FCC 47 CFR PART 15 SUBPART E
INDUSTRY CANADA RSS-210 ISSUE 8

CERTIFICATION TEST REPORT

FOR

GOGO AIRCRAFT ON-BOARD WI-FI SYSTEM

MODEL NUMBER: NWAP0212

FCC ID: WPX-NWAP
IC: 8014A-NWAP

REPORT NUMBER: 13N15659-6, Revision B

ISSUE DATE: JANUARY 21, 2014

Prepared for
GOGO LLC
1250 N. ARLINGTON HEIGHTS RD.
ITASCA, IL 60143

Prepared by
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	10/28/13	Initial Issue	F. Ibrahim
A	01/06/14	Revised section 6	F. Ibrahim
B	01/21/14	Revised frequency from 5150-5250 MHz to 5190-5230 MHz – page 7	S. Kuwatani

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: GOGO LLC
1250 N. ARLINGTON HEIGHTS RD.
ITASCA, IL 60143

EUT DESCRIPTION: GOGO AIRCRAFT ON-BOARD WI-FI SYSTEM

MODEL: NWAP0212

SERIAL NUMBER: 1650

DATE TESTED: September 03 – October 24, 2013

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart E	Pass
INDUSTRY CANADA RSS-210 Issue 8 Annex 9	Pass
INDUSTRY CANADA RSS-GEN Issue 3	Pass

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For
UL Verification Services Inc. By:

FRANK IBRAHIM
WiSE PROGRAM MANAGER
UL Verification Services Inc.

Tested By:

THANH NGUYEN
EMC ENGINEER
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC 06-96, FCC KDB 789033, ANSI C63.10-2009, RSS-GEN Issue 3, and RSS-210 Issue 8.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☒ Chamber A	☐ Chamber D
☐ Chamber B	☐ Chamber E
☐ Chamber C	☐ Chamber F

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://www.ccsemc.com.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Conducted Disturbance, 0.15 to 30 MHz	3.52 dB
Radiated Disturbance, 30 to 1000 MHz	4.94 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an 802.11a/b/g/n Aircraft on-board Wi-Fi system.

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5190-5230	802.11n HT40	13.768	23.812

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an IFA antenna, with a maximum gain of 7.30 dBi in 5 GHz bands.

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was flash/ap3g1-k9w7-mx, rev. 124-25d.JA1

The driver software installed was Cisco IOS C1260.

The test utility software used during testing was Teraterm, rev. 4.79

5.5. WORST-CASE CONFIGURATION AND MODE

The fundamental of the EUT was investigated in two orthogonal orientations X & Y of the antennas position, it was determined that Y orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Y orientation.

Worst-case data rates as provided by the client were:
802.11b mode: 11 Mbps
802.11g mode: 6 Mbps
802.11n HT40mode: MCS0

AC line conducted emissions test was not performed since the EUT is installed on air planes and operated by DC voltage.

For Colocation investigation, the channel with highest output power was selected for each mode of operation to show compliance, when the two radios of 2.4 GHz and 5 GHz bands are collocated. This was performed in conducted method to show when the radios are collocated there are no signals appearing above the system noise floor level due to colocation.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Dell	Latitude E6400	4VGYRK1	DoC
Laptop Docking Station	Dell	PR02X	CN-0CY640-12961-89M-7911-A01	DoC
Power Supply	Dell	DA90PS0-00	CN-0XD757-48661-65U-B68J	DoC

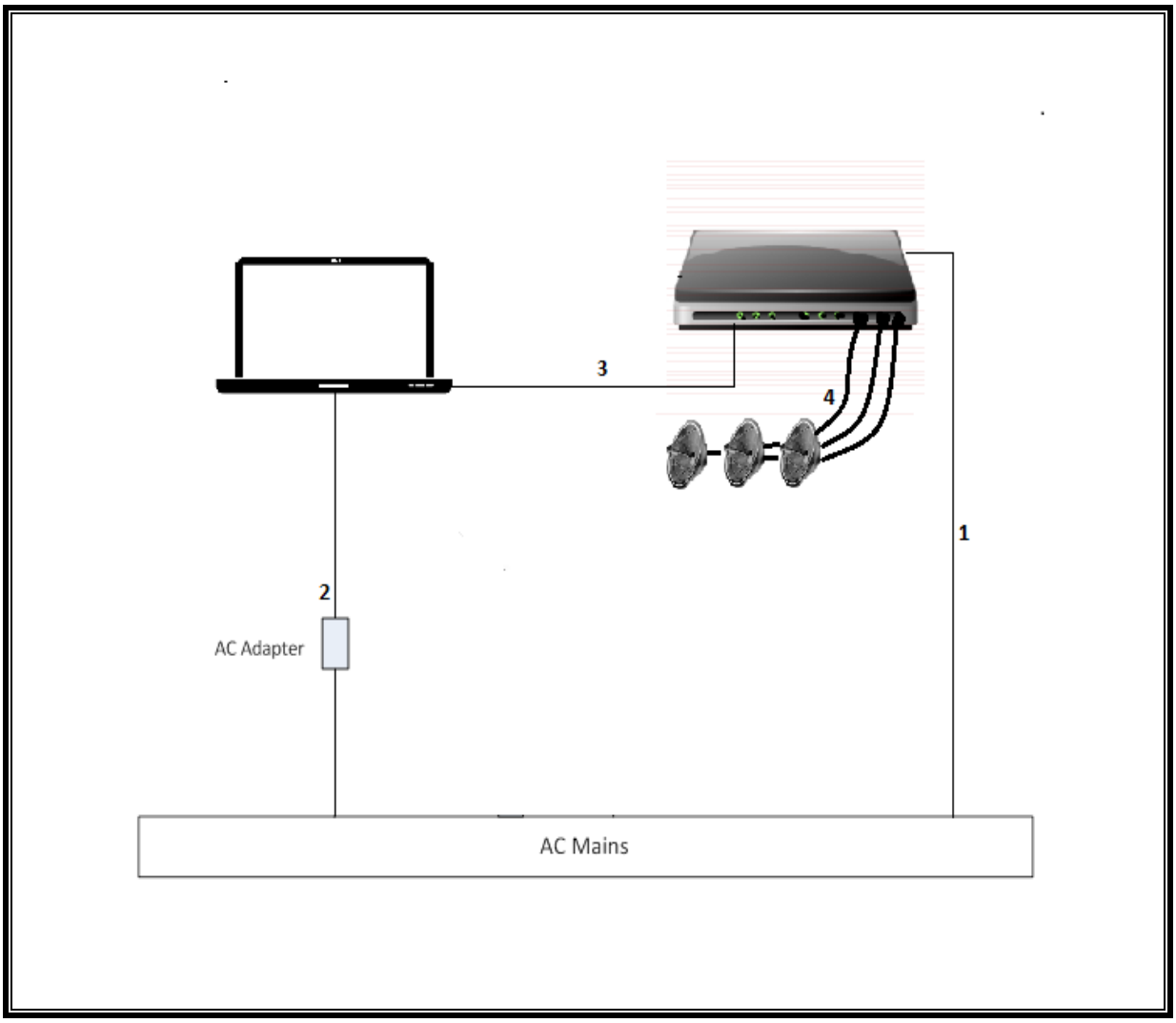
I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identical ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	US 115Vac	Shield	1.5m	
2	DC	1	DC	Shield	1m	
3	I/O	1	Serial	Un-Shield	0.8m	
4	Antenna	3	Coax	Shield	0.8m	

TEST SETUP

The EUT is communicated with laptop computer during the tests. Script command exercised the radio card.

SETUP DIAGRAM FOR TESTS



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment List					
Description	**Manufacturer**	**Model**	**Asset**	**Cal Date**	**Cal Due**
Spectrum Analyzer, 44 GHz	Agilent / HP	E4446A	C01069	12/20/12	12/20/13
Spectrum Analyzer,9KHz-40GHz	HP	8564E	C00986	04/01/13	04/01/14
EMI Test Receiver, 9 kHz-7 GHz	R & S	ESCI 7	1000741	08/13/13	08/13/14
EMI Test Receiver, 30 MHz	R & S	ESHS 20	N02396	08/15/13	08/18/14
Peak Power Meter	Agilent / HP	E4416A	C00963	12/13/11	12/13/13
Peak / Average Power Sensor	Agilent / HP	E9327A	C00964	12/13/11	12/13/13
Antenna, Horn, 1-18 GHz	ETS	3117	C01022	02/21/13	02/21/14
Antenna, Horn,18- 26 GHz	ARA	MWH-1826/B	C00946	11/12/12	11/12/13
Antenna, Horn, 26-40 GHz	ARA	MWH-2640	C00891	06/28/13	06/28/14
Antenna, Bilog, 30MHz-1 GHz	Sunol Sciences	JB1	T243	03/06/13	03/06/14
RF Preamplifier, 100KHz - 1300MHz	HP	----	C00825	06/01/13	06/01/14
RF Preamplifier, 1GHz - 18GHz	Miteq	NSP4000-SP2	924343	03/23/13	03/23/14
RF Preamplifier, 1GHz - 26.5GHz	HP	8449B	F00351	06/27/13	06/27/14
AC Power Supply, 2,500VA 45-500Hz	Elgar-Ametek	CW2501M	F00013	CNR	CNR
RF Preamplifier, 1GHz - 40GHz	Miteq	NSP4000-SP2	C00990	08/20/13	08/20/14
Attenuator / Switch driver	HP	11713A	T457	CNR	CNR
Low Pass Filter 5GHz	Micro-Tronics	LPS17541	F00219	CNR	CNR
High Pass Filter 6GHz	Micro-Tronics	HPS17542	F00222	CNR	CNR
High Pass Filter 3GHz	Micro-Tronics	HPM17543	F00224	CNR	CNR

7. ON TIME, DUTY CYCLE AND MEASUREMENT METHODS

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

7.1. ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
5GHz Band						
802.11HT 40 , 2TX	0.6667	0.6783	0.983	98.29%	0.00	0.010

7.2. MEASUREMENT METHODS

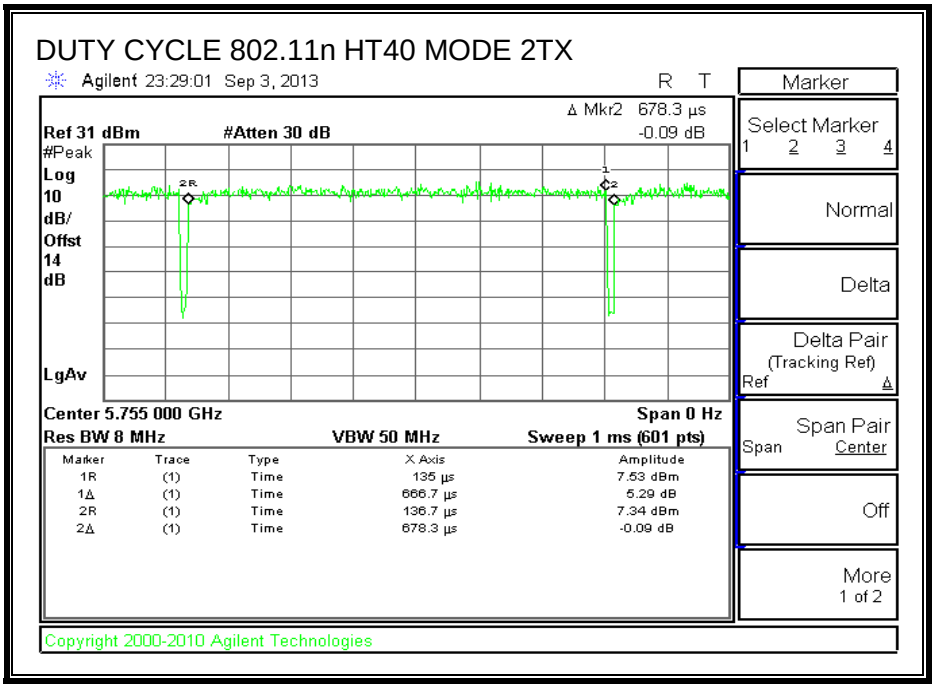
7.2.1. MEASUREMENT METHOD FOR POWER AND PPSD

The Duty Cycle is greater than or equal to 98% therefore KDB 789033 Method SA-1 is used.

7.2.2. MEASUREMENT METHOD FOR AVG SPURIOUS EMISSIONS ABOVE 1 GHz

The Duty Cycle is greater than or equal to 98%, KDB 789033 Method AD with Power RMS Averaging is used.

7.3. DUTY CYCLE PLOTS



8. ANTENNA PORT TEST RESULTS

8.1. 802.11n HT40 MODE IN THE 5.2 GHz BAND

8.1.1. 26 dB BANDWIDTH

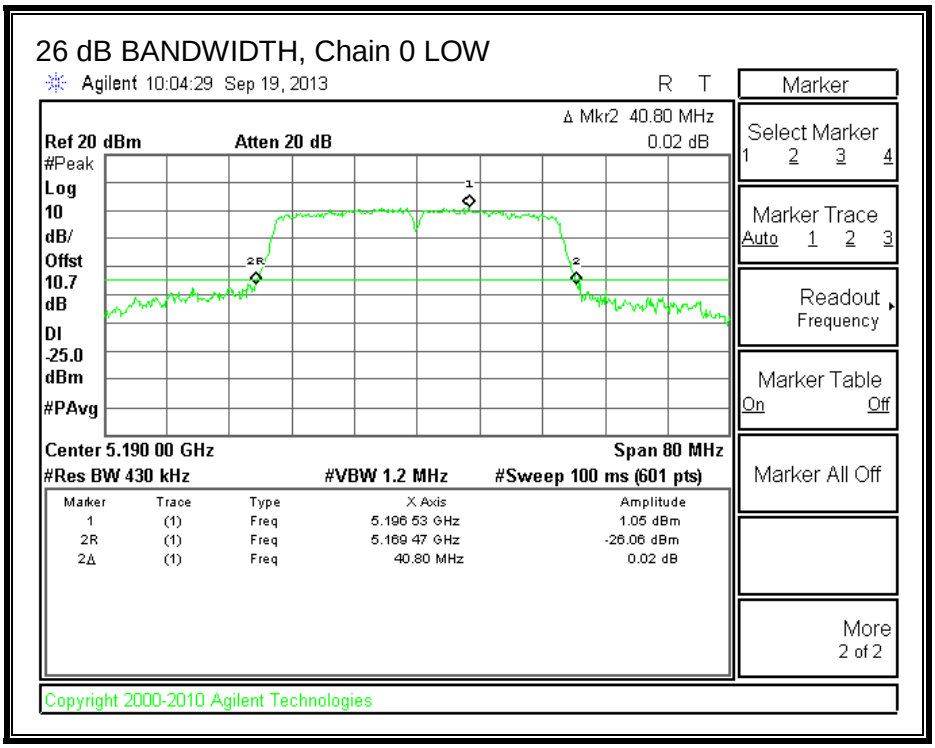
LIMITS

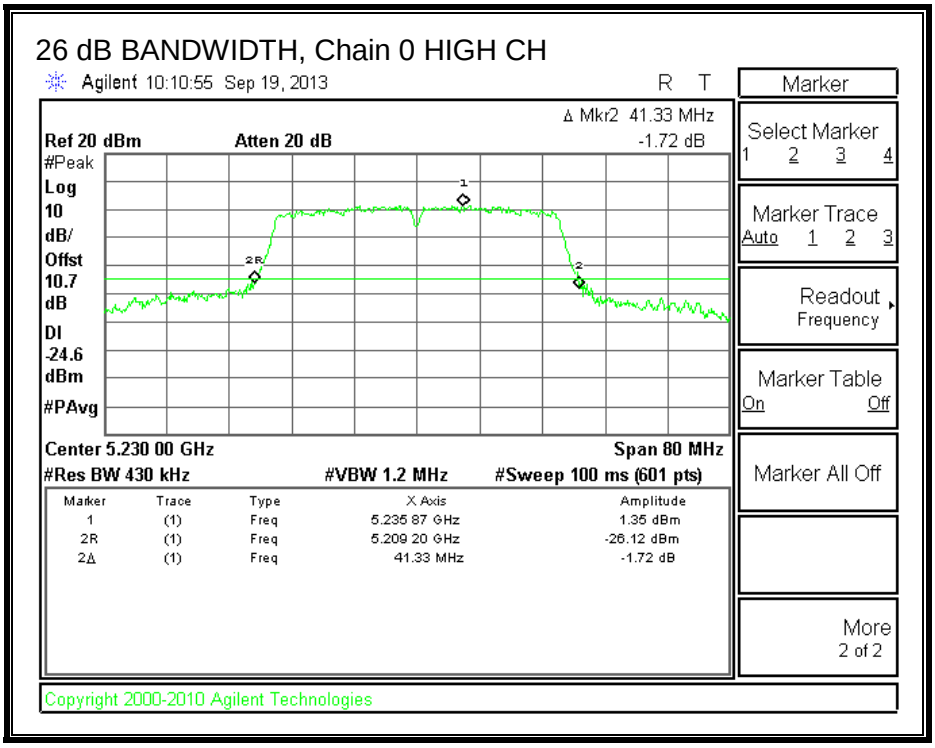
None; for reporting purposes only.

RESULTS

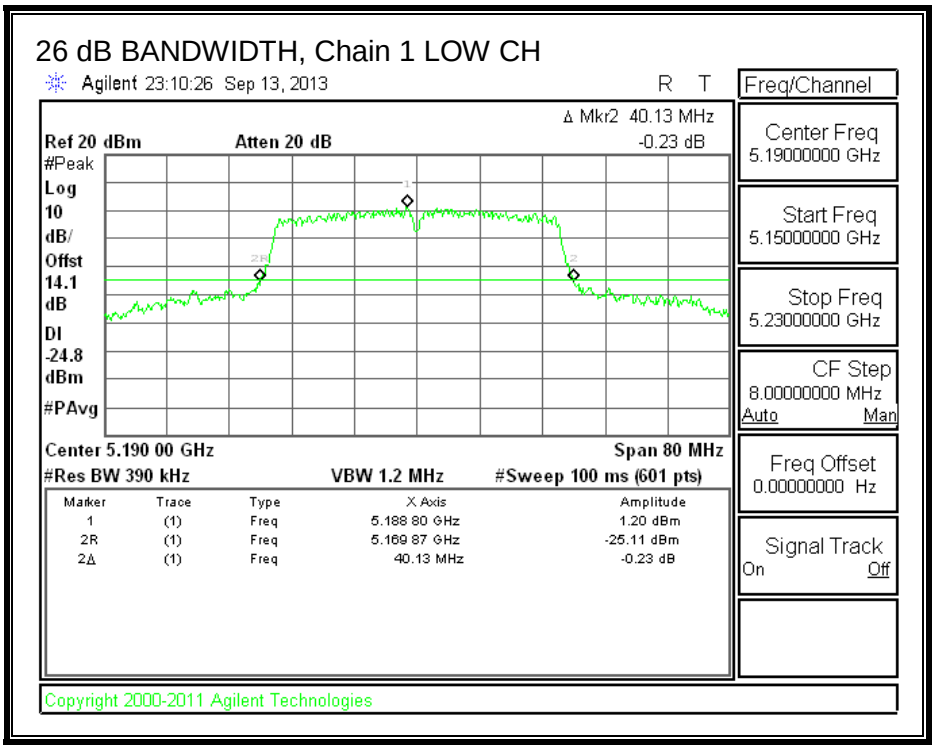
Channel	Frequency (MHz)	26 dB BW Chain 0 (MHz)	26 dB BW Chain 1 (MHz)
Low	5190	40.80	40.13
High	5230	41.33	42.00

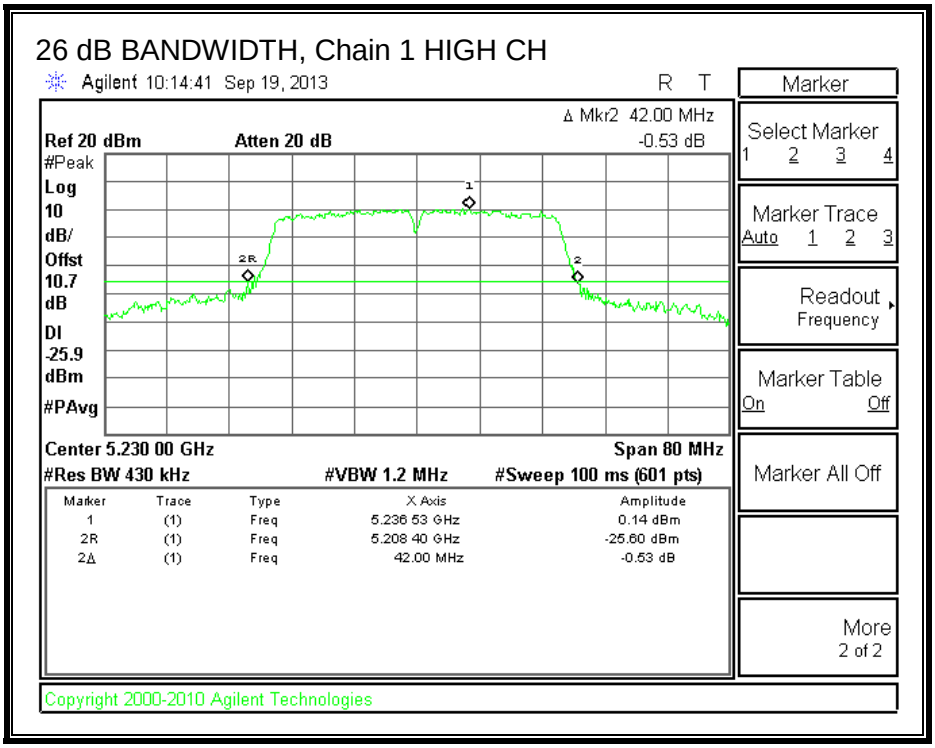
26 dB BANDWIDTH, Chain 0





26 dB BANDWIDTH, Chain 1





8.1.2. 99% BANDWIDTH

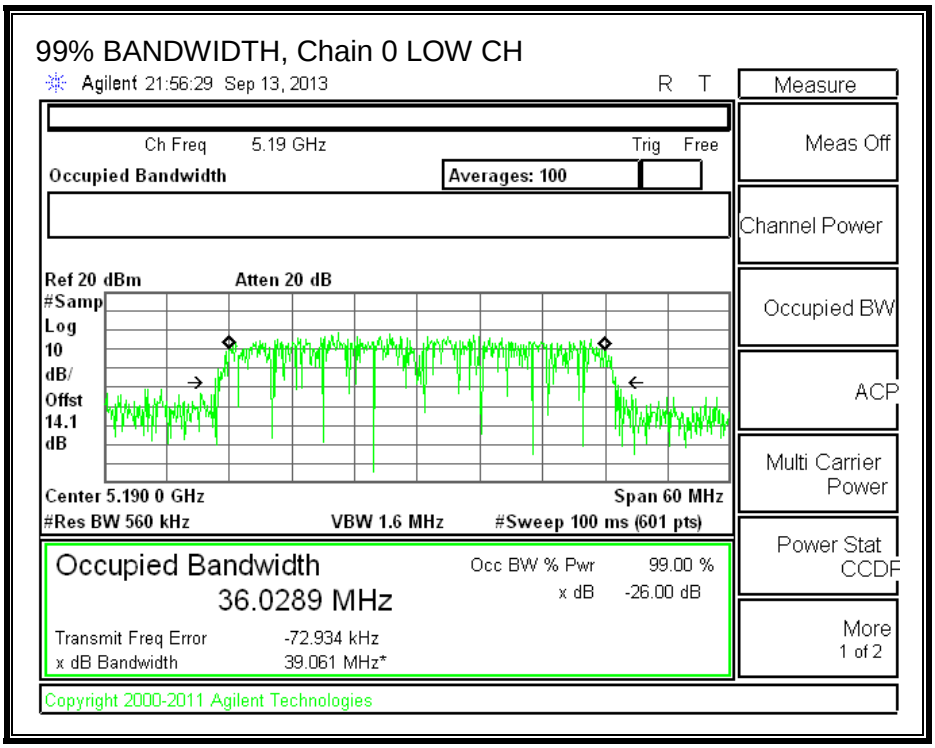
LIMITS

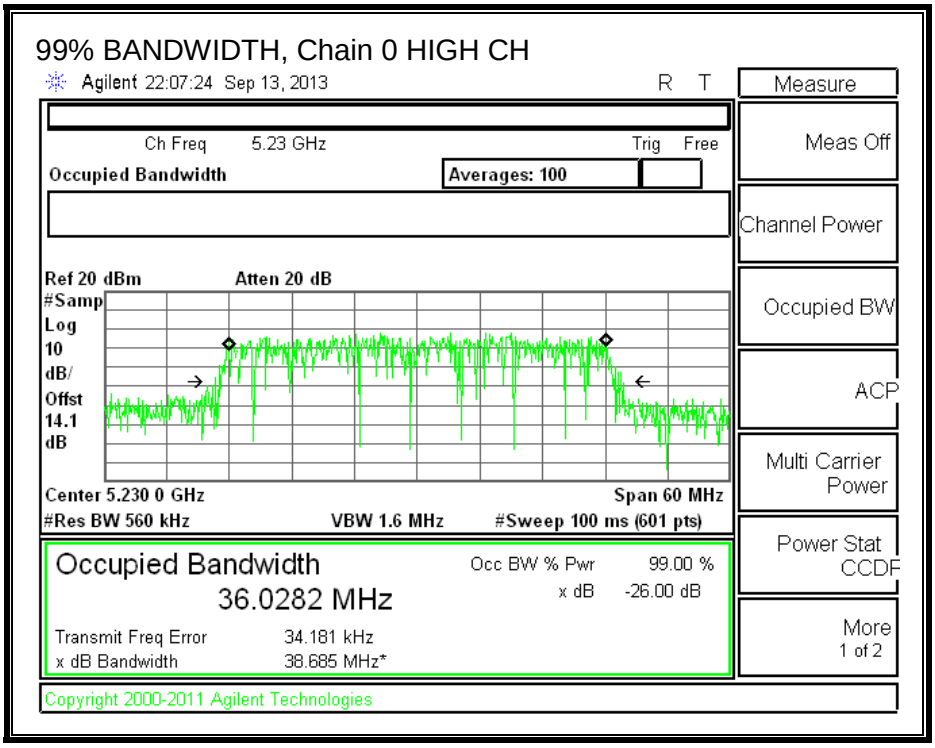
None; for reporting purposes only.

RESULTS

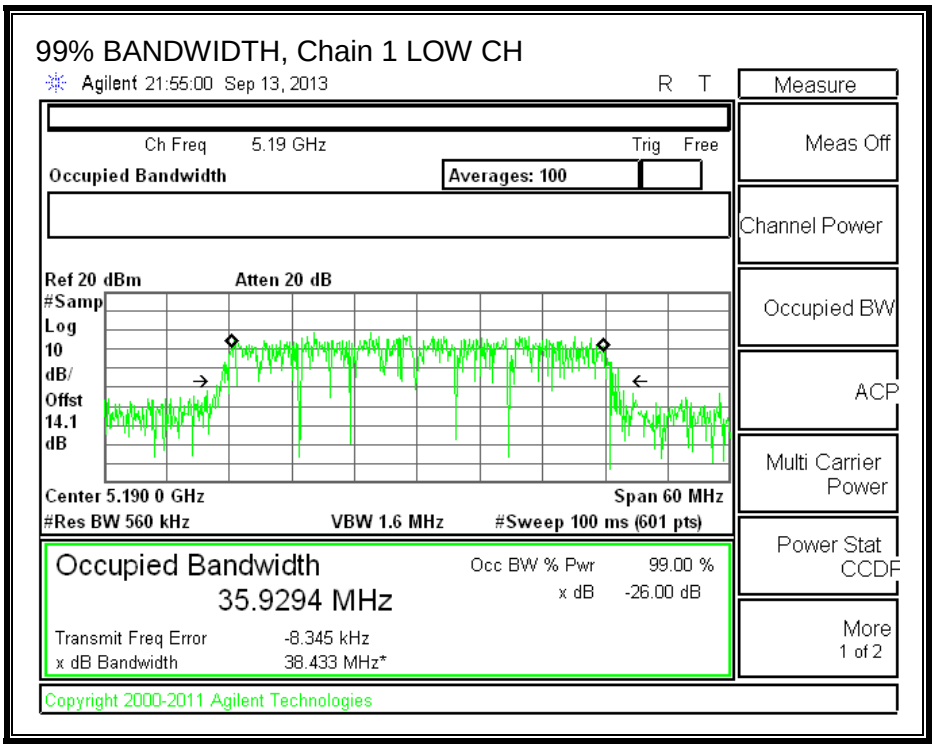
Channel	Frequency (MHz)	99% BW Chain 0 (MHz)	99% BW Chain 1 (MHz)
Low	5190	36.0289	35.9294
High	5230	36.0282	36.0634

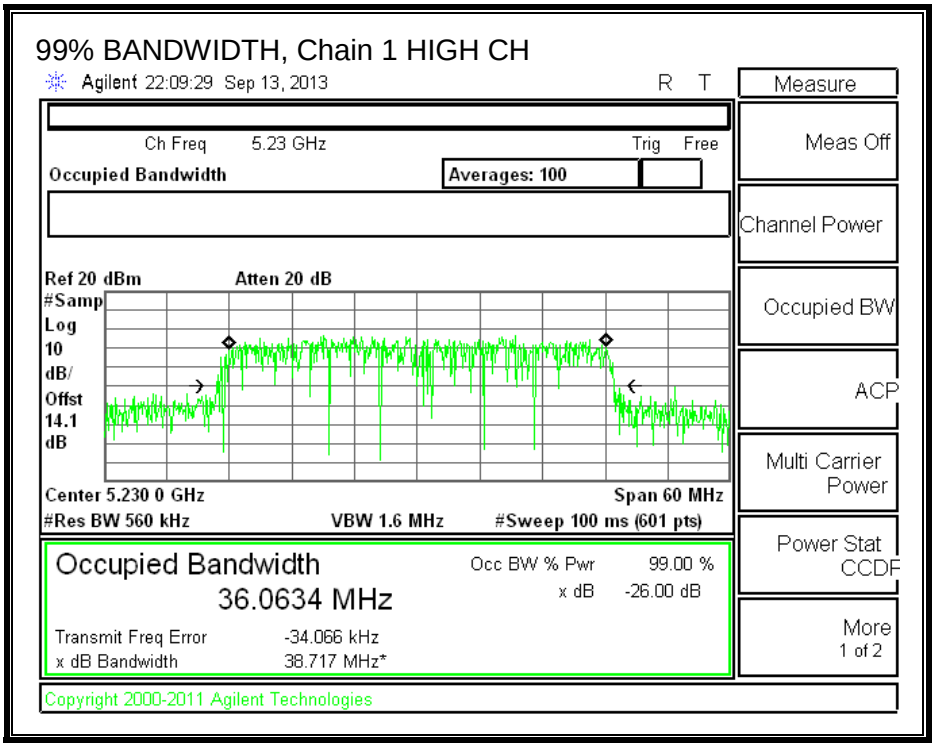
99% BANDWIDTH, Chain 0





99% BANDWIDTH, Chain 1





8.1.3. AVERAGE POWER

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10.7dB (including 10 dB pad and .7 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

RESULTS

Average Power Results

Channel	Frequency (MHz)	Chain 0 Power (dBm)	Chain 1 Power (dBm)	Total Power (dBm)
Low	5190	10.30	9.80	13.07
High	5230	10.85	9.78	13.36

8.1.4. OUTPUT POWER AND PPSD

LIMITS

FCC §15.407 (a) (1)

For the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed the lesser of 50 mW or 4 dBm + 10 log B, where B is the 26–dB emission bandwidth in MHz. In addition, the peak power spectral density shall not exceed 4 dBm in any 1–MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

IC RSS-210 A9.2 (1)

The maximum e.i.r.p. shall not exceed 200 mW or 10 + 10 log10 B, dBm, whichever power is less. B is the 99% emission bandwidth in MHz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

DIRECTIONAL ANTENNA GAIN

For output power, the TX chains are uncorrelated and the antenna gain is the same for each chain. The directional gain is equal to the antenna gain, which is equal to 7.30 dBi.

For PPSD, the TX chains are correlated and the antenna gain is the same for each chain. The directional gain is:

Antenna Gain (dBi)	10 * Log (2 chains) (dB)	Correlated Chains Directional Gain (dBi)
7.30	3.01	10.31

RESULTS

Bandwidth and Antenna Gain

Channel	Frequency (MHz)	Min 26 dB BW (MHz)	Min 99% BW (MHz)	Uncorrelated Directional Gain (dBi)	Correlated Directional Gain (dBi)
Low	5190	40.13	35.9294	7.30	10.31
High	5230	41.33	36.0282	7.30	10.31

Limits

Channel	Frequency (MHz)	FCC Power Limit (dBm)	IC EIRP Limit (dBm)	Max IC Power (dBm)	Power Limit (dBm)	FCC PPSD Limit (dBm)	IC eirp PSD Limit (dBm)	PPSD Limit (dBm)
Low	5190	15.70	23.00	15.70	15.70	-0.31	10.00	-0.31
High	5230	15.70	23.00	15.70	15.70	-0.31	10.00	-0.31

Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd Power & PPSD

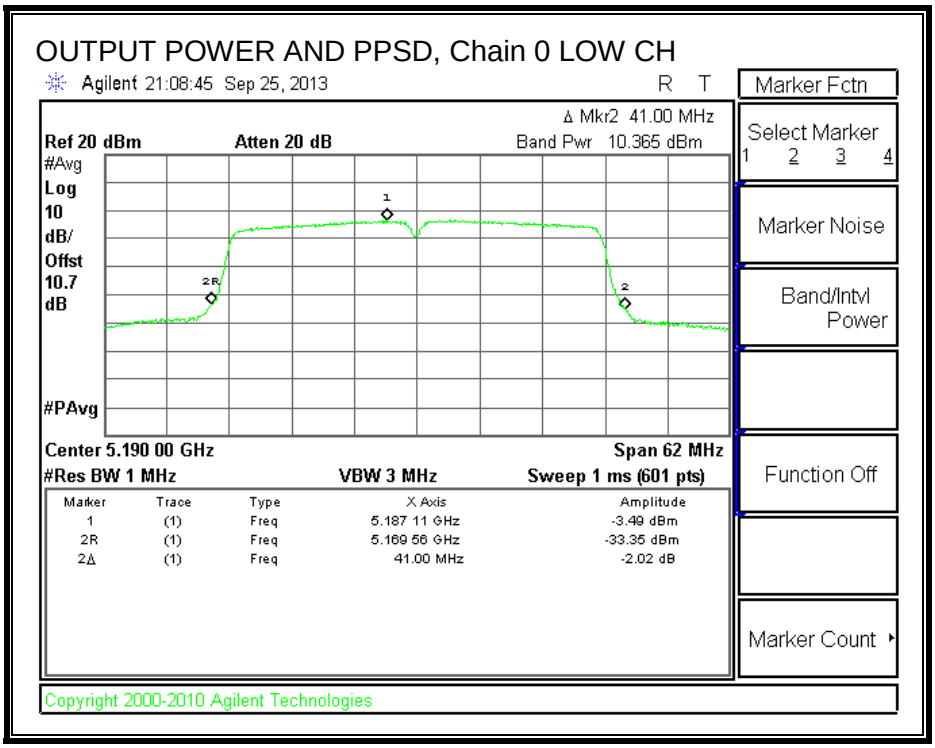
Output Power Results

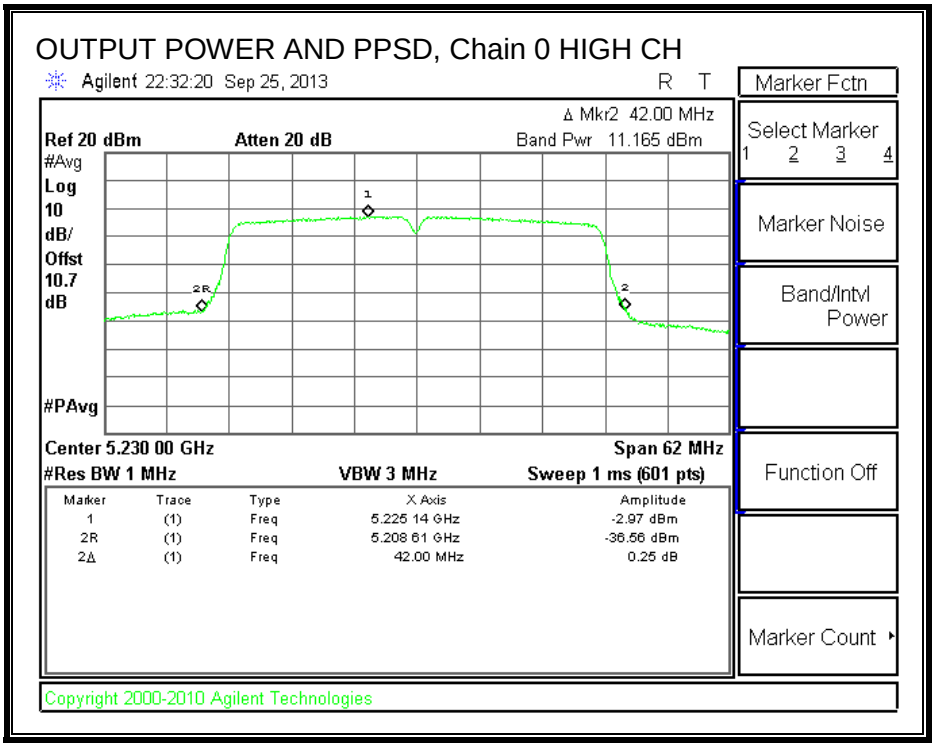
Channel	Frequency (MHz)	Chain 0 Meas Power (dBm)	Chain 1 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Power Margin (dB)
Low	5190	10.365	10.345	13.365	15.70	-2.335
High	5230	11.165	10.308	13.768	15.70	-1.932

PPSD Results

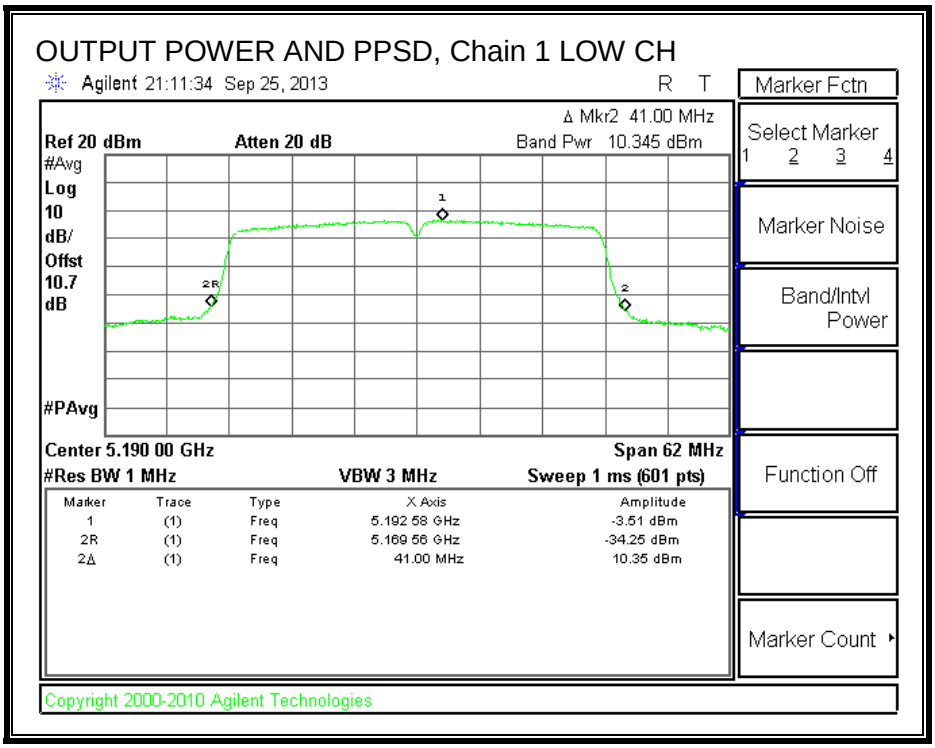
Channel	Frequency (MHz)	Chain 0 Meas PPSD (dBm)	Chain 1 Meas PPSD (dBm)	Total Corr'd PPSD (dBm)	PPSD Limit (dBm)	PPSD Margin (dB)
Low	5190	-3.49	-3.51	-0.49	-0.31	-0.18
High	5230	-2.97	-3.73	-0.32	-0.31	-0.01

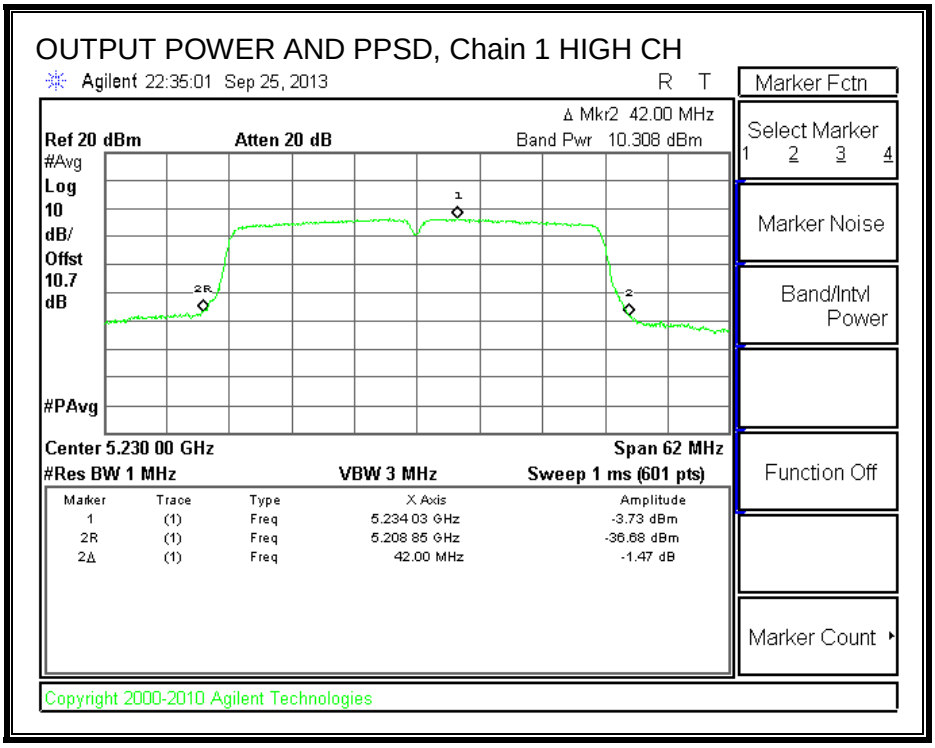
OUTPUT POWER AND PPSD, Chain 0





OUTPUT POWER AND PPSD, Chain 1





8.1.5. PEAK EXCURSION

LIMITS

FCC §15.407 (a) (6)

The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak transmit power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

RESULTS

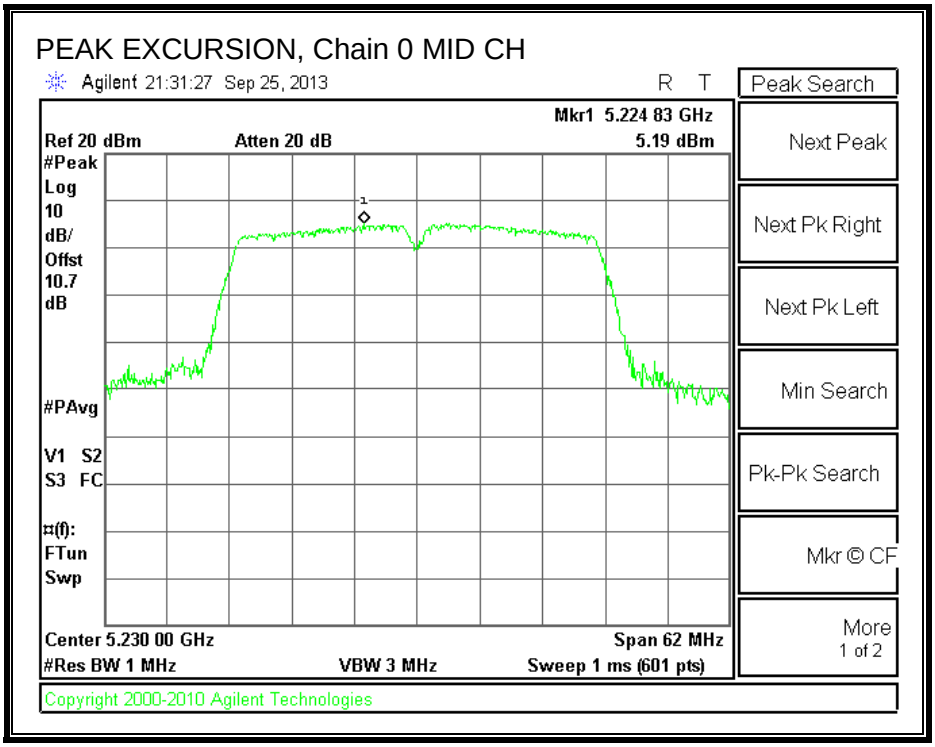
Chain 0

Channel	Frequency (MHz)	PK Level (dBm)	PSD (dBm)	DCCF (dB)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
High	5230	5.19	-2.97	0.00	8.16	13	-4.84

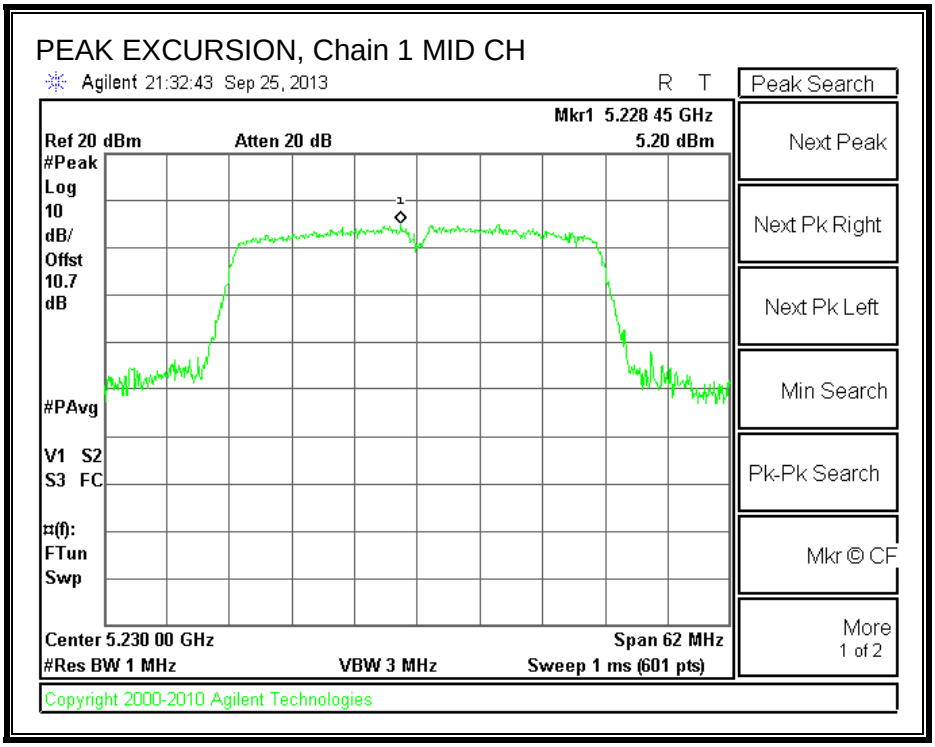
Chain 1

Channel	Frequency (MHz)	PK Level (dBm)	PSD (dBm)	DCCF (dB)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
High	5230	5.20	-3.73	0.00	8.93	13	-4.07

PEAK EXCURSION, Chain 0

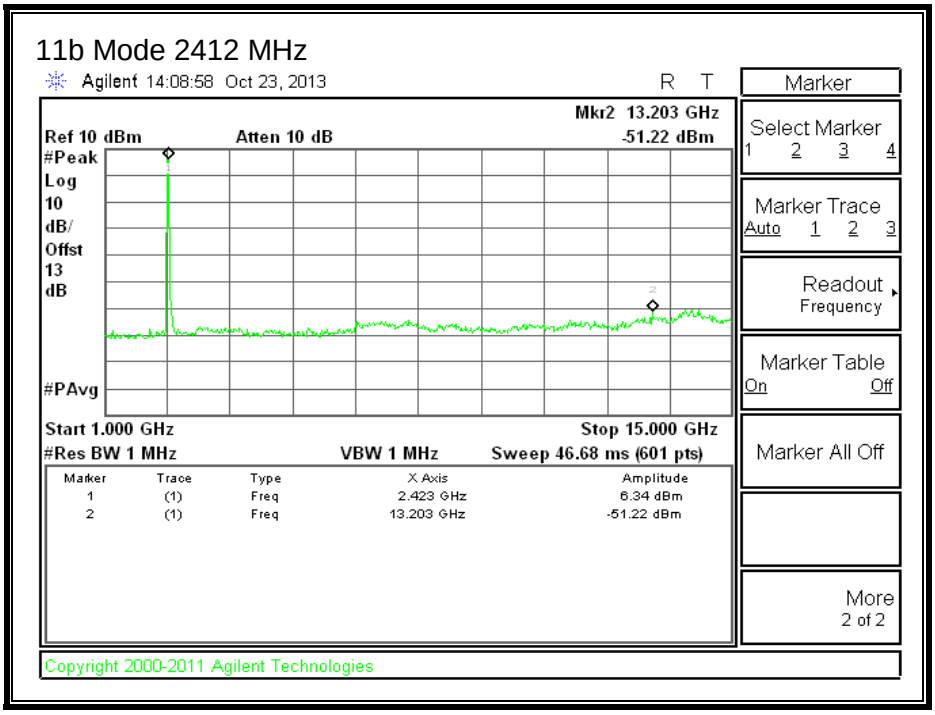


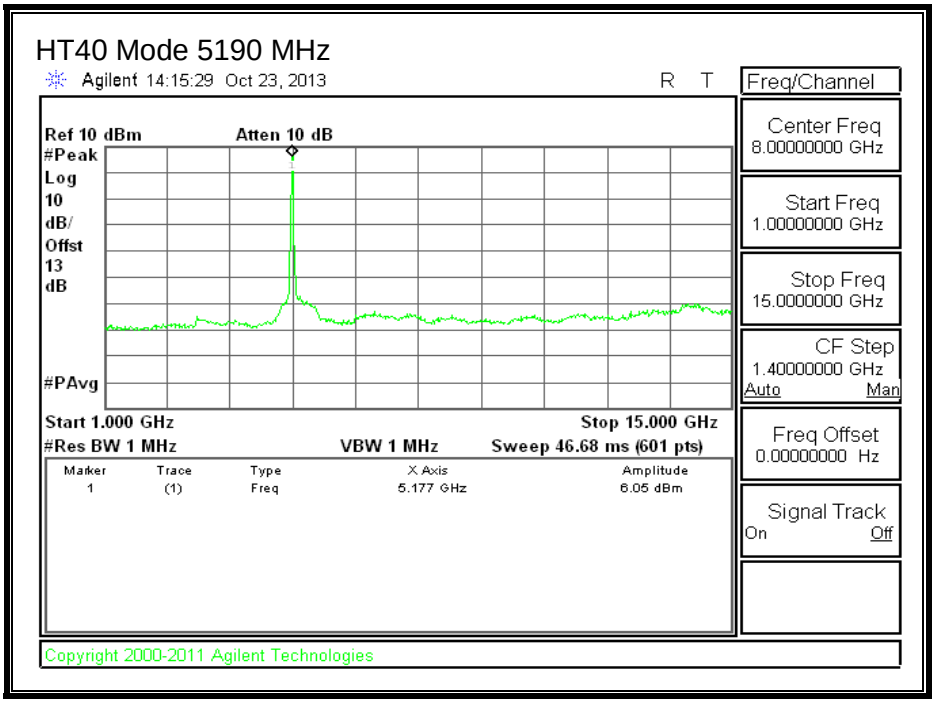
PEAK EXCURSION, Chain 1



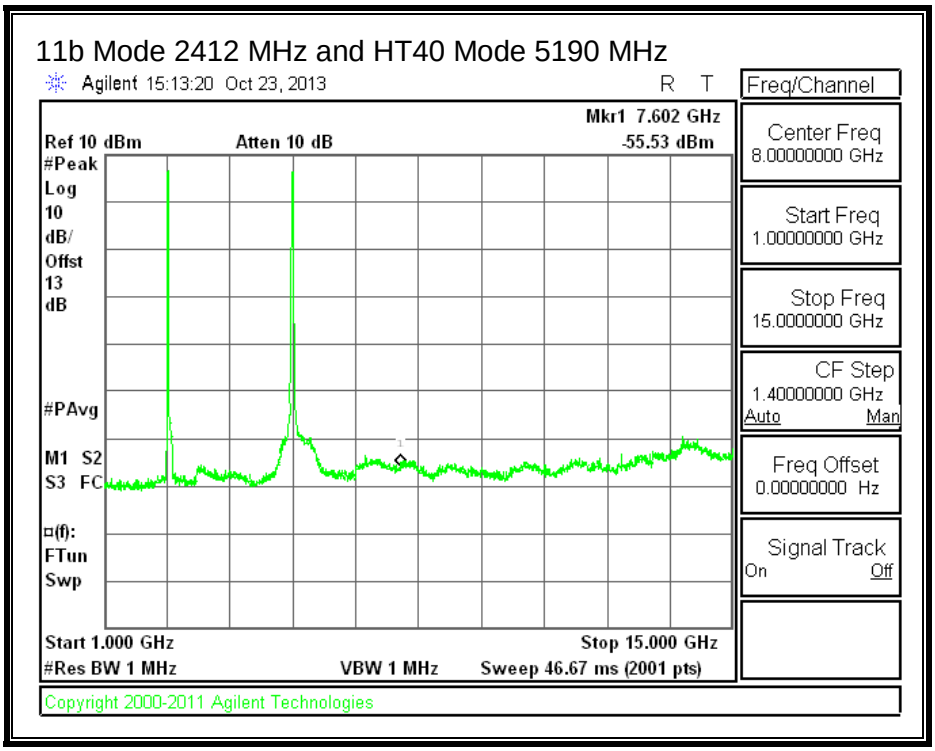
8.2. COLOCATION

802.11b Mode 2.4 GHz and 802.11n HT40 Mode 5.2 GHz

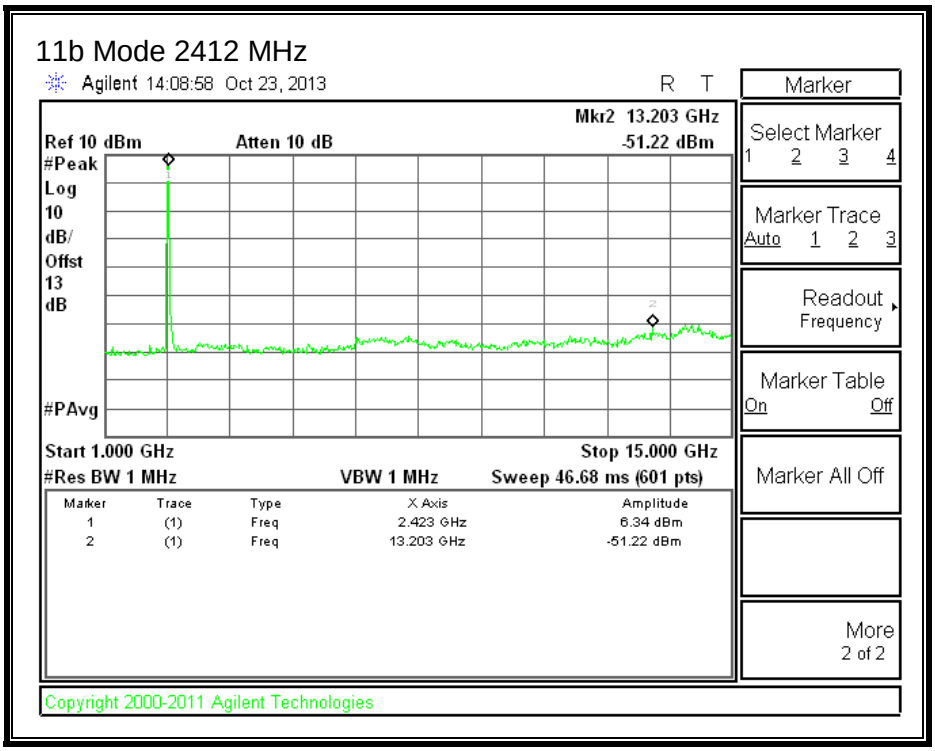




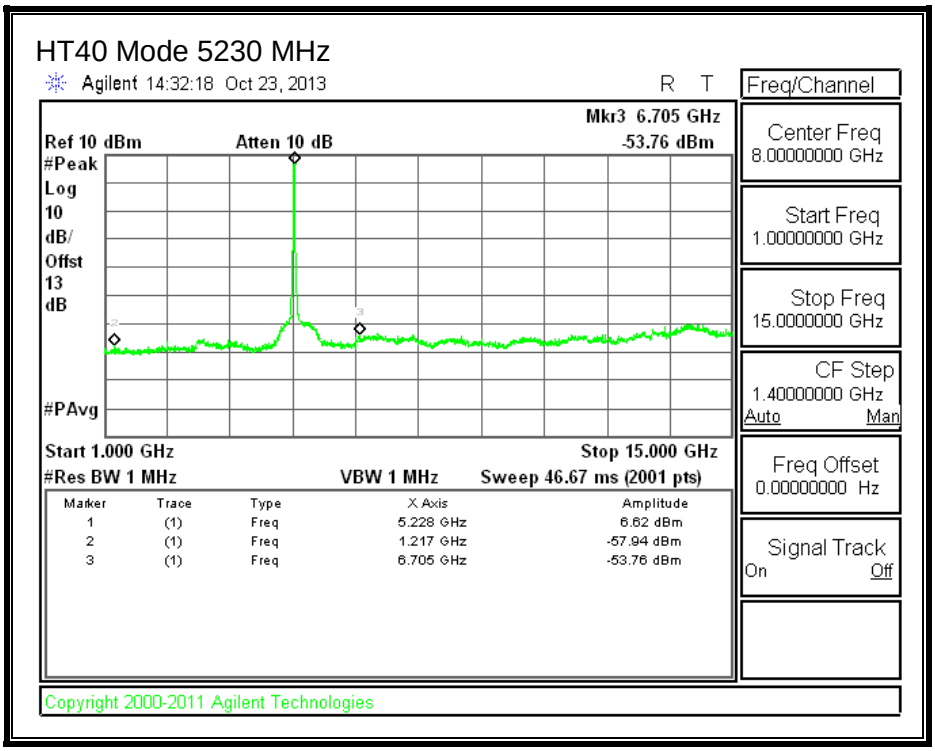
Colocation



11b Mode 2412 MHz



HT40 Mode 5230 MHz



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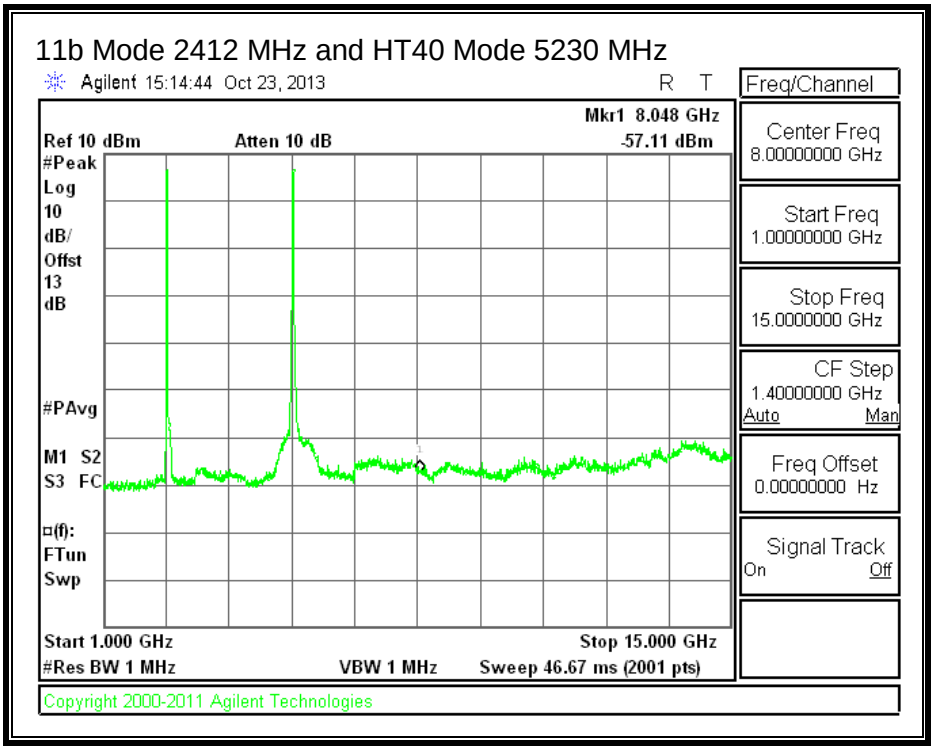
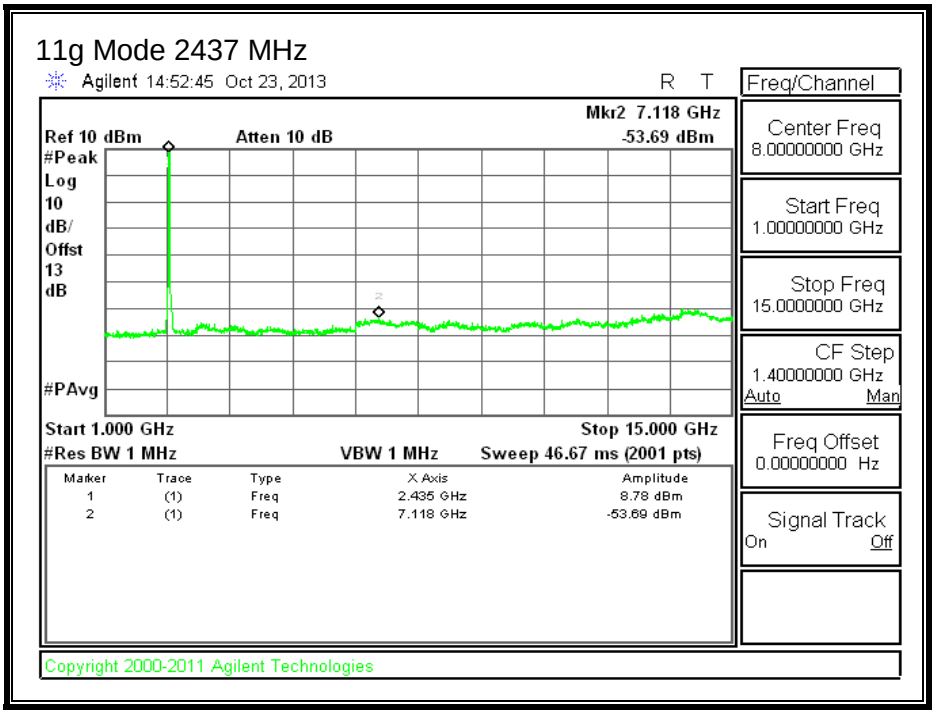
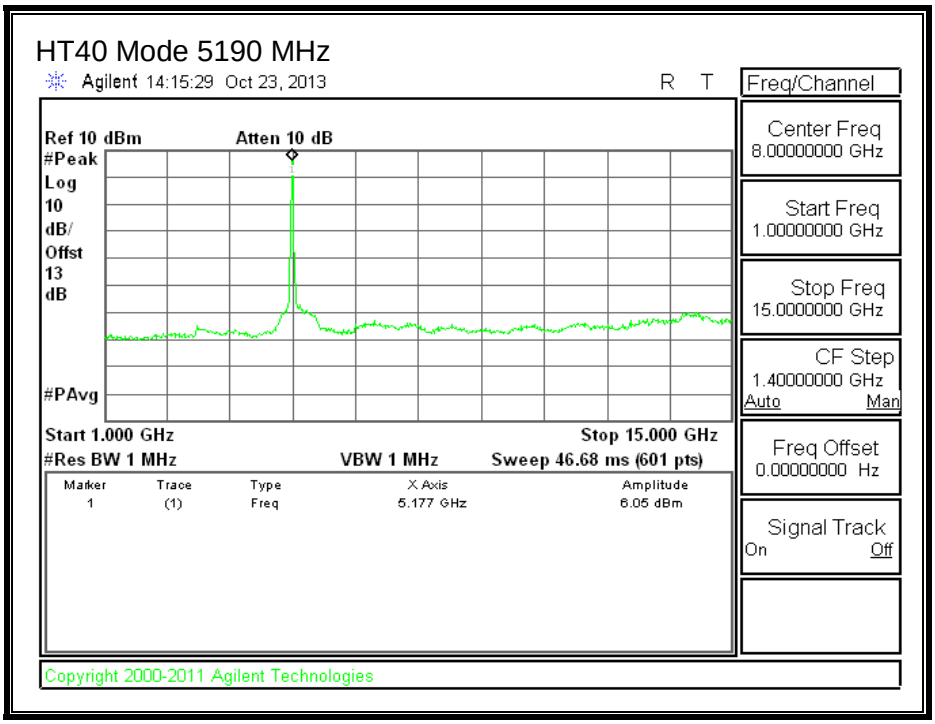


802.11g Mode 2.4 GHz and 802.11n HT40 Mode 5.2 GHz





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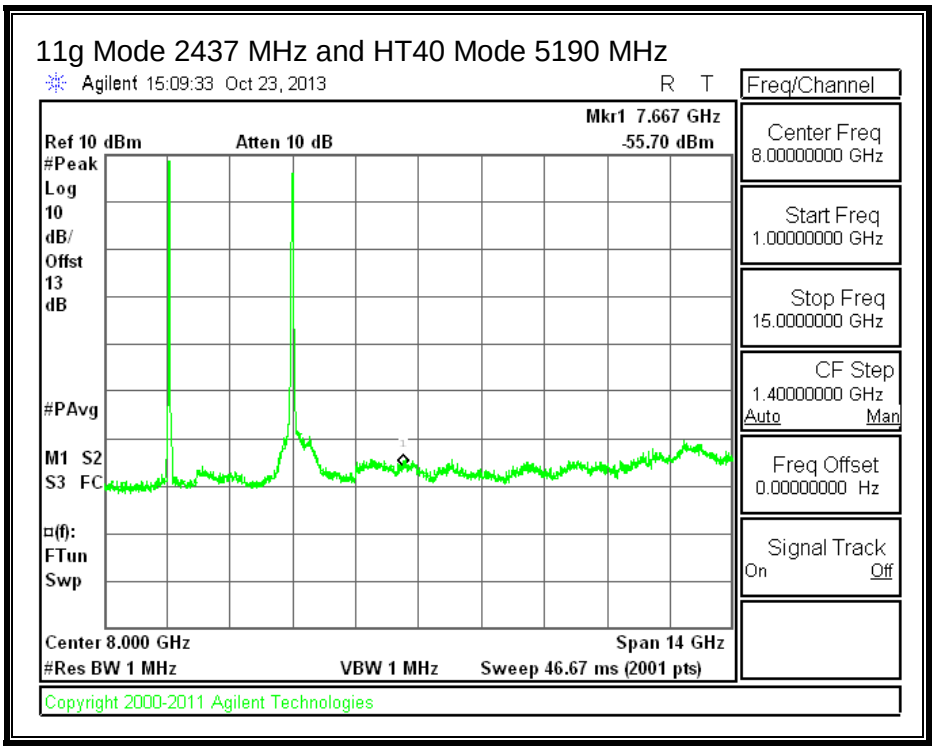
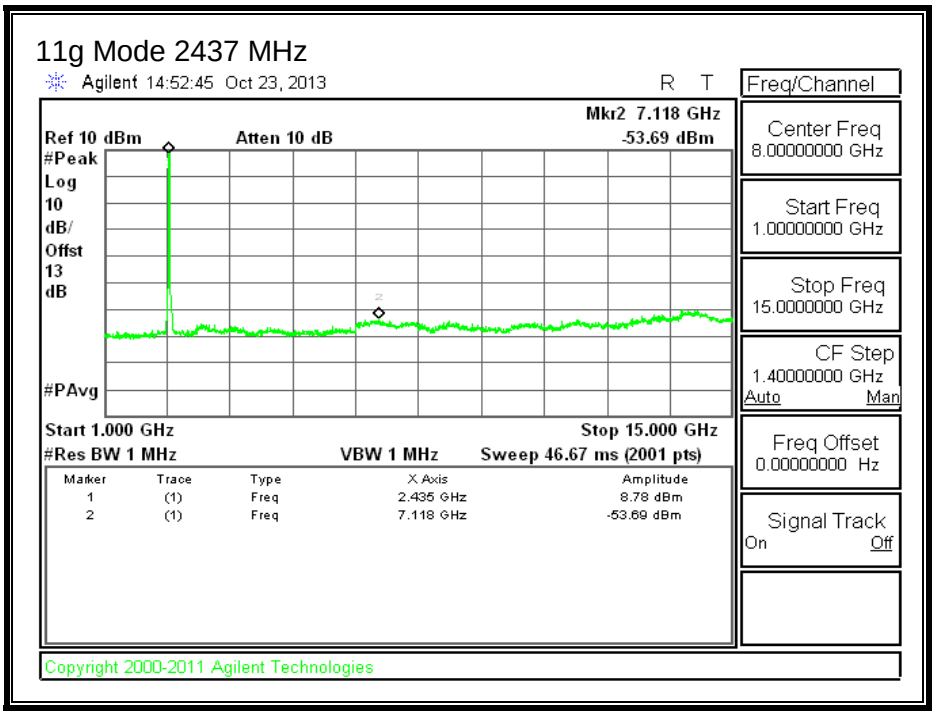
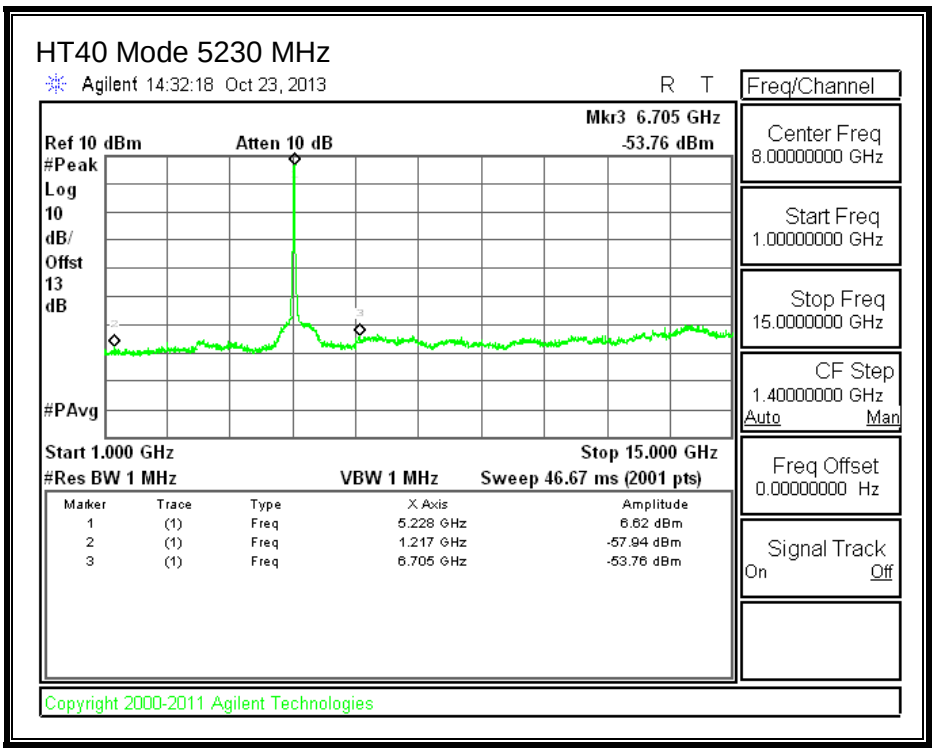
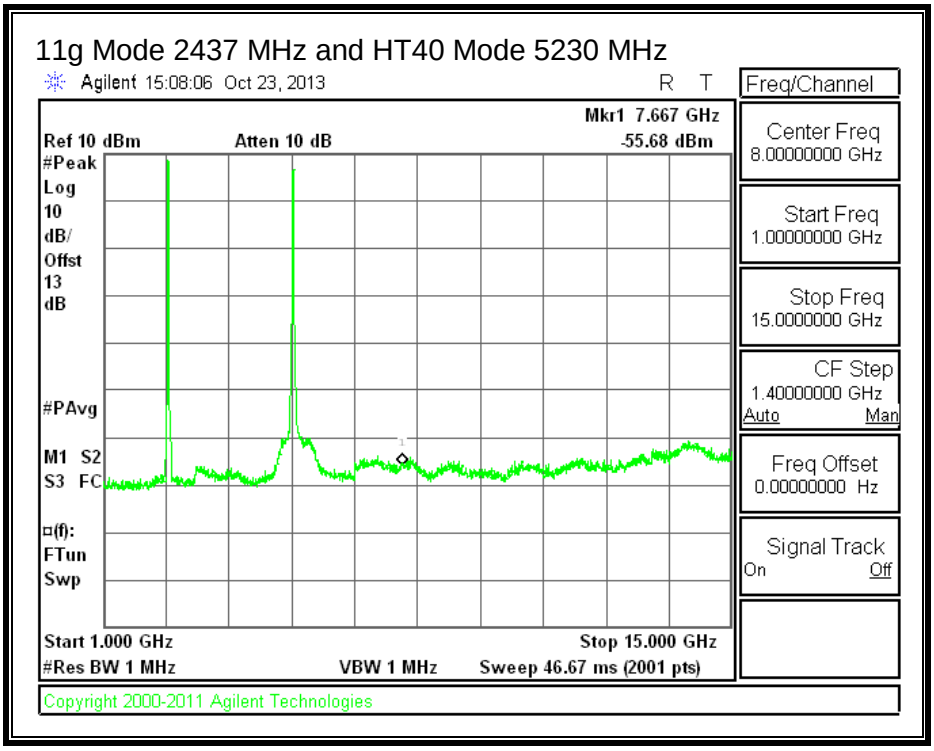


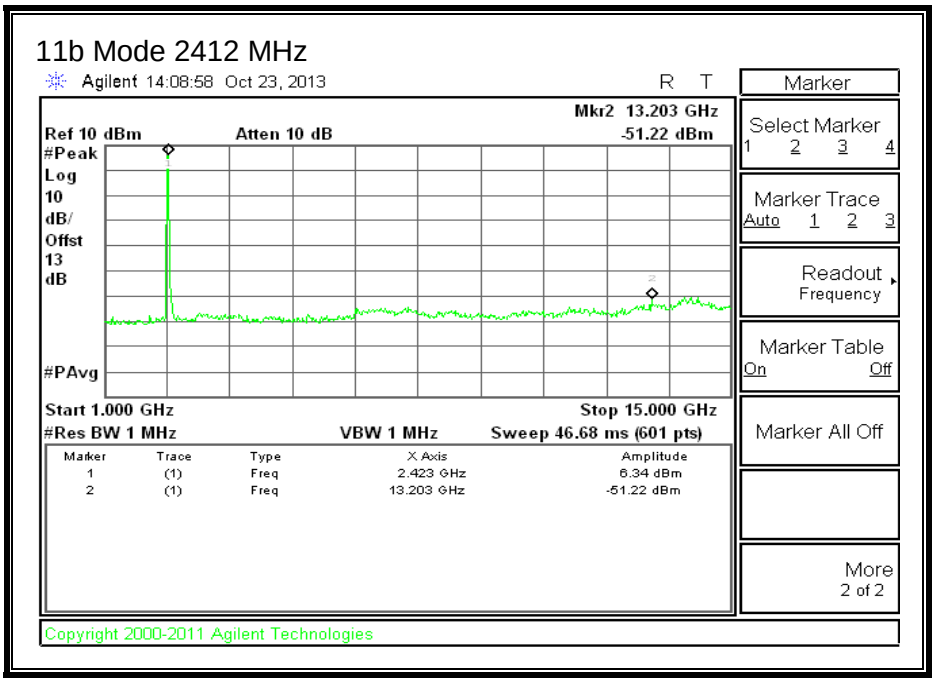


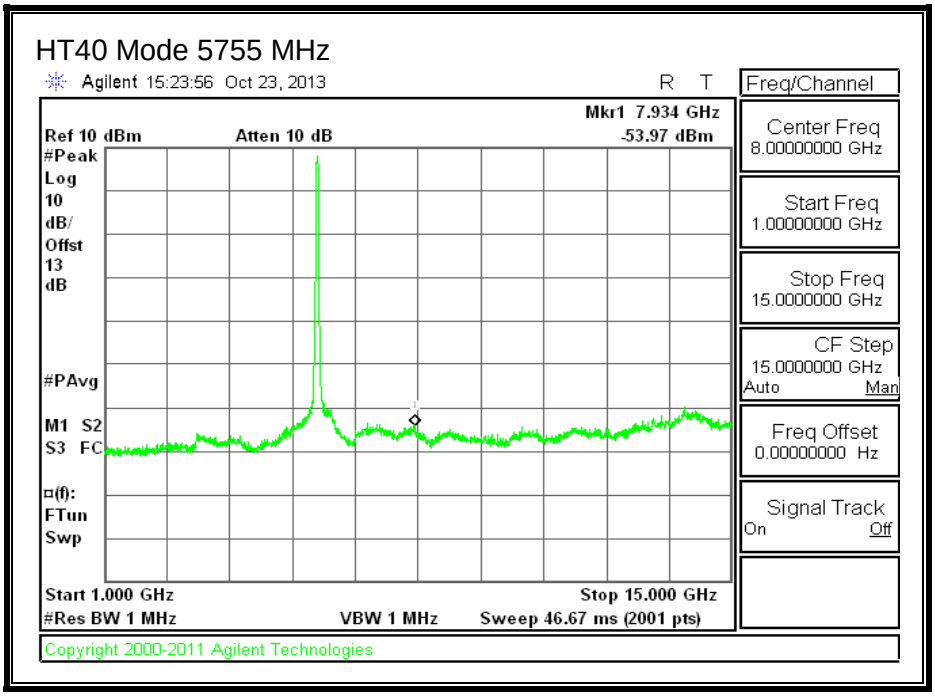


Colocation

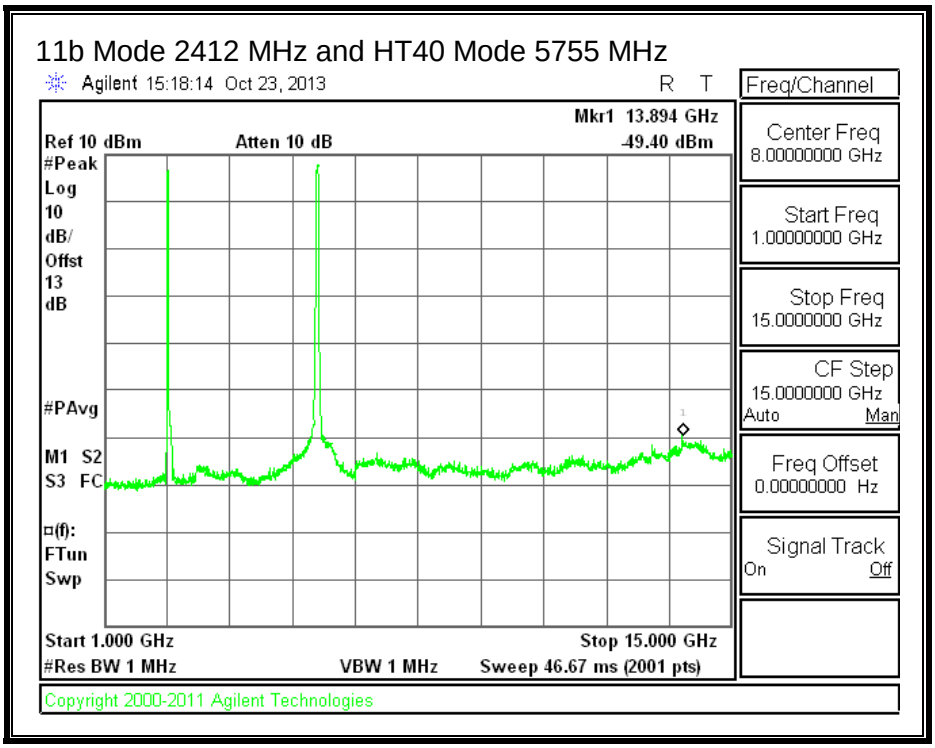


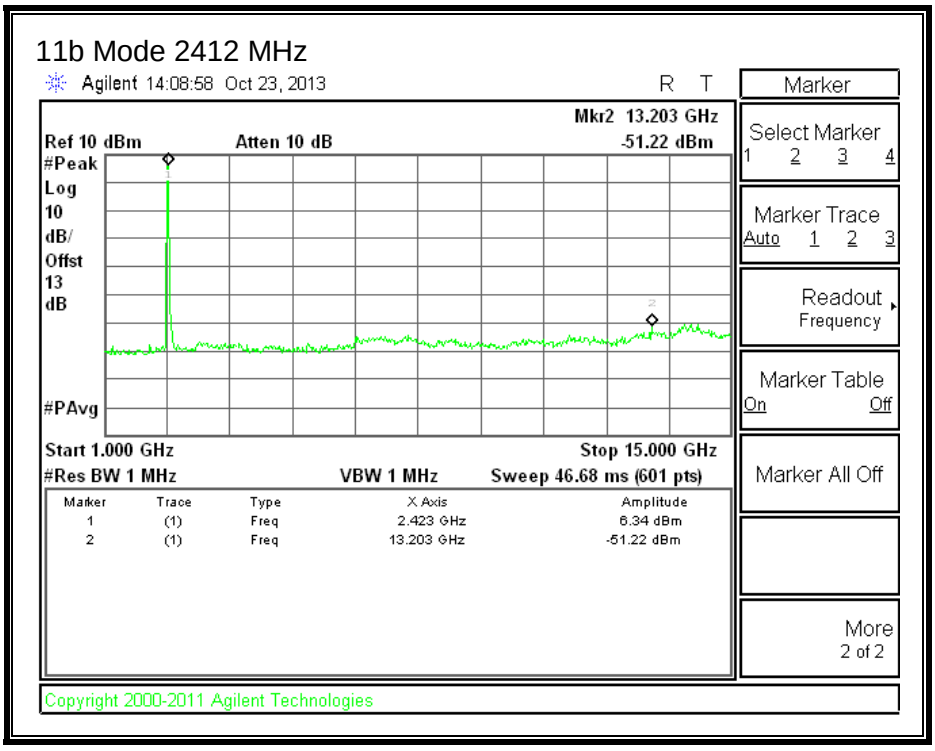
802.11b Mode 2.4 GHz and 802.11n HT40 Mode 5.8 GHz

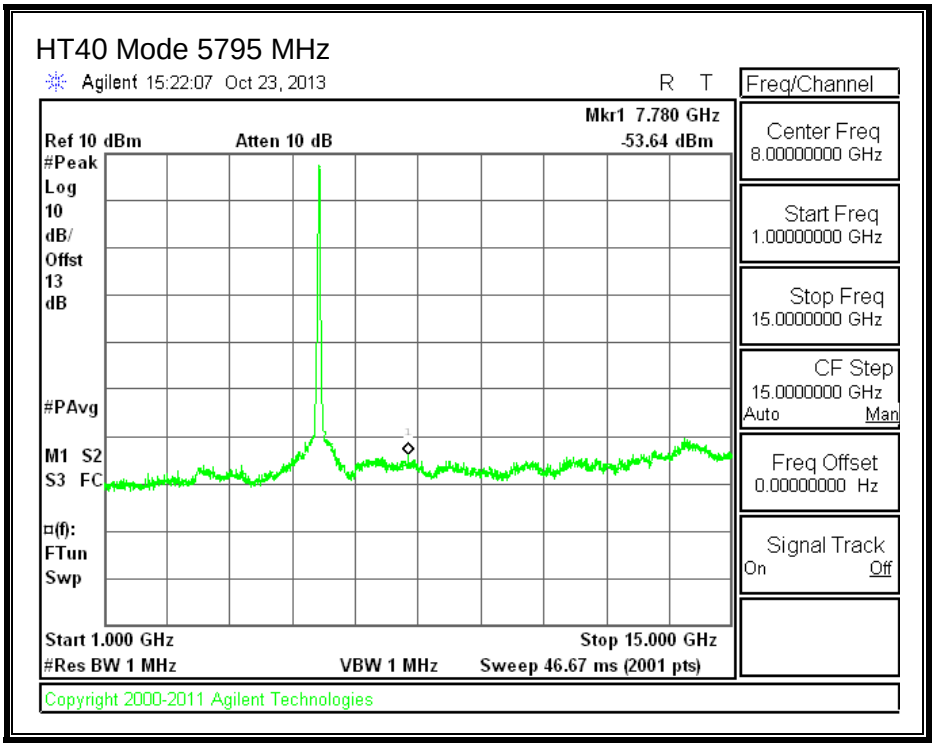




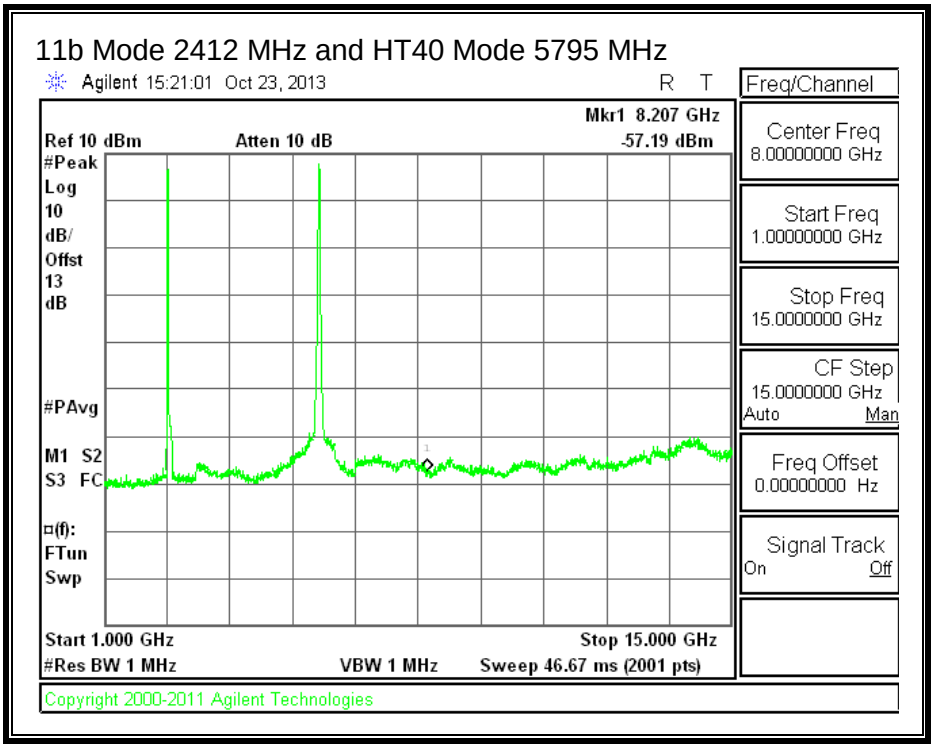
Colocation



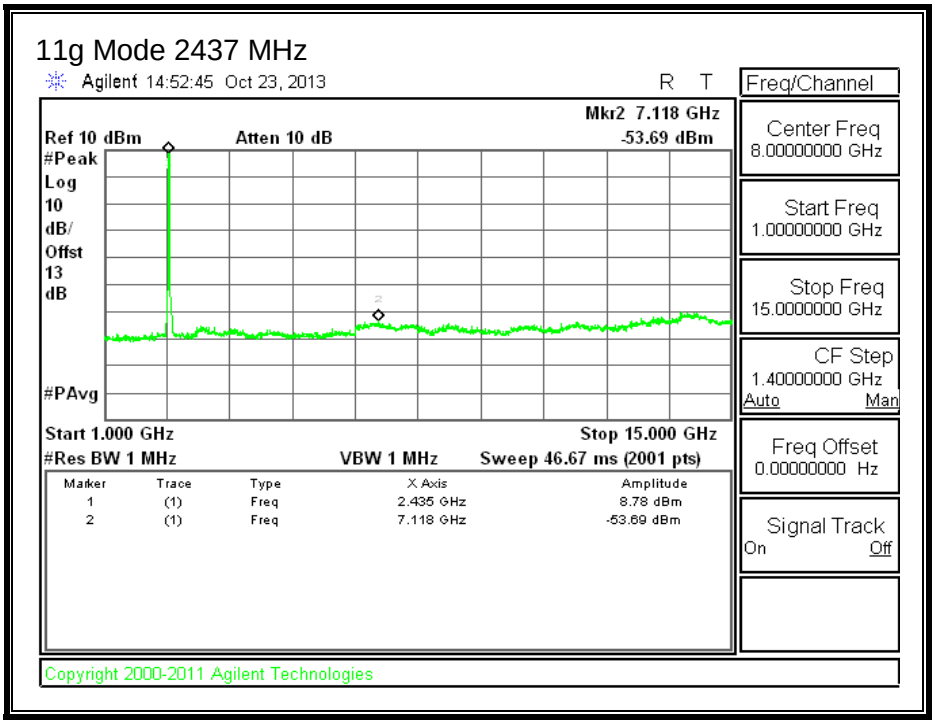


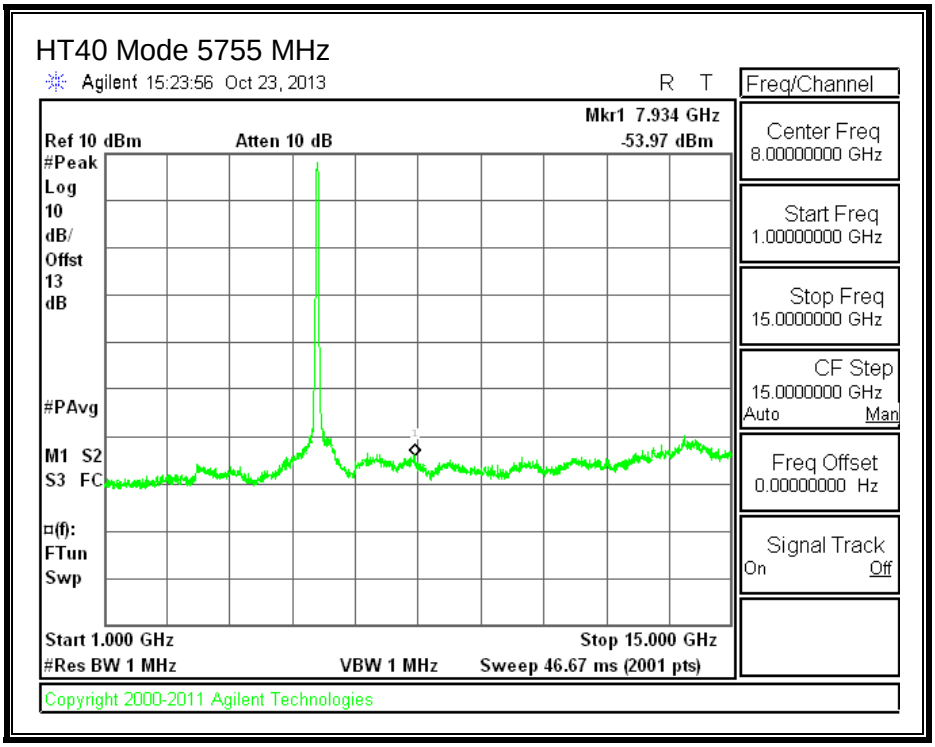


Colocation

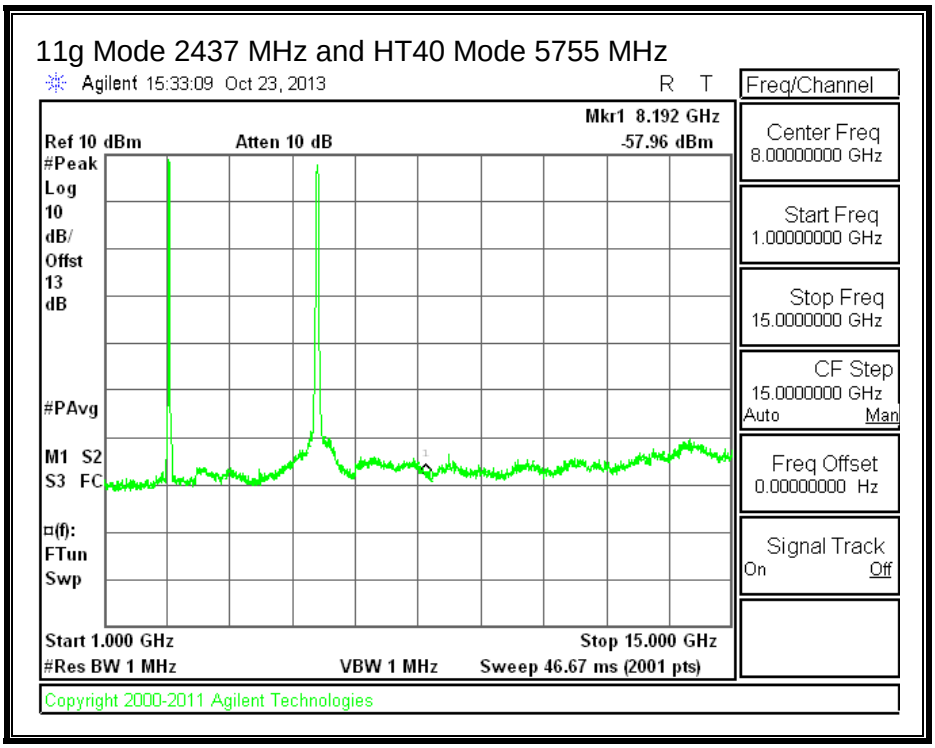


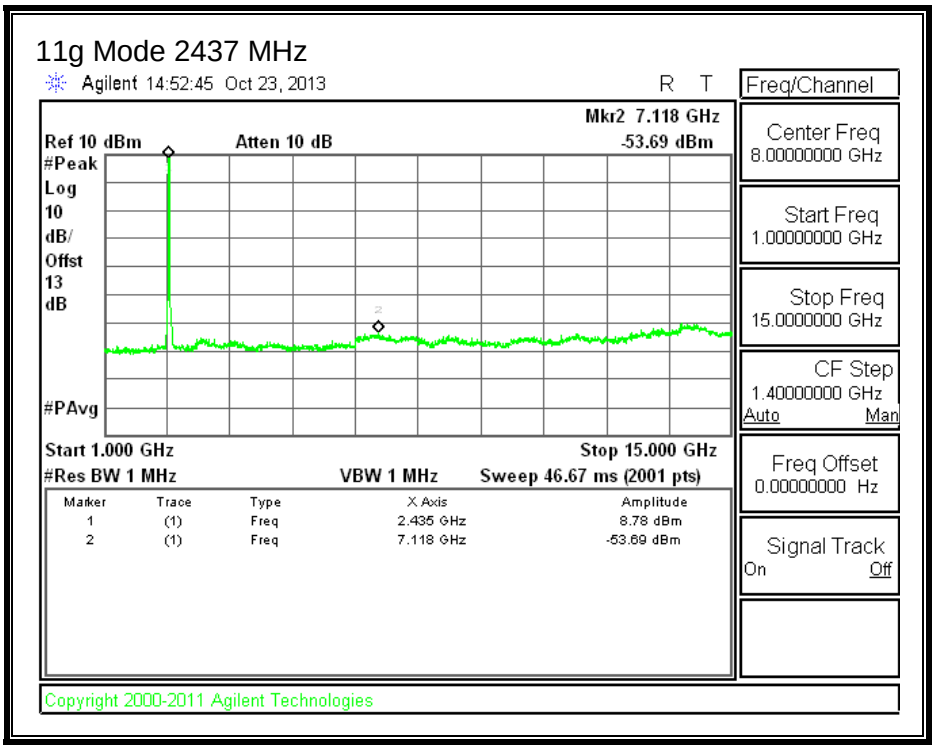
802.11g Mode 2.4 GHz and 802.11n HT40 Mode 5.8 GHz

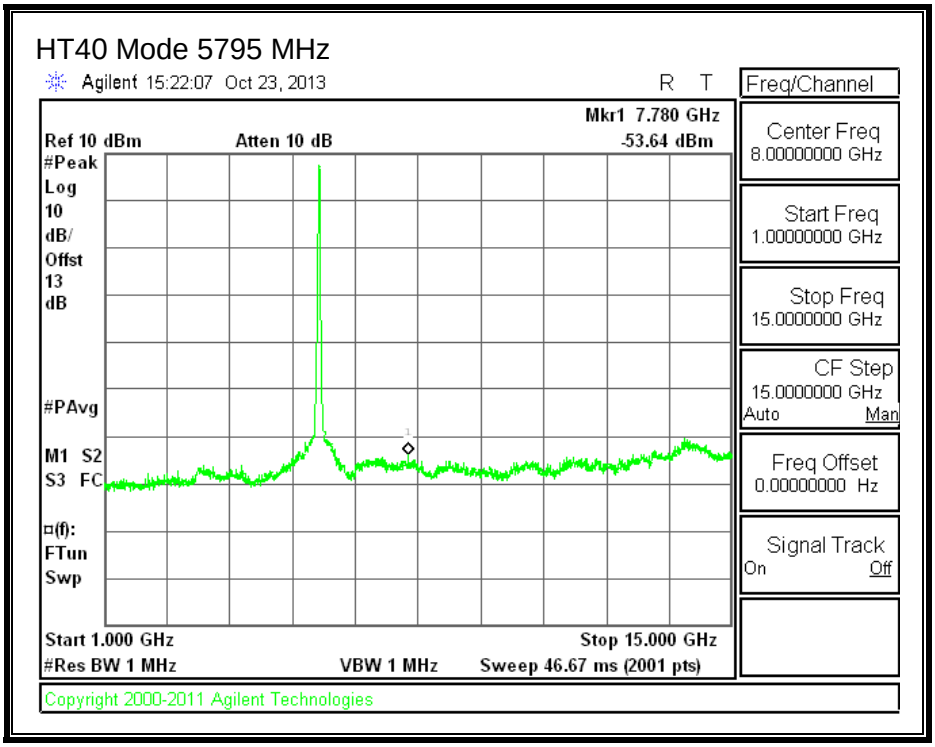




Colocation







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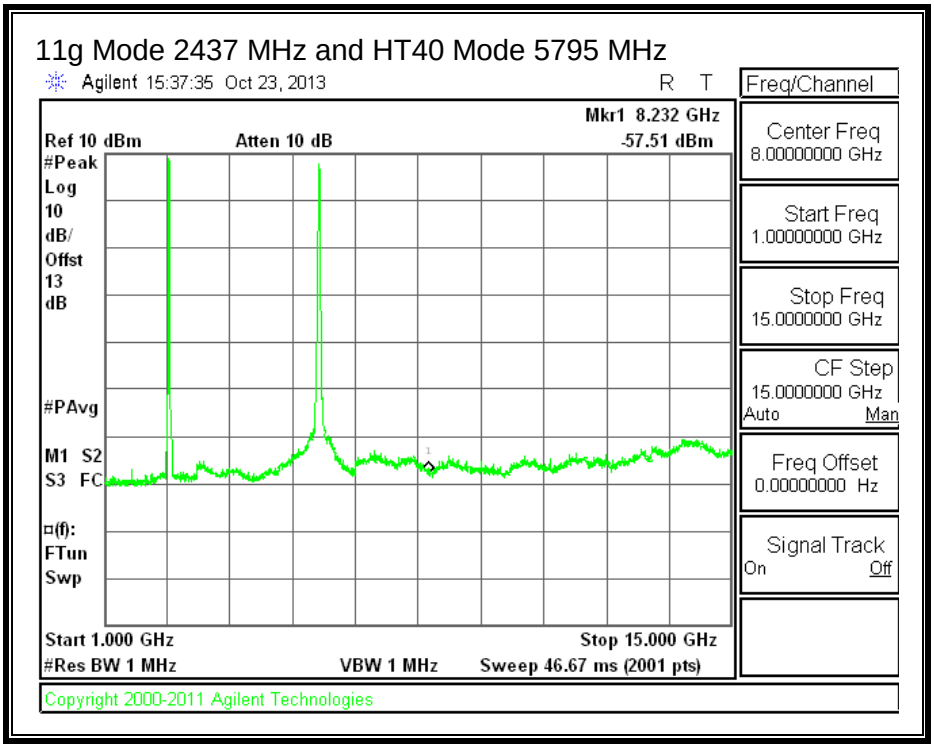


9. RADIATED TEST RESULTS

9.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209

IC RSS-210 Clause 2.6 (Transmitter)

IC RSS-GEN Clause 6 (Receiver)

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

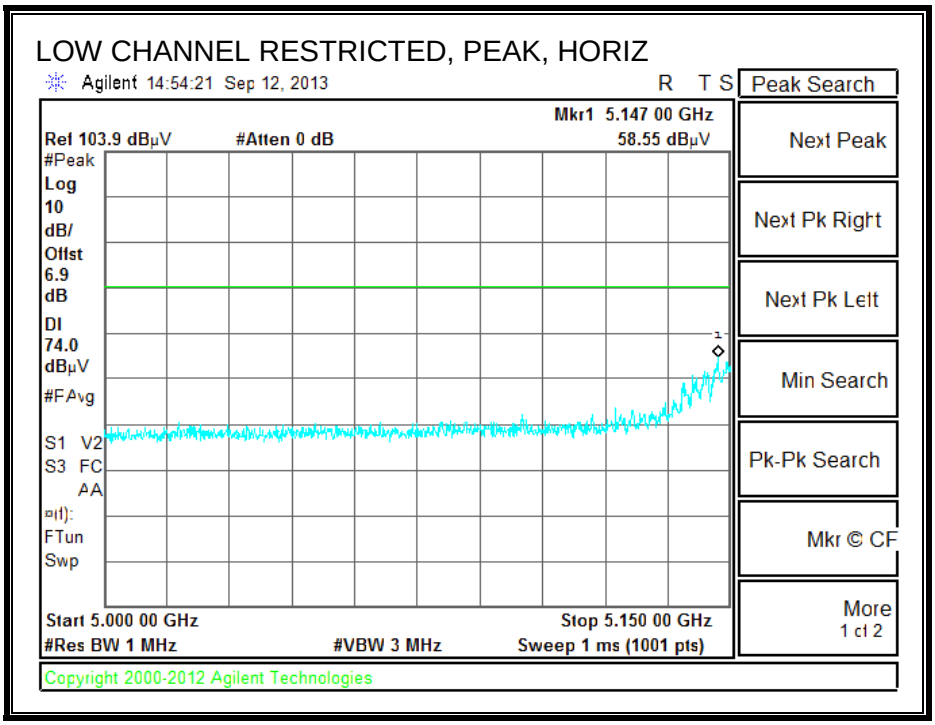
For measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements and as applicable for average measurements.

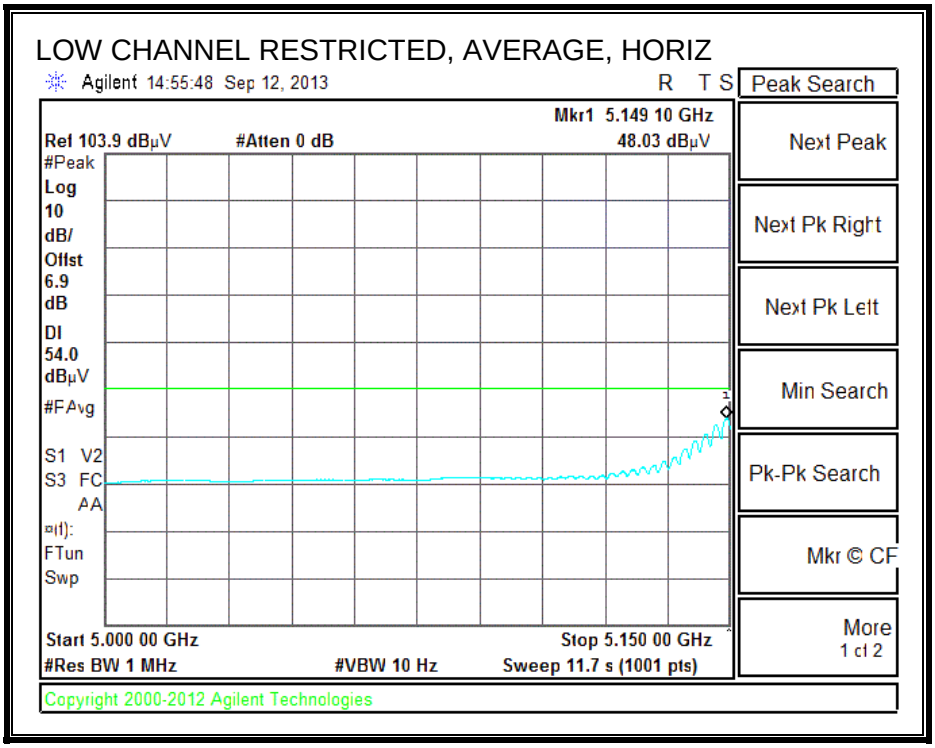
The spectrum from 30 MHz to 40 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

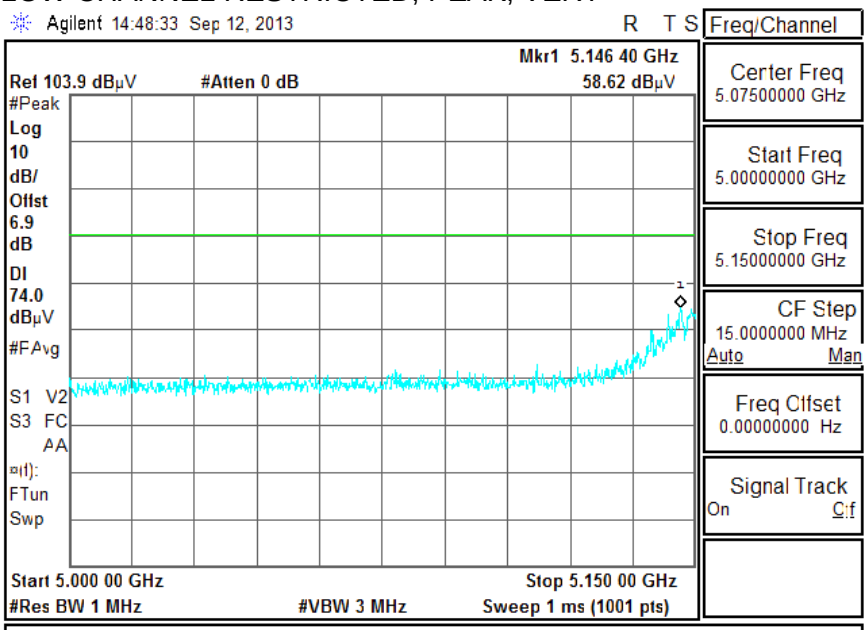
9.2. TX ABOVE 1 GHz 802.11n HT40 MODE IN THE 5.2 GHz BAND

RESTRICTED BANDEDGE (LOW CHANNEL)

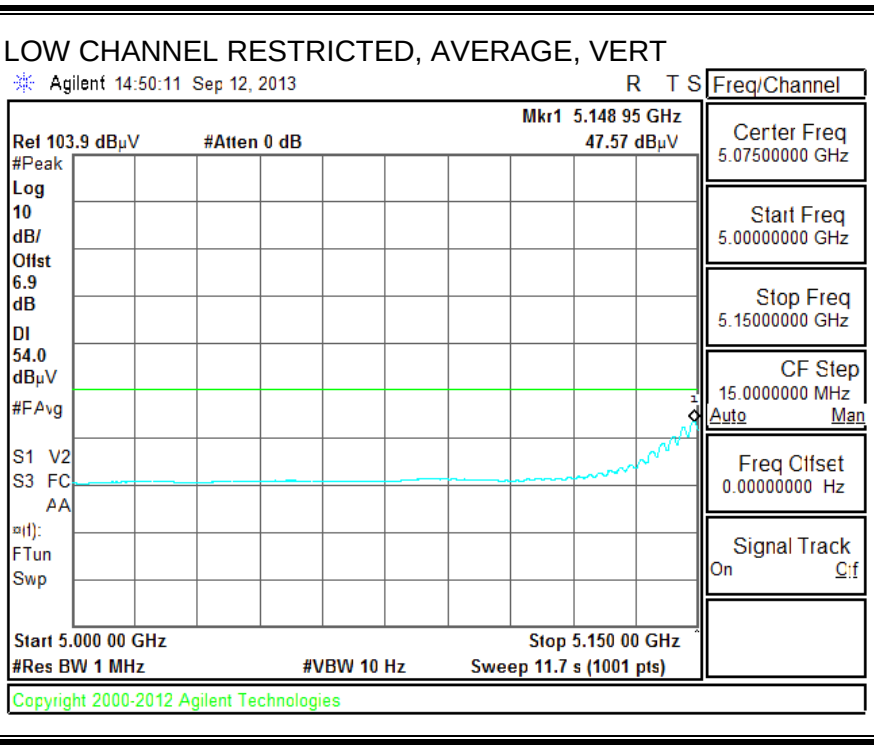




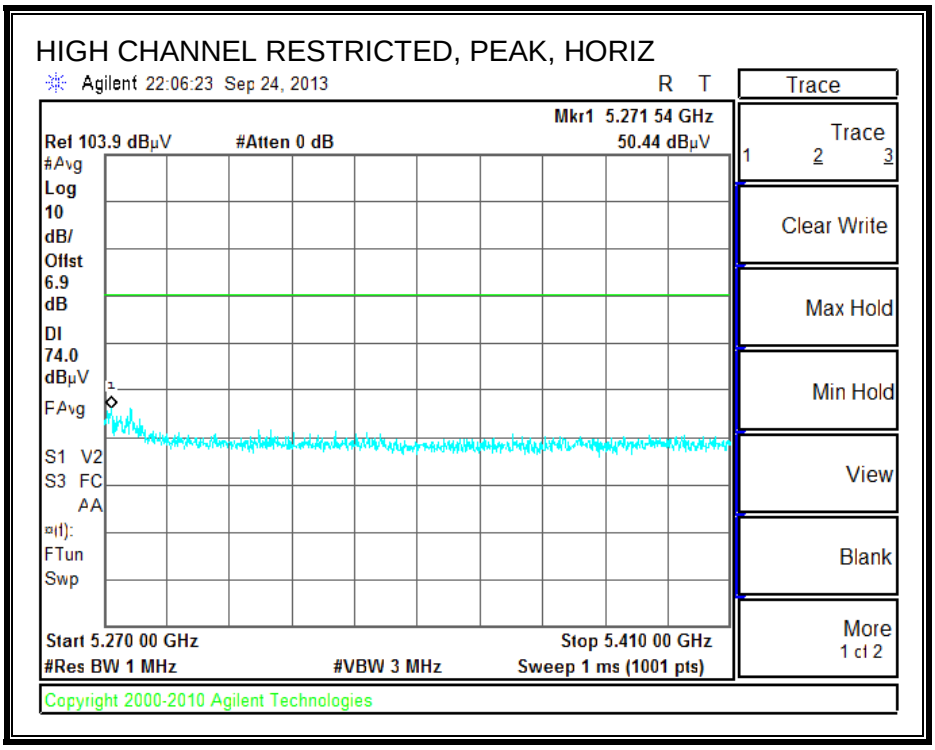
LOW CHANNEL RESTRICTED, PEAK, VERT

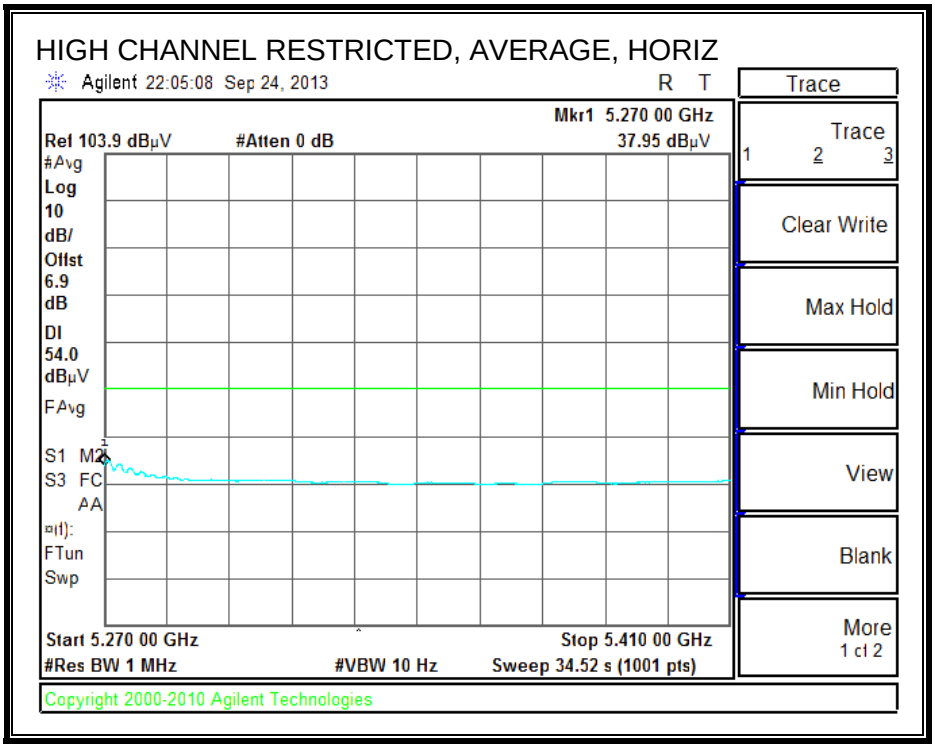


LOW CHANNEL RESTRICTED, AVERAGE, VERT

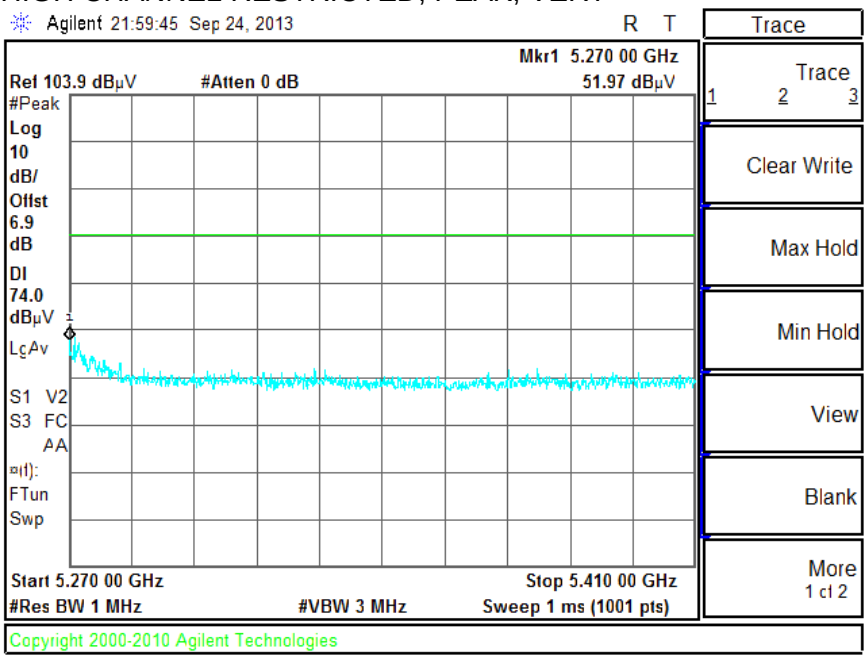


RESTRICTED BANDEDGE (HIGH CHANNEL)

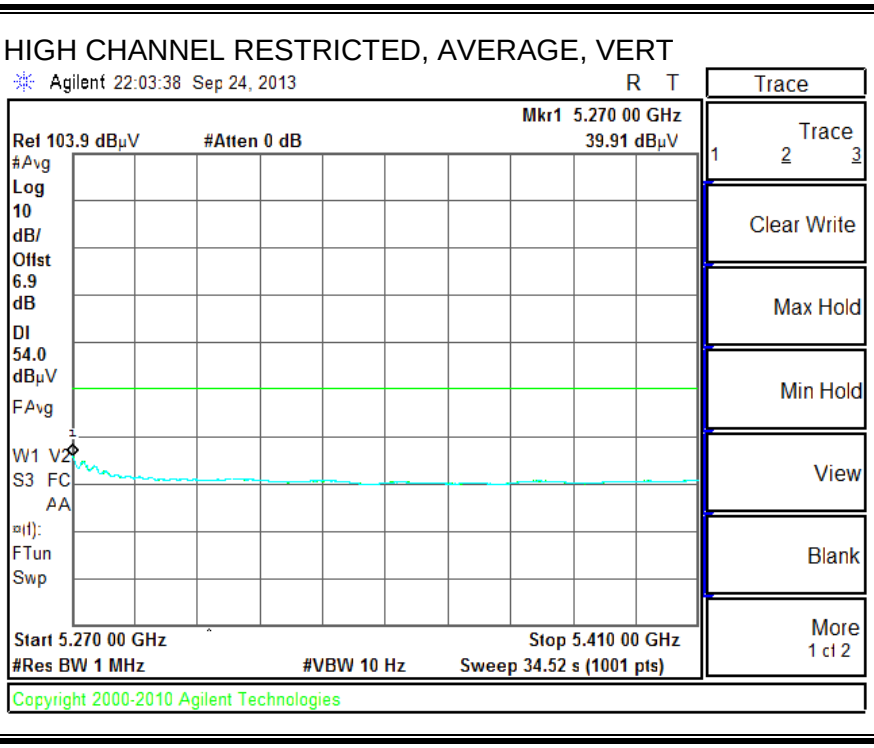




HIGH CHANNEL RESTRICTED, PEAK, VERT



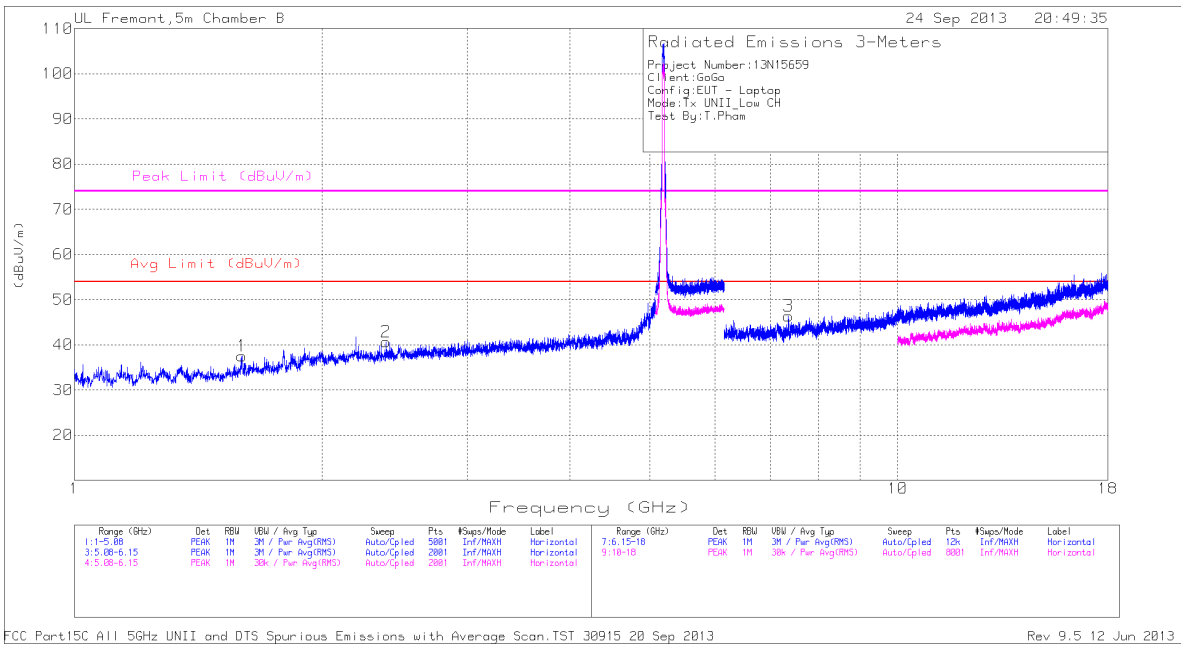
HIGH CHANNEL RESTRICTED, AVERAGE, VERT



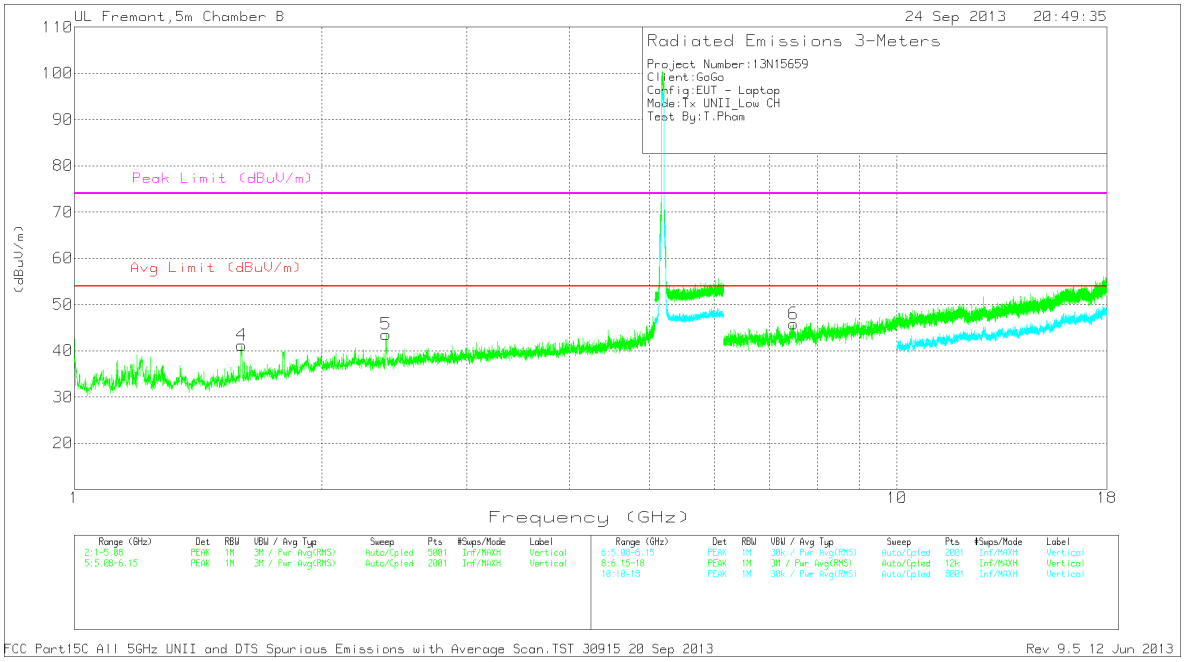
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



LOW CHANNEL HORIZONTAL AND VERTICAL DATA

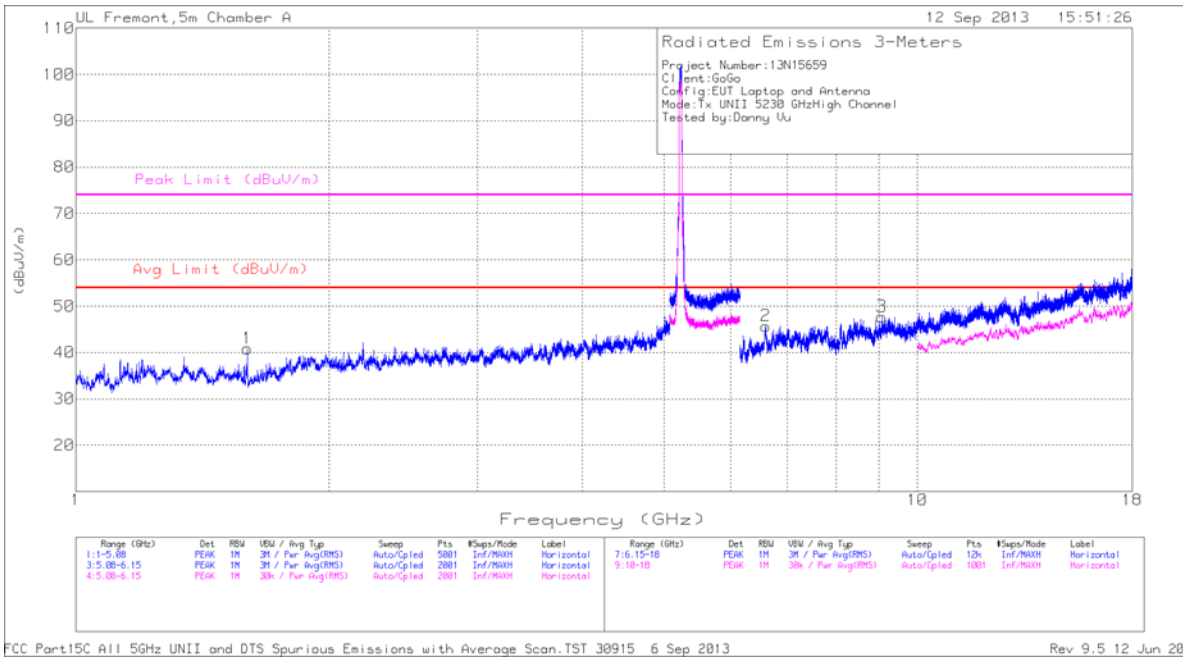
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.598	42.51	PK	28.9	-33.9	37.51	53.97	-16.46	74	-36.49	0-360	200	H
2	2.391	41.63	PK	32.3	-33.3	40.63	53.97	-13.34	74	-33.37	0-360	200	H
4	1.597	46.19	PK	28.9	-33.9	41.19	53.97	-12.78	74	-32.81	0-360	200	V
5	2.393	44.53	PK	32.3	-33.3	43.53	53.97	-10.44	74	-30.47	0-360	200	V
3	7.366	38.88	PK	35.9	-28.4	46.38	53.97	-7.59	74	-27.62	0-360	200	H
6	7.485	36.19	PK	36	-26.4	45.79	53.97	-8.18	74	-28.21	0-360	100	V

PK - Peak detector

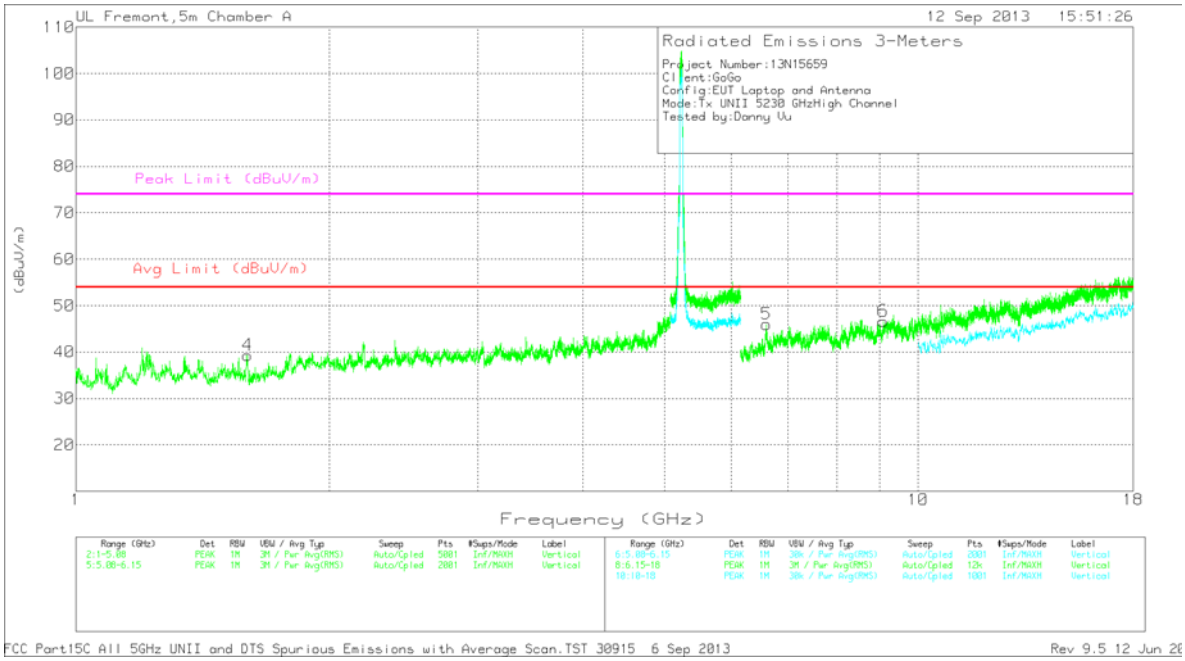
HIGH CHANNEL

HORIZONTAL PLOT



HIGH CHANNEL

VERTICAL PLOT



VERTICAL AND HORIZONTAL DATA

Trace Markers

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T136 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1599	46.96	PK	28.3	-34.4	40.86	53.97	-13.11	74	-33.14	0-360	200	H
1599	45.38	PK	28.3	-34.4	39.28	53.97	-14.69	74	-34.72	0-360	100	V
6.604	35.22	PK	35.5	-25	45.72	53.97	-8.25	74	-28.28	0-360	100	H
9.071	36.43	PK	36	-24.7	47.73	53.97	-6.24	74	-26.27	0-360	100	H
6.604	35.51	PK	35.5	-25	46.01	53.97	-7.96	74	-27.99	0-360	200	V
9.09	35.65	PK	36	-25	46.65	53.97	-7.32	74	-27.35	0-360	200	V

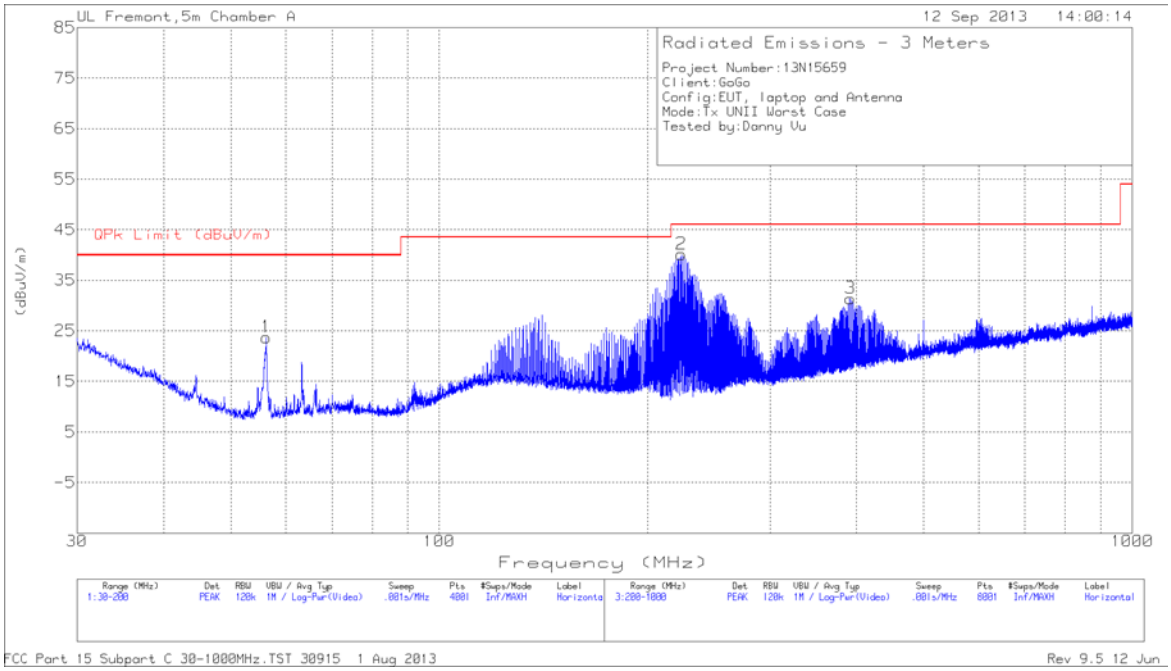
PK - Peak detector

FCC Part15C All 5GHz UNII and DTS Spurious Emissions with Average Scan.TST 30915 6 Sep 2013 Rev 9.5 12 Jun 2013

9.3. WORST-CASE BELOW 1 GHz

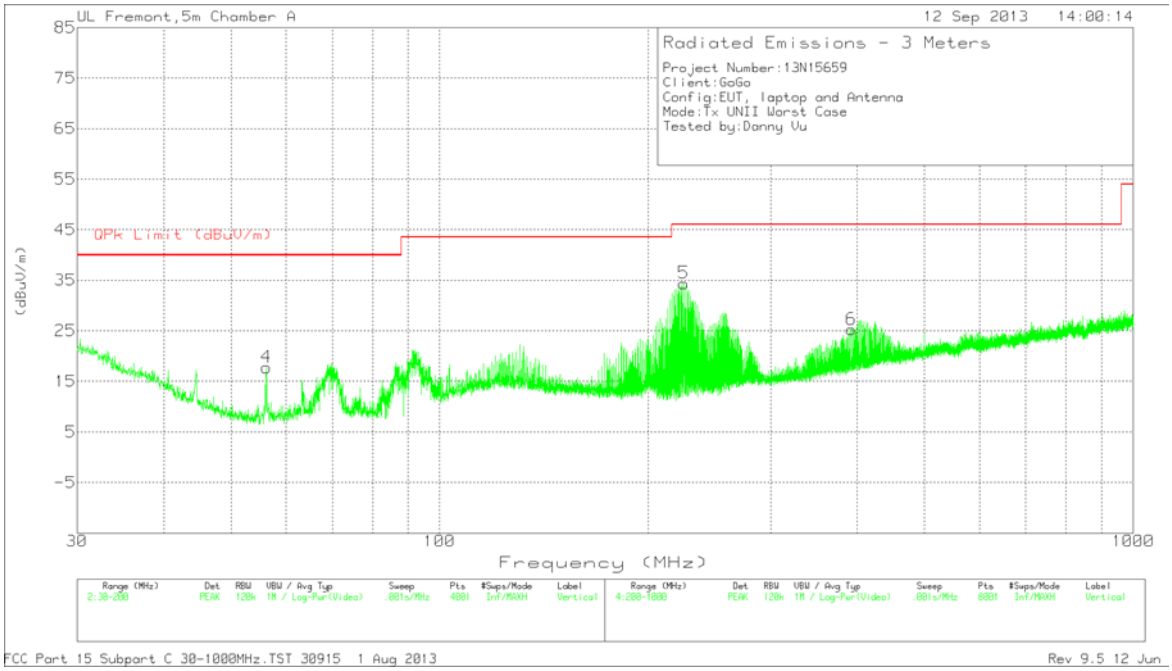
SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, HORIZONTAL)

HORIZONTAL PLOT



SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, VERTICAL)

VERTICAL PLOT



HORIZONTAL AND VERTICAL DATA

Trace Markers

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T477 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
56.265	43.99	PK	7	-27.3	23.69	40	-16.31	0-360	300	H
56.265	38.08	PK	7	-27.3	17.78	40	-22.22	0-360	100	V
223.5	55.52	PK	10.6	-26	40.12	46.02	-5.9	0-360	100	H
392.2	41.17	PK	15.2	-25	31.37	46.02	-14.65	0-360	100	H
225	49.68	PK	10.7	-26	34.38	46.02	-11.64	0-360	200	V
392.3	35.06	PK	15.2	-25	25.26	46.02	-20.76	0-360	300	V

PK - Peak detector

FCC Part 15 Subpart C 30-1000MHz.TST 30915 1 Aug 2013 Rev 9.5 12 Jun 2013