Washington Laboratories, Ltd.

FCC PART 15.247 CERTIFICATION TEST REPORT

For the

Stealth Reader - Water (WM2F)

FCC ID: 2ACOA-WM2F

REPORT# 15327-01-01 REV 0

Prepared for:

Zenner Performance Meters, Inc. d.b.a. 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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OCTOBER 25, 2017

WLL REPORT# 15327-01-01 Rev 0

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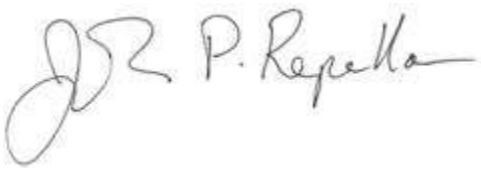


John P. Repella
Manager, EMC & Wireless Services

Reviewed by:

Steven D. Koster

President

ABSTRACT

This report has been prepared on behalf of Zenner Performance Meters, Inc. d.b.a. 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 Performance Meters, Inc. d.b.a. Zenner USA Stealth Reader - Water (WM2F).

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 Performance Meters, Inc. d.b.a. Zenner USA Stealth Reader - Water (WM2F) 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	October 25, 2017

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 COMPLIANCE STATEMENT

The Zenner Performance Meters, Inc. d.b.a. Zenner USA Stealth Reader - Water (WM2F) 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 terminal) emissions were performed. All measurements were performed in accordance with FCC Public Notice DA-00-705 "Measurement Guidance for Frequency Hopping Spread Spectrum Systems. 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:	0023404
Quotation Number:	70250

1.4 TEST DATES

Testing was performed on the following date(s): 10/10/2017 – 10/13/2017

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	**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

Table 1: Device Summary

Item	Transceiver Module
Manufacturer:	Zenner Performance Meters, Inc. d.b.a. Zenner USA
FCC ID:	2ACOA-WM2F
ISED ID:	Not Applicable
Model:	Stealth Reader - Water (WM2F)
Serial Number of Unit Tested	9000010 (7wire configuration), 9000016 (3 wire configuration)
FCC Rule Parts:	§15.247
Innovation, Science and Economic Development Canada:	Not Applicable
Frequency Range:	902-928MHz
Maximum Output Power:	479.1mW (26.805dBm)
Modulation:	FHSS FSK Mesh Mode – 40kHz Modulation Drive-by Mode – 80kHz Modulation
Occupied Bandwidth:	141.7kHz Mesh Mode, 271.6kHz Drive-by Mode
Keying:	Automatic
Type of Information:	Data
Number of Channels:	50
Power Output Level	Fixed
Antenna Connector	None, Antenna soldered to PCB
Antenna Type	Helical, Zenner USA, 220-0001-001, 0dB
Interface Cables:	3 or 7 wire connections for water meter
Power Source & Voltage:	Dual Parallel Primary Cell 3.6V Lithium Thionyl Chloride Batteries

The Zenner Performance Meters, Inc. d.b.a. Zenner USA Stealth Reader - Water (WM2F) is a self-contained transceiver radio that communicates between a water meter and other Zenner Stealth System equipment. The radio operates in the 902-928 MHz Band.

2.2 TEST CONFIGURATION

The Stealth Reader - Water (WM2F) was configured in two modes of operation for test, the Mesh Mode and the Drive-by Mode. with ??

The WM2F was tested as a stand-alone device with power provided directly to the EUT from Lab Power supply supplying 3.7Vdc for bench tests. Radiated tests were performed with fully charged batteries. The EUT was connected to a support laptop for RF control via RS-232 maintenance port connection to a 6 pin header. The RF radiated tests were performed with the helical antenna mounted to the transmitter board. For the antenna port conducted measurements, the antenna was removed from the PCB and a short length of coaxial cable was attached to the PCB. This cable was then connected to a spectrum analyzer through appropriate attenuation.

2.3 TESTING ALGORITHM

The Stealth Reader - Water (WM2F) was programmed via a 6 pin maintenance port on the EUT to a RS232 port on the support laptop. The support laptop used Tera Term to command the EUT to transmit on the lowest, center, and highest channels. Commands were also sent to allow the unit to transmit in a hopping fashion. The unit was preloaded with a typical data payload to transmit.

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. 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
Conducted Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	±4.55 dB
Conducted Power (up to 160 W)	CISPR16-4-2	±0.3 dB
Conducted RF	CISPR16-4-2	±0.3 dB

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

Radiated & Bench Conducted Emissions		Test Date:	10/13/2017
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
337	WLL - 1.2-5GHZ	BAND PASS FILTER	4/19/2018
281	ITC - 21A-3A1 Waveguide	4.51-10.0GHZ	8/1/2018
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	11/7/2017
425	ARA - DRG-118/A	ANTENNA 1-18GHZ	11/23/2017
849	AH SYSTEMS - SAC-18G-16	HF COAXIAL CABLE	1/18/2018
823	AGILENT – EXA N9010A	SPECTRUM ANALYZER	12/21/2017
865	STORM - 874-0101-036	HIGH FREQ CABLE	5/22/2018
558	HP - 8447D	AMPLIFIER	1/16/2018
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	12/31/2017

4 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

FCC Rule Part	Description	Result
15.247 (a)(1)	20dB Bandwidth	Pass
15.247 (b)	Transmit Output Power	Pass
15.247 (a)(1)	Channel Separation	Pass
15.247 (a)(1)	Number of Channels	Pass
15.247 (a)(1)	Time of Occupancy	Pass
15.247 (d)	Occupied BW / Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	AC Conducted Emissions	Pass
FCC Rule Part	**Description**	**Result**
15.207	AC Conducted Emissions	Pass
15.209	General Field Strength Limits	Pass

4.1 DUTY CYCLE CORRECTION AND 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 figure shows the plot of the dwell time for the transmitter. Based on this plot, the dwell time per hop is 176.0ms for 'Mesh Mode' and 175.8ms for 'Drive-by mode'. The unit makes a single hop transmission every 6 seconds. FCC part 15.247 also requires that for hopping signals with an occupied bandwidth of greater than 250kHz the total transmit dwell time must be no more than 0.4 seconds per 10 seconds . For signals less than 250 kHz the limit is 0.4 seconds per 20 seconds. 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 limit.

Both modes of operation have a time of occupancy of greater than 100ms, therefore, no duty cycle correction is applied.

Table 5: Duty Cycle/Time of Occupancy Results

Test	Result	Limit	Pass/Fail
Dwell time per Hop (Mesh Mode)	176.0ms	NA	NA
Dwell time per 100ms (Mesh Mode)	N/A	NA	NA
Time of Occupancy (Mesh Mode)	176.0ms/20 sec	0.4s/20 sec	Pass
Dwell time per Hop (Drive-by Mode)	175.6ms	NA	NA
Dwell time per 100ms (Drive-by Mode)	N/A	NA	NA
Time of Occupancy (Drive-by Mode)	176.5ms/20 sec	0.4s/10 sec	Pass

Figure 1: Duty Cycle Plot, Mesh Mode

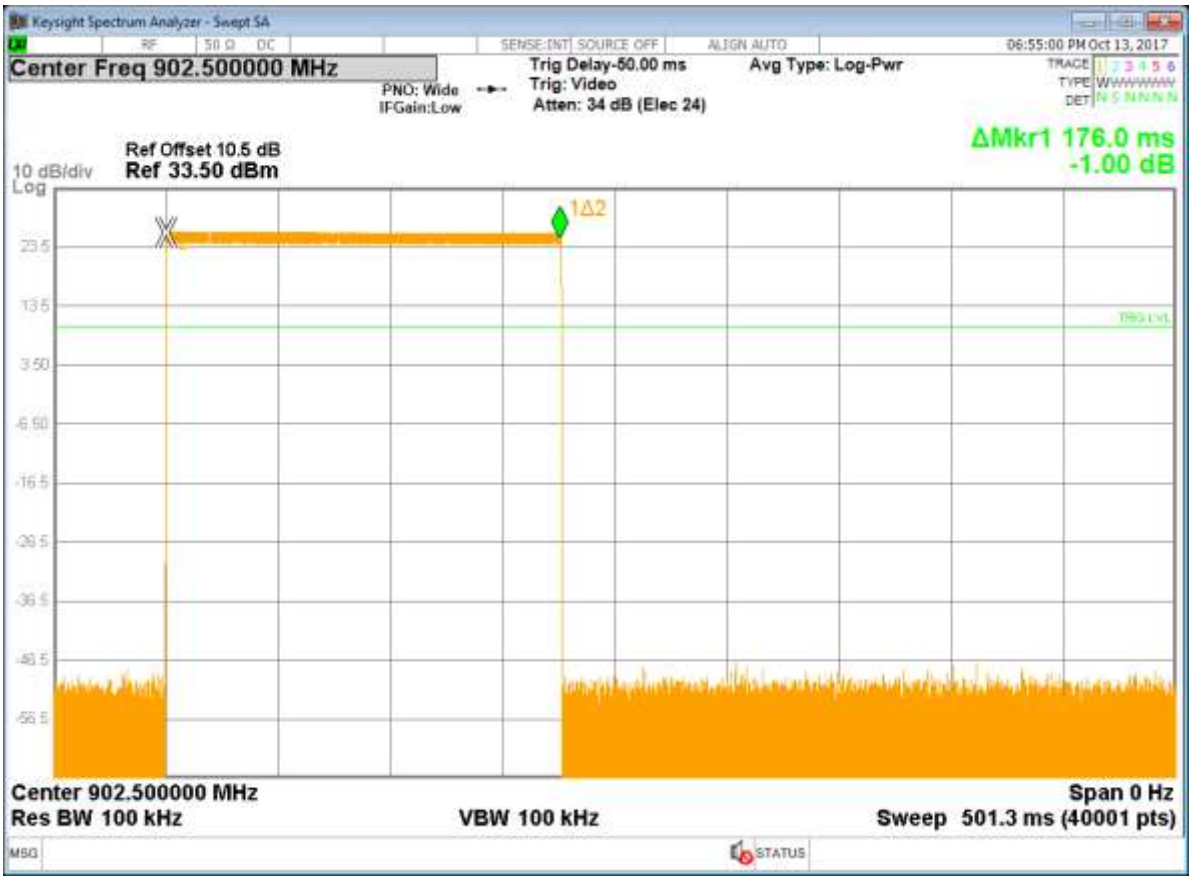


Figure 2: Time of Occupancy, Mesh Mode

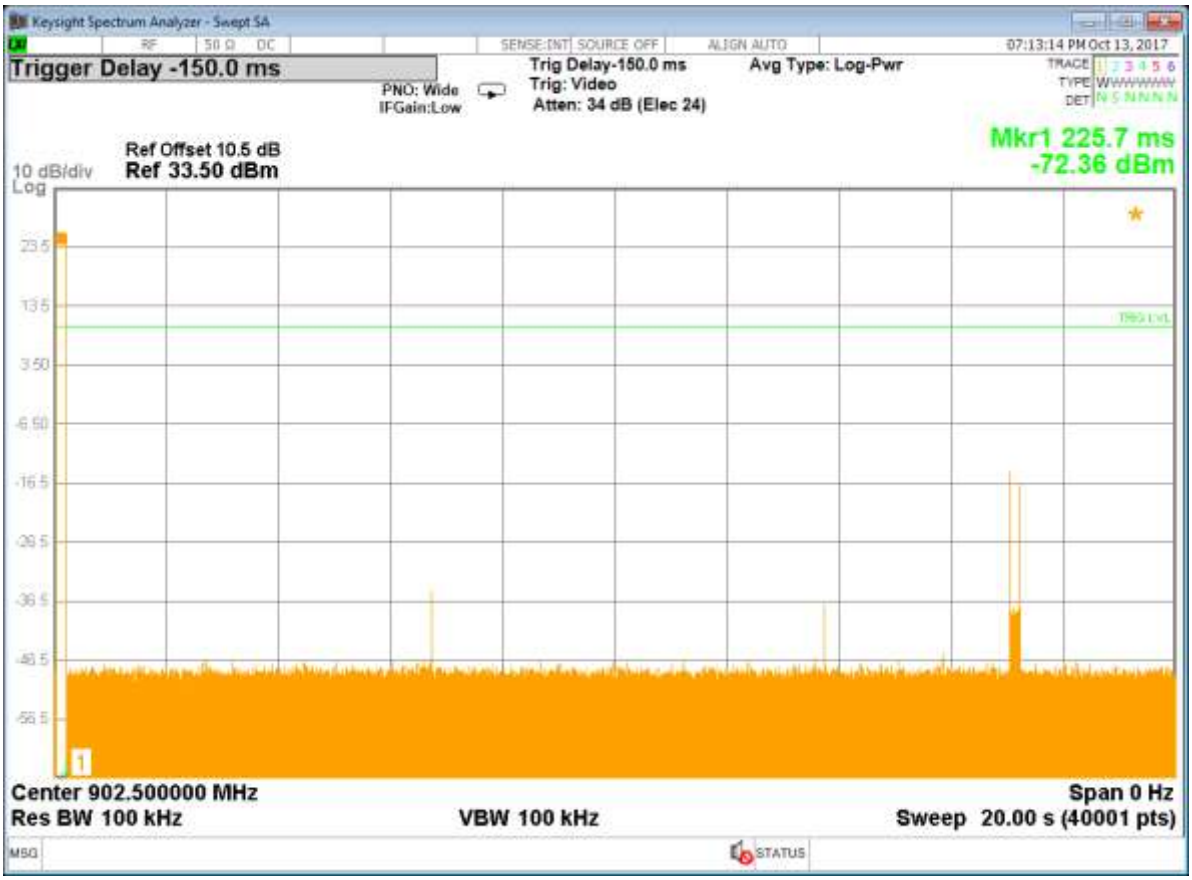


Figure 3: Duty Cycle Plot, Drive-by Mode

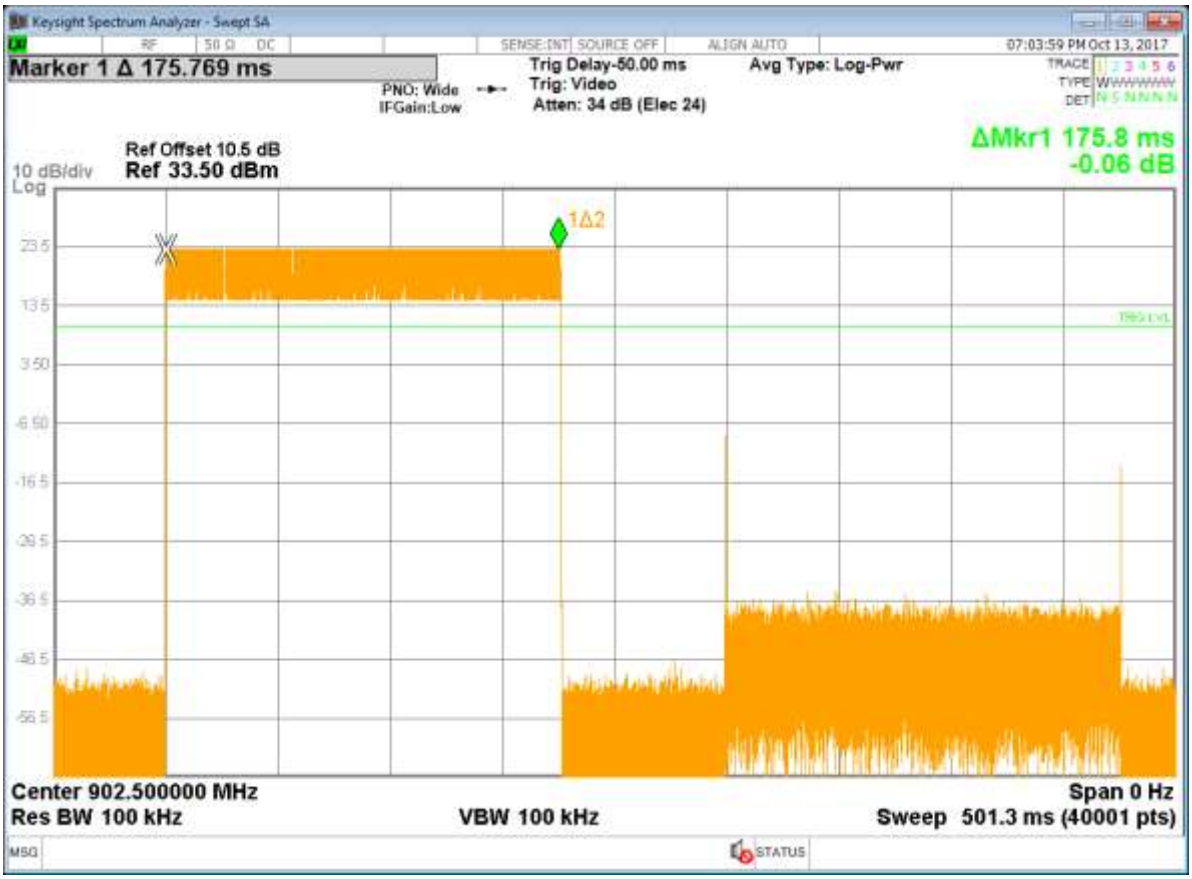


Figure 4: Time of Occupancy, Drive-by Mode

4.3 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 RF Spectrum Analyzer. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system.

Table 6: RF Power Output

Frequency	Mode Tested	Level (dBm)	Limit (dBm)	Pass/Fail
Low Channel: 902.5MHz	Mesh Mode	26.805	30	Pass
Mid Channel: 915MHz	Mesh Mode	26.370	30	Pass
High Channel: 927MHz	Mesh Mode	25.789	30	Pass
Low Channel: 902.5MHz	Drive-by Mode	26.724	30	Pass
Mid Channel: 915MHz	Drive-by Mode	26.376	30	Pass
High Channel: 927MHz	Drive-by Mode	25.750	30	Pass

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

Figure 6: RF Peak Power, Mid Channel, Mesh Mode

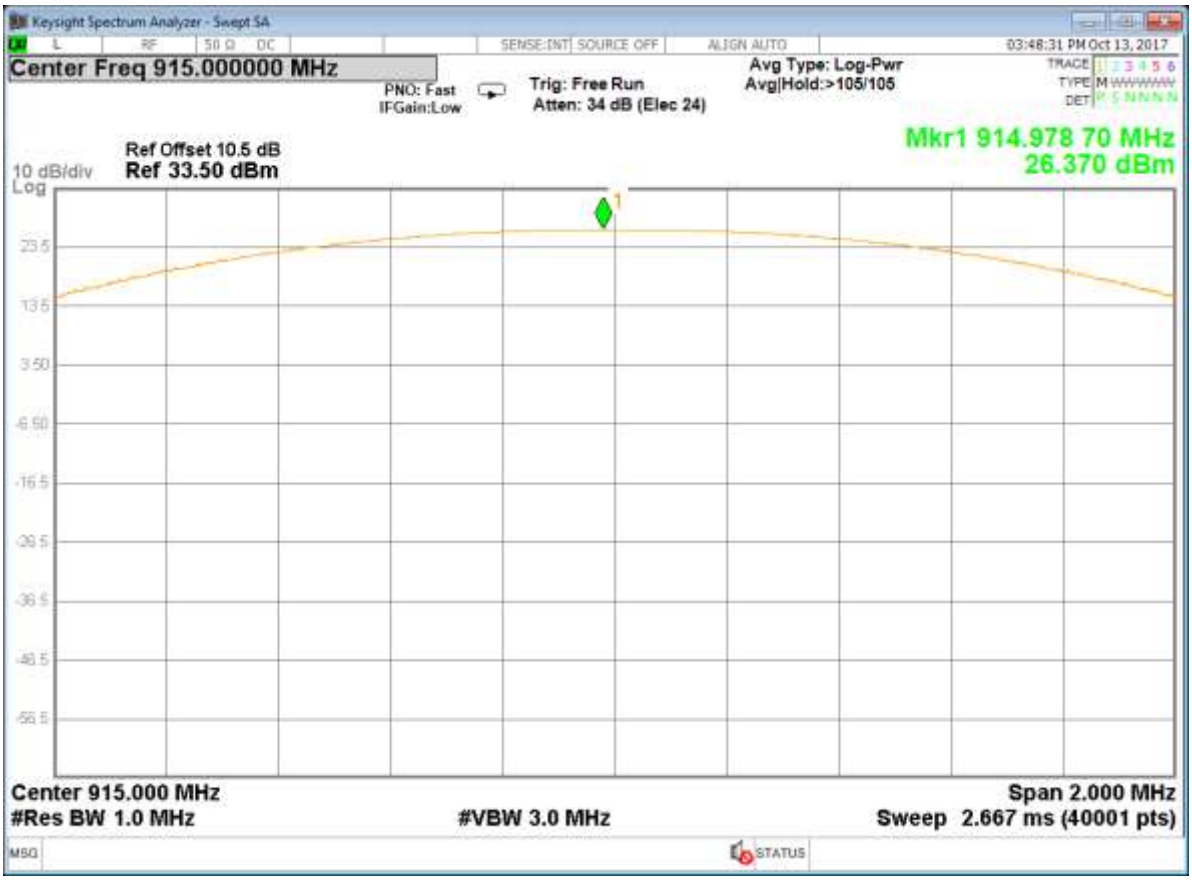


Figure 7: RF Peak Power, High Channel, Mesh Mode

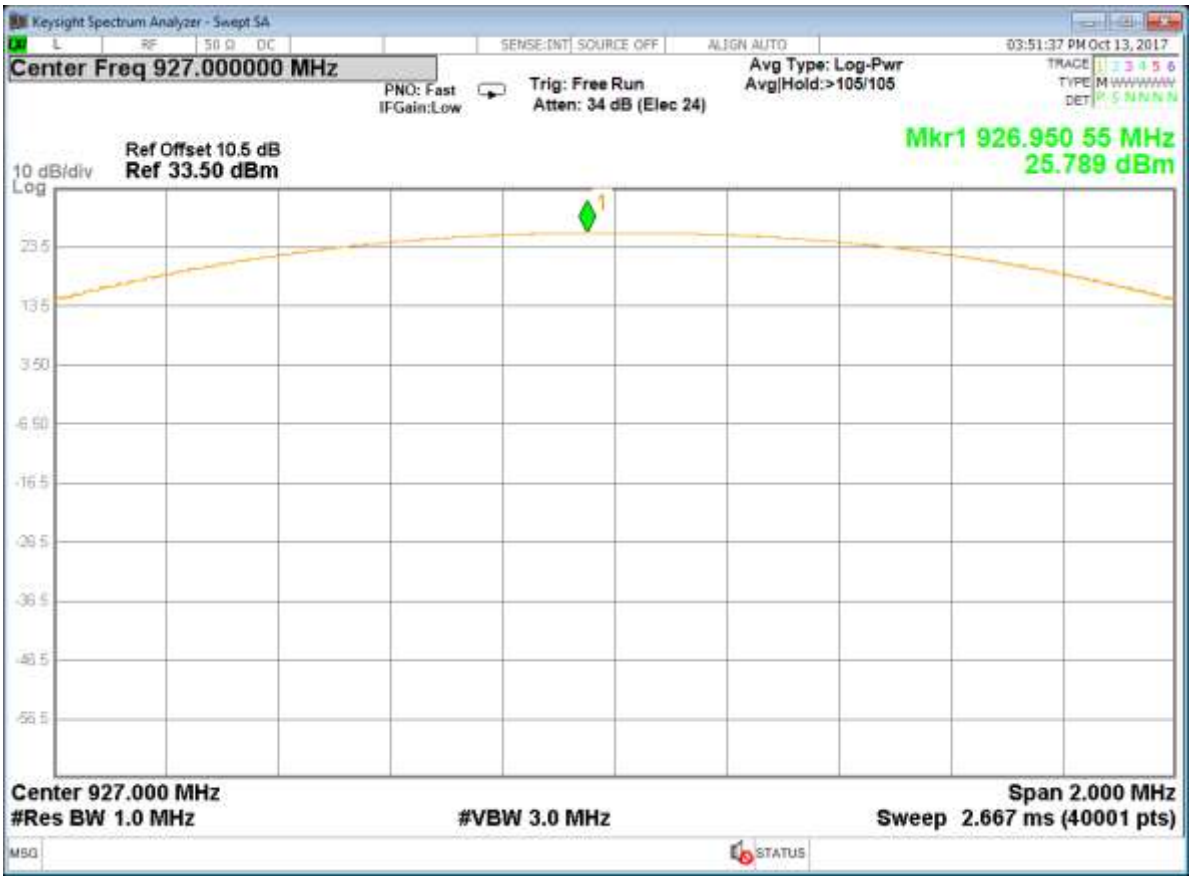


Figure 8: RF Peak Power, Low Channel, Drive-by Mode

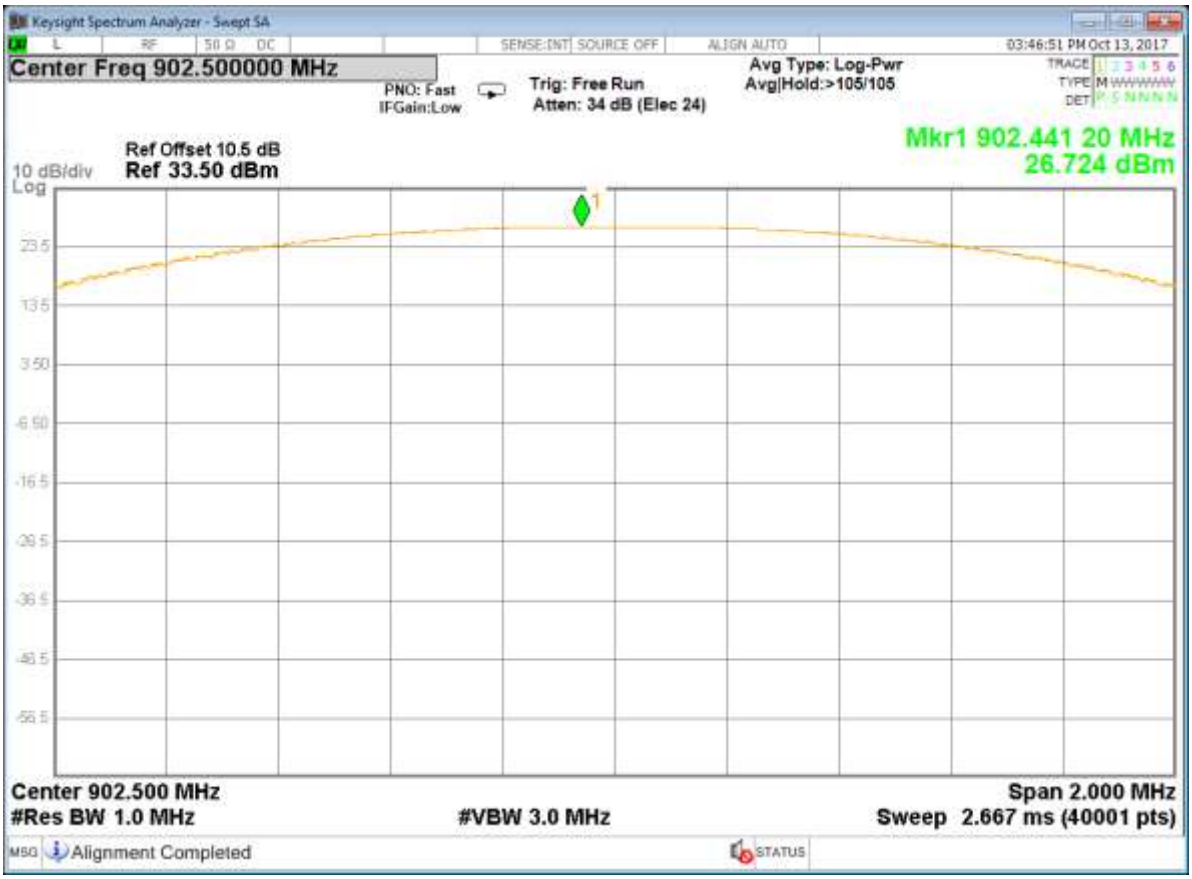


Figure 9: RF Peak Power, Mid Channel, Drive-by Mode

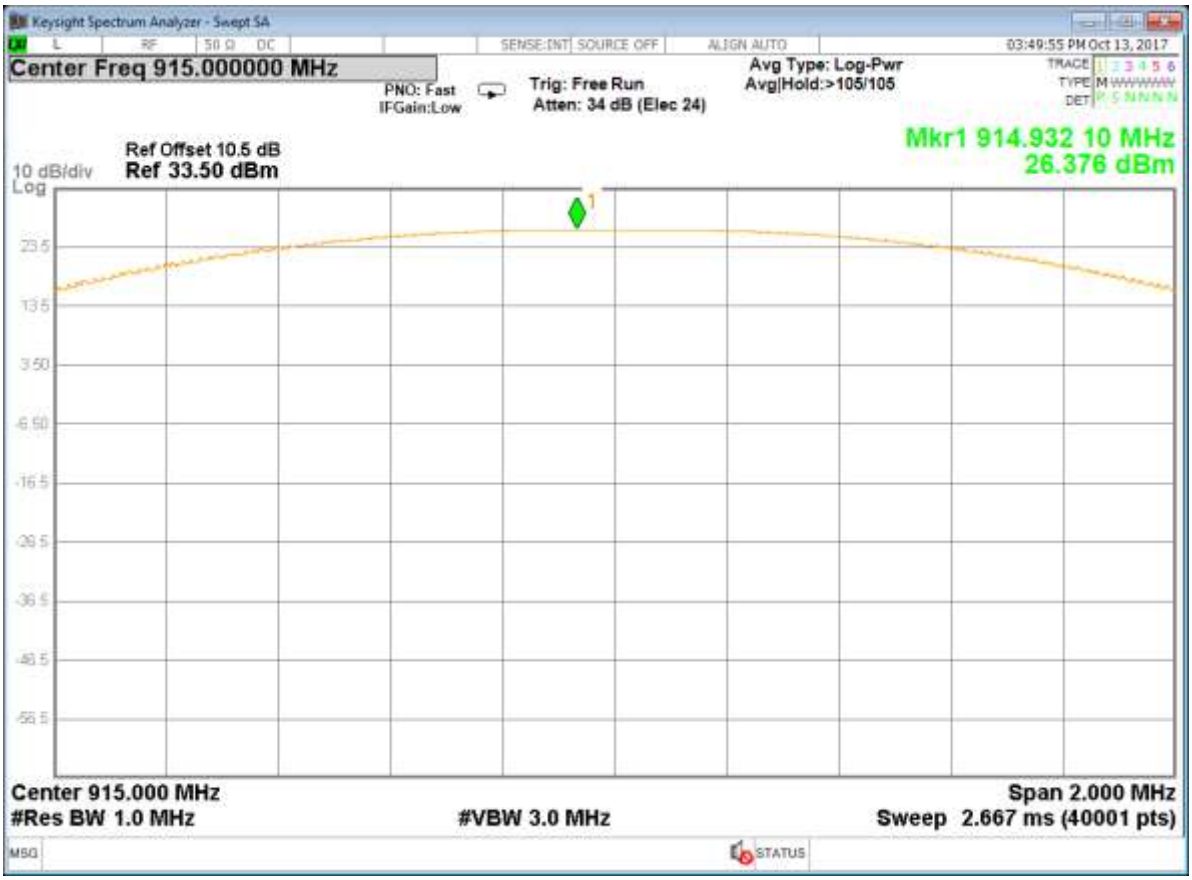
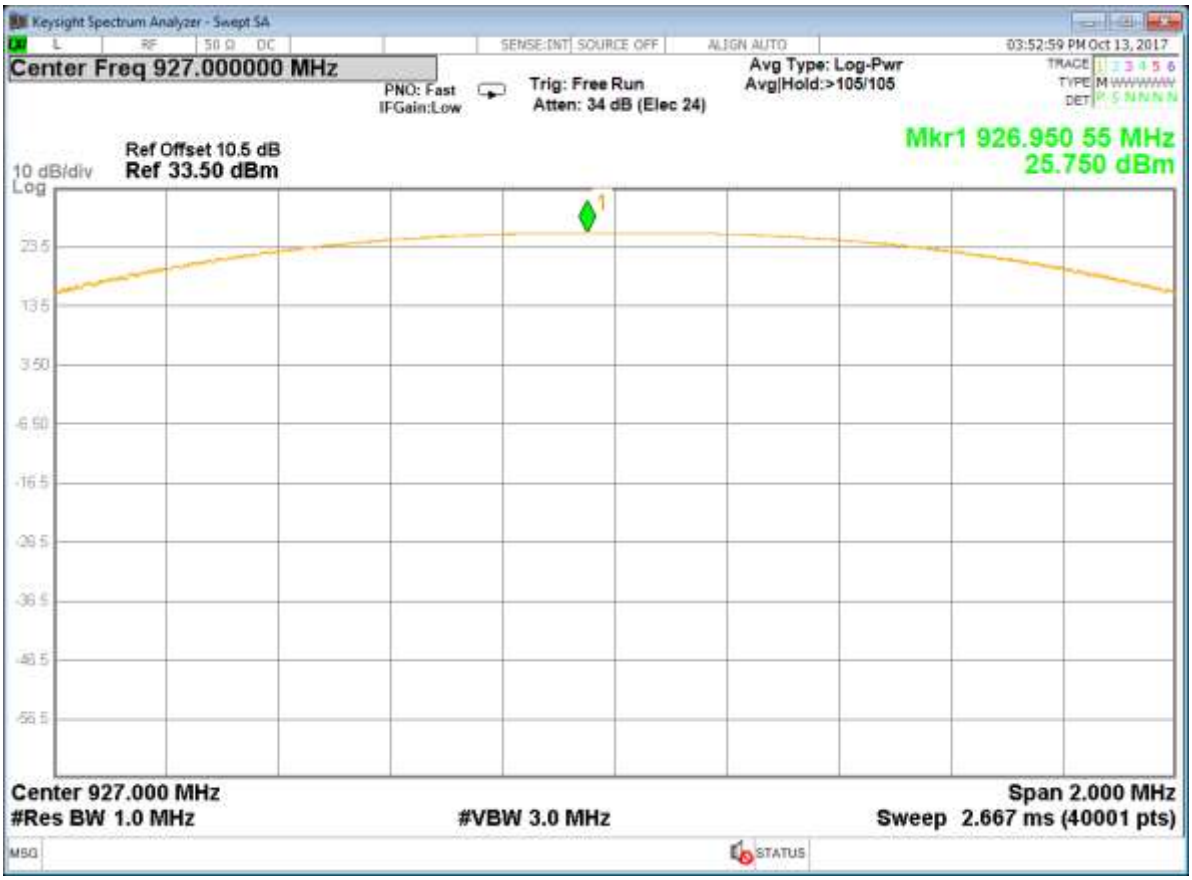


Figure 10: RF Peak Power, High Channel, Drive-by Mode



4.4 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

Frequency	Mode Tested	Bandwidth (kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.5MHz	Mesh Mode	141.7	500	Pass
Mid Channel: 915MHz	Mesh Mode	141.7	500	Pass
High Channel: 927MHz	Mesh Mode	140.0	500	Pass
Low Channel: 902.5MHz	Drive-by Mode	271.6	500	Pass
Mid Channel: 915MHz	Drive-by Mode	271.6	500	Pass
High Channel: 927MHz	Drive-by Mode	271.3	500	Pass

Figure 11: Occupied Bandwidth, Low Channel, Mesh Mode

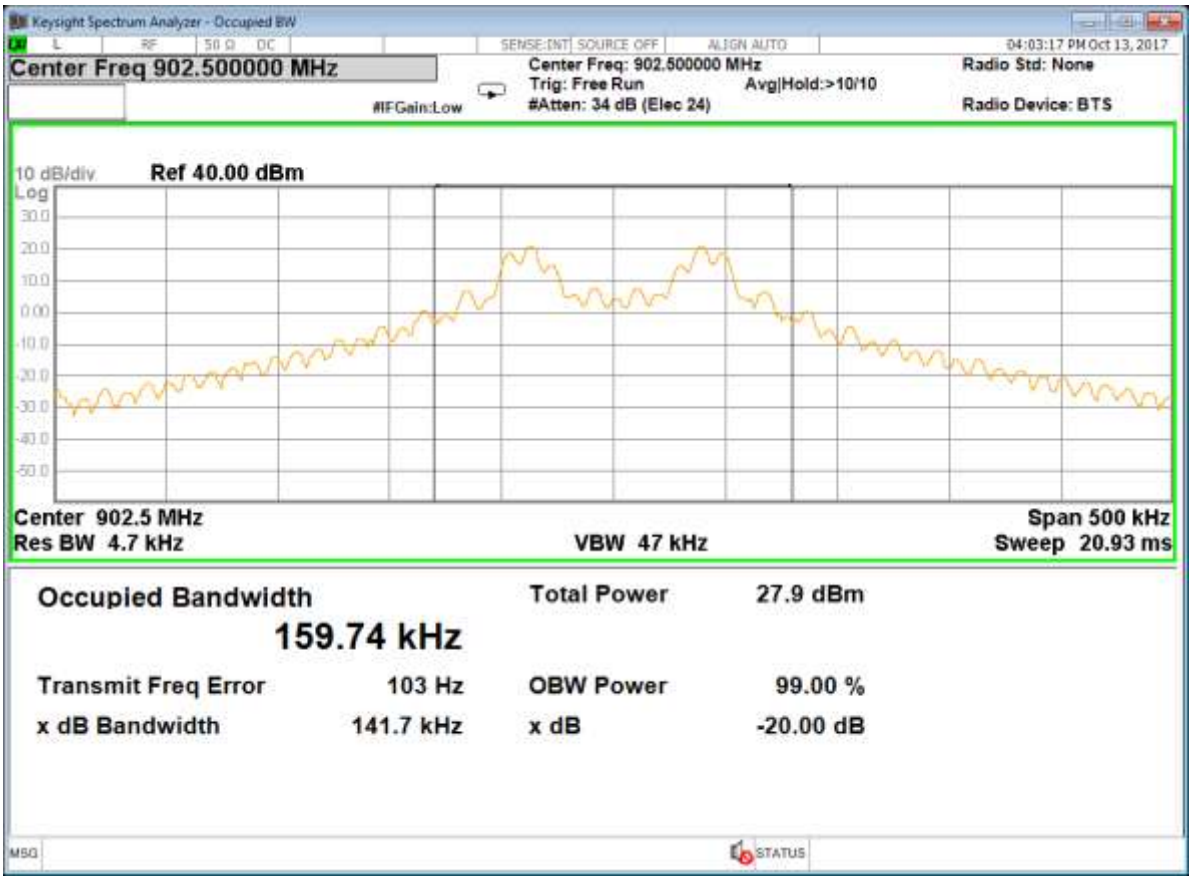


Figure 12: Occupied Bandwidth, Mid Channel, Mesh Mode

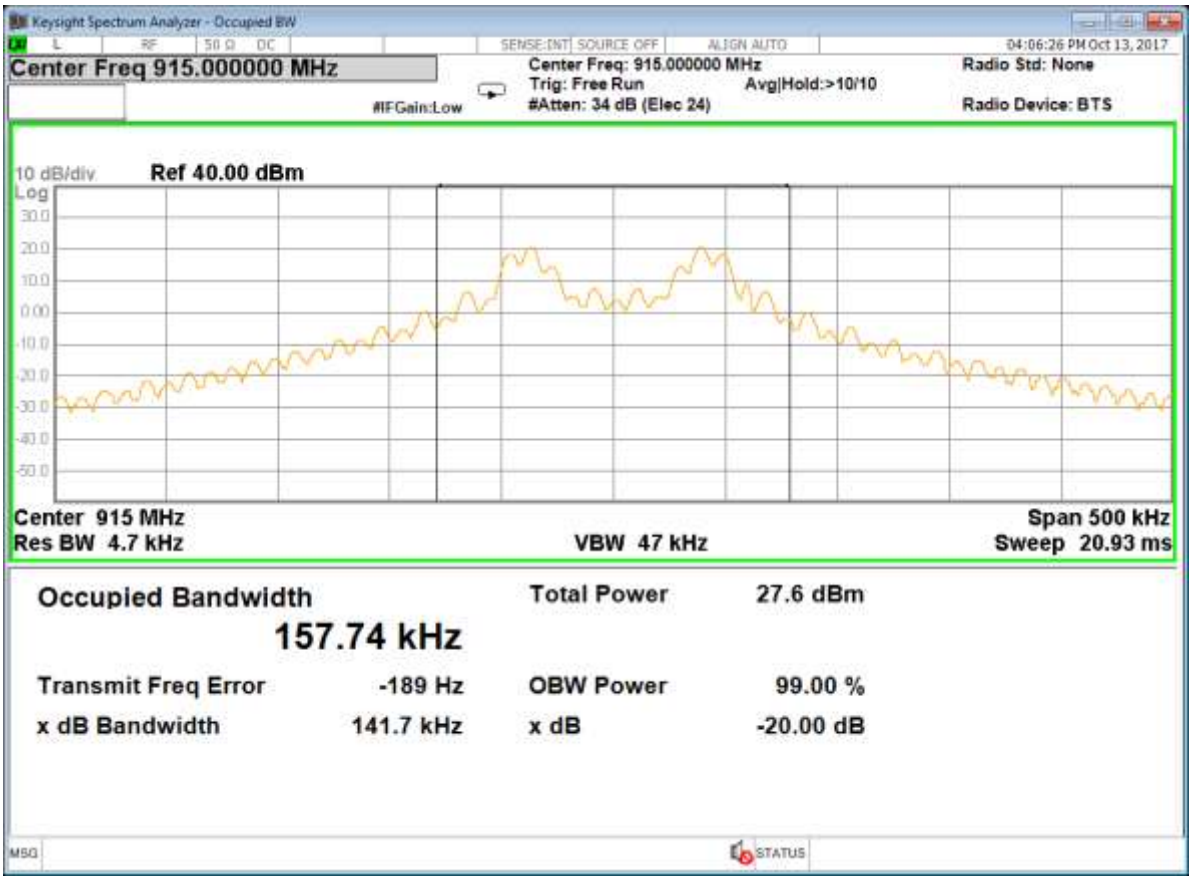


Figure 13: Occupied Bandwidth, High Channel, Mesh Mode

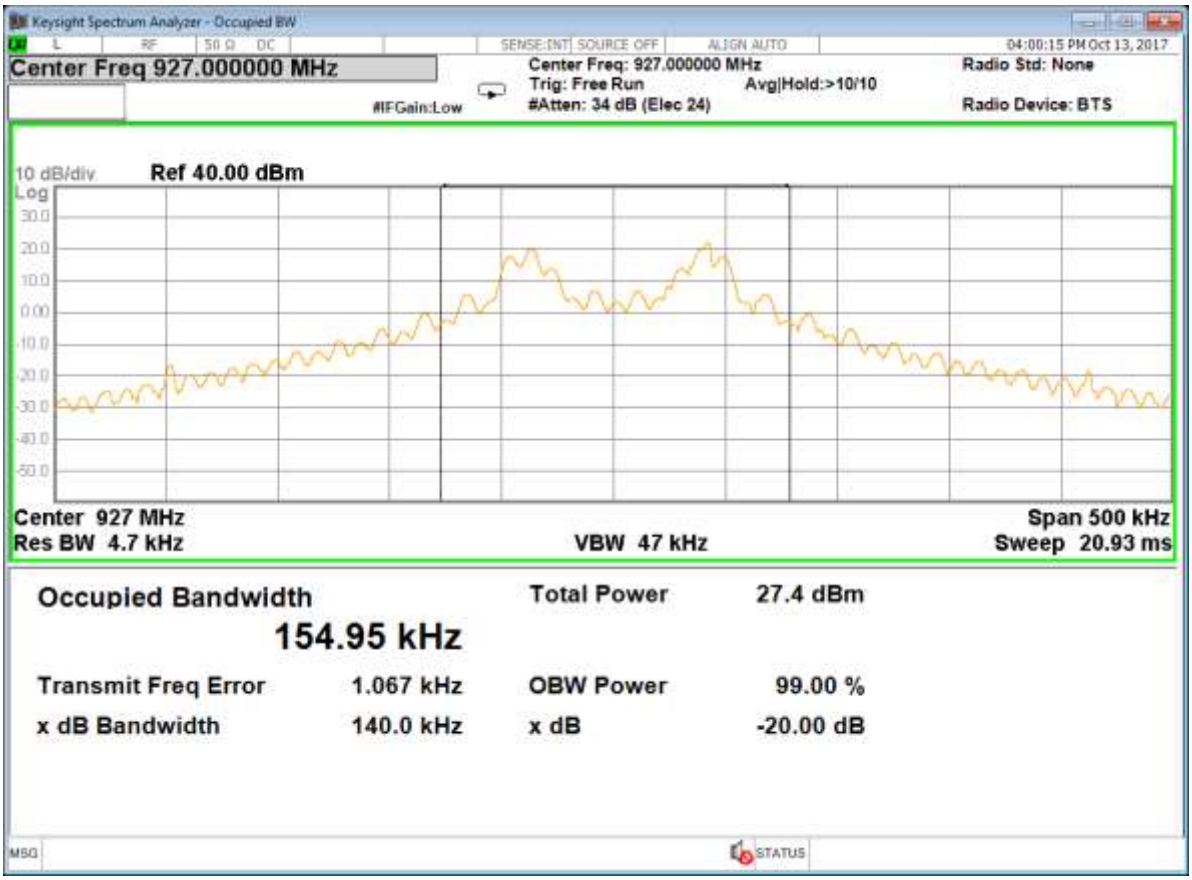


Figure 14: Occupied Bandwidth, Low Channel, Drive-by Mode

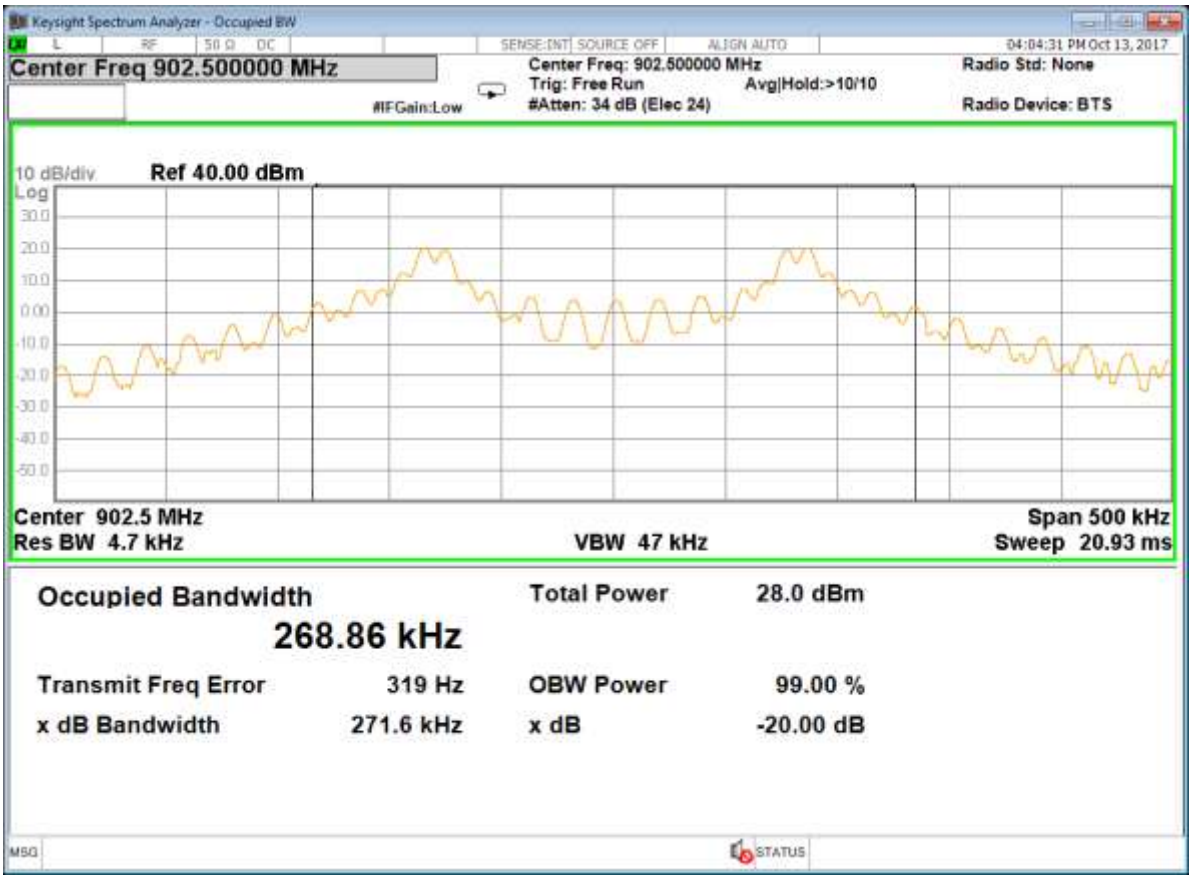


Figure 15: Occupied Bandwidth, Mid Channel, Drive-by Mode

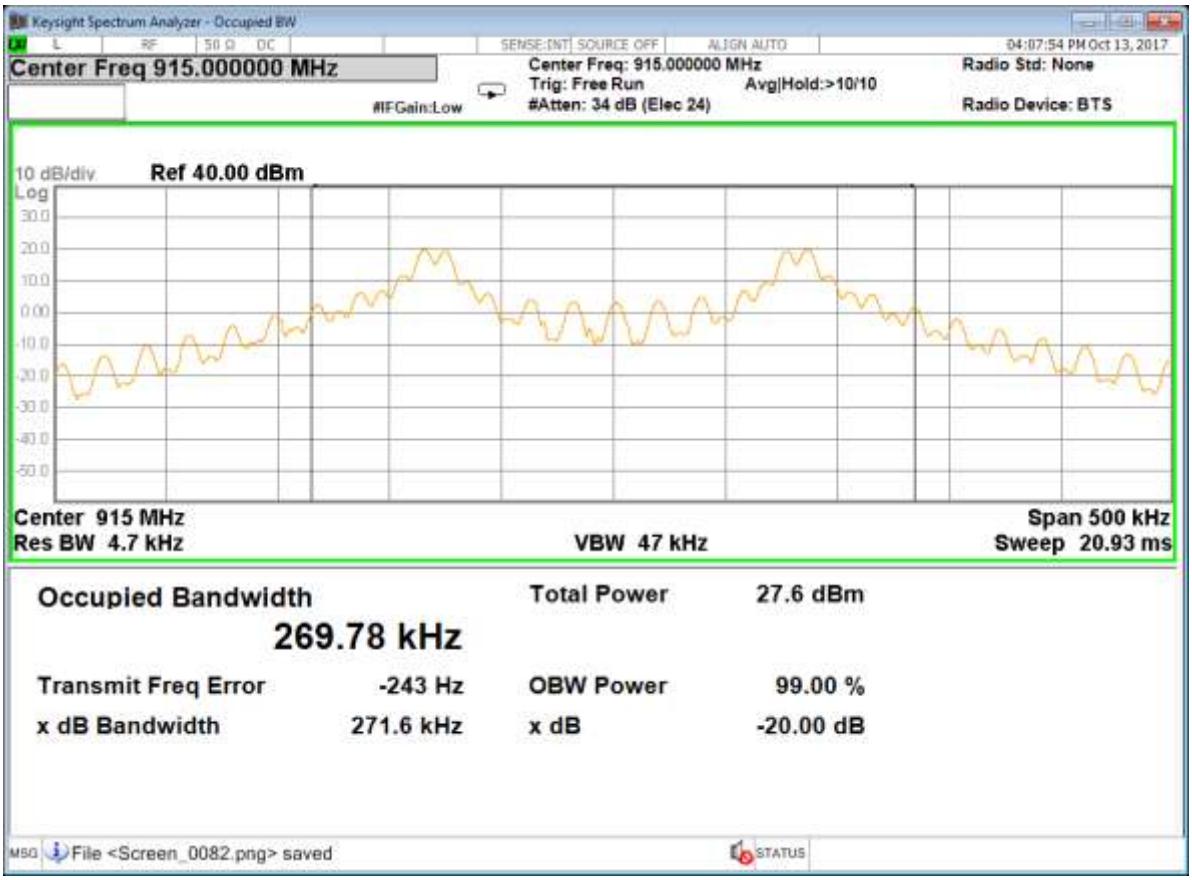
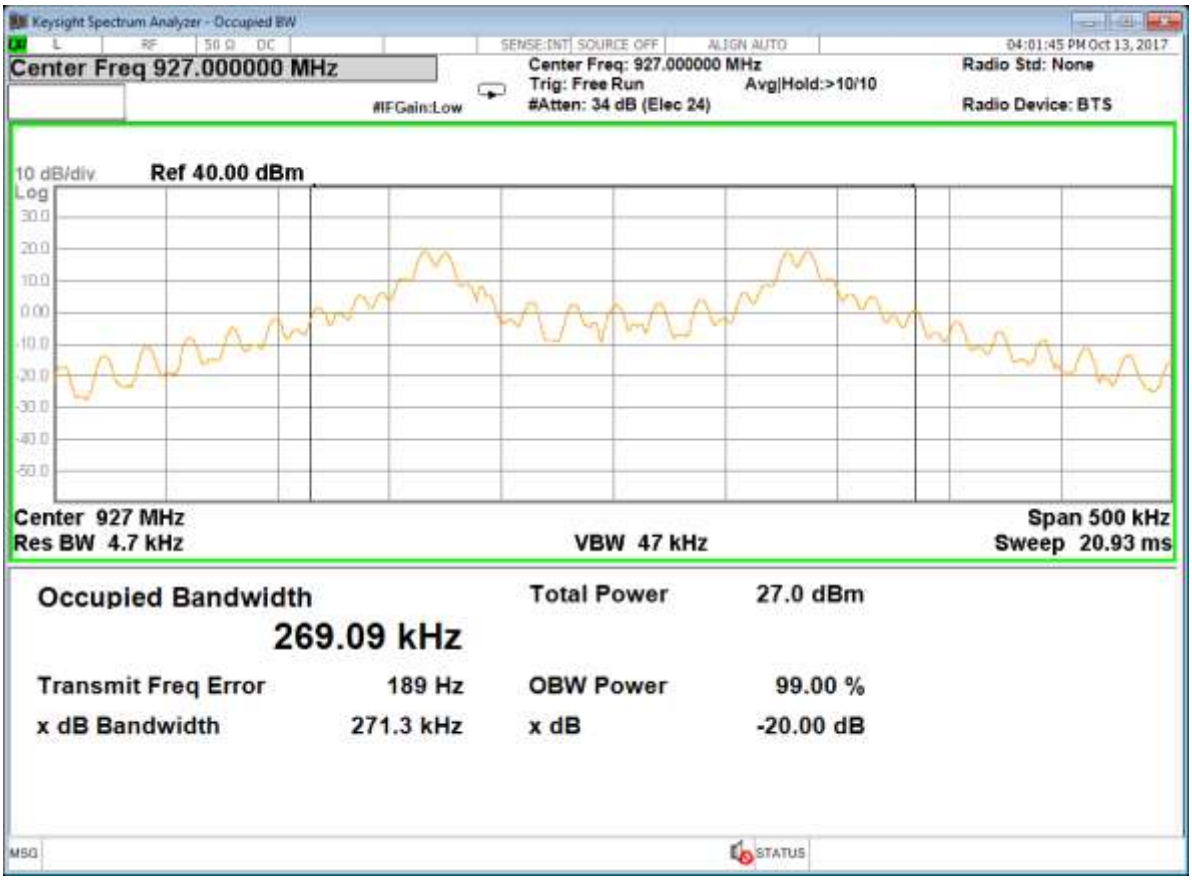


Figure 16: Occupied Bandwidth, High Channel, Drive-by Mode



4.5 CHANNEL SPACING AND NUMBER OF HOP CHANNELS (FCC PART §15247(A)(1)

Per the FCC requirements, frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20 dB bandwidth, whichever is greater. The maximum 20dB bandwidth measured is 271.6kHz so the channel spacing must be more than 271.6kHz.

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 30 kHz and the video bandwidth was set to 100 kHz. The channel spacing of 2 adjacent channels was measured using a spectrum analyzer span setting of 100 kHz. Also, the number of hopping channels was measured from 902-928MHz using a RBW/VBW setting of 30/100 kHz.

The following are plots of the channel spacing and number of hopping channels data. The channel spacing was measured to be 500.15kHz and the number of channels used is 50.

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

Table 8: Channel Spacing and Number of Channels Results

Frequency	Mode Tested	Result	Limit	Pass/Fail
Channel Spacing	Mesh Mode	500.325kHz	271.6kHz Minimum	Pass
Number of channels	Mesh Mode	50 channels	25 Channels Minimum	Pass
Channel Spacing	Drive-By Mode	500.150kHz	271.6kHz Minimum	Pass
Number of channels	Drive-By Mode	50 channels	25 Channels Minimum	Pass

Figure 17: Channel Spacing, Mesh Mode

Figure 18: Number of Hopping Channels, Mesh Mode

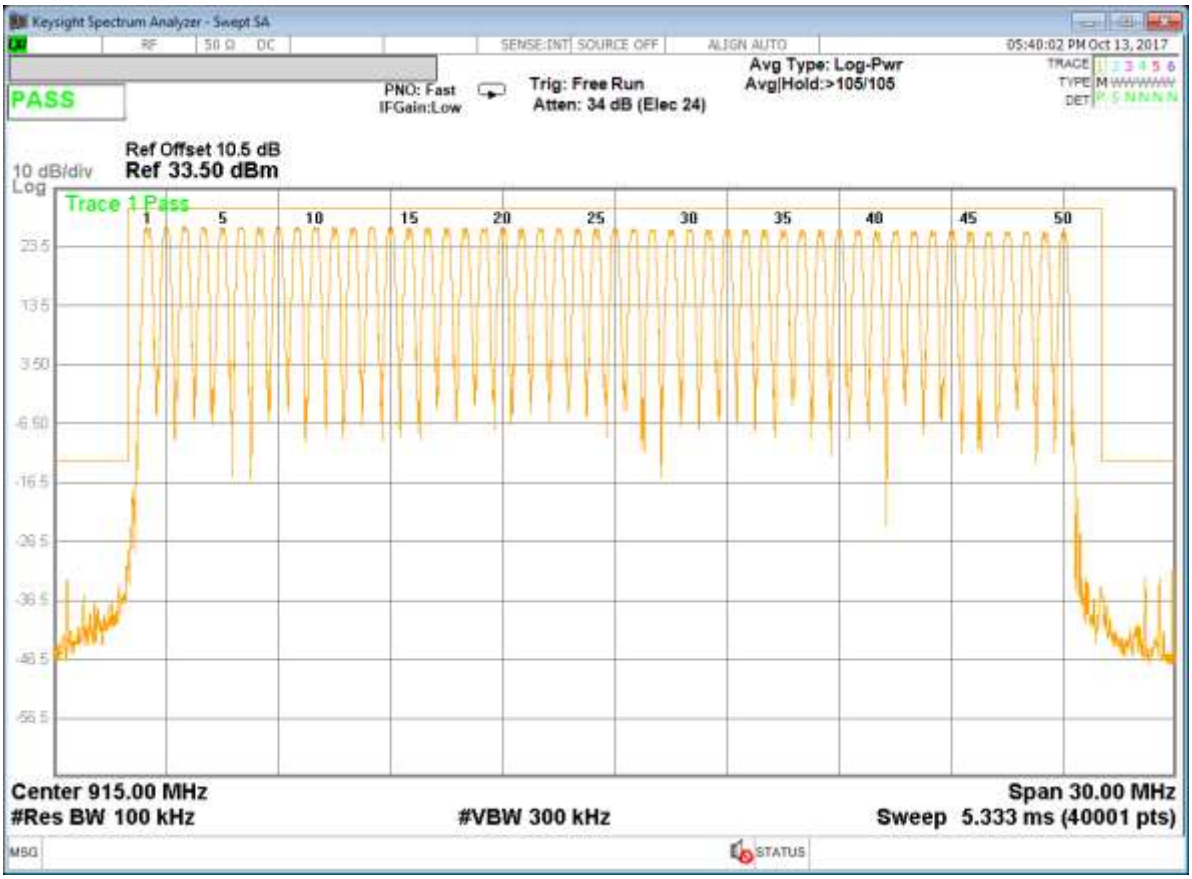
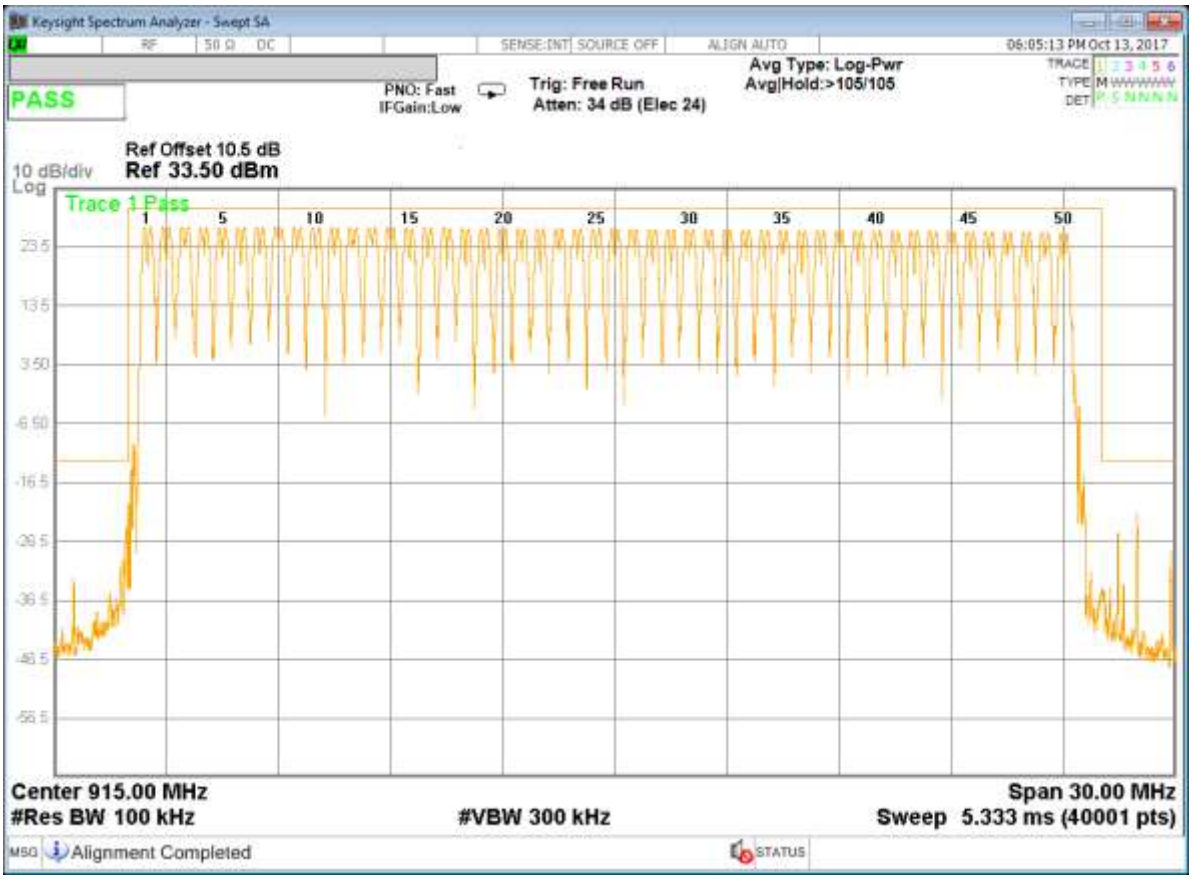


Figure 19: Channel Spacing, Drive-by Mode

Figure 20: Number of Hopping Channels, Drive-by Mode



4.6 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 21: Conducted Spurious Emissions, Mesh Mode, Low Channel 30 - 900MHz

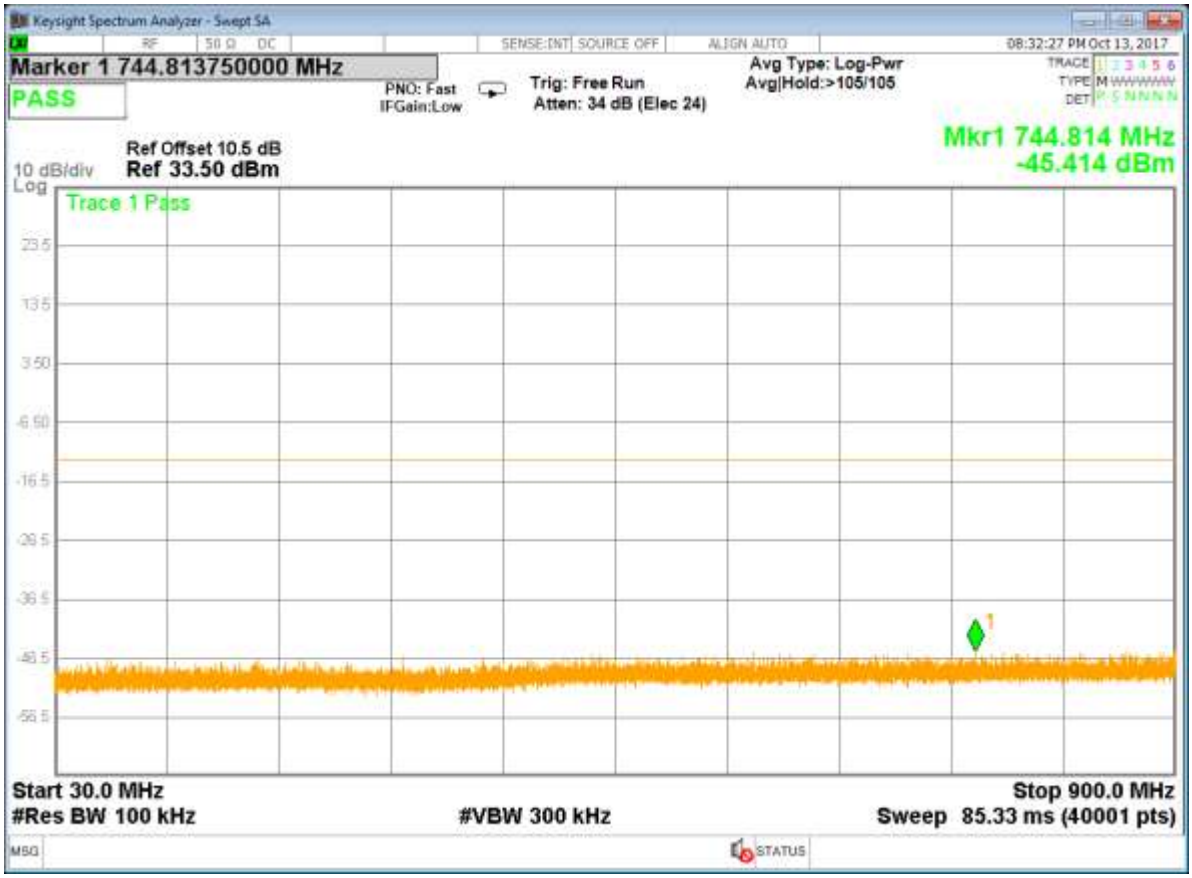


Figure 22: Conducted Spurious Emissions, Mesh Mode, Low Channel 900 – 930MHz

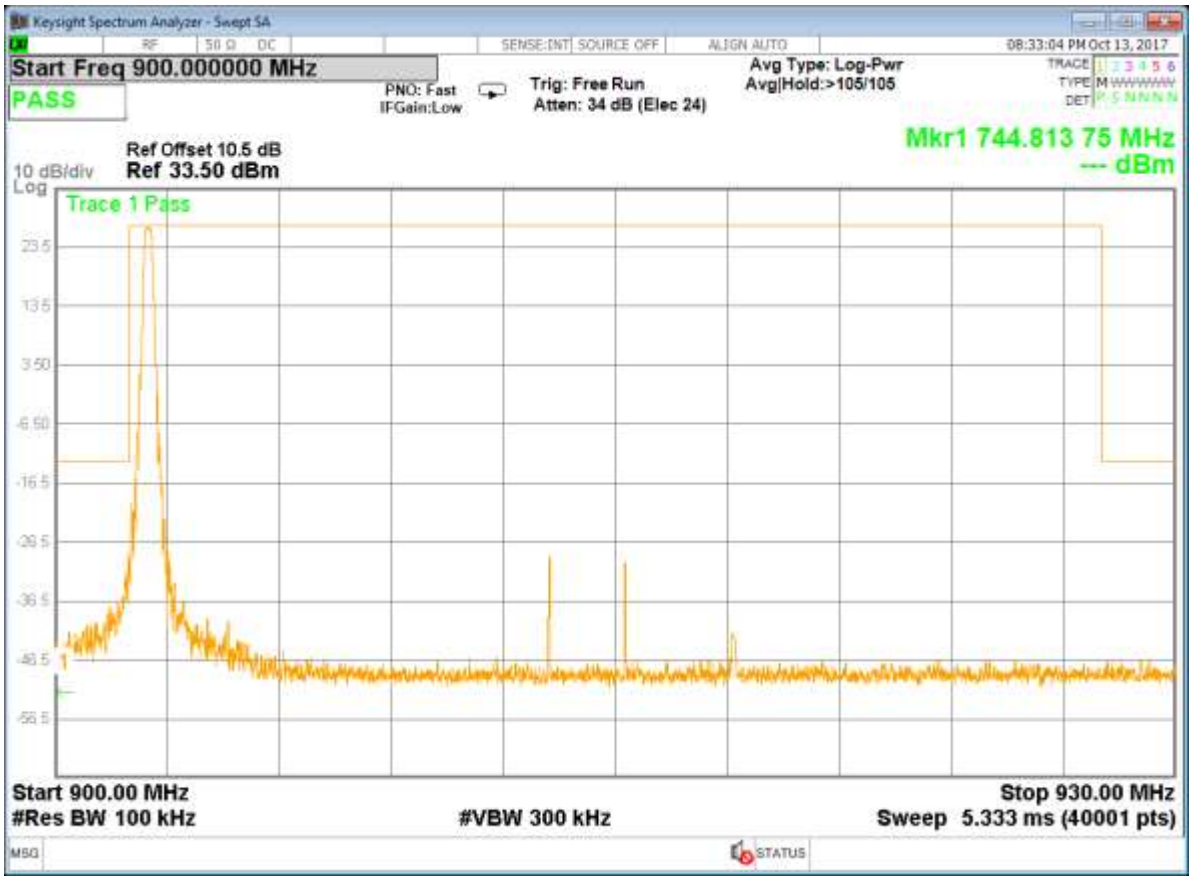


Figure 23: Conducted Spurious Emissions, Mesh Mode, Low Channel 930 – 5000MHz

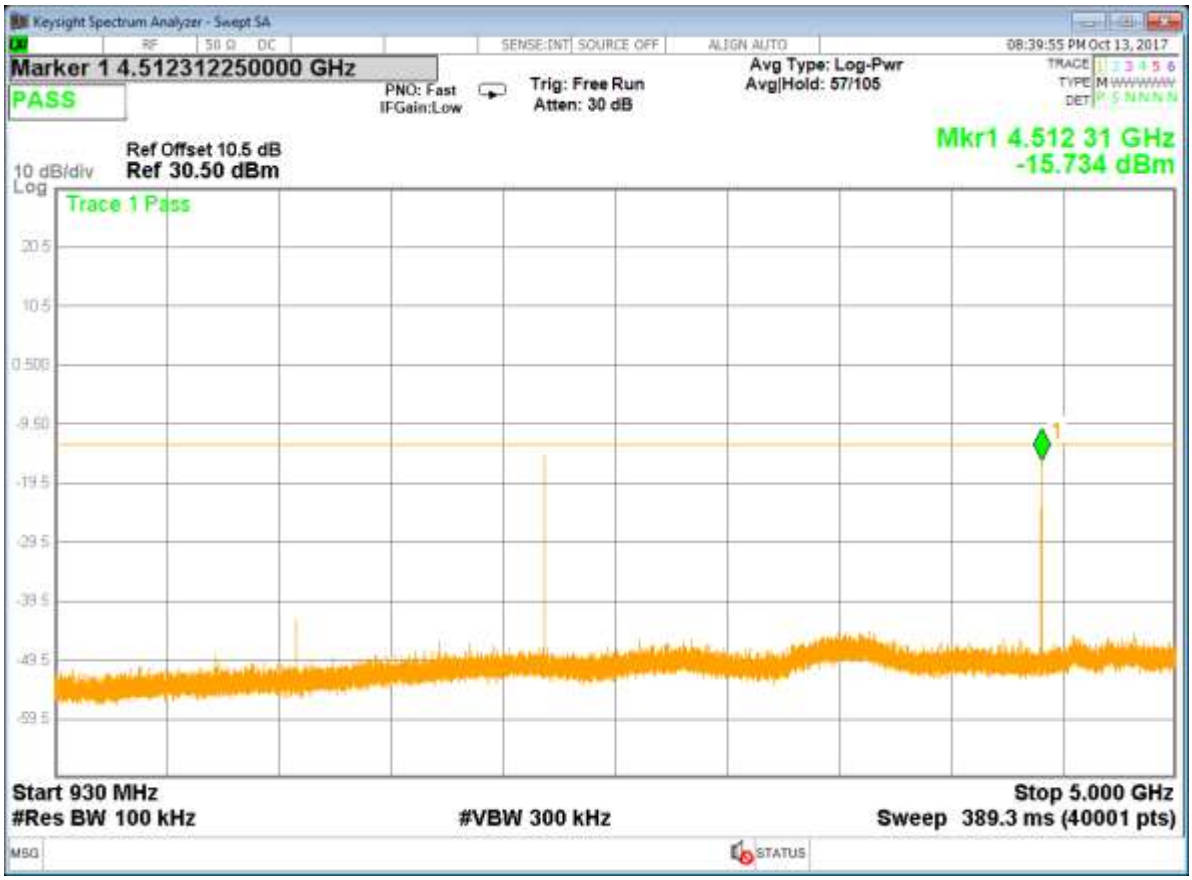


Figure 24: Conducted Spurious Emissions, Mesh Mode, Low Channel 5 – 10GHz

Figure 25: Conducted Spurious Emissions, Mesh Mode, Center Channel 30 - 900MHz

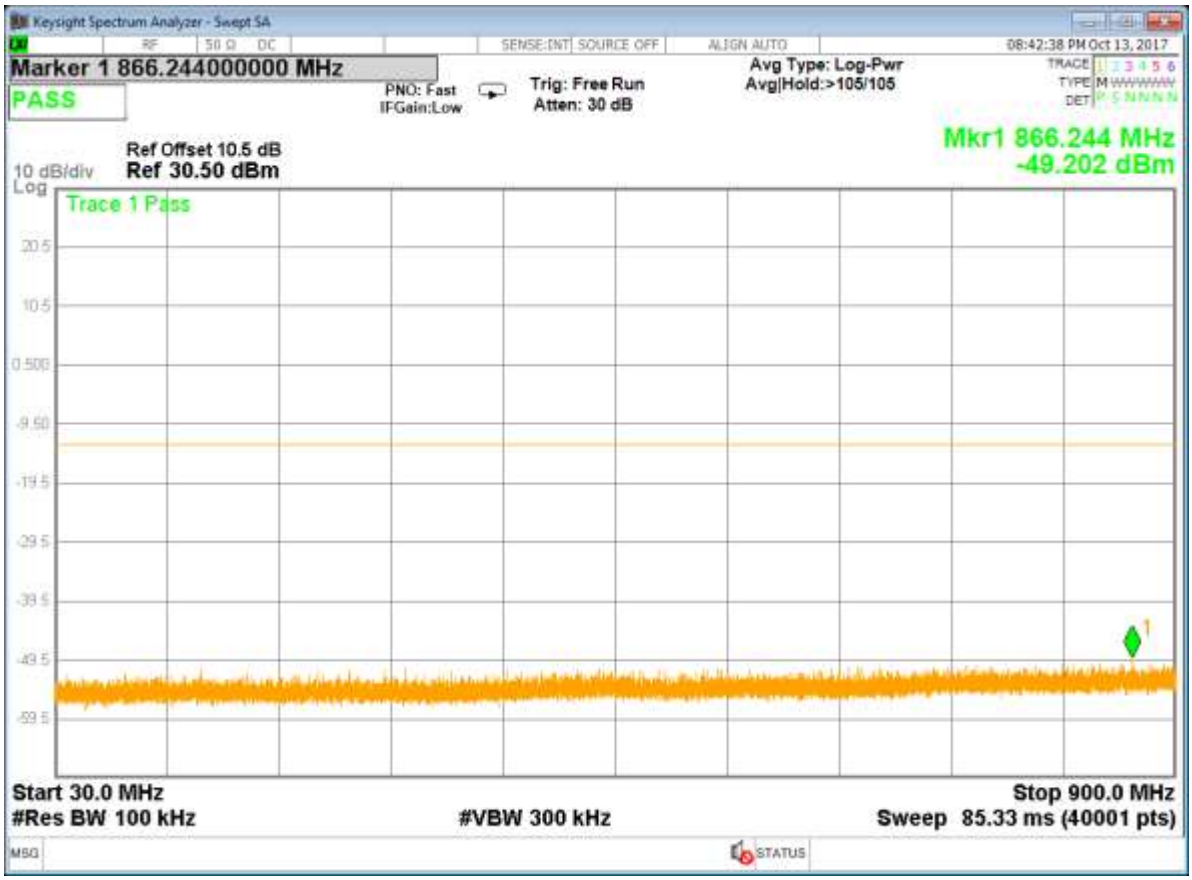


Figure 26: Conducted Spurious Emissions, Mesh Mode, Center Channel 900 – 930MHz

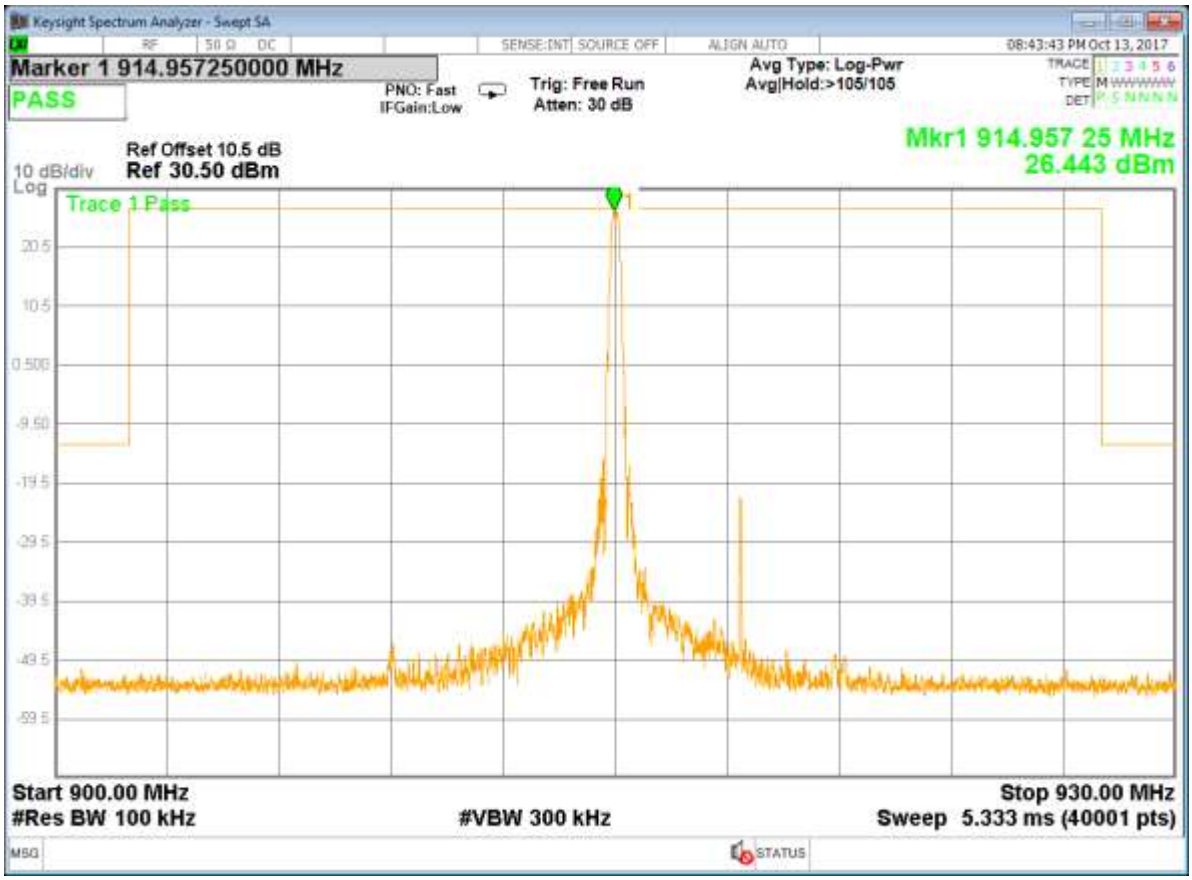


Figure 27: Conducted Spurious Emissions, Mesh Mode, Center Channel 930 – 5000MHz

Figure 28: Conducted Spurious Emissions, Mesh Mode, Center Channel 5 – 10GHz

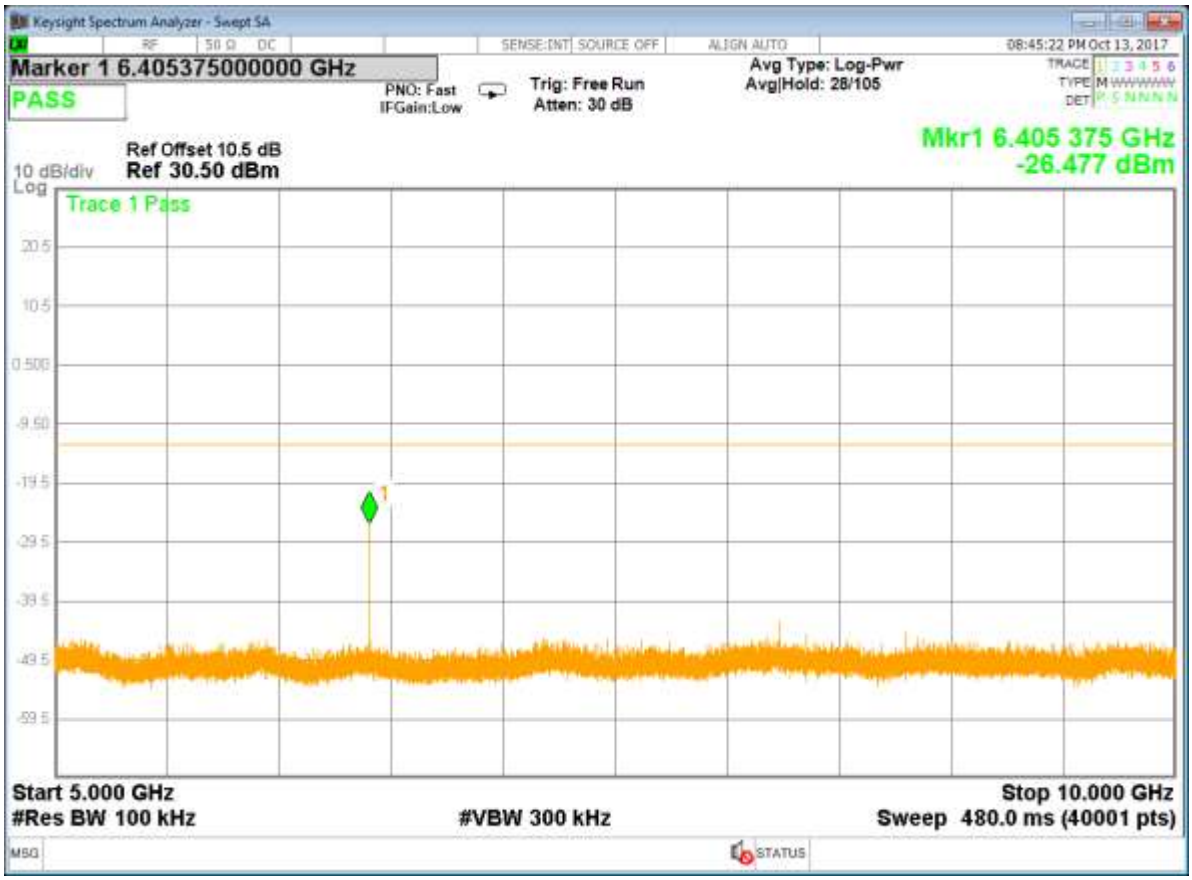


Figure 29: Conducted Spurious Emissions, Mesh Mode, High Channel 30 - 900MHz

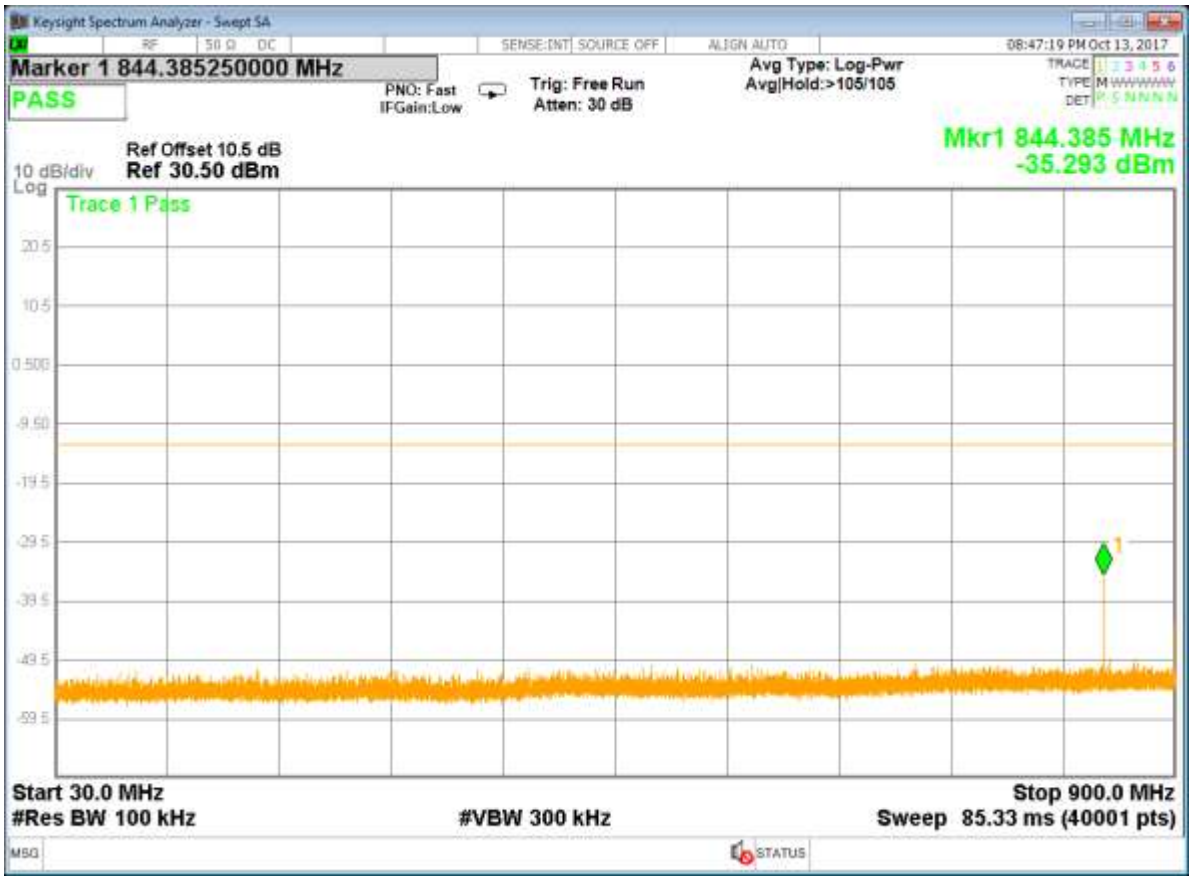


Figure 30: Conducted Spurious Emissions, Mesh Mode, High Channel 900 – 930MHz

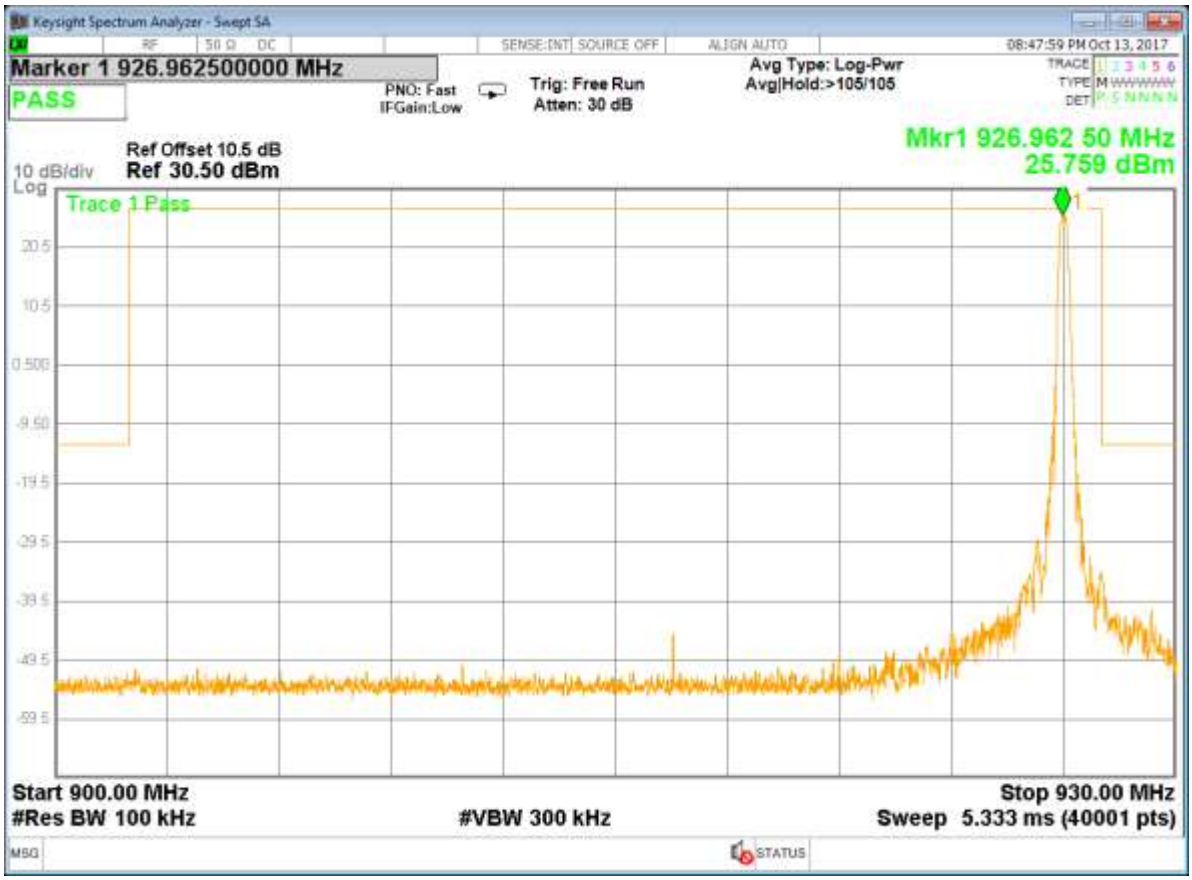


Figure 31: Conducted Spurious Emissions, Mesh Mode, High Channel 930 – 5000MHz

Figure 32: Conducted Spurious Emissions, Mesh Mode, High Channel 5 – 10GHz

Figure 33: Conducted Spurious Emissions, Drive-by Mode, Low Channel 30 - 900MHz

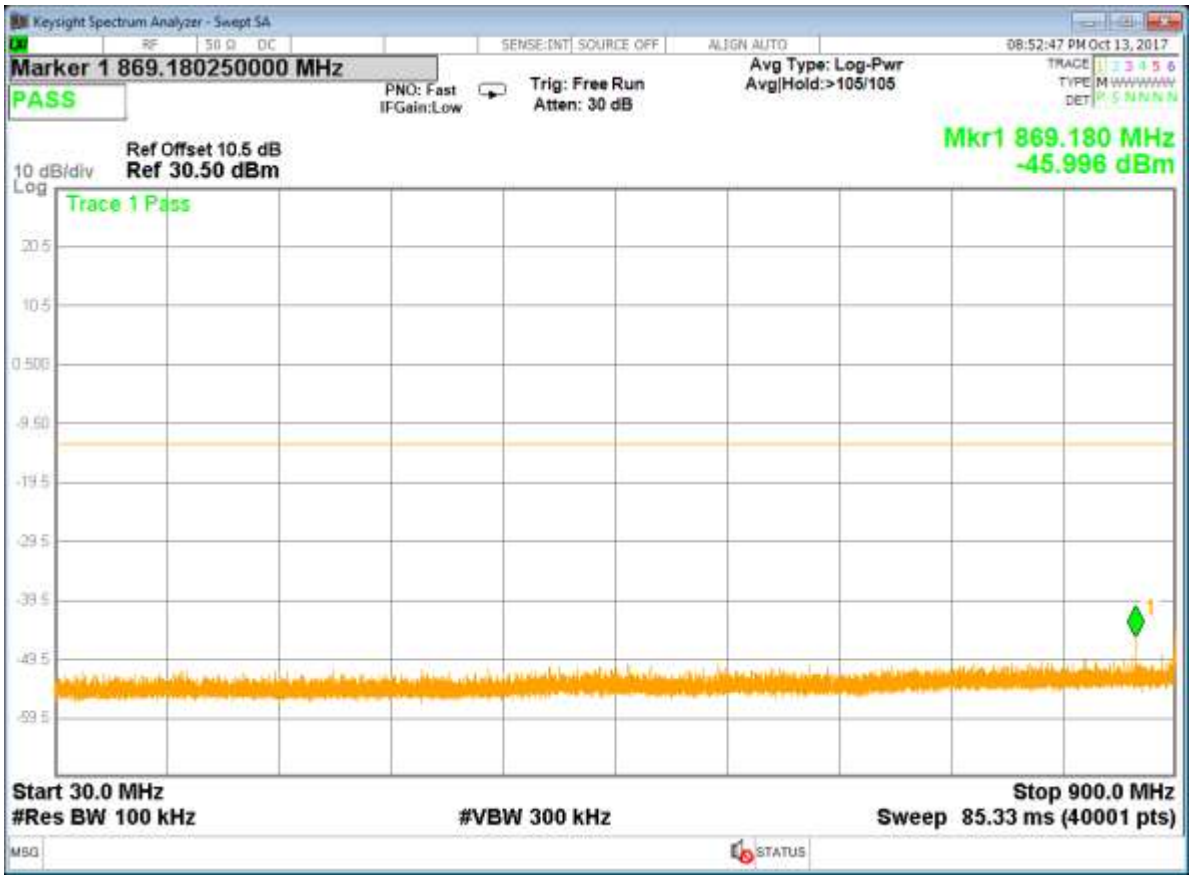


Figure 34: Conducted Spurious Emissions, Drive-by Mode, Low Channel 900 – 930MHz

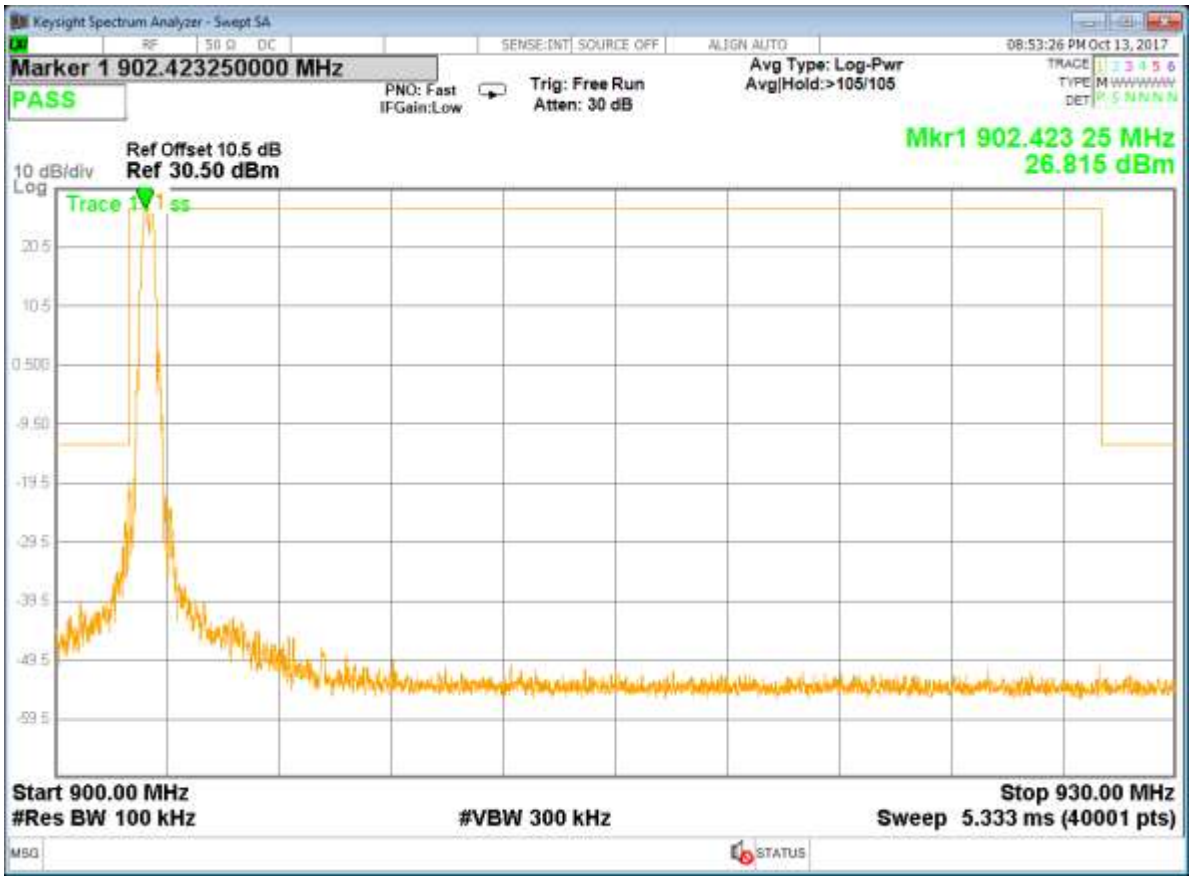


Figure 35: Conducted Spurious Emissions, Drive-by Mode, Low Channel 930 – 5000MHz

Figure 36: Conducted Spurious Emissions, Drive-by Mode, Low Channel 5 – 10GHz

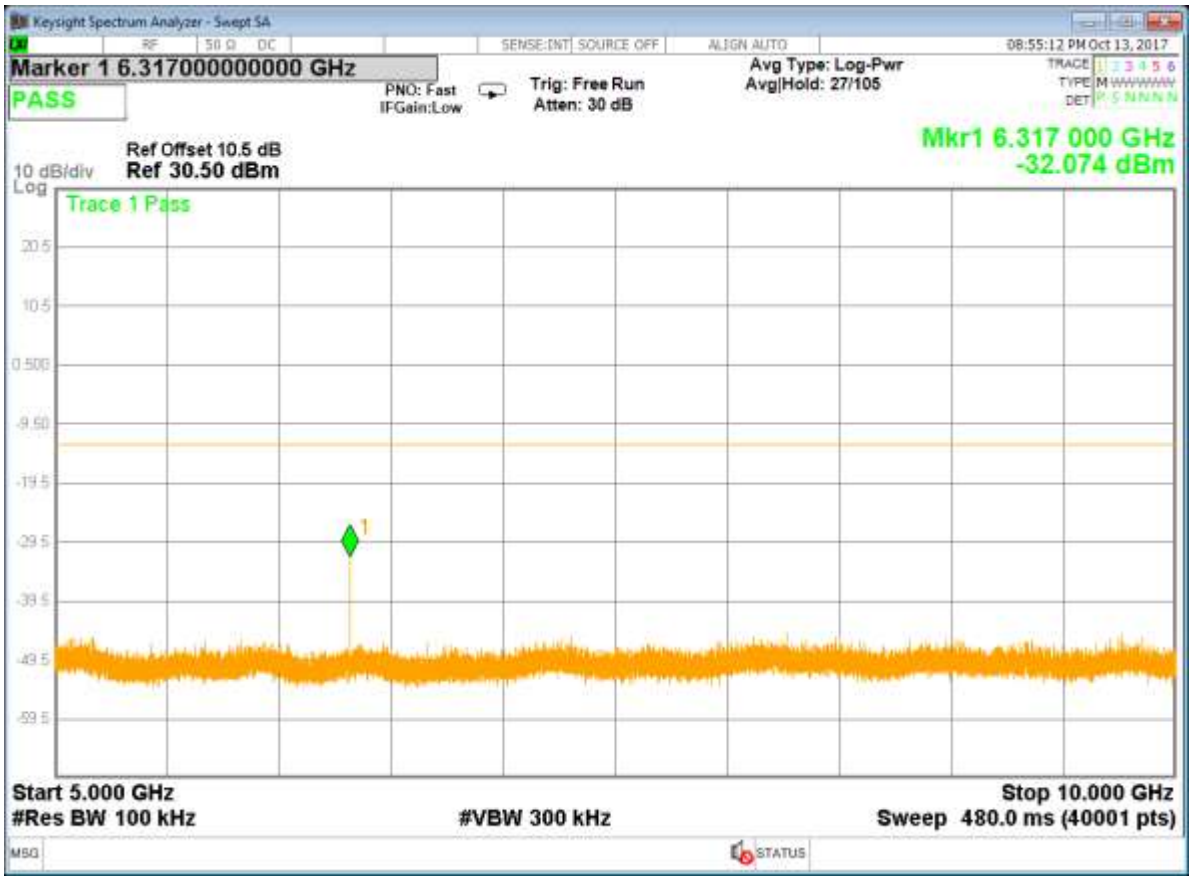


Figure 37: Conducted Spurious Emissions, Drive-by Mode, Center Channel 30 - 900MHz

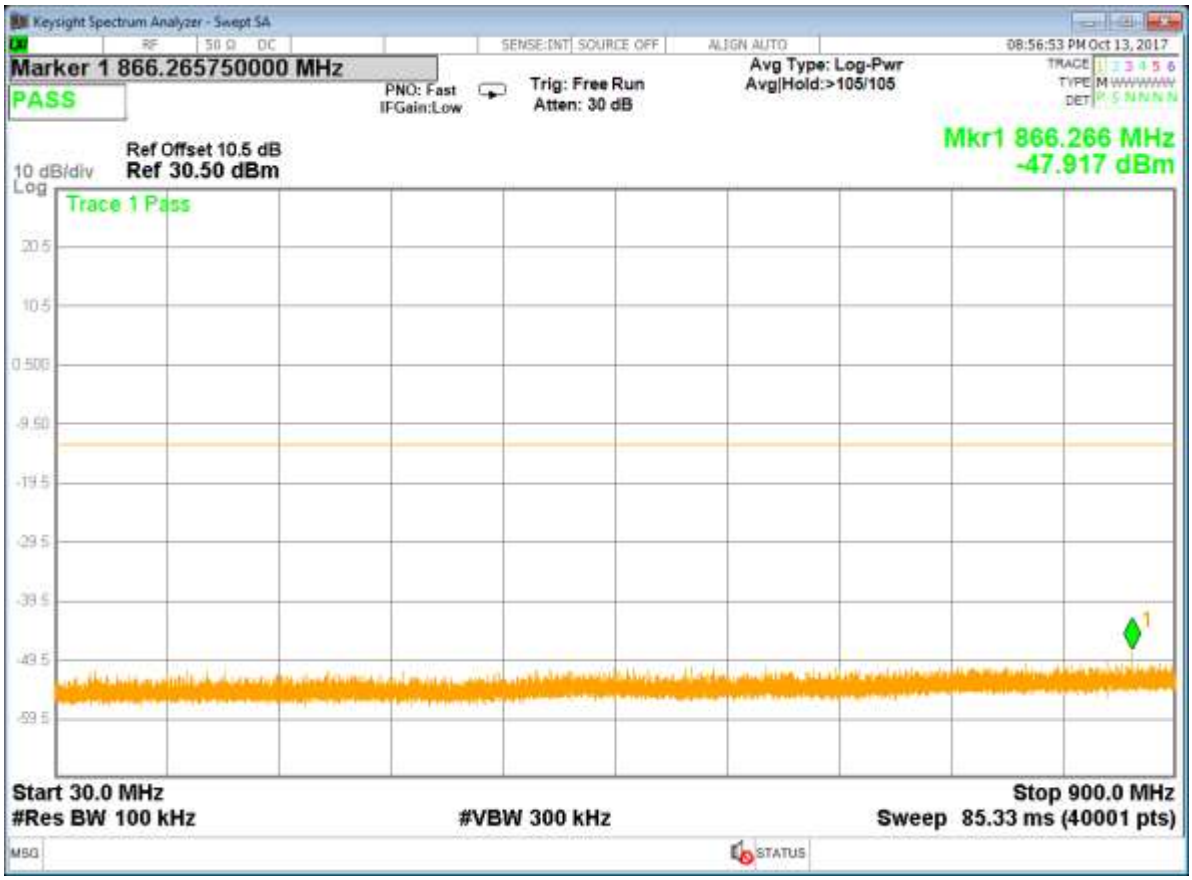


Figure 38: Conducted Spurious Emissions, Drive-by Mode, Center Channel 900 – 930MHz

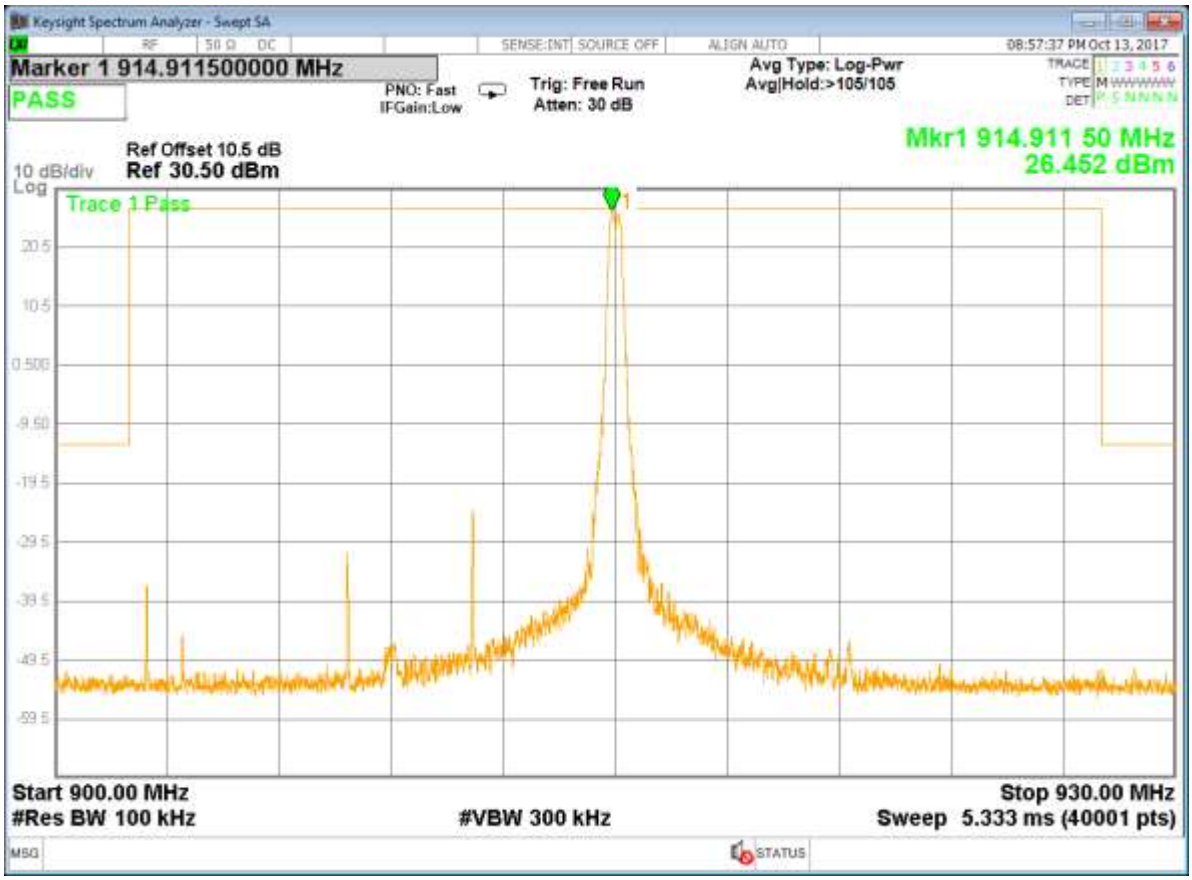


Figure 39: Conducted Spurious Emissions, Drive-by Mode, Center Channel 930 – 5000MHz

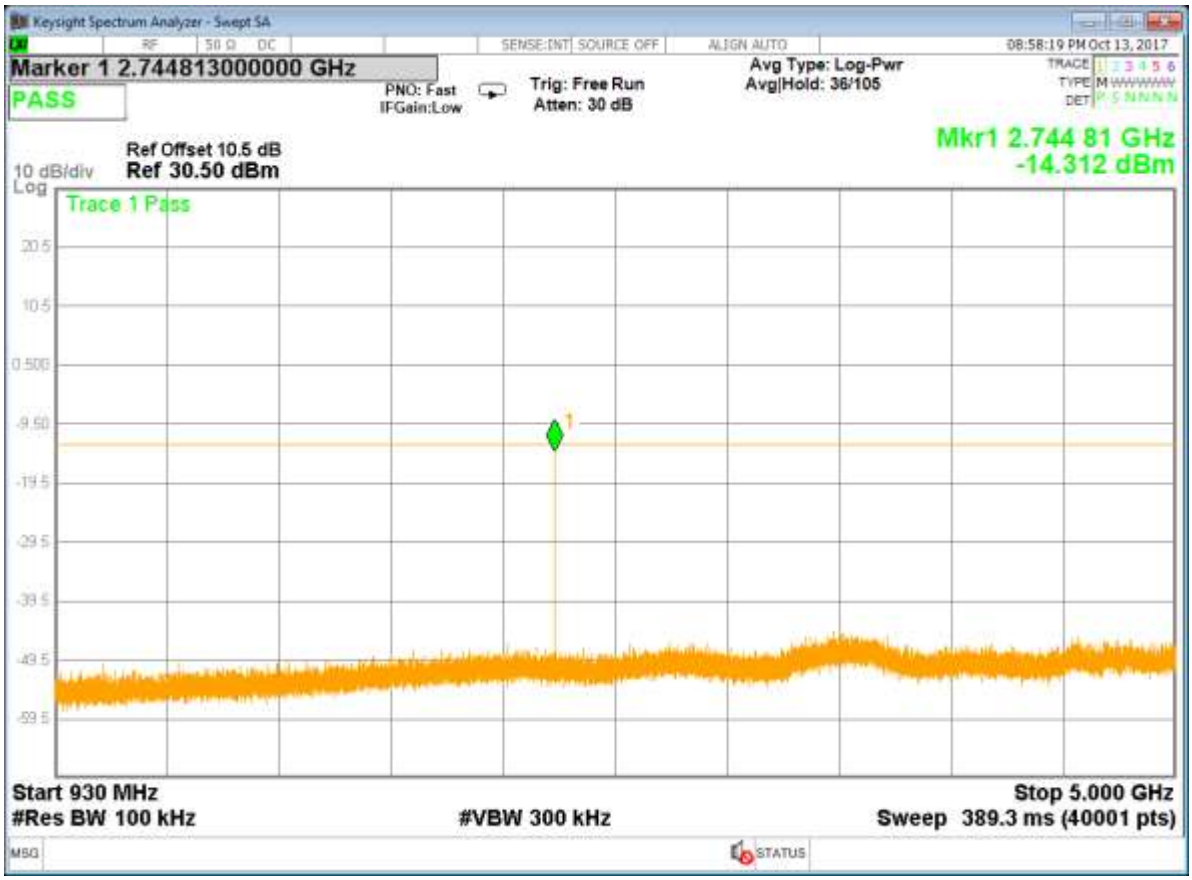


Figure 40: Conducted Spurious Emissions, Drive-by Mode, Center Channel 5 – 10GHz

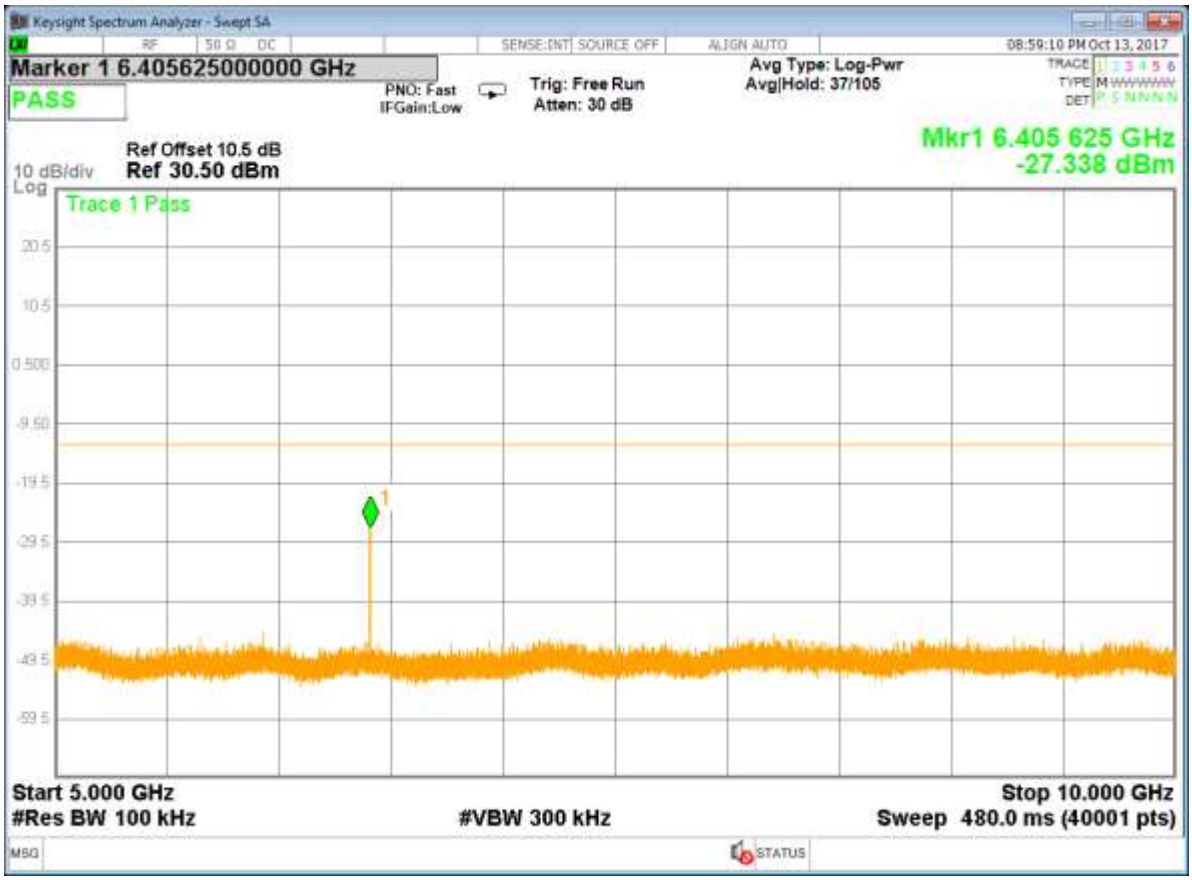


Figure 41: Conducted Spurious Emissions, Drive-by Mode, High Channel 30 - 900MHz

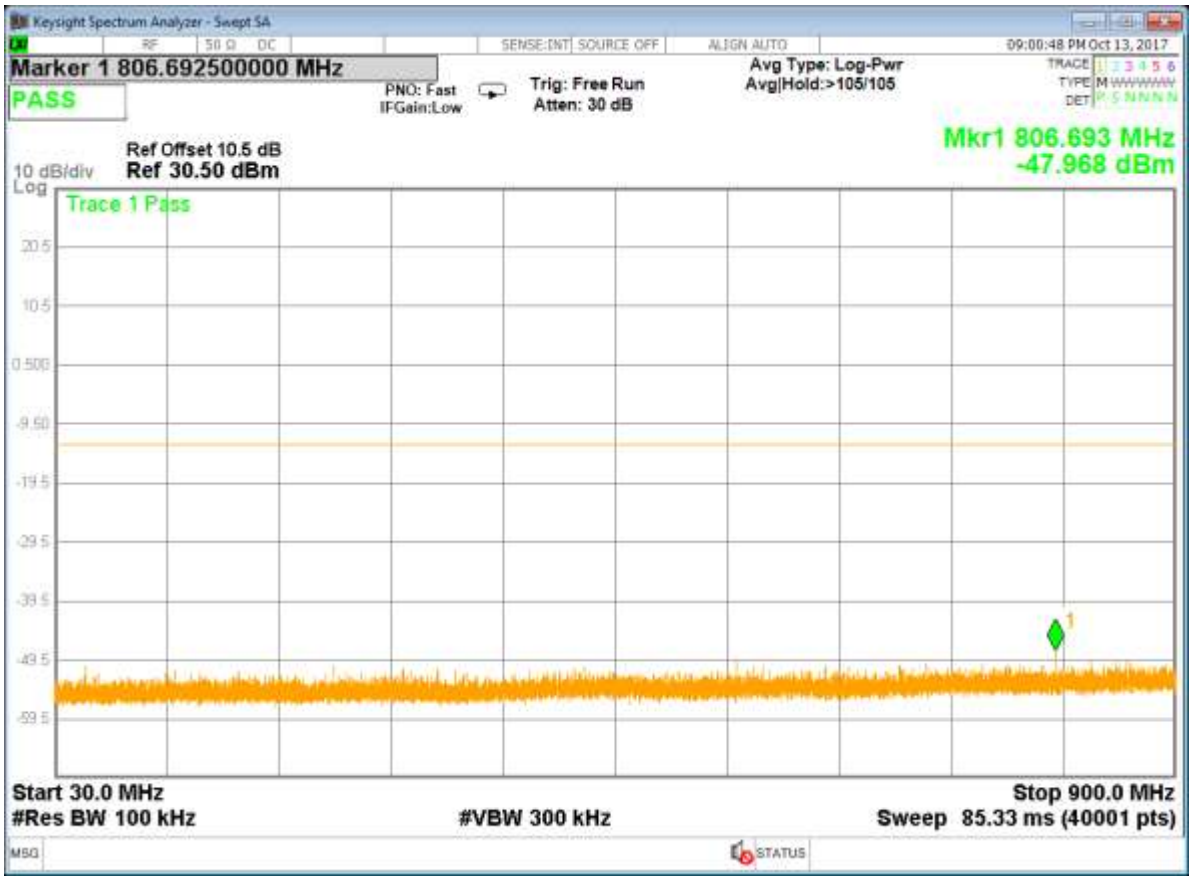


Figure 42: Conducted Spurious Emissions, Drive-by Mode, High Channel 900 – 930MHz

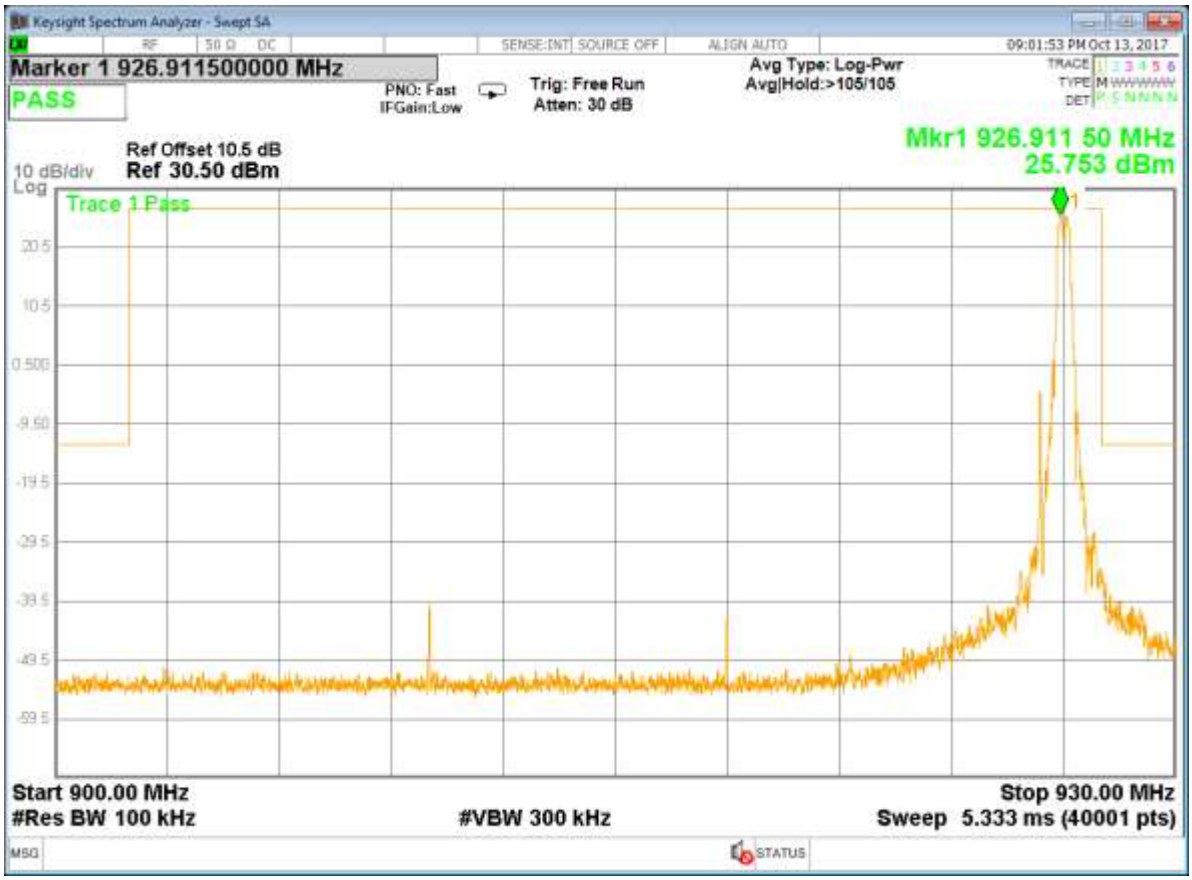


Figure 43: Conducted Spurious Emissions, Drive-by Mode, High Channel 930 – 5000MHz

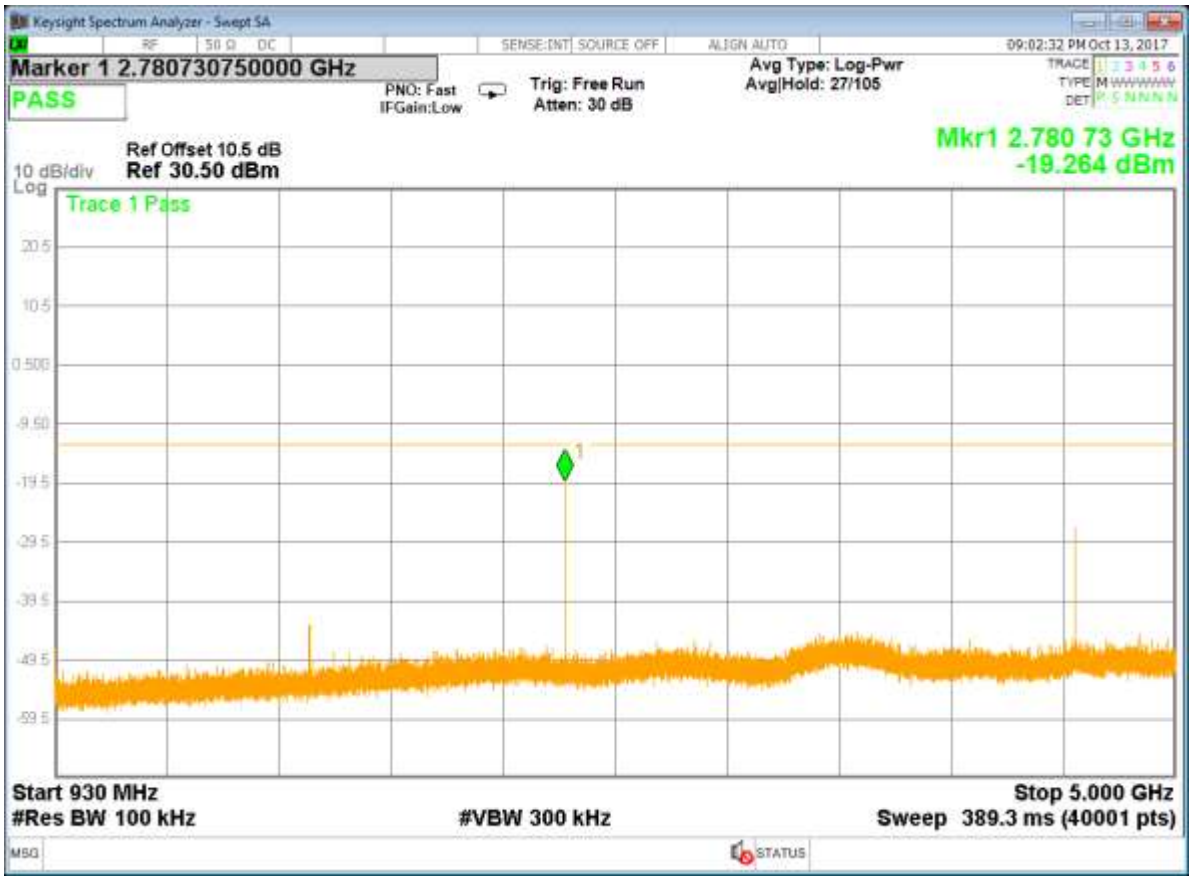


Figure 44: Conducted Spurious Emissions, Drive-by Mode, High Channel 5 – 10GHz

4.7 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 plots of the conducted band edge emissions data follow below.

Figure 45: Band-edge, Mesh Mode, Hopping

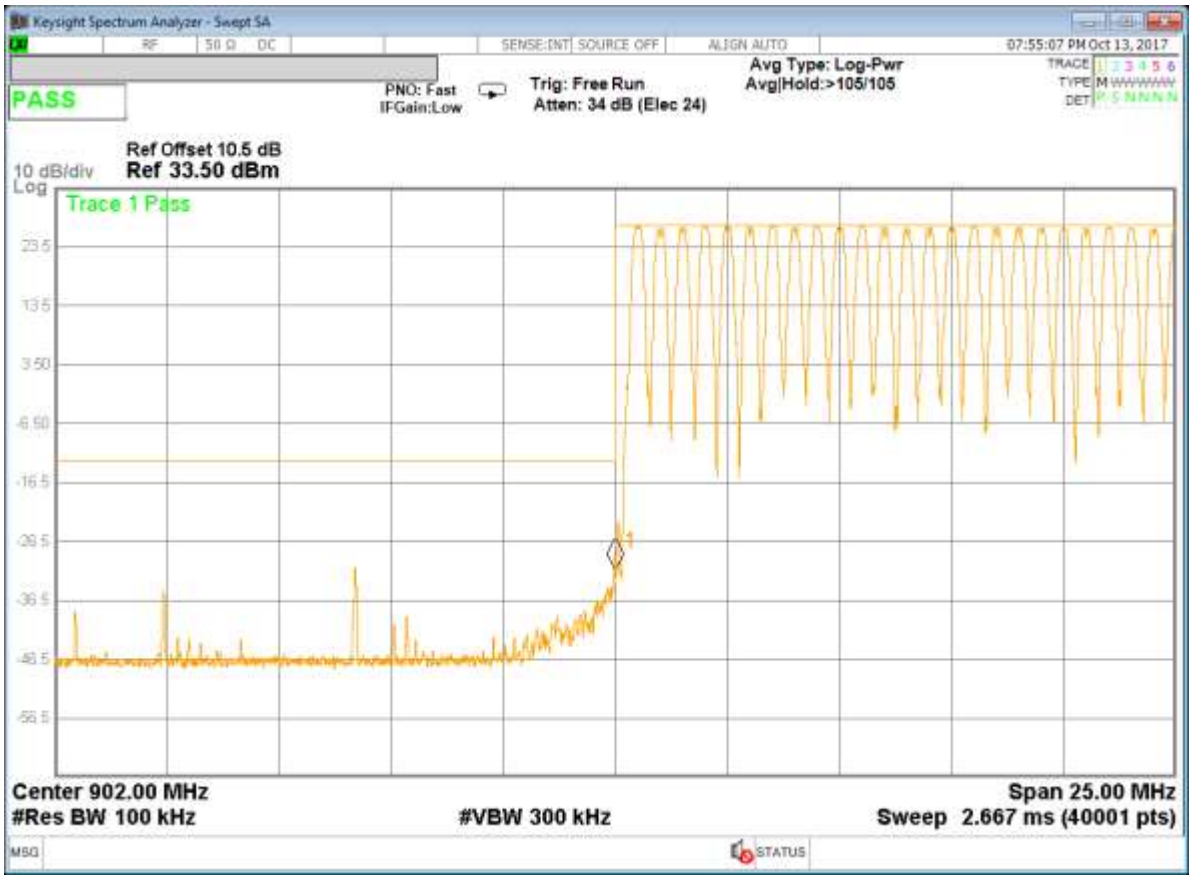


Figure 46: Low Channel, Mesh Mode, Lower Band-edge

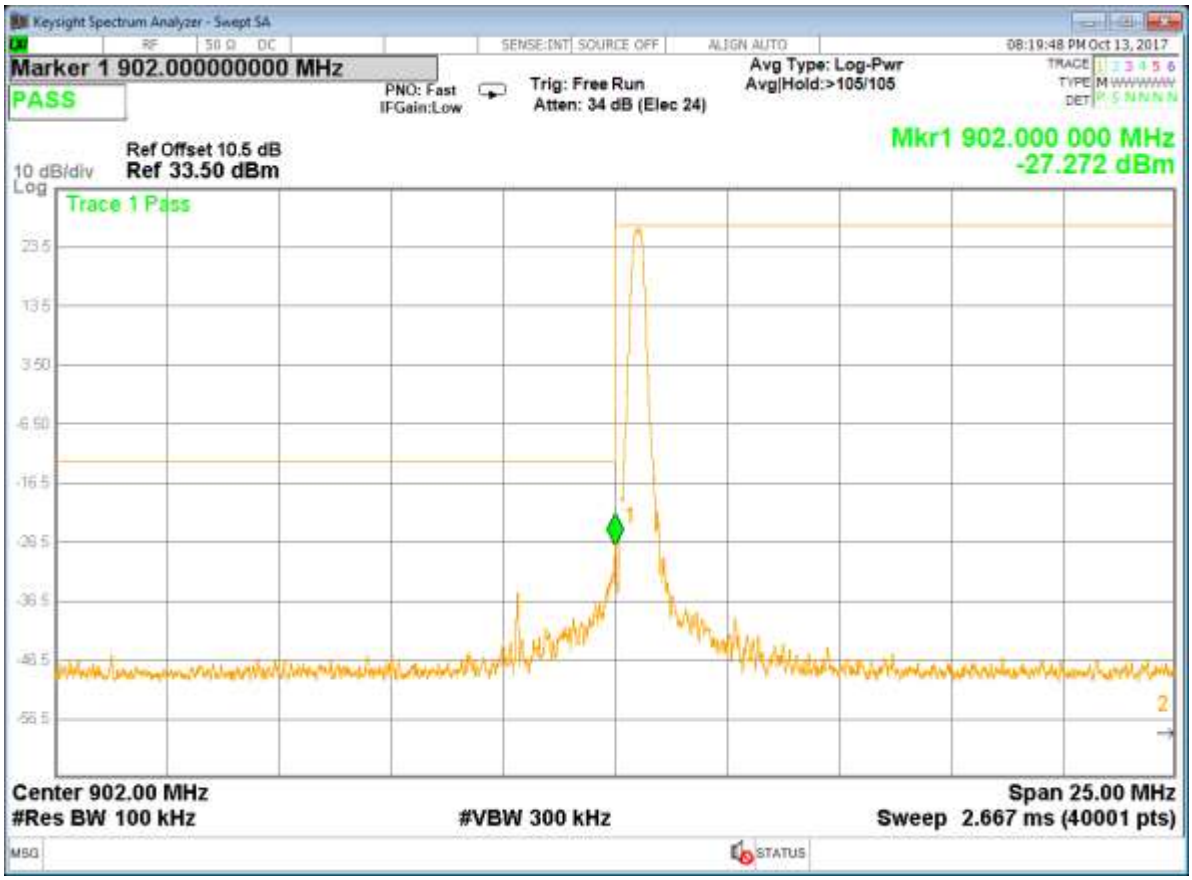


Figure 47: Upper Band-edge, Mesh Mode, Hopping

Figure 48: High Channel, Mesh Mode, Upper Band-edge

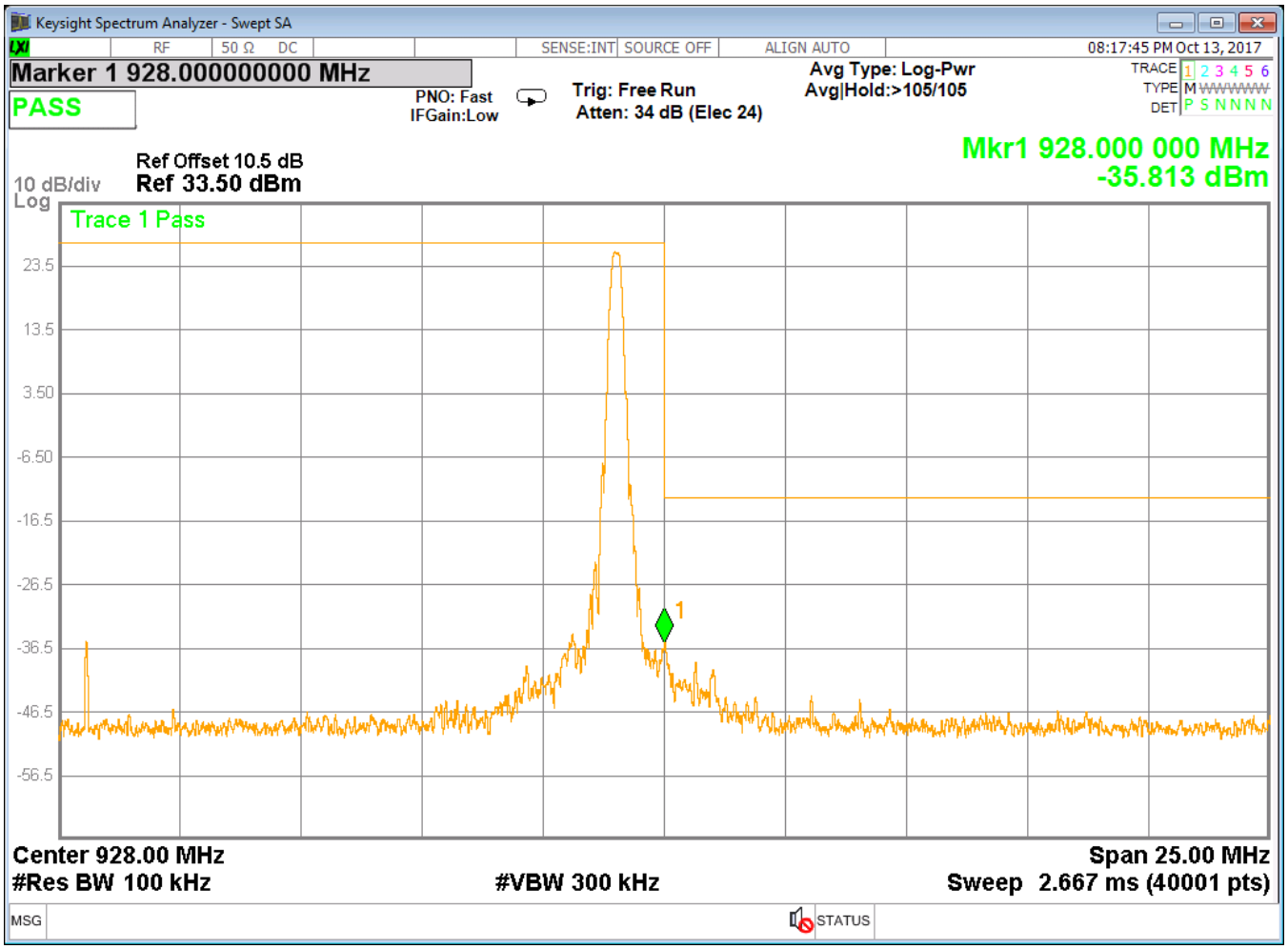


Figure 49: Lower Band-edge, Drive-by Mode, Hopping

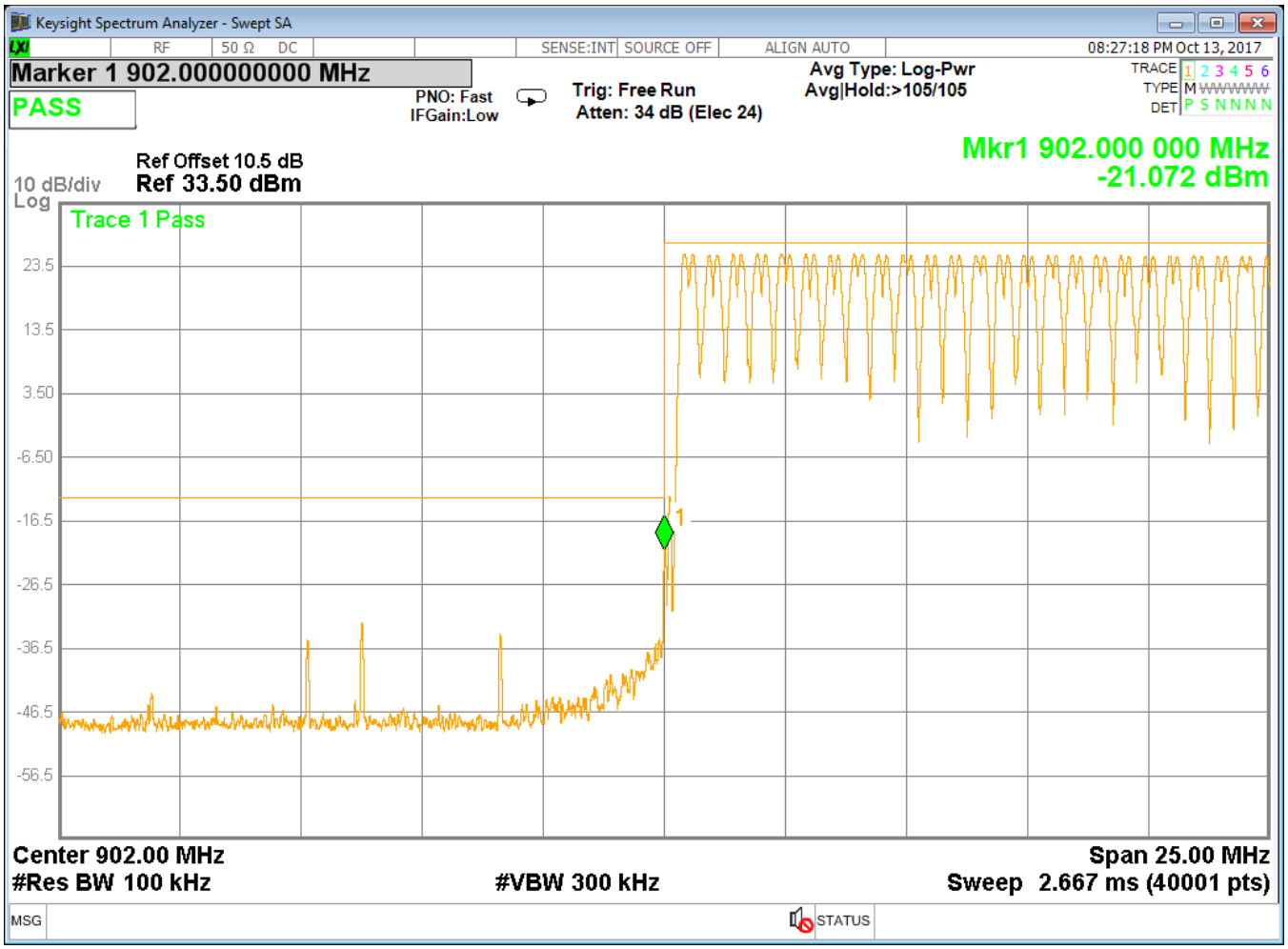


Figure 50: Low Channel, Drive-by Mode, Lower Band-edge

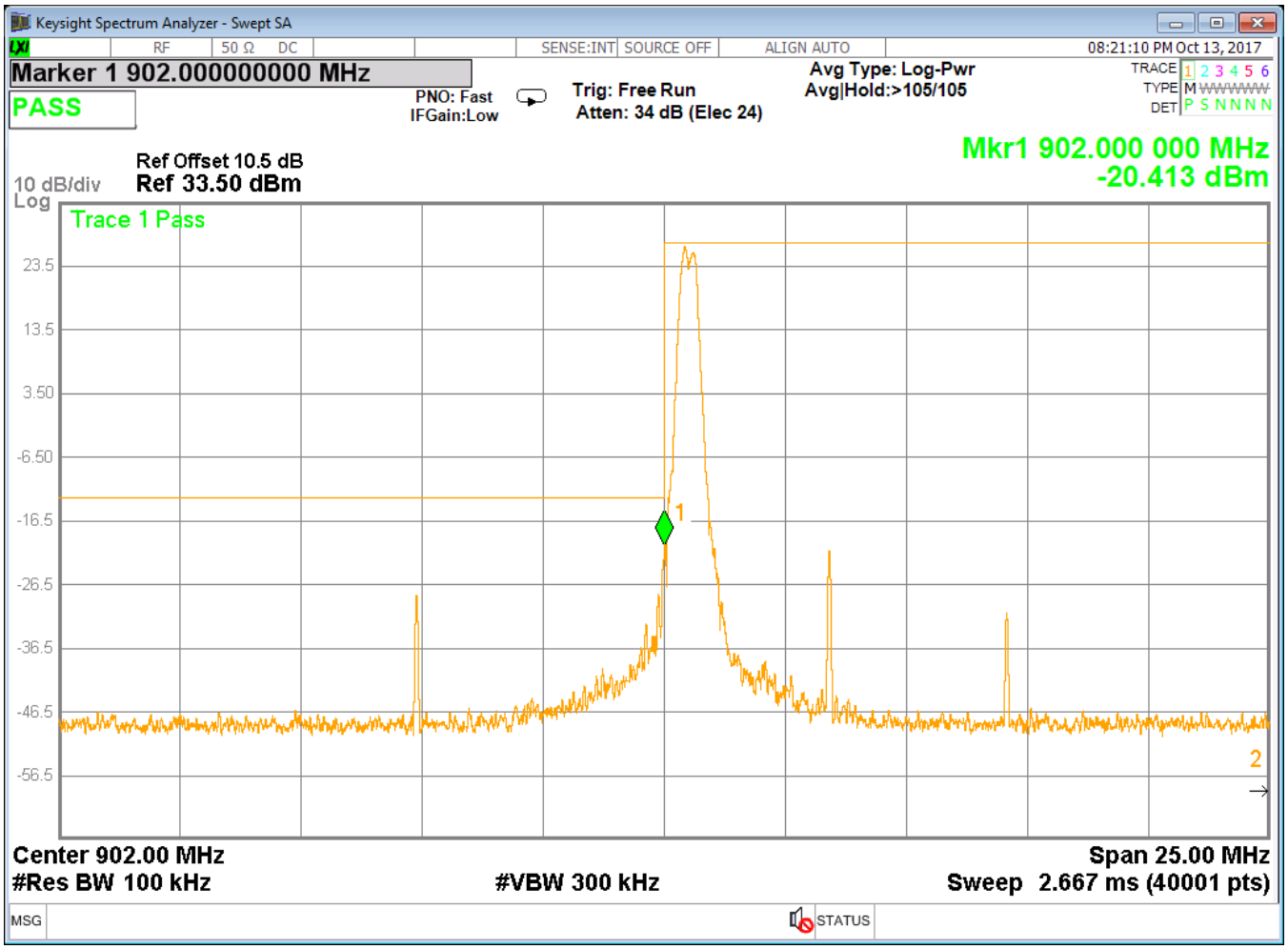


Figure 51: Upper Band-edge, Drive-by Mode, Hopping

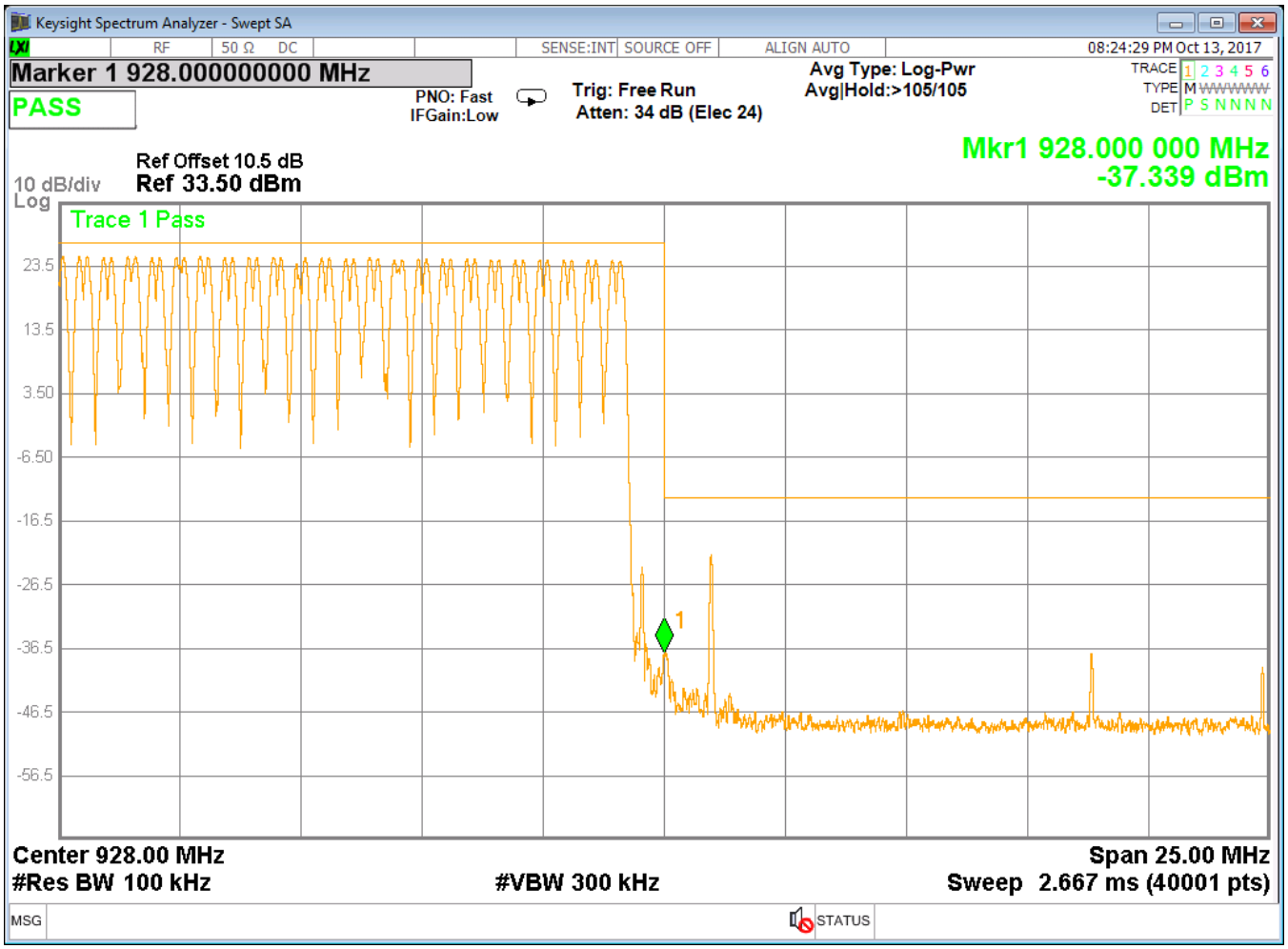
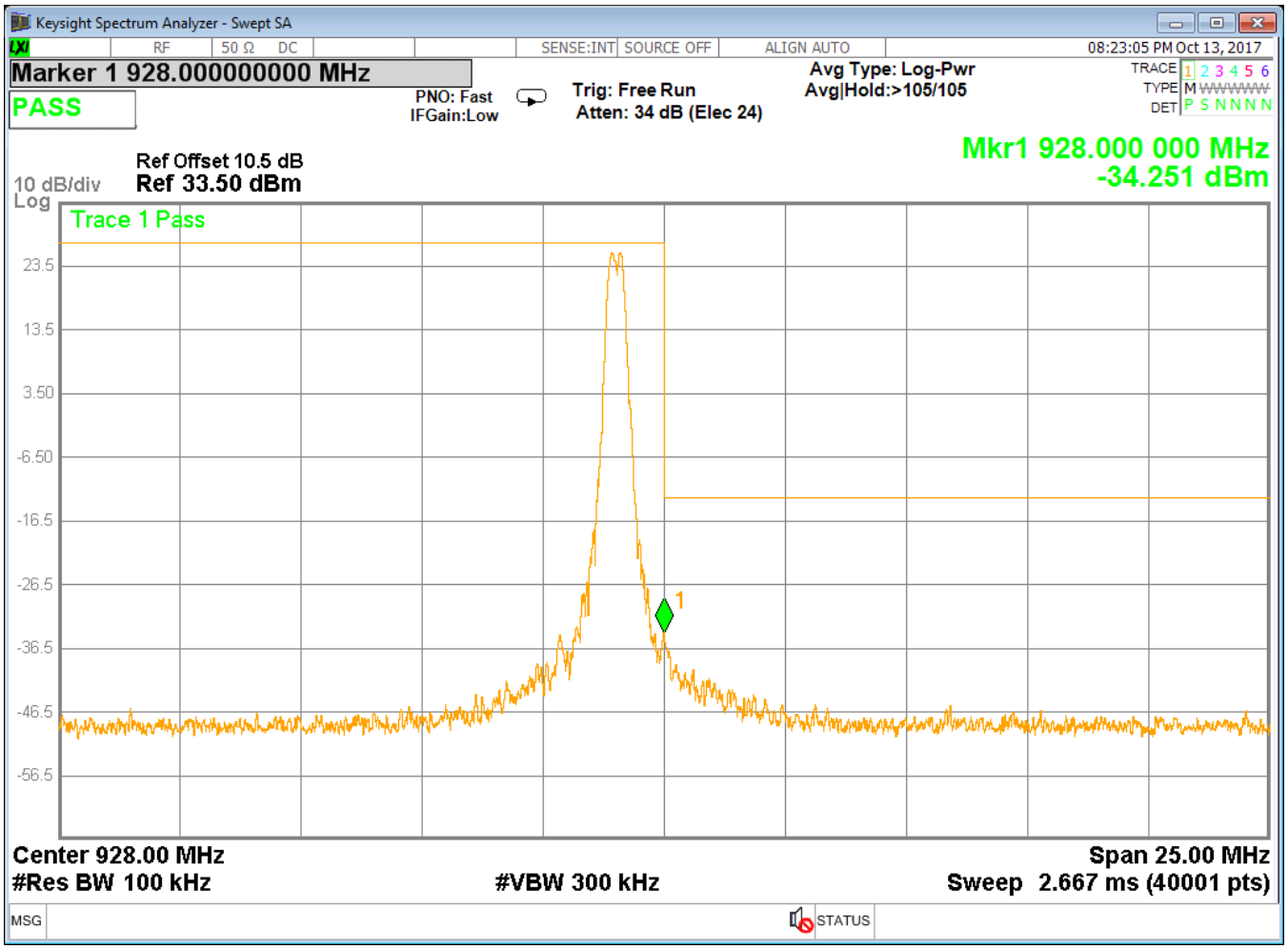


Figure 52: High Channel, Drive-by Mode, Upper Band-edge



4.8 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.

4.8.1 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 evaluated 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 bandwidth

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	36.05	-11.6	16.7	150.0	-19.0	
264.01	V	180.00	1.00	32.64	-11.7	11.1	200.0	-25.1	
120.00	H	135.00	3.50	39.52	-11.6	25.0	150.0	-15.6	
264.01	H	0.00	3.50	42.47	-11.7	34.5	200.0	-15.3	

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

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
2707.50	V	45.00	1.00	60.66	1.2	1235.2	5000.0	-12.1	Peak
2707.50	V	45.00	1.00	50.74	1.2	394.2	500.0	-2.1	Average
3610.00	V	90.00	1.00	49.98	3.0	446.8	5000.0	-21.0	Peak
3610.00	V	90.00	1.00	36.66	3.0	96.4	500.0	-14.3	Average
4512.50	V	135.00	1.00	55.38	5.2	1073.9	5000.0	-13.4	Peak
4512.50	V	135.00	1.00	36.59	5.2	123.4	500.0	-12.2	Average
5415.00	V	135.00	1.20	45.53	9.2	542.2	5000.0	-19.3	Peak
5415.00	V	135.00	1.20	32.70	9.2	123.8	500.0	-12.1	Average
8122.50	V	270.00	1.20	45.88	15.6	1186.7	5000.0	-12.5	Peak
8122.50	V	270.00	1.20	33.03	15.6	270.3	500.0	-5.3	Average
9025.00	V	225.00	1.20	47.20	17.1	1641.5	5000.0	-9.7	Peak
9025.00	V	225.00	1.20	34.31	17.1	372.2	500.0	-2.6	Average
2707.50	H	45.00	1.50	61.88	1.2	1421.5	5000.0	-10.9	Peak
2707.50	H	45.00	1.50	51.78	1.2	444.4	500.0	-1.0	Average
3610.00	H	90.00	1.50	50.97	3.0	500.7	5000.0	-20.0	Peak
3610.00	H	90.00	1.50	39.22	3.0	129.4	500.0	-11.7	Average
4512.50	H	90.00	1.50	58.70	5.2	1573.8	5000.0	-10.0	Peak
4512.50	H	90.00	1.50	37.17	5.2	132.0	500.0	-11.6	Average
5415.00	H	135.00	1.50	47.87	9.2	709.9	5000.0	-17.0	Peak
5415.00	H	135.00	1.50	35.85	9.2	177.9	500.0	-9.0	Average
8122.50	H	270.00	1.50	46.96	15.6	1343.9	5000.0	-11.4	Peak
8122.50	H	270.00	1.50	33.75	15.6	293.7	500.0	-4.6	Average
9025.00	H	270.00	1.50	48.90	17.1	1996.3	5000.0	-8.0	Peak
9025.00	H	270.00	1.50	34.80	17.1	393.8	500.0	-2.1	Average

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

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
2745.00	V	45.00	1.00	54.24	1.2	592.0	5000.0	-18.5	Peak
2745.00	V	45.00	1.00	50.70	1.2	393.8	500.0	-2.1	Average
3660.00	V	90.00	1.00	42.81	3.1	197.4	5000.0	-28.1	Peak
3660.00	V	90.00	1.00	37.07	3.1	101.9	500.0	-13.8	Average
4575.00	V	135.00	1.00	46.58	5.4	398.7	5000.0	-22.0	Peak
4575.00	V	135.00	1.00	41.56	5.4	223.7	500.0	-7.0	Average
9150.00	V	135.00	1.50	44.72	17.4	1281.2	5000.0	-11.8	Peak
9150.00	V	135.00	1.50	33.80	17.4	364.6	500.0	-2.7	Average
2745.00	H	45.00	1.50	55.20	1.2	661.2	5000.0	-17.6	Peak
2745.00	H	45.00	1.50	50.90	1.2	403.0	500.0	-1.9	Average
3660.00	H	45.00	1.50	48.31	3.1	371.7	5000.0	-22.6	Peak
3660.00	H	45.00	1.50	42.60	3.1	192.6	500.0	-8.3	Average
4575.00	H	90.00	1.50	47.94	5.4	466.1	5000.0	-20.6	Peak
4575.00	H	90.00	1.50	44.80	5.4	324.8	500.0	-3.7	Average
8235.00	H	270.00	1.50	45.62	15.7	1163.7	5000.0	-12.7	Peak
8235.00	H	270.00	1.50	35.80	15.7	375.7	500.0	-2.5	Average
9150.00	H	270.00	1.50	45.90	17.4	1468.5	5000.0	-10.6	Peak
9150.00	H	270.00	1.50	34.20	17.4	381.8	500.0	-2.3	Average

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

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
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
3710.00	V	90.00	1.00	48.30	3.2	374.1	5000.0	-22.5	Peak
3710.00	V	90.00	1.00	35.60	3.2	86.7	500.0	-15.2	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
3710.00	H	90.00	1.50	47.60	3.2	345.2	5000.0	-23.2	Peak
3710.00	H	90.00	1.50	34.50	3.2	76.4	500.0	-16.3	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

4.9 RECEIVER RADIATED SPURIOUS EMISSIONS

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.

4.9.1 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)	Pol H/V	Azim Degree	Ant. Ht (m)	SA Level dBuV	Corr Factor (dB)	Corr. Level uV/m	Limit uV/m	Mar (dB)	Comments
45.62	V	180.00	1.00	44.82	-16.0	27.7	100.0	-11.2	
57.17	V	180.00	1.00	40.67	-19.0	12.2	100.0	-18.3	
71.99	V	180.00	1.00	44.37	-17.4	22.4	100.0	-13.0	
312.03	V	180.00	2.00	38.73	-10.4	26.1	200.0	-17.7	
455.95	V	180.00	2.00	40.23	-6.6	48.1	200.0	-12.4	
468.01	V	45.00	2.50	35.18	-6.0	28.7	200.0	-16.9	
504.01	V	180.00	1.20	31.59	-5.1	21.0	200.0	-19.6	
45.62	H	180.00	3.50	37.69	-16.0	12.2	100.0	-18.3	
57.17	H	180.00	3.50	38.46	-19.0	9.4	100.0	-20.5	
71.99	H	180.00	3.50	44.85	-17.4	23.6	100.0	-12.5	
312.03	H	135.00	3.50	32.85	-10.4	13.3	200.0	-23.6	
455.95	H	315.00	3.20	40.12	-6.6	47.5	200.0	-12.5	
468.01	H	90.00	3.20	36.93	-6.0	35.1	200.0	-15.1	
504.01	H	90.00	3.00	35.77	-5.1	34.0	200.0	-15.4	

No other frequencies were observed.

4.10 AC CONDUCTED EMISSIONS (FCC PART §15.207)

4.10.1 Requirements

Test Arrangement: Table Top

Compliance Standard: FCC Class B

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

4.10.2 Test Procedure

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

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

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

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

Example:

Spectrum Analyzer Voltage: VdBµV

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

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

4.10.3 Test Data

This EUT is battery powered only and therefore, conducted emissions are not applicable to this system.