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FCC Certification Test Report

For the

REUTECH

MSR ESPRIT

FCC ID: YSD-5840-HG-2000

WLL JOB# **15807-01 Rev 2**
December 17, 2018

Prepared for:

Reutech
35 Electron Avenue
Stellenbosch, Capetown, 7599 South Africa

Prepared By:

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7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ilac-MRA

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY AT-1448

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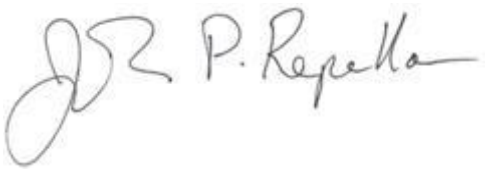

John P Repella
Manager, EMC & Wireless Services

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Reutech to support the attached Application for Equipment Authorization. The test report and application are submitted for a Licensed Transmitter under Part 90 of the FCC Rules and Regulations (08/2015). This Certification Test Report documents the test configuration and test results for a Reutech MSR Esprit.

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.

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These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by the ANSI-ASQ National Accreditation Board/ANAB. Refer to certificate and scope of accreditation AT-1448.

The Testing completed by Washington Laboratories LTD. for the Reutech MSR Esprit complies with the limits for a Licensed Transmitter device under FCC Part 90.

Revision History	Reason	Date
Rev 0	Initial Release	December 17, 2018
Rev 1	Modifications from ACB	January 28, 2019
Rev 2	Modifications from ACB	February 15, 2019

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The Reutech MSR Esprit complies with the limits for a Licensed Transmitter device under FCC Part 90 (08/2015).

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with ANSI C63.4, ANSI/TIA/EIA-603D & ANSI C63.26. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Reutech 35 Electron Avenue Stellenbosch, Capetown, 7600 South Africa
Purchase Order Number:	Deposit Terms
Quotation Number:	70367B

1.4 Test Dates

Testing was performed on the following date(s):	11/09/2018-11/13/2018

1.5 Test and Support Personnel

Washington Laboratories, LTD	John P. Repella
Customer Representative	Leon Nel

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

2 Equipment Under Test

2.1 EUT Identification & Description

The EUT (Radio Frequency Unit - RFU) is the radar unit of the MSR ESPRIT system that performs slope stability monitoring in open pit mines. It does so by generating and transmitting a frequency modulated continuous wave (FMCW) waveform over a bandwidth of 308MHz in the band 9.5 to 9.975GHz through numerous low gain, wide beam patch antennas to cover the entire field of view. The transmit beam is steered electronically by applying phase modulation to the various patch antenna elements. The reflection from the rockface is received by the receiver where it is down converted, filtered, digitized and processed before it goes to the system data processor (external to the RFU)

2D operation: In this mode either the 1x2 Horizontally Polarized array left and right or 1x2 Vertically Polarized array left and right are utilized to illuminate the mine slope. The reflections from the mine slope are received via the same receive antenna patch arrays and are processed utilizing the same processing chain hardware for all modes.

3D operation: In this mode the 20x2 Horizontally Polarized array left and right are utilized to illuminate the mine slope. Test mode operation: In this mode the test antenna dipole is used to emit a signal that is utilized to test the receive antenna arrays.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Reutech
FCC ID:	YSD-5840-HG-2000
Model:	MSR Esprit
FCC Rule Parts:	§90.103
Frequency Range:	9.5 to 9.975GHz (operationally 9.567 to 9.875GHz is utilized)
Maximum Output Power:	2.77 W (34.43 dBm) (EIRP in 3D mode)
Modulation:	Frequency Modulated Continuous Wave (FMCW)
Necessary Bandwidth:	308 MHz
Keying:	None
Type of Information:	Data
Number of Channels:	Swept
Power Output Level	Nominal (17dBm)
Antenna Connector	SMA
Antenna Type	MIMO Patch radiators configured in arrays fed separately by microstrip transmission line feed networks. The OEM for the patch antenna arrays is RRS. Each patch element has a theoretical gain of 7.4 dBi
Frequency Tolerance:	±100ppm
Emission Type(s):	F0N
Emissions Designator:	308MF0N
Power Source & Voltage:	24VDC

2.2 Test Configuration

The EUT is mounted on a stand and is powered from an external DC power supply. Communication with the EUT is achieved via an ethernet connection between the laptop hosting the Message Manager application and the EUT. See Figure 1.

Each array transmits in sequence, i.e., not simultaneously.

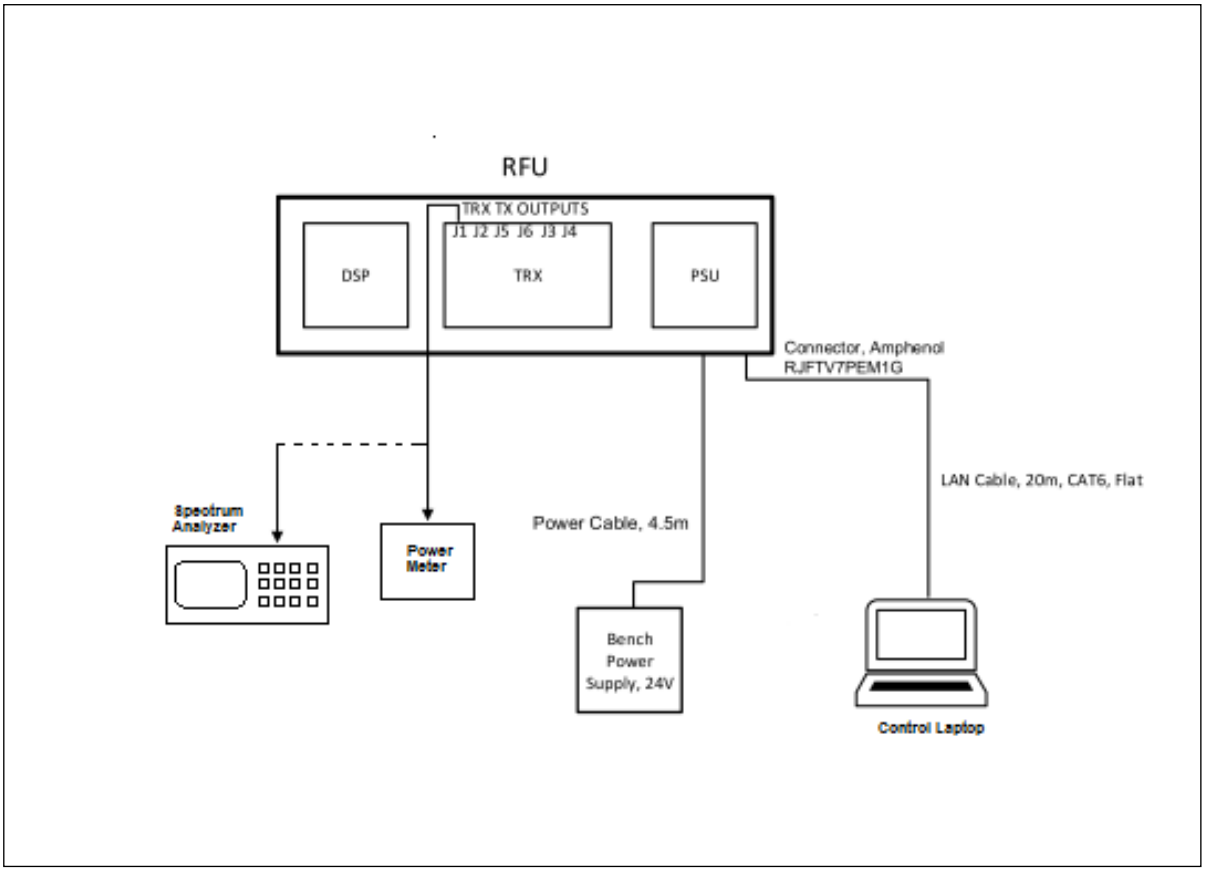

Figure 1: Test Configuration

Under normal operation, the EUT sweeps a CW signal from 9.5GHz to 9.975GHz. Figures 14 & 15 show plots of the normal operational output of the EUT.

2.3 Testing Algorithm

The MSR Esprit was operated by selecting the operating mode, individual CW frequency or Sweep mode, utilizing the test software provided.

Conducted measurements were taken by connecting the Spectrum Analyzer or power meter to TRX TX ports as shown in Figure 2 with the remaining ports terminated.

The Message Manager was used to set up Primary TX mode and measure the output power at the particular port. An offset was used to compensate for attenuator and cable losses and the power level was recorded. The measurement was conducted at TX frequencies of 9.5GHz, 9.75GHz and 9.975GHz in the Primary 2D mode at TRX TX ports J5 and J6 and. In the Primary 3D mode at TRX TX ports J3 and J4.

Note: Ports 1, 2, 5 and 6 are equivalent in configuration and therefore only ports 5 and 6 were tested for this group.

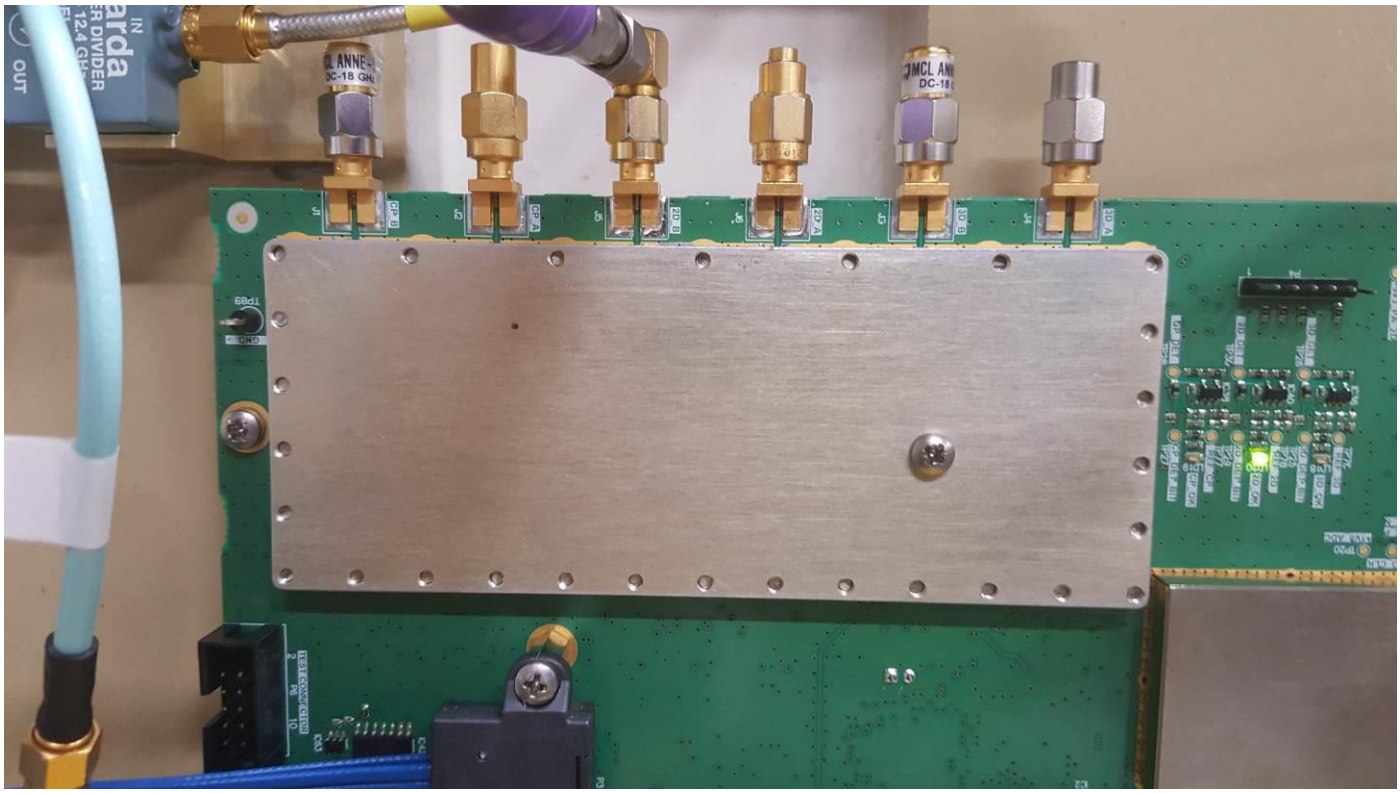

Figure 2: TRX Ports

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 ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

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

ANSI C63.4 “American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz”

Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (ANSI/TIA/EIA-603C)

ANSI C63.26:2015 “American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services”

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 (R2002) 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

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

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

$$U = k u_c$$

Where U = expanded uncertainty
k = coverage factor
k ≤ 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
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	±4.55 dB

Parameter	Uncertainty	Actual (+/-)
Radio Frequency	±1 x 10^{-7}	±8.64E-08 parts
RF Power conducted (up to 160 W)	±0.75 dB	±0.3dB
Conducted RF Power variations	±0.75 dB	±0.3dB

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

Test Name:	**Various**	Test Date:	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
528	AGILENT/PSA E4446A	SPECTRUM ANALYZER 3Hz-44GHz	12/19/2018
823	AGILENT/EXA 9010A	SPECTRUM ANALYZER 10Hz-26.5GHz	04/21/2019
425	ARA/DRG-118/A	ANTENNA 1-18GHz	01/03/2020
644	SUNOL SCIENCES/JB1	BICONALOG ANTENNA 26MHz-1GHz	01/16/2020
559	HP/8447D	PRE-AMPLIFIER 100kHz-1GHz	02/12/2019
522	HP /8449B	PRE-AMPLIFIER 1-26.5GHz	02/12/2019
U90108-2	Oleson Microwave Labs/M19HW	U Band Harmonic Mixer	08/16/2019
E90108-1	Oleson Microwave Labs/M12HW	E Band Harmonic Mixer	08/16/2019
F91210-1	Oleson Microwave Labs/M08HW	F Band Harmonic Mixer	08/16/2019
DPL.26.01	Oleson Microwave Labs/DPL.26	Diplexer	08/16/2019

4 Test Results

4.1 RF Power Output: (FCC Part §2.1046) (C63.26 Section 5.2)

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.

System Notes:

All RF signals in the ESPRIT Radar Sensor are generated in the Transceiver (TRX). The TRX also contains all the RF amplifiers for the Transmit (TX) signals. The TRX has seven TX ports, six of which have the same output level of 17 dBm and are connected to four Transmit Antenna PCB's via coaxial cables. The four TX Antenna PCB's are actually two sets of similar PCB's. In the first set each PCB contains a 1 x 2 array of vertically polarized patch radiators and a 1 x 2 array of horizontally polarized patch radiators. These arrays are fed separately by microstrip transmission lines. In the second set each PCB contains a 20 x 2 array of horizontally polarized patch radiators. The arrays are again fed by microstrip transmission line feed networks. **Per section 90.205(r), there is no power limit at the fundamental emissions frequencies.**

Table 4: RF Power Output 2D_A J5

Frequency (GHz)	Level(dBm)	Limit
9.500	16.390	N/A
9.750	17.081	N/A
9.975	17.157	N/A

Table 5: RF Power Output 2D_B J6

Frequency (GHz)	Level(dBm)	Limit
9.500	17.023	N/A
9.750	16.906	N/A
9.975	15.635	N/A

Table 6: RF Power Output 3D_B J3

Frequency (GHz)	Level(dBm)	Limit
9.500	18.928	N/A
9.750	18.120	N/A
9.975	17.973	N/A

Table 7: RF Power Output 3D_A J4

Frequency (GHz)	Level(dBm)	Limit
9.500	18.397	N/A
9.750	18.043	N/A
9.975	17.929	N/A

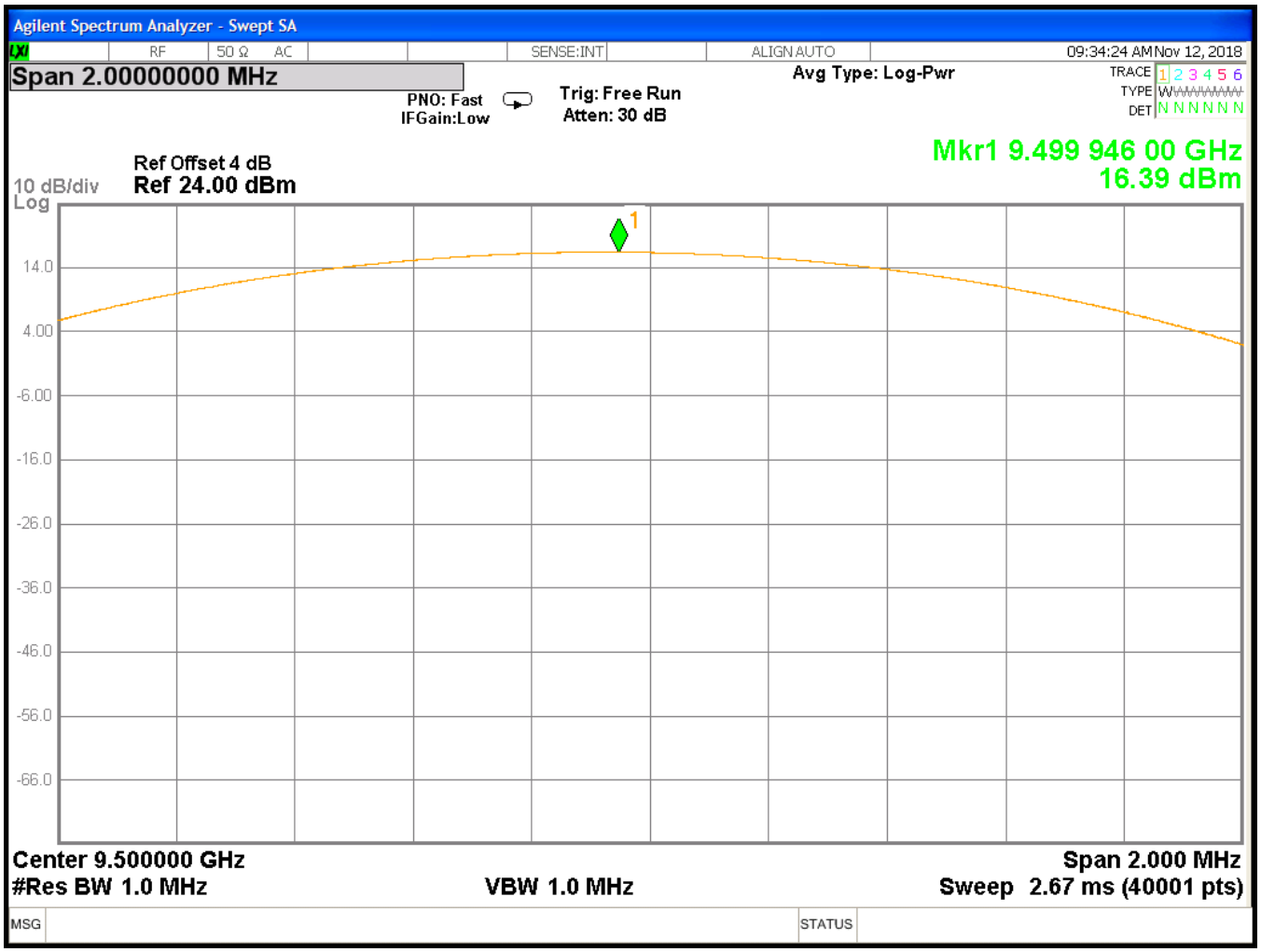

Figure 3: RF Peak Power, 2D_A J5 Low Channel

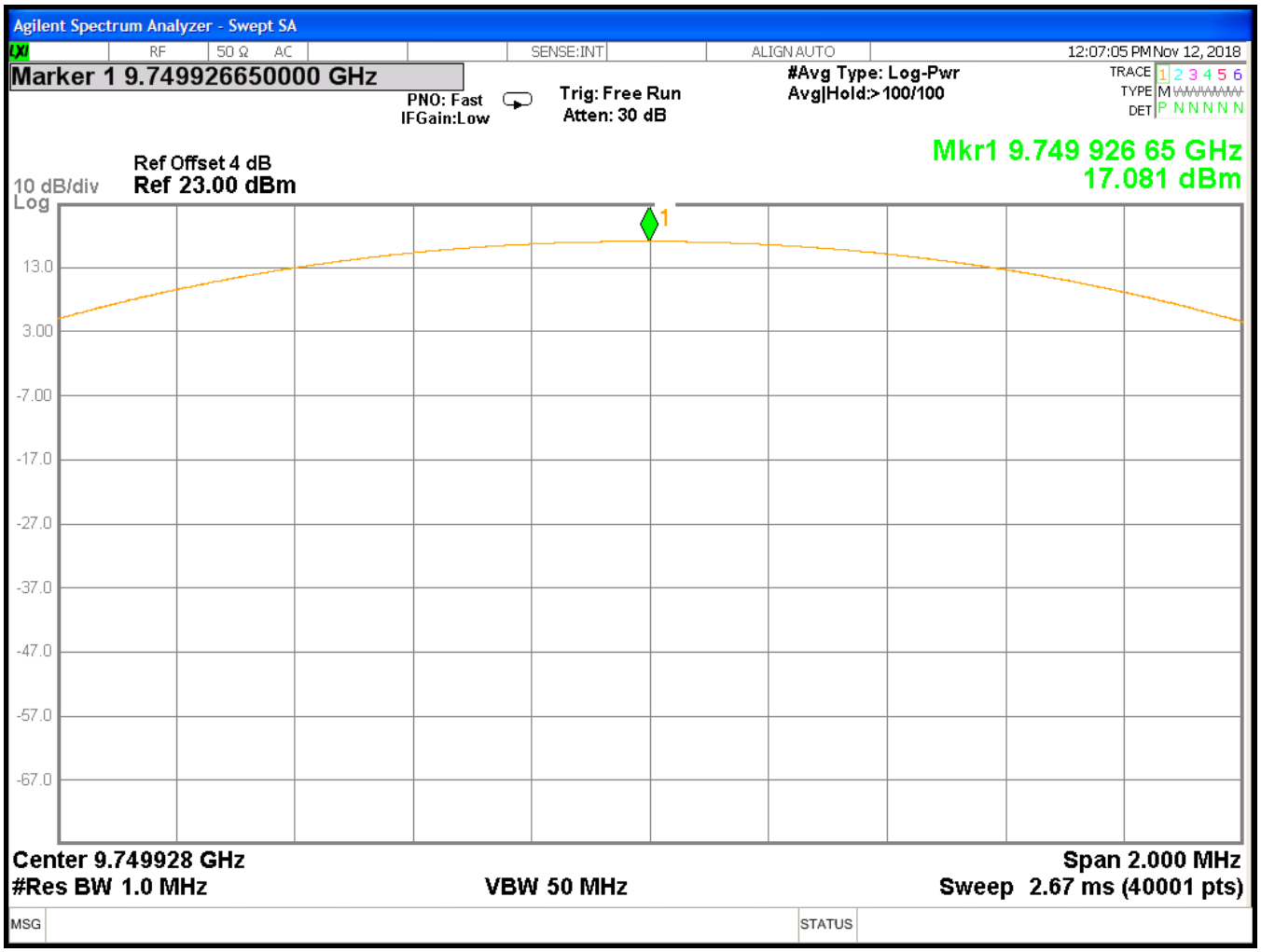

Figure 4: RF Peak Power, 2D_A J5 Mid Channel

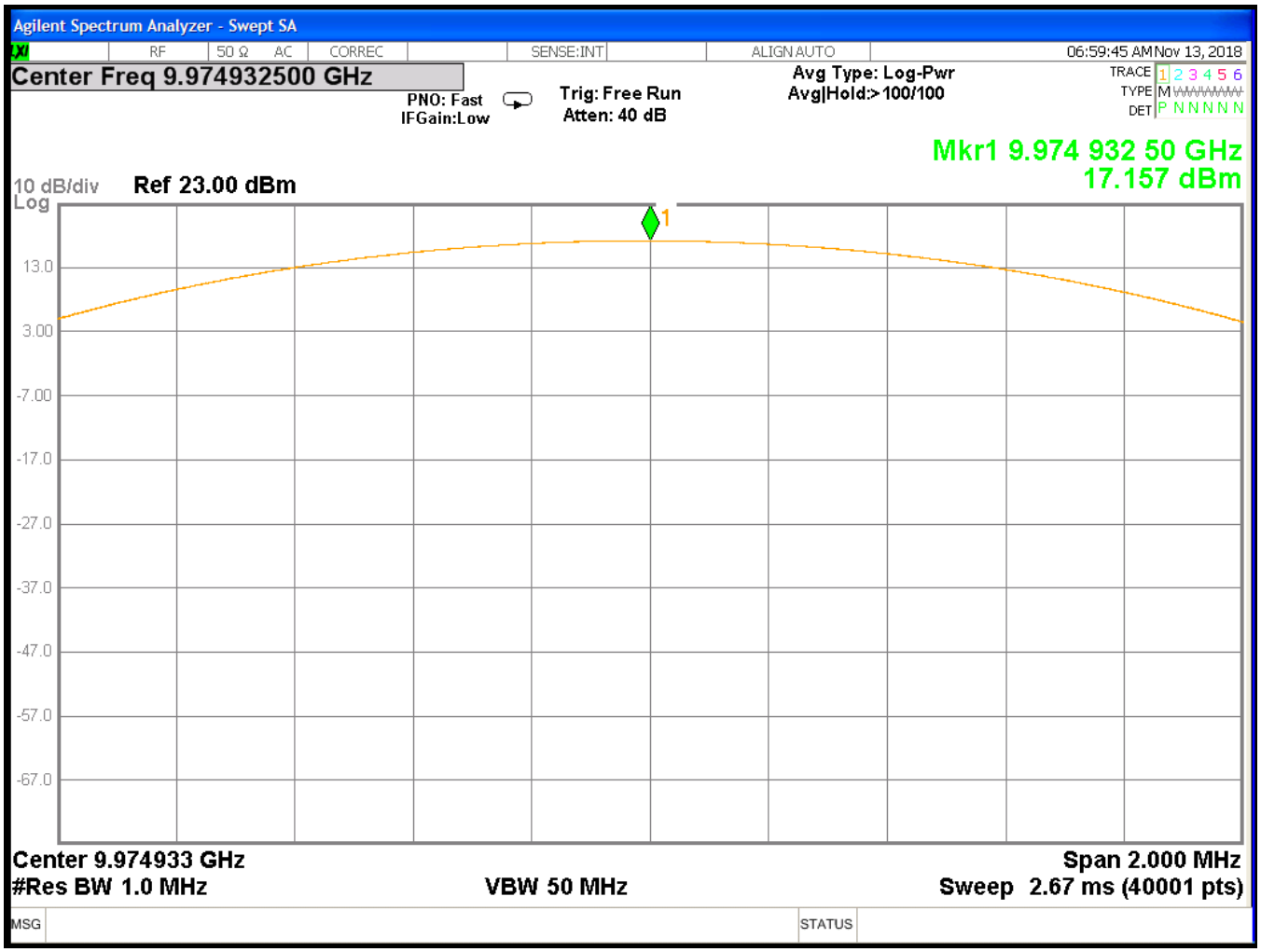

Figure 5: RF Peak Power, 2D_A J5 High Channel

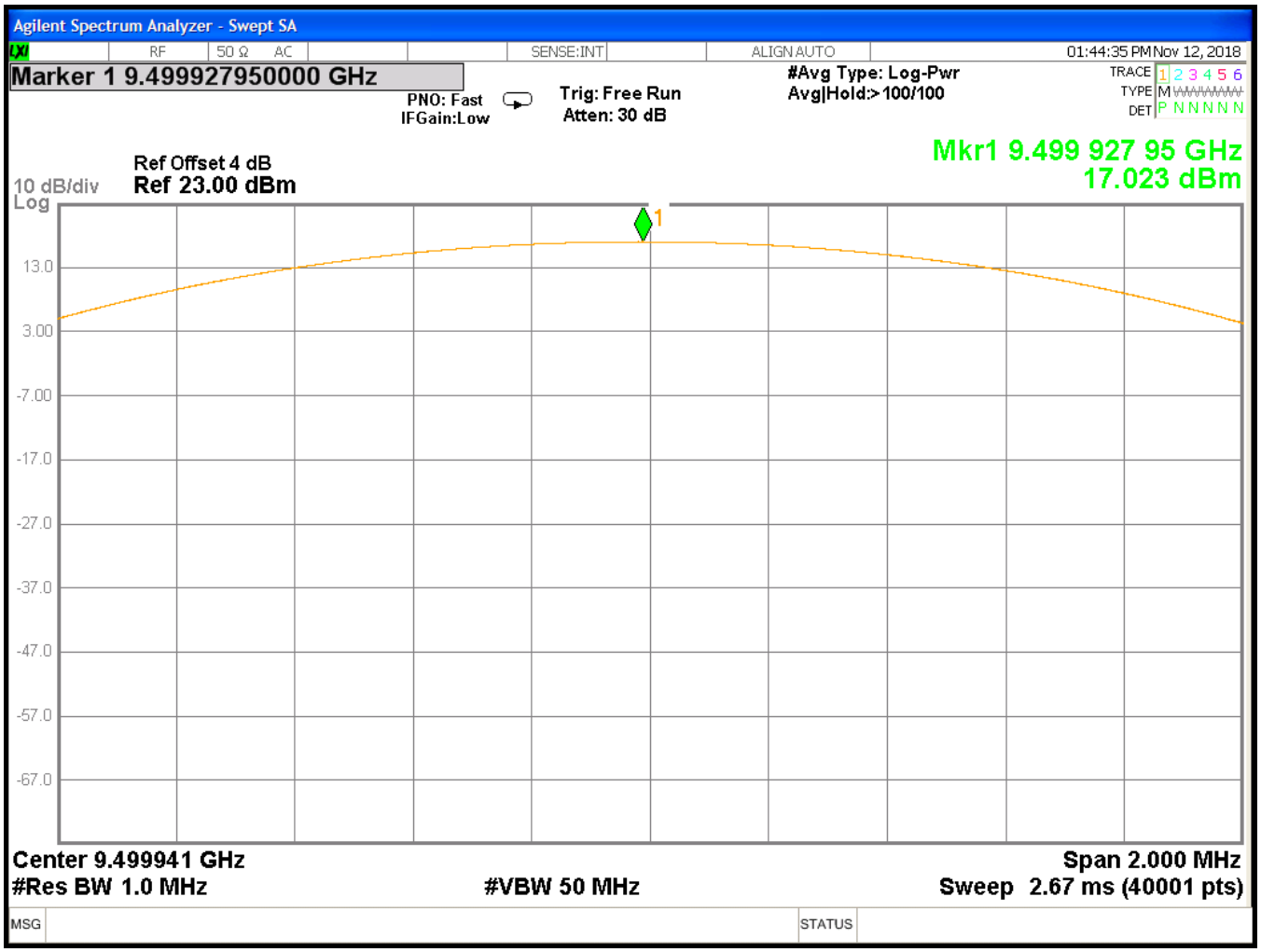

Figure 6: RF Peak Power, 2D J6 Low Channel

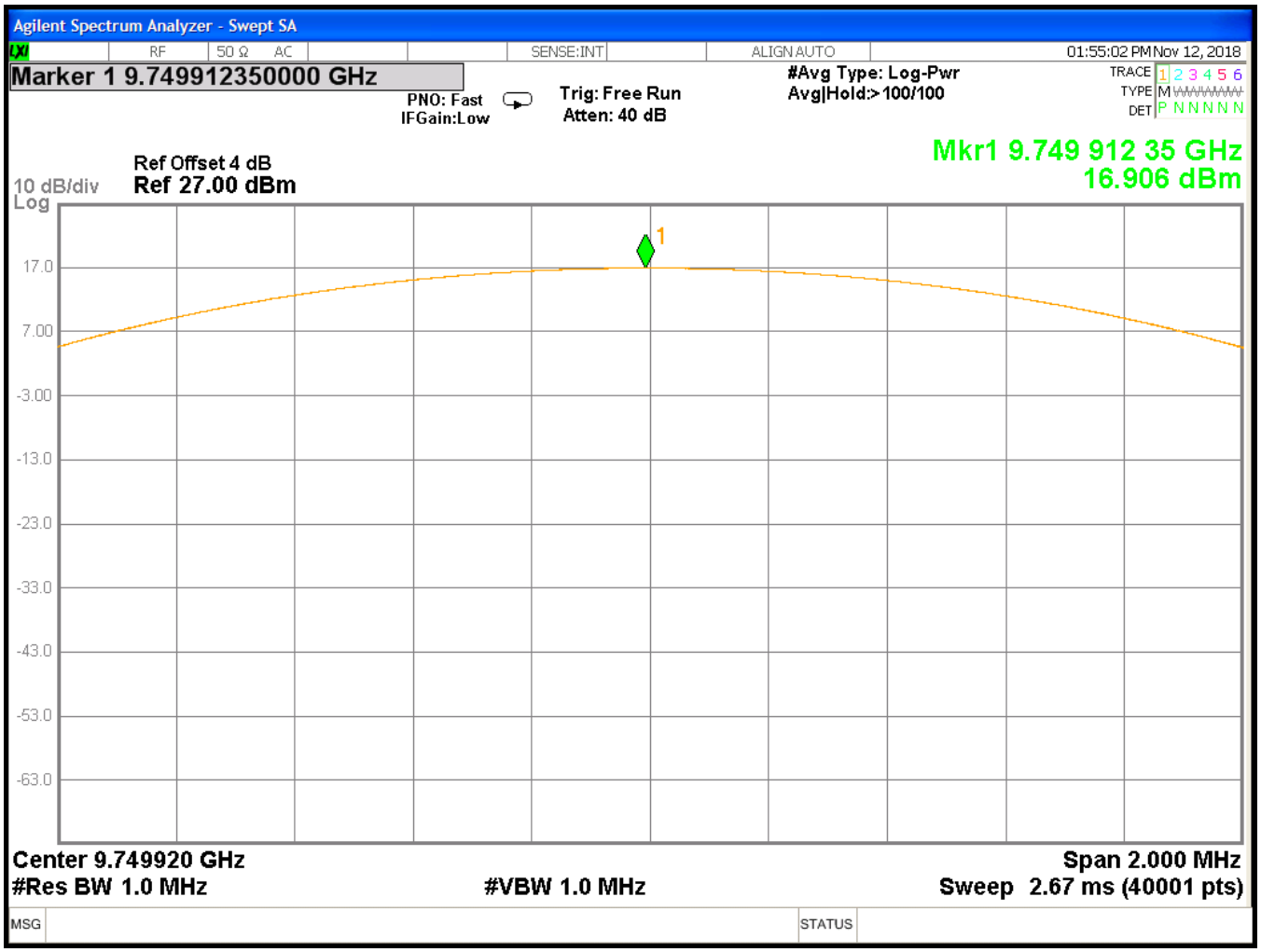

Figure 7: RF Peak Power, 2D_B J6 Mid Channel

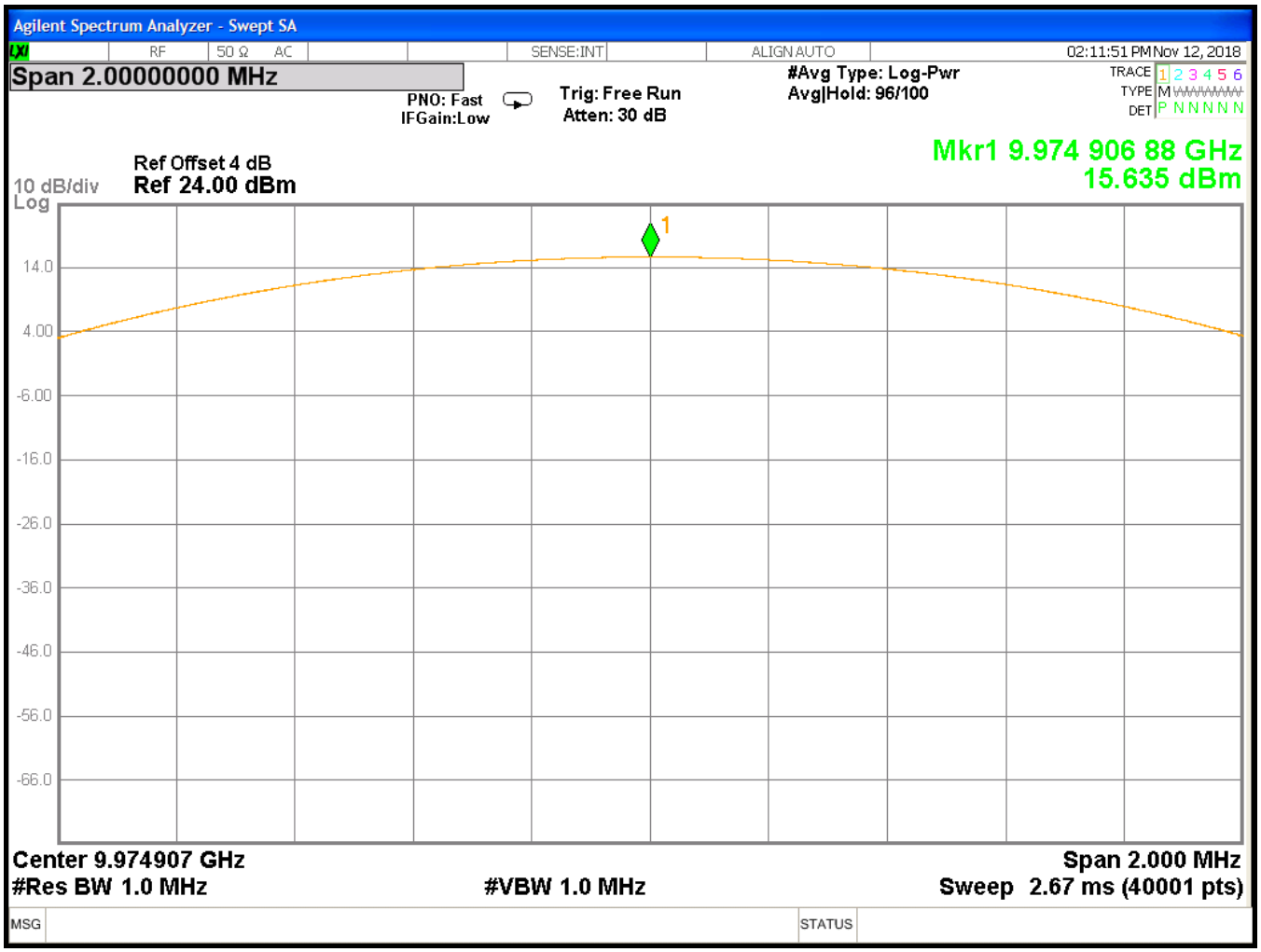

Figure 8: RF Peak Power, 2D_B J6 High Channel

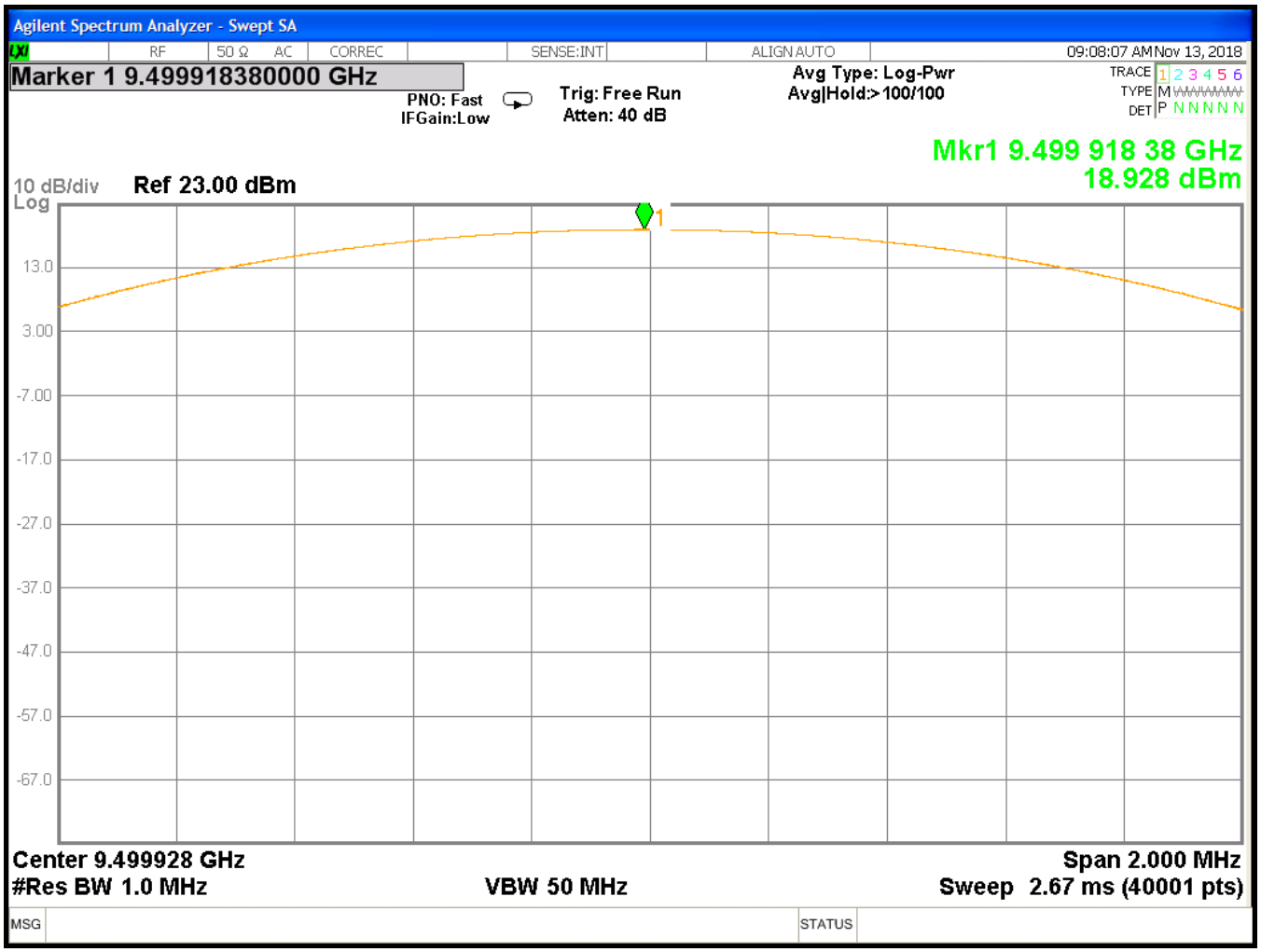

Figure 9: RF Peak Power, 3D_B J3 Low Channel

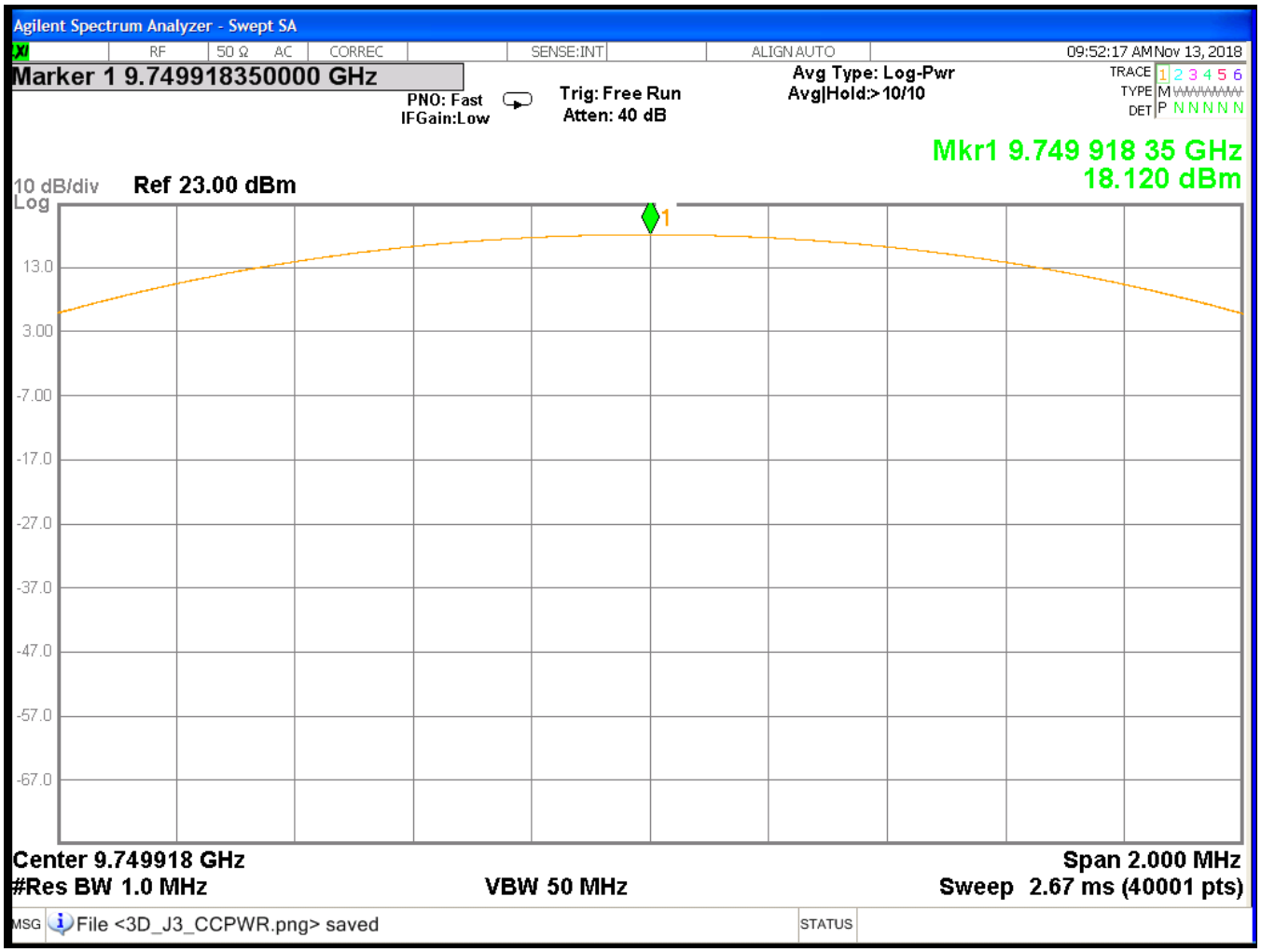

Figure 10: RF Peak Power, 3D_B J3 Mid Channel

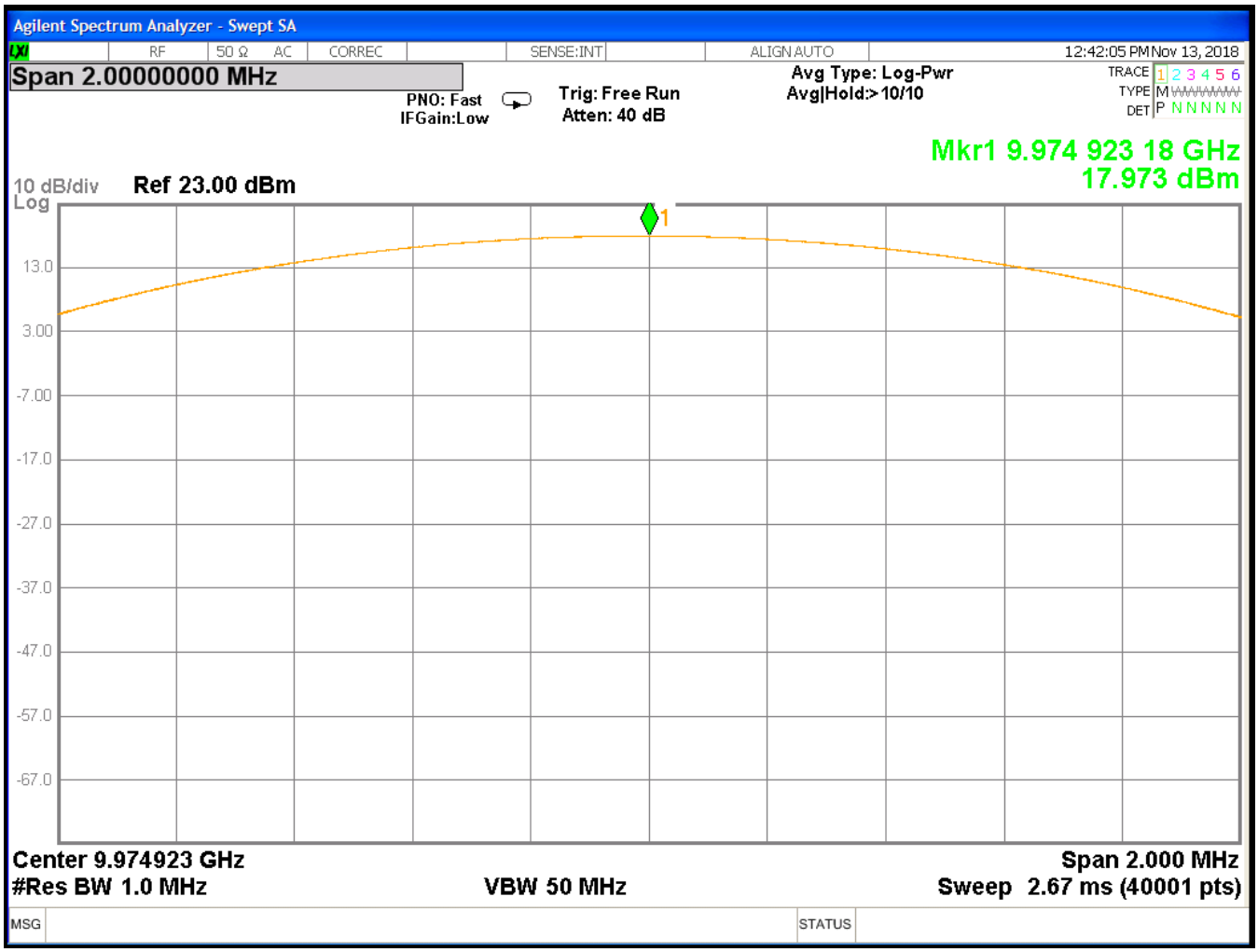

Figure 11: RF Peak Power, 3D_B J3 High Channel

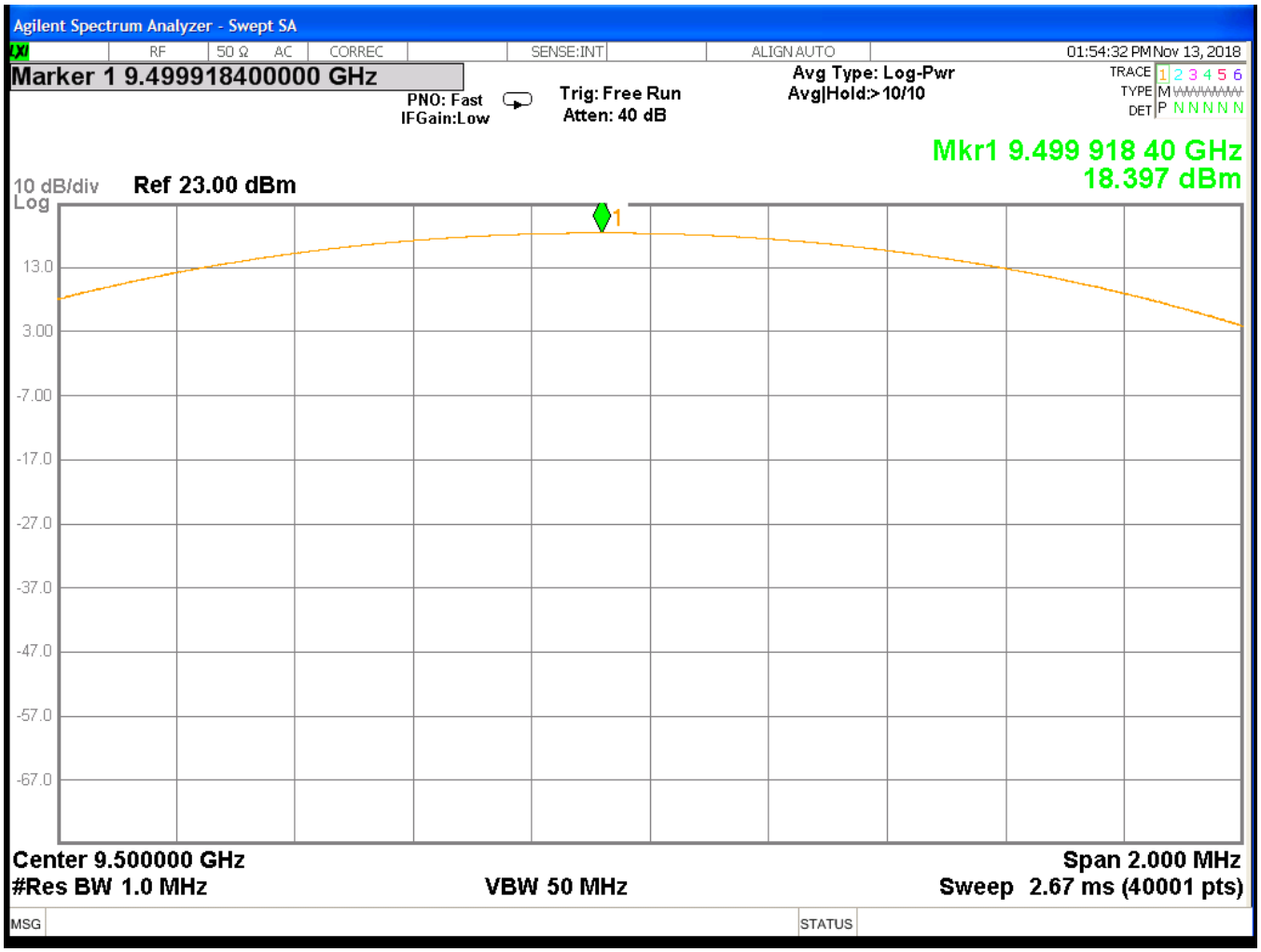

Figure 12: RF Peak Power, 3D_A J4 Low Channel

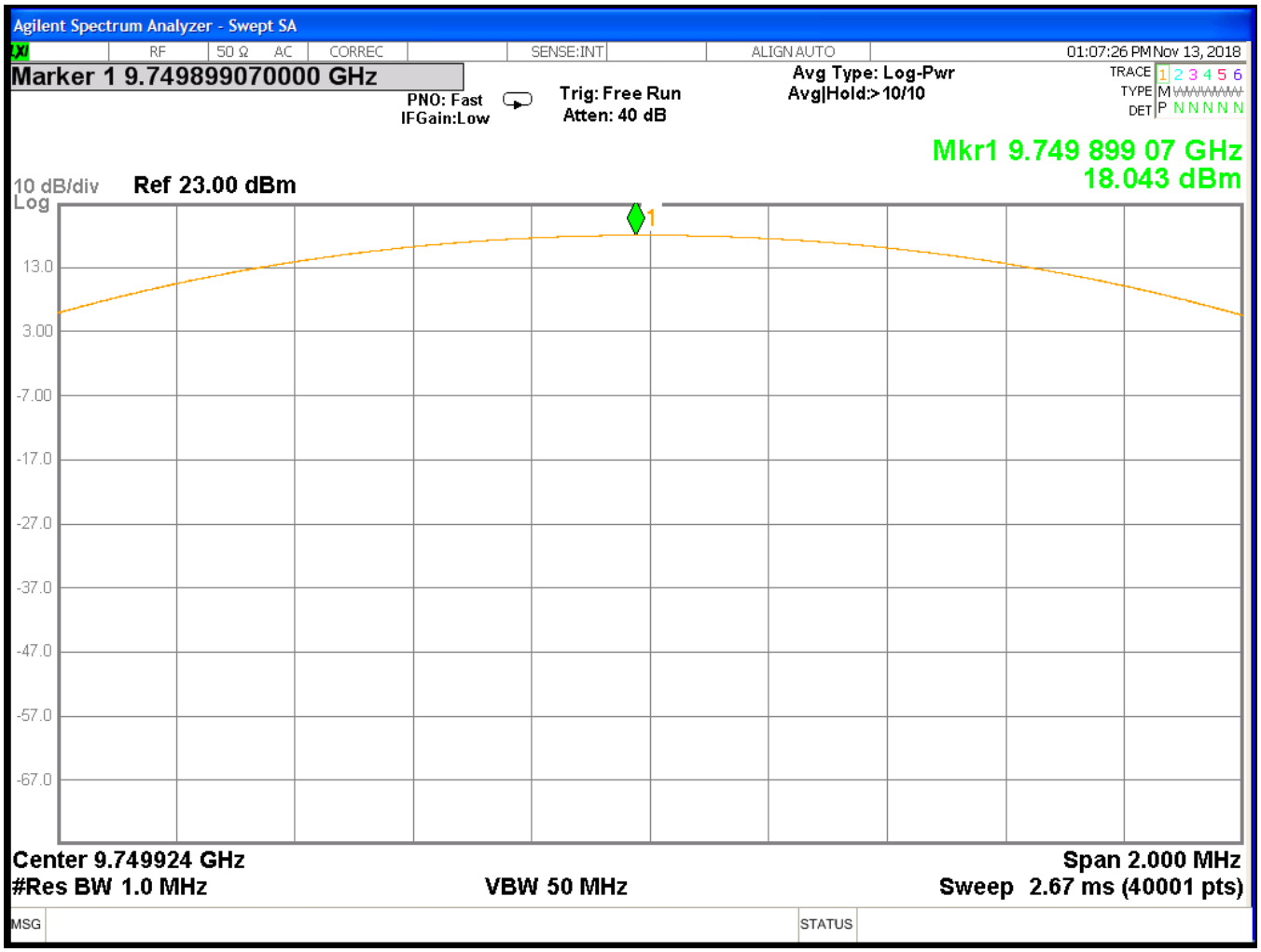

Figure 13: RF Peak Power, 3D_A J4 Mid Channel

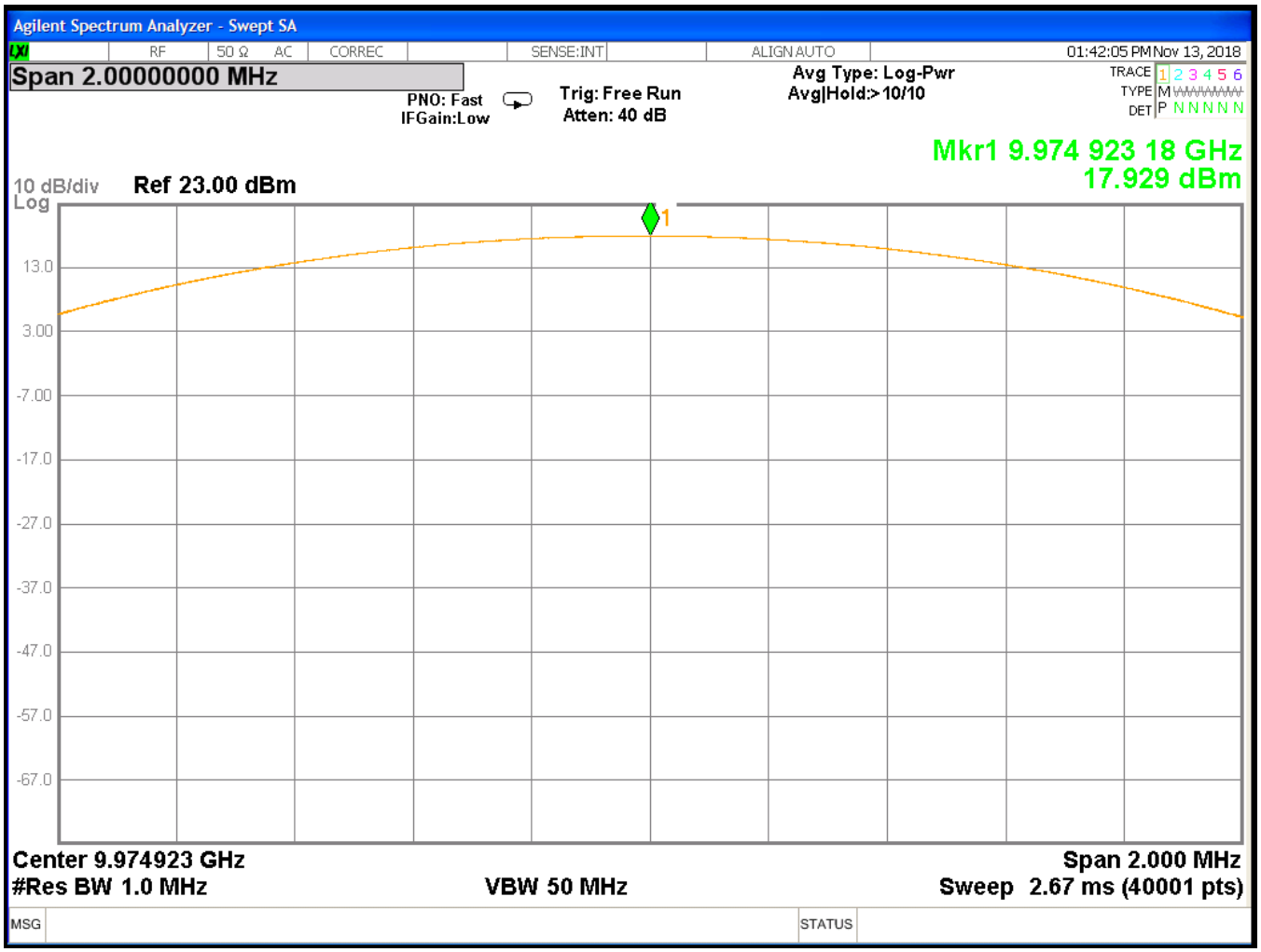

Figure 14: RF Peak Power, 3D_A J4 High Channel

4.2 Radiated EIRP Measurements (C63.26 Section 5.5.3)

Radiated measurements using a standard OATS test arrangement. Direct field strength measurements of the maximum emission amplitude level (maximized as described previously), a signal generator and transmit antenna are substituted in place of the EUT. The output power of the signal generator is adjusted to replicate the maximized signal amplitude measured in the direct field strength measurement. The signal generator power setting is then used to determine the EIRP of the EUT spurious emission(s).

To calculate the emissions power the following equation is used:

Pe = Ps(dBm) − cable loss (dB) + antenna gain (dBd)

Where:

Pe = equivalent emission power in dBm

Ps = source (signal generator) power in dBm

Manufacturer's Calculated Parameters

	TX Set 1 1x2 H-pol left and right	TX Set 2 1x2 V-pol left and right	TX Set 3 20x2 H-pol left and right
Gain (dBi)	6.3	6.3	6.3
Number of Antenna Elements (N)	4	4	80
TX Cable Loss(dB)	1.8	1.8	1.8
Microstrip Feed Loss(dB)	3.5	3.5	4.3
Phase Modulator Loss(dB)	3.5	3.5	3.5
Total Power Gain(dB)	3.5	3.5	15.8

	TX Set 1 1x2 H-pol left and right	TX Set 2 1x2 V-pol left and right	TX Set 3 20x2 H-pol left and right
Conducted PWR (dBm)	17.8	17.8	17.6
Directive Gain (dB)	3.5	3.5	15.8
EIRP (dBm)	21.3	21.3	33.4
EIPR(W)	0.14	0.14	2.2

Table 8: Radiated EIRP Measurements

Frequency (MHz)	Polarity (H/V)	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors(dB)	Corr. Level (dBuV/m)	EIRP (dBm)	Limit (dBm)	Margin (dB)	Comments
9500.00	V	0.0	1.0	61.2	50.8	112.0	16.7	N/A	N/A	2D
9500.00	V	0.0	1.0	67.0	50.8	117.7	22.5	N/A	N/A	3D
9750.00	V	0.0	1.0	61.4	51.2	112.6	17.3	N/A	N/A	2D
9750.00	V	0.0	1.0	64.0	51.2	115.2	19.9	N/A	N/A	3D
9975.00	V	0.0	1.0	63.5	51.9	115.4	20.1	N/A	N/A	2D
9975.00	V	0.0	1.0	67.0	51.9	118.9	23.6	N/A	N/A	3D
9500.00	H	0.0	1.6	65.2	50.8	116.0	20.7	N/A	N/A	2D
9500.00	H	0.0	1.6	77.2	50.8	128.0	32.7	N/A	N/A	3D
9750.00	H	0.0	1.6	65.3	51.2	116.5	21.3	N/A	N/A	2D
9750.00	H	0.0	1.6	77.4	51.2	128.6	33.4	N/A	N/A	3D
9975.00	H	0.0	1.6	63.5	51.9	115.4	20.1	N/A	N/A	2D
9975.00	H	0.0	1.6	76.8	51.9	128.7	33.4	N/A	N/A	3D

4.3 Occupied Bandwidth & Emissions Mask:

Emissions bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer. The mask was determined using the criteria specified in FCC Part §90.210(c).

4.3.1 Occupied Bandwidth

Under normal operation, the EUT sweeps a CW signal from 9.5GHz to 9.975GHz. Figures 14 & 15 show plots of the normal operational output of the EUT at the 2D and 3D ports.

The occupied bandwidth of the fundamental carrier is immeasurable as it is a CW carrier.

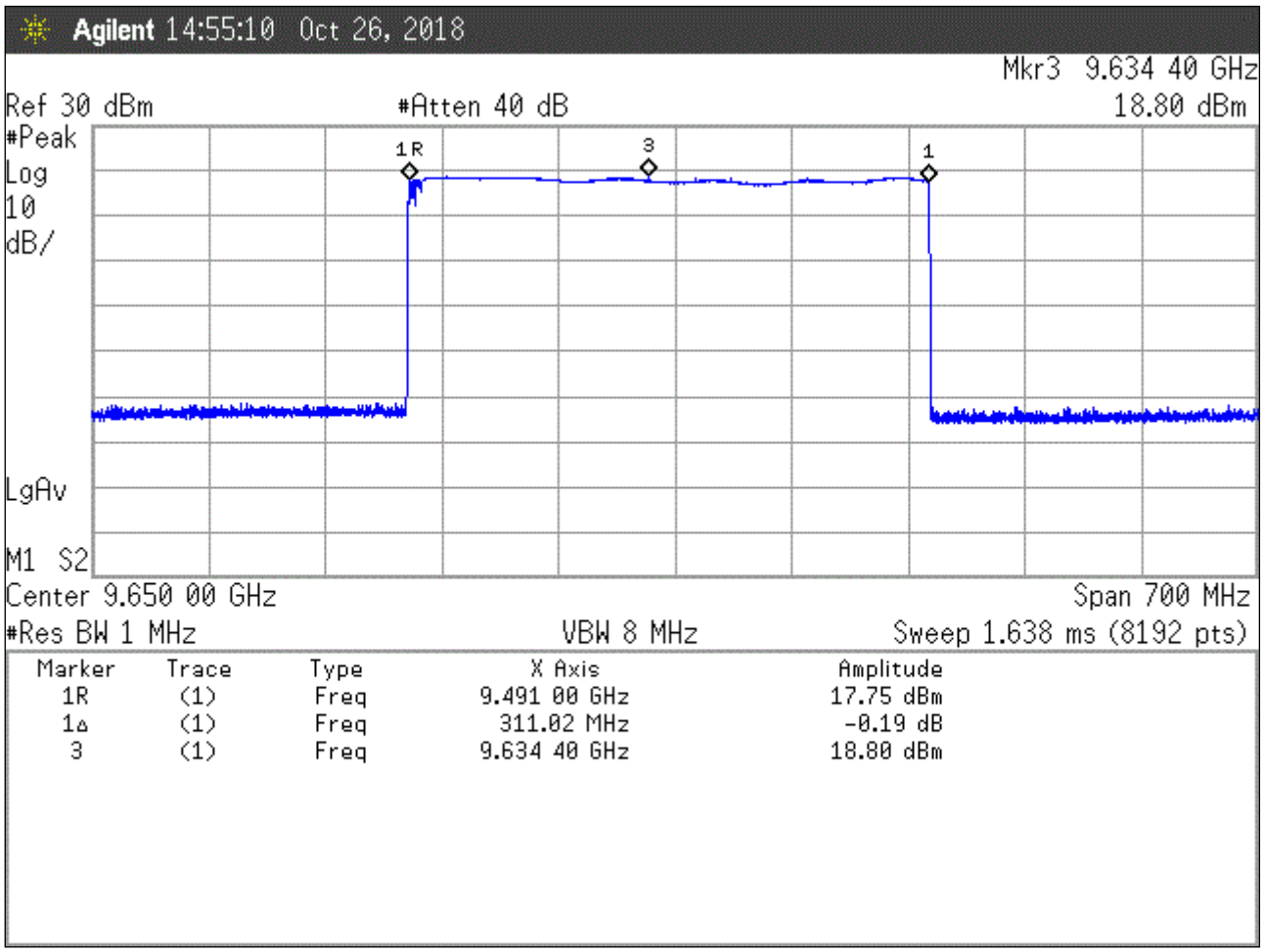

Figure 15: Occupied Bandwidth, 2D

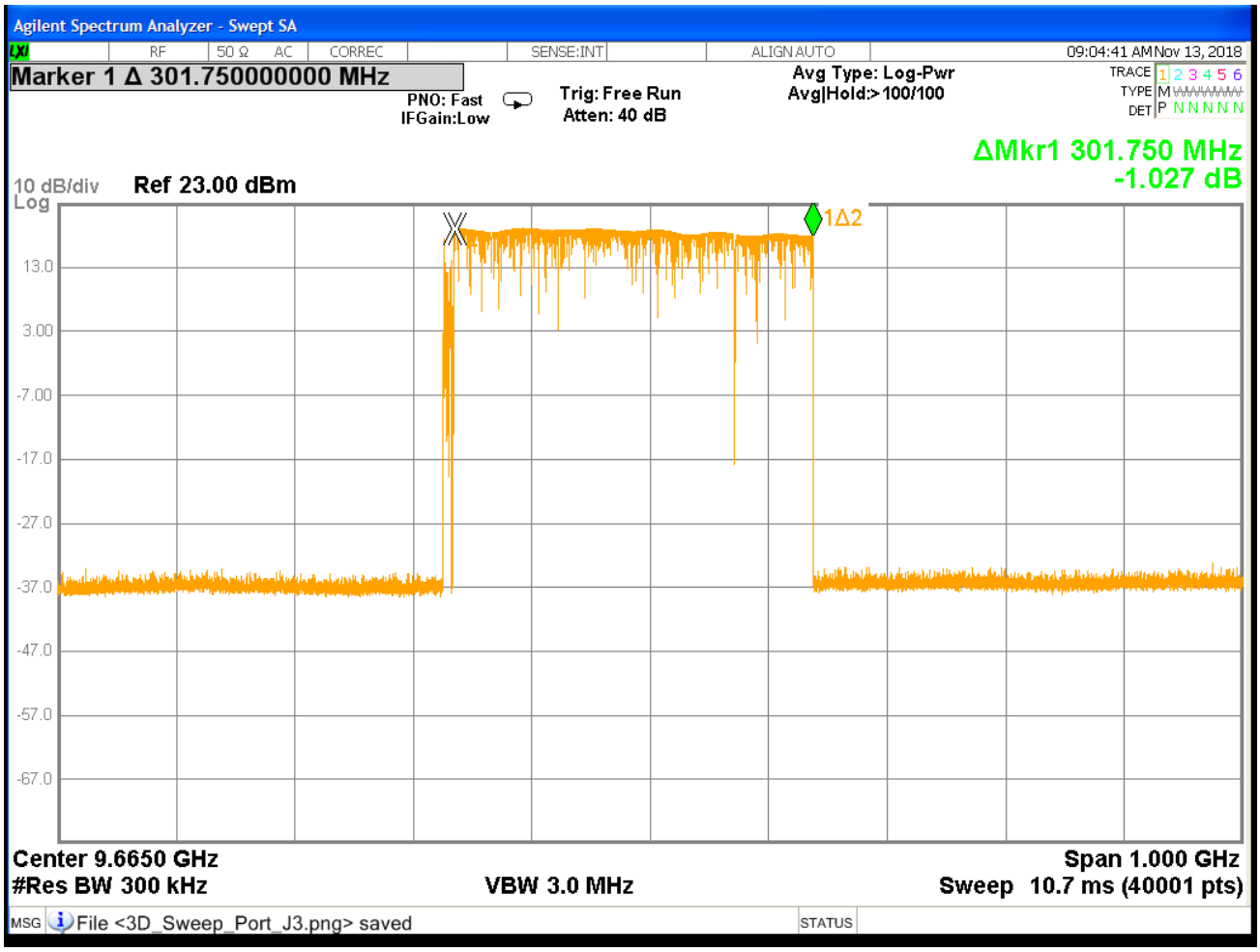

Figure 16: Occupied Bandwidth, 3D

4.3.2 Emissions Mask

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

Mask C

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (fd/5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (fd 2/11) dB or 50 dB, whichever is the lesser attenuation;

(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

The Emissions bandwidth was measured as shown below:

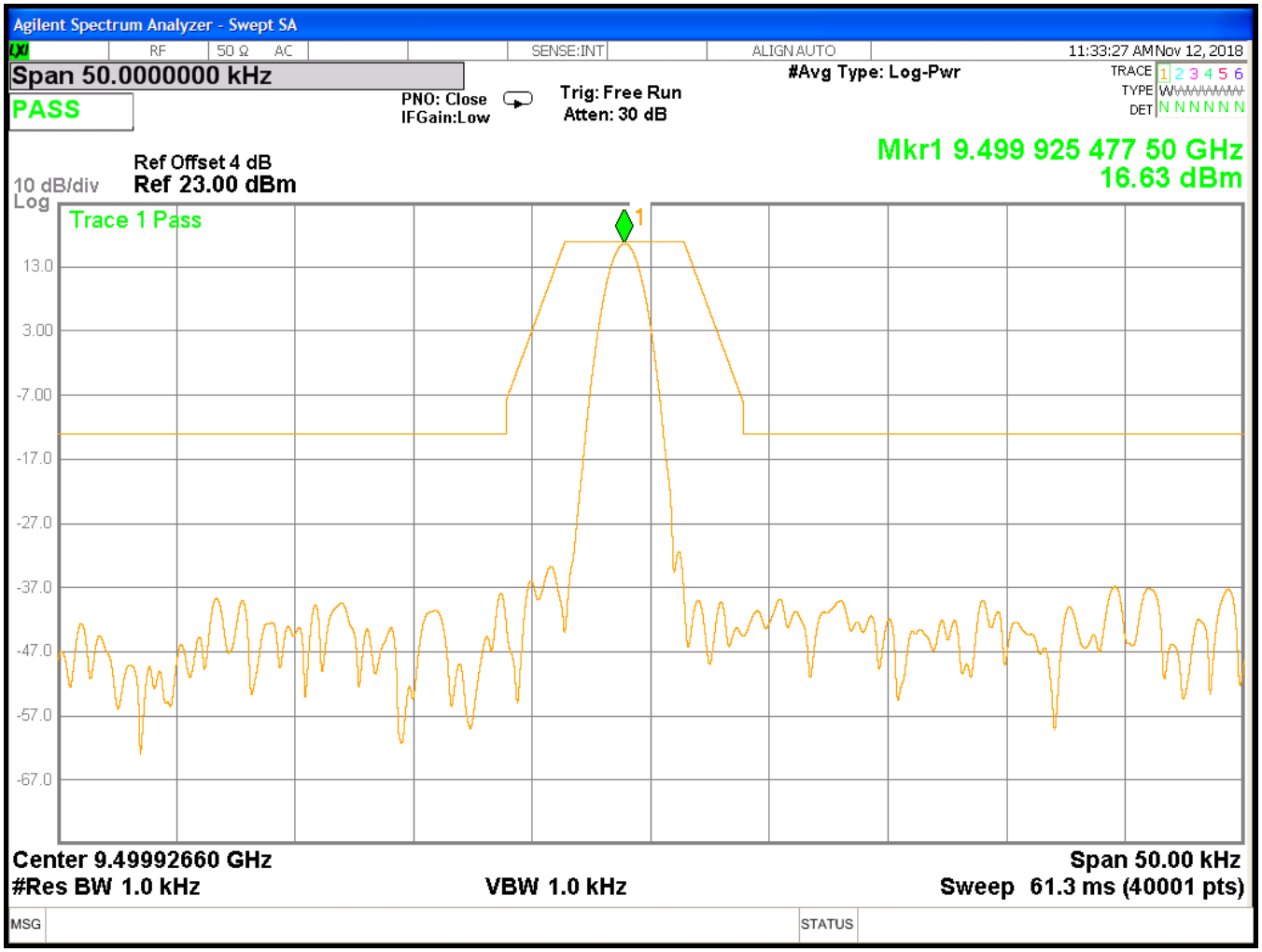

Figure 17: Emissions Bandwidth, 2D_B J5, Low Channel

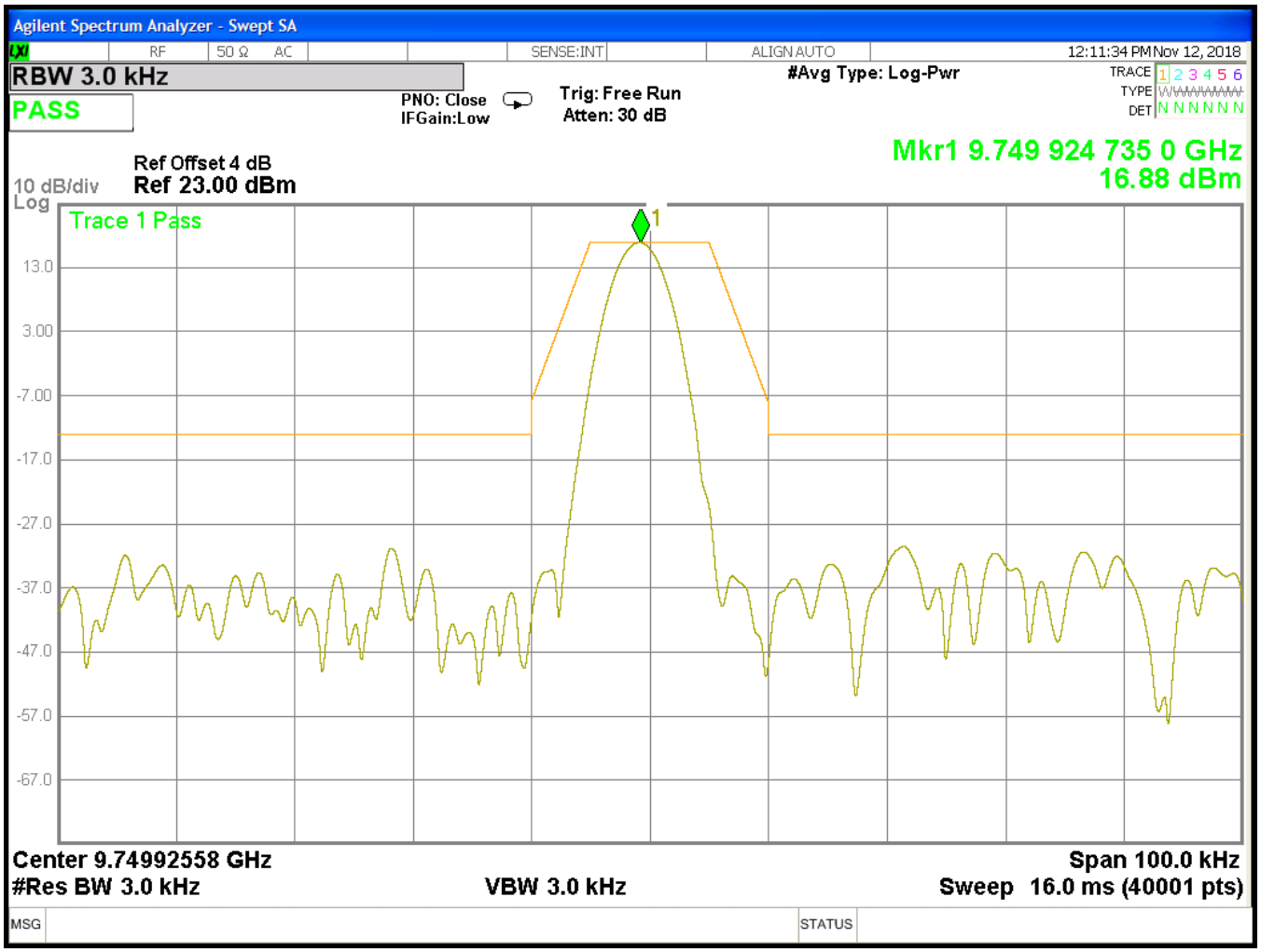

Figure 18: Emissions Bandwidth, 2D_B J5, Mid Channel

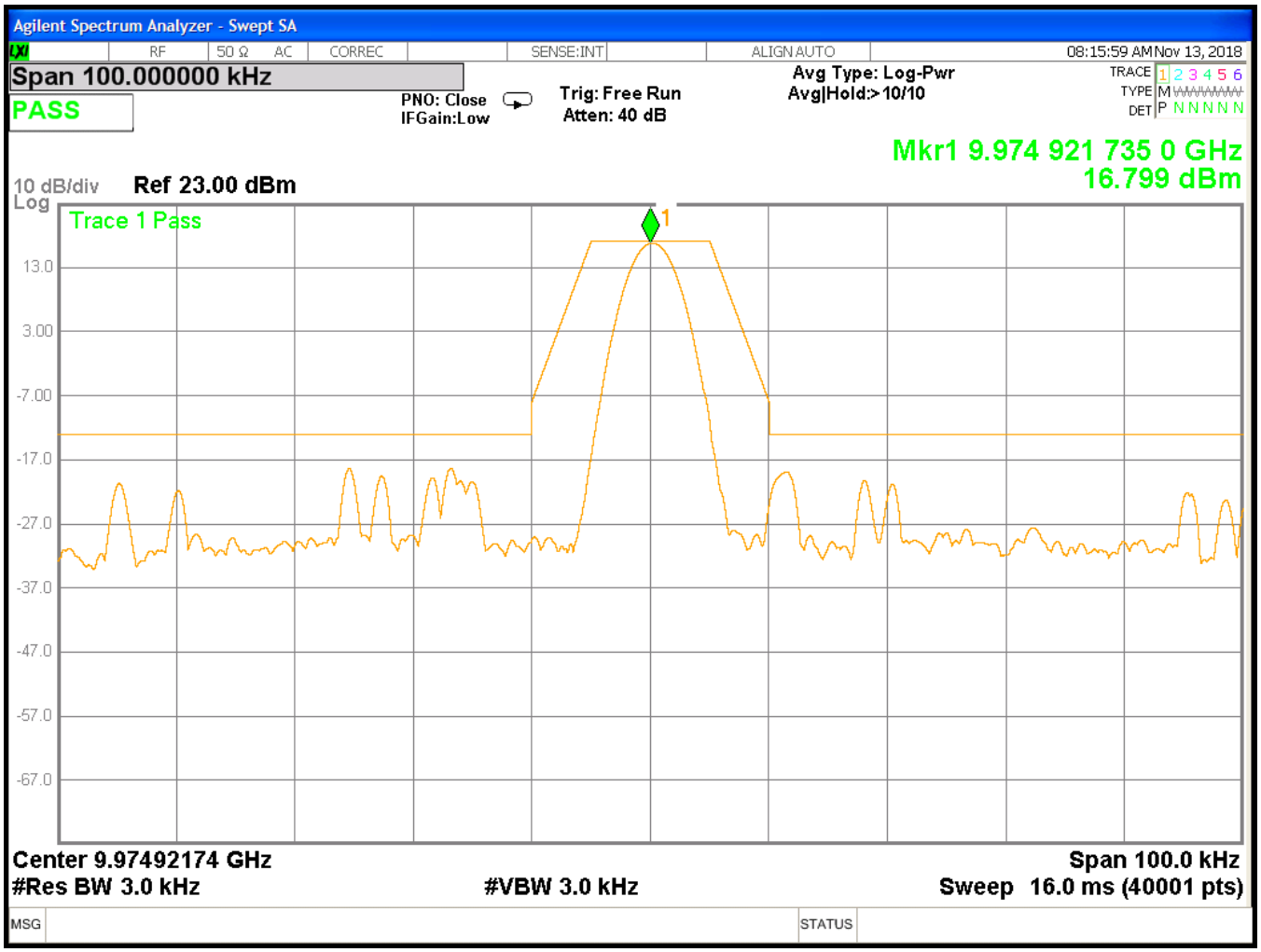

Figure 19: Emissions Bandwidth, 2D_B J5, High Channel

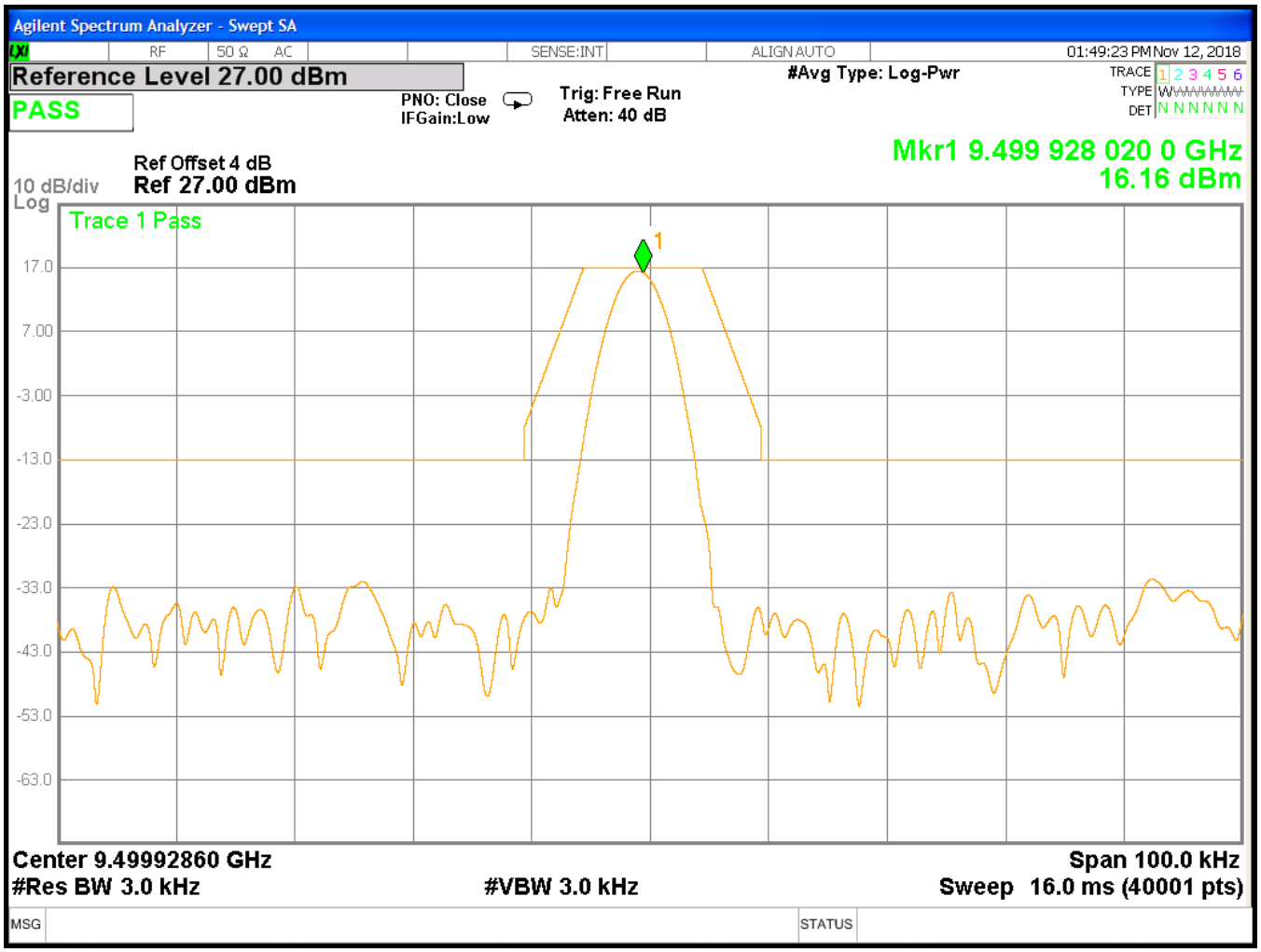

Figure 20: Emissions Bandwidth, 2D_A J6, Low Channel

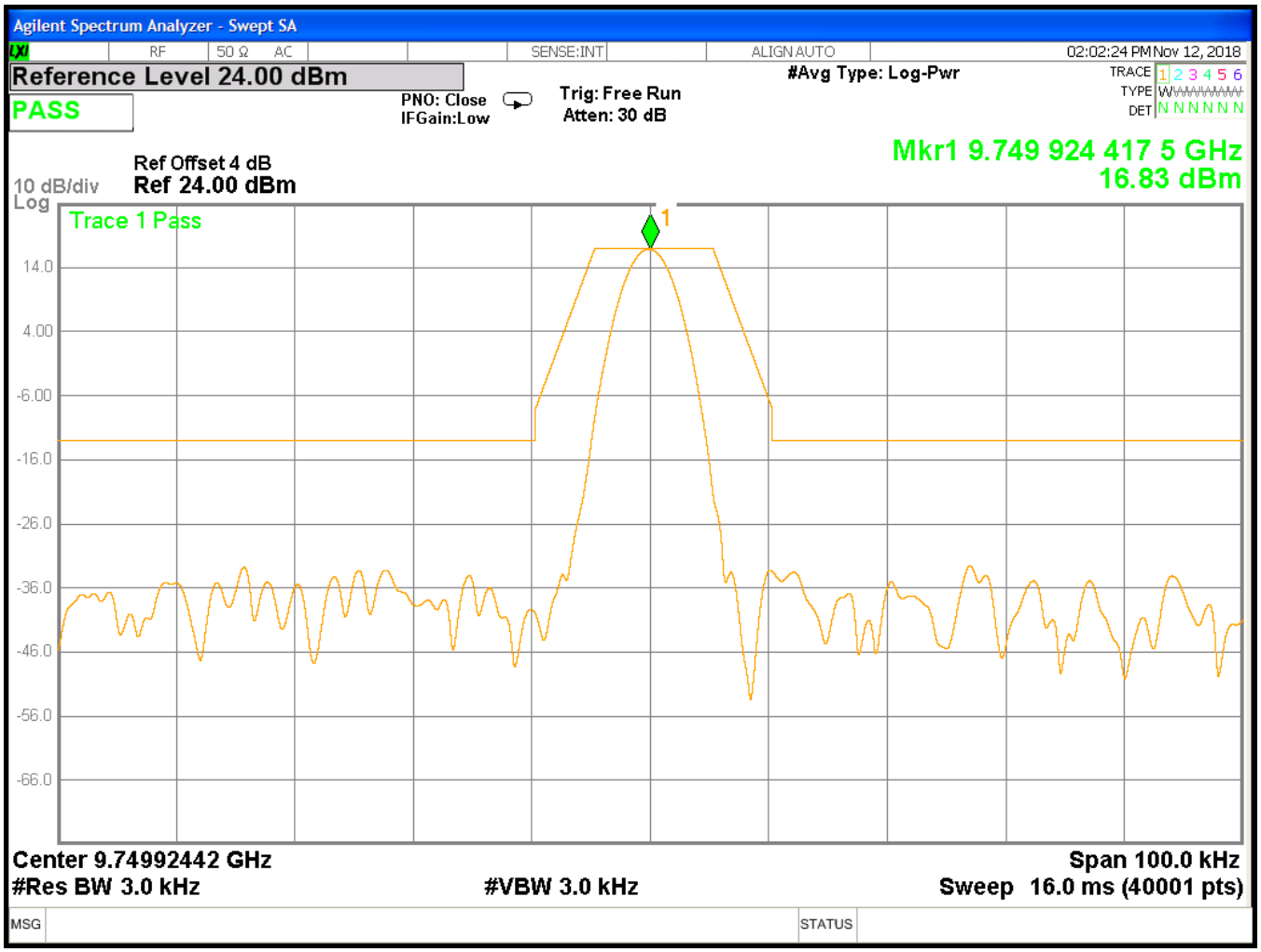

Figure 21: Emissions Bandwidth, 2D_A J6, Mid Channel

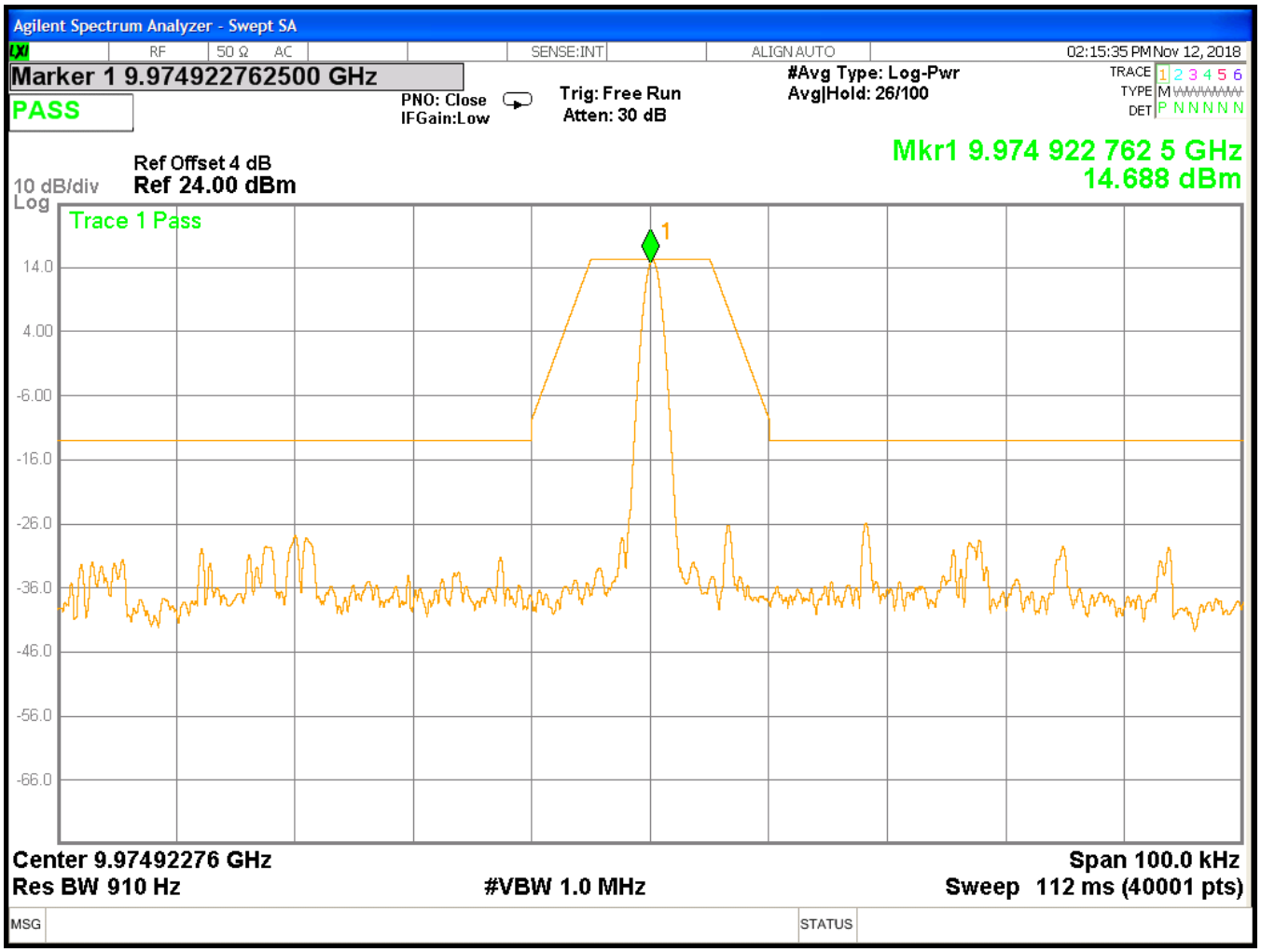

Figure 22: Emissions Bandwidth, 2D_A J6, High Channel

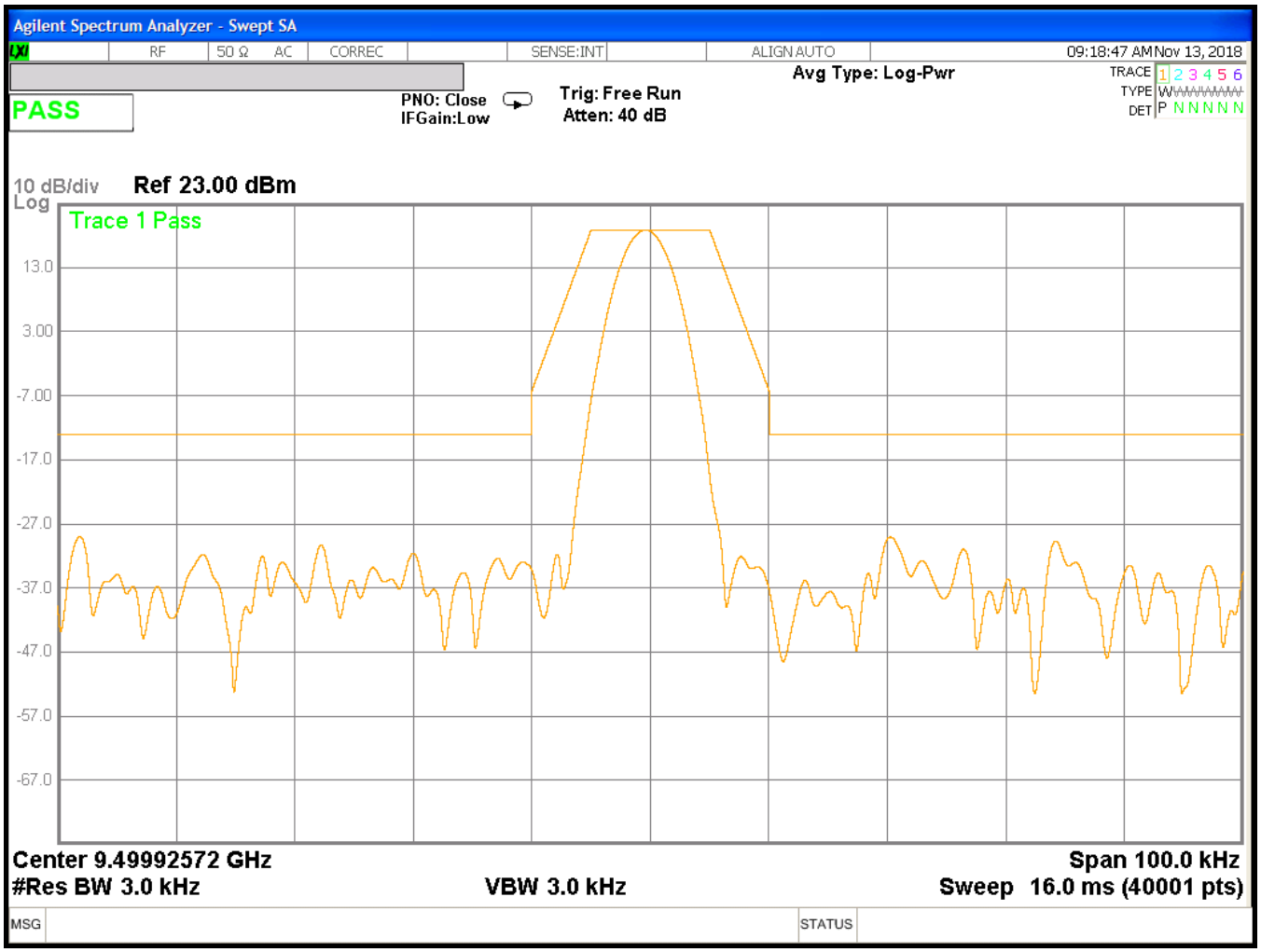

Figure 23: Emissions Bandwidth, 3D_B J3, Low Channel

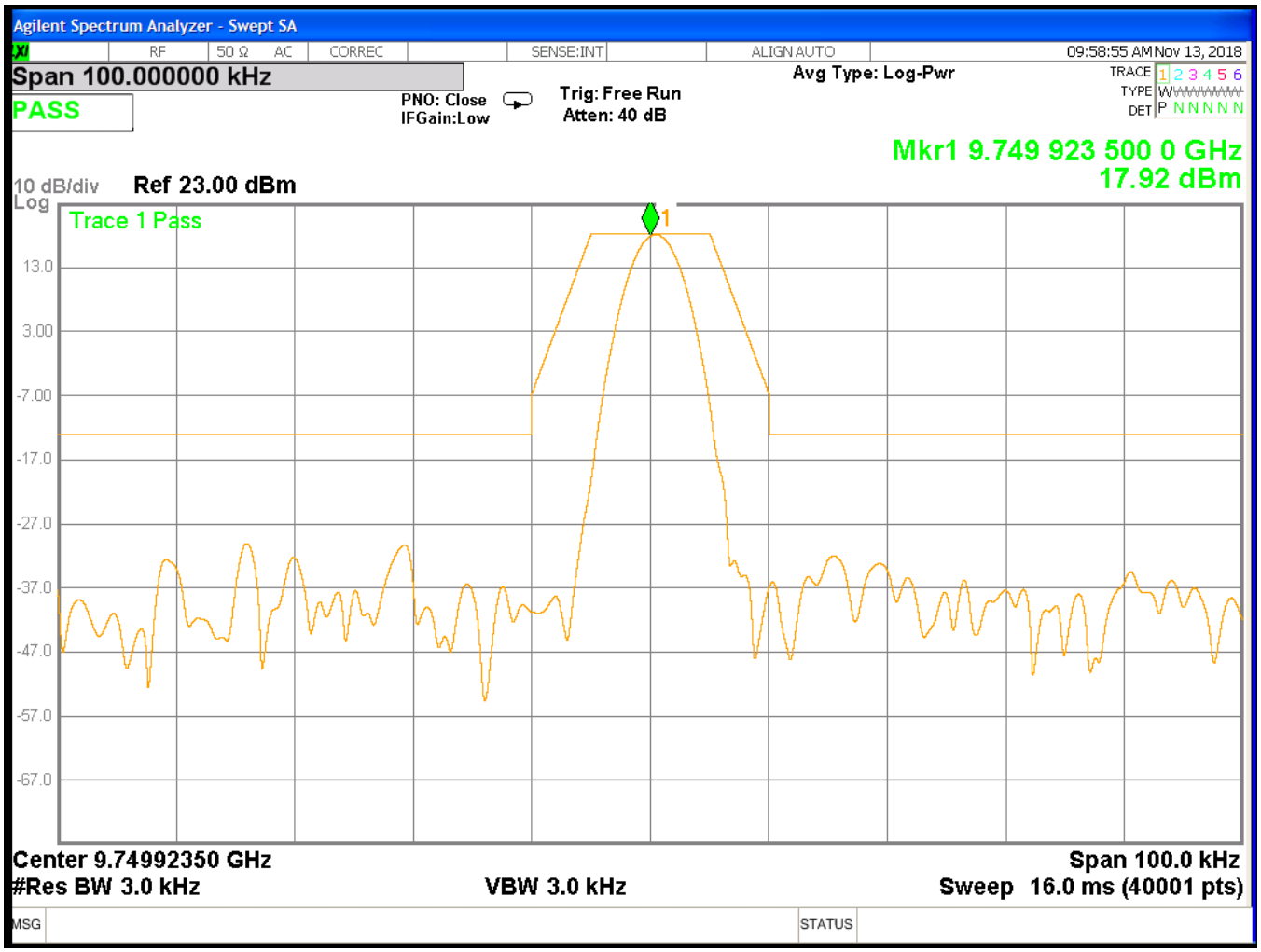

Figure 24: Emissions Bandwidth, 3D_B J3, Mid Channel

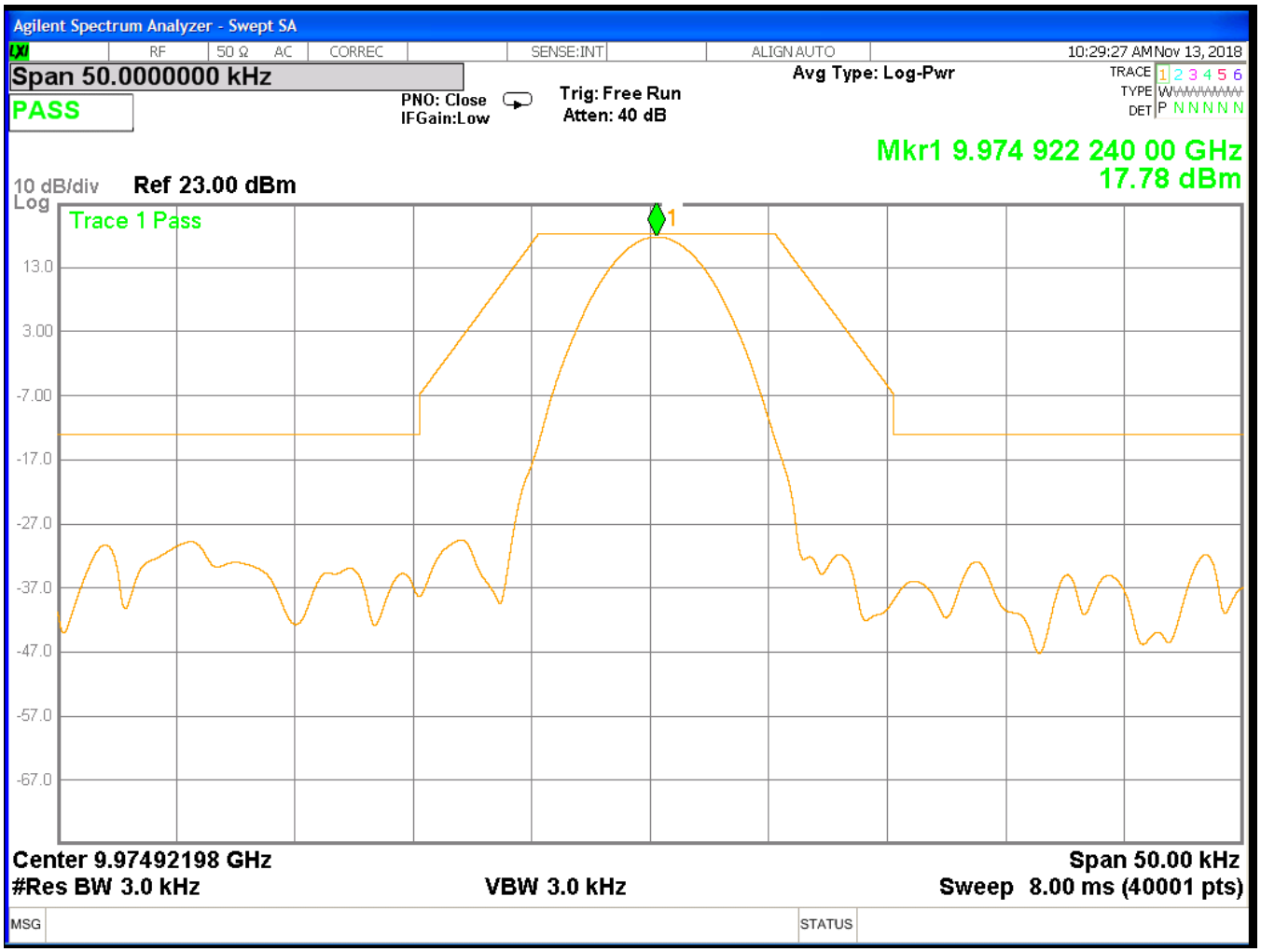

Figure 25: Emissions Bandwidth, 3D_B J3, High Channel

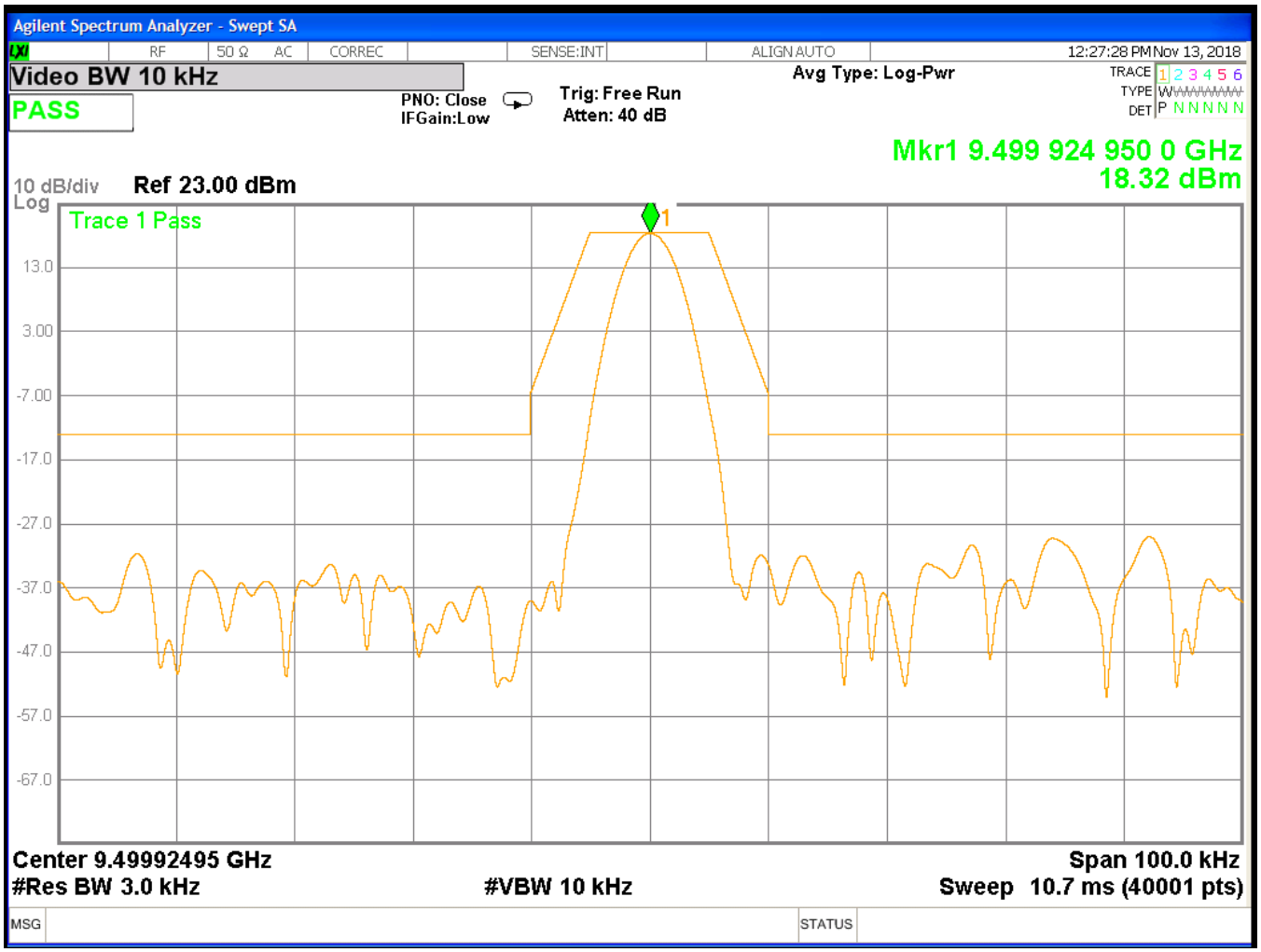

Figure 26: Emissions Bandwidth, 3D_A J4, Low Channel

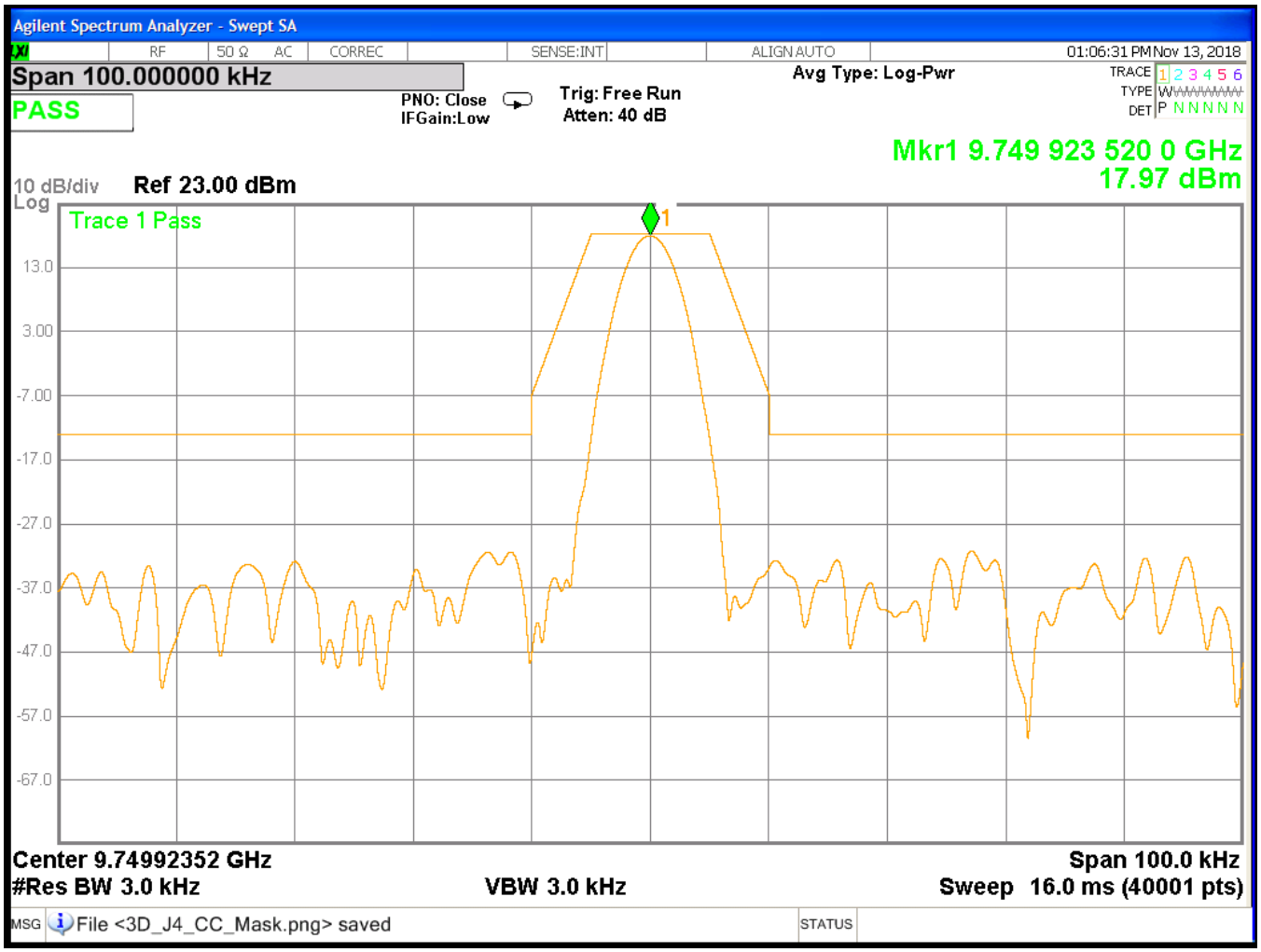

Figure 27: Emissions Bandwidth, 3D_A J4, Mid Channel

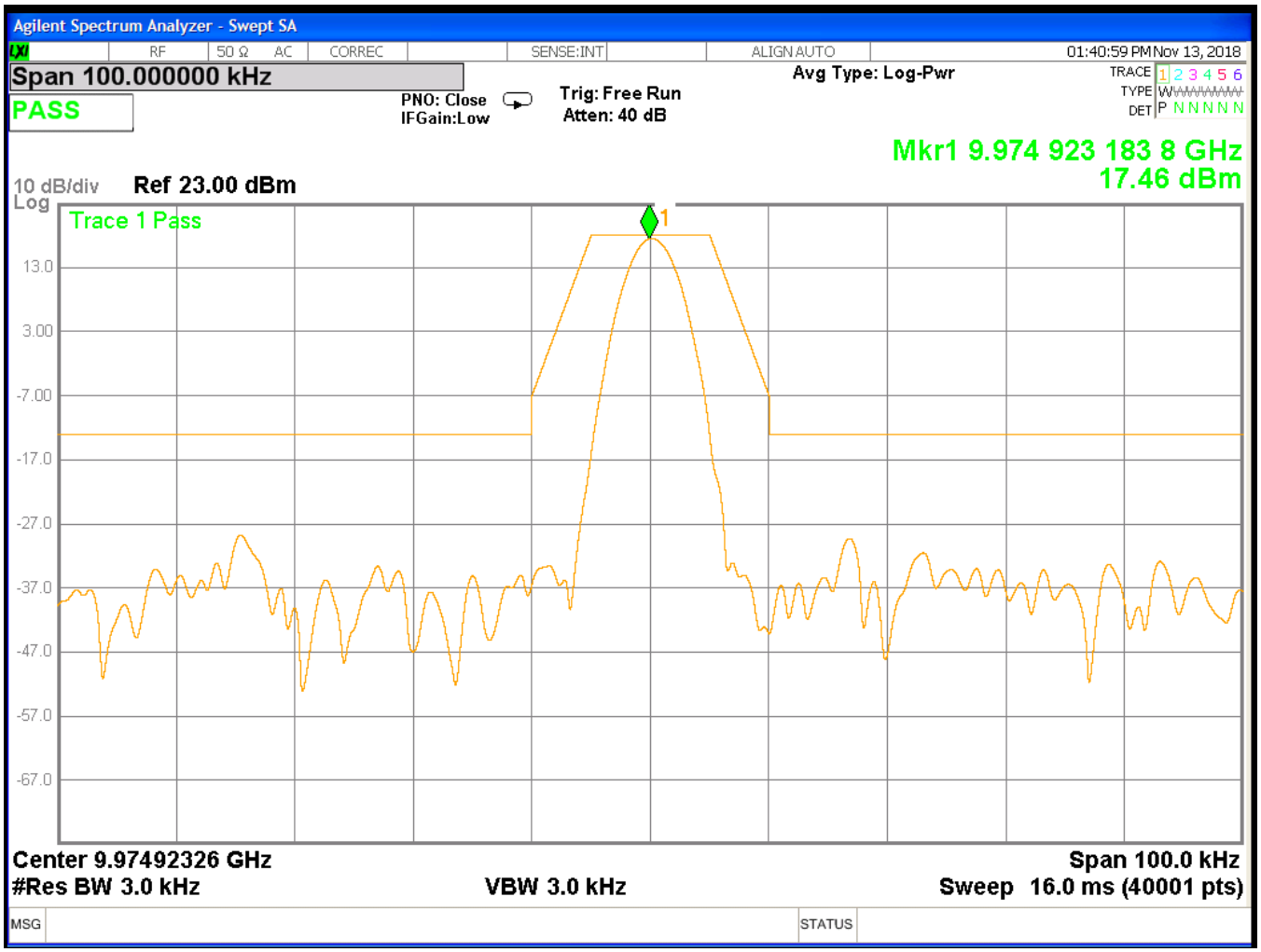

Figure 28: Emissions Bandwidth, 3D_A J4, High Channel

Table 9 provides a summary of the Emissions Bandwidth Results. There is no limit per 90.2099(b)(5).

Table 9: Emissions Mask Results

Frequency	Bandwidth	Limit	Pass/Fail
Low Channel	-	None	Pass
Mid Channel	-	None	Pass
High Channel	-	None	Pass

Table 10: Emissions Mask Results

Frequency	Bandwidth	Limit	Pass/Fail
Low Channel	-	None	Pass
Mid Channel	-	None	Pass
High Channel	-	None	Pass

Table 11: Emissions Mask Results

Frequency	Bandwidth	Limit	Pass/Fail
Low Channel	-	None	Pass
Mid Channel	-	None	Pass
High Channel	-	None	Pass

Table 12: Emissions Mask Results

Frequency	Bandwidth	Limit	Pass/Fail
Low Channel	-	None	Pass
Mid Channel	-	None	Pass
High Channel	-	None	Pass

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

FCC Part §90.210(c) states:

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (fd/5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (fd 2/11) dB or 50 dB, whichever is the lesser attenuation;

(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator and cables. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 1MHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit. The emissions outside of the allocated frequency band were then scanned from 30 MHz up to the tenth harmonic of the carrier (100GHz).

The following are plots of the conducted spurious emissions data.

2D_A J5

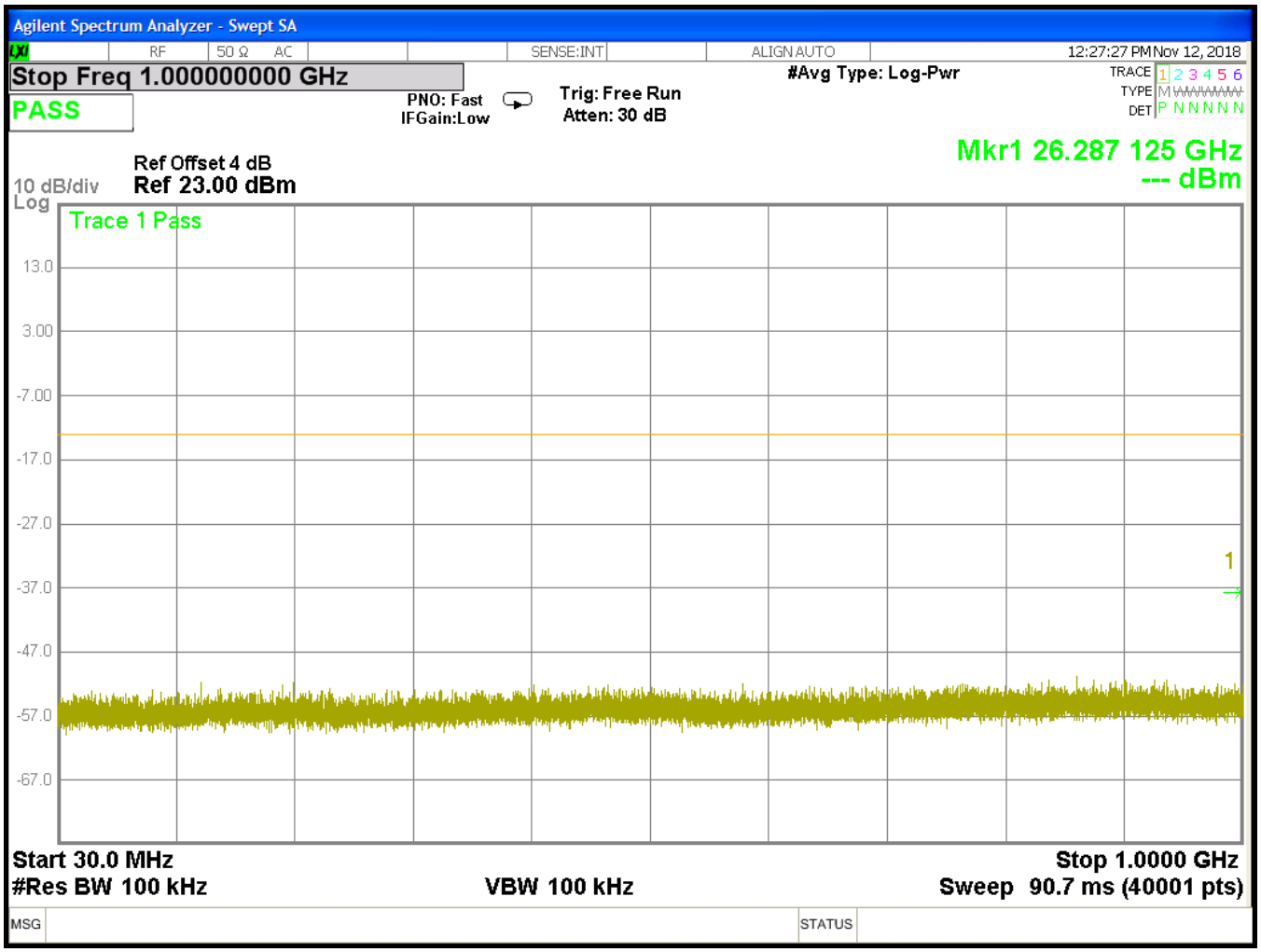

Figure 29: Conducted Spurious Emissions, Center Channel 30 - 1000MHz

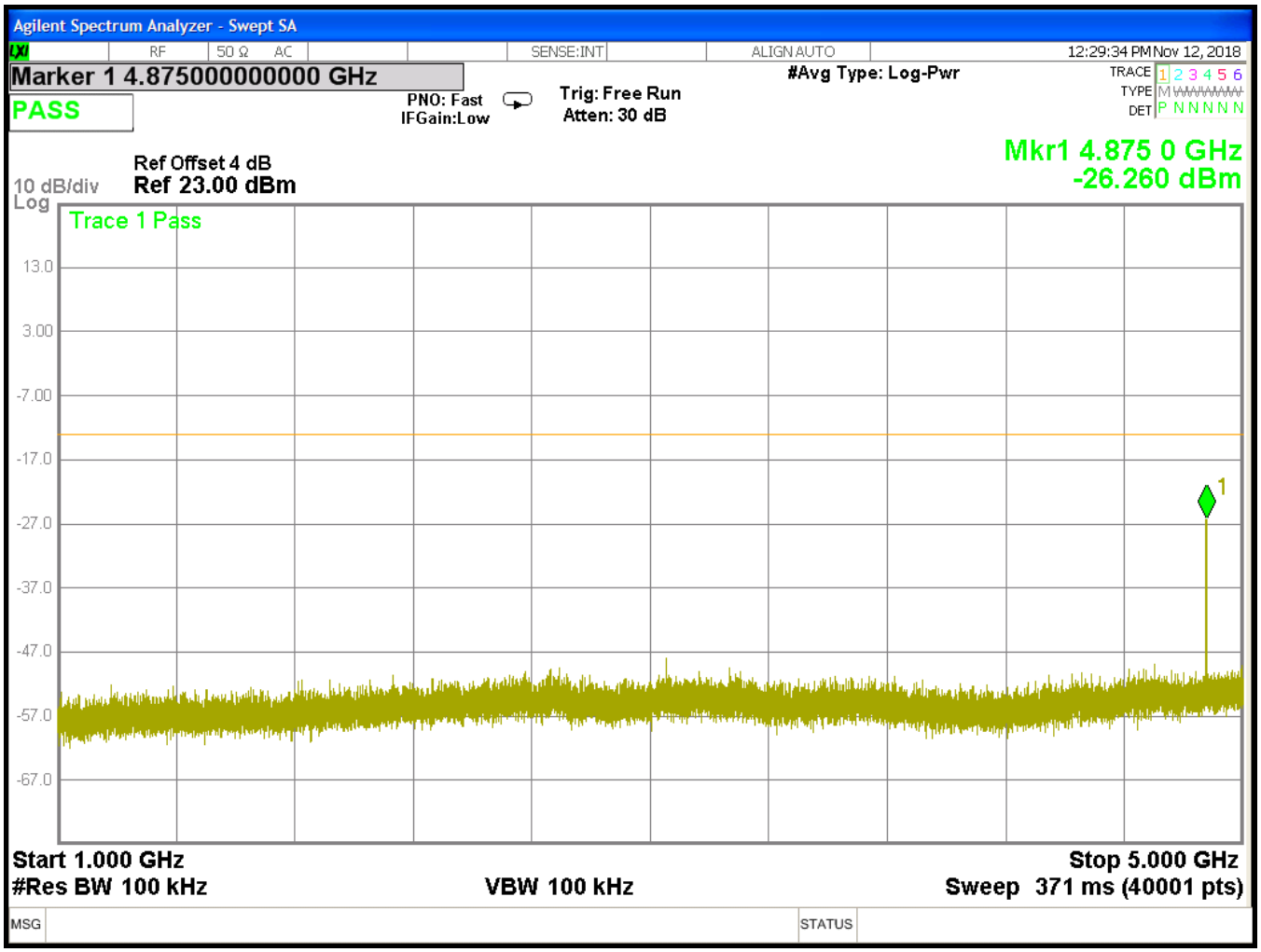

Figure 30: Conducted Spurious Emissions, Center Channel 1 – 5GHz

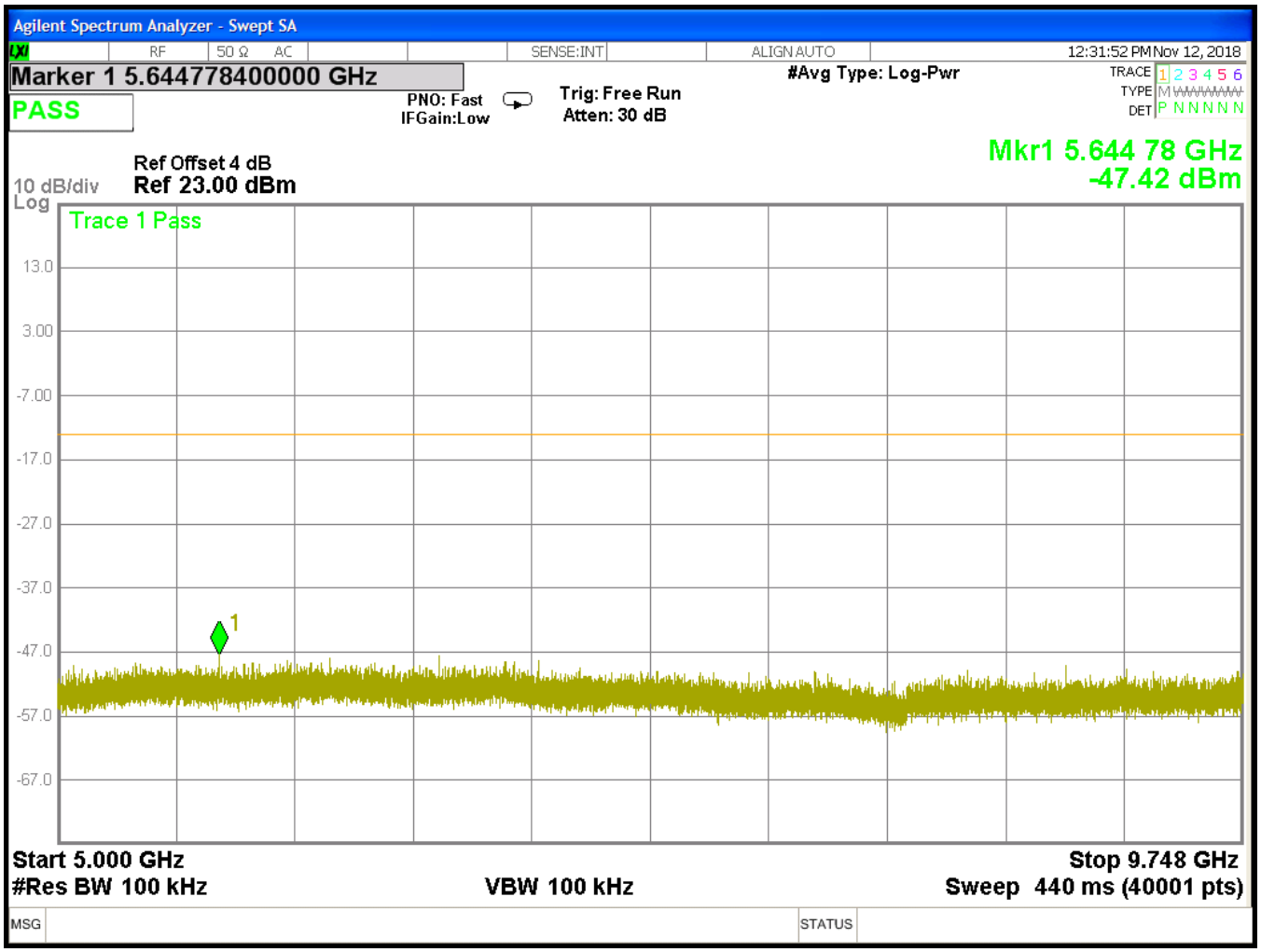

Figure 31: Conducted Spurious Emissions, Center Channel 5 – 9.748GHz

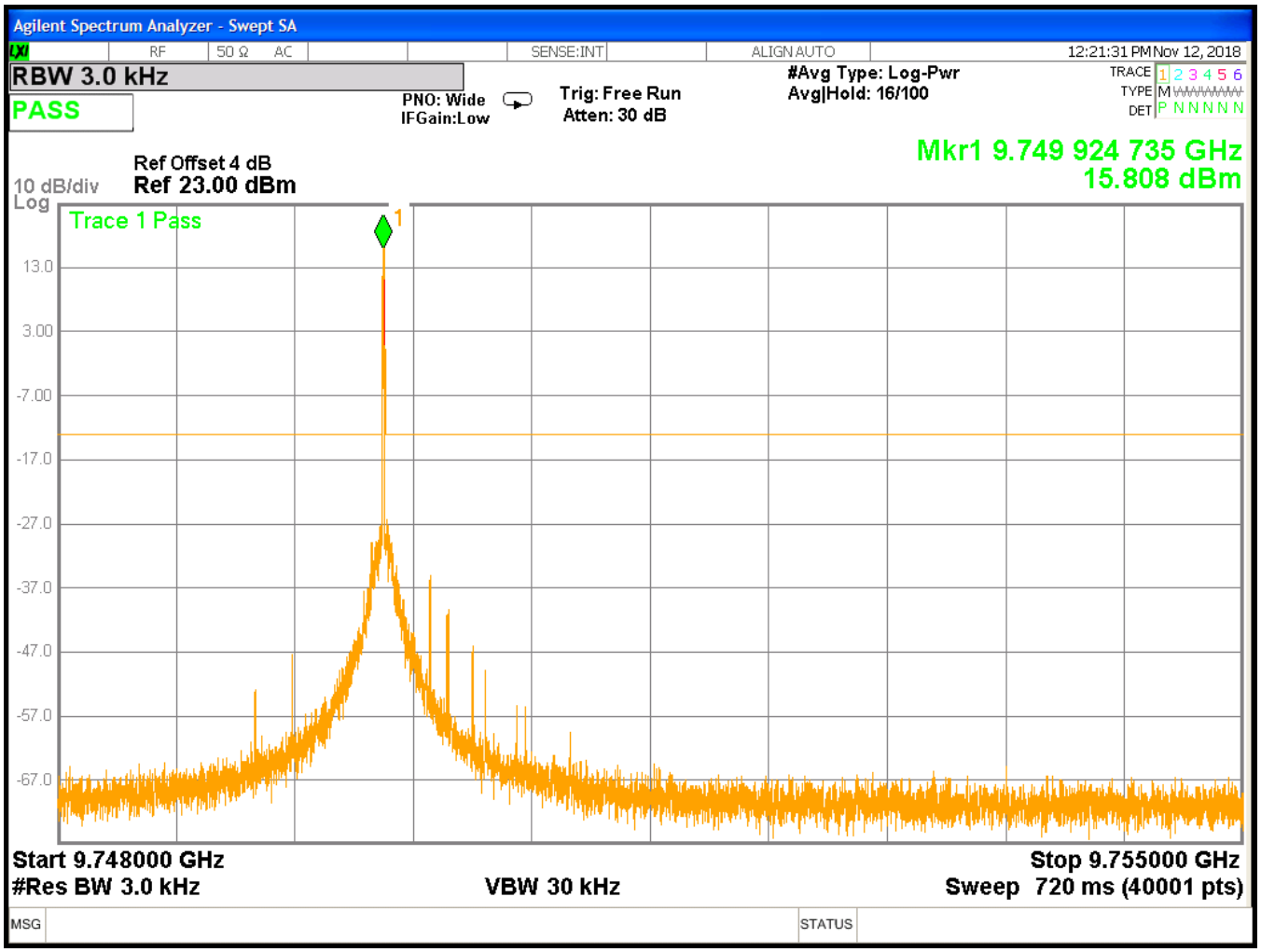

Figure 32: Conducted Spurious Emissions, Center Channel 9.748 – 9.755GHz

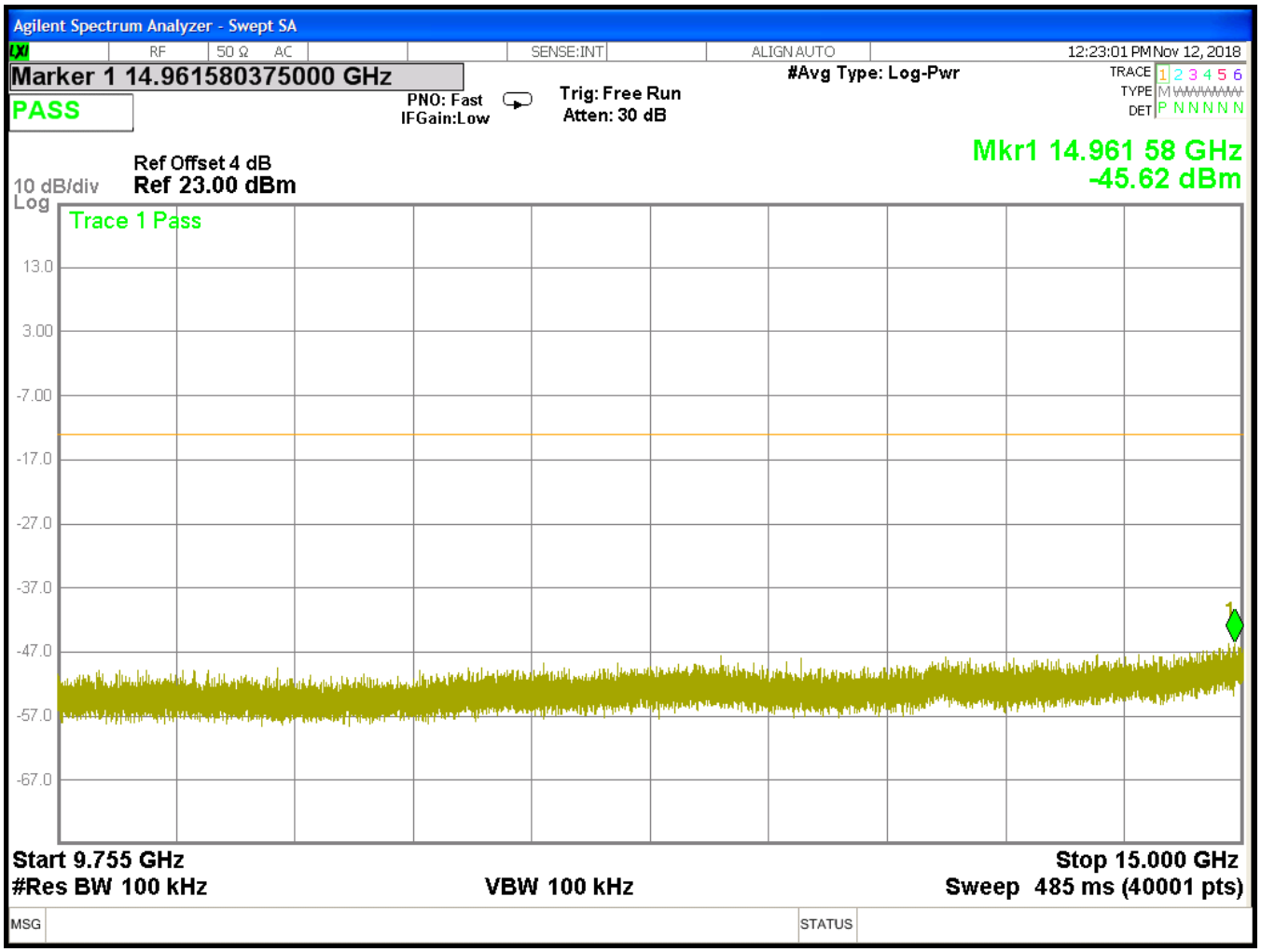

Figure 33: Conducted Spurious Emissions, Center Channel 9.755 - 15GHz

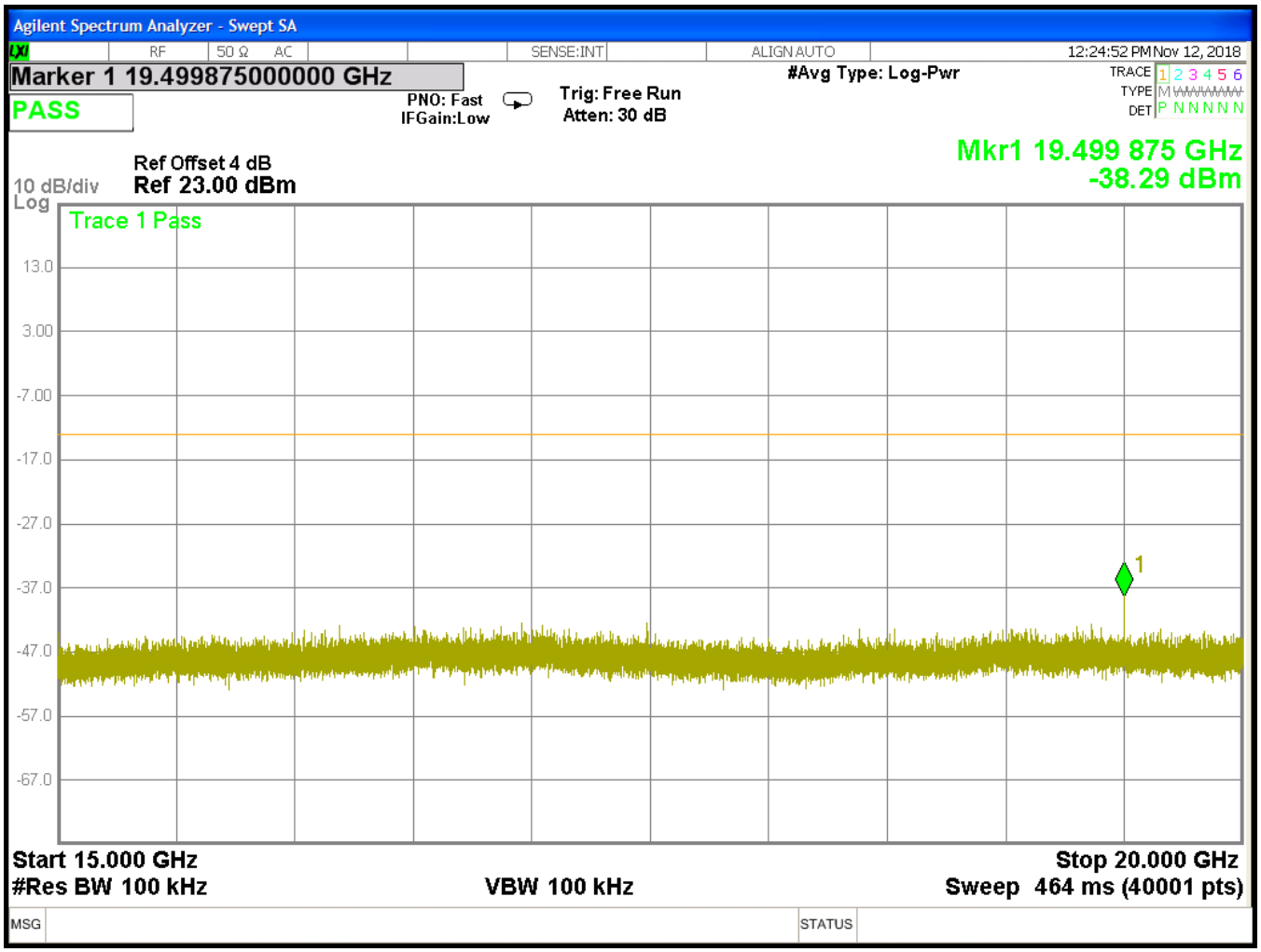

Figure 34: Conducted Spurious Emissions, Center Channel 15 - 20GHz

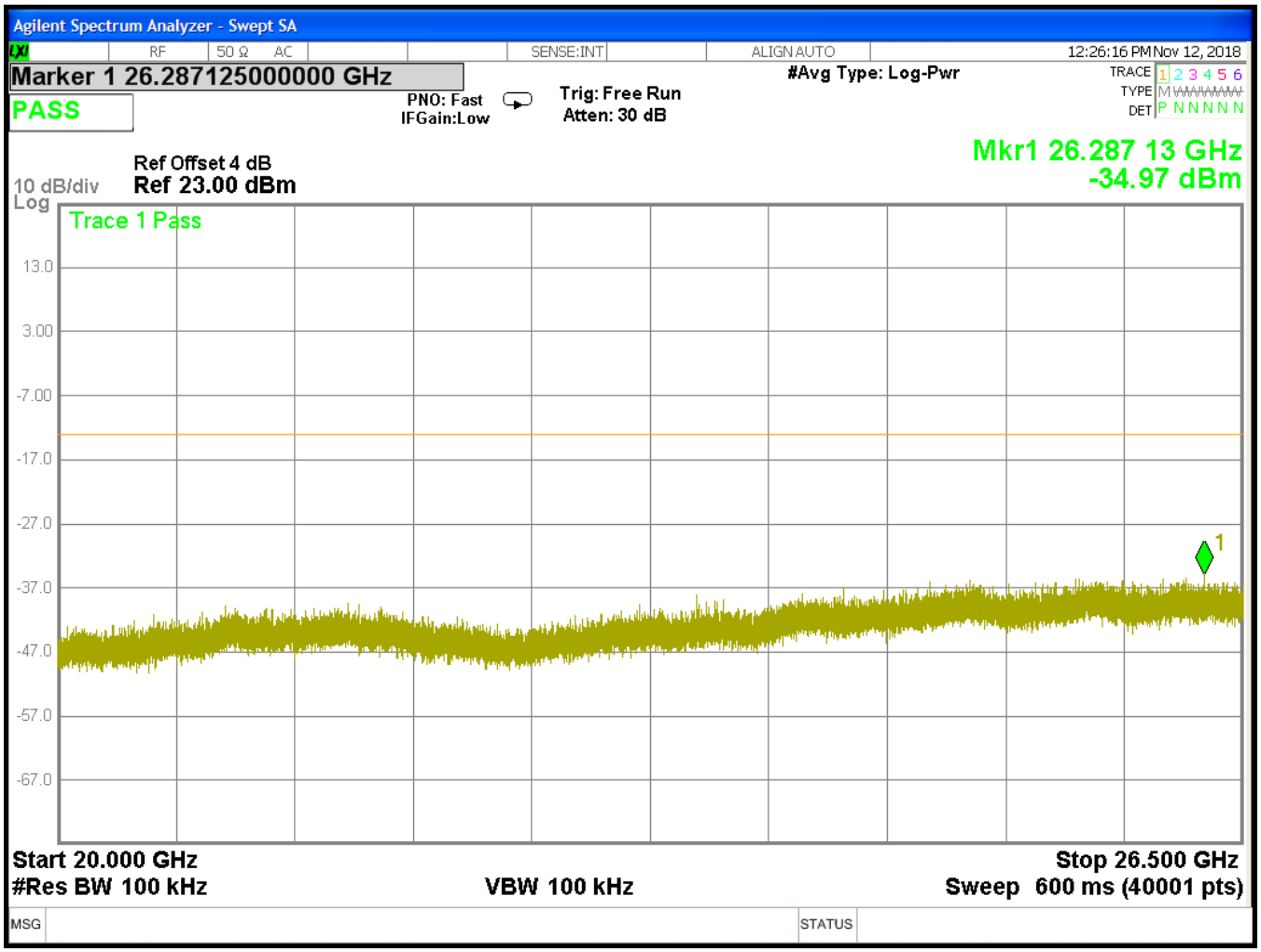

Figure 35: Conducted Spurious Emissions, Center Channel 20 – 26.5GHz

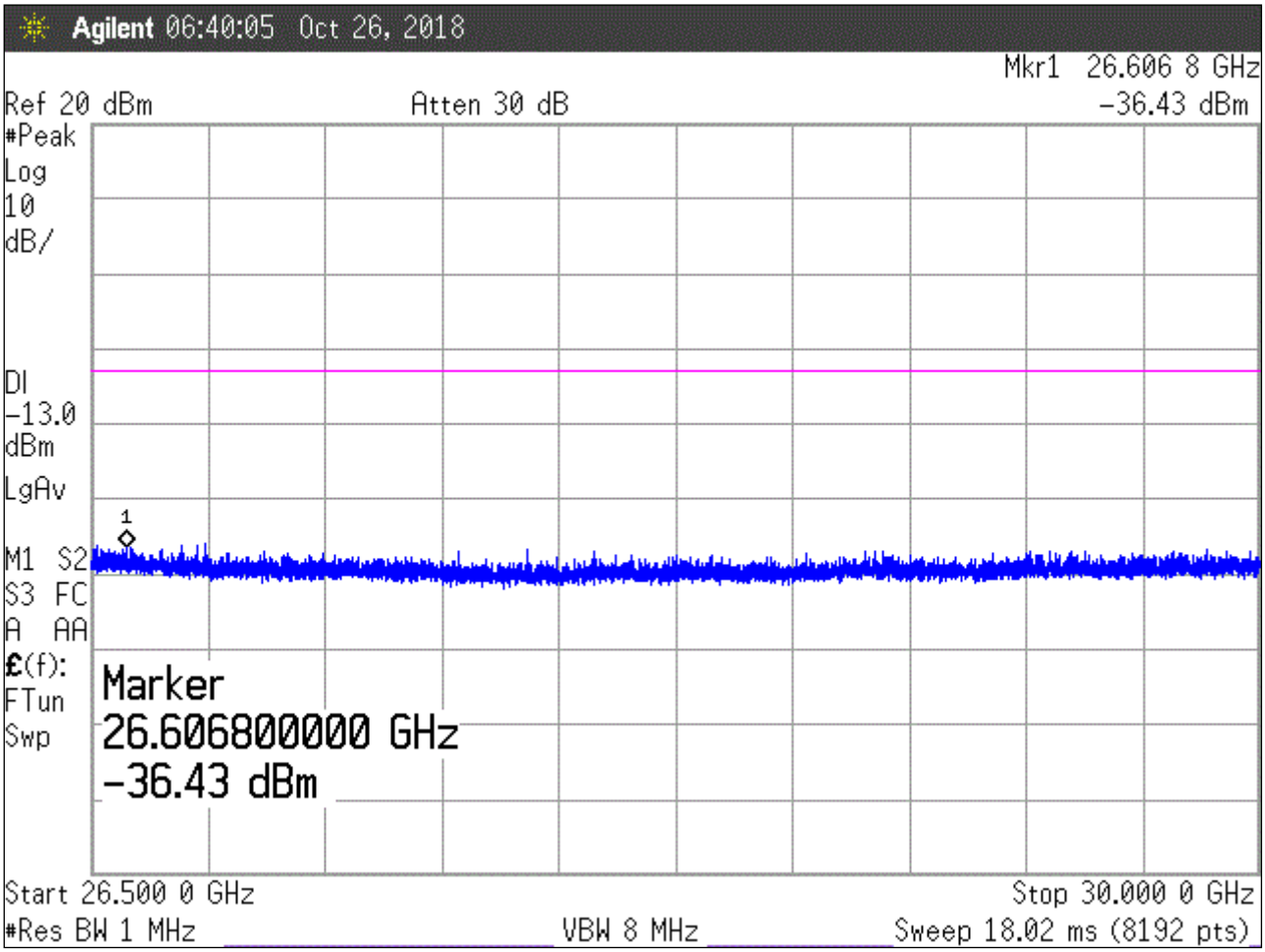

Figure 36: Conducted Spurious Emissions, Center Channel 26.5 – 30GHz

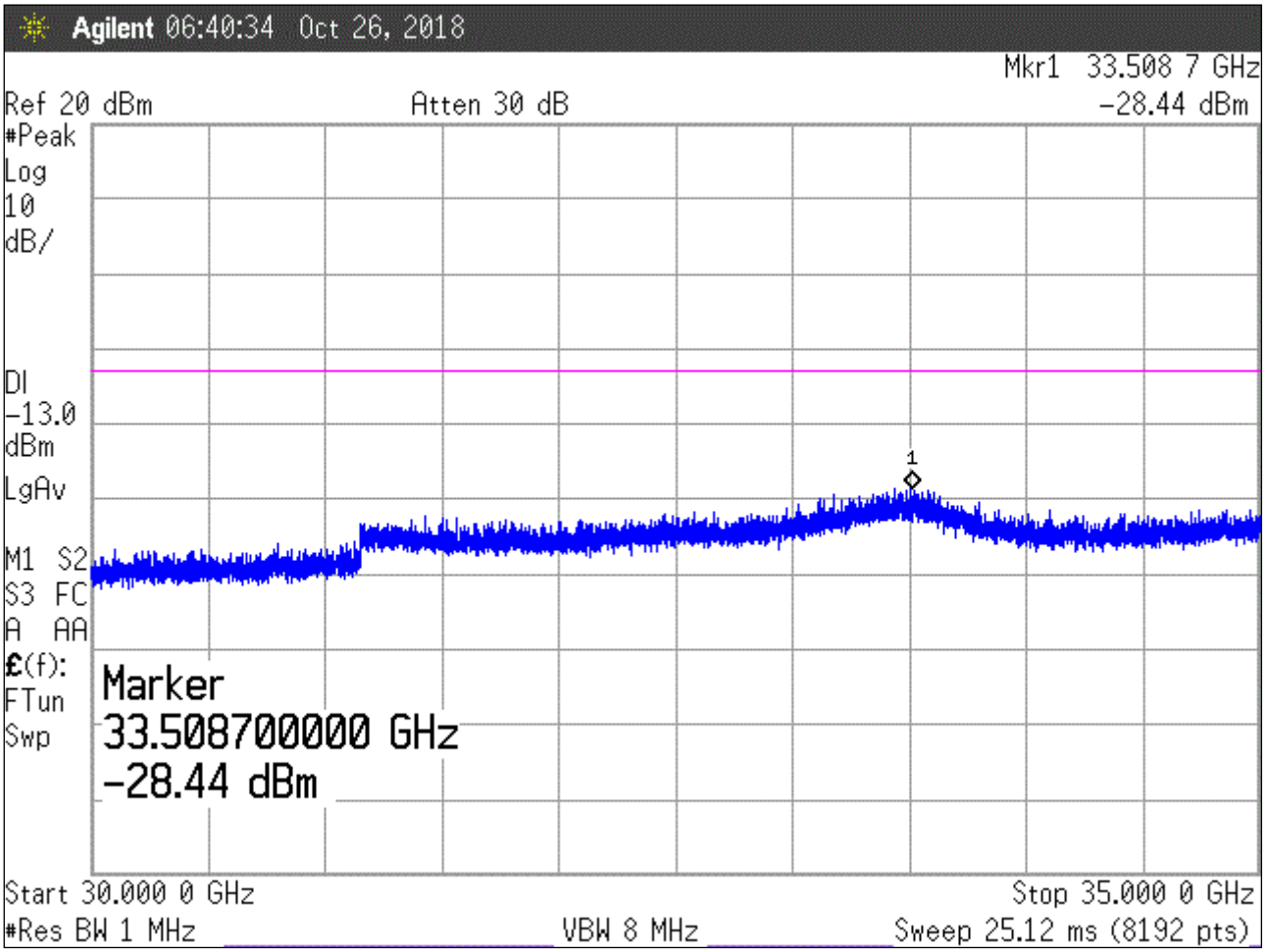

Figure 37: Conducted Spurious Emissions, Center Channel 30 – 35GHz

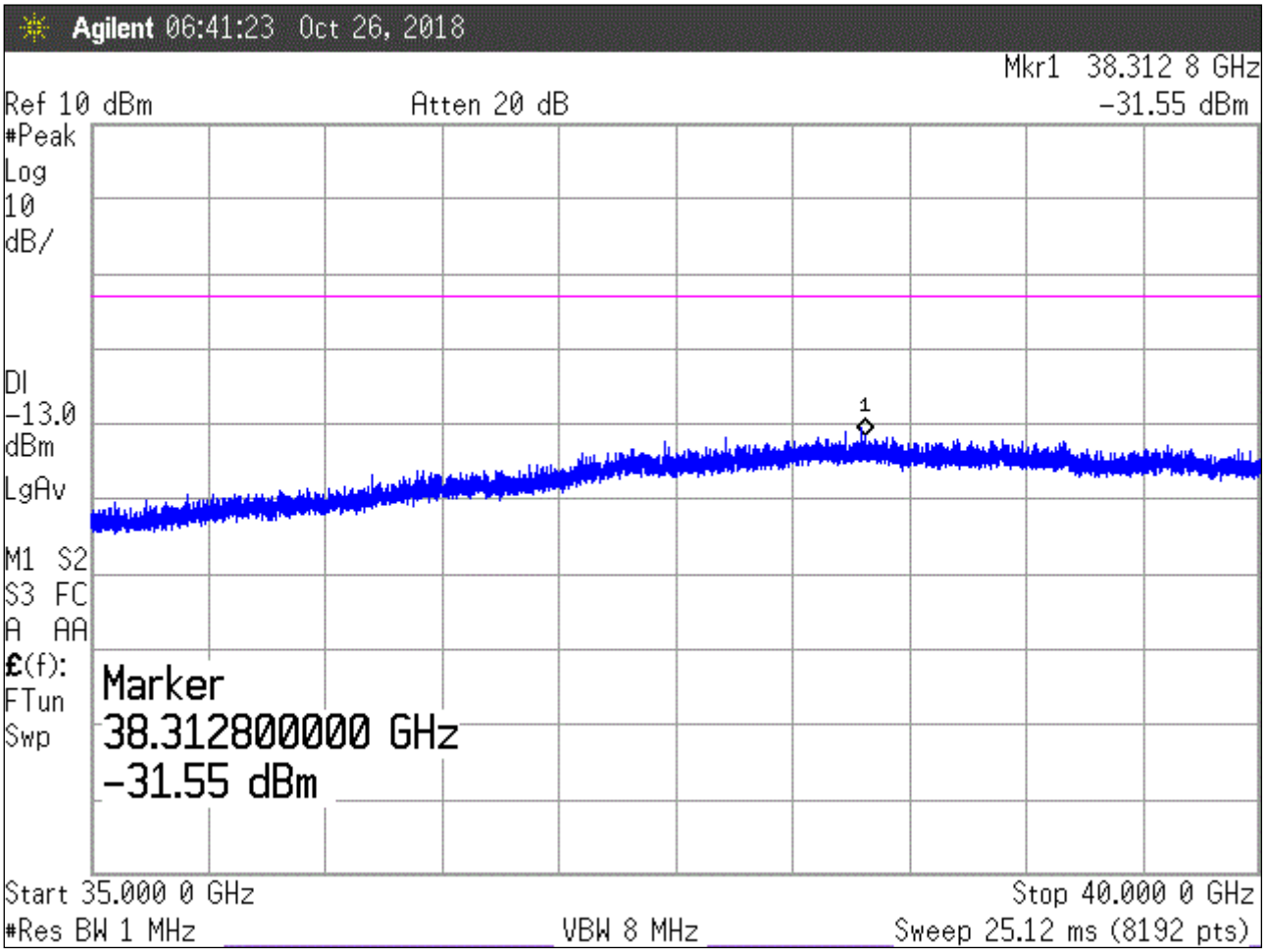

Figure 38: Conducted Spurious Emissions, Center Channel 35 – 40GHz

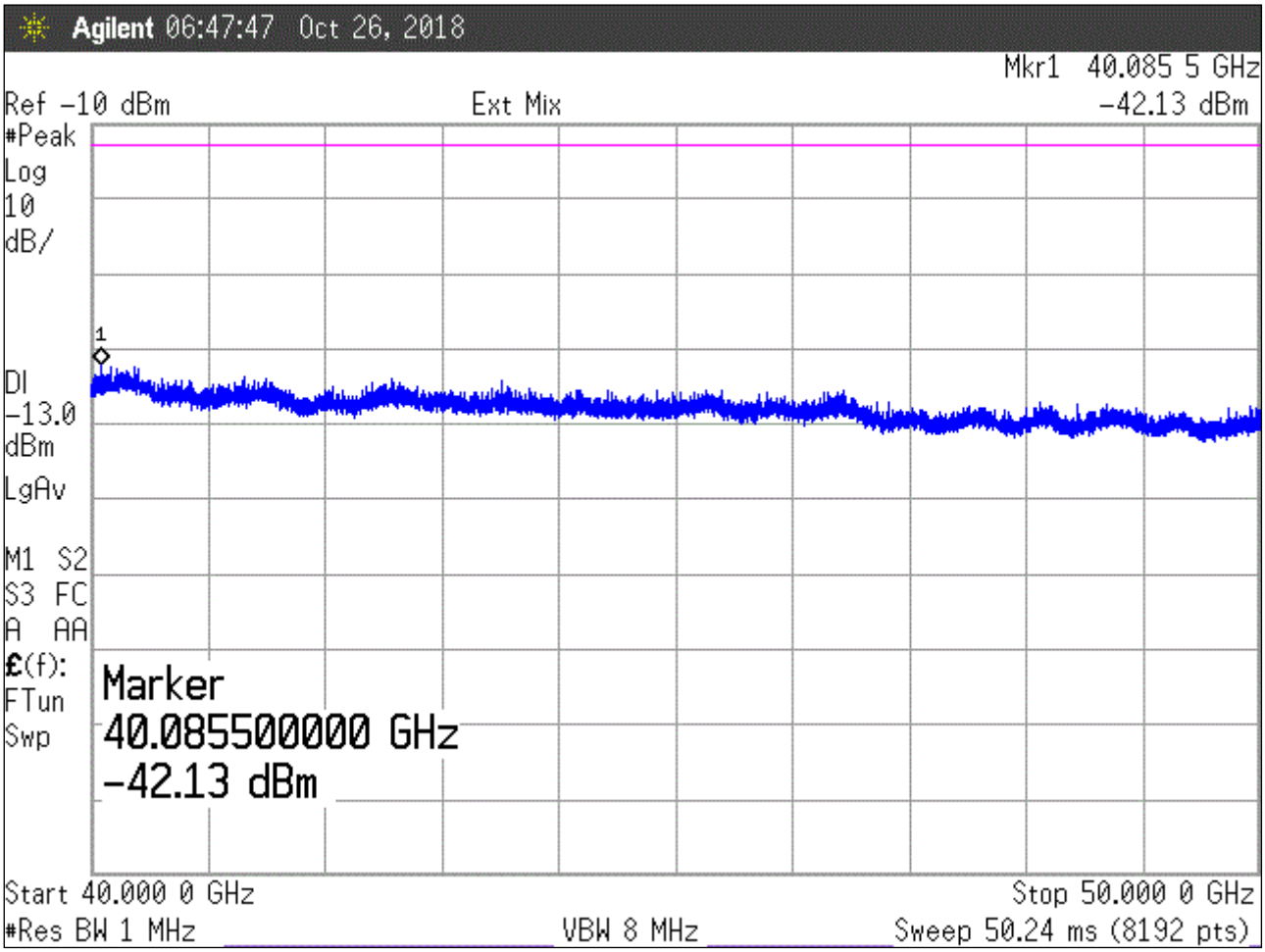

Figure 39: Conducted Spurious Emissions, Center Channel 40 – 50GHz

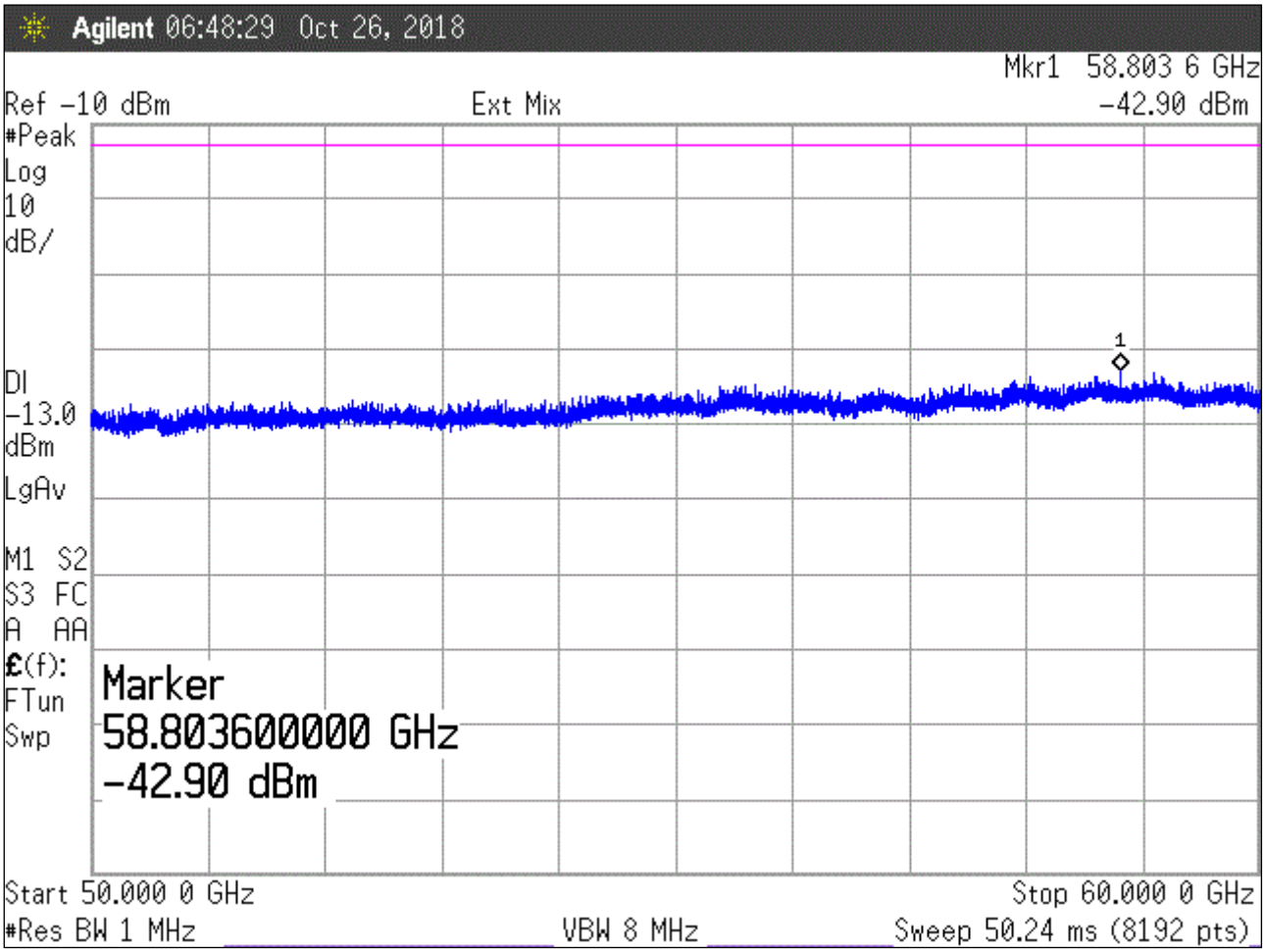

Figure 40: Conducted Spurious Emissions, Center Channel 50 – 60GHz

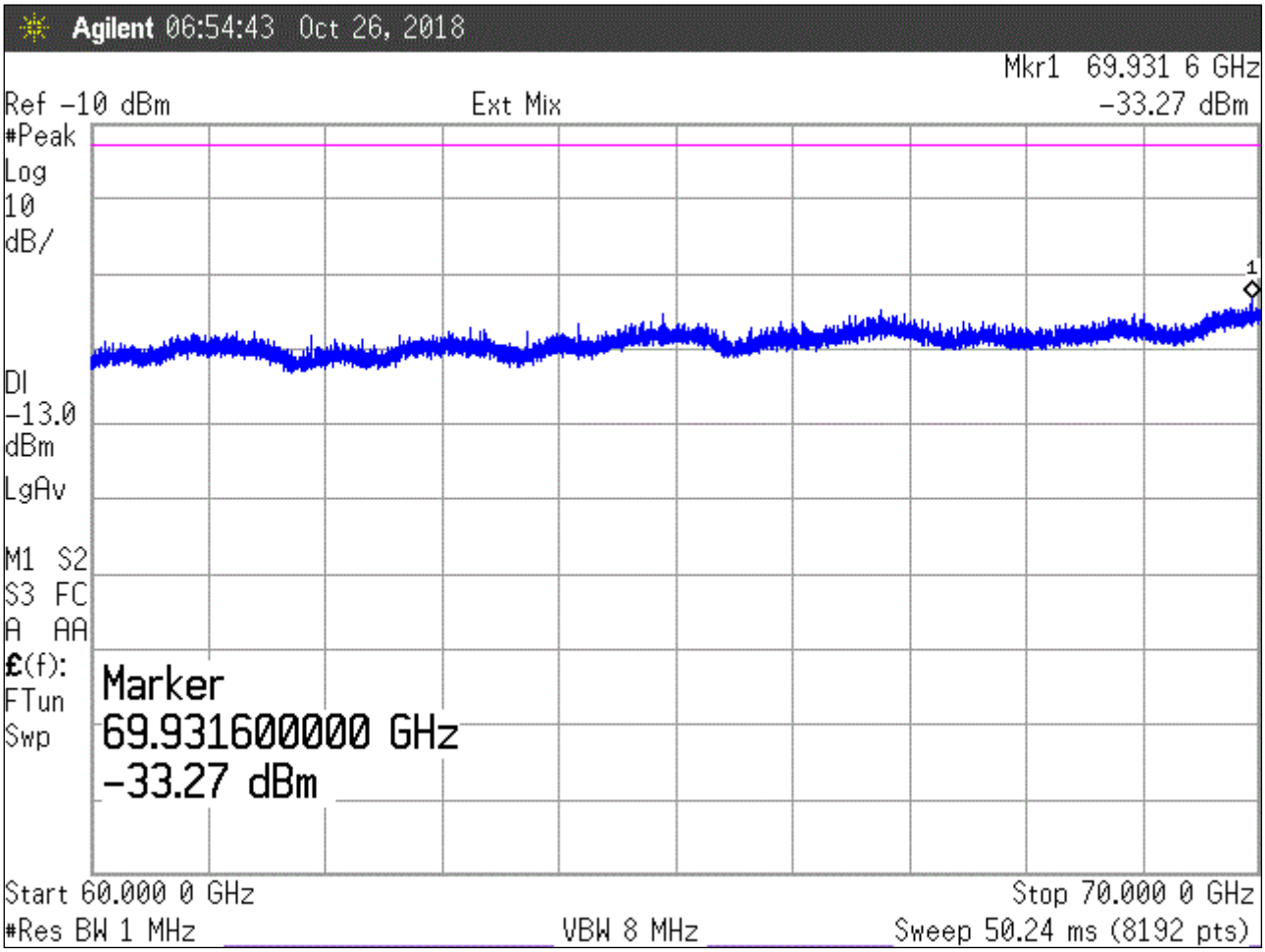

Figure 41: Conducted Spurious Emissions, Center Channel 60 – 70GHz

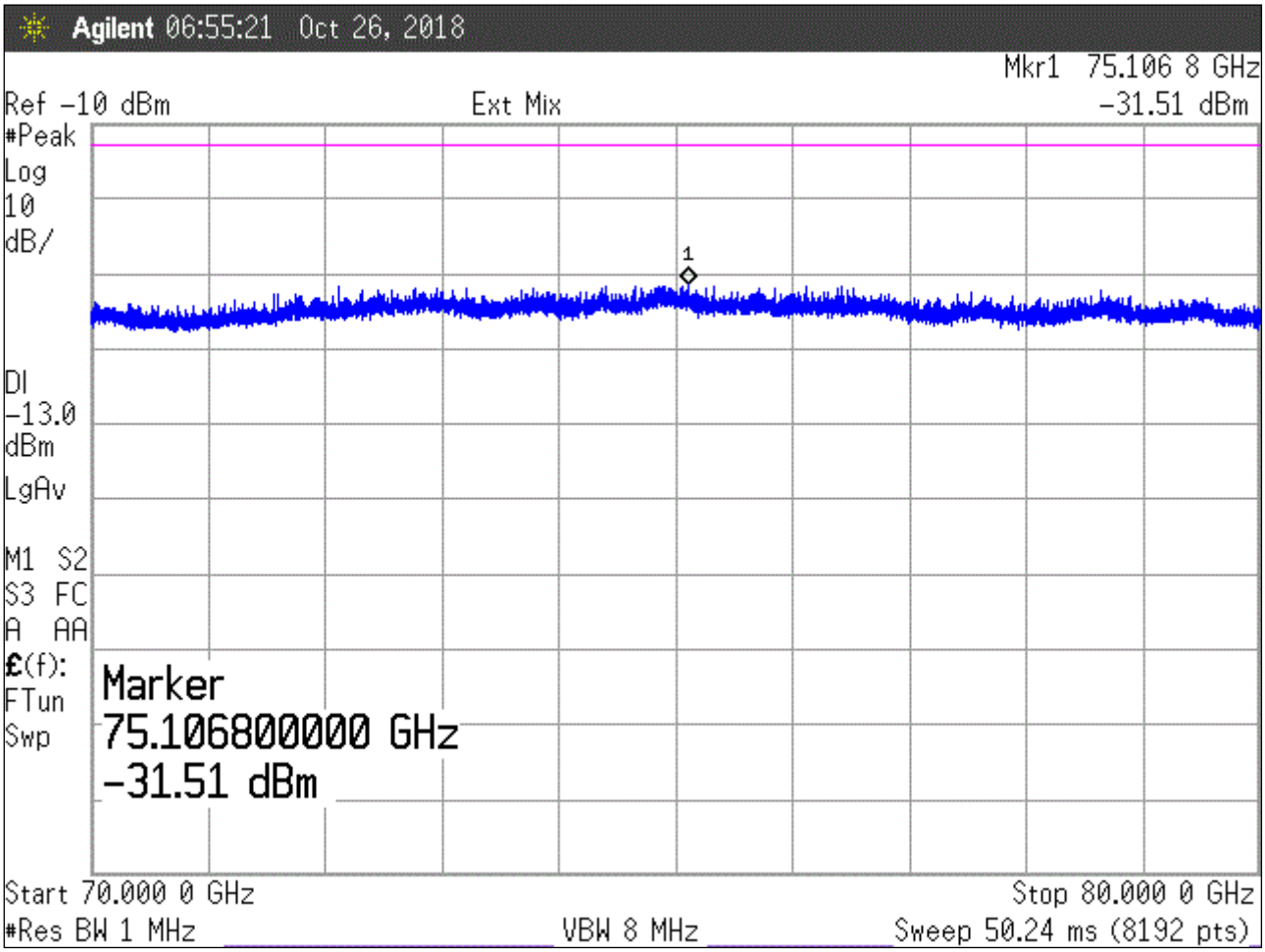

Figure 42: Conducted Spurious Emissions, Center Channel 70 – 80GHz

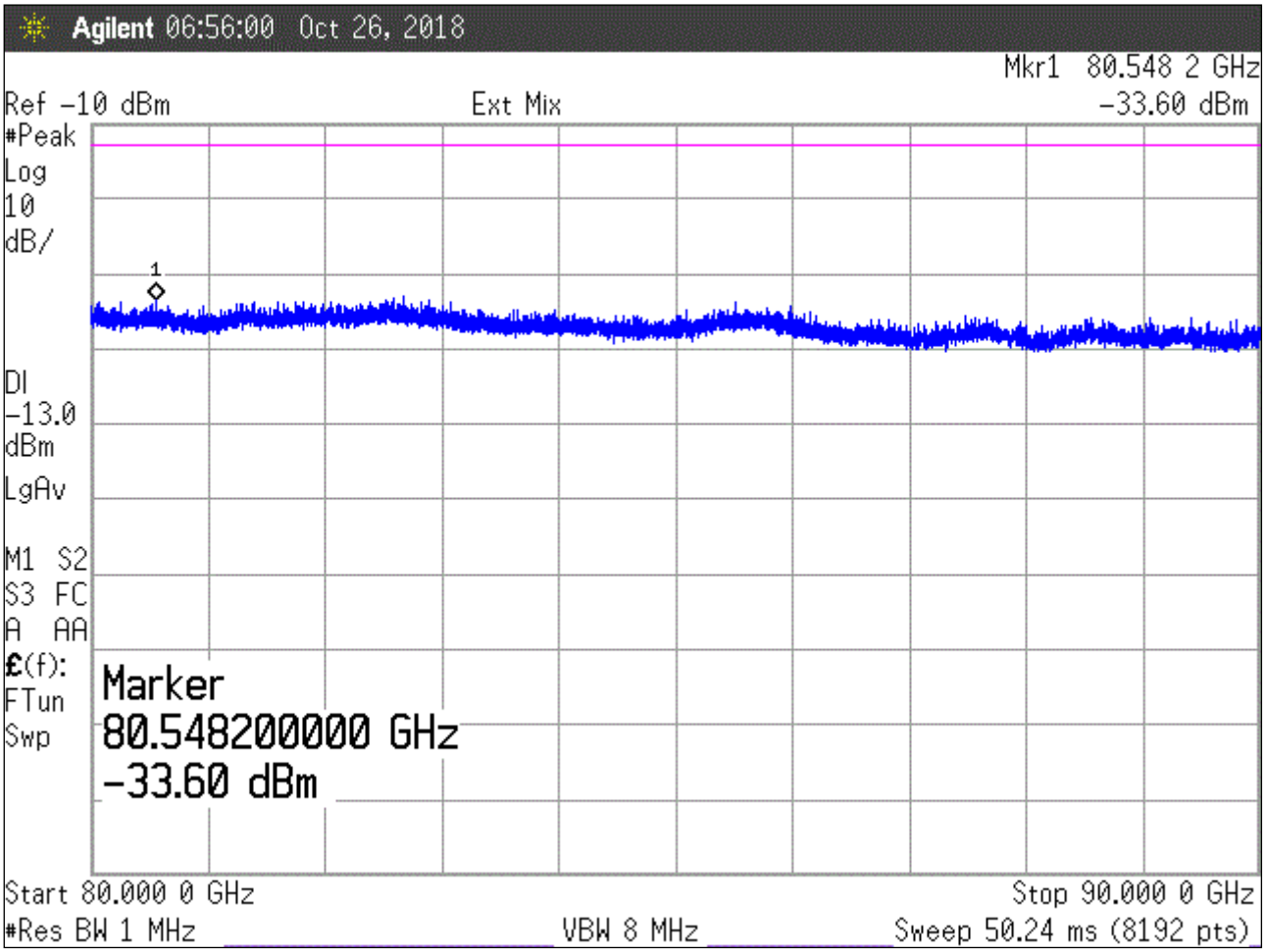

Figure 43: Conducted Spurious Emissions, Center Channel 80 – 90GHz

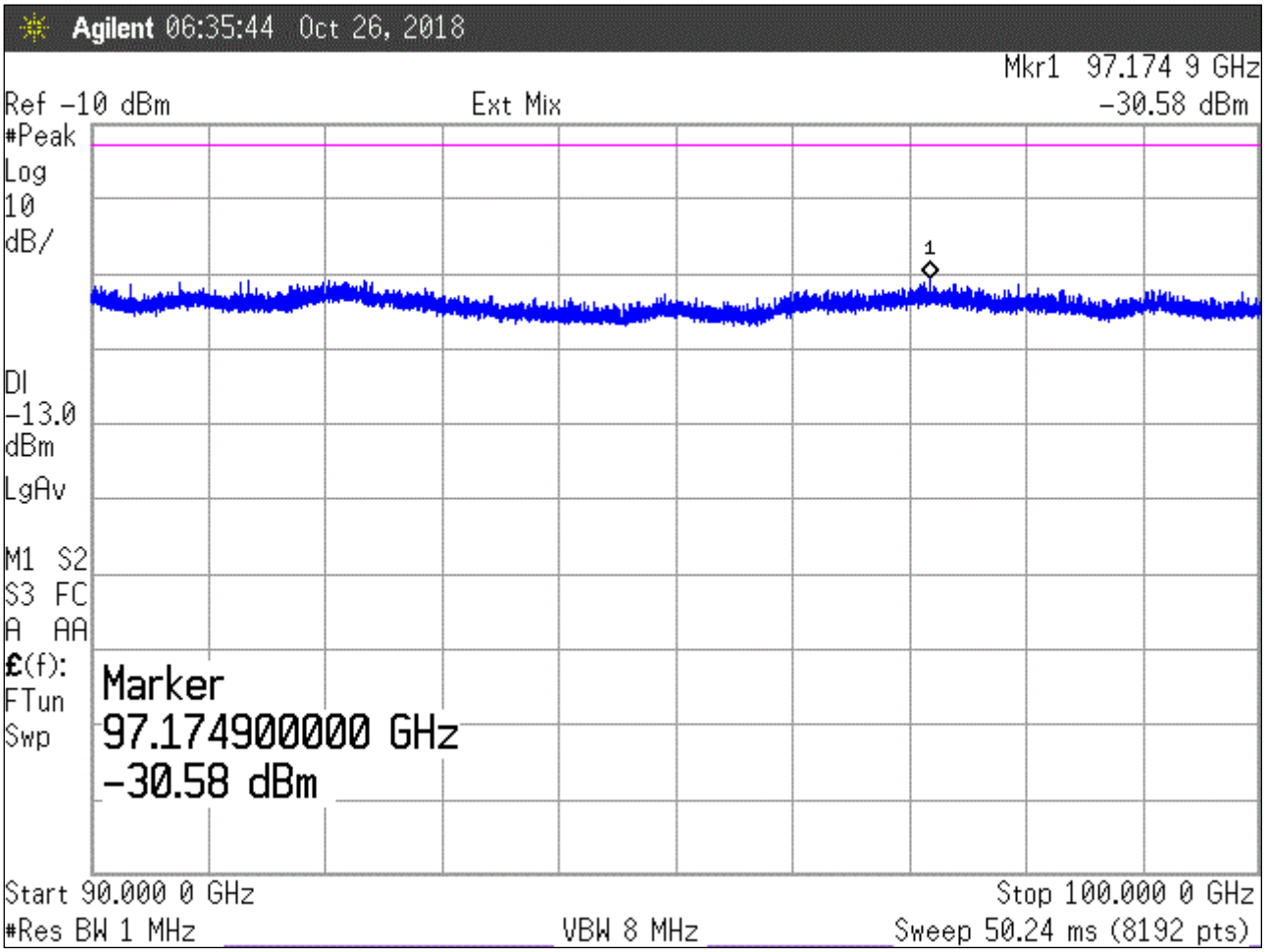

Figure 44: Conducted Spurious Emissions, Center Channel 90 – 100GHz

2D_B J6

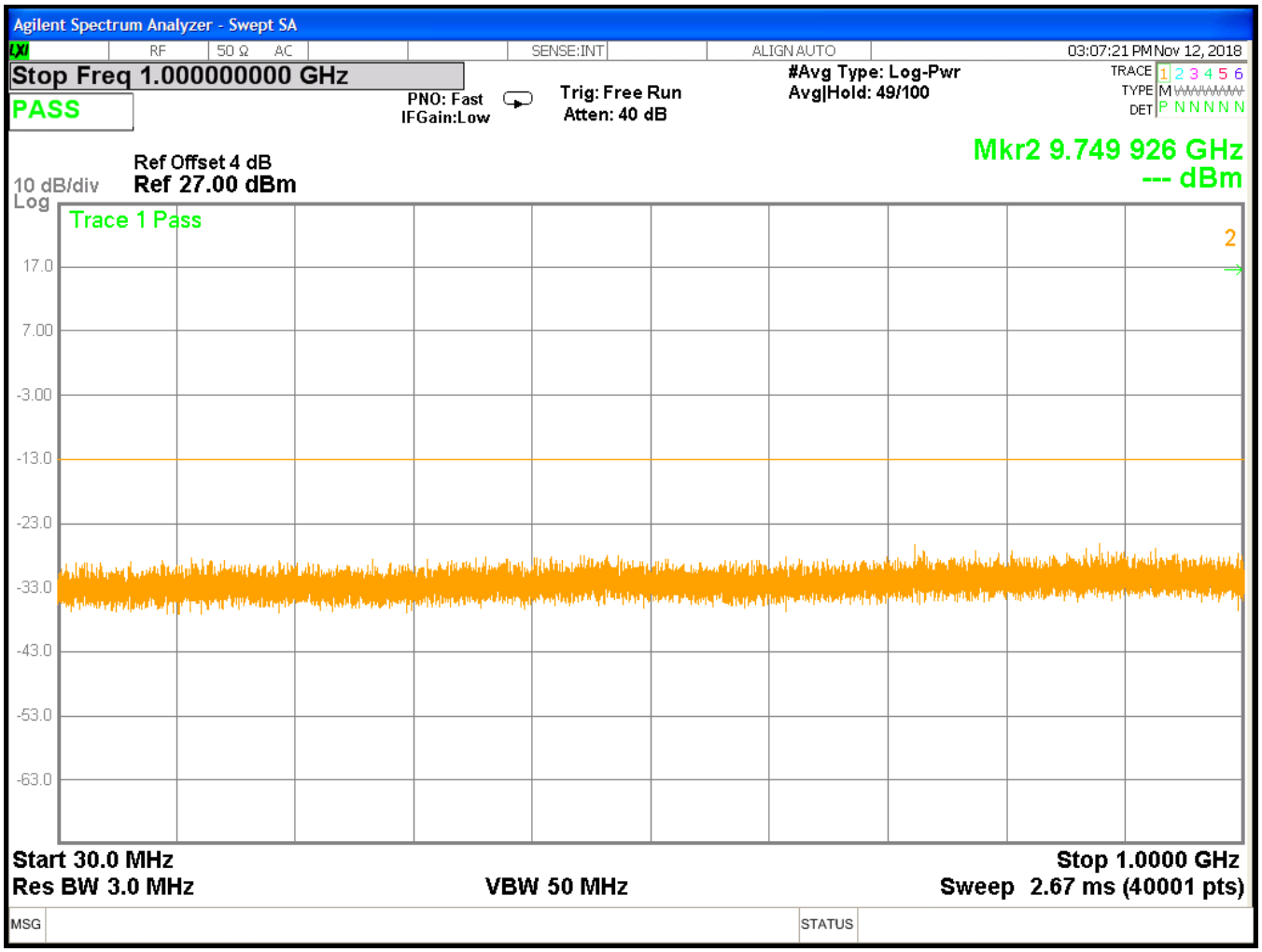

Figure 45: Conducted Spurious Emissions, Center Channel 30 - 1000MHz

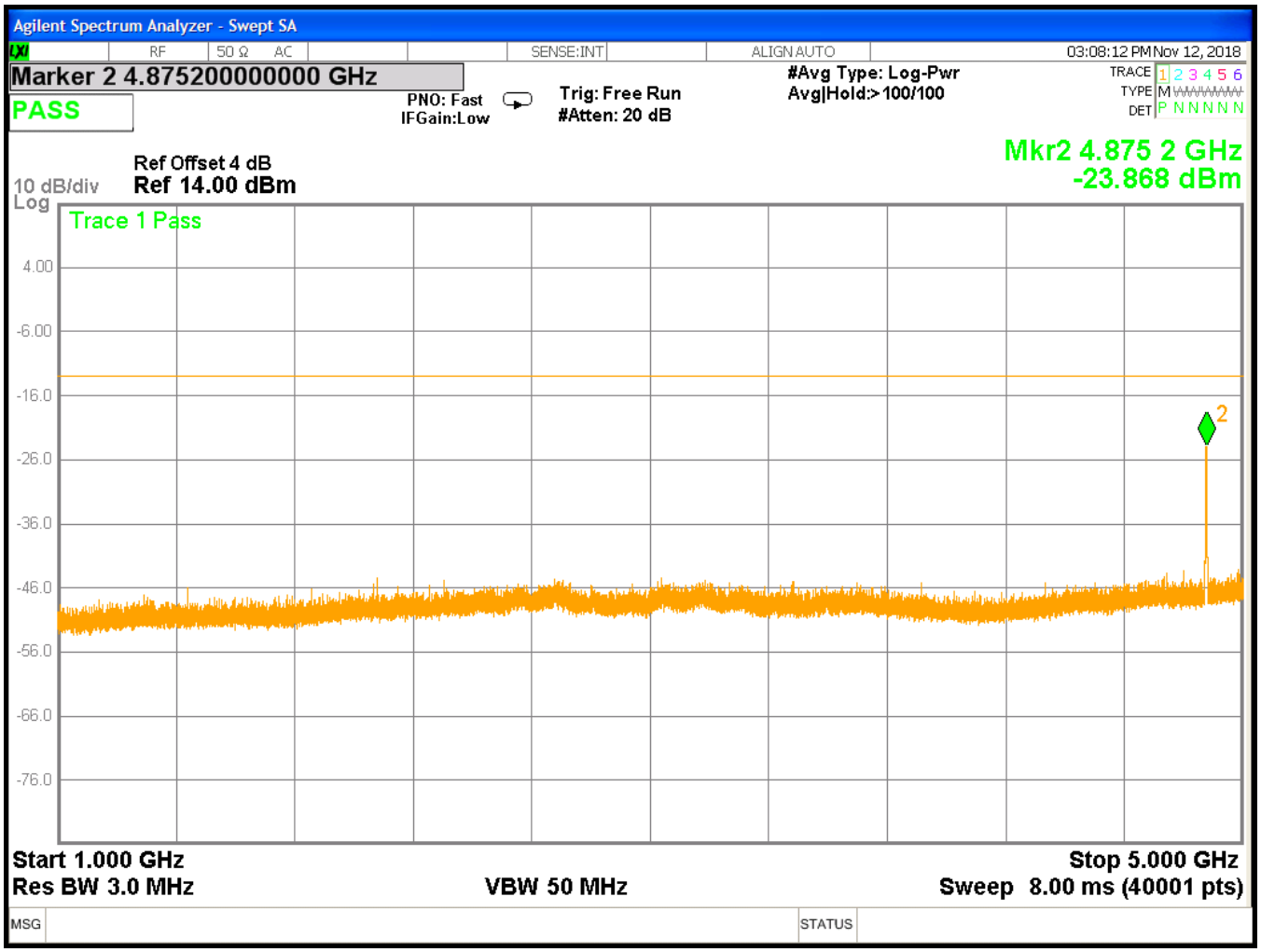

Figure 46: Conducted Spurious Emissions, Center Channel 1 – 5GHz

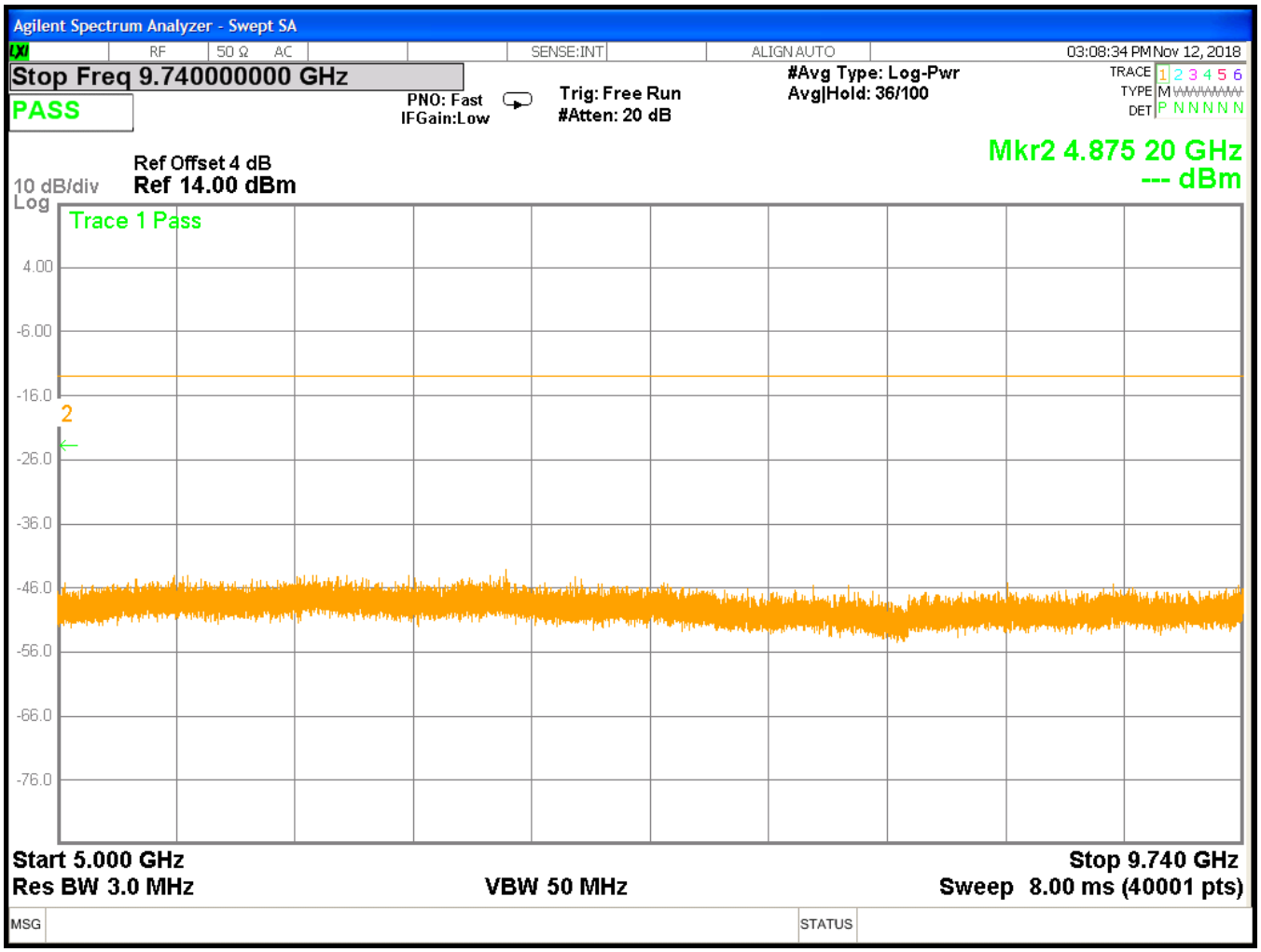

Figure 47: Conducted Spurious Emissions, Center Channel 5 – 9.74GHz

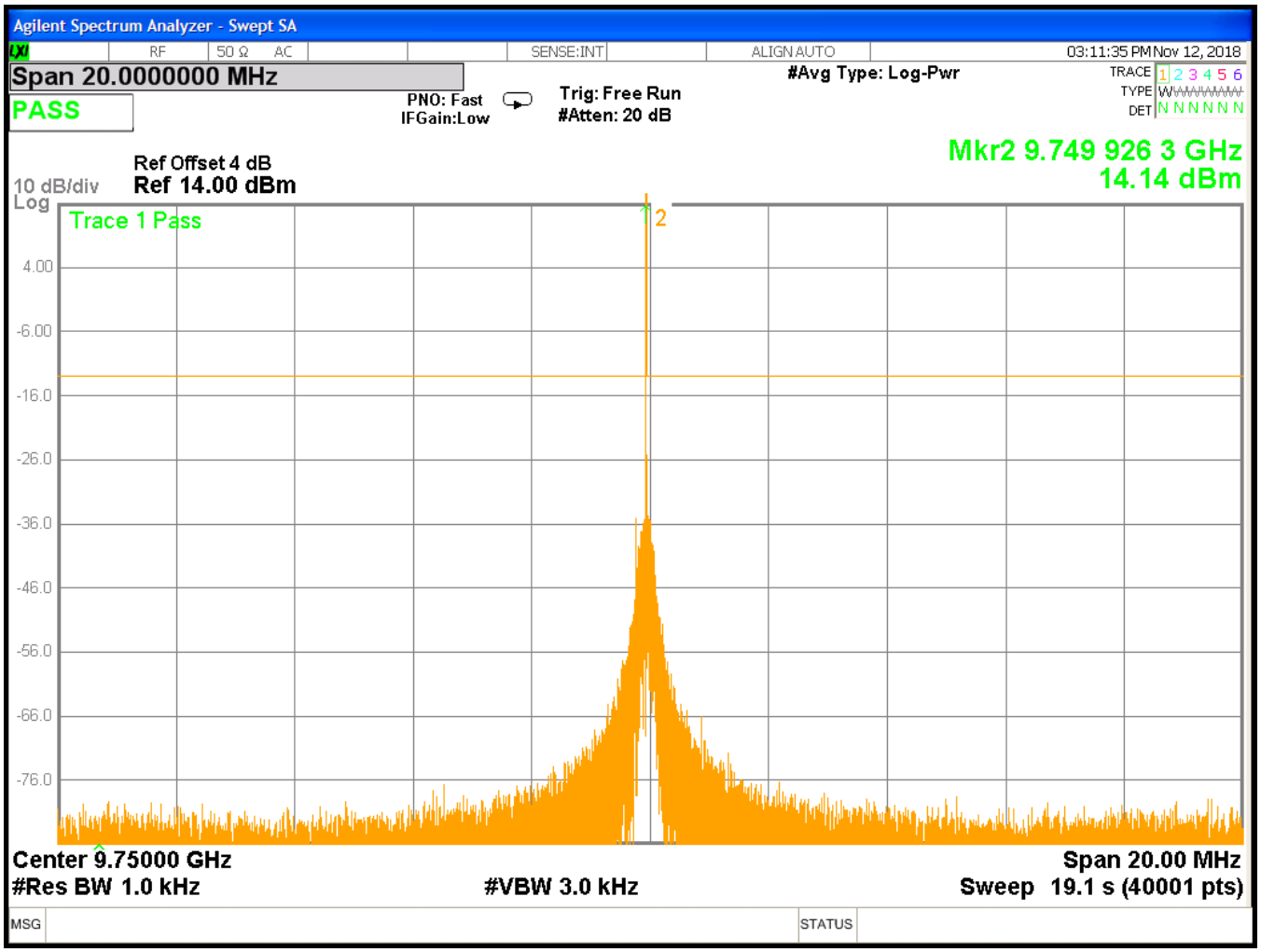

Figure 48: Conducted Spurious Emissions, Center Channel 9.74 – 9.76GHz

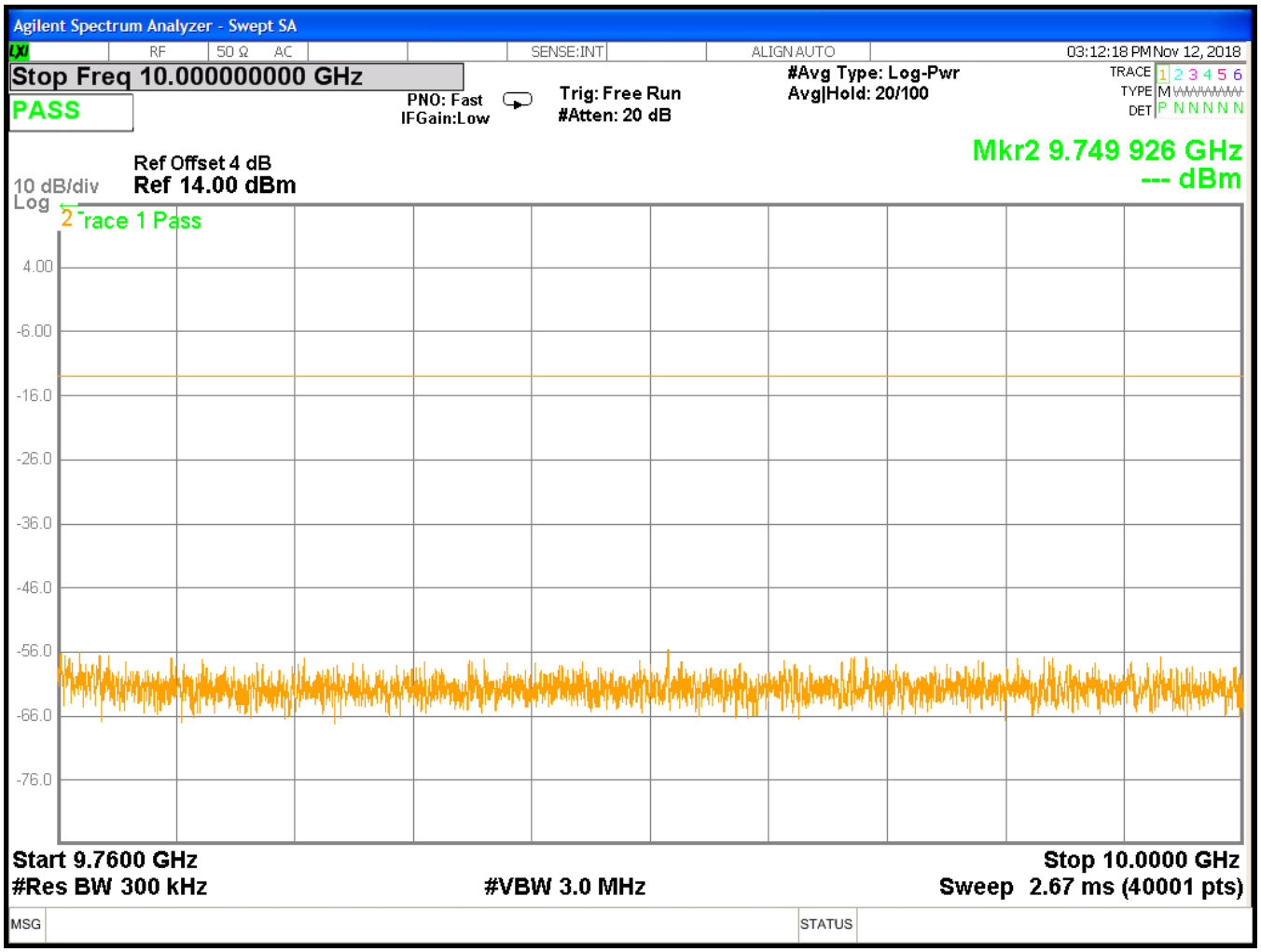

Figure 49: Conducted Spurious Emissions, Center Channel 9.76 - 10GHz

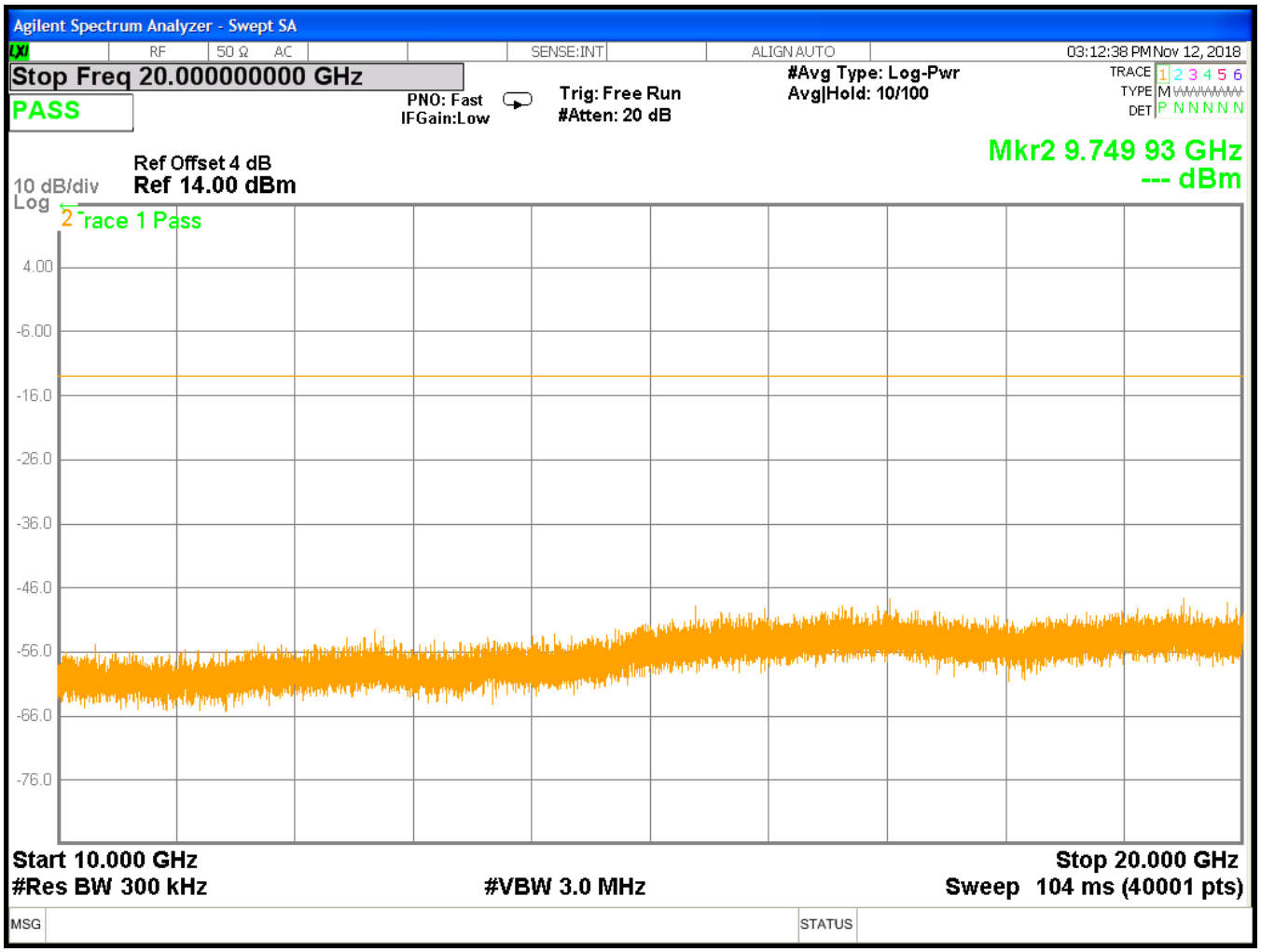

Figure 50: Conducted Spurious Emissions, Center Channel 10 - 20GHz

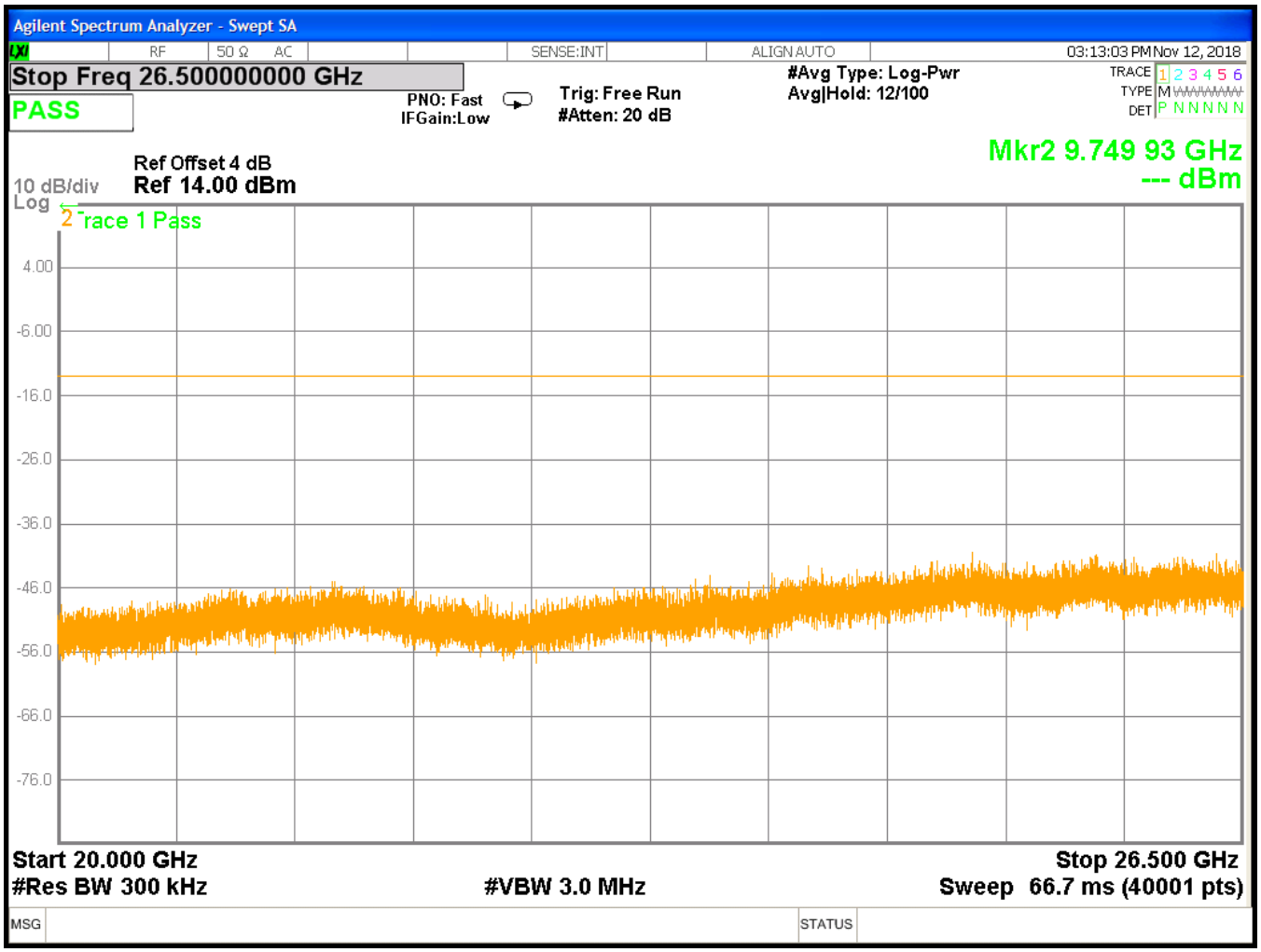

Figure 51: Conducted Spurious Emissions, Center Channel 20 – 26.5GHz

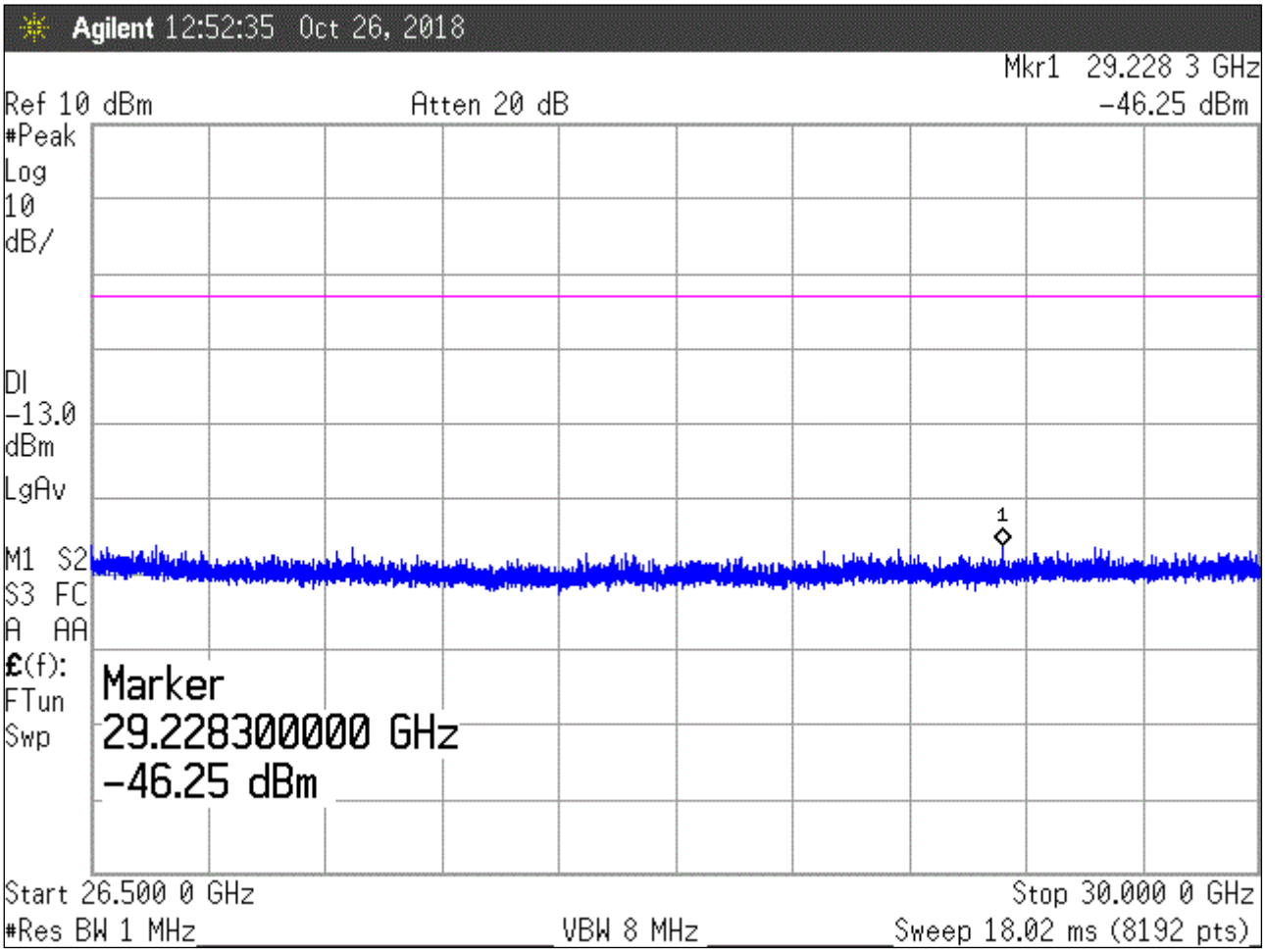

Figure 52: Conducted Spurious Emissions, Center Channel 26.5 – 30GHz

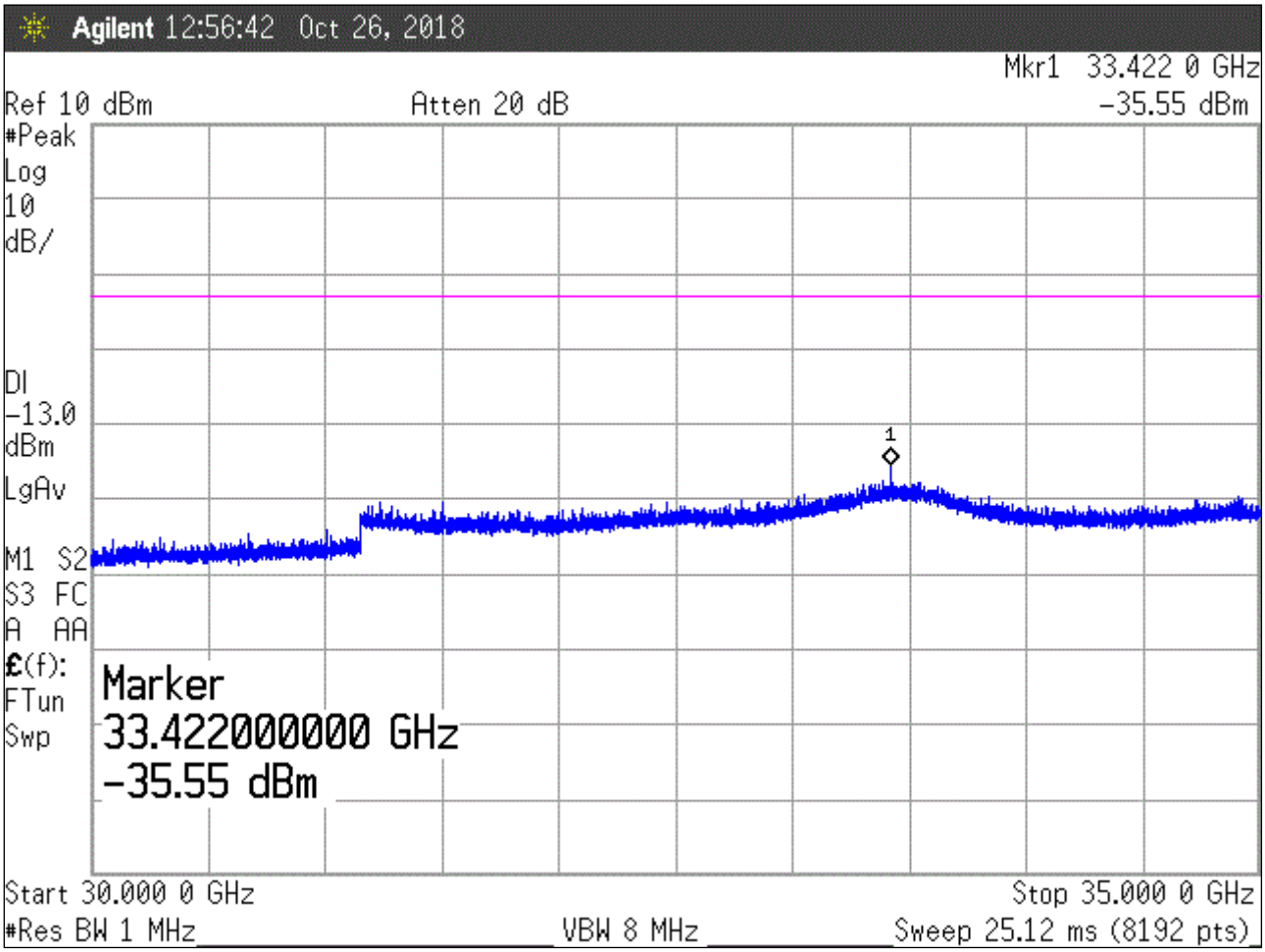

Figure 53: Conducted Spurious Emissions, Center Channel 30 – 35GHz

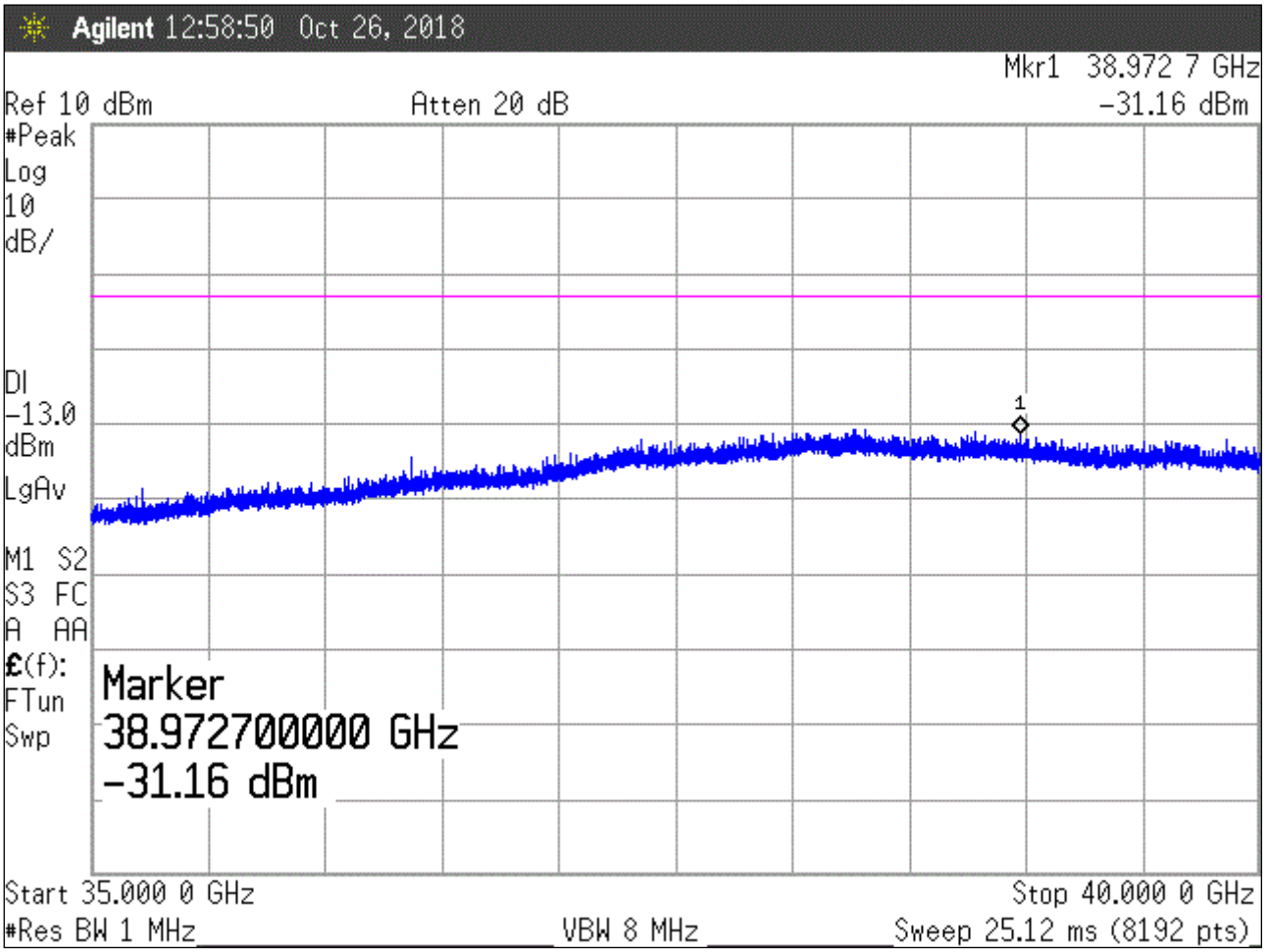

Figure 54: Conducted Spurious Emissions, Center Channel 35 – 40GHz

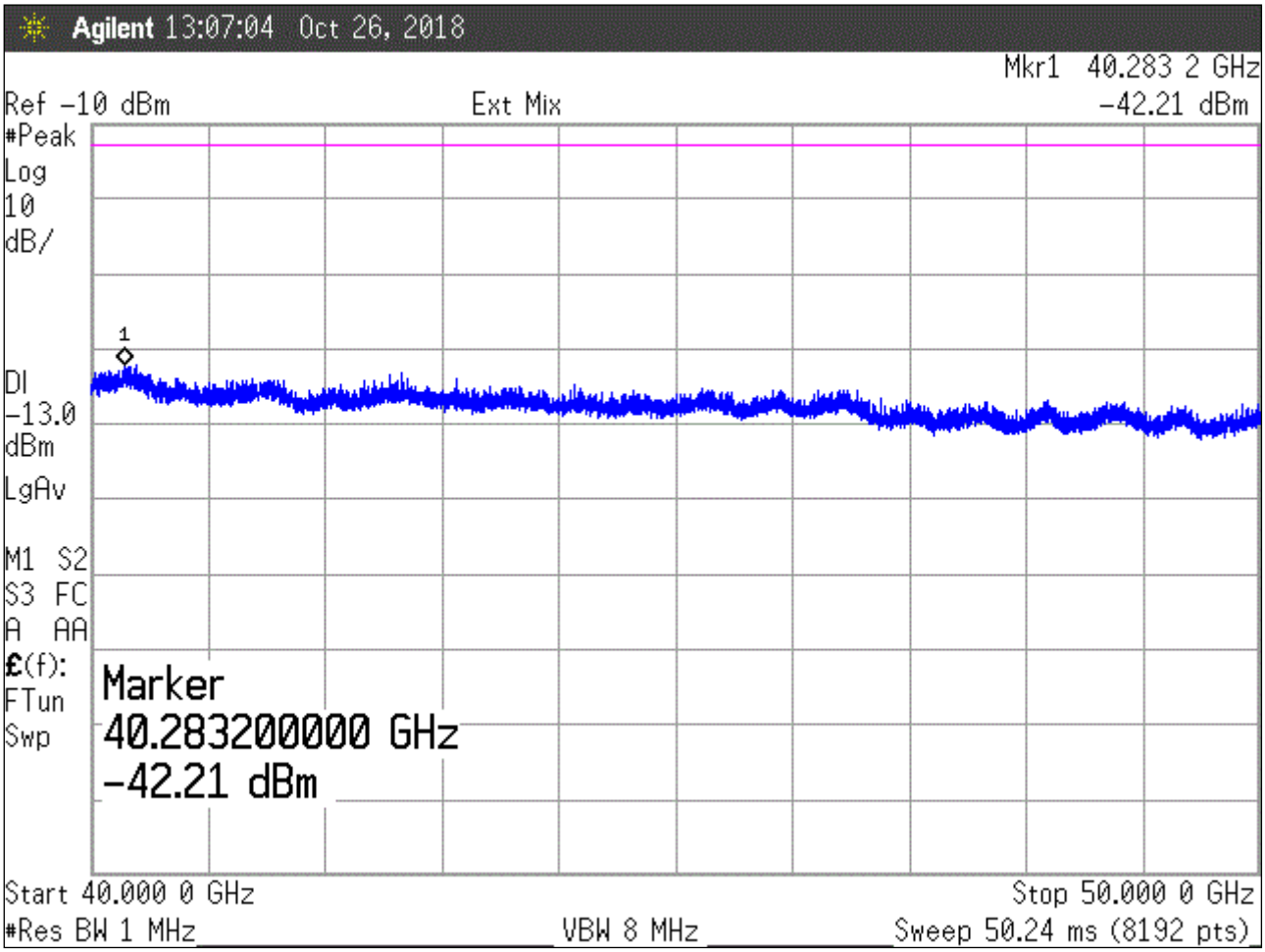

Figure 55: Conducted Spurious Emissions, Center Channel 40 – 50GHz

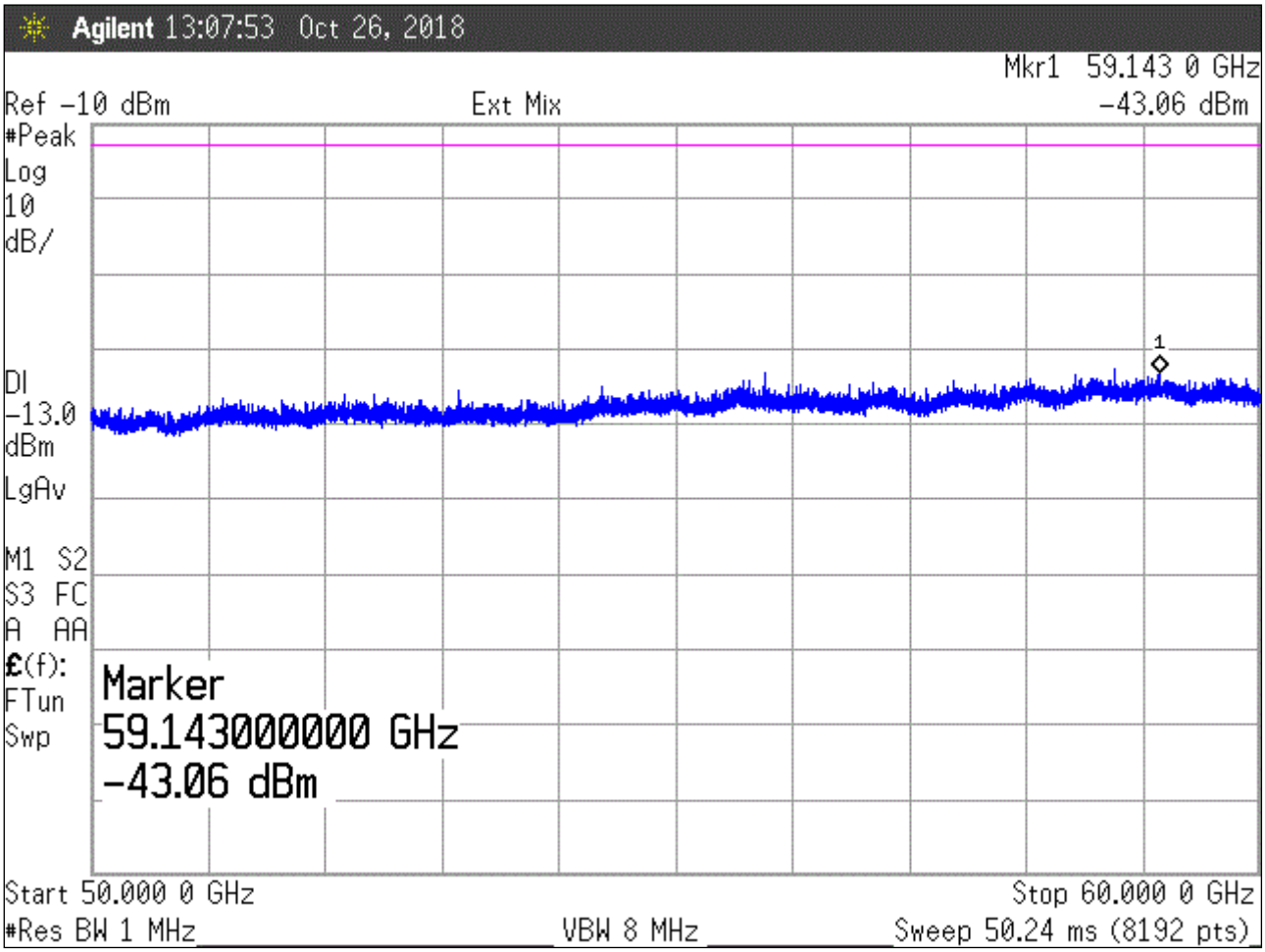

Figure 56: Conducted Spurious Emissions, Center Channel 50 – 60GHz

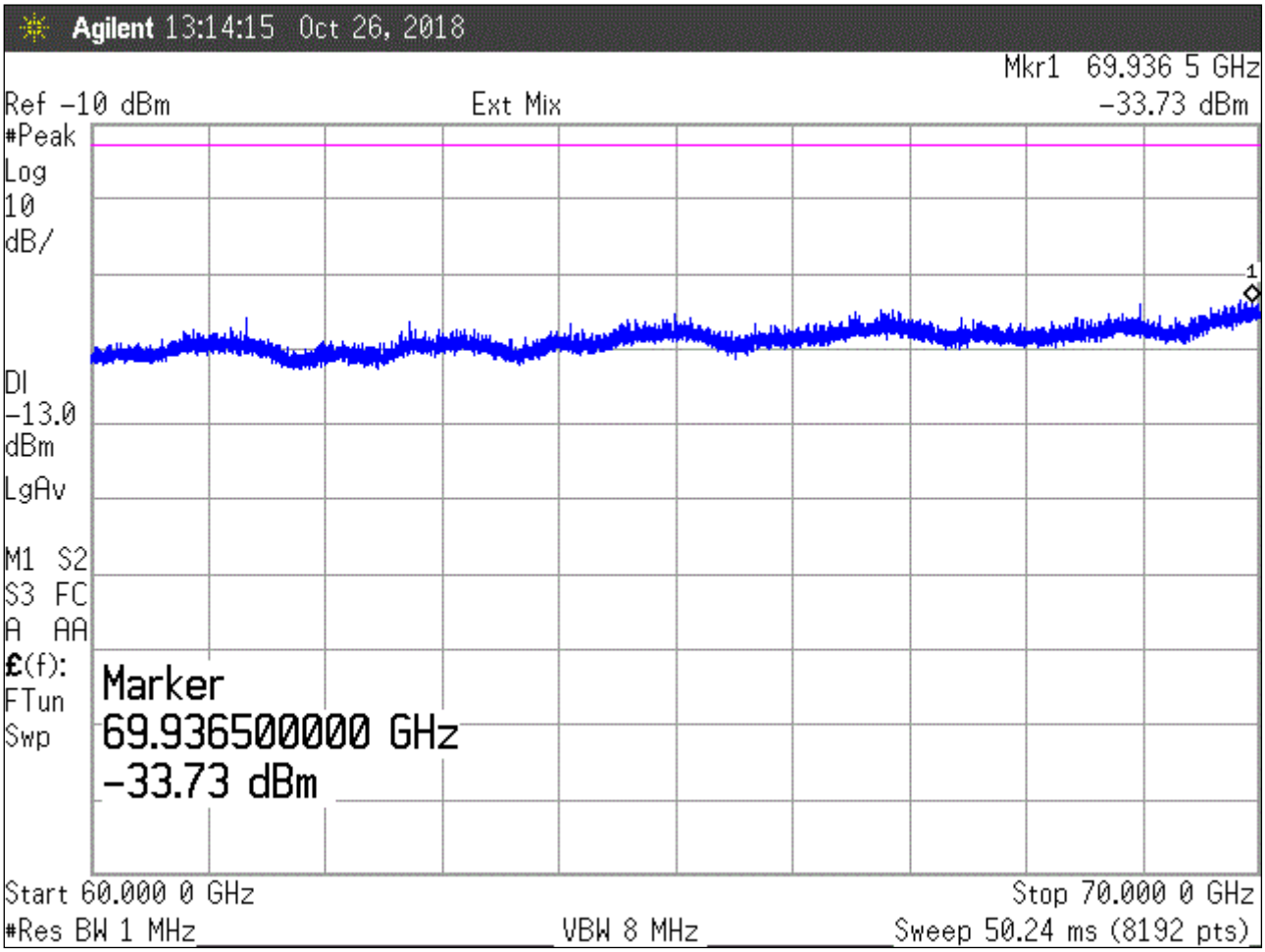

Figure 57: Conducted Spurious Emissions, Center Channel 60 – 70GHz

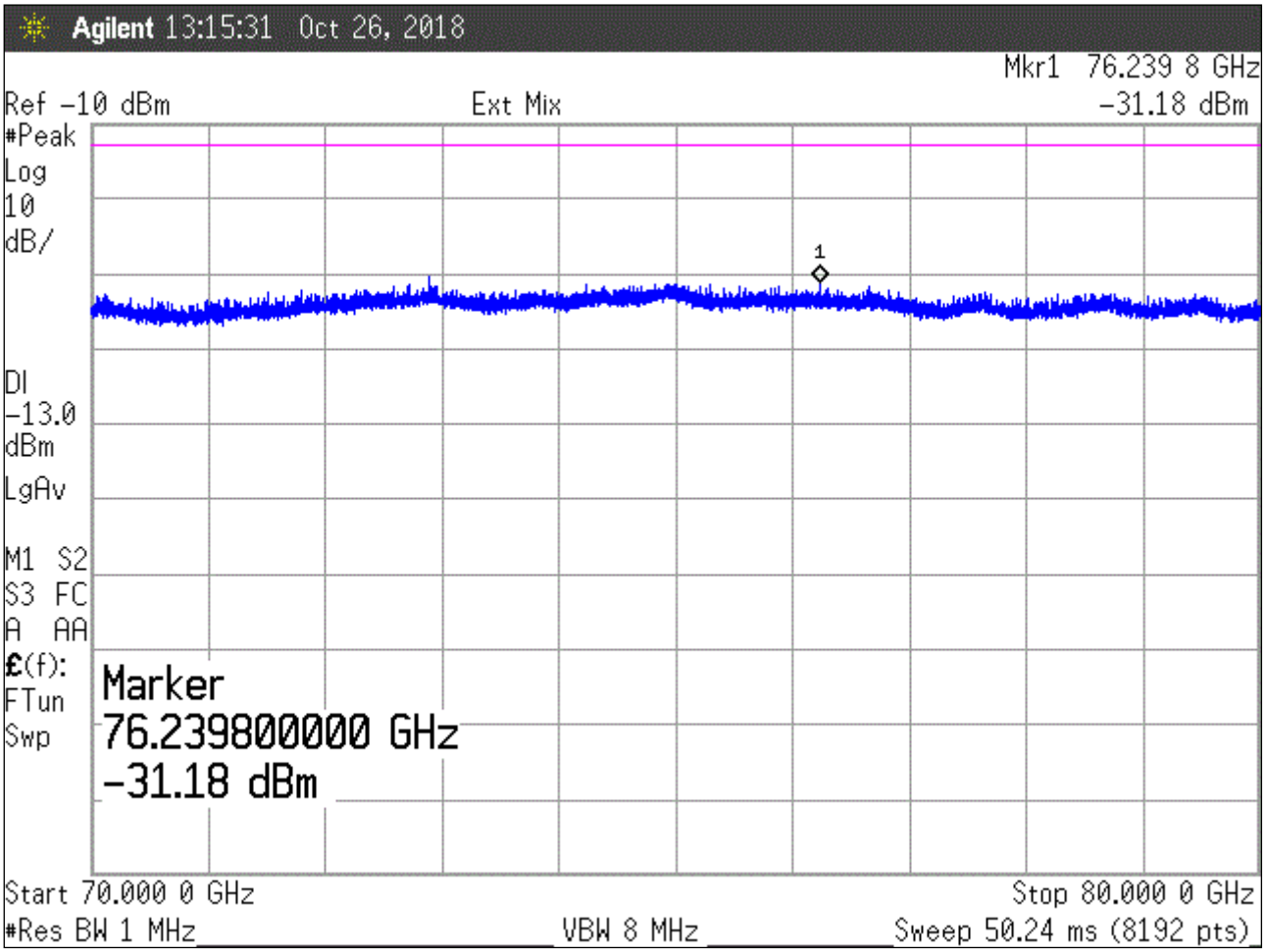

Figure 58: Conducted Spurious Emissions, Center Channel 70 – 80GHz

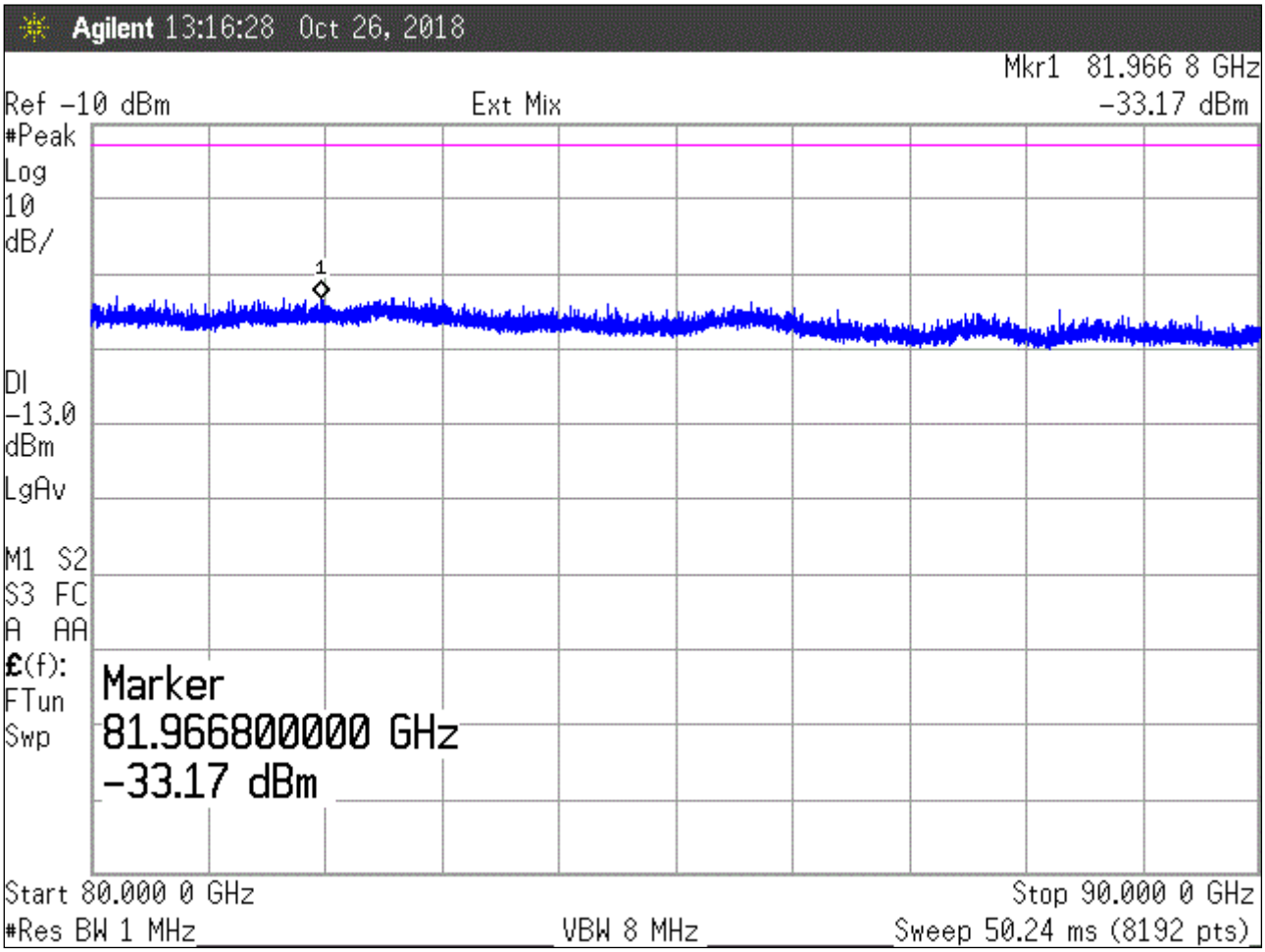

Figure 59: Conducted Spurious Emissions, Center Channel 80 – 90GHz

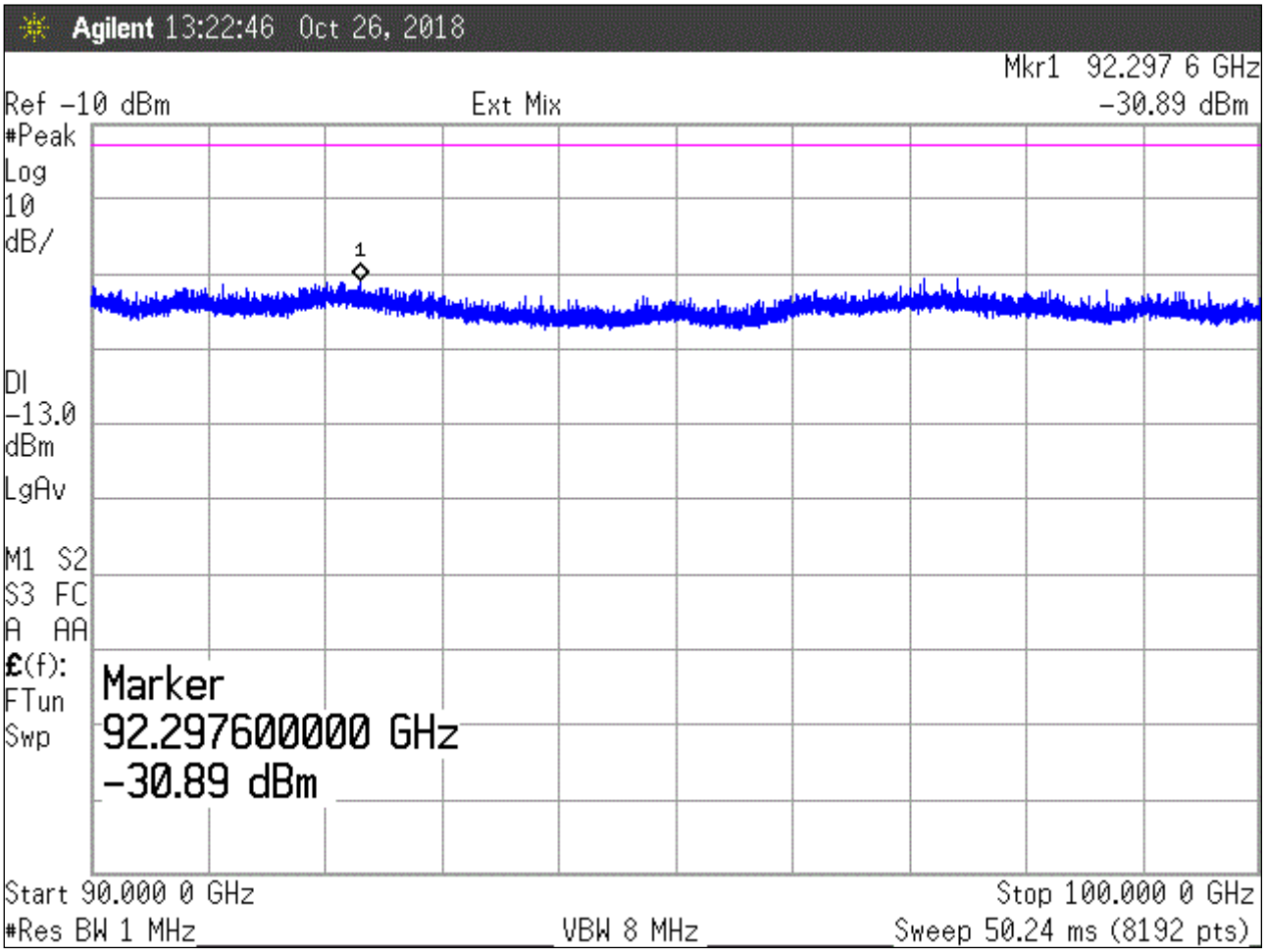

Figure 60: Conducted Spurious Emissions, Center Channel 90 – 100GHz

3D_B J3

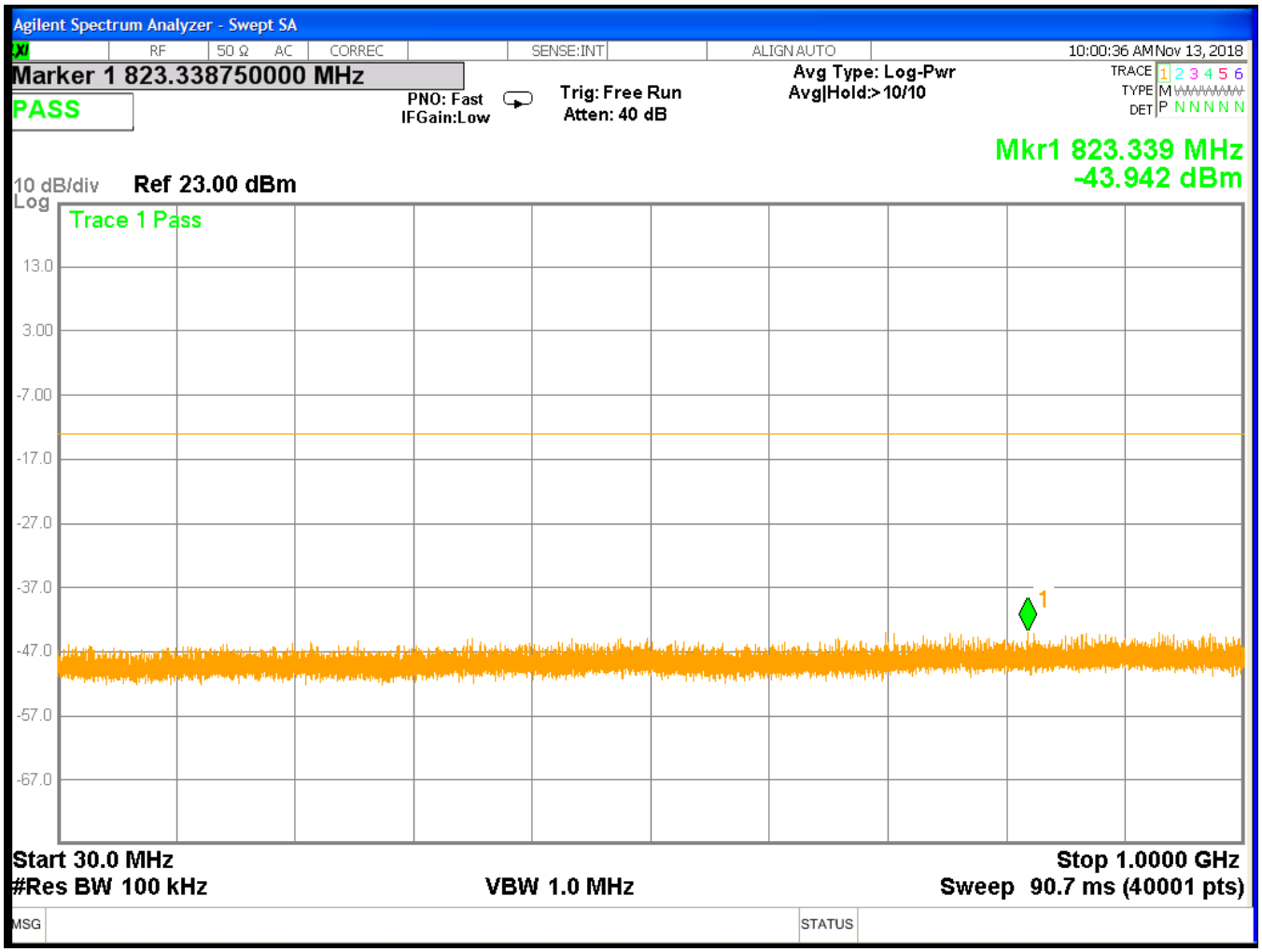

Figure 61: Conducted Spurious Emissions, Center Channel 30 - 1000MHz

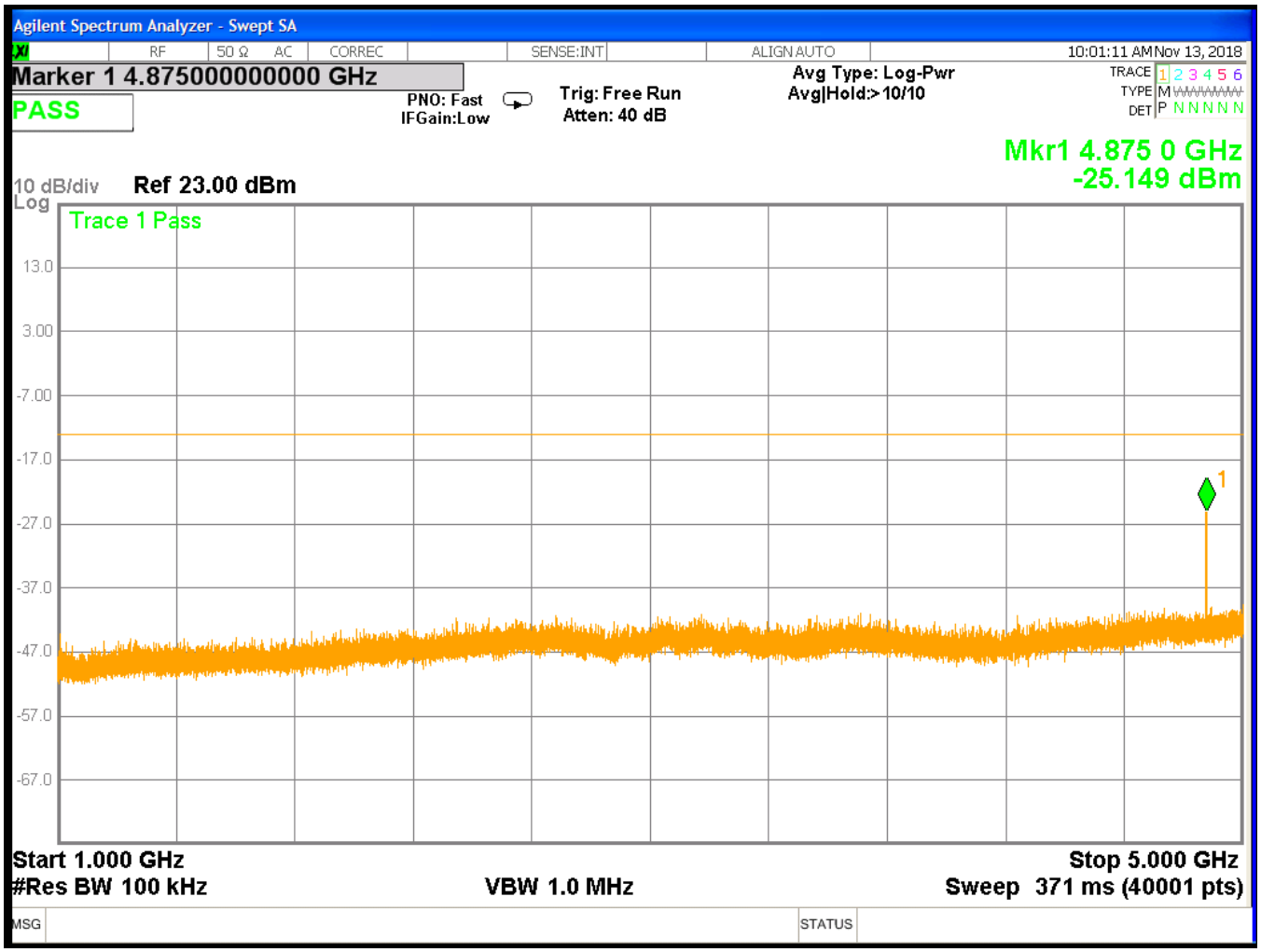

Figure 62: Conducted Spurious Emissions, Center Channel 1 – 5GHz

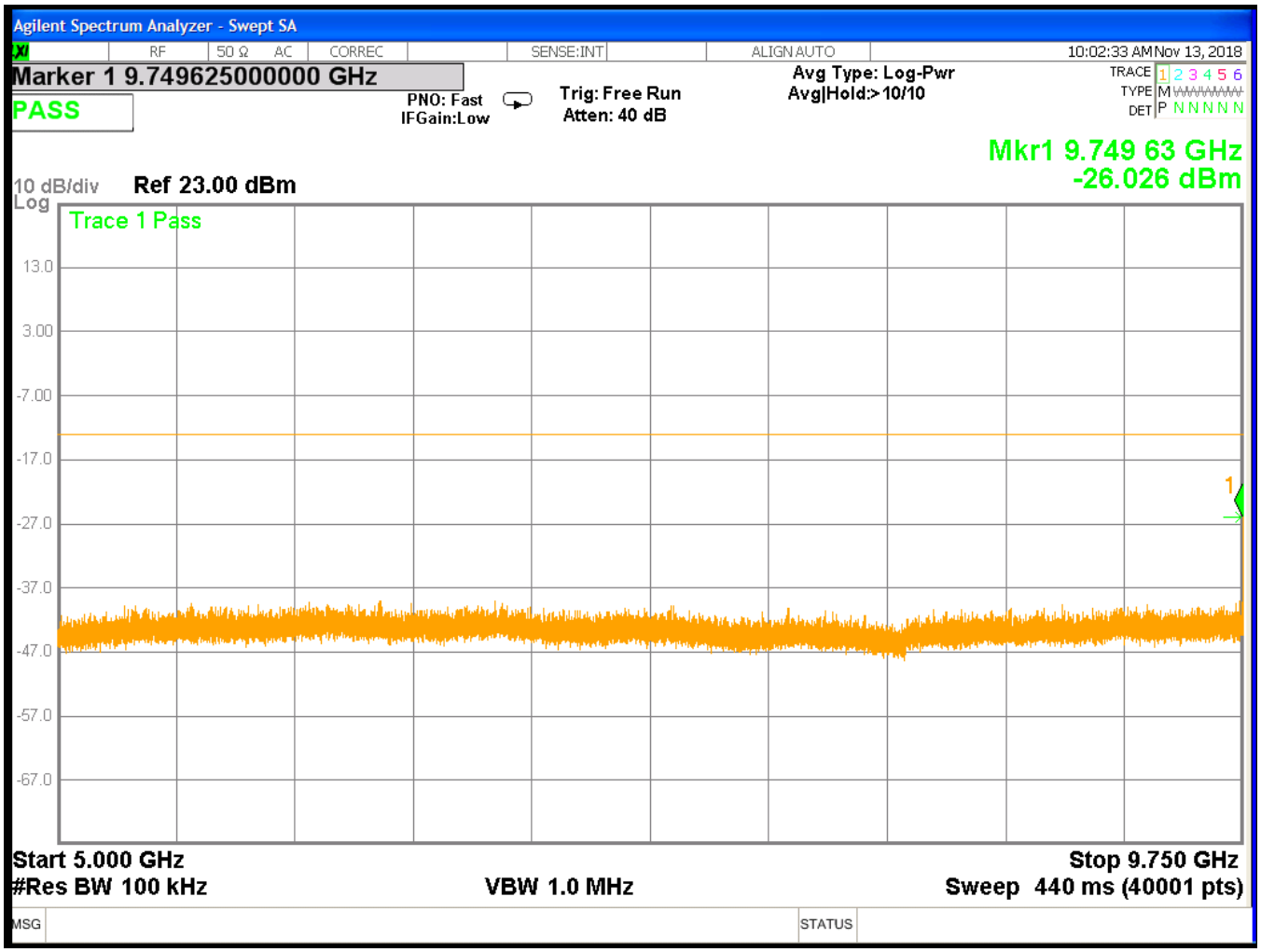

Figure 63: Conducted Spurious Emissions, Center Channel 5 – 9.75GHz

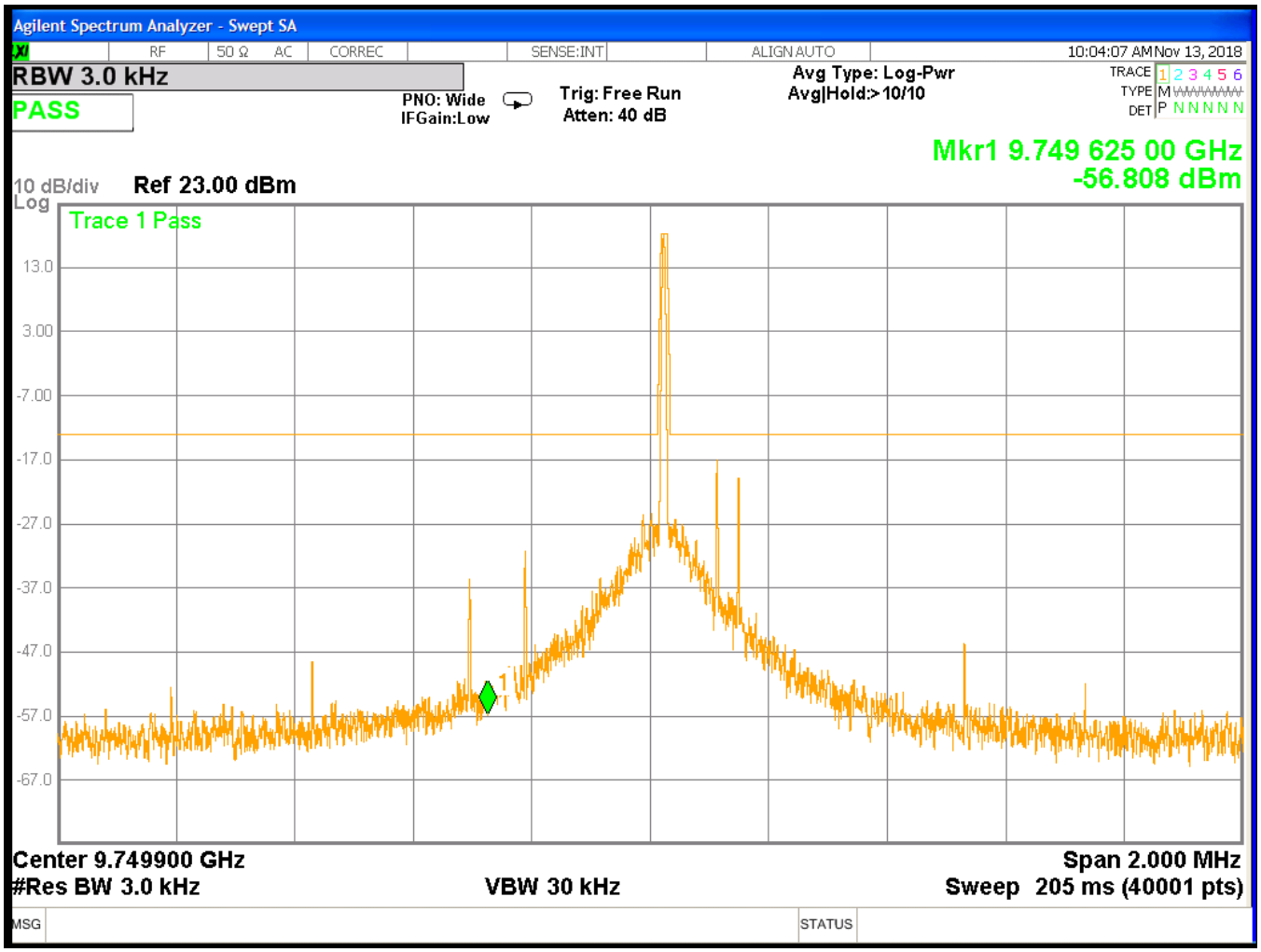

Figure 64: Conducted Spurious Emissions, Center Channel 9.75 – 9.76GHz

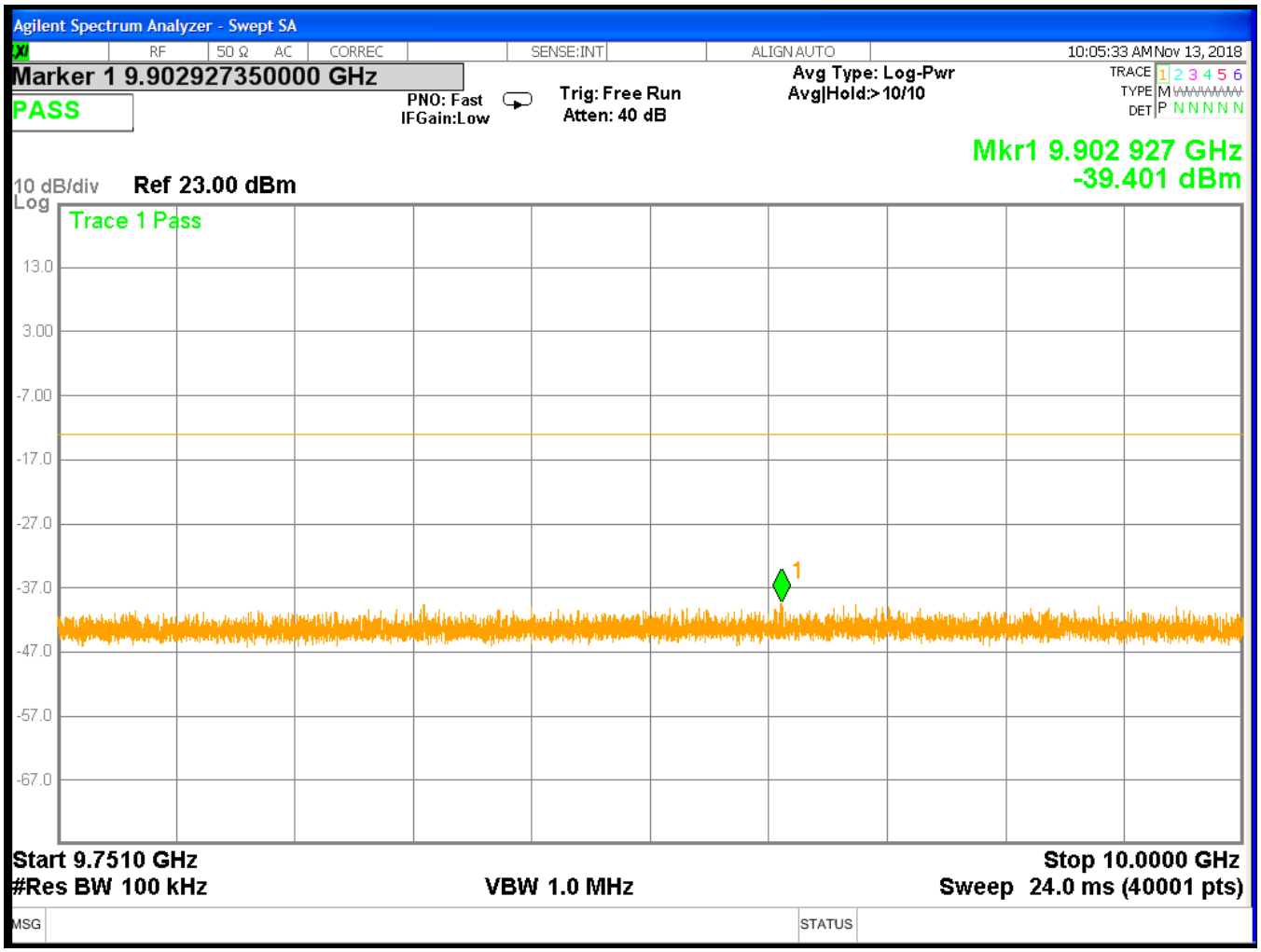

Figure 65: Conducted Spurious Emissions, Center Channel 9.75 - 10GHz

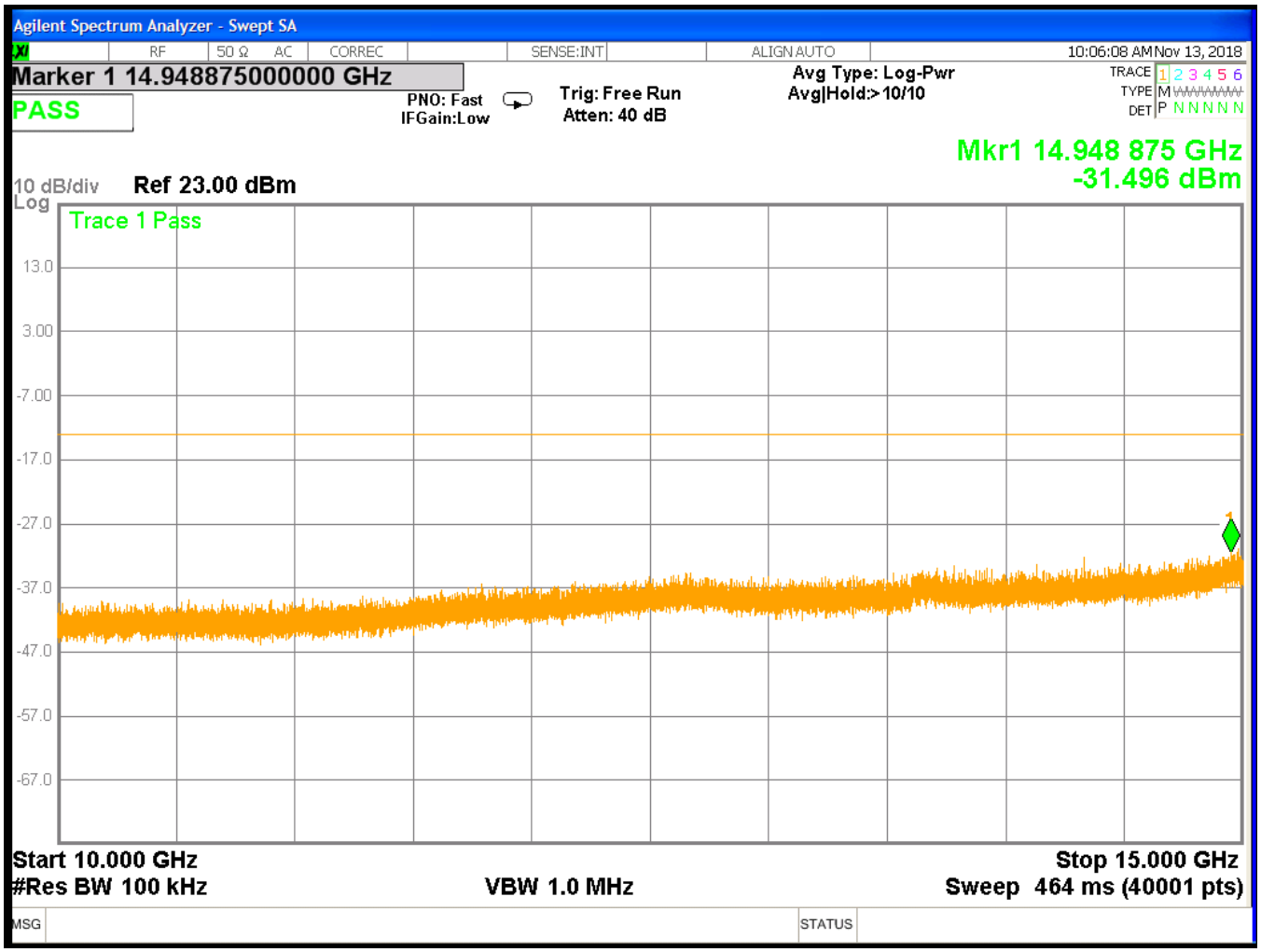

Figure 66: Conducted Spurious Emissions, Center Channel 10 - 55GHz

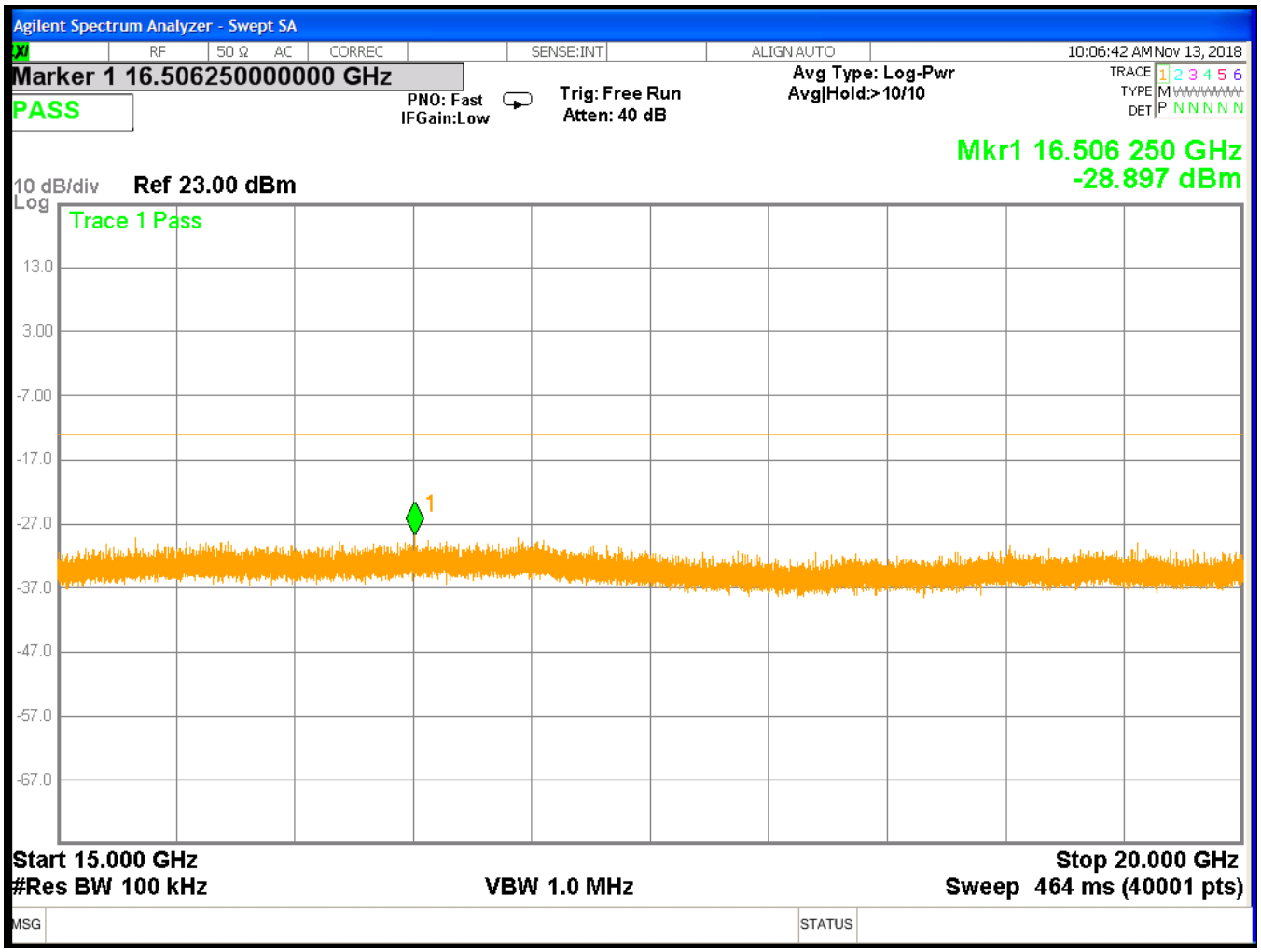

Figure 67: Conducted Spurious Emissions, Center Channel 15 – 20GHz

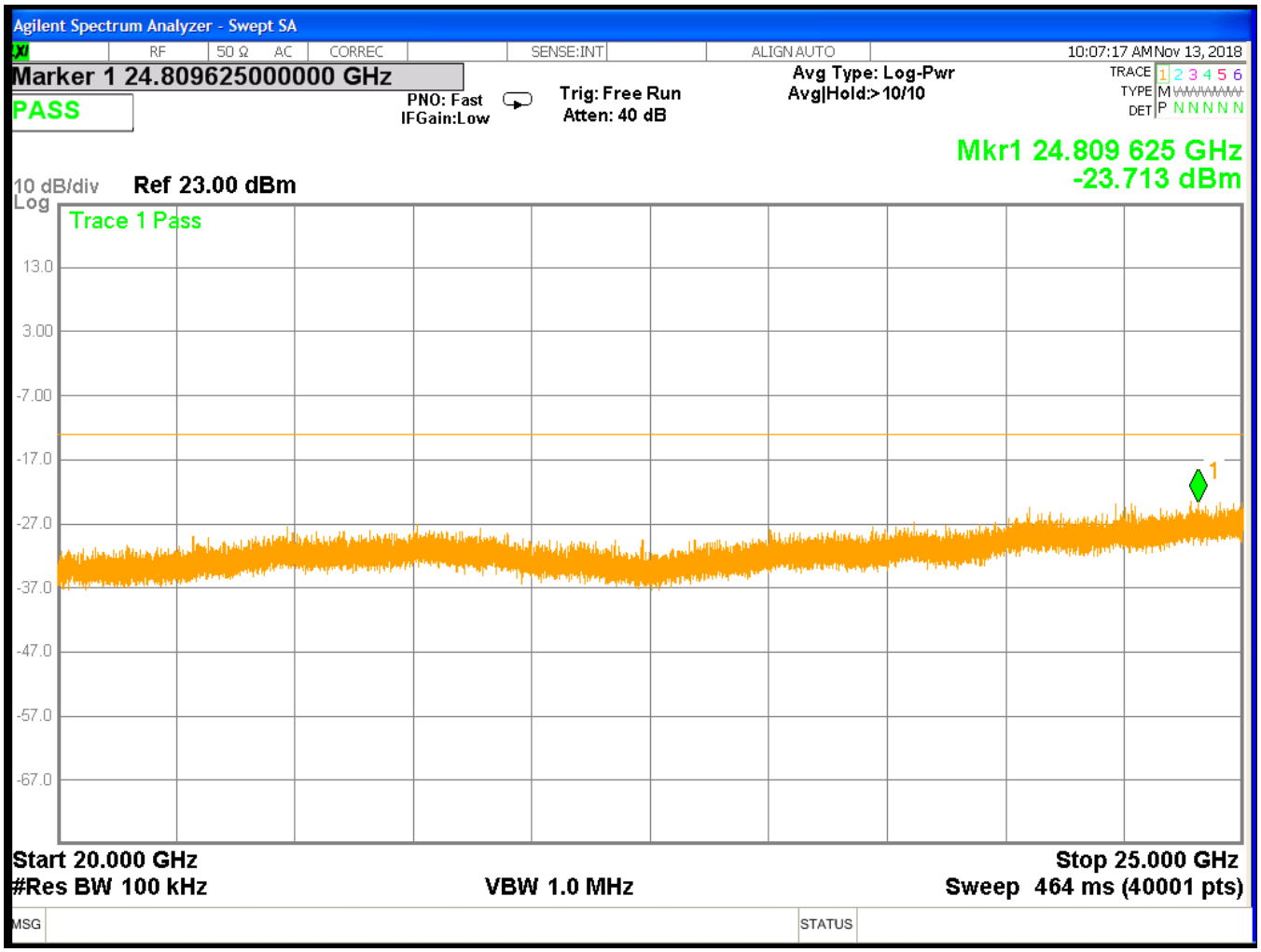

Figure 68: Conducted Spurious Emissions, Center Channel 20 – 25GHz

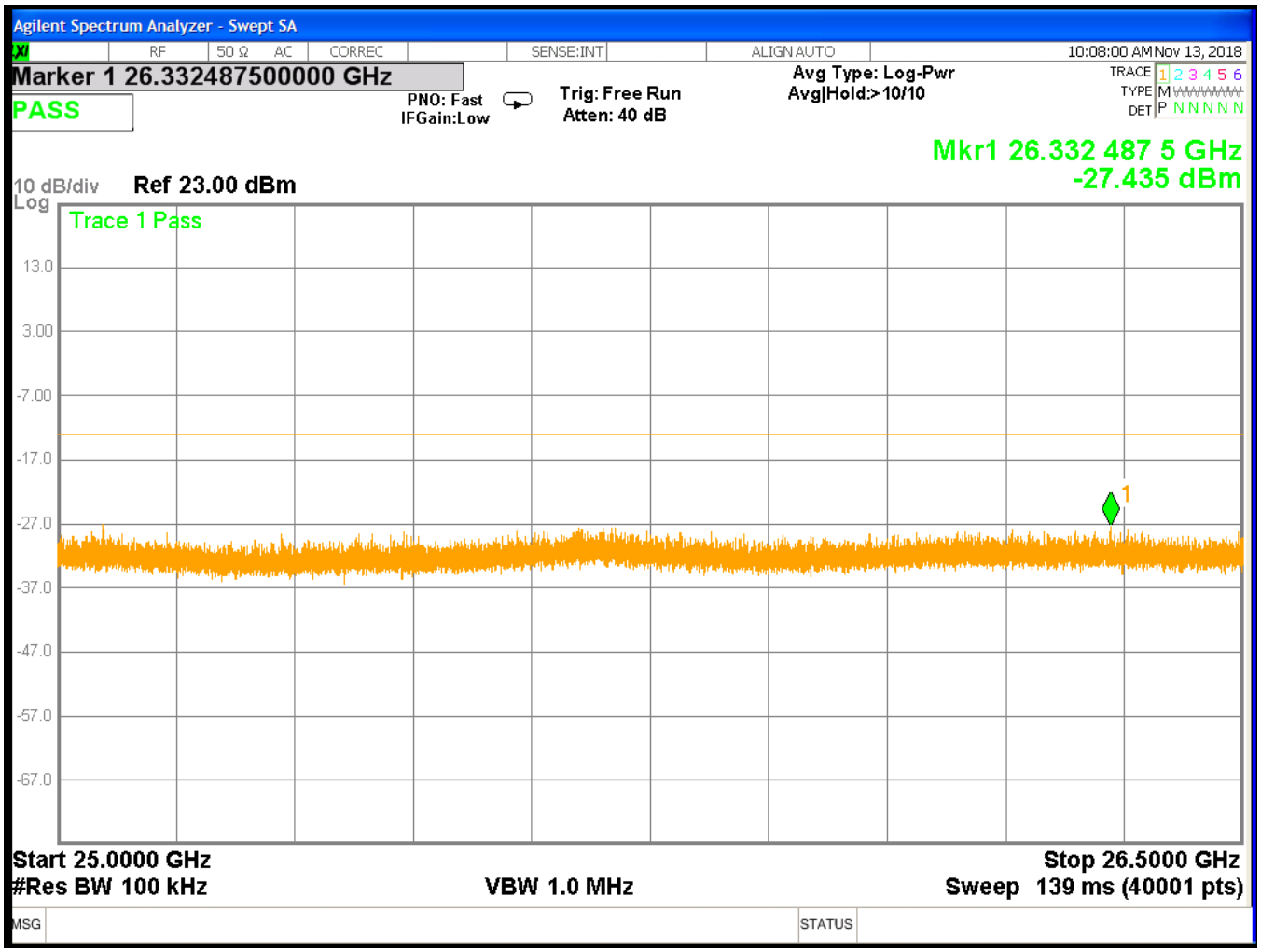

Figure 69: Conducted Spurious Emissions, Center Channel 25 – 26.5GHz

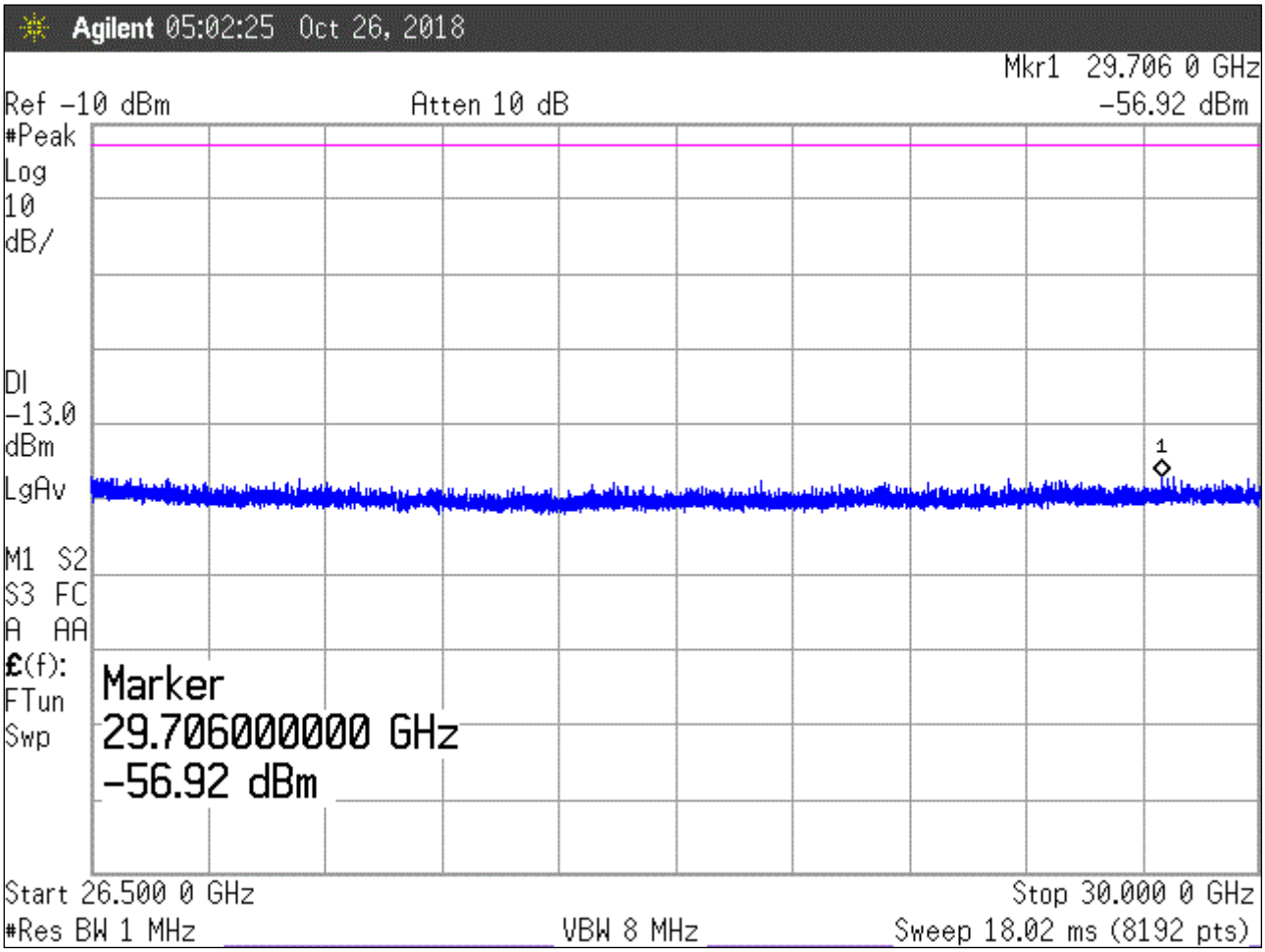

Figure 70: Conducted Spurious Emissions, Center Channel 26.5 – 30GHz

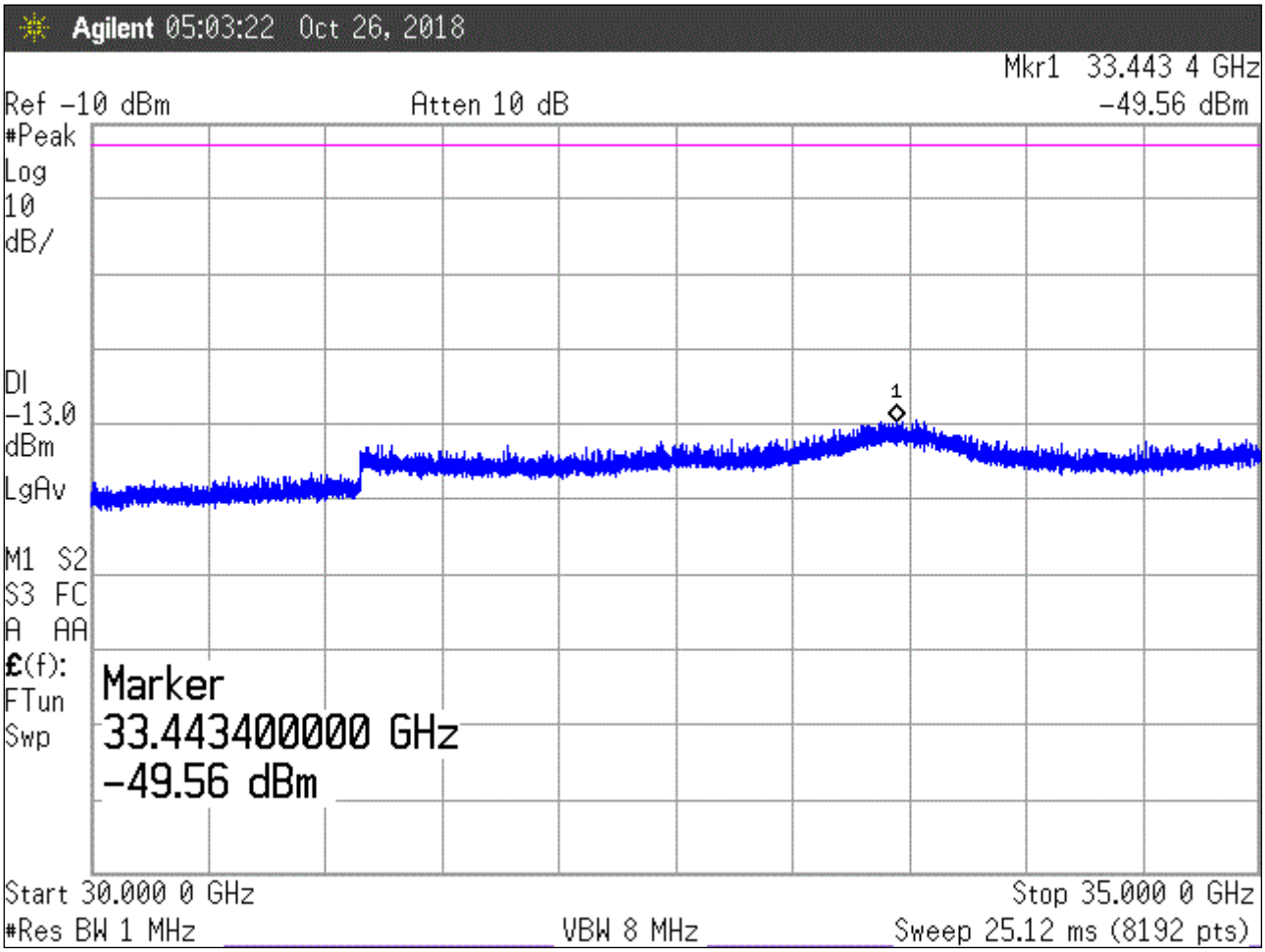

Figure 71: Conducted Spurious Emissions, Center Channel 30 – 35GHz

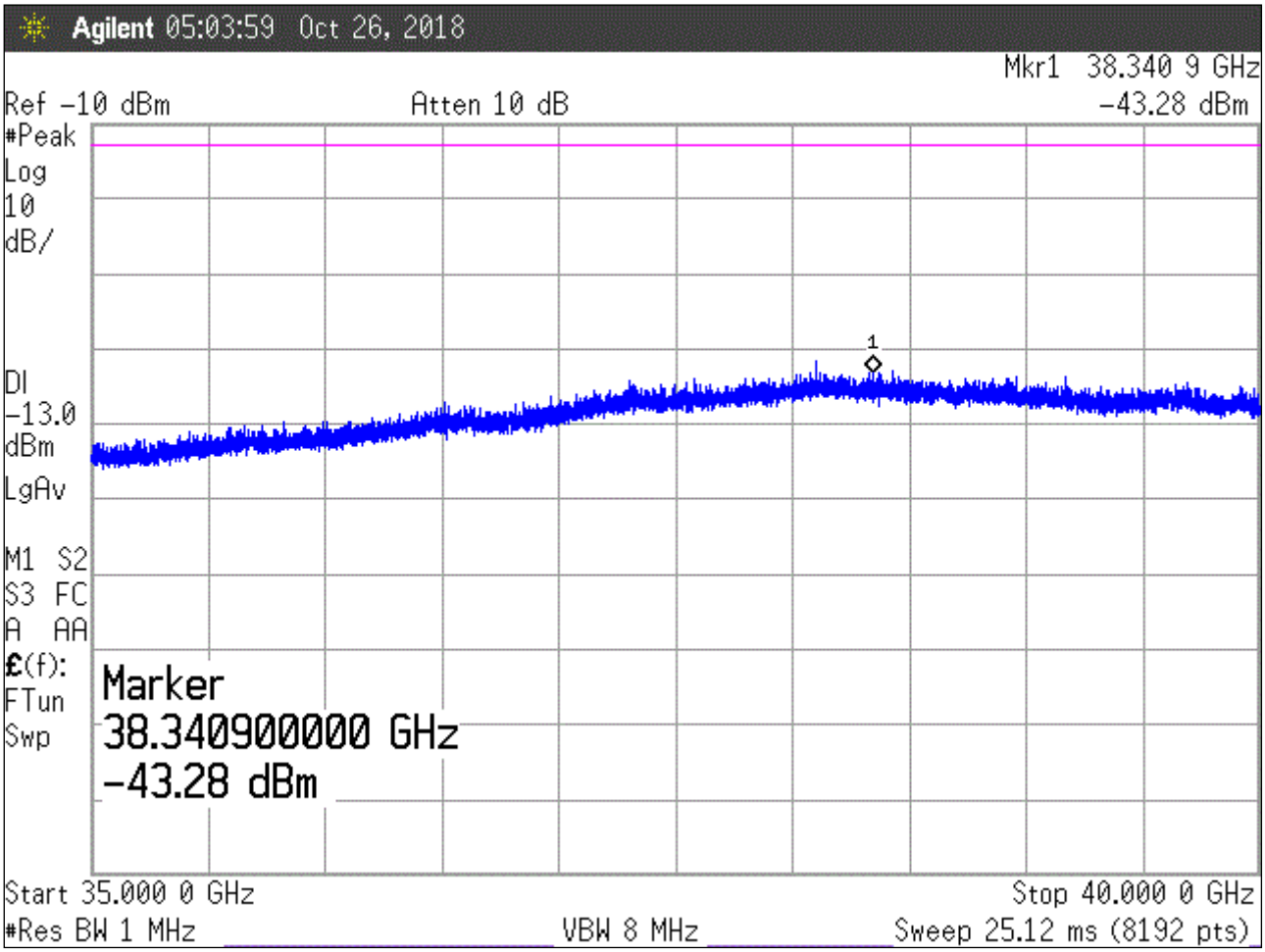

Figure 72: Conducted Spurious Emissions, Center Channel 35 – 40GHz

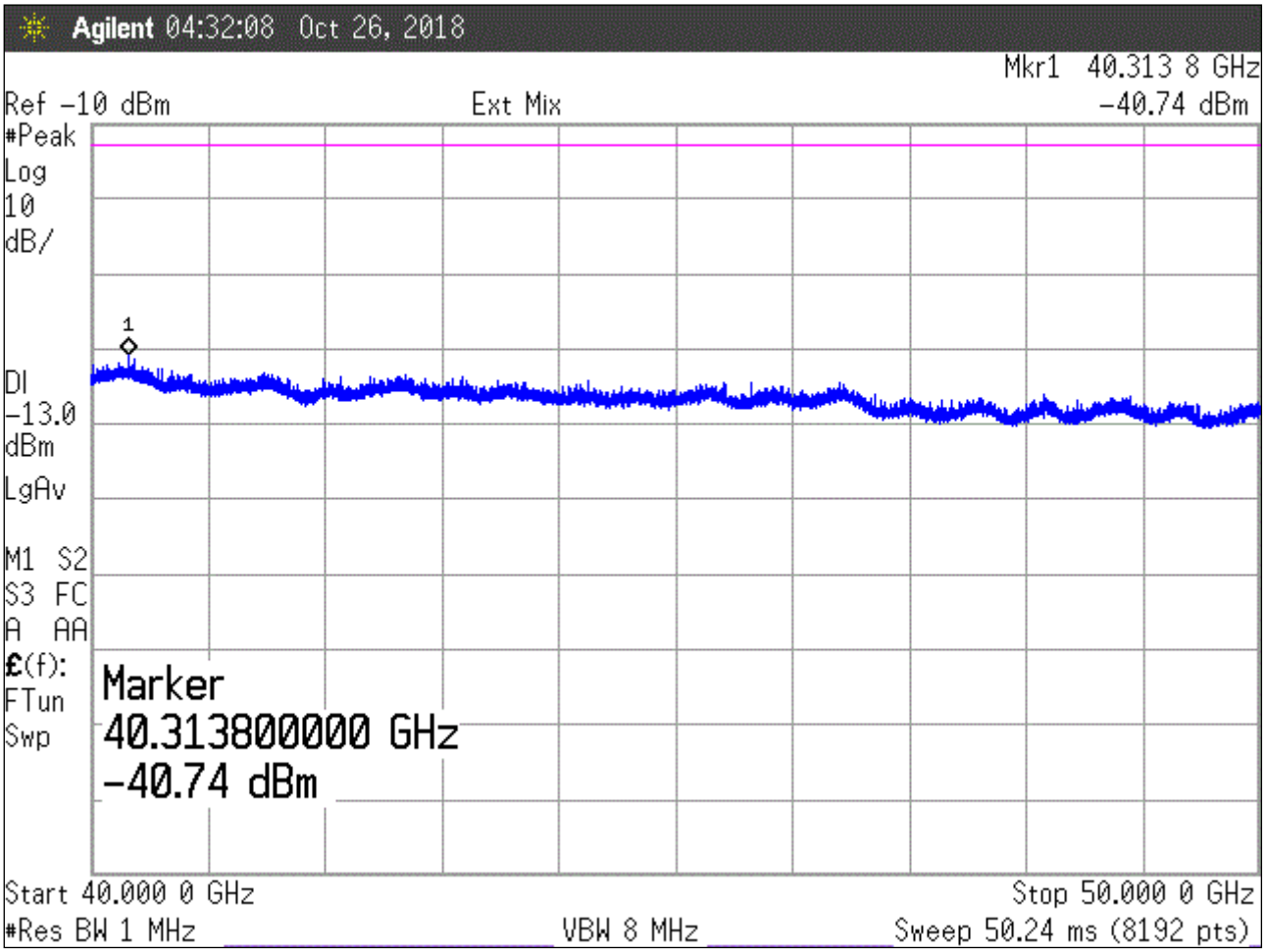

Figure 73: Conducted Spurious Emissions, Center Channel 40 – 50GHz

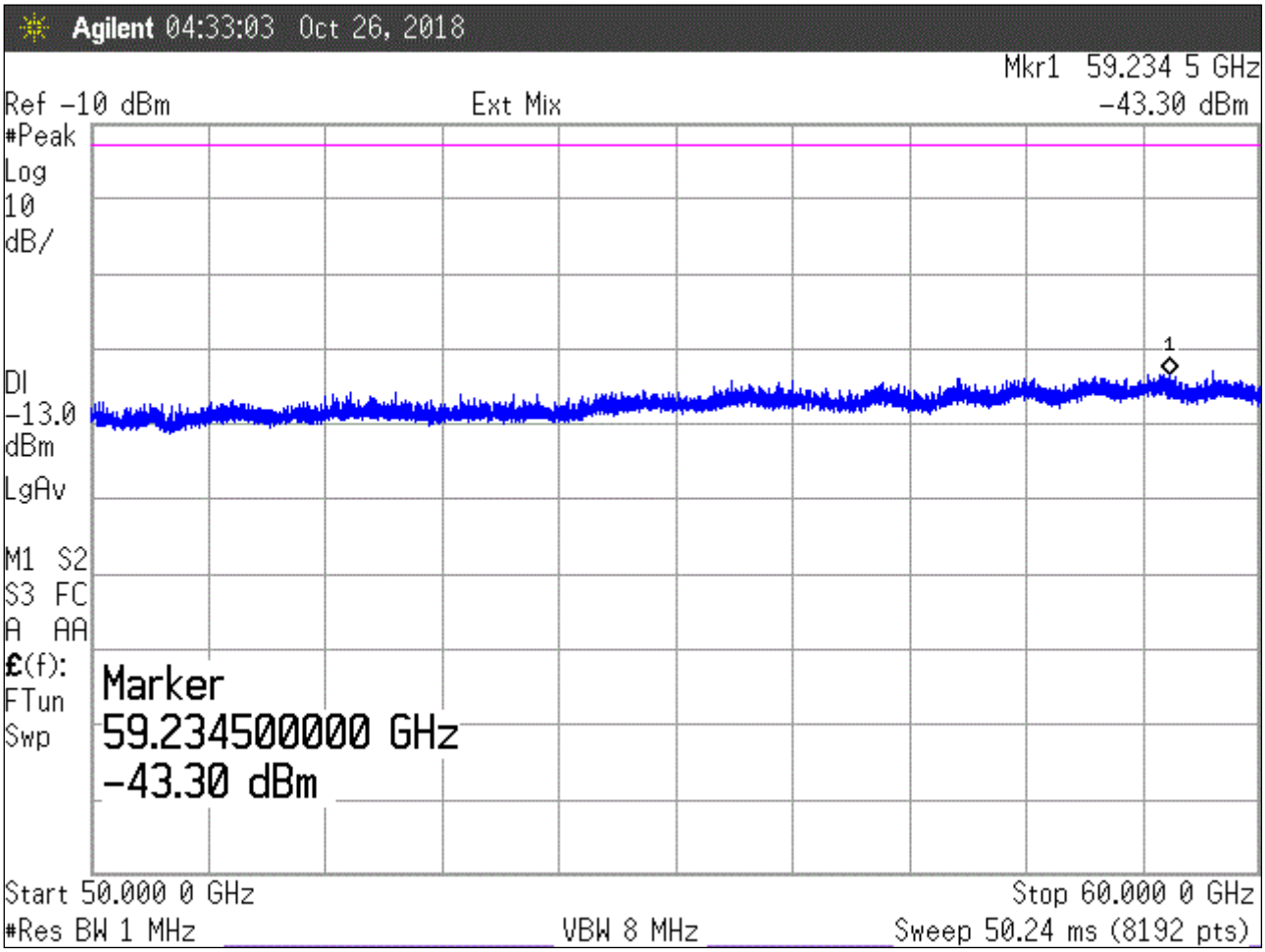

Figure 74: Conducted Spurious Emissions, Center Channel 50 – 60GHz

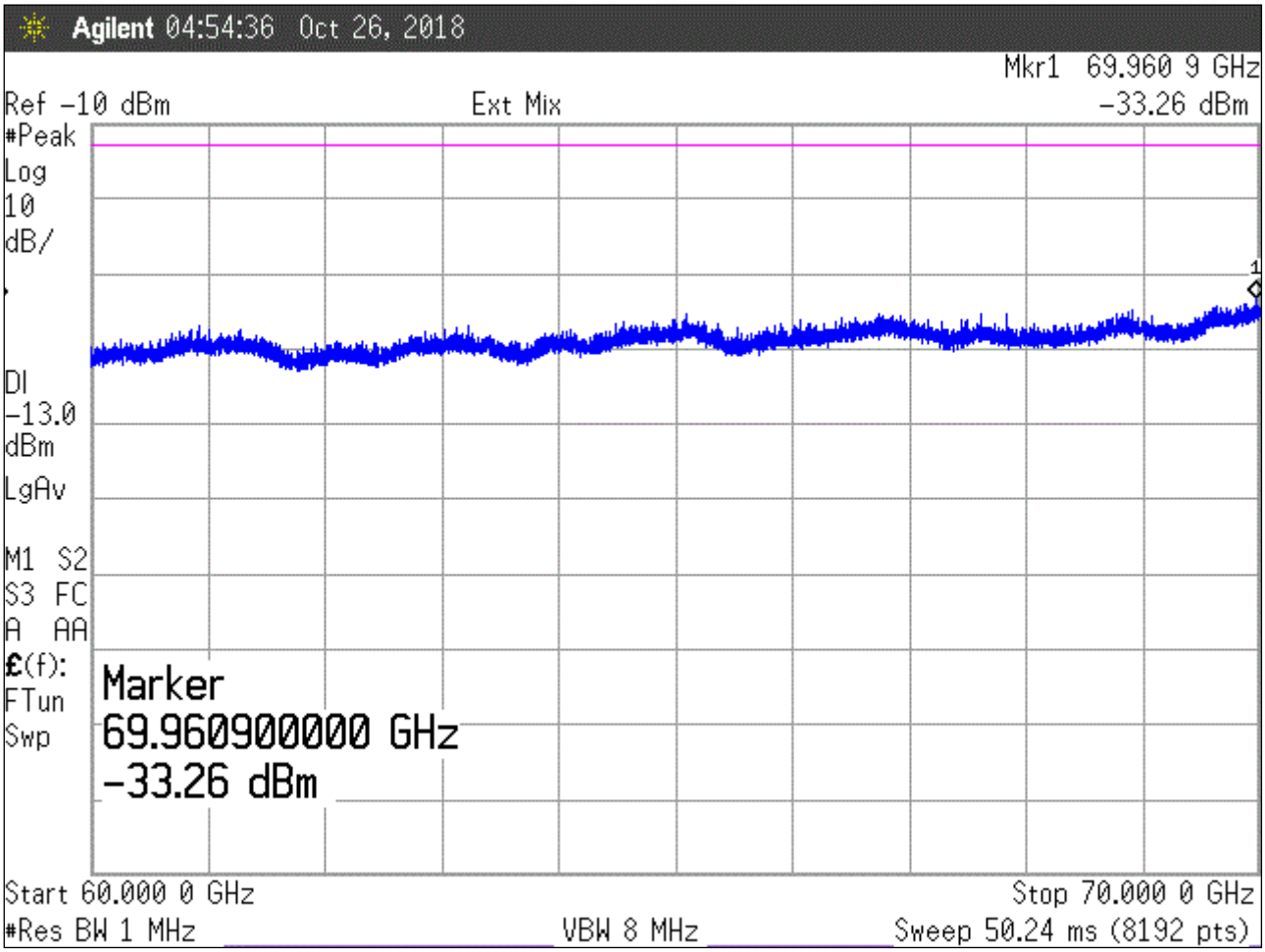

Figure 75: Conducted Spurious Emissions, Center Channel 60 – 70GHz

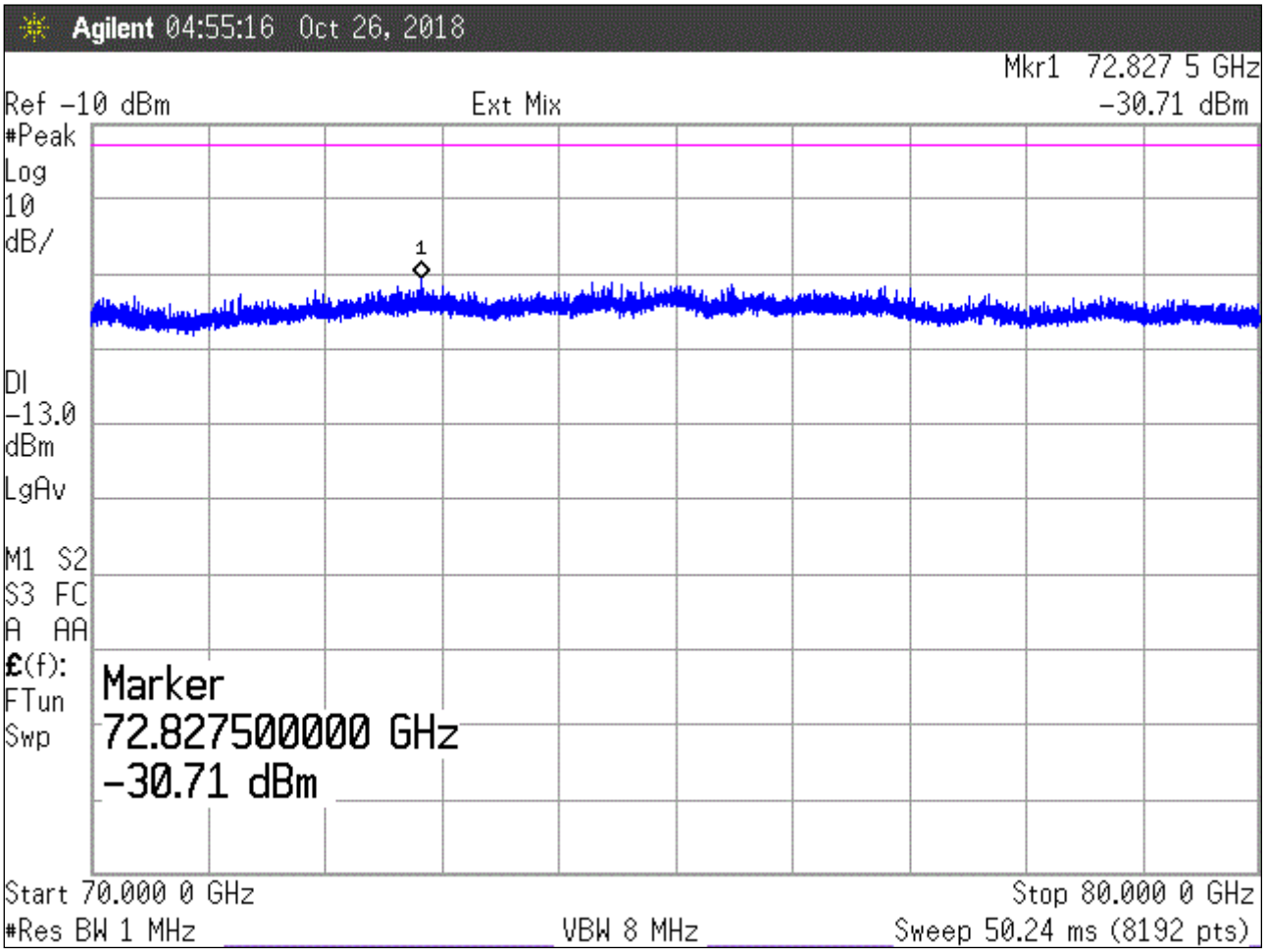

Figure 76: Conducted Spurious Emissions, Center Channel 70 – 80GHz

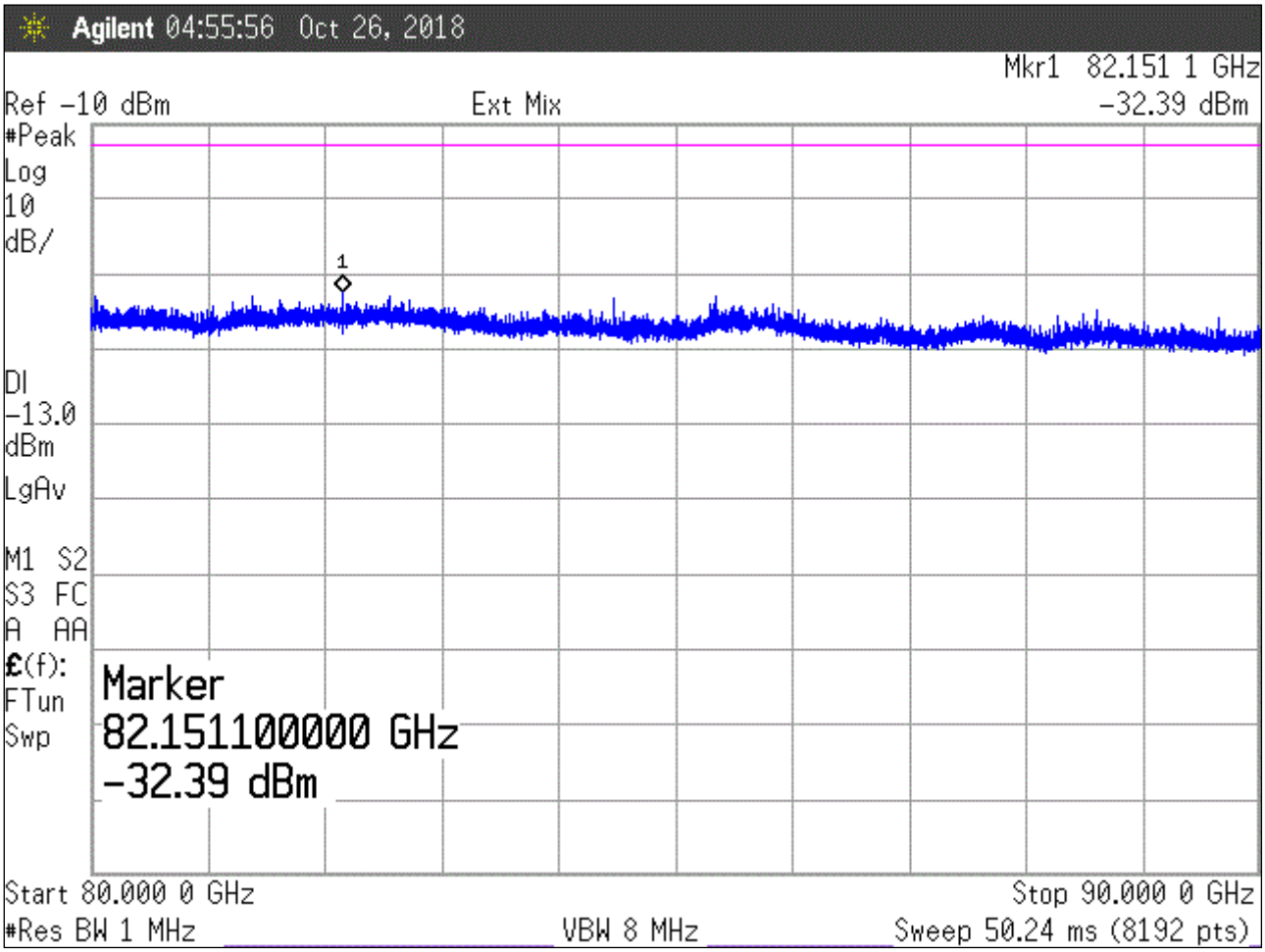

Figure 77: Conducted Spurious Emissions, Center Channel 80 – 90GHz

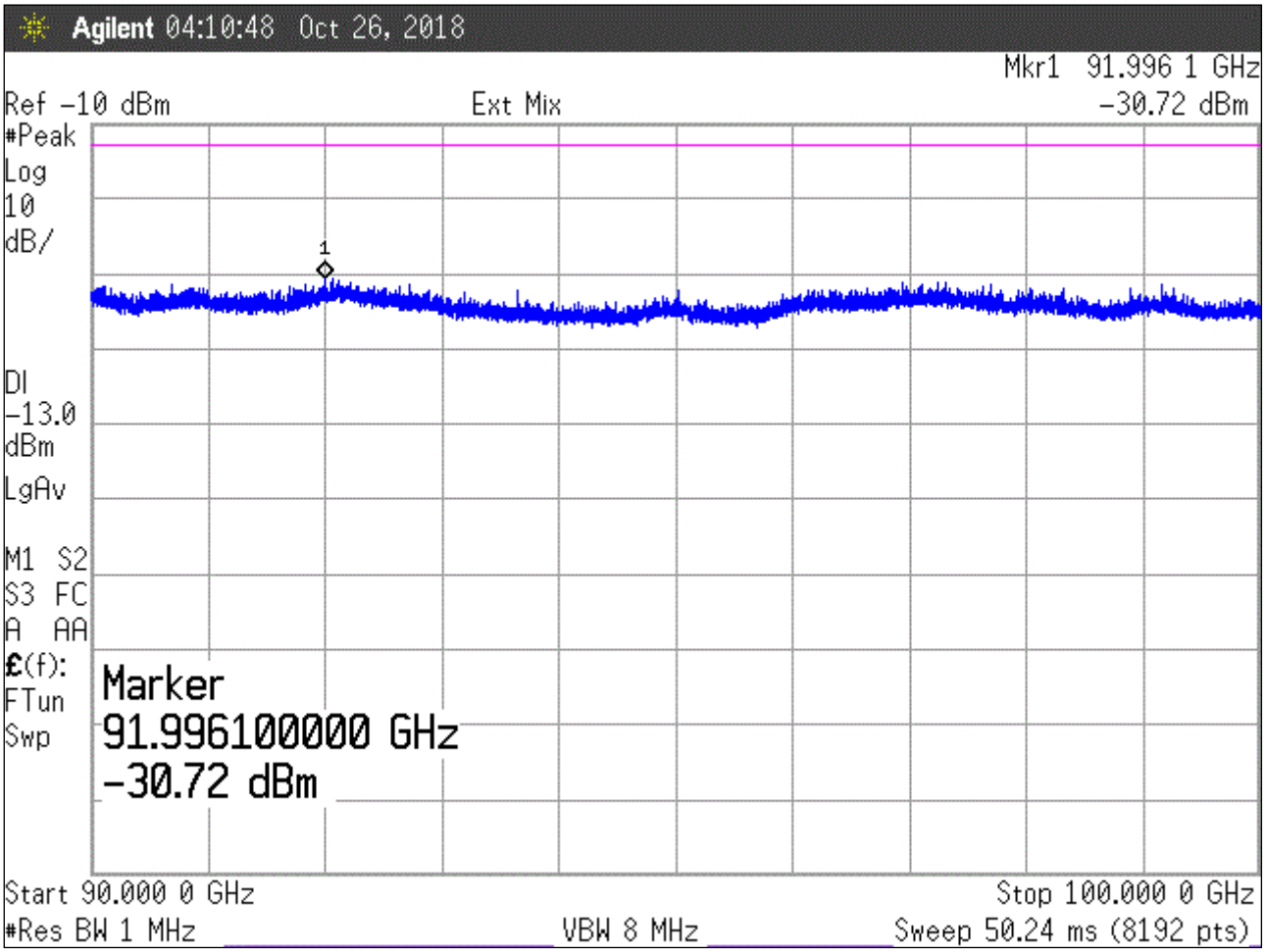

Figure 78: Conducted Spurious Emissions, Center Channel 90 – 100GHz

3D_A J4

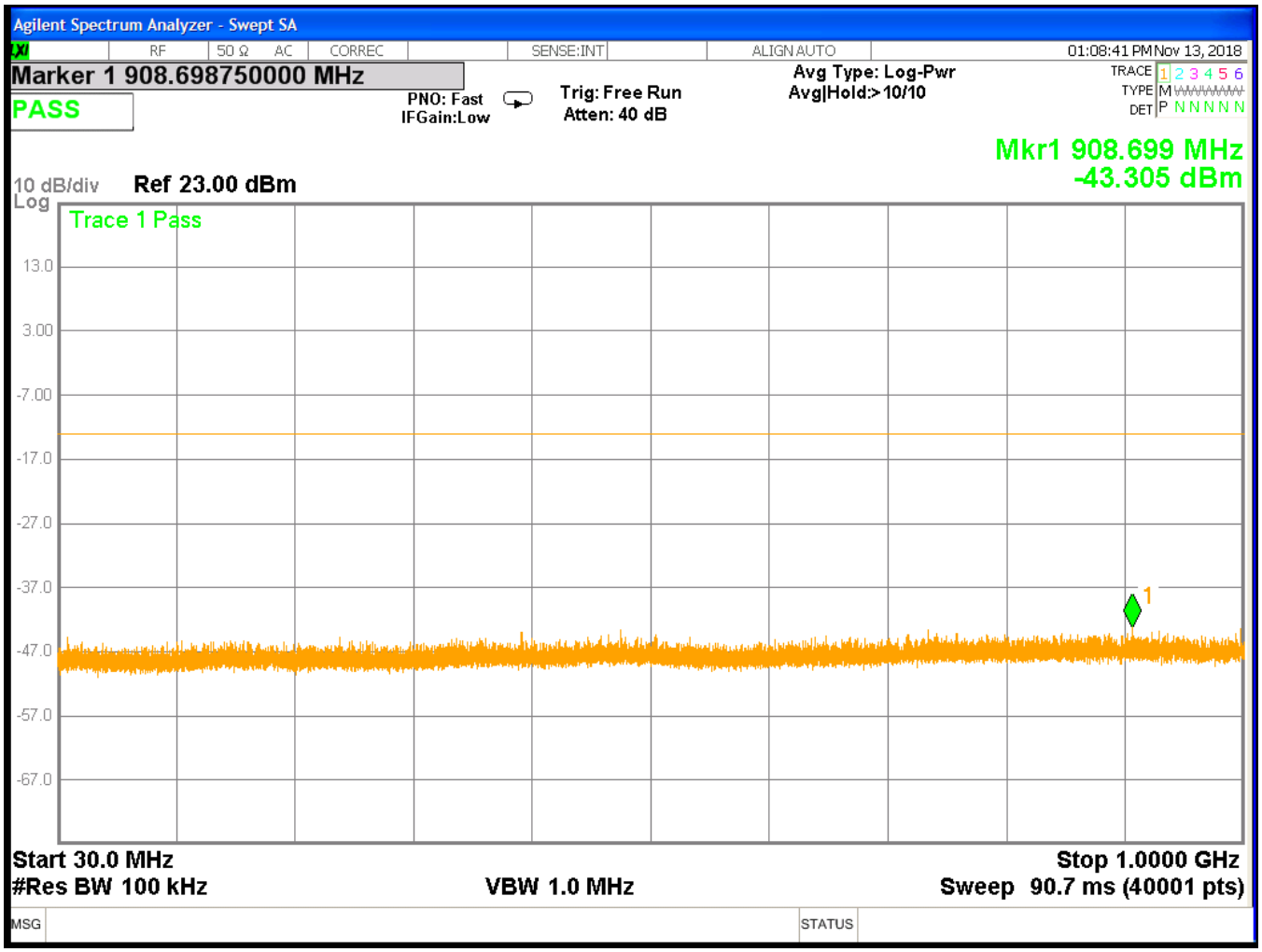

Figure 79: Conducted Spurious Emissions, Center Channel 30 - 1000MHz

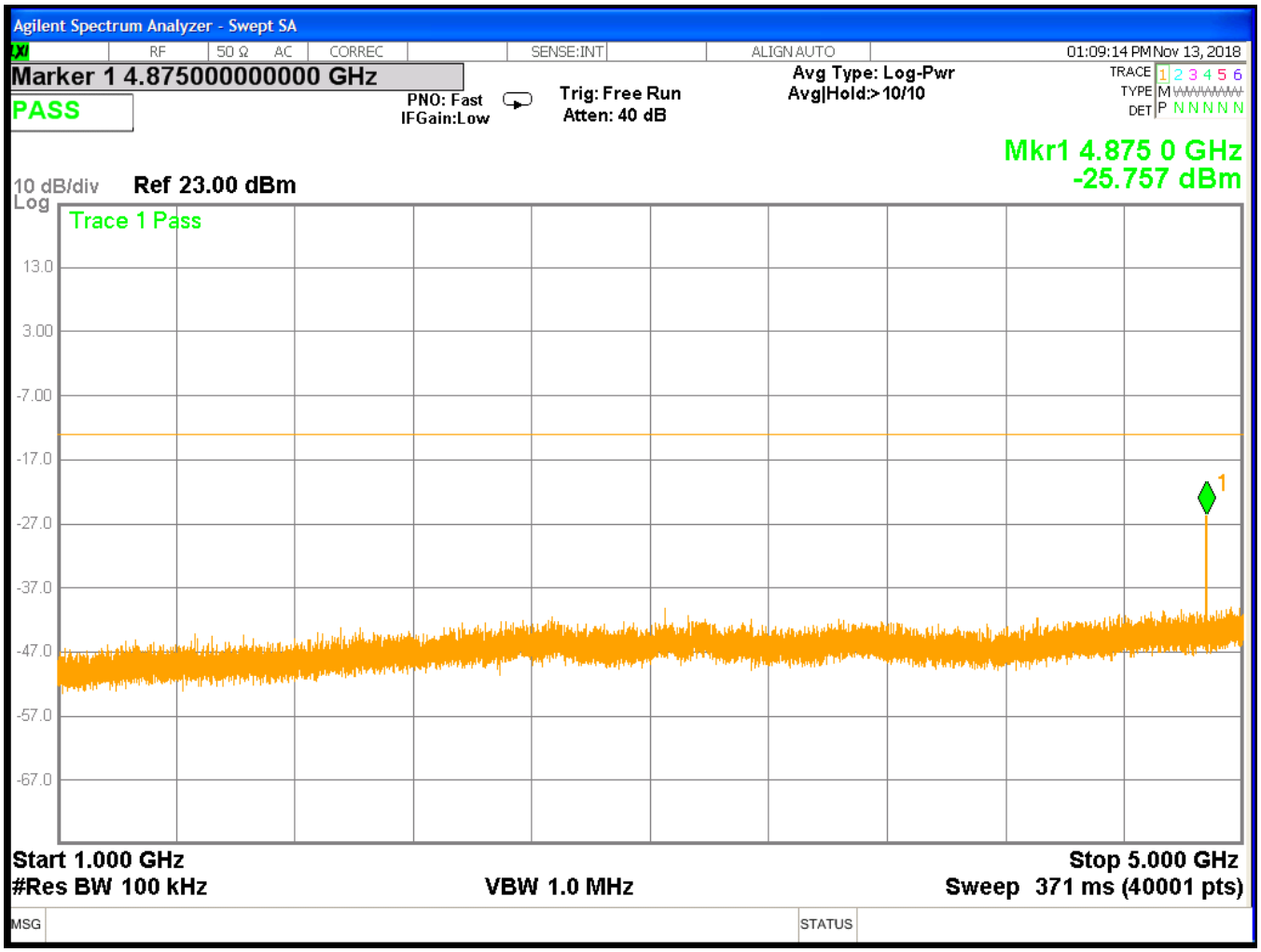

Figure 80: Conducted Spurious Emissions, Center Channel 1 – 5GHz

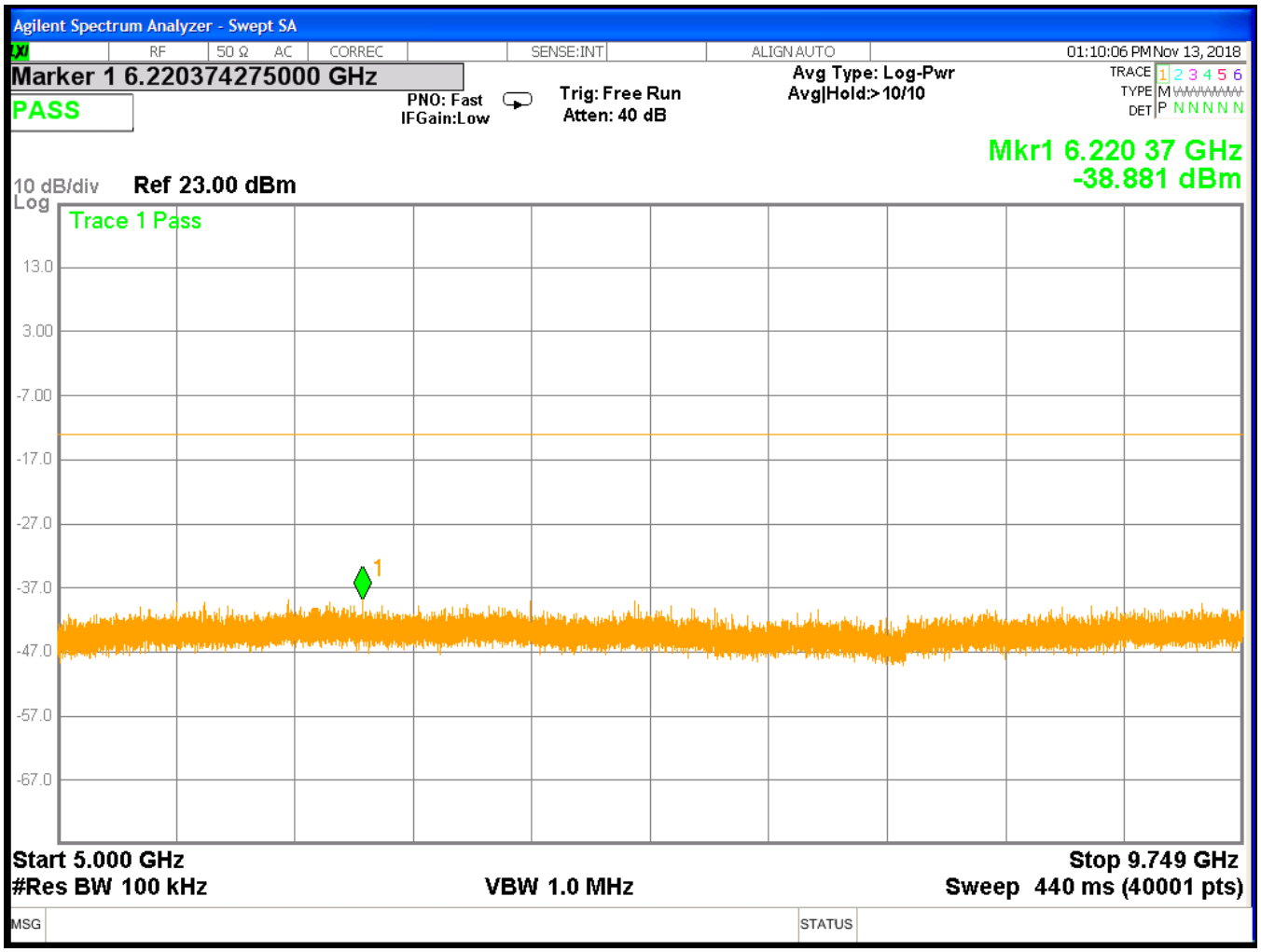

Figure 81: Conducted Spurious Emissions, Center Channel 5 – 9.749GHz

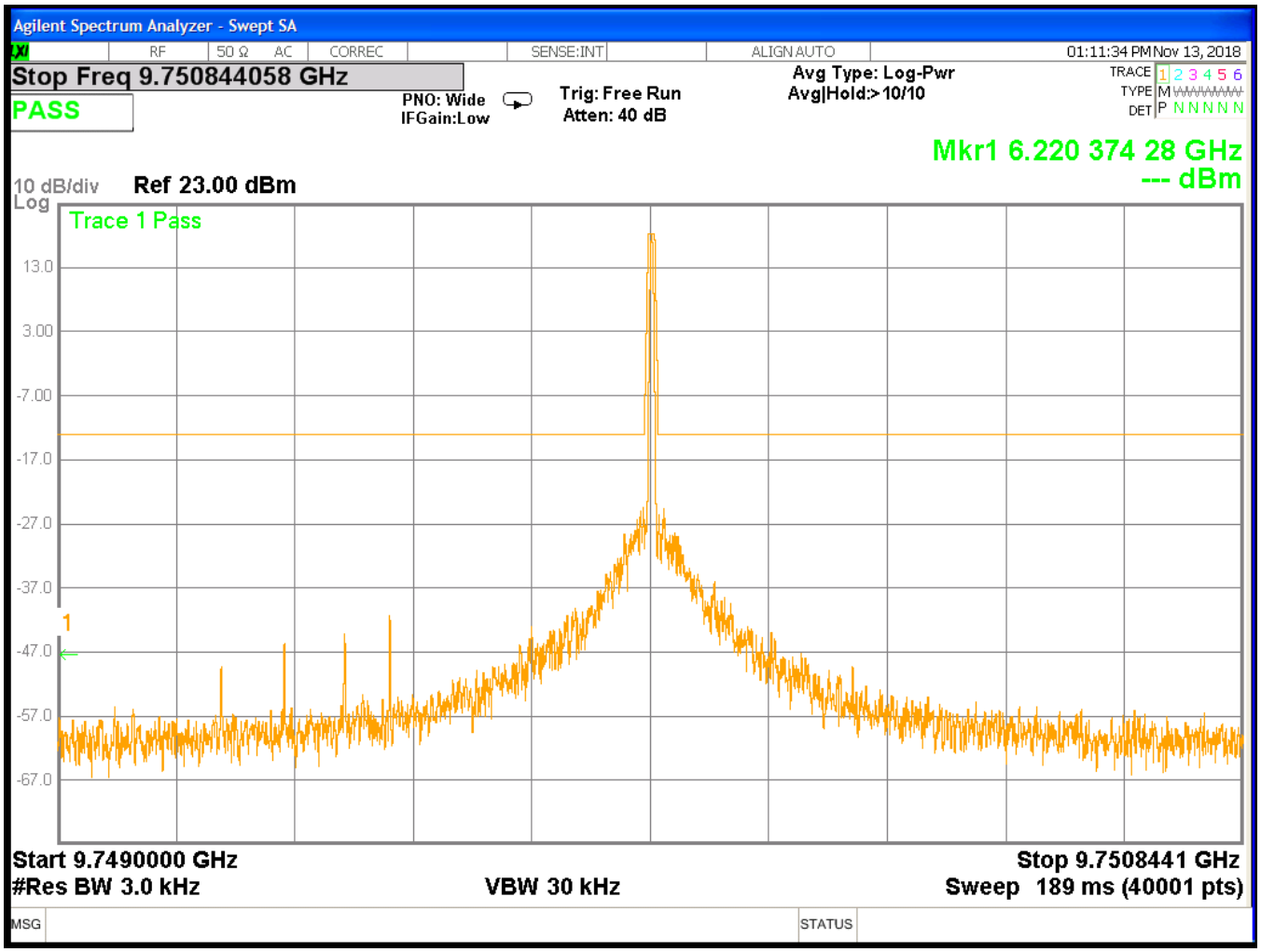

Figure 82: Conducted Spurious Emissions, Center Channel 9.749 – 9.750GHz

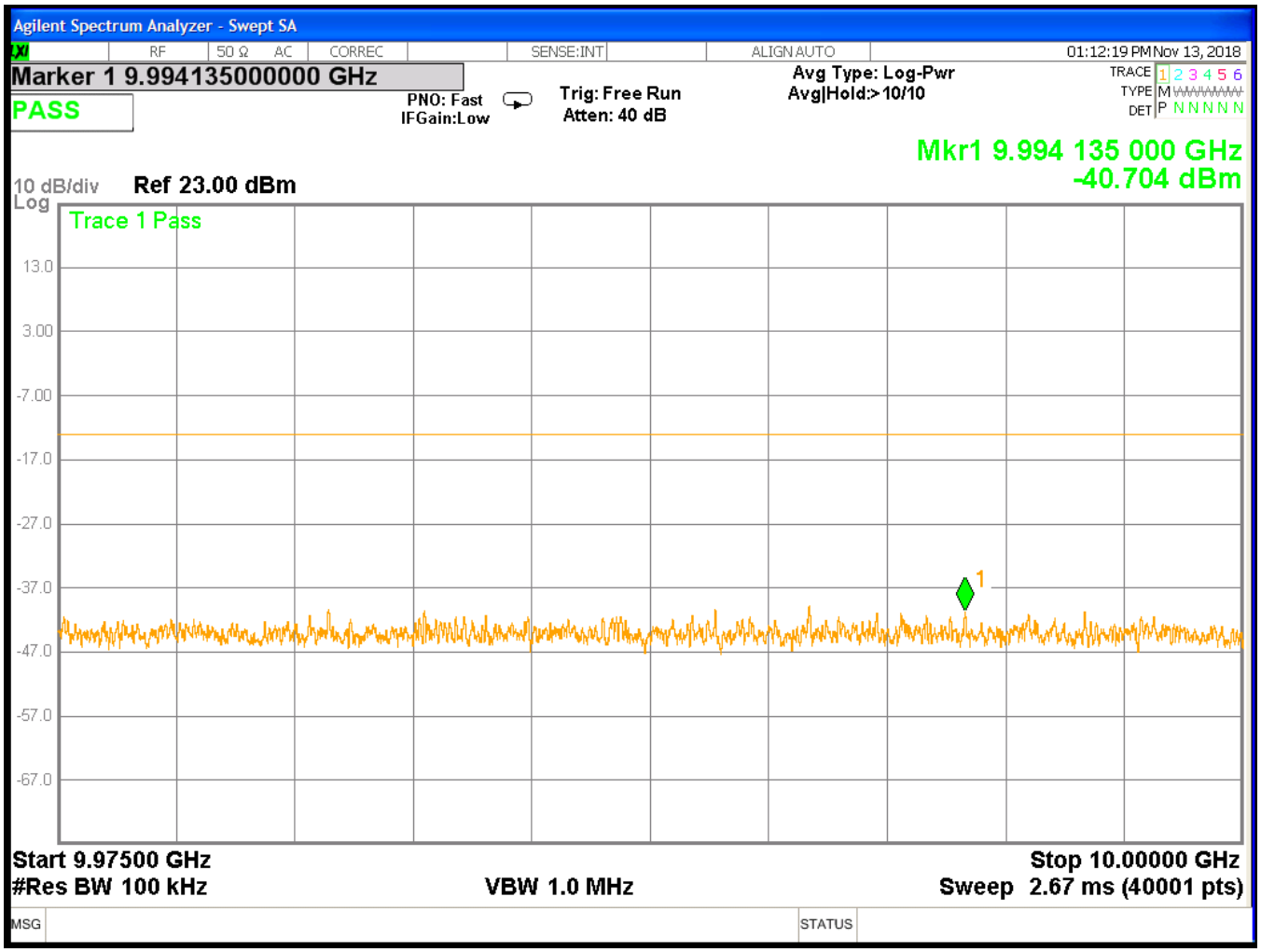

Figure 83: Conducted Spurious Emissions, Center Channel 9.75 - 10GHz

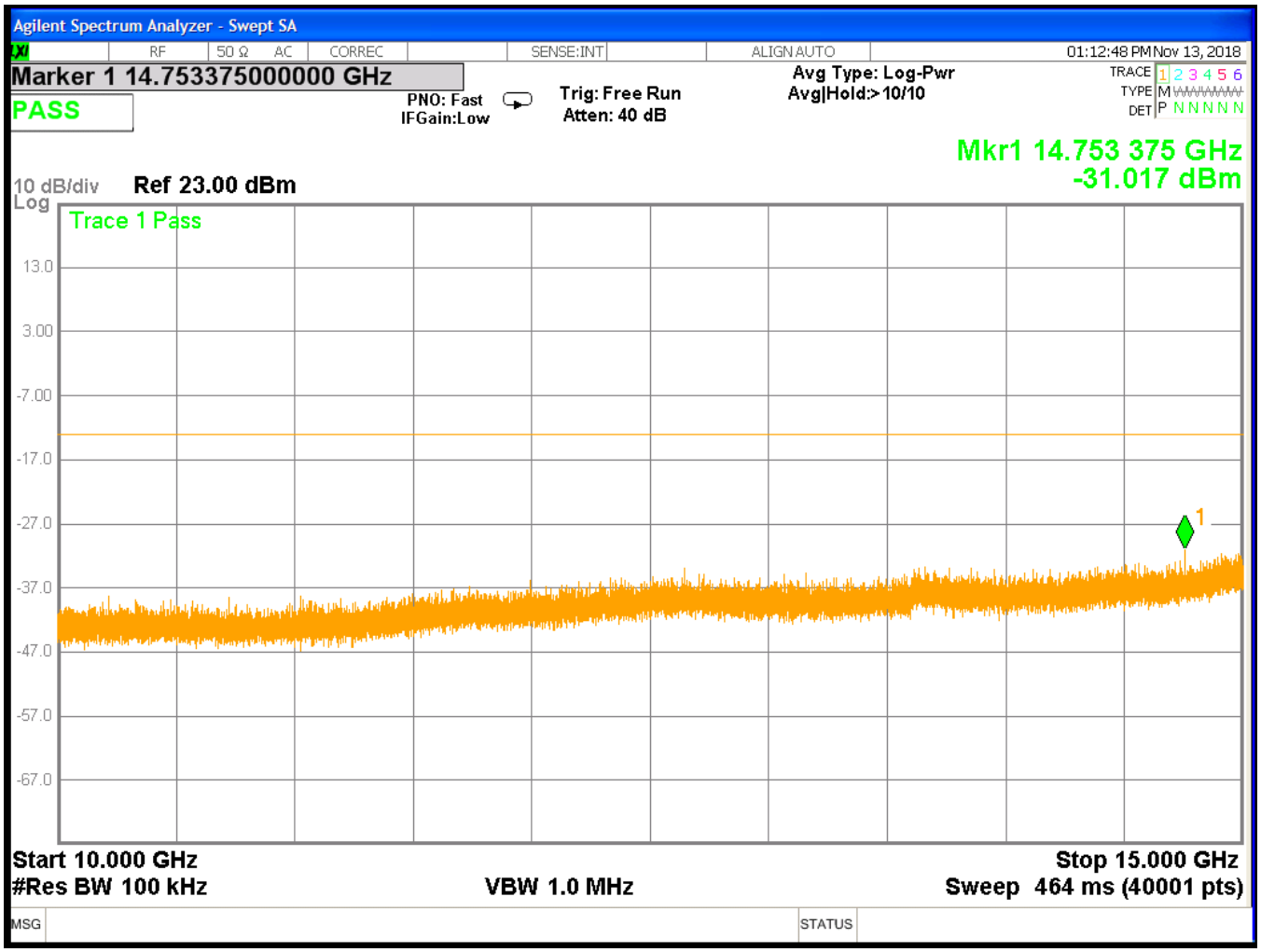

Figure 84: Conducted Spurious Emissions, Center Channel 10 - 15GHz

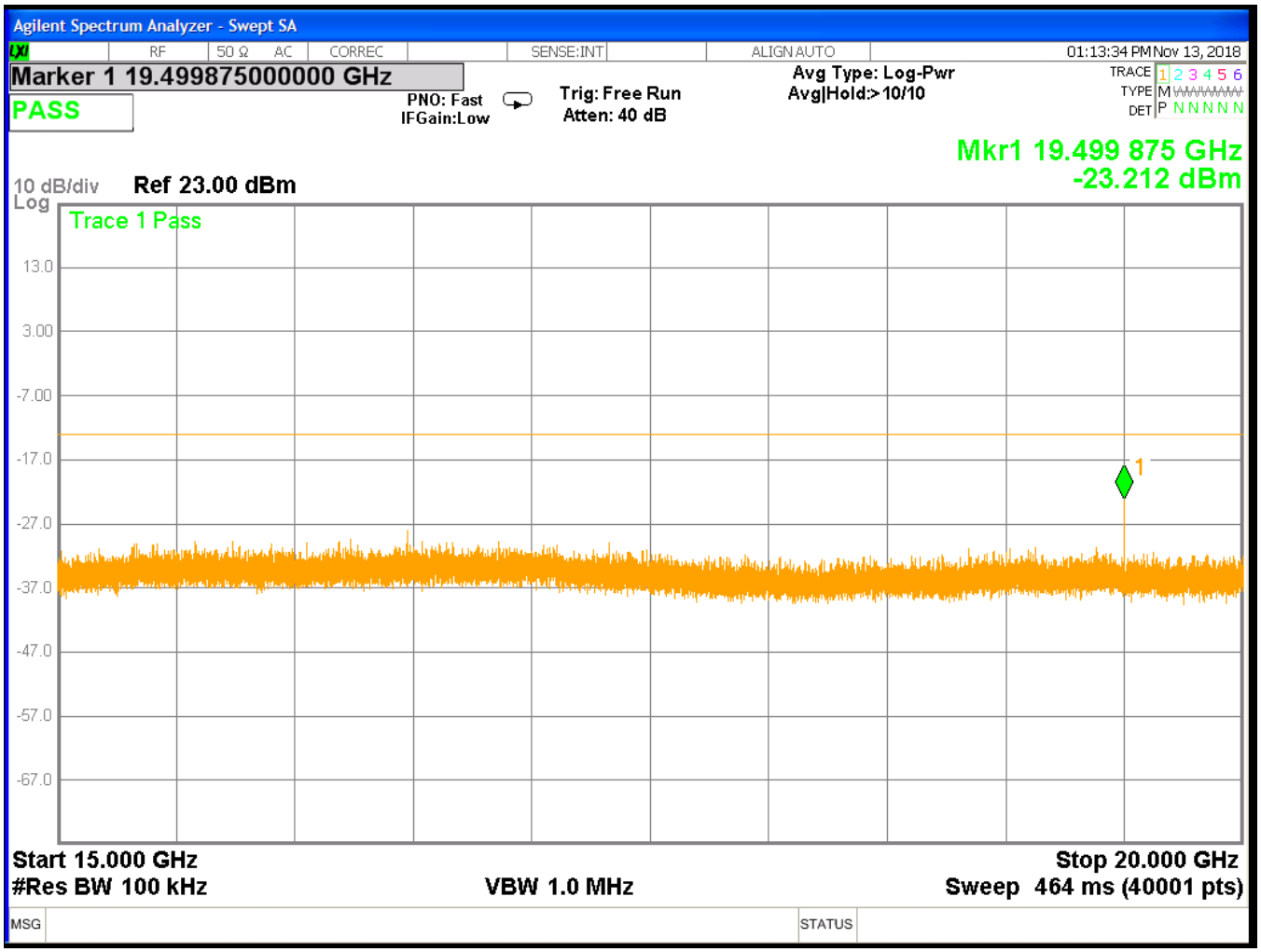

Figure 85: Conducted Spurious Emissions, Center Channel 15 – 20GHz

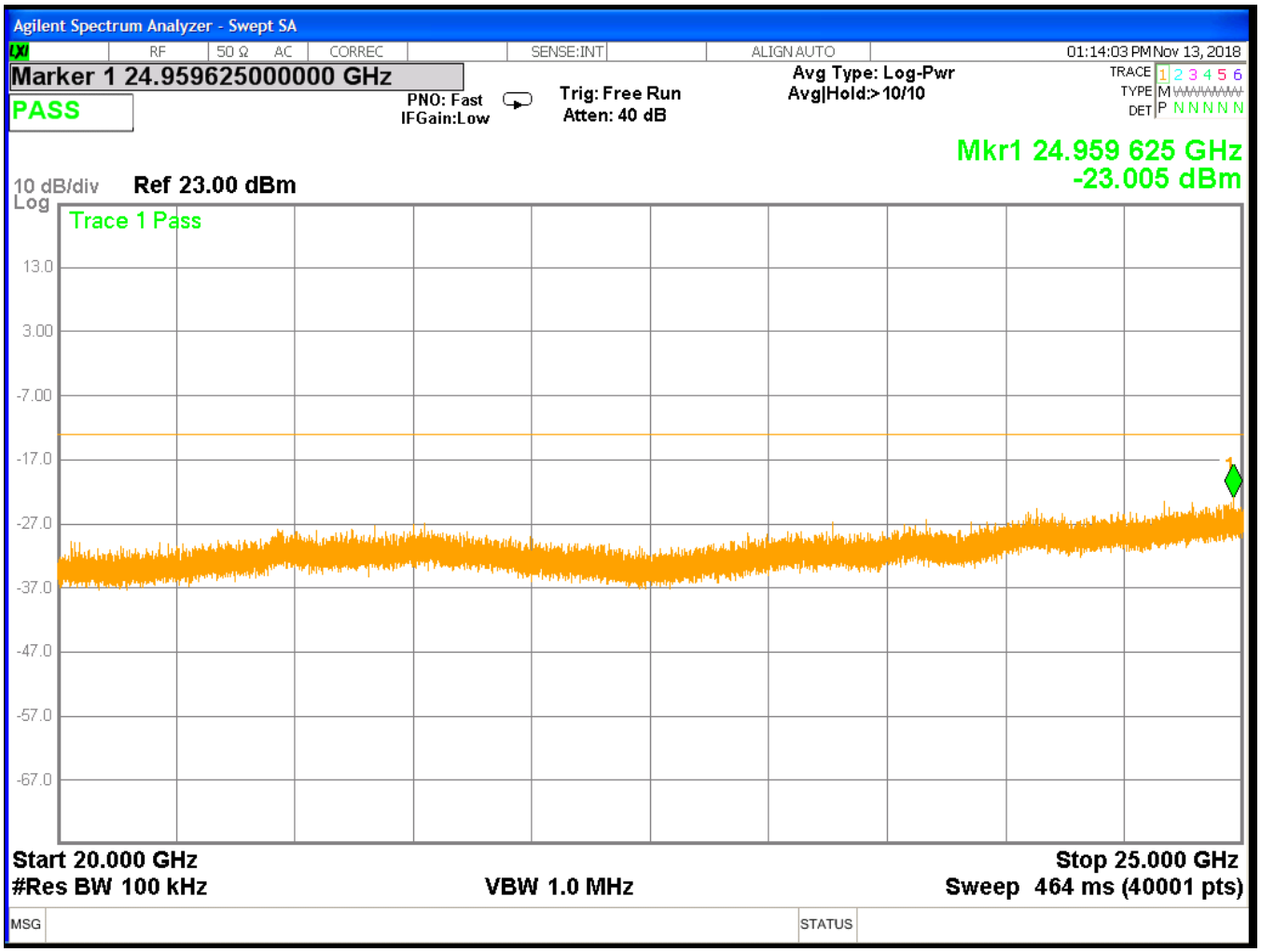

Figure 86: Conducted Spurious Emissions, Center Channel 20 – 25GHz

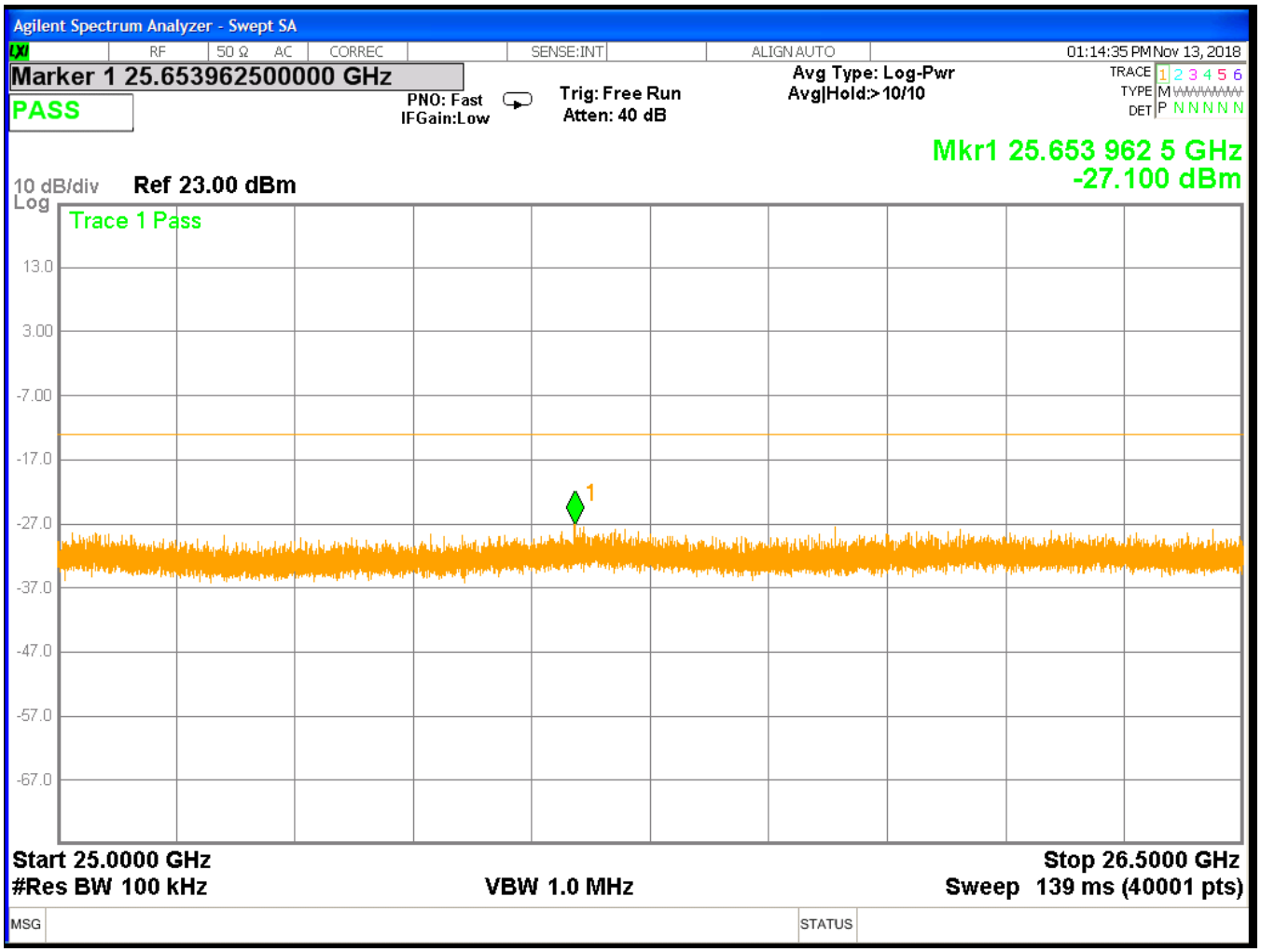

Figure 87: Conducted Spurious Emissions, Center Channel 25 – 26.5GHz

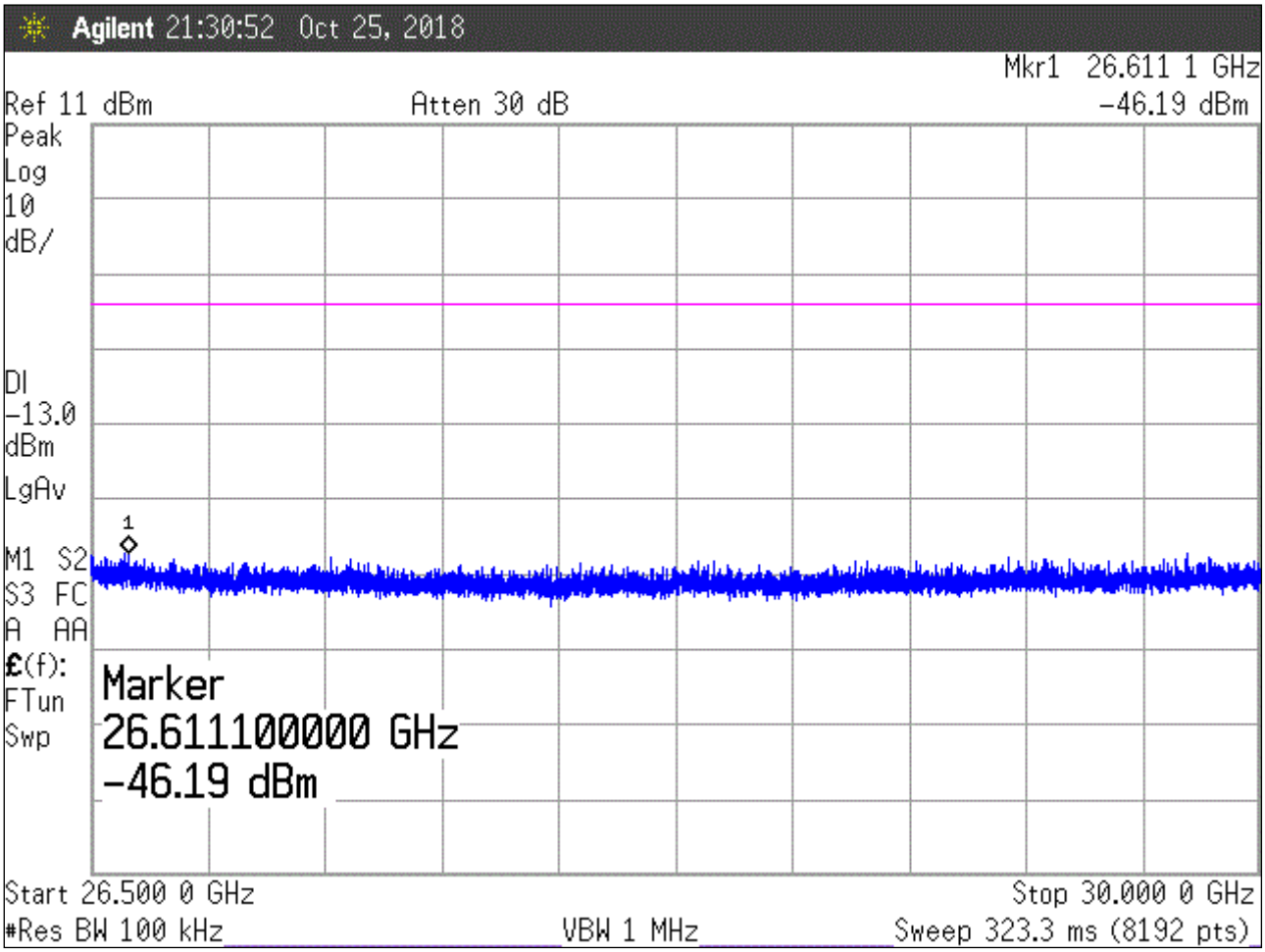

Figure 88: Conducted Spurious Emissions, Center Channel 26.5 – 30GHz

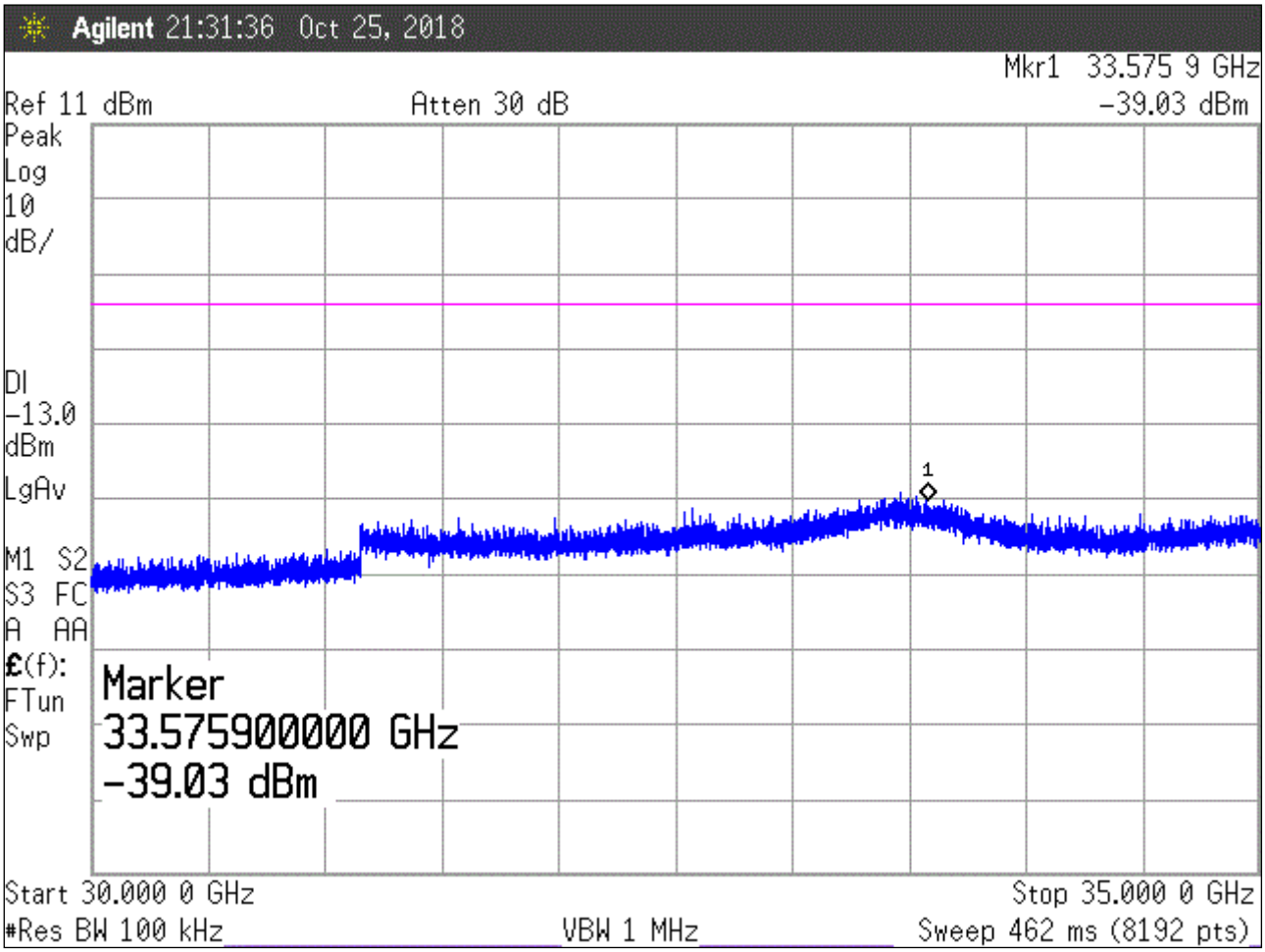

Figure 89: Conducted Spurious Emissions, Center Channel 30 – 35GHz

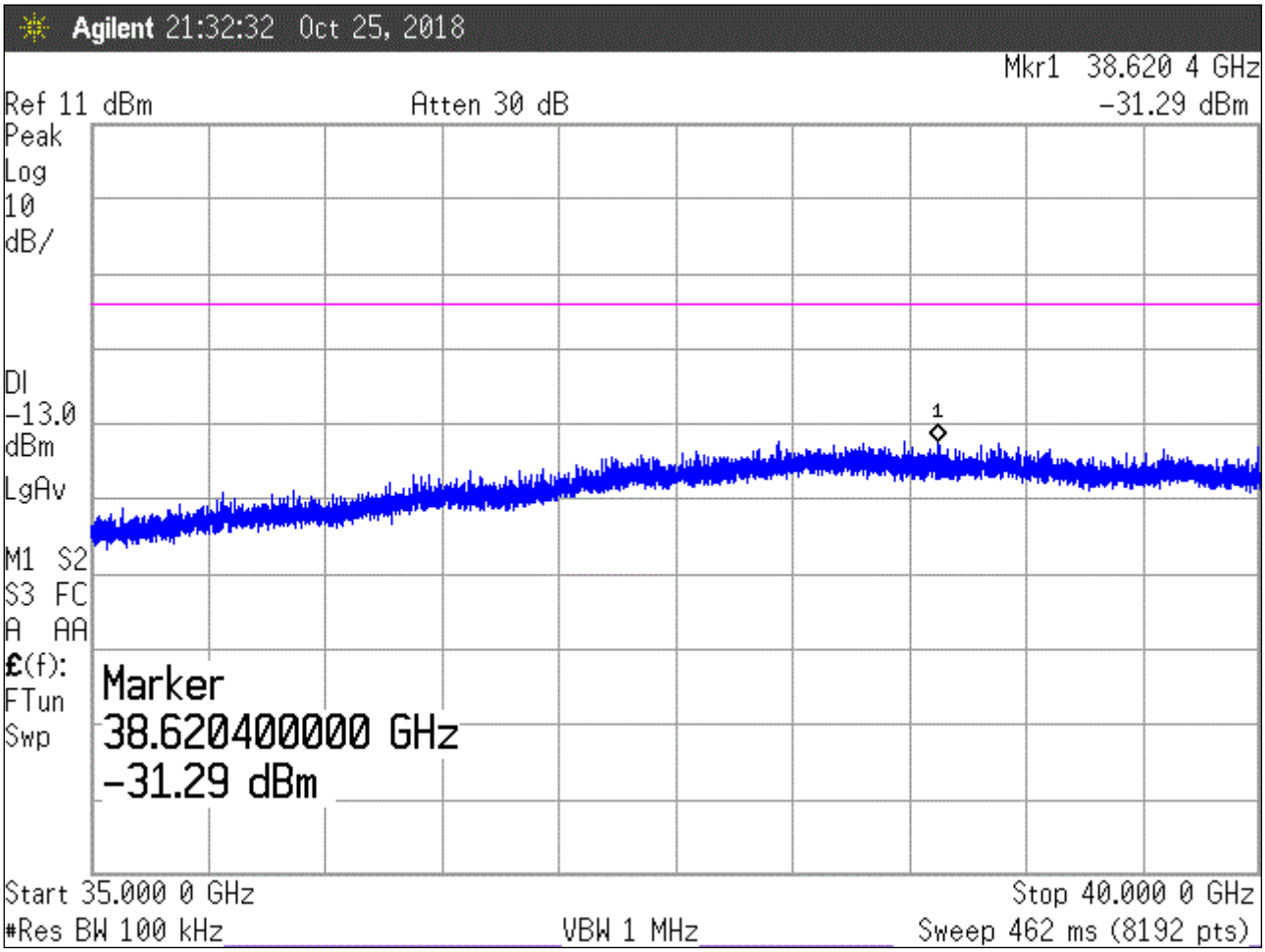

Figure 90: Conducted Spurious Emissions, Center Channel 35 – 40GHz

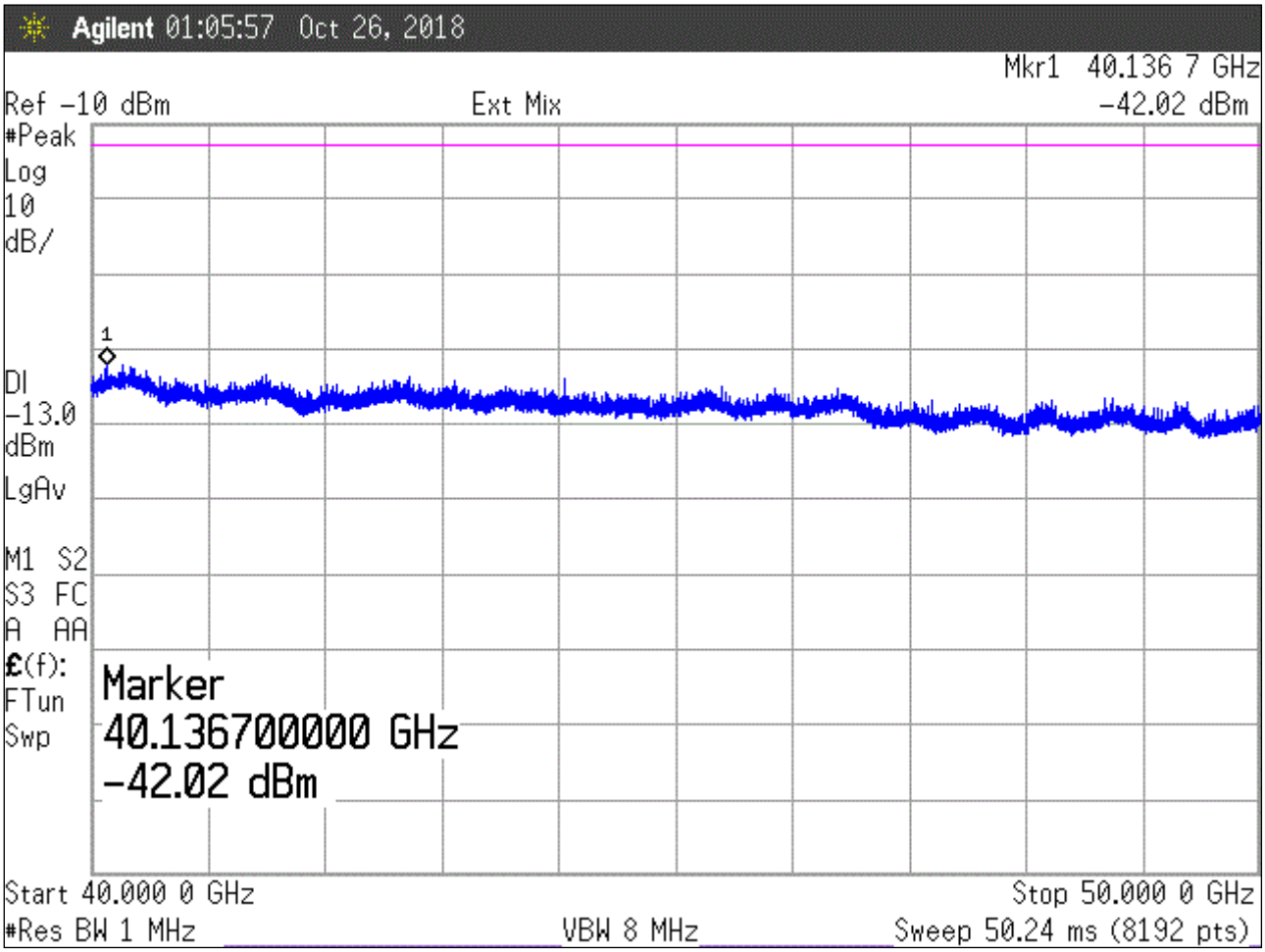

Figure 91: Conducted Spurious Emissions, Center Channel 40 – 50GHz

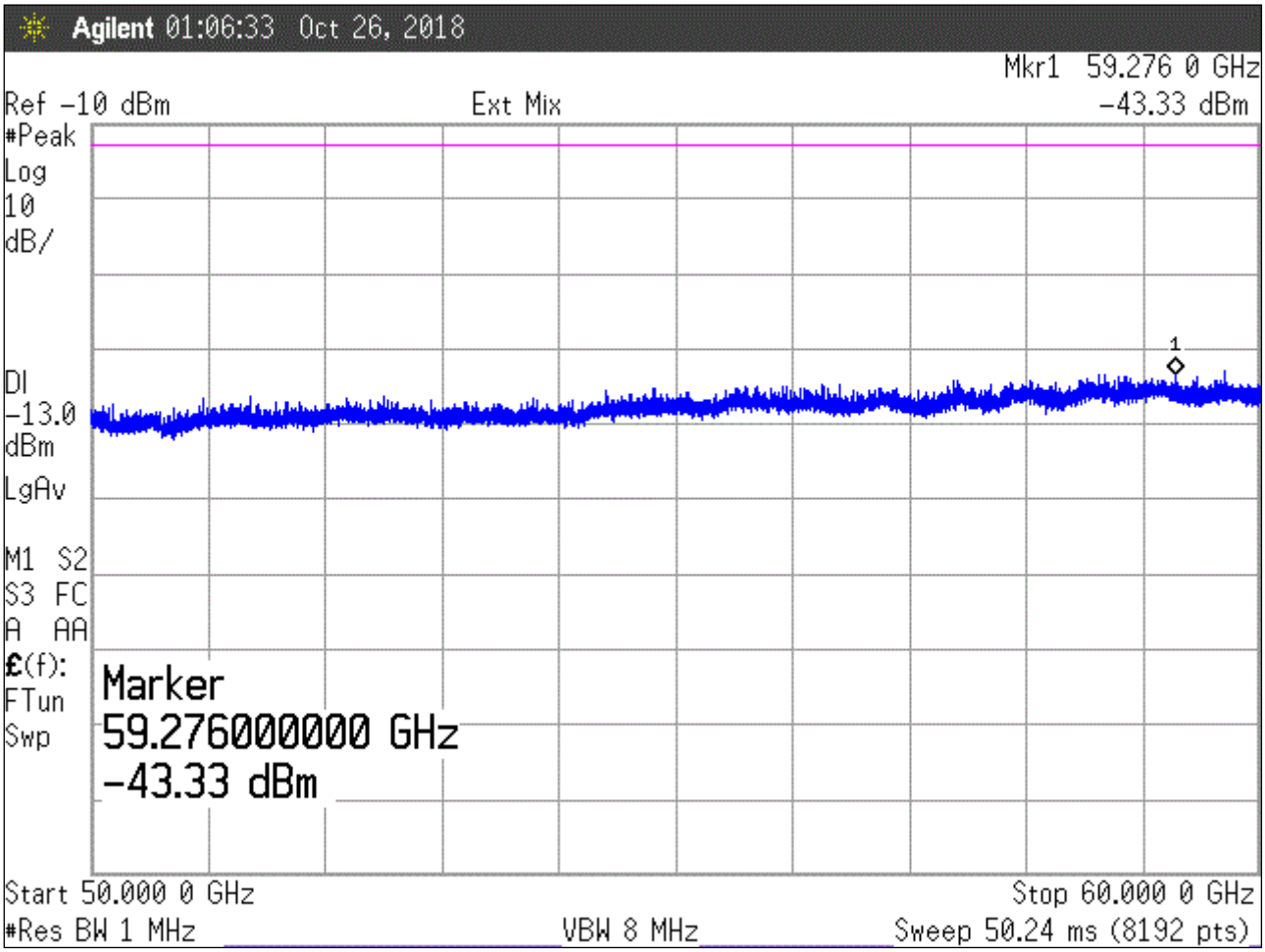

Figure 92: Conducted Spurious Emissions, Center Channel 50 – 60GHz

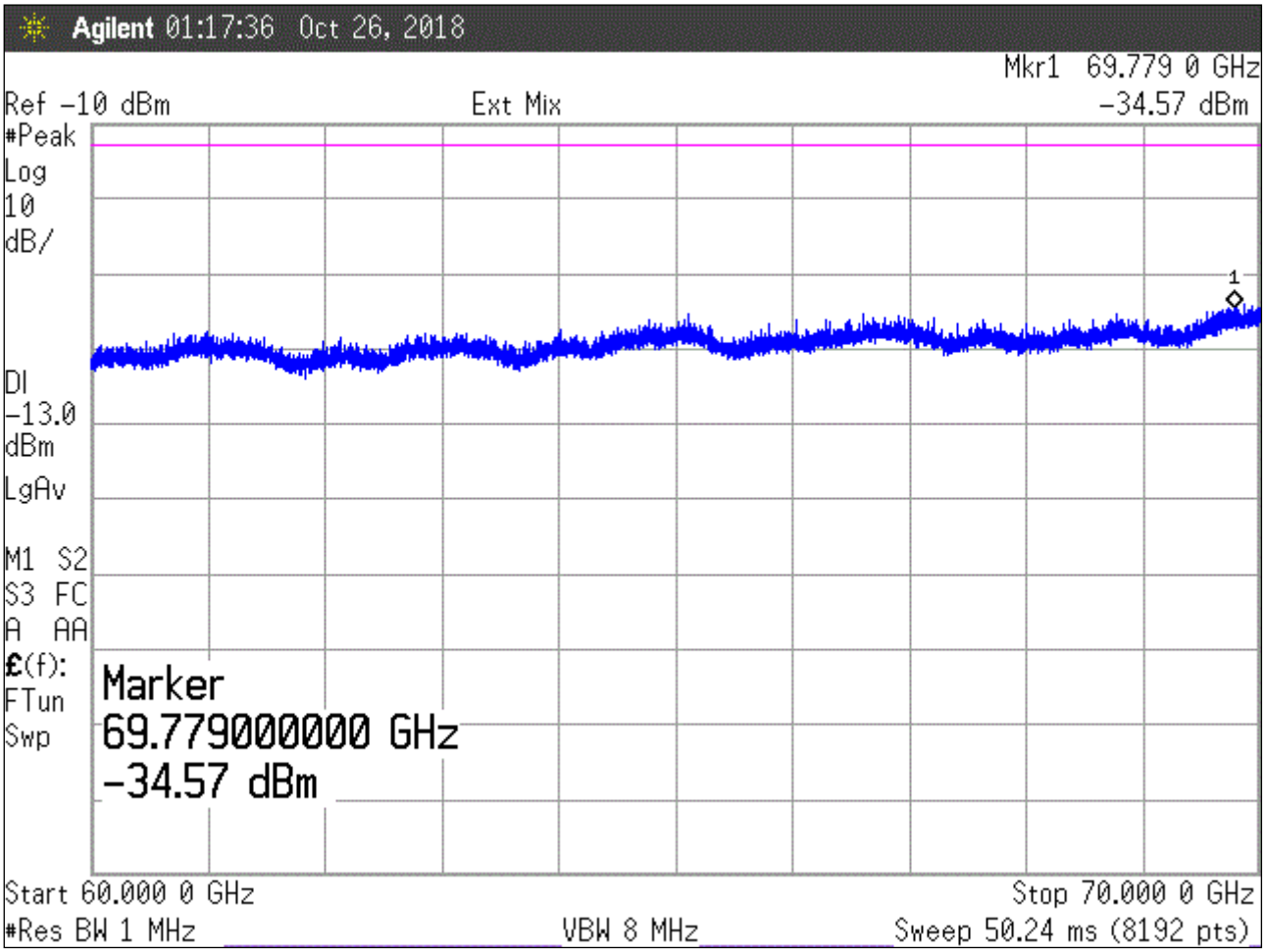

Figure 93: Conducted Spurious Emissions, Center Channel 60 – 70GHz

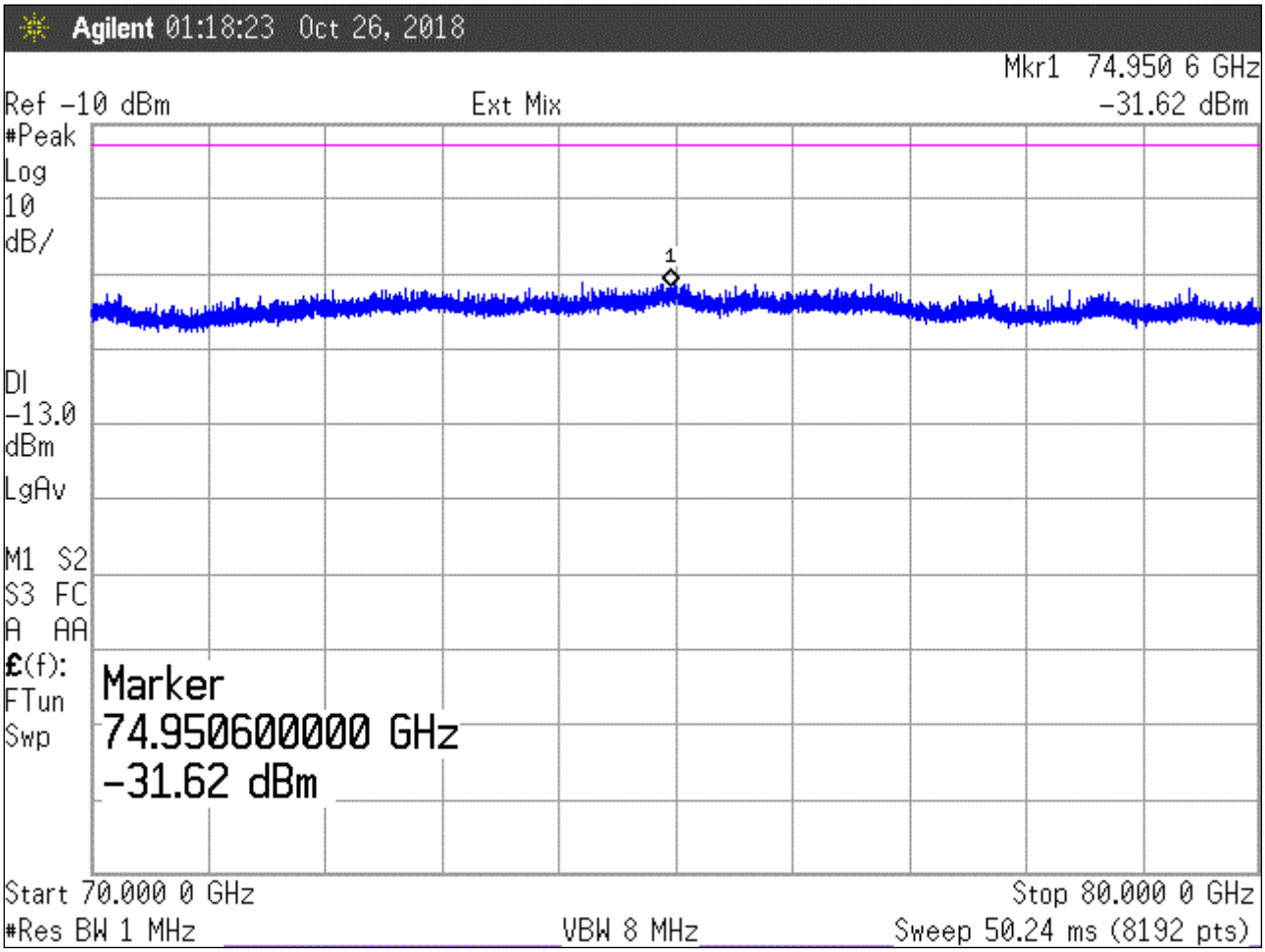

Figure 94: Conducted Spurious Emissions, Center Channel 70 – 80GHz

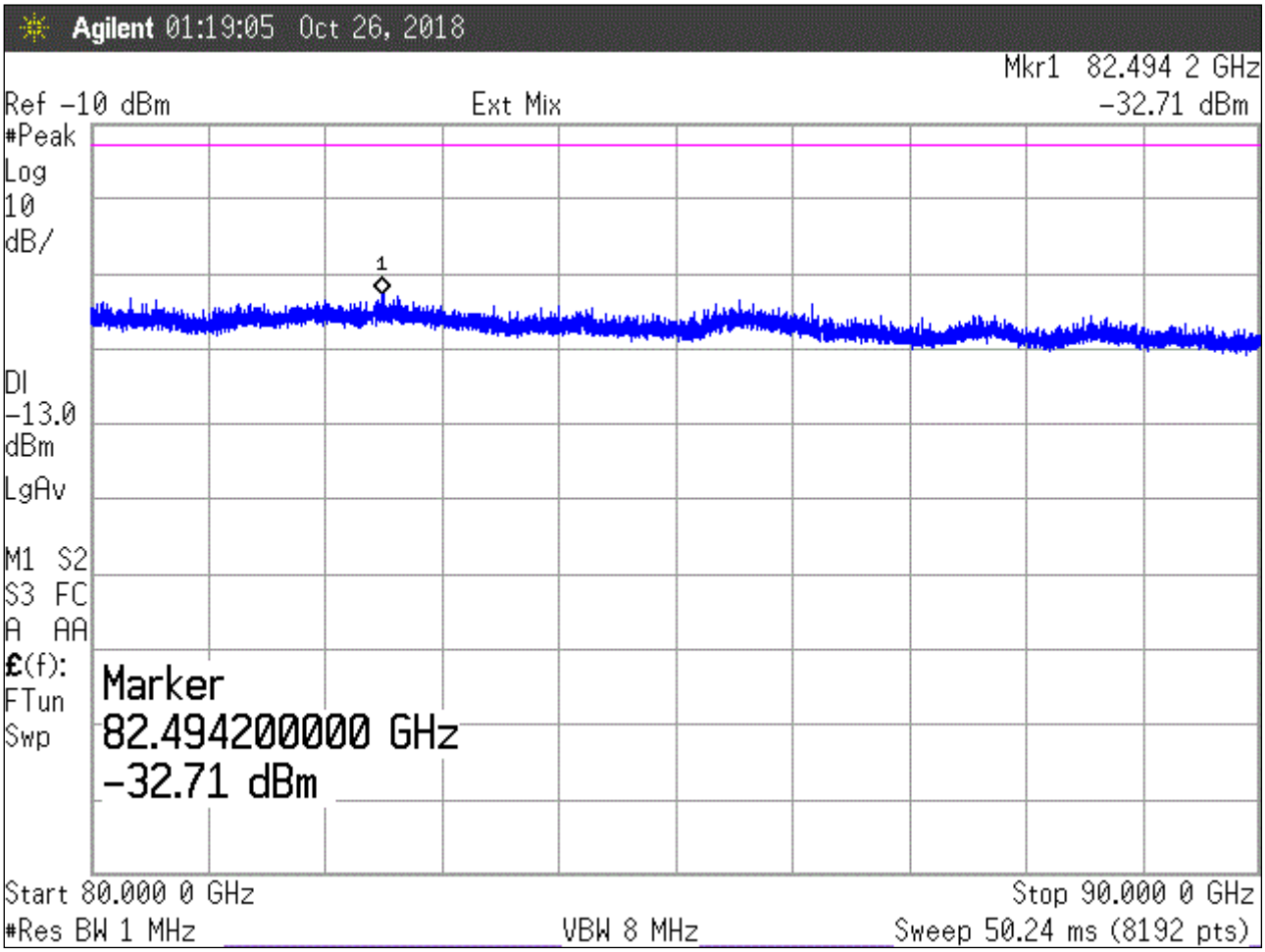

Figure 95: Conducted Spurious Emissions, Center Channel 80 – 90GHz

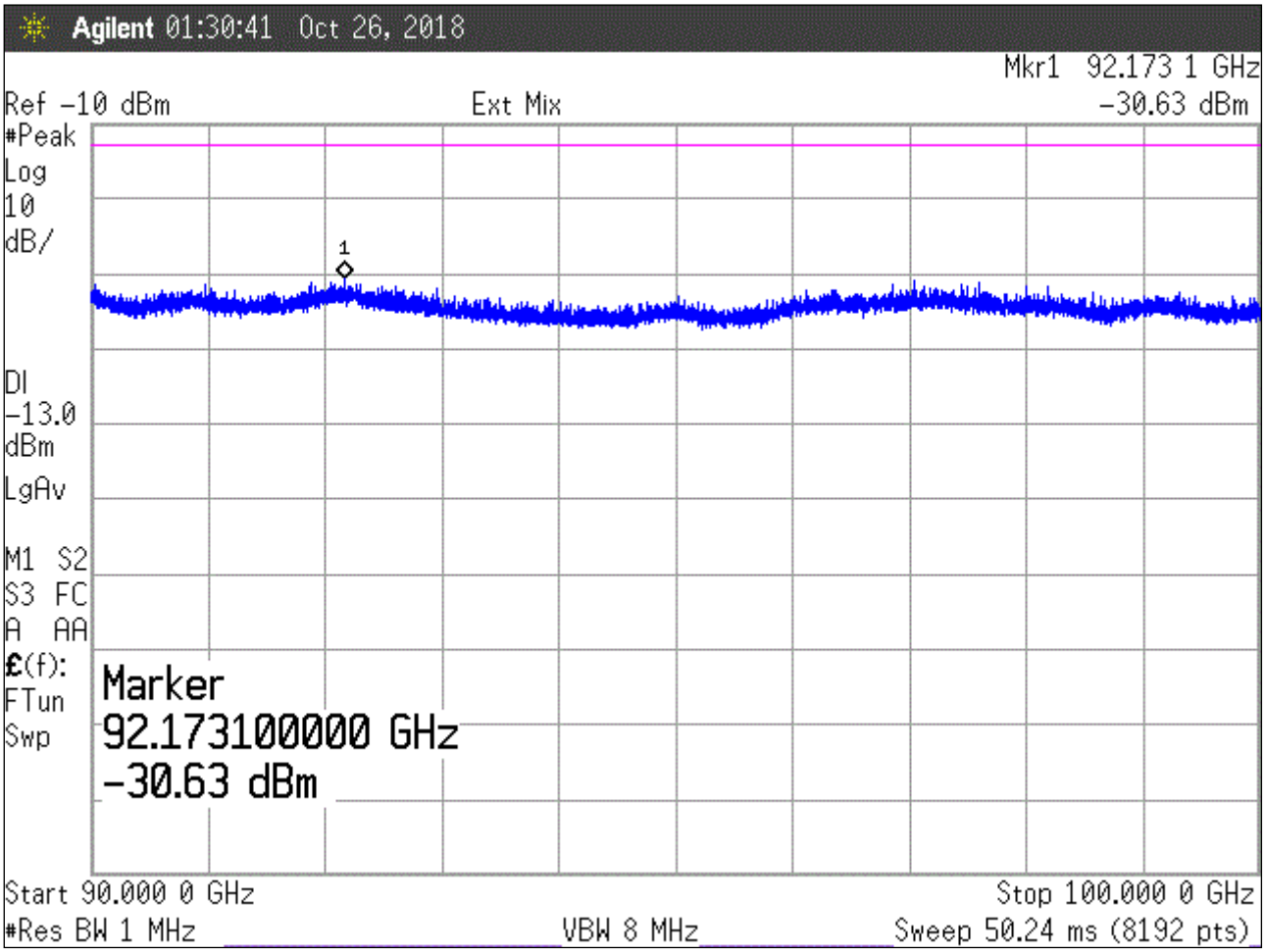

Figure 96: Conducted Spurious Emissions, Center Channel 90 – 100GHz

4.5 Radiated Spurious Emissions: (FCC Part §2.1053) (C63.26 Section 5.5.3)

The EUT must comply with the requirements for radiated spurious emissions. These emissions must meet the limits specified in §90.210 (c) for peak measurements.

Final testing was performed with the unit on a non-conducted 1.5 m high support.

4.5.1 Test Procedure

Radiated measurements using a standard OATS test arrangement. Direct field strength measurements of the maximum emission amplitude level (maximized as described previously), a signal generator and transmit antenna are substituted in place of the EUT. The output power of the signal generator is adjusted to replicate the maximized signal amplitude measured in the direct field strength measurement. The signal generator power setting is then used to determine the EIRP of the EUT spurious emission(s). The EIRP results were then compared to the limit of -13dBm. Test results are tabulated in Table 13 & Table 14.

Table 13: Radiated Emission Test Data < 1GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
50.00	V	180.0	1.0	52.0	-29.5	-30.5	8.0	-3.8	-34.4	-13	-21.4
62.02	V	180.0	1.0	45.9	-37.9	-39.1	7.8	-1.7	-40.8	-13	-27.8
109.39	V	90.0	1.0	39.0	-38.7	-40.3	13.0	-2.0	-42.4	-13	-29.4
110.11	V	180.0	1.0	39.1	-38.5	-40.1	13.1	-2.1	-42.2	-13	-29.2
124.99	V	180.0	1.0	35.7	-40.2	-41.9	14.1	-2.0	-43.9	-13	-30.9
249.98	V	180.0	1.5	35.4	-50.2	-52.4	11.4	6.8	-45.6	-13	-32.6
319.61	V	180.0	1.5	29.7	-52.6	-55.0	13.9	6.4	-48.6	-13	-35.6
326.64	V	180.0	1.5	27.7	-54.6	-57.0	14.0	6.5	-50.5	-13	-37.5
332.17	V	180.0	1.5	26.5	-55.9	-58.3	14.0	6.6	-51.7	-13	-38.7
343.24	V	180.0	1.5	27.9	-54.2	-56.6	14.1	6.8	-49.8	-13	-36.8
375.01	V	135.0	1.8	37.8	-54.2	-56.7	15.0	6.7	-50.0	-13	-37.0
39.42	H	180.0	4.0	45.7	-21.4	-22.3	14.5	-12.3	-34.6	-13	-21.6
50.00	H	180.0	4.0	39.9	-41.8	-42.8	8.0	-3.8	-46.7	-13	-33.7
62.02	H	180.0	4.0	41.4	-42.3	-43.5	7.8	-1.7	-45.2	-13	-32.2
70.22	H	180.0	4.0	46.0	-37.5	-38.8	8.3	-1.2	-40.0	-13	-27.0
109.70	H	135.0	4.0	39.6	-37.5	-39.1	13.1	-2.1	-41.2	-13	-28.2
110.58	H	180.0	4.0	44.4	-32.6	-34.2	13.2	-2.1	-36.3	-13	-23.3
124.99	H	180.0	4.0	43.3	-32.6	-34.3	14.1	-2.0	-36.3	-13	-23.3
249.98	H	180.0	3.0	41.8	-44.1	-46.3	11.4	6.8	-39.5	-13	-26.5
319.61	H	270.0	2.0	27.8	-54.4	-56.8	13.9	6.4	-50.4	-13	-37.4
326.64	H	270.0	2.0	26.1	-56.1	-58.5	14.0	6.5	-52.0	-13	-39.0
332.17	H	270.0	2.0	28.3	-53.9	-56.3	14.0	6.6	-49.7	-13	-36.7
343.28	H	135.0	2.0	28.8	-53.4	-55.8	14.1	6.8	-49.0	-13	-36.0
375.01	H	225.0	2.0	39.6	-41.4	-43.9	15.0	6.7	-37.2	-13	-24.2
400.00	H	90.0	2.0	39.7	-41.7	-44.2	15.0	7.3	-37.0	-13	-24.0

Table 14: Radiated Emissions Test Data > 1GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor(dB)	Sub. Ant. Gain(dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
1374.99	V	0.0	1.0	47.9	-57.8	-62.8	25.3	7.7	-55.2	-13	-42.2
1625.07	V	45.0	1.0	46.7	-59.4	-64.9	25.2	9.2	-55.7	-13	-42.7
1875.00	V	45.0	1.0	47.1	-56.7	-62.7	26.5	9.2	-53.5	-13	-40.5
2325.58	V	180.0	1.0	53.7	-47.1	-53.9	28.2	9.3	-44.5	-13	-31.5
1374.99	H	0.0	1.5	49.0	-56.6	-61.6	25.3	7.7	-54.0	-13	-41.0
1625.07	H	45.0	1.5	47.0	-59.1	-64.6	25.2	9.2	-55.4	-13	-42.4
1875.00	H	45.0	1.5	47.5	-56.3	-62.3	26.5	9.2	-53.1	-13	-40.1
2325.58	H	180.0	1.6	54.2	-46.6	-53.4	28.2	9.3	-44.0	-13	-31.0

Radiated spurious emissions were scanned to 40GHz.

4.6 Frequency Stability: (FCC Part §2.1055) (C63.26 Section 5.6)

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances.

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The radio circuitry has several supplies. 24VDC is supplied to the System Data Processor card, which provides the 1GHz clock to the Up Converter/Receiver module. The Up converter/Receiver is powered via 12VDC. To demonstrate the frequency stability of the system due to voltage variations, both power supplies were varied using an external adjustable power supply to 85% of the normal input voltage and 115% of the normal voltage. The frequency of the Center channel was measured and recorded at each voltage setting. Results are found in Table 16.

The frequency stability of the transmitter was examined for the temperature range of -30°C to +50°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the spectrum analyzer. The results are found in Table 15 & Table 16.

Table 15: Frequency Deviation as a Function of Temperature (2D_A J5)

Temperature (C)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)1	Pass/Fail
22(ambient)	9749.923356	0	-	**NA**
-30	9749.961122	37766	-	Pass
-20	9749.961899	38543	-	Pass
-10	9749.962544	39188	-	Pass
0	9749.964735	41379	-	Pass
10	9749.964855	41499	-	Pass
20	9749.923368	12	-	Pass
30	9749.908969	-14387	-	Pass
40	9749.902568	-20788	-	Pass
50	9749.877004	-46352	-	Pass

1 Per FCC 90.213(a) the required tolerance is determined during licensing.

Table 16: Frequency Deviation as a Function of Voltage (2D_A J5)

Voltage	Frequency (MHz)	Deviation (Hz)	Limit (+/Hz)	Pass/Fail
Nominal Voltage	9749.923356	0	None	**NA**
110% of Nominal Voltage (26.4Vdc)	9749.922899	-457	None	Pass
85% of Nominal Voltage (20.6Vdc)	9749.923555	199	None	Pass

Table 17: Frequency Deviation as a Function of Temperature (3D_A J4)

Temperature(C)	Frequency (MHz)	Deviation (Hz)	Limit	Pass/Fail
20(ambient)	9749.922896	0	None	**NA**
-30	9749.961441	38545	None	Pass
-20	9749.962566	39670	None	Pass
-10	9749.963251	40355	None	Pass
0	9749.964780	41884	None	Pass
10	9749.943987	21091	None	Pass
20	9749.922934	38	None	Pass
30	9749.911158	-11738	None	Pass
40	9749.899811	-23085	None	Pass
50	9749.875190	-47706	None	Pass

Table 18: Frequency Deviation as a Function of Voltage (3D_A J4)

Voltage	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
Nominal Voltage	9749.922896	0	974992	**NA**
110% of Nominal Voltage (26.4Vdc)	9749.923658	762	974992	Pass
85% of Nominal Voltage (20.4Vdc)	9749.922998	102	974992	Pass