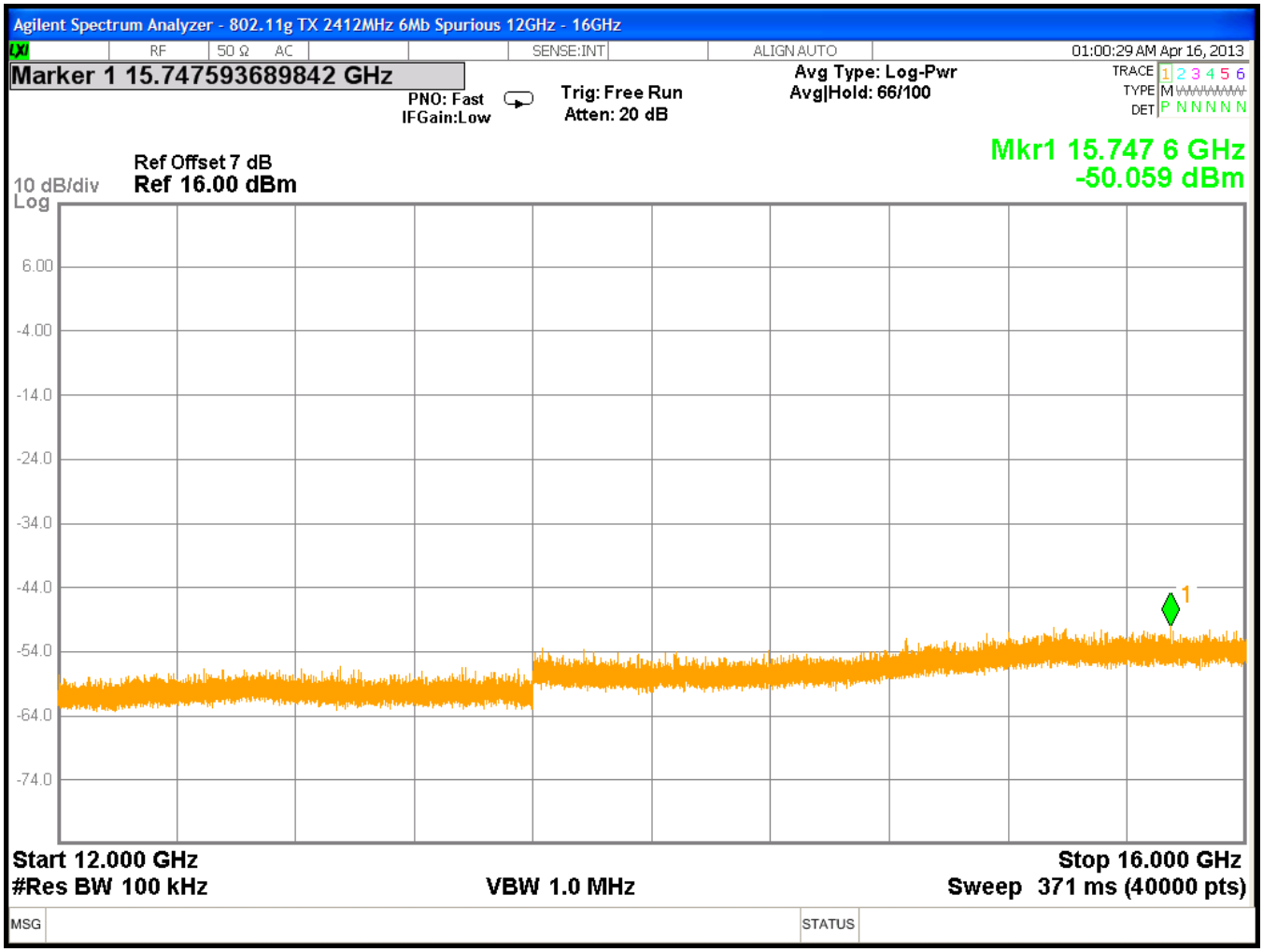

Figure 61: Conducted Spurious Emissions, 2412MHz, 6Mbps, 12 - 16GHz

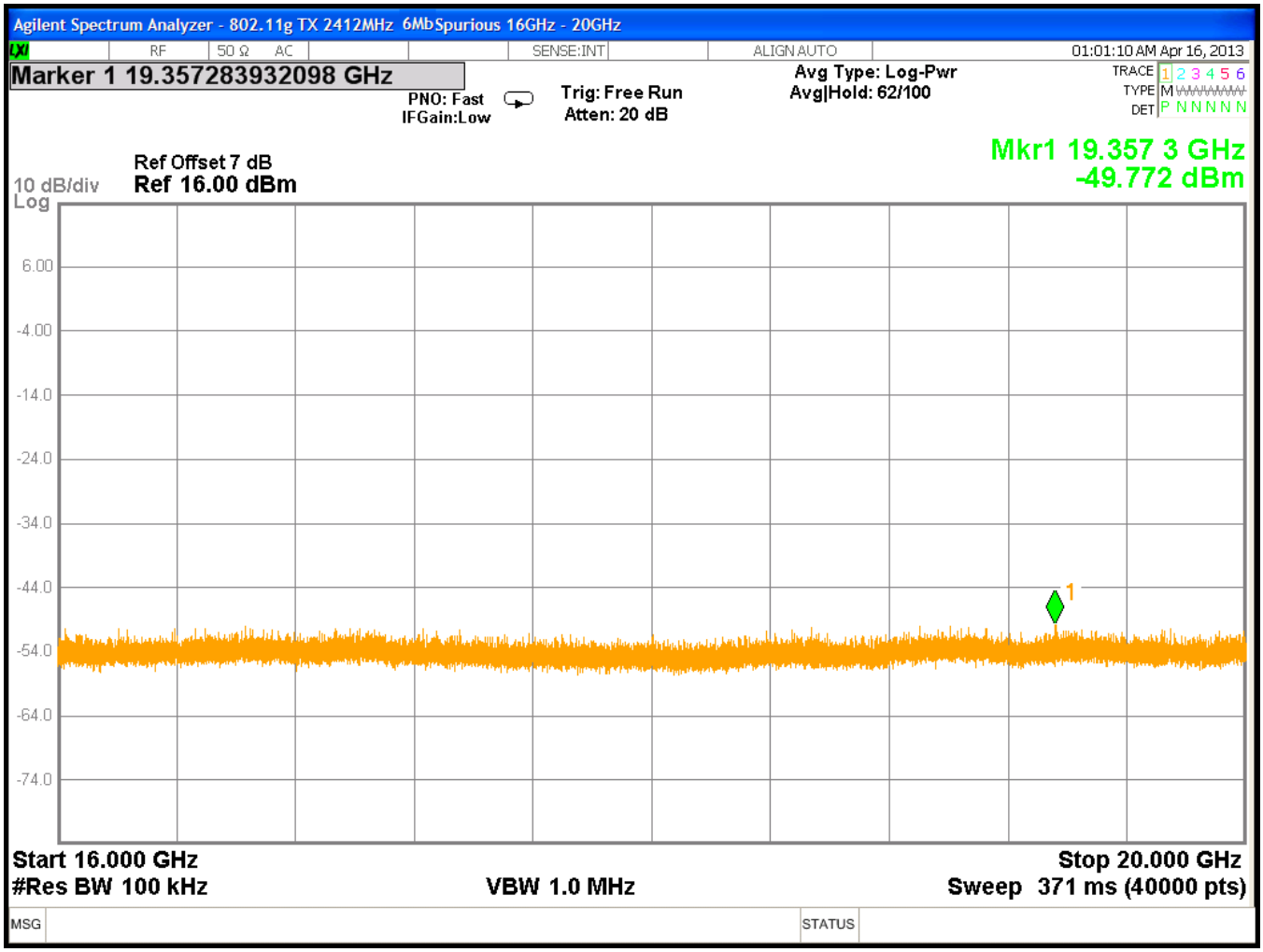

Figure 62: Conducted Spurious Emissions, 2412MHz, 6Mbps, 16 - 20GHz

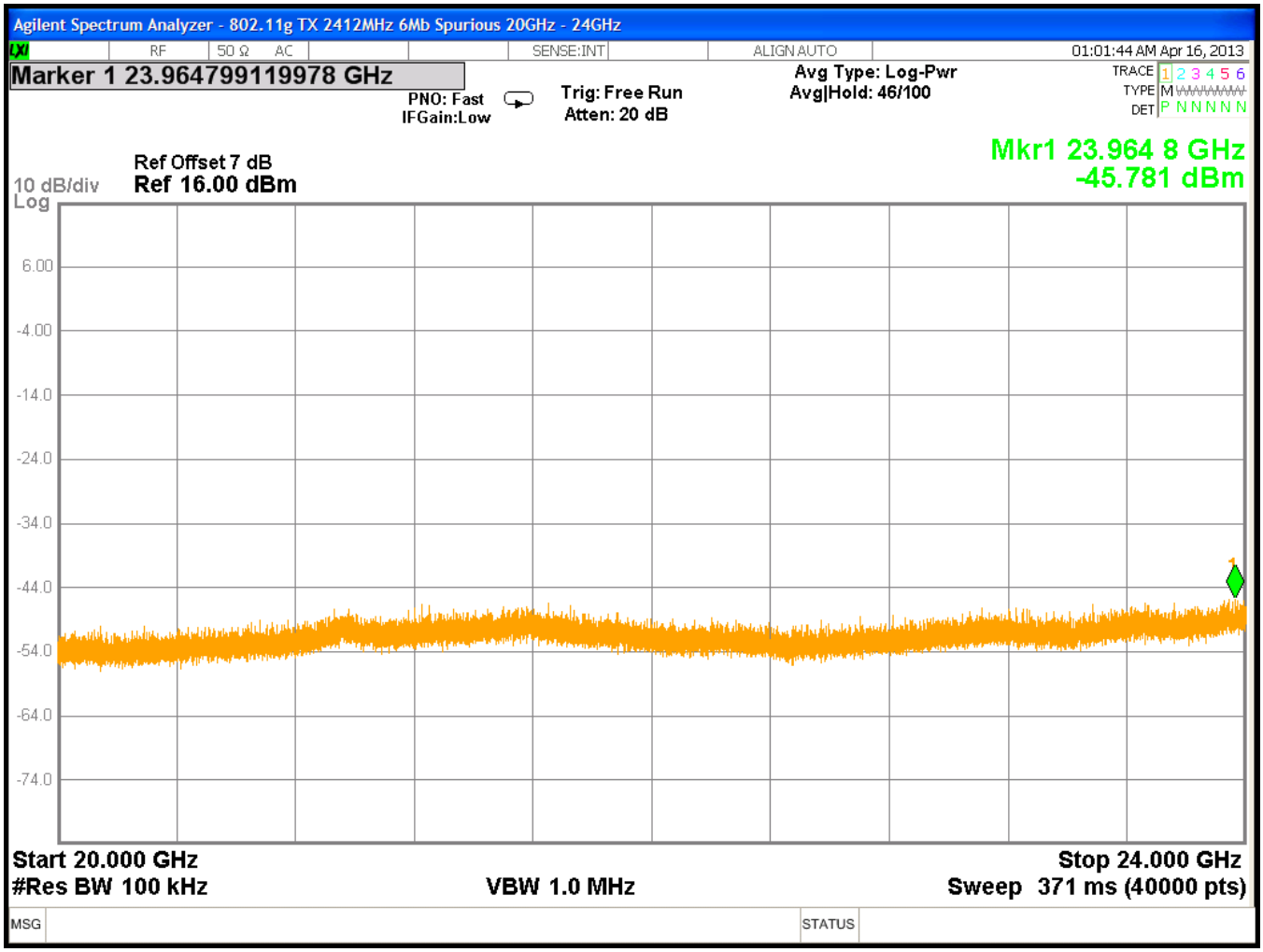

Figure 63: Conducted Spurious Emissions, 2412MHz, 6Mbps, 20 - 24GHz

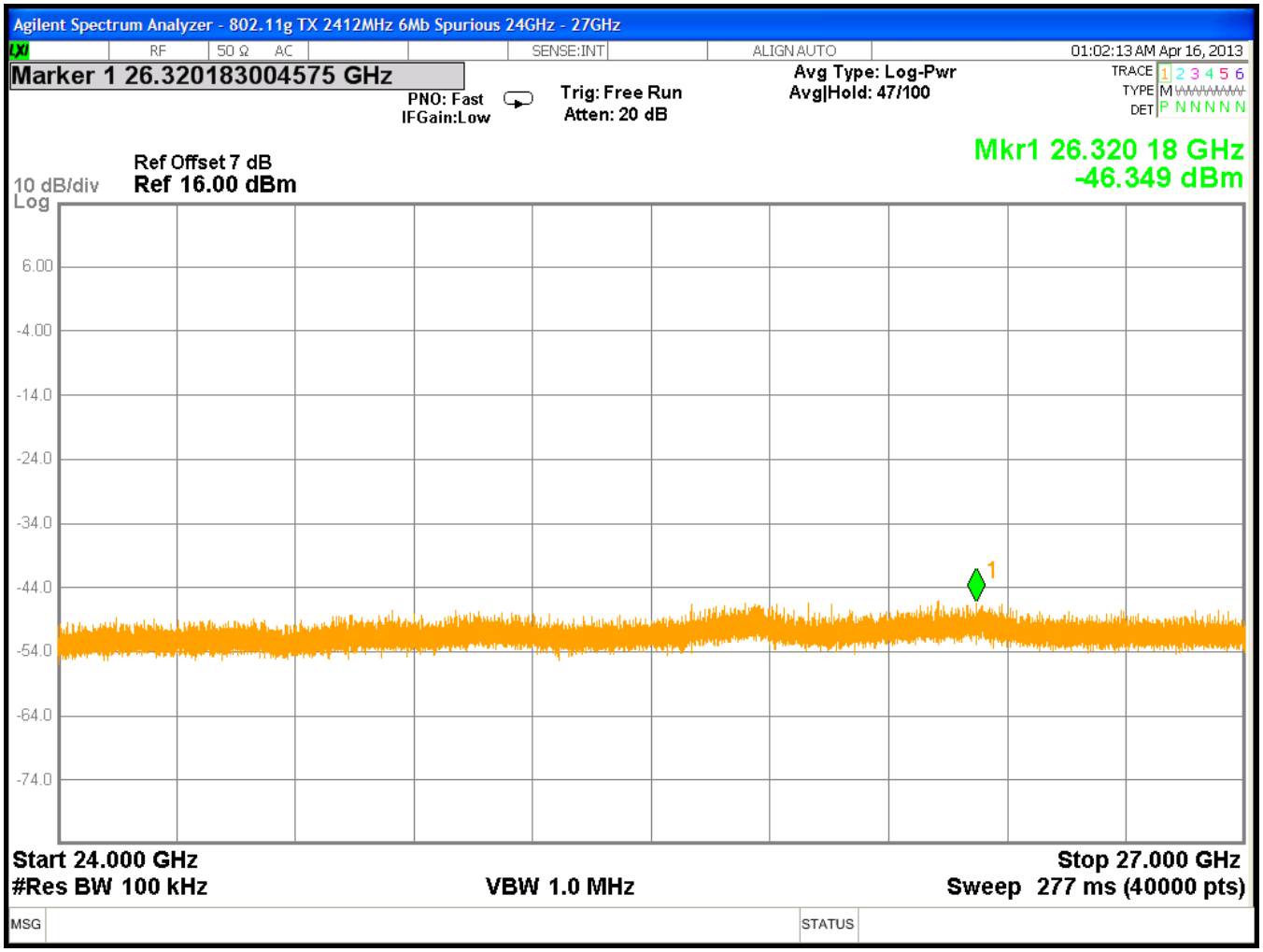

Figure 64: Conducted Spurious Emissions, 2412MHz, 6Mbps, 24 - 27GHz

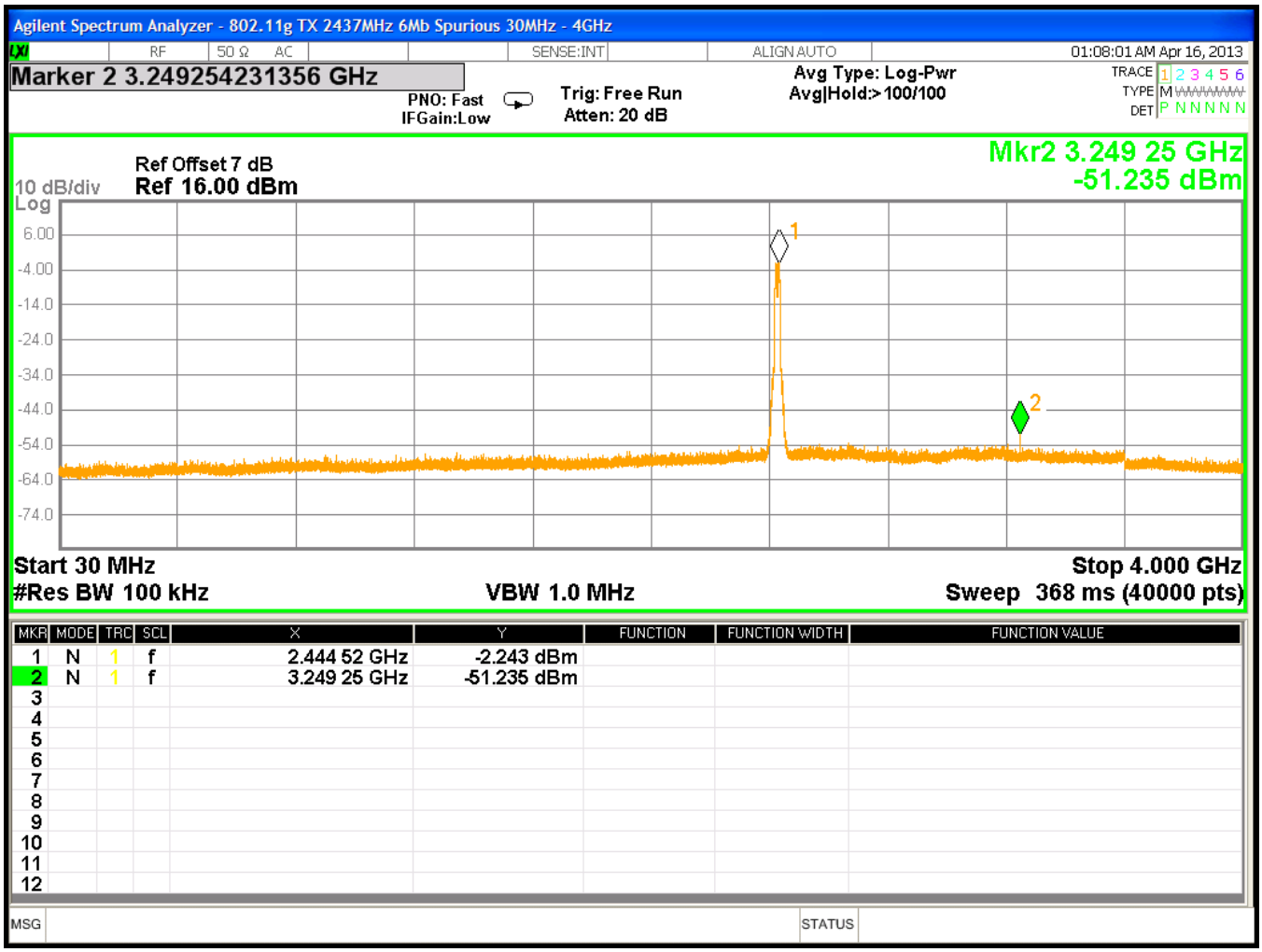

Figure 65: Conducted Spurious Emissions, 2437MHz, 6Mbps, 30MHz – 4GHz

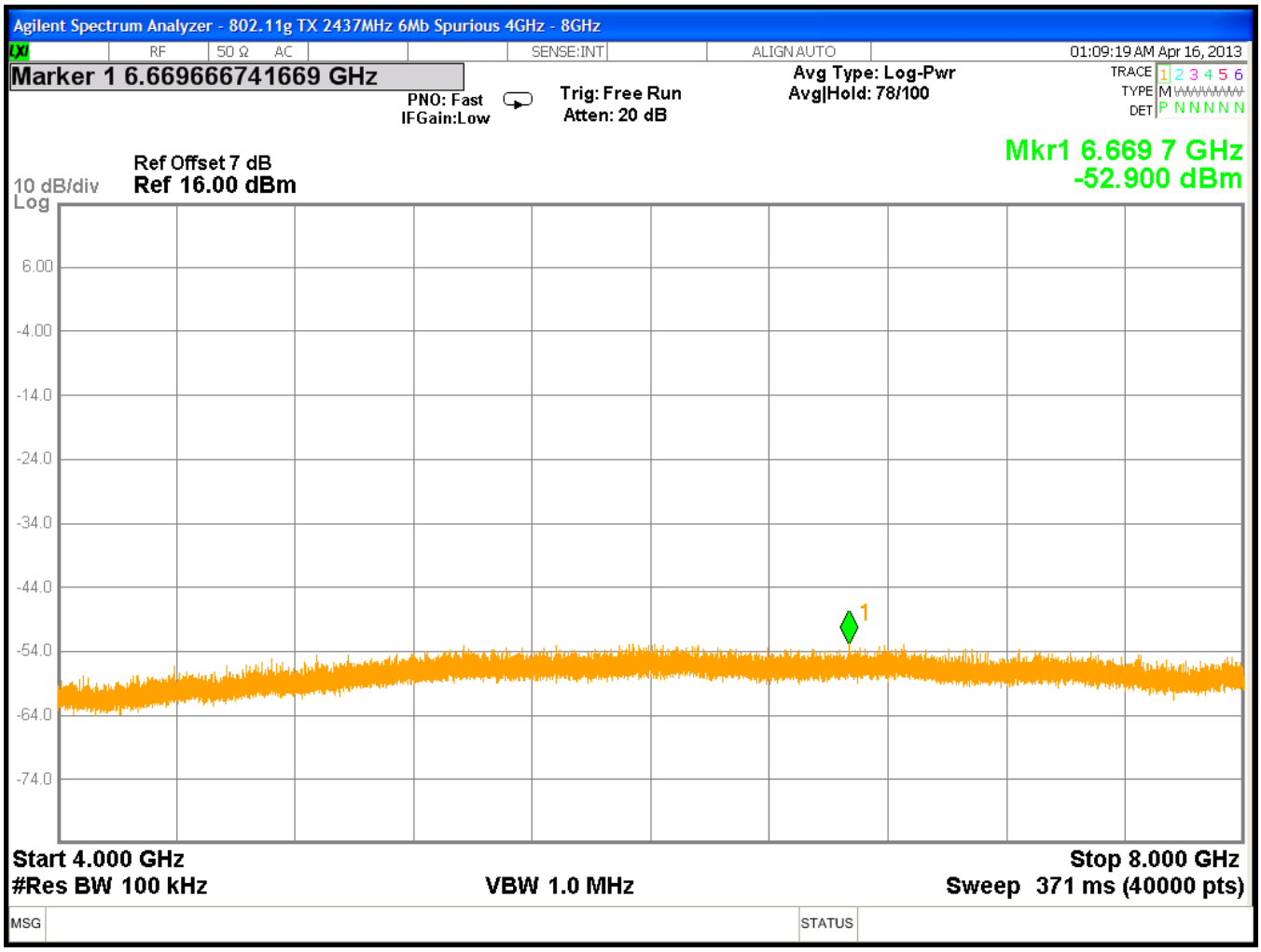

Figure 66: Conducted Spurious Emissions, 2437MHz, 6Mbps, 4 – 8GHz

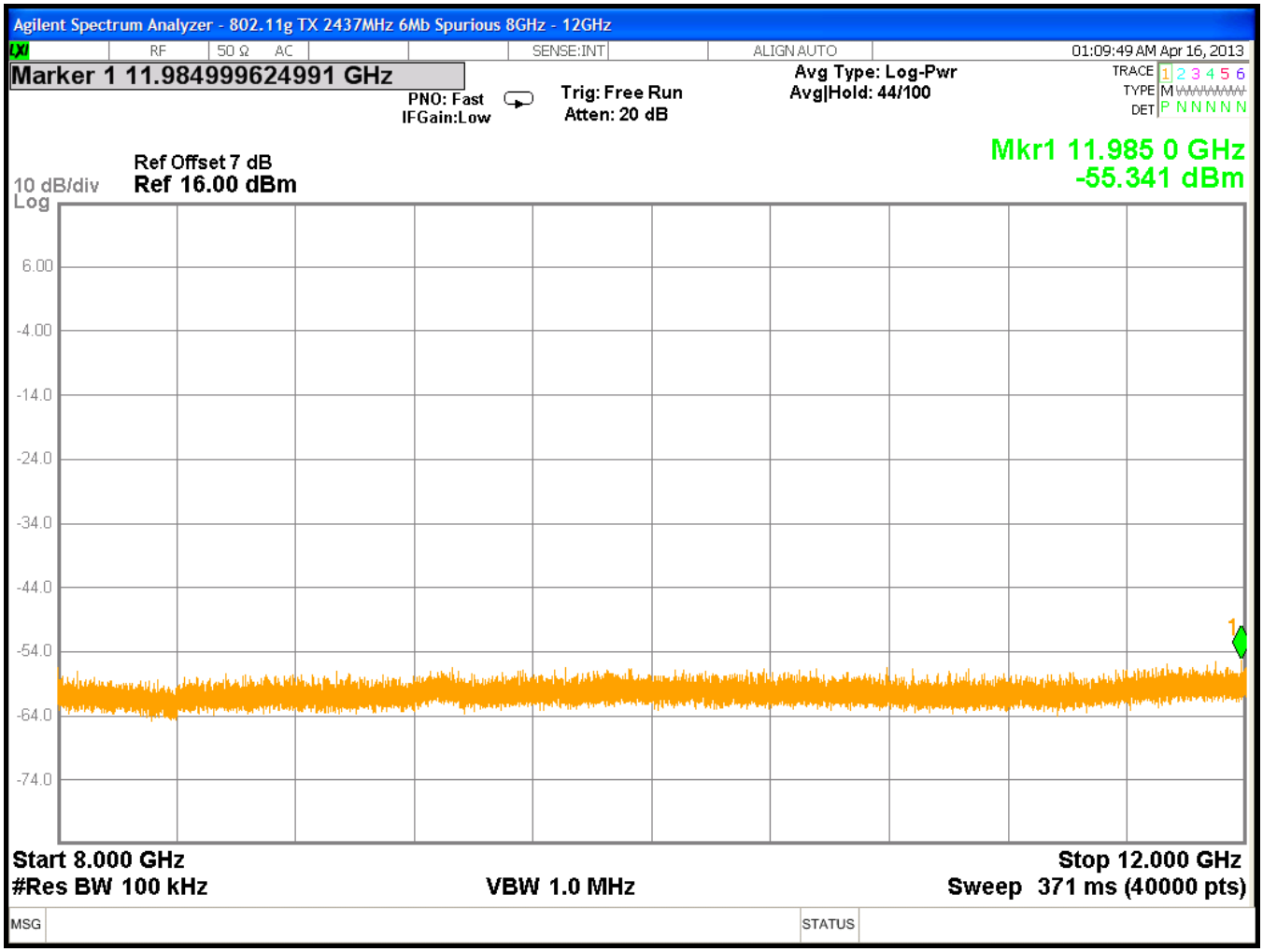

Figure 67: Conducted Spurious Emissions, 2437MHz, 6Mbps, 8 - 12GHz

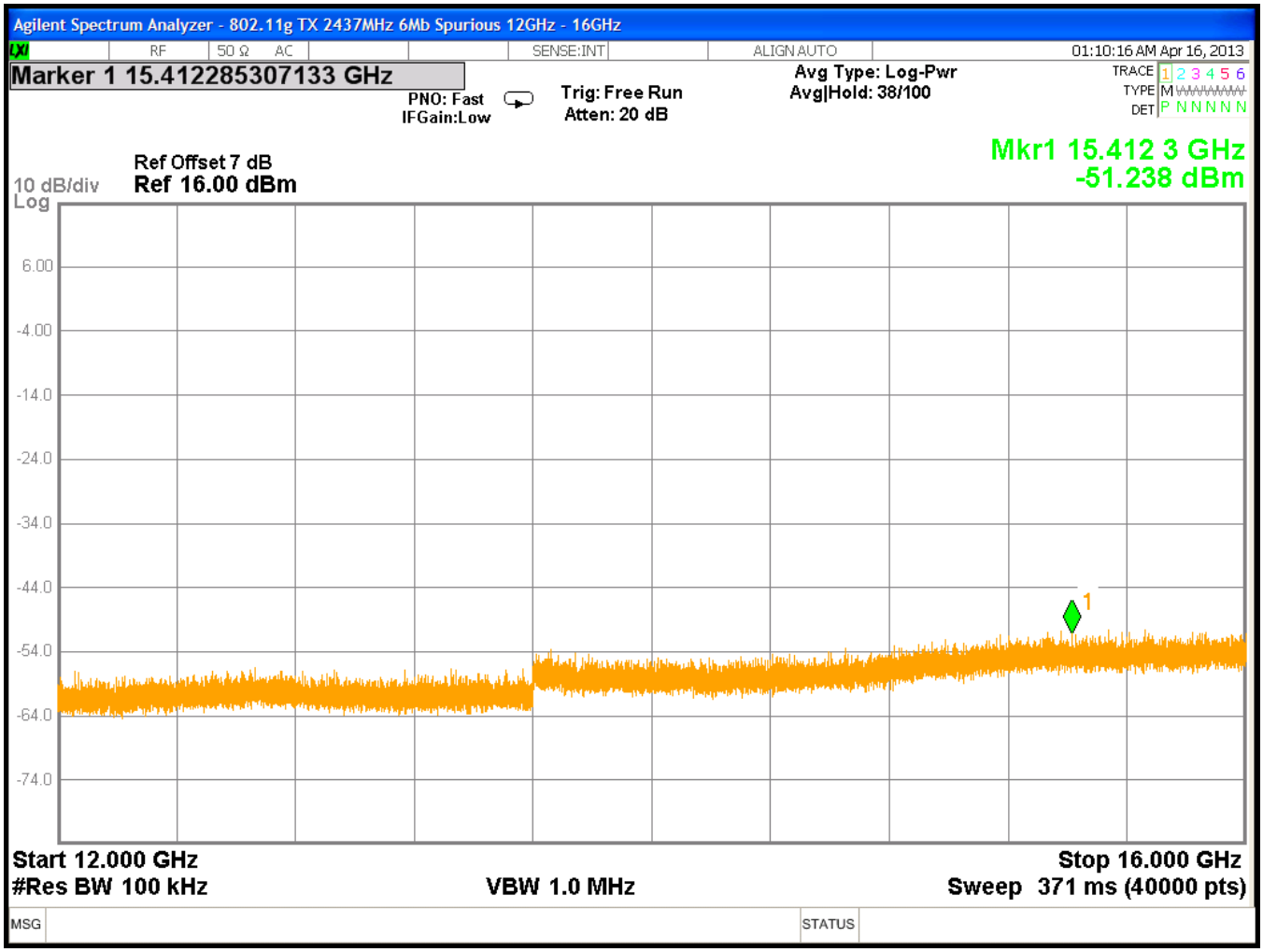

Figure 68: Conducted Spurious Emissions, 2437MHz, 6Mbps, 12 - 16GHz

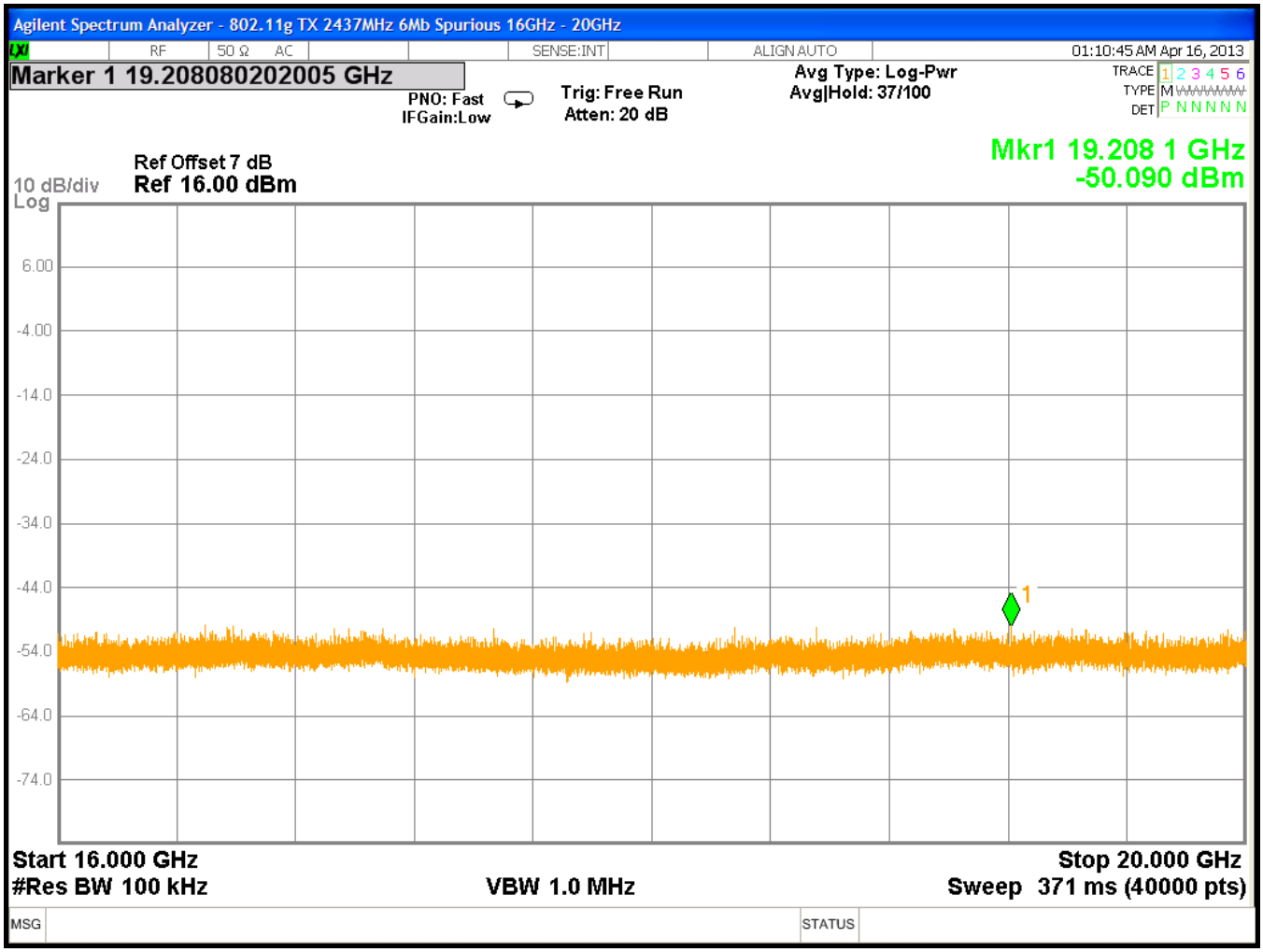

Figure 69: Conducted Spurious Emissions, 2437MHz, 6Mbps, 16 - 20GHz

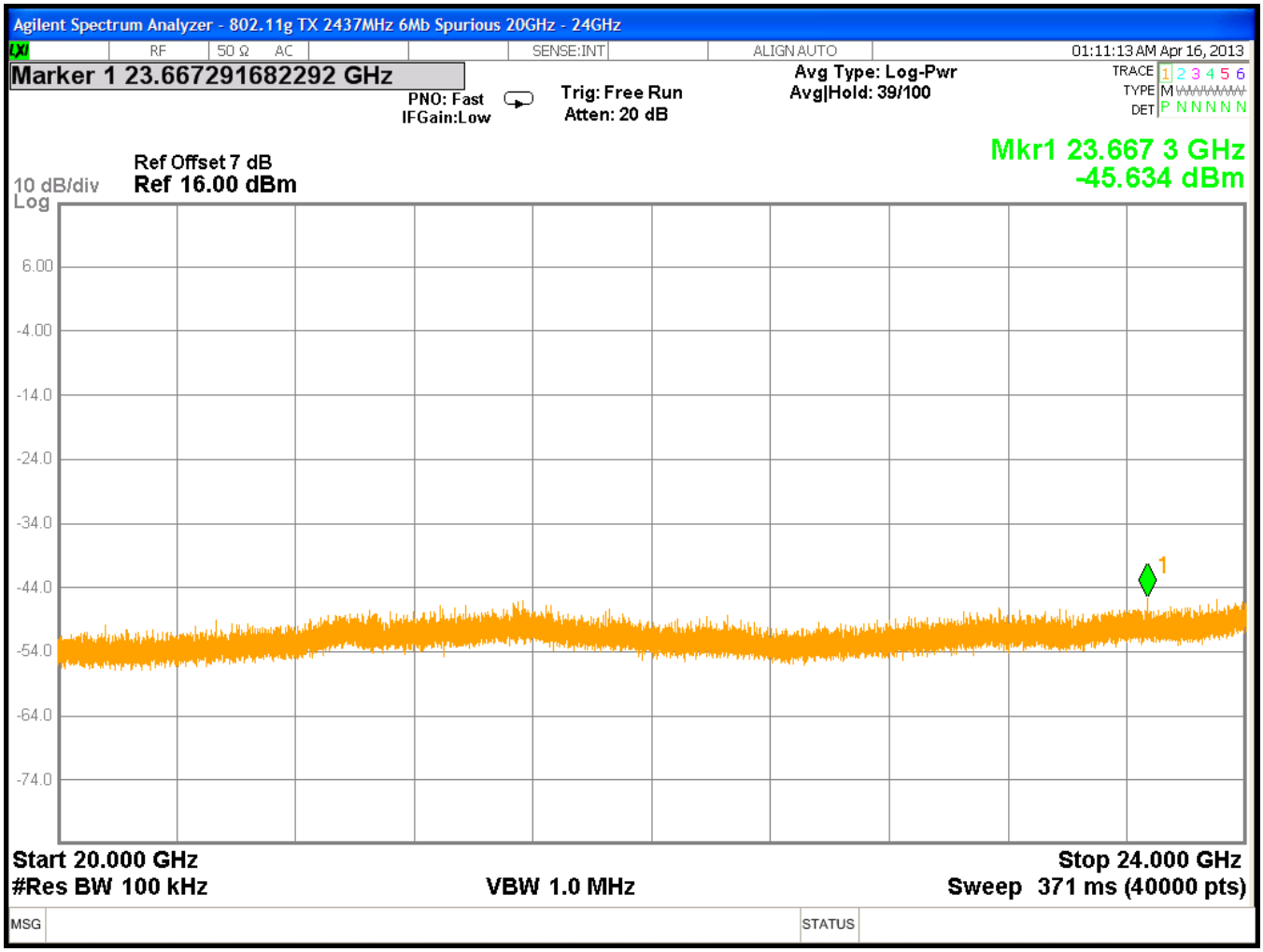

Figure 70: Conducted Spurious Emissions, 2437MHz, 6Mbps, 20 - 24GHz

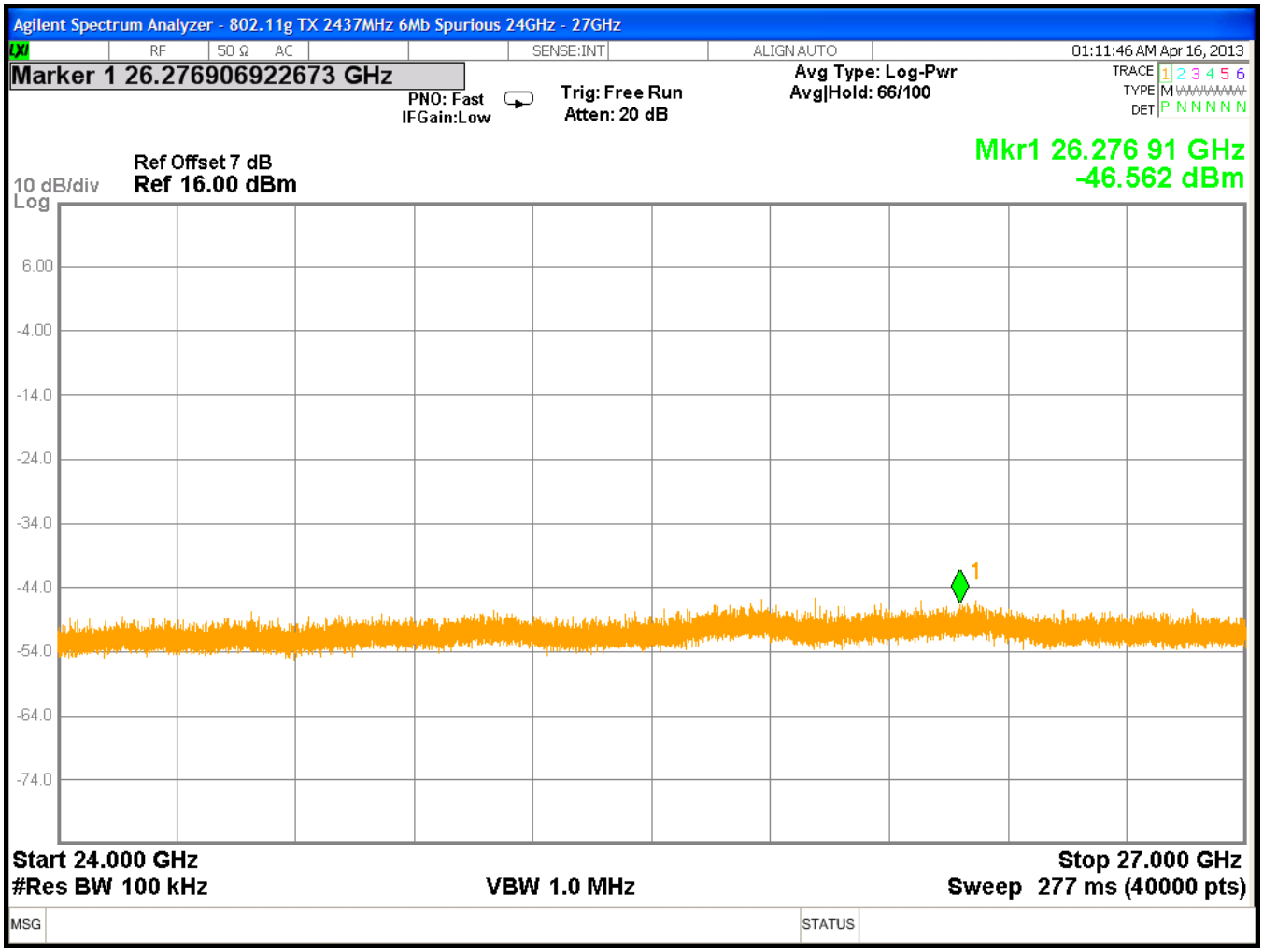

Figure 71: Conducted Spurious Emissions, 2437MHz, 6Mbps, 24 - 27GHz

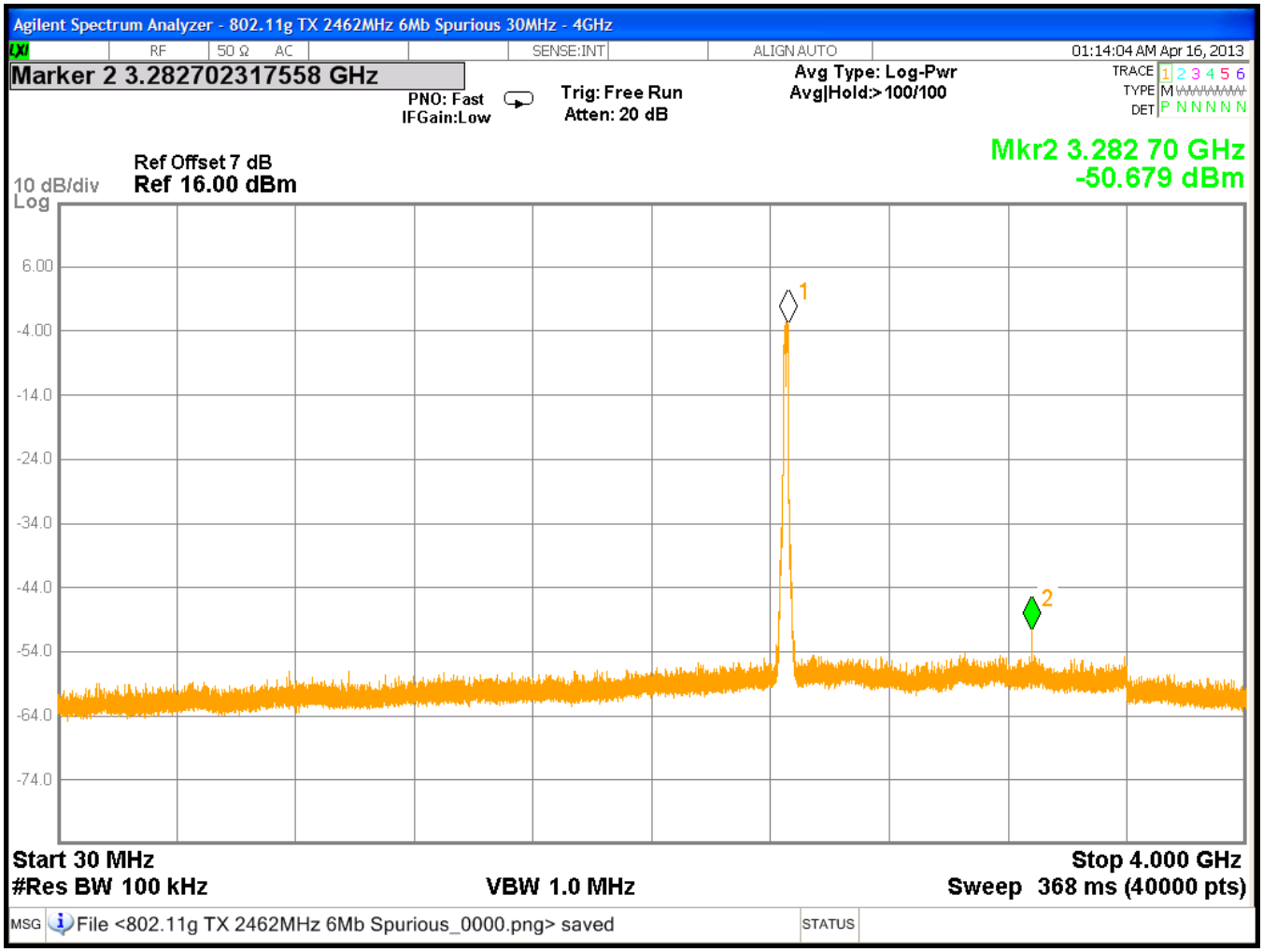

Figure 72: Conducted Spurious Emissions, 2437MHz, 6Mbps, 30MHz – 4GHz

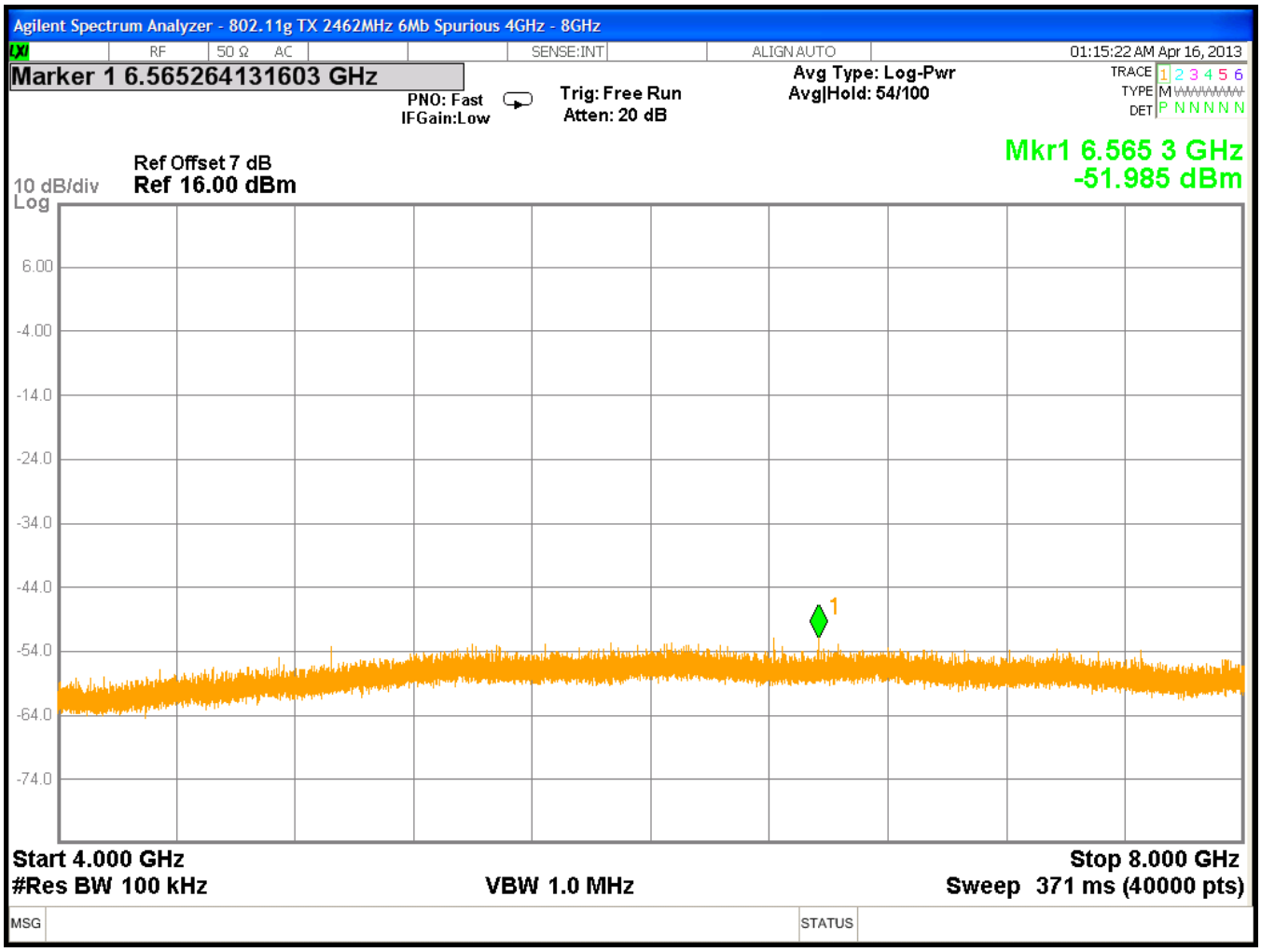

Figure 73: Conducted Spurious Emissions, 2462MHz, 6Mbps, 4 – 8GHz

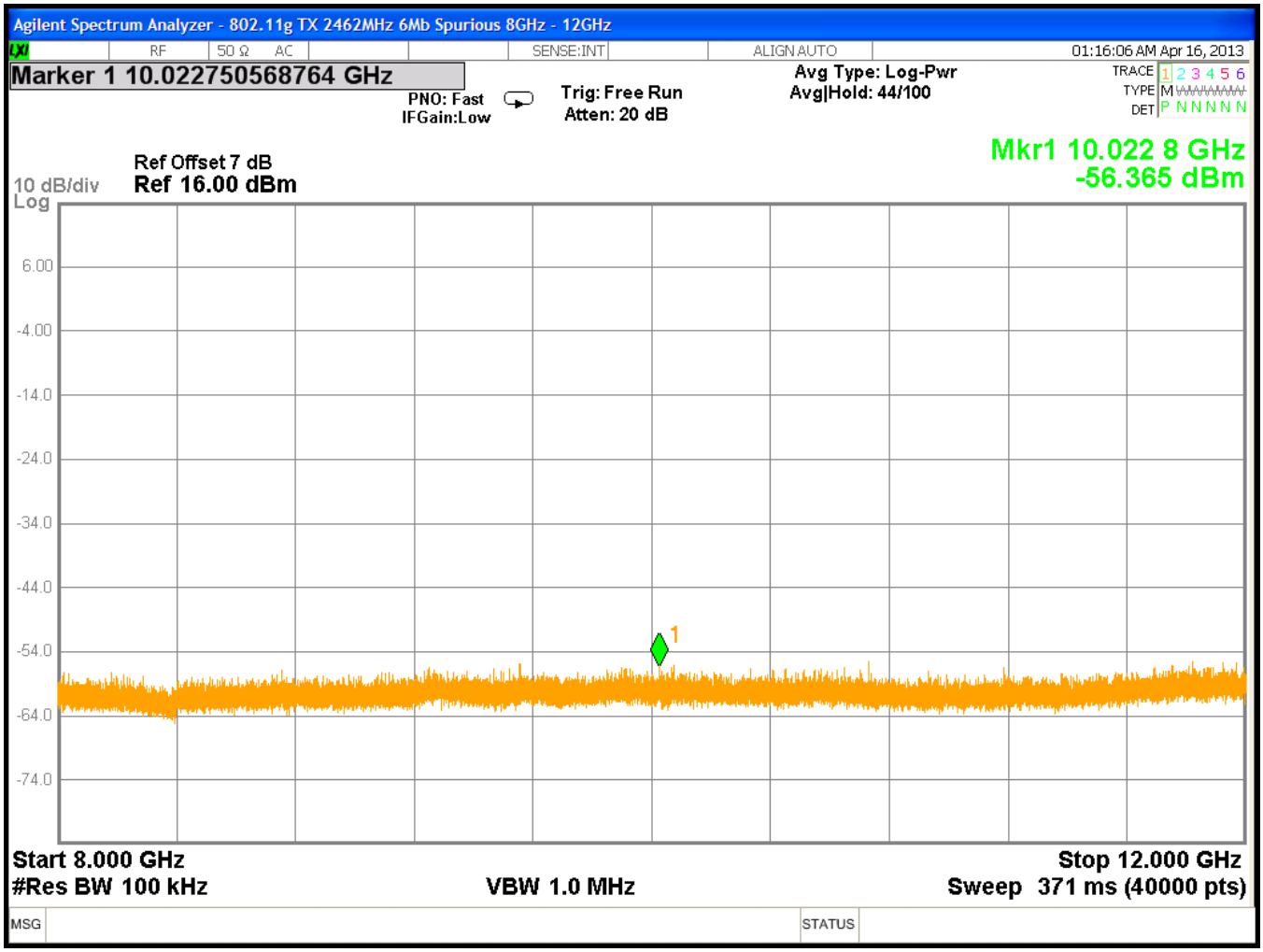

Figure 74: Conducted Spurious Emissions, 2462MHz, 6Mbps, 8 - 12GHz

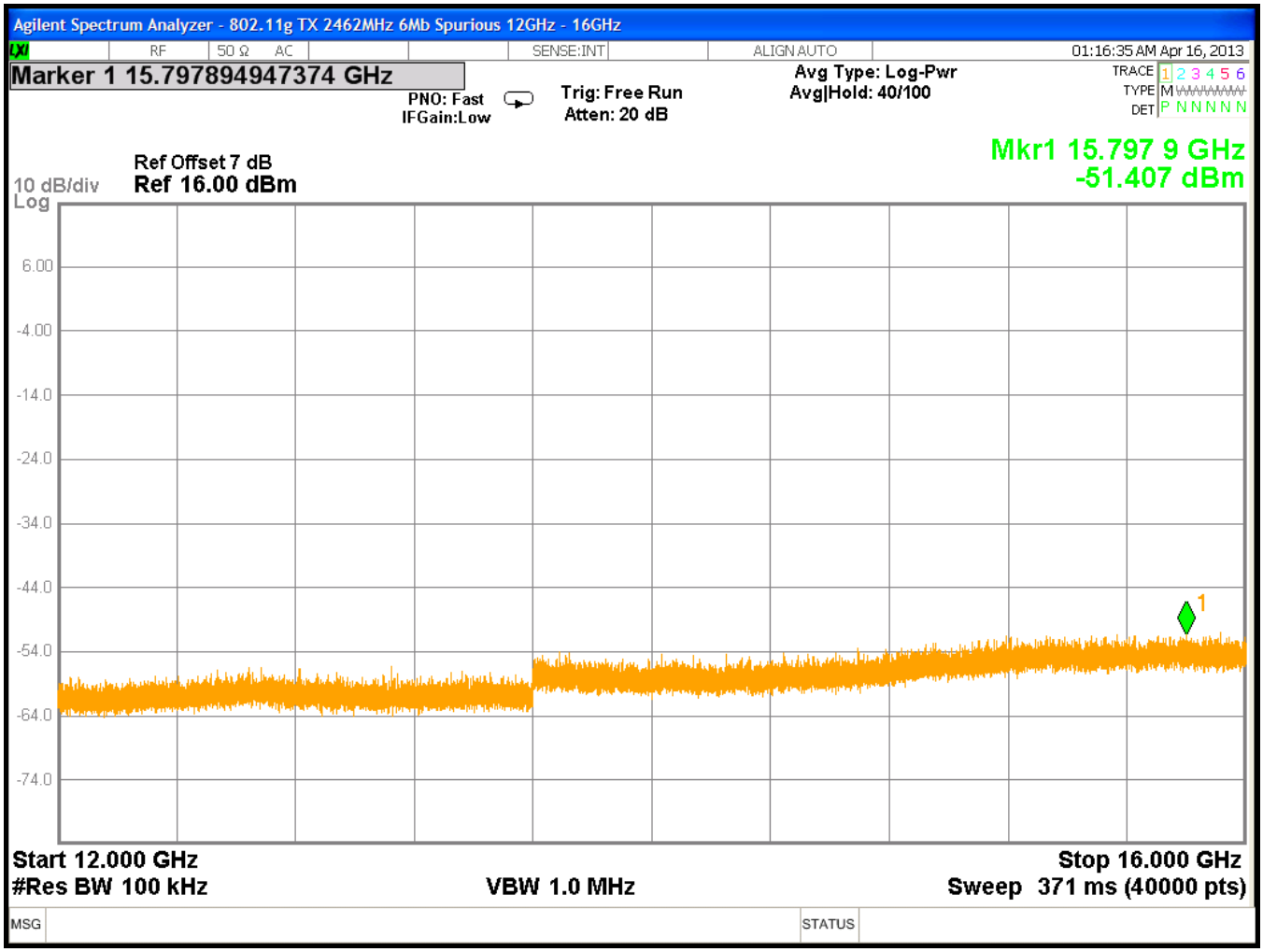

Figure 75: Conducted Spurious Emissions, 2462MHz, 6Mbps, 12 - 16GHz

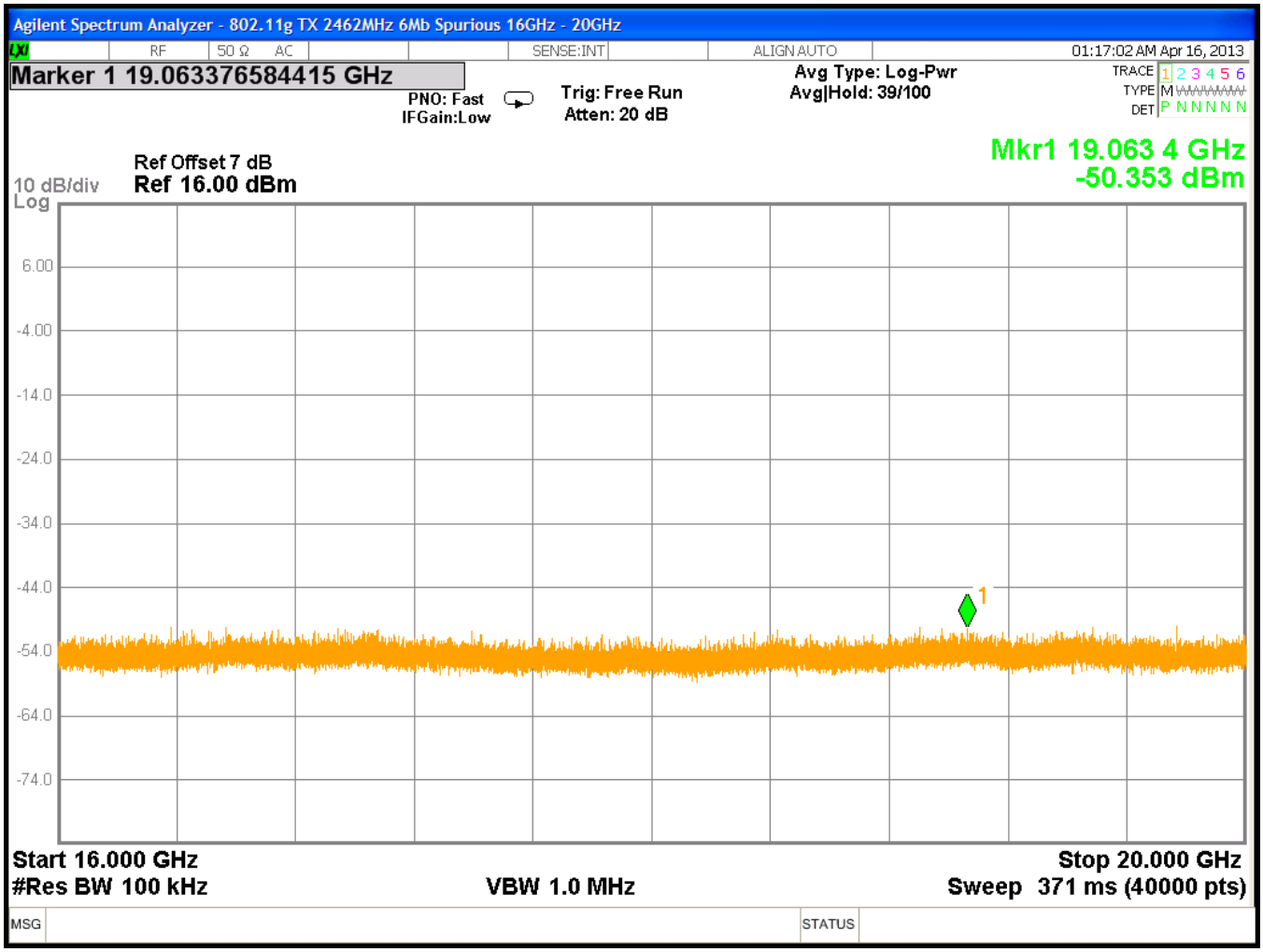

Figure 76: Conducted Spurious Emissions, 2462MHz, 6Mbps, 16 - 20GHz

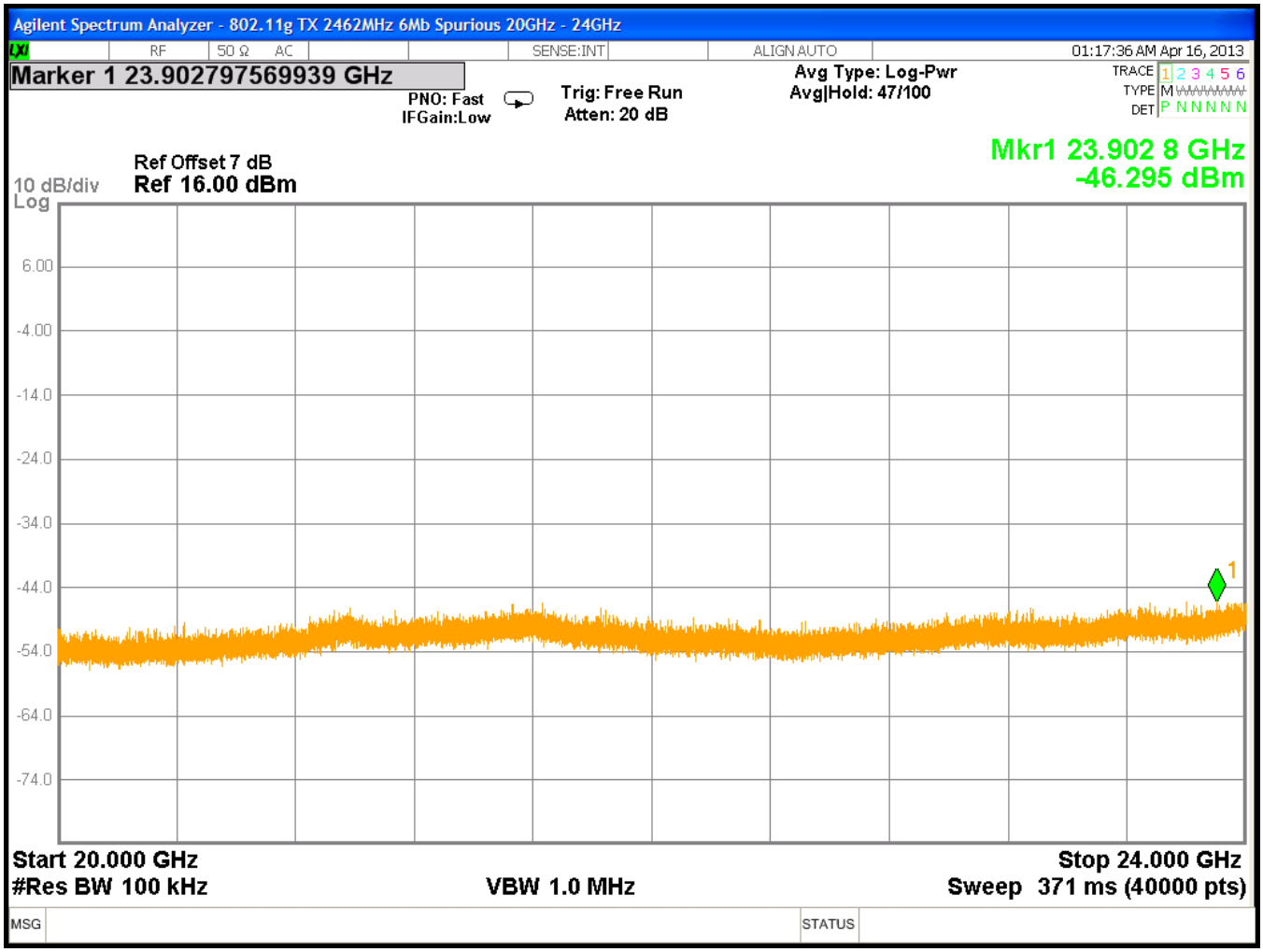

Figure 77: Conducted Spurious Emissions, 2462MHz, 6Mbps, 20 - 24GHz

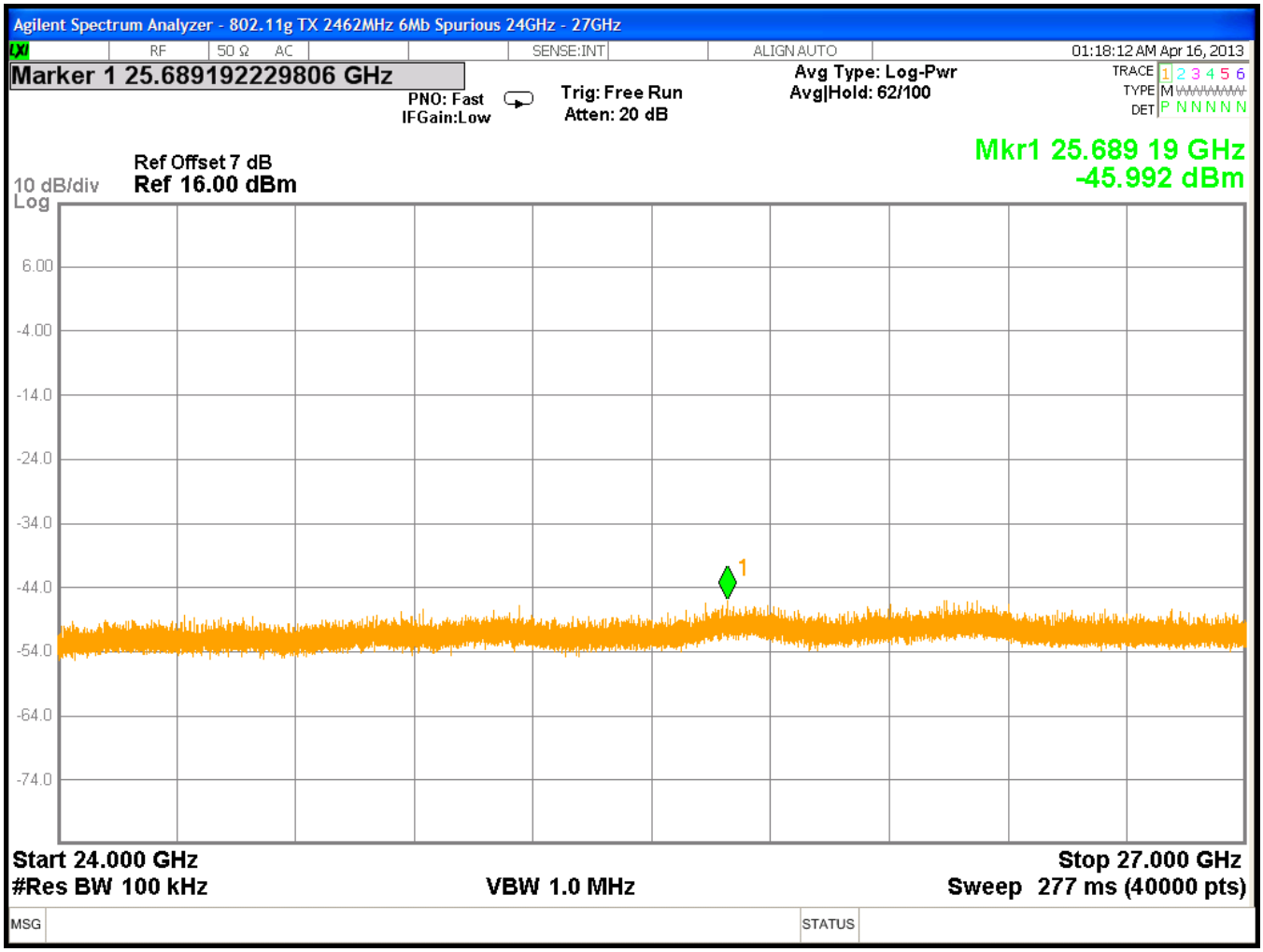

Figure 78: Conducted Spurious Emissions, 2462MHz, 6Mbps, 24 - 27GHz

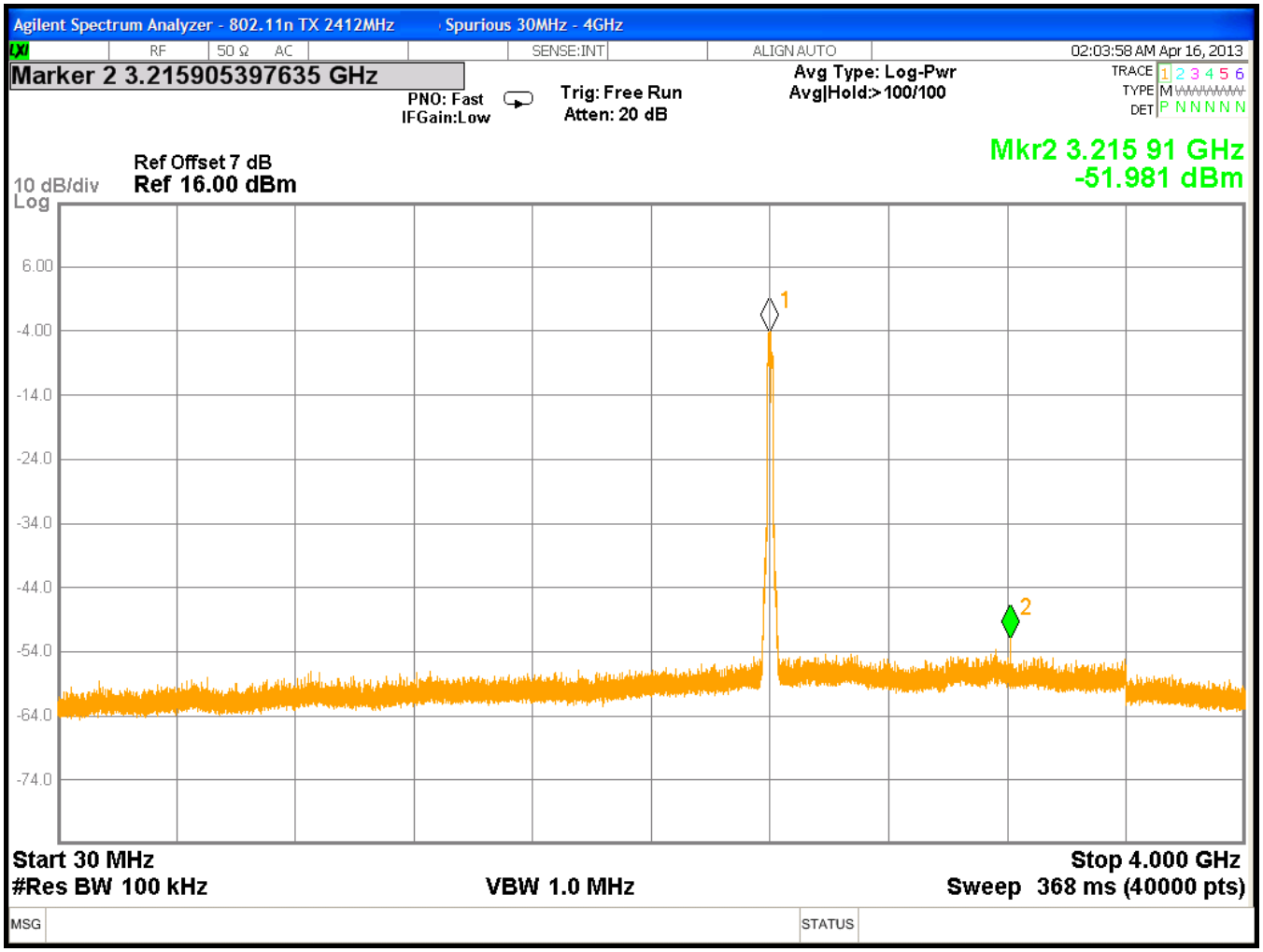

Figure 79: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 30MHz – 4GHz

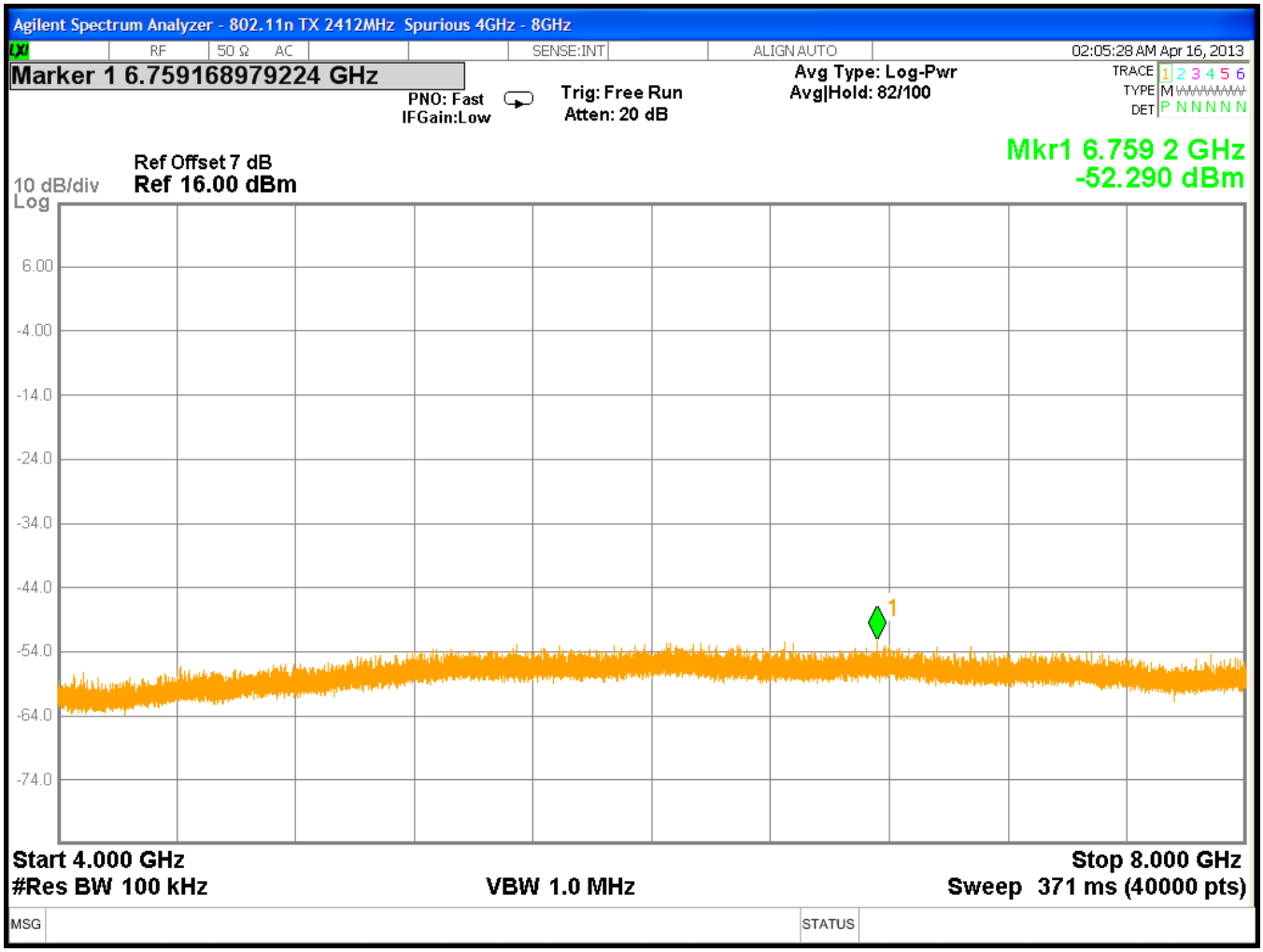

Figure 80: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 4 – 8GHz

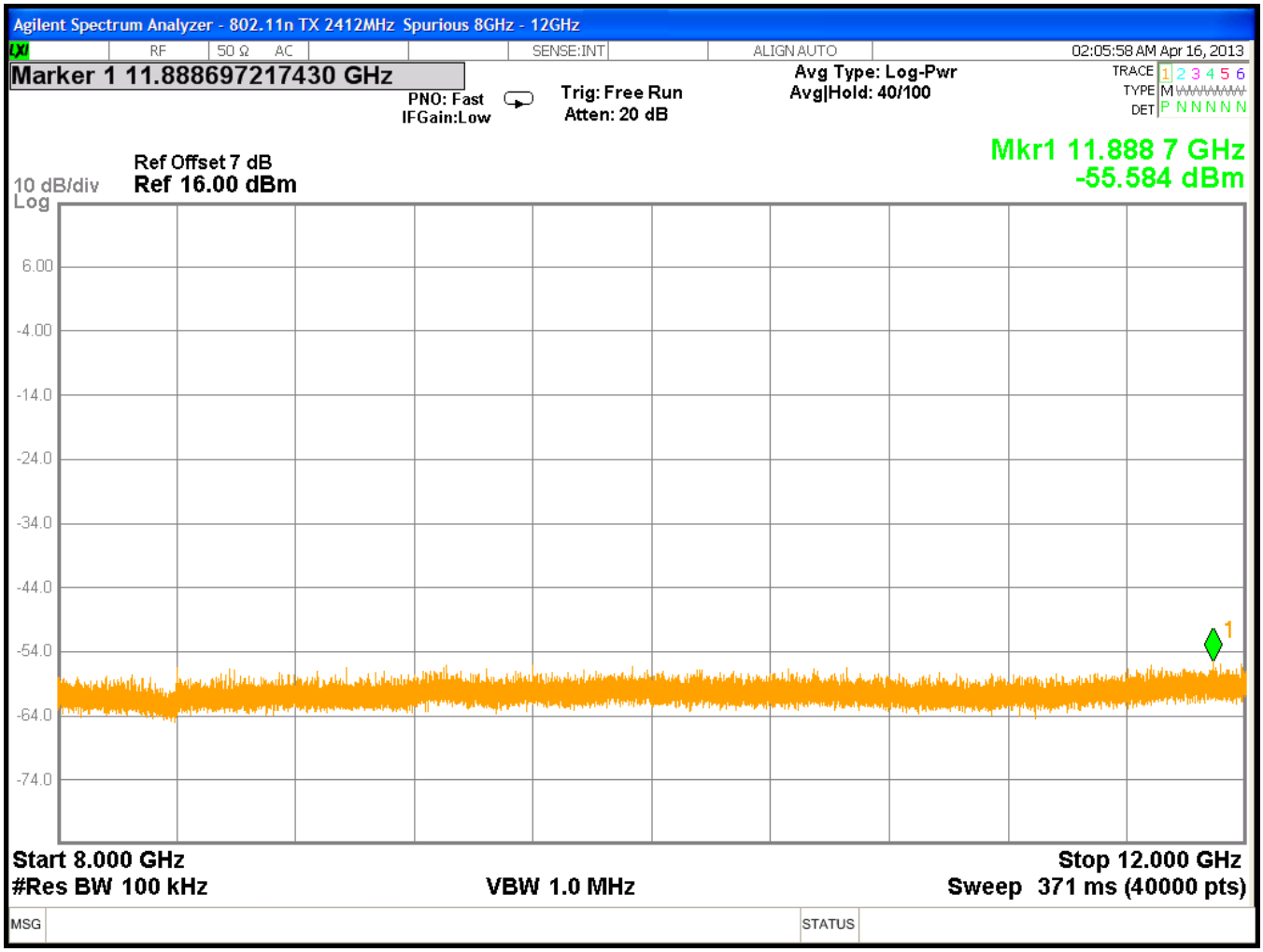

Figure 81: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 8 - 12GHz

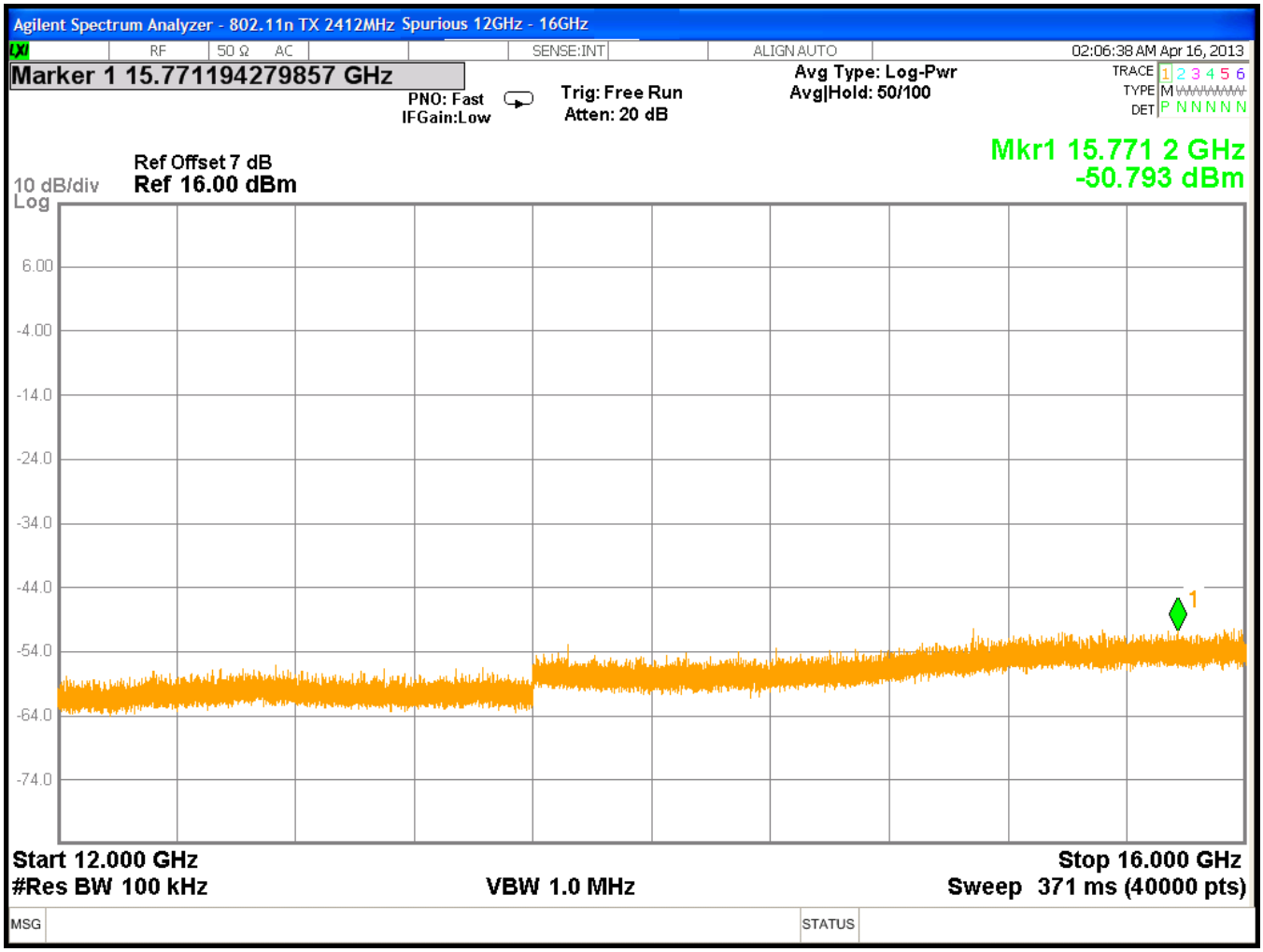

Figure 82: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 12 - 16GHz

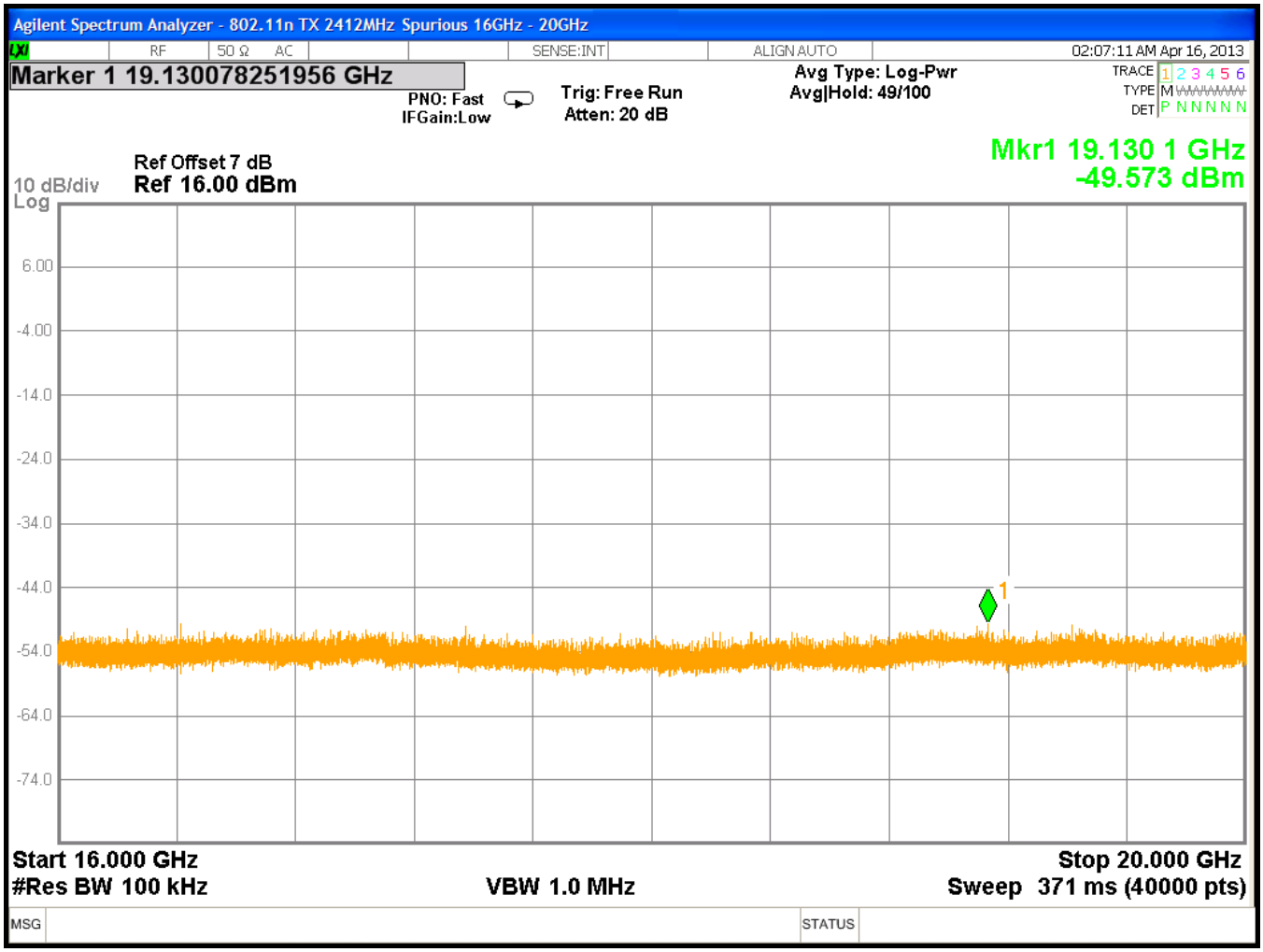

Figure 83: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 16 - 20GHz

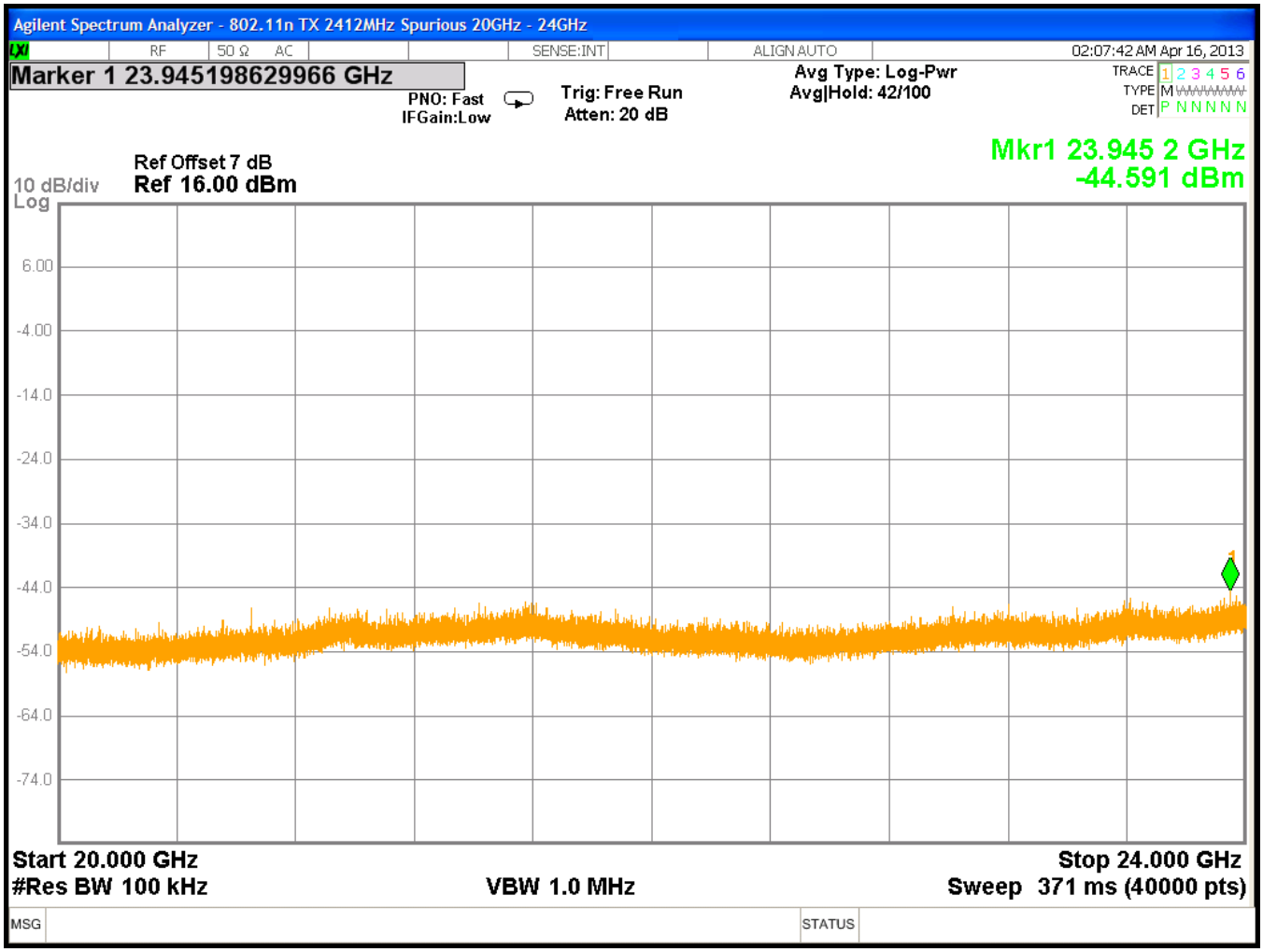

Figure 84: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 20 - 24GHz

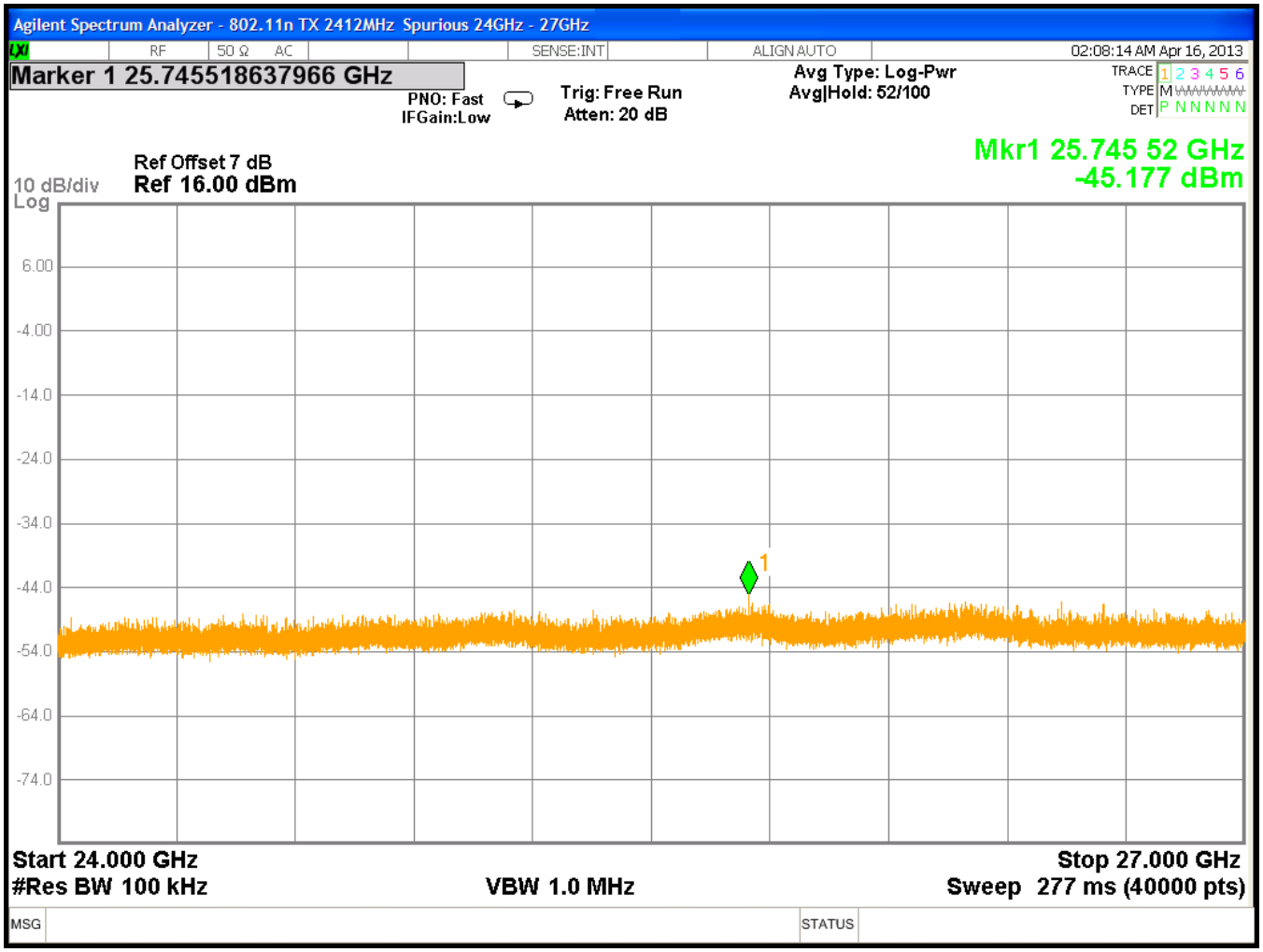

Figure 85: Conducted Spurious Emissions, 2412MHz, 6.5Mbps, 24 - 27GHz

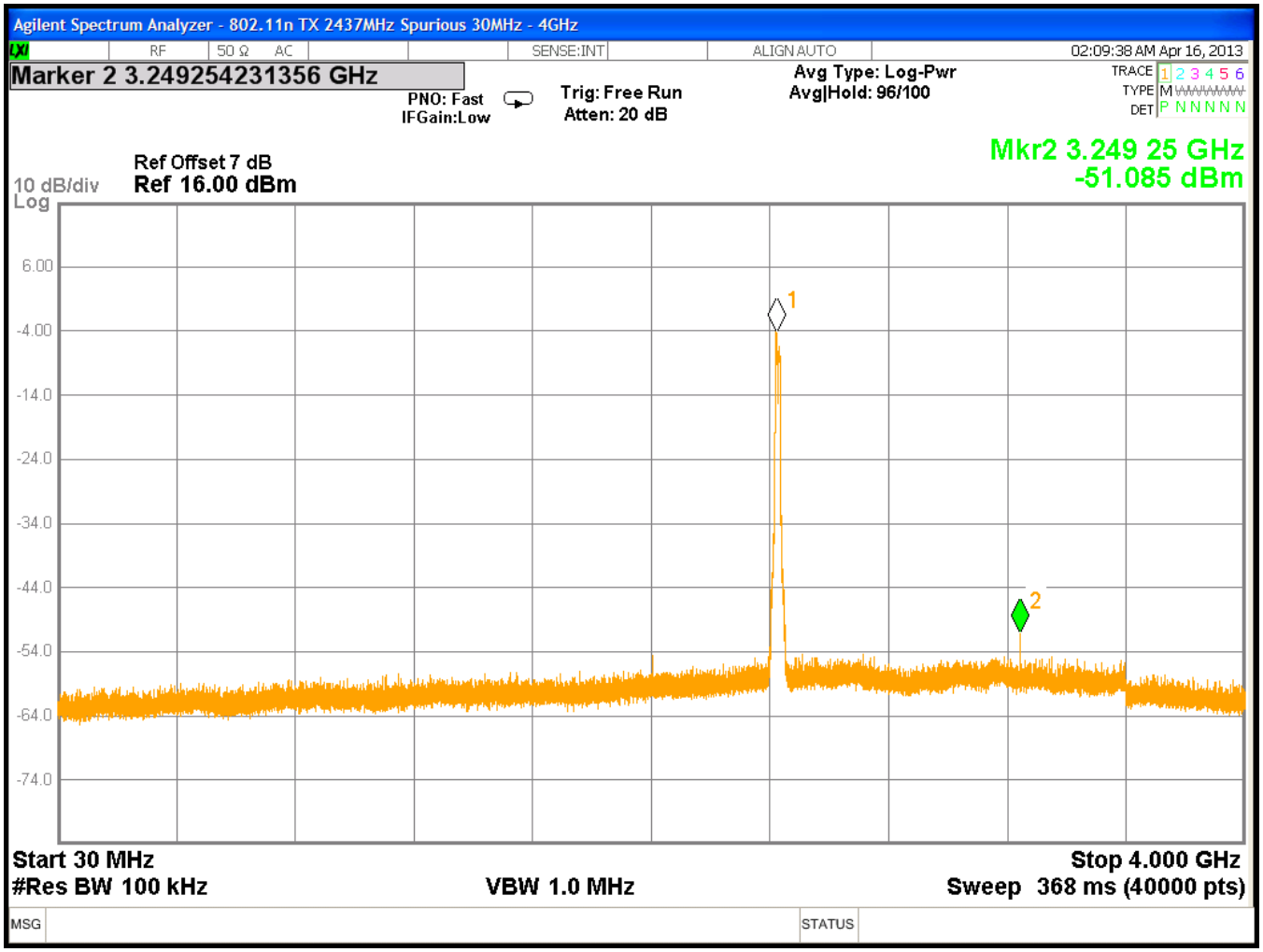

Figure 86: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 30MHz – 4GHz

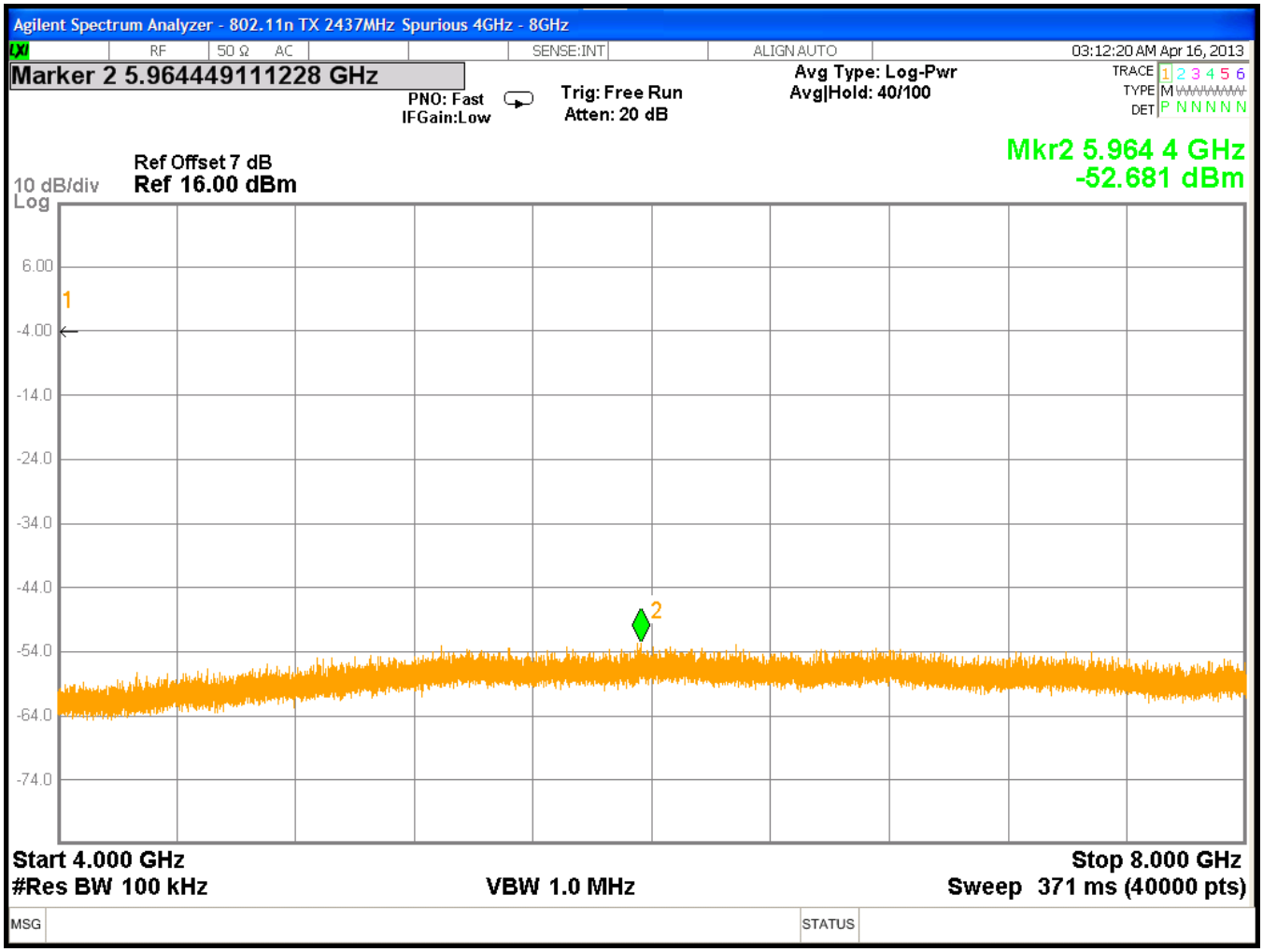

Figure 87: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 4 – 8GHz

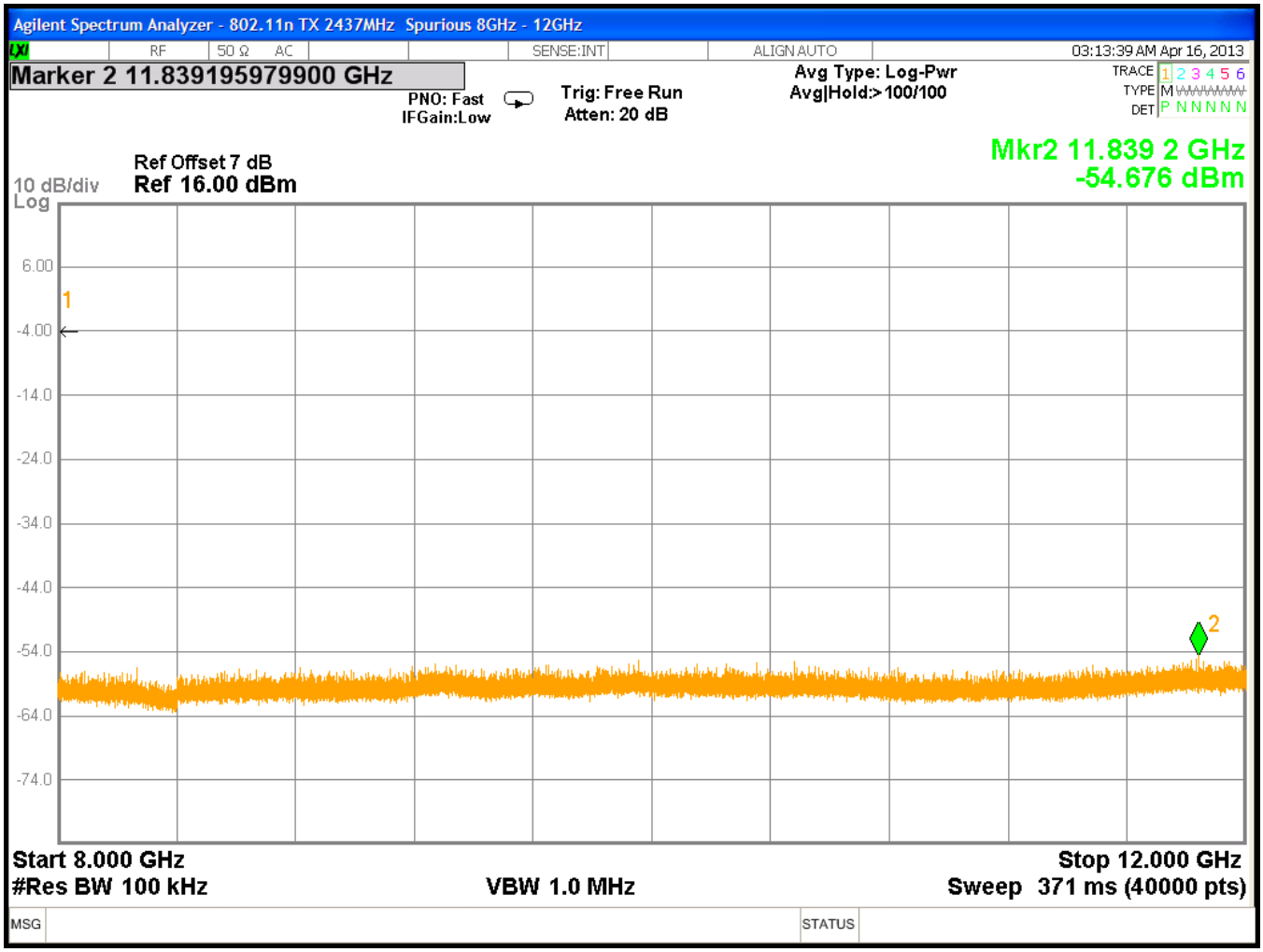

Figure 88: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 8 - 12GHz

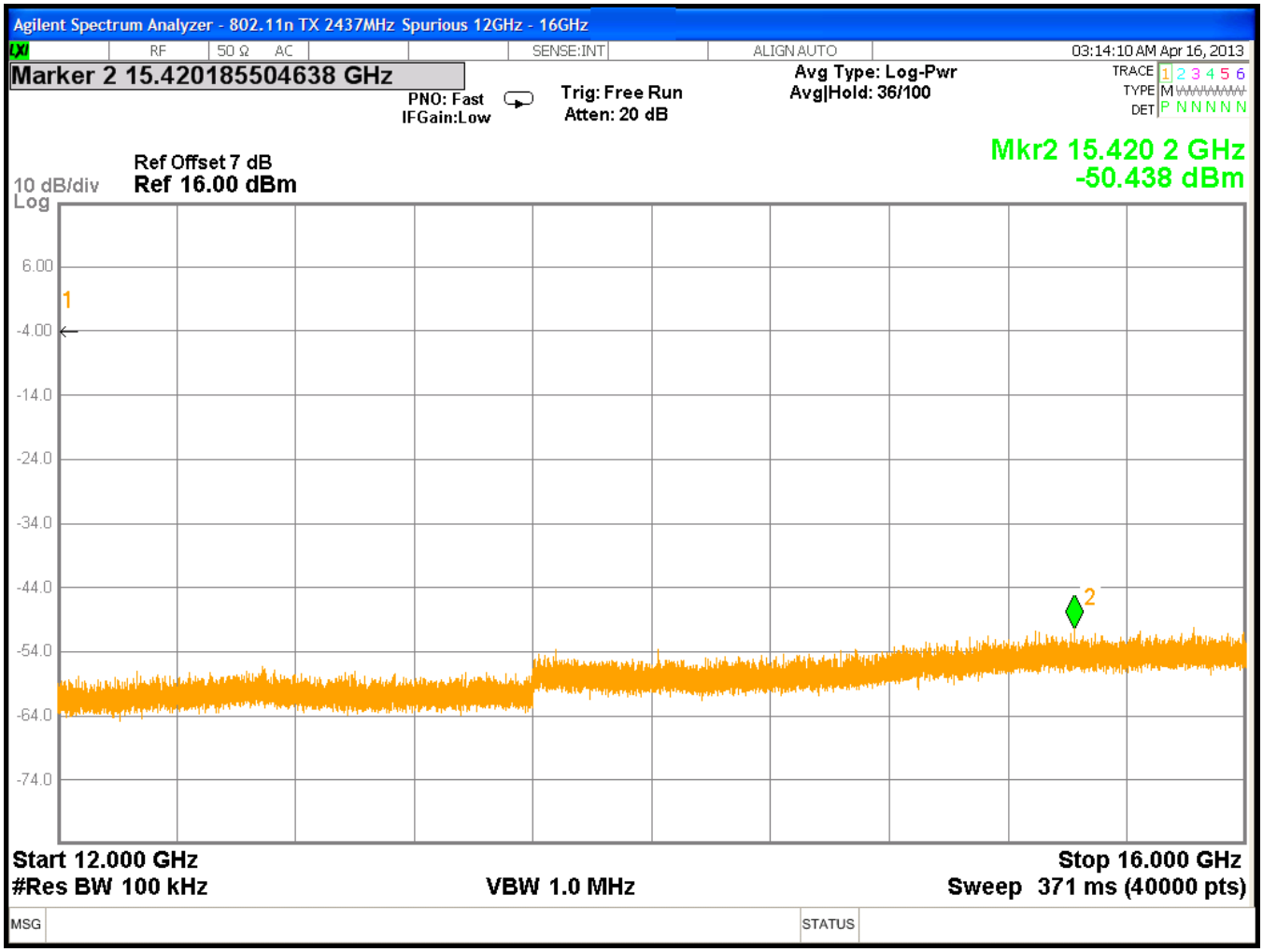

Figure 89: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 12 - 16GHz

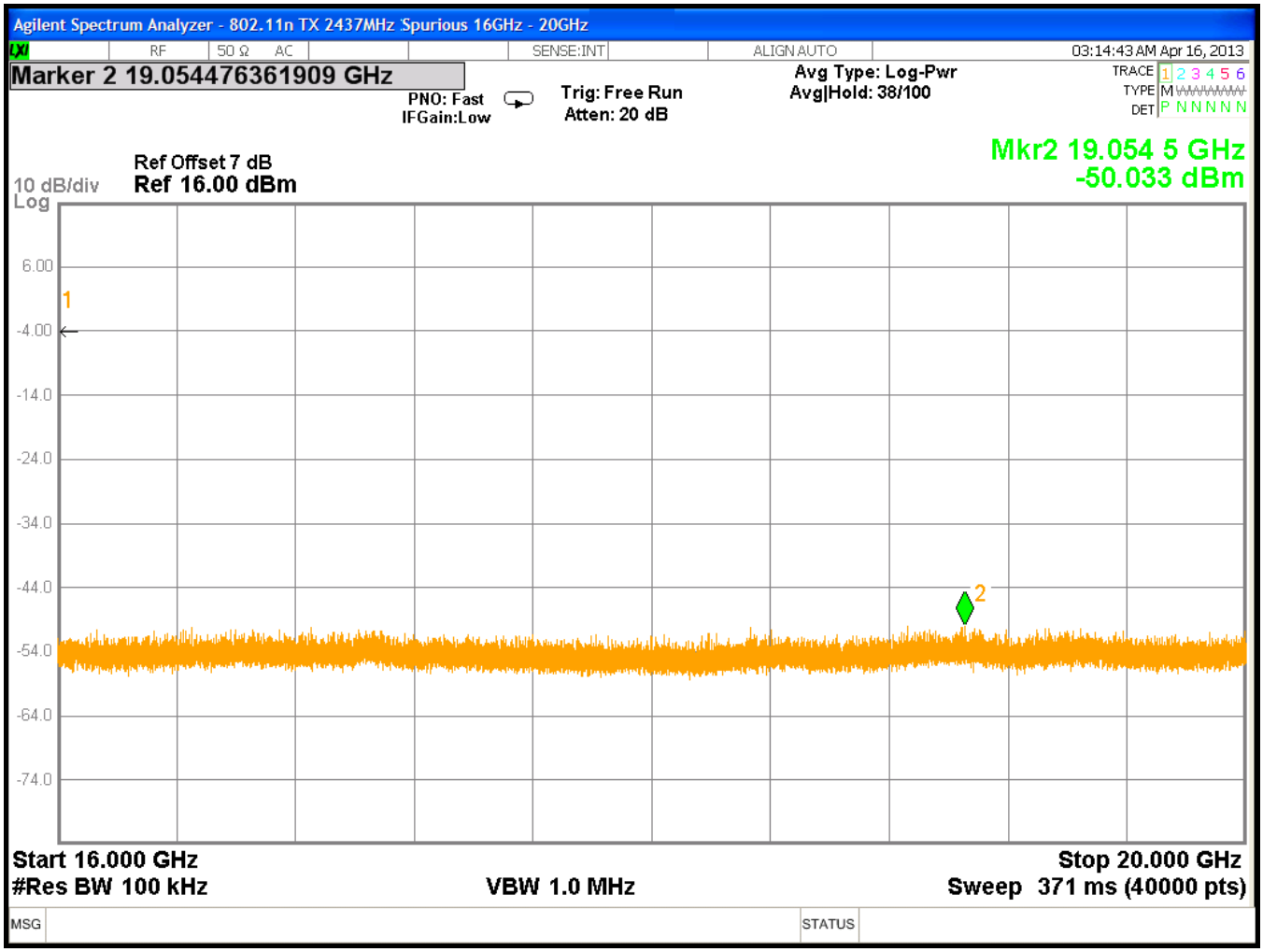

Figure 90: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 16 - 20GHz

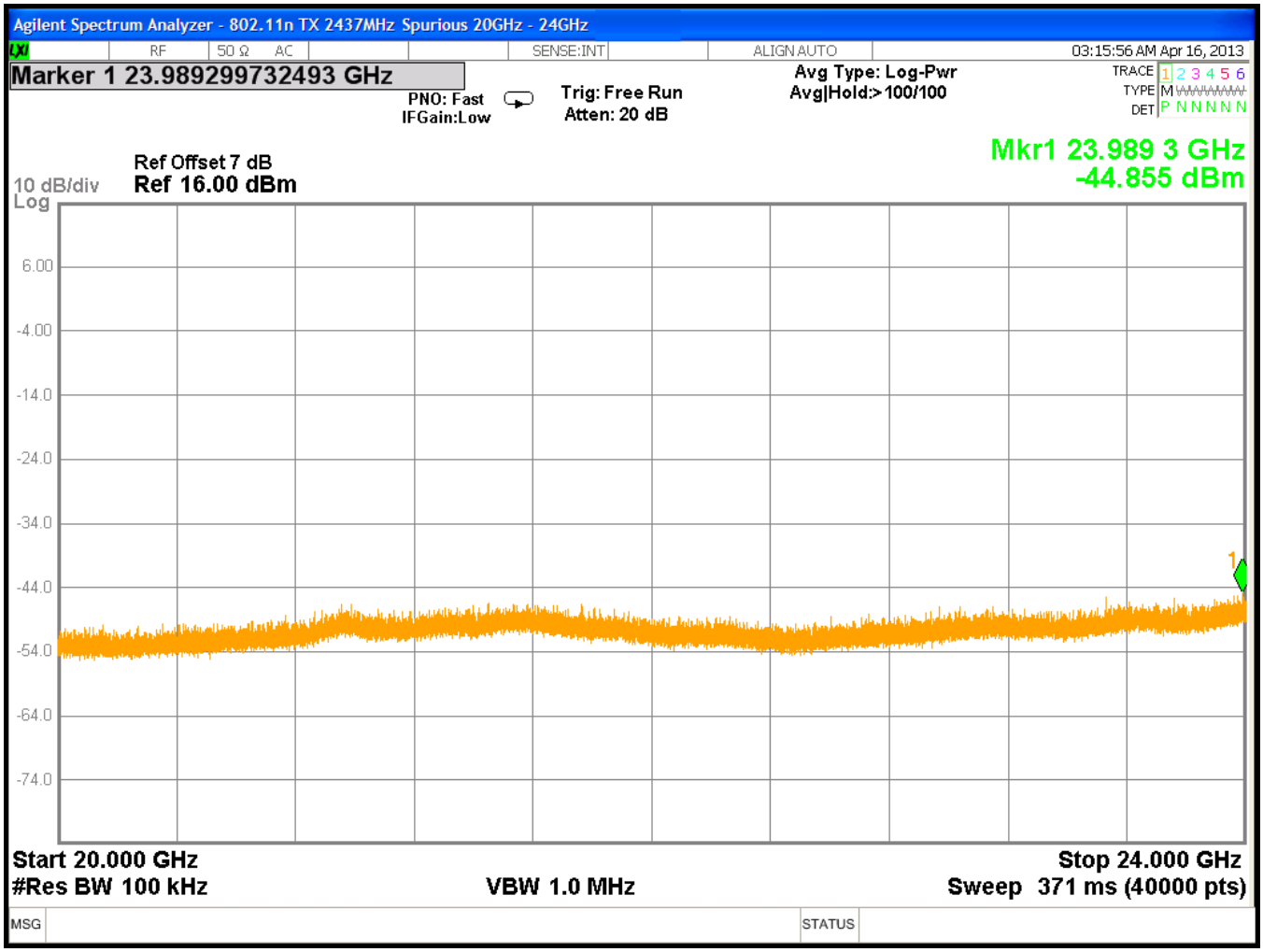

Figure 91: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 20 - 24GHz

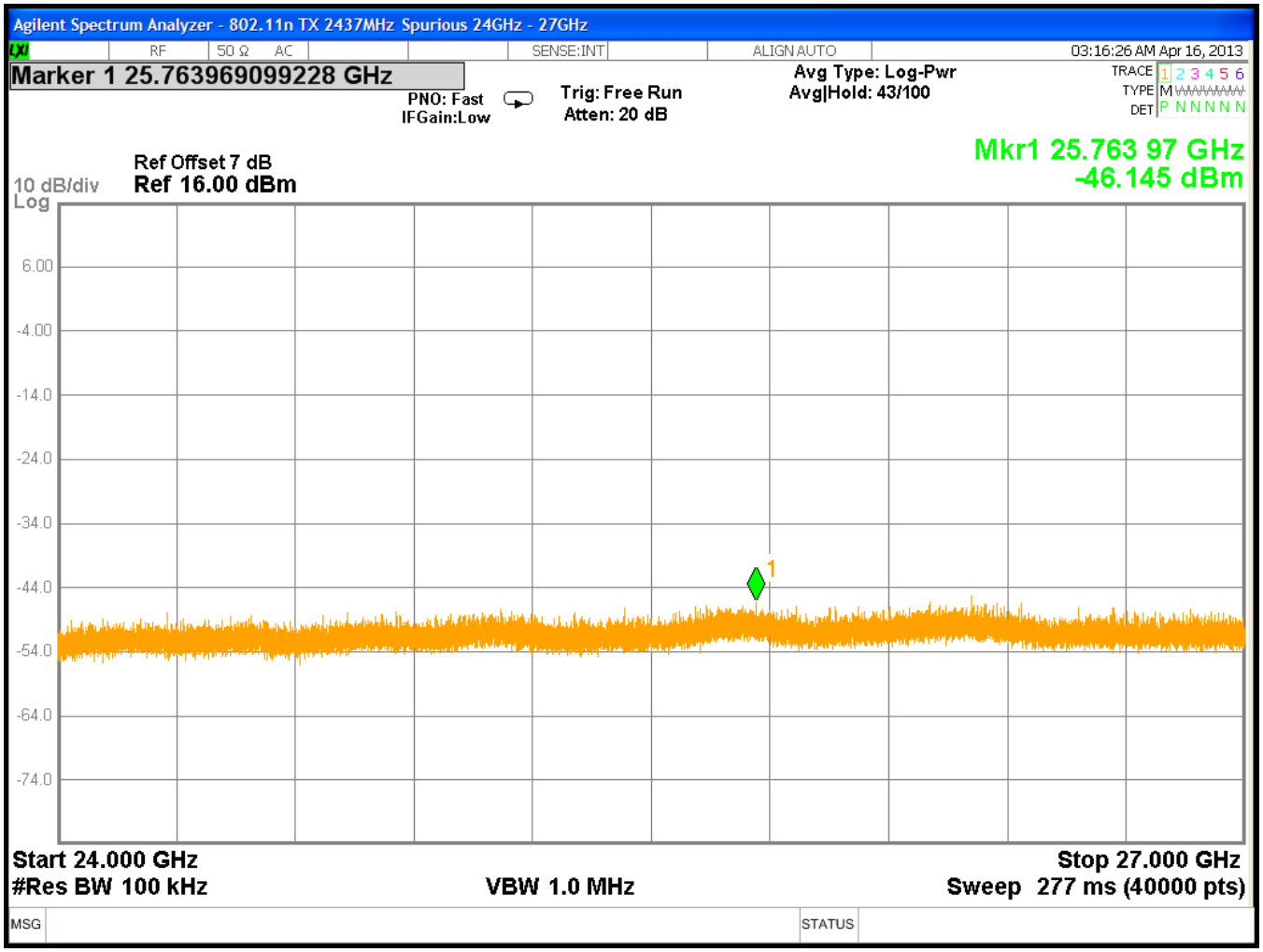

Figure 92: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 24 - 27GHz

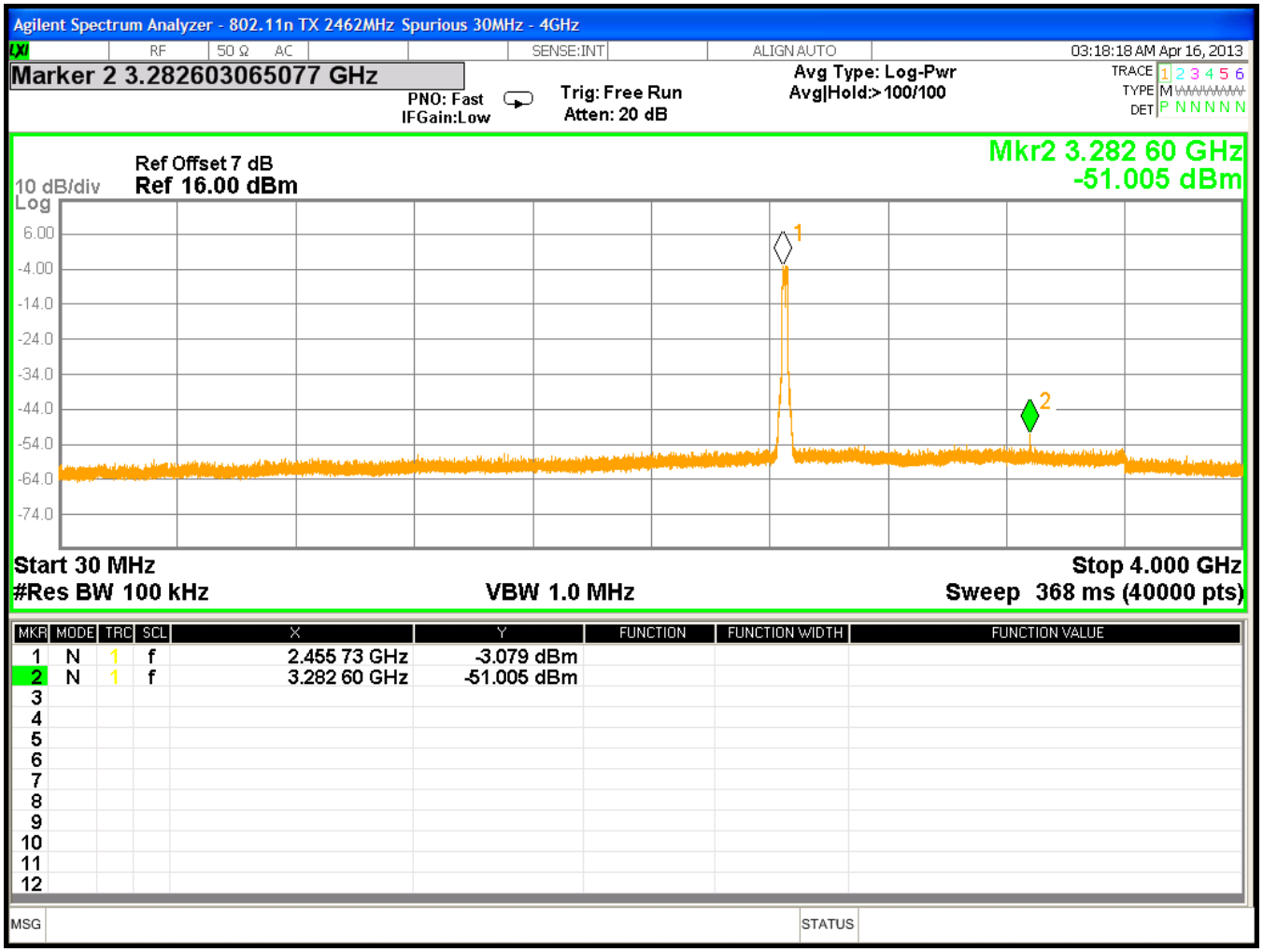

Figure 93: Conducted Spurious Emissions, 2437MHz, 6.5Mbps, 30MHz – 4GHz

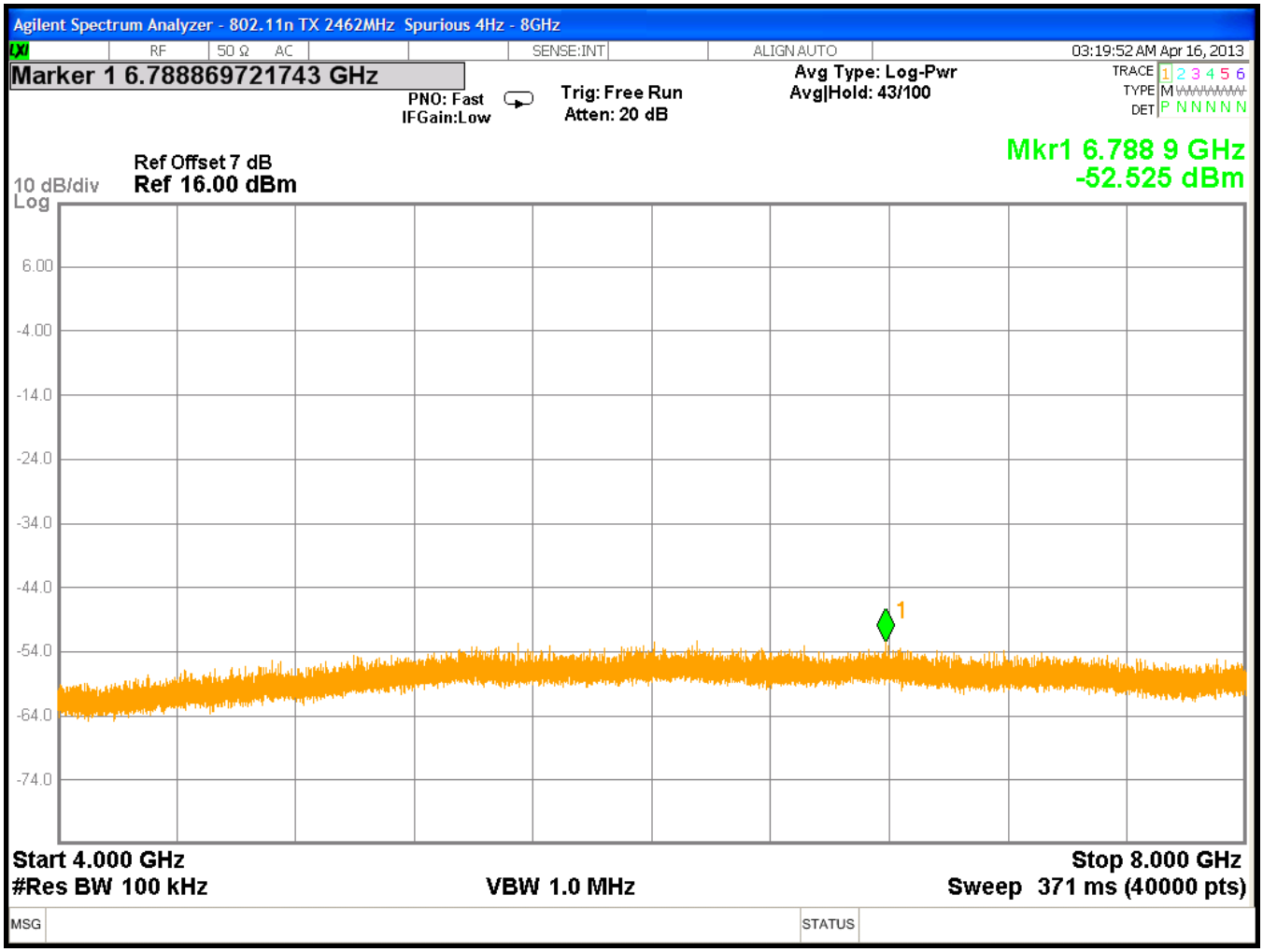

Figure 94: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 4 – 8GHz

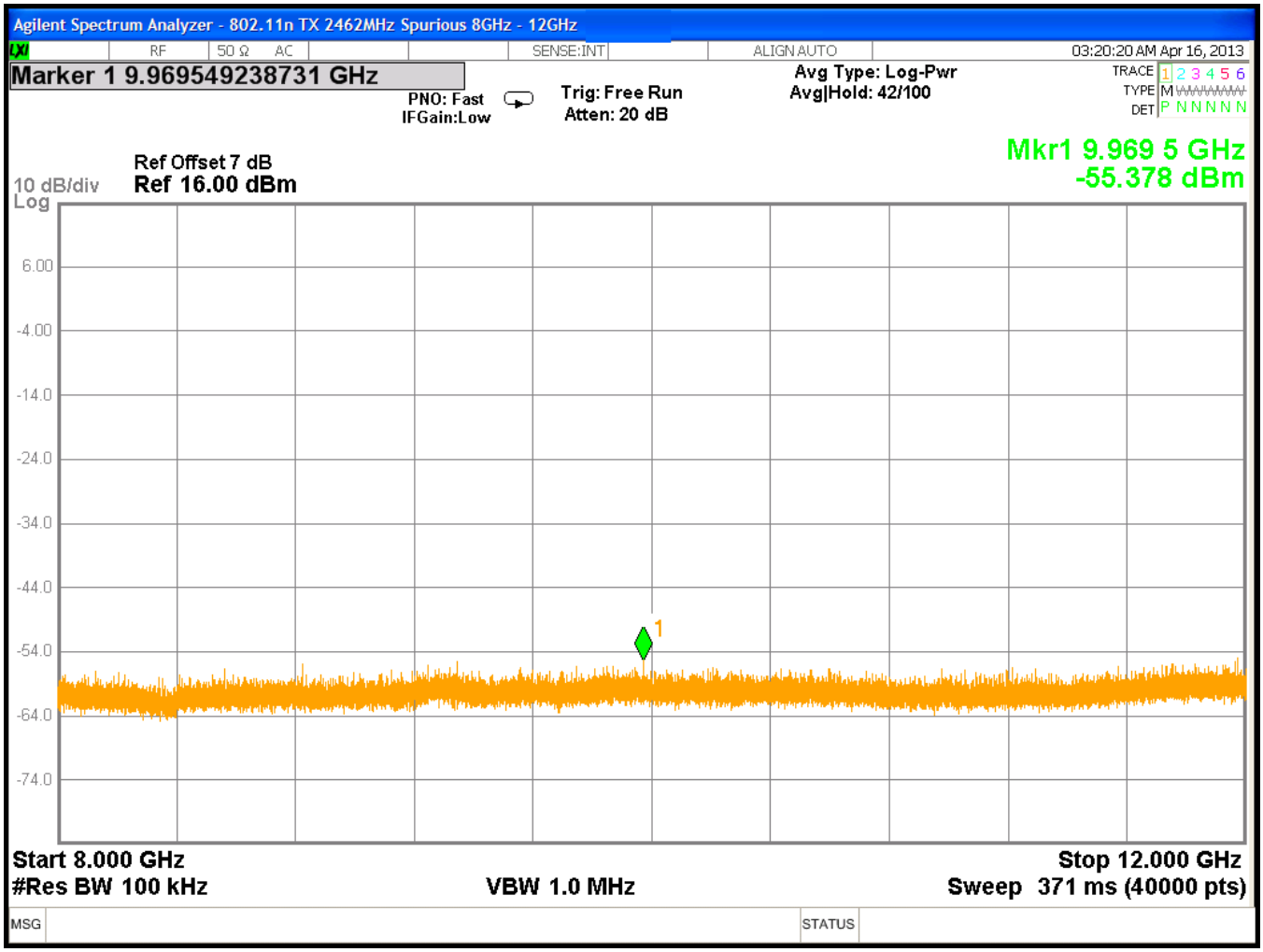

Figure 95: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 8 - 12GHz

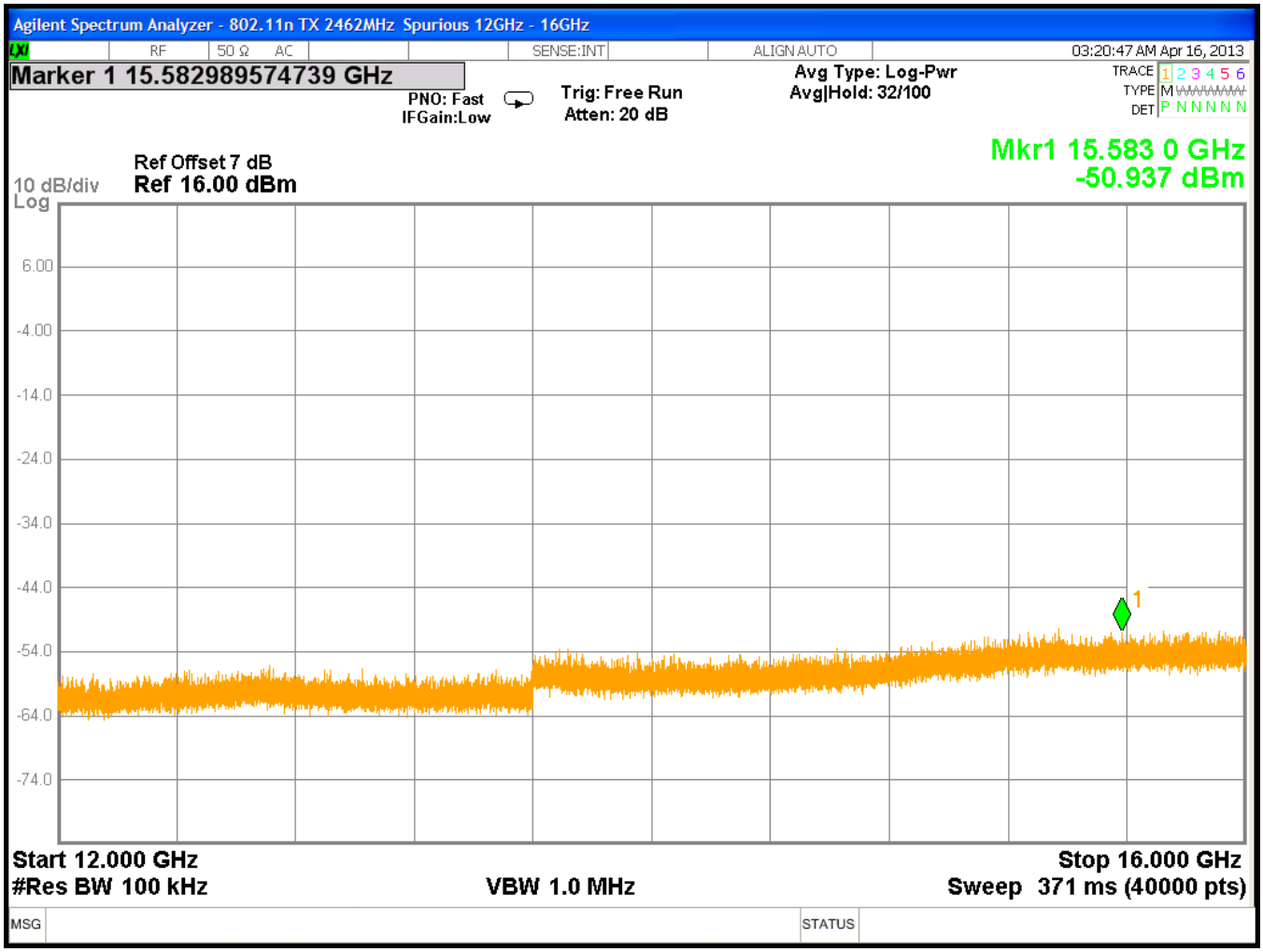

Figure 96: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 12 - 16GHz

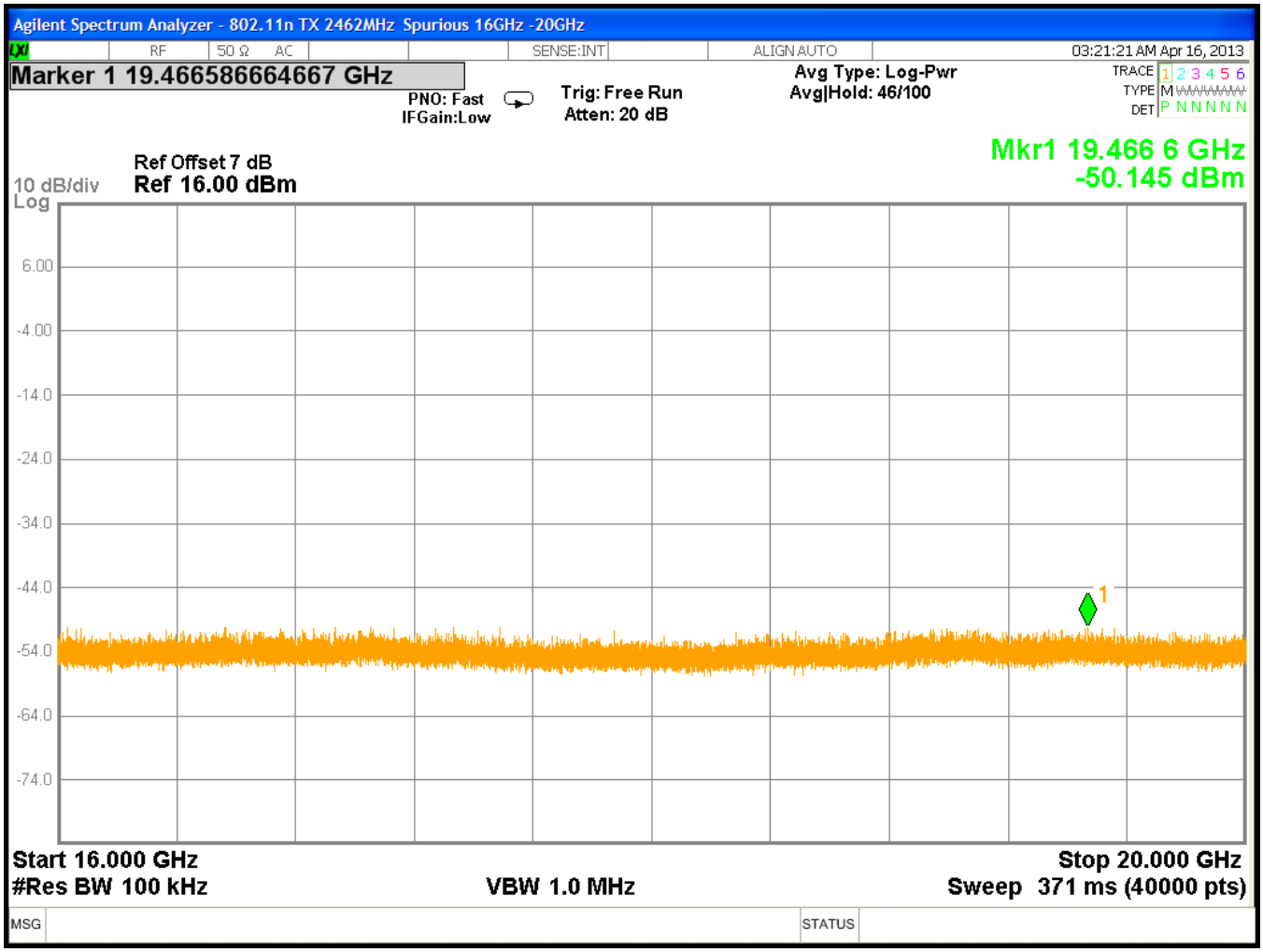

Figure 97: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 16 - 20GHz

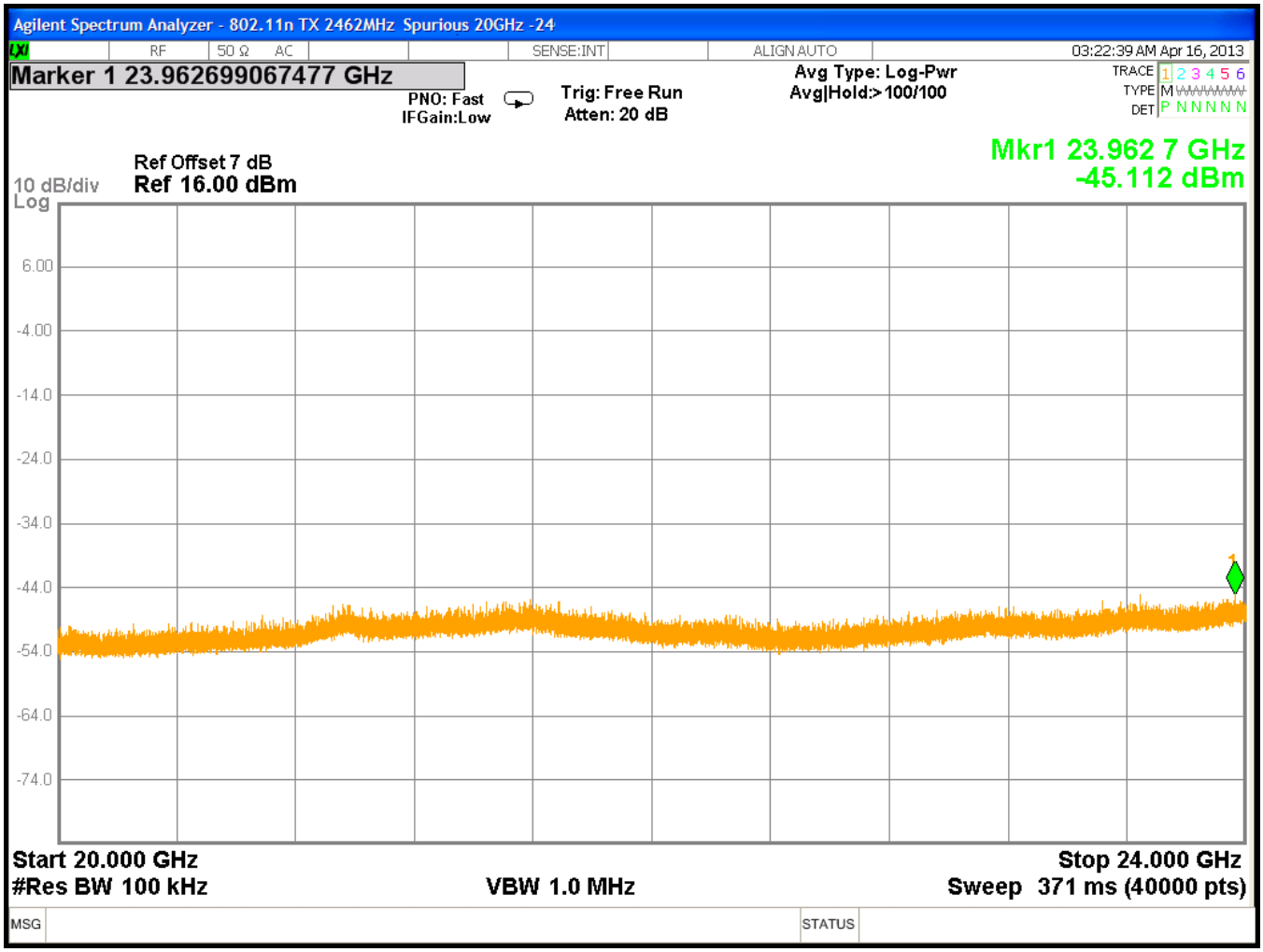

Figure 98: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 20 - 24GHz

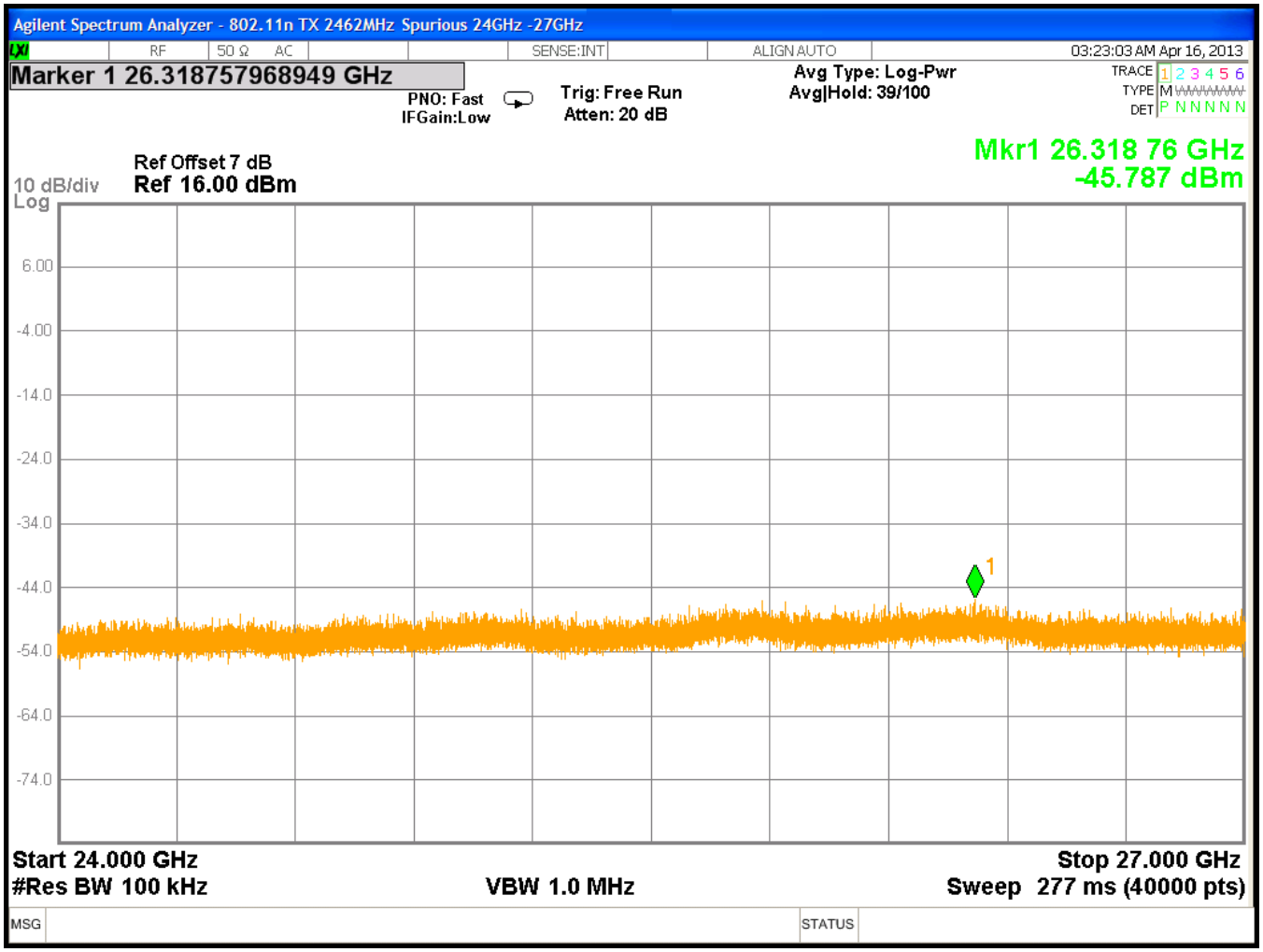

Figure 99: Conducted Spurious Emissions, 2462MHz, 6.5Mbps, 24 - 27GHz

3.5.1 Band Edge Compliance

Close-up plots of the upper and lower channels with respect to the nearest authorized band-edges are provided below. The tests were performed in the same manner as the above conducted spurious emissions tests

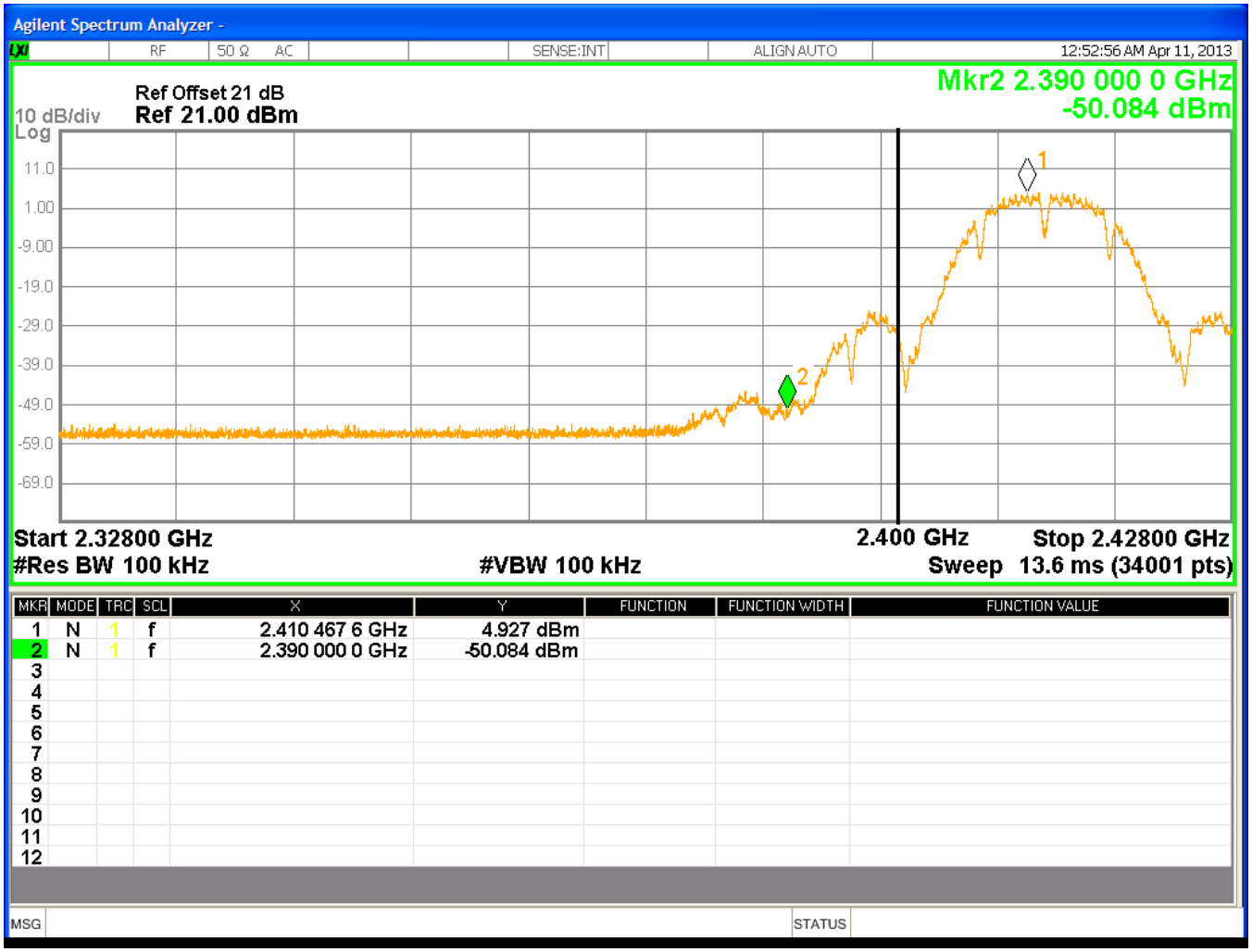

Figure 100: Lower Band-edge, 2412MHz, 802.11b, 1Mbps

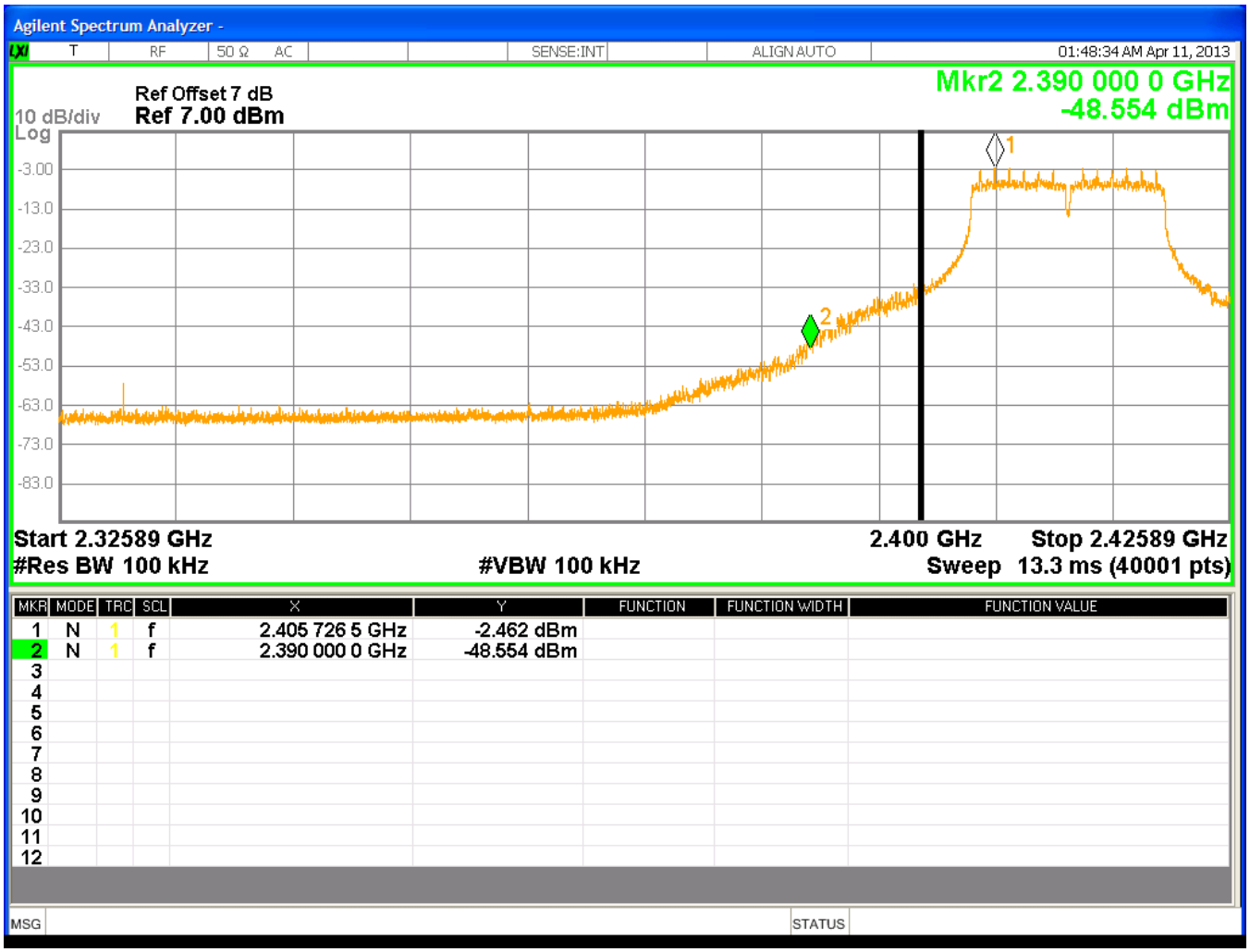

Figure 101: Lower Band-edge, 2412MHz,802.11g, 6Mbps

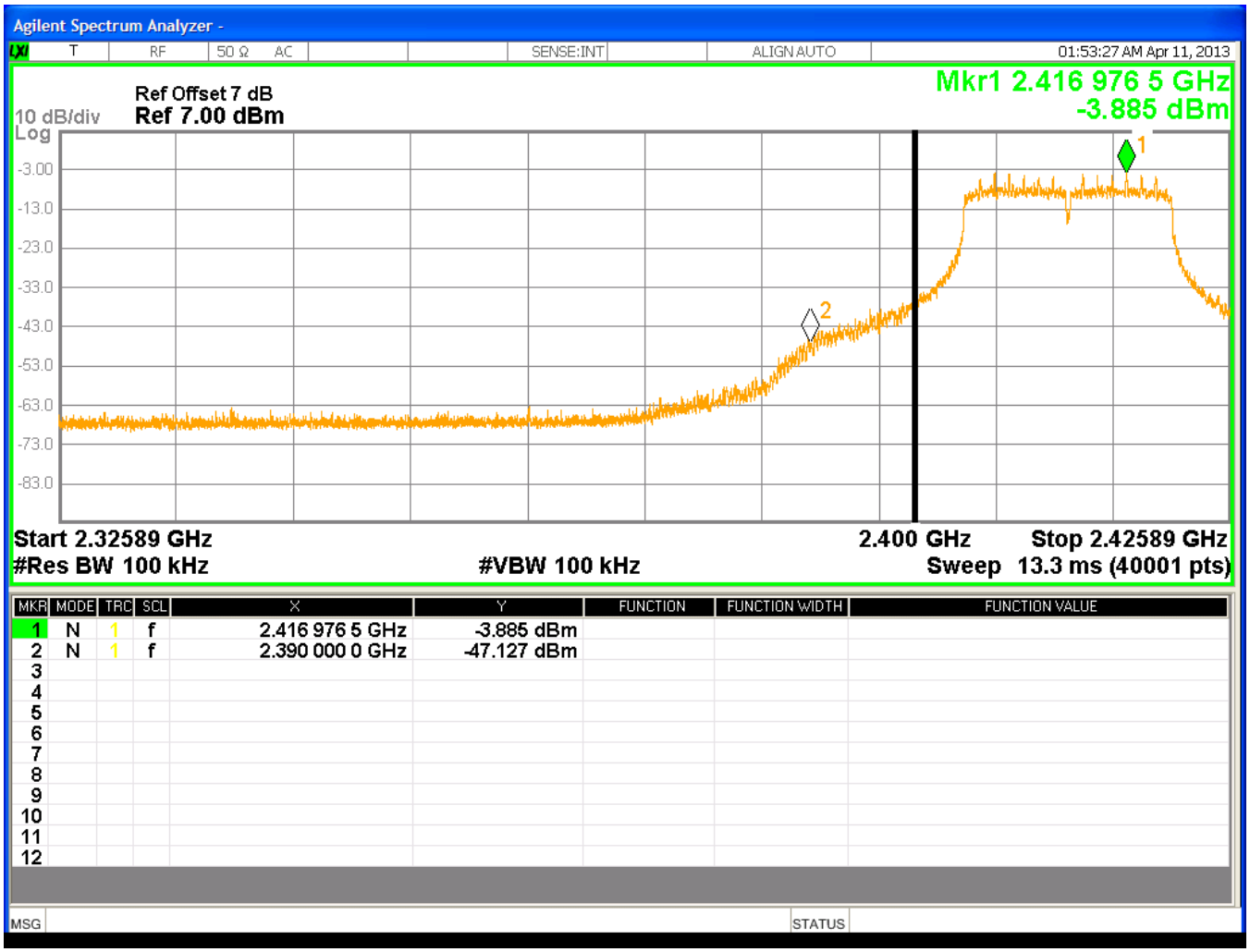

Figure 102: Lower Band-edge, 2412MHz, 802.11n, 6.5 Mbps

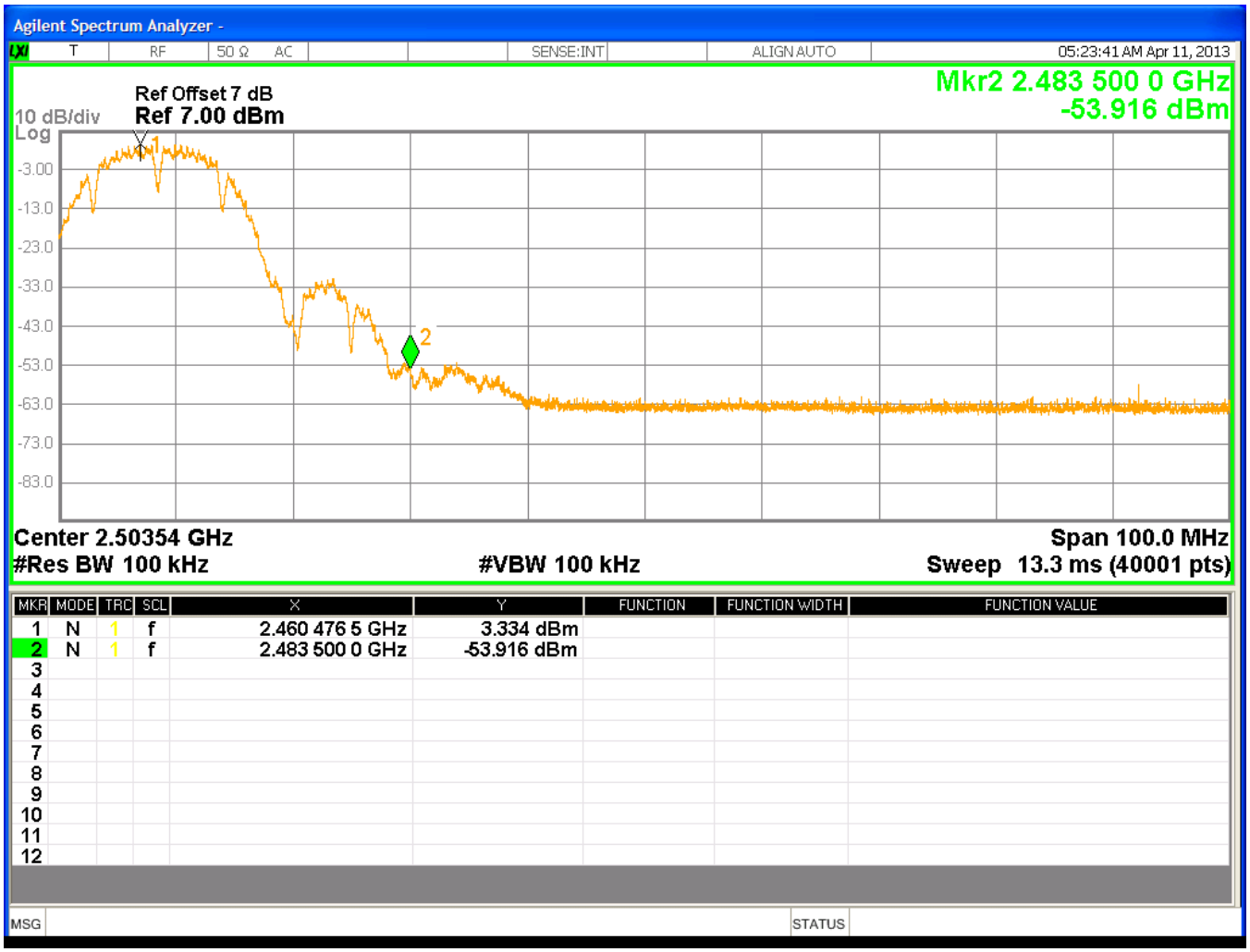

Figure 103: Upper Band-edge, 2462MHz, 802.11b, 1Mbps

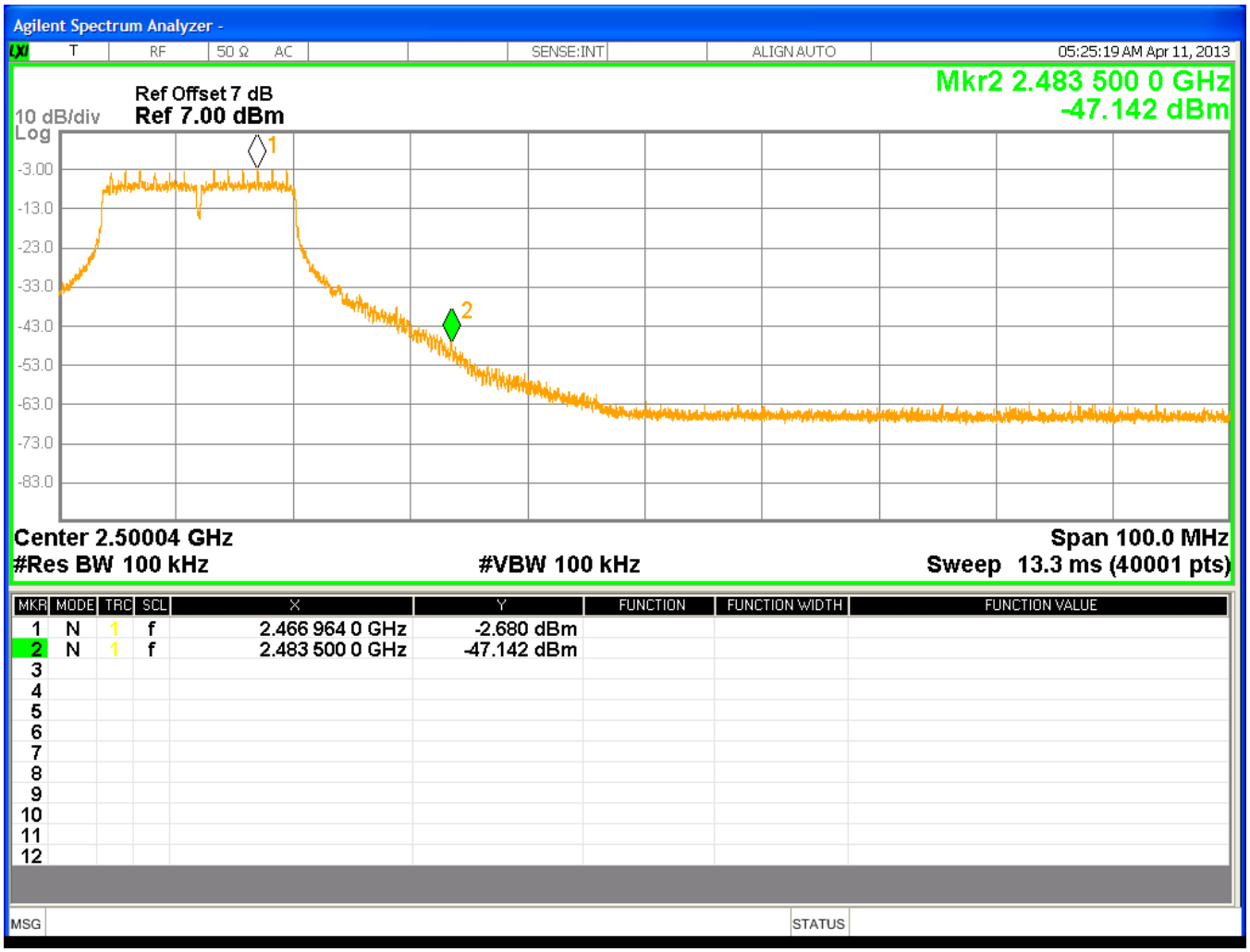

Figure 104: Upper Band-edge, 2462MHz,802.11g, 6Mbps

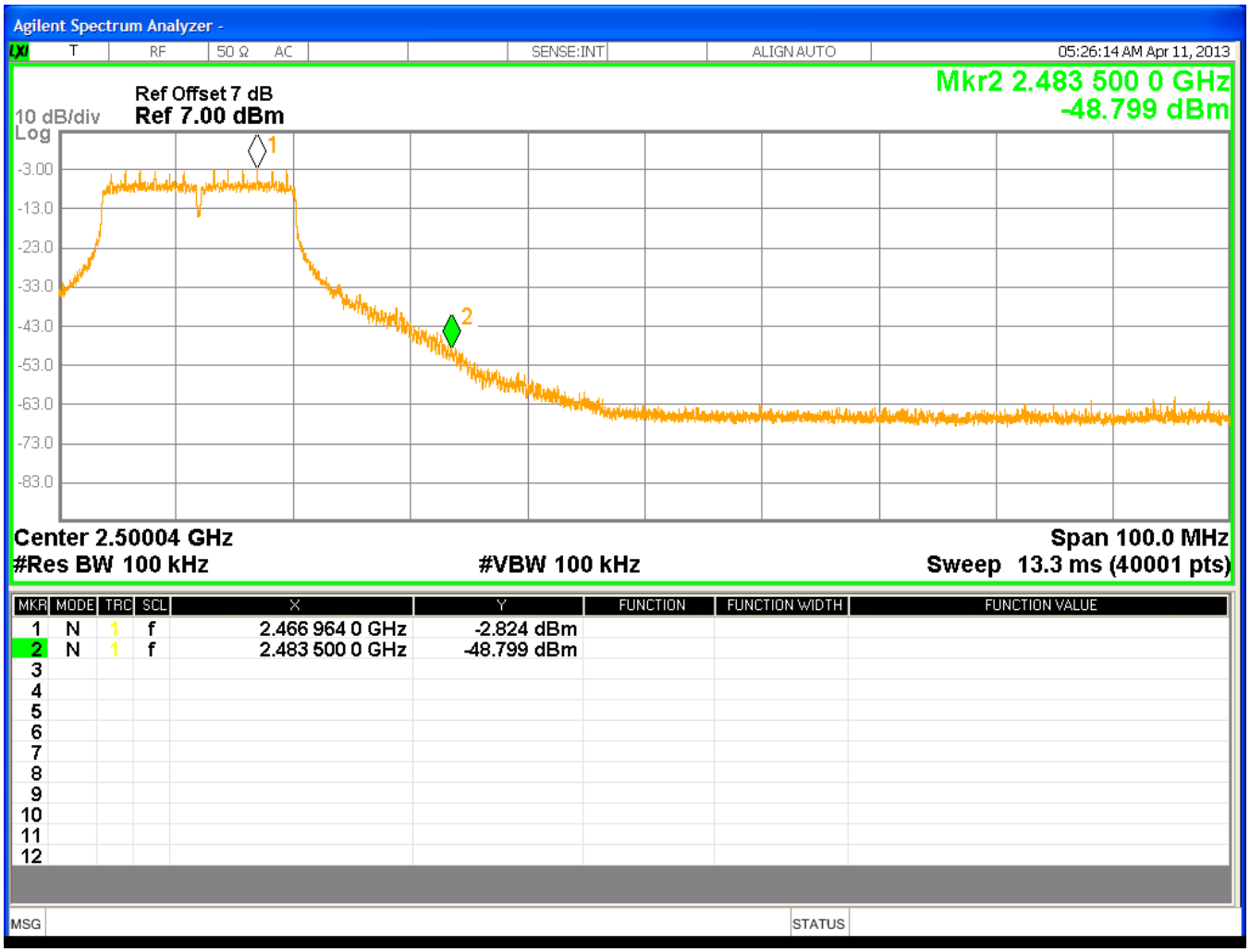

Figure 105: Upper Band-edge, 2462MHz,802.11n, 6.5Mbps

3.6 AC Conducted Emissions (FCC Part §15.207)

3.6.1 Requirements

Test Arrangement: Table Top

Compliance Standard: FCC Class B

FCC Compliance Limits		
Frequency	**Quasi-peak**	**Average**
0.15 - 0.5MHz	66 to 56dBµV	56 to 46dBµV
0.5 - 5MHz	56dBµV	46dBµV
5 - 30MHz	60dBµV	50dBµV

3.6.2 Test Procedure

The EUT was placed on an 80 cm high 1 X 1.5 m non-conductive table above a ground plane. Power to the EUT was provided through a Solar Corporation 50 Ω/50 µH Line Impedance Stabilization Network bonded to a 3 X 2 meter ground plane. The LISN has its AC input supplied from a filtered AC power source. Power was supplied to the peripherals through a second LISN. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Power and data cables were moved about to obtain maximum emissions.

The 50 Ω output of the LISN was connected to the input of the spectrum analyzer and the emissions in the frequency range of 150 kHz to 30 MHz were measured. The detector function was set to quasi-peak, peak, or average as appropriate, and the resolution bandwidth during testing was at least 9 kHz, with all post-detector filtering no less than 10 times the resolution bandwidth. For average measurements the post-detector filter was set to 10 Hz.

At frequencies where quasi-peak or peak measurements comply with the average limit, no average measurements need be performed.

At frequencies where quasi-peak or peak measurements comply with the average limit, no average measurements need be performed. The Conducted emissions level to be compared to the FCC limit is calculated as shown in the following example.

Example:

Spectrum Analyzer Voltage: VdBµV

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Electric Field: EdBµV = V dBµV + LISN dB + CF dB

3.6.3 Test Data

The EUT complied with the Class B Conducted Emissions requirements. The module was provided power via a support motherboard from a 120VDC to 5VDC switching adaptor (model DP15-0503000A4). Table 9 provides the test results for phase and neutral line power line conducted emissions.

Table 9: Conducted Emissions Data 120VAC, Transmit On

NEUTRAL

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.168	36.1	19.0	10.2	1.0	47.2	30.1	65.1	55.1	-17.8	-24.9
0.233	28.3	8.6	10.2	0.7	39.2	19.5	62.3	52.3	-23.2	-32.9
2.712	17.4	4.5	10.2	1.1	28.7	15.8	56.0	46.0	-27.3	-30.2
5.664	17.1	6.2	10.8	1.2	29.1	18.2	60.0	50.0	-30.9	-31.8
14.612	36.2	24.2	11.3	1.0	48.5	36.5	60.0	50.0	-11.5	-13.5
20.482	24.1	14.4	11.5	1.0	36.6	26.9	60.0	50.0	-23.4	-23.1

PHASE

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.169	35.8	18.2	10.2	1.0	46.9	29.3	65.0	55.0	-18.1	-25.7
0.378	17.6	6.8	10.2	0.4	28.2	17.4	58.3	48.3	-30.1	-30.9
2.510	12.0	3.4	10.1	0.9	23.0	14.4	56.0	46.0	-33.0	-31.6
5.760	16.1	6.3	10.8	0.8	27.7	17.9	60.0	50.0	-32.3	-32.1
14.818	35.0	24.0	11.3	0.8	47.2	36.2	60.0	50.0	-12.8	-13.8
20.482	25.8	15.0	11.5	0.8	38.2	27.4	60.0	50.0	-21.8	-22.6

Table 10: Conducted Emissions Data 120VAC, Transmit Off

NEUTRAL

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.191	28.9	18.6	10.2	0.9	39.9	29.6	64.0	54.0	-24.1	-24.4
0.390	22.8	10.3	10.2	0.6	33.5	21.0	58.1	48.1	-24.5	-27.0
2.510	16.7	4.7	10.1	1.1	27.9	15.9	56.0	46.0	-28.1	-30.1
5.760	18.4	6.4	10.8	1.2	30.4	18.4	60.0	50.0	-29.6	-31.6
14.900	35.4	24.1	11.3	1.0	47.7	36.4	60.0	50.0	-12.3	-13.6
21.087	24.1	14.2	11.5	1.1	36.8	26.9	60.0	50.0	-23.2	-23.1

Phase

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.185	28.3	13.2	10.2	0.9	39.3	24.2	64.2	54.2	-24.9	-30.0
0.390	25.3	9.5	10.2	0.4	35.9	20.1	58.1	48.1	-22.1	-27.9
2.510	16.5	4.6	10.1	0.9	27.5	15.6	56.0	46.0	-28.5	-30.4
5.760	17.1	6.7	10.8	0.8	28.7	18.3	60.0	50.0	-31.3	-31.7
14.900	33.1	22.4	11.3	0.8	45.3	34.6	60.0	50.0	-14.7	-15.4
21.087	25.4	17.0	11.5	1.0	38.0	29.6	60.0	50.0	-22.0	-20.4

3.7 Radiated Spurious Emissions: (FCC Part §15.205 & §15.209)

The EUT must comply with the requirements for radiated spurious emissions that fall within the restricted bands. These emissions must meet the limits specified in §15.209 and §15.35(b) for peak measurements.

3.7.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The unit was pre-scanned in 3 orthogonal positions with full testing performed in the worst case position.

The emissions were measured using the following resolution bandwidths:

Table 11: Spectrum Analyzer Settings

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>100 kHz
>1000 MHz	1 MHz	10 Hz (Avg.), 1MHz (Peak)

Worst case emissions are presented.

The following data shows the EUT with the 3.8dBi antenna. The unit was tested in 3 orthogonal positions with the worst case data presented.

Testing was performed in the 802.11b 11Mbps mode with the exception of the restricted band edges closed to the in-band signal which was tested in the 802.11 b, g and n mode with the worst case shown.

Table 12: Radiated Emission Test Data, Low Channel (Restricted Bands)

TX 2412MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
74.20	V	270.00	1.00	18.30	9.0	23.1	100.0	-12.7	Peak
81.35	V	270.00	1.00	18.80	9.0	24.6	100.0	-12.2	Peak
167.76	V	95.00	1.00	11.80	14.3	20.2	150.0	-17.4	Peak
335.40	V	175.00	2.60	8.60	18.0	21.4	200.0	-19.4	Peak
1533.62	V	180.00	2.07	49.50	-7.2	130.4	5000.0	-31.7	Peak
1533.62	V	180.00	2.07	45.70	-7.2	84.2	500.0	-15.5	Average
4824.00	V	0.00	1.78	45.95	2.0	249.7	5000.0	-26.0	Peak
4824.00	V	0.00	1.78	33.00	2.0	56.2	500.0	-19.0	Average
7236.00	V	180.00	1.64	45.90	10.1	632.0	5000.0	-18.0	Peak
7236.00	V	180.00	1.64	31.60	10.1	121.8	500.0	-12.3	Average
12060.00	V	0.00	1.33	44.20	10.9	566.3	5000.0	-18.9	Peak
12060.00	V	0.00	1.33	30.12	10.9	112.0	500.0	-13.0	Average
14472.00	V	5.00	1.36	46.40	16.2	1348.4	5000.0	-11.4	Peak
14472.00	V	5.00	1.36	31.60	16.2	245.4	500.0	-6.2	Average
73.61	H	45.00	4.00	15.00	9.0	15.8	100.0	-16.0	Peak
119.84	H	0.00	4.00	17.60	15.8	46.8	150.0	-10.1	Peak
133.73	H	85.00	4.00	14.60	15.0	30.4	150.0	-13.9	Peak
167.76	H	345.00	4.00	13.90	14.3	25.7	150.0	-15.3	Peak
263.61	H	275.00	2.09	14.60	15.8	33.1	200.0	-15.6	Peak
1533.62	H	185.00	2.17	49.28	-7.2	127.1	5000.0	-31.9	Peak
1533.62	H	185.00	2.17	39.40	-7.2	40.7	500.0	-21.8	Average
4824.00	H	0.00	1.35	46.00	2.0	251.1	5000.0	-26.0	Peak
4824.00	H	0.00	1.35	32.00	2.0	50.1	500.0	-20.0	Average
7236.00	H	0.00	1.35	44.60	10.1	544.1	5000.0	-19.3	Peak
7236.00	H	0.00	1.33	31.40	10.1	119.0	500.0	-12.5	Average
12060.00	H	0.00	1.30	43.75	10.9	537.9	5000.0	-19.4	Peak
12060.00	H	0.00	1.30	28.90	10.9	97.3	500.0	-14.2	Average
14472.00	H	180.00	1.25	46.20	16.2	1317.7	5000.0	-11.6	Peak
14472.00	H	180.00	1.25	32.10	16.2	259.9	500.0	-5.7	Average

Table 13: Radiated Emission Test Data, Center Channel (Restricted Bands)

TX 2437MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
74.20	V	270.00	1.00	18.30	9.0	23.1	100.0	-12.7	Peak
81.35	V	270.00	1.00	18.80	9.0	24.6	100.0	-12.2	Peak
167.76	V	95.00	1.00	11.80	14.3	20.2	150.0	-17.4	Peak
335.40	V	175.00	2.60	8.60	18.0	21.4	200.0	-19.4	Peak
1533.62	V	180.00	2.07	49.50	-7.2	130.4	5000.0	-31.7	Peak
1533.62	V	180.00	2.07	45.70	-7.2	84.2	500.0	-15.5	Average
4874.00	V	185.00	1.83	44.47	2.2	214.5	5000.0	-27.3	Peak
4874.00	V	185.00	1.83	37.40	2.2	95.1	500.0	-14.4	Average
7311.00	V	90.00	1.66	40.53	10.1	340.5	5000.0	-23.3	Peak
7311.00	V	90.00	1.66	30.80	10.1	111.1	500.0	-13.1	Average
12185.00	V	280.00	1.60	37.70	11.4	283.9	5000.0	-24.9	Peak
12185.00	V	280.00	1.60	30.10	11.4	118.3	500.0	-12.5	Average
73.61	H	45.00	4.00	15.00	9.0	15.8	100.0	-16.0	Peak
119.84	H	0.00	4.00	17.60	15.8	46.8	150.0	-10.1	Peak
133.73	H	85.00	4.00	14.60	15.0	30.4	150.0	-13.9	Peak
167.76	H	345.00	4.00	13.90	14.3	25.7	150.0	-15.3	Peak
263.61	H	275.00	2.09	14.60	15.8	33.1	200.0	-15.6	Peak
1533.62	H	185.00	2.17	49.28	-7.2	127.1	5000.0	-31.9	Peak
1533.62	H	185.00	2.17	39.40	-7.2	40.7	500.0	-21.8	Average
4874.00	H	125.00	2.00	40.60	2.2	137.4	5000.0	-31.2	Peak
4874.00	H	125.00	2.00	30.70	2.2	44.0	500.0	-21.1	Average
7311.00	H	180.00	1.77	41.10	10.1	363.6	5000.0	-22.8	Peak
7311.00	H	180.00	1.77	29.30	10.1	93.5	500.0	-14.6	Average
12185.00	H	275.00	1.77	42.62	11.4	500.2	5000.0	-20.0	Peak
12185.00	H	275.00	1.77	30.40	11.4	122.5	500.0	-12.2	Average

Table 14: Radiated Emission Test Data, High Channel (Restricted Bands)

TX 2462MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
74.20	V	270.00	1.00	18.30	9.0	23.1	100.0	-12.7	Peak
81.35	V	270.00	1.00	18.80	9.0	24.6	100.0	-12.2	Peak
167.76	V	95.00	1.00	11.80	14.3	20.2	150.0	-17.4	Peak
335.40	V	175.00	2.60	8.60	18.0	21.4	200.0	-19.4	Peak
2483.50	V	0.00	1.60	41.80	-3.0	87.1	5000.0	-35.2	Peak
2483.50	V	0.00	1.60	30.20	-3.0	22.9	500.0	-26.8	Average
4924.00	V	10.00	1.97	41.90	2.3	162.4	5000.0	-29.8	Peak
4924.00	V	10.00	1.97	36.20	2.3	84.2	500.0	-15.5	Average
7386.00	V	180.00	1.90	41.90	10.1	399.8	5000.0	-21.9	Peak
7386.00	V	180.00	1.90	29.40	10.1	94.8	500.0	-14.4	Average
12310.00	V	180.00	1.80	40.20	11.5	386.1	5000.0	-22.2	Peak
12310.00	V	180.00	1.80	30.10	11.5	120.7	500.0	-12.3	Average
73.61	H	45.00	4.00	15.00	9.0	15.8	100.0	-16.0	Peak
119.84	H	0.00	4.00	17.60	15.8	46.8	150.0	-10.1	Peak
133.73	H	85.00	4.00	14.60	15.0	30.4	150.0	-13.9	Peak
167.76	H	345.00	4.00	13.90	14.3	25.7	150.0	-15.3	Peak
263.61	H	275.00	2.09	14.60	15.8	33.1	200.0	-15.6	Peak
1533.62	H	185.00	2.17	49.28	-7.2	127.1	5000.0	-31.9	Peak
1533.62	H	185.00	2.17	39.40	-7.2	40.7	500.0	-21.8	Average
2483.50	H	0.00	1.76	40.20	-3.0	72.5	5000.0	-36.8	Peak
2483.50	H	0.00	1.76	29.90	-3.0	22.1	500.0	-27.1	Average
4924.00	H	185.00	1.56	37.10	2.3	93.4	5000.0	-34.6	Peak
4924.00	H	185.00	1.56	29.70	2.3	39.9	500.0	-22.0	Average
7386.00	H	270.00	1.50	39.50	10.1	303.3	5000.0	-24.3	Peak
7386.00	H	270.00	1.50	30.90	10.1	112.7	500.0	-12.9	Average
12310.00	H	270.00	1.50	36.90	11.5	264.1	5000.0	-25.5	Peak
12310.00	H	270.00	1.50	29.90	11.5	118.0	500.0	-12.5	Average

Table 15: Radiated Emission Test Data, Band Edge

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
802.11b 11Mb									
2483.50	V	0.00	2.00	39.40	-3.0	66.1	5000.0	-37.6	Peak
2483.50	V	0.00	2.00	29.20	-3.0	20.4	500.0	-27.8	Average
	V								
802.11g 54Mb									
2483.50	V	0.00	2.00	39.50	-3.0	66.9	5000.0	-37.5	Peak
2483.50	V	0.00	2.00	29.90	-3.0	22.1	500.0	-27.1	Average
802.11n 65Mb									
2483.50	V	0.00	2.00	41.84	-3.0	87.5	500.0	-15.1	
2483.50	V	0.00	2.00	30.20	-3.0	22.9	500.0	-26.8	
802.11b 11Mb									
2483.50	H	0.00	1.63	41.80	-3.0	87.1	5000.0	-35.2	Peak
2483.50	H	0.00	1.63	29.90	-3.0	22.1	500.0	-27.1	Average
802.11g 54Mb									
2483.50	H	0.00	1.63	42.00	-3.0	89.2	5000.0	-35.0	Peak
2483.50	H	0.00	1.63	29.50	-3.0	21.1	500.0	-27.5	Average
802.11n 65Mb									
2483.50	H	0.00	1.63	40.83	-3.0	77.9	5000.0	-36.1	
2483.50	H	0.00	1.63	29.70	-3.0	21.6	500.0	-27.3	

