Washington Laboratories, Ltd.

FCC PART 15.247 CERTIFICATION TEST REPORT

For the

ATR7000

FCC ID: UZ7ATR7000
IC ID: 109AN-ATR7000

REPORT# 15707-01 REV 0

Prepared for:

Zebra Technologies Corporation

1 Zebra Plaza

Holtsville, NY 11742

Prepared By:

Washington Laboratories, Ltd.

7560 Lindbergh Drive

Gaithersburg, Maryland 20879

FCC Part 15.247 Certification Test Report

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Zebra Technologies Corporation

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FCC ID: UZ7ATR7000
ISED ID: 109AN-ATR7000

AUGUST 31, 2018
WLL REPORT# 15707-01 REV 0

Prepared by:

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ABSTRACT

This report has been prepared on behalf of Zebra Technologies Corporation 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 Zebra Technologies Corporation ATR7000.

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 Zebra Technologies Corporation ATR7000 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	AUGUST 31, 2018

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1 INTRODUCTION

1.1 COMPLIANCE STATEMENT

The Zebra Technologies Corporation ATR7000 complies with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 and ISED Canada RSS-247.

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. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 CONTRACT INFORMATION

Customer:	Zebra Technologies Corporation
Address	1 Zebra Plaza
	Holtsville, NY 11742
Purchase Order Number:	111276154
Quotation Number:	70632

1.4 TEST DATES

Testing was performed on the following date(s): 8/8/2018 – 8/16/2018

1.5 TEST AND SUPPORT PERSONNEL

Washington Laboratories, LTD	Nikolas Allen
Customer Representative	Larry Zhou

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

The AAR2 Reader is a member of the Zebra family of Radio Frequency Identification (RFID) products. RFID is a wireless data acquisition method used to remotely retrieve product data such as part number, date of manufacture, quantity, version, and other information.

Table 1: Device Summary

Item	RFID
Manufacturer:	Zebra Technologies Corporation
FCC ID:	UZ7ATR7000
ISED ID:	109AN-ATR7000
Model:	ATR7000
Serial Number of Unit Tested	18205010504899
FCC Rule Parts/ ISED Rule Parts:	§15.247/ RSS-247
Frequency Range:	902 – 928 MHz
Maximum Output Power:	211.3mW (23.25dBm)
Modulation:	FHSS
Occupied Bandwidth (99%):	103.11 kHz for all modulations
FCC/ ISED Emission Designator:	103KAXN
Keying:	Automatic, Manual
Type of Information:	Data
Number of Channels:	50
Power Output Level	Fixed
Highest TX Spurious Emission:	1721.2 uV/m @3m; 3610.99 MHz
Highest RX Spurious Emission:	27.5 uV/m @3m; 238.38 MHz
Antenna Connector	MMCX Plug, male pin
Antenna Type	Dual Bifilar (7X)
Interface Cables:	RG-316
Maximum Data Rate	8192 kSymbols
Power Source & Voltage:	24 VDC Supply or POE+ (802.3at)

2.2 TEST CONFIGURATION

The ATR7000 was configured to run off of a 24 VDC power supply & POE+ supply. Programming commands were given through a support laptop connected through a LAN port. A Putty interface was used.

2.3 TESTING ALGORITHM

The ATR7000 was tested in either a fully operational mode, hopping between all available channels, or hopping on a single channel.

To imitate a worst-case mode of transmission the device was set to operate at boresight; boresight being beam number 397 in the Power Session software and beam number 5897 in the Putty interface. For radiated emissions the device was propped up on a jig such that the device radiated directly at the measuring antenna.was programmed for FHSS operation via ?? Worst cast emission levels are provided in the test results data. Conducted measurements were made directly at the antenna ports.

2.4 TEST LOCATION

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The 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

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

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a,\,b,\,c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

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

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

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:	**Conducted Emissions Voltage**	**Test Date:**	**8/16/2018**
Asset #	Manufacturer/Model	Description	Cal. Due
00125	SOLAR	8028-50-TS-24-BNC	5/23/2019
00126	SOLAR	8028-50-TS-24-BNC	5/23/2019
00053	HP	11947A	2/1/2019
00528	AGILENT	E4446A	12/19/2018
Test Name:	**Radiated Emissions**	**Test Date:**	**8/16/2018**
00528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	12/19/2018
00627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	2/12/2019
00558	HP - 8447D	AMPLIFIER	2/9/2019
00825	MEGAPHASE - TM40-K1K5-36	RF CABLE - 2.9MM-2.9MM 36	10/3/2018
00849	AH SYSTEMS - SAC-18G-16	HF COAXIAL CABLE	1/18/2019
00644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/16/2020

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 and RSS-247 Issue 2. 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 [5.4a]	Transmit Output Power	Pass
15.247 (a)(1)	RSS-247 [5.1b]	Channel Separation	Pass
15.247 (a)(1)	RSS-247 [5.4d]	Number of Channels	Pass
15.247 (a)(1)	RSS-247 [5.1c]	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	Pass
Frequency Hopping Spread Spectrum - RX/Digital Test Summary			
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

4.1 DUTY CYCLE CORRECTION AND TIME OF OCCUPANCY

For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

The transmitter shall have a time of occupancy for systems having a 20dB bandwidth greater than

250 kHz of no more than 0.4 seconds 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.

Table 5: Duty Cycle/Time of Occupancy Results

Test	Result	Limit	Pass/Fail
Dwell time per Hop	388.4ms	400	NA
Dwell time per 100ms	100ms 0 dB Correction	NA	NA
Time of Occupancy	.3907s/10 sec	0.4s/20 sec	Pass

Figure 1: Duty Cycle Plot

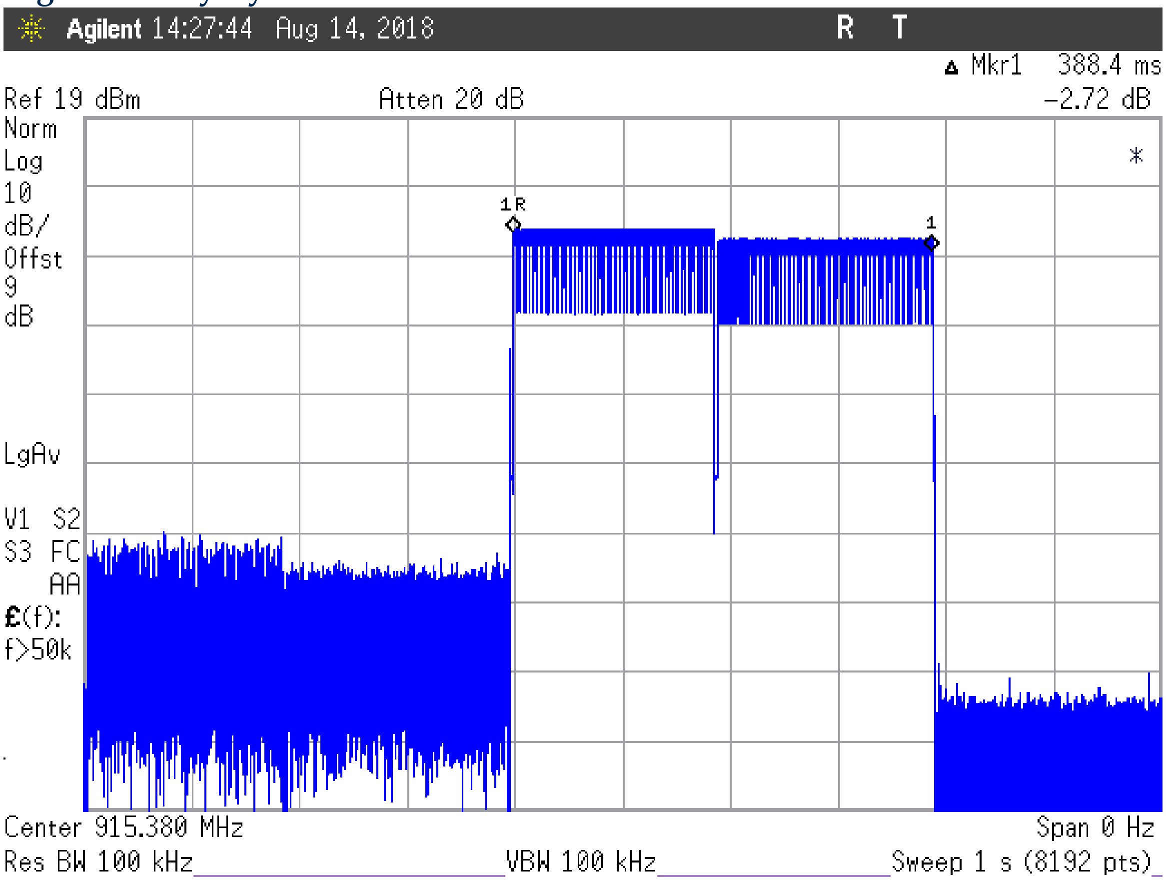


Figure 2: Dwell Time per 100ms

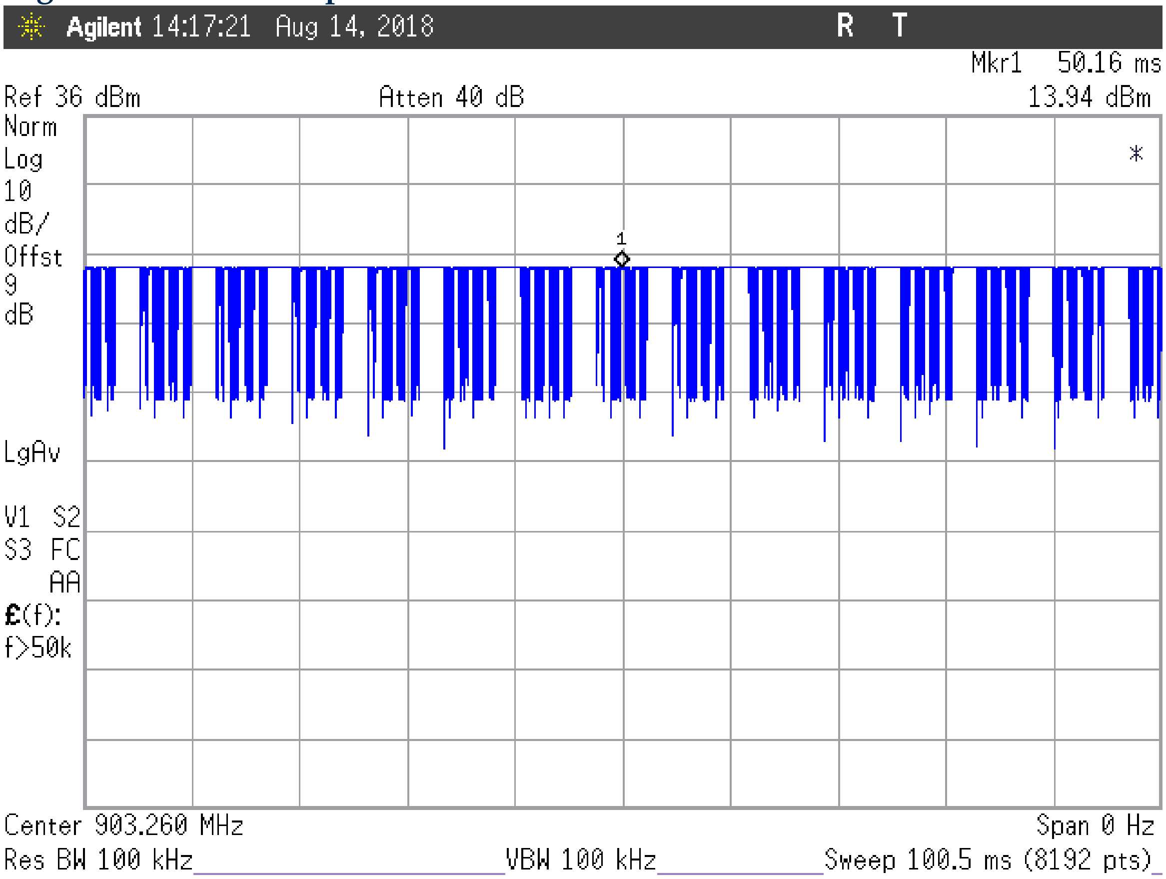
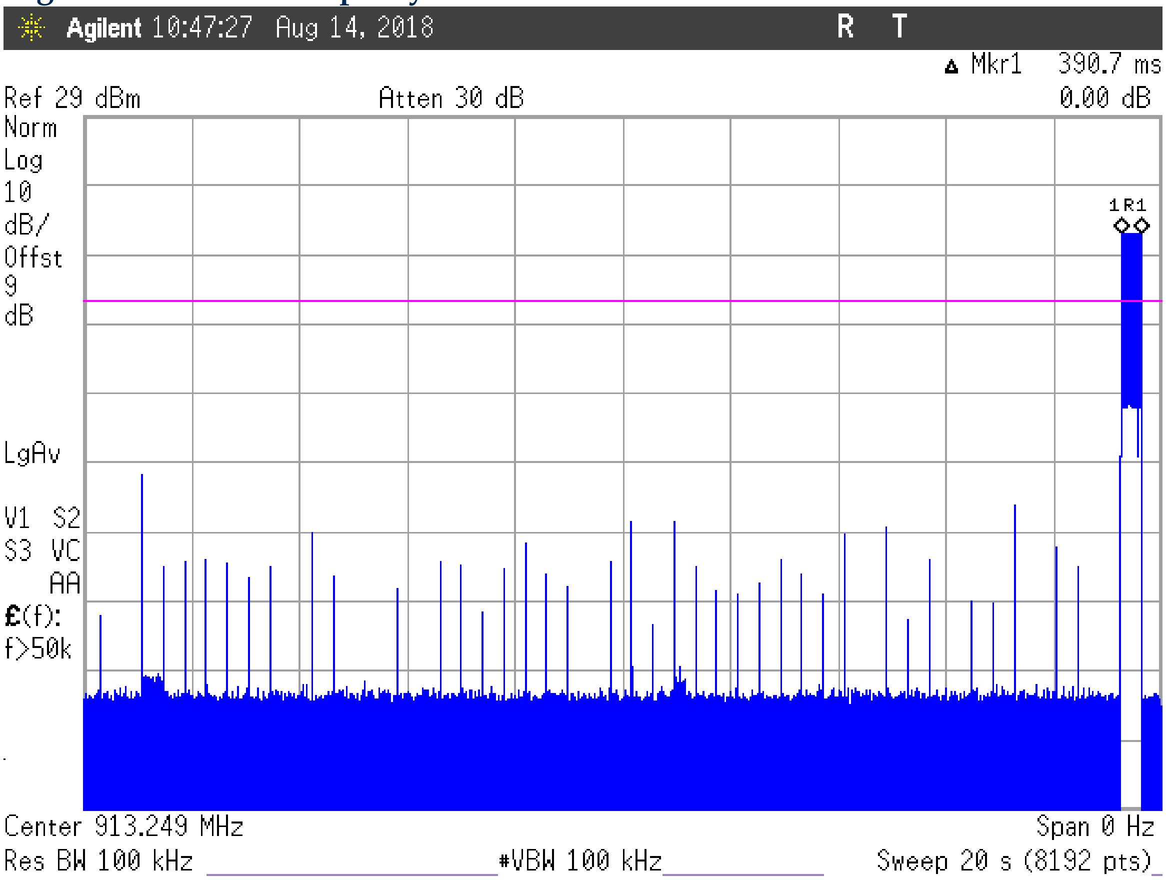


Figure 3: Time of Occupancy



4.2 RF Power Output: (15.247 (b) & RSS-247 [5.4a])

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 measurement was repeated on all antenna ports and then summed to get the total power outputted. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system. The measured data is displayed in Table 6.

Table 6: RF Power Output

Frequency	Level (dBm)	Limit (dBm)	Pass/Fail
Low Channel: 902.75 MHz	23.17	30	Pass
Mid Channel: 915.25 MHz	23.04	30	Pass
High Channel: 927.25 MHz	23.25	30	Pass

Table 7: Worst Case Conducted Emission

Antenna	Amplitude LC (mW)	Amplitude CC (mW)	Amplitude HC (mW)
1	19.8	19.1	18.5
2	9.6	9.4	9.1
3	18.9	18.4	18.2
4	10.4	10.0	10.1
5	19.9	19.3	19.7
6	8.1	7.9	7.8
7	17.9	17.2	17.3
8	21.4	20.6	21.2
9	18.5	17.9	18.5
10	9.9	9.5	10.9
11	16.2	15.6	17.8
12	9.3	9.1	10.6
13	18.0	17.2	20.2
14	10.3	9.9	11.4
Total:	208.2	201.1	211.3
Total [dBm]:	23.18	23.03	23.25

Figure 4: RF Peak Power, Low Channel Antenna 1

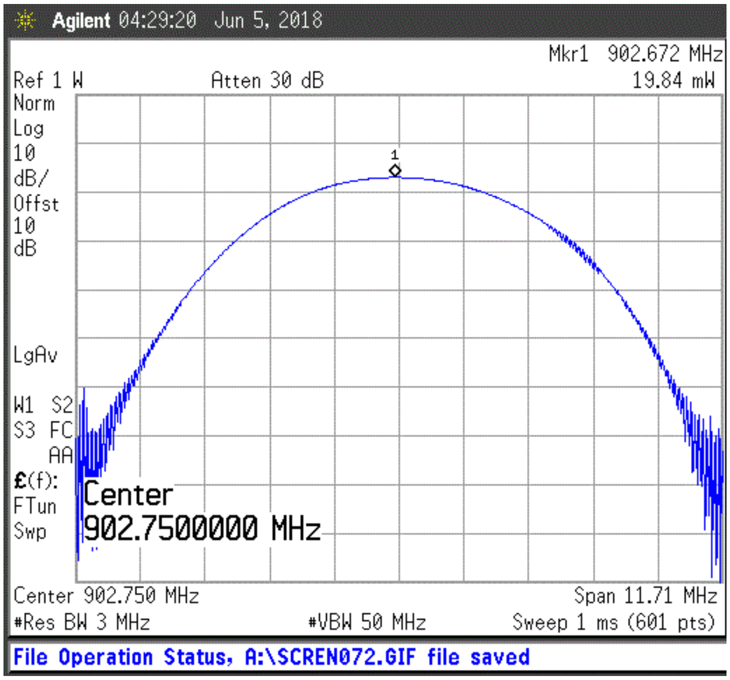


Figure 5: RF Peak Power, Low Channel Antenna 2

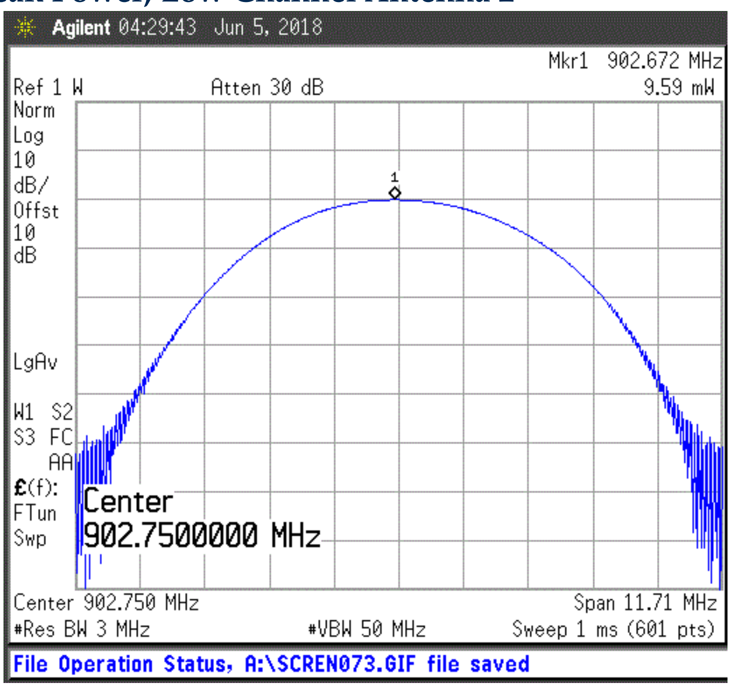


Figure 6: RF Peak Power, Low Channel Antenna 3

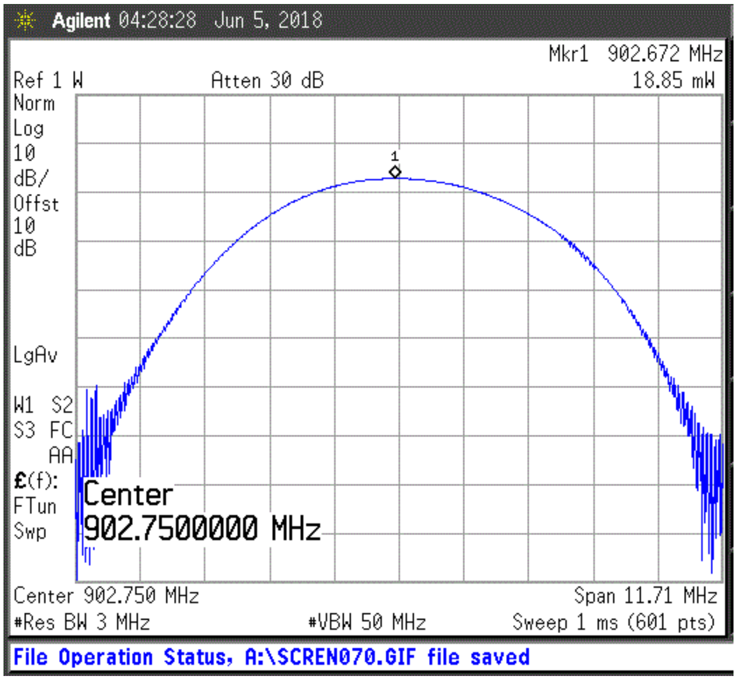


Figure 7: RF Peak Power, Low Channel Antenna 4

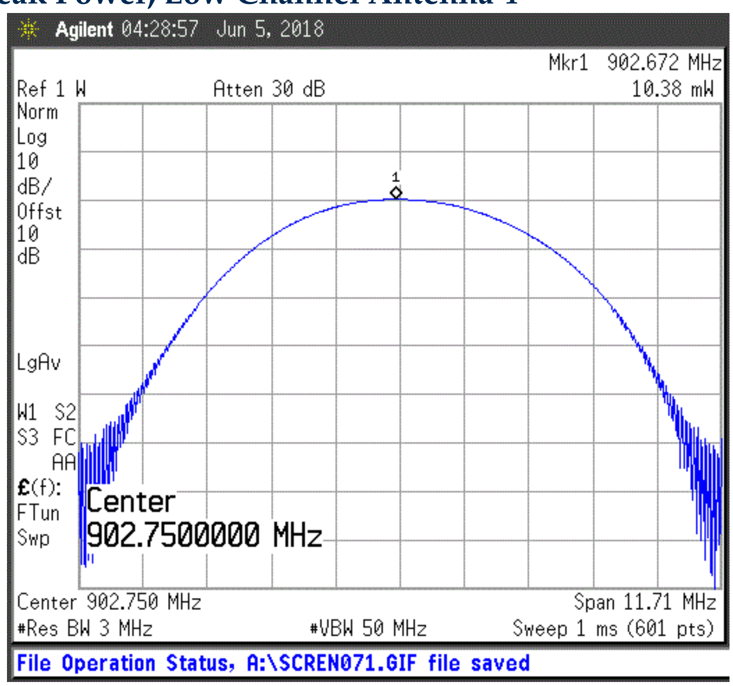


Figure 8: RF Peak Power, Low Channel Antenna 5

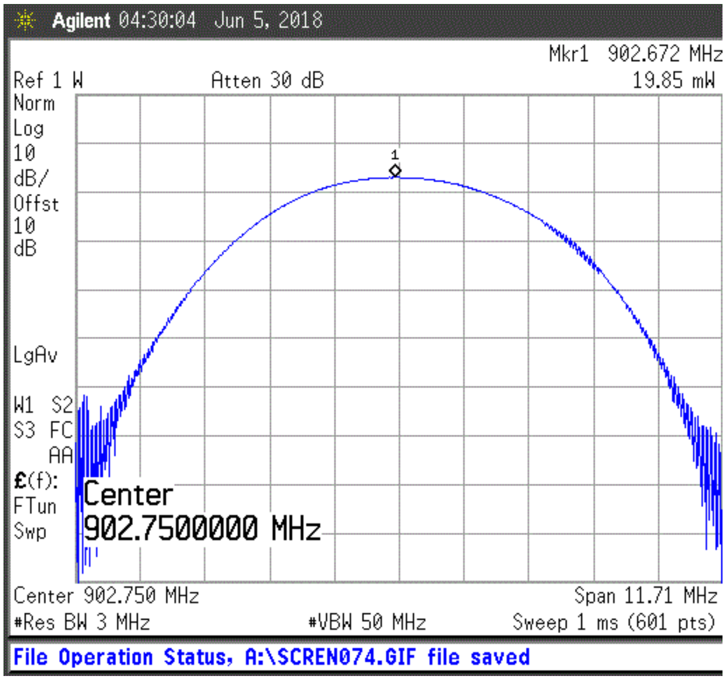


Figure 9: RF Peak Power, Low Channel Antenna 6

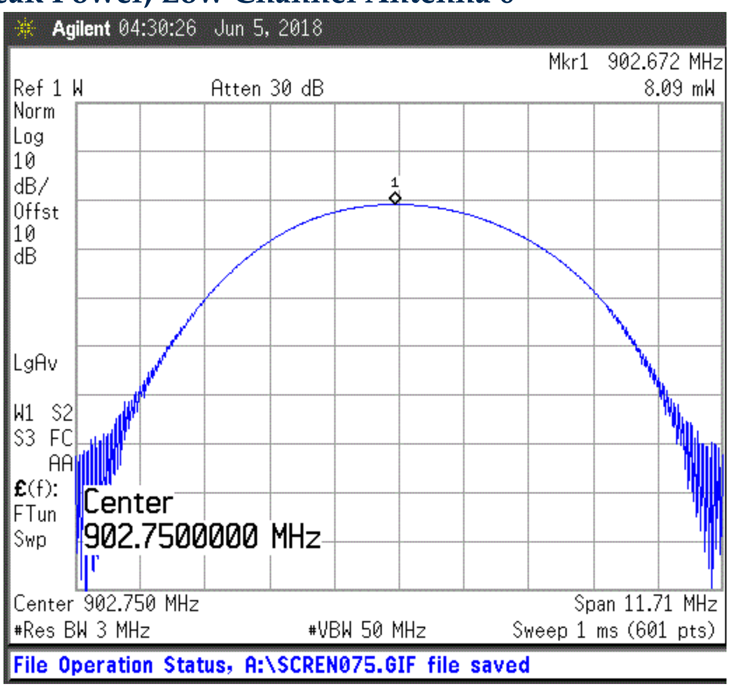


Figure 10: RF Peak Power, Low Channel Antenna 7

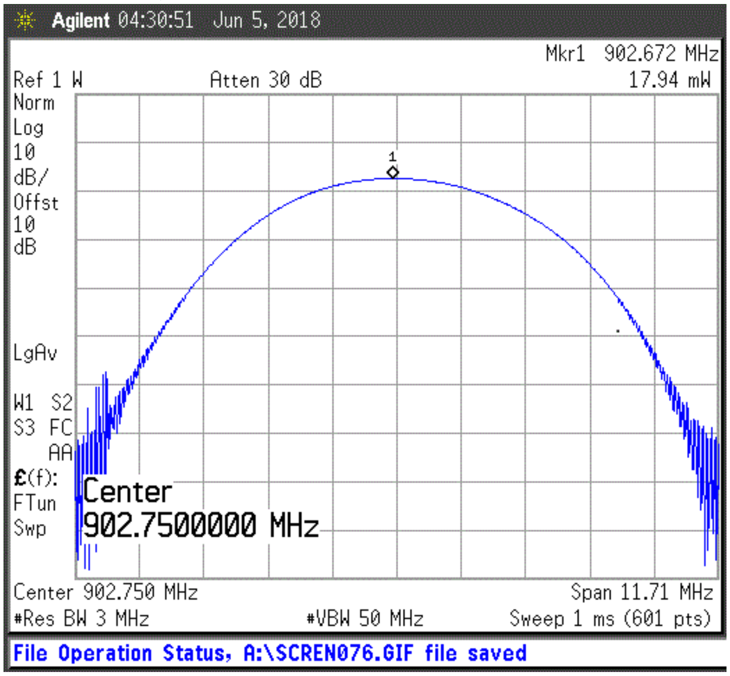


Figure 11: RF Peak Power, Low Channel Antenna 8

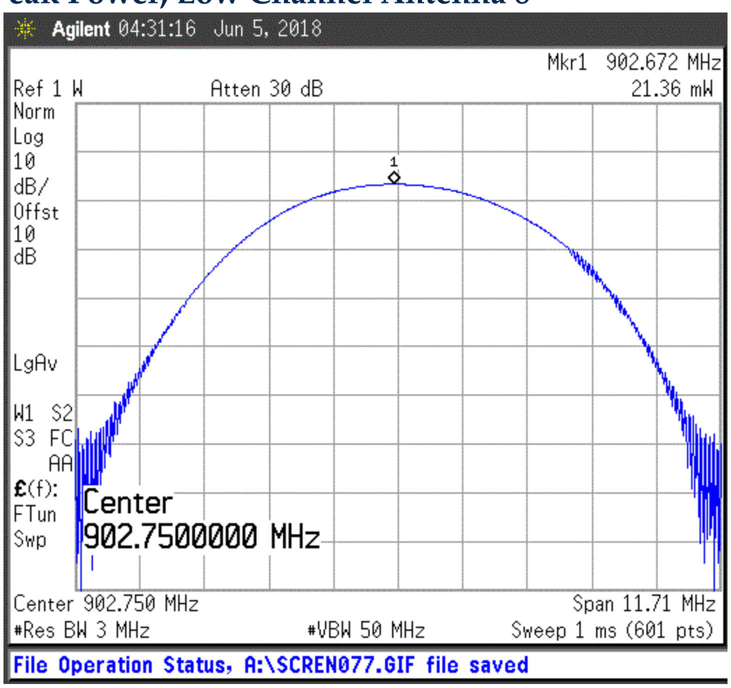


Figure 12: RF Peak Power, Low Channel Antenna 9

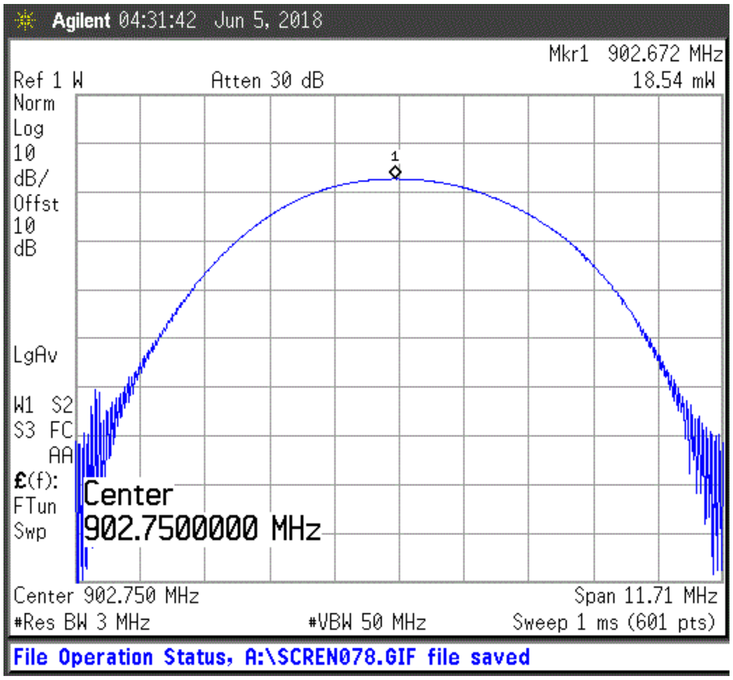


Figure 13: RF Peak Power, Low Channel Antenna 10

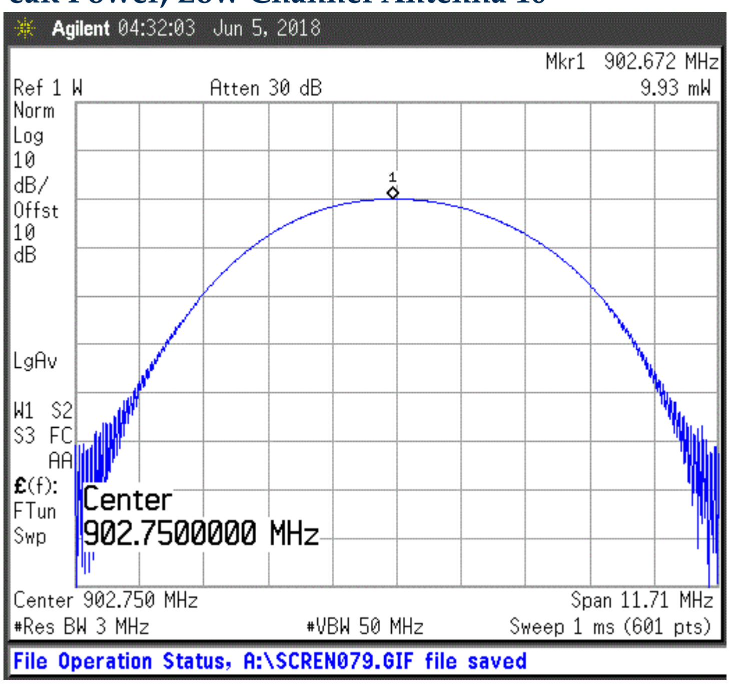


Figure 14: RF Peak Power, Low Channel Antenna 11

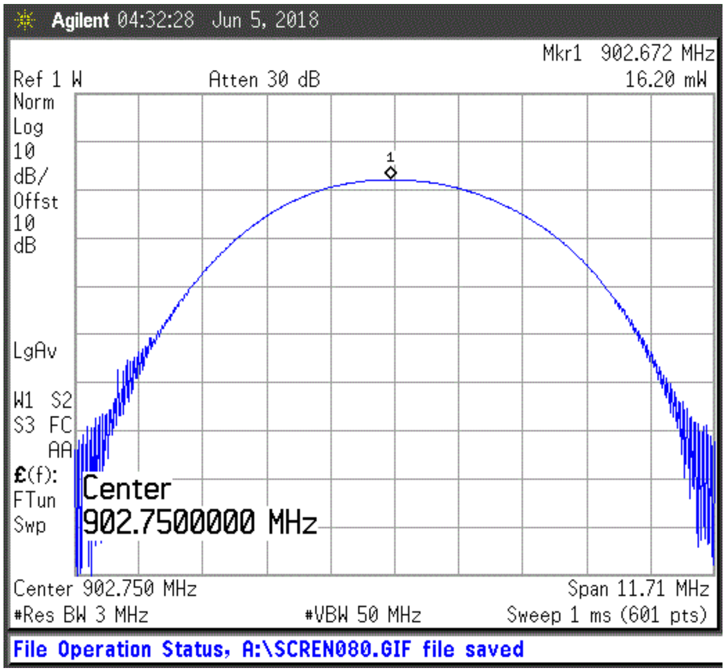


Figure 15: RF Peak Power, Low Channel Antenna 12

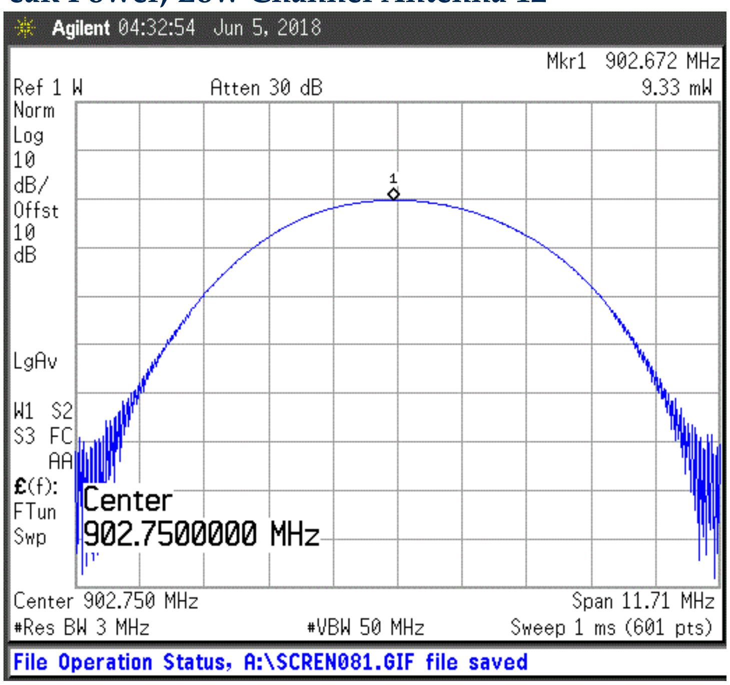


Figure 16: RF Peak Power, Low Channel Antenna 13

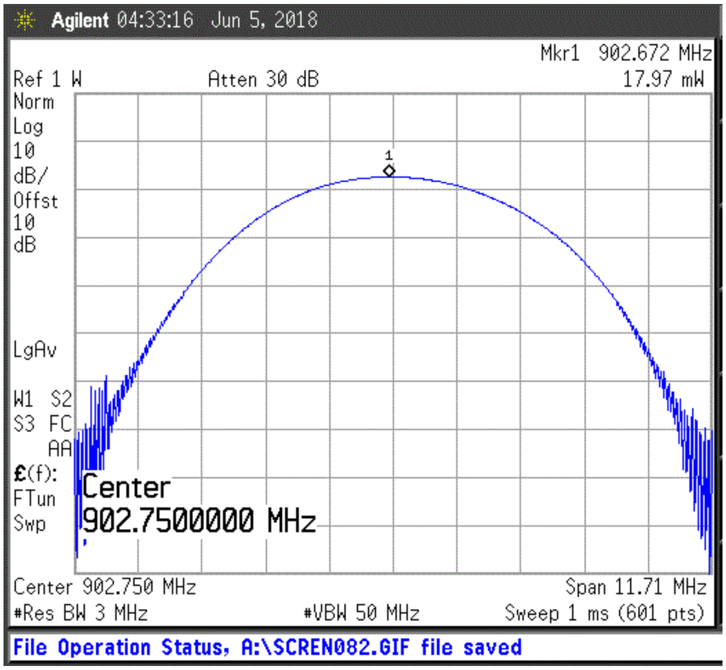


Figure 17: RF Peak Power, Low Channel Antenna 14

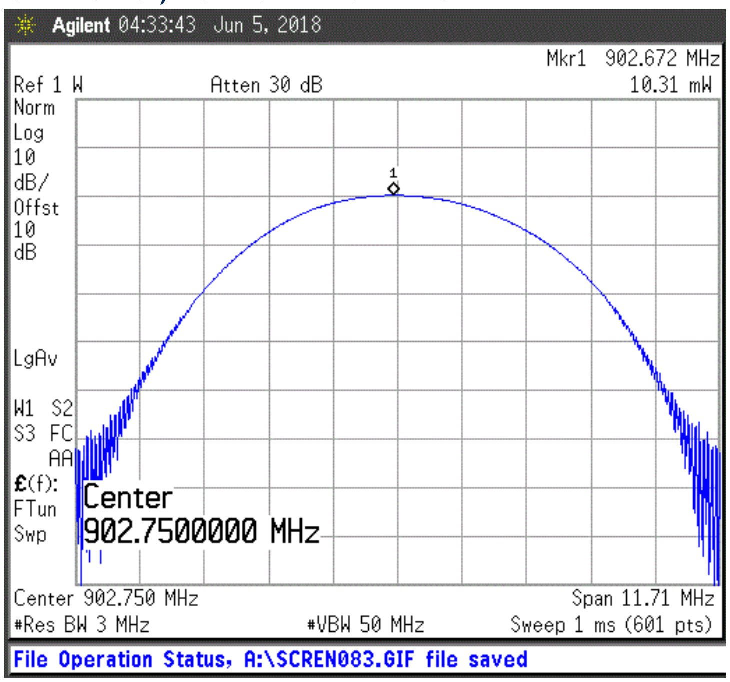


Figure 18: RF Peak Power, Mid Channel Antenna 1

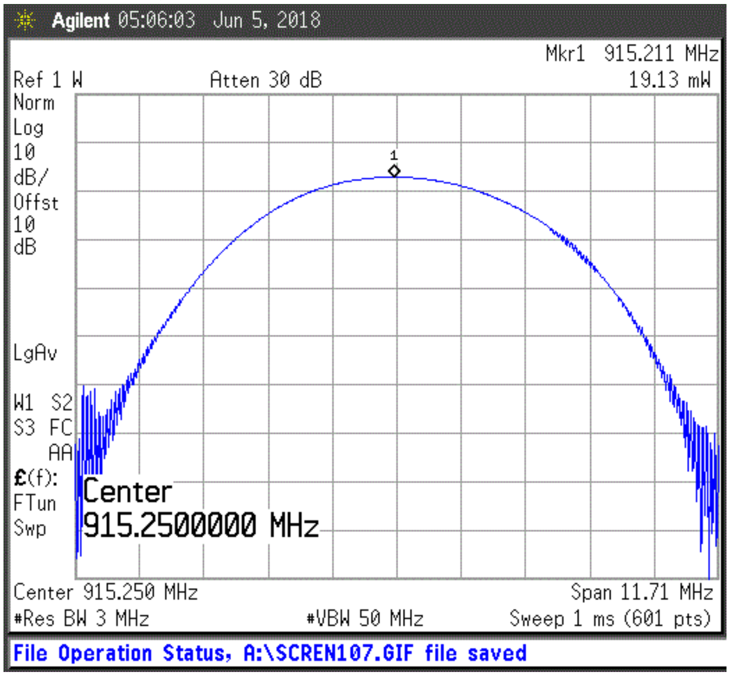


Figure 19: RF Peak Power, Mid Channel Antenna 2

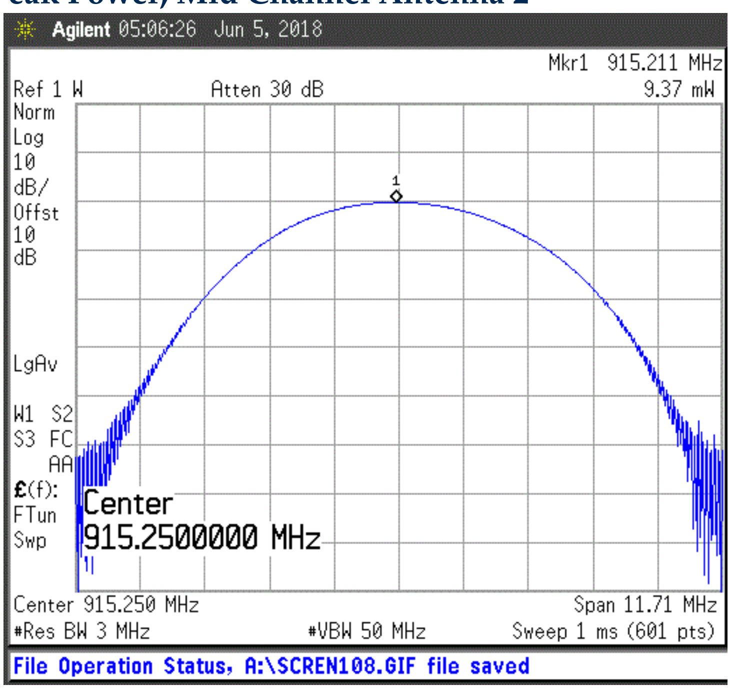


Figure 20: RF Peak Power, Mid Channel Antenna 3

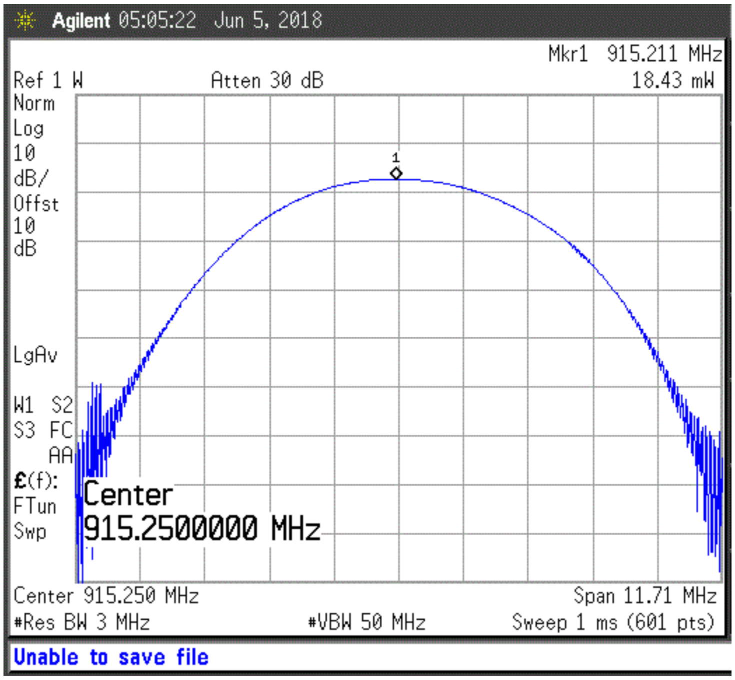


Figure 21: RF Peak Power, Mid Channel Antenna 4

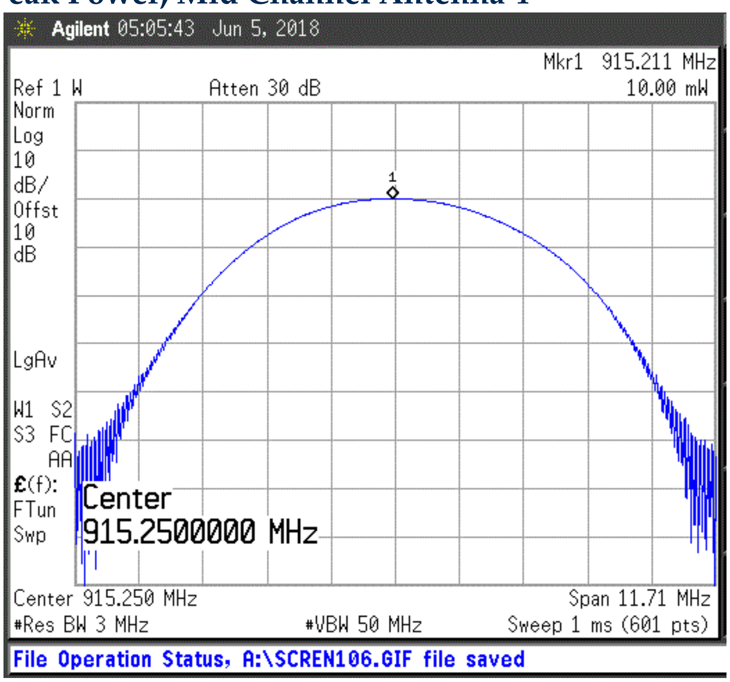


Figure 22: RF Peak Power, Mid Channel Antenna 5

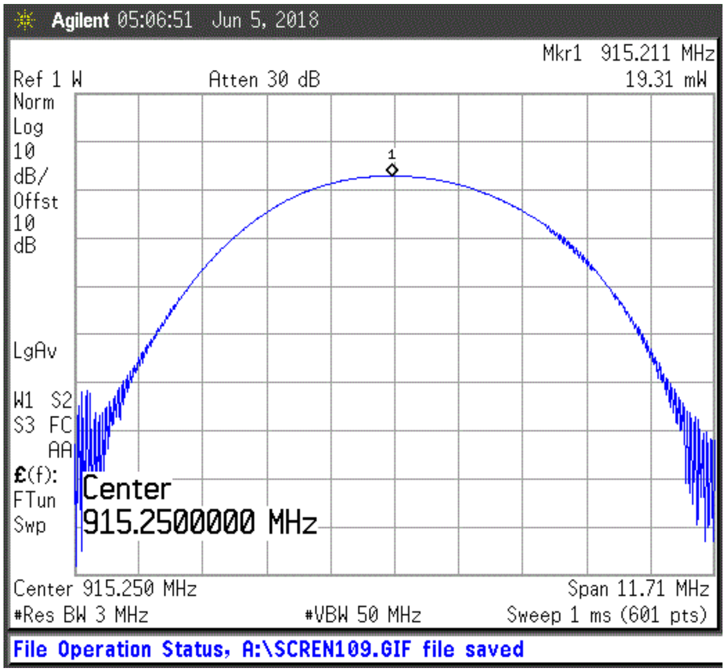


Figure 23: RF Peak Power, Mid Channel Antenna 6

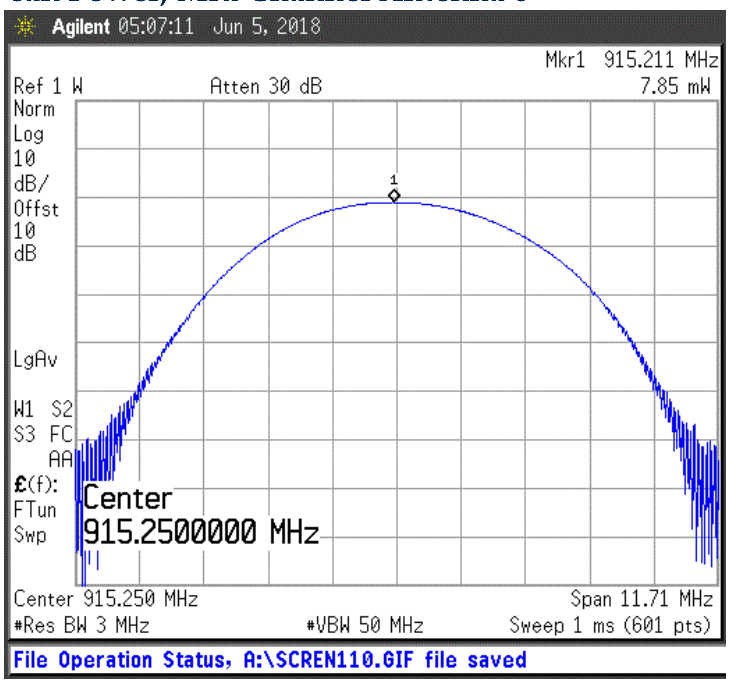


Figure 24: RF Peak Power, Mid Channel Antenna 7

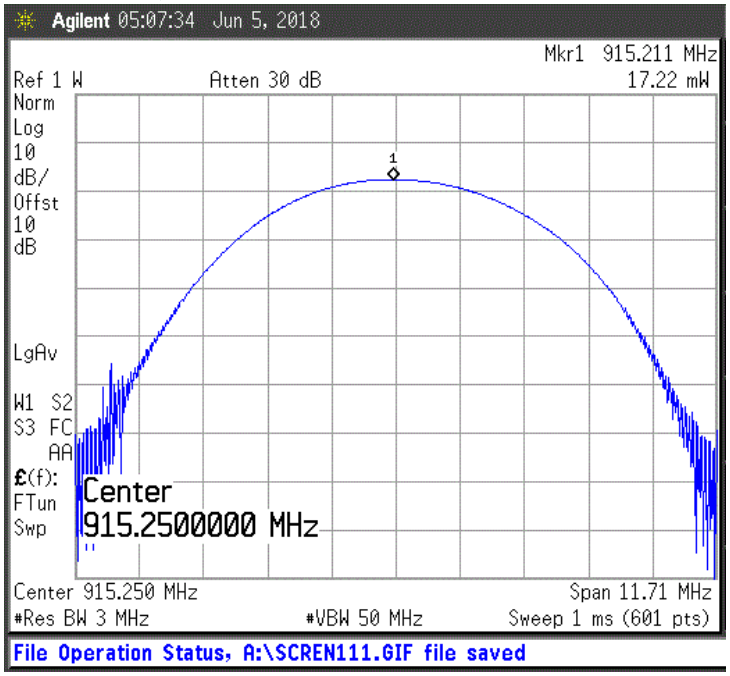


Figure 25: RF Peak Power, Mid Channel Antenna 8

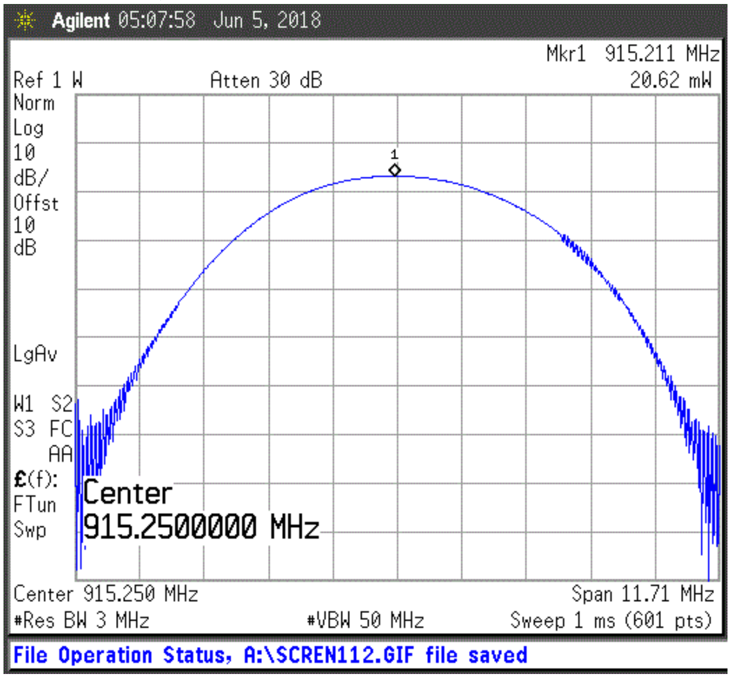


Figure 26: RF Peak Power, Mid Channel Antenna 9

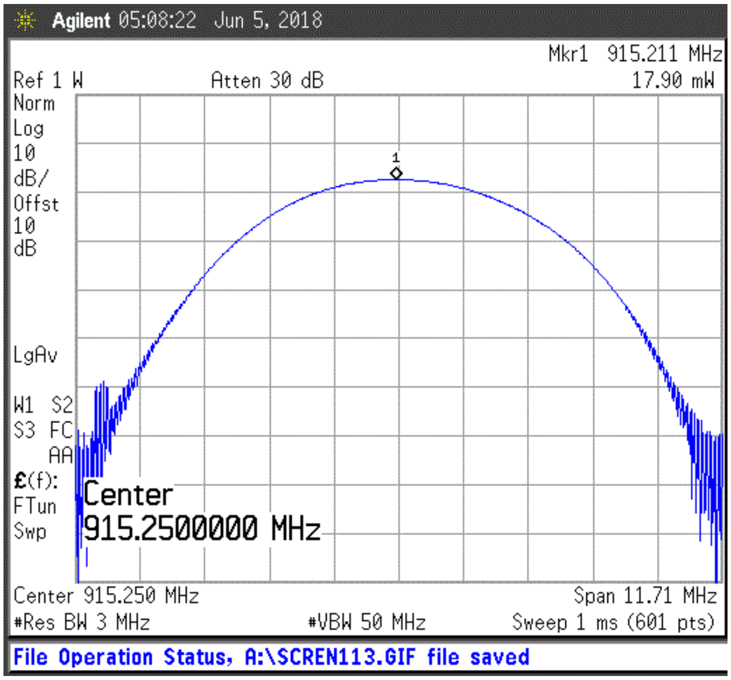


Figure 27: RF Peak Power, Mid Channel Antenna 10

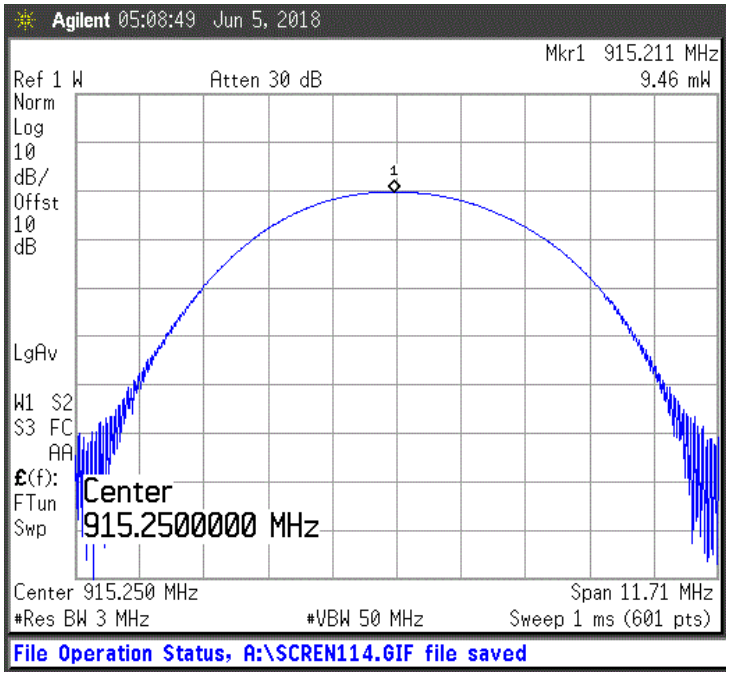


Figure 28: RF Peak Power, Mid Channel Antenna 11

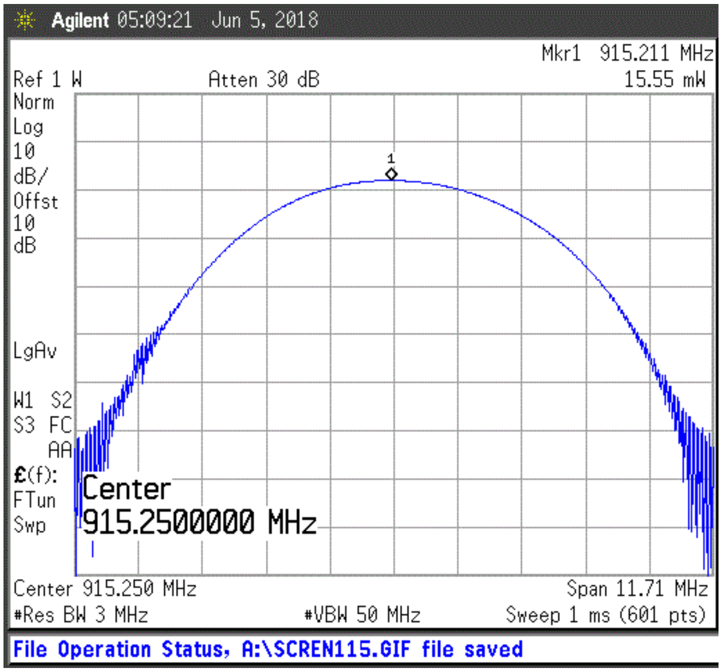


Figure 29: RF Peak Power, Mid Channel Antenna 12

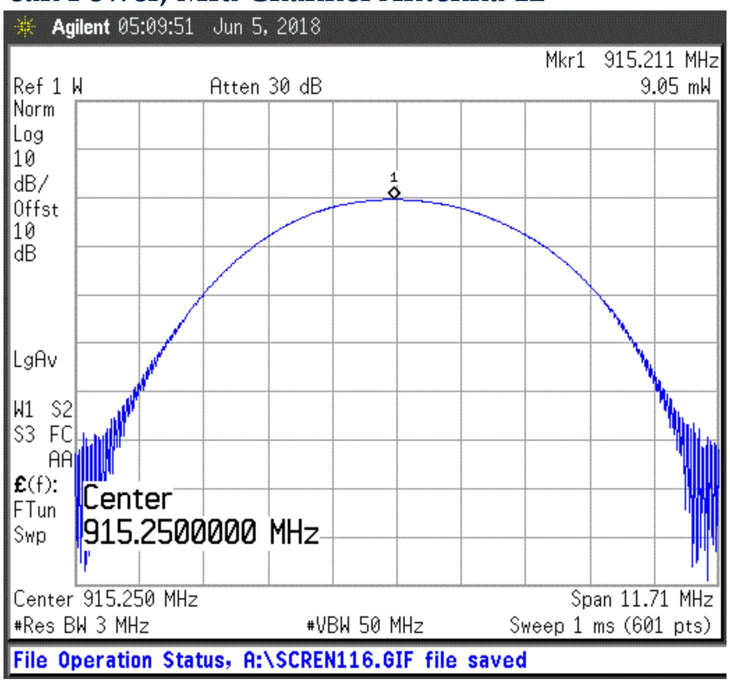


Figure 30: RF Peak Power, Mid Channel Antenna 13

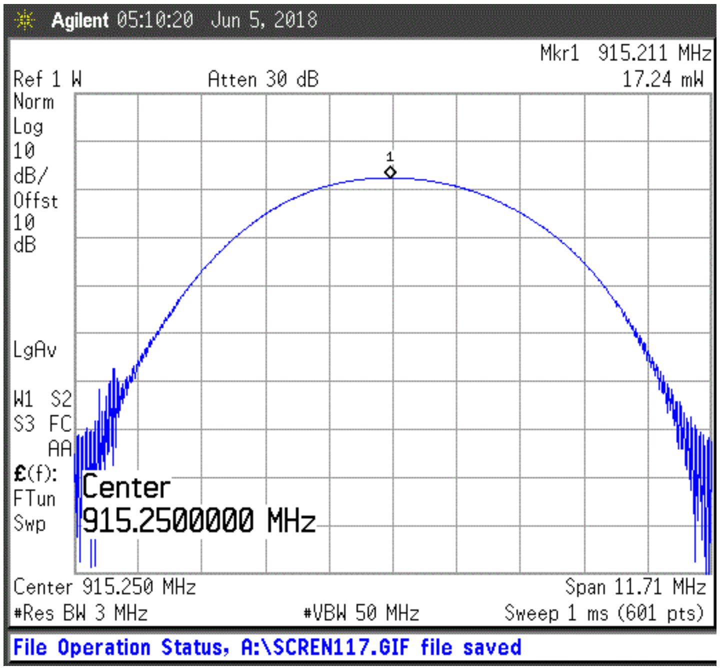


Figure 31: RF Peak Power, Mid Channel Antenna 14

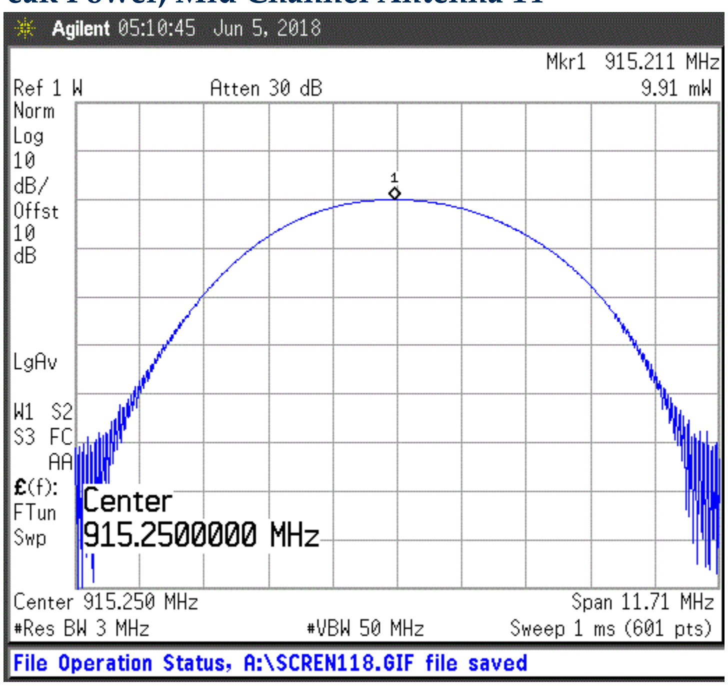


Figure 32: RF Peak Power, High Channel Antenna 1

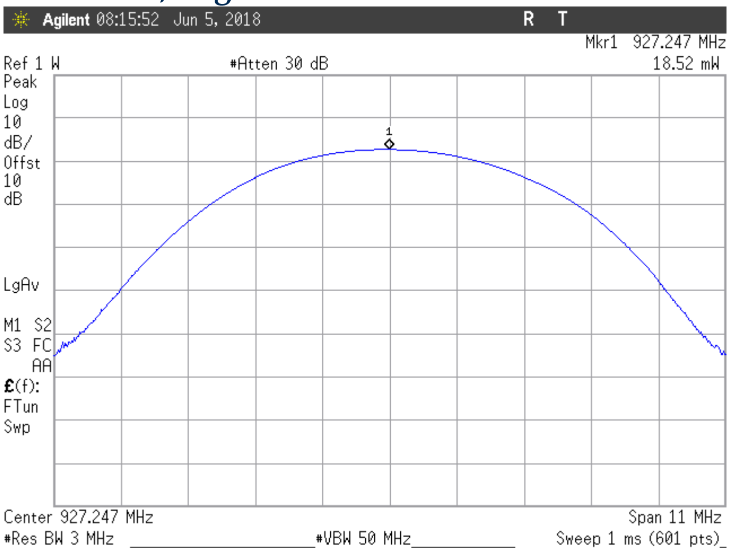


Figure 33: RF Peak Power, High Channel Antenna 2

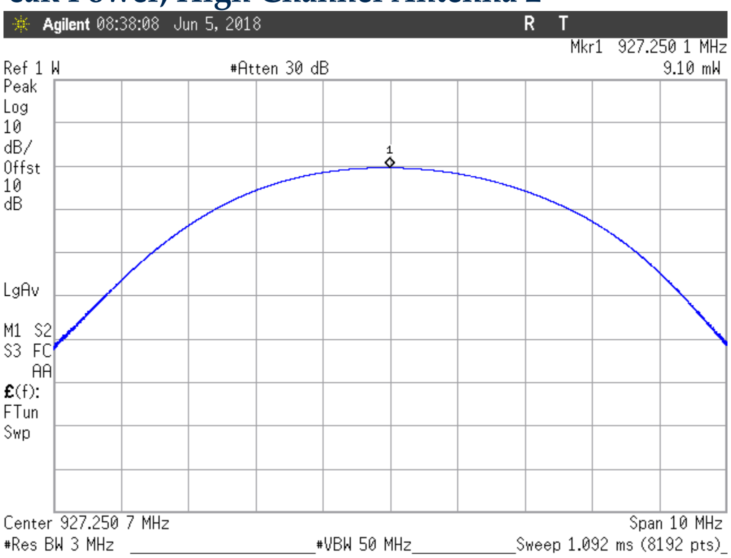


Figure 34: RF Peak Power, High Channel Antenna 3

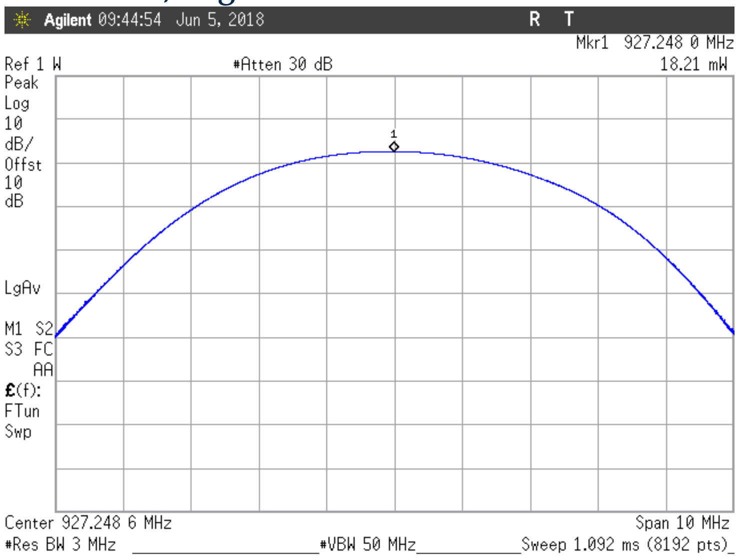


Figure 35: RF Peak Power, High Channel Antenna 4

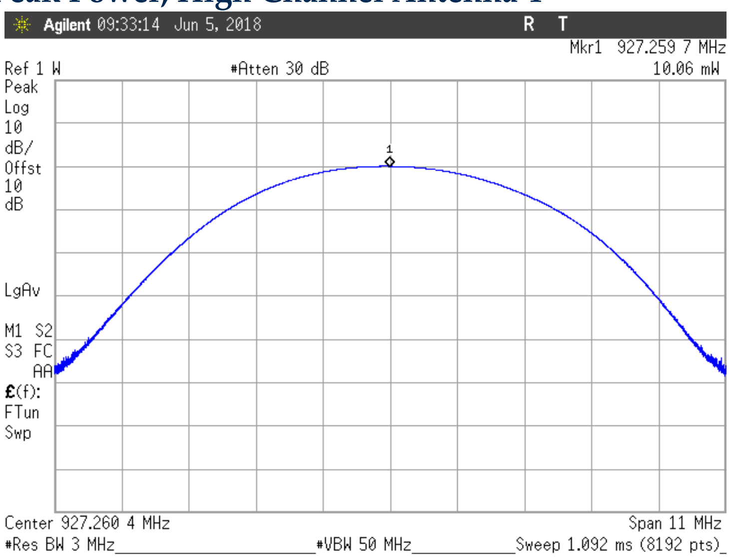


Figure 36: RF Peak Power, High Channel Antenna 5

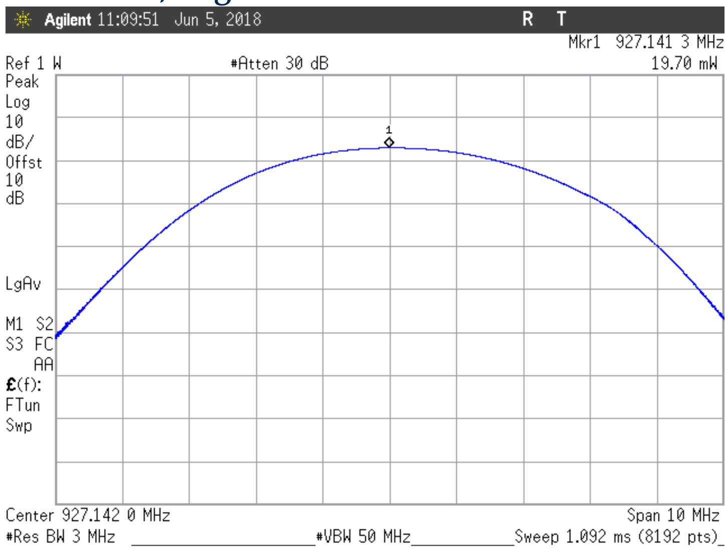


Figure 37: RF Peak Power, High Channel Antenna 6

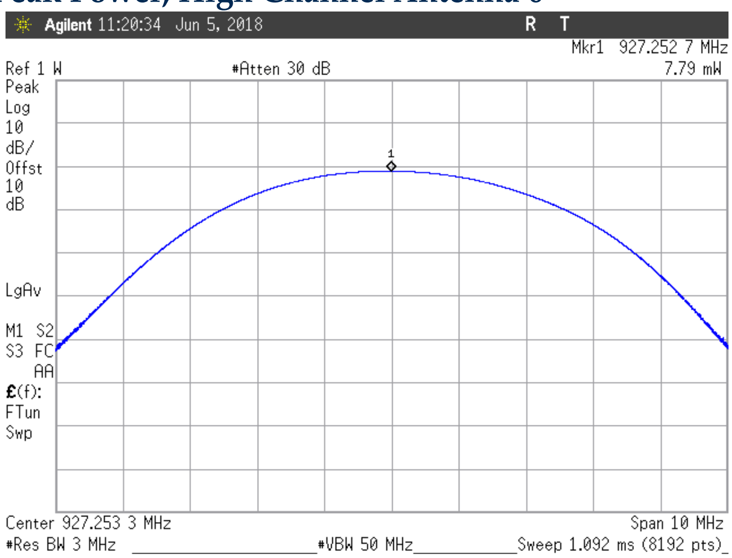


Figure 38: RF Peak Power, High Channel Antenna 7

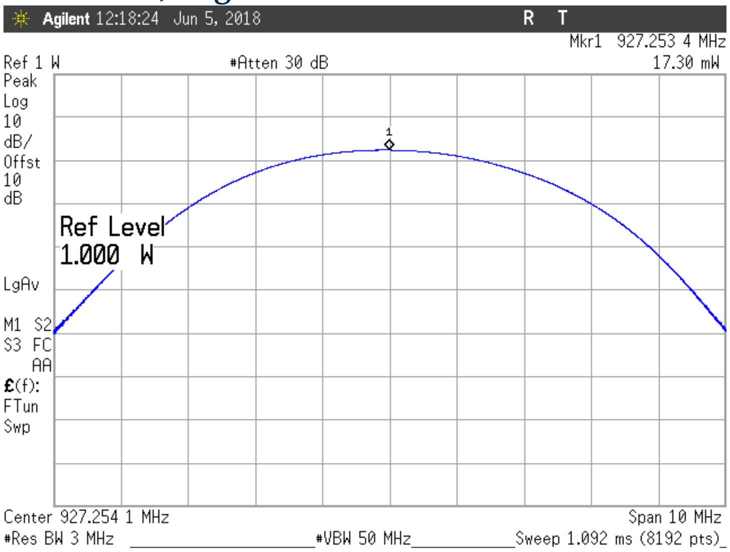


Figure 39: RF Peak Power, High Channel Antenna 8

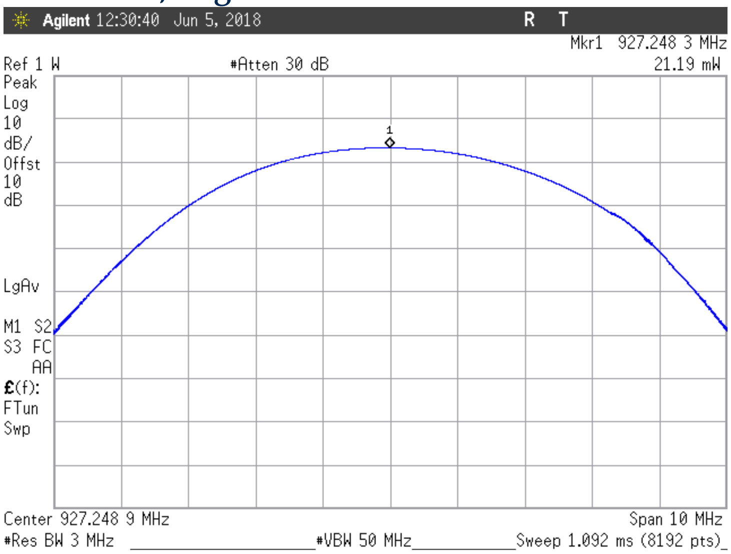


Figure 40: RF Peak Power, High Channel Antenna 9

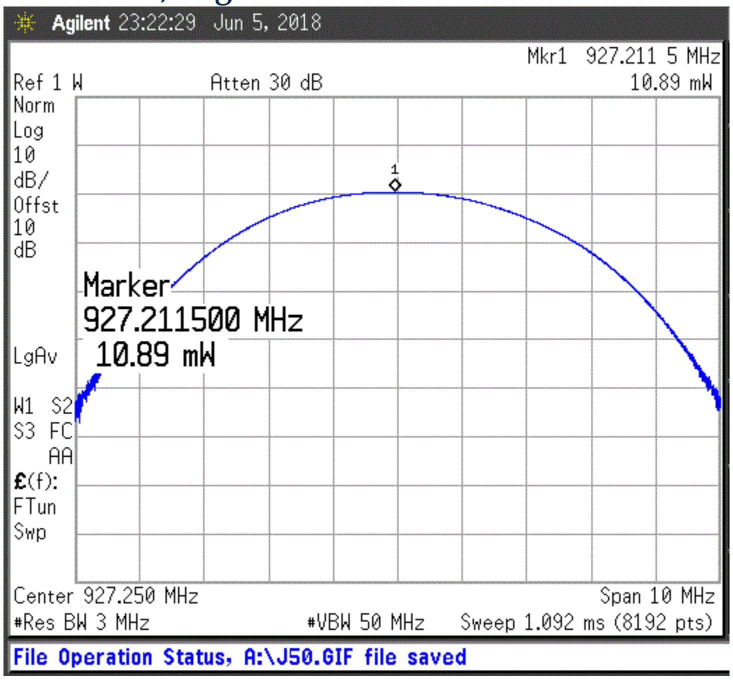


Figure 41: RF Peak Power, High Channel Antenna 10

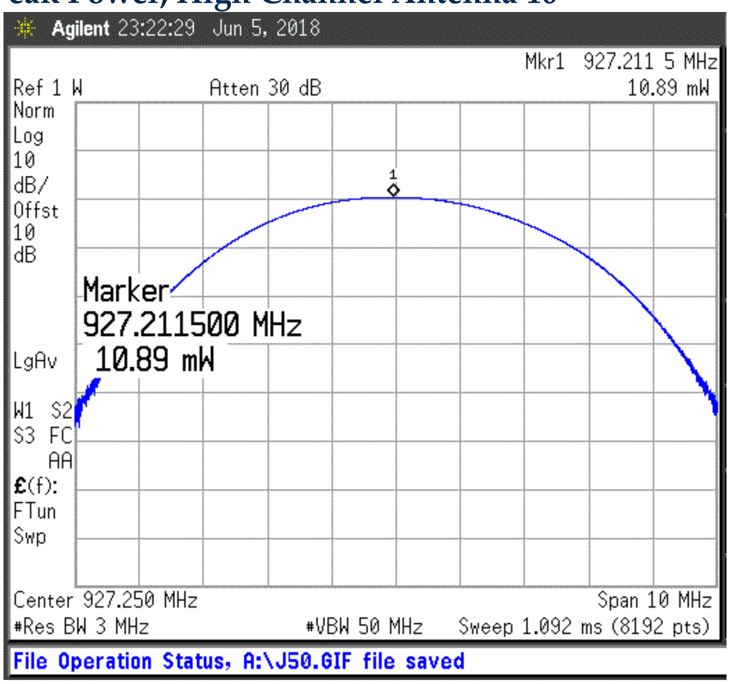


Figure 42: RF Peak Power, High Channel Antenna 11

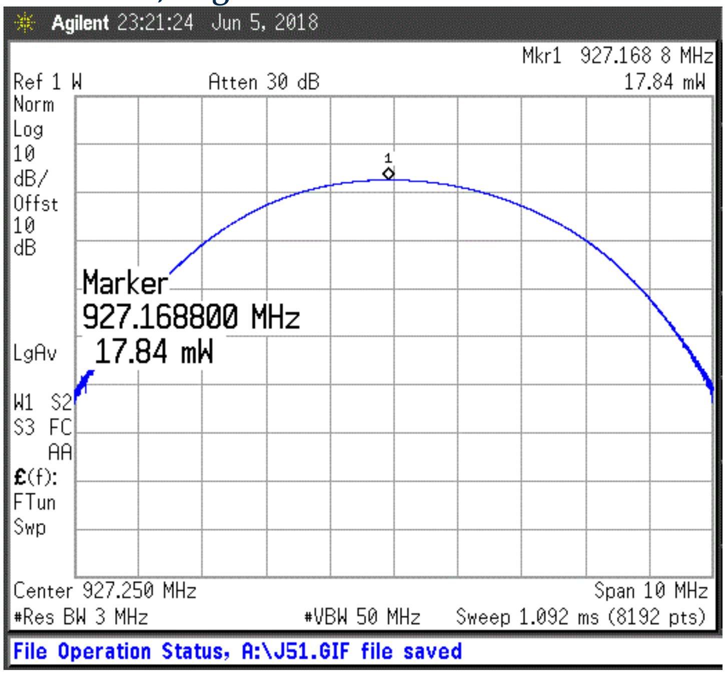


Figure 43: RF Peak Power, High Channel Antenna 12

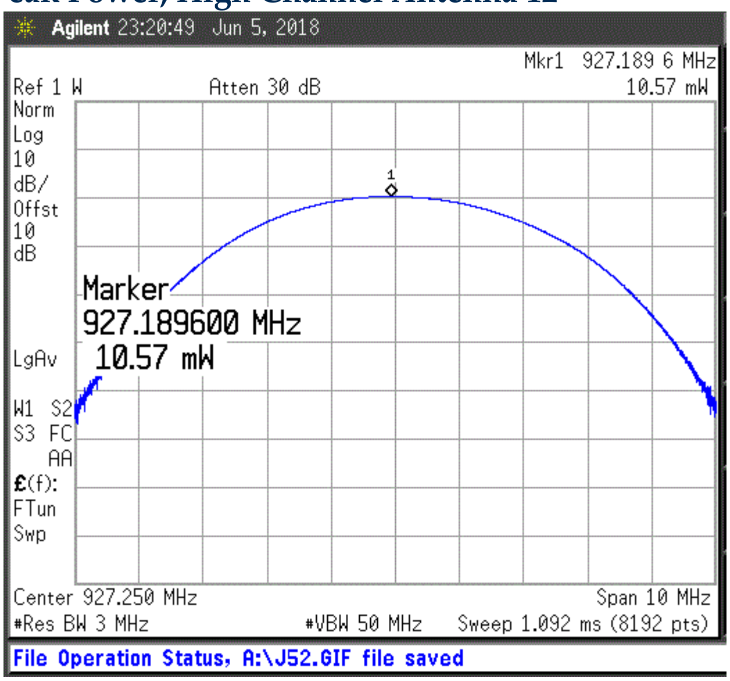


Figure 44: RF Peak Power, High Channel Antenna 13

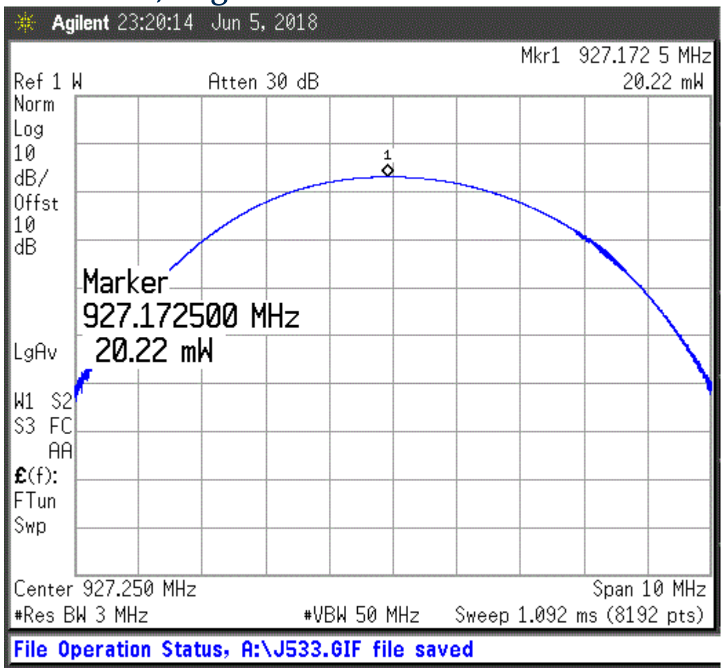
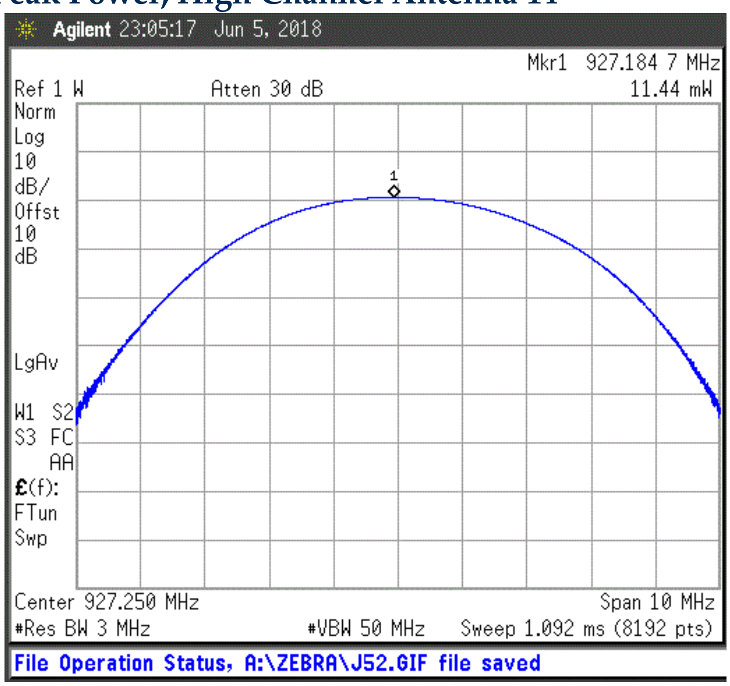


Figure 45: RF Peak Power, High Channel Antenna 14



4.3 Occupied Bandwidth: (FCC Part §15.247 (a)(1) & RSS-247 [5.1a]9)

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 8 provides a summary of the Occupied Bandwidth Results.

Table 8: Occupied Bandwidth Results

Frequency	Bandwidth (kHz)	Limit (kHz)	Pass/Fail
Low Channel: 902.75 MHz	101.04	500	Pass
Mid Channel: 915.25 MHz	103.11	500	Pass
High Channel: 927.25 MHz	102.96	500	Pass

Figure 46: Occupied Bandwidth, Low Channel

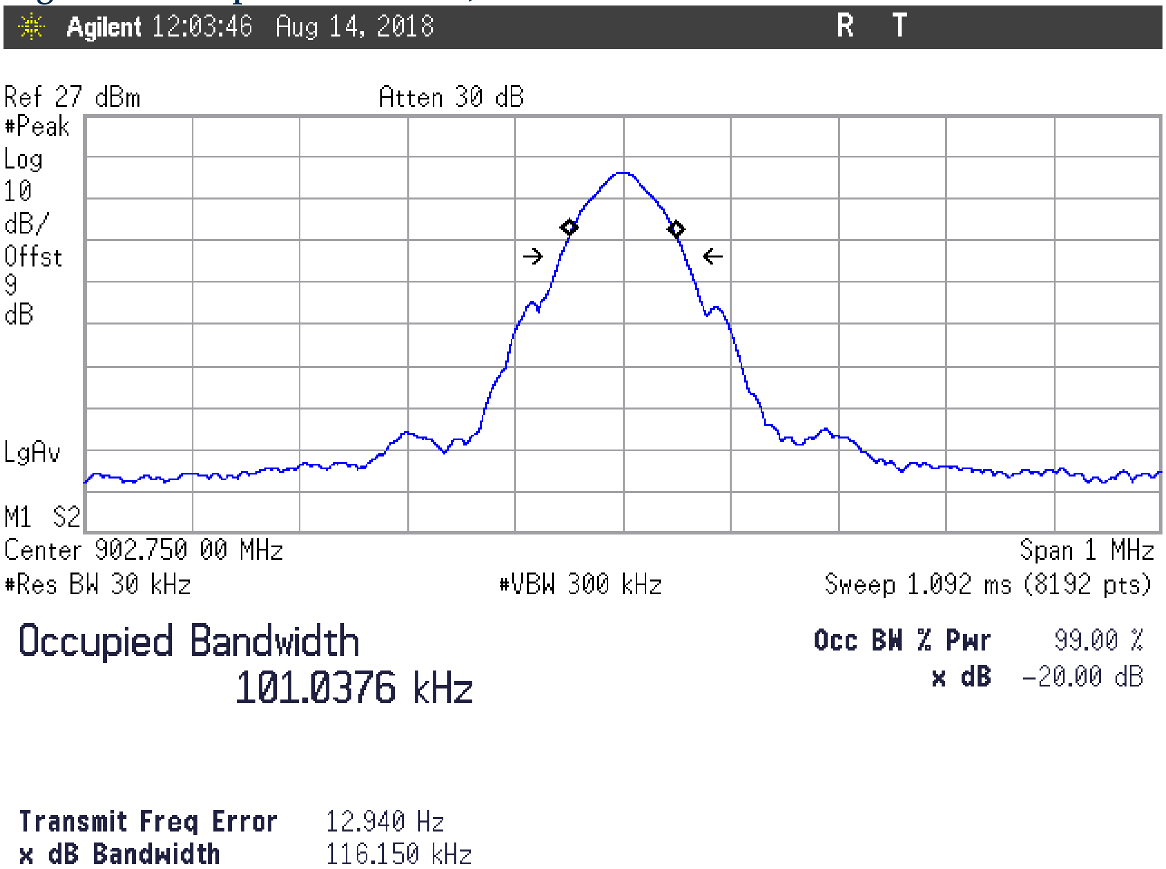


Figure 47: Occupied Bandwidth, Mid Channel

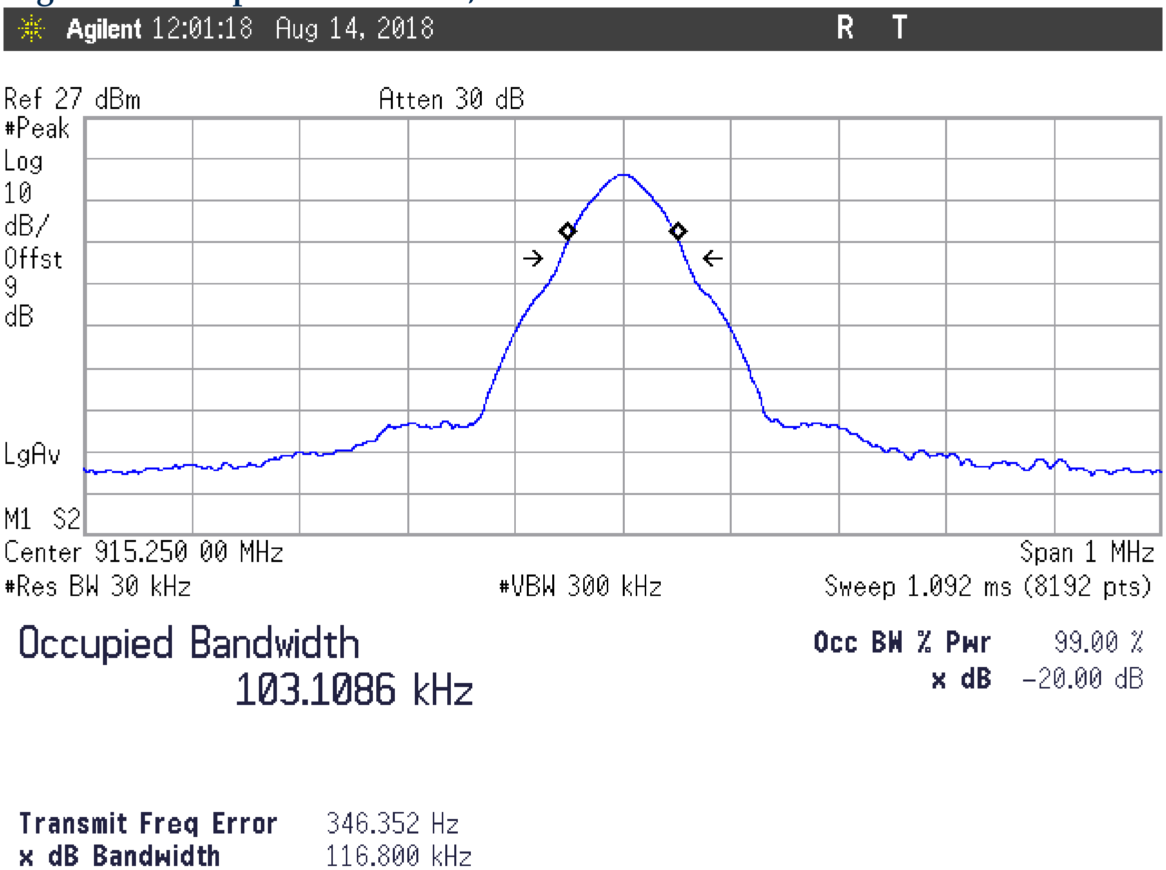
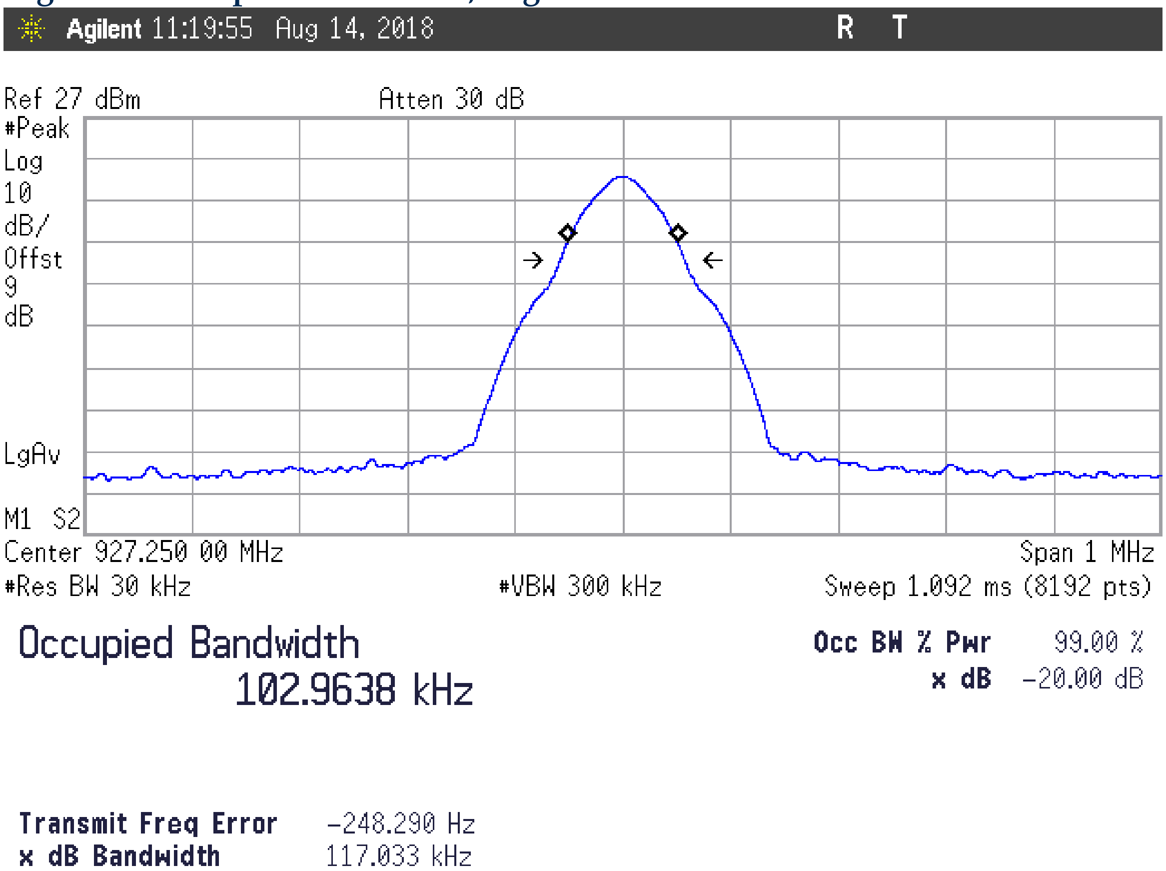


Figure 48: Occupied Bandwidth, High Channel



4.4 Channel Spacing & Number of Channels (15.247 (a)(1) &RSS-247 [5.4d]

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 103.11 kHz so the channel spacing must be more than 105 kHz. In addition, for a 2.4GHz transmitter the number of hopping channels shall be stated.

The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. 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 496.86 kHz and the number of channels used is 50.

Table 9: Channel Spacing and Number of Channels Results

Frequency	Result	Limit	Pass/Fail
Channel Spacing	496.86 kHz	105 kHz Minimum	Pass
Number of channels	50 channels	25 Channels Minimum	Pass

Figure 49: Channel Spacing

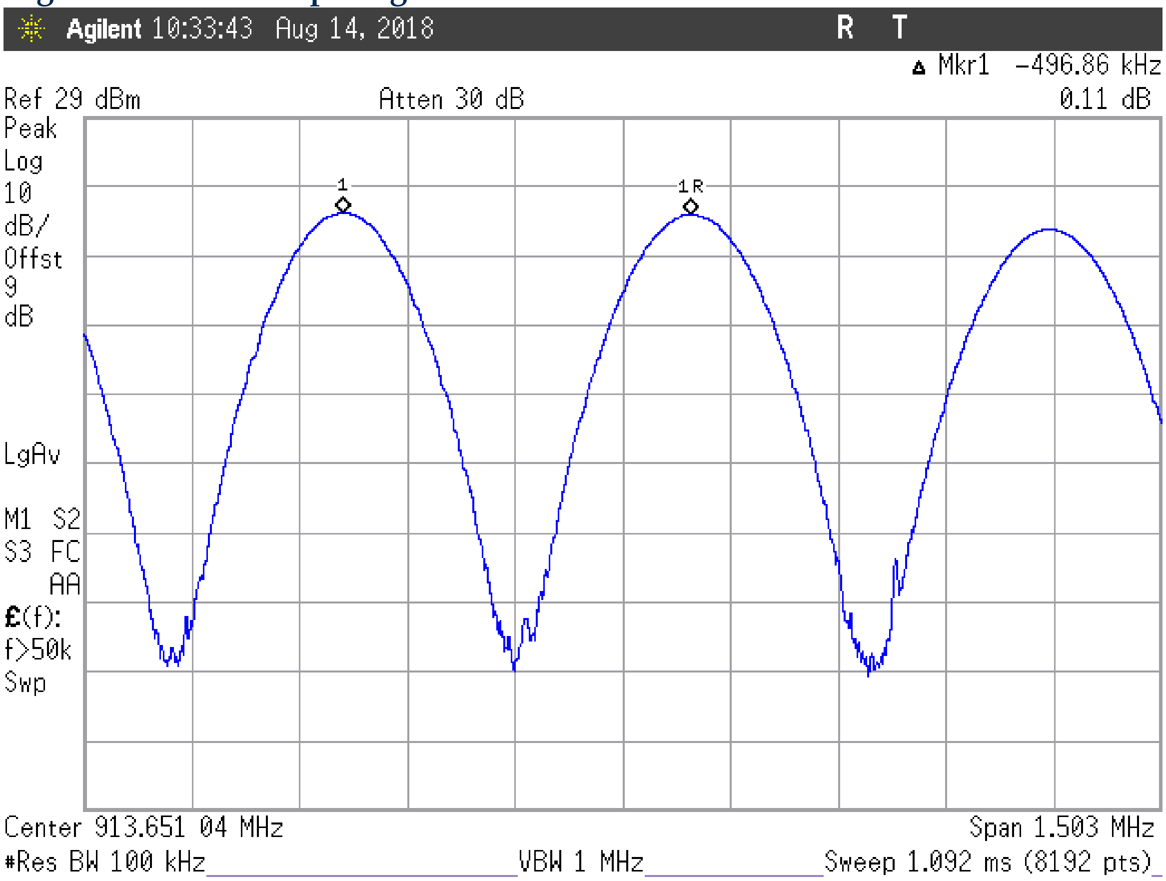
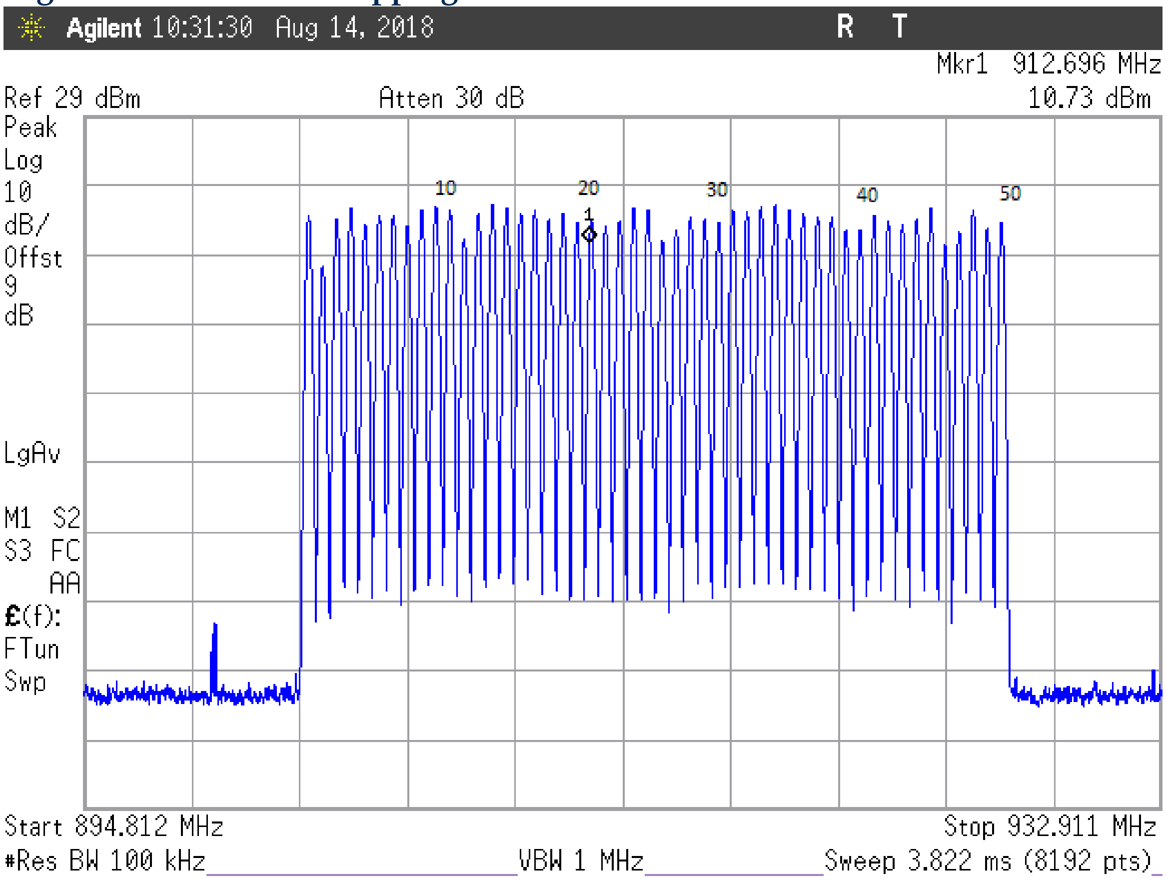


Figure 50: Number of Hopping Channels



4.5 CONDUCTED SPURIOUS EMISSIONS AT ANTENNA TERMINALS

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 10dB 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 worst case conducted spurious emissions data.

Figure 51: Conducted Spurious Emissions, High Power, Low Channel 30 - 902MHz

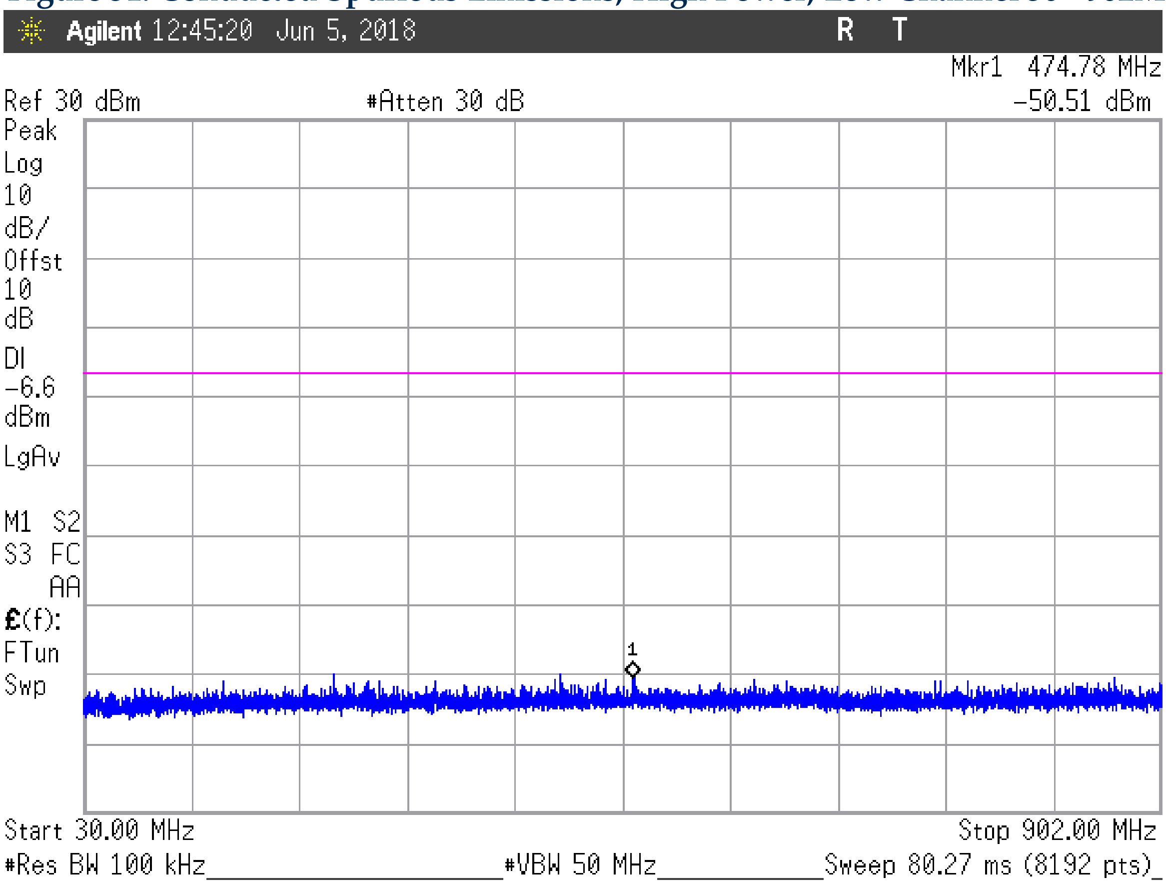


Figure 52: Conducted Spurious Emissions, High Power, Low Channel 902 – 930MHz

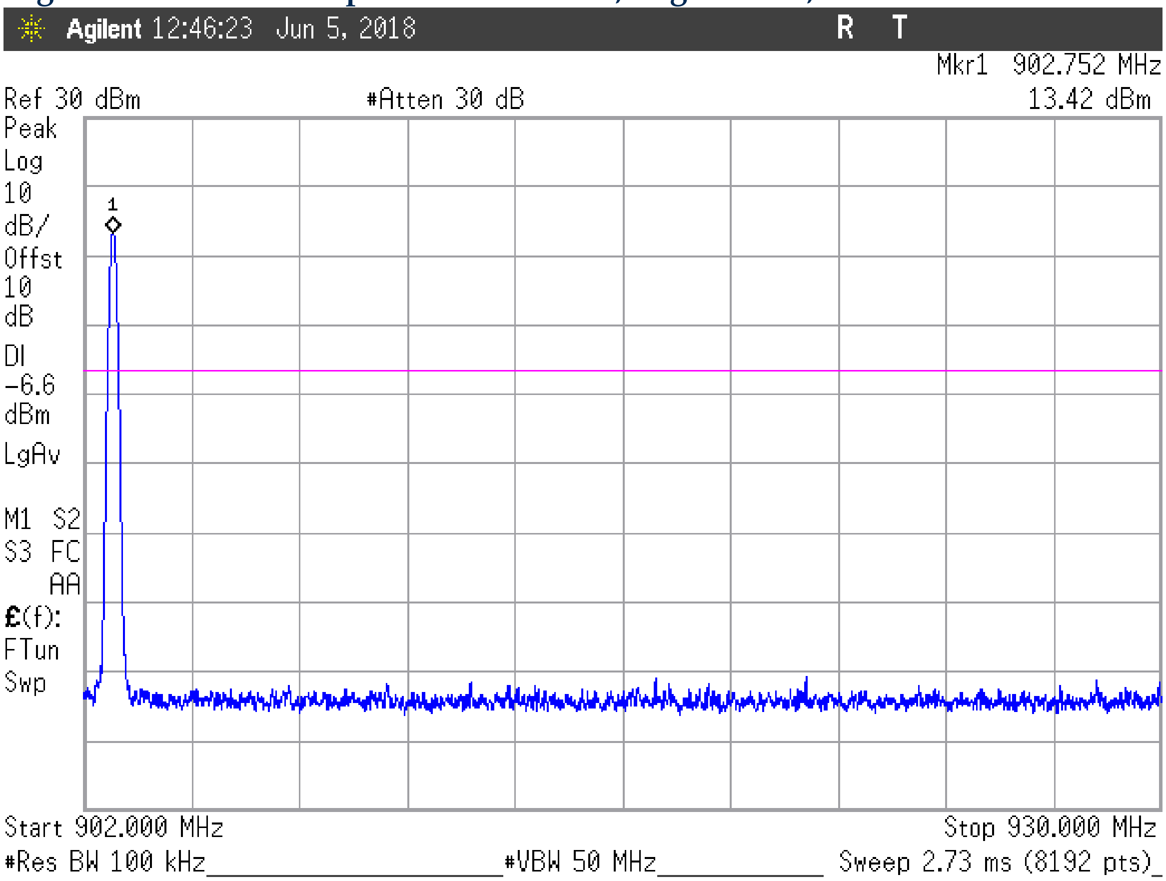


Figure 53: Conducted Spurious Emissions, High Power, Low Channel 930 – 1000MHz

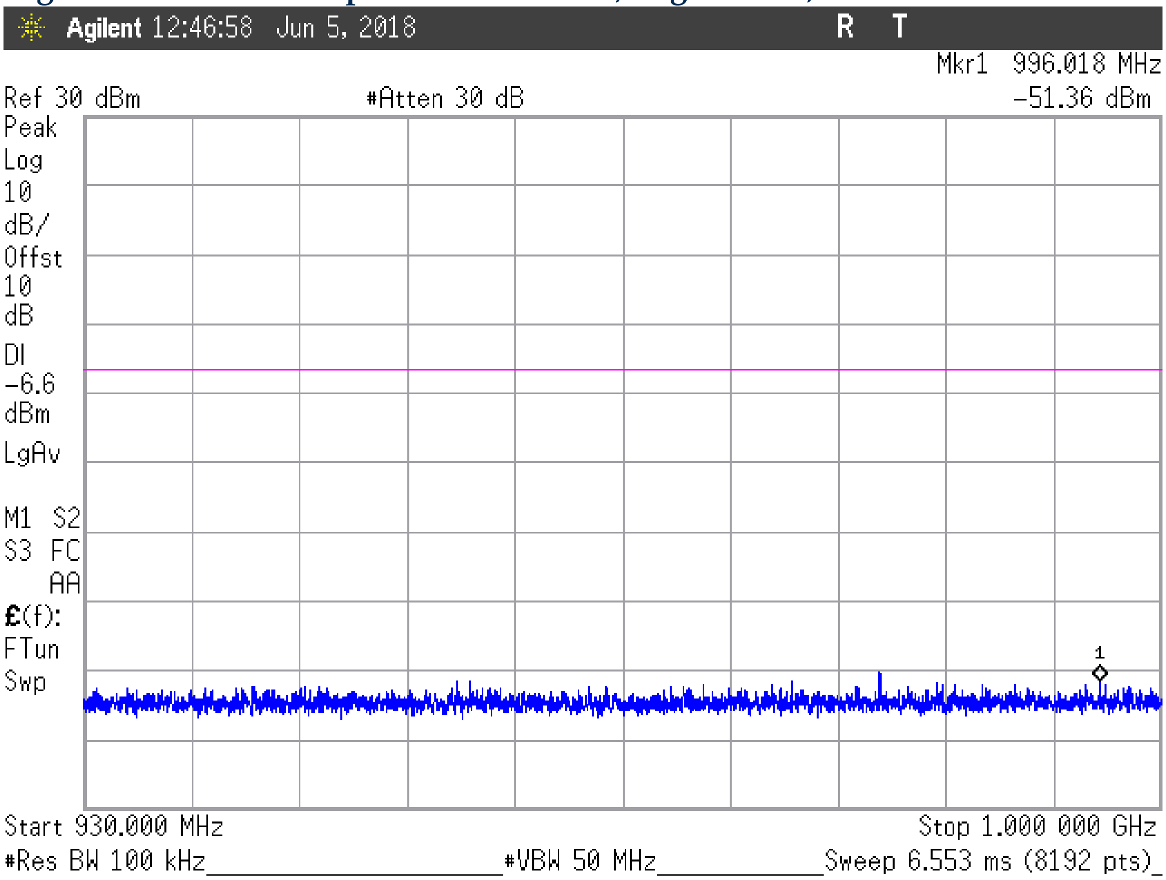


Figure 54: Conducted Spurious Emissions, High Power, Low Channel 1 – 5GHz

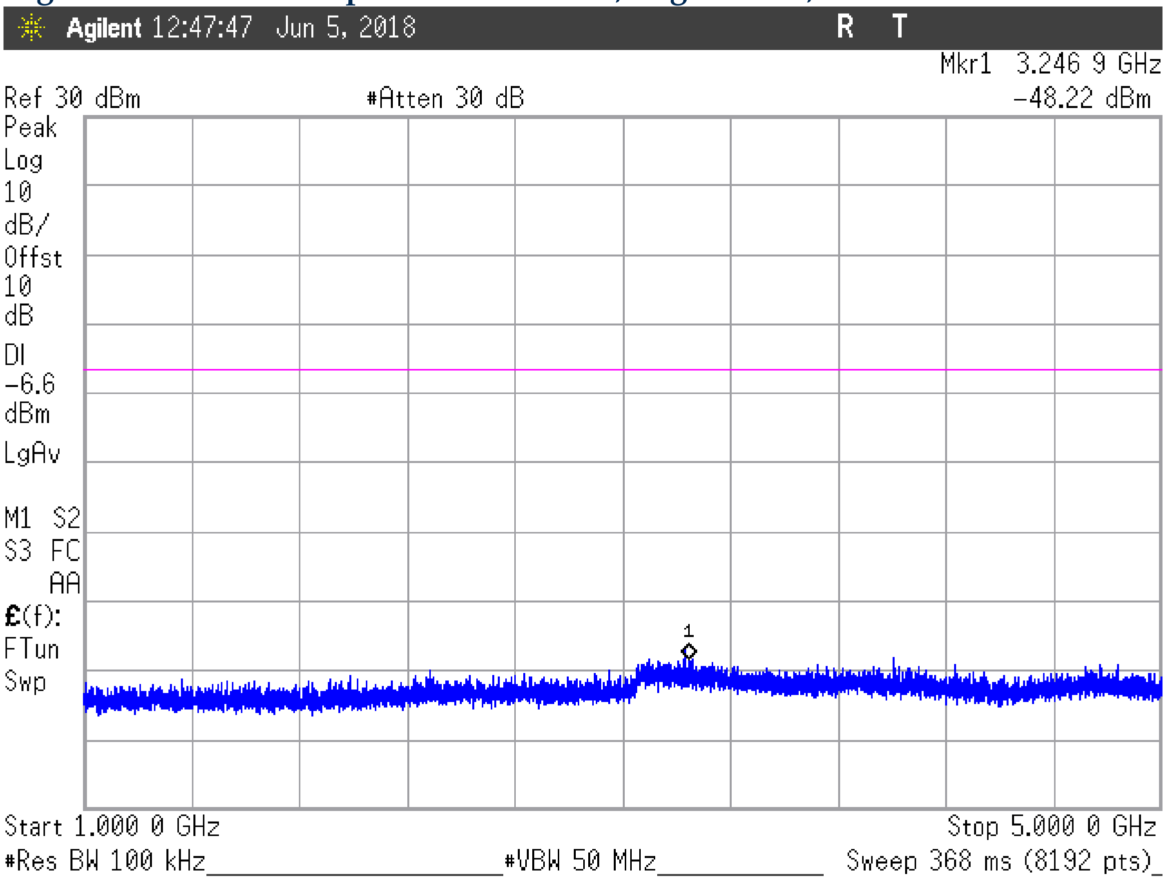


Figure 55: Conducted Spurious Emissions, High Power, Low Channel 5 – 10GHz

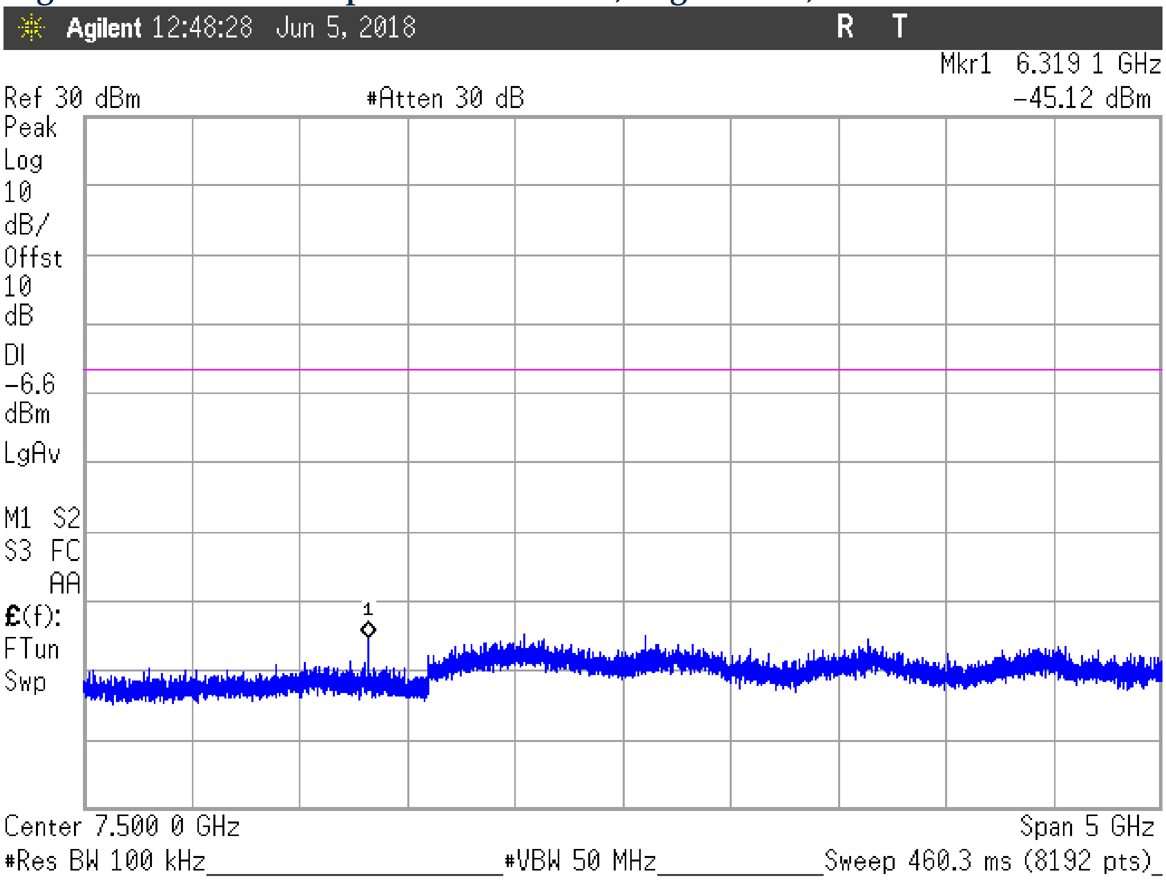


Figure 56: Conducted Spurious Emissions, High Power, Center Channel 30 - 902MHz

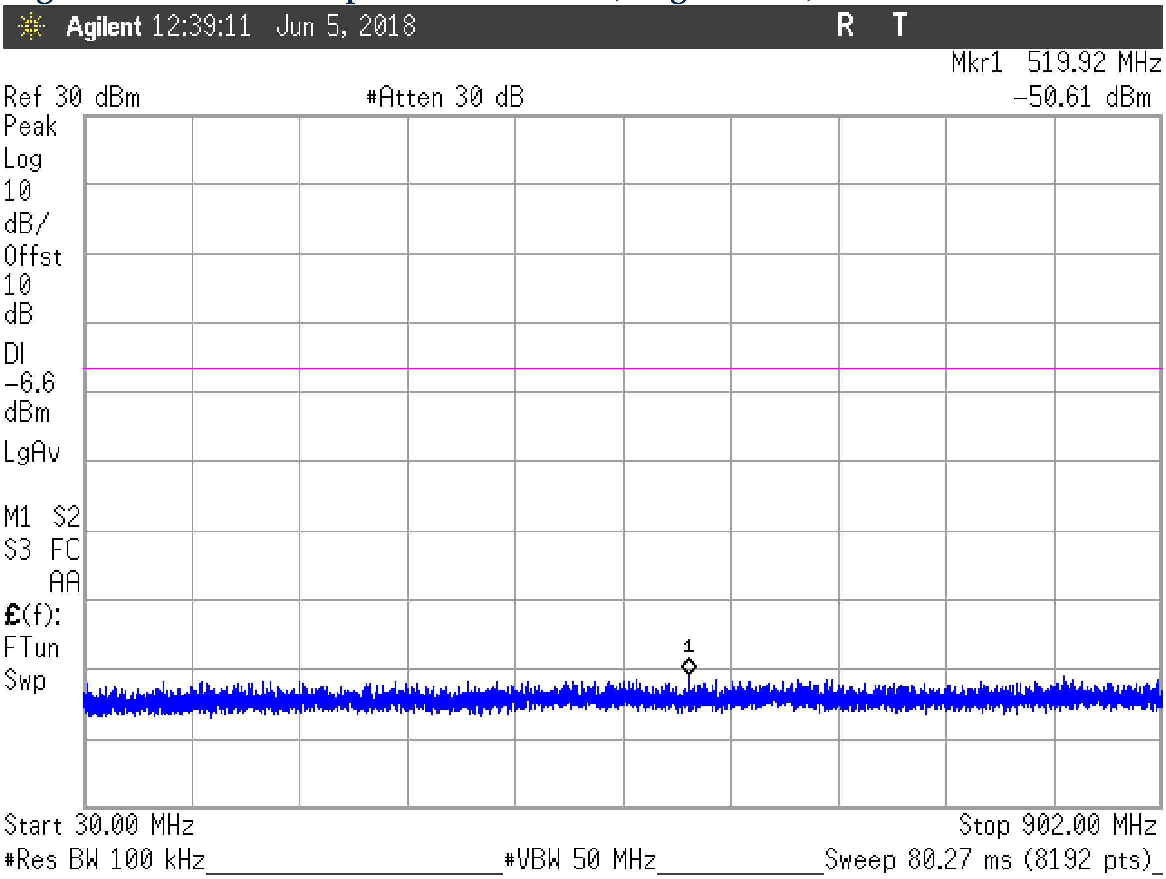


Figure 57: Conducted Spurious Emissions, High Power, Center Channel 902 – 930MHz

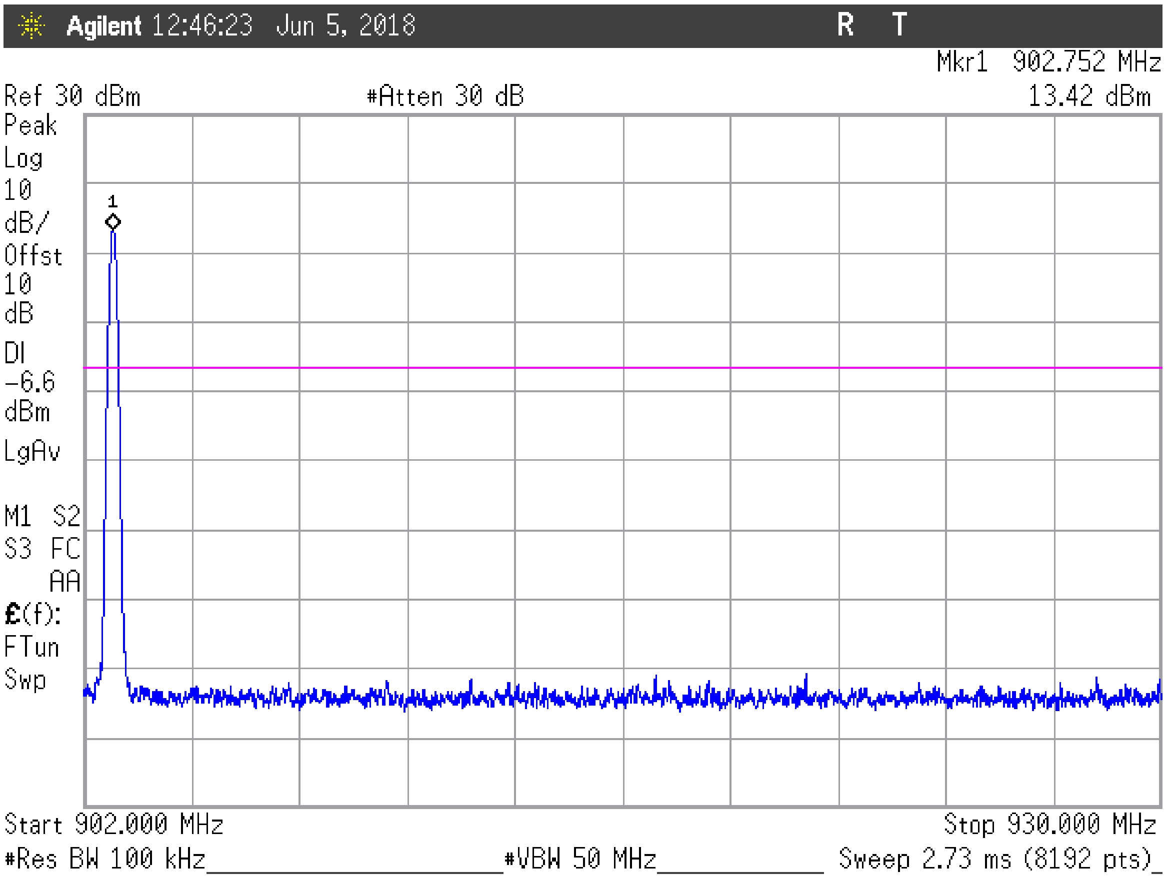


Figure 58: Conducted Spurious Emissions, High Power, Center Channel 930 – 1000MHz

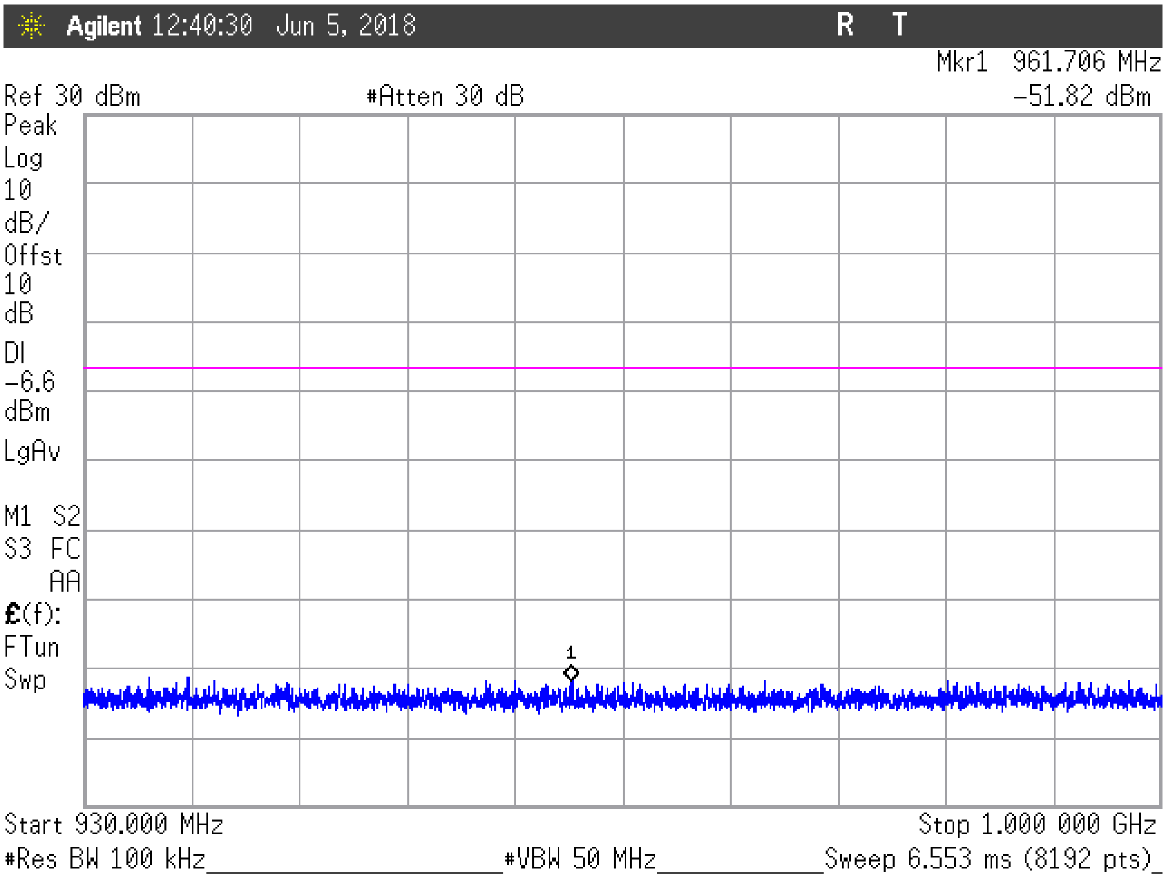


Figure 59: Conducted Spurious Emissions, High Power, Center Channel 1 – 5GHz

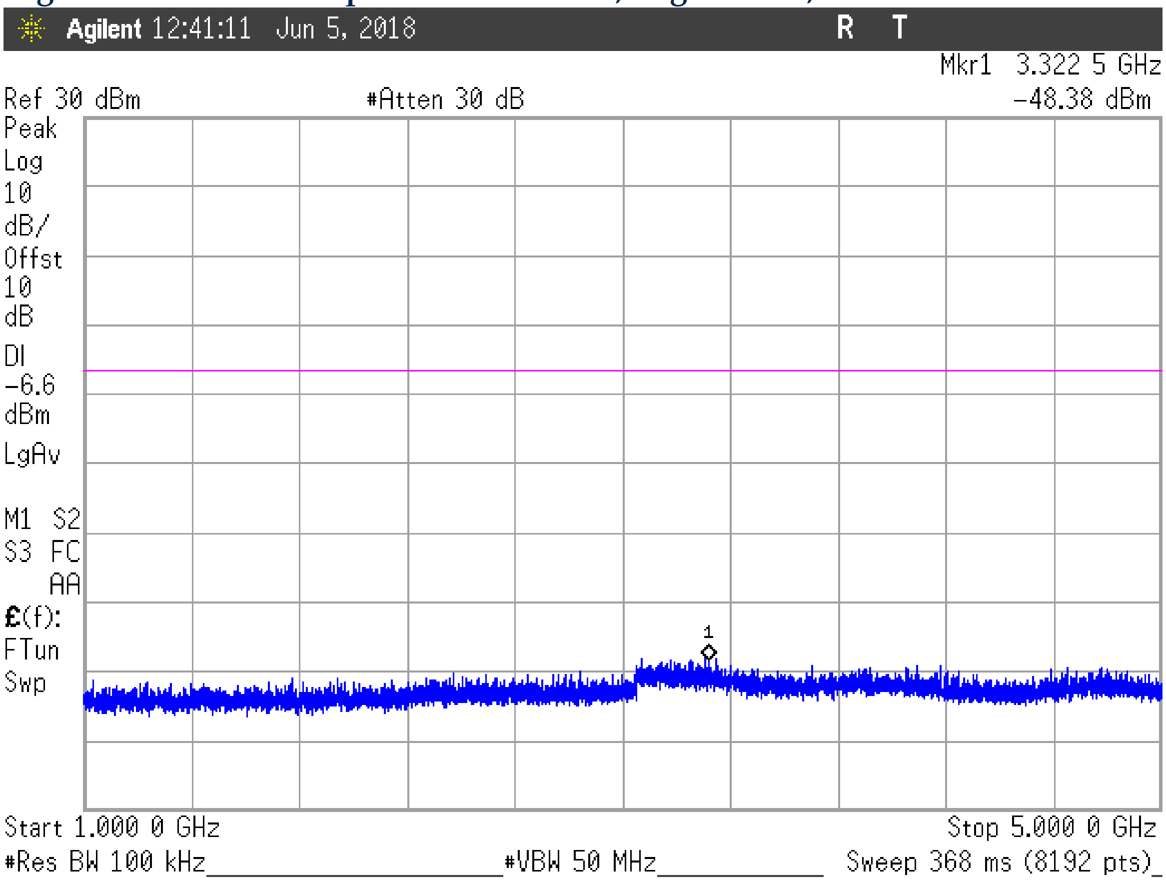


Figure 60: Conducted Spurious Emissions, High Power, Mid Channel 5 – 10GHz

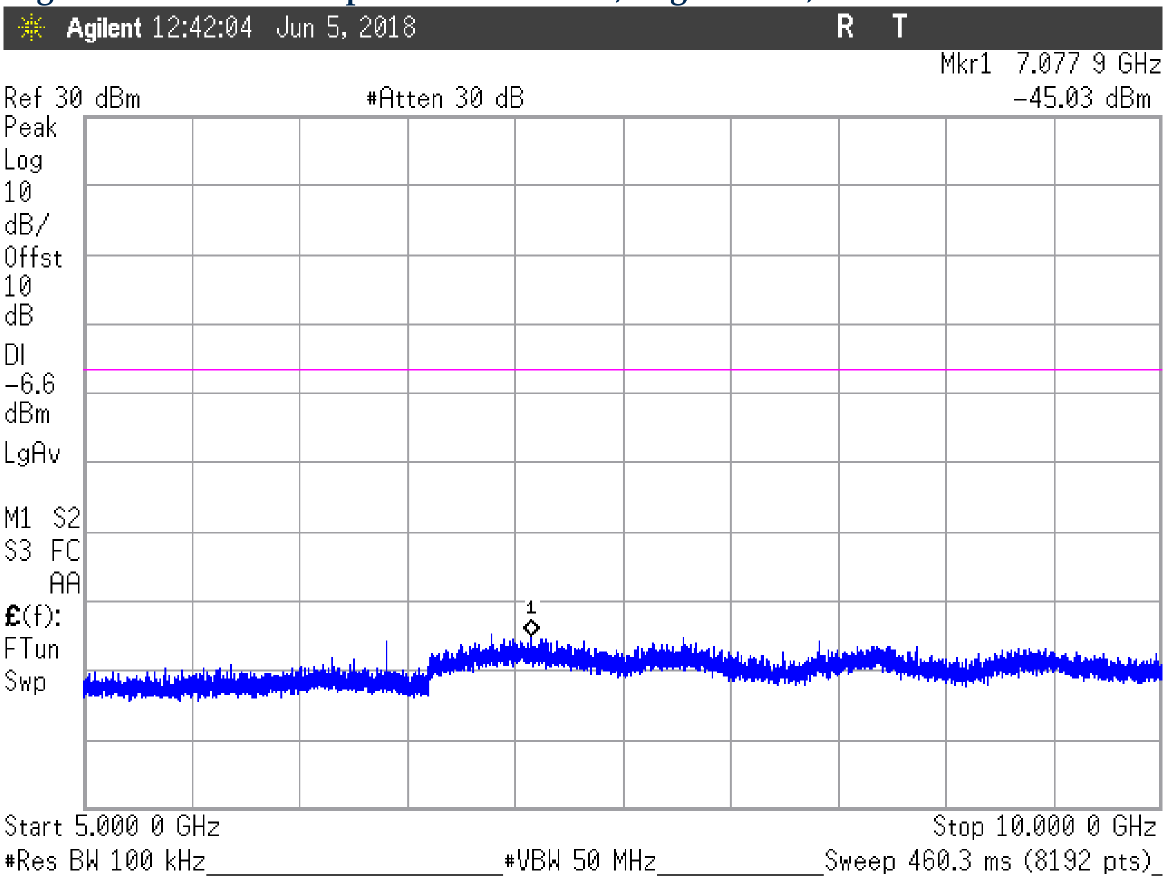


Figure 61: Conducted Spurious Emissions, High Power, High Channel 30 - 902MHz

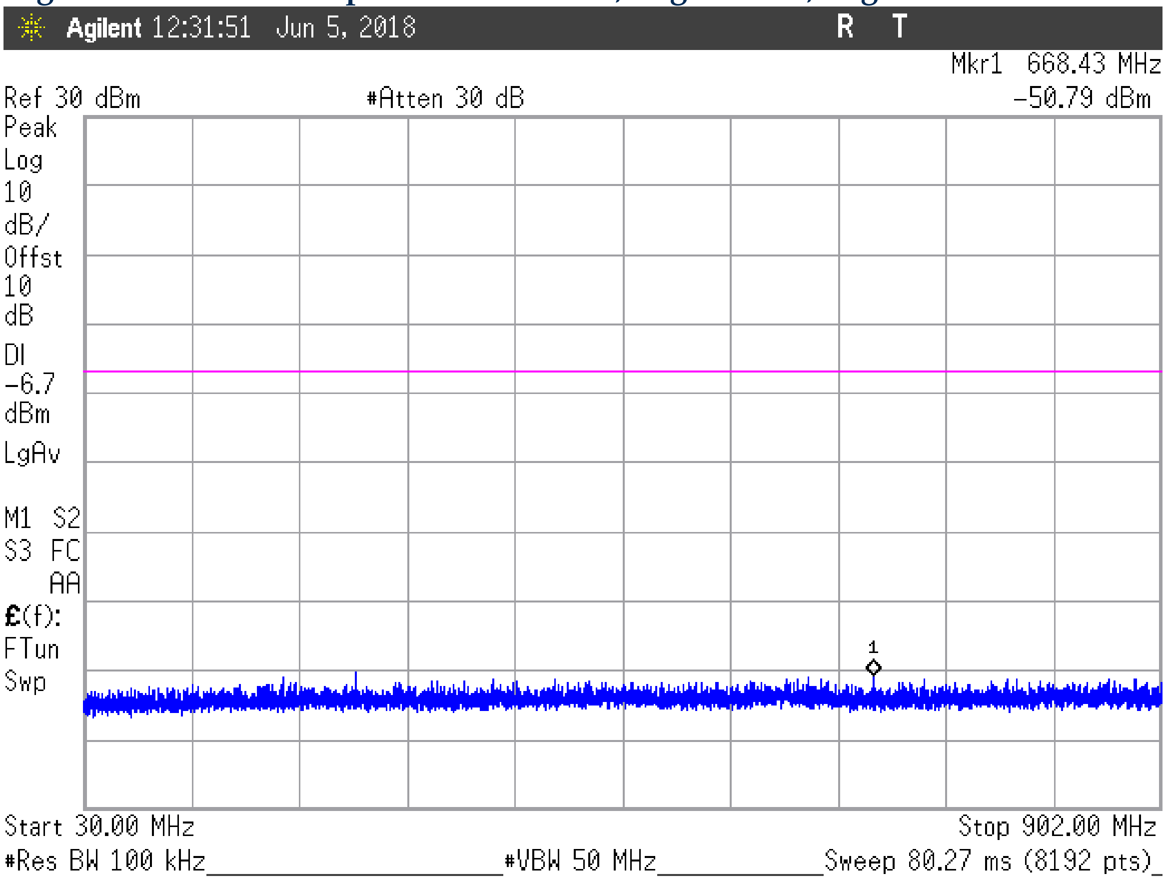


Figure 62: Conducted Spurious Emissions, High Power, High Channel 902 – 930MHz

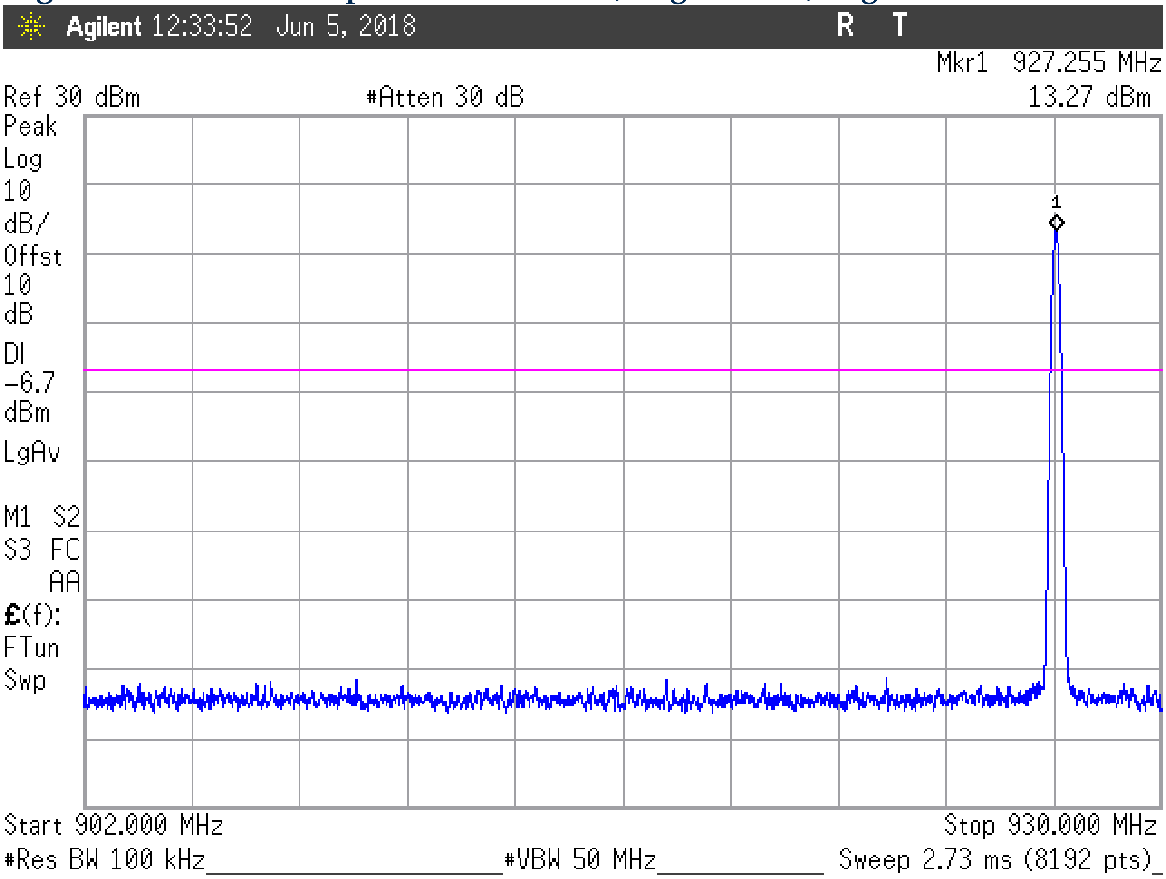


Figure 63: Conducted Spurious Emissions, High Power, High Channel 930 – 1000MHz

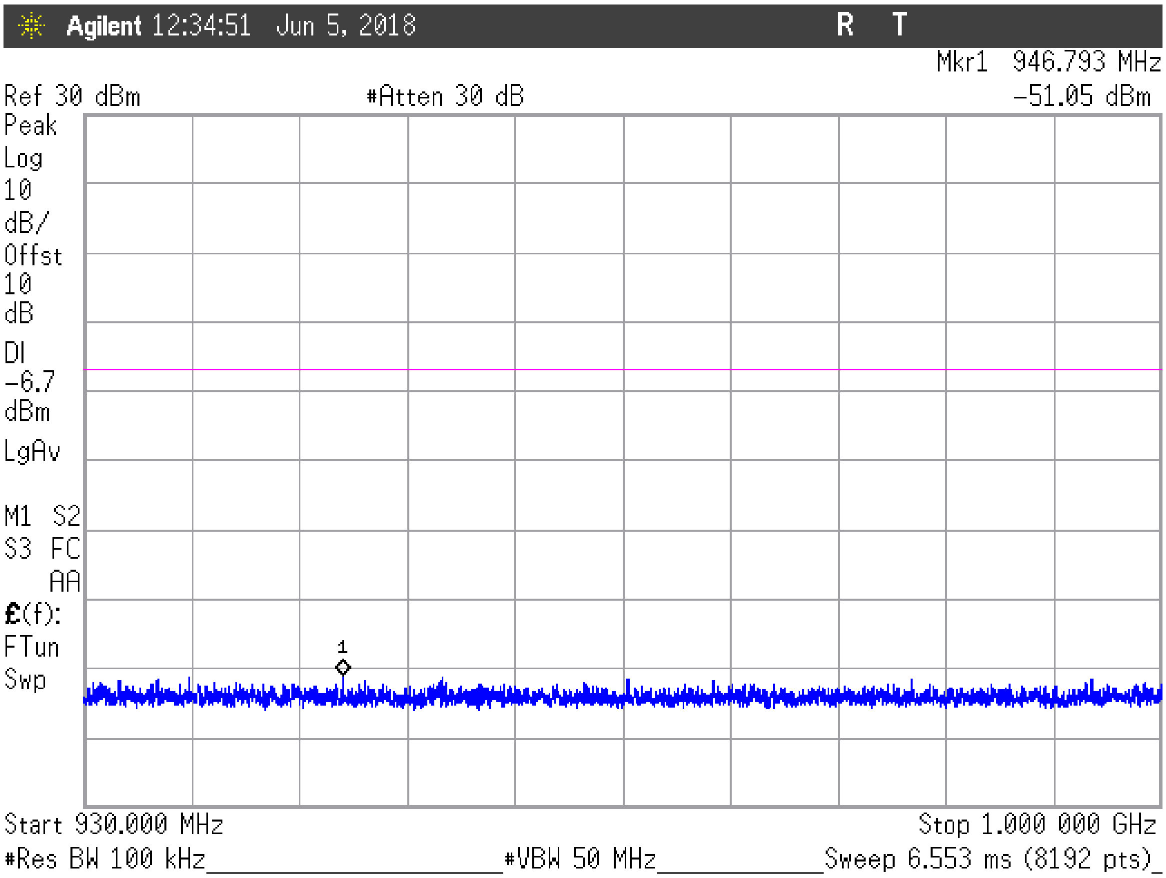


Figure 64: Conducted Spurious Emissions, High Power, High Channel 1 – 5GHz

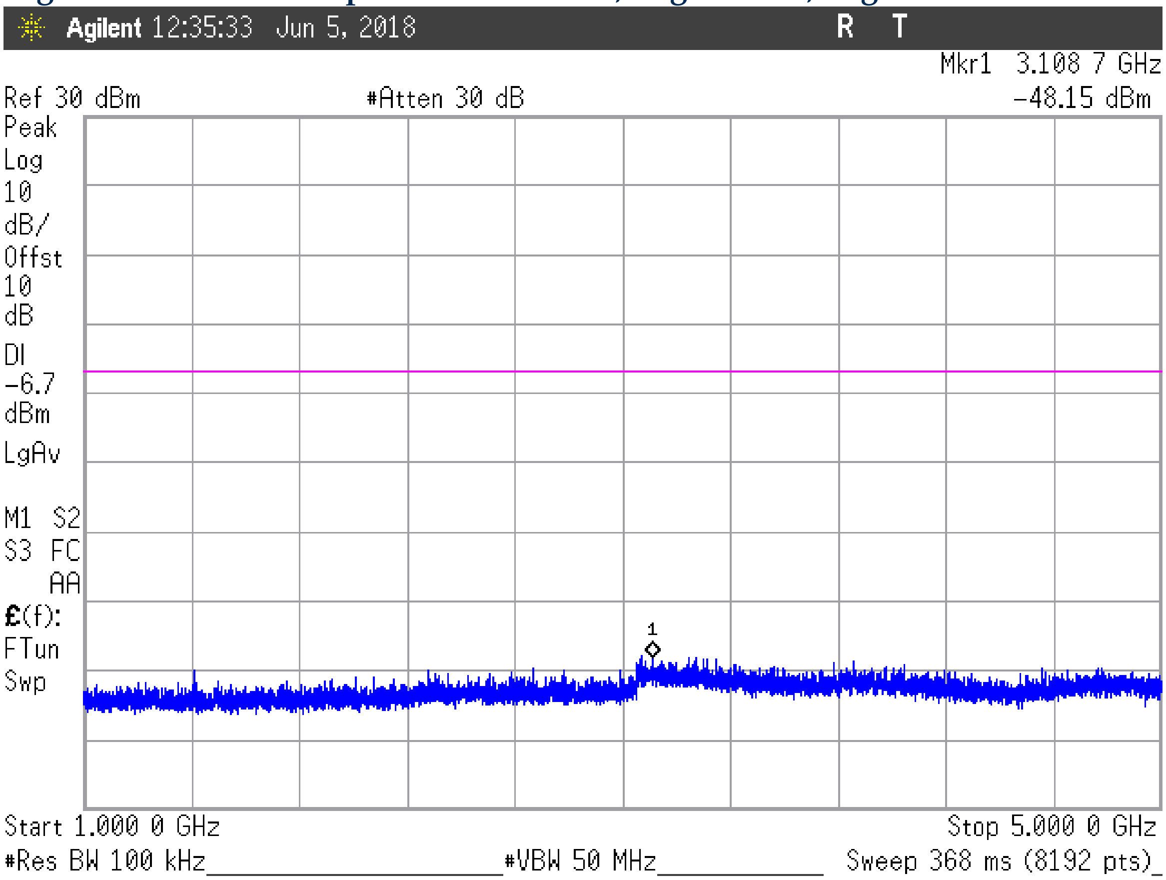
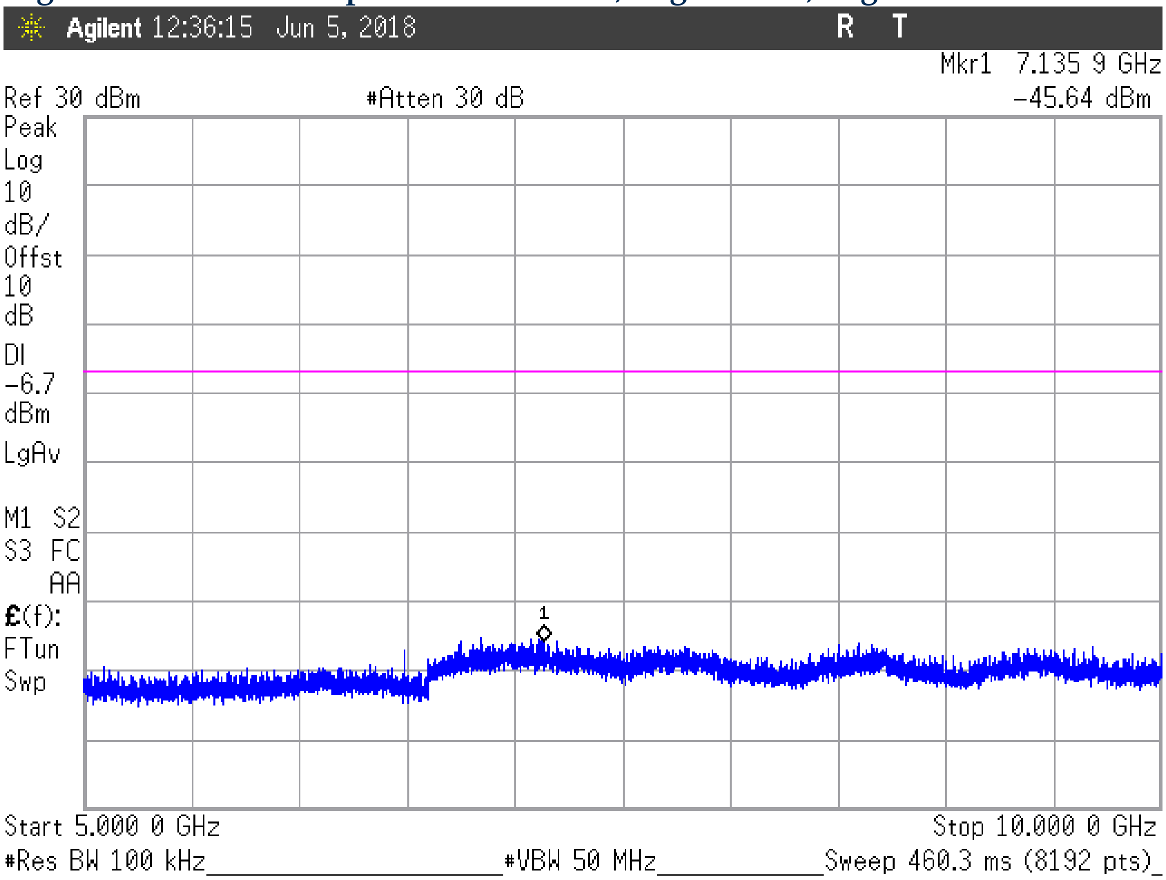


Figure 65: Conducted Spurious Emissions, High Power, High Channel 5 – 10GHz



4.6 Band Edge Compliance (15.247 (d) and RSS-247 [5.5])

In accordance with 15.247 (d) and RSS-247 [5.5] and with measurement guidance from C63.10 Section 6.10.4 devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned off and then repeated with the hopping function turned on. The purpose of the test with the hopping function turned on is to confirm that the RF power remains off while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back on. 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.

Figure 66: Lower Band-edge, Hopping Mode

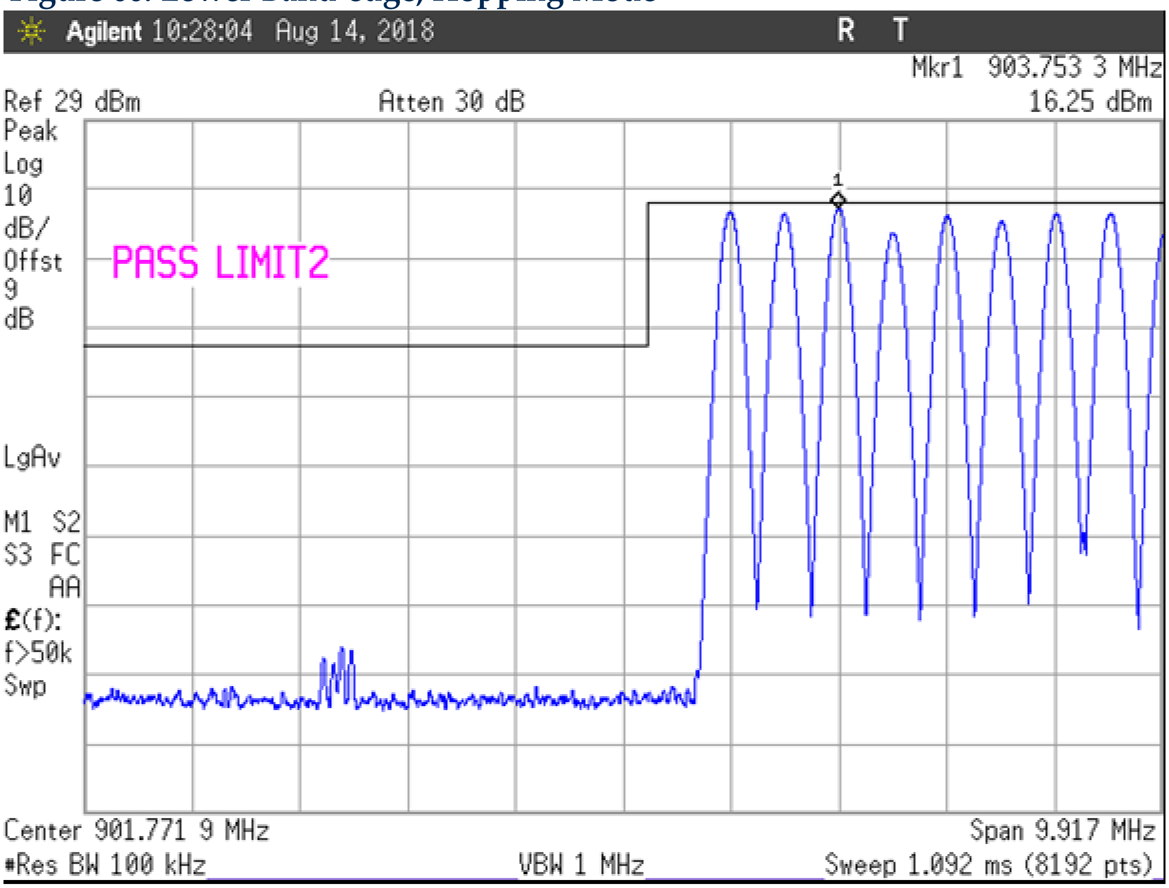


Figure 67: Upper Band-edge, Hopping Mode

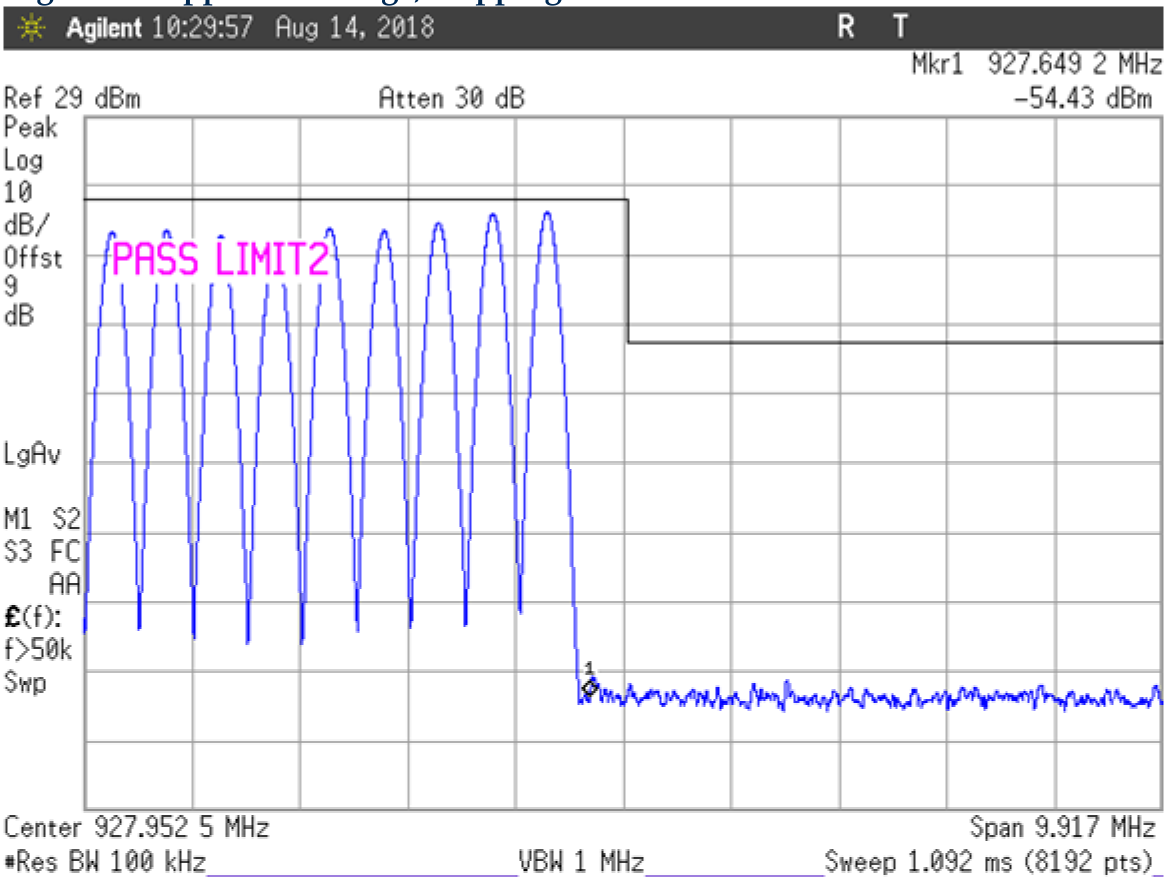


Figure 68: Low Channel, Lower Band-edge

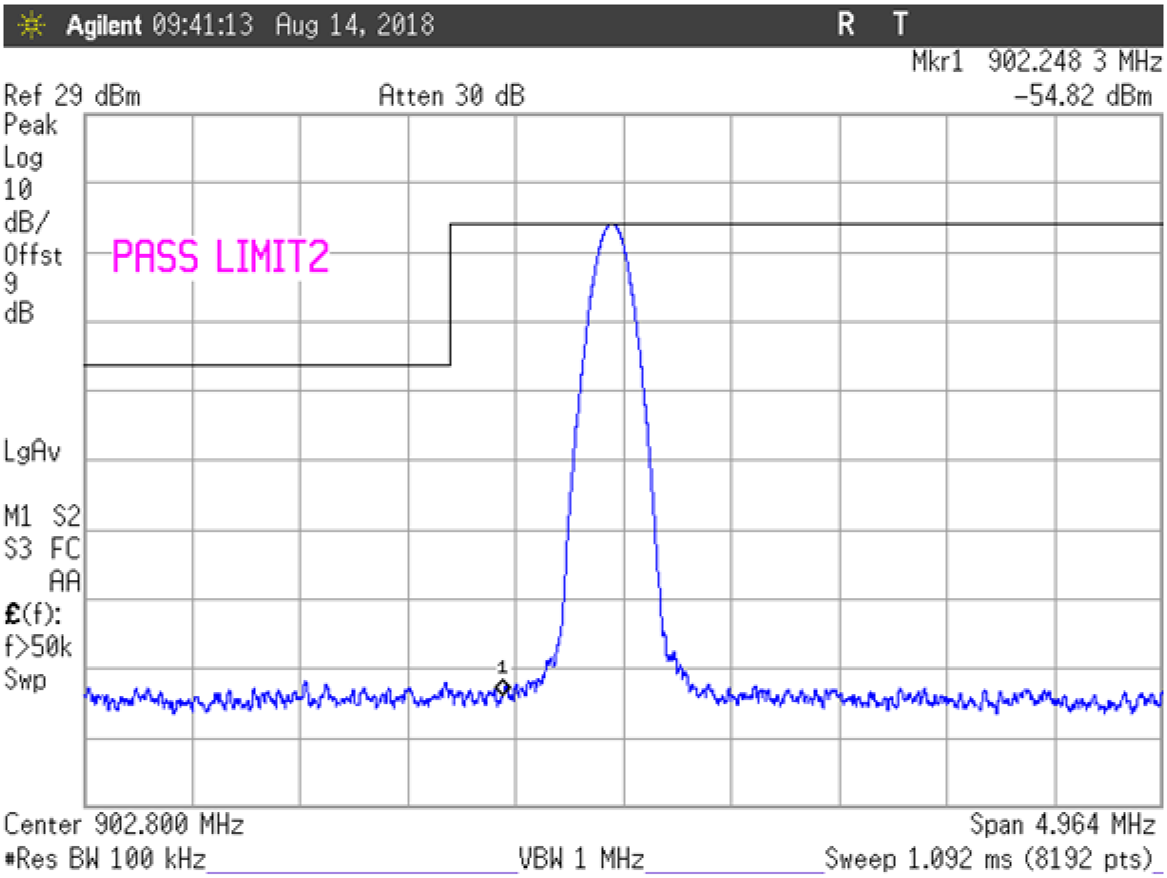
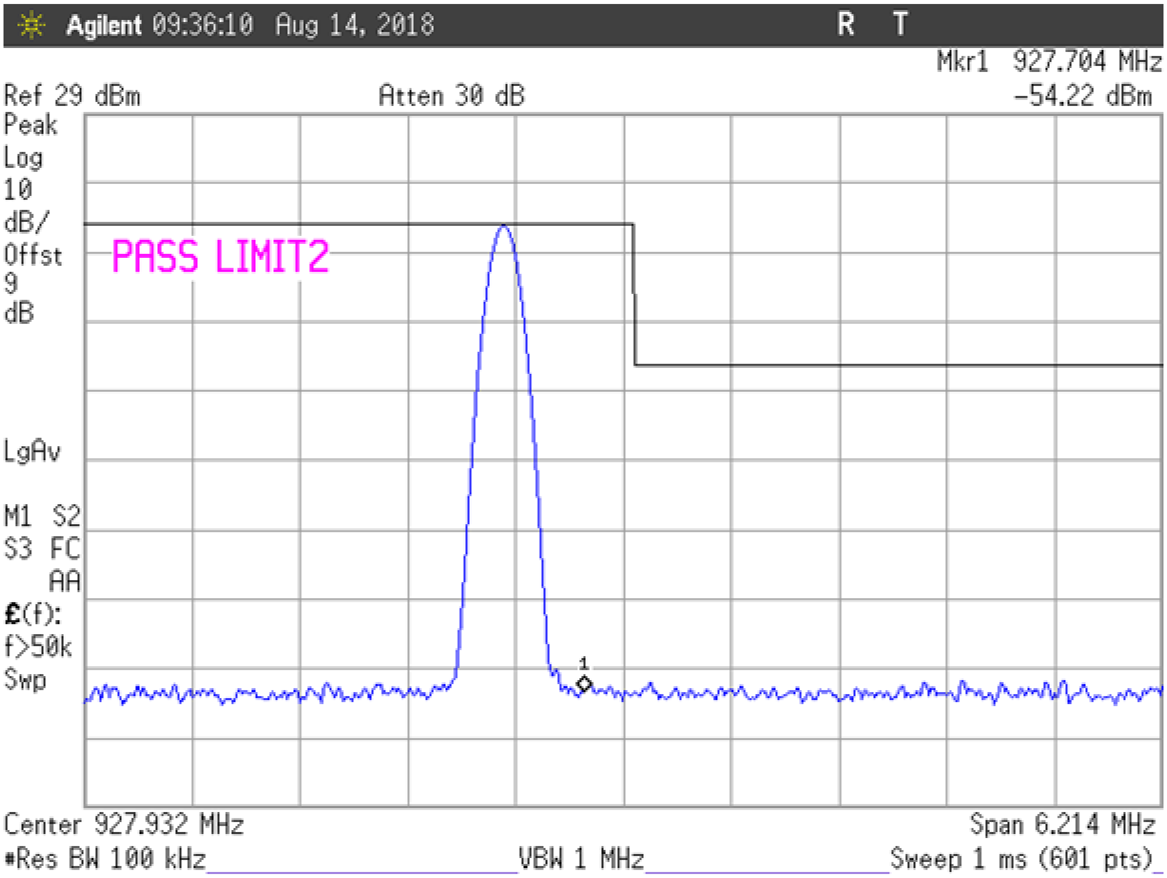


Figure 69: High Channel, Upper Band-edge



4.7 Radiated Spurious Emissions: (§15.247(D) & RSS-GEN SEC. 8.9 & 8.10)

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.

4.7.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2014. 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 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, Low Frequency Data (<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)
85.80		0.00	1.00	39.44	-17.6	12.3	100.0	-18.2
228.85	V	180.00	1.00	41.76	-13.6	25.5	200.0	-17.9
238.38	V	180.00	1.00	42.12	-13.3	27.5	200.0	-17.2
286.05	V	0.00	1.00	38.58	-11.3	23.2	200.0	-18.7
324.21	V	315.00	1.00	36.76	-10.7	20.1	200.0	-20.0
352.80	V	0.00	1.00	35.66	-10.0	19.3	200.0	-20.3
83.55	H	0.00	4.00	35.69	-17.6	8.0	100.0	-21.9
240.05	H	0.00	4.00	39.67	-13.2	21.0	200.0	-19.6
285.44	H	0.00	4.00	34.50	-11.3	14.5	200.0	-22.8
320.66	H	0.00	4.00	31.69	-10.8	11.1	200.0	-25.1

(Covers all antenna configurations)

Same for all channels

Table 12: Radiated Emission Test Data, High Frequency Data >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)
2708.29	V	0.0	1.0	52.4	-1.3	360.2	500.0	-2.8
2708.29	V	0.0	1.0	60.9	-1.3	963.3	5000.0	-14.3
3610.99	V	0.0	1.0	43.4	1.4	174.3	500.0	-9.2
3610.99	V	0.0	1.0	63.3	1.4	1721.2	5000.0	-9.3
4513.75	V	0.0	1.0	41.8	3.7	189.2	500.0	-8.4
4513.75	V	0.0	1.0	60.1	3.7	1548.7	5000.0	-10.2
2708.29	H	0.0	0.0	51.3	-1.3	317.6	500.0	-3.9
2708.29	H	0.0	0.0	62.1	-1.3	1097.3	5000.0	-13.2
3610.99	H	0.0	0.0	43.4	1.4	173.5	500.0	-9.2
3610.99	H	0.0	0.0	59.7	1.4	1140.0	5000.0	-12.8
4513.75	H	0.0	0.0	41.8	3.7	189.2	500.0	-8.4
4513.75	H	0.0	3.0	59.3	3.7	1414.1	5000.0	-11.0

Table 13: Radiated Emission Test Data, High Frequency Data >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)
2745.75	V	0.0	1.0	50.4	-1.2	287.8	500.0	-4.8
2745.75	V	0.0	1.0	61.5	-1.2	1033.1	5000.0	-13.7
3661.00	V	0.0	1.0	44.3	1.5	193.8	500.0	-8.2
3661.00	V	0.0	1.0	59.7	1.5	1142.6	5000.0	-12.8
4576.25	V	0.0	1.0	43.3	4.0	231.3	500.0	-6.7
4576.25	V	0.0	1.0	59.8	4.0	1542.5	5000.0	-10.2
2745.75	H	0.0	4.0	51.2	-1.2	314.9	500.0	-4.0
2745.75	H	0.0	4.0	62.2	-1.2	1117.2	5000.0	-13.0
3661.00	H	0.0	4.0	43.8	1.5	183.2	500.0	-8.7
3661.00	H	0.0	4.0	60.0	1.5	1182.7	5000.0	-12.5
4576.25	H	0.0	4.0	42.3	4.0	206.6	500.0	-7.7
4576.25	H	0.0	4.0	59.9	4.0	1555.0	5000.0	-10.1

Table 14: Radiated Emission Test Data, High Frequency Data >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)
2781.75	V	0.0	1.0	48.6	-1.1	236.5	500.0	-6.5
2781.75	V	0.0	1.0	58.9	-1.1	772.2	5000.0	-16.2
3709.00	V	0.0	1.0	43.4	1.5	177.4	500.0	-9.0
3709.00	V	0.0	1.0	46.8	1.5	261.8	5000.0	-25.6
4636.25	V	0.0	1.0	36.5	4.4	110.4	500.0	-13.1
4636.25	V	0.0	1.0	44.2	4.4	267.3	5000.0	-25.4
2781.75	H	0.0	0.0	50.2	-1.1	284.9	500.0	-4.9
2781.75	H	0.0	0.0	53.6	-1.1	420.5	5000.0	-21.5
3709.00	H	0.0	0.0	46.7	1.5	258.8	500.0	-5.7
3709.00	H	0.0	0.0	48.5	1.5	317.7	5000.0	-23.9
4636.25	H	0.0	0.0	41.1	4.4	186.8	500.0	-8.5
4636.25	H	0.0	3.0	46.6	4.4	351.2	5000.0	-23.1

4.8 Receiver Radiated Spurious Emissions: (§15.247(d) & RSS-GEN Sec. 7)

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.

4.8.1 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.

The emissions were measured using the following resolution bandwidths:

Table 15: 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 16: 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)
85.80		0.00	1.00	39.44	-17.6	12.3	100.0	-18.2
228.85	V	180.00	1.00	41.76	-13.6	25.5	200.0	-17.9
238.38	V	180.00	1.00	42.12	-13.3	27.5	200.0	-17.2
286.05	V	0.00	1.00	38.58	-11.3	23.2	200.0	-18.7
324.21	V	315.00	1.00	36.76	-10.7	20.1	200.0	-20.0
352.80	V	0.00	1.00	35.66	-10.0	19.3	200.0	-20.3
83.55	H	0.00	4.00	35.69	-17.6	8.0	100.0	-21.9
240.05	H	0.00	4.00	39.67	-13.2	21.0	200.0	-19.6
285.44	H	0.00	4.00	34.50	-11.3	14.5	200.0	-22.8
320.66	H	0.00	4.00	31.69	-10.8	11.1	200.0	-25.1

No frequencies noted above 1GHz

4.9 AC Conducted Emissions (FCC Part §15.207 & RSS-GEN Section 8.8)

4.9.1 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

4.9.2 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 C63.4-2014. 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

4.9.3 Test Data

The EUT complied with the Class B Conducted Emissions requirements. This system runs off of 120VAC providing power to 24VDC power brick. The 24VDC power brick was found to produce worst case emissions and the worst case emissions are shown in Table 7. The following tables provide the test results for phase and neutral line power line conducted emissions.

Conducted Emissions was tested with the 915MHz radio in the “transmit on” state.

Table 17: Conducted Emissions Data 120VAC, Transmit On(Worst Case)

NEUTRAL										
Frequency (MHz)	**Level QP (dBμV)**	**Level AVG (dBμV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBμV)**	**Level Corr Avg (dBμV)**	**Limit QP (dBμV)**	**Limit AVG (dBμV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.168	47.5	40.7	10.2	0.3	58.0	51.2	65.1	55.1	-7.1	-3.9
0.235	41.6	34.8	10.2	0.3	52.0	45.2	62.3	52.3	-10.3	-7.0
14.261	38.8	29.6	11.3	0.6	50.6	41.5	60.0	50.0	-9.4	-8.5
14.310	39.3	29.5	11.3	0.6	51.2	41.4	60.0	50.0	-8.8	-8.6
14.400	39.0	29.3	11.3	0.6	50.9	41.2	60.0	50.0	-9.1	-8.8
15.354	34.6	25.2	11.4	0.7	46.6	37.2	60.0	50.0	-13.4	-12.8
PHASE										
Frequency (MHz)	**Level QP (dBμV)**	**Level AVG (dBμV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBμV)**	**Level Corr Avg (dBμV)**	**Limit QP (dBμV)**	**Limit AVG (dBμV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.186	48.9	39.0	10.2	0.1	59.1	49.2	64.2	54.2	-5.1	-5.0
0.217	43.1	36.1	10.2	0.1	53.3	46.3	62.9	52.9	-9.6	-6.6
0.316	36.3	29.6	10.2	0.2	46.7	39.9	59.8	49.8	-13.1	-9.9
14.364	39.1	29.5	11.3	0.4	50.8	41.2	60.0	50.0	-9.2	-8.8
14.729	37.3	27.6	11.3	0.4	49.0	39.3	60.0	50.0	-11.0	-10.7
15.448	35.2	26.3	11.4	0.5	47.0	38.1	60.0	50.0	-13.0	-11.9