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Emissions
Test Report

EUT Name: Newcastle, Newport

Model No.: FS1E5, FS1E5W, FS2E5, FS2E5W

CFR 47 Part 15.407:2009 and RSS 210: 2010

Prepared for:

Denny Lim
WatchGuard Technologies, Inc
505 Fifth Ave S, Suite 500
Seattle, WA 98104
Tel: 206-613-6600

Prepared by:

TUV Rheinland of North America, Inc.
1279 Quarry Lane
Pleasanton, CA 94566
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

Report/Issue Date: November 16, 2011
Report Number: 31152150.003

Statement of Compliance

Manufacturer:	WatchGuard Technologies. Inc
Requester / Applicant:	505 Fifth Ave S, Suite 500
Name of Equipment:	Newcastle, Newport
Model No.	FS1E5, FS1E5W, FS2E5, FS2E5W
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.407:2009 and RSS 210: 2010
Test Dates:	30 August 2011 to 29 September 2011

Guidance Documents:

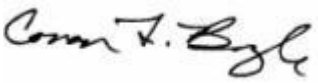
Emissions: ANSI C63.10-2009

Test Methods:

Emissions: ANSI C63.10-2009

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by NVLAP or any agency of the U.S. Government. This report contains data that are not covered by NVLAP accreditation. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.



Suresh Kondapalli		Conan Boyle	
Test Engineer	Date November 16, 2011	NVLAP Signatory	Date November 16, 2011

500011-0 **US5254** **2932M-1**

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.407:2009 and RSS 210: 2010 based on the results of testing performed on August 30 – September 29, 2011, on the Newcastle, Newport Model FS1E5, FS1E5W, FS2E5, FS2E5W manufactured by WatchGuard Technologies This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4	Test Parameters (from Standard)	Result
Spurious Emission in Received Mode	CFR47 15.109, RSS-GEN Sect.7.2.3	Class A	**Complied**
Spurious Emission in Transmitted Mode	CFR47 15.209, CFR47 15.407 (b) RSS-GEN Sect.7.2.3, RSS 210 Sect. A.9.2	Class B	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS 210 Sect.2.6	Class B	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.7.2.2	Class B	**Complied**
Occupied Bandwidth	CFR47 15.407 (a), RSS GEN Sect.4.4.1	≥ 500 kHz	**Complied**
Maximum Output Power	CFR47 15.407 (a), RSS 210 Sect. A.9.2	Band 1: 16.97 dBm Band 2&3: 23.97 dBm	**Complied**
Peak Power Spectral Density	CFR47 15.407 (a), RSS 210 Sect. A.9.2	Band 1: 4 dBm/MHz Band 2&3: 11 dBm/MHz	**Complied**
Peak Excursion Ratio	CFR47 15.407 (a)(6)	< 13 dB	**Complied**
Conducted Emission – Antenna Port	CFR47 15.407 (b), RSS 210 Sect.6.2.2	30 MHz -40 GHz < 27 dBm/MHz	**Complied**
Frequency Stability	CFR47 15.407 (g), RSS GEN Sect. 4.7.	±20 ppm	**Complied**
Dynamic Frequency Selection	CFR47 15.407 (h) (iii), RSS 210 Sect. A.9.3	CMT – 10 s CCTT – 260 ms	**Complied**

Note: Since EUT is portable device where the end user will have the direct contact, RF exposure/ SAR testing is required. This test completed separately.

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Lane, Ste. A, Pleasanton, CA 94566 is recognized by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US5254). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / NVLAP

TUV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2005 and ISO 9002 (Lab Code 500011-0). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M-1). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America at 1279 Quarry Lane, Ste. A, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures. (Registration Nos. R-3715, G-460, C-4161 and T-1189).

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Lane, Ste. A, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / NVLAP accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA. The 2305 Mission College, Santa Clara, 95054, USA location is considered a Pleasanton annex.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2009, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by NVLAP (Lab Code 500011-0). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2009, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.2.2 Immunity Test Facility

ESD, EFT, Surge, PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty

	U_{lab}	U_{cispr}
Radiated Disturbance		
30 MHz – 40,000 MHz	3.2 dB	5.2 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	2.4 dB	3.6 dB
Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.5 dB

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 1.59 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 4.01 dB

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The WatchGuard Newport XTM 2 series is network security device with Firewall Access Point (AP) provides 10/100/1000Mb wired and 802.11n wireless network.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In case of an EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

The final operating mode was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.4 Unique Antenna Connector

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.219, or 15.221.

3.4.1 Results

The Newcastle, Newport has three external Omni directional antennae. All external antennae use reversed SMA connector.

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.407: 2009 and RSS 210 Annex 9: 2010. These test methods are listed under the laboratory's NVLAP Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

The maximum output power and harmonics shall not exceed CFR47 Part 15.407 (a):2009 and RSS 210 A9.2: 2010.

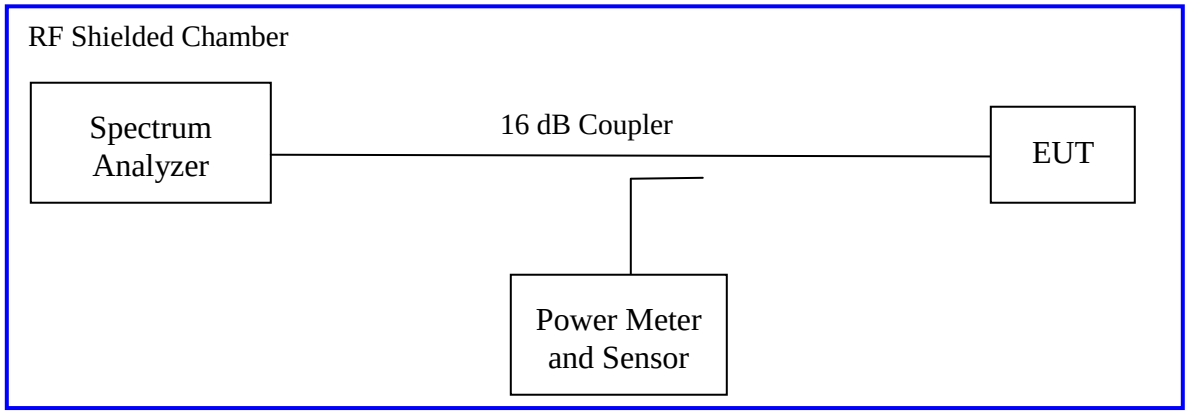
The maximum transmitted powers are

Band 5150-5250 MHz:50 mW or 4 dBm + 10Log B.

4.1.1 Test Method

The ANSI C63.10-2009 Section 6.10.3.1 conducted method was used to measure the channel power output. The preliminary investigation was performed at different data rate/ chain to determine the highest power output for each mode. The worst findings were conducted on 3 channels in each operating range per CFR47 Part 15.407(a): 2009 and RSS 210 A.9.2; 5150 MHz to 5250 MHz.The worst mode results indicated below.

Test Setup:



Method #1 of "Measurement of Digital Transmission Systems Operating under Section 15.247"applies since the EUT continuously transmit; where T, Transmission Duration Pulse, is greater than analyzer sweep time. Sample detector was used.

Each chain was measured individually and applied the measure-and-sum approach per KDB66291.

4.1.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 2: RF Output Power at the Antenna Port – Test Results

Test Conditions: Conducted Measurement, Normal Temperature						
Antenna Type: 3 External			**Power Setting:** See test plan			
Max. Antenna Gain: + 2.0 dBi			**Signal State:** Modulated at 100%.			
Ambient Temp.: 21 °C			**Relative Humidity:**39%			
802.11a Mode, 1x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5180	16.97	14.49	15.85	14.00		-1.12
5220	16.97	15.05	15.73	14.56		-1.24
5240	16.97	15.02	15.66	14.86		-1.31
Note: The highest output power was observed at 6 Mbps.						
802.11n (HT20) Mode, 1x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5180	16.97	15.47	15.97	13.79		-1.00
5220	16.97	15.87	15.92	14.45		-1.05
5240	16.97	15.63	15.72	14.74		-1.15
Note: The highest output power was observed at HT20 6.5 Mbps, 1 Data Stream.						
802.11n (HT20) Mode, 2x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5180	16.97	9.58	12.21		14.09	-2.07
5220	16.97	8.87	11.09		13.12	-3.85
5240	16.97	9.03	10.88		13.09	-3.86
Note: The highest output power was observed at HT20 13 Mbps, 2 Data Streams.						

802.11n (HT20) Mode, 3x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5180	16.97	12.55	10.32	7.43	15.38	-1.57
5220	16.97	11.61	9.66	8.06	14.78	-2.17
5240	16.97	11.72	9.65	7.57	14.74	-2.23
Note: The highest output power was observed at HT20 19.5 Mbps, 3 Data Streams.						
802.11n (HT40) Mode, 1x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5190	16.97	12.64	12.29	11.29		-4.33
5230	16.97	12.74	12.99	12.33		-3.98
Note: The highest output power was observed at HT40 13.5 Mbps, 1 Data Stream.						
802.11n (HT40) Mode, 2x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5190	16.97	12.22	10.87		14.06	-2.91
5230	16.97	12.79	10.59		14.83	-2.14
Note: The highest output power was observed at HT40 27 Mbps, 2 Data Streams.						
802.11n (HT40) Mode, 3x3						
Operating Channel	**Limit [dBm]**	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**Total Power [dBm]**	**Margin [dB]**
5190	16.97	9.30	11.10	8.13	14.45	-2.52
5230	16.97	9.44	10.46	8.34	14.26	-2.71
Note: The highest output power was observed at HT40 40.5 Mbps, 3 Data Streams.						

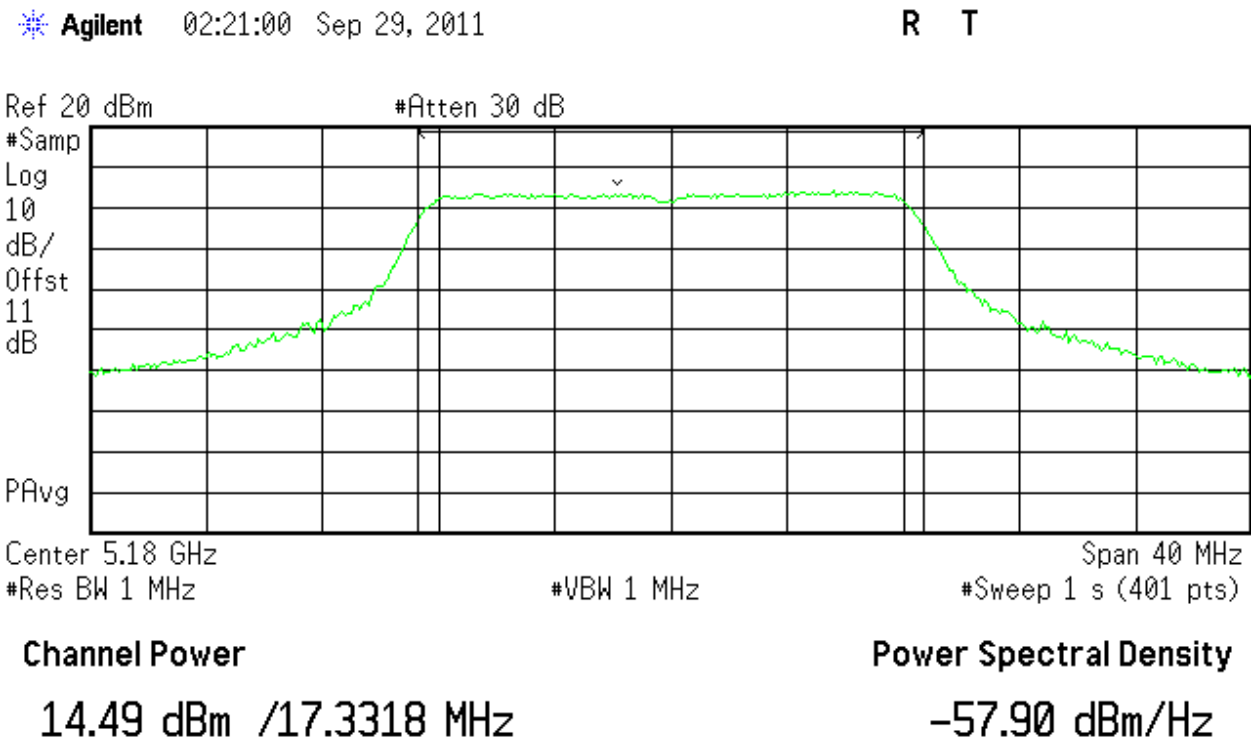


Figure 1: Maximum Transmitted Power, 5180 MHz at 802.11a, Chain 0

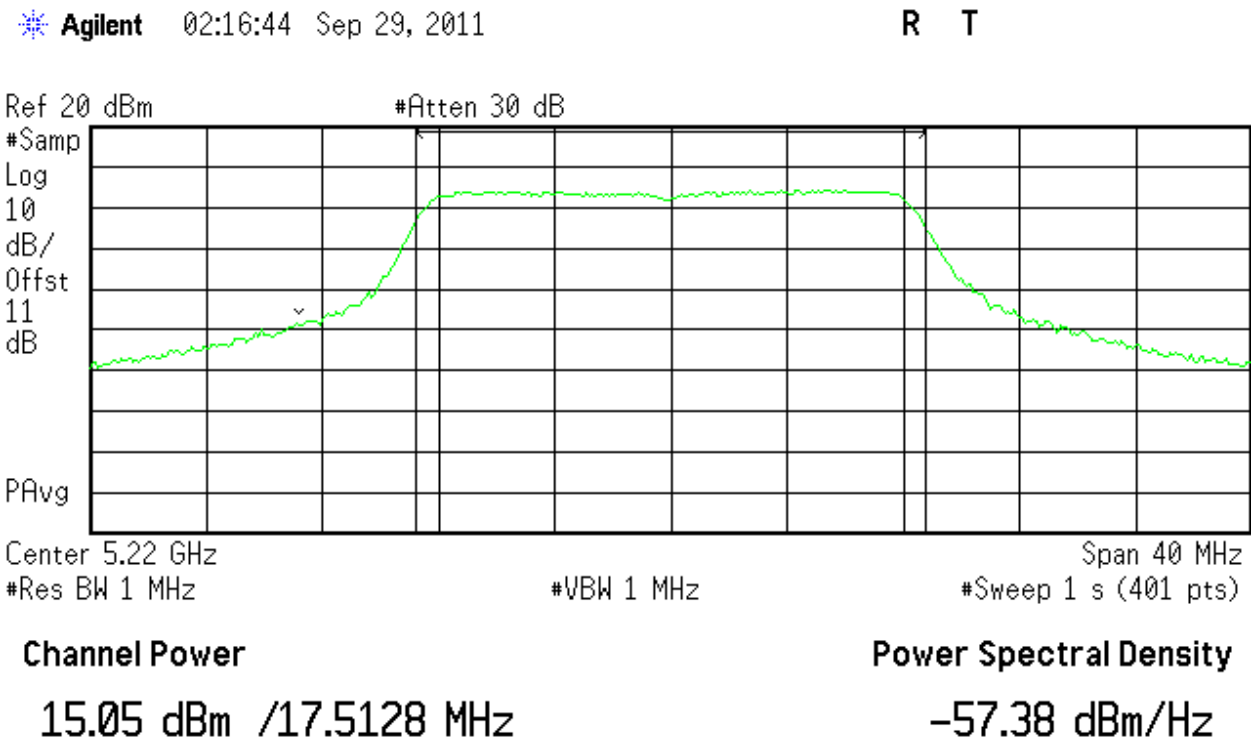


Figure 2: Maximum Transmitted Power, 5220 MHz at 802.11a, Chain 0

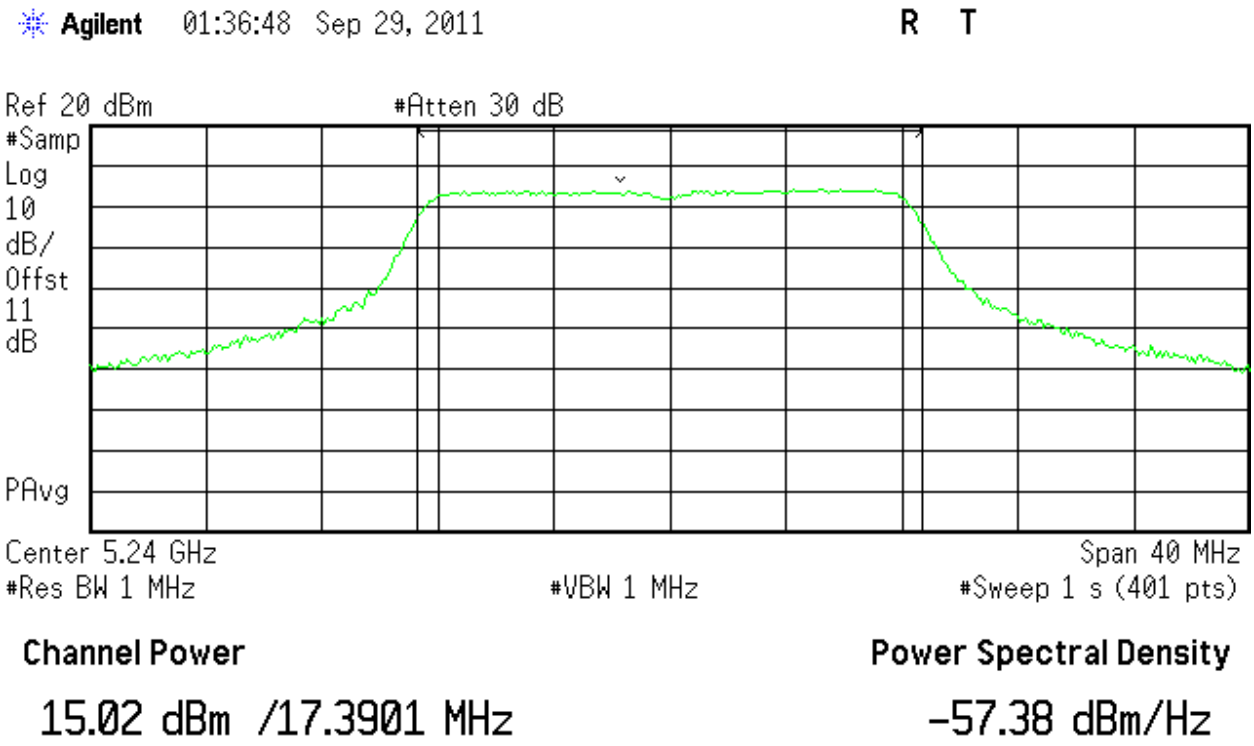


Figure 1: Maximum Transmitted Power, 5240 MHz at 802.11a, Chain 0

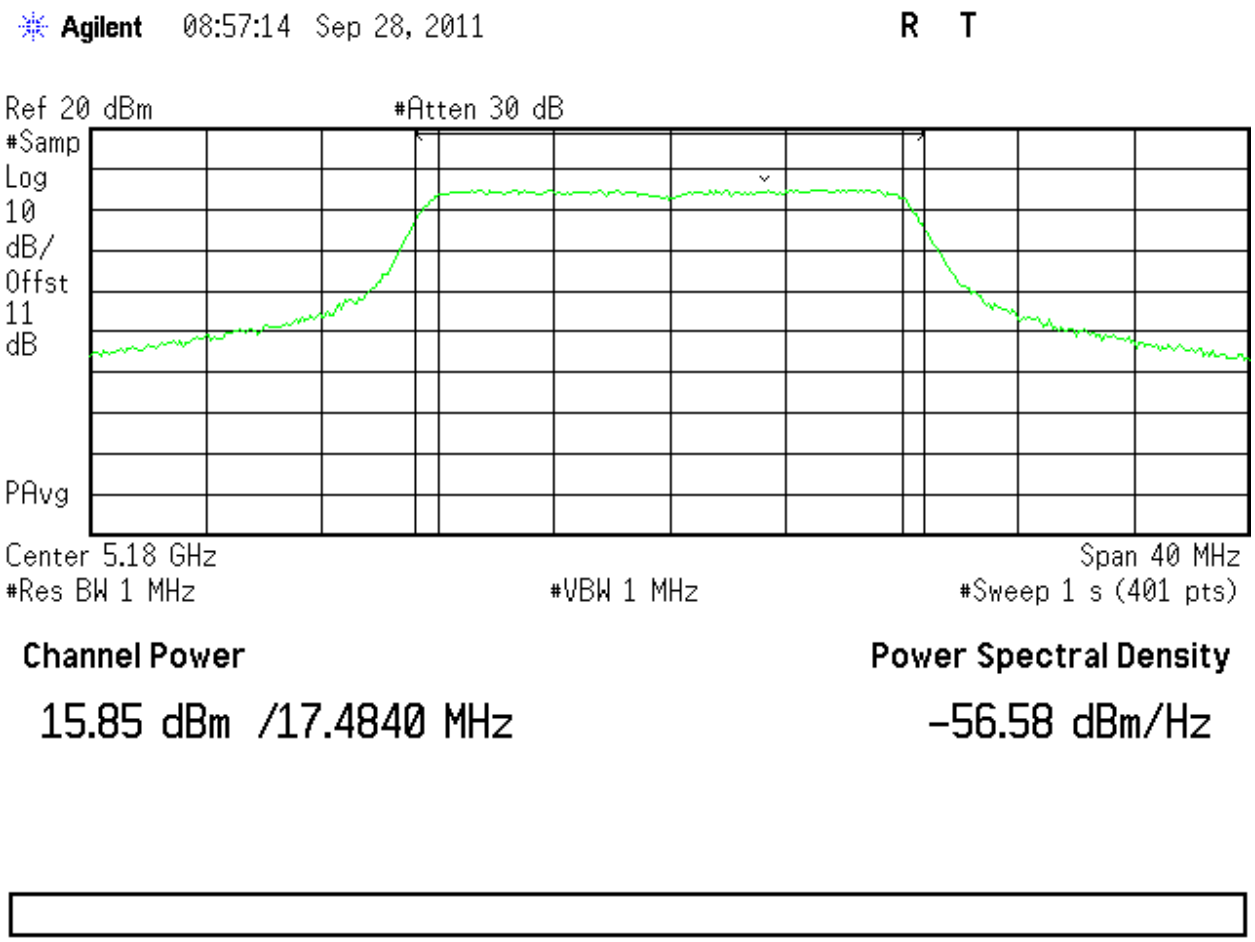


Figure 2: Maximum Transmitted Power, 5180 MHz at 802.11a, Chain 1

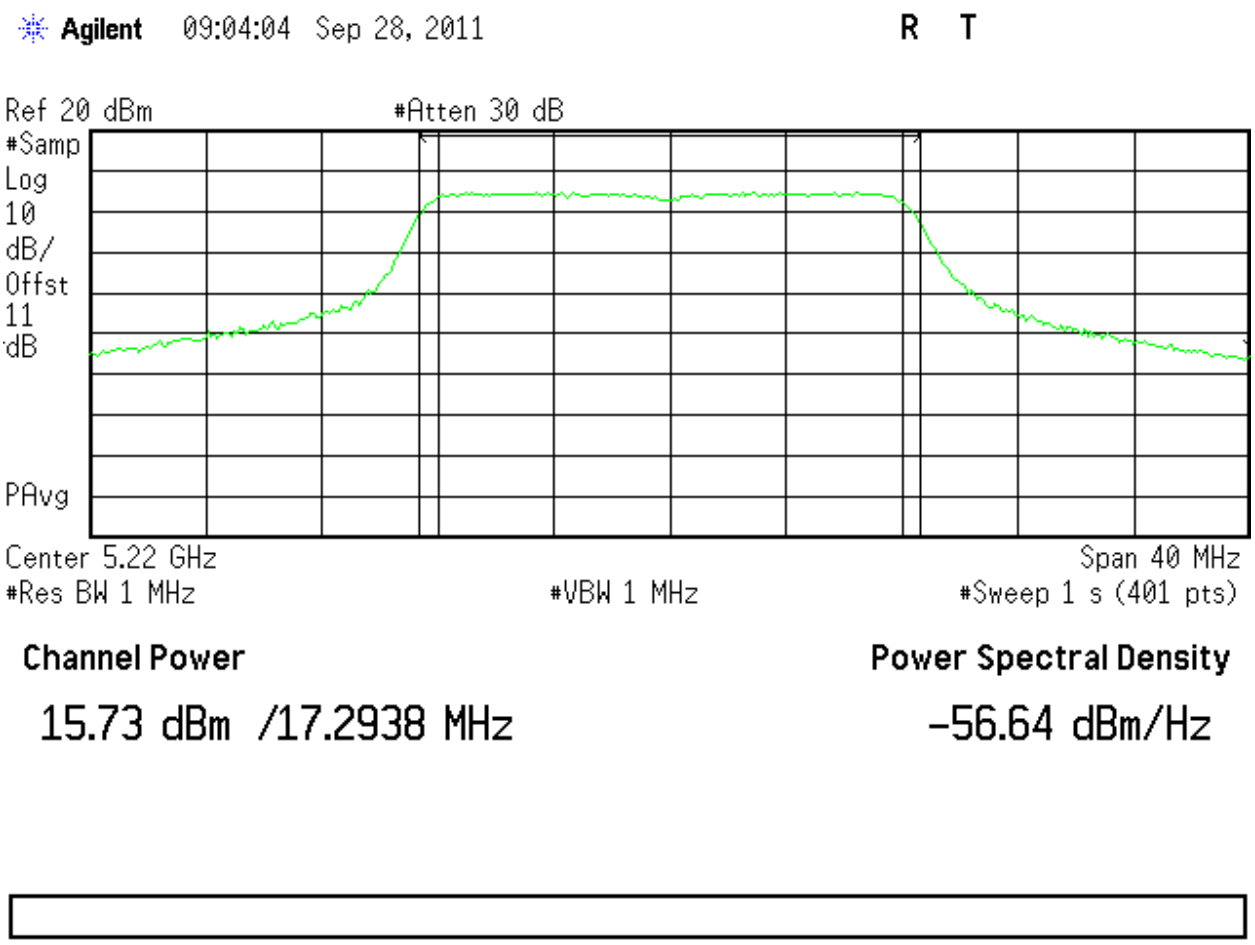


Figure 3: Maximum Transmitted Power, 5220 MHz at 802.11a, Chain 1

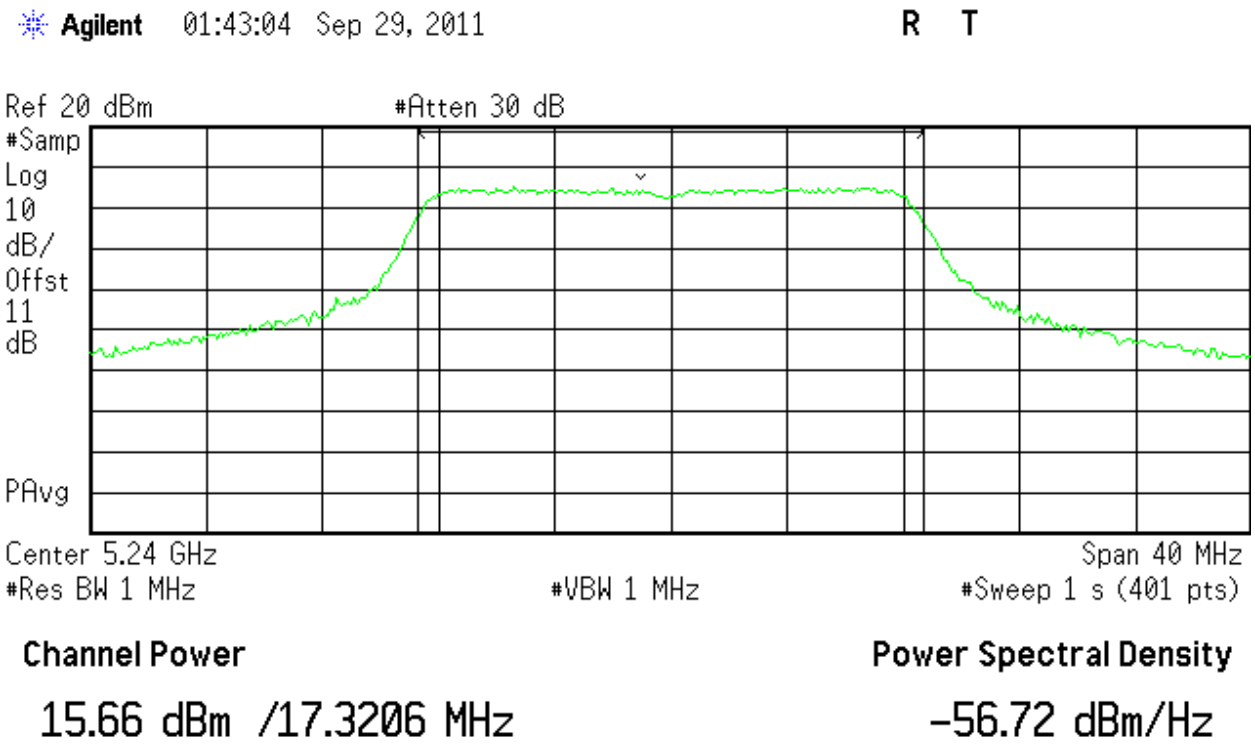


Figure 4: Maximum Transmitted Power, 5240 MHz at 802.11a, Chain 1

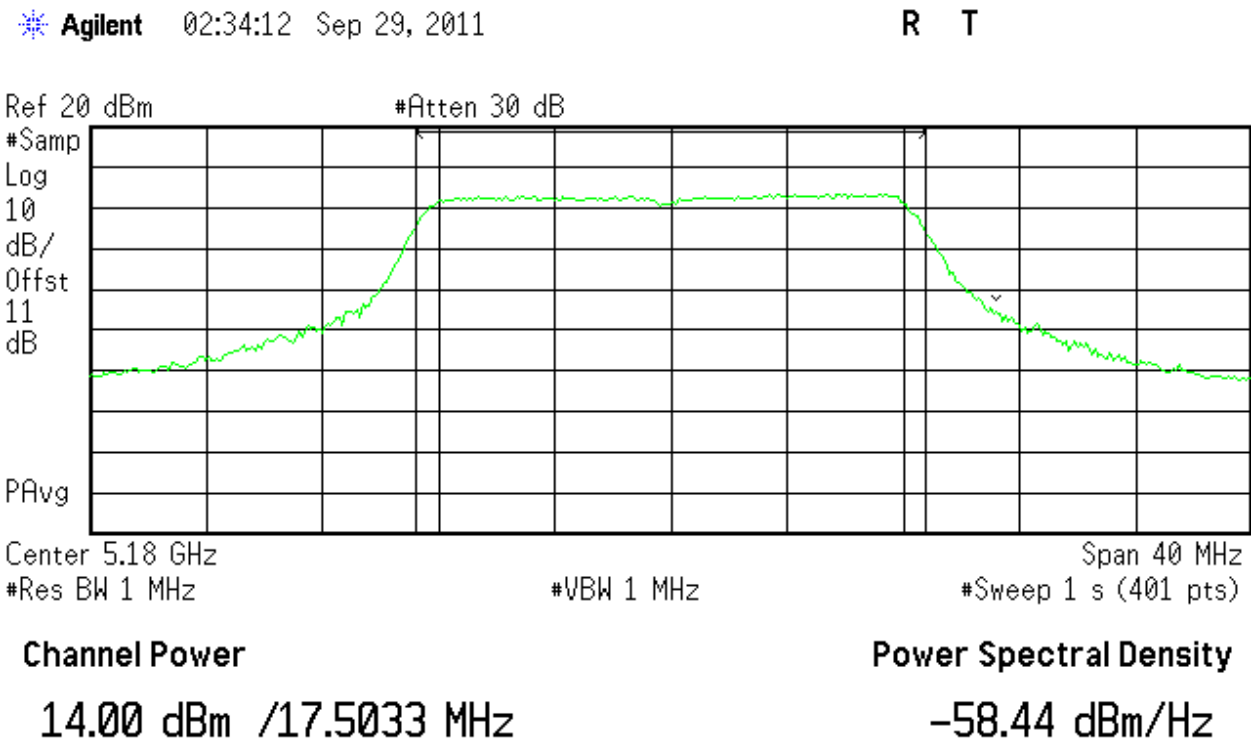


Figure 5: Maximum Transmitted Power, 5180 MHz at 802.11a, Chain 2

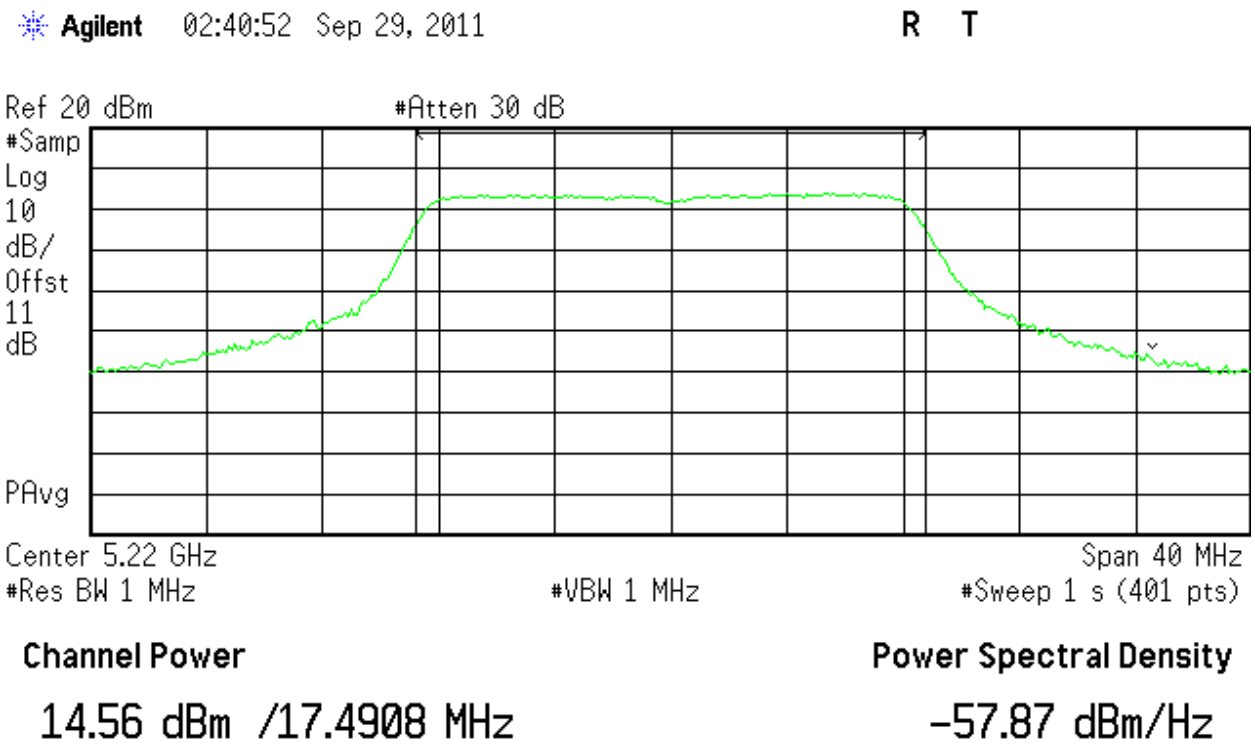


Figure 6: Maximum Transmitted Power, 5220 MHz at 802.11a, Chain 2

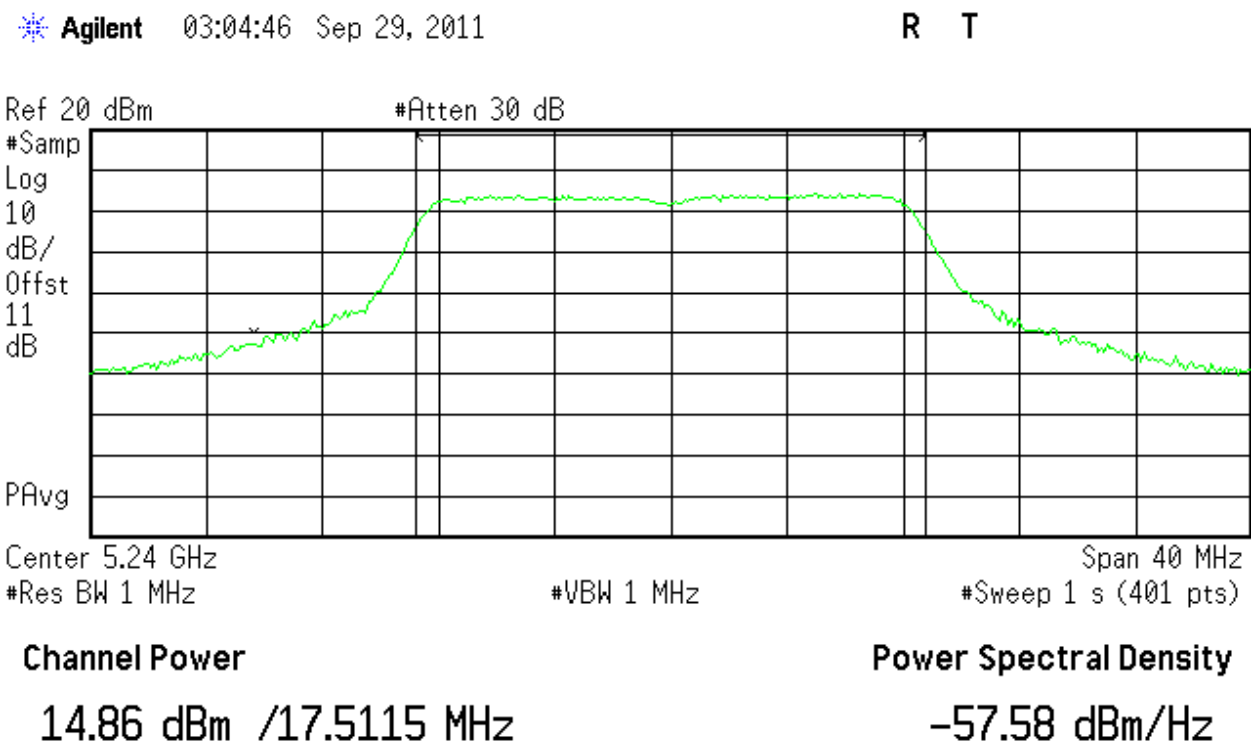


Figure 7: Maximum Transmitted Power, 5240 MHz at 802.11a, Chain 2

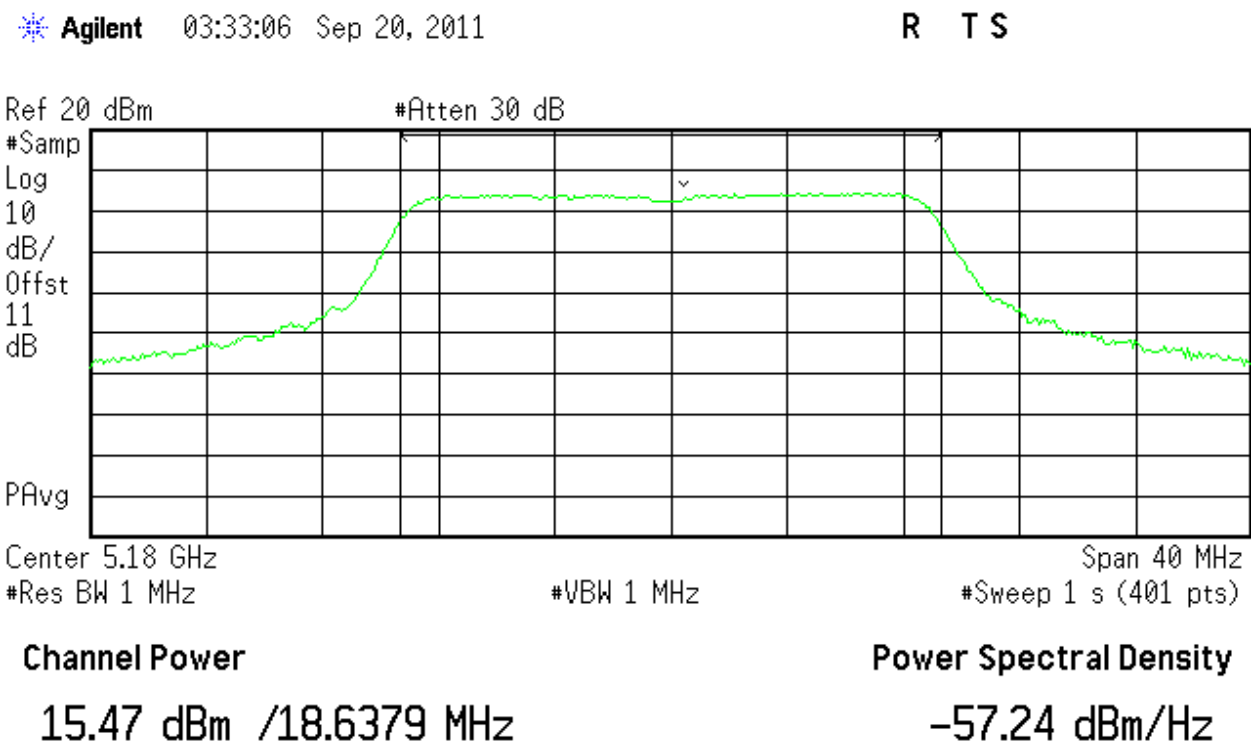


Figure 8: Maximum Transmitted Power, 5180 MHz at 802.11n HT20, Chain 0 – 6.5Mbps

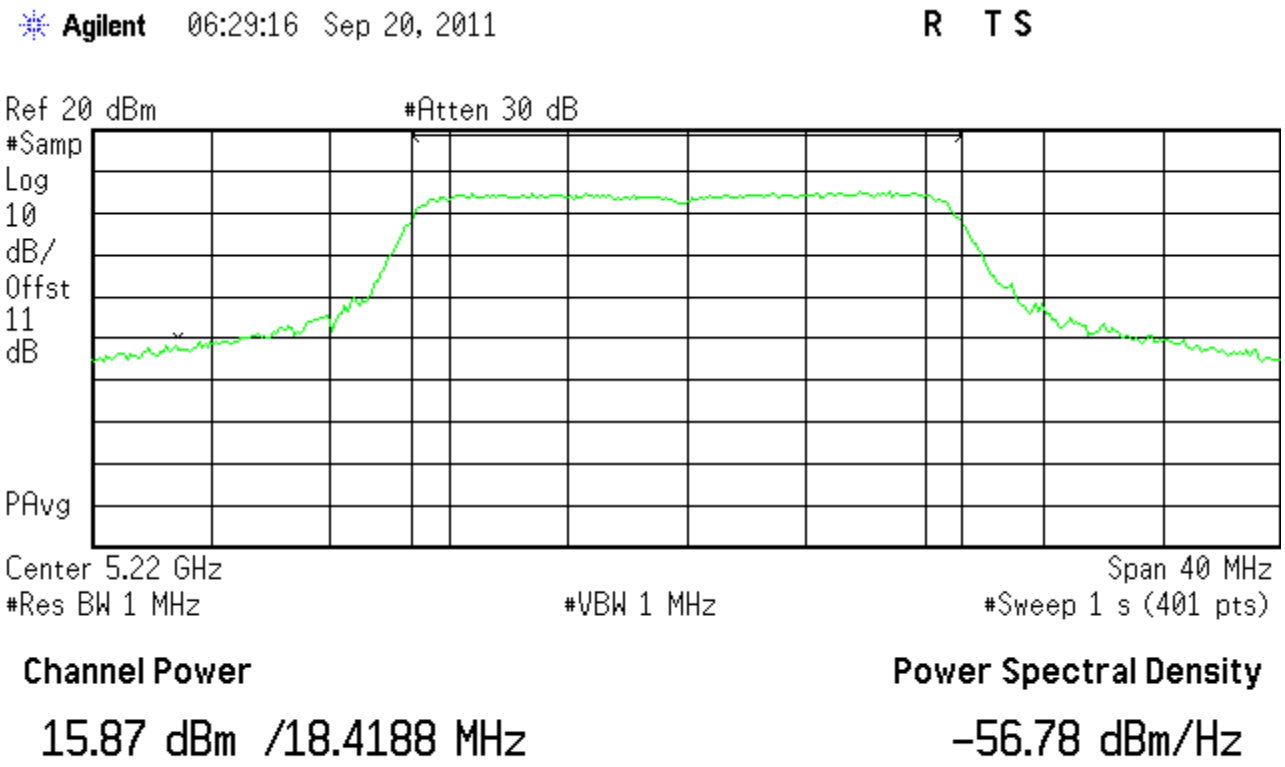


Figure 9: Maximum Transmitted Power, 5220 MHz at 802.11n HT20, Chain 0 – 6.5Mbps

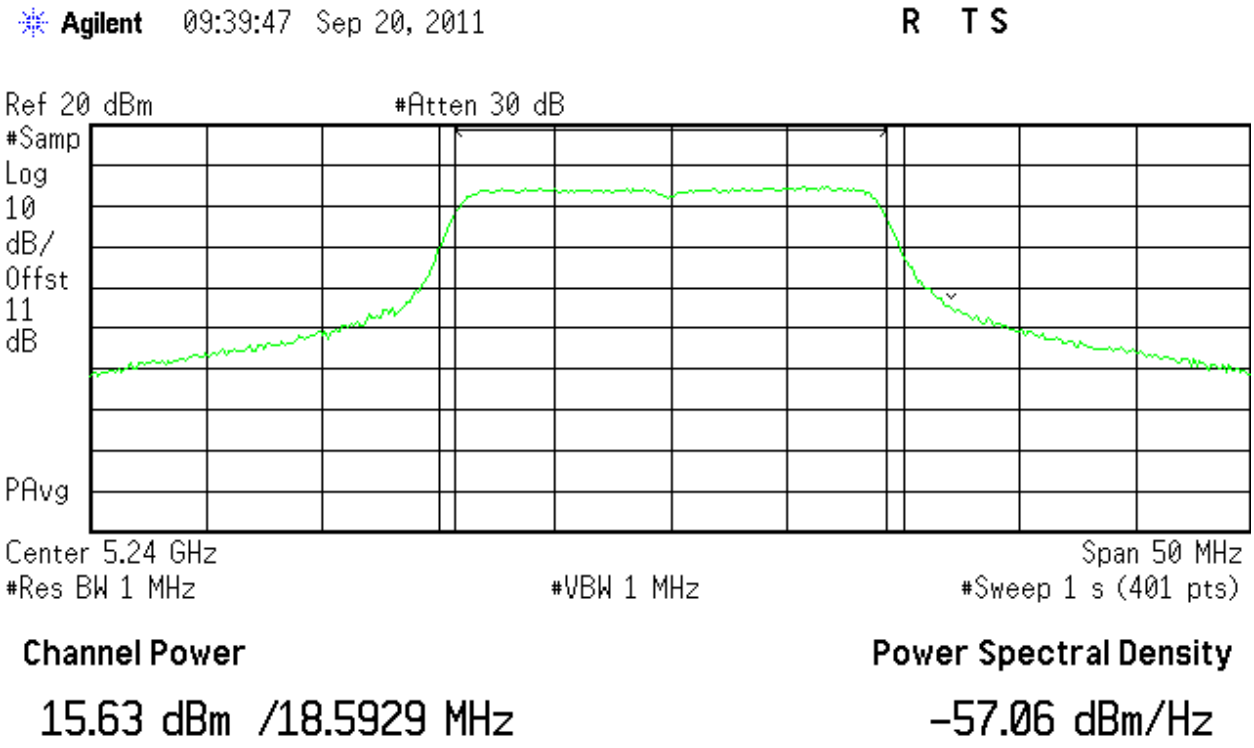


Figure 10: Maximum Transmitted Power, 5240 MHz at 802.11n HT20, Chain 0 – 6.5Mbps

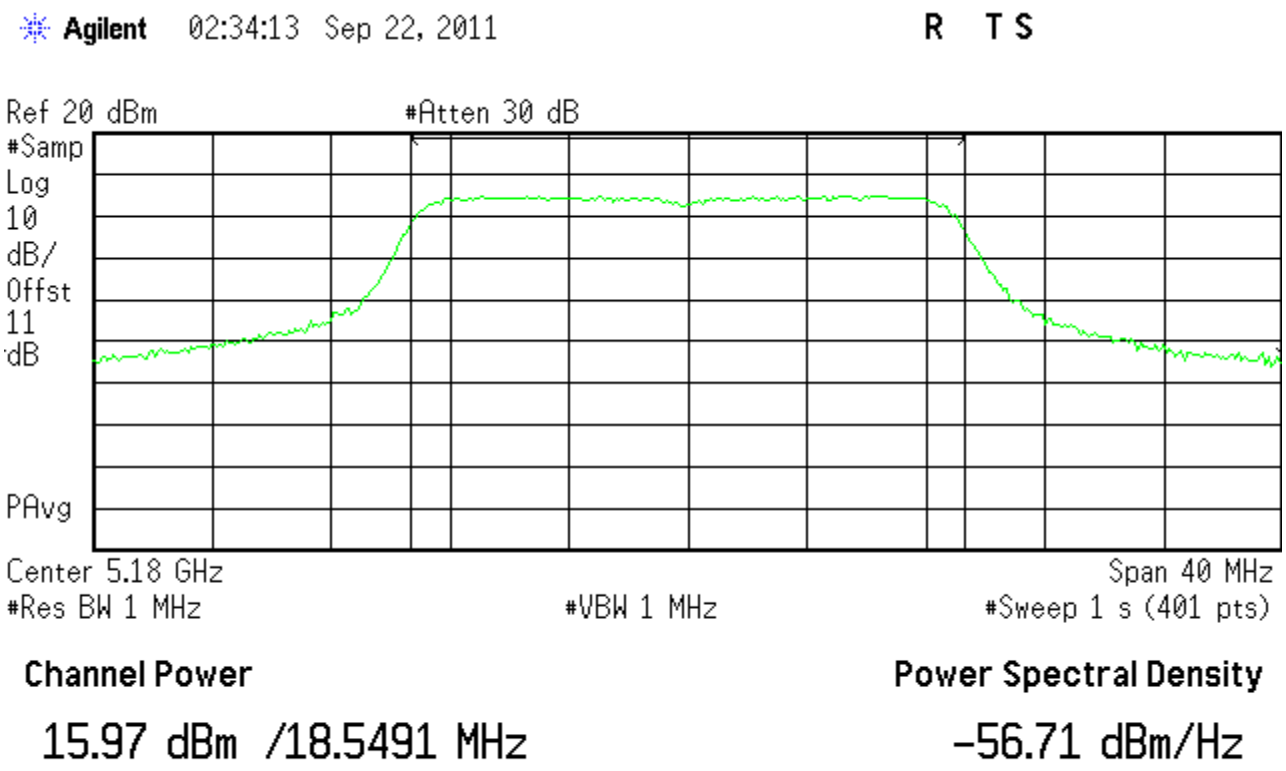


Figure 11: Maximum Transmitted Power, 5180 MHz at 802.11n HT20, 1x3 Chain 1– 6.5 Mbps

Note: All modes stated in the table 2 were investigated worst case plots are placed remaining plots are available in TUV job folder

4.2 Occupied Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

The 26 dB bandwidth is defined the bandwidth of 26 dBr from highest transmitted level of the fundamental frequency.

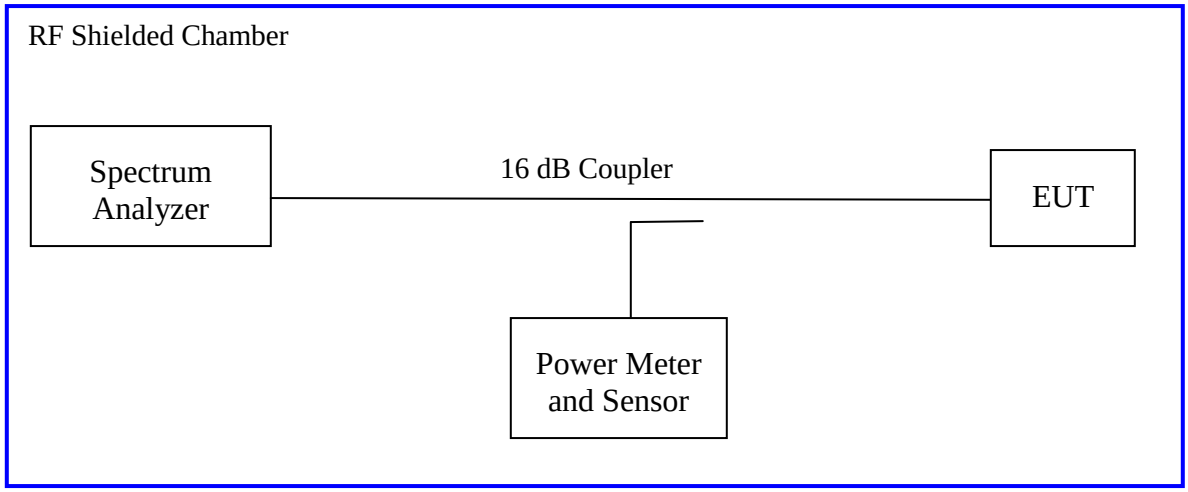
There is no restriction limits for the bandwidth. The 26 dB bandwidth was used to determine the limit for maximum conducted output power per CFR47 Part 15.407(a).

To obtain the tighter limit,

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth. The measurement was performed with modulation per CFR47 15.407(a) 2009 and RSS Gen Sect. 4.4.1:2010. The preliminary investigation was performed to find the narrowest 26 dB bandwidth for each operational mode at different data rates. This worst finding was performed on 3 channels in each operating frequency range; 5150 MHz to 5250 MHz. The worst results indicated below.

Test Setup:



4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only							
Antenna Type: 3 External			**Power Setting:** See Test Plan				
Max. Antenna Gain: + 2.0 dBi			**Signal State:** Modulated				
Ambient Temp.: 21 °C			**Relative Humidity:**33%				
Bandwidth (MHz) for 802.11a							
Freq. (MHz)	**Stream**	**Ch 0 99% BW**	**Ch 1 99% BW**	**Ch 2 99% BW**	**Ch 0 26 dB BW**	**Ch 1 26 dB BW**	**Ch 2 26 dB BW**
5180	1	16.58	16.61	16.57	21.76	22.02	22.04
5220	1	16.62	16.62	16.59	22.17	22.63	21.58
5240	1	16.59	16.61	16.60	22.28	22.21	21.85
Note: The bandwidth was measured at 6Mbps for 802.11a mode.							
Bandwidth (MHz) for 802.11n HT20							
Freq. (MHz)	**Stream**	**Ch 0 99% BW**	**Ch 1 99% BW**	**Ch 2 99% BW**	**Ch 0 26 dB BW**	**Ch 1 26 dB BW**	**Ch 2 26 dB BW**
5180	1	18.59	18.55	18.50	26.29	27.51	26.38
5220	1	18.62	18.63	18.52	26.39	27.19	26.49
5240	1	18.67	18.07	18.47	27.16	20.00	25.44
Note: The bandwidth was measured at 6.5Mbps at 1 data stream.							
Bandwidth (MHz) for 802.11n HT40							
Freq. (MHz)	**Stream**	**Ch 0 99% BW**	**Ch 1 99% BW**	**Ch 2 99% BW**	**Ch 0 26 dB BW**	**Ch 1 26 dB BW**	**Ch 2 26 dB BW**
5190	1	36.74	36.73	38.81	49.11	49.93	49.14
5230	1	36.77	36.80	36.79	49.40	49.95	48.98
Note: The bandwidth was measured at 13.5Mbps at 1 data stream							

Note: Other modes HT20 2 & 3 streams and HT40 2 & 3 streams investigated. Only worst case results are reported here.

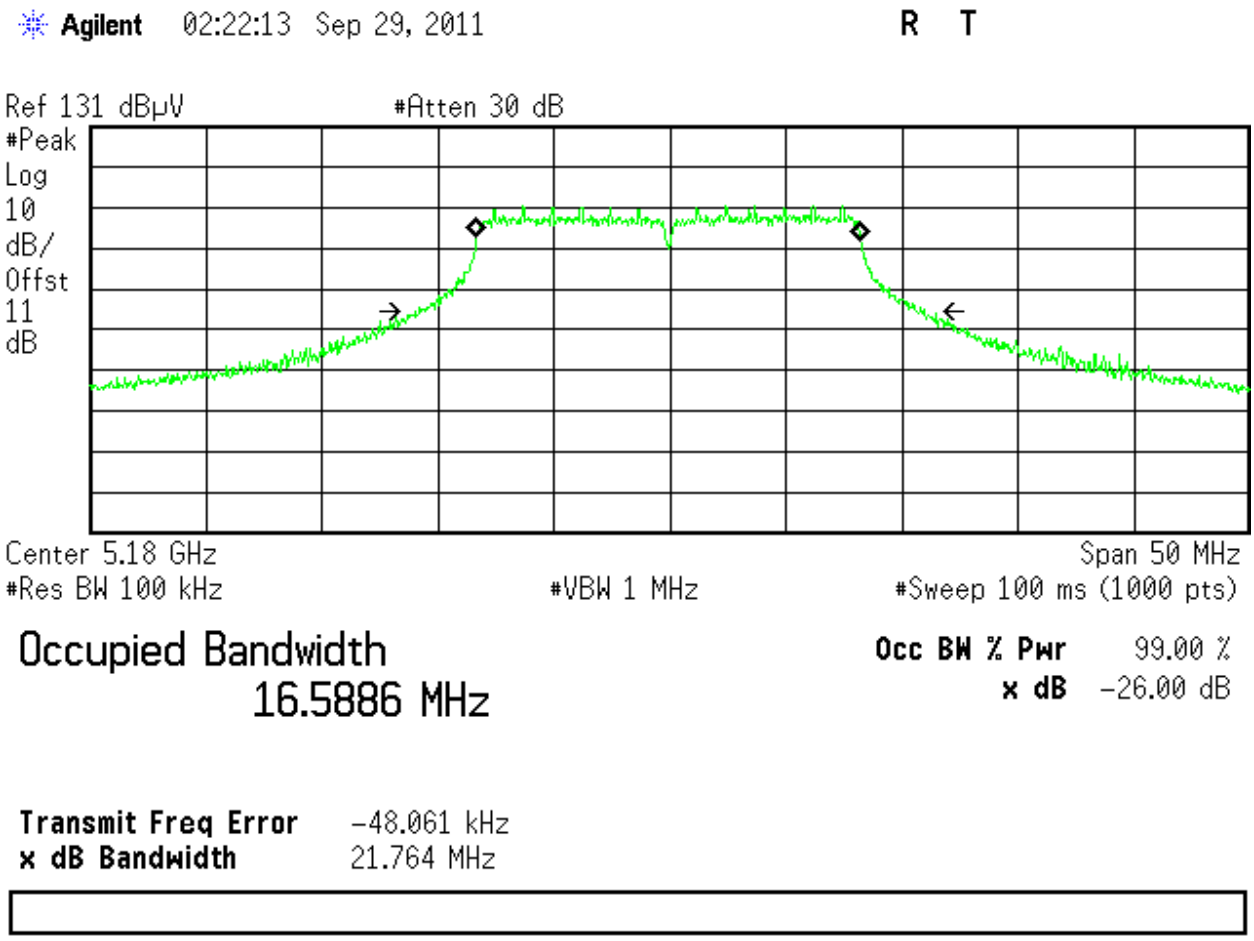


Figure 12: 26 dB and 99% Bandwidth at 5180 MHz, Chain 0

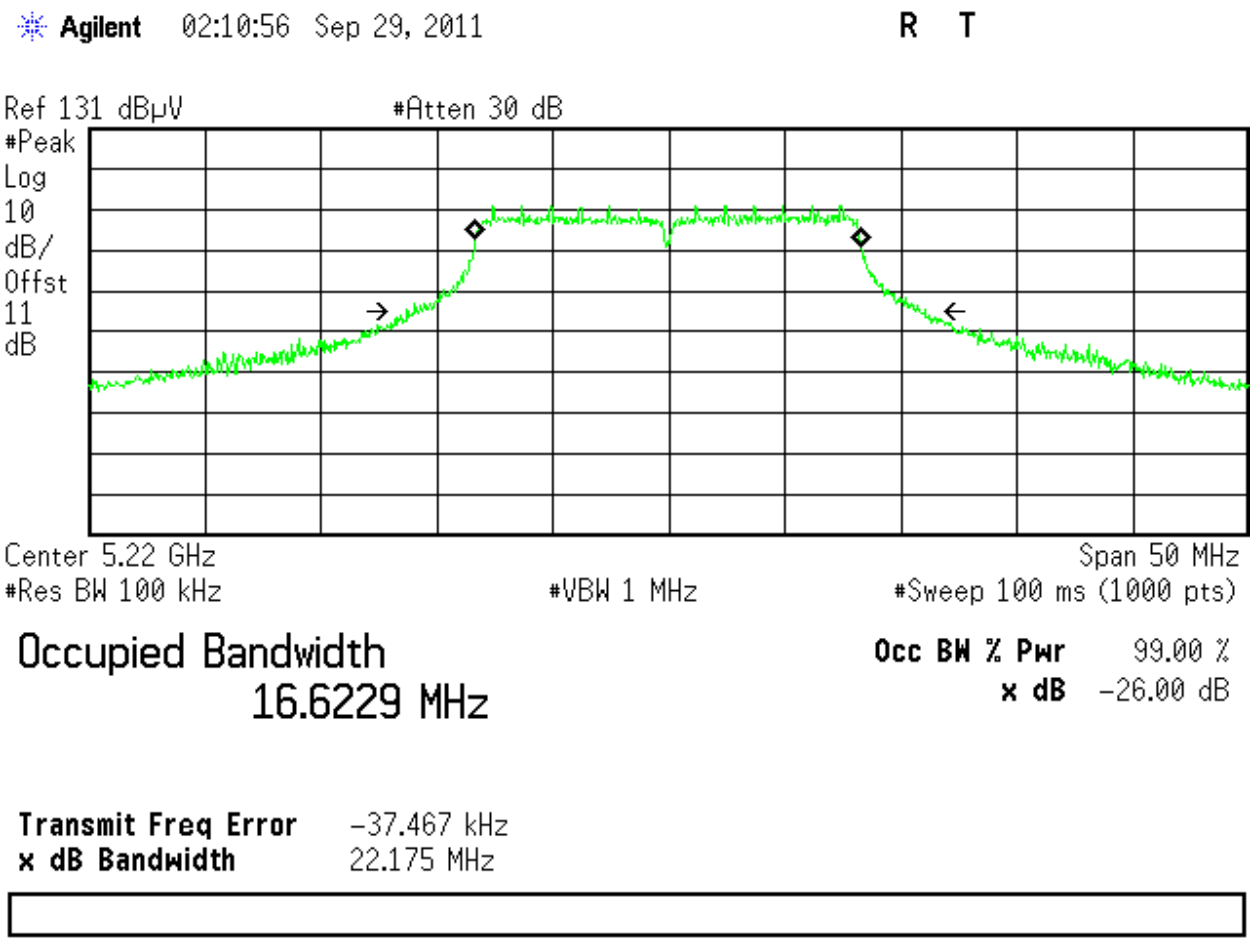


Figure 13: 26 dB and 99% Bandwidth at 5220 MHz, Chain 0

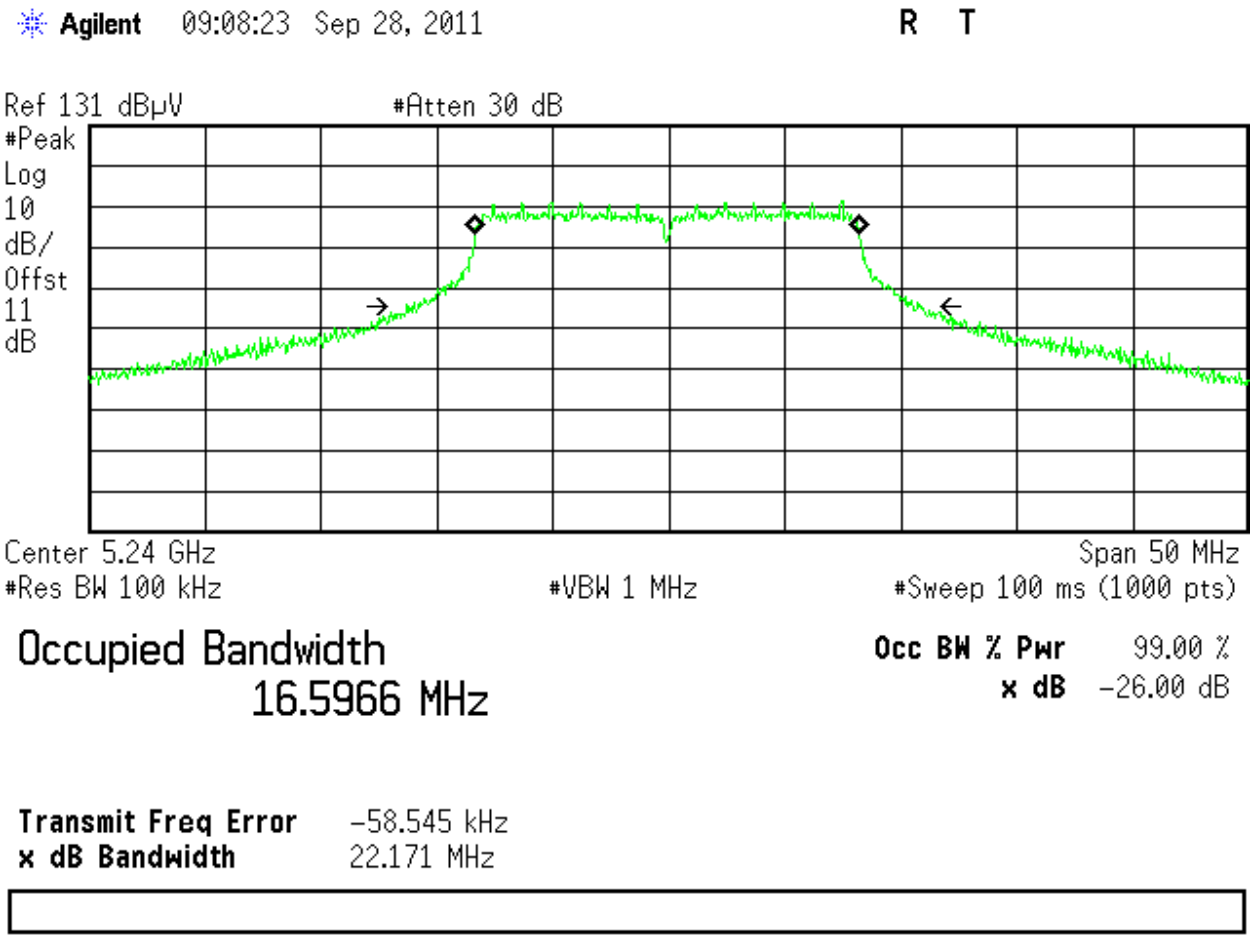


Figure 14: 26 dB and 99% Bandwidth – 5240 MHz, Chain 0

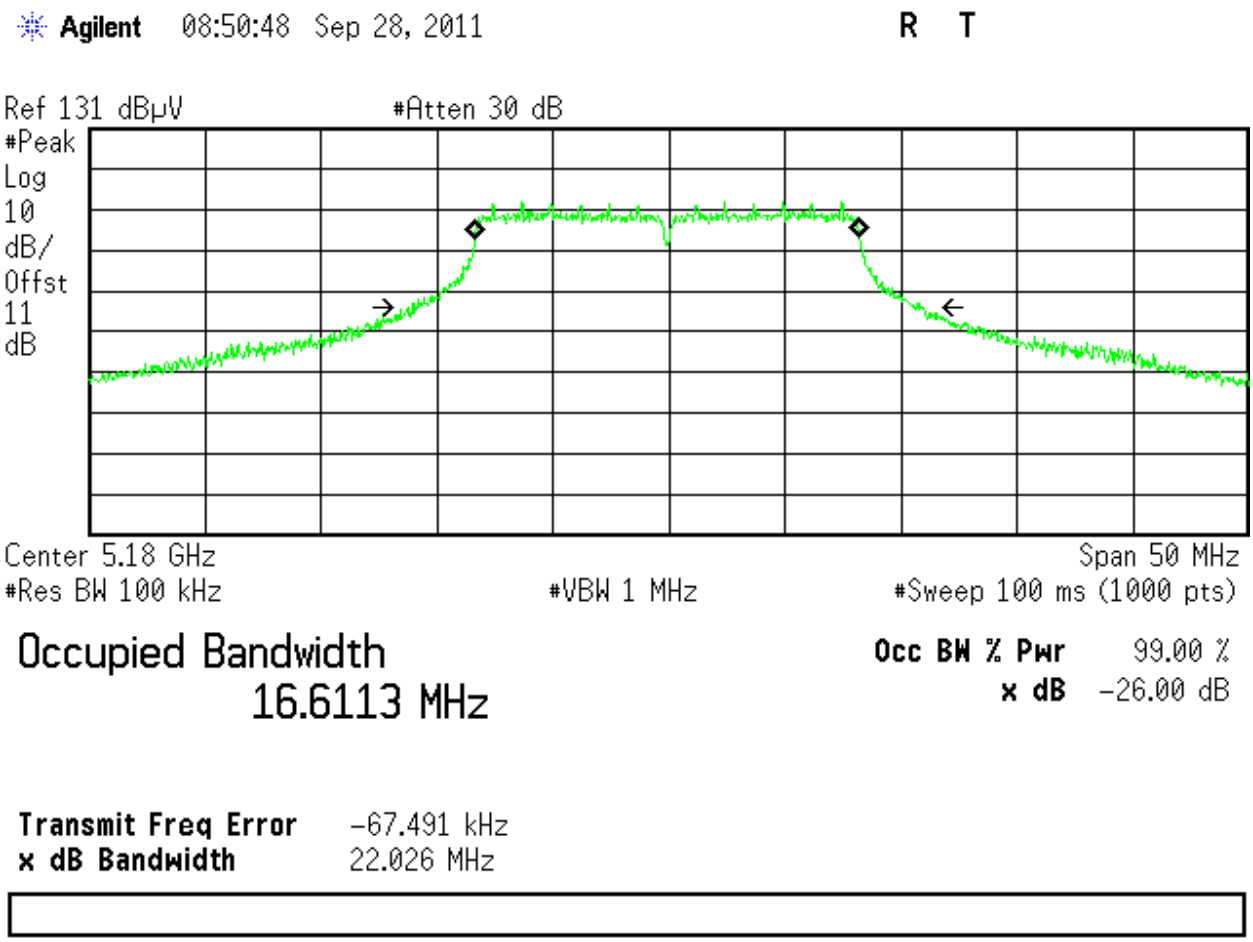


Figure 15: 26 dB and 99% Bandwidth – 5180 MHz, Chain 1

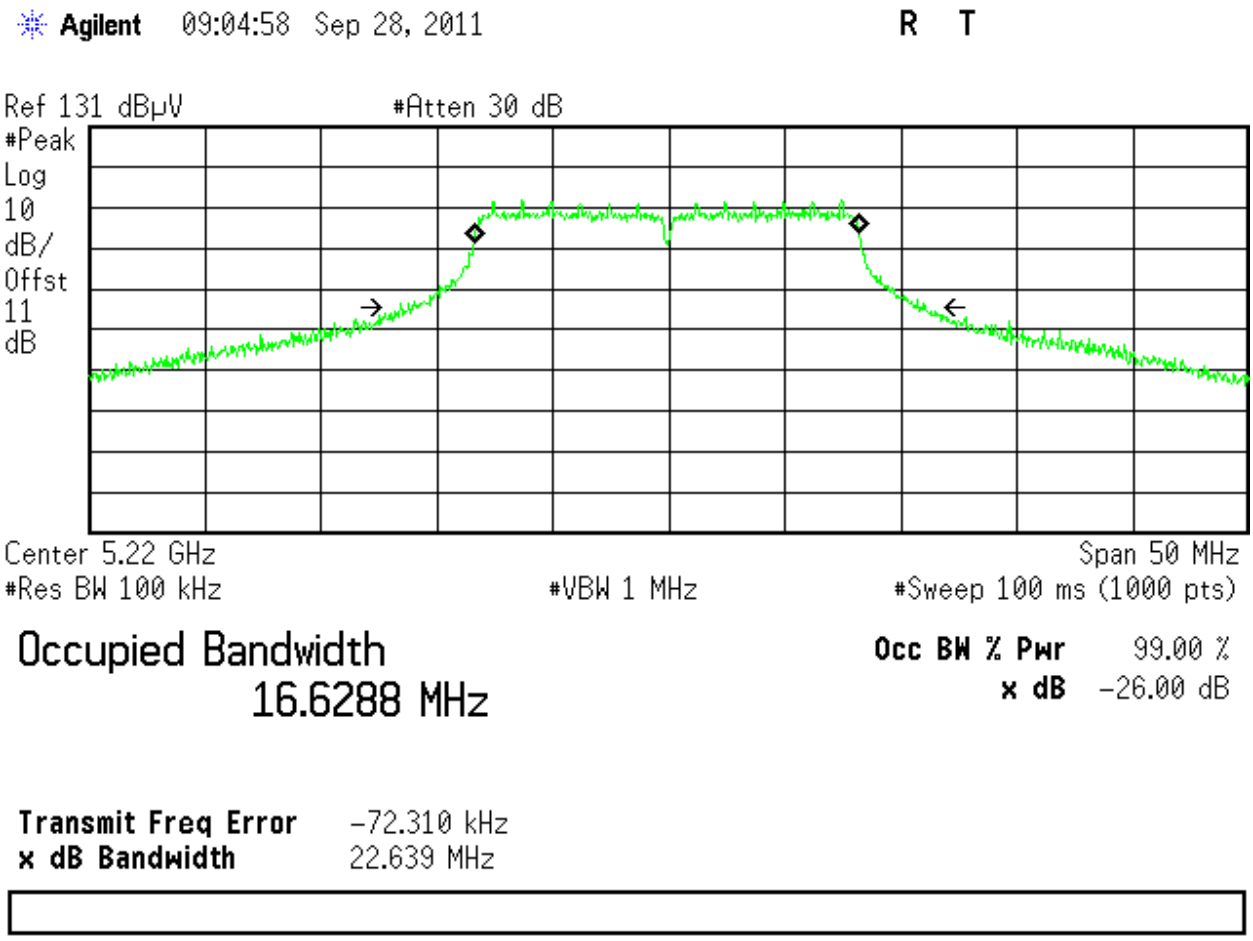


Figure 16: 26 dB and 99% Bandwidth – 5220 MHz, Chain 1

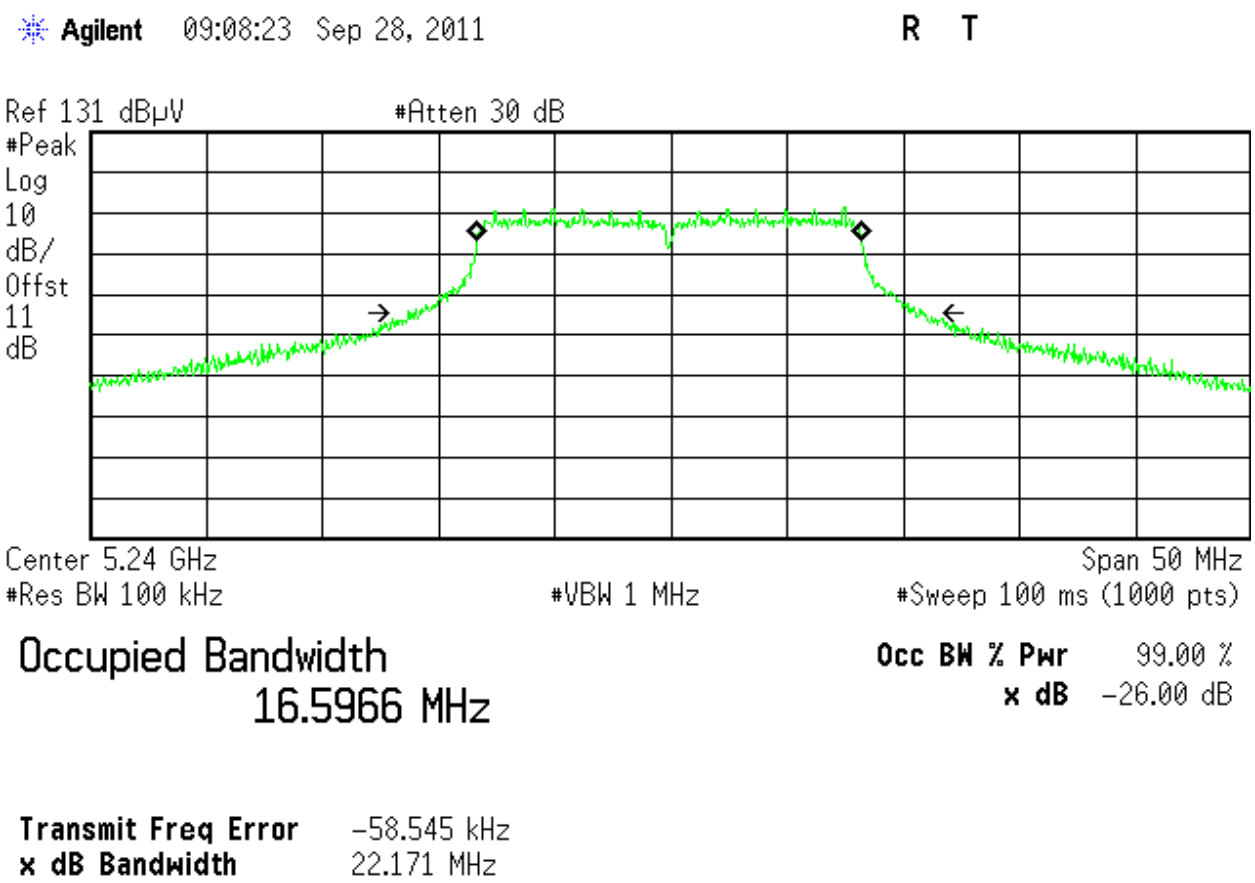


Figure 17: 26 dB and 99% Bandwidth – 5240 MHz, Chain 1

4.3 Peak Excursion

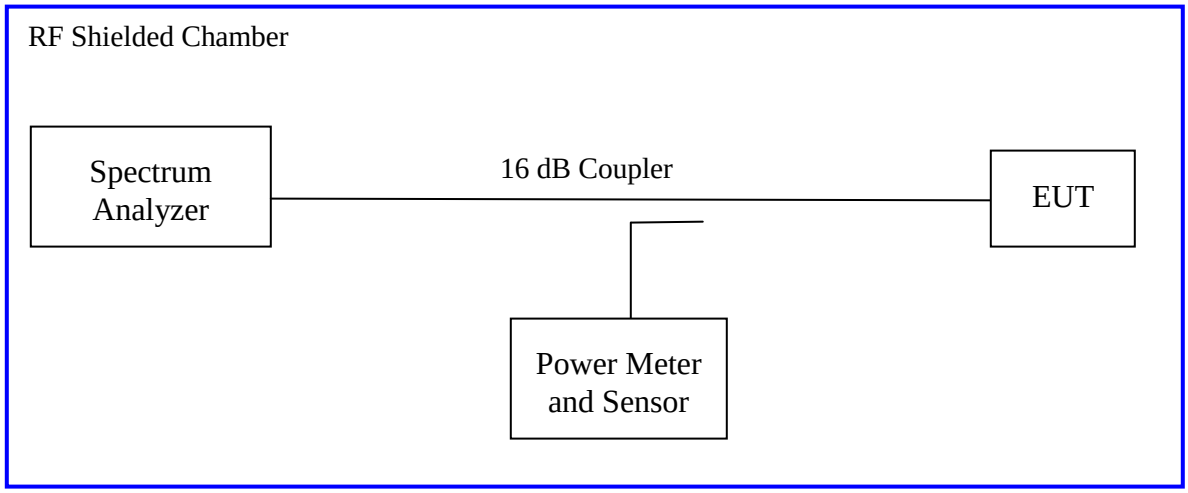
According to the CFR47 Part 15.407 (a)(6), the ratio of the peak excursion of the modulation envelope(measured suing a peak hold function) to the maximum conducted output power shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

4.3.1 Test Method

The ANSI C63.10-2009 Section 6.10.4 conducted method was used to measure the peak excursion.

The measurement was performed with modulation per CFR47 Part 15.407 (a) (6) This test was conducted on 3 channels in each operating frequency range of 5150 MHz to 5250 MHz The worst sample result indicated below.

Test Setup:



4.3.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Peak Excursion – Test Results

Test Conditions: Conducted Measurement, Normal Temperature					
Antenna Type: 3 External			**Power Setting:** see test plan		
Max. Antenna Gain: +2.0 dBi			**Signal State:** Modulated (100%)		
Ambient Temp.: 21 °C			**Relative Humidity:**31%		
802.11a Mode, 1x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5180	13.0	9.08	8.71	8.669	-3.92
5220	13.0	8.9	9.43	11.11	-1.89
5240	13.0	7.8	8.55	9.076	-3.92
Note: The peak excursion was observed at 6 Mbps.					
802.11n (HT20) Mode, 1x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5180	13.0	8.45	8.95	7.89	-4.05
5220	13.0	10.02	8.06	8.59	-2.98
5240	13.0	8.58	7.989	8.99	-4.01
Note: The peak excursion was observed at HT20 6.5 Mbps, 1 Data Stream.					
802.11n (HT20) Mode, 2x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5180	13.0	8.23	9.01		-3.99
5220	13.0	9.73	8.82		-3.72
5240	13.0	8.81	8.24		-4.19
Note: The peak excursion was observed at HT20 13 Mbps, 2 Data Streams.					

802.11n (HT20) Mode, 3x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5180	13.0	8.23	8.69	8.68	-4.31
5220	13.0	8.99	10.02	9.85	-2.98
5240	13.0	8.57	8.59	9.63	-3.37
Note: The peak excursion was observed at HT20 19.5 Mbps, 3 Data Streams.					
802.11n (HT40) Mode, 1x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5190	13.0	8.945	10.19	8.51	-2.81
5230	13.0	8.99	9.39	8.71	-3.61
Note: The peak excursion was observed at HT40 13.5 Mbps, 1 Data Stream					
802.11n (HT40) Mode, 2x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5190	13.0	8.93	9.59		-3.41
5230	13.0	8.61	9.55		-3.45
Note: The peak excursion was observed at HT40 27 Mbps, 2 Data Streams.					
802.11n (HT40) Mode, 3x3					
Operating Channel	**Limit [dB]**	**Chain 0 [dB]**	**Chain 1 [dB]**	**Chain 2 [dB]**	**Margin [dB]**
5190	13.0	9.43	9.41	9.20	-3.57
5230	13.0	9.30	9.662	9.91	-3.09
Note: The peak excursion was observed at HT40 40.5 Mbps, 3 Data Streams.					

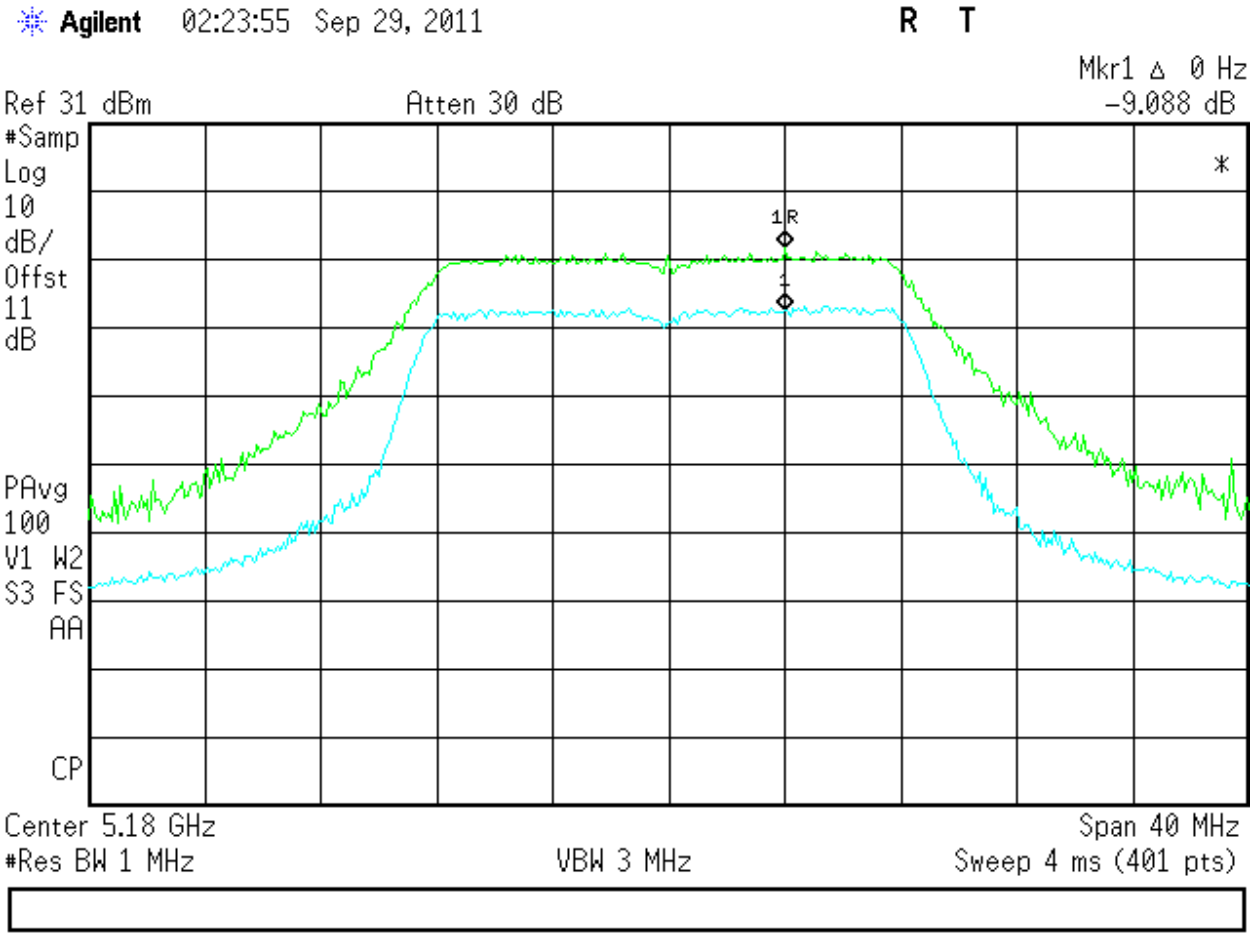


Figure 18: Peak Excursion, 5180 MHz at 802.11a, Chain 0 - 6Mbps

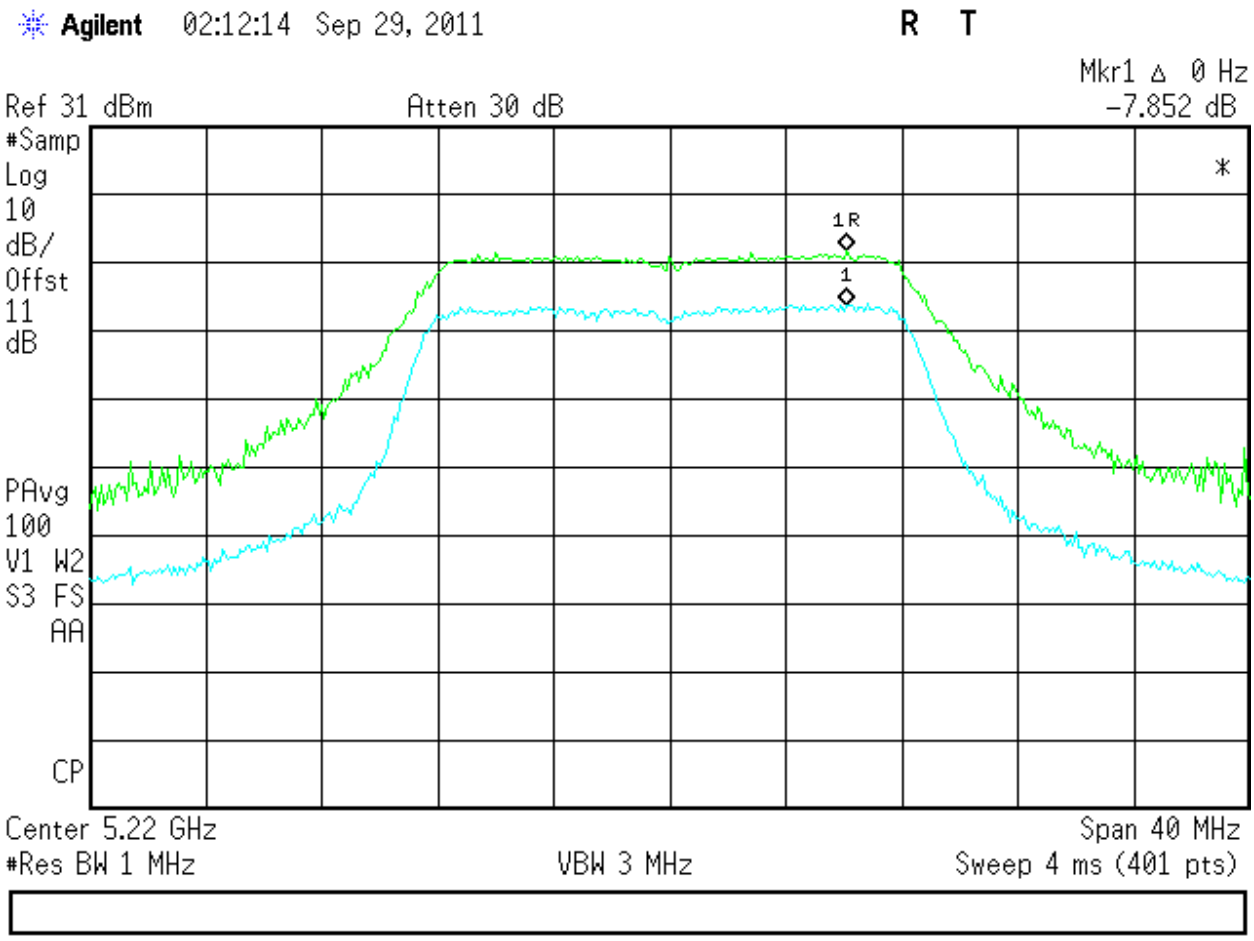


Figure 19: Peak Excursion, 5220 MHz at 802.11a, Chain 0 - 6Mbps

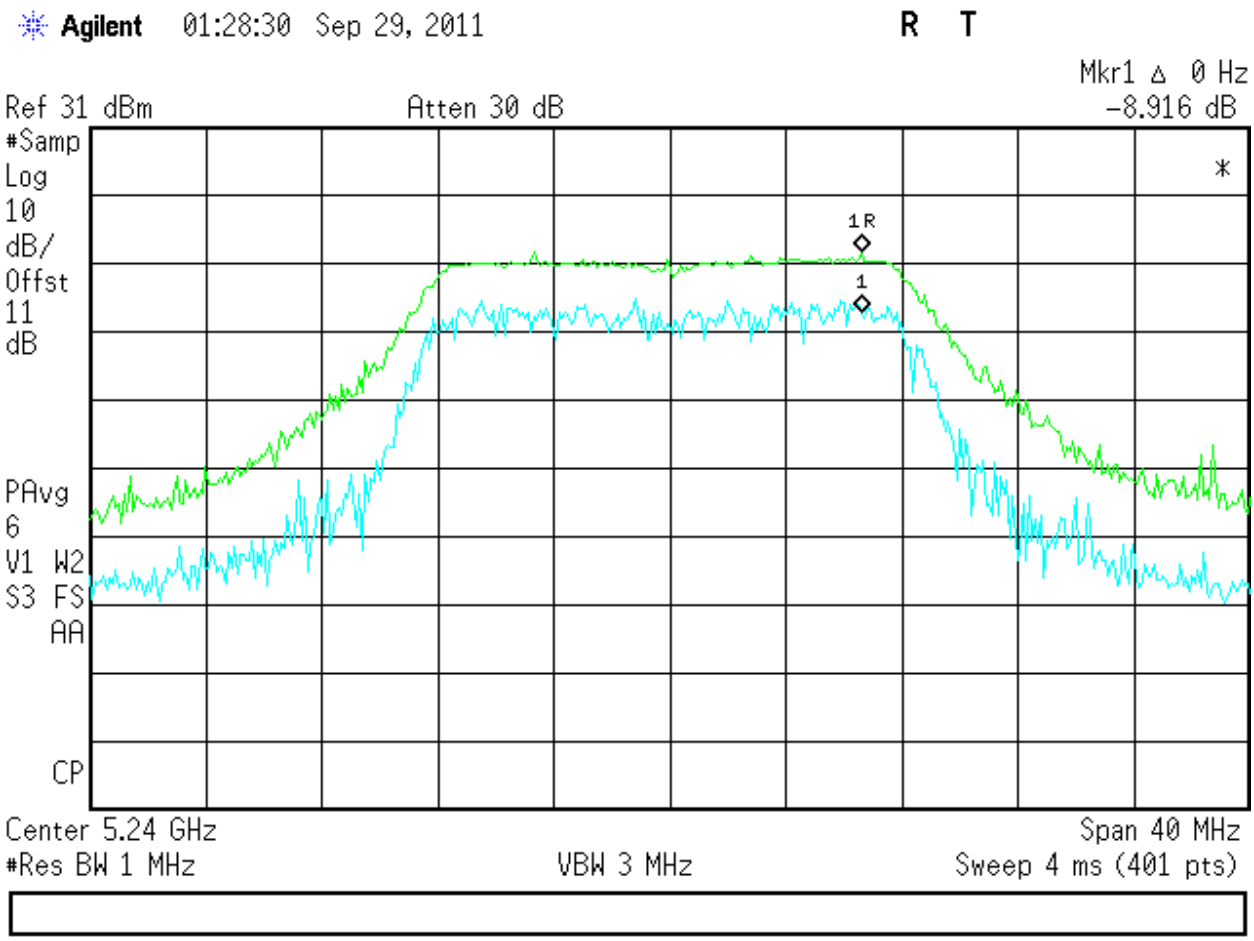


Figure 20: Peak Excursion, 5240 MHz at 802.11a, Chain 0 - 6Mbps

Note: All the modes stated ion the table 4 were evaluated only sample plots are placed here. All the plots are available in the project folder.

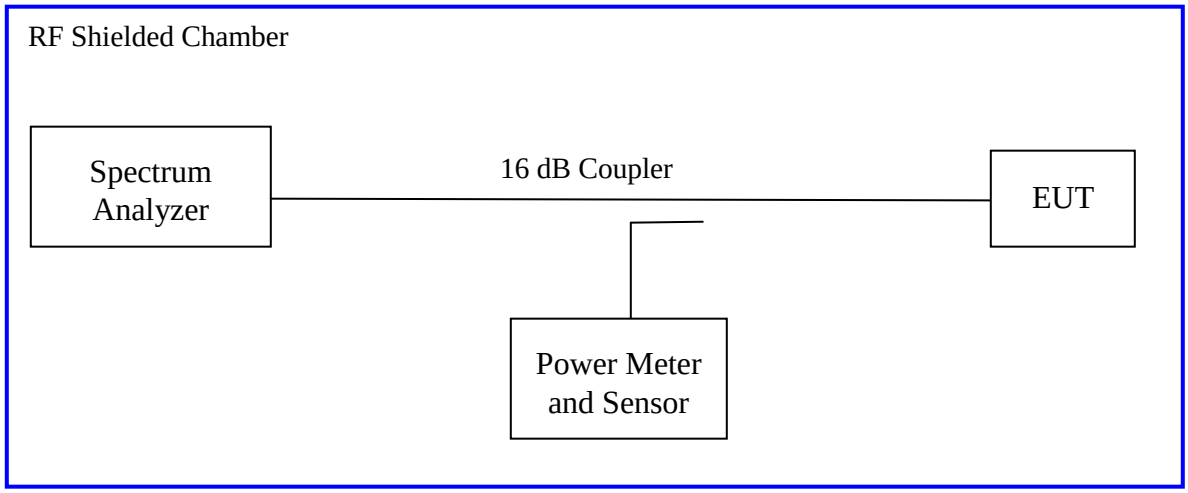
4.4 Peak Power Spectral Density

According to the CFR47 Part 15.407 (a)(5) and RSS 210 (A9.2), the spectral power density output of the antenna port shall be less than 4dBm at 5150 MHz to 5250 MHz, in any 1 MHz band during any time interval of continuous transmission.

4.4.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10-2009 Section 6.11.2. The measurement was performed with modulation per CFR47 Part 15.407 (a) and RSS 210 (A9.2). The pre-evaluation was performed to find the worst modes. The worst findings were conducted on 3 channels in each operating frequency range of 5150 MHz to 5250 MHz, The power spectral density is extracted from channel power measurements by adding 60 dB to spectral density measured during power measurements.

Test Setup:



4.4.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 5: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only							
Antenna Type: 3 External			**Power Setting:** See Test plan				
Max. Antenna Gain: + 2.0 dBi			**Signal State:** Modulated (100%)				
Ambient Temp.: 21 °C			**Relative Humidity:**31%				
Peak Power Spectral Density							
802.11a Mode							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5180	2.10	3.42	1.56		3.42	4.00	-0.58
5220	2.62	3.36	2.13		3.36	4.00	-0.64
5240	2.62	3.28	2.42		3.28	4.00	-0.72
Note: The highest peak power spectral density was observed at 6 Mbps.							

802.11n (HT20) Mode, 1x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5180	2.76	2.29	1.09		2.76	4.0	-2.24
5220	3.22	2.23	1.76		3.22	4.0	-0.78
5240	2.94	3.01	2.07		3.01	4.0	-0.99
Note: The highest peak power spectral density was observed at HT20 6.5Mbps, 1 Data Stream.							

802.11n (HT20) Mode, 2x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5180	-4.04	-0.43		3.01	2.58	4.0	-1.42
5220	-3.77	-1.53		3.01	1.48	4.0	-2.52
5240	-3.58	-1.79		3.01	1.22	4.0	-2.78
Note: 1. The highest peak output power was observed at HT20 13 Mbps, 2 Data Stream. 2. CF was accounted for the number of data streams being used, 10*Log(N) per KDB 662911; where N is number of outputs.							

802.11n (HT20) Mode, 3x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5180	-2.89	-2.40	-5.29	4.77	2.37	4.0	-1.63
5220	-2.62	-3.09	-4.55	4.77	2.15	4.0	-1.85
5240	-2.93	-.305	-5.11	4.77	1.84	4.0	-2.16
Note: 1. The highest peak output power was observed at HT20 19.5 Mbps, 3 Data Streams. 2. CF was accounted for the number of data streams being used, 10*Log(N) per KDB 662911; where N is number of outputs.							

802.11n (HT40) Mode, 1x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5190	-3.02	-3.37	-4.37		-3.02	4.0	-7.02
5230	0.48	-2.67	-3.34		0.48	4.0	-3.52
Note: The highest peak output power was observed at HT40 13.5 Mbps, 1 Data Stream.							

802.11n (HT40) Mode, 2x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5190	-3.44	-4.80		3.01	-0.40	4.0	-4.40
5230	-2.87	-5.11		3.01	0.14	4.0	-3.86

Note: 1. The highest peak output power was observed at HT40 27 Mbps, 2 Data Streams.
2. CF was accounted for the number of data streams being used, 10*Log(N) per KDB 662911; where N is number of outputs.

802.11n (HT40) Mode, 3x3							
Frequency (MHz)	**Chain 0 [dBm]**	**Chain 1 [dBm]**	**Chain 2 [dBm]**	**CF [dB]**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
5190	-6.63	-4.55	-7.51	4.77	0.22	4.0	-3.78
5230	-6.22	-5.19	-7.31	4.77	-0.42	4.0	-4.42

Note: 1. The highest peak output power was observed at HT40 40.5 Mbps, 3 Data Streams.
2. CF was accounted for the number of data streams being used, 10*Log(N) per KDB 662911; where N is number of outputs.

Note:

The power spectral density is extracted from channel power measurements by adding 60 dB to spectral density measured during power measurements. Please see table 1 and plot # 1 to 11

4.5 Transmitter Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.407(b), RSS 210 Sect. A.9.2

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Pres-scans were performed to determine the worst axis, data rate/chains.

4.5.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans performed on the worst axis, Y-Axis, for three operating channels;

6 Mbit/s for 802.11a mode: 5180 MHz, 5220 MHz, 5240 MHz, 5260 MHz, 5300 MHz, 5320 MHz, 5500 MHz, 5600 MHz, and 5700 MHz.

6.5 Mbit/s for 802.11n HT20 Mode: 5180 MHz, 5220 MHz, 5240 MHz, 5260 MHz, 5300 MHz, 5320 MHz, 5500 MHz, 5600 MHz, and 5700 MHz.

40.5 Mbit/s for 802.11n HT40 Mode: 5180 MHz, 5220 MHz, 5240 MHz, 5260 MHz, 5300 MHz, 5320 MHz, 5500 MHz, 5600 MHz, and 5700 MHz.

4.5.1.3 Deviations

None.

4.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2009 and RSS 210 A1.1.2 2007.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F(kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

According to CFR47 15.407 (b), all harmonics and spurious emissions which are outside the 5150 MHz - 5250 MHz, 5250 MHz – 5350 MHz, or 5470 MHz – 5725MHz shall not exceed -27 dBm/MHz. This is equivalent to 68.2 dBuV/m at 3 meter distance.

4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 6: Transmit Spurious Emission at Band-Edge Requirements

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only								
Antenna Type: 3 External				**Power Setting:** See test plan				
Max. Antenna Gain: +2.0 dBi				**Signal State:** Modulated at 100%				
Ambient Temp.: 22 °C				**Relative Humidity:**34%				
Band-Edge Results								
Operating Channel	**Mode**	**Polarity**	**Pk Emission level dBuv**	**Peak Limit**	**Margin dB**	**Avg Emission level dBuv**	**Ave. Limit**	**Margin dB**
5180 MHz	802.11a	Horz.	67.50	68.2	-0.70	50.78	54.00	-3.22
5240 MHz	802.11a	Horz.	62.00	68.2	-6.2	48.92	54.00	-5.08
5180 MHz	802.11n (HT20)	Horz.	66.75	68.2	-1.25	53.90	54.00	-0.10
5240 MHz	802.11n (HT20)	Horz.	64.01	68.2	-4.09	50.20	54.00	-3.80
5190 MHz	802.11n (HT40)	Horz.	67.58	68.2	-0.62	50.90	54.00	-3.90
5230 MHz	802.11n (HT40)	Horz.	63.47	68.2	-4.73	50.09	54.00	-3.91
Note: 1. All the band-edge measurements met the restricted band requirements of CFR47 15.205. 2. It is also complied with the -27 dBm/MHz (68.2dBuV/m at 3m) requirements as stated in CFR47 15.407 (b) (1) to 15.407 (b) (3). 3. Preliminary tests on the device indicated Horizontal Polarization of antenna is worst the case for all a, HT 20 and HT 40 modes. 4. Upper band edge is measured at 5350 MHz								

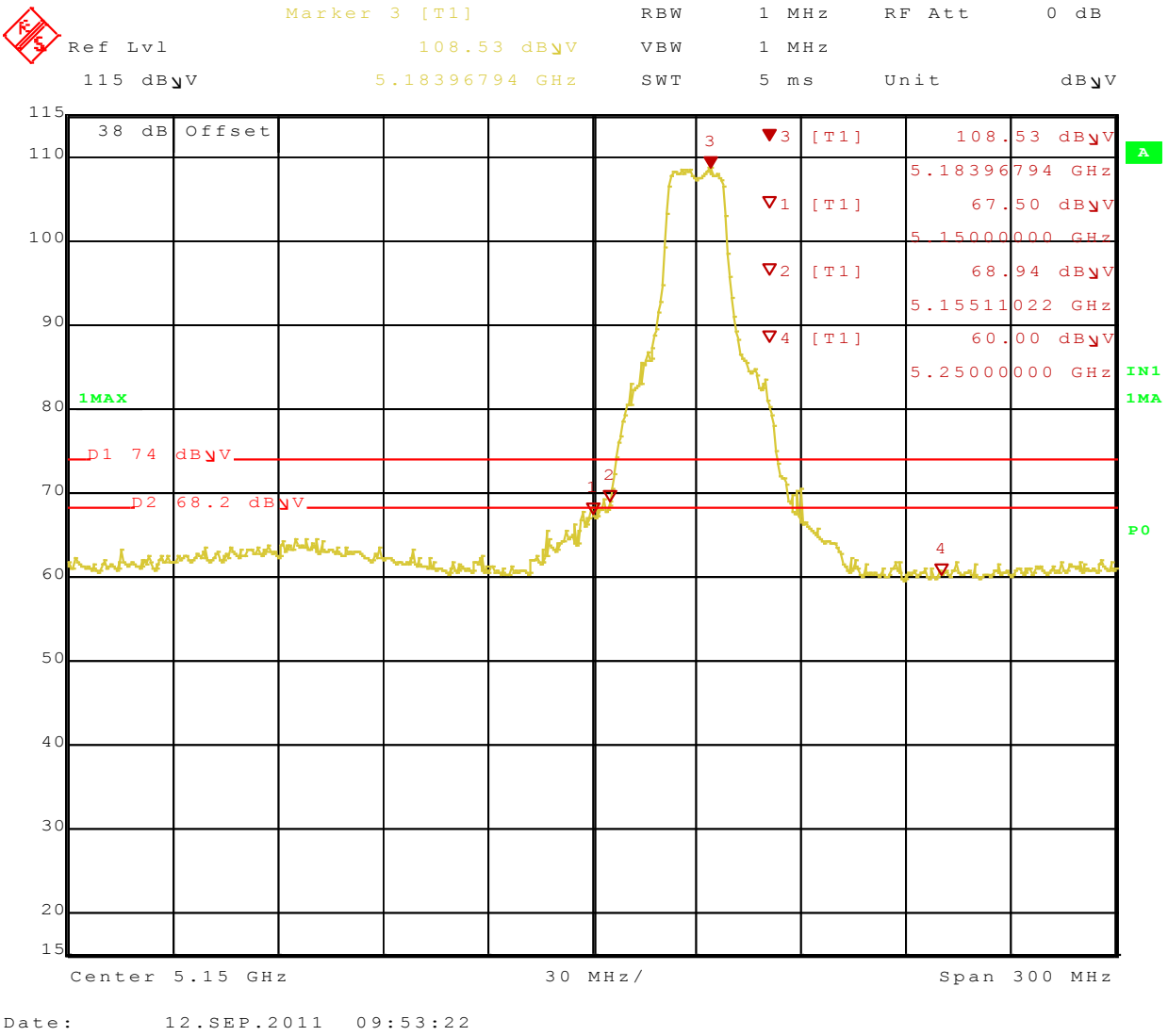


Figure 21: Radiated Emission at the Edge for Channel 5180 MHz at 6Mbps – Horz. (Peak)

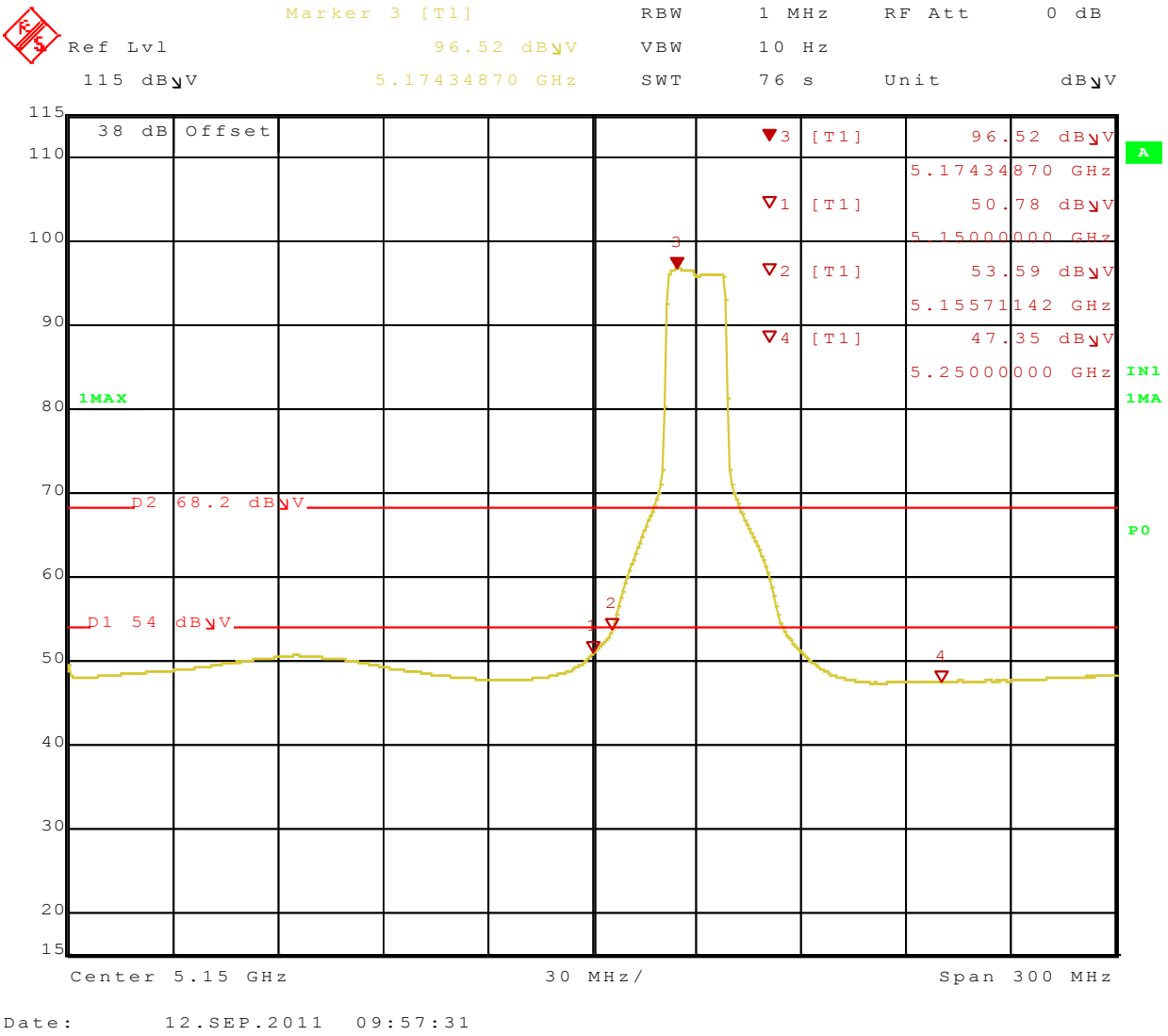


Figure 22: Radiated Emission at the Edge for Channel 5180 MHz at 6Mbps – Horz. (Ave.)

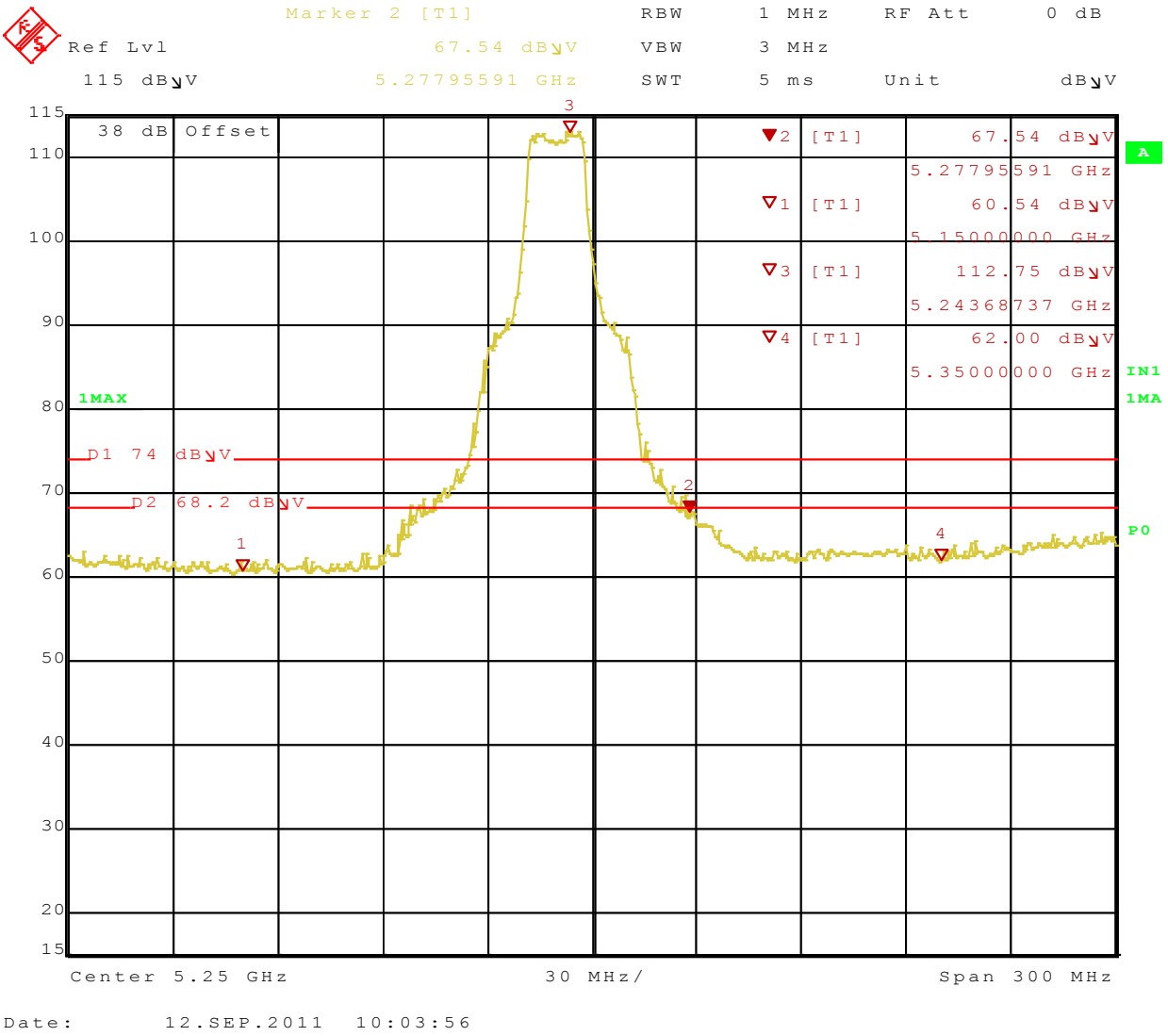


Figure 23: Radiated Emission at the Edge for Channel 5240 MHz at 6Mbps – Horz. (Peak)

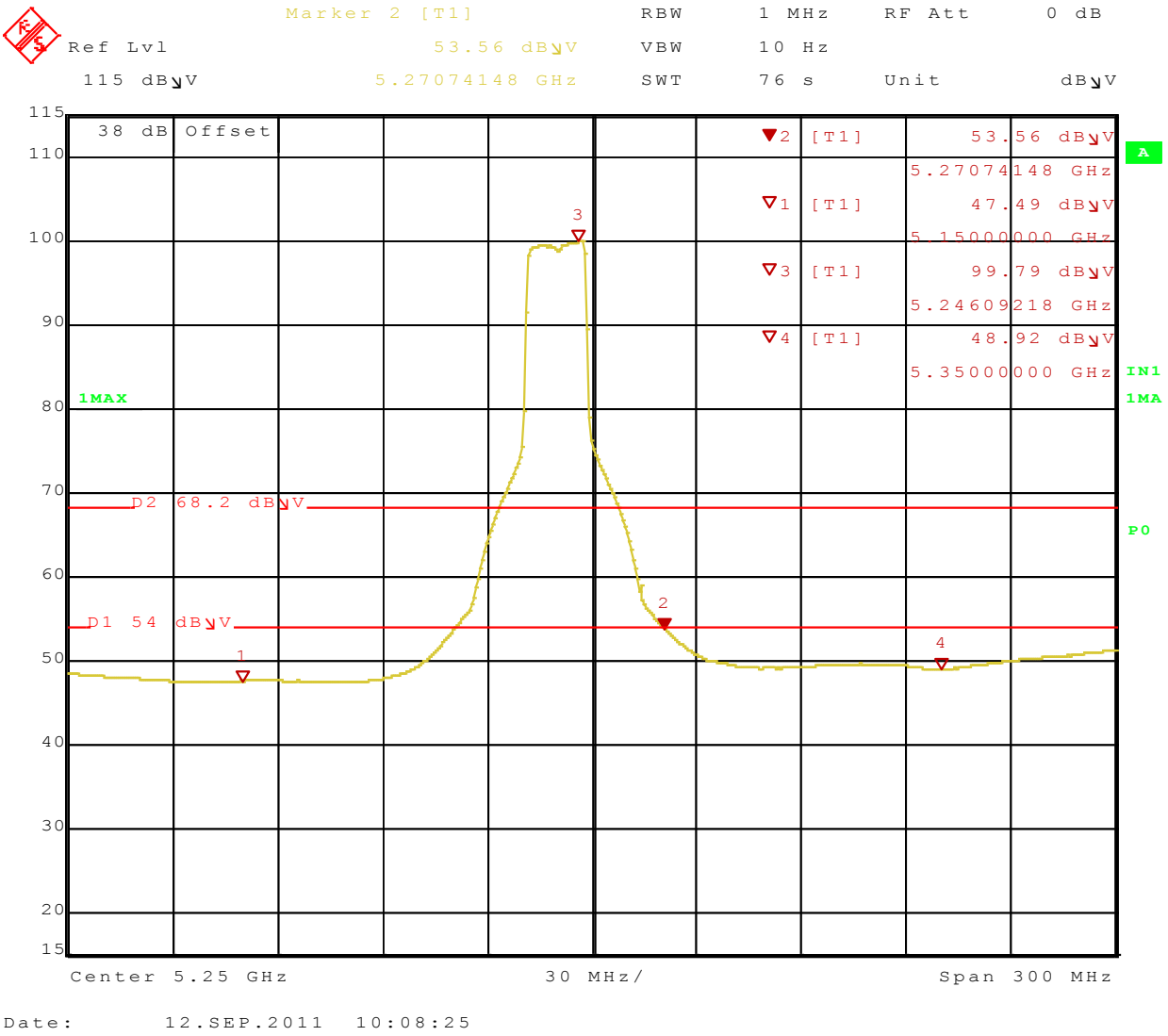


Figure 24: Radiated Emission at the Edge for Channel 5240 MHz at 6Mbps – Horz. (Ave.)

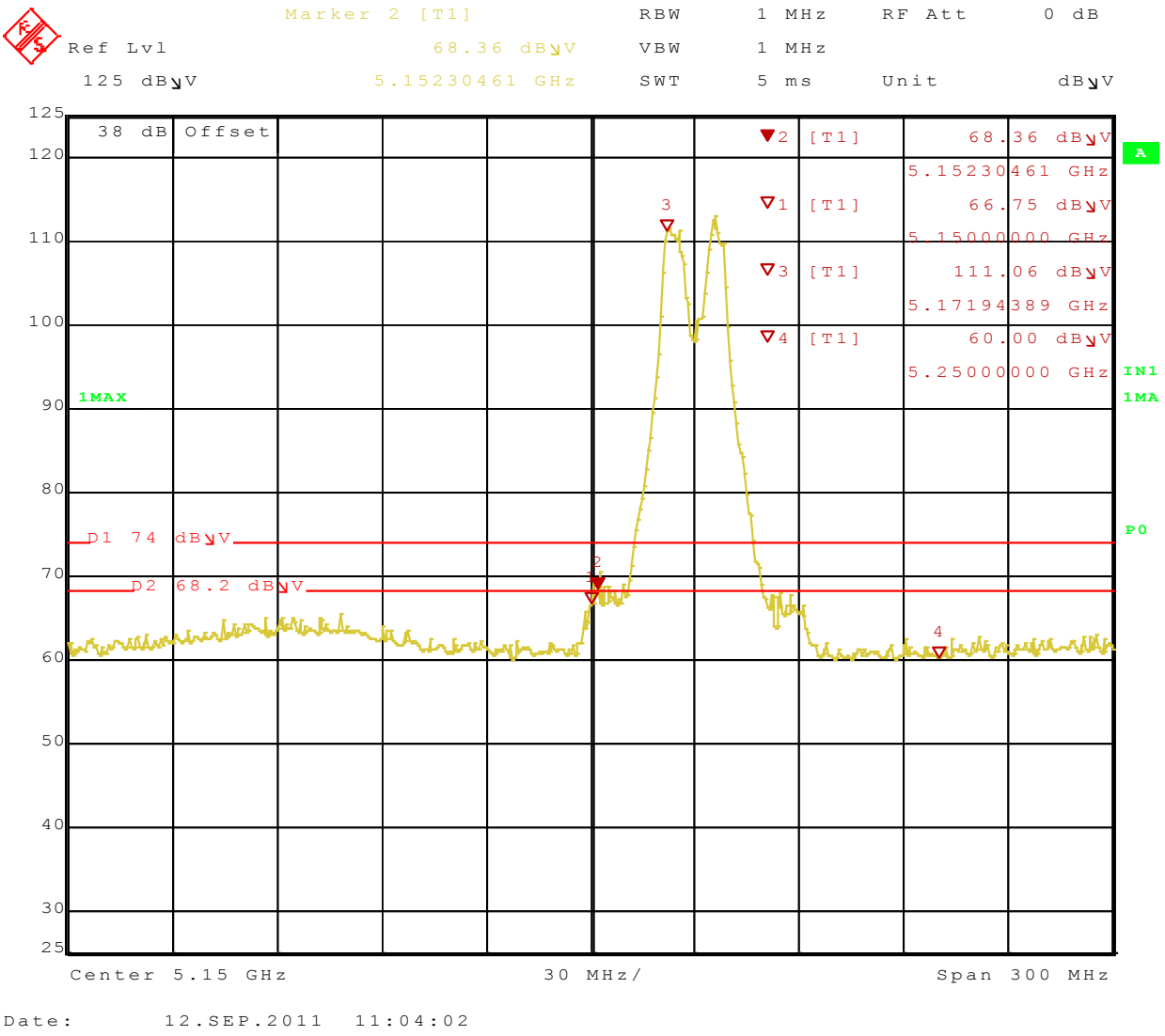


Figure 25: Radiated Emission at the Edge for Channel 5180 MHz at HT 20 19.5Mbps – Horz (Peak)

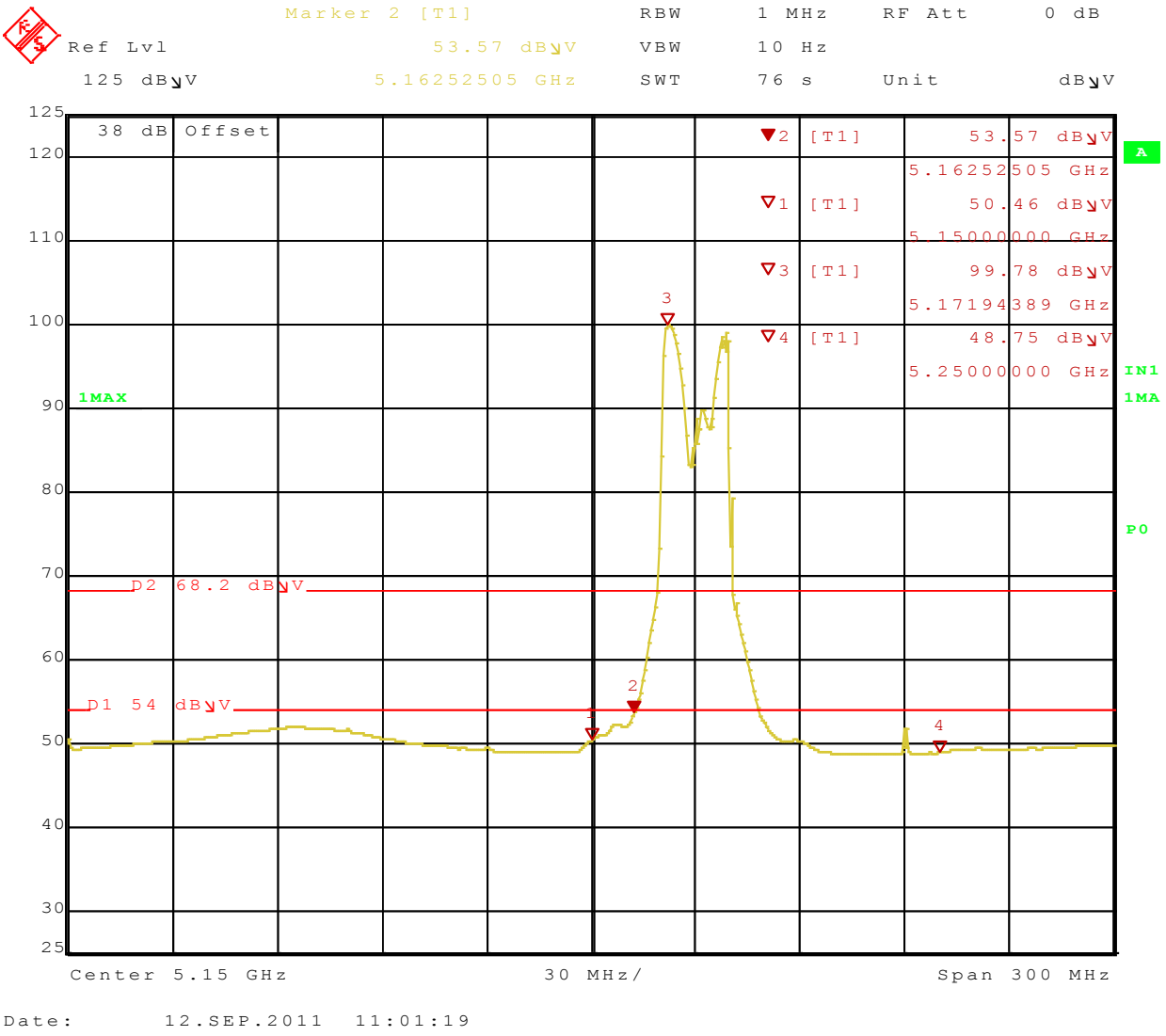


Figure 26: Radiated Emission at the Edge for Channel 5180 MHz at at HT 20 19.5Mbps – Horz. (Ave.)

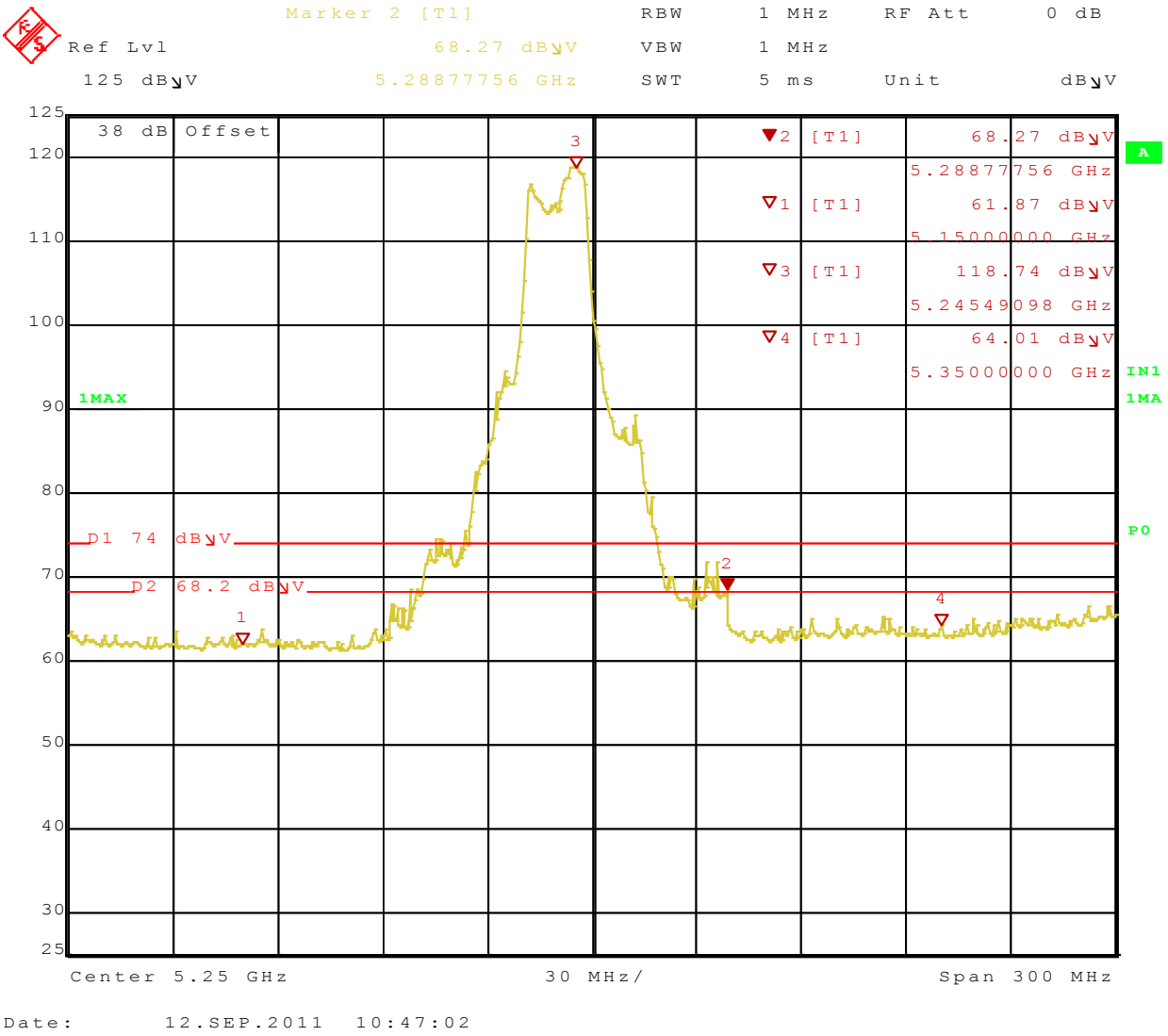


Figure 27: Radiated Emission at the Edge for Channel 5240 MHz at at HT 20 19.5Mbps – Horz. (Peak)

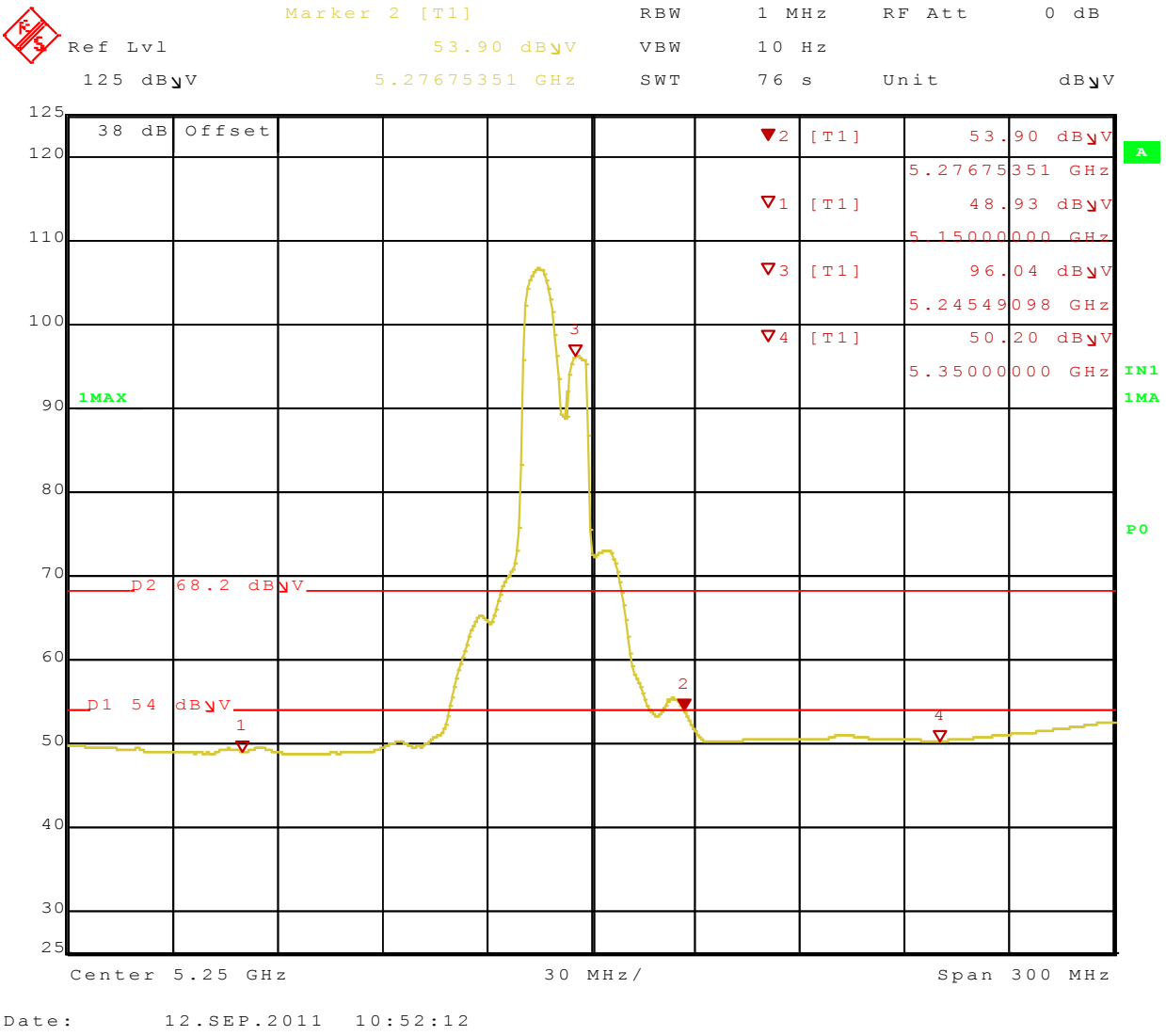


Figure 28: Radiated Emission at the Edge for Channel 5240 MHz at at HT 20 19.5Mbps – Horz. (Ave.)

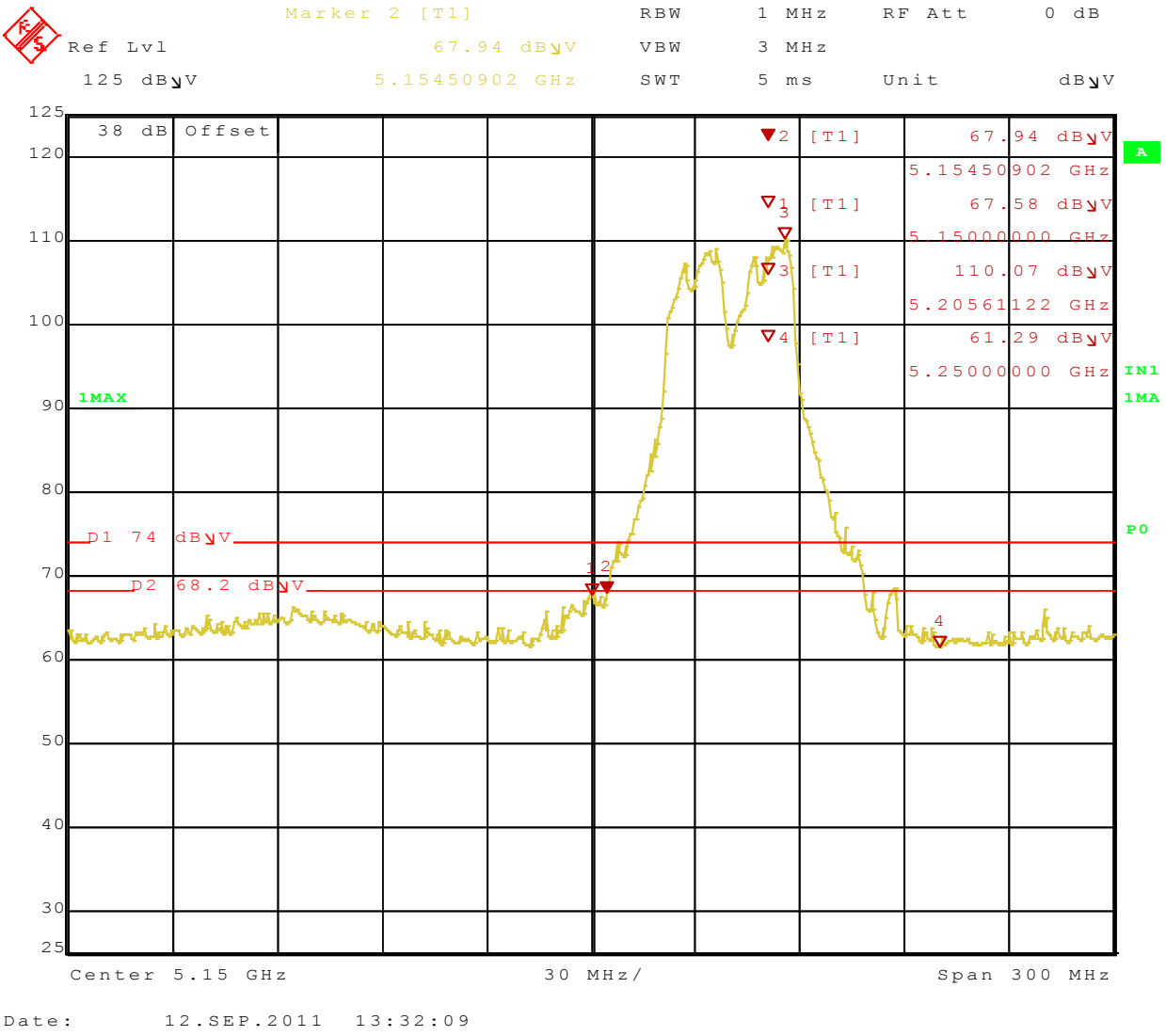


Figure 29: Radiated Emission at the Edge for Channel 5190 MHz HT 40 at 40.5 – Horz (Peak)

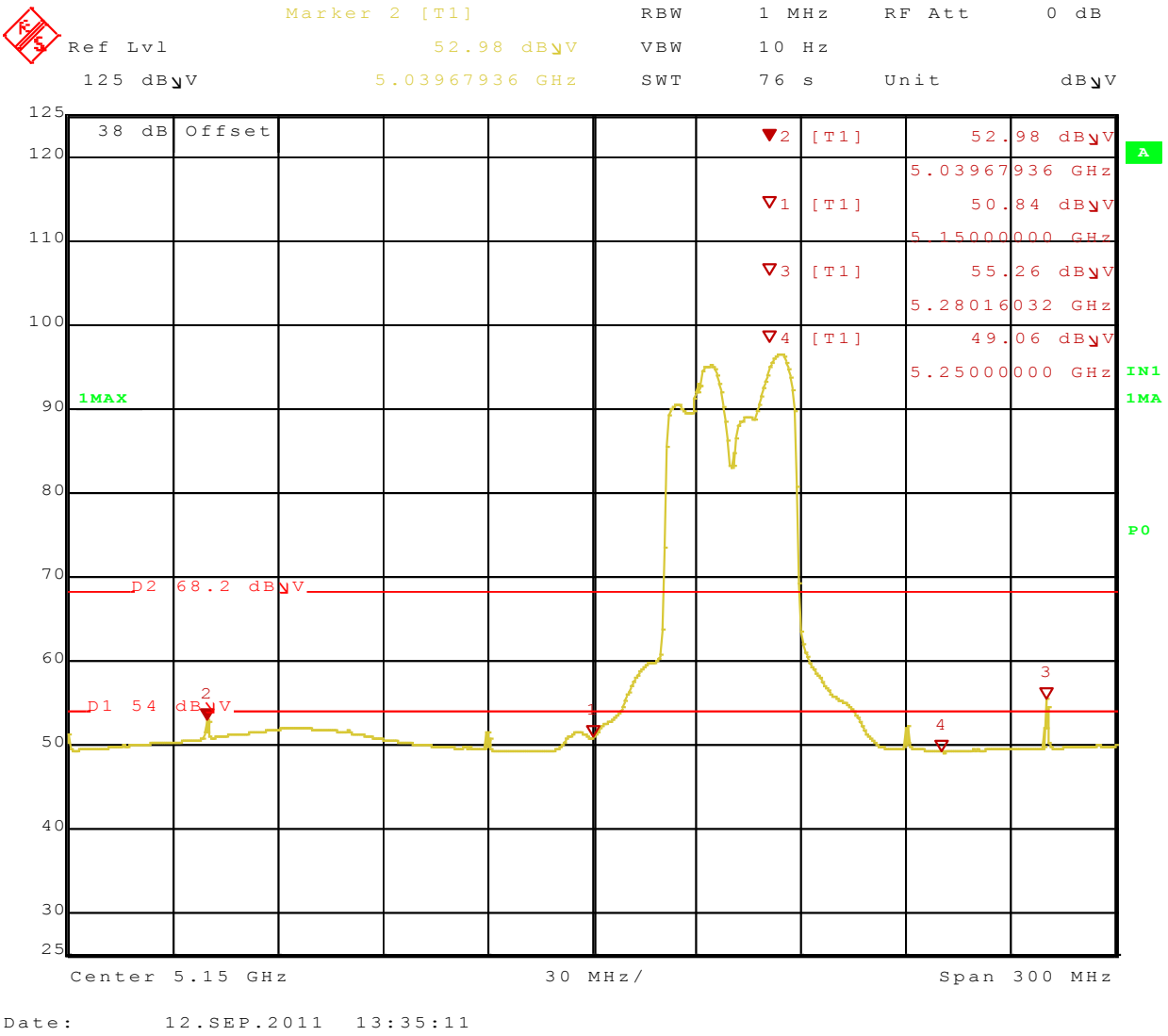


Figure 30: Radiated Emission at the Edge for Channel 5190 MHz HT 40 at 40.5Mbps – Horz. (Ave.)

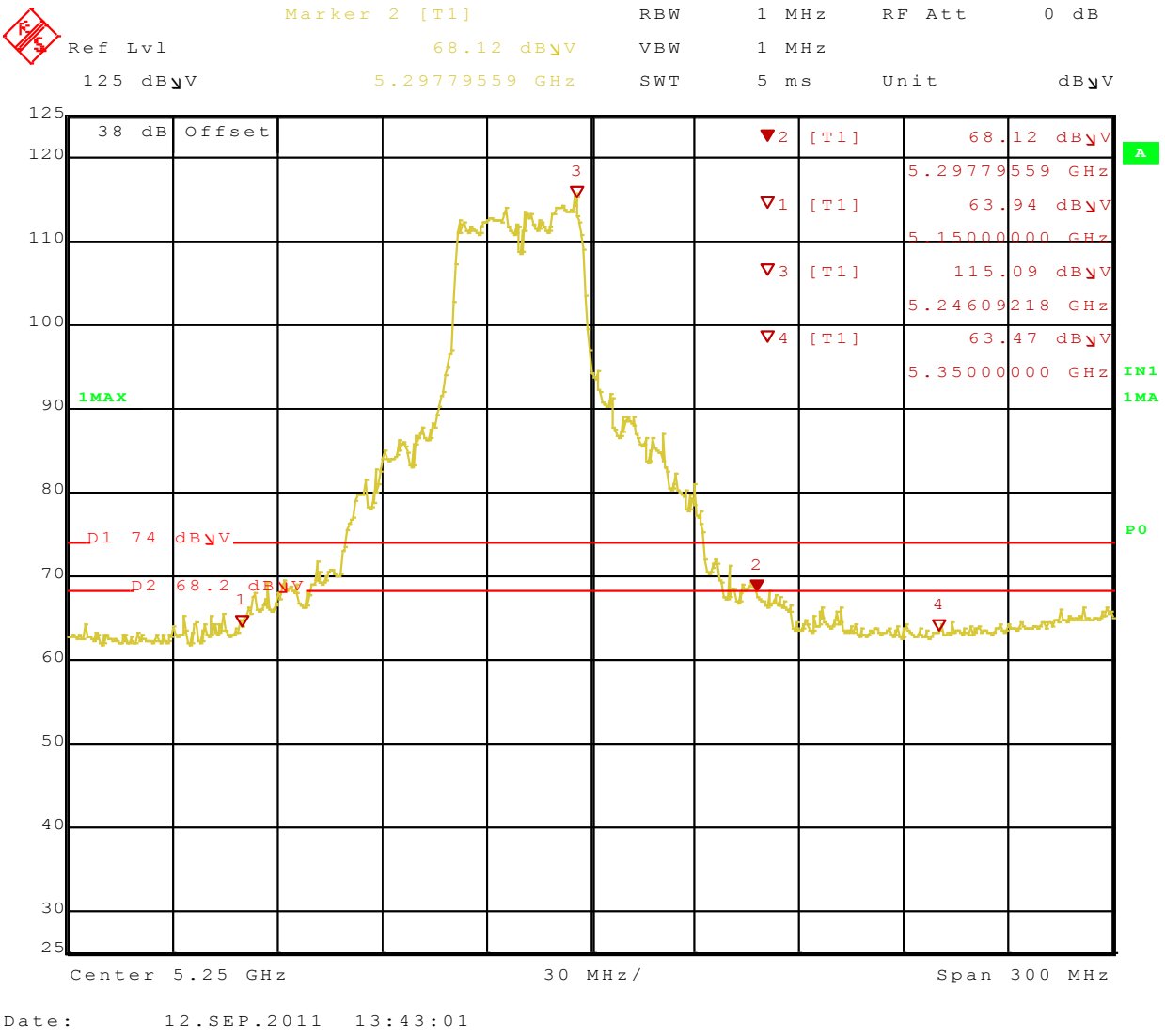


Figure 31: Radiated Emission at the Edge for Channel 5230 MHz HT 40 at 40.5 – Horz (Peak)

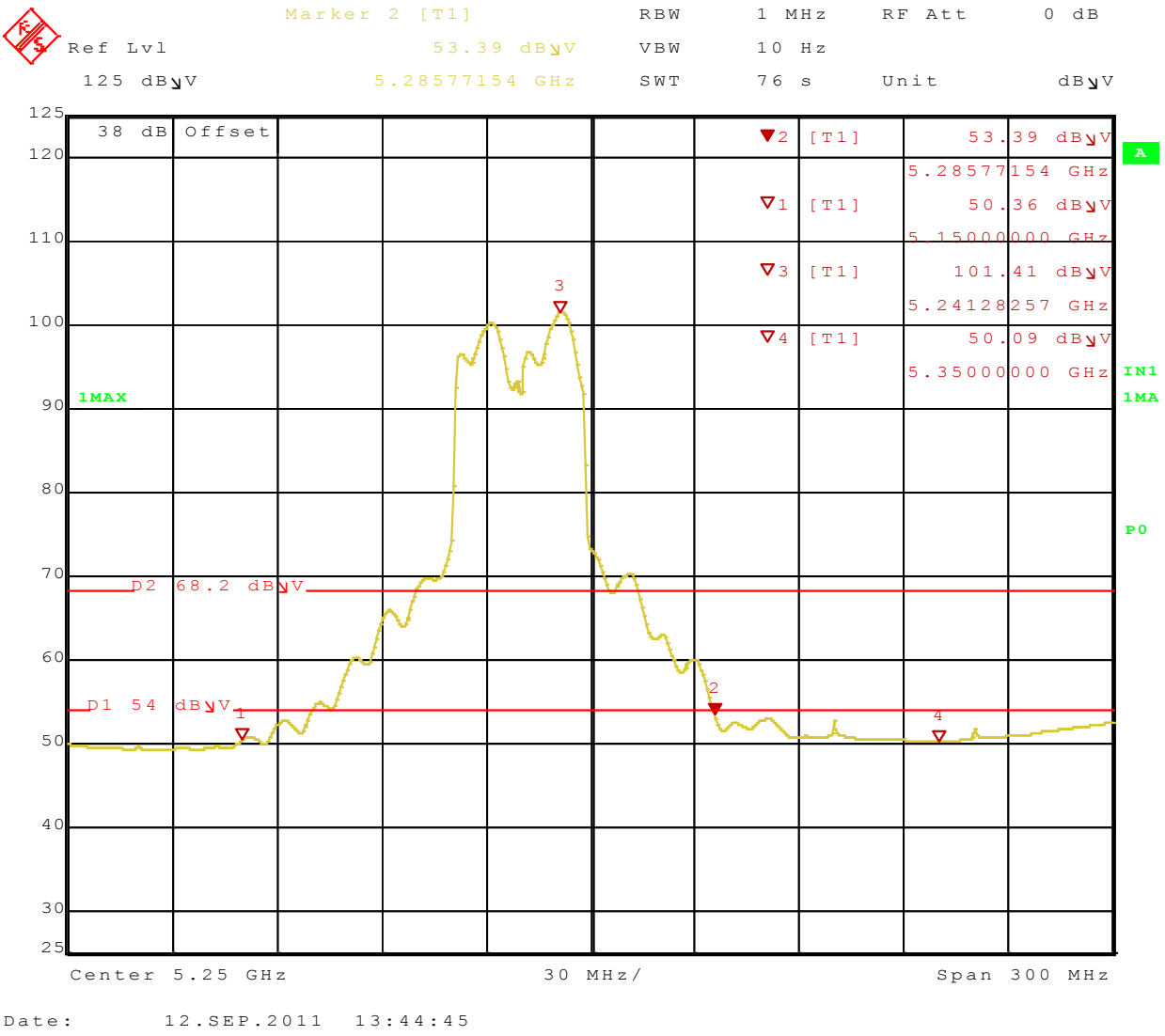


Figure 32: Radiated Emission at the Edge for Channel 5230 MHz HT 40 at 40.5 – Horz (Avg)

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EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 38%rh
		Temp / Hum out	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM Ave (dBuV/m)	Total CF dBuV	E-Field Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
30 MHz to 1GHzTransmitted at 802.11a, 5180 MHz 6Mbps										
200.00	H	160	113	51.67	48.51	-10.22	38.29	43.52	-5.23	Spurious
241.18	H	105	52	54.97	52.58	-10.21	42.37	46.02	-3.65	Spurious
374.98	H	282	102	45.31	43.51	-7.16	36.35	46.02	-9.67	Spurious
749.96	H	95	321	46.78	45.33	-0.63	44.70	46.02	-1.32	Spurious
874.98	H	95	101	37.79	37.20	0.74	37.94	46.02	-8.08	Spurious
62.05	V	95	159	56.19	49.23	-16.45	32.78	40.00	-7.22	Spurious
240.05	V	94	21	54.28	50.17	-10.33	39.84	46.02	-6.18	Spurious
374.98	V	156	163	48.79	47.62	-7.46	40.16	46.02	-5.86	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis at 802.11a, 5220 MHz 6Mbps.
Emissions at 2333MHz are broadband emission. It emitted from Newport power source, and it is not related to the radio module. The Newport is marketed as Class A Device. All other emissions passed Class B limit.

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EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 33%rh
EUT Serial		**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM Ave (dBuV/m)	Total CF dBuV	E-Field Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
Transmitted Data at 5180 MHz @ 16.5 dBm										
1200.07	V	164	389	52.71	43.2	-5.35	37.85	53.98	-16.13	Spurious
1329.82	V	198	458	48.37	38.97	-4.96	34.02	53.98	-19.96	Spurious
2333.08	H	241	36	59.53	57.71	-0.57	57.14	53.98	3.16	Spurious
3666.34	H	121	58	54.11	49.5	3.46	52.96	53.98	-1.02	Spurious
5000.14	H	167	283	47.24	41.6	5.61	47.21	53.98	-6.77	Spurious
10345.01	H	111	6	38.31	26.02	13.17	39.19	53.98	-14.79	Harmonic
15541.2	V	111	54	40.28	25.79	14.81	40.6	53.98	-13.38	Harmonic
Transmitted Data at 5220 MHz @ 16.5 dBm										
1596.01	V	215	80	53.58	36.86	-3.91	32.95	53.98	-21.03	Spurious
2333.08	H	196	-16	56.84	54.5	-0.57	53.93	53.98	-0.05	Spurious
2500.07	H	201	209	47.04	48.38	0.02	48.4	53.98	-5.58	Spurious
3666.31	H	201	56	53.1	49.18	3.46	52.64	53.98	-1.34	Spurious
4666.41	H	245	65	42.15	34.6	4.61	39.21	53.98	-14.77	Spurious
10425.01	H	245	388	39.09	26.32	13.26	39.58	53.98	-14.4	Harmonic
Transmitted Data at 5240 MHz @ 16.5 dBm										
1200.07	V	106	130	50.98	35.29	-5.35	29.94	53.98	-24.04	Spurious
2333.2	H	146	417	57.48	56.17	-0.57	55.6	53.98	1.62	Spurious
3666.28	H	147	412	53.78	49.68	3.45	53.13	53.98	-0.85	Spurious
5000.01	H	181	95	47.31	41.36	5.61	46.97	53.98	-7.01	Spurious
7358.23	V	137	376	38.45	26.73	10.42	37.15	53.98	-16.83	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis, 6Mbps. Emission at 2.3332GHz is from Digital part of device which complies with Class A limits

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EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 33%rh
EUT Serial	Prototype	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Emission Freq	ANT Polar	ANT Pos	Table Pos	FIM (Pk) Pk	FIM Ave	Total CF	E-Field Ave	Spec Limit	Spec Margin	Type
Transmitted Data at @ dBm HT 20 Mode worst case results from low, mid and high channels										
1100.01	V	180	23	48.95	36.67	-5.68	30.99	53.98	-22.99	Spurious
2114.81	V	180	424	43.64	32.6	-1.39	31.2	53.98	-22.78	Spurious
2333.08	V	171	414	54.96	53.48	-0.57	52.91	53.98	-1.07	Spurious
3666.37	V	147	364	49.3	42.58	3.46	46.03	53.98	-7.95	Spurious
4999.62	H	147	-10	44.97	38.51	5.61	44.12	53.98	-9.86	Spurious
7250.82	H	147	474	41.24	26.64	10.32	36.96	53.98	-17.02	Spurious
1595.86	V	200	125	61.86	39.51	-3.91	35.6	53.98	-18.38	Harmonic
10435.3	H	168	79	40.64	26.33	13.26	39.59	53.98	-14.39	Harmonic
10446.8	V	170	422	39.23	26.4	13.26	39.66	53.98	-14.32	Harmonic
10446.8	H	170	322	44.36	26.3	13.26	39.56	53.98	-14.42	Harmonic

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis, 6Mbps.

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EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 33%rh
EUT Serial	Prototype	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM Ave (dBuV/m)	Total CF dBuV	E-Field Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
Transmitted Data at MHz HT40 @ 14 dBm all channels										
1199.99	V	156	58	50.03	41.5	-5.35	36.15	53.98	-17.83	Spurious
1300.17	V	142	52	41.82	32.54	-5.04	27.5	53.98	-26.48	Spurious
2333.14	V	139	55	53.54	52.02	-0.57	51.45	53.98	-2.53	Spurious
3666.28	V	149	-1	44.53	41.25	3.45	44.7	53.98	-9.28	Spurious
4999.62	V	170	64	46.04	40.52	5.61	46.13	53.98	-7.85	Spurious
10473.4	V	170	20	34.06	26.56	13.25	39.81	53.98	-14.17	Harmonic
1600.13	H	224	441	49.98	35.5	-3.89	31.61	53.98	-22.37	Spurious
2333.26	H	212	384	58.01	55.81	-0.57	55.24	53.98	1.26	Spurious
2447.04	H	212	365	43.64	25.94	-0.2	25.74	53.98	-28.24	Spurious
3666.34	H	233	392	48.43	43.54	3.46	47	53.98	-6.98	Spurious
4839.95	H	224	412	48.65	43.66	5.14	48.8	53.98	-5.18	Spurious
5520.01	H	257	104	47.32	37.02	6.88	43.9	53.98	-10.08	Spurious
7295.00	H	124	322	39.21	26.72	10.36	37.08	53.98	-16.9	Spurious
9627.86	V	124	59	29.86	29.68	12.75	42.43	53.98	-11.55	Spurious
10425.00	H	124	128	37.25	26.07	13.26	39.33	53.98	-14.65	Harmonic
1600.13	H	224	441	49.98	35.5	-3.89	31.61	53.98	-22.37	Harmonic
3999.86	H	126	292	45.4	34.68	-3.91	30.77	53.98	-23.21	Spurious
5000.01	H	124	108	53.12	51.62	-0.57	51.05	53.98	-2.93	Spurious
5480.03	H	126	-73	42.67	38.83	3.46	42.28	53.98	-11.7	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis, 6Mbps.

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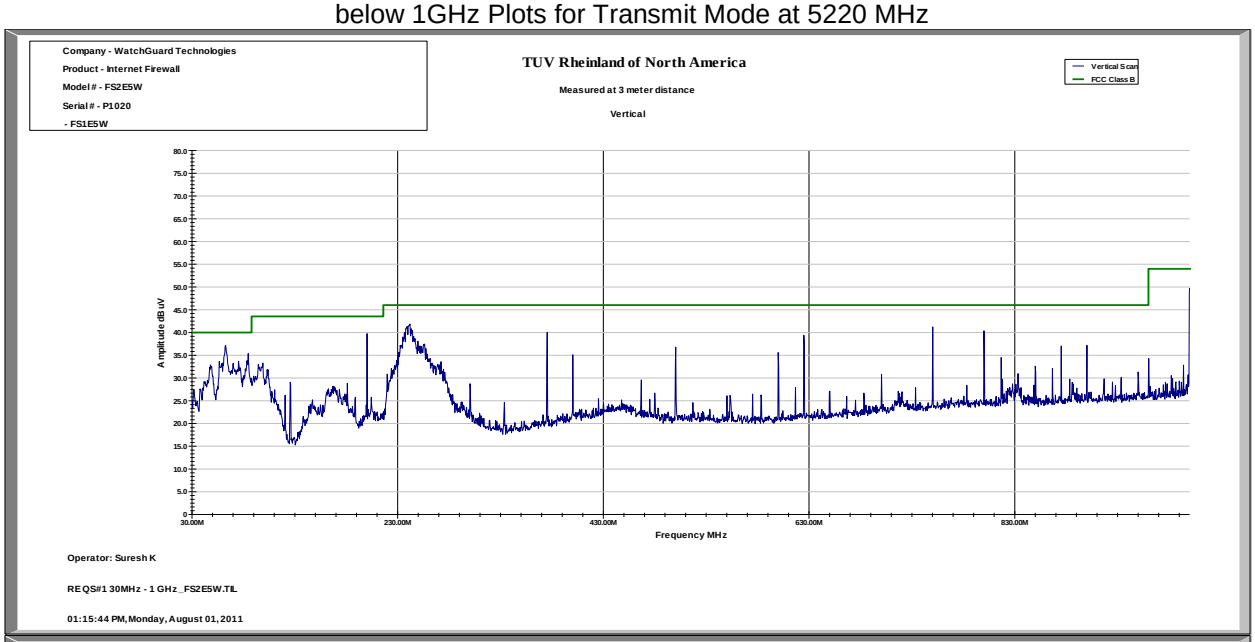
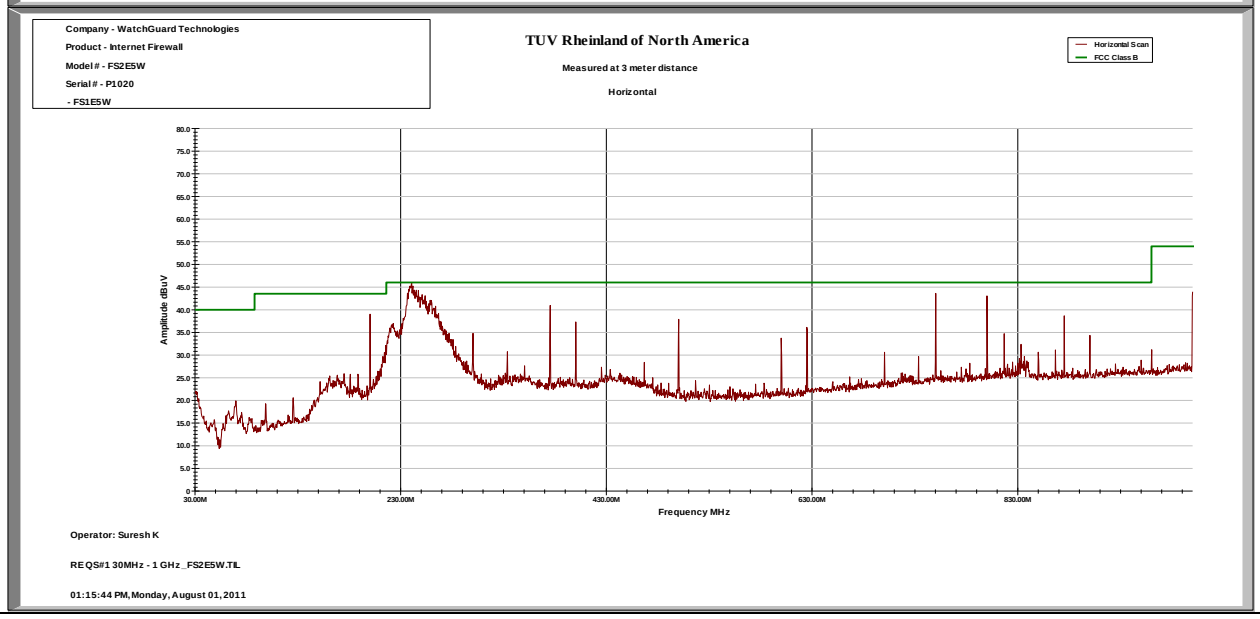
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 39%rh
EUT Serial		**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

below 1GHz Plots for Transmit Mode at 5220 MHz





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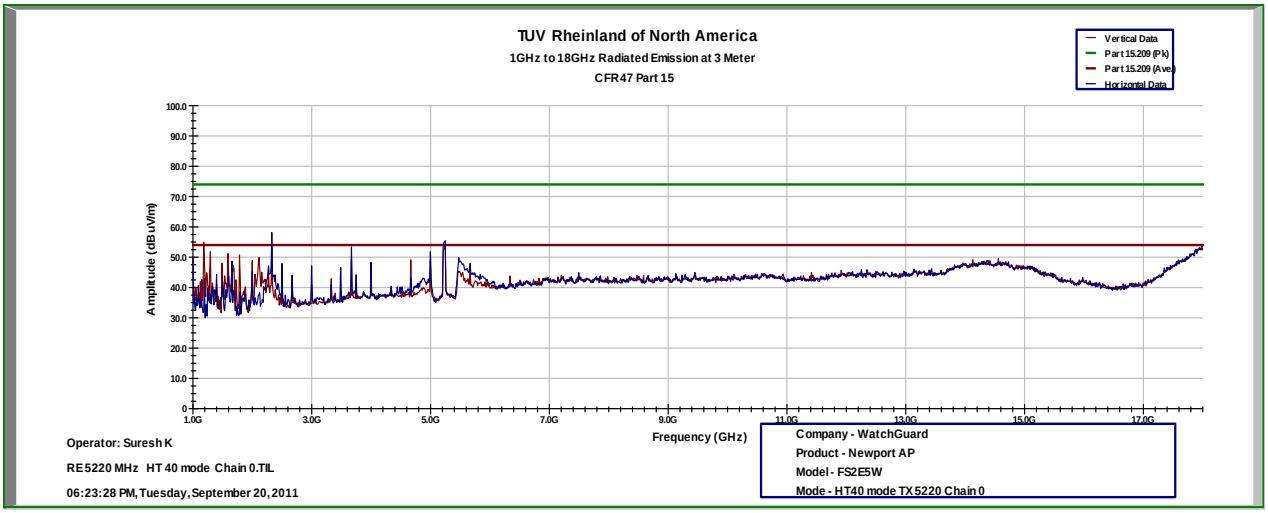
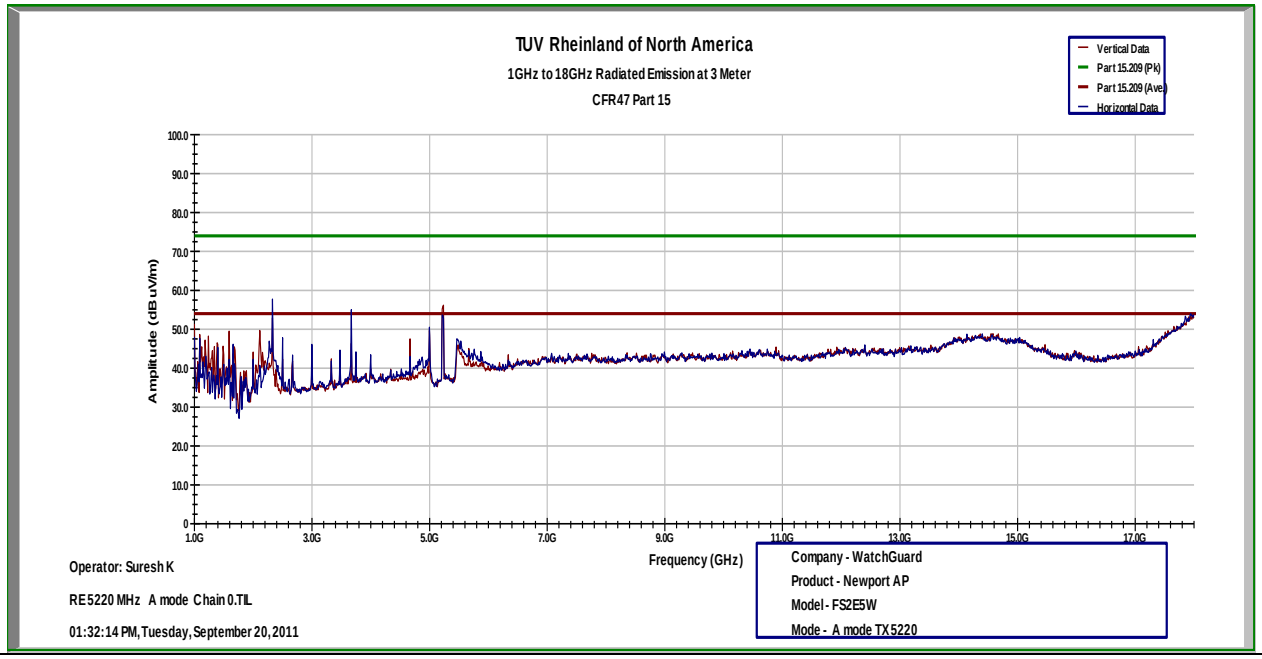
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 39%rh
EUT Serial	Prototype	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	1m - RA42-K-F-4B-C	**Performed by**	Jeremy Luong

Above 1GHz Plots for Transmit Mode at 5180 MHz



Above 1GHz Plots for Transmit Mode at 5220 MHz



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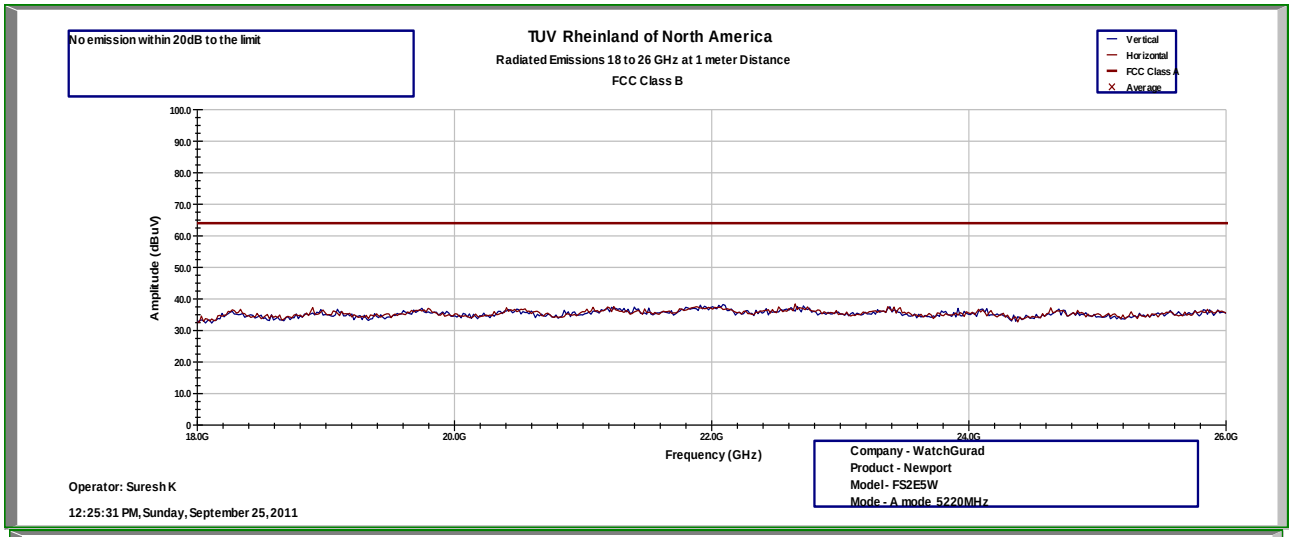
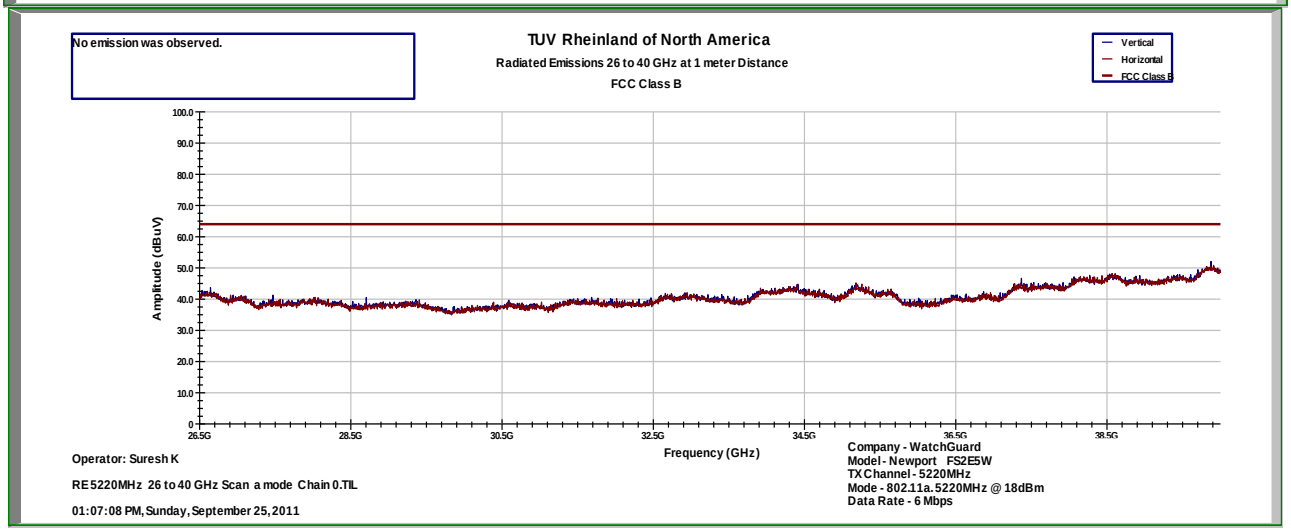
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 39%rh
EUT Serial		**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Above 1GHz Plots for Transmit Mode at 5220 MHz





Notes: Limit was extrapolated to 1m distance for 18GHz – 40 GHz range.

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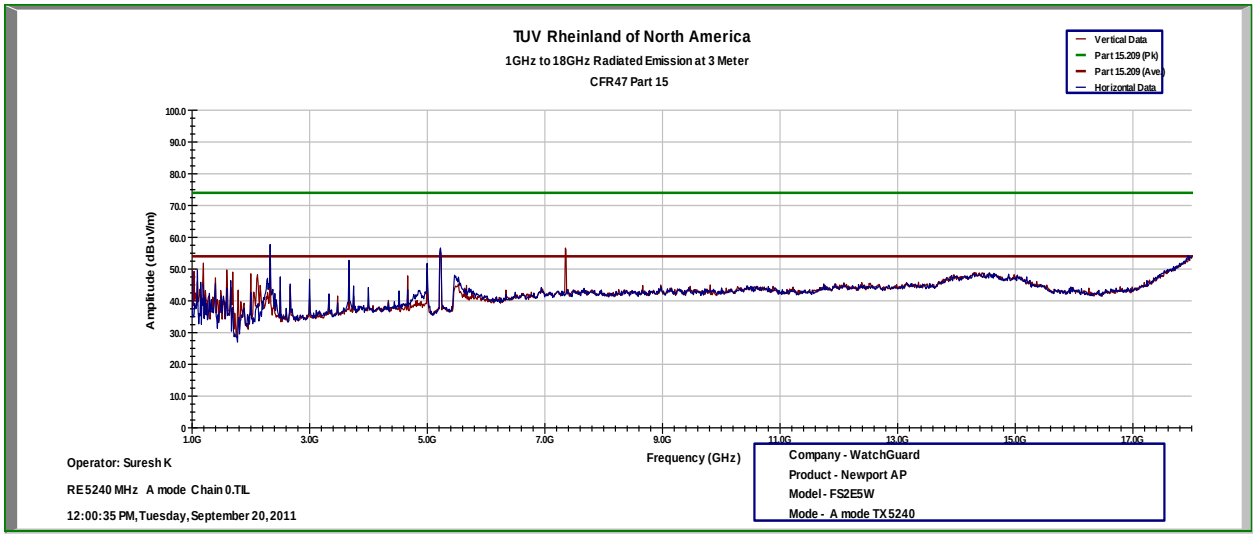
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 39%rh
EUT Serial	Prototype	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11a at 6Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Jeremy Luong

Above 1GHz Plots for Transmit Mode at 5240 MHz



Notes: Limit was extrapolated to 1m distance for 18GHz – 40 GHz range.

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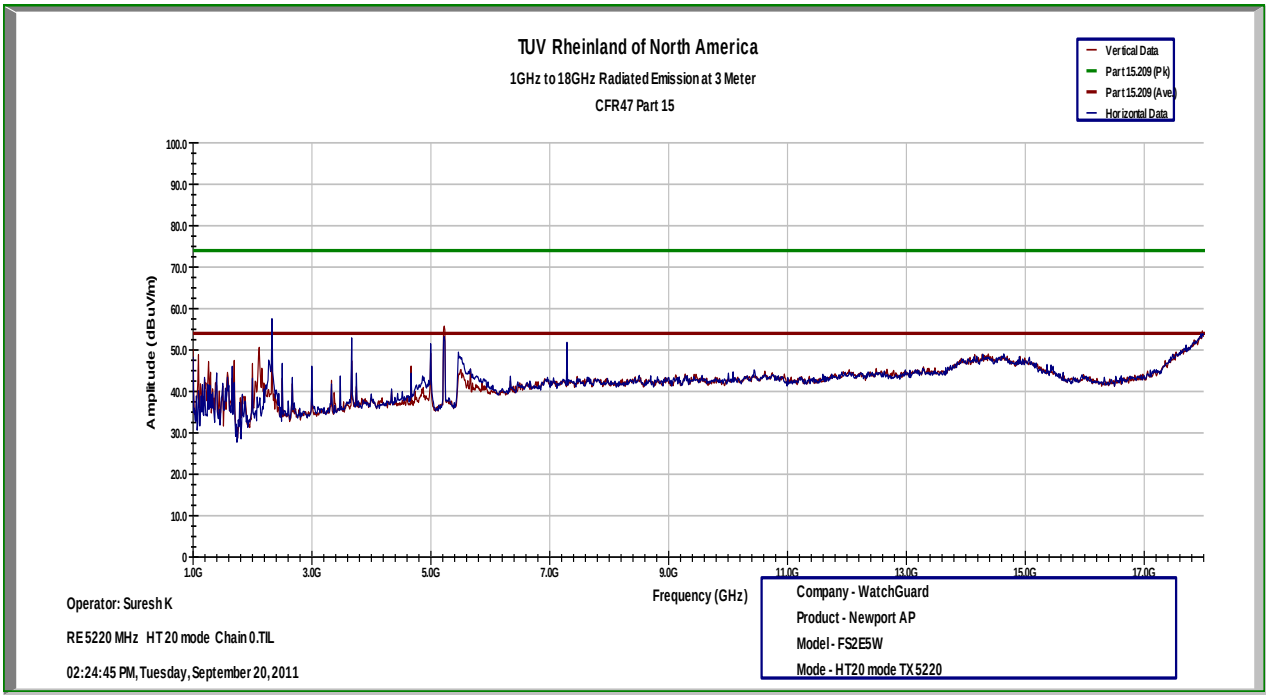
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23°C / 39%rh
EUT Serial		**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11n HT20 at 6.5Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Jeremy Luong

Above 1GHz Plots for Transmit HT20 Mode at 5220 MHz



All Emissions were at least 10 dB below noise floor level for 18 to 40Ghz range

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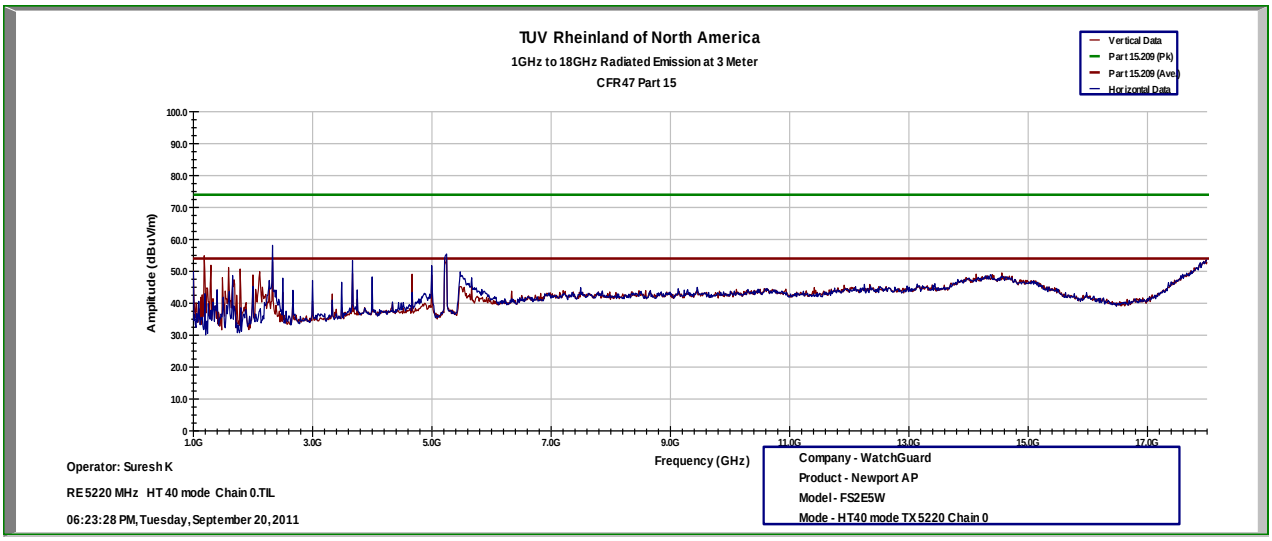
EUT Name	Newcastle, Newport	**Date**	September 20, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	22°C / 39%rh
EUT Serial		**Temp / Hum out**	N/A
EUT Config.	Y-Axis, 802.11n HT20 at 6.5Mbps	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Jeremy Luong

Above 1GHz Plots for Transmit HT40 Mode at 5230 MHz



Notes: Limit was extrapolated to 1m distance for 18GHz – 40 GHz range.

4.5.4 Sample Calculation

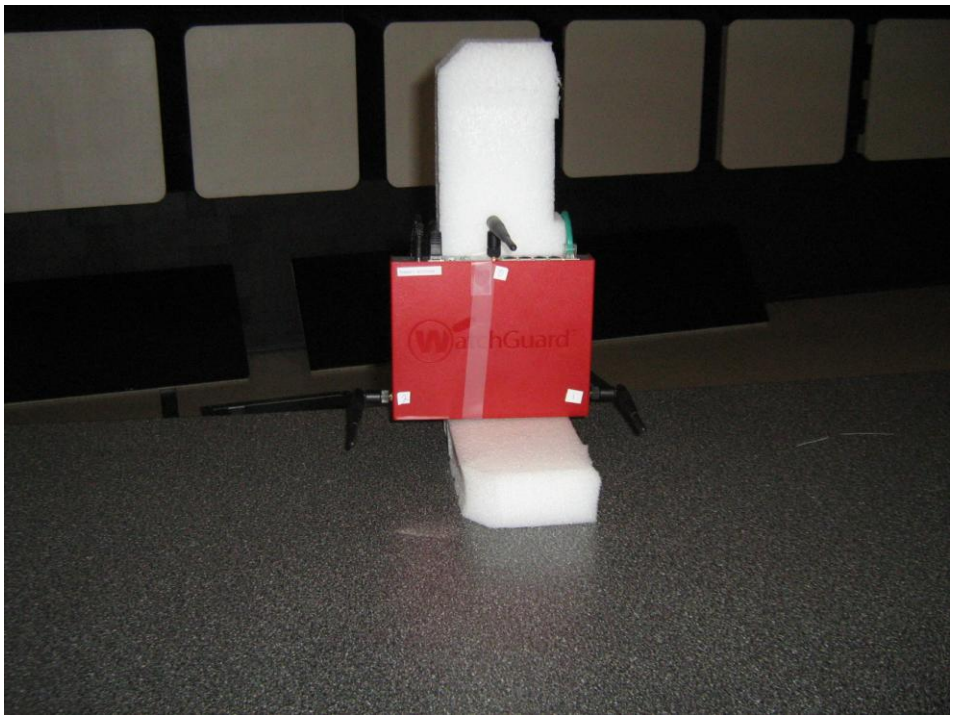
The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

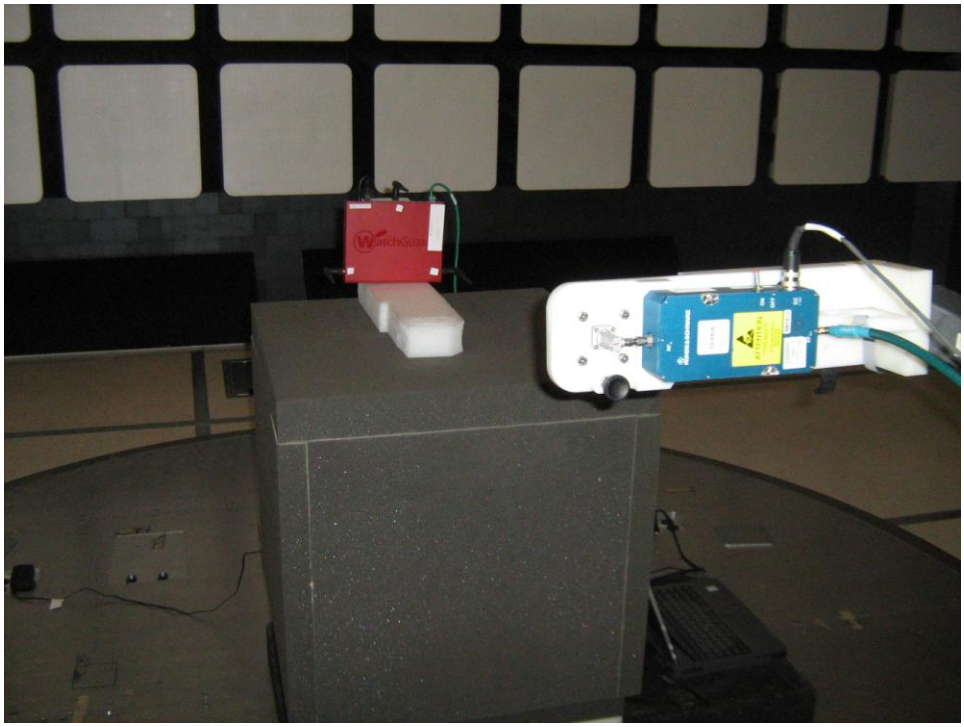
Field Strength (dBμV/m) = FIM - AMP + CBL + ACF

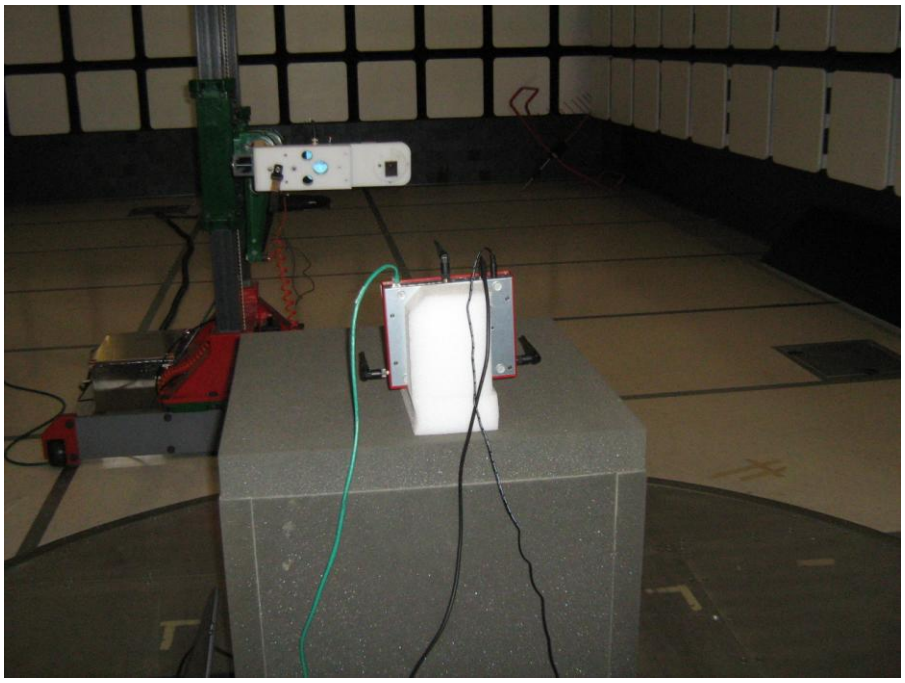
Where: FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

4.5.5 Test setup Photos







4.6 Receiver Spurious Emissions

Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode.

The spurious emissions of the receiver shall not exceed the values in CFR47 Part 15.109 and RSS 210 Sect 2.7.

4.6.1 Test Methodology

4.6.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Pre-scans were performed to determine the worst orientation.

4.6.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans were performed at the middle channel for each frequency band on Y-Axis.

20 MHz Receiving Bandwidth:

Operating Frequency 5220 MHz for 5150 MHz – 5250 MHz band

40 MHz Receiving Bandwidth:

Operating Frequency 5230 MHz for 5150 MHz – 5250 MHz band

4.6.1.3 Deviations

None.

4.6.2 Receiver Spurious Emission Limit

The spurious emissions of the receiver shall not exceed the values in CFR47 Part 15.109: 2009 and RSS GEN Sect 6.2 2010.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F(kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

4.6.3 Test Results

The final measurement data indicates the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and 1.5.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.6.3.1 Final Data

The data recorded in this section contains the final results under the worst-case conditions and without any modifications or special accessories implemented as the manufacturer intends.

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EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 36%rh
EUT Serial	70AB00010-BC75	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 20 MHz Bandwidth	**Line AC / Freq**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	See Note
Dist/Ant Used	3m – JB3	**Performed by**	Suresh Kondapalli

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP (dBuV/m)	Total CF dBuV	E-Field QP (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
30 MHz to 1GHz Radiated Emission - Receive Mode @ 5220 MHz										
246.26	H	108	250	47.61	44.16	-10.22	33.94	56.90	-22.96	Spurious
624.97	H	124	342	46.97	46.16	-3.09	43.07	56.90	-13.83	Spurious
749.91	H	107	61	41.78	40.83	-0.63	40.20	56.90	-16.70	Spurious
800.01	H	102	50	45.95	45.23	0.04	45.27	56.90	-11.63	Spurious
999.90	H	116	280	44.00	40.33	2.91	43.24	60.00	-16.76	Spurious
499.95	V	106	13	48.23	47.00	-5.66	41.34	56.90	-15.56	Spurious
626.08	V	191	12	24.00	22.71	-3.29	19.42	56.90	-37.48	Spurious
749.91	V	139	7	43.43	42.96	-1.23	41.73	56.90	-15.17	Spurious
799.99	V	127	26	43.20	43.01	-0.46	42.55	56.90	-14.35	Spurious
999.89	V	105	6	48.25	47.88	2.51	50.39	60.00	-9.61	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested with a Bandwidth of 20 MHz.
Newport is a Class A device per CFR47 Part 15.109

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EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 36%rh
EUT Serial	70AB00010-BC75	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 20 MHz Bandwidth	**Line AC / Freq**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	See Note
Dist/Ant Used	3m – JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP (dBuV/m)	Total CF dBuV	E-Field QP (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
1 to 18 GHz Radiated Emission - Receive Mode @ 5220 MHz										
2333.18	V	167	35	56.18	52.56	-0.57	51.99	60.00	-8.01	Spurious
2333.22	H	110	364	66.89	56.41	-0.57	55.84	60.00	-4.16	Spurious
3480.05	H	110	265	48.39	45.22	2.79	48.01	60.00	-11.99	Spurious
3666.38	H	145	78	51.93	44.23	3.46	47.69	60.00	-12.31	Spurious
4999.58	H	108	380	48.56	43.09	5.61	48.70	60.00	-11.30	Spurious
4999.62	V	156	-12	47.94	36.27	5.61	41.88	60.00	-18.12	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested with a Bandwidth of 20 MHz
Newport is a Class A device per CFR47 Part 15.109

SOP 1 Radiated Emissions

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EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	22°C / 39%rh
EUT Serial	70AB00010-BC75	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 40 MHz Bandwidth	**Line AC / Freq**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	See Note
Dist/Ant Used	3m – JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP (dBuV/m)	Total CF dBuV	E-Field QP (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
1GHz to 18 GHz Radiated Emission - Receive Mode @ 5230 MHz										
2333.17	V	168	393	53.40	52.04	-0.57	51.47	60.00	-8.53	Spurious
2333.18	H	110	9	57.27	56.32	-0.57	55.75	60.00	-4.25	Spurious
2500.11	H	144	425	47.44	43.58	0.02	43.60	60.00	-16.40	Spurious
3486.66	H	210	118	48.36	45.45	2.81	48.26	60.00	-11.74	Spurious
3666.38	H	172	419	55.26	47.30	3.46	50.76	60.00	-9.24	Spurious
4999.56	H	167	-24	47.66	42.29	5.61	47.90	60.00	-12.10	Spurious
4999.62	V	98	378	47.31	41.87	5.61	47.48	60.00	-12.52	Spurious

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested with a Bandwidth of 40 MHz
Newport is a Class A device per CFR47 Part 15.109

SOP 1 Radiated Emissions

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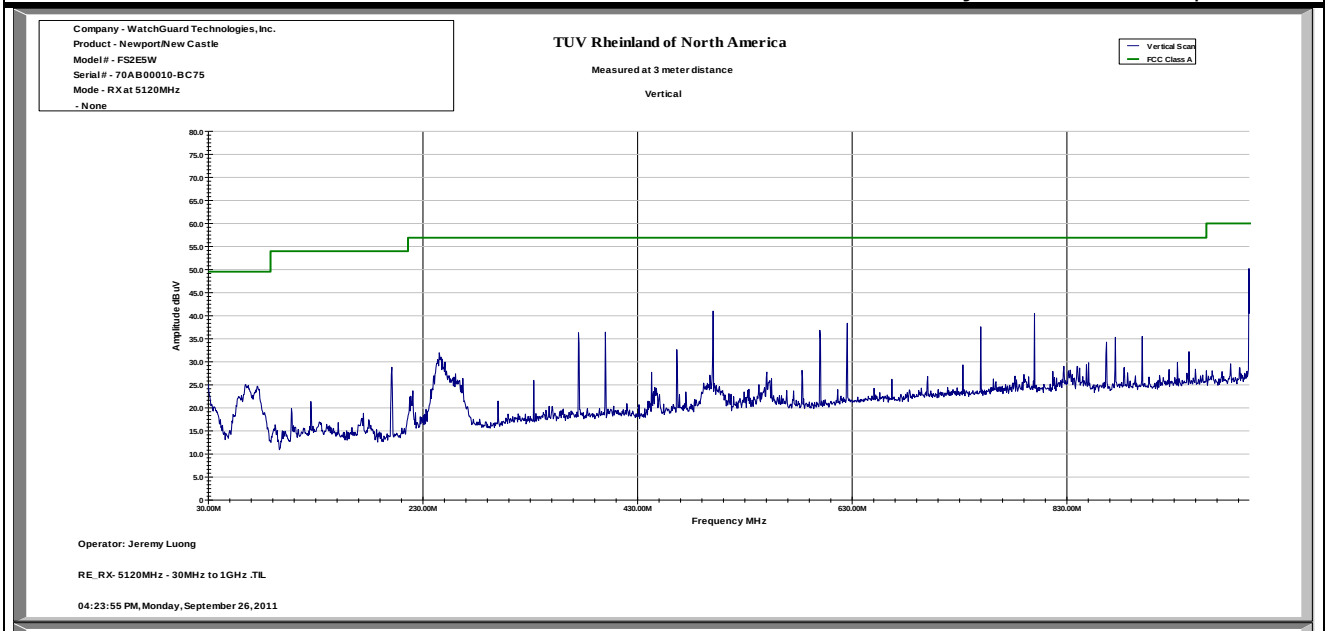
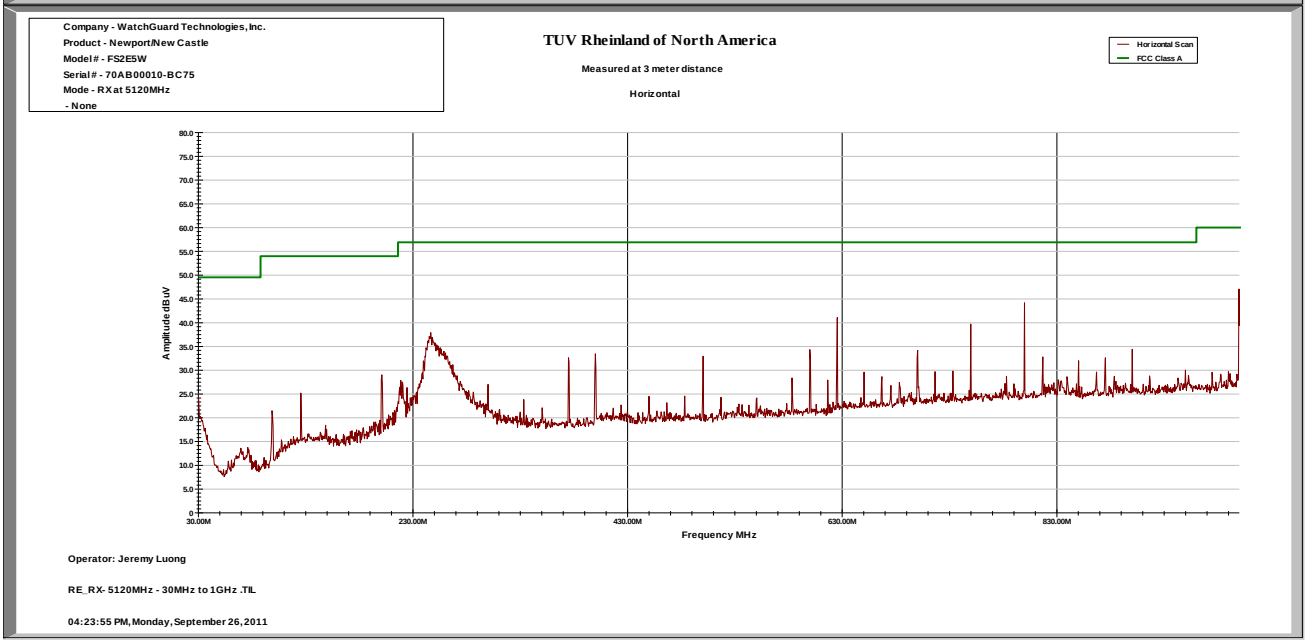
EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 36%rh
EUT Serial	Prototype	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 5220 MHz, 20 MHz Bandwidth	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	120 kHz / 300 kHz
Dist/Ant Used	3m – JB3	**Performed by**	Suresh Kondapalli





Notes: Tested with a Bandwidth of 20 MHz

SOP 1 Radiated Emissions

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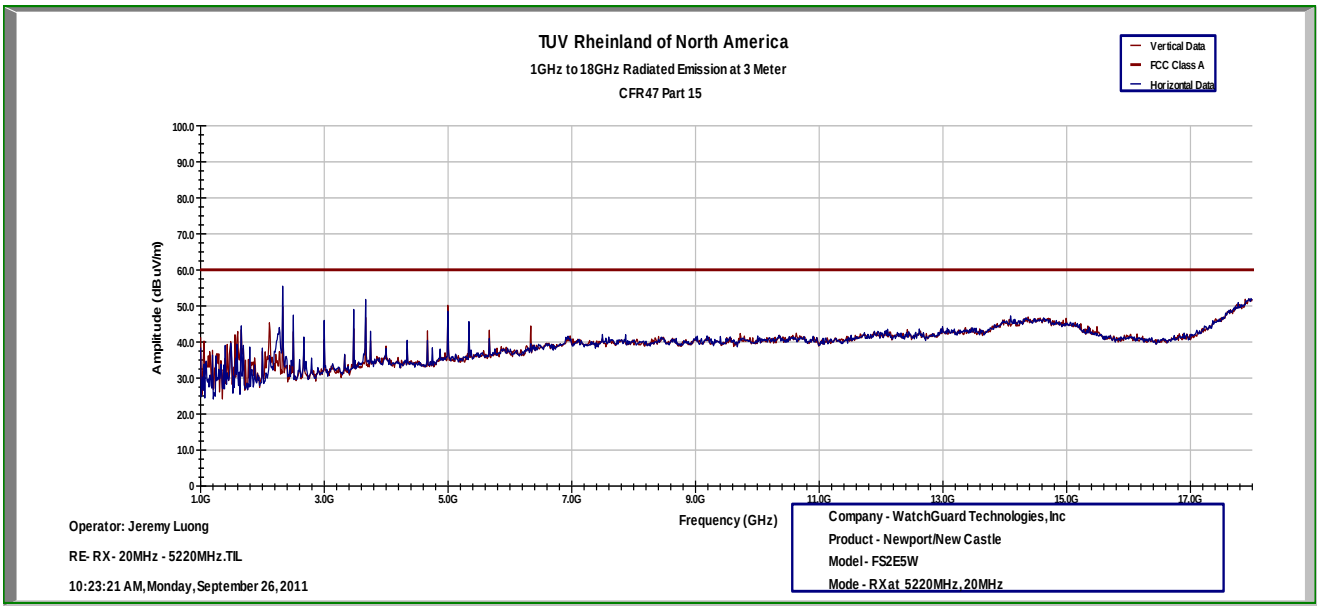
EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 36%rh
EUT Serial	70AB00010-BC75	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 5300 MHz, 20 MHz Bandwidth	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	120 kHz / 300 kHz
Dist/Ant Used	3m – JB3	**Performed by**	Jeremy Luong



Notes: Tested with a Bandwidth of 20 MHz

SOP 1 Radiated Emissions

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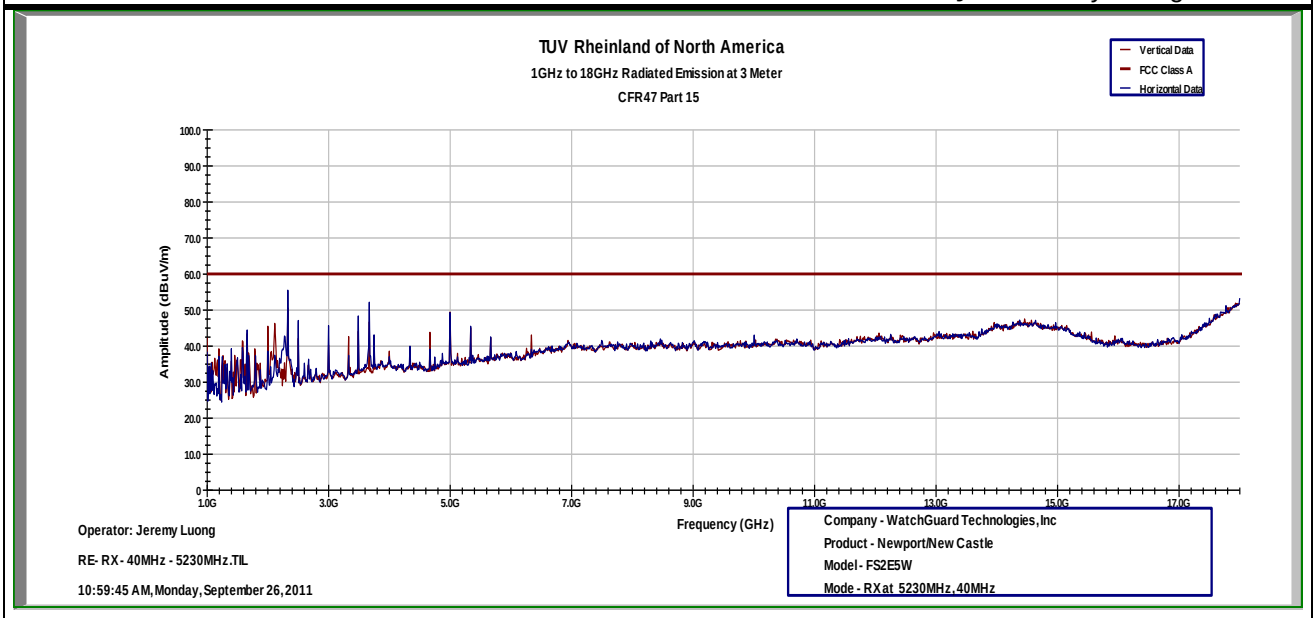
EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	21°C / 37%rh
EUT Serial	70AB00010-BC75	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, RX at 5230 MHz, 40 MHz Bandwidth	**Line AC**	120Vac 60Hz
Standard	CFR47 Part 15 Subpart b	**RBW / VBW**	120 kHz / 300 kHz
Dist/Ant Used	3m – JB3	**Performed by**	Jeremy Luong



Notes: Tested with a Bandwidth of 40 MHz

Sample Calculation

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = FIM - AMP + CBL + ACF

Where: FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

4.7 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4: 2003. These test methods are listed under the laboratory's NVLAP Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207: 2009 and RSS 210: 2010.

4.7.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50μH / 50Ω LISNs.

Testing is either performed in Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.7.1.1 Deviations

There were no deviations from this test methodology.

4.7.2 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 7: AC Conducted Emissions – Test Results

Test Conditions: Conducted Measurement at Normal Conditions only		
Antenna Type: 3 X external	**Power Level:** See Test Plan	
AC Power: 120 Vac/60 Hz	**Configuration:** Tabletop	
Ambient Temperature: 22° C	**Relative Humidity:** 37% RH	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Hot)	0.15 to 30 MHz	Pass
Line 2 (Neutral)	0.15 to 30 MHz	Pass

SOP 2 Conducted Emissions

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EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23° C / 34% rh
EUT Serial	70AB00010-8C75	**Temp / Hum out**	N/A
EUT Config.	3 External Antennas	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab #5 / Solar 9348-50-R-24-BNC, Line 1	**Performed by**	Suresh Kondapalli

Frequency	Quasi-Peak	QP Limit	QP Margin	Average	Ave Limit	Ave Margin
MHz	dBuV	dBuV	dB	dBuV	dBuV	dB
0.153	51.55	26.63	79	66	-27.45	-39.37
0.154	51.09	26.91	79	66	-27.91	-39.09
0.178	48.38	25.1	79	66	-30.62	-40.9
0.488	41.61	37.77	79	66	-37.39	-28.23
7.08	34.33	28.41	73	60	-38.67	-31.59
14.1	30.8	26.08	73	60	-42.2	-33.92

Spec Margin = QP./Ave. - Limit, ± Uncertainty

Combined Standard Uncertainty $u_c(y)$ = ± 1.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: EUT was setup as table top equipment and transmitted at 5220 MHz in HT20 at 6.5Mbps

SOP 2 Conducted Emissions

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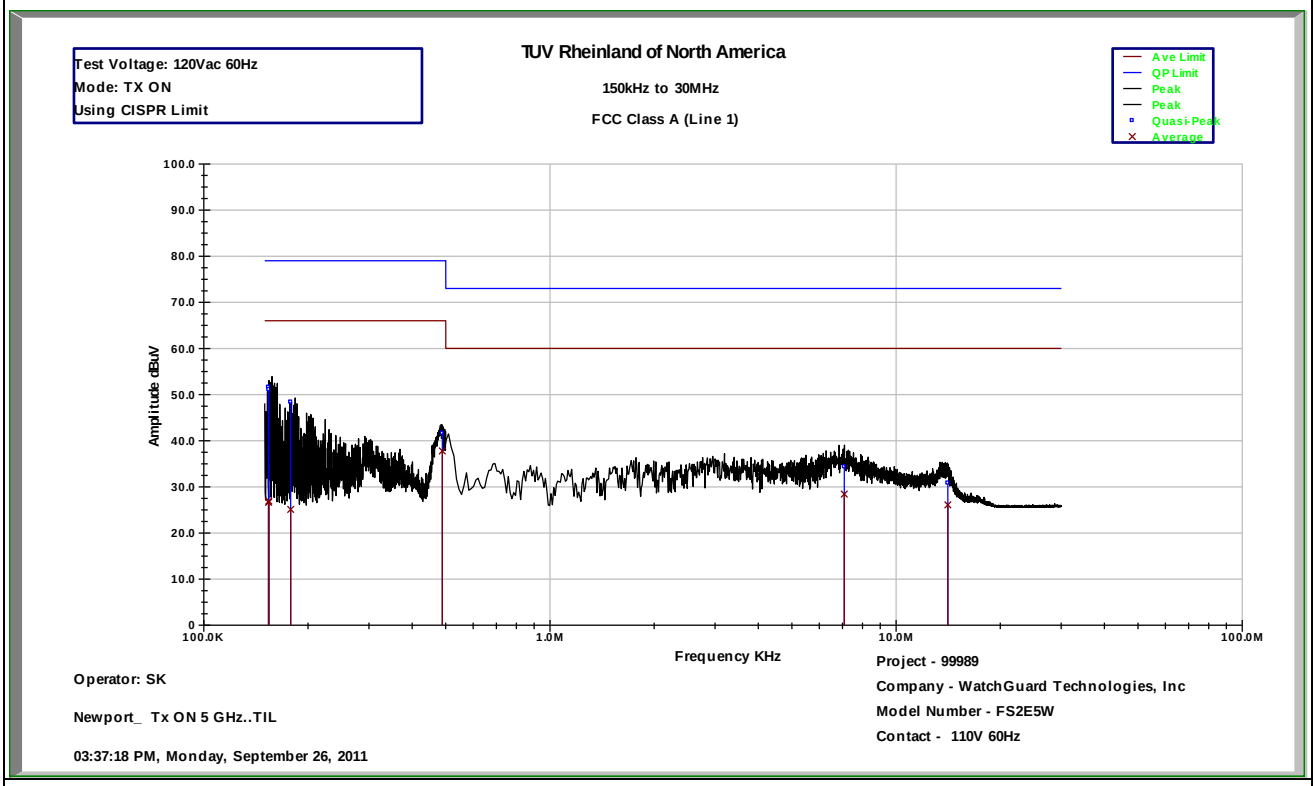
EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23° C / 34% rh
EUT Serial	70AB0001E-6BB4	**Temp / Hum out**	N/A
EUT Config.	3 External Antennas	**Line AC**	120Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab #5 / Solar 9348-50-R-24-BNC, Line 1	**Performed by**	Jeremy Luong

150 kHz to 30 MHz Plot for Line 1 (Hot)



Notes: Class A limits are used EUT meets FCC Class B limit.

SOP 2 Conducted Emissions

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EUT Name	Newcastle, Newport	**Date**	September 26. 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23° C / 34% rh
EUT Serial	70AB0001E-6BB4	**Temp / Hum out**	N/A
EUT Config.	3 External Antennas	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15.107	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab #5 / Solar 9348-50-R-24-BNC, Line 2	**Performed by**	Suresh Kondapalli

Frequency	Quasi-Peak	QP Limit	QP Margin	Average	Ave Limit	Ave Margin
MHz	dBuV	dBuV	dB	dBuV	dBuV	dB
0.150	51.64	29.02	79	66	-27.36	-36.98
0.154	51.61	29.42	79	66	-27.39	-36.58
0.155	51.09	29.08	79	66	-27.91	-36.92
0.184	44.68	21.23	79	66	-34.32	-44.77
0.495	37.02	31.29	79	66	-41.98	-34.71
13.67	29.75	25.06	73	60	-43.25	-34.94

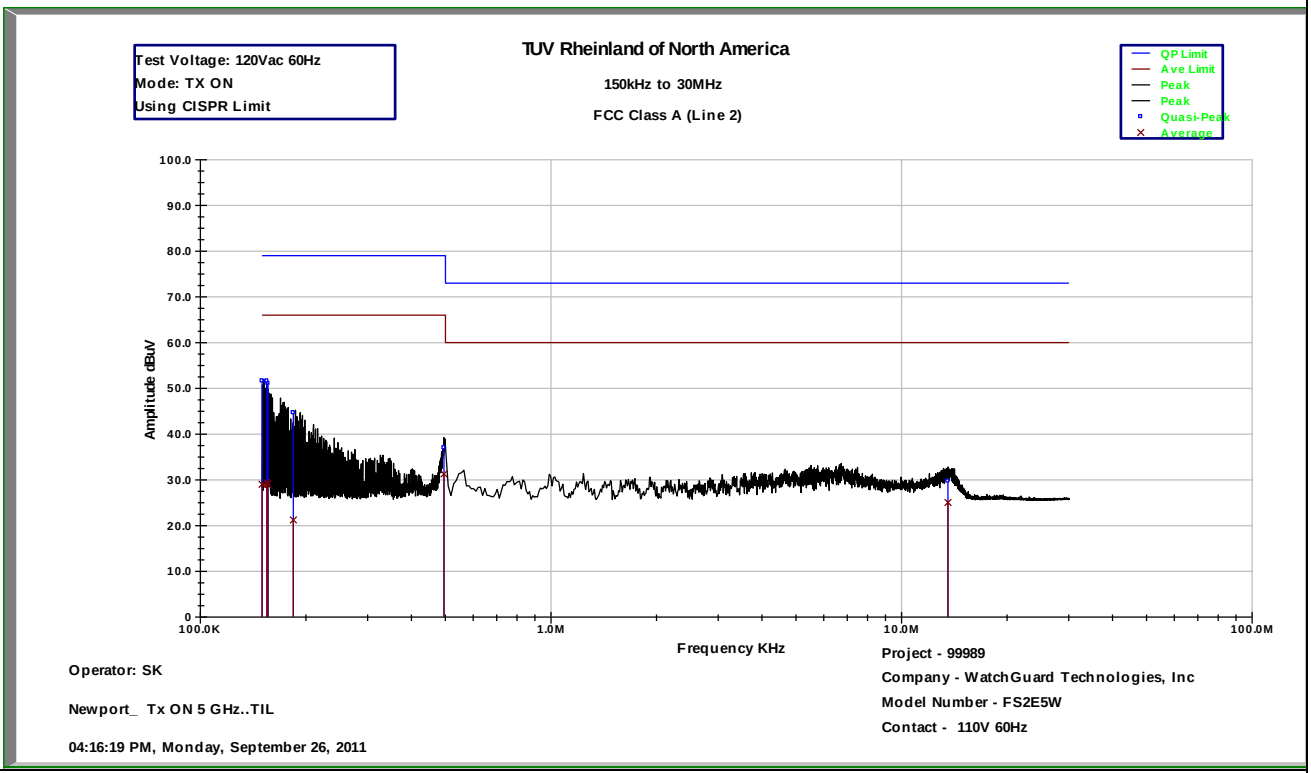
Spec Margin = QP./Ave. - Limit, ± Uncertainty

Combined Standard Uncertainty $u_c(y)$ = ± 1.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: EUT was setup as table top equipment and transmitted at 5220 MHz in HT20 at 6.5Mbps

SOP 2 Conducted Emissions		Tracking # 31152150.003 Page 4 of 4	
EUT Name	Newcastle, Newport	**Date**	September 26, 2011
EUT Model	FS1E5, FS1E5W, FS2E5, FS2E5W	**Temp / Hum in**	23° C / 34% rh
EUT Serial	70AB0001E-6BB4	**Temp / Hum out**	N/A
EUT Config.	3 External Antennas	**Line AC**	120Vac/60Hz
Standard	CFR47 Part 15.107	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab #5/ Solar 9348-50-R-24-BNC, Line 2	**Performed by**	Suresh Kondapalli

150 kHz to 30 MHz Plot for Line 2 (Neutral)



Note: Meet FCC Class B Limit.

4.7.3 Test Setup Photos

4.8 Frequency Stability

In accordance with 47 CFR Part 15.407(g) the frequency stability of U-NII devices must be such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the users manual. The Manufacturer calls out operating temperature ranges of +0º to +50º C

4.8.1 Test Methodology

The manufacturer of the equipment is responsible for ensuring that the frequency stability is such that emissions are always maintained within the band of operation under all conditions. This test performs according to ANSI C63.10-2009 Section 6.8

4.8.2 Manufacturer Declaration

The frequency stability of the reference oscillator sets the frequency stability of the RF transceiver signals. Therefore all of the RF signal should have ±20ppm stability.

This stability accounts for room temp tolerance of the crystal oscillator circuit, frequency variation across temperature, and crystal ageing.

Worst case:
5.220 GHz - ±20ppm/104.4 kHz

±20ppm at 5 GHz translates to a maximum frequency shift of ±104 kHz. As the edge of the channels are at least one MHz from either of the band edges, ±104 kHz is more than sufficient to guarantee that the intentional emission will remain in the band over the entire operating range of the radio.

4.8.3 Limit

CFR47 Part 407(g) - Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

4.8.4 Test results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

WatchGuard declared the operation range as 0 to 40°C

Table 8: Frequency Stability – Test Results

Temperature	-6 dB Lower Edge (MHz)	+6 dB Upper Edge (MHz)	Center Frequency (MHz)	PPM
40°C	5211.6300	5228.2800	5219.9960	-6.32
Normal Temp	5211.7330	5228.1920	5219.9630	0
0°C	5211.6900	5228.3100	5220.0000	+7.08
Note: All frequency drifts were less than ±20 ppm.				

Test was performed in 802.11 a mode. Other temperatures and mode were evaluated. The start time 2min , 5min and 10 min from start of temperature were evaluated, only worst case values are reported here.

4.8.5 Voltage Variation

In accordance with 47 CFR Part 15.31 (e) intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

4.8.5 Test Methodology

The ac supply voltage was varied between 85% and 115% of the nominal rated supply voltage. The fundamental frequency was observed during the variation. The Newport was powered 120V/60Hz by programmable power supply. The voltage was varied from 102Vac to 138Vac mean while the fundamental frequencies were observed and record for the maximum drift in ppm; part per millions.

4.8.6 Test results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). The fundamental frequencies drifted less than ±20ppm.

Table 9: Voltage Variation – Test Results

Frequency MHz	**Nominal** (120Vac) MHz	**Lo Voltage (102Vac)** MHz	**Hi Voltage (138Vac)** MHz	**Max Drift** ppm
5180	5178.329299	5178.322727	5178.338233	2.97
5220	5218.365227	5218.365227	5128.338233	-1.7
5240	5238.386727	5238.365227	5238.338233	-5.2

5 Test Equipment Use List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal dd/mm/yy	Next Cal dd/mm/yy
Bilog Antenna	Sunol Science	JB3	A102606	2/18/2010	2/18/2012
Horn Antenna	Sunol Scienece	DRH-118	A040806	9/29/2010	9/29/2012
Antenna (18-26GHz)	CMT	RA42-K-F-4B-C	020131-004	10/15/2010	10/15/2011
Antenna (26-40 GHz)	CMT	RA28-K-F-4B-C	011469R-003	10/15/2010	10/15/2011
EMI Receiver	Hewlett Packard	8546A	3807A00445	2/5/2011	2/5/2012
Preselector	Hewlett Packard	85460A	3704A00407	2/5/2011	2/5/2012
Amplifier	Hewlett Packard	8447D	2944A07996	1/17/2011	1/17/2012
Spectrum Analyzer	Rhode&Schwarz	ESIB	832427/002	1/18/2011	1/18/2012
Amplifier	Rhode&Schwarz	TS-PR18	3545.7008.03	9/29/2010	9/29/2012
Amplifier	Rhode&Schwarz	TS-PR26	100011	10/15/2010	10/15/2011
Amplifier	Rhode&Schwarz	TS-PR40	100012	10/15/2010	10/15/2011
Signal Generator	Anritsu	MG3694A	42803	1/26/2011	1/26/2012
Notch Filter	Micro-Tronics	BRM50702	37	1/19/2011	1/19/2012
Notch Filter	Micro-Tronics	BRC50703	11	1/19/2011	1/19/2012
High Pass Filter (3.5 GHz)	Hewlett Packard	84300-80038	820004	1/19/2011	1/19/2012
High Pass Filter (8.5 GHz)	Micro-Tronics	HPM50107	4	1/19/2011	1/19/2012
Power Supplier	Kikosui	PCR8000W	CM000912	1/19/2011	1/19/2012
Digital Multimeter	Fluke	177	92780314	1/18/2011	1/18/2012
Power Meter	Agilent	E4418B	MY45103902	1/18/2011	1/18/2012
Power Sensor	Hewlett Packard	8482A	55-5131	10/27/2010	10/27/2011
EMI Receiver	Hewlett Packard	8546A	3942A00514	11/22/2010	11/22/2011
Preselector	Hewlett Packard	85460A	3704A00485	11/22/2010	11/22/2011
LISN	Solar Electronics	Type 9348-50-R-24-BNC	68509	1/17/2011	1/17/2012
Signal Generator	Anritsu	MG3694A	42803	1/26/2011	1/26/2012
Thermo Chamber	Associated Environmental	SK-3102	5999	VBU	VBU
Spectrum Analyzer	Rhode&Schwarz	FSL6	100169	10/13/2010	10/13/2011
Spectrum Analyzer	Agilent	E4404B	MY41440636	8/19/2010	10/19/2011
Spectrum Analyzer	Agilent	E4407B	SG43304468	10/05/2011	10/05/2012

Calibration of equipment past due for re-calibration will be performed expeditiously. If any equipment is found to be out of tolerance at that time, affected customers will be notified accordingly.

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 10: Customer Information

Company Name	WatchGuard Technolgies, Inc
Address	505 Fifth Ave S, Suite 500
City, State, Zip	Seattle, WA 98104
Country	USA
Phone	Tel: 206-613-6600
Fax	None

Table 11: Technical Contact Information

Name	Denny Lim
E-mail	Denny.Lim@watchguard.com
Phone	Tel: 206-613-6600
Fax	None

6.3 Equipment Under Test (EUT)

Table 12: EUT Specifications

EUT Specification	
Dimensions	
AC Adapter ( )	Input Voltage: 100-240 Vac 50-60 Hz Input Current: 1200ma Output Voltage: 19V DC Output Current: 4.74Amps
Environment	Indoor
Operating Temperature Range:	0 to 40 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Hardware Version	Rev. 9
Part Number	None
RF Software Version	ART2.13
Radio Module 2 802.11-radio modules	
Operating Mode	802.11a, b, g, HT20, and HT40
Transmitter Frequency Band	2.412 GHz to 2.462 GHz 5.15 GHz to 5.25 GHz (Indoor Use) 5.725 GHz to 5.85 GHz
Max. Rated Power Output	See Channel Planning Table.
Power Setting @ Operating Channel	See Channel Planning Table.
Antenna Type	3 External antennas. (2 dBi Monopole)
Modulation Type	☐ AM ☐ FM ☐ DSSS ☒ OFDM ☒ Other describe: CCK , CCK_5 and CCK_11
Data Rate	802.11b: 1, 2, 5.5, 11 Mbps at 1 Spatial Stream 802.11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps at 1 Spatial Stream 802.11a: 6, 9, 12, 18, 24, 36, 48, 54 Mbps at 1 Spatial Stream 802.11n HT20: 1 Spatial Stream: 6.5, 13, 19.5, 26, 39, 52, 58.5, 65 Mbps 2 Spatial Streams: 13, 26, 39, 58, 78, 104, 117, 130 Mbps 3 Spatial Streams: 19.5, 39, 58.5, 78, 117, 156, 175.5, 195 Mbps 802.11n HT40: 1 Spatial Stream: 13.5, 27, 40.5, 54, 81, 108, 121.5, 135 Mbps 2 Spatial Streams: 27, 54, 81, 108, 162, 216, 243, 270 Mbps 3 Spatial Streams: 40.5, 81, 121.5, 162, 243, 324, 364.5, 405 Mbps

EUT Specification	
TX/RX Chain (s)	MIMO (3x3)
Directional Gain Type	☒ Uncorrelated ☒ No Beam-Forming ☐ Other describe:
Type of Equipment	☐ Table Top ☒ Wall-mount ☐ Floor standing cabinet ☐ Other
Note: None	

Table 13: EUT Channel Power Specifications

No.	Frequency (MHz)		Target Power Value					
		802.11a	802.11 HT20	802.11 HT 20 2X3	802.11 HT20 3X3	802.11 HT40	802.11n HT40 2X3	802.11n HT40 3X3
36	5180	16.0	14.0	12.0	11.0	13.0	12.0	11.0
40	5200	16.0	14.0	12.0	11.0	13.0	12.0	
44	5220	16.0	14.0	12.0	11.0	13.0	12.0	11
48	5240	16.0	14.0	12.0	11.0	13.0	12.0	
Note: 1. The center operating frequency is shifted upward by 10 MHz for HT40. 2. The adjusted power target values are updated at the evaluated frequencies.								

Table 14: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
USB x1	Not used for Radio test	☐ No	☐ Metric: 1.8m	☒ M
RJ45 (x5)	Connected to Laptop	☒ Yes	☐ Metric: 10 m	☒ M
Console	Connected to Laptop	☐ No	☐ Metric: 3 m	☒ M

Table 23: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.407
Newport/ Newcastle	Sr#70AB000 10-8C75	3 External Antenna	TX Emission, RX Emission,
		Direct via SMA	Transmit Power, Peak Power Spectral Density, Peak Excursion Ratio Occupied Bandwidth Frequency Stability
	Sr#70AB000 1E-6BB4	3 External Antenna	AC Conducted Emission Peak

Table 15: Description of Test Configuration used for Radiated Measurement.

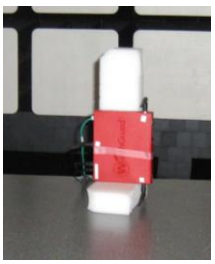
Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
Newport/ Newcastle	3 External	* Transmit * Receive	.  Flat on table Antennas up Vertical	 EUT set on wall, laying on longer side. All Antennas Horizontal	 Laying on smaller side
Note: Pre-scans were performed in 3 orthogonal axis, and **Y-axis was worst case.**					

Table 16: Final Test Mode for All 3 Bands

Test	802.11a	802.11n HT20	802.11n HT40
Occupied Bandwidth FCC Part 15.407(a)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps	Band 1: 5180, 5220, 5240 MHz 1 Stream – 6.5Mbps	Band 1: 5190, 5230 MHz 1 Stream – 13.5Mbps
Output Power FCC Part 15.407(a)(1-2)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps	Band 1: 5180, 5220, 5240 MHz 1 Stream – 6.5Mbps 2 Streams – 13Mbps 3 Streams – 19.5Mbps	Band 1: 5190, 5230 MHz 1 Stream – 13.5Mbps 2 Streams – 27Mbps 3 Streams – 40.5Mbps
Peak Excursion Ratio FCC Part 15.407(a)(6)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps	Band 1: 5180, 5220, 5240 MHz 1 Stream – 6.5Mbps 2 Streams – 13Mbps 3 Streams – 19.5Mbps	Band 1: 5190, 5230 MHz 1 Stream – 13.5Mbps 2 Streams – 27Mbps 3 Streams – 40.5Mbps
Peak Power Spectral Density FCC Part 15.407(a)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps	Band 1: 5180, 5220, 5240 MHz 1 Stream – 6.5Mbps 2 Streams – 13Mbps 3 Streams – 19.5Mbps	Band 1: 5190, 5230 MHz 1 Stream – 13.5Mbps 2 Streams – 27Mbps 3 Streams – 40.5Mbps
Band-Edge (Radiated) FCC Part 15.205, 15.209, 15.407(b)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps	Band 1: 5180, 5220, 5240 MHz 3 Stream – 19.5Mbps	Band 1: 5190, 5230 MHz 1 Stream – 13.5Mbps

Test	802.11a	802.11n HT20	802.11n HT40
Transmitted Spurious Emission (30 MHz – 1GHz) FCC Part 15.205, 15.209, 15.407(b)			
Transmitted Spurious Emission (Above 1GHz) FCC Part 15.205, 15.209, 15.407(b)	Band 1: 5180, 5220, 5240 MHz @ 6Mbps (Y-Axis)	Band 1: 5180, 5220, 5240 MHz 1 Stream – 6.5Mbps (Y-Axis)	Band 1: 5190, 5230 MHz 3 Stream – 40.5Mbps (Y-Axis)
Conducted Spurious Emission (antenna port). FCC Part 15.407 (b)	According to CFR47 15.407 (b) EIPR shall not exceed -27 dBm/MHz. This is equivalent to the field strength of 68.2dBuV/m at 3 meter distance. The EUT is satisfied the requirement by meeting the limit under CFR47 Part 15.209.		
Received Spurious Emission (at 20 MHz & 40 MHz Bandwidth) FCC Part 15.109		Band 1: 5220 MHz (Y-Axis)	Band 1: 5230 MHz (Y-Axis)
AC Conducted Emission FCC Part 15.207			
Frequency Stability FCC Part 15.407 (g)	Continuous wave at 5220 MHz		
Voltage Variation FCC Part 15.31 (e)	Continuous wave at 5180, 5220, 5240 MHz.		

Note: 1. Band 1: 5150 MHz – 5250 MHz,.
2. All radiated emission performed on Y-Axis.
3. At single data stream, all 3 transmitted chains were verified. Since Chain 1 output was highest, all final testing performed with Chain 1 active.
4. All tests were pre-scanned for worst case before final testing.
5. 3 x 2 dBi Omni directional antenna External attached for all radiated emission testing; pre-scan was worst with
6. AC Conducted Emissions were verified for all modes. Worst mode was selected for final test.

6.4 Test Specifications

Testing requirements

Table 17: Test Specifications

Emissions and Immunity	
Standard	Requirement
CFR 47 Part 15.407: 2009	All
RSS 210 Issue 8, 2010	All

END OR REPORT