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FCC & ISED Certification Test Report

For the

EATON'S COOPER POWER SYSTEMS

LCR6700 RFN DEVICE

FCC ID: P9X- LCR6700RFN

IC: 6766A- LCR6700RFN

WLL JOB# 15354-01 Rev 3
March16, 2018

Prepared for:

Eaton's Cooper Power Systems
910 Clopper Road, Suite 201 S
Gaithersburg MD 20878

Prepared By:

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

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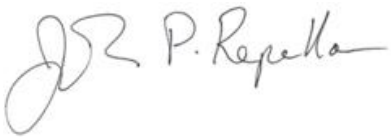

John P. Repella
Manager, EMC & Wireless Services

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Eaton's Cooper Power Systems to support the attached Application for Equipment Authorization. The test report and application are submitted for a Frequency Hopping Spread Spectrum Transmitter under Part 15.247 (10/2015) of the FCC Rules and Regulations and Spectrum Management and Telecommunications Policy RSS-247 Issue 2 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Cooper Power Systems LCR6700 RFN device.

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

The Cooper Power Systems LCR6700 RFN device complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 and Industry Canada RSS-247.

Revision History	Description of Change	Date
Rev 0	Initial Release	November 02, 2018
Rev 1	Updated to include additional data	February 16, 2018
Rev 2	Update to address ACB reviewers comments	March 6, 2018
Rev 3	Updated to address additional reviewers comments	March 16, 2018

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1 Introduction

1.1 Compliance Statement

The Cooper Power Systems LCR6700 RFN Module complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 (10/2016) and Industry Canada RSS-247 Issue 2.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with C63.10 "ANSI Procedures for Compliance Testing of Unlicensed Wireless Devices". The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Eaton's Cooper Power Systems 910 Clopper Road, Suite 201 S Gaithersburg MD 20878
Purchase Order Number:	4509063957
Quotation Number:	70209

1.4 Test Dates

Testing was performed on the following date(s):	10/22/2017 to 10/24/2017 & 2/15/2018

1.5 Test and Support Personnel

Washington Laboratories, LTD	Nikolas M. Allen, John P. Repella
Customer Representative	Steve Seymour

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 LCR6700 RFN is a radio frequency communications device designed for use in Eaton radio communications products. The LCR6700 RFN provides a 915 MHz radio interface to an RF mesh network. The radio device operates in license-free bands at 915 MHz (902.75 to 927.25 MHz). The LCR6700 RFN is fully compatible with mesh network hardware, protocols and operations. Five radio transmission data rates are available: 9.6 kb/s, 19.2 kb/s, 38.4 kb/s, 76.8 kb/s and 153.6 kb/s. The transmission power of the 915 MHz radio is adjustable from 30 dBm to -20 dBm.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Eaton's Cooper Power Systems
FCC ID:	P9X-LCR6700RFN
IC:	6766A-LCR6700RFN
Model:	LCR6700 RFN
FCC Rule Parts:	§15.247
Industry Canada:	RSS-247
Frequency Range:	902.75 – 927.25MHz
Maximum Output Power:	29.97dBm (993mW)
Modulation:	FSK
Occupied Bandwidth(20dB):	470kHz(153.6kbps), 294.3kHz(76.8kbps),254.3 kHz(38.4kbps), 289.8kHz(19.2kbps), 288.6kHz(9.6kbps)
Occupied Bandwidth (99%):	439.1kHz(153.6kbps), 289.9kHz(76.8kbps), 265.8kHz(38.4kbps), 305.4kHz(19.2kbps),303.9 kHz(9.6kbps)
Keying:	Automatic
Type of Information:	Data
Number of Channels:	50
Power Output Level	Variable from 29.97dBm to -6.27dBm
Antenna Connector	Soldered thru-hole.
Antenna Type	On-Board Antenna 2.4dBi (Wire Antenna)
Interface Cables:	None (plug in module)
Power Source & Voltage:	115-230Vac regulated by onboard power supply
FCC Emission Designator	470KFXD
ISED Emissions Designator	439KFXD(153.6kbps), 290KFXD(76.8kbps), 266KFXD(38.4kbps), 305KFXD(19.2kbps), 304KFXD(9.6kbps)
Highest TX Spurious Emission	490.1uV/m @ 3m; 7418.00MHz
Highest RX Spurious Emission	186.9uV/m @ 3m; 426.20MHz

2.2 Test Configuration

The Eaton's Cooper Power Systems LCR6700 RFN, Equipment Under Test (EUT), was operated from a AC wall supply providing 120V. Programming commands were sent from a support laptop via a custom RS232 adaptor board to a header on the EUT module. The measurements were performed on the EUT in 3 orthogonals and worst case emissions are represented in the test results section of the report. A piece of closed cell foam was used to support the EUT and antenna.

2.3 Testing Algorithm

The LCR6700 RFN was programmed for operation from a support laptop via a custom RS232 adaptor board to a header on the EUT. Terra-terminal program was used on the support laptop to enter commands setting the EUT to the desired channel or hopping mode.

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

2.4 Test Location

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

2.5 Measurements

2.5.1 References

ANSI C63.10 "Procedures for Compliance Testing of Unlicensed Wireless Devices"

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

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

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

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

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

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:	**Radiated & Conducted Emissions, Antenna Port Conducted Emissions**	Test Date:	**10/23/2017**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHz	10/23/2017
337	WLL - 1.2-5GHz	FILTER BAND PASS	10/23/2017
276	ELECTRO-METRICS - BPA-1000	RF PRE-AMPLIFIER	1/18/2018
627	AGILENT - 8449B	AMPLIFIER 1-26GHz	11/7/2017
825	MEGAPHASE - TM40-K1K5-36	RF CABLE - 2.9MM-2.9MM 36	10/3/2018
528	AGILENT - E4446A	3Hz - 44GHz ANALYZER SPECTRUM	12/19/2018
125	SOLAR - 8028-50-TS-24-BNC	LISN	2/16/2018
126	SOLAR - 8028-50-TS-24-BNC	LISN	2/16/2018
53	HP - 11947A	LIMITER TRANSIENT	2/15/2018

4 Test Summary

The Table Below shows the results of testing for compliance with a Frequency Hopping System in accordance with FCC Part 15.247 10/2014 and RSS-247 Issue 2. Full test results are shown in Section 5.

Table 4: Test Summary Table

TX Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.247 (a)(1)(i)	RSS-247 Section 5.1 (1)	20dB Bandwidth 99% Bandwidth	Pass
15.247 (b)(2)	RSS-247 Section 5.4 (1)	Transmit Output Power	Pass
15.247 (a)(1)	RSS-247 Section 5.1 (2)	Channel Separation	Pass
15.247 (a)(1)(i)	RSS-247 Section 5.1 (3)	Number of Channels =50 minimum	Pass
15.247 (a)(1)(i)	RSS-247 Section 5.1 (3)	Time of Occupancy	Pass
15.247 (d)	RSS-247 Section 5.5	Occupied BW / Out-of-Band Emissions (Band Edge @ 20dB below)	Pass
15.205 15.209	RSS-247 Section 5.5	General Field Strength Limits (Restricted Bands & RE Limits)	Pass
15.207	RSS-Gen	AC Conducted Emissions	Pass
RX/Digital Test Summary (Frequency Hopping Spread Spectrum)			
FCC Rule Part	**IC Rule Part**	**Description**	**Result**
15.207	RSS-Gen	AC Conducted Emissions	Pass
15.209	RSS-Gen	General Field Strength Limits	Pass

5 Test Results

5.1 Duty Cycle Correction and Time of Occupancy

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

The duty cycle correction factor is calculated by:

20*log (dwell time/100 ms)

The following table and figures show the data for the occupancy time for the transmitter. Based on this information, the dwell time per hop is 20.106ms. The maximum total dwell time per 100ms is 40.208ms. This corresponds to a duty cycle correction of -7.913dB for radiated spurious emissions.

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 high speed power meter (>5Ms/s). The unit was set to hopping mode with the power meter trigger set to 902.75MHz. The worst case results are shown in the table and plots below.

Table 5: Duty Cycle Data Rate Summary

Data Rate (kbps)	Medium Utilization (%)	Duty Cycle (%)	Min. Gap Time (ms)	Max. Sequence Time (ms)	Max. Sequence Time (100ms)
9.6	0.970	46.096	29.189	40.184	40.184
19.2	0.973	47.768	15.617	20.106	40.208
38.4	0.805	46.771	15.755	19.684	39.368
76.8	0.760	41.226	2.202	9.917	39.647
153.6	0.875	41.795	12.829	9.216	36.853

Table 6: Duty Cycle/Time of Occupancy Results

Test	Result	Limit	Pass/Fail
Occupancy per Hop	20.1062ms	NA	NA
Occupancy per 100ms	40.208ms dB Correction	NA	NA
Time of Occupancy	0.241 s/10 sec	0.4s/10 sec	Pass

Calculations assume max occupancy for each hop to produce 0.241s of total occupancy.

Data Rate: 19.2kbps (Worst Case)

Medium Utilization (%)	Duty Cycle (%)	Max. Sequence Time (ms)
0.973	47.768	20.1062

Burst #	Start Time (ms)	Stop Time (ms)	On Time (ms)	Off Time (ms)
1	22.1948	42.2966	20.1018	21.9806
2	64.2772	84.3834	20.1062	15.6166
Total			40.208	

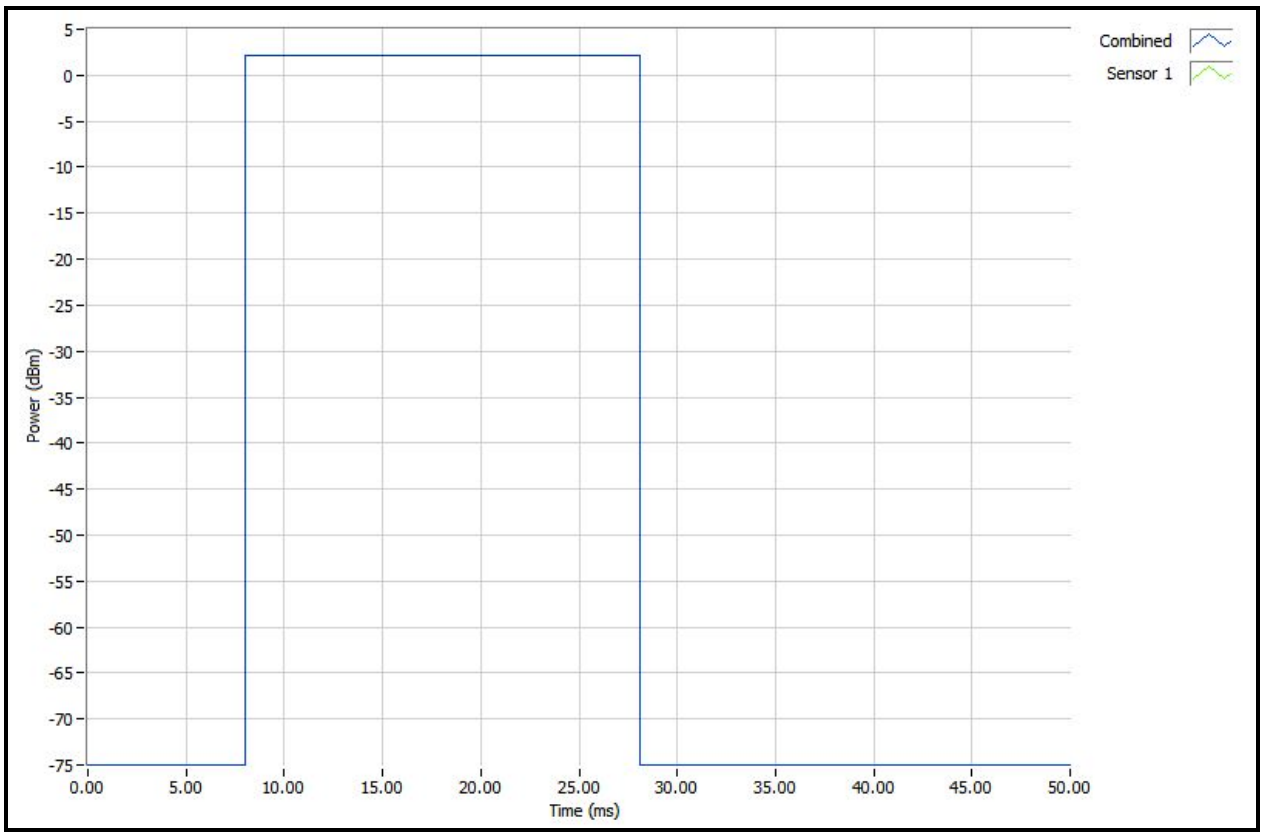

Figure 1: Single Hop Occupancy

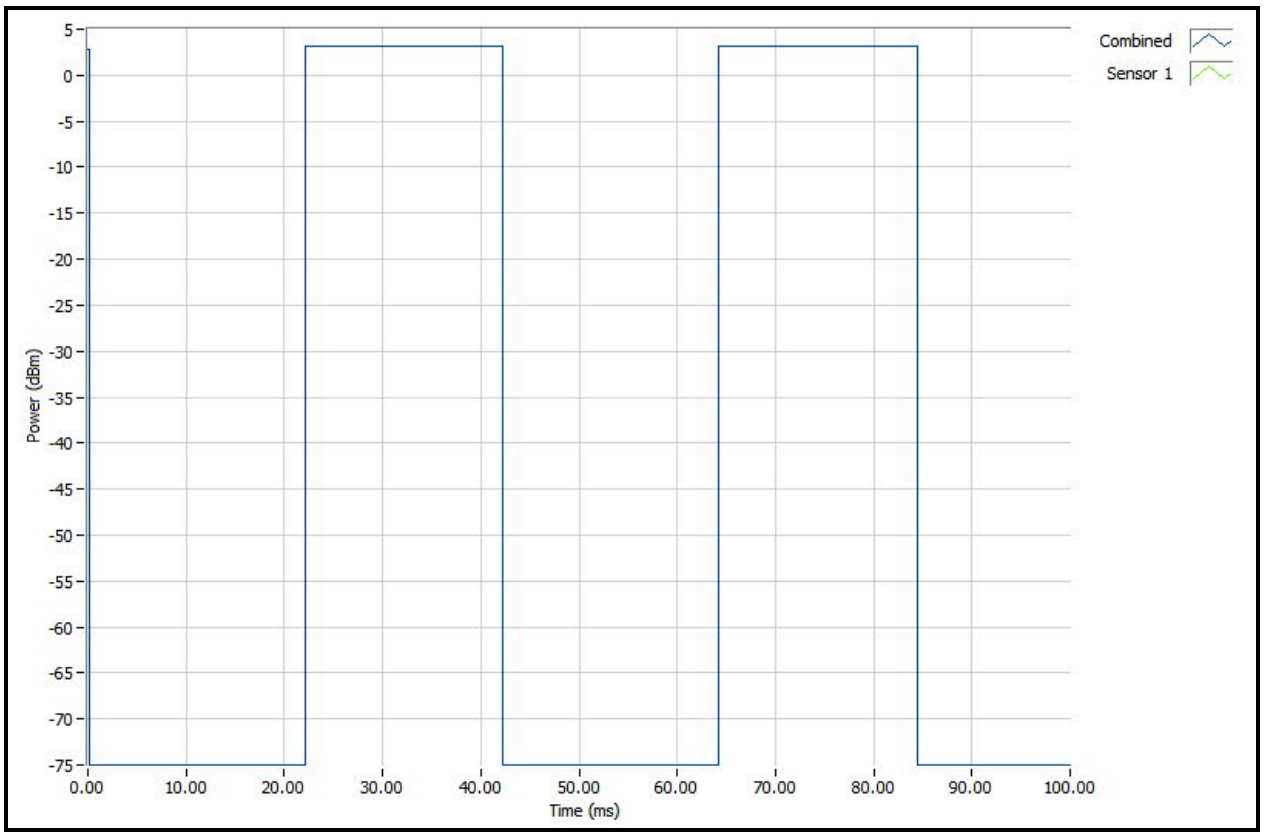

Figure 2: Occupancy per 100ms

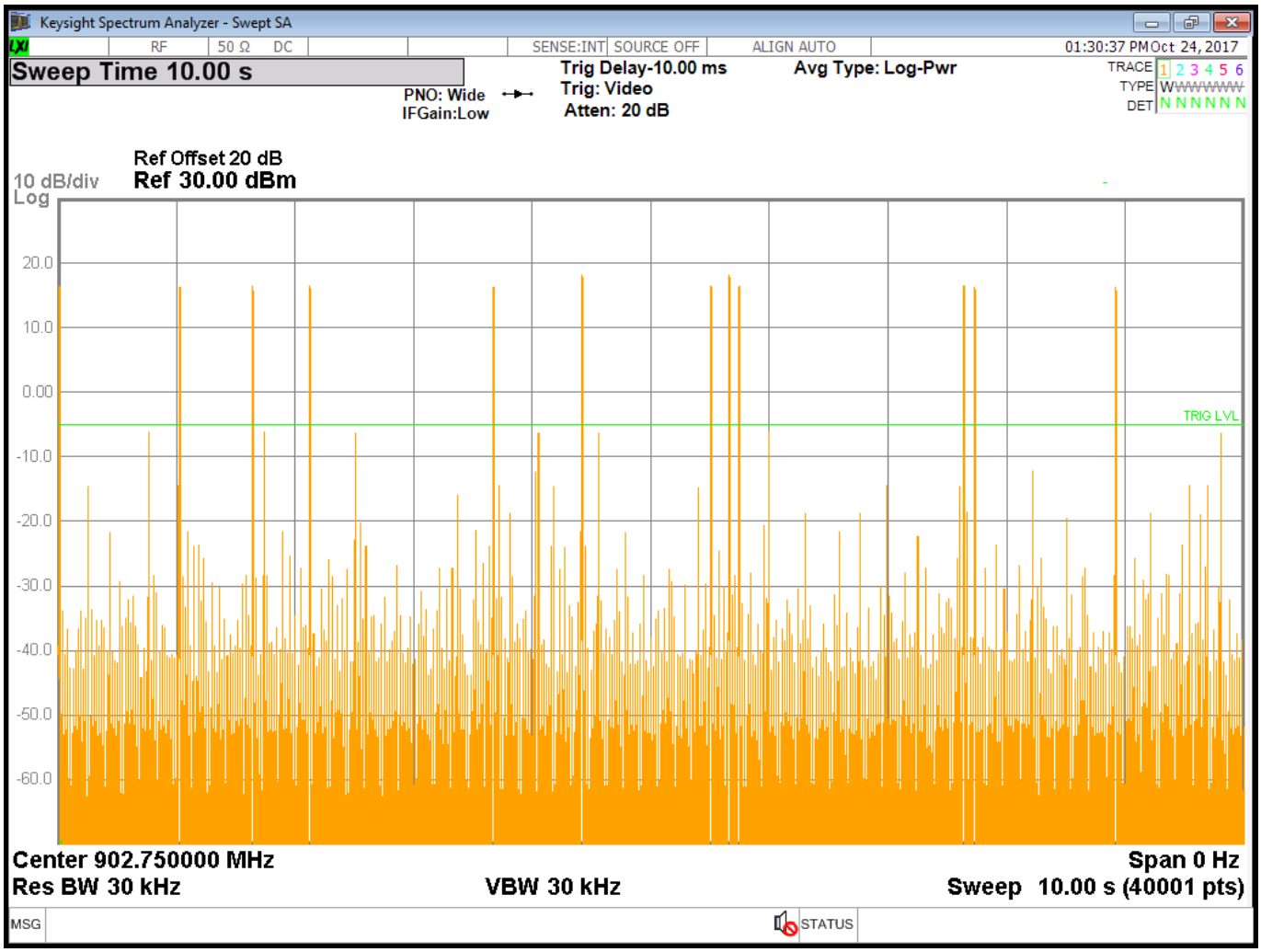

Figure 3: Time of Occupancy 10s

5.2 RF Power Output: (FCC Part §2.1046)

To measure the output power the hopping sequence was stopped and the transmitter was EUT was set to transmit a CW signal. The frequency dwelled on a low, center, and high 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. The EUT has an adjustable output range, and therefore the highest and lowest power available is shown below.

Table 7: RF Power Output

Frequency	Power Setting	Level (dBm)	Limit (dBm)	Pass/Fail
Low Channel: 902.75MHz	High	29.97	30	Pass
Center Channel: 914.75MHz	High	29.85	30	Pass
High Channel: 927.25MHz	High	29.58	30	Pass
Low Channel: 902.75MHz	Low	-6.27	30	Pass
Center Channel: 914.75MHz	Low	-6.62	30	Pass
High Channel: 927.25MHz	Low	-6.98	30	Pass

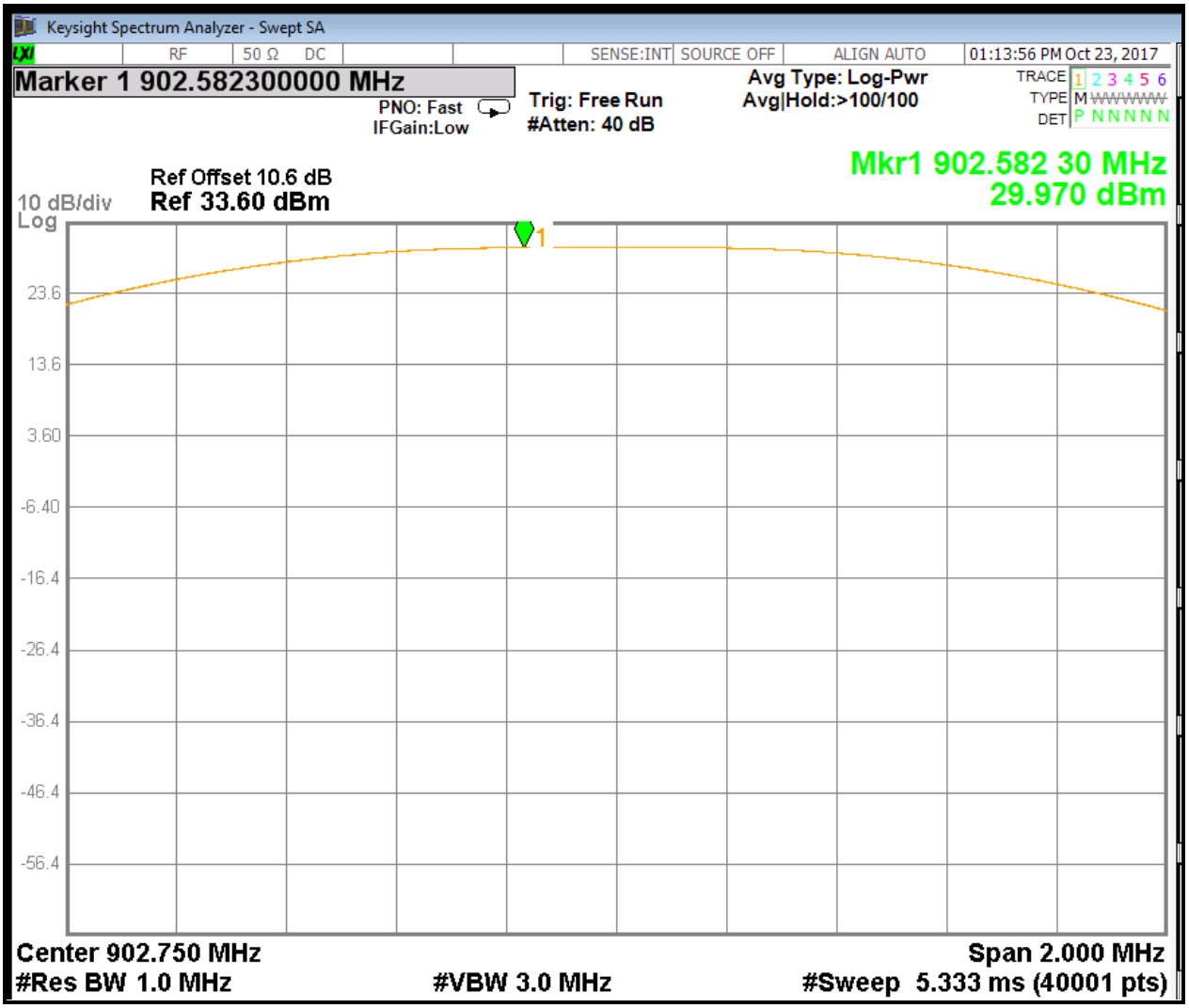

Figure 4: RF Peak Power, High Power, Low Channel

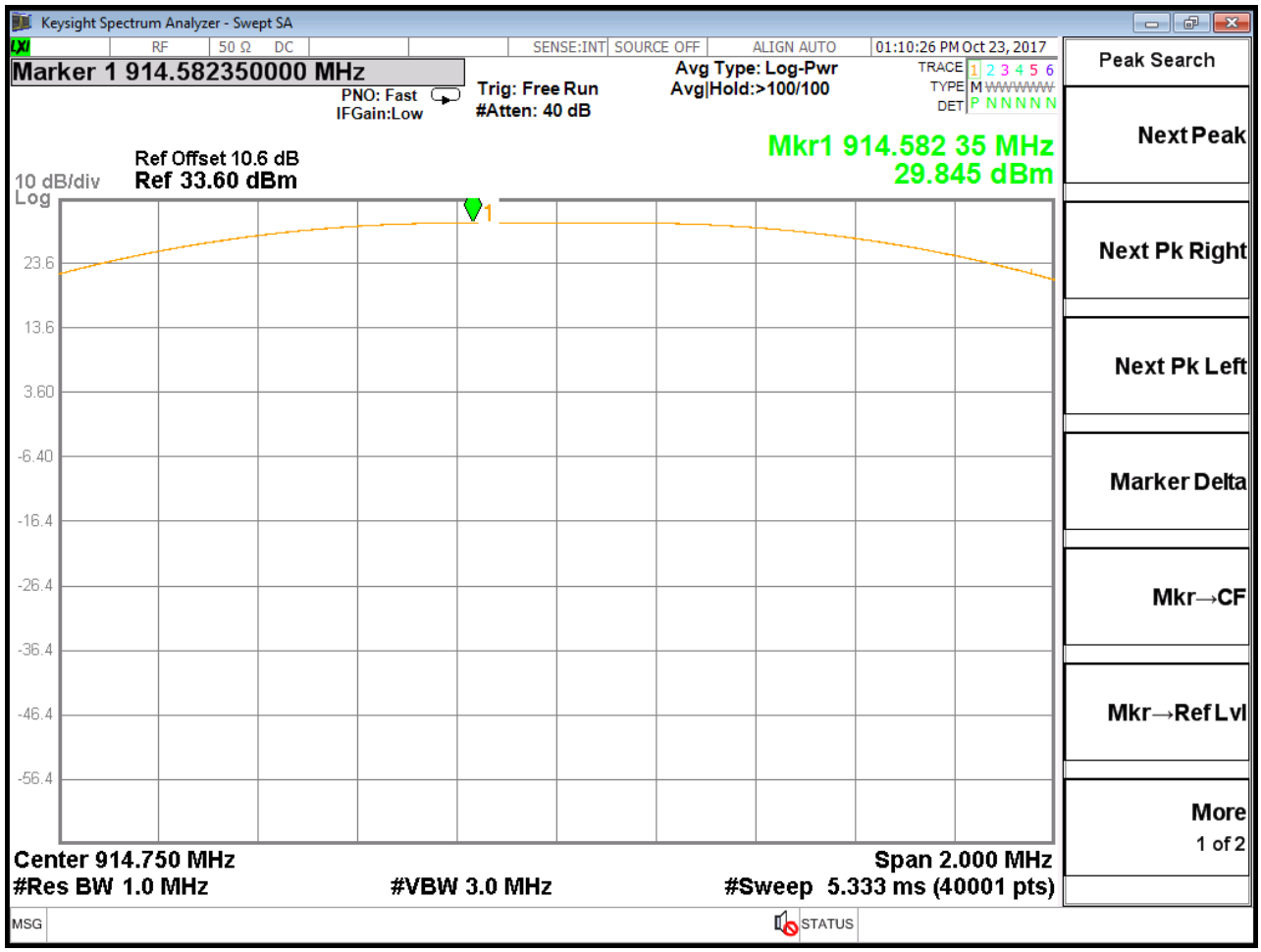

Figure 5: RF Peak Power, High Power, Center Channel

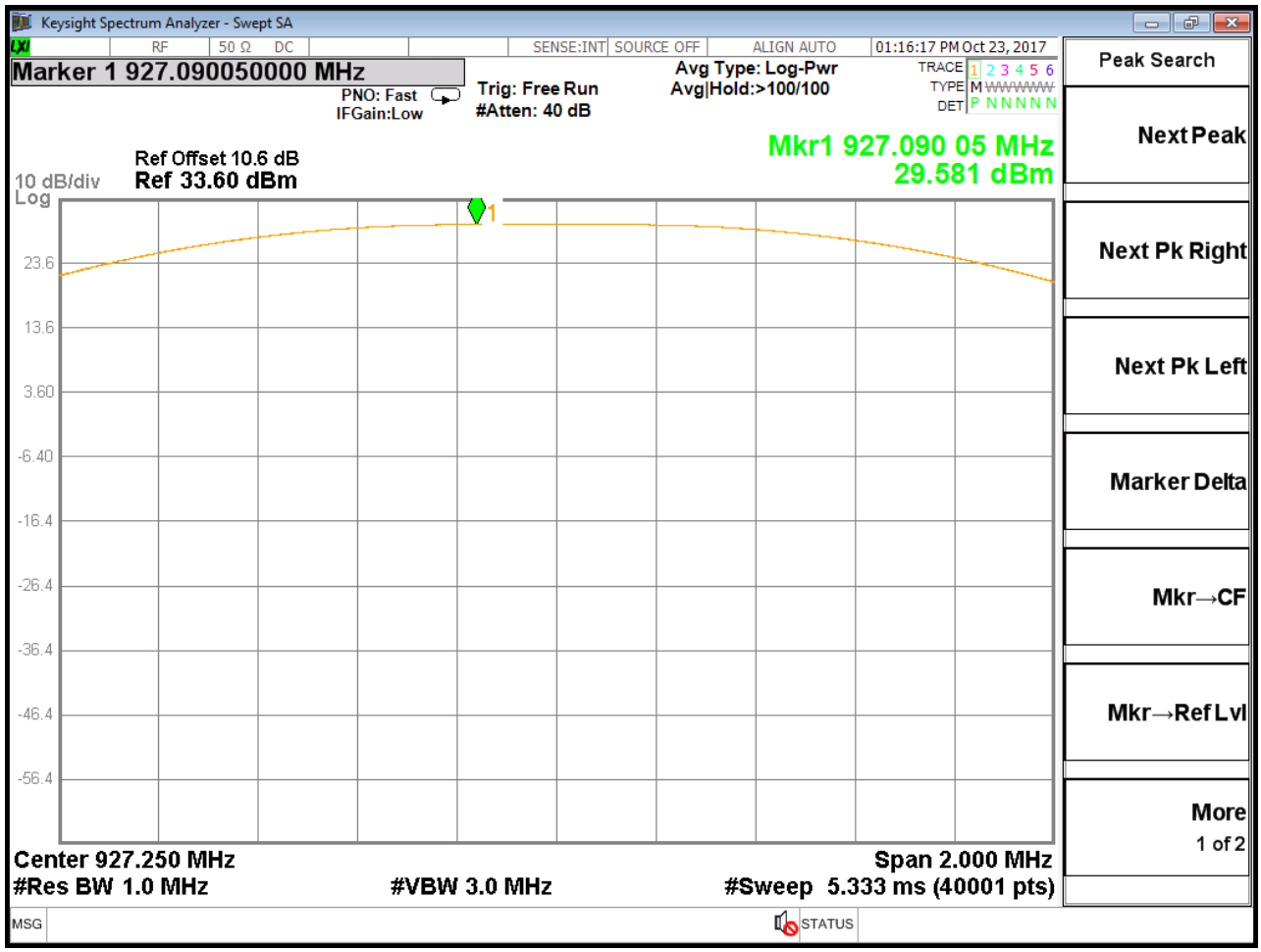

Figure 6: RF Peak Power, High Power, High Channel

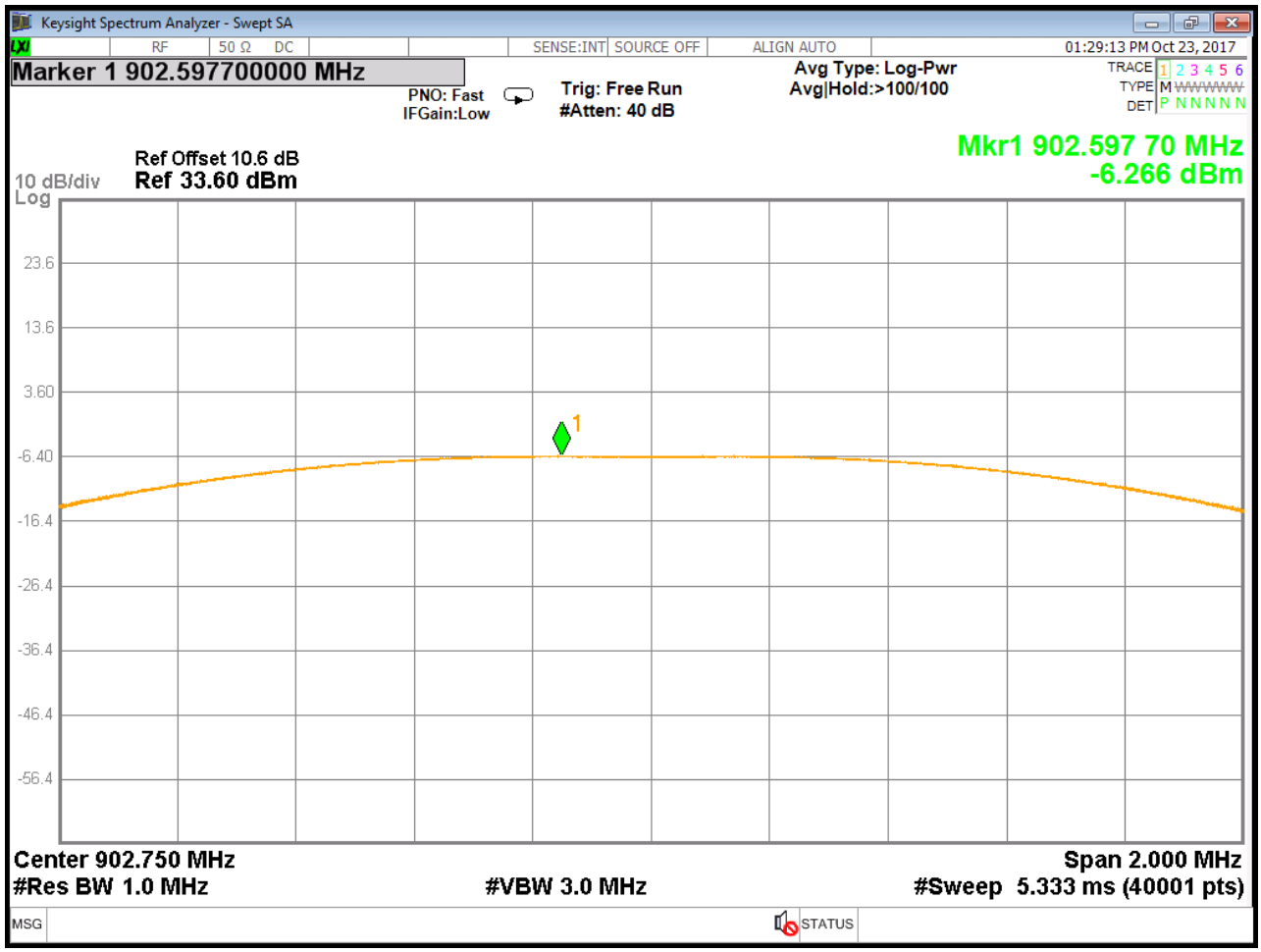

Figure 7: RF Peak Power, Low Power, Low Channel

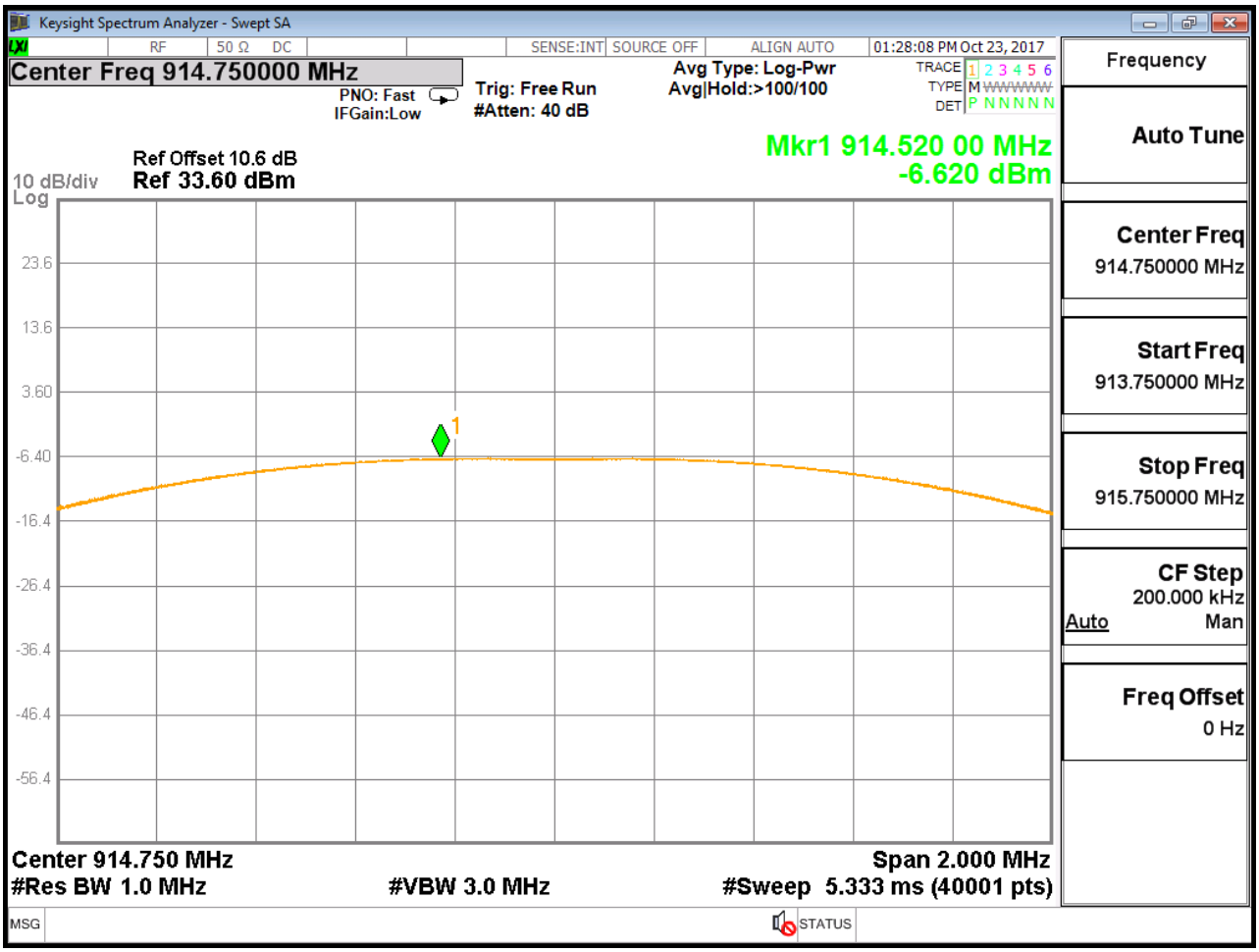

Figure 8: RF Peak Power, Low Power, Center Channel

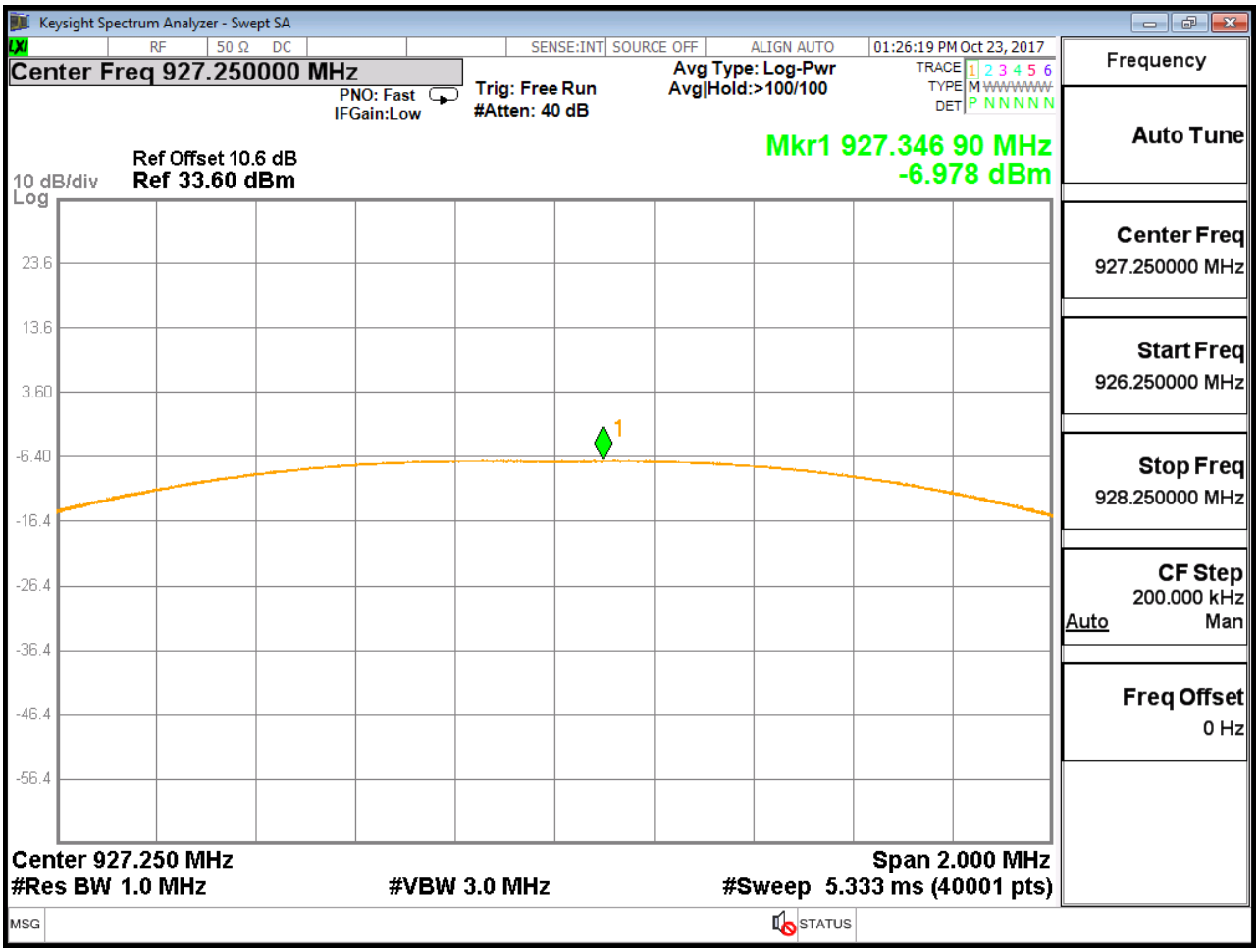

Figure 9: RF Peak Power, Low Power, High Channel

5.3 Occupied Bandwidth: (FCC Part §2.1049)

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

The automatic bandwidth measurement capability was employed using the X dB bandwidth mode with X set to 6 dB, (i.e., RBW = 10 kHz, VBW ≥ 3 × RBW, and peak detector with maximum hold) is implemented by the instrumentation function. Care was taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥6dB. At full modulation, the occupied bandwidth was measured and is summarized in Table 8 for the available data rates. Figures 10-12 provide a sample of the occupied bandwidth measurements for the highest data rate.

Table 8: Occupied Bandwidth Results

Data Rate: 153.6kbps	20dB Bandwidth (kHz)	99% Power Bandwidth(kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75MHz	468.40	432.70	500	Pass
Center Channel: 914.75MHz	470.00	437.47	500	Pass
High Channel: 927.25MHz	469.20	439.10	500	Pass

Data Rate: 76.8kbps	20dB Bandwidth (kHz)	99% Power Bandwidth(kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75MHz	294.30	289.98	500	Pass
Center Channel: 914.75MHz	287.00	274.40	500	Pass
High Channel: 927.25MHz	289.97	276.70	500	Pass

Data Rate: 38.4kbps	20dB Bandwidth (kHz)	99% Power Bandwidth(kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75MHz	254.30	265.80	500	Pass
Center Channel: 914.75MHz	253.80	264.95	500	Pass
High Channel: 927.25MHz	253.80	265.02	500	Pass

Data Rate: 19.2kbps	20dB Bandwidth (kHz)	99% Power Bandwidth(kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75MHz	288.10	300.32	500	Pass
Center Channel: 914.75MHz	289.80	304.53	500	Pass
High Channel: 927.25MHz	289.30	305.54	500	Pass

Data Rate: 9.6kbps	20dB Bandwidth (kHz)	99% Power Bandwidth(kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75MHz	288.60	303.91	500	Pass
Center Channel: 914.75MHz	288.50	300.50	500	Pass
High Channel: 927.25MHz	285.60	300.58	500	Pass

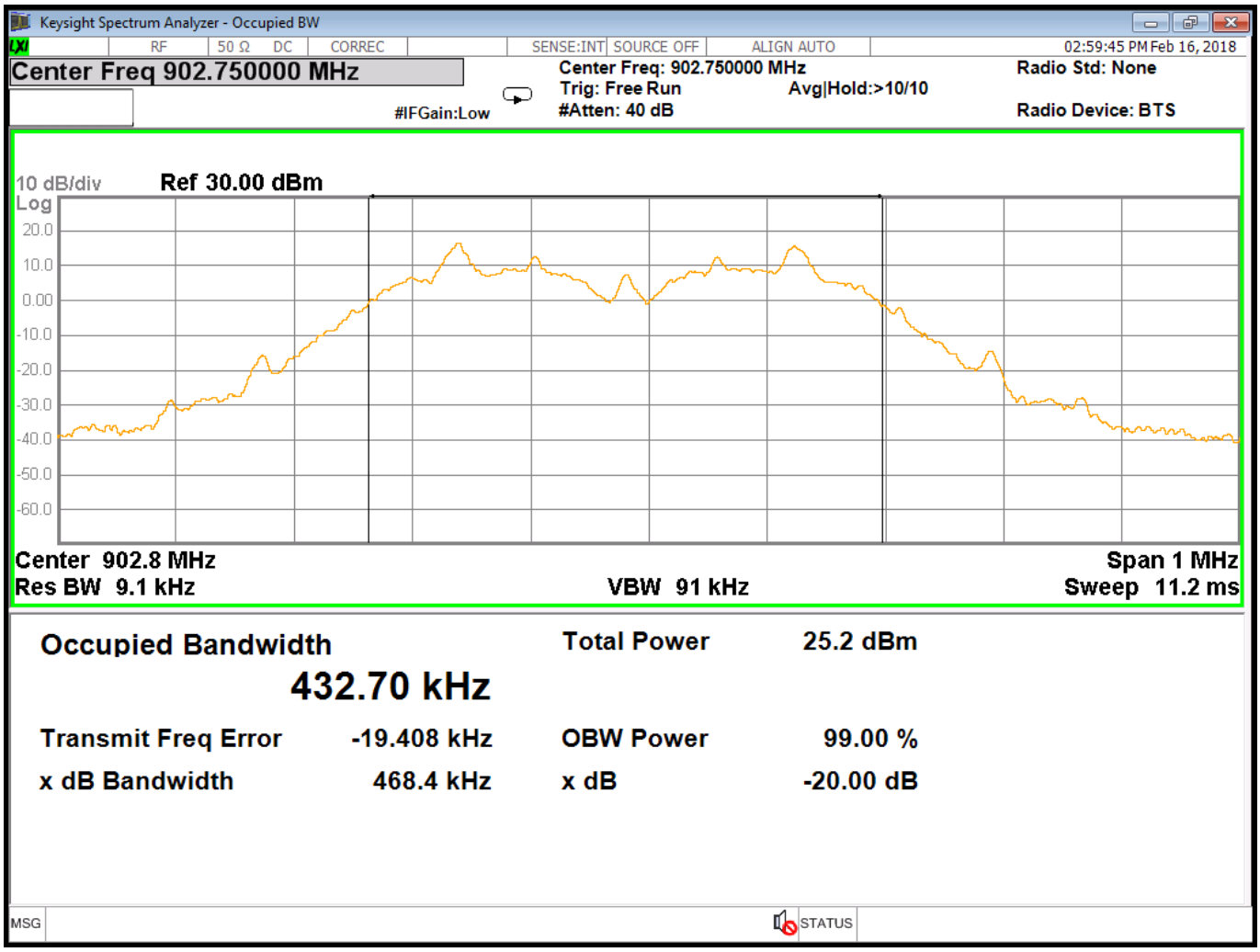

Figure 10: Occupied Bandwidth, Low Channel

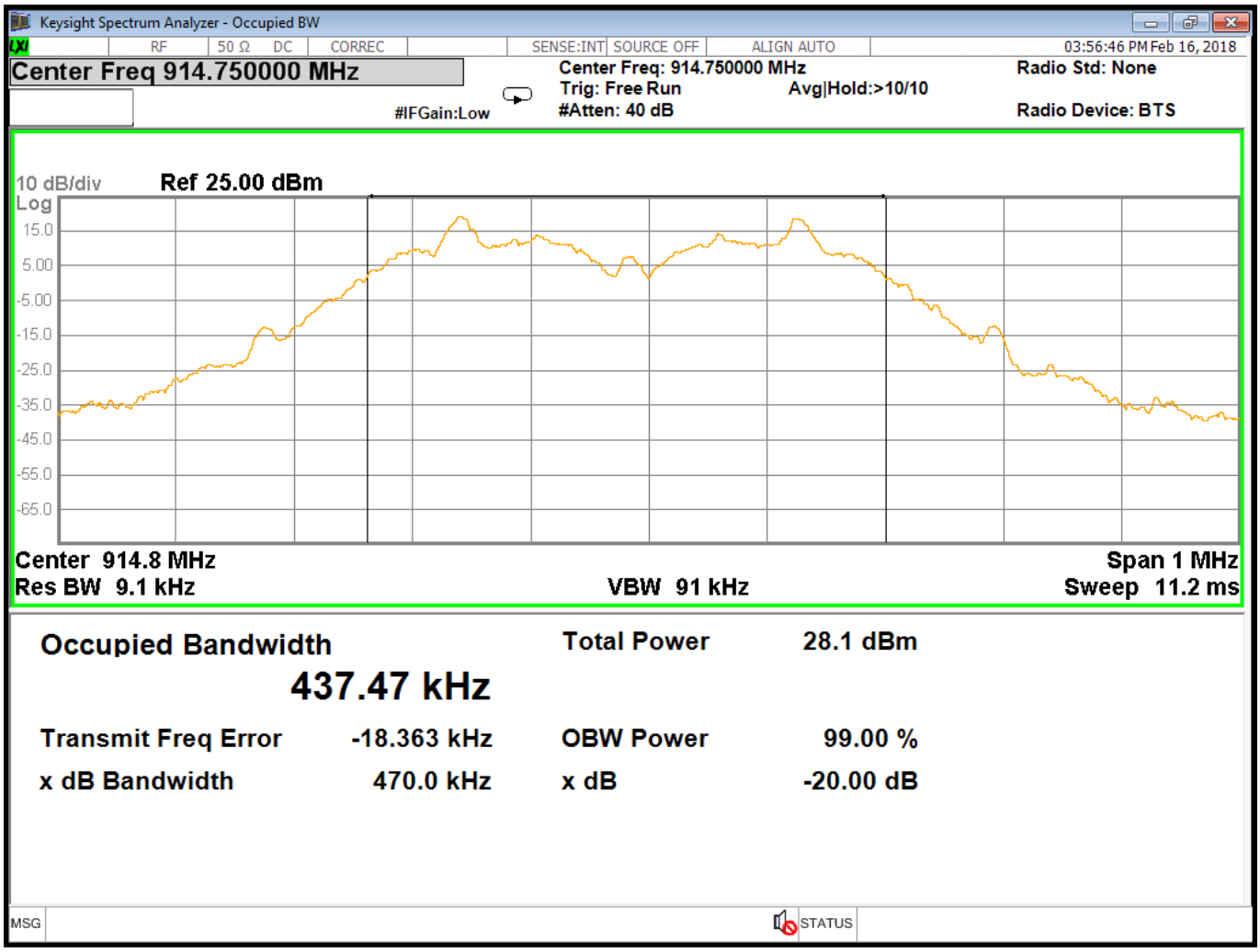

Figure 11: Occupied Bandwidth, Center Channel

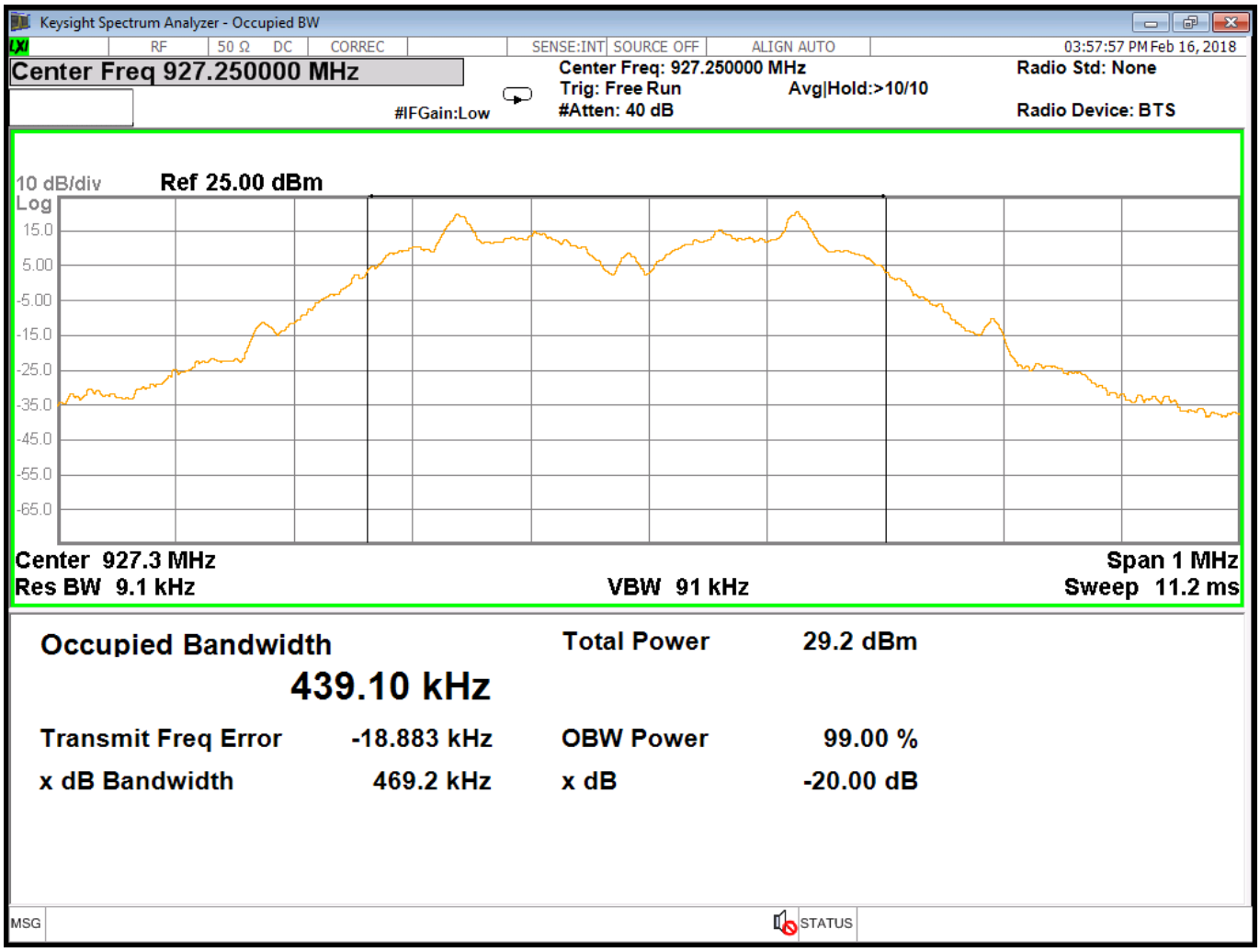

Figure 12: Occupied Bandwidth, High Channel

5.4 Channel Spacing and Number of Hop Channels (FCC Part §15.247(a)(1)

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 is 470 kHz so the channel spacing must be more than 470 kHz. In addition, for a 902-928MHz transmitter with an occupied bandwidth greater than 250 kHz the minimum number of hopping channels shall be 25.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 20 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 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 498 kHz and the number of channels used is 50.

Table 9: Channel Spacing and Number of Channels Results

	Result	Limit	Pass/Fail
Channel Spacing	498 kHz	470.0 kHz Minimum	Pass
Number of channels	50 channels	25 Channels Minimum	Pass

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

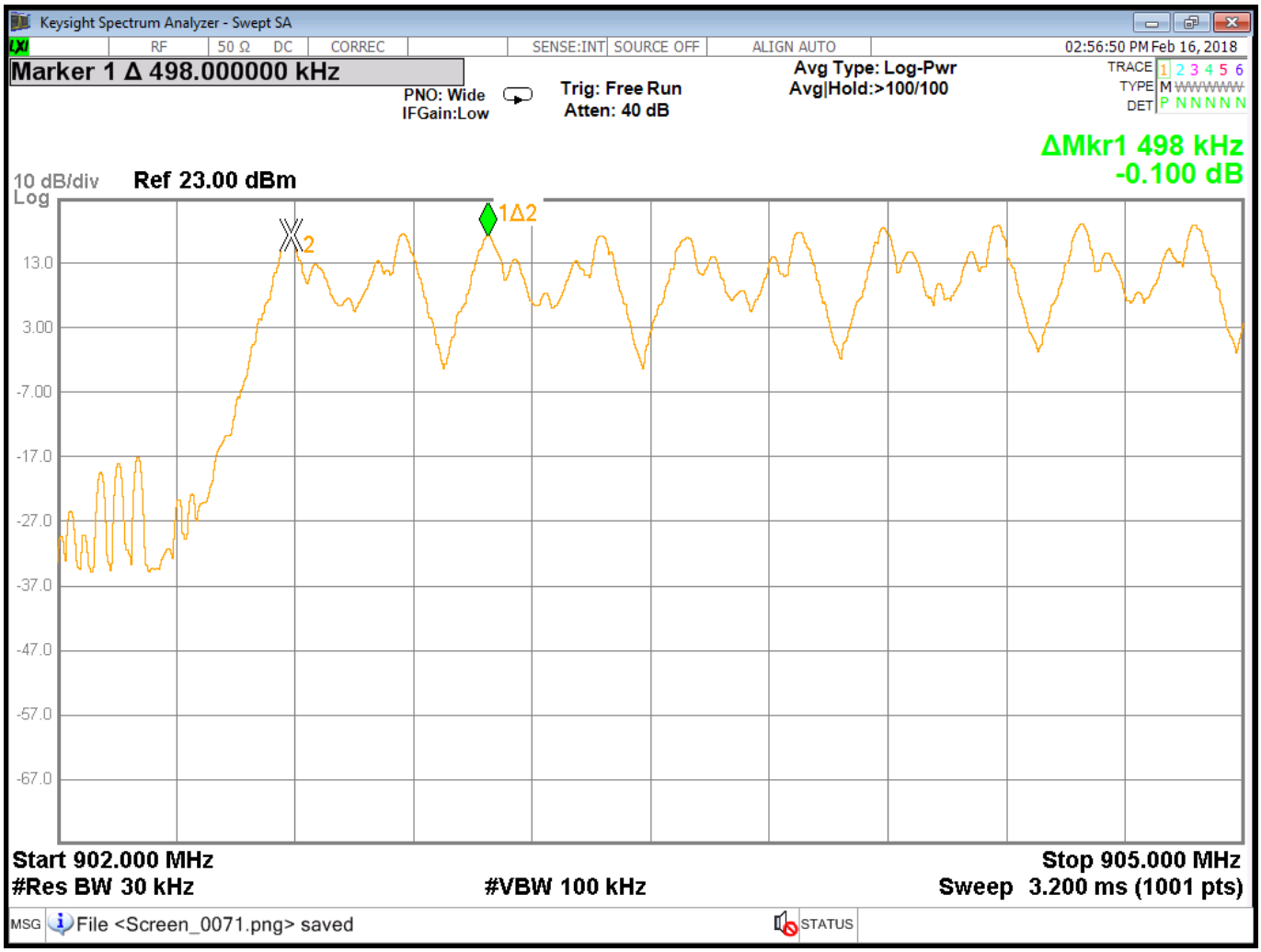

Figure 13: Channel Spacing

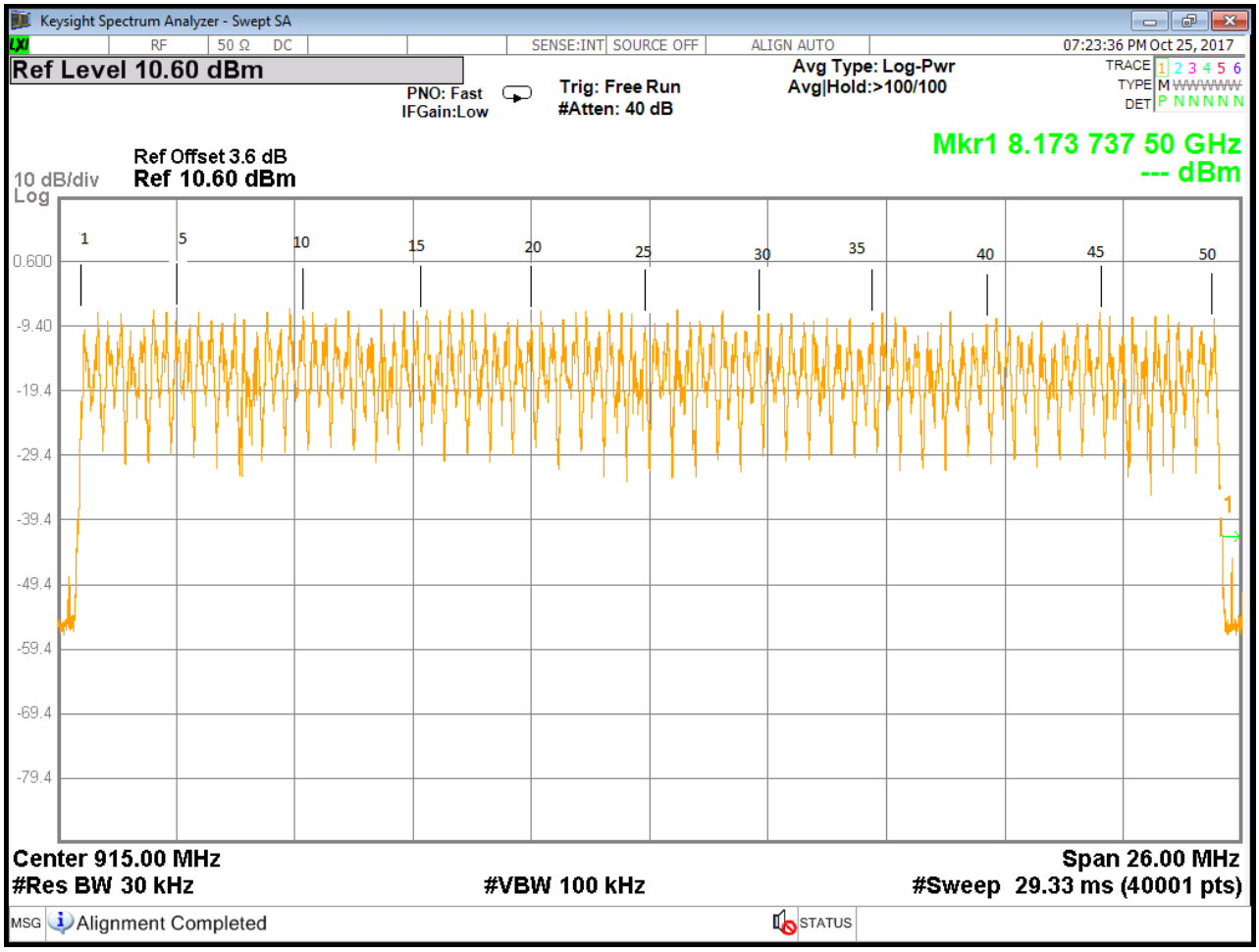

Figure 14: Number of Hopping Channels

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

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

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 3 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.

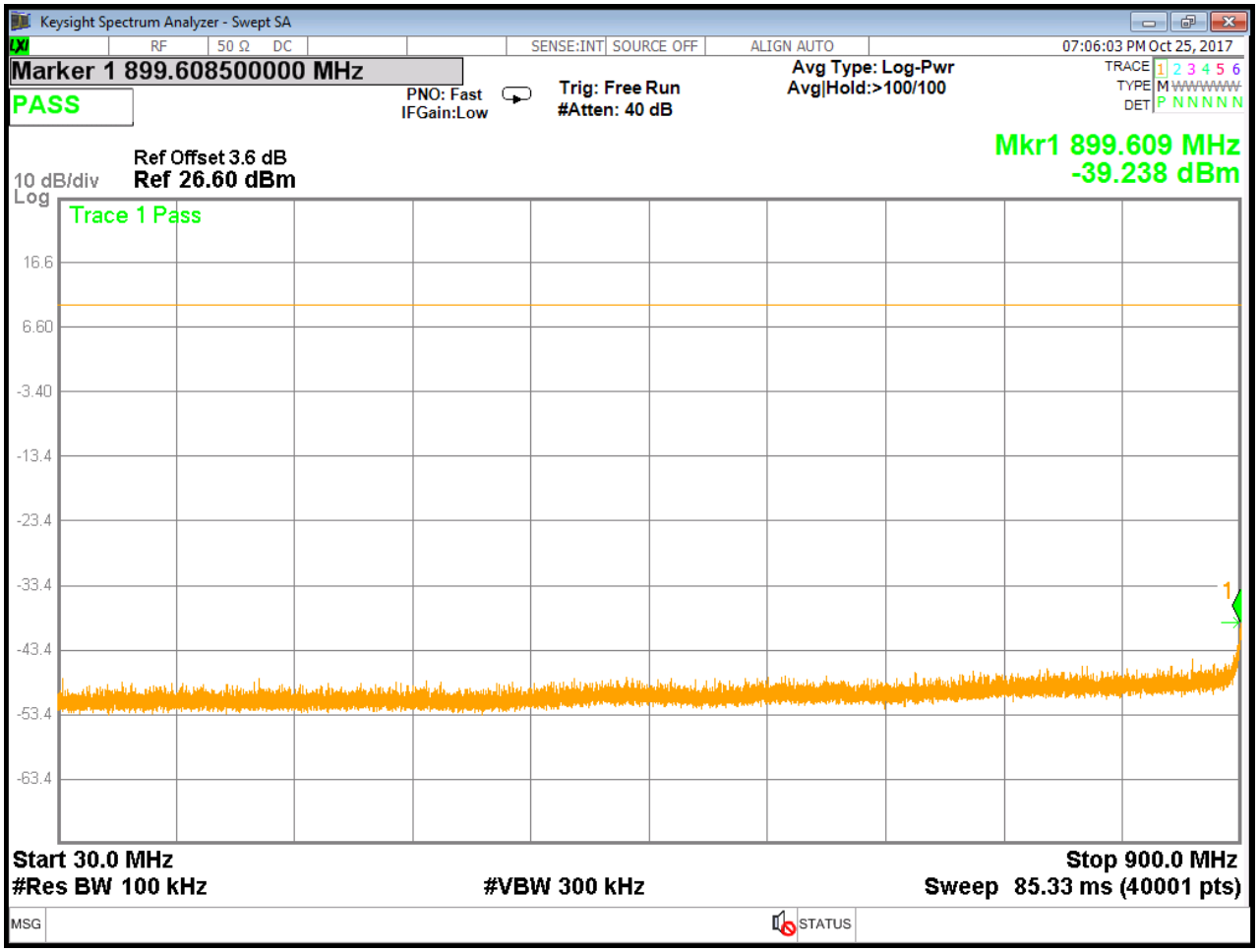

Figure 15: Conducted Spurious Emissions, High Power, Low Channel 30 - 900MHz

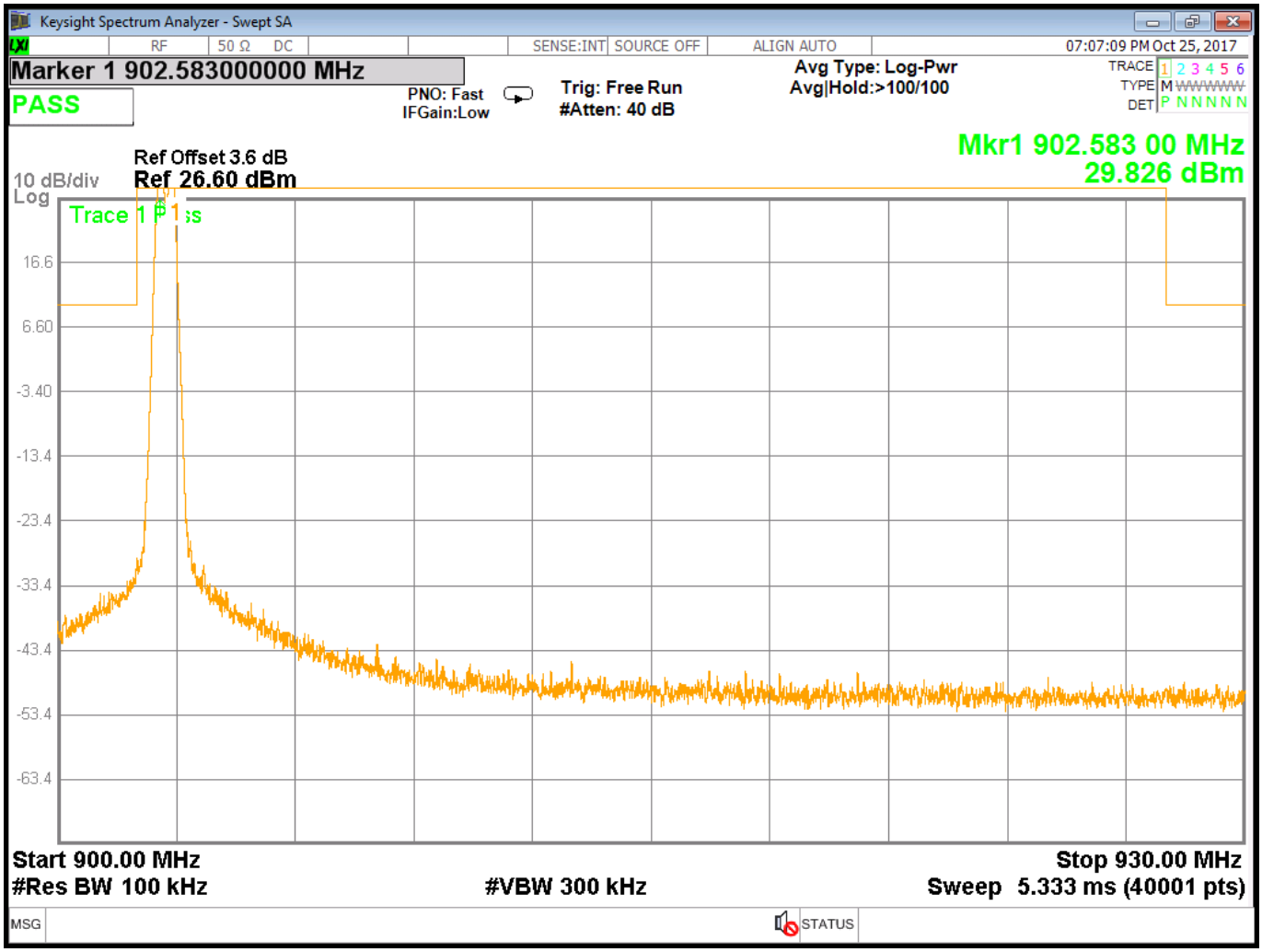

Figure 16: Conducted Spurious Emissions, High Power, Low Channel 900 – 930MHz

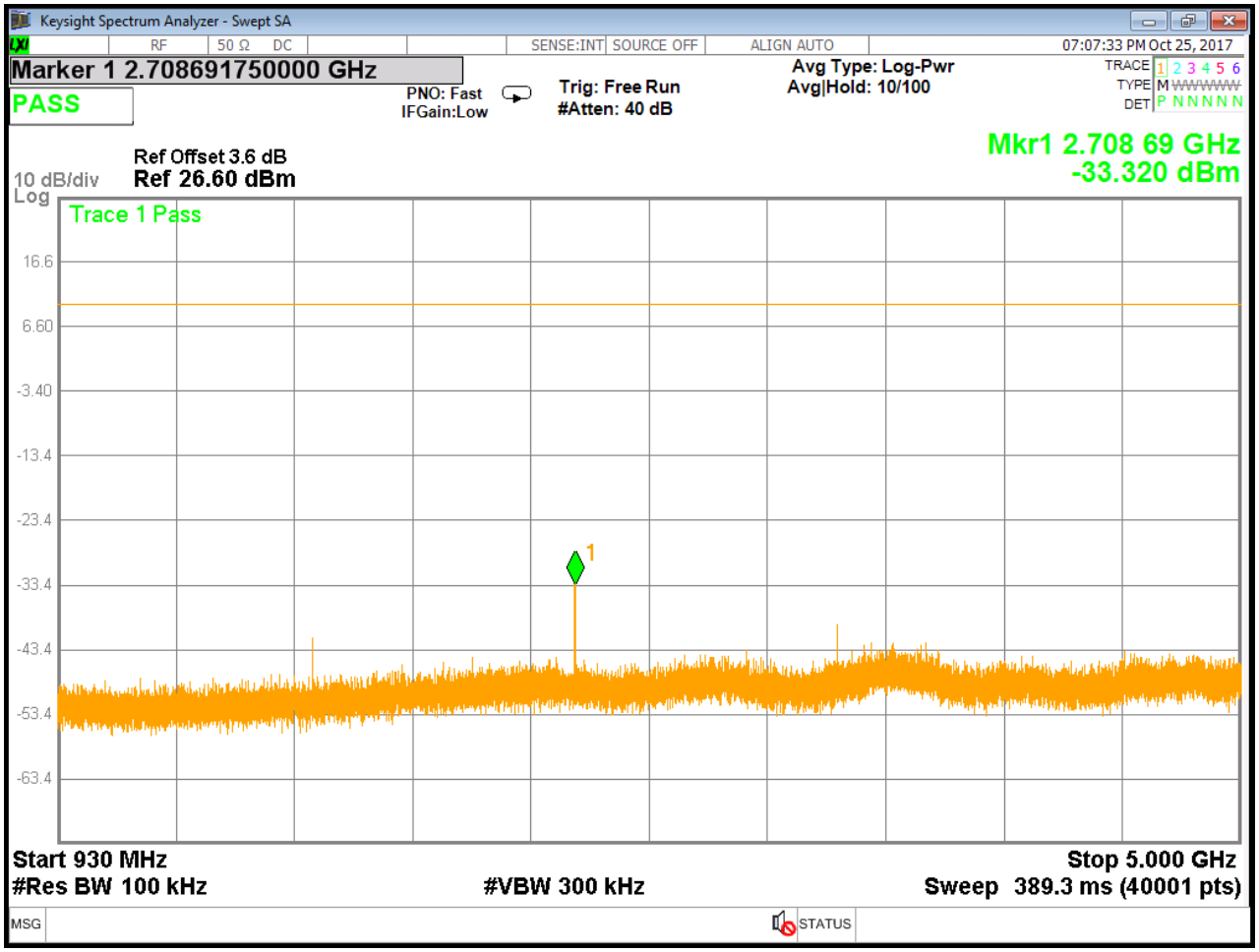

Figure 17: Conducted Spurious Emissions, High Power, Low Channel 930-5000MHz

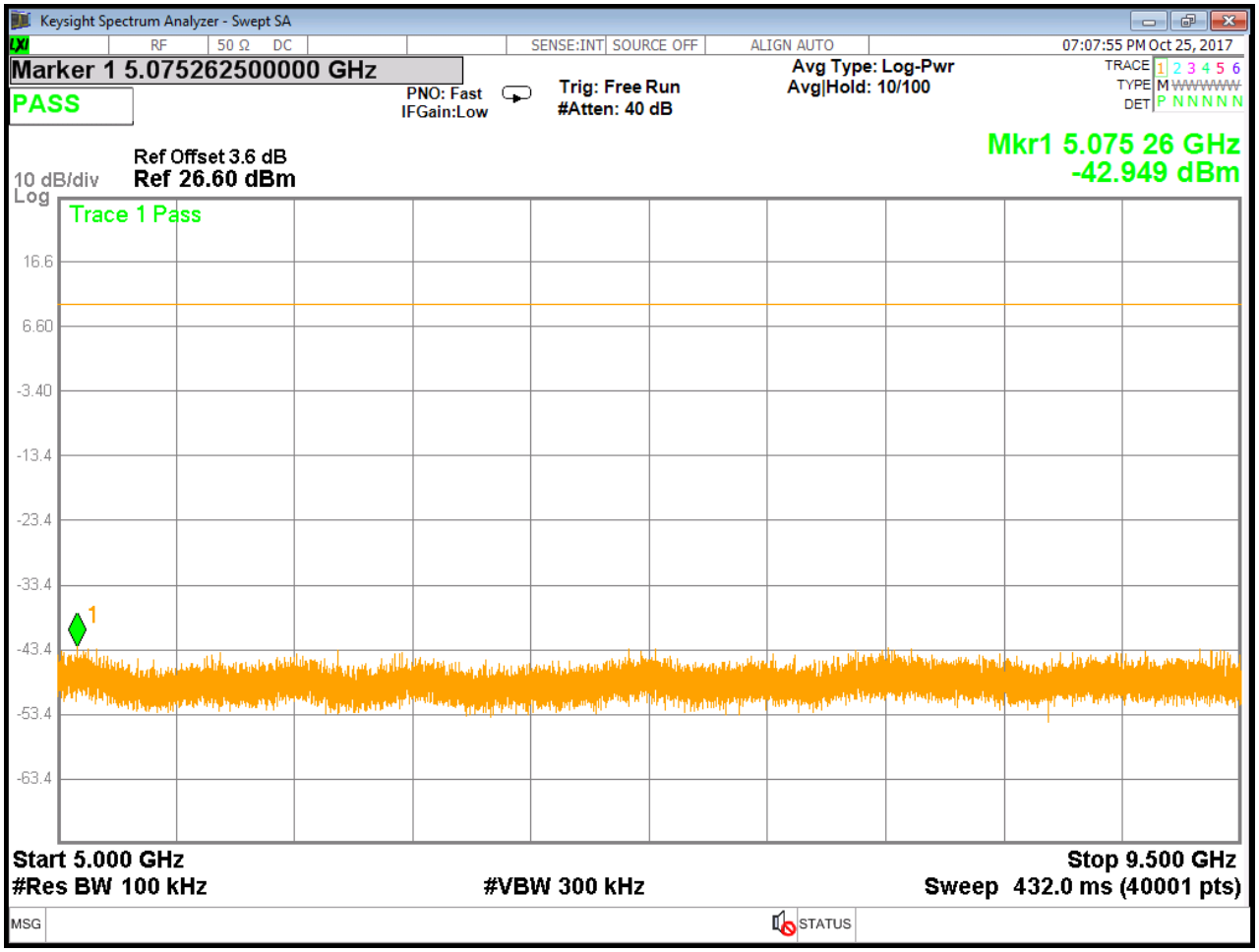

Figure 18: Conducted Spurious Emissions, High Power, Low Channel 5-9.5GHz

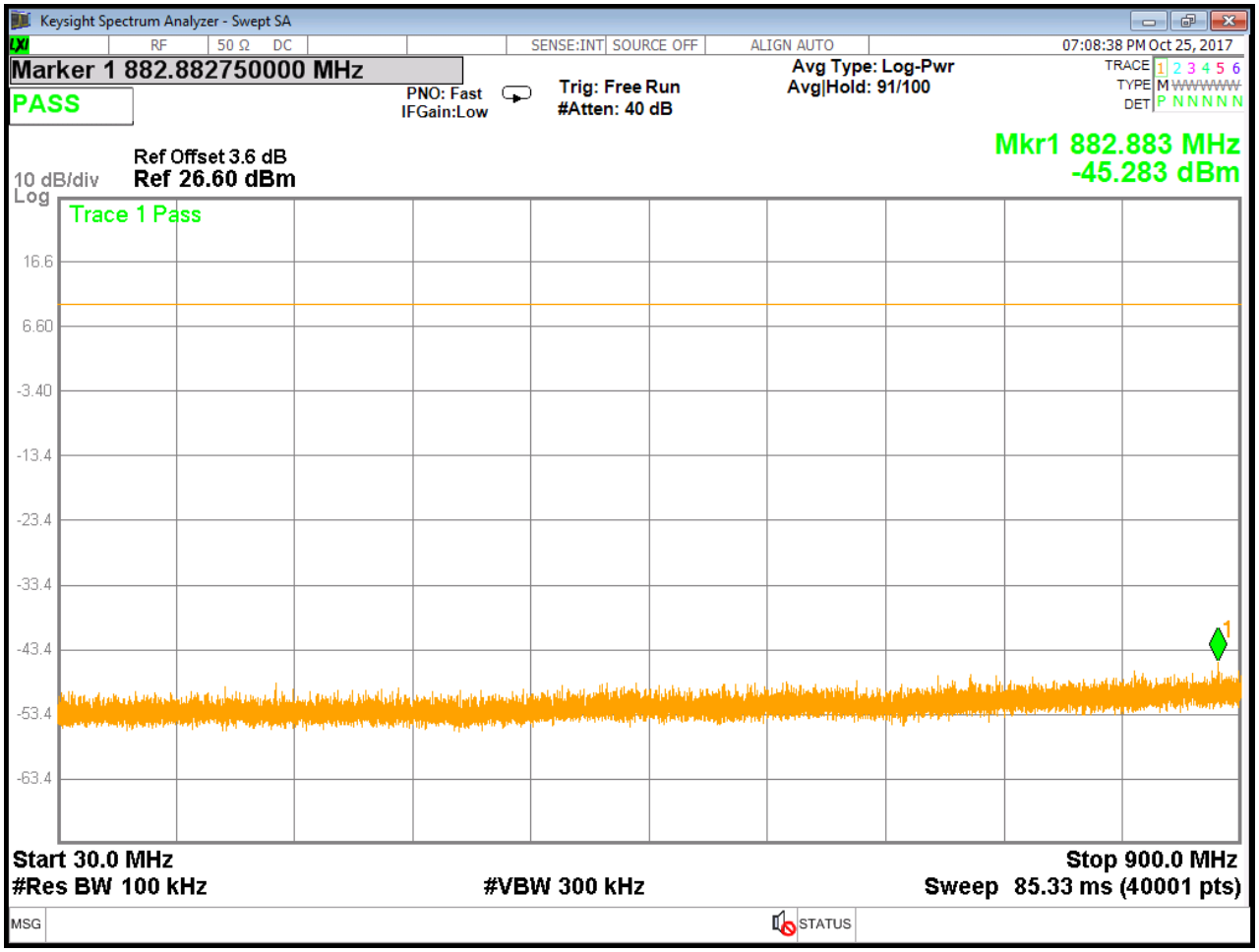

Figure 19: Conducted Spurious Emissions, High Power, Center Channel 30 - 900MHz

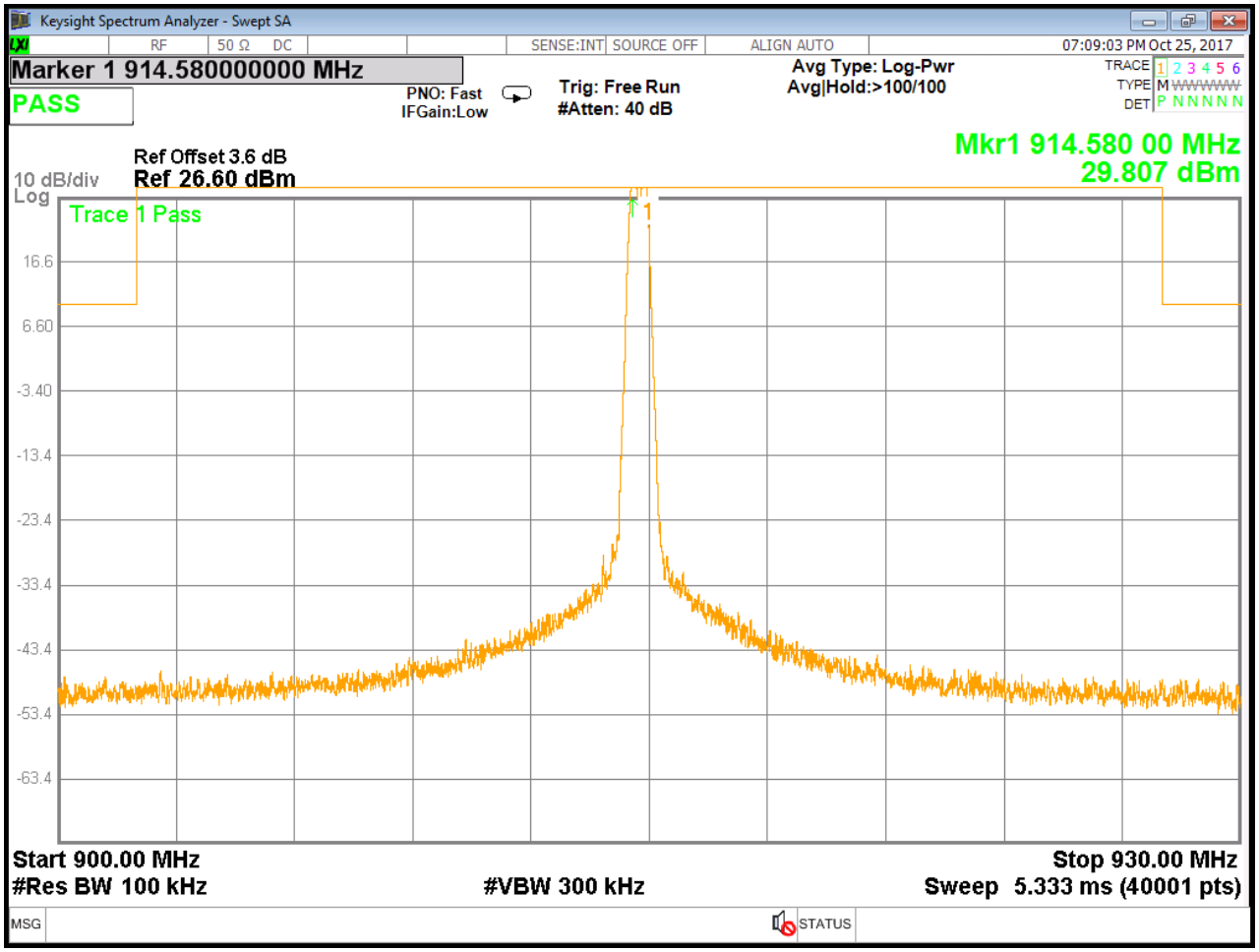

Figure 20: Conducted Spurious Emissions, High Power, Center Channel 900 – 930MHz

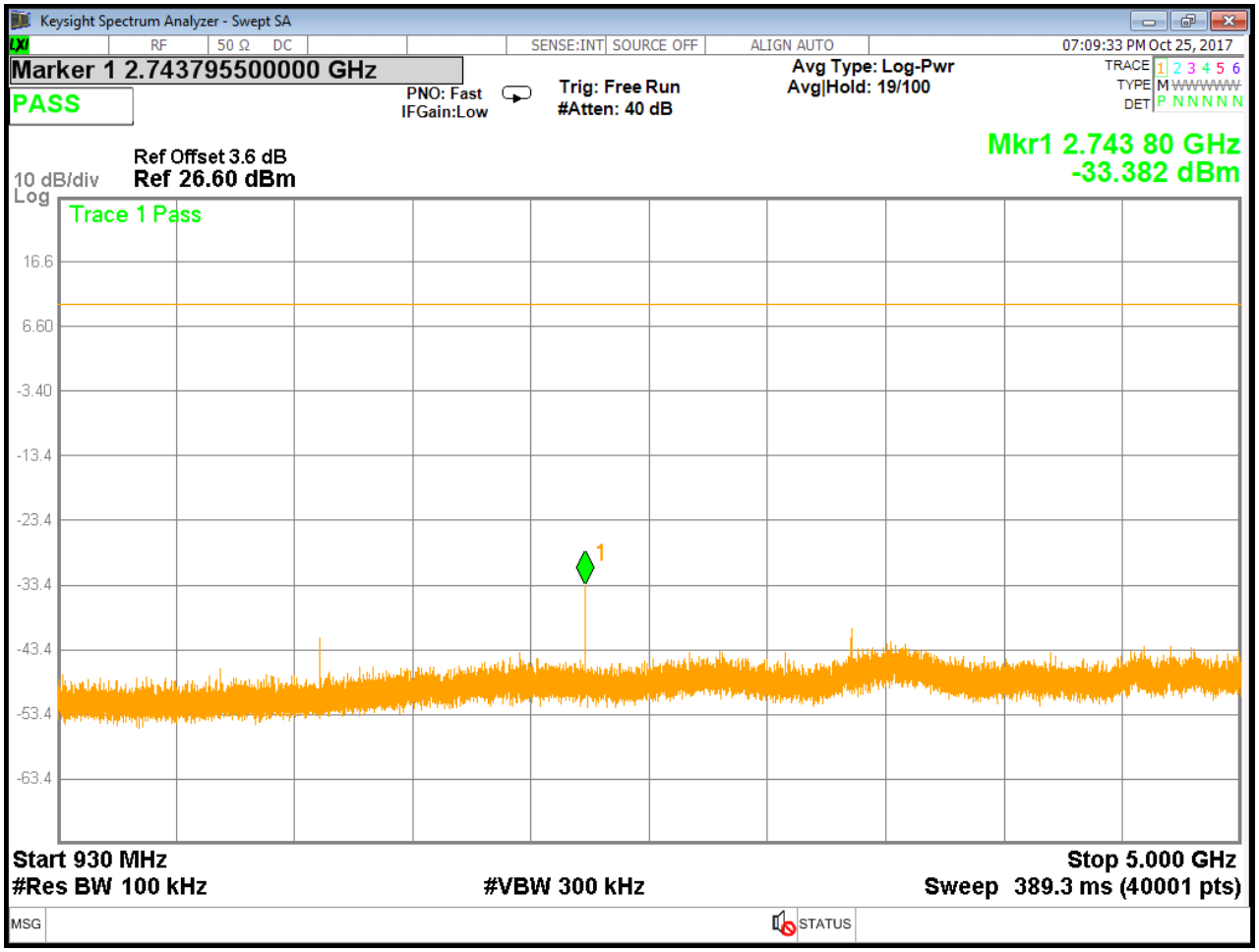

Figure 21: Conducted Spurious Emissions, High Power, Center Channel 930-5000MHz

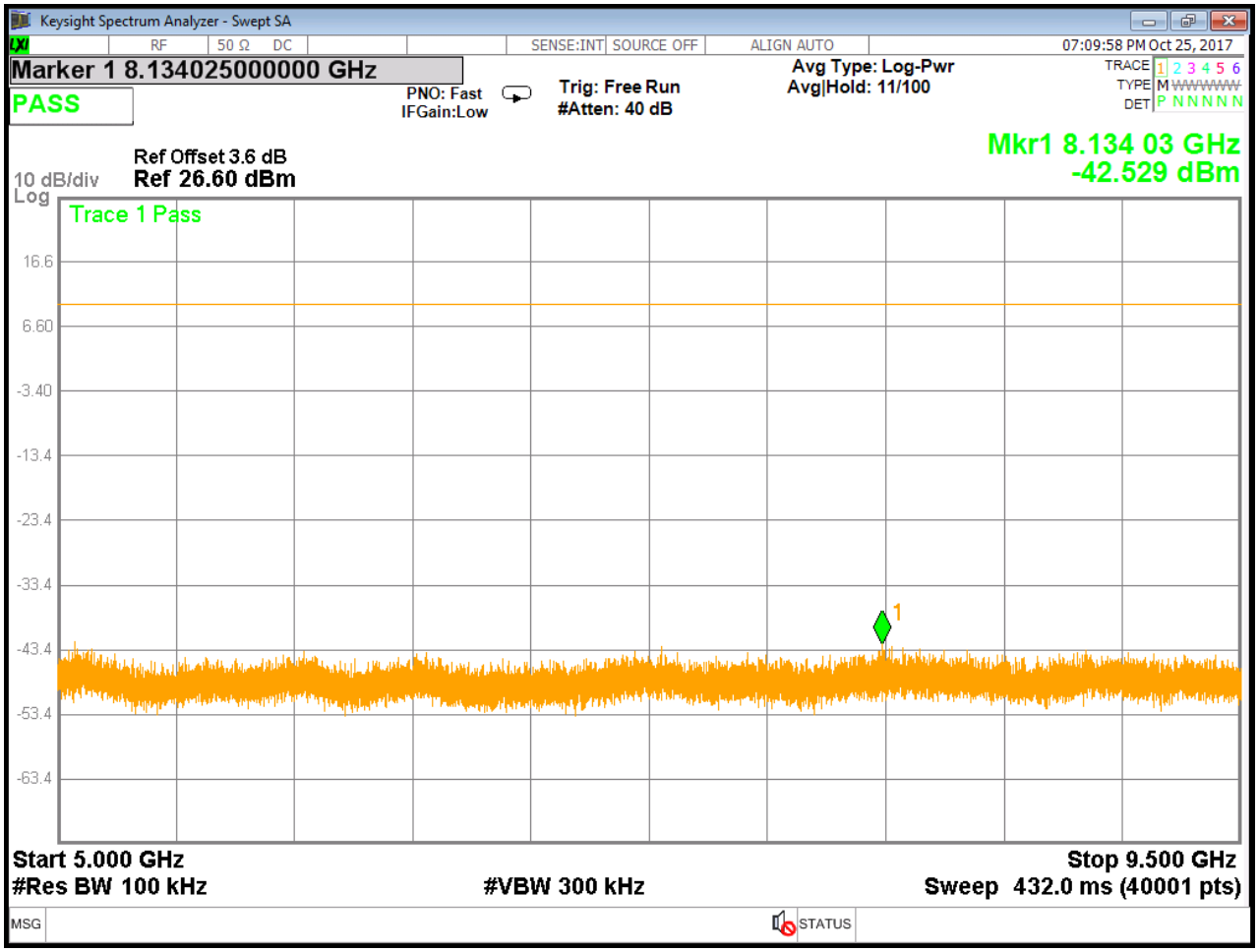

Figure 22: Conducted Spurious Emissions, High Power, Center Channel 5-9.5GHz

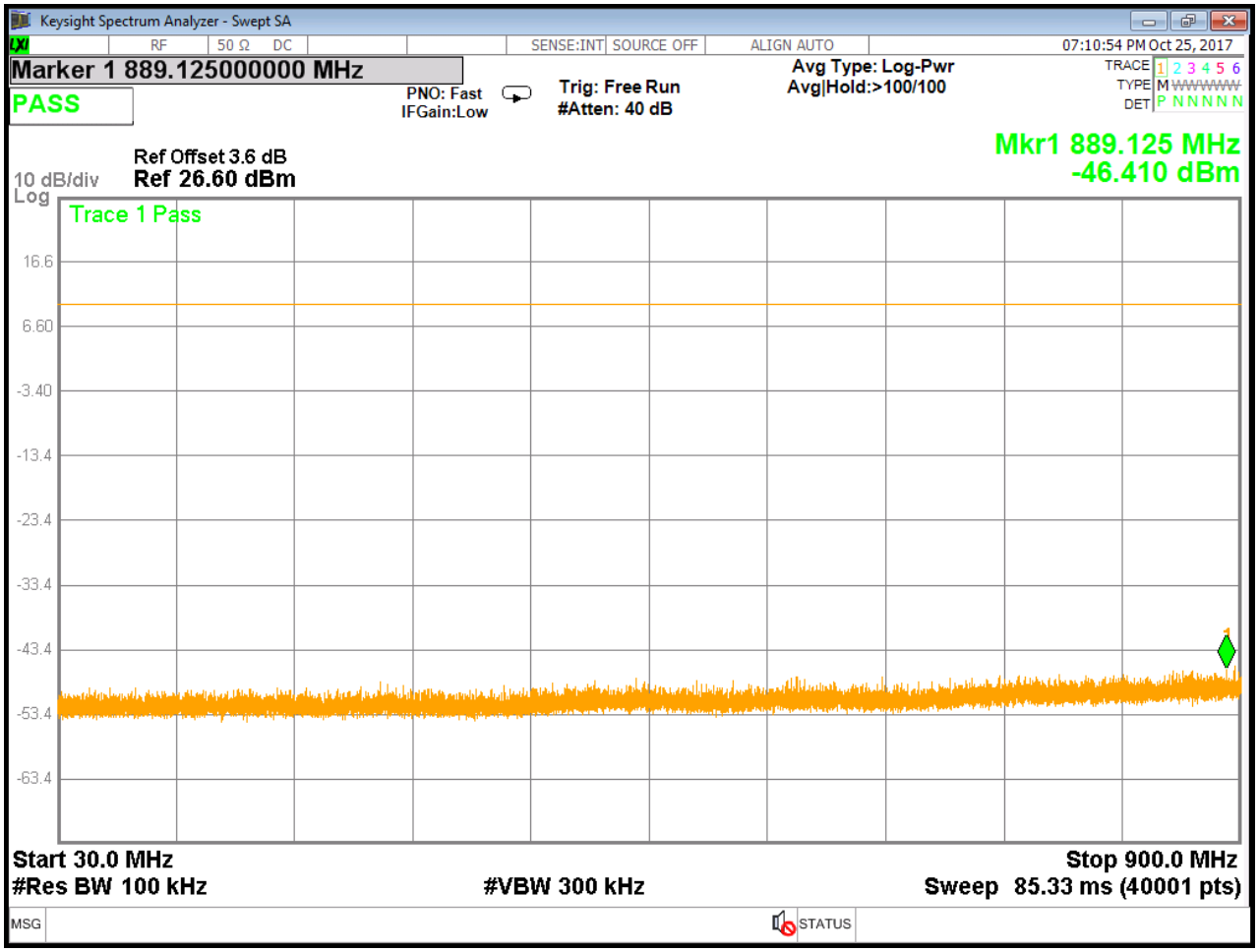

Figure 23: Conducted Spurious Emissions, High Power, High Channel 30 - 900MHz

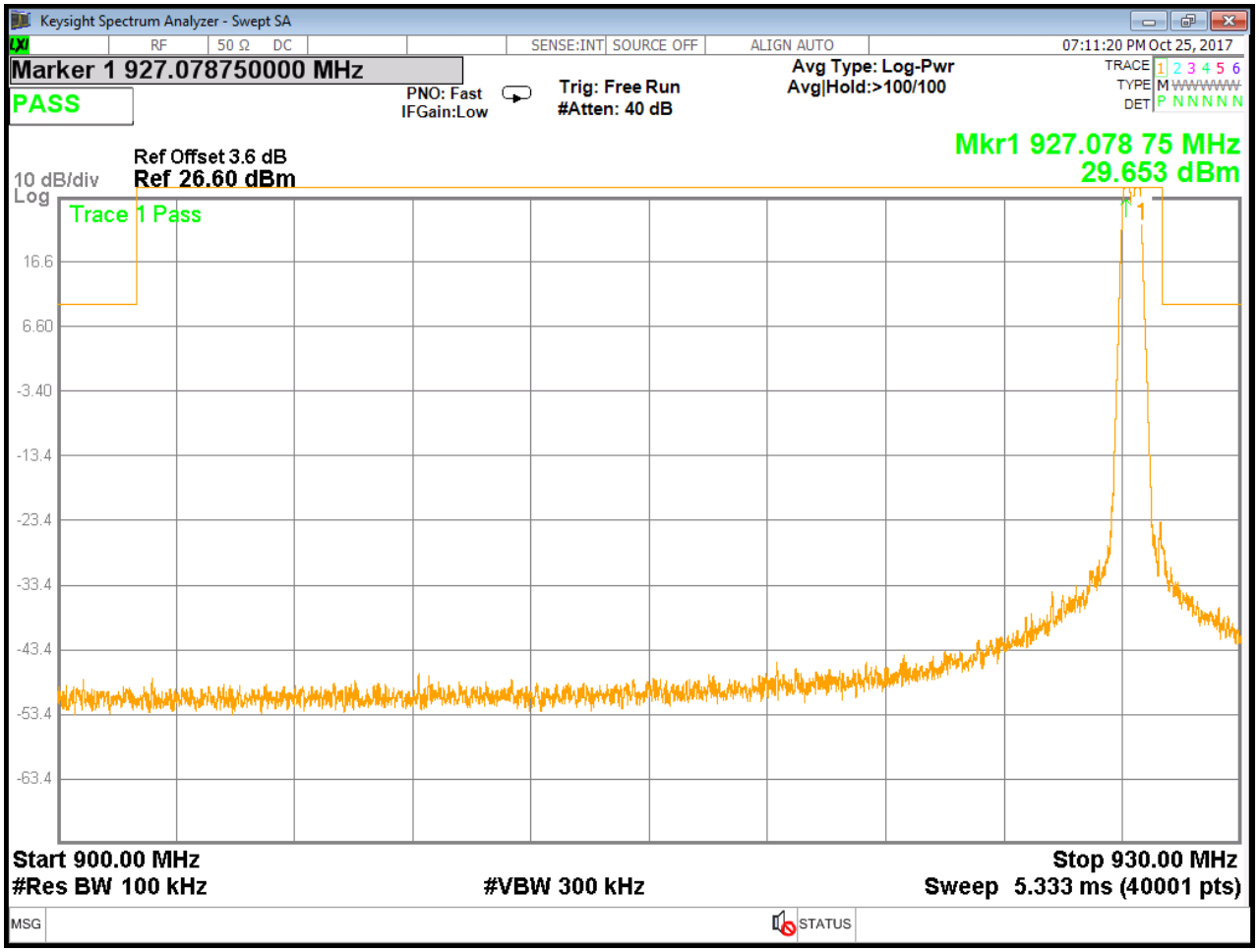

Figure 24: Conducted Spurious Emissions, High Power, High Channel 900 – 930MHz

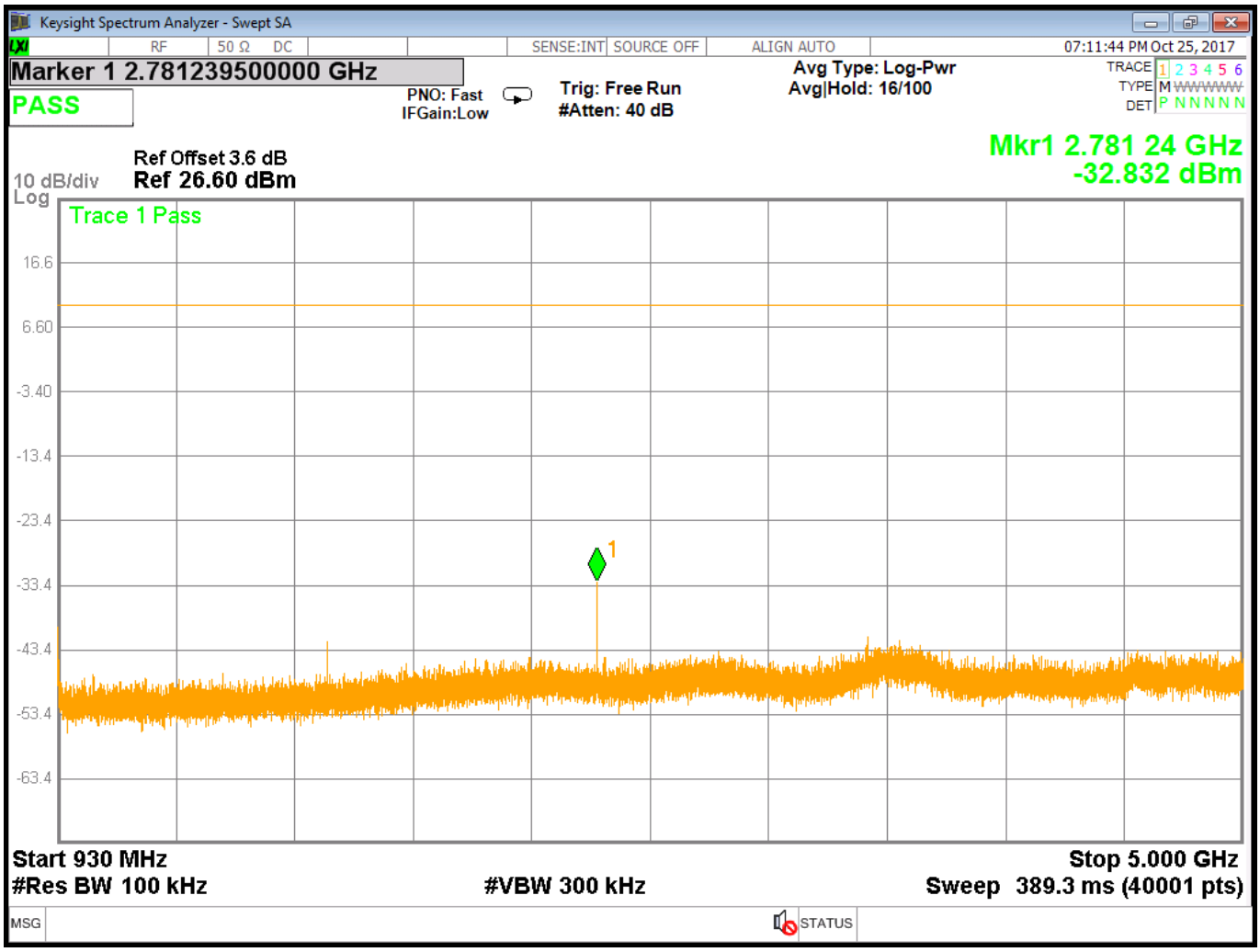

Figure 25: Conducted Spurious Emissions, High Power, High Channel 930-5000MHz

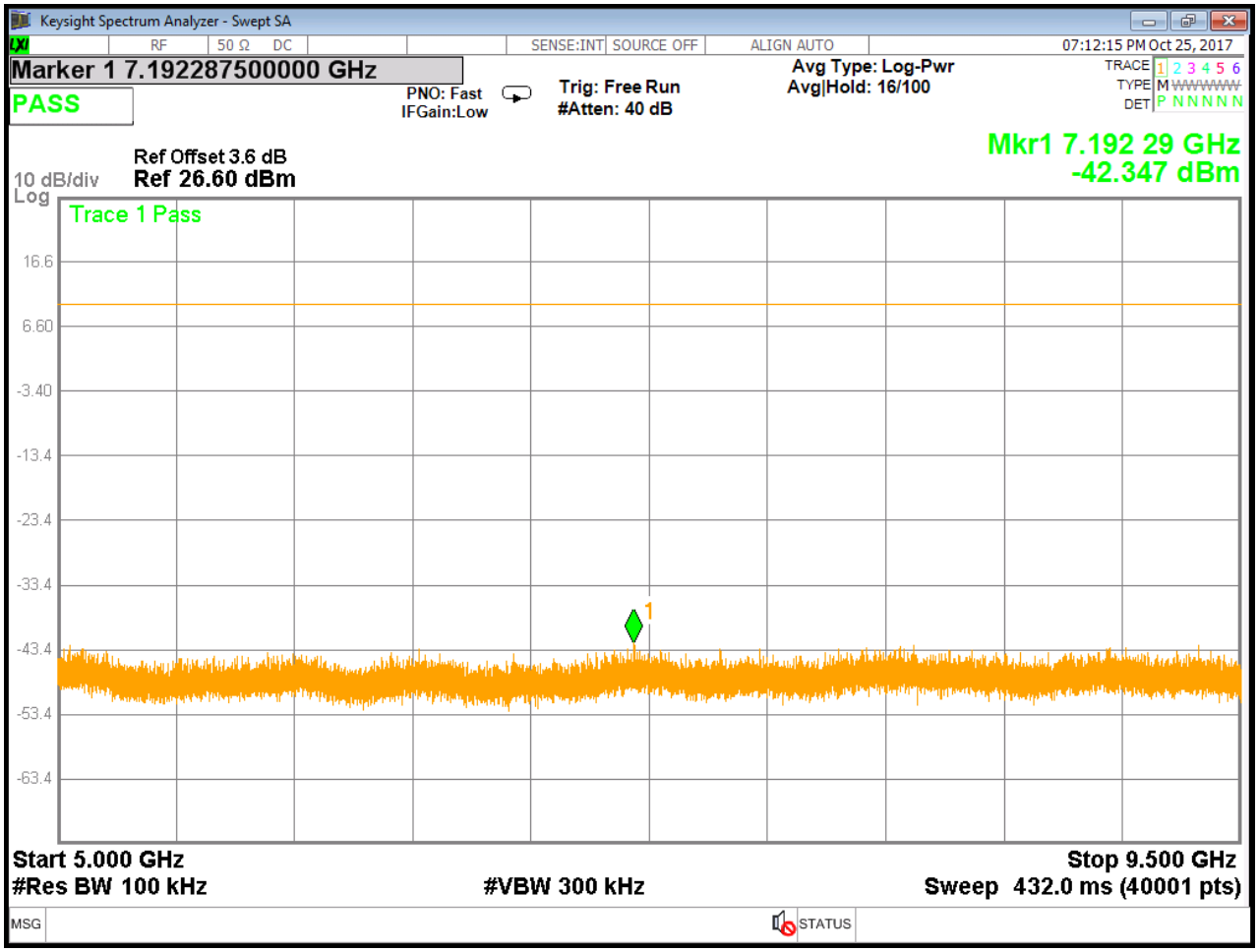

Figure 26: Conducted Spurious Emissions, High Power, High Channel 5-9.5GHz

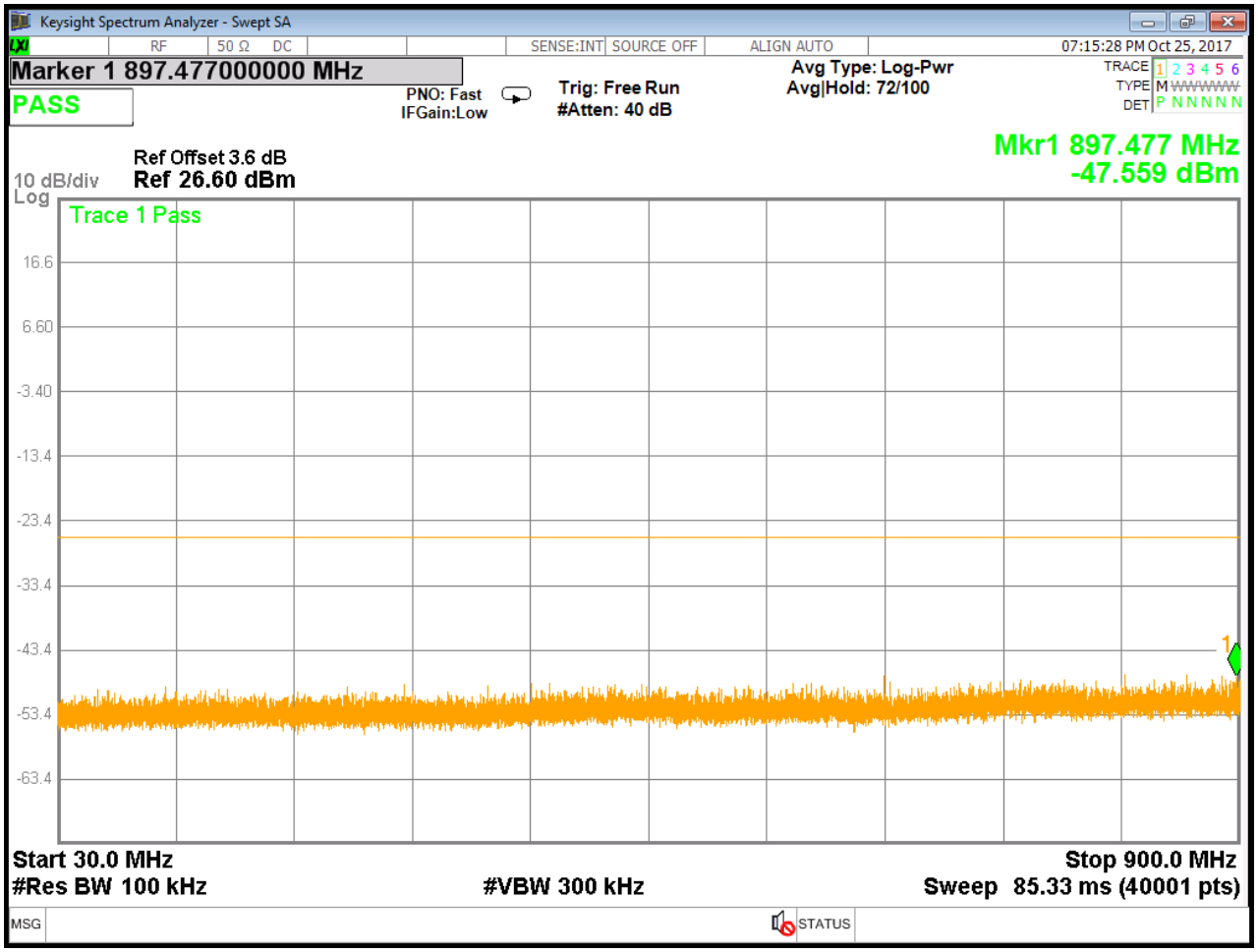

Figure 27: Conducted Spurious Emissions, Low Power, Low Channel 30 - 900MHz

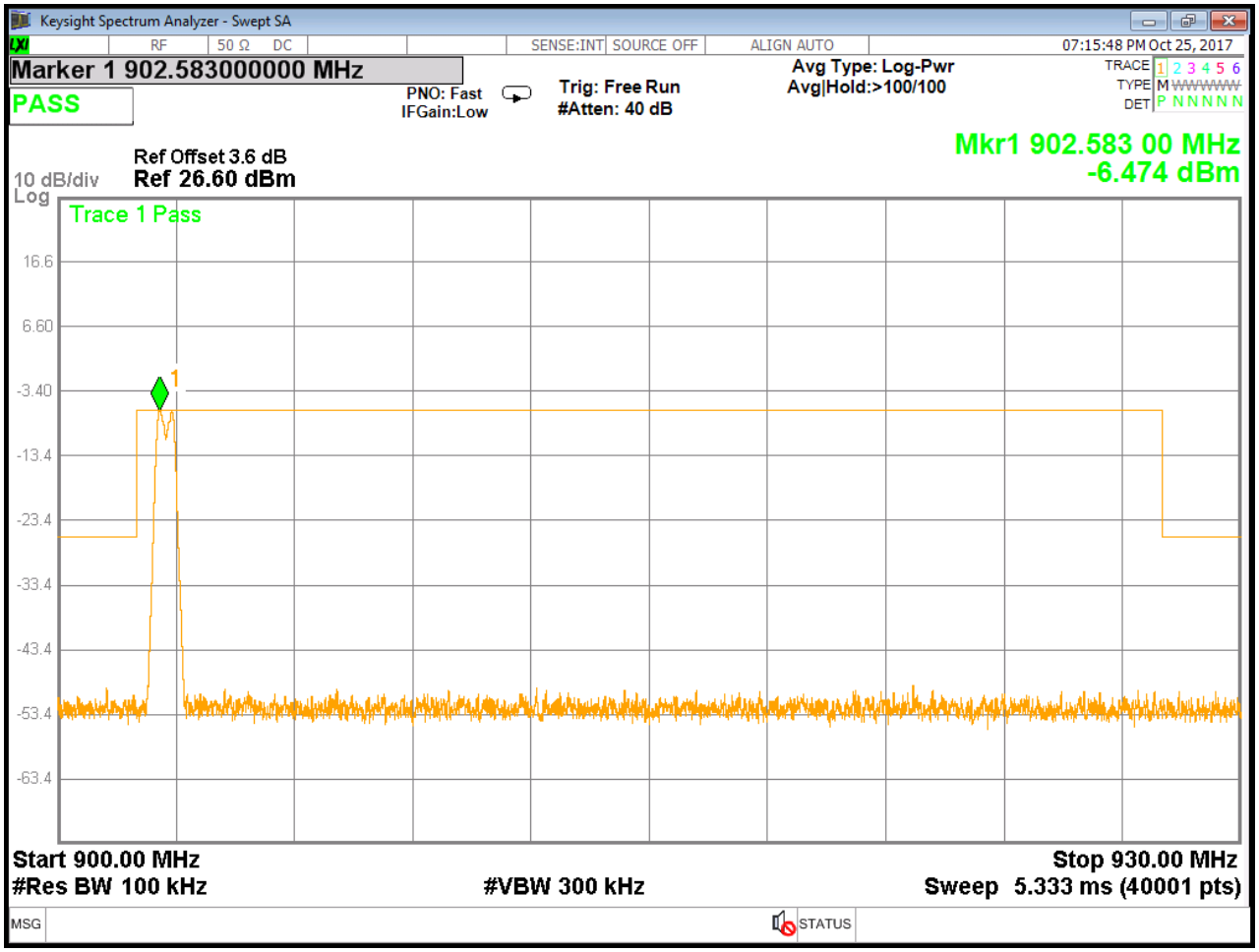

Figure 28: Conducted Spurious Emissions, Low Power, Low Channel 900 – 930MHz

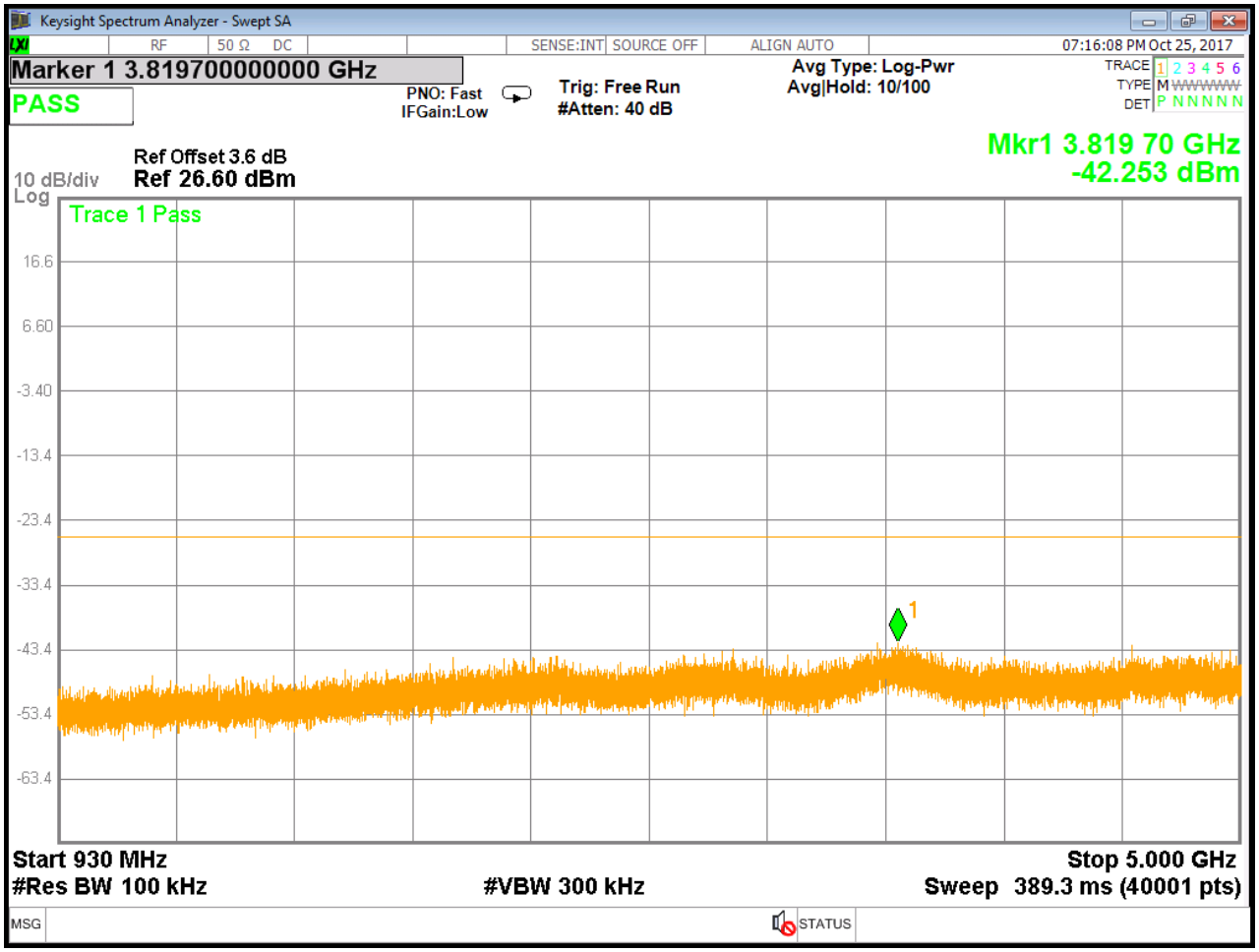

Figure 29: Conducted Spurious Emissions, Low Power, Low Channel 930-5000MHz

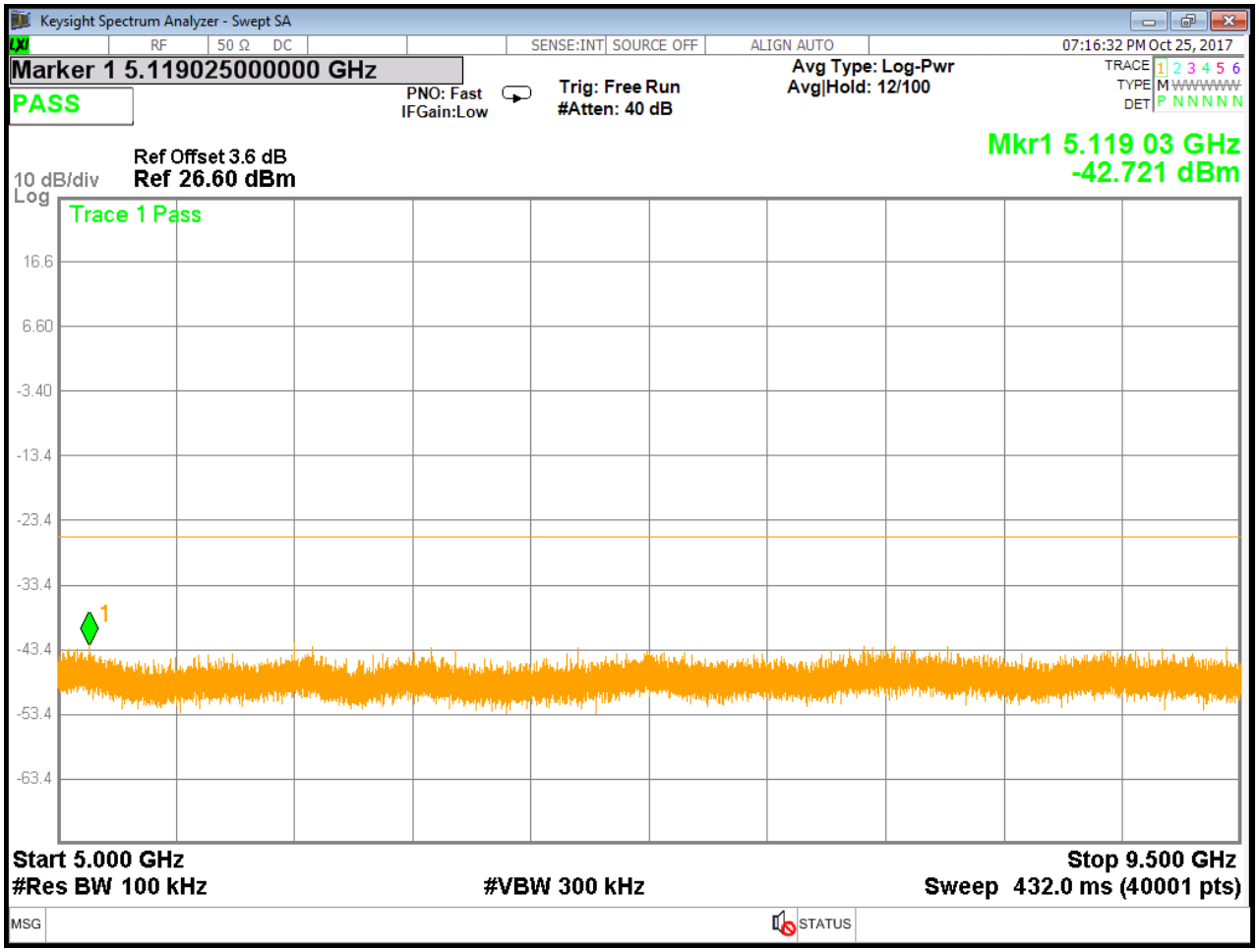

Figure 30: Conducted Spurious Emissions, Low Power, Low Channel 5-9.5GHz

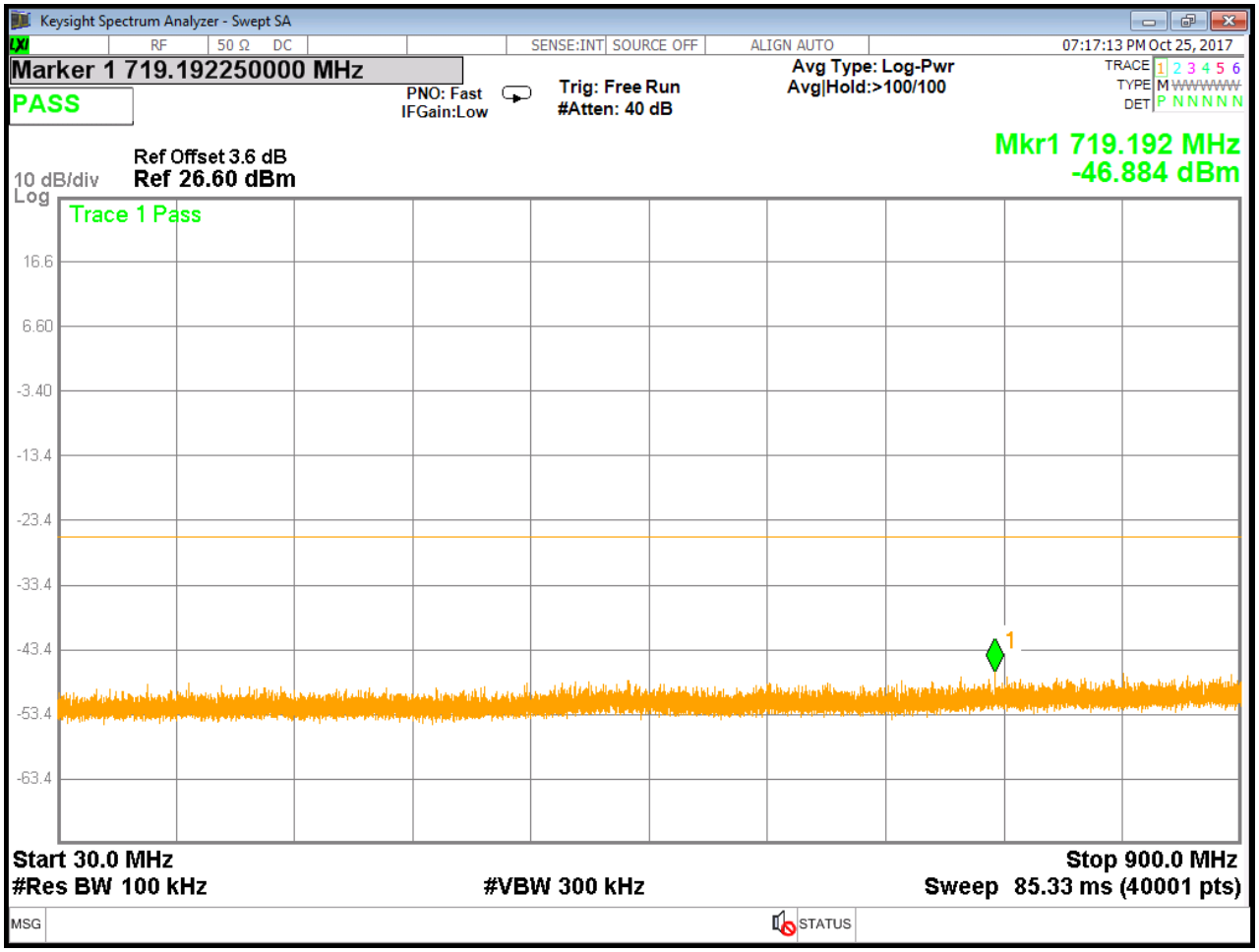

Figure 31: Conducted Spurious Emissions, Low Power, Center Channel 30 - 900MHz

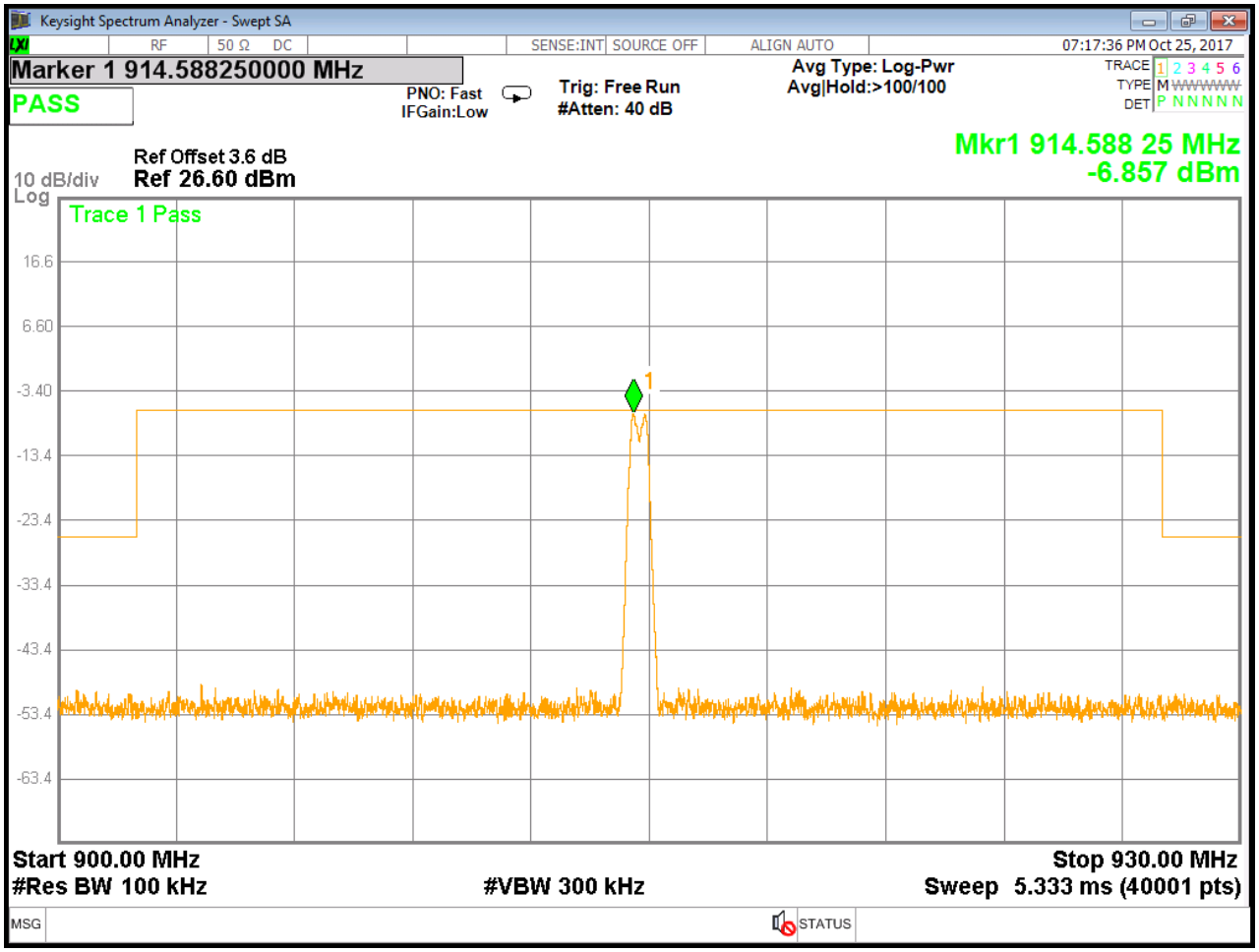

Figure 32: Conducted Spurious Emissions, Low Power, Center Channel 900 – 930MHz

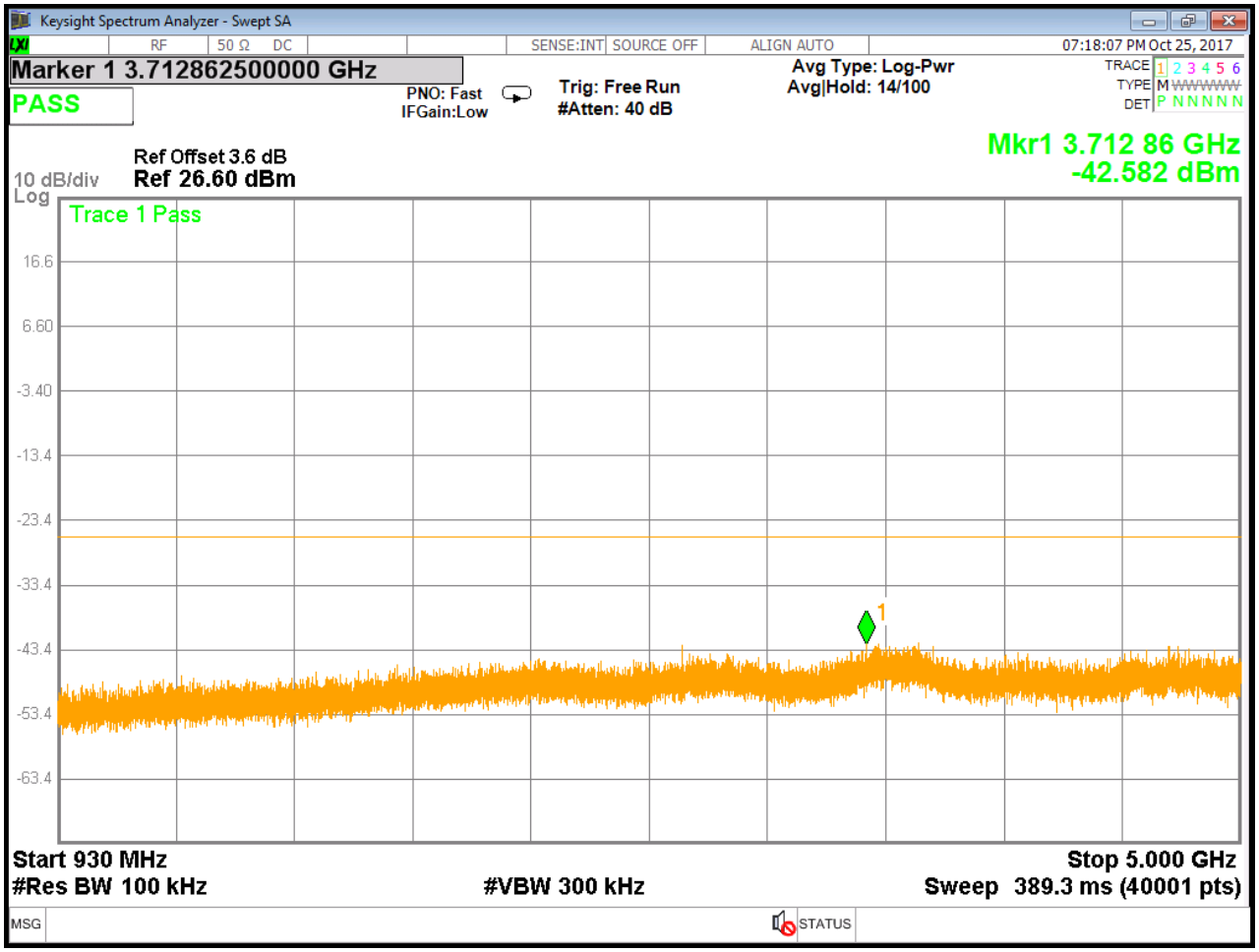

Figure 33: Conducted Spurious Emissions, Low Power, Center Channel 930-5000MHz

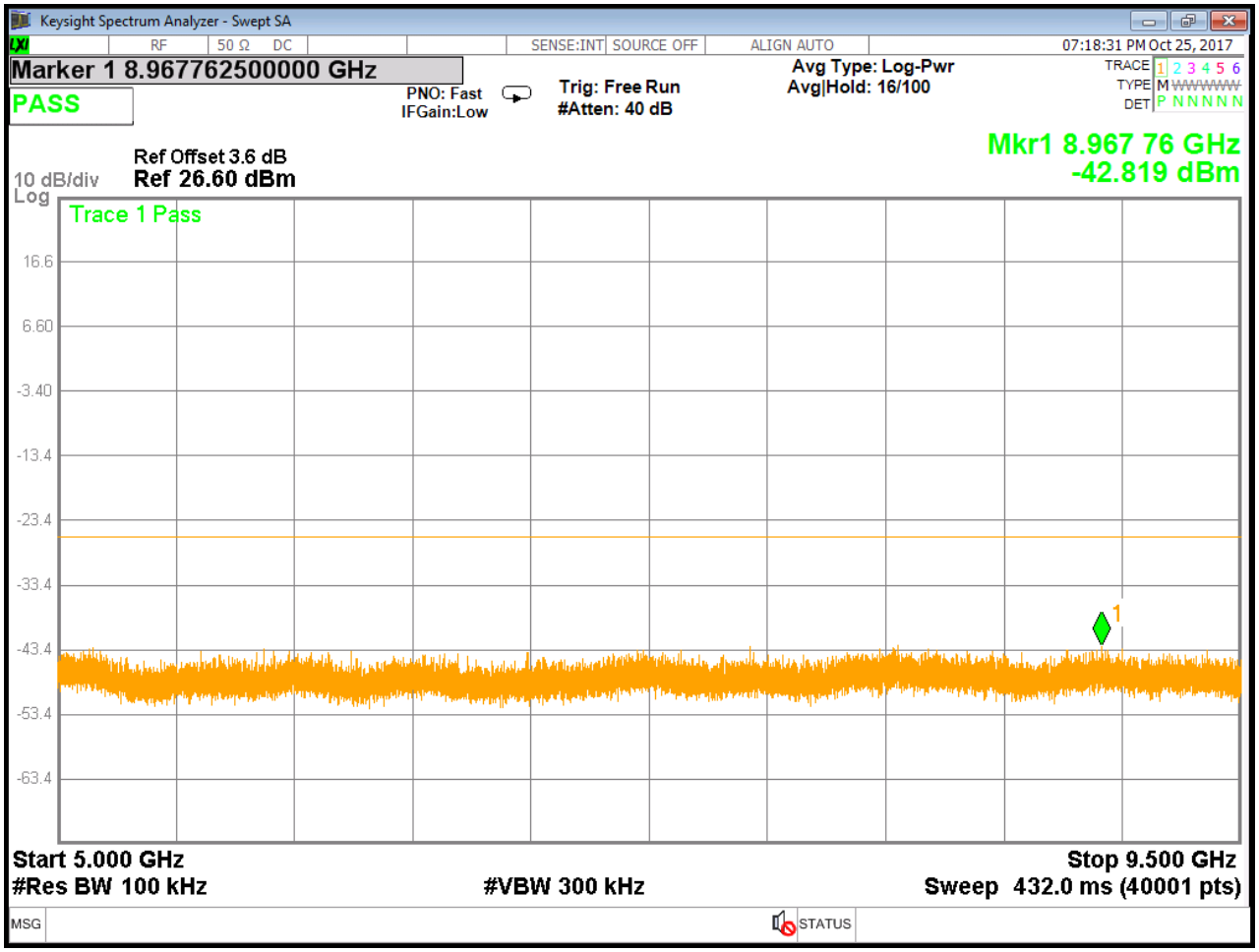

Figure 34: Conducted Spurious Emissions, Low Power, Center Channel 5-9.5GHz

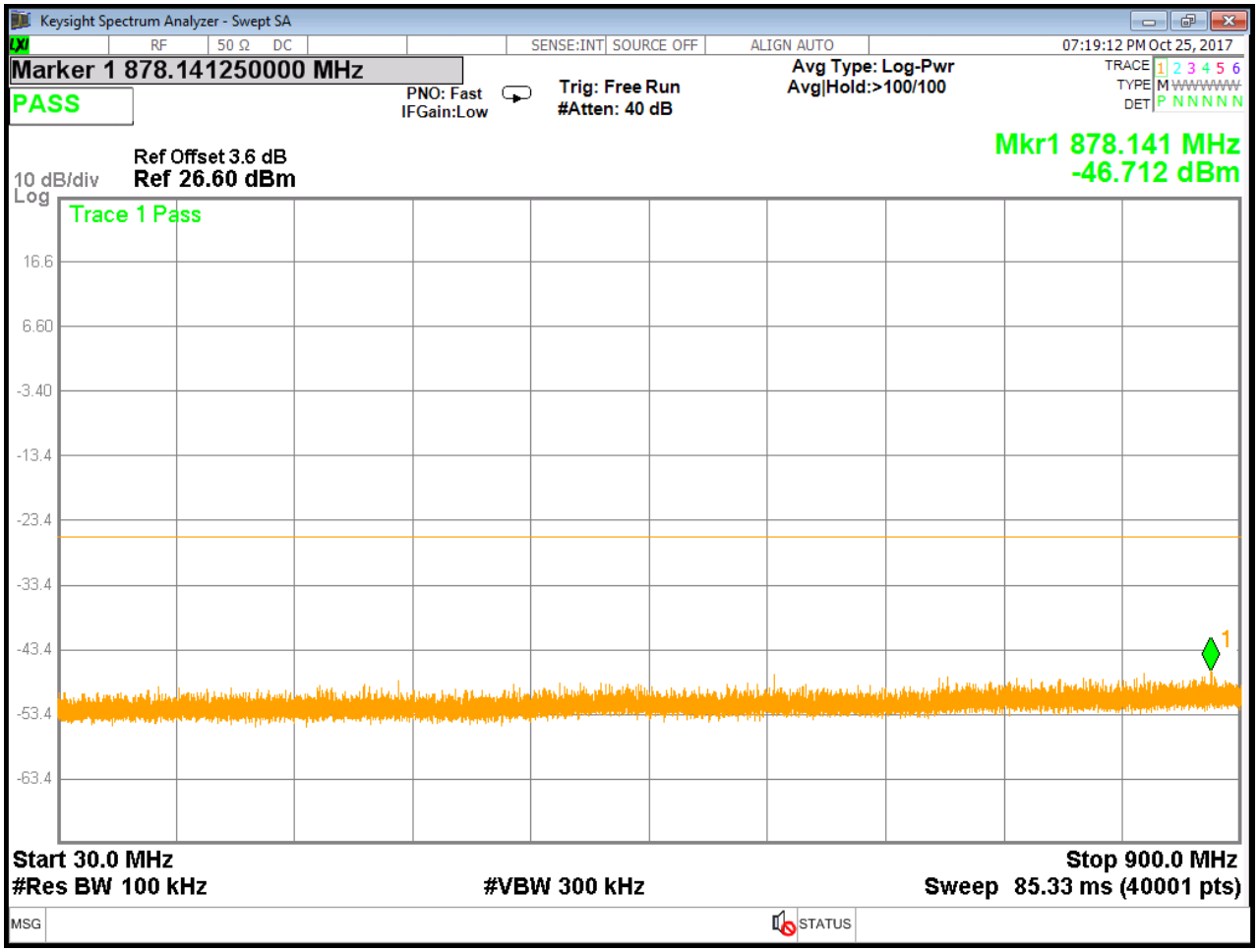

Figure 35: Conducted Spurious Emissions, Low Power, High Channel 30 - 900MHz

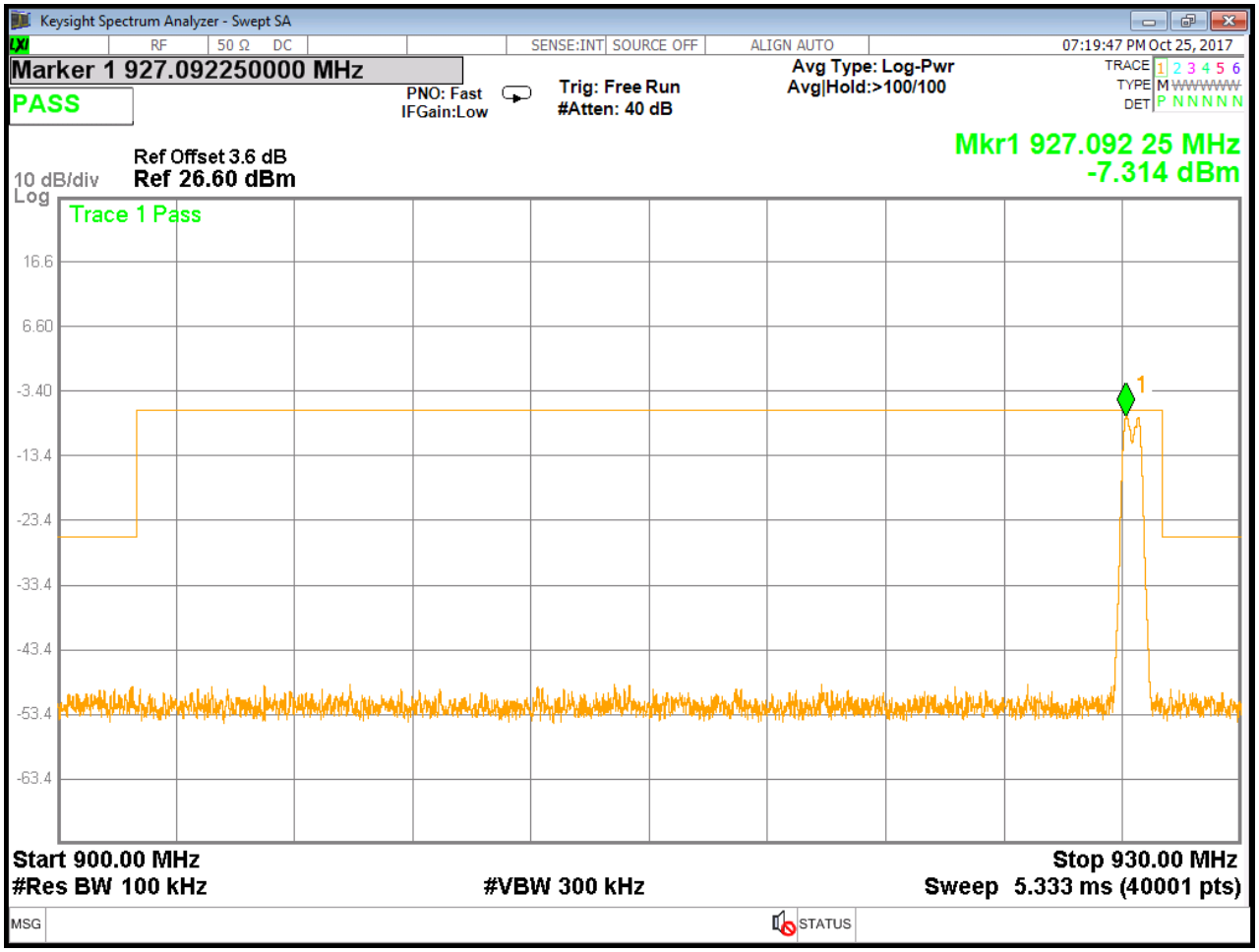

Figure 36: Conducted Spurious Emissions, Low Power, High Channel 900 – 930MHz

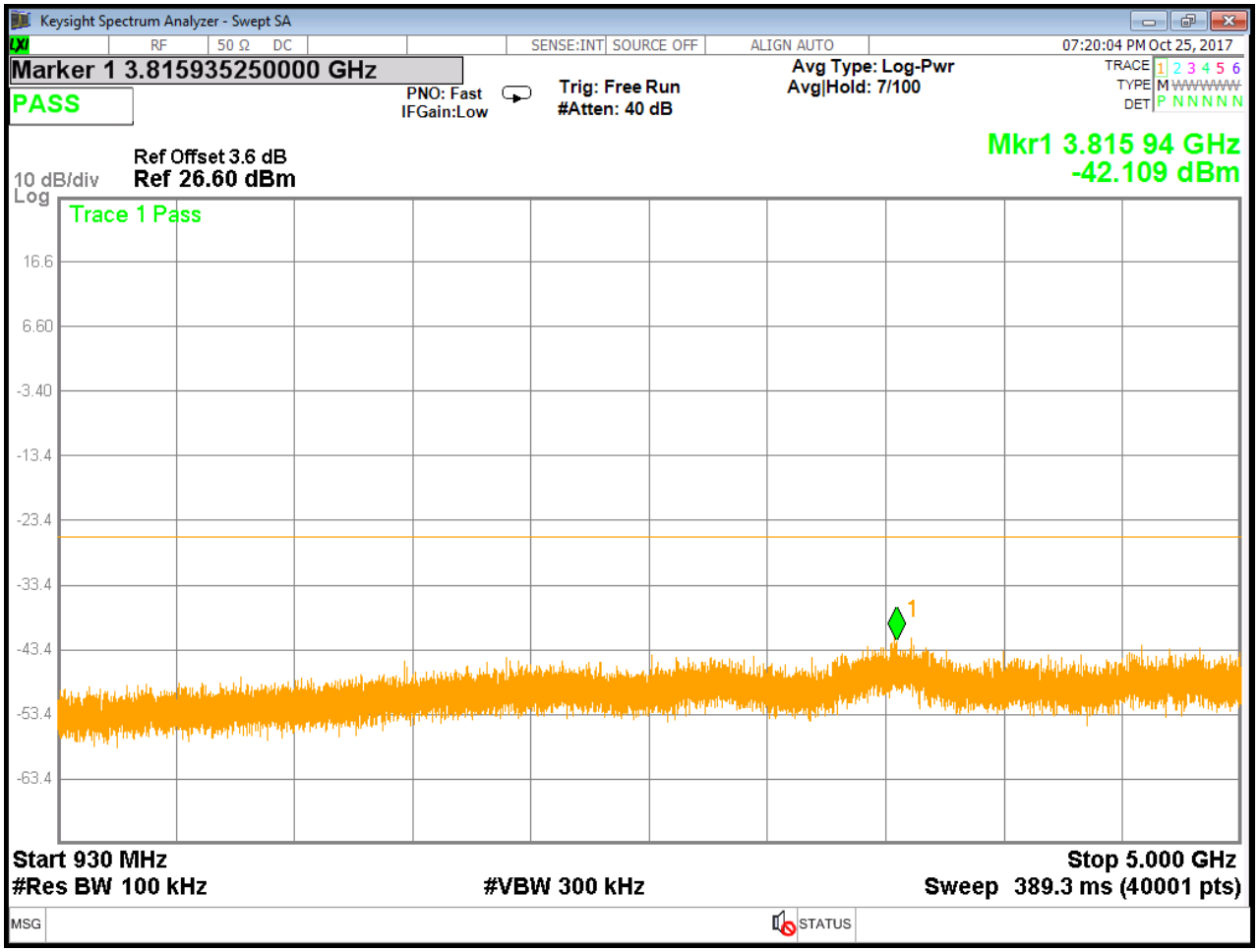

Figure 37: Conducted Spurious Emissions, Low Power, High Channel 930-5000MHz

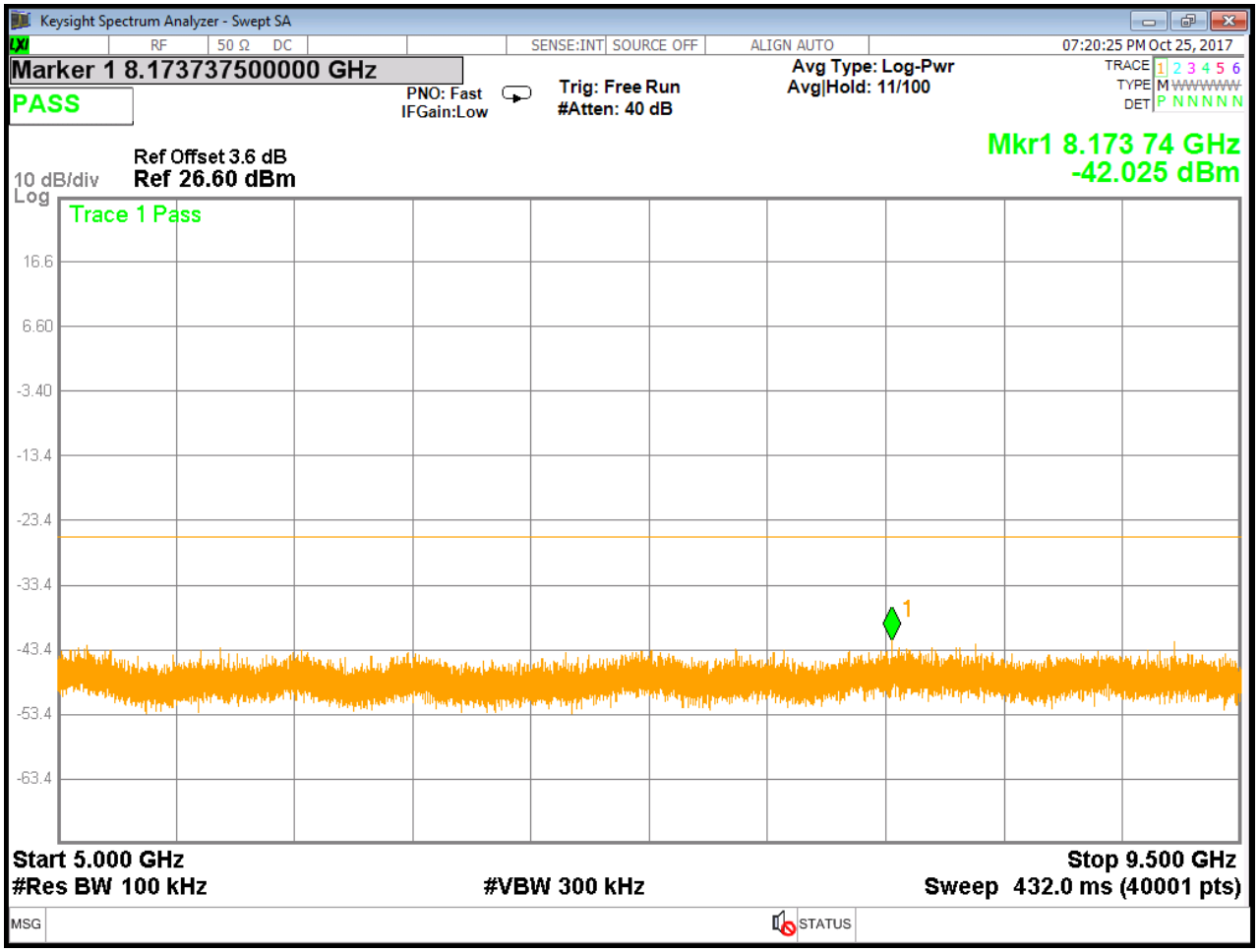

Figure 38: Conducted Spurious Emissions, Low Power, High Channel 5-9.5GHz

5.5.1 Band Edge Compliance

In accordance with FCC Public Notice DA-00-705 close-up plots of the upper and lower channels in both hopping and non-hopping modes with respect to the nearest authorized band-edges are provided below. The tests were performed in the same manner as the above conducted spurious emissions tests.

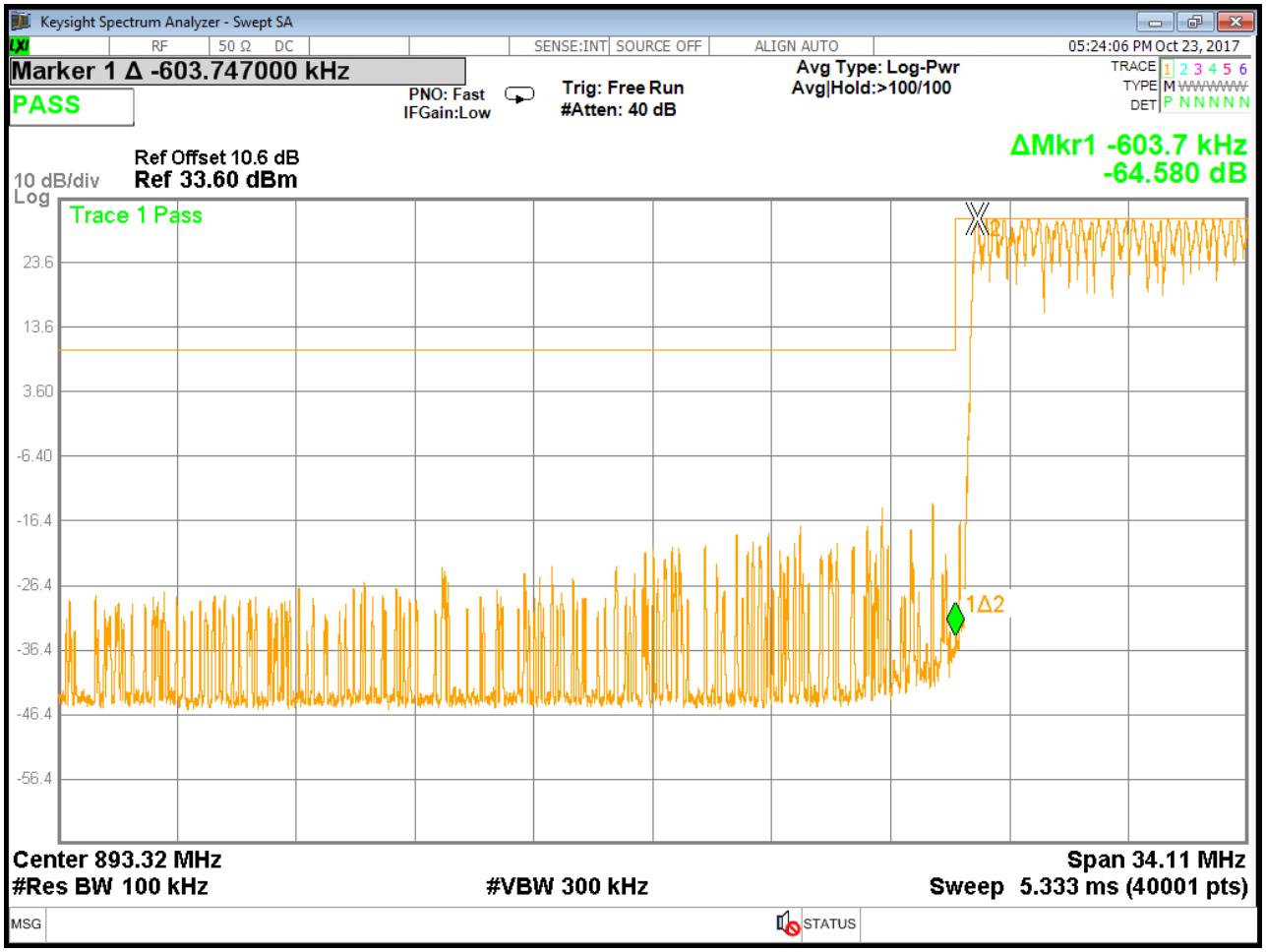

Figure 39: Lower Band-edge, High Power Setting

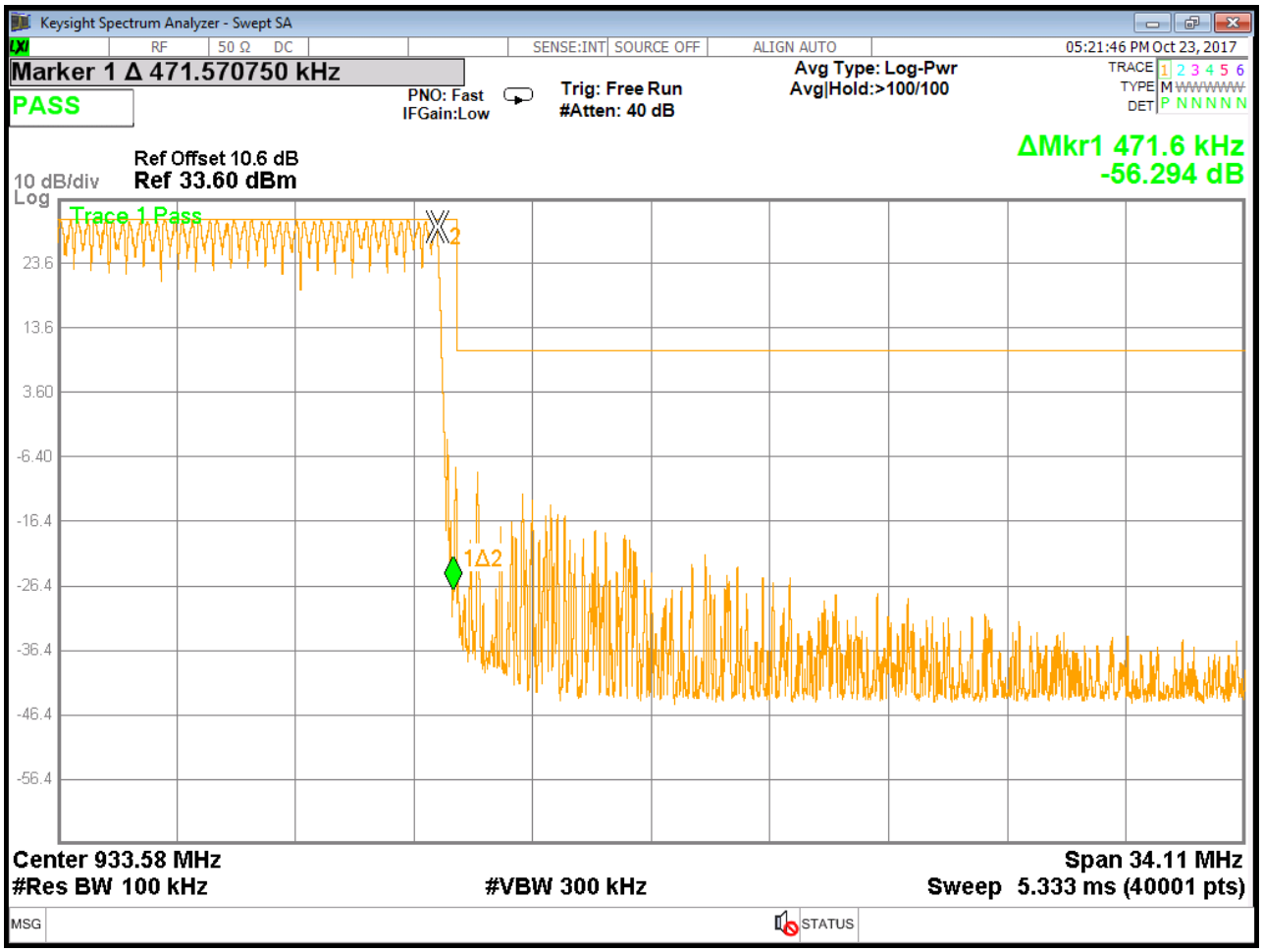

Figure 40: Upper Band-edge, High Power Setting

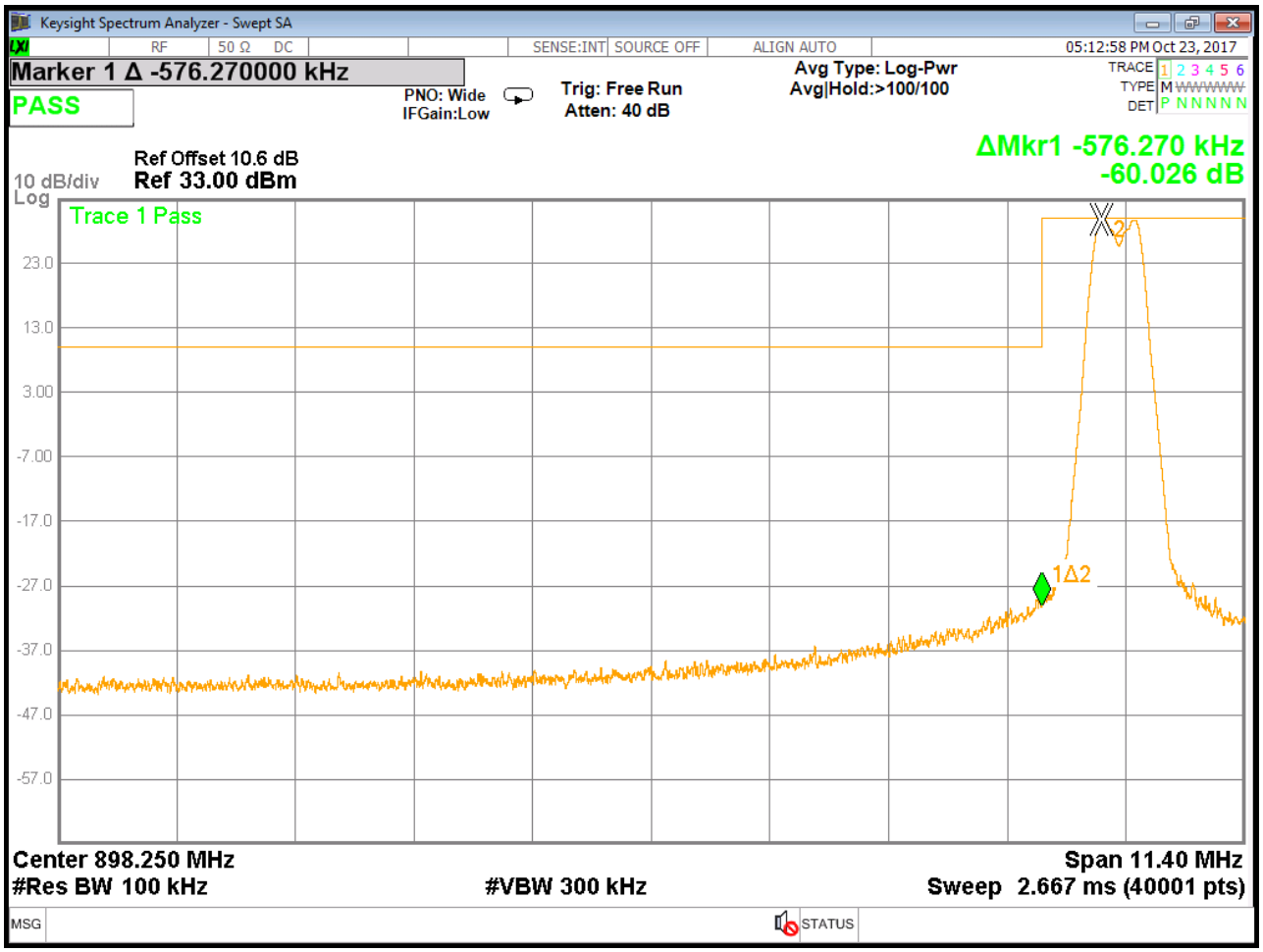

Figure 41: Low Channel (Single Hop), Band-edge, High Power Setting

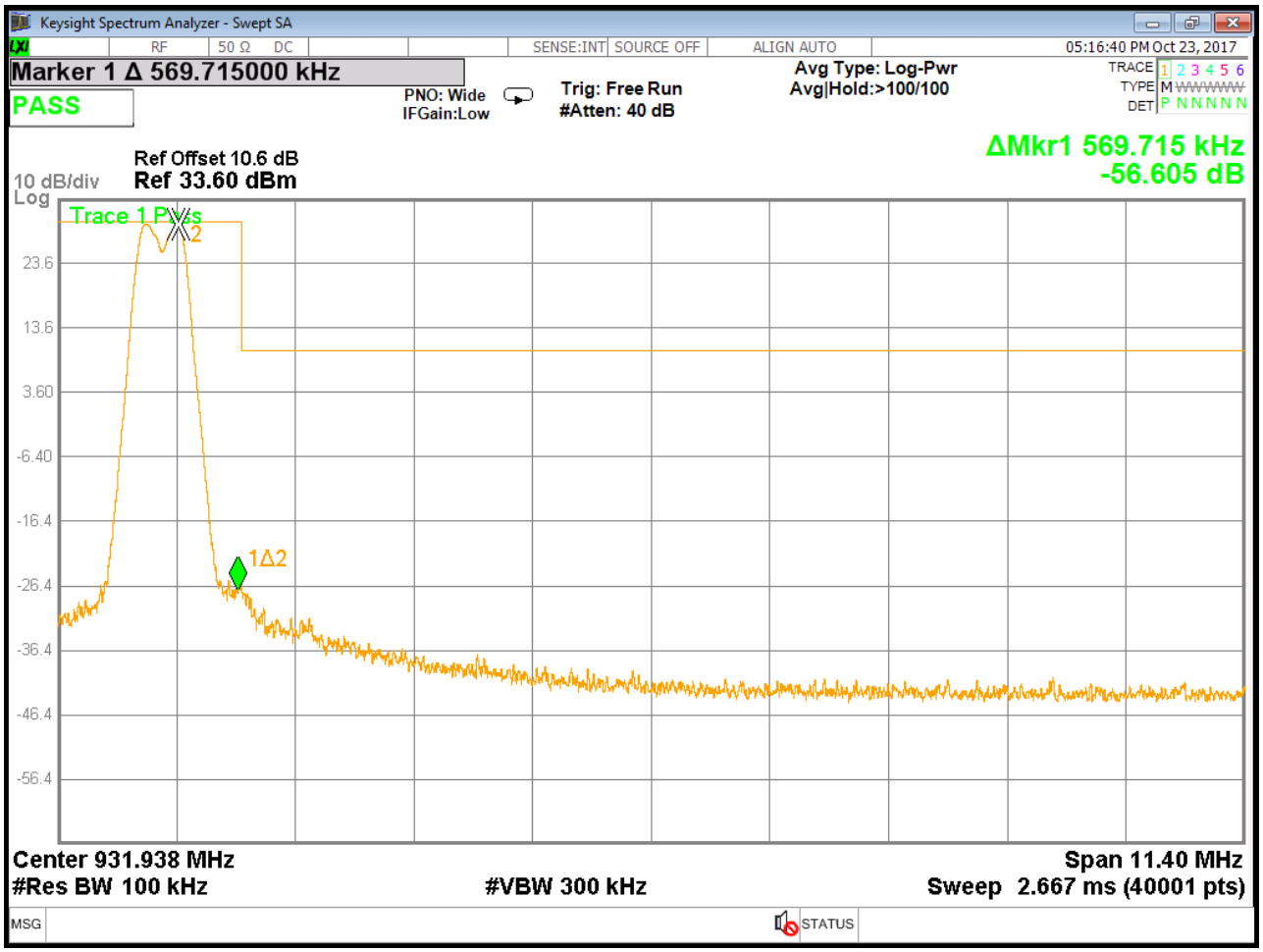

Figure 42: High Channel (Single Hop), Band-edge, High Power Setting

Figure 43: Low Channel, Lower Band-edge, Low Power Setting

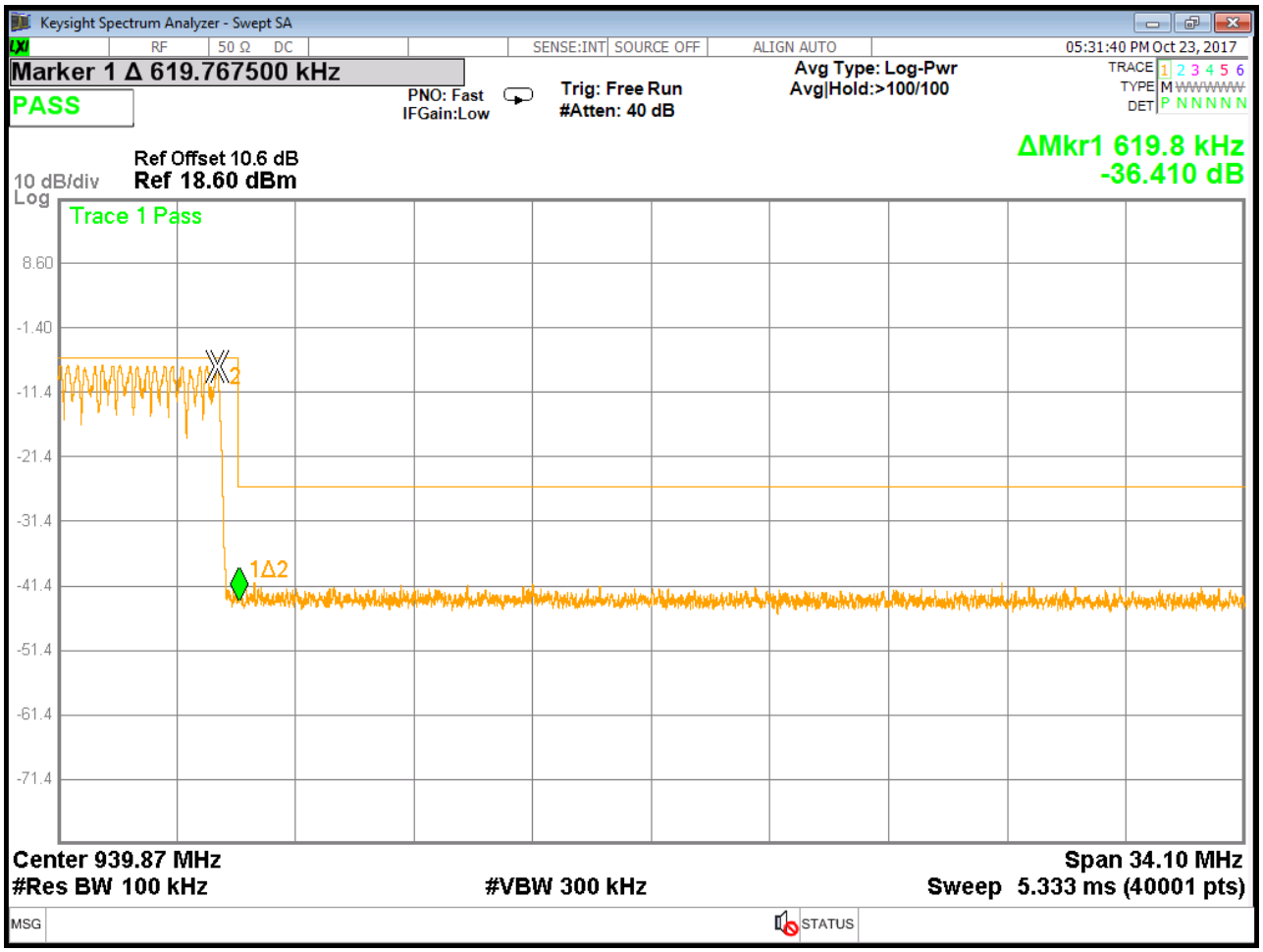

Figure 44: High Channel, Upper Band-edge, Low Power Setting

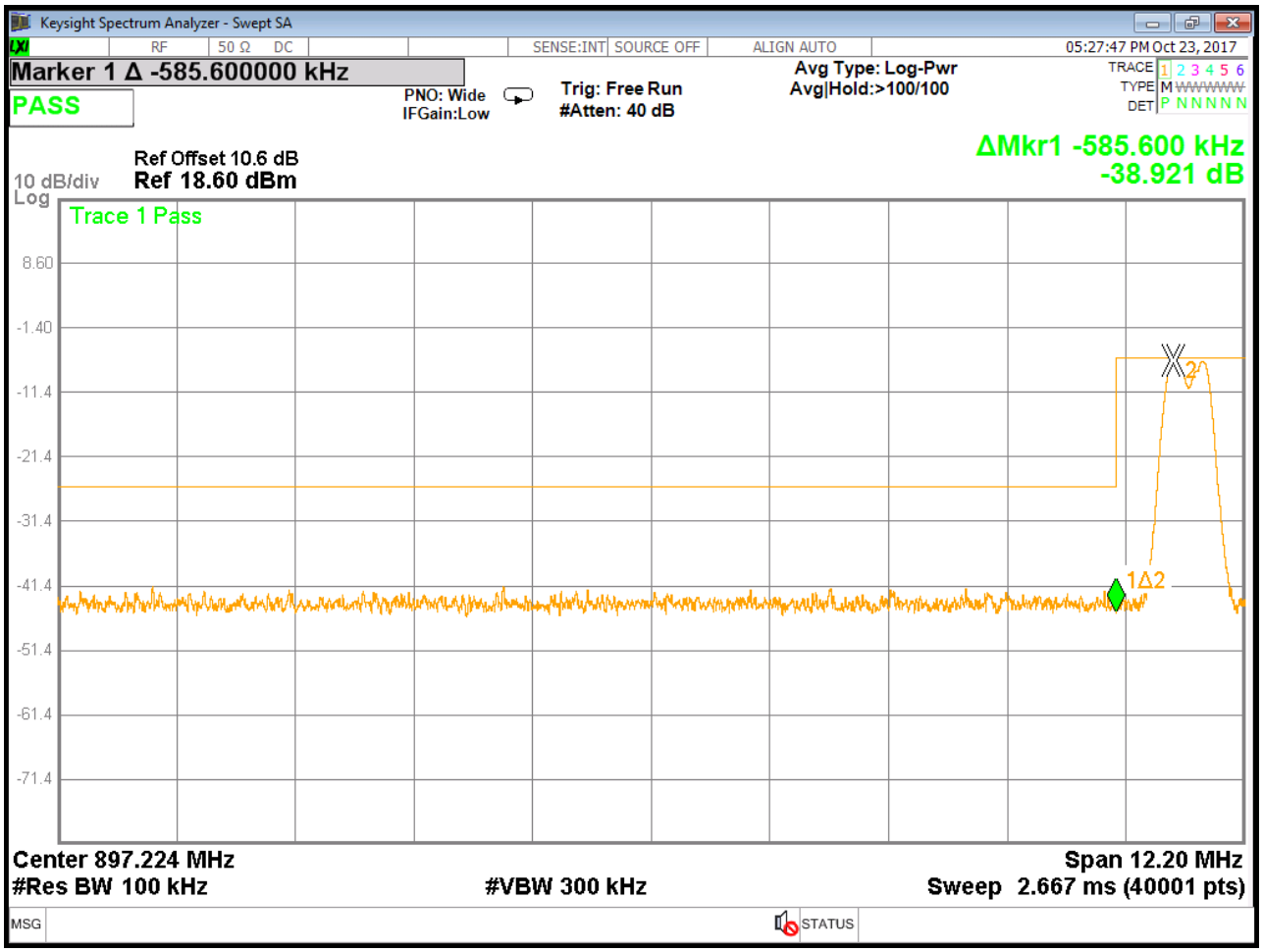

Figure 45: Low Channel (Single Hop), Band-edge, Low Power Setting

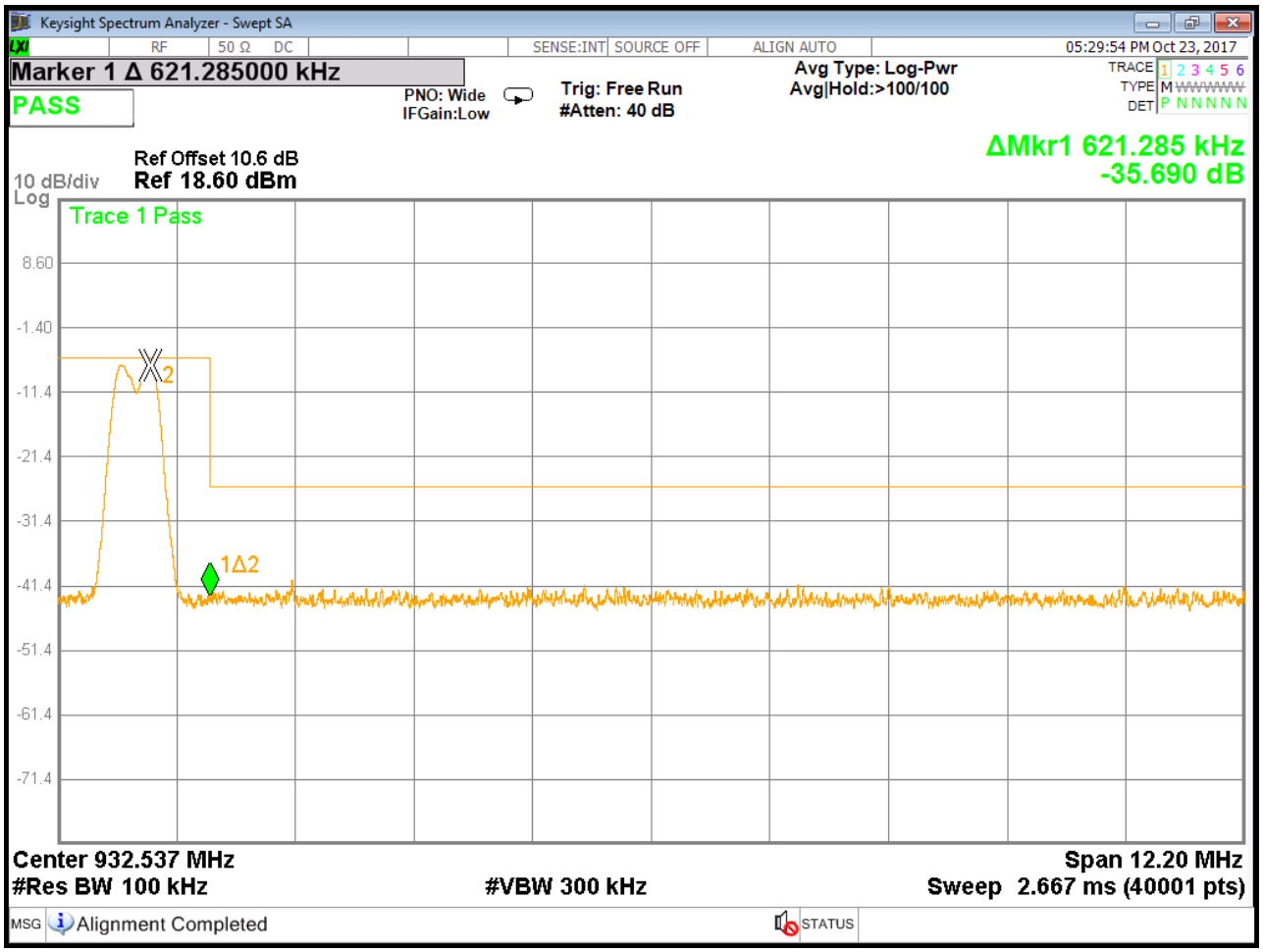

Figure 46: High Channel (Single Hop), Band-edge, Low Power Setting

5.6 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.

5.6.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The EUT was set to transmit continuously on one of three channels (the lowest, a center and the highest available channel). 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 measurements were performed on the EUT in 3 orthogonals and worst case emissions are represented.

The emissions were measured using the following resolution bandwidths:

Table 10: 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 11: Radiated Emission Test Data < 1GHz

Same for all channels

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)	Peak or Average	Comments
45.25	V	0.00	1.00	52.50	-14.1	83.6	100.0	-1.6	Peak	
47.74	V	180.00	1.00	54.20	-15.5	86.3	100.0	-1.3	Peak	
75.65	V	90.00	1.02	47.15	-15.5	38.0	100.0	-8.4	Peak	
128.28	V	180.00	2.00	51.40	-9.2	129.4	150.0	-1.3	Peak	
263.84	V	270.00	2.00	36.35	-9.0	23.2	200.0	-18.7	Peak	
310.13	V	0.00	2.00	29.24	-7.7	12.0	200.0	-24.4	Peak	
311.79	V	180.00	2.00	34.95	-7.6	23.4	200.0	-18.7	Peak	
429.20	V	90.00	2.00	32.44	-3.8	27.0	200.0	-17.4	Peak	
431.72	V	180.00	2.00	38.04	-3.6	52.4	200.0	-11.6	Peak	
709.13	V	0.00	2.00	39.50	1.7	115.2	200.0	-4.8	Peak	
45.25	H	90.00	2.00	51.11	-14.1	71.2	100.0	-3.0	Peak	
47.74	H	180.00	2.00	54.23	-15.5	86.6	100.0	-1.2	Peak	
75.65	H	180.00	2.00	48.74	-15.5	45.7	100.0	-6.8	Peak	
128.28	H	90.00	1.50	50.25	-9.2	113.4	150.0	-2.4	Peak	
263.84	H	180.00	1.50	46.53	-9.0	75.0	200.0	-8.5	Peak	
310.13	H	270.00	1.50	52.46	-7.7	173.8	200.0	-1.2	Peak	
311.79	H	180.00	1.25	49.17	-7.6	120.1	200.0	-4.4	Peak	
429.20	H	90.00	1.20	49.24	-3.8	186.6	200.0	-0.6	Peak	
431.72	H	90.00	1.00	45.56	-3.6	124.6	200.0	-4.1	Peak	
709.13	H	270.00	1.00	0.00	1.7	1.2	200.0	-44.3	Peak	

Table 12: Radiated Emission >1GHz, (Linx ¼ Wave Helical On-Board)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
2708.60	V	90.00	1.00	45.73	5.5	365.8	5000.0	-22.7	
3611.00	V	270.00	1.00	35.90	8.4	163.7	5000.0	-29.7	
4513.75	V	180.00	1.00	40.96	11.5	421.8	5000.0	-21.5	
5416.50	V	0.00	1.00	36.10	16.2	413.0	5000.0	-21.7	
6319.25	V	180.00	1.00	34.37	18.8	454.1	5000.0	-20.8	
7222.00	V	270.00	1.00	34.97	22.7	764.9	5000.0	-16.3	
2708.60	V	180.00	1.00	37.23	5.5	137.5	500.0	-11.2	
3611.00	V	270.00	1.00	28.51	8.4	69.9	500.0	-17.1	
4513.75	V	180.00	1.00	24.91	11.5	66.5	500.0	-17.5	
5416.50	V	0.00	1.00	25.02	16.2	115.3	500.0	-12.7	
6319.25	V	180.00	1.00	25.06	18.8	155.5	500.0	-10.1	
7222.00	V	270.00	1.00	27.50	22.7	323.7	500.0	-3.8	
2708.60	H	90.00	2.00	46.06	5.5	380.0	5000.0	-22.4	
3611.00	H	180.00	2.00	35.19	8.4	150.8	5000.0	-30.4	
4513.75	H	180.00	2.00	35.33	11.5	220.6	5000.0	-27.1	
5416.50	H	180.00	2.00	35.43	16.2	382.3	5000.0	-22.3	
6319.25	H	180.00	2.00	34.31	18.8	451.0	5000.0	-20.9	
7222.00	H	270.00	2.00	35.88	22.7	849.3	5000.0	-15.4	
2708.60	H	0.00	2.00	41.50	5.5	224.8	500.0	-6.9	
3611.00	H	90.00	2.00	28.66	8.4	71.1	500.0	-16.9	
4513.75	H	180.00	2.00	28.97	11.5	106.1	500.0	-13.5	
5416.50	H	180.00	2.00	25.11	16.2	116.5	500.0	-12.7	
6319.25	H	180.00	2.00	25.20	18.8	158.0	500.0	-10.0	

Table 13: Radiated Emission >1GHz, (Linx ¼ Wave Helical On-Board)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
2744.25	V	180.00	1.00	42.31	5.7	250.8	5000.0	-26.0	
3659.00	V	90.00	1.00	42.65	8.5	362.1	5000.0	-22.8	
4573.75	V	270.00	1.00	42.61	11.7	522.3	5000.0	-19.6	
5488.50	V	90.00	1.00	45.68	16.4	1263.8	5000.0	-11.9	
6403.25	V	180.00	1.00	44.28	18.8	1429.7	5000.0	-10.9	
7318.00	V	180.00	1.00	46.09	22.8	2788.4	5000.0	-5.1	
2744.25	V	180.00	1.00	34.77	5.7	105.3	500.0	-13.5	
3659.00	V	90.00	1.00	36.92	8.5	187.2	500.0	-8.5	
4573.75	V	270.00	1.00	37.72	11.7	297.4	500.0	-4.5	
5488.50	V	90.00	1.00	34.70	16.4	357.0	500.0	-2.9	
6403.25	V	180.00	1.00	34.50	18.8	463.7	500.0	-0.7	
7318.00	V	180.00	1.00	30.80	22.8	479.6	500.0	-0.4	
2744.25	H	180.00	2.00	55.48	5.7	1142.5	5000.0	-12.8	
3659.00	H	90.00	2.00	44.75	8.5	461.1	5000.0	-20.7	
4573.75	H	270.00	2.00	46.59	11.7	825.8	5000.0	-15.6	
5488.50	H	90.00	2.00	43.99	16.4	1040.4	5000.0	-13.6	
6403.25	H	180.00	2.00	44.23	18.8	1421.5	5000.0	-10.9	
7318.00	H	180.00	2.00	46.16	22.8	2811.0	5000.0	-5.0	
2744.25	H	180.00	2.00	47.80	5.7	471.9	500.0	-0.5	
3659.00	H	90.00	2.00	36.11	8.5	170.5	500.0	-9.3	
4573.75	H	270.00	2.00	38.08	11.7	310.0	500.0	-4.2	
5488.50	H	90.00	2.00	34.45	16.4	346.9	500.0	-3.2	
6403.25	H	180.00	2.00	34.71	18.8	475.1	500.0	-0.4	
7318.00	H	180.00	2.00	30.80	22.8	479.6	500.0	-0.4	

Table 14: Radiated Emission >1GHz, (Linx ¼ Wave Helical On-Board)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
2781.75	V	180.00	1.00	55.03	5.8	1103.3	5000.0	-13.1	
3709.00	V	180.00	1.00	45.08	8.7	487.0	5000.0	-20.2	
4636.25	V	270.00	1.00	42.12	12.2	521.3	5000.0	-19.6	
5563.50	V	90.00	1.00	44.21	16.4	1074.4	5000.0	-13.4	
6490.75	V	180.00	1.00	44.59	19.1	1535.7	5000.0	-10.3	
7418.00	V	180.00	1.00	42.17	23.0	1804.3	5000.0	-8.9	
2781.75	V	180.00	1.00	45.24	5.8	357.4	500.0	-2.9	
3709.00	V	90.00	1.00	34.98	8.7	152.2	500.0	-10.3	
4636.25	V	270.00	1.00	34.49	12.2	216.6	500.0	-7.3	
5563.50	V	90.00	1.00	35.13	16.4	377.7	500.0	-2.4	
6490.75	V	180.00	1.00	34.62	19.1	487.3	500.0	-0.2	
7418.00	V	180.00	1.00	30.85	23.0	490.1	500.0	-0.2	
2781.75	H	270.00	2.00	55.78	5.8	1202.8	5000.0	-12.4	
3709.00	H	180.00	2.00	44.42	8.7	451.4	5000.0	-20.9	
4636.25	H	0.00	2.00	45.27	12.2	749.1	5000.0	-16.5	
5563.50	H	90.00	2.00	47.51	16.4	1570.9	5000.0	-10.1	
6490.75	H	180.00	2.00	44.35	19.1	1493.8	5000.0	-10.5	
7418.00	H	180.00	2.00	46.11	23.0	2839.9	5000.0	-4.9	
2781.75	H	270.00	2.00	45.73	5.8	378.2	500.0	-2.4	
3709.00	H	180.00	2.00	36.01	8.7	171.4	500.0	-9.3	
4636.25	H	0.00	2.00	37.33	12.2	300.3	500.0	-4.4	
5563.50	H	90.00	2.00	34.92	16.4	368.7	500.0	-2.6	
6490.75	H	180.00	2.00	34.58	19.1	485.1	500.0	-0.3	
7418.00	H	180.00	2.00	28.50	23.0	373.9	500.0	-2.5	

5.7 AC Conducted Emissions (FCC Part §15.207)

5.7.1 Requirements

Test Arrangement: Table Top

Compliance Standard: FCC Part 15 (10/2015), Class B

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

5.7.2 Test Procedure

The requirements of FCC Part 15 and ICES-003 call for the EUT to be placed on an 80cm-high 1 X 1.5-meter 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 EUT had wire leads provided for power and these leads were connected to a standard IEC male plug with a short length of power cable (1m). This cable was connected to the LISN and 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.

The 50 Ω measurement port 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.

These emissions must meet the limits specified in §15.207 for quasi-peak and average measurements. At frequencies where quasi-peak or peak measurements comply with the average limit, no average measurements need be performed.

5.7.3 Test Equipment

Test Name:	**Radiated Emissions & Bench Conducted Emissions**	Test Date:	**10/23/2017**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	11/10/2017
125	SOLAR - 8028-50-TS-24-BNC	LISN	2/16/2018
126	SOLAR - 8028-50-TS-24-BNC	LISN	2/16/2018
53	HP - 11947A	LIMITER TRANSIENT	2/15/2018

5.7.4 Test Data

The EUT complied with the Class B Conducted Emissions requirements. Table 15 provides the test results for the conducted emissions.

Test Engineer(s): Nikolas M. Allen

Test Date(s): 10/23/17-10/25/17

Table 15: Conducted Emissions

Frequency (MHz)	Level QP (dBµV)	Level AVG (dBµV)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dBµV)	Level Corr Avg (dBµV)	Limit QP (dBµV)	Limit AVG (dBµV)	Margin QP (dB)	Margin AVG (dB)
0.165	28.1	10.9	10.2	0.3	38.6	21.4	65.2	55.2	-26.7	-33.9
1.162	26.3	23.4	10.3	0.3	36.8	33.9	56.0	46.0	-19.2	-12.1
12.700	20.4	13.7	11.2	0.4	32.1	25.4	60.0	50.0	-27.9	-24.6
14.473	25.7	13.5	11.3	0.6	37.6	25.4	60.0	50.0	-22.4	-24.6
15.622	23.3	9.8	11.4	0.7	35.4	21.9	60.0	50.0	-24.6	-28.1
1.090	26.2	19.2	10.3	0.3	36.7	29.7	56.0	46.0	-19.3	-16.3
16.650	33.2	16.8	11.4	0.8	45.4	29.0	60.0	50.0	-14.6	-21.0
25.342	25.0	13.0	11.7	1.2	37.8	25.9	60.0	50.0	-22.2	-24.1
0.717	27.2	12.5	10.3	0.3	37.8	23.1	56.0	46.0	-18.2	-22.9
13.386	24.0	9.5	11.3	0.4	35.7	21.1	60.0	50.0	-24.3	-28.9
13.858	24.0	11.2	11.3	0.4	35.7	22.9	60.0	50.0	-24.3	-27.1
14.491	25.0	10.6	11.3	0.4	36.7	22.3	60.0	50.0	-23.3	-27.7
14.580	14.6	9.8	11.3	0.4	26.4	21.5	60.0	50.0	-33.6	-28.5
1.150	31.0	20.5	10.3	0.3	41.5	31.1	56.0	46.0	-14.5	-14.9
15.900	33.7	16.2	11.4	0.5	45.6	28.1	60.0	50.0	-14.4	-21.9
19.583	25.1	13.4	11.5	0.6	37.2	25.5	60.0	50.0	-22.8	-24.5

