Washington Laboratories, Ltd.

FCC PART 15.247 CERTIFICATION TEST REPORT

For the

GMIU

FCC ID: 2ACOA-GM1

REPORT# 15402-01 REV 1

Prepared for:

Zenner USA

15280 Addison Road - Suite 340

Addison, TX 75001

Prepared By:

Washington Laboratories, Ltd.

7560 Lindbergh Drive

Gaithersburg, Maryland 20879

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DECEMBER 21, 2017
WLL REPORT# 15402-01 Rev 1

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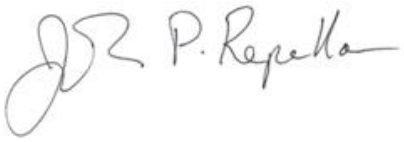

John P. Repella
Manager, EMC & Wireless Services

Reviewed by:

Michael F. Violette, P.E.
CEO

ABSTRACT

This report has been prepared on behalf of Zenner USA to support the attached Application for Equipment Authorization. The test report and application are submitted for a Frequency Hopping Spread Spectrum (FHSS) Transmitter under Part 15.247 of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy. This Certification Test Report documents the test configuration and test results for the Zenner USA GMIU.

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. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

The Zenner USA GMIU complies with the limits for a Frequency Hopping Spread Spectrum (FHSS) Transmitter device under FCC Part 15.247 and Innovation, Science and Economic Development Canada (ISED) RSS-247.

Revision History	Description of Change	Date
Rev 0	Initial Release	December 21, 2017
Rev 1	Test report updated to address reviewers comments	February 07, 2018

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1 INTRODUCTION

1.1 COMPLIANCE STATEMENT

The Zenner USA GMIU complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247.

1.2 TEST SCOPE

Tests for radiated and conducted (at antenna terminals) emissions were performed. All measurements were performed in accordance with the appropriate sections of C63.10:2013 "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices" dealing with Frequency Hopping devices. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 CONTRACT INFORMATION

Customer:	Zenner Performance Meters, Inc. d.b.a. Zenner USA
Address	15280 Addison Road - Suite 340
	Addison, TX 75001
Purchase Order Number:	ZENN15402-1 PO#: 0023509
Quotation Number:	70476

1.4 TEST DATES

Testing was performed on the following date(s): 12/04/2017-12/08/2017 & 2/5/2018

1.5 TEST AND SUPPORT PERSONNEL

Washington Laboratories, LTD	John P. Repella
Customer Representative	Kenneth Derry P.E.

1.6 ABBREVIATIONS

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	Amperes
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	Centi**m**eter
CW	Continuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	Electro**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

Table 1: Device Summary

Item	Self-contained radio transceiver
Manufacturer:	Zenner USA
FCC ID:	2ACOA-GM1
ISED ID:	Not Applicable
Model:	GMIU 208-2017-007
Serial Number of Unit Tested	Not-Available
FCC Rule Parts:	§15.247
Innovation, Science and Economic Development Canada:	Not Applicable
Frequency Range:	902-928NHz
Maximum Output Power:	489.8mW (26.9dBm)
Modulation:	FSK (40/80kHz)
Occupied Bandwidth:	138.8kHz(Mesh Mode), 358.8kHz(Drive-by Mode)
Emissions Designator:	139KF1D, 359KF1D
Keying:	Automatic
Type of Information:	Data
Number of Channels:	50
Power Output Level	Fixed
Antenna Connector	None (Onboard Trace)
Antenna Type	Printed Circuit (PCB Embedded F-Type)
Interface Cables:	None
Maximum Data Rate	Mesh Mode 19.2 kbps, Drive-by Mode 50kbps
Power Source & Voltage:	Dual Parallel Lithium Thionyl Chloride Batteries 3.6Vdc

The Zenner USA Stealth Reader Gas Meter Interface Unit (GMIU) is a battery operated gas meter reading device. It is designed to read residential gas utility meters and report data wirelessly. It is part of the STEALTH(R) wireless network, operating in the unlicensed 902 MHz to 928 MHz ISM band and utilizing frequency hopping spread spectrum (FHSS). There are 2 modes of radio operation, Mesh mode and Drive-by mode. The GMIU is an end-point in the system.

2.2 TEST CONFIGURATION

The GMIU operates on 50 channels separated by 500 kHz spacing. The first channel transmits at 902.5MHz and the last channel transmits at 927MHz. The GMIU was set on a test bench and connected via appropriate cabling and attenuation to a spectrum analyzer for the antenna port conducted measurements. For the radiated emissions testing, the GMIU was setup on a qualified OATS.

2.3 TESTING ALGORITHM

The GMIU was connected to a laptop pc via a Sparkfun adapter and USB serial connector.

HyperTerminal, terminal emulation software was used to send text-based commands via the Serial port connection. Various commands were used to set the power, mode/modulation, and channel. The EUT was programmed for FHSS operation via ?? Worst cast 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 ISED 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 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 2014) 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

ANSI C63.10 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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

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

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 2 below.

Table 2: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Radiated Emissions	FCC Part 15	±4.55 dB

Parameter	Uncertainty	Actual (+/-)
Radio Frequency	±1 x 10^{-7}	8.64E-08
RF Power conducted (up to 160 W)	±0.75 dB	0.3dB
Conducted RF Power variations using a test fixture	±0.75 dB	0.3dB
Radiated RF power	±6 dB	N/A
Average sensitivity (radiated)	±3 dB	N/A

2.7 TEST EQUIPMENT

Table 3 lists the test equipment used for measurements along with the calibration information.

Table 3: Test Equipment List

Test Name:	Bench Conducted &Radiated Emissions	Test Date:	12/6/2017 & 2/5/2018
Asset #	Manufacturer/Model	Description	Cal. Due
823	AGILENT/9010A	3Hz–26.5GHz SPECTRUM ANALYZER	12/21/2017
276	ELECTRO-METRICS/BPA-1000	RF PRE-AMPLIFIER	01/18/2018
627	AGILENT/8449B	AMPLIFIER 1-26GHz	12/07/2017
280	ITC/21C-3A1	WAVEGUIDE 3.45-11.0GHz	CNR
742	PENN ENGINEERING/WR284	2.2-4.15GHz BANDPASS FILTER	CNR
382	SUNOL SCIENCES CORPORATION/JB1	ANTENNA BICONLOG	04/30/2018
610	WLL/RG-223	BNC COAXIAL CABLE(1.0m)	01/23/2018
425	ARA/DRG-118/A	ANTENNA DRG 1-18GHz	04/30/2018
281	ITC/21A-3A1	WAVEGUIDE 4.51-10.0GHz	CNR
605	AGILENT/N1911A	P-SERIES POWER METER	04/29/2019

3 TEST RESULTS

The Table below shows the results of testing for compliance with a Frequency Hopping Spread Spectrum device in accordance with FCC Part 15.247 10/2014. Full test results are shown in subsequent sub-sections.

Table 4: Test Summary Table

Frequency Hopping Spread Spectrum - TX Test Summary			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (a)(1)	RSS-247 [5.1a]	20dB Bandwidth	Pass
15.247 (b)	RSS-247 [5.4(a/b/c)]	Transmit Output Power	Pass
15.247 (a)(1)	RSS-247 [5.1b]	Channel Separation	Pass
15.247 (a)(1)	RSS-247 [5.4(c/d/e)]	Number of Channels	Pass
15.247 (a)(1)	RSS-247 [5.1(c/d/e)]	Time of Occupancy	Pass
15.247 (d)	RSS-247 [5.5]	Occupied BW / Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-Gen [8.9/8.10]	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen [8.8]	AC Conducted Emissions	N/A
Frequency Hopping Spread Spectrum - RX/Digital Test Summary			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.207	RSS-Gen	AC Conducted Emissions	N/A
15.209	RSS-Gen	General Field Strength Limits	Pass

3.1 TIME OF OCCUPANCY

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

20 x LOG (dwell time/100 ms)

The following figures show the plots of the dwell time for the transmitter. Based on this plot, the dwell time per hop is 176.5ms for 'Mesh Mode' and 40.26ms for 'Drive-by mode'. FCC part 15.247 also requires that for hopping signals with an occupied bandwidth of greater than 250kHz the total transmit dwell time must be no more than 0.4 seconds per 10 seconds . For signals less than 250 kHz the limit is 0.4 seconds per 20 seconds. The 'Mesh mode bandwidth is less than 250 kHz and the 'Drive-by' mode bandwidth than 250 kHz both modes were tested and complied to their respective requirements.

Applicable to the Drive-By Mode

The transmitter shall have a time of occupancy for systems having a 20dB bandwidth greater than 250 kHz of no more than 0.4seconds in any 10 second period.
These tests were conducted with the RF output connected through appropriate attenuators to the input of a spectrum analyzer set to zero span mode. The unit was set to hopping mode with the spectrum analyzer set to 902.75MHz. The results are shown in the plots below. In this mode the unit only transmits once every 20s.

Applicable to the Mesh Mode

The transmitter shall have a time of occupancy for systems having a 20dB bandwidth less than 250 kHz of no more than 0.4seconds in any 20 second period.
These tests were conducted with the RF output connected through appropriate attenuators to the input of a spectrum analyzer set to zero span mode. The unit was set to hopping mode with the spectrum analyzer set to 902.75MHz. The results are shown in the plots below.

Table 5: Duty Cycle/Time of Occupancy Results

Test	Result	Limit	Pass/Fail
Dwell time per Hop (Mesh Mode)	176.5ms	NA	NA
Dwell time per 100ms (Mesh Mode)	N/A	NA	NA
Time of Occupancy (Mesh Mode)	0.353s/20 sec	0.4s/20 sec	Pass
Dwell time per Hop (Drive-by Mode)	40.26ms	NA	NA
Dwell time per 100ms (Drive-by Mode)	40.26ms	NA	NA
Time of Occupancy (Drive-by Mode)	0.0403ms/10 sec	0.4s/10 sec	Pass

Figure 1: Duty Cycle Plot (Mesh Mode)

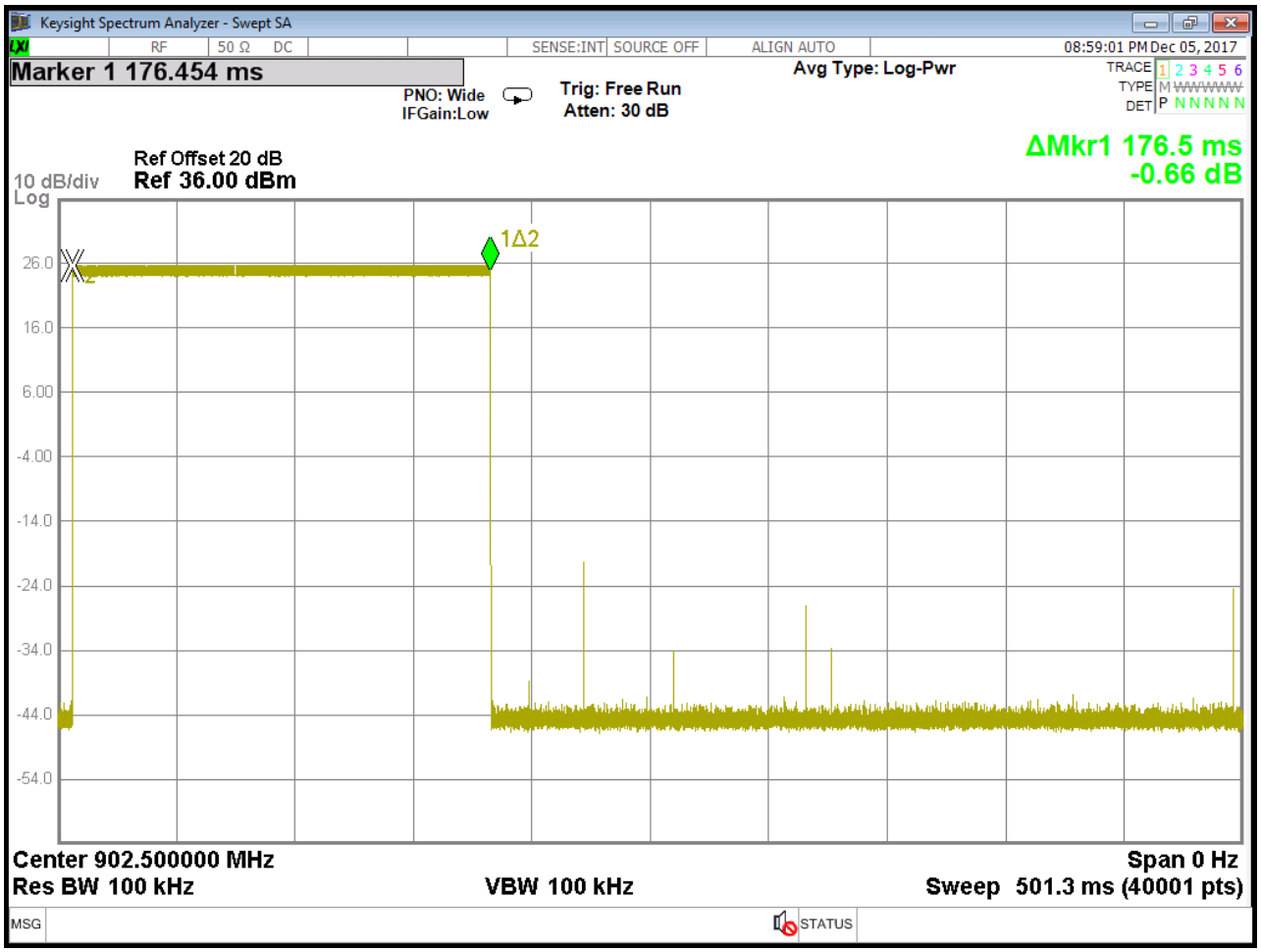


Figure 2: Occupancy per 20s

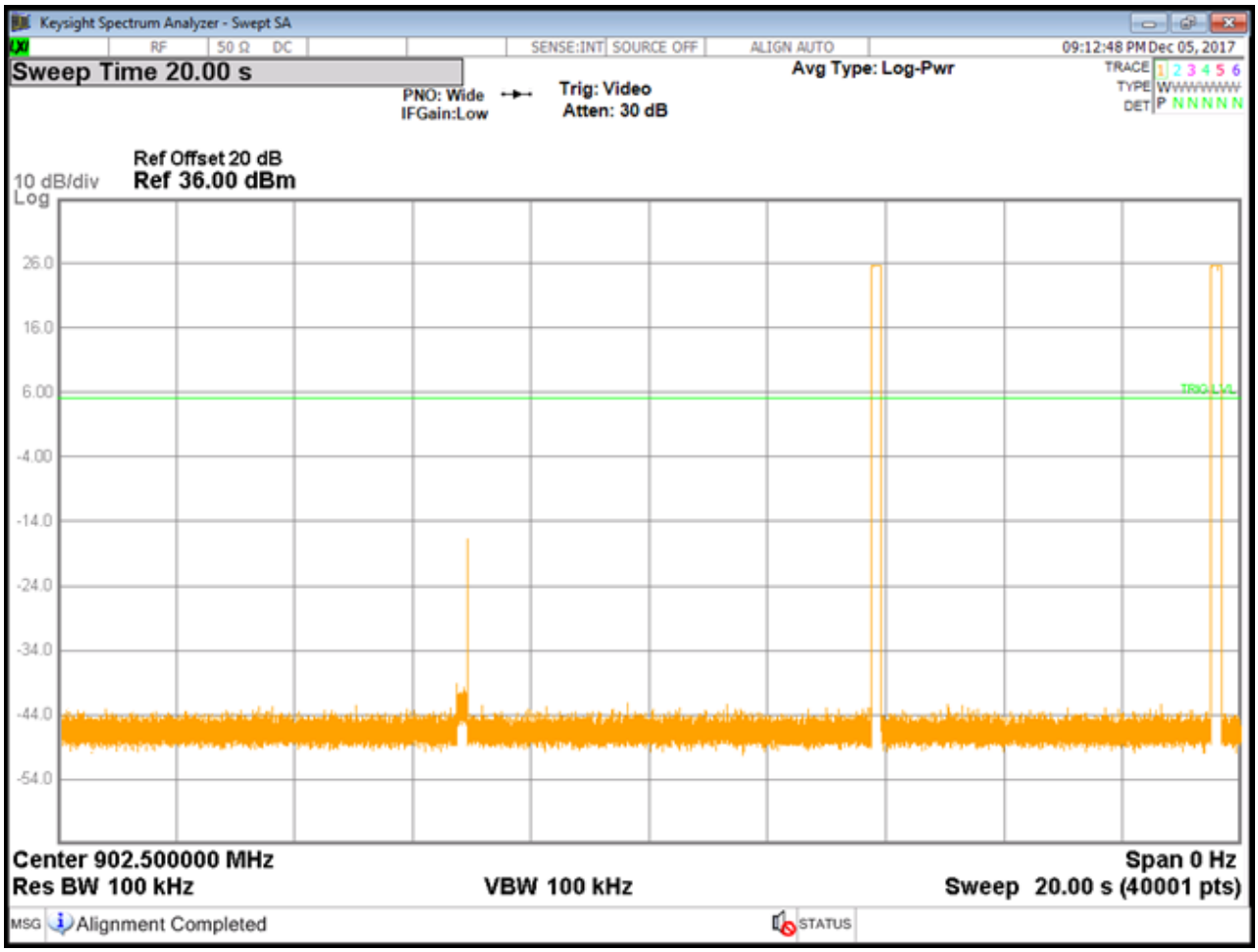
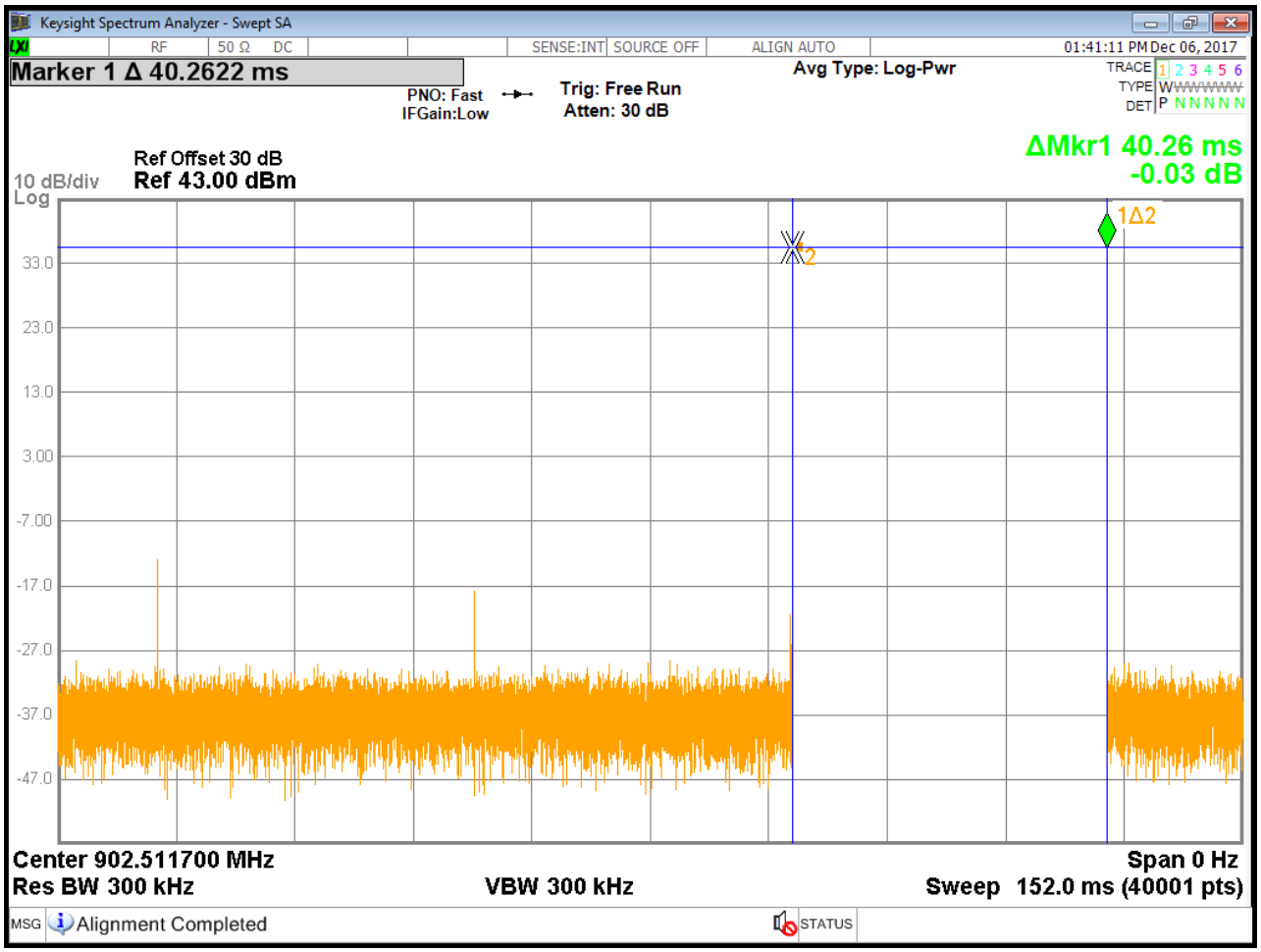


Figure 3: Duty Cycle Plot (Drive-By Mode)



3.3 RF POWER OUTPUT: (FCC PART §2.1046)

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

Table 6: RF Power Output

Mesh Mode

Channel	Level (dBm)	Limit (dBm)	Pass/Fail
Low Channel: 902.5MHz	26.5	30	Pass
Mid Channel: 915MHz	26.3	30	Pass
High Channel: 927MHz	26.0	30	Pass

Drive-By Mode

Channel	Level (dBm)	Limit (dBm)	Pass/Fail
Low Channel: 902.5MHz	26.9	30	Pass
Mid Channel: 915MHz	26.4	30	Pass
High Channel: 927MHz	26.2	30	Pass

3.4 OCCUPIED BANDWIDTH: (FCC PART §2.1049)

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer. For Frequency Hopping Spread Spectrum Systems, FCC Part 15.247 requires the maximum 20 dB bandwidth not exceed 500 kHz.

At full modulation, the occupied bandwidth was measured as shown.

Table 7 provides a summary of the Occupied Bandwidth Results.

Table 7: Occupied Bandwidth Results

Mesh Mode

Frequency	Bandwidth (kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.5MHz	138.8	500	Pass
Mid Channel: 915MHz	138.7	500	Pass
High Channel: 927MHz	138.7	500	Pass

Drive-By Mode

Frequency	Bandwidth (kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.5MHz	358.8	500	Pass
Mid Channel: 915MHz	358.3	500	Pass
High Channel: 927MHz	358.2	500	Pass

Figure 4: Occupied Bandwidth, Low Channel, Mesh Mode

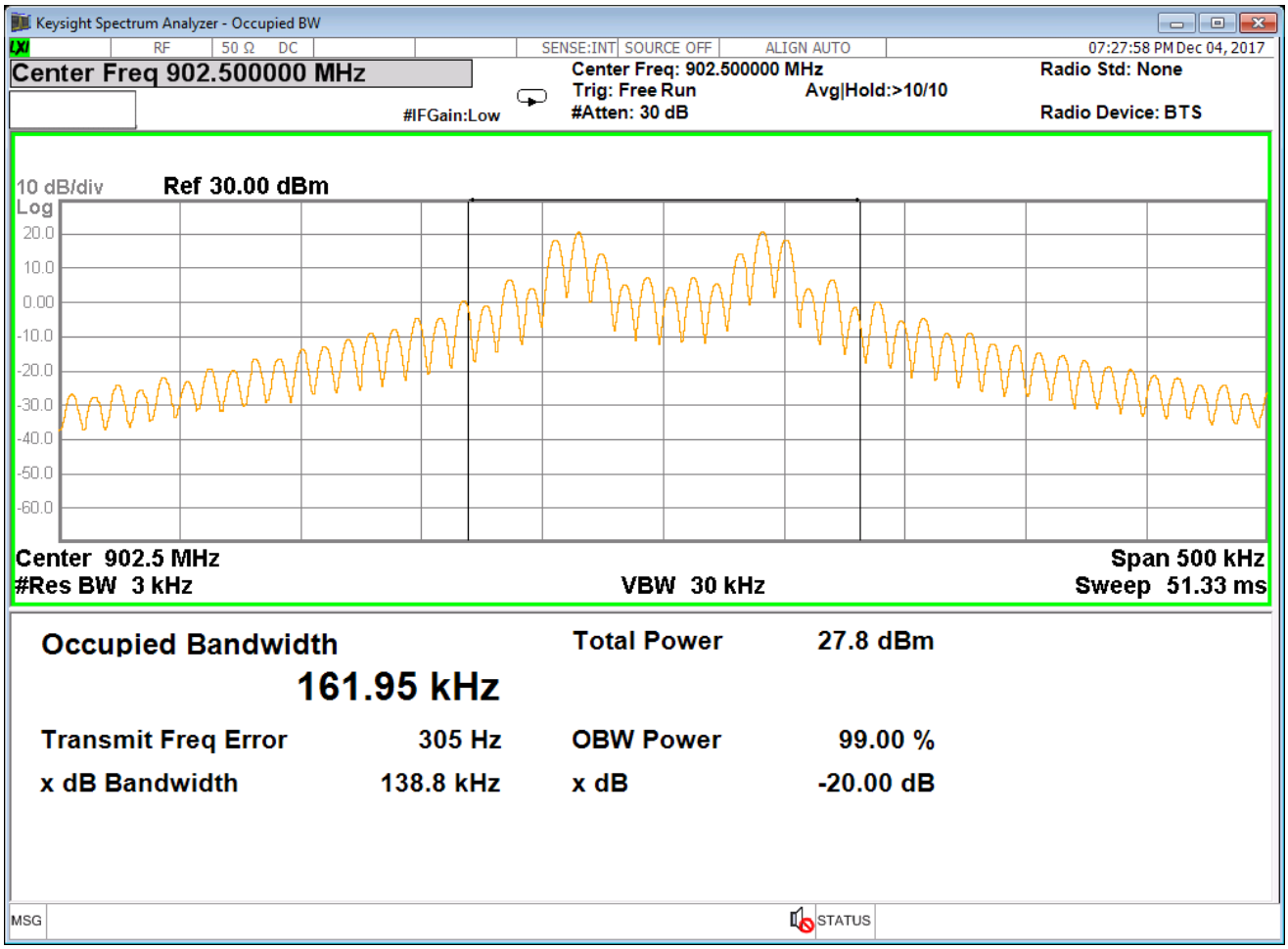


Figure 5: Occupied Bandwidth, Mid Channel, Mesh Mode

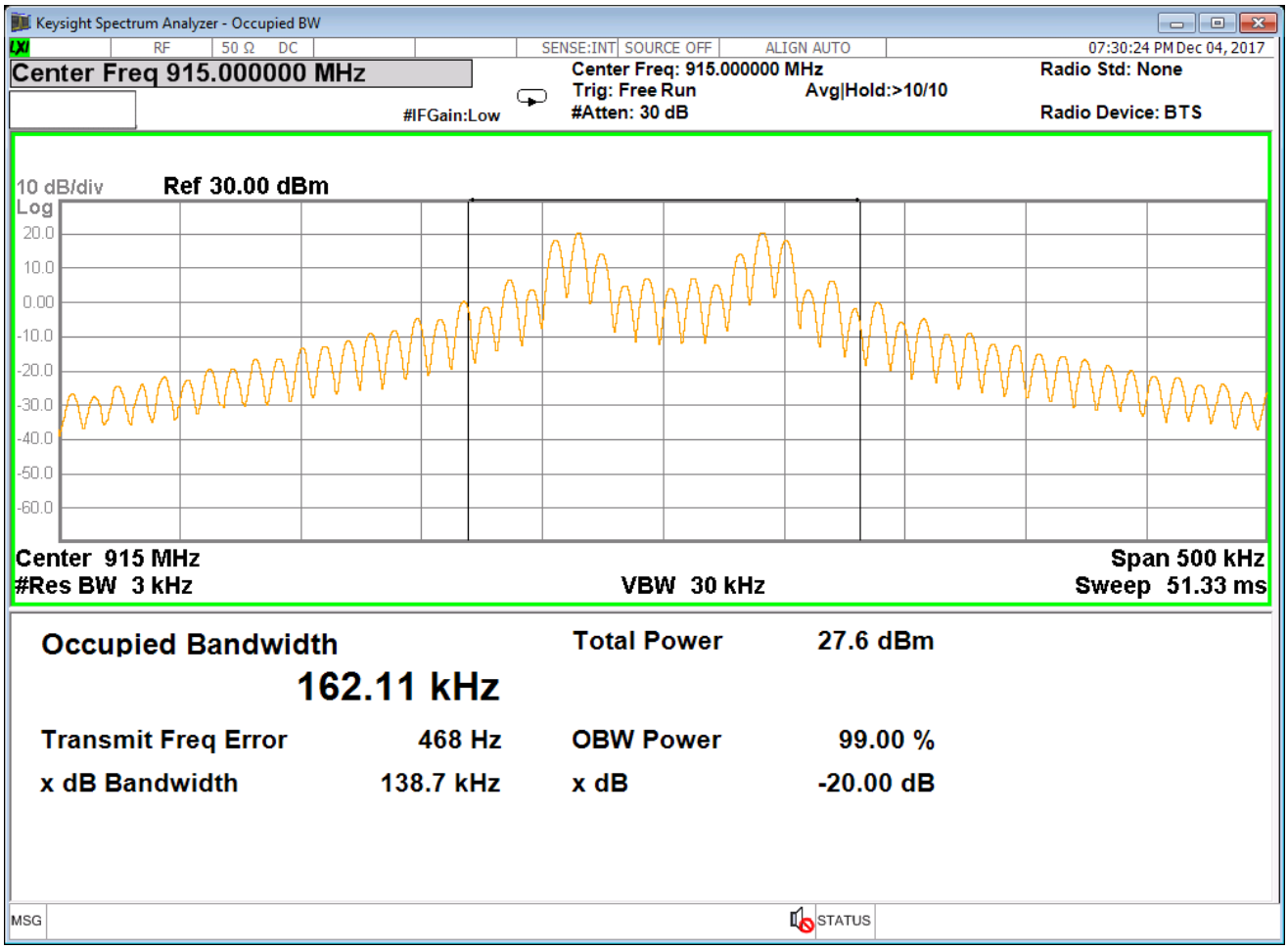


Figure 6: Occupied Bandwidth, High Channel, Mesh Mode

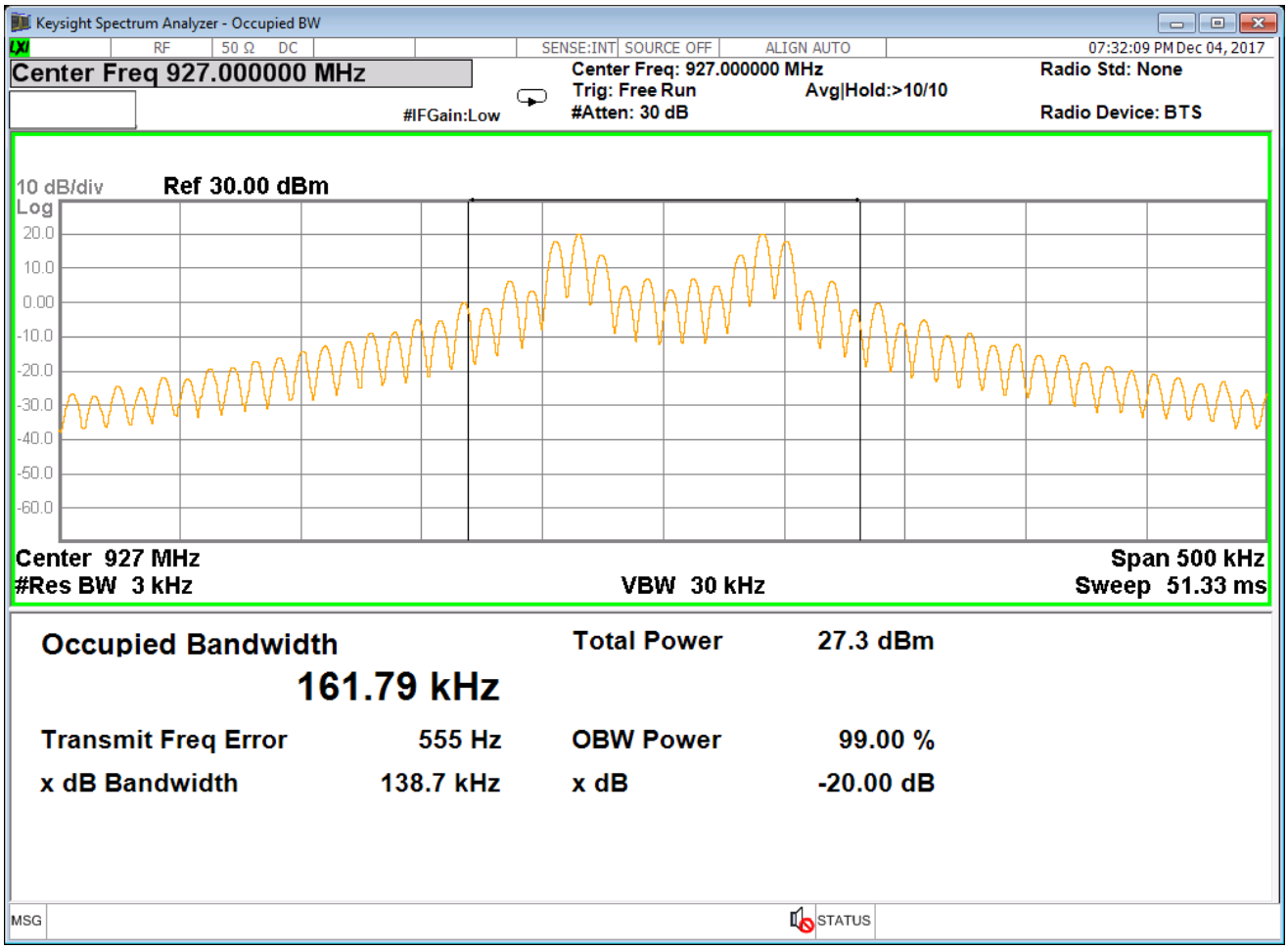


Figure 7: Occupied Bandwidth, Low Channel, Drive-By Mode

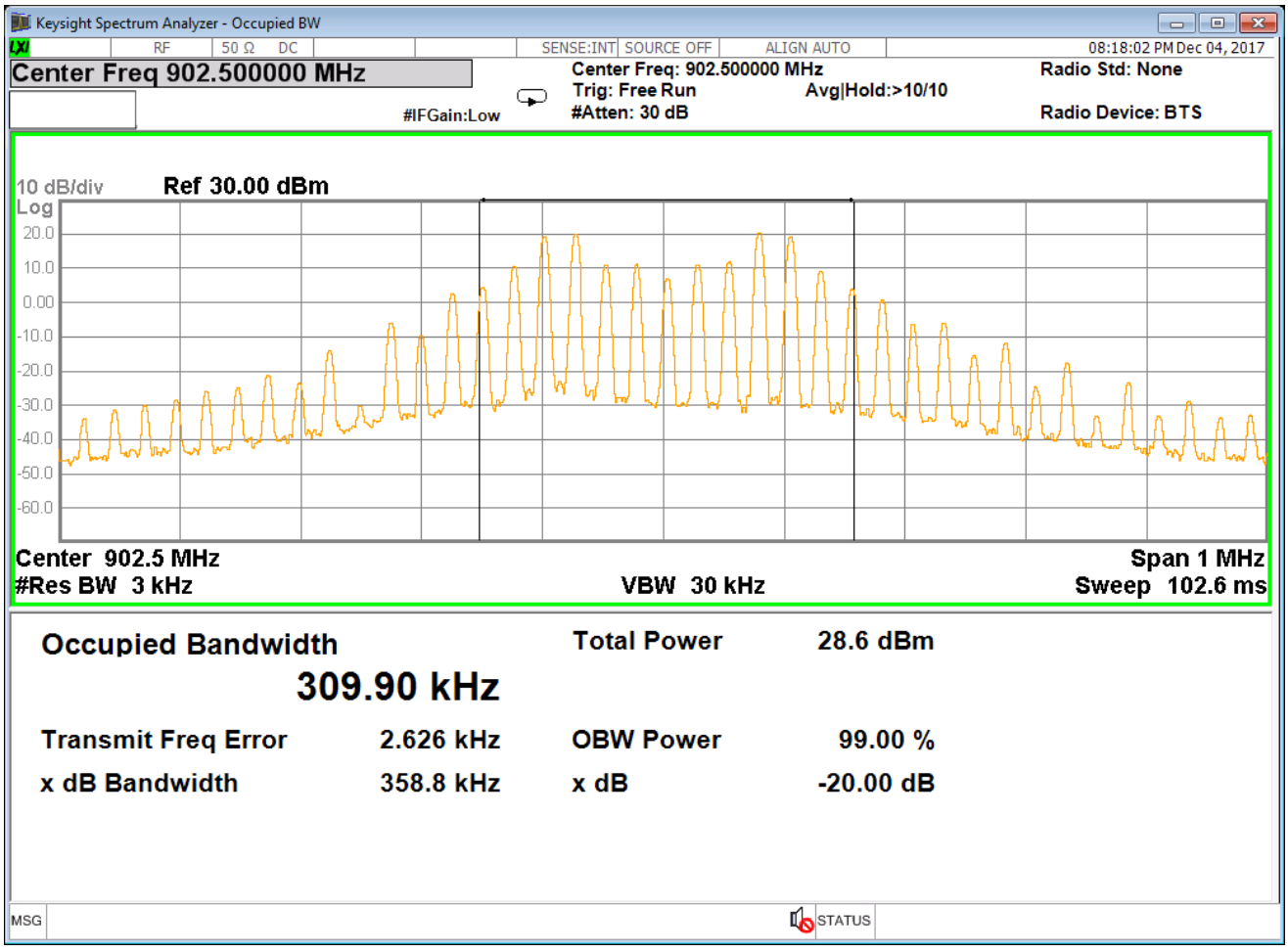


Figure 8: Occupied Bandwidth, Mid Channel, Drive-By Mode

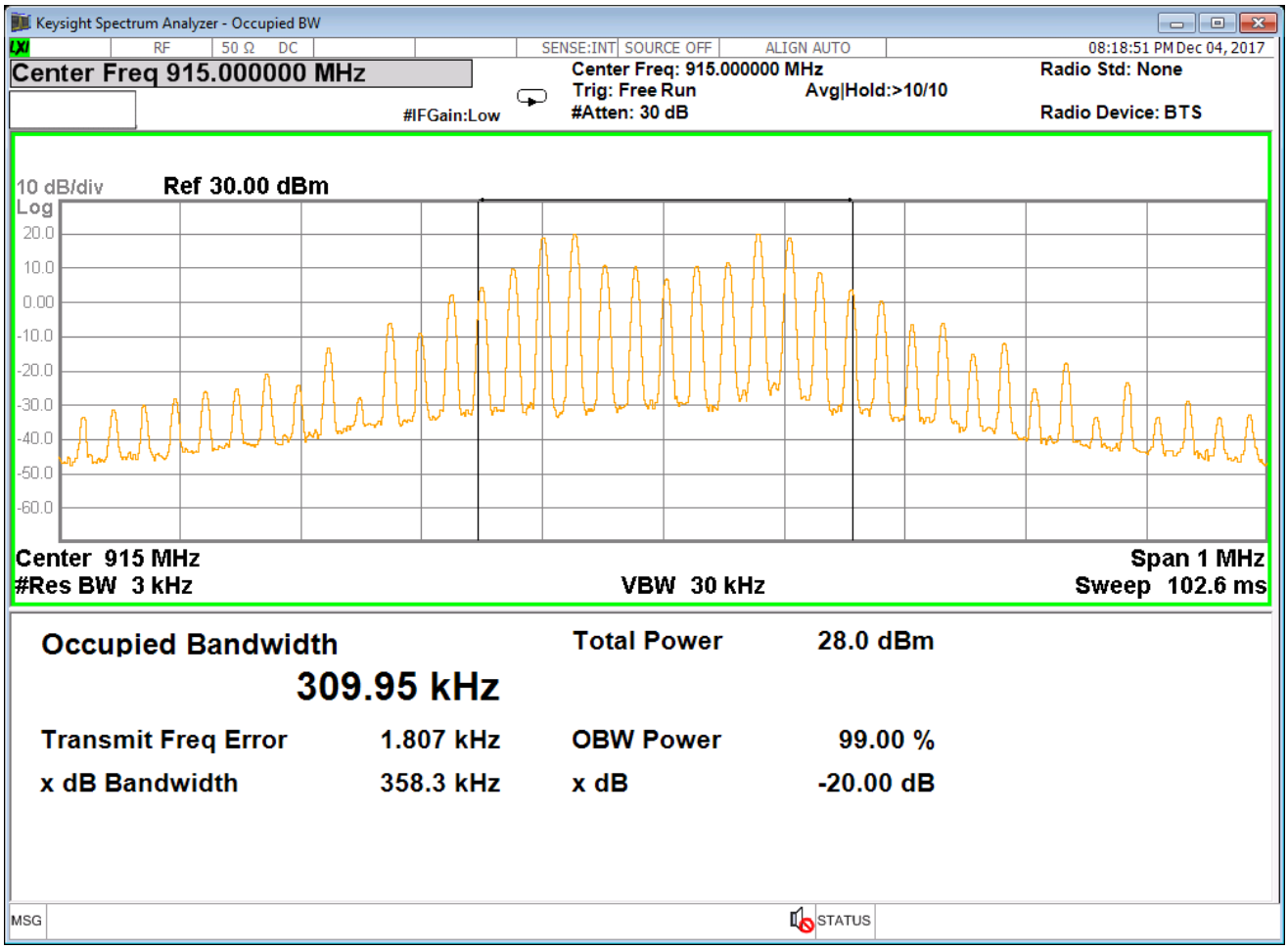
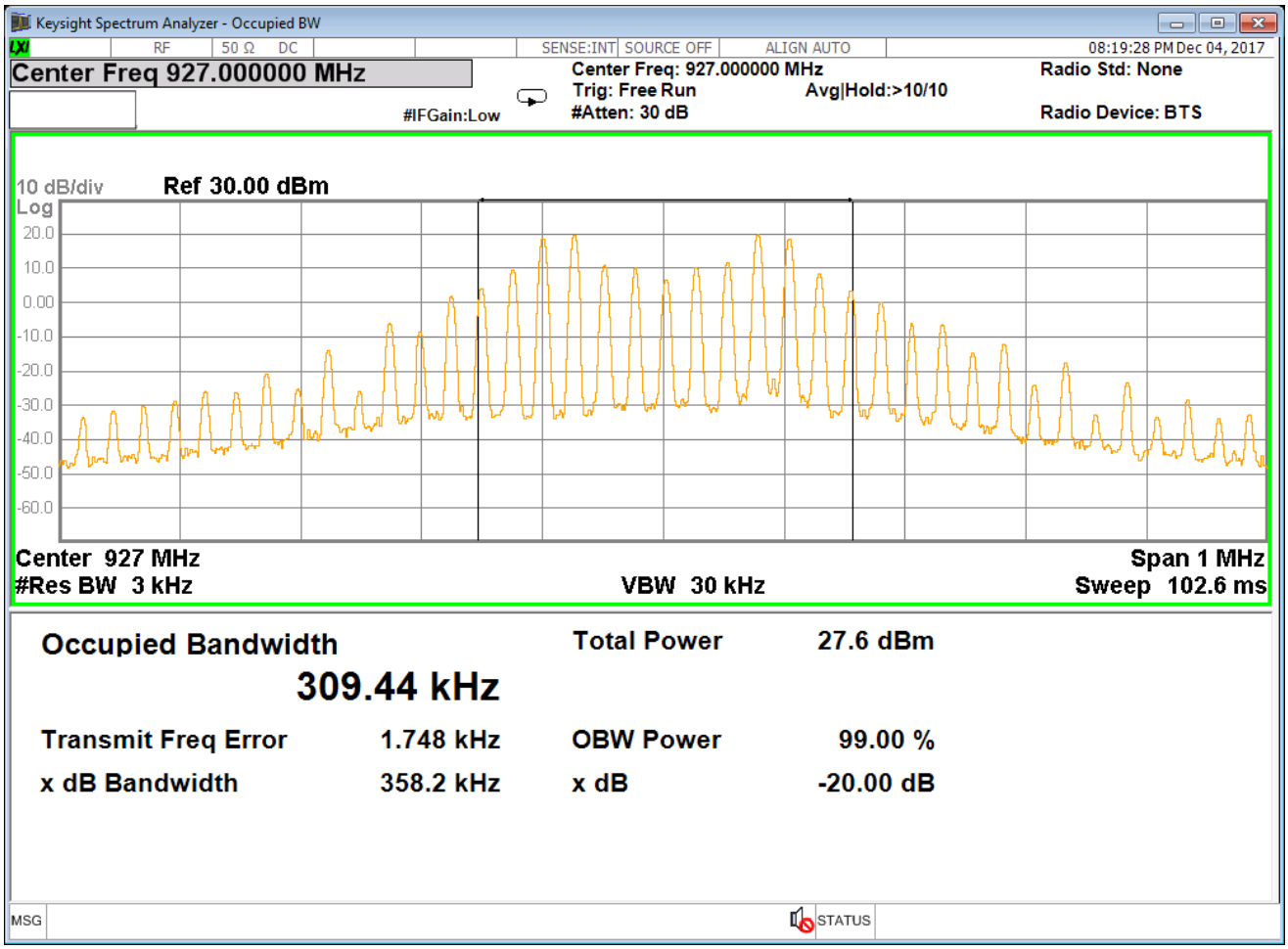


Figure 9: Occupied Bandwidth, High Channel, Drive-By Mode



3.5 CHANNEL SPACING AND NUMBER OF HOP CHANNELS (FCC PART §15.247(A)(1)

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator and cable. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 1MHz. The channel spacing of 2 adjacent channels was measured using a spectrum analyzer span setting appropriate for the measurement.

Per the FCC requirements, frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20dB bandwidth, whichever is greater. The maximum 20dB bandwidth measured for the Mesh mode is 138.8 kHz so the channel spacing must be more than 250 kHz. Additionally, if the hopping channel 20dB BW is less than 250 kHz, the system shall use at least 50 hopping channels.

The maximum 20dB bandwidth measured for the Drive-By mode is 358.8 kHz so the channel spacing must be more than 250 kHz. Additionally, if the hopping channel 20dB BW is less than 250 kHz, the system shall use at least 25 hopping channels.

Note: In the following plots, each channel is composed of 2 distinct peaks.

Table 8: Channel Spacing and Number of Channels Results

Mesh Mode

Frequency	Result	Limit	Pass/Fail
Channel Spacing	500kHz	250kHz Minimum	Pass
Number of channels	50 Channels	≥50 Channels	Pass

Drive-By Mode

Frequency	Result	Limit	Pass/Fail
Channel Spacing	500kHz	500kHz	Pass
Number of channels	50 Channels	≥25 Channels	Pass

Figure 10: Channel Spacing, Mesh Mode

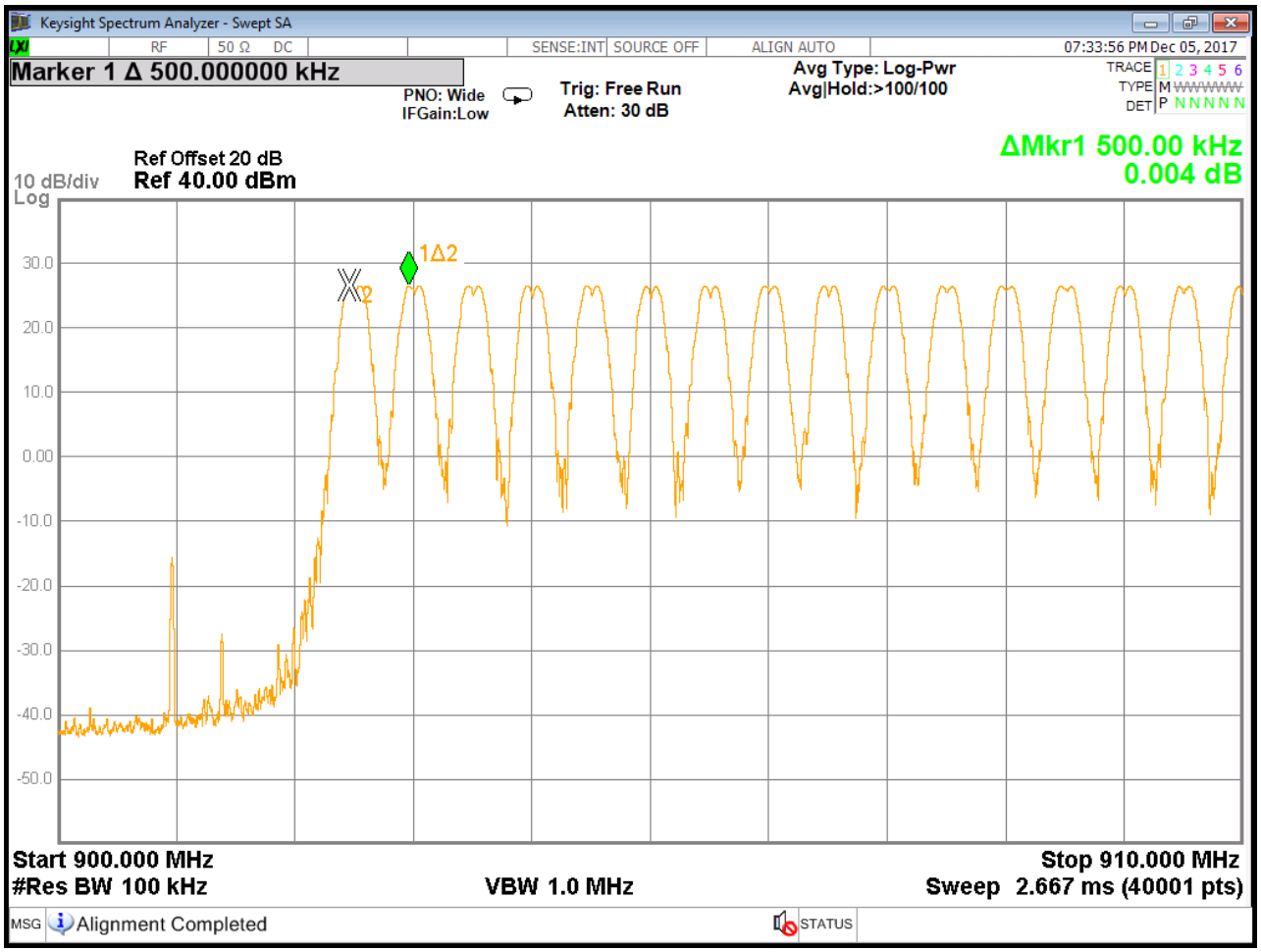


Figure 11: Number of Hopping Channels, Mesh Mode

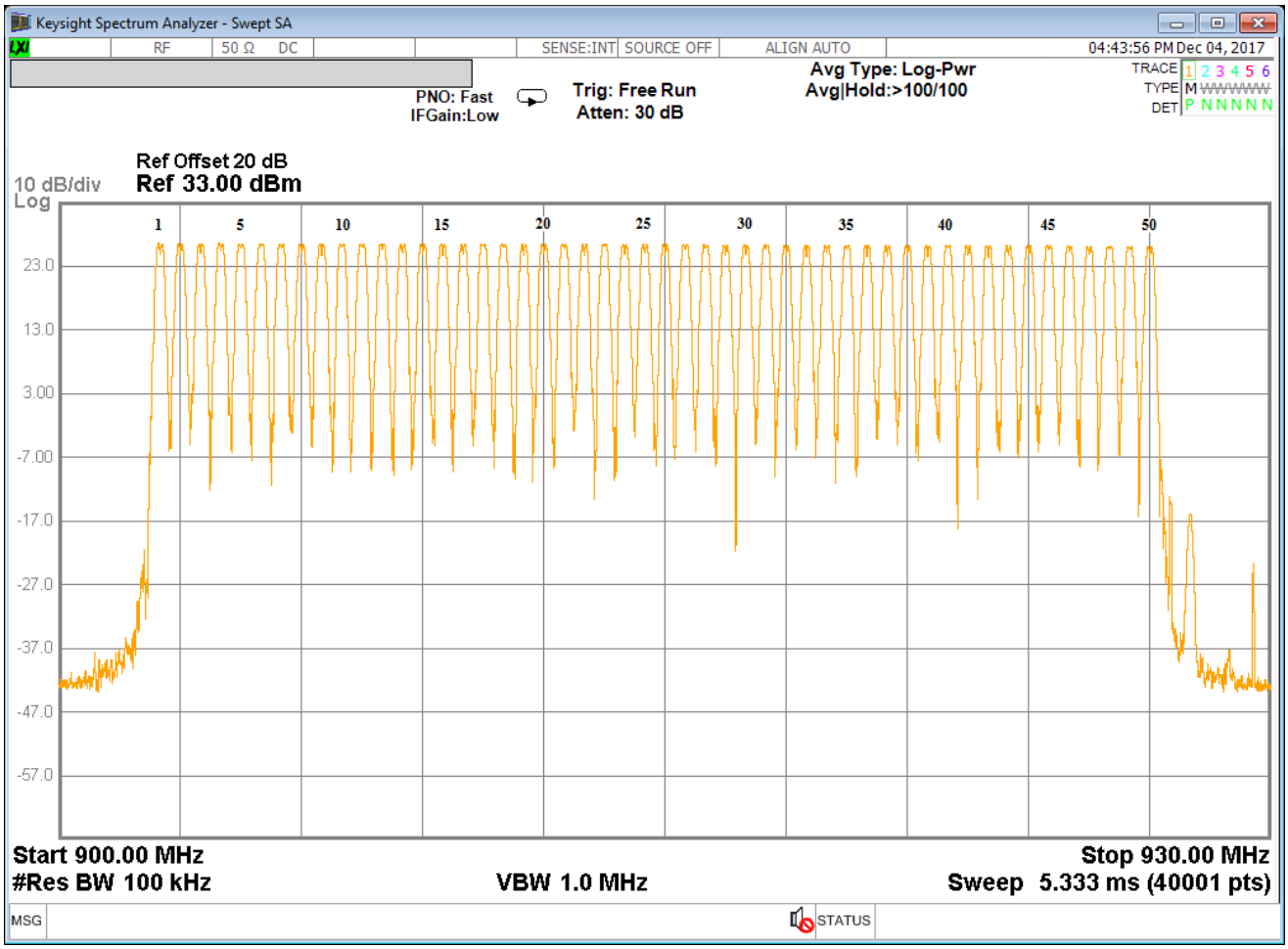


Figure 12: Channel Spacing, Drive-By Mode

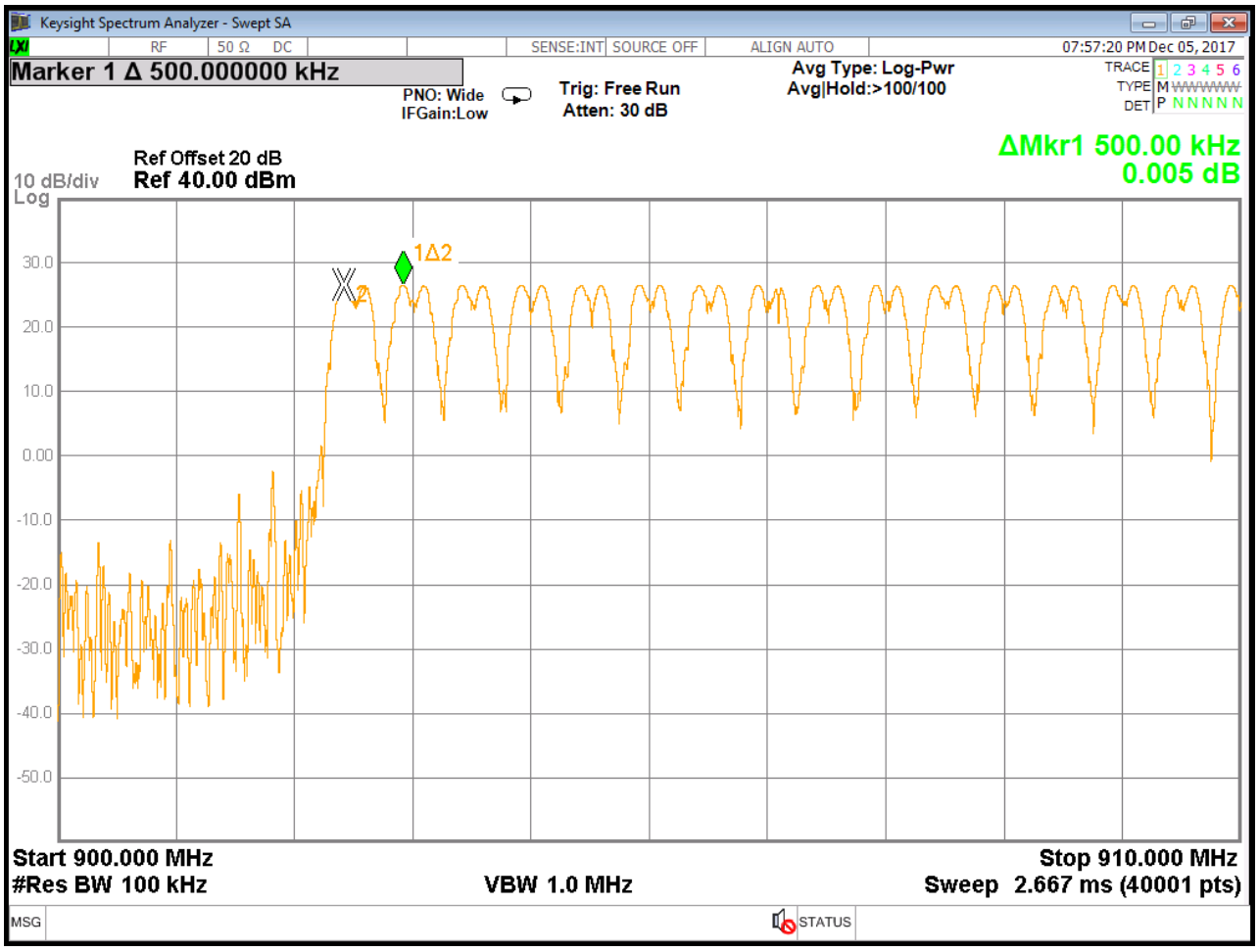
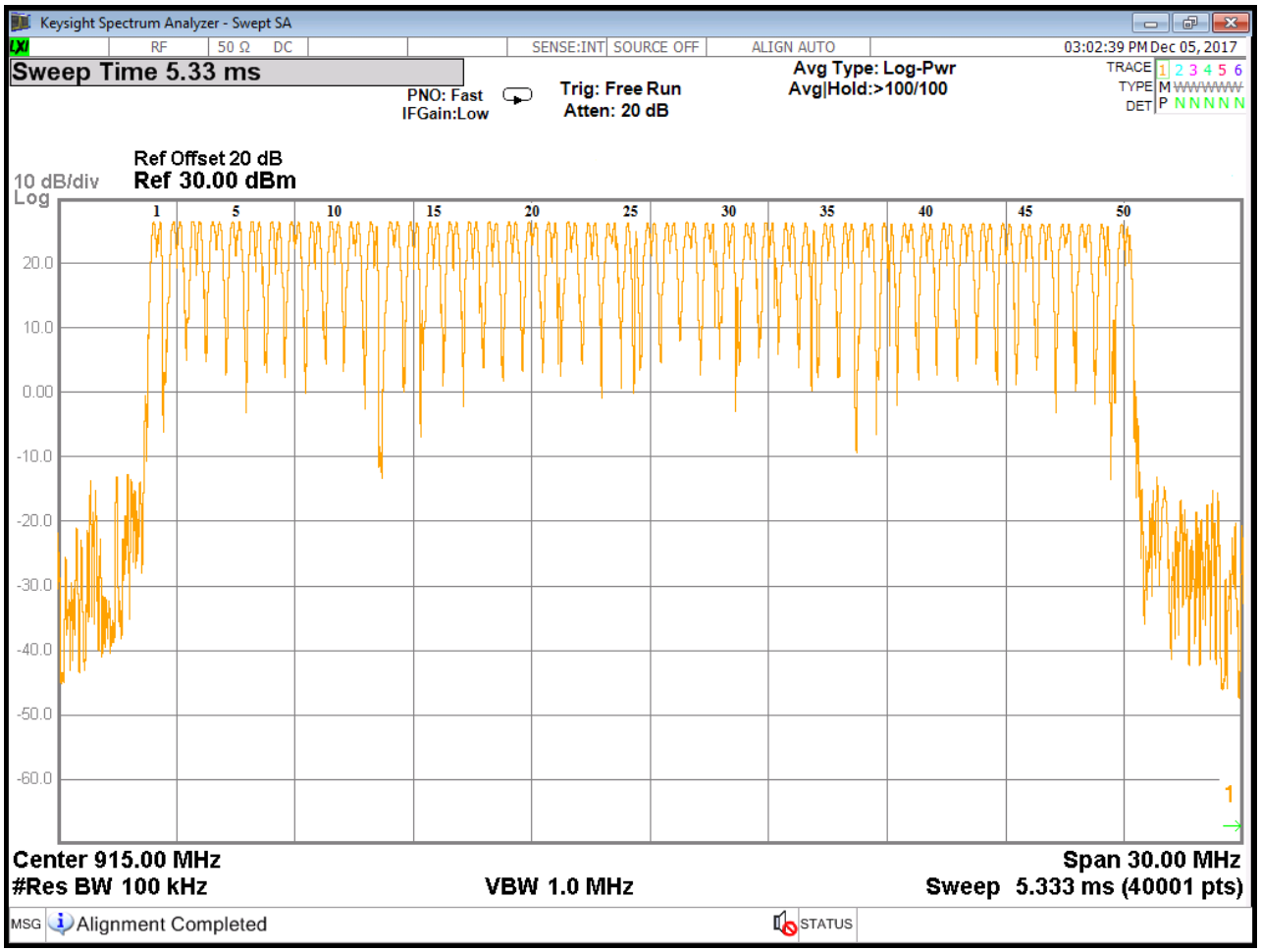


Figure 13: Number of Hopping Channels, Drive-By Mode



3.6 CONDUCTED SPURIOUS EMISSIONS AT ANTENNA TERMINALS (FCC PART §2.1051)

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

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 300 kHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit (20 dB below the carrier frequency amplitude). The emissions outside of the allocated frequency band were then scanned from 30 MHz up to the tenth harmonic of the carrier.

The following are plots of the conducted spurious emissions data.

Figure 14: Conducted Spurious Emissions, Mesh Mode, Low Channel 30 - 900MHz

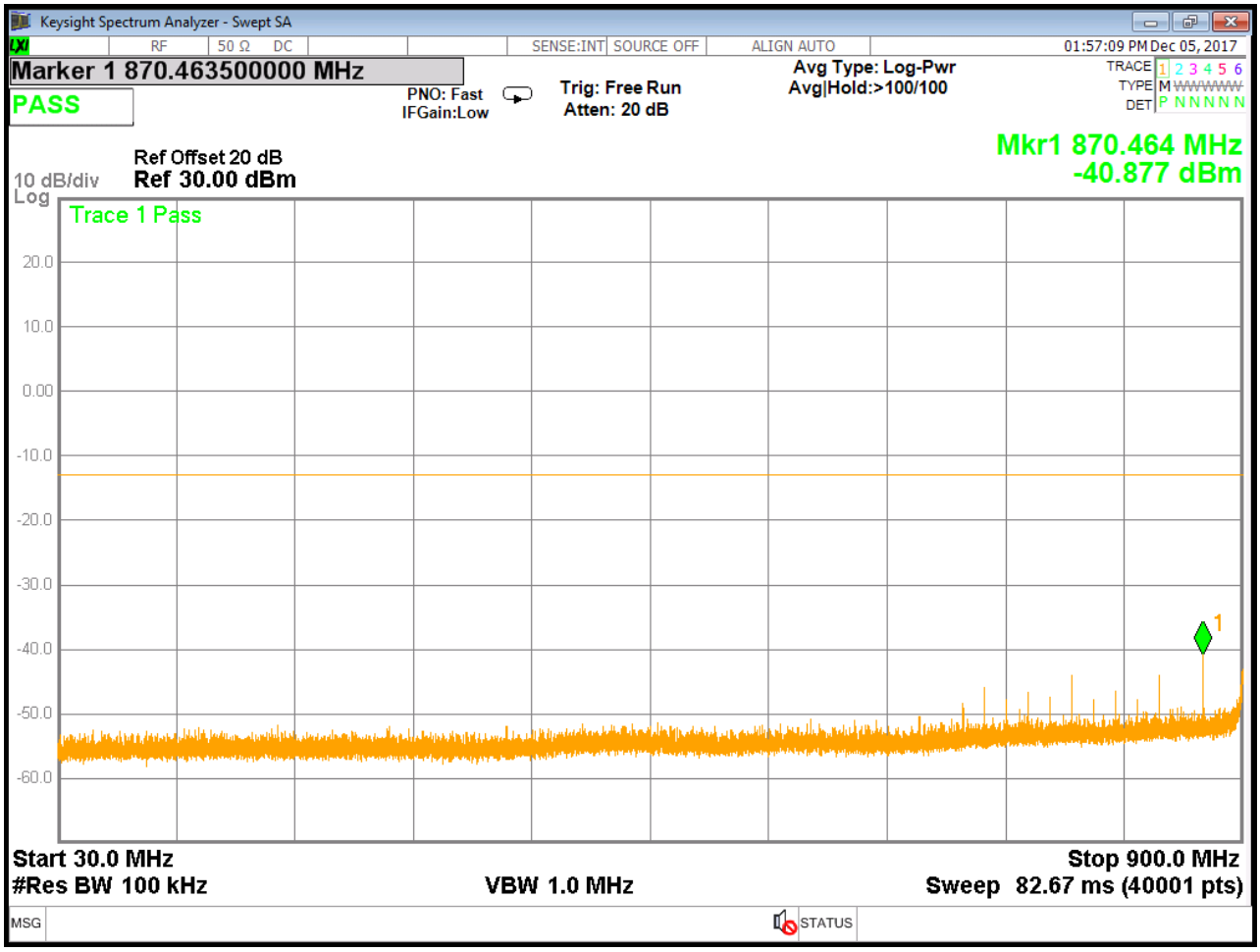


Figure 15: Conducted Spurious Emissions, Mesh Mode, Low Channel 900 – 930MHz

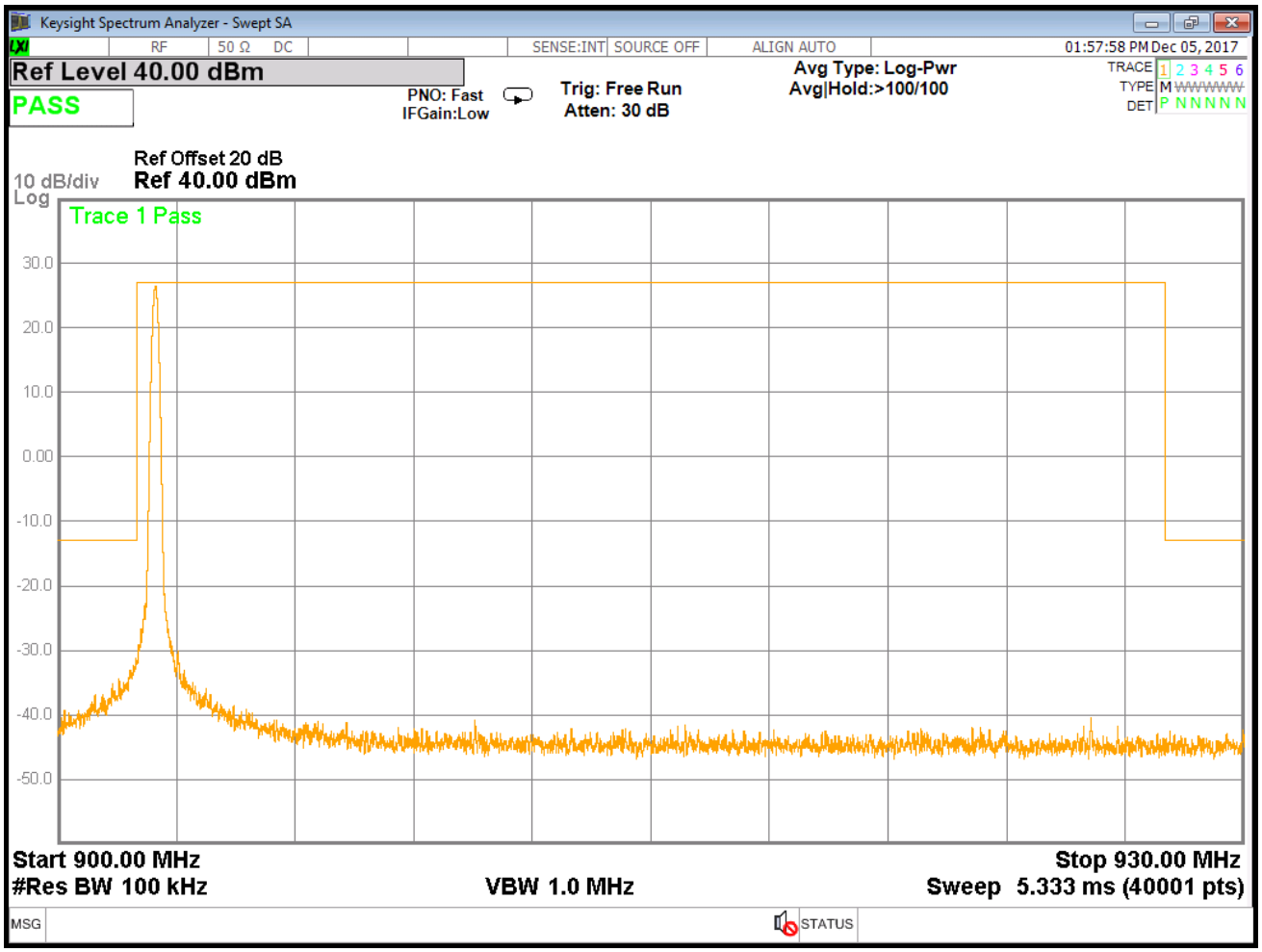


Figure 16: Conducted Spurious Emissions, Mesh Mode, Low Channel 930 – 5000MHz

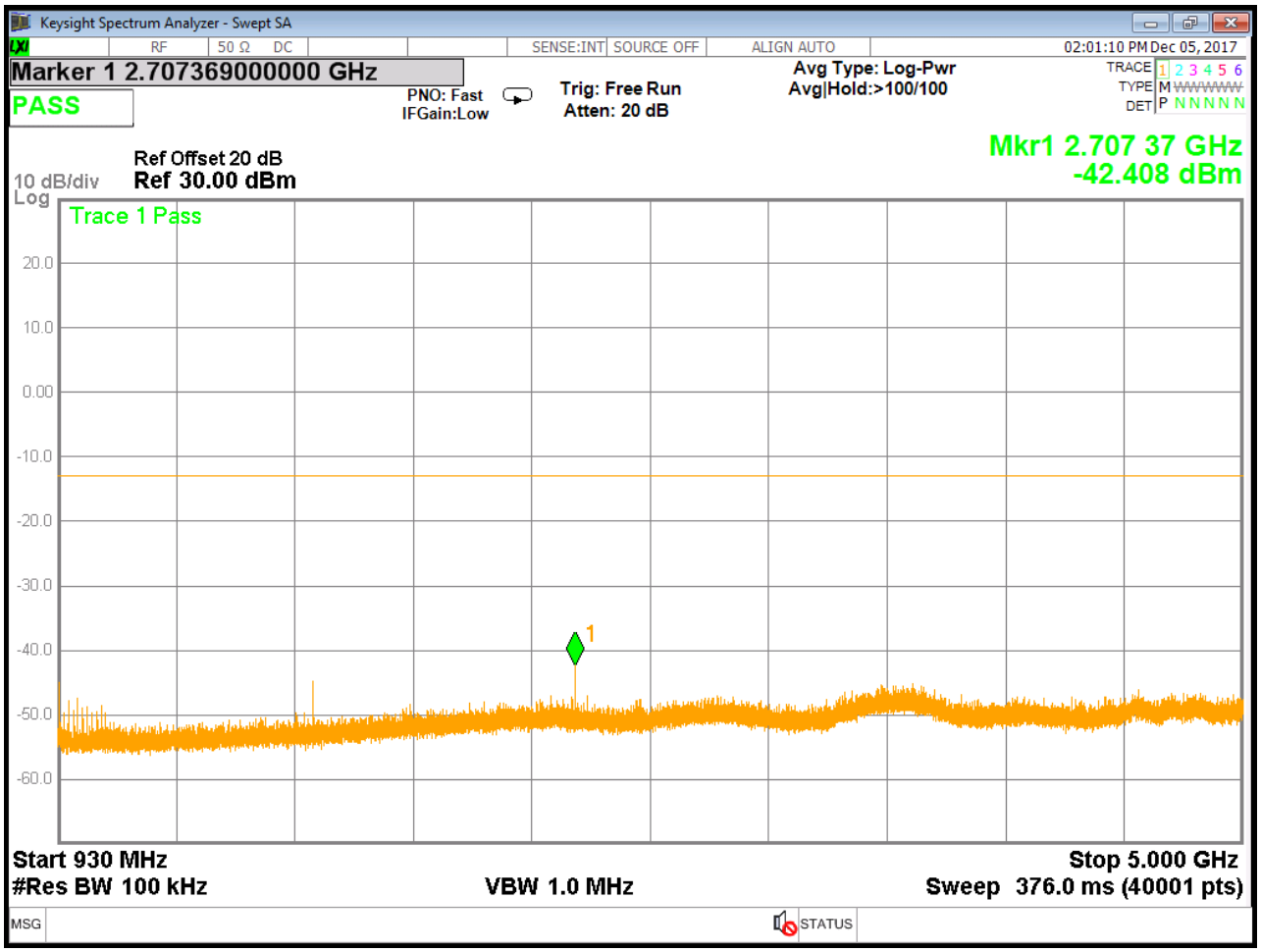


Figure 17: Conducted Spurious Emissions, Mesh Mode, Low Channel 5 – 10GHz

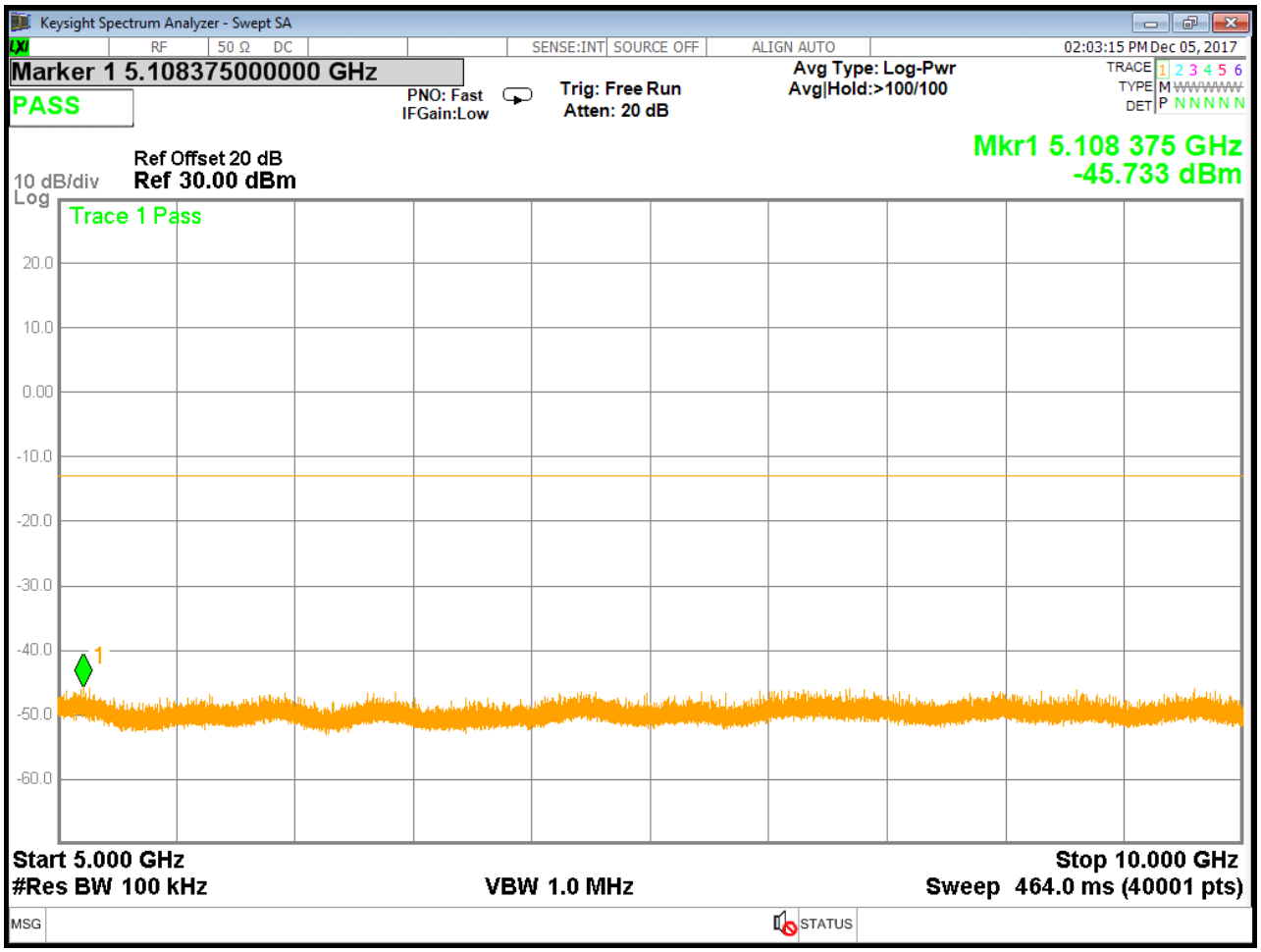


Figure 18: Conducted Spurious Emissions, Mesh Mode, Center Channel 30 - 900MHz

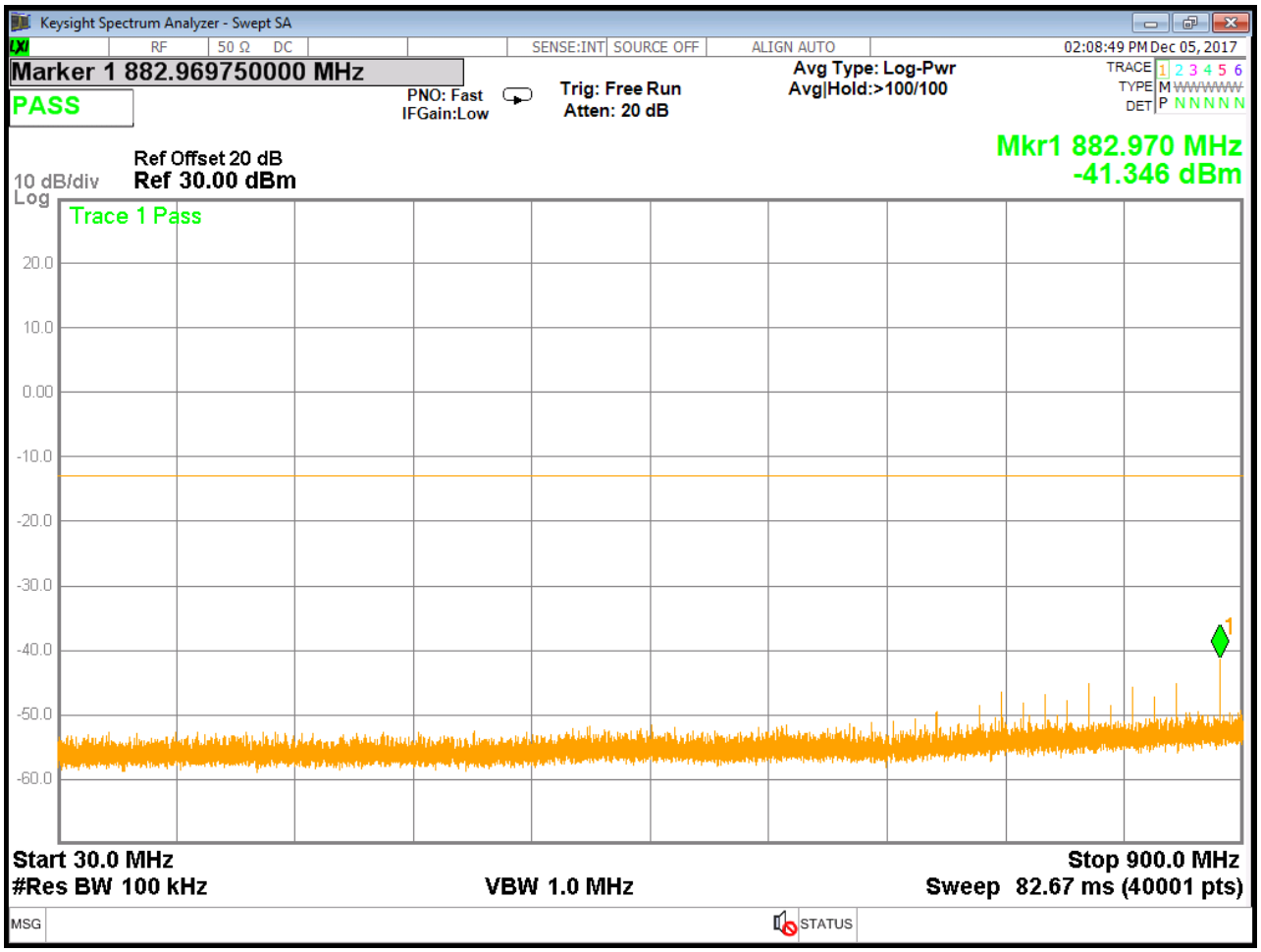


Figure 19: Conducted Spurious Emissions, Mesh Mode, Center Channel 900 – 930MHz

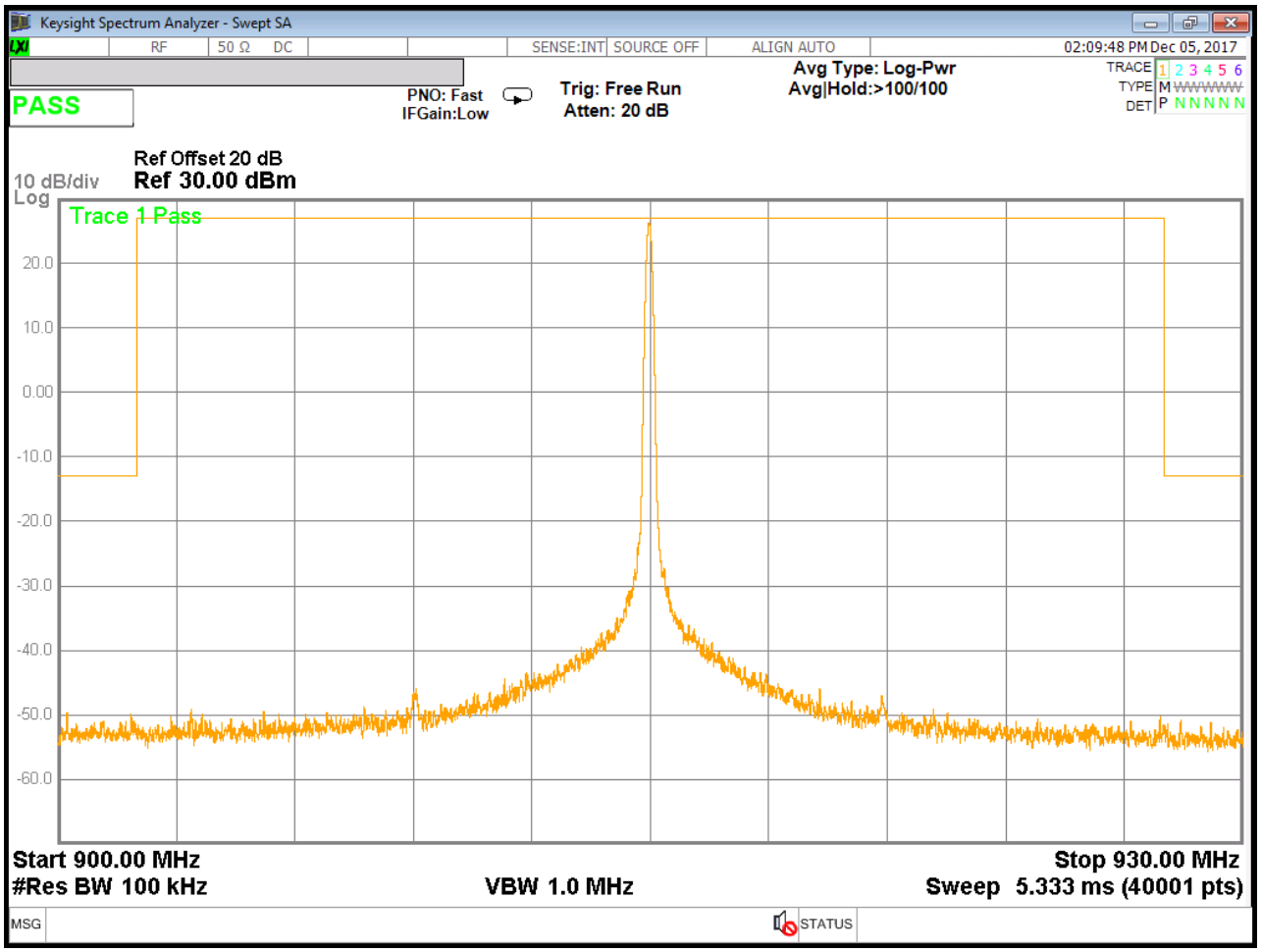


Figure 20: Conducted Spurious Emissions, Mesh Mode, Center Channel 930 – 5000MHz

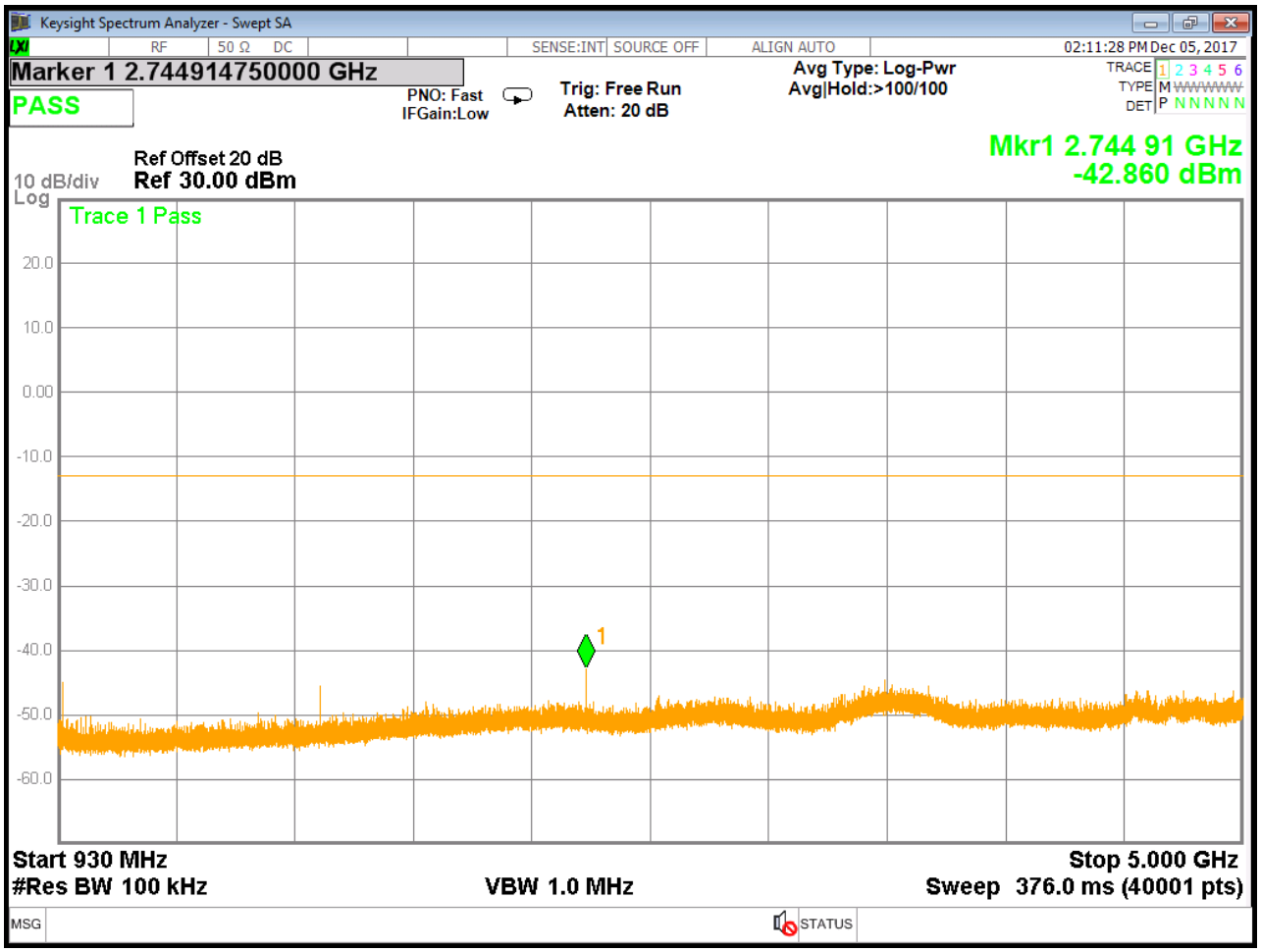


Figure 21: Conducted Spurious Emissions, Mesh Mode, Center Channel 5 – 10GHz

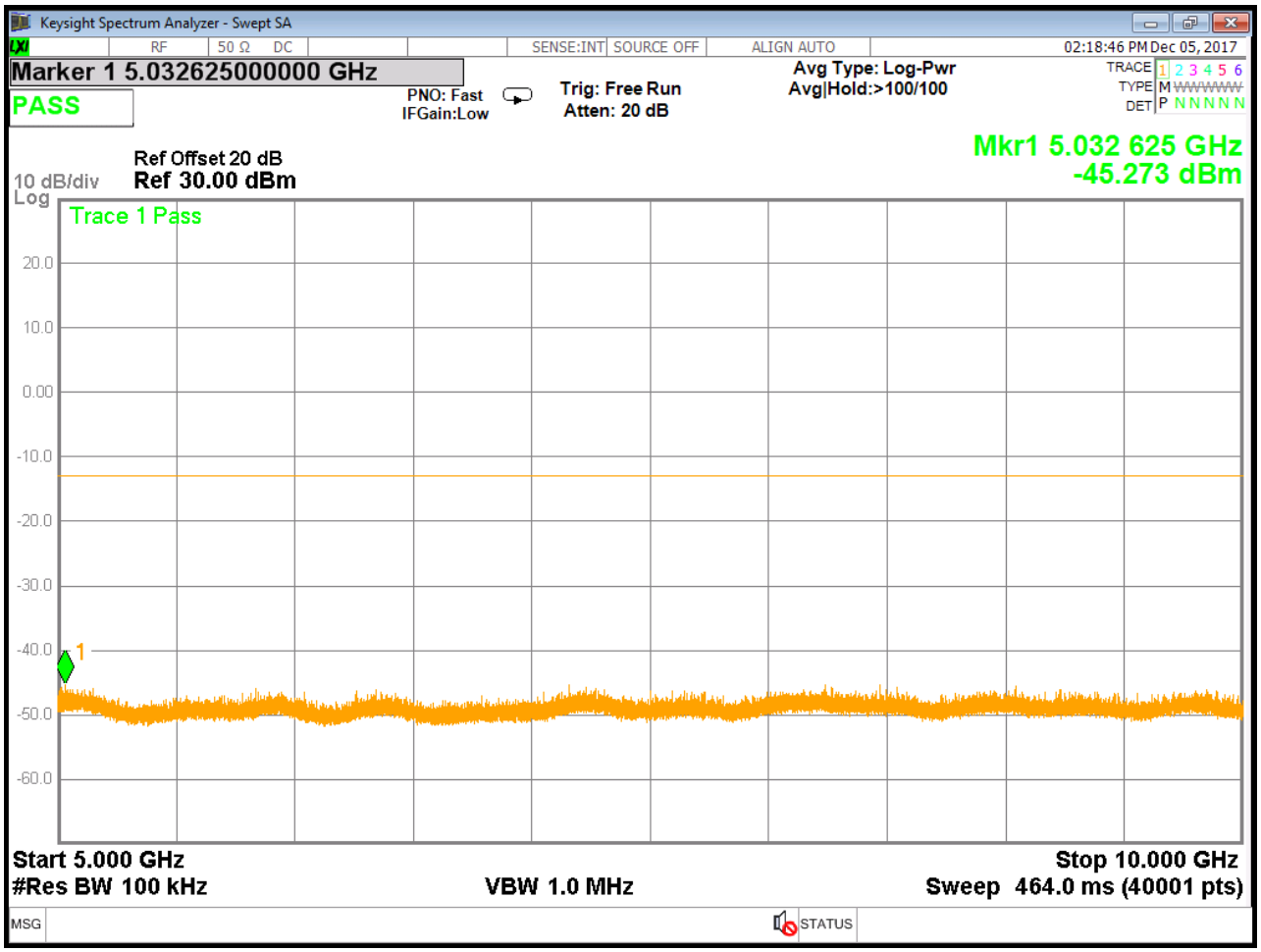


Figure 22: Conducted Spurious Emissions, Mesh Mode, High Channel 30 - 900MHz

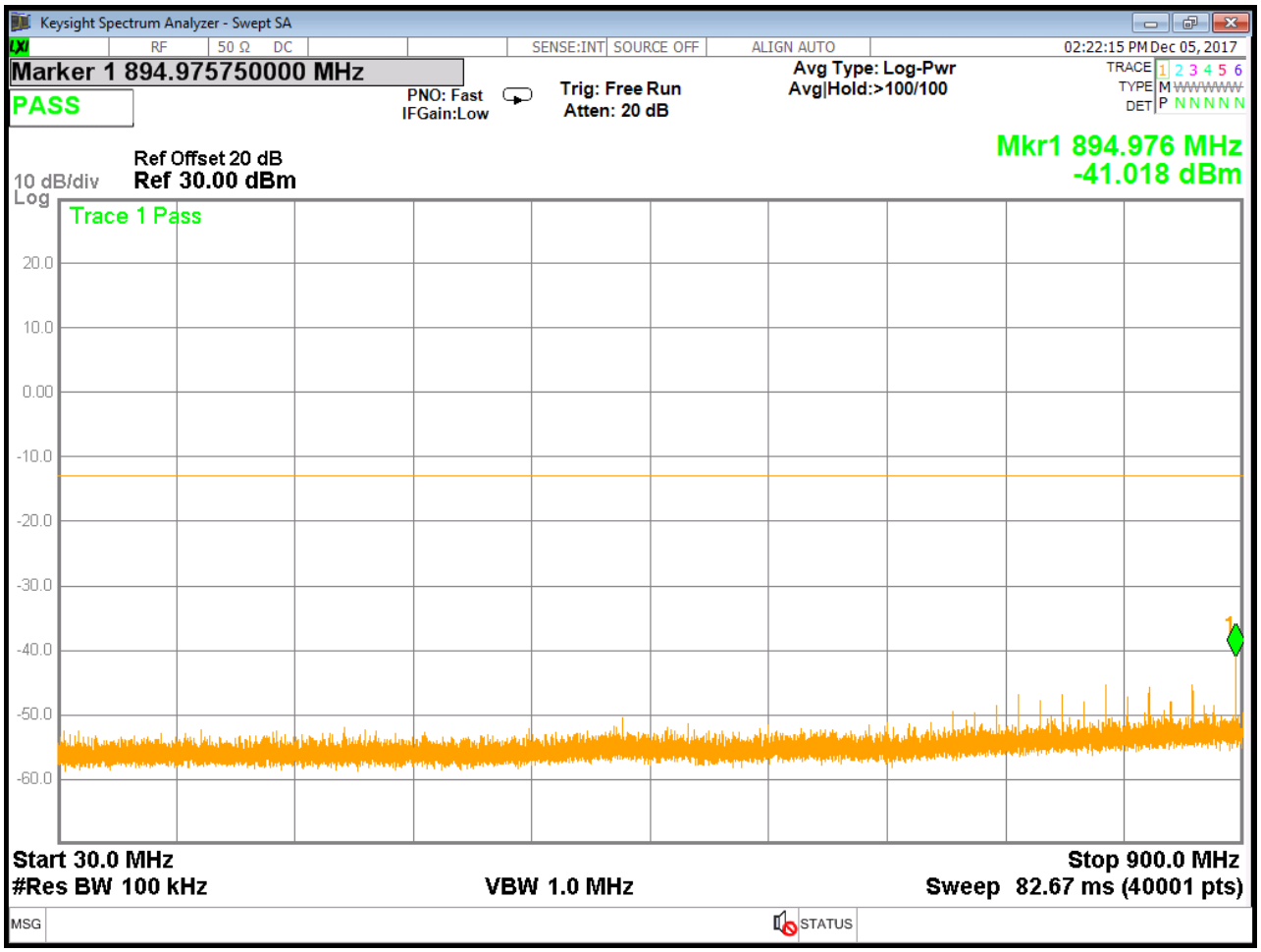


Figure 23: Conducted Spurious Emissions, Mesh Mode, High Channel 900 – 930MHz

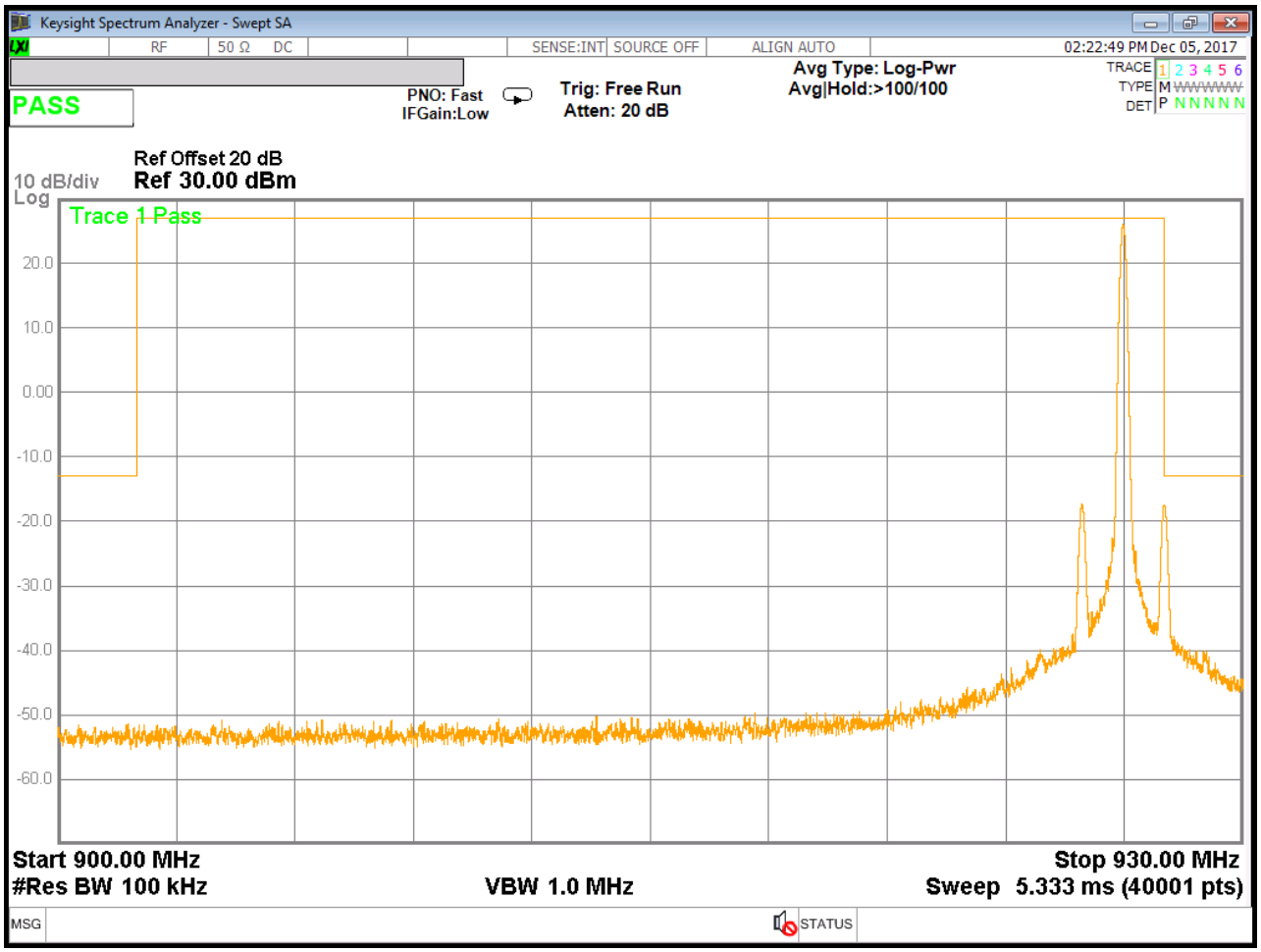


Figure 24: Conducted Spurious Emissions, Mesh Mode, High Channel 930 – 5000MHz

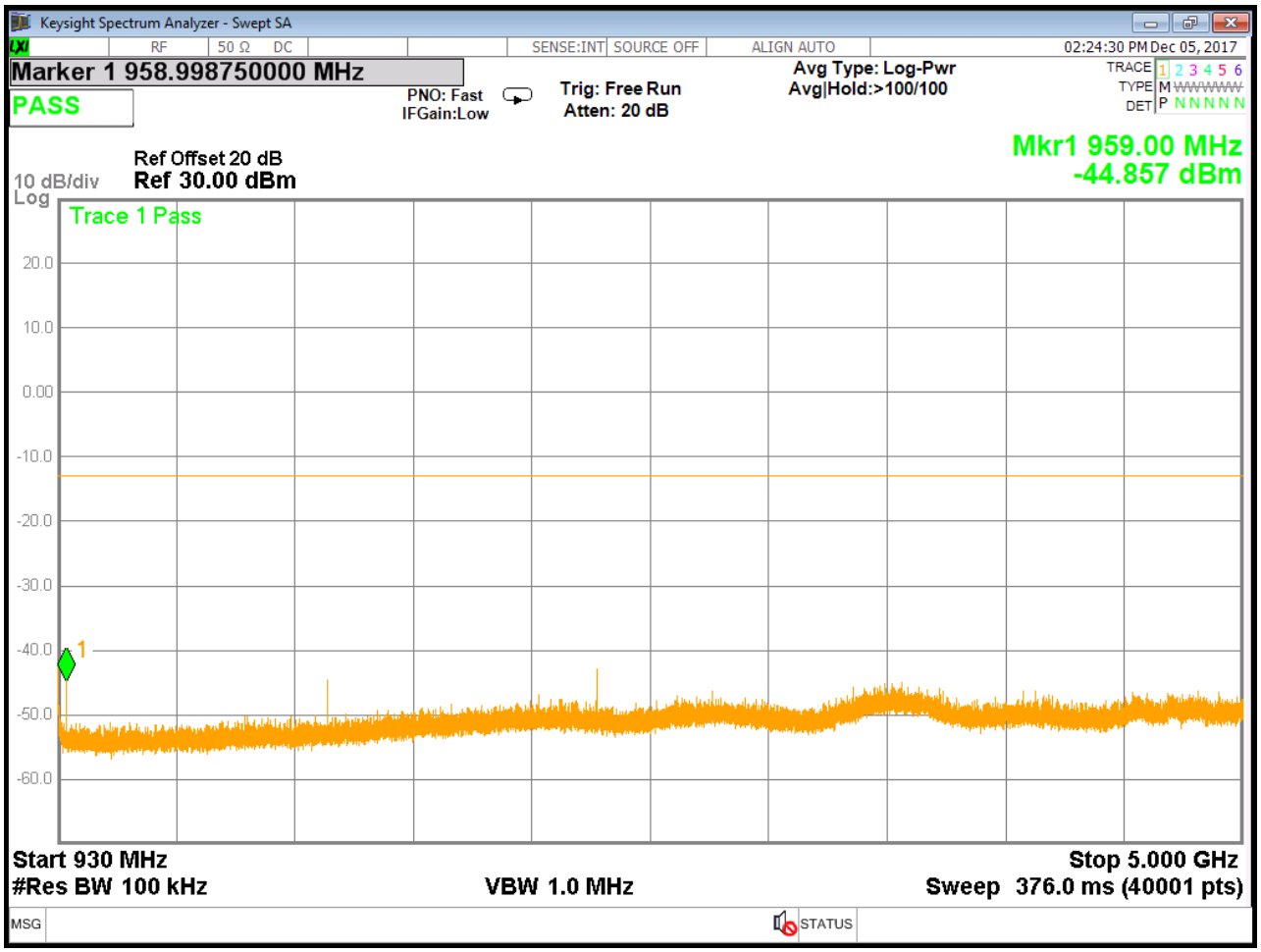


Figure 25: Conducted Spurious Emissions, Mesh Mode, High Channel 5 – 10GHz

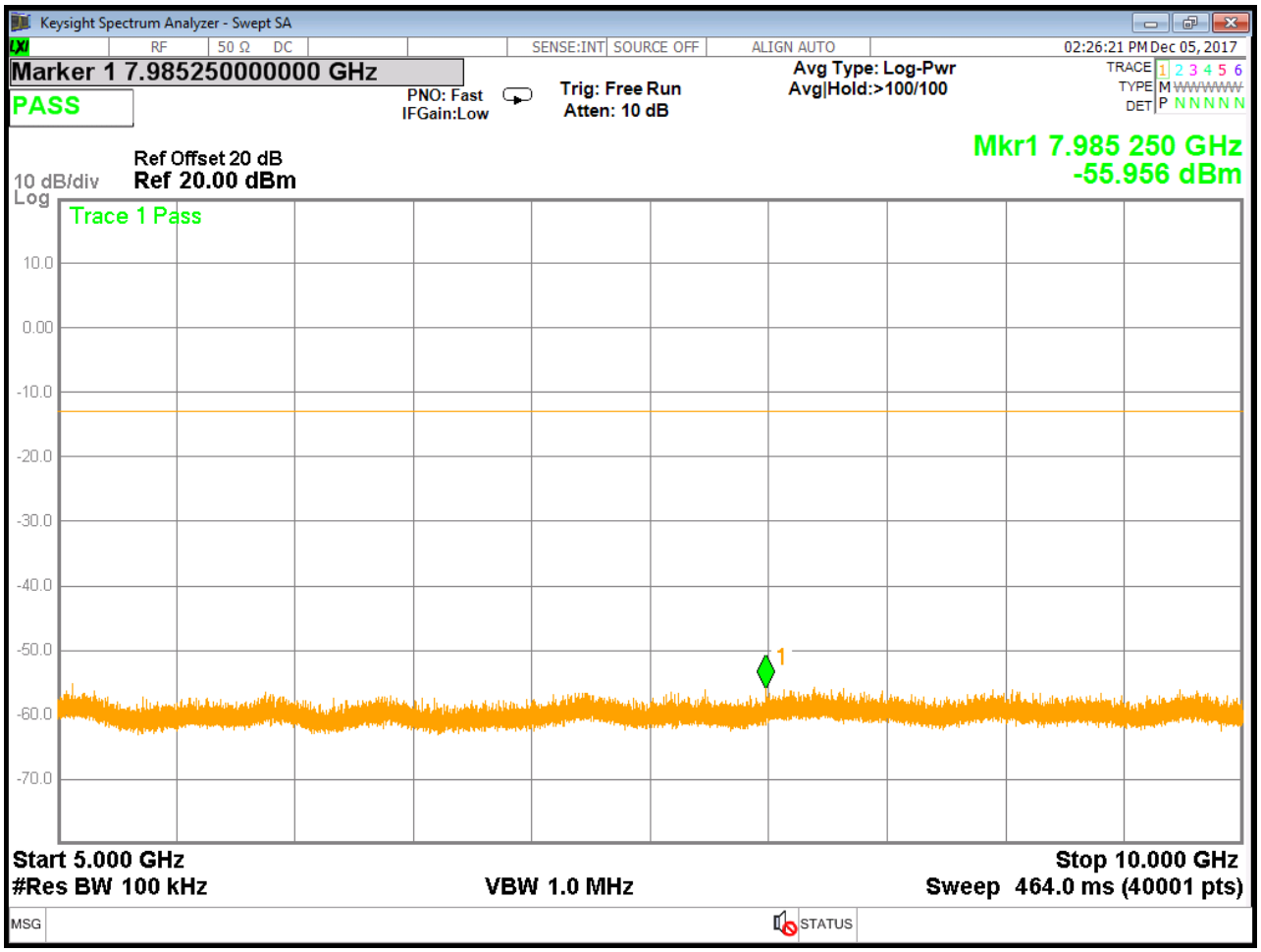


Figure 26: Conducted Spurious Emissions, Drive-By Mode, Low Channel 30 - 900MHz

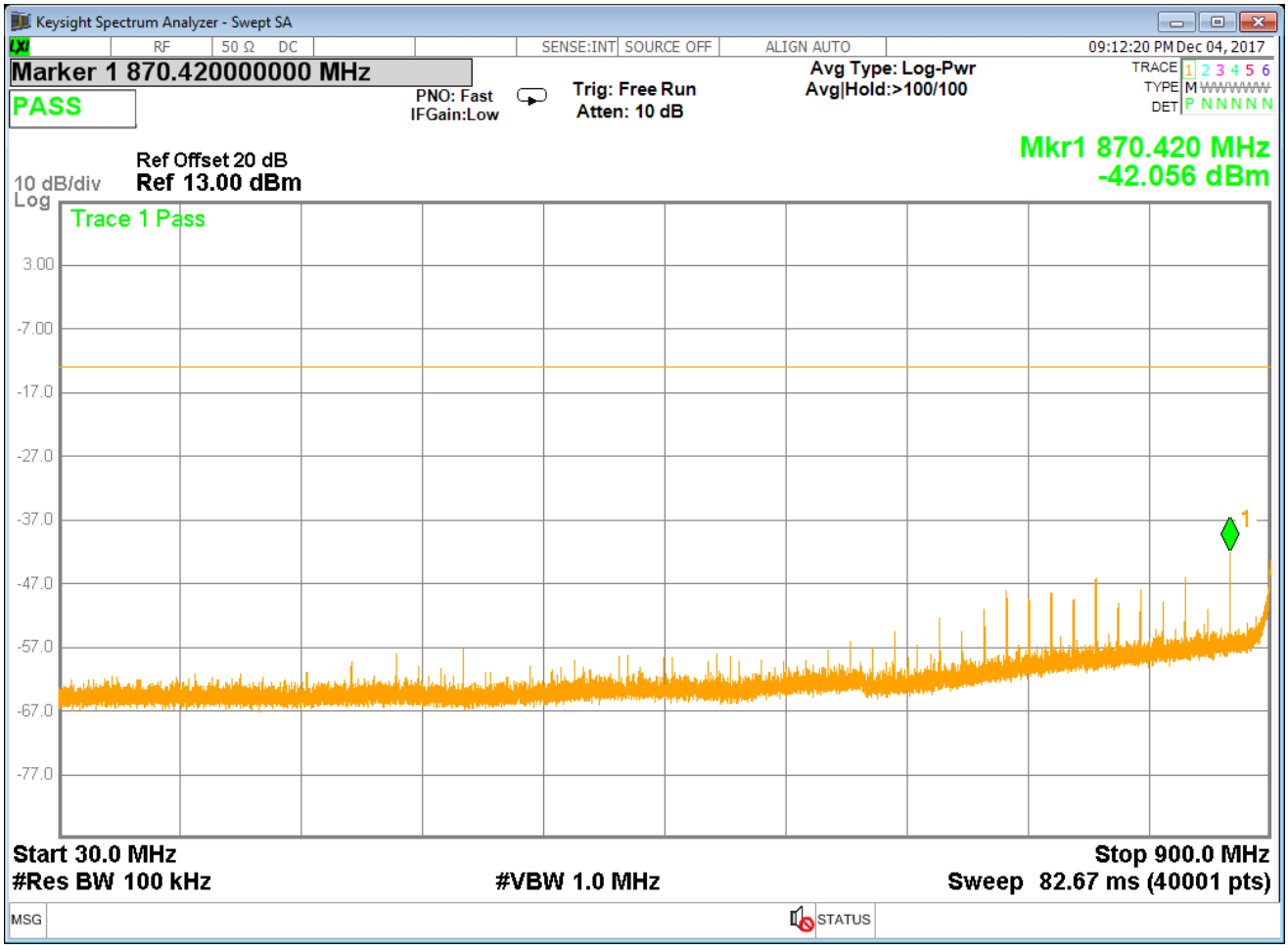


Figure 27: Conducted Spurious Emissions, Drive-By Mode, Low Channel 900 – 930MHz

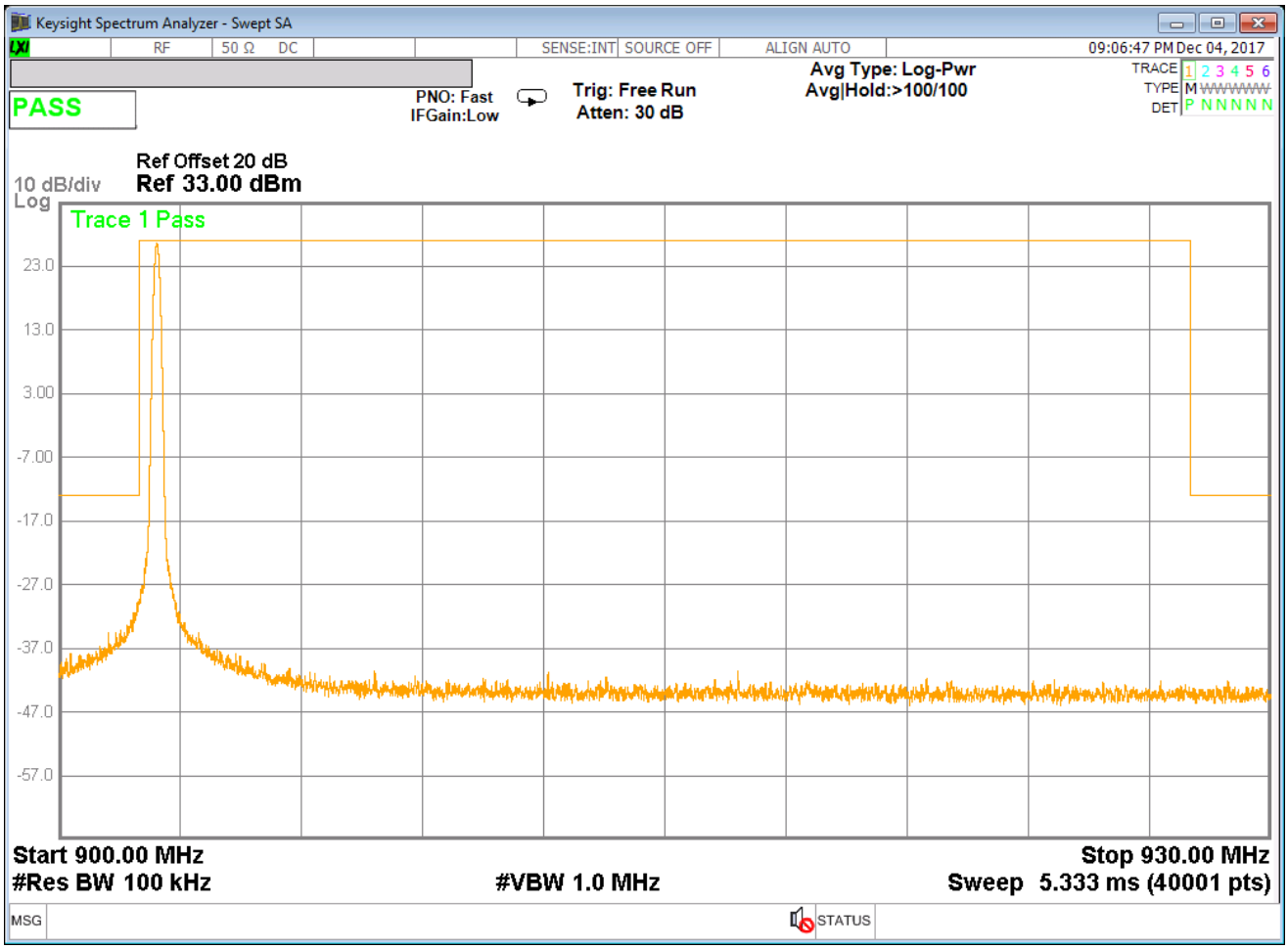


Figure 28: Conducted Spurious Emissions, Drive-By Mode, Low Channel 930 – 5000MHz

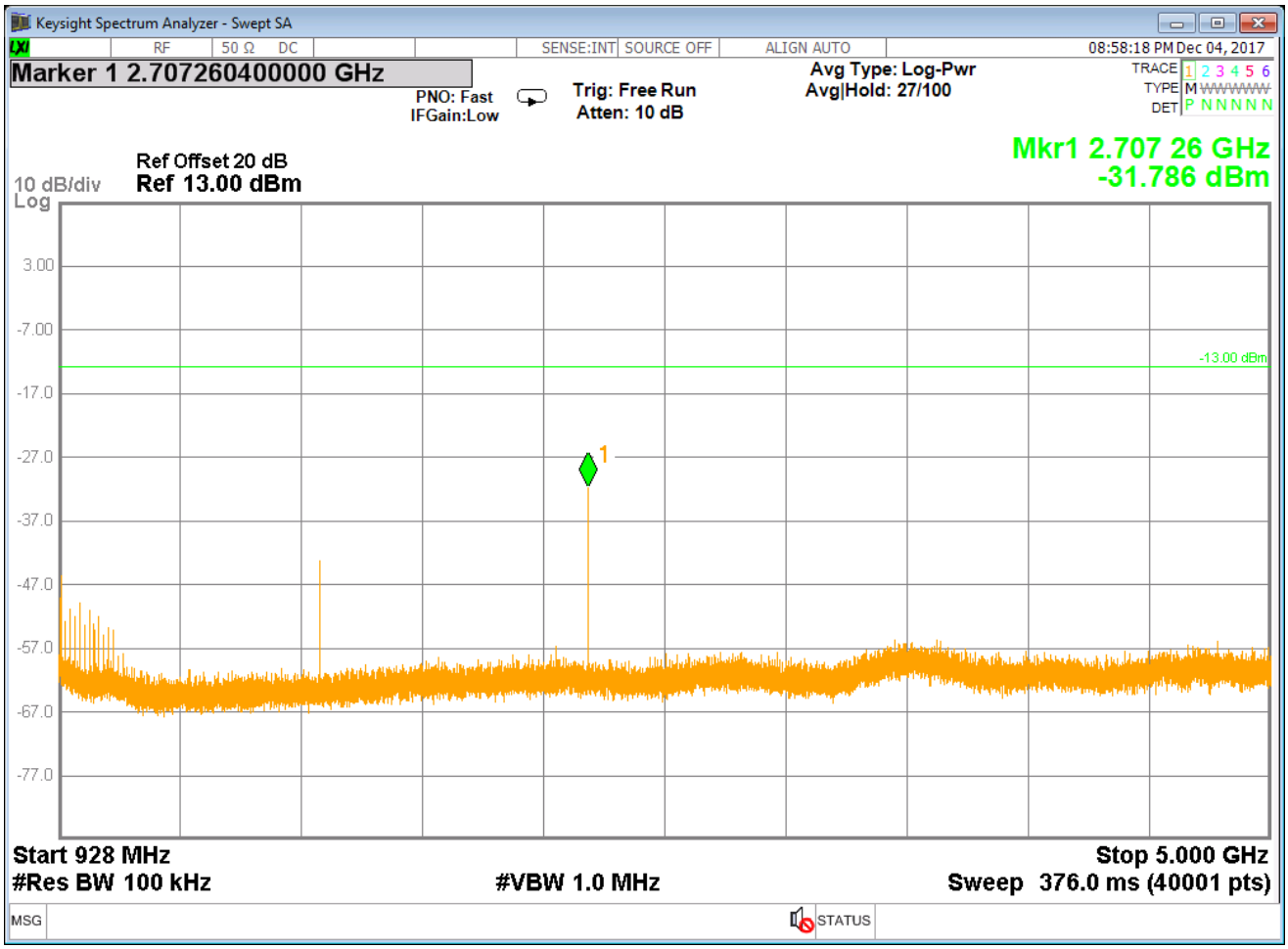


Figure 29: Conducted Spurious Emissions, Drive-By Mode, Low Channel 5 – 10GHz

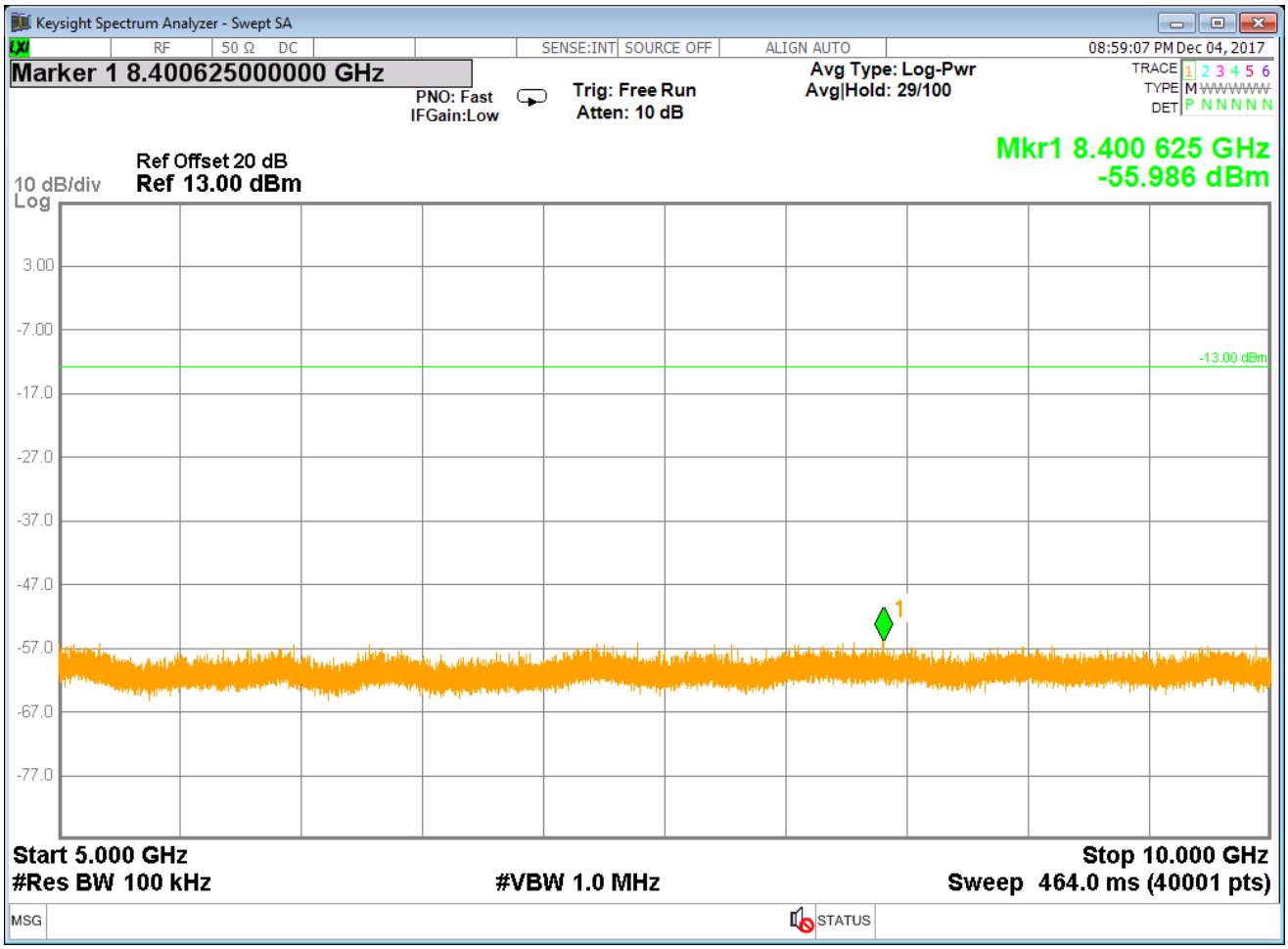


Figure 30: Conducted Spurious Emissions, Drive-By Mode, Center Channel 30 - 900MHz

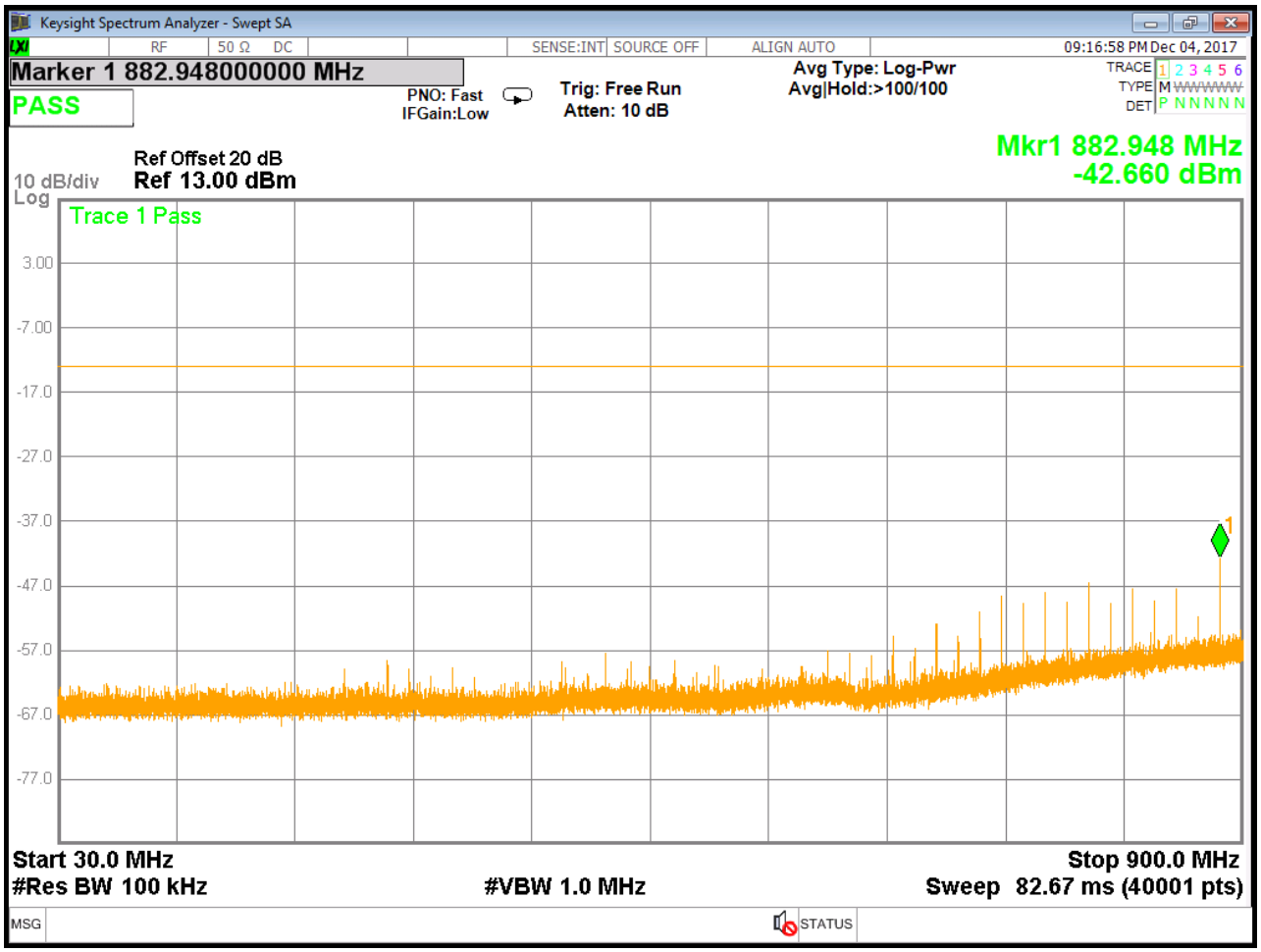


Figure 31: Conducted Spurious Emissions, Drive-By Mode, Center Channel 900 – 930MHz

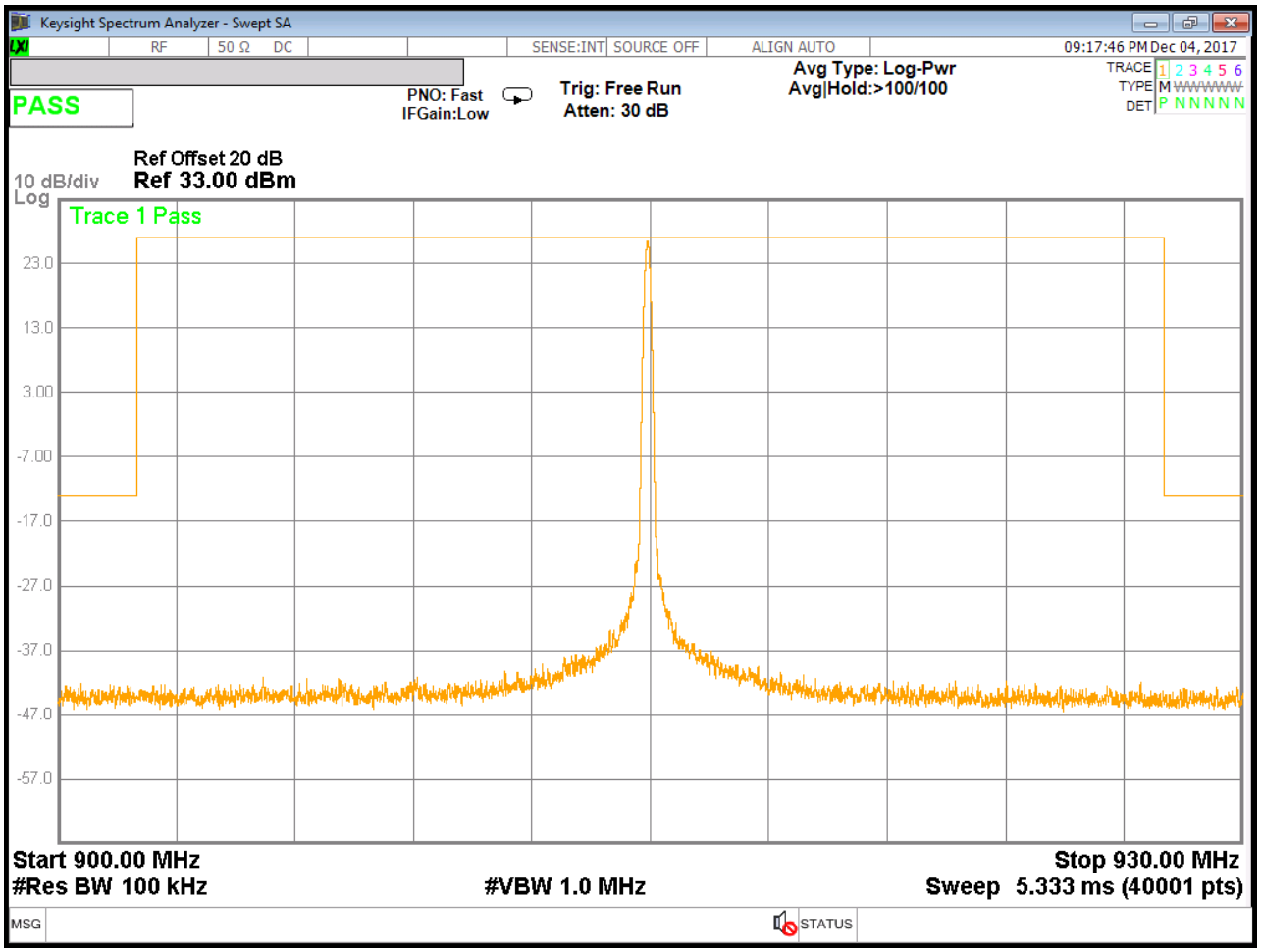


Figure 32: Conducted Spurious Emissions, Drive-By Mode, Center Channel 930 – 5000MHz

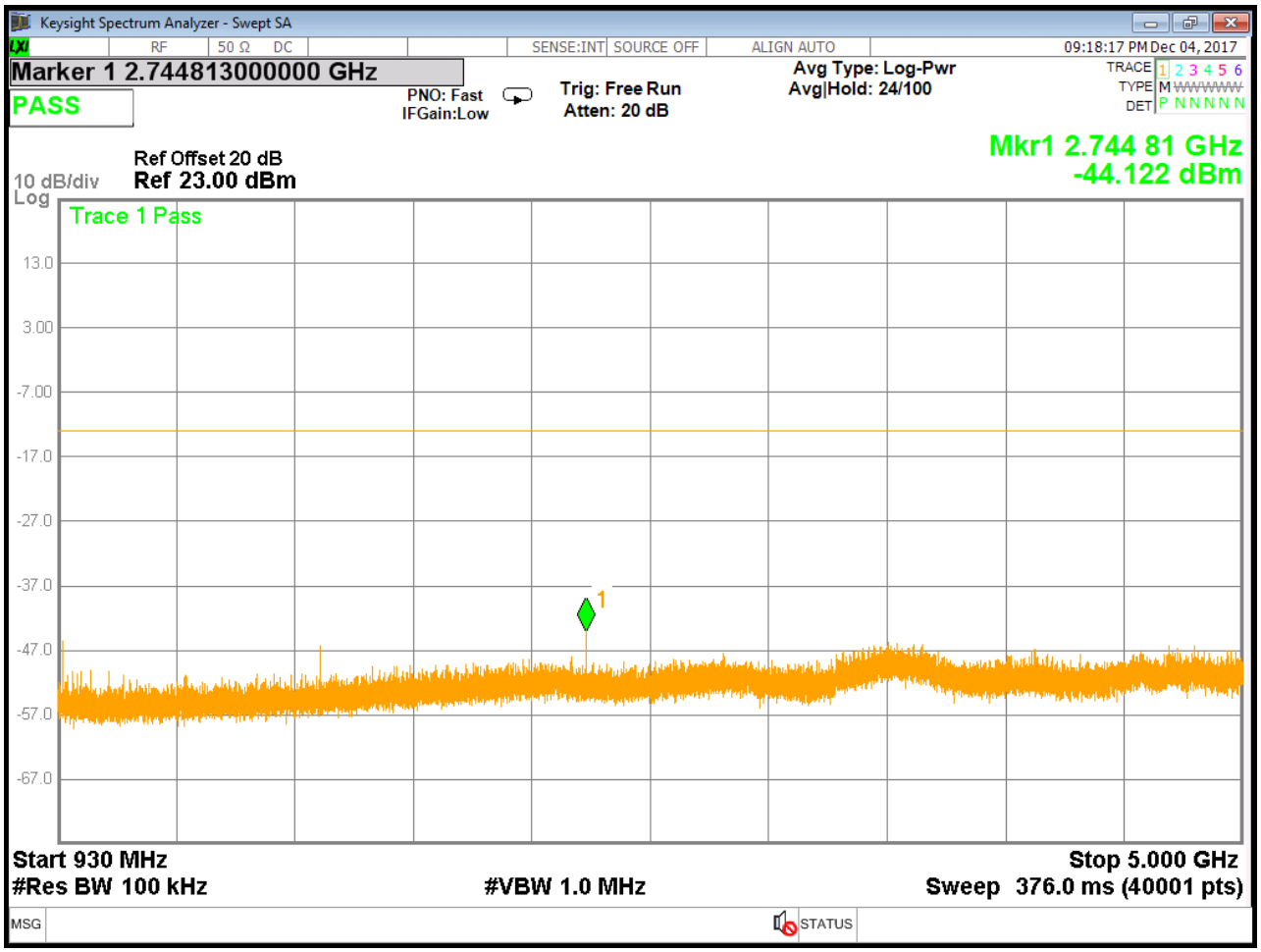


Figure 33: Conducted Spurious Emissions, Drive-By Mode, Center Channel 5 – 10GHz

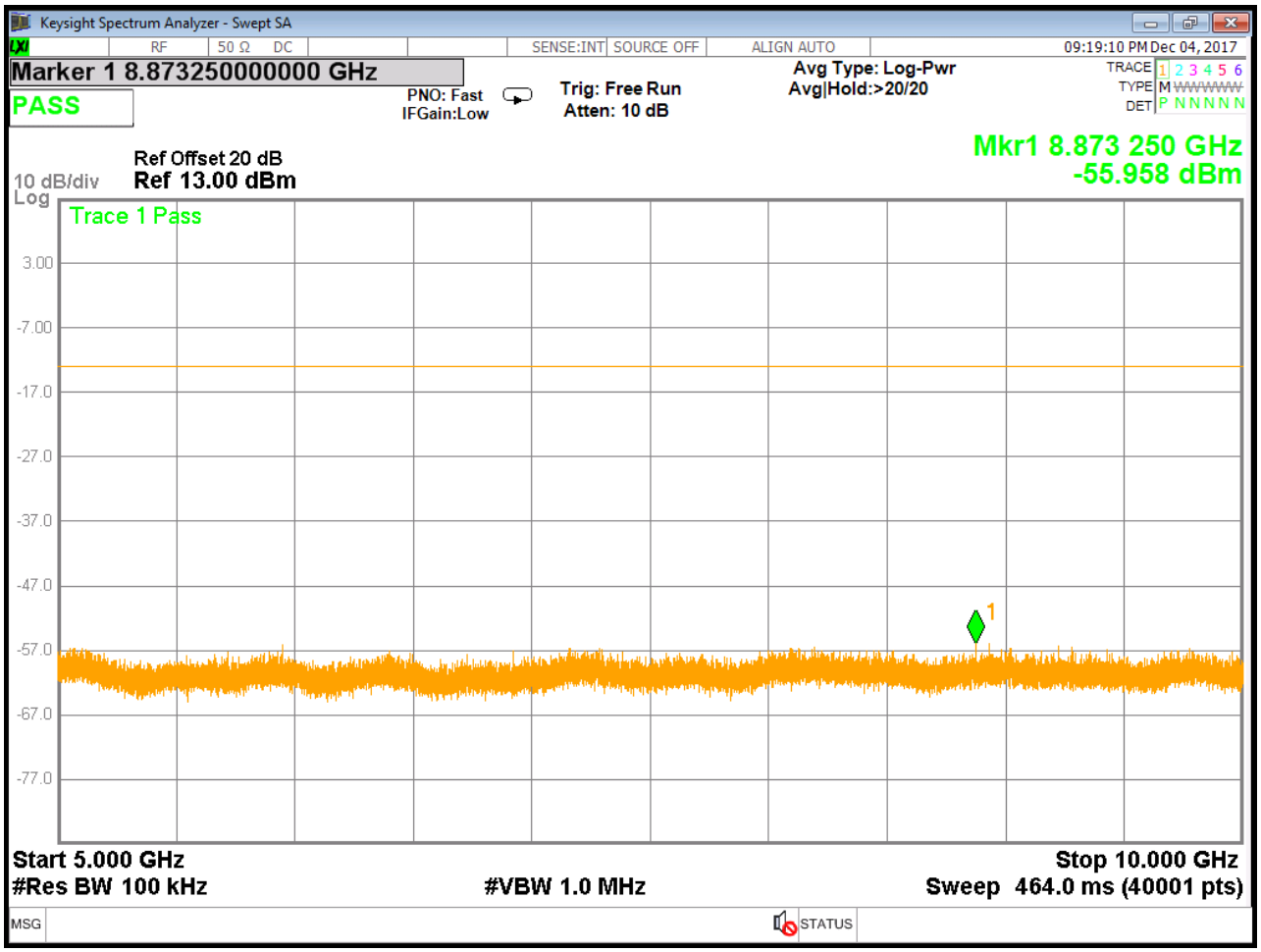


Figure 34: Conducted Spurious Emissions, Drive-By Mode, High Channel 30 - 900MHz

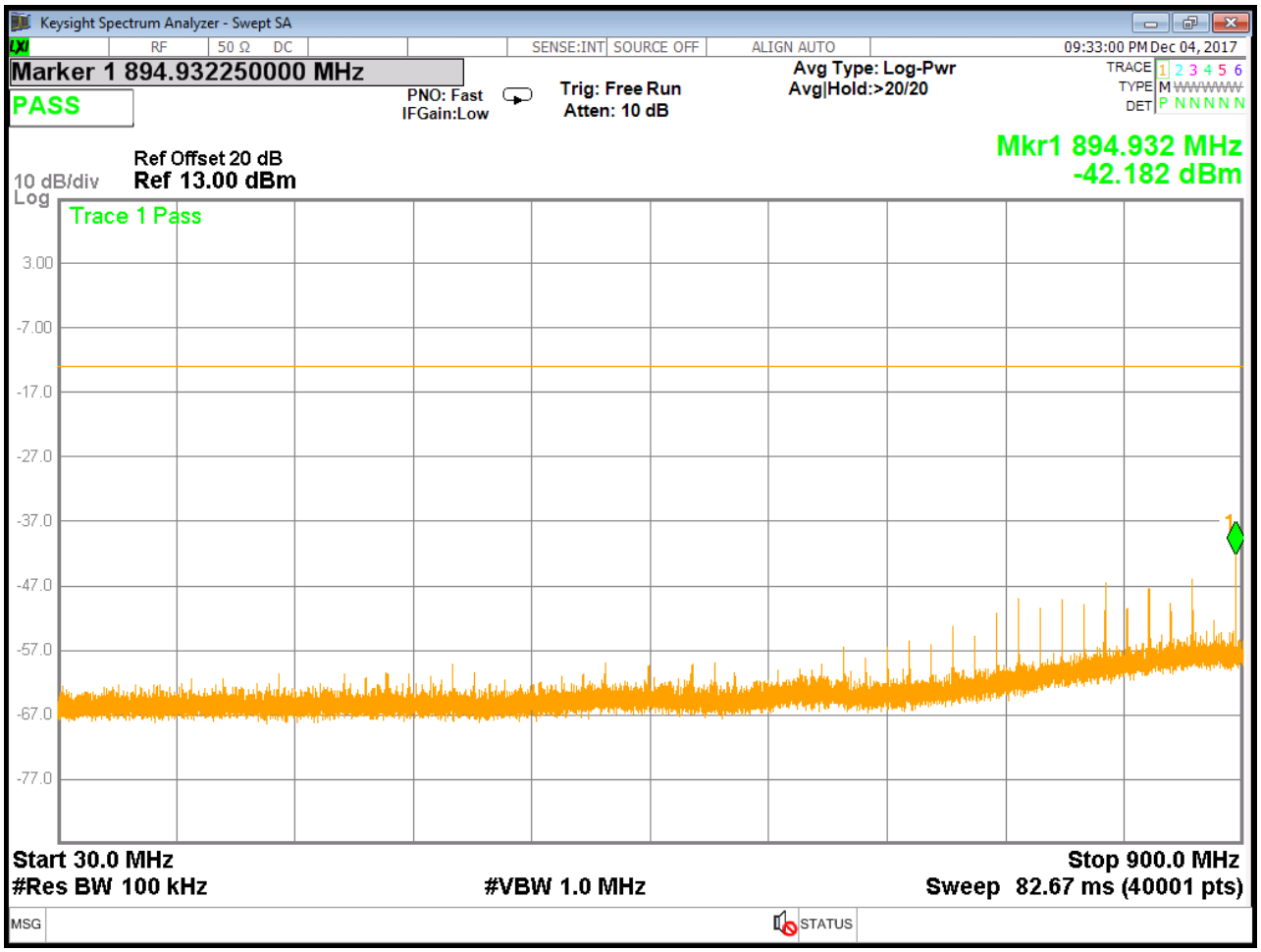


Figure 35: Conducted Spurious Emissions, Drive-By Mode, High Channel 900 – 930MHz

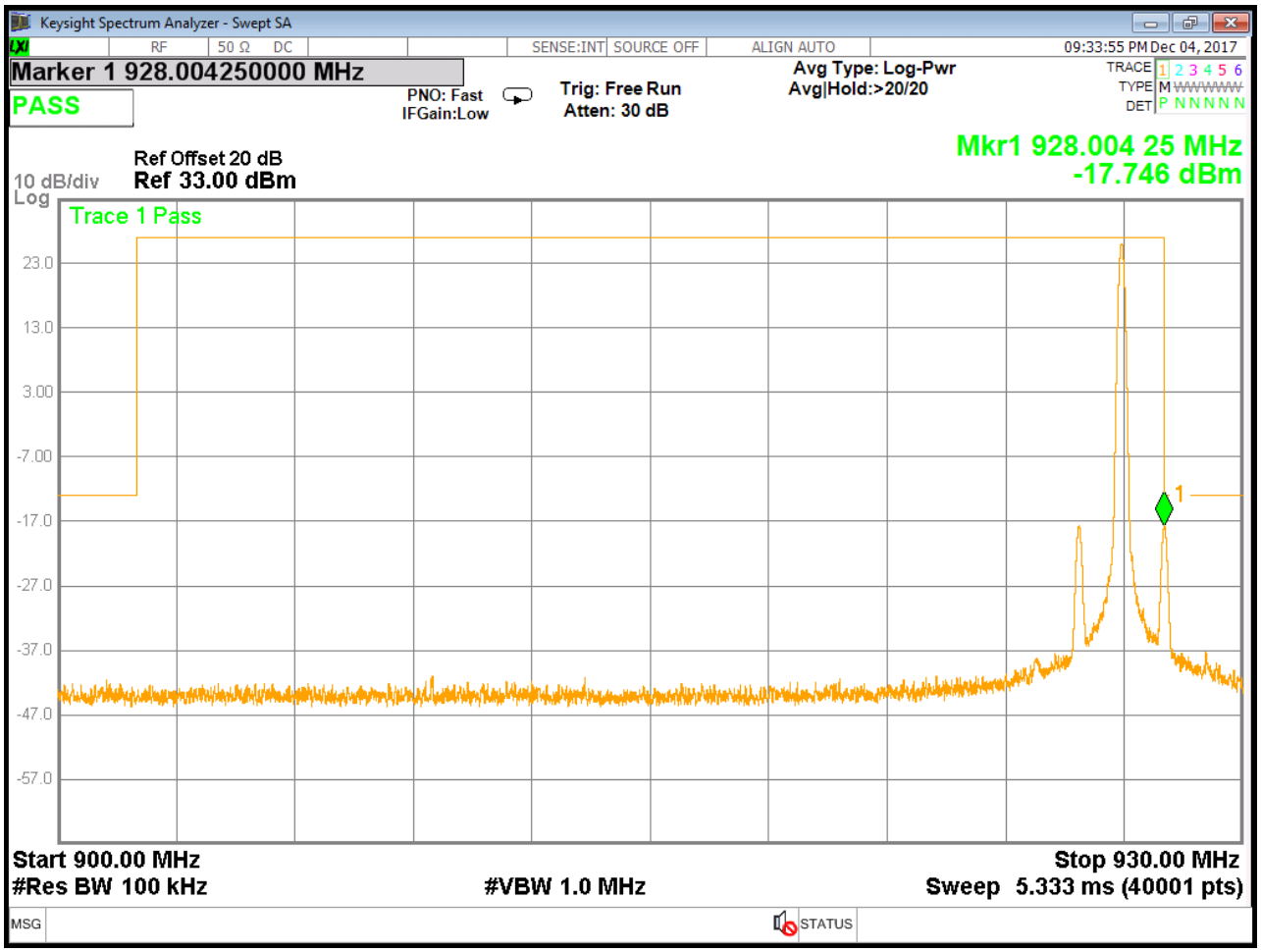


Figure 36: Conducted Spurious Emissions, Drive-By Mode, High Channel 930 – 5000MHz

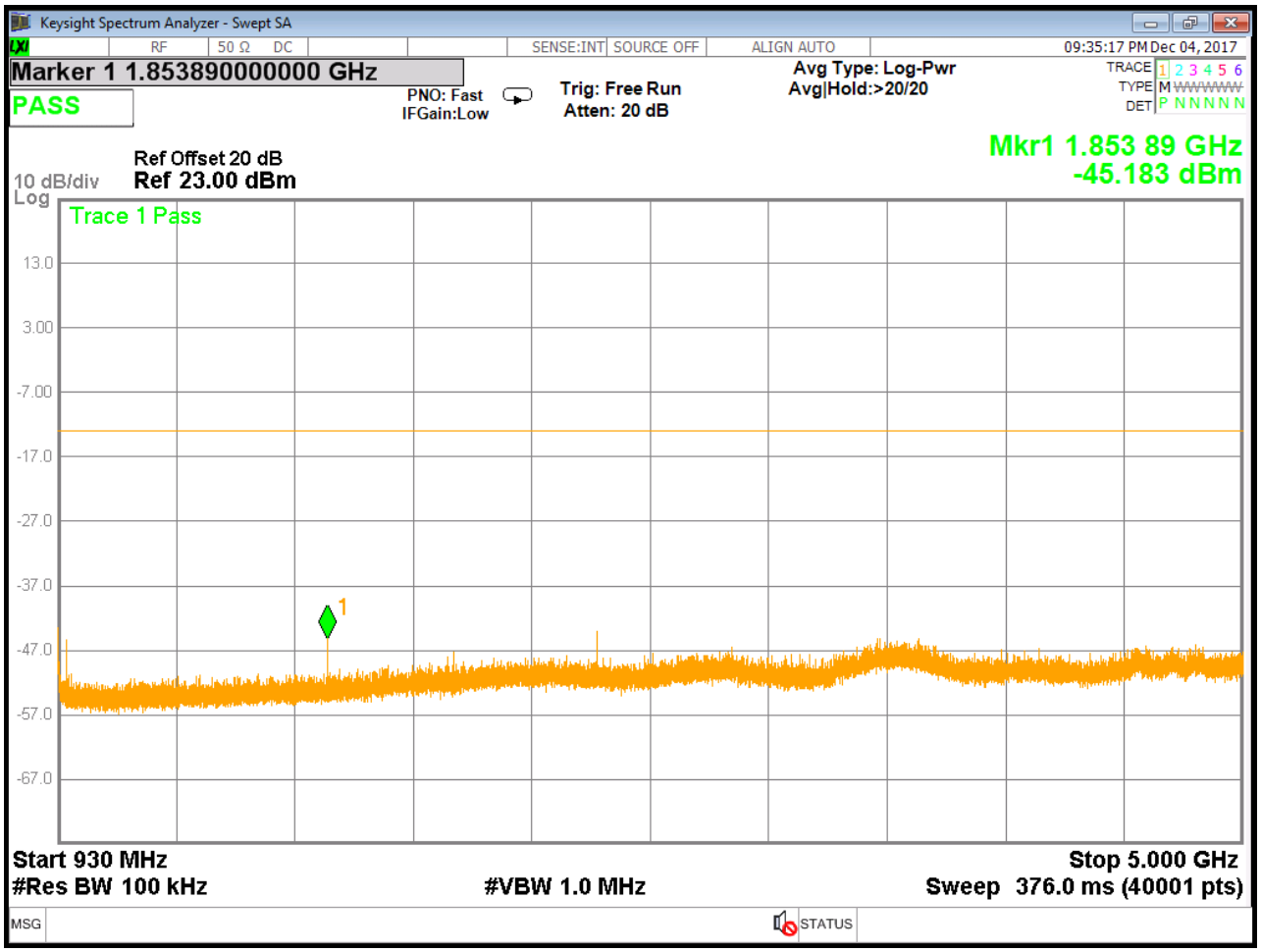
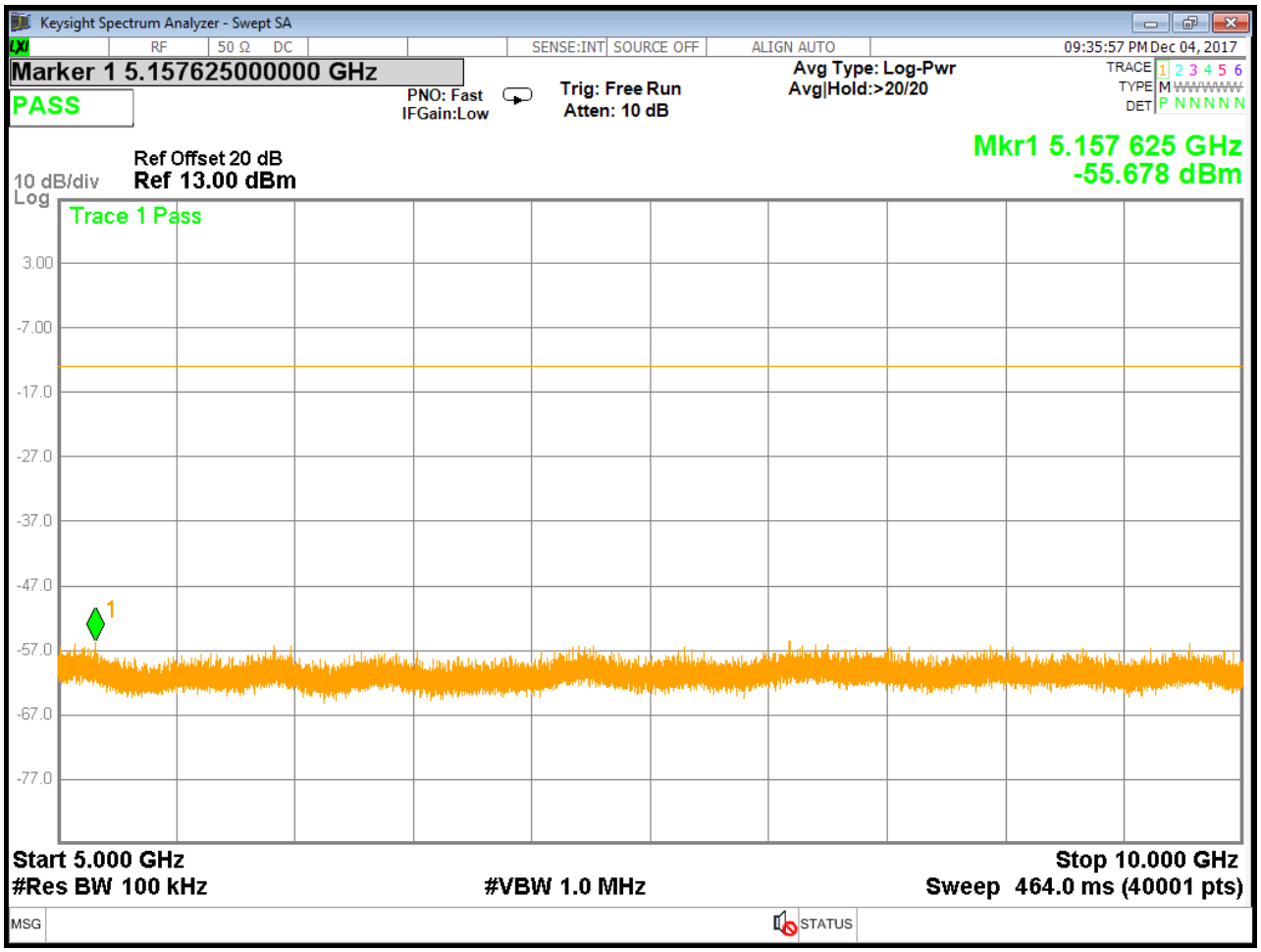


Figure 37: Conducted Spurious Emissions, Drive-By Mode, High Channel 5 – 10GHz



3.7 BAND EDGE COMPLIANCE

In accordance with C63.10, the marker delta method was used to demonstrate band edge compliance. Close up plots of the upper and lower 902-928MHz Band-edges in both Mesh and Drive-by modes are provided below with the EUT fixed at the lower and upper frequencies. Plots are also provided with the EUT hopping functions enabled. Emissions must be attenuated 20dB from the peak emission outside of the 902-928 Band.

The following are plots of the conducted spurious emissions data.

Figure 38: Mesh Mode, Lower Band-edge, Hopping Mode

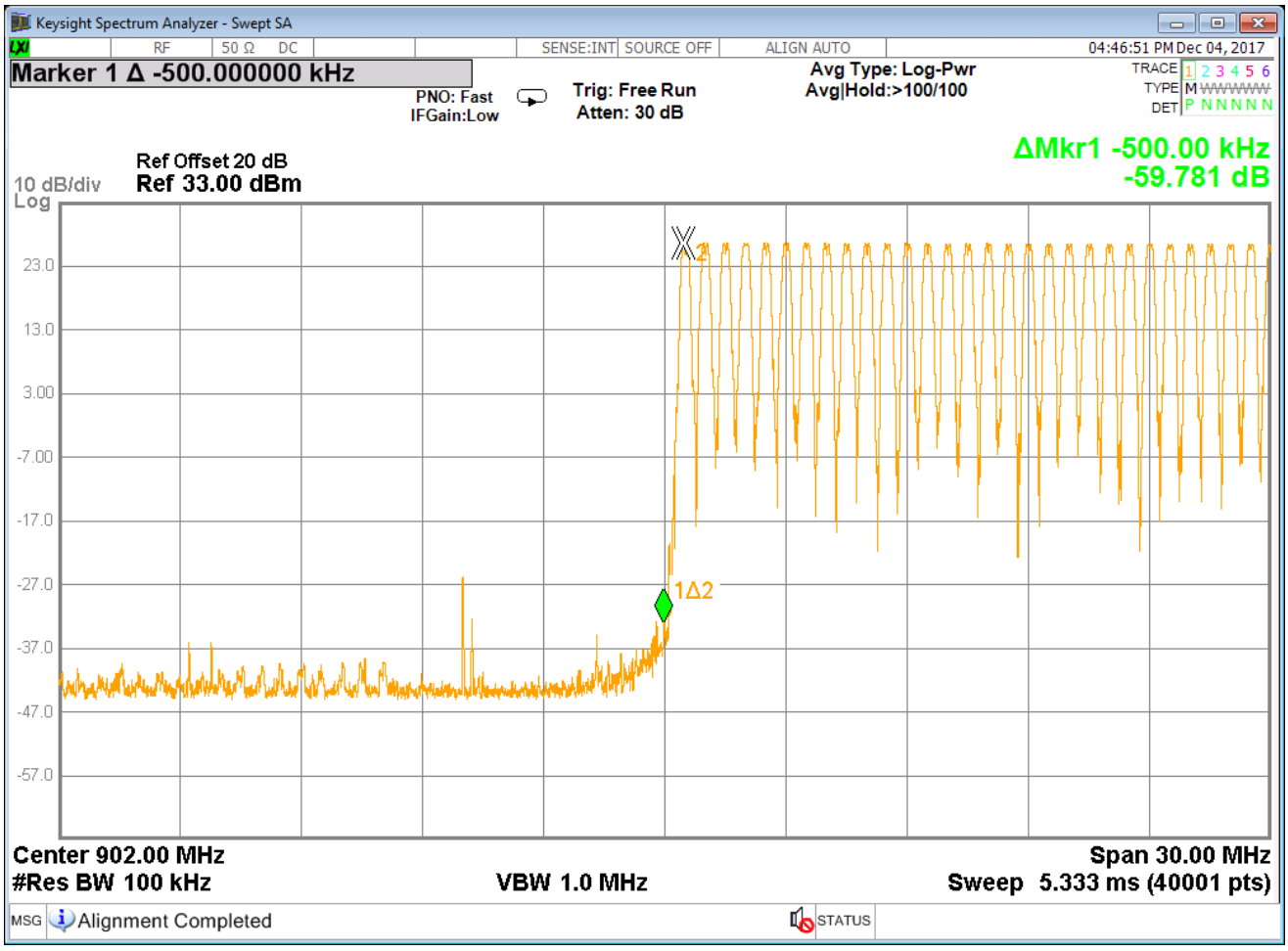


Figure 39: Mesh Mode, Upper Band-edge, Hopping Mode

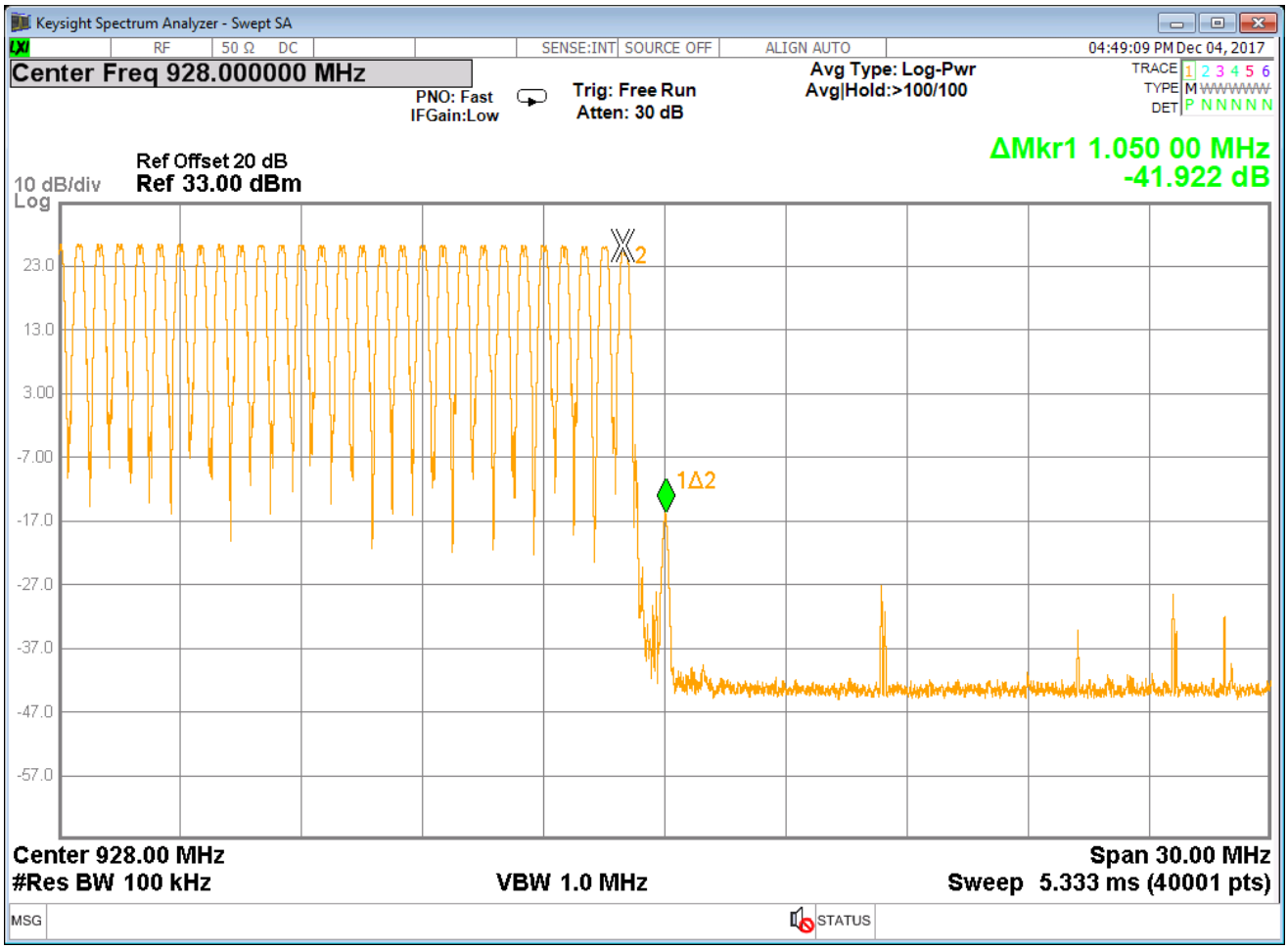


Figure 40: Mesh Mode, Lower Band-edge, Non-Hopping

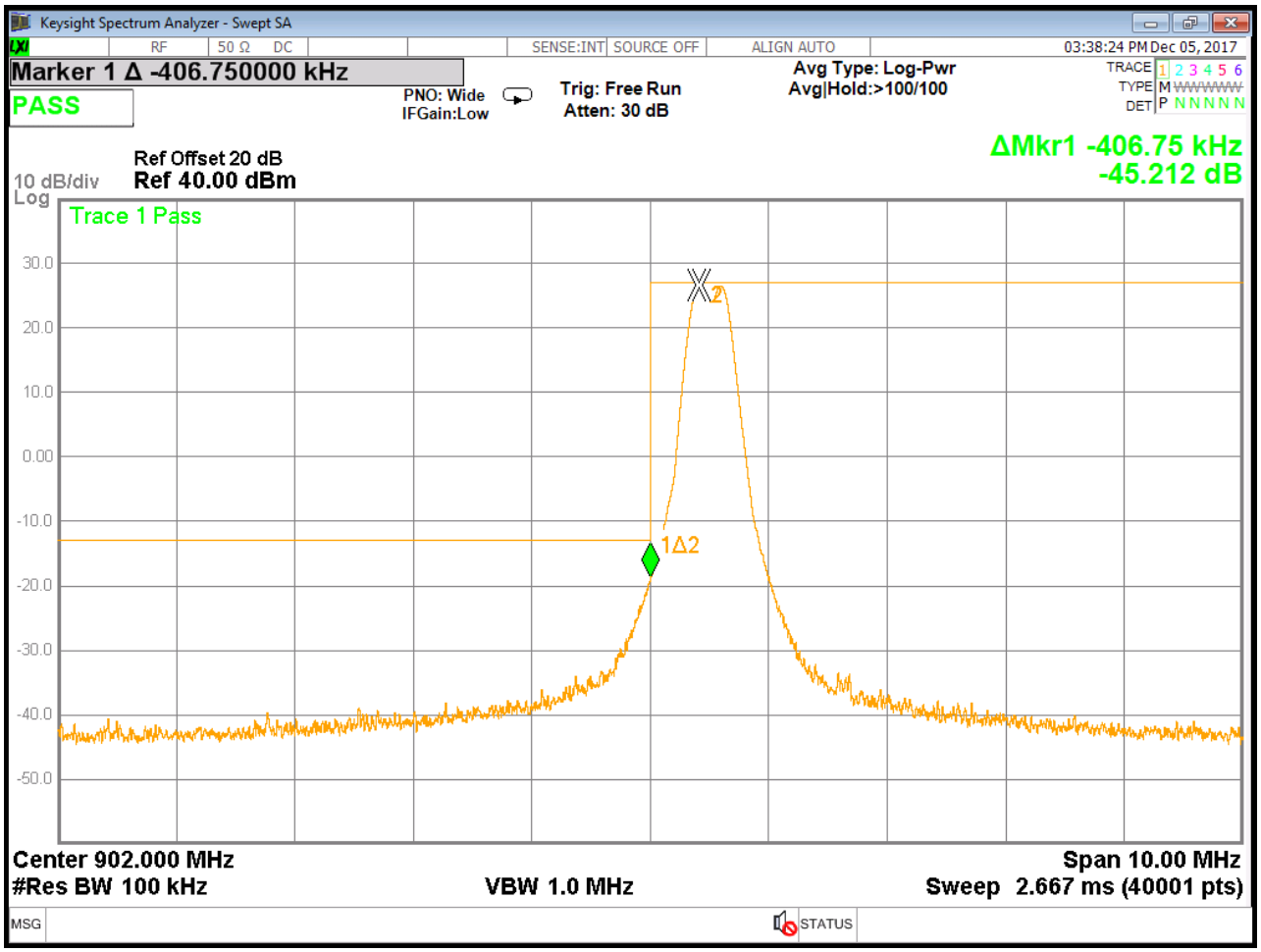


Figure 41: Mesh Mode, Upper Band-edge, Non-Hopping

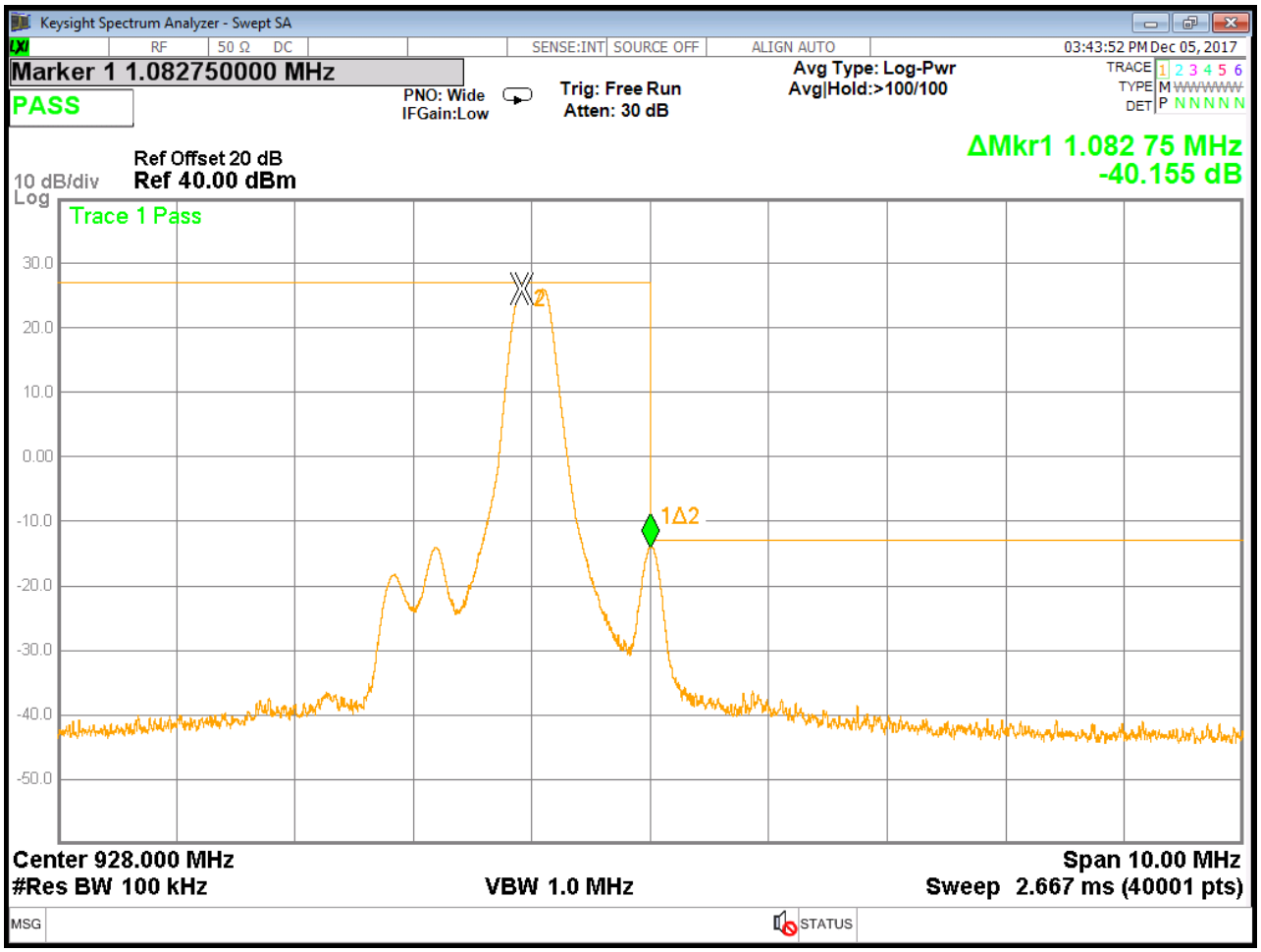


Figure 42: Drive-By Mode, Lower Band-edge, Hopping Mode

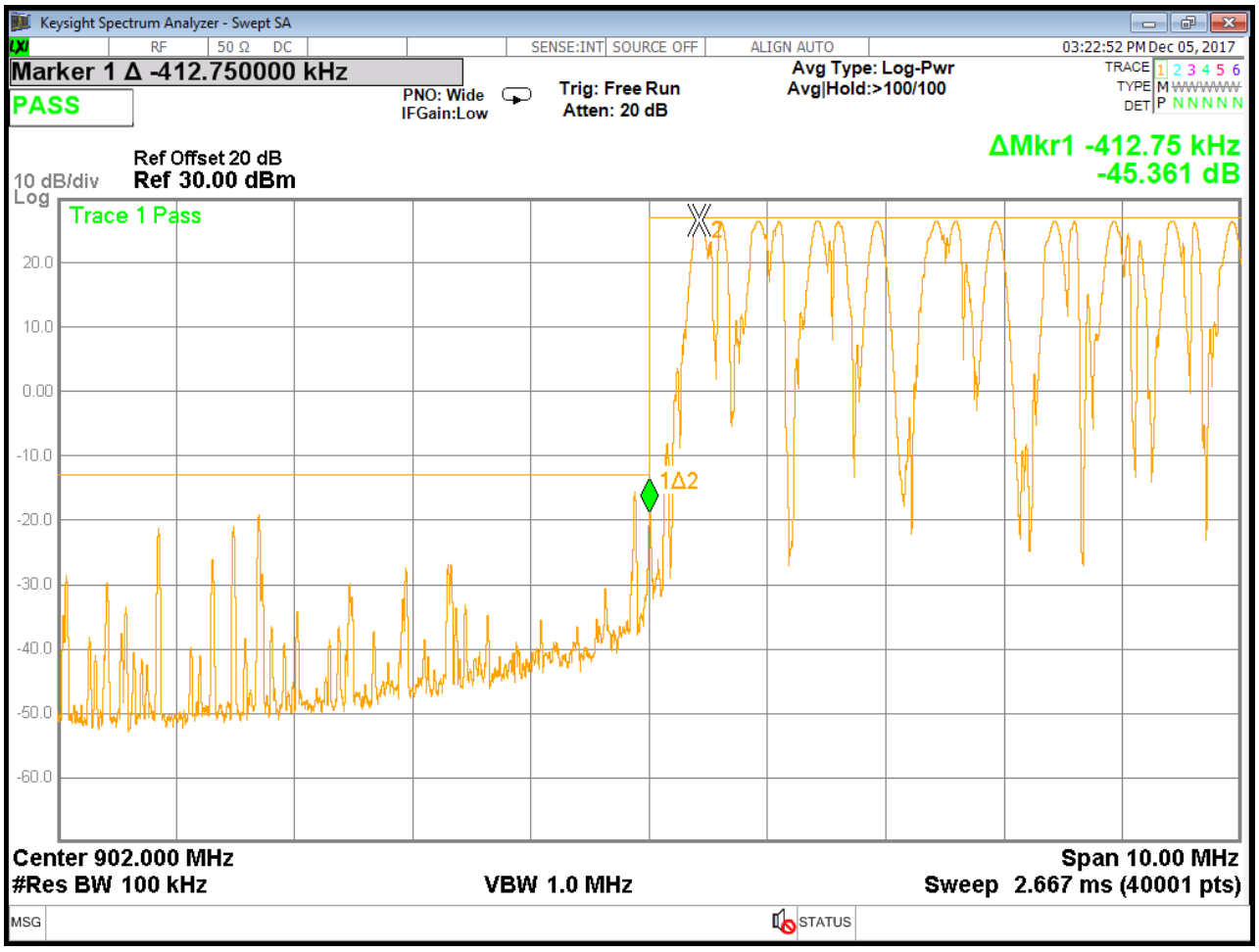


Figure 43: Drive-By Mode, Upper Band-edge, Hopping Mode

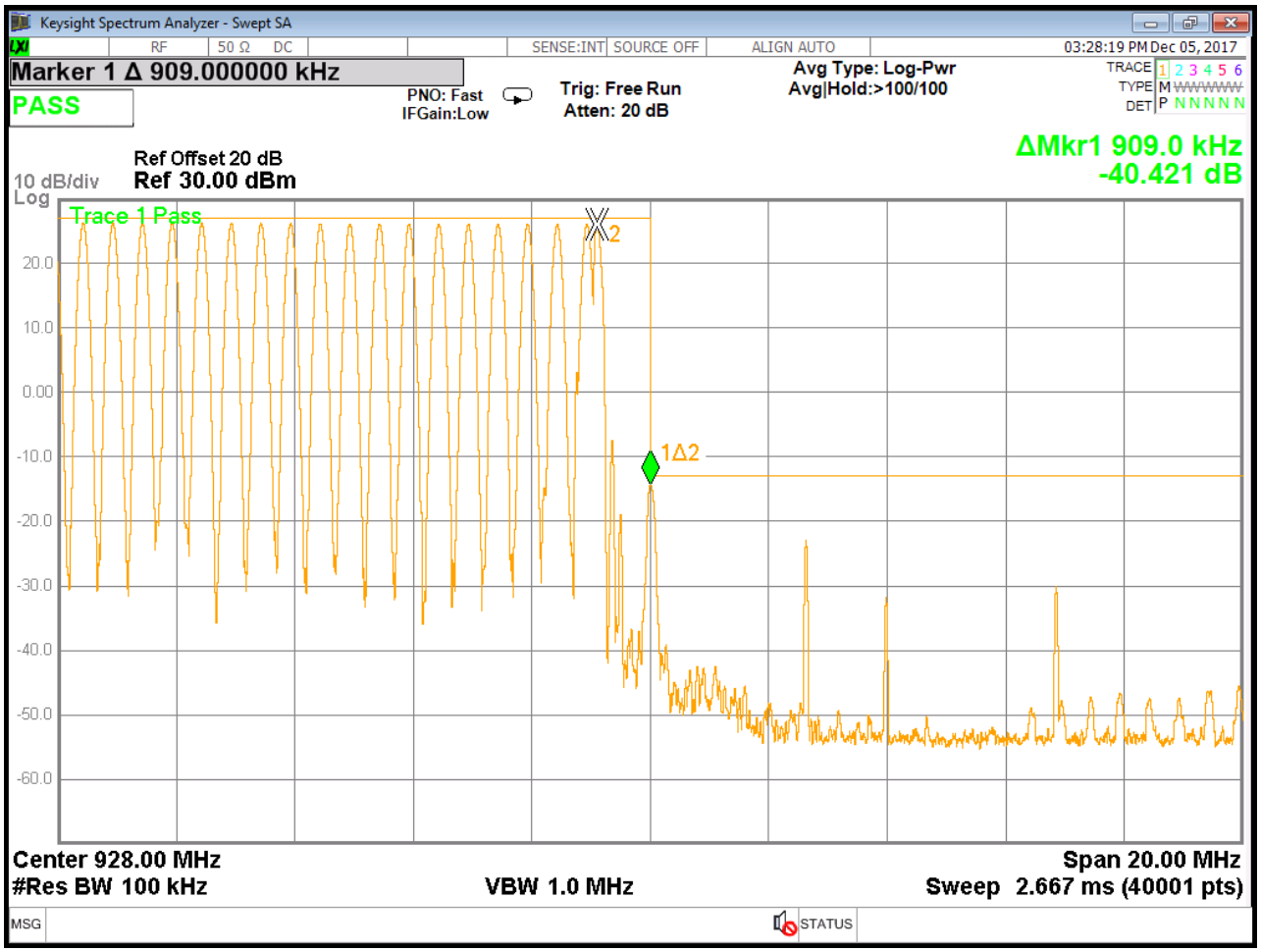


Figure 44: Drive-By Mode, Lower Band-edge, Non-Hopping

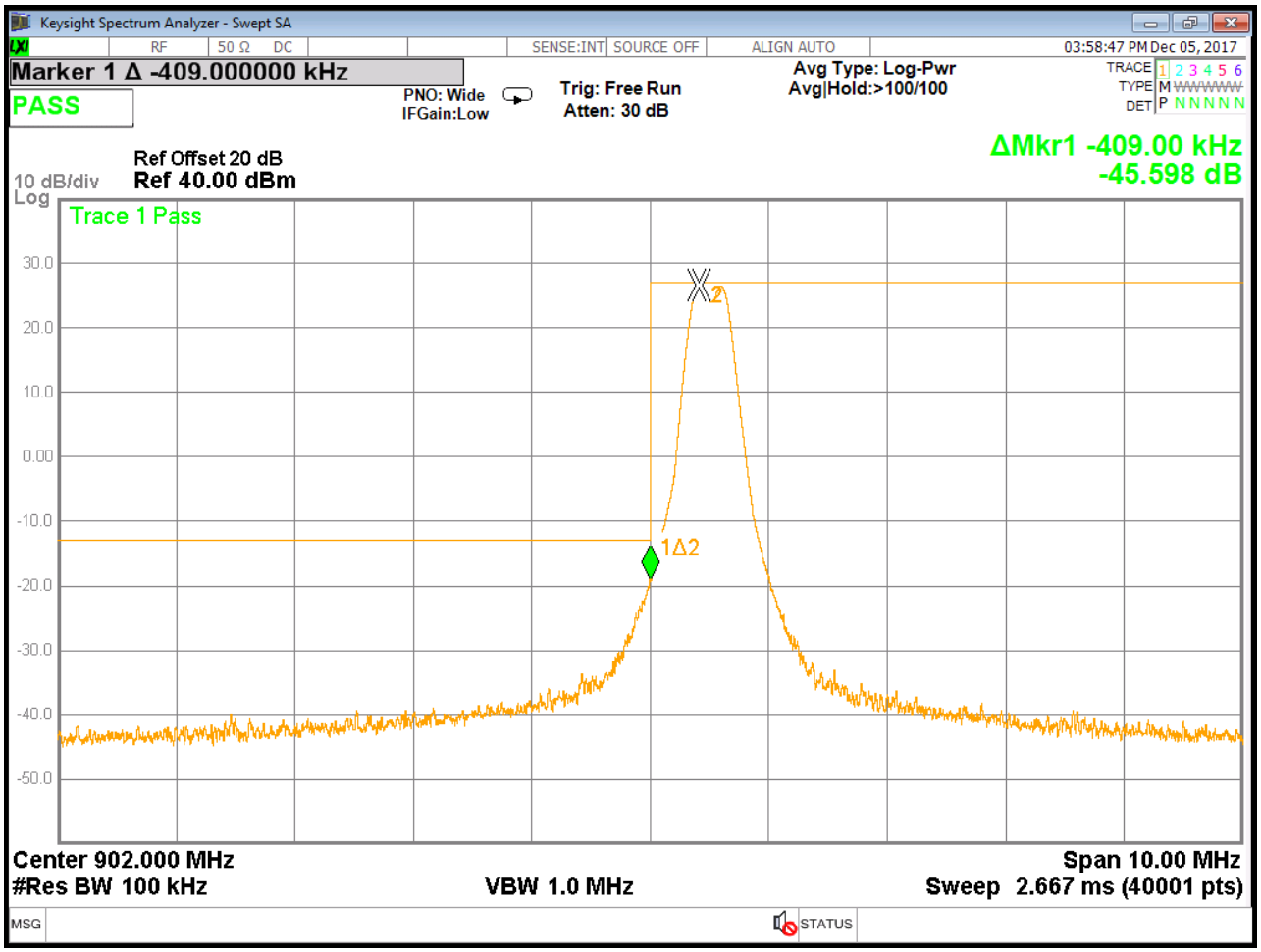
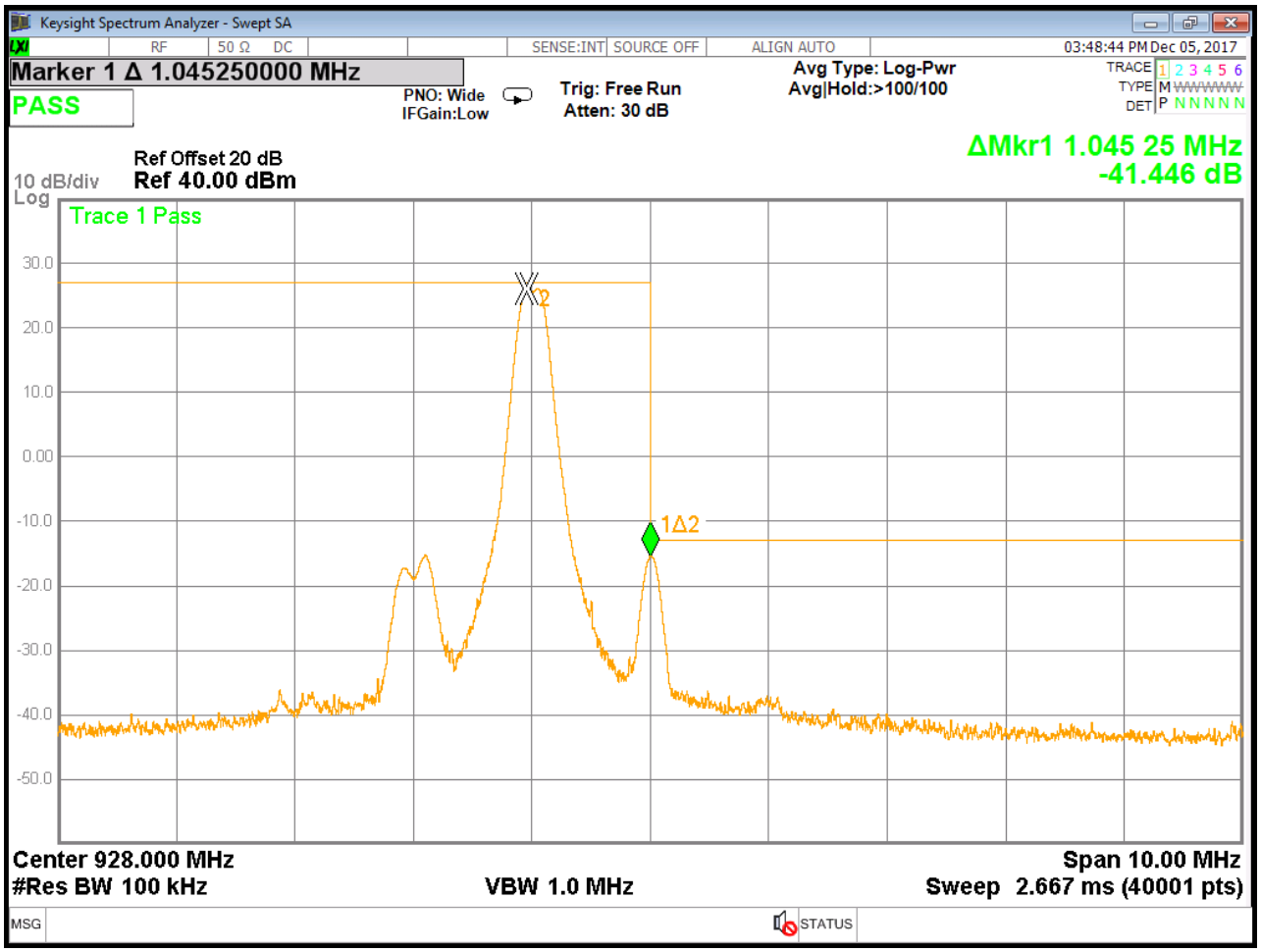


Figure 45: Drive-By Mode, Upper Band-edge, Non-Hopping



3.8 RADIATED SPURIOUS EMISSIONS: (FCC PART §2.1053)

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.

3.8.1 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 C63.4-2014. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

For emission measurements above 1 GHz, the EUT was placed at a height of 1.5 m above the floor on a support made of styrene. The 1.5 m height EUT was achieved by placing the styrene on top of a table with a height of 0.8 m. The EUT was oriented in 3 orthogonals, upright, lying flat and on its side to account for multiple mounting orientations.

The EUT has 2 modes of operation, Mesh Mode and Drive-by Mode. Both modes were evaluated and worst case emissions are represented with the EUT in its upright position and operating in the Mesh Mode.

The emissions were measured using the following resolution bandwidths:

Table 9: Spectrum Analyzer Settings

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

Table 10: Radiated Emission Test Data, Restricted Bands <1GHz

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
120.00	V	180.00	1.00	31.53	-9.5	12.6	150.0	-21.5	Peak
240.02	V	225.00	1.00	34.96	-11.6	14.7	200.0	-22.7	Peak
257.52	V	0.00	1.80	34.20	-11.4	13.8	200.0	-23.2	Peak
120.00	H	225.00	3.50	35.20	-9.5	19.2	150.0	-17.9	Peak
240.02	H	315.00	3.50	34.21	-11.6	13.4	200.0	-23.5	Peak
257.52	H	0.00	2.80	34.89	-11.4	15.0	200.0	-22.5	Peak

Table 11: Radiated Emission Test Data, Restricted Bands >1GHz, Low Channel

Freq MHz	Pol H/V	Azi Degree	Ant. Ht m	SA Level dBuV	Corr Factor dB	Corr. Level uV/m	Limit uV/m	Mar dB	Com
2707.50	V	180.00	1.00	61.72	1.2	1395.5	5000.0	-11.1	Peak
2707.50	V	180.00	1.00	45.22	1.2	208.8	500.0	-7.6	Average
3610.00	V	90.00	1.00	51.50	3.0	532.2	5000.0	-19.5	Peak
3610.00	V	90.00	1.00	35.10	3.0	80.6	500.0	-15.9	Average
4512.50	V	135.00	1.00	49.75	5.2	561.6	5000.0	-19.0	Peak
4512.50	V	135.00	1.00	38.31	5.2	150.5	500.0	-10.4	Average
8122.50	V	135.00	1.20	47.20	15.6	1381.5	5000.0	-11.2	Peak
8122.50	V	135.00	1.20	34.05	15.6	304.0	500.0	-4.3	Average
9025.00	V	315.00	1.20	48.60	17.1	1928.6	5000.0	-8.3	Peak
9025.00	V	315.00	1.20	34.40	17.1	376.0	500.0	-2.5	Average
2707.50	H	45.00	1.50	60.42	1.2	1201.5	5000.0	-12.4	Peak
2707.50	H	45.00	1.50	47.72	1.2	278.4	500.0	-5.1	Average
3610.00	H	90.00	1.50	51.20	3.0	514.1	5000.0	-19.8	Peak
3610.00	H	90.00	1.50	35.03	3.0	79.9	500.0	-15.9	Average
4512.50	H	90.00	1.50	55.38	5.2	1073.9	5000.0	-13.4	Peak
4512.50	H	90.00	1.50	35.24	5.2	105.7	500.0	-13.5	Average

Table 12: Radiated Emission Test Data, Restricted Bands >1GHz, Center Channel

Freq MHz	Pol H/V	Azi Degree	Ant. Ht m	SA Level dBuV	Corr Factor dB	Corr. Level uV/m	Limit uV/m	Mar dB	Com
2745.00	V	180.00	1.00	60.18	1.2	1173.0	5000.0	-12.6	Peak
2745.00	V	180.00	1.00	49.81	1.2	355.5	500.0	-3.0	Average
3660.00	V	90.00	1.00	49.78	3.1	440.3	5000.0	-21.1	Peak
3660.00	V	90.00	1.00	37.83	3.1	111.2	500.0	-13.1	Average
4575.00	V	135.00	1.00	56.44	5.4	1240.7	5000.0	-12.1	Peak
4575.00	V	135.00	1.00	39.41	5.4	174.7	500.0	-9.1	Average
9150.00	V	315.00	1.20	46.87	17.4	1642.0	5000.0	-9.7	Peak
9150.00	V	315.00	1.20	33.82	17.4	365.5	500.0	-2.7	Average
2745.00	H	45.00	1.50	63.88	1.2	65.1	70.0	-4.9	Peak
2745.00	H	45.00	1.50	45.31	1.2	46.5	70.0	-23.5	Average
3660.00	H	90.00	1.50	52.26	3.1	55.4	74.0	-18.6	Peak
3660.00	H	90.00	1.50	36.01	3.1	39.1	74.0	-34.9	Average
4575.00	H	90.00	1.50	59.78	5.4	65.2	74.0	-8.8	Peak
4575.00	H	90.00	1.50	35.39	5.4	40.8	74.0	-33.2	Average
9150.00	H	270.00	1.50	45.60	17.4	1418.6	5000.0	-10.9	Peak
9150.00	H	270.00	1.50	33.40	17.4	348.2	500.0	-3.1	Average

Table 13: Radiated Emission Test Data, Restricted Bands >1GHz, High Channel

Freq MHz	Pol H/V	Azi Degree	Ant. Ht m	SA Level dBuV	Corr Factor dB	Corr. Level uV/m	Limit uV/m	Mar dB	Com
2782.50	V	45.00	1.00	60.10	1.2	1166.4	5000.0	-12.6	Peak
2782.50	V	45.00	1.00	49.50	1.2	344.2	500.0	-3.2	Average
4637.50	V	135.00	1.00	53.43	5.8	919.9	5000.0	-14.7	Peak
4637.50	V	135.00	1.00	34.50	5.8	104.0	500.0	-13.6	Average
7420.00	V	135.00	1.20	44.50	14.9	931.3	5000.0	-14.6	Peak
7420.00	V	135.00	1.20	31.40	14.9	206.1	500.0	-7.7	Average
2782.50	H	45.00	1.50	58.60	1.2	981.4	5000.0	-14.1	Peak
2782.50	H	45.00	1.50	46.20	1.2	235.4	500.0	-6.5	Average
4637.50	H	90.00	1.50	52.80	5.8	855.5	5000.0	-15.3	Peak
4637.50	H	90.00	1.50	35.20	5.8	112.8	500.0	-12.9	Average
7420.00	H	135.00	1.50	43.20	14.9	801.8	5000.0	-15.9	Peak
7420.00	H	135.00	1.50	32.20	14.9	226.0	500.0	-6.9	Average

3.9 RECEIVER RADIATED SPURIOUS EMISSIONS: (RSS-210 SECT 2.6)

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 §15.109 for peak measurements.

3.9.1 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 C63.4-2014. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The emissions were measured using the following resolution bandwidths:

Table 14: Spectrum Analyzer Settings

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

Table 15: Radiated Emission Test Data, Receiver

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
45.87	V	180.00	1.00	42.04	-14.2	24.7	100.0	-12.2	
60.01	V	180.00	1.00	47.42	-16.8	34.1	100.0	-9.3	
64.23	V	180.00	1.00	46.61	-16.2	33.1	100.0	-9.6	
72.01	V	90.00	1.00	47.56	-15.6	39.6	100.0	-8.0	
120.00	V	180.00	1.00	31.53	-9.5	12.6	150.0	-21.5	
240.02	V	225.00	1.00	34.96	-11.6	14.7	200.0	-22.7	
257.52	V	0.00	1.80	34.20	-11.4	13.8	200.0	-23.2	
312.04	V	0.00	1.80	34.20	-9.6	16.9	200.0	-21.5	
384.03	V	0.00	1.80	34.93	-8.2	21.6	200.0	-19.3	
576.05	V	180.00	1.60	32.74	-3.6	28.6	200.0	-16.9	

45.87	H	0.00	3.50	41.02	-14.2	21.9	100.0	-13.2	
60.01	H	0.00	3.50	45.18	-16.8	26.3	100.0	-11.6	
64.01	H	0.00	3.50	40.42	-16.2	16.2	100.0	-15.8	
72.00	H	0.00	3.50	49.28	-15.6	48.3	100.0	-6.3	
120.00	H	225.00	3.50	35.20	-9.5	19.2	150.0	-17.9	
240.02	H	315.00	3.50	34.21	-11.6	13.4	200.0	-23.5	
257.52	H	0.00	2.80	34.89	-11.4	15.0	200.0	-22.5	
312.04	H	0.00	2.80	33.78	-9.6	16.1	200.0	-21.9	
384.03	H	180.00	2.50	33.21	-8.2	17.7	200.0	-21.1	
512.01	H	180.00	2.50	32.63	-4.8	24.5	200.0	-18.2	

No frequencies noted above 1GHz

3.10 AC CONDUCTED EMISSIONS (FCC PART §15.207)

The unit is battery powered and therefore AC conducted emissions are not applicable.