



MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*

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March 16, 2012

Fortress Technologies
2 Technology Park Drive
Westford, MA 01886

Dear John Pacheco,

Enclosed is the EMC Wireless report for the Fortress Technologies, Infrastructure Mesh Point ES440 (containing M25 Radio) as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Title 47 of the CFR, Part 15.407 and Industry Canada RSS-210, Annex 9, Issue 8, Dec. 2010 for Intentional Radiators.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
MET LABORATORIES, INC.

Jill Valdes
Documentation Department

Reference: (\\Fortress Technologies\\EMC31152B-FCC407 Rev. 1 (UNII2))

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Electromagnetic Compatibility Criteria Test Report

For The:

**Fortress Technologies
Model Infrastructure Mesh Point ES440 (containing M5 Radio)**

Tested Under:
**the Certification Rules
contained in
Title 47 of the CFR, Part 15.407
and
Industry Canada RSS-210, Annex 9
for Intentional Radiators**

MET Report: EMC31152A-FCC407 Rev. 1 (UNII2)

March 16, 2012

Prepared For:
**Fortress Technologies
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Westford, MA 01886**

Prepared By:
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Electromagnetic Compatibility Criteria Test Report

For the:

Fortress Technologies
Model Vehicle Mesh Point ES440 (containing M5 Radio)

the Certification Rules
contained in
Title 47 of the CFR, Part 15.407
and
Industry Canada RSS-210, Annex 9
for Intentional Radiators

Jeff Pratt, Project Engineer
Electromagnetic Compatibility Lab

Jill Valdes
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of Part 15.407, of the FCC Rules and RSS-210 Annex 9 of the Industry Canada Rules under normal use and maintenance.

Shawn McMillen, Wireless Manager
Electromagnetic Compatibility Lab



Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	January 25, 2012	Initial Issue.
1	March 16, 2012	Revised to reflect engineer corrections.



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List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dBμA	Decibels above one microamp
dBμV	Decibels above one microvolt
dBμA/m	Decibels above one microamp per meter
dBμV/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μH	microhenry
μ	microfarad
μs	microseconds
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane



I. Executive Summary



A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Fortress Technologies Vehicle Mesh Point ES440 (containing M5 Radio), with the requirements of FCC Part §15.407 and Industry Canada RSS-210 Annex 9. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the Vehicle Mesh Point ES440 (containing M5 Radio). Fortress Technologies should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Vehicle Mesh Point ES440 (containing M5 Radio), has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC Part §15.407 and Industry Canada RSS-210, Annex 9, in accordance with Fortress Technologies, purchase order number 3020. All tests were conducted using measurement procedure ANSI C63.4-2003.

FCC Reference	Industry Canada Reference	Description	Results
15.107	ICES-003	Conducted Emissions	Not Applicable – The device is vehicle mounted.
15.109	ICES-003	Radiated Emissions	Not Applicable – The device is vehicle mounted.
15.203	RSS-GEN 7.1.4	Antenna Requirements	Compliant
15.207	RSS-GEN 7.2.2; RSS-210 2.2	Conducted Emissions	Compliant
15.403 (i)	A8.2	26 dB Occupied Bandwidth	Compliant
15.407 (a)(2)	A9.2(3)	Conducted Transmitter Output Power	Compliant
15.407 (a)(2)	A9.2(3)	Power Spectral Density	Compliant
15.407 (a)(6)	N/A	Peak Excursion	Compliant
15.407 (b)(2), (3), (5), (6)	A9.3(4)	Undesirable Emissions	Compliant
15.407(f)	RSS-GEN	RF Exposure	Compliant
15.407(g)	2.1	Frequency Stability	Compliant
N/A	RSS-Gen(4.8)	Receiver Spurious Emissions	Compliant

Table 1. Executive Summary of EMC Part 15.407 & RSS-210 Annex 9 Compliance Testing



II. Equipment Configuration



A. Overview

MET Laboratories, Inc. was contracted by Fortress Technologies to perform testing on the Vehicle Mesh Point ES440 (containing M5 Radio), under Fortress Technologies' purchase order number 3020.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Fortress Technologies Vehicle Mesh Point ES440 (containing M5 Radio).

The results obtained relate only to the item(s) tested.

Model(s) Tested:	Vehicle Mesh Point ES440 (containing M5 Radio)		
Model(s) Covered:	Vehicle Mesh Point ES440 (containing M5 Radio)		
EUT Specifications:	Primary Power: 120 VAC, 60 Hz		
	FCC ID: WYK-ES440 IC ID: 8190A-ES440		
	Type of Modulations:	OFDM	
	Emission Designators:	D7D	
	Equipment Code:	NII	
	Peak RF Output Power:	M5	43.75mW
	EUT Frequency Ranges:	5745-5805 MHz	
Analysis:	The results obtained relate only to the item(s) tested.		
Environmental Test Conditions:	Temperature: -20 to + 55° C		
	Relative Humidity: 30-60%		
	Barometric Pressure: 860-1060 mbar		
Evaluated by:	Jeff Pratt		
Report Date(s):	March 16, 2012		

Table 2. EUT Summary



B. References

RSS-210, Issue 8, Dec. 2010	Low-power License-exempt Radiocommunications Devices (All Frequency Bands): Category I Equipment
CFR 47, Part 15, Subpart E	Unlicensed National Information Infrastructure Devices (UNII)
ANSI C63.4:2003	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI/NCSL Z540-1-1994	Calibration Laboratories and Measuring and Test Equipment - General Requirements
ANSI/ISO/IEC 17025:2000	General Requirements for the Competence of Testing and Calibration Laboratories

Table 3. References

C. Test Site

All testing was performed at MET Laboratories, Inc., 914 W. Patapsco Ave, Baltimore, MD 21230. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

D. Description of Test Sample

The Fortress Technologies Infrastructure Mesh Point ES440 (containing M25 Radio), Equipment Under Test (EUT), is a dual radio access point/bridge. It embeds two COTS high power radios and two Ethernet ports in a ruggedized enclosure. The radio operates in accordance to the 802.11a, 802.11b, 802.11g and 802.11n standards. This test report addresses the 802.11n mode (i.e. HT20 and HT40).

The ES440 is intended to provide outdoor mobile connectivity in a secure manner both wired and wirelessly.



Photograph 1. Fortress Technologies, Inc. Infrastructure Mesh Point ES440 (containing M5 Radio)



E. Equipment Configuration

All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Name / Description	Model Number	Serial Number
1	Fortress Vehicle Mesh Point	ES440	110310076

Table 4. Equipment Configuration

F. Support Equipment

Support equipment was not necessary for the operation and testing of the Vehicle Mesh Point ES440 (containing M5 Radio).

G. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Termination Point
N/A	Ant (1 & 2)	Antenna	2	Spectrum Analyzer
N/A	AC Power Port	Provides power	1	External AC Charger

Table 5. Ports and Cabling Information

H. Mode of Operation

HT20 and HT40 modes may be configured using the UI of the product. Additionally, these modes may be configured using the UI of the product. Additionally, these modes may be entered by using ART, the Atheros Radio Test tool. This is a standard tool provide by Atheros for directly manipulating and configuring their chips during testing and manufacturing.

I. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

J. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Fortress Technologies upon completion of testing.



III. Electromagnetic Compatibility Criteria for Intentional Radiators



Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement:

§ 15.203: 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.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

- a.) Antenna must be permanently attached to the unit.
- b.) Antenna must use a unique type of connector to attach to the EUT.
- c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results:

The unit is professionally installed. Therefore, the EUT as tested is compliant with the criteria of §15.203.

Frequency	Gain/Model	Manufacturer
5 GHz	9 dBi / EC09-5500	Mobile Mark Communications

Test Engineer(s):

Dusmantha Tennakoon

Test Date(s):

05/09/11

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207 Conducted Emissions Limits

Test Requirement(s): § 15.207 (a): For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dB μ V)	
	Quasi-Peak	Average
* 0.15- 0.45	66 - 56	56 - 46
0.45 - 0.5	56	46
0.5 - 30	60	50

Table 6. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Procedure: The EUT was placed on a non-metallic table, 80 cm above the ground plane inside a semi-anechoic chamber. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω /50 μ H Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.4-1992 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz"*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω /50 μ H LISN as the input transducer to an EMC/field intensity meter.



Test Results: The EUT was compliant with the Class A requirement(s) of this section. Pre-scans revealed that emissions profiles and amplitudes of emissions were similar when the EUT was transmitting on low, mid and high channels. Therefore, final measurements were taken when the EUT was transmitting on high channel (i.e. 5805 MHz)

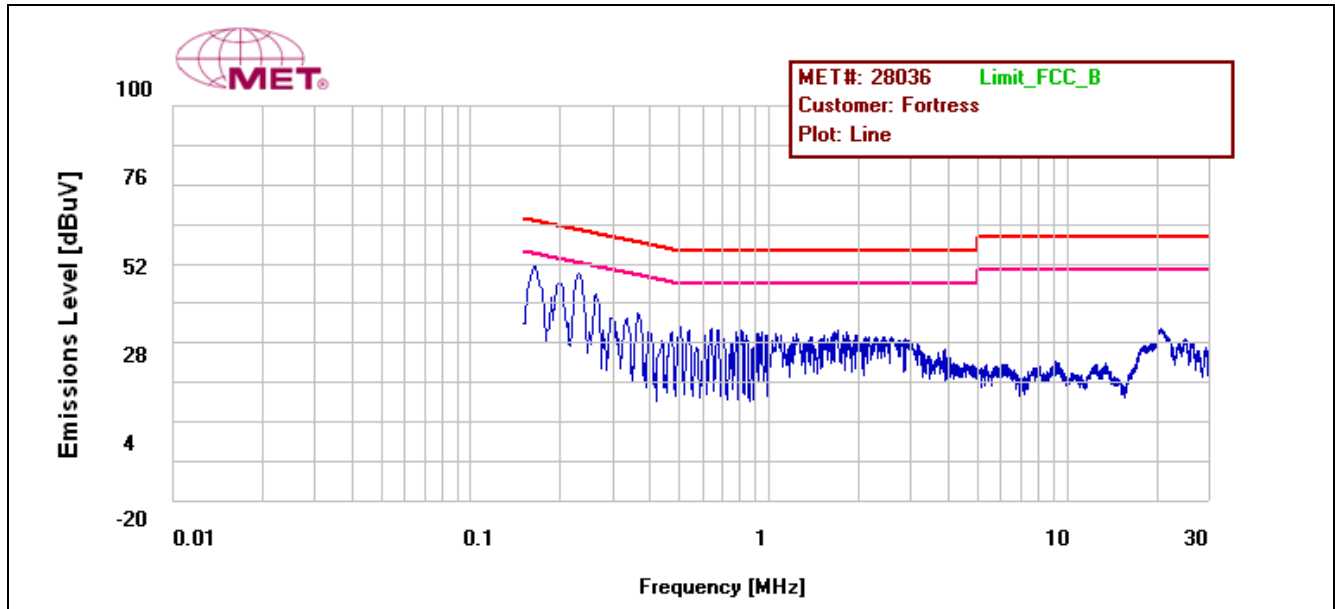
Test Engineer(s): Anderson Soungpanya

Test Date(s): 11/24/09

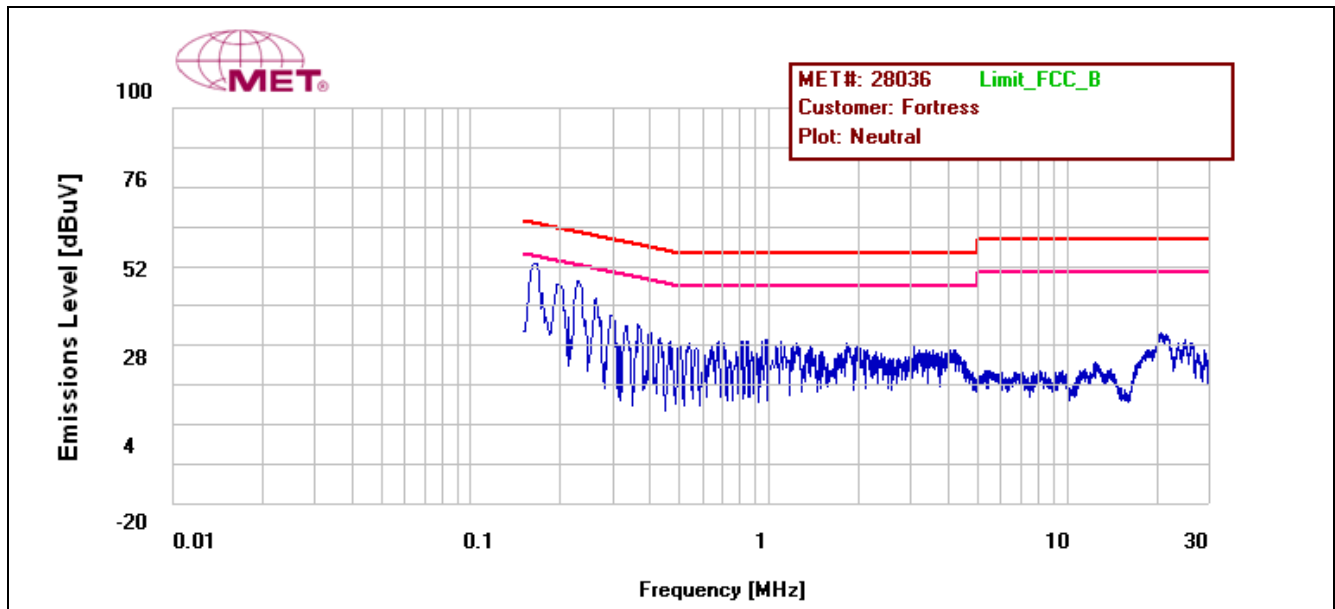
Conducted Emissions - Voltage, AC Power, (120V/60Hz)

Line	Freq (MHz)	QP Amplitude	QP Limit	Delta	Pass	Average Amplitude	Average Limit	Delta	Pass
Line	0.169	50.65	65.012	-14.37	Pass	42.36	55.01	-12.65	Pass
Line	0.204	48.02	63.453	-15.44	Pass	43.13	53.45	-10.32	Pass
Line	2.24	35.33	56	-20.67	Pass	22.21	46.00	-23.78	Pass
Neutral	0.17	51.64	64.963	-13.33	Pass	42.05	54.96	-12.91	Pass
Neutral	0.203	47.03	63.494	-16.47	Pass	40.44	53.49	-13.05	Pass
Neutral	2.24	36.82	56	-19.18	Pass	29.15	46.00	-16.84	Pass

Table 7. Conducted Emissions - Voltage, AC Power, M5 Radio



Plot 1. Conducted Emission, Phase Line Plot, M5 Radio



Plot 2. Conducted Emission, Neutral Line Plot, M5 Radio

Conducted Emission Limits Test Setup



Photograph 2. Conducted Emissions, Test Setup, M5 Radio



Photograph 3. Conducted Emissions, Test Setup, Side View, M5 Radio

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 403(c) 26dB Bandwidth – M5 Radio

Test Requirements: § 15.403 (i): For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

Test Procedure: The transmitter was set to low, mid and high operating frequencies at the highest output power and connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth, VBW > RBW. The 26 dB Bandwidth was measured and recorded.

Test Results The 26 dB Bandwidth was compliant with the requirements of this section and was determined from the plots on the following pages.

Test Engineer(s): Dusmantha Tennakoon

Test Date(s): 05/09/11

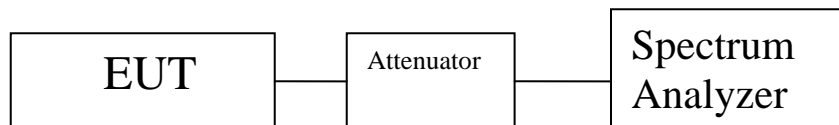


Figure 1. Occupied Bandwidth, Test Setup

Frequency (MHz)	26 dB Bandwidth (MHz)
5260	26.058
5300	26.559
5320	26.990
5500	25.214
5580	23.258
5700	26.797

Table 8. 26 dB Occupied Bandwidth, Test Results, HT20

Frequency (MHz)	99% Bandwidth (MHz)
5260	17.6612
5300	17.7176
5320	17.7455
5500	17.7766
5580	17.7361
5700	17.7722

Table 9. 99% Occupied Bandwidth, Test Results, HT20

Frequency (MHz)	26 dB Bandwidth (MHz)
5270	46.017
5310	44.285
5510	44.088
5550	44.009
5670	47.004

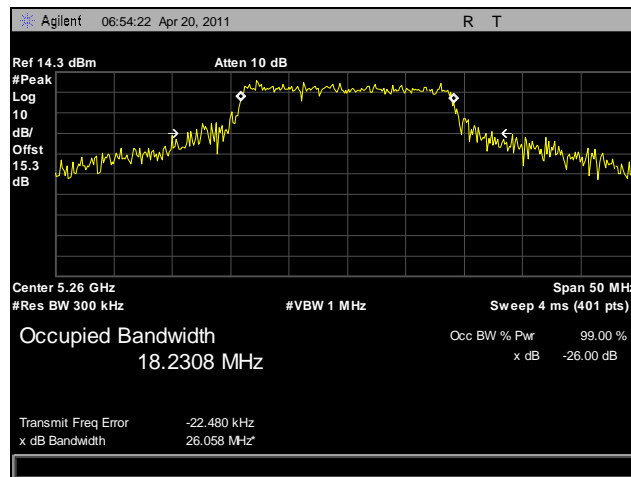
Table 10. 26 dB Occupied Bandwidth, Test Results, HT40

Frequency (MHz)	99% Bandwidth (MHz)
5270	36.1480
5310	36.5779
5510	36.7548
5550	36.7045
5670	36.4103

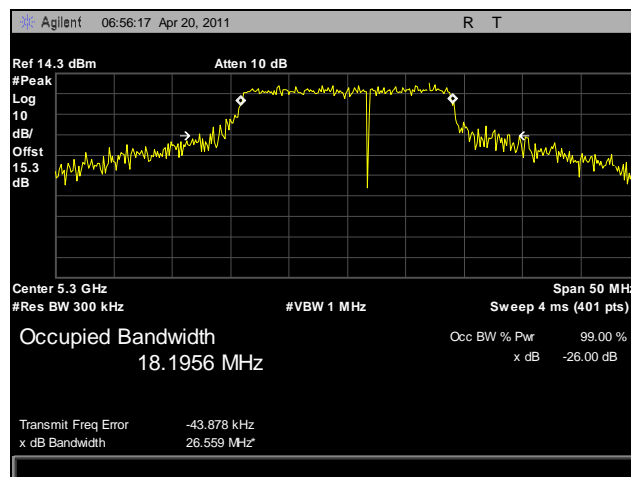
Table 11. 99% Occupied Bandwidth, Test Results, HT40



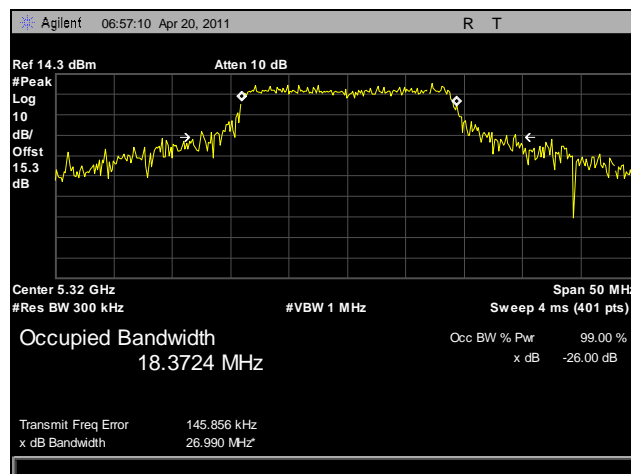
26 dB Occupied Bandwidth Test Results, HT20



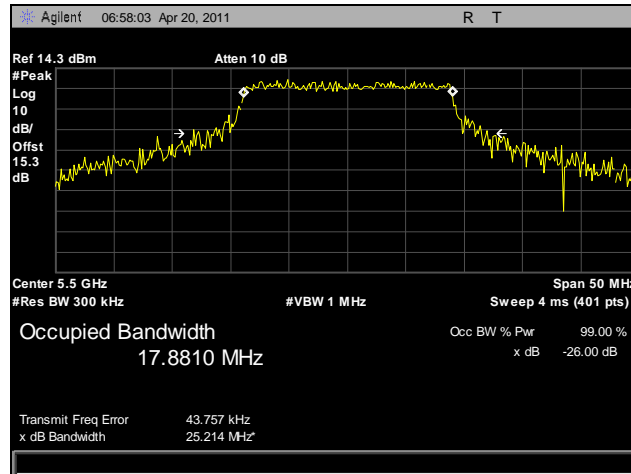
Plot 3. 26 dB Occupied Bandwidth, 5260 MHz, HT20



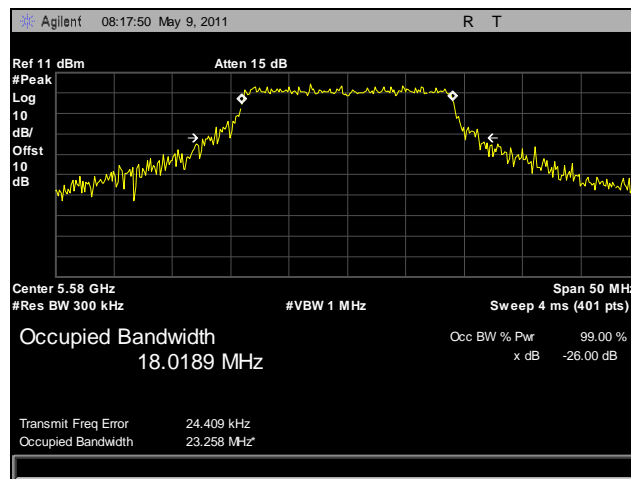
Plot 4. 26 dB Occupied Bandwidth, 5300 MHz, HT20



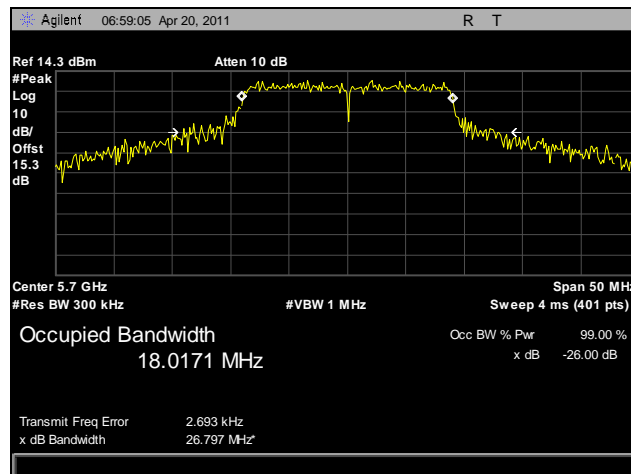
Plot 5. 26 dB Occupied Bandwidth, 5320 MHz, HT20



Plot 6. 26 dB Occupied Bandwidth, 5500 MHz, HT20

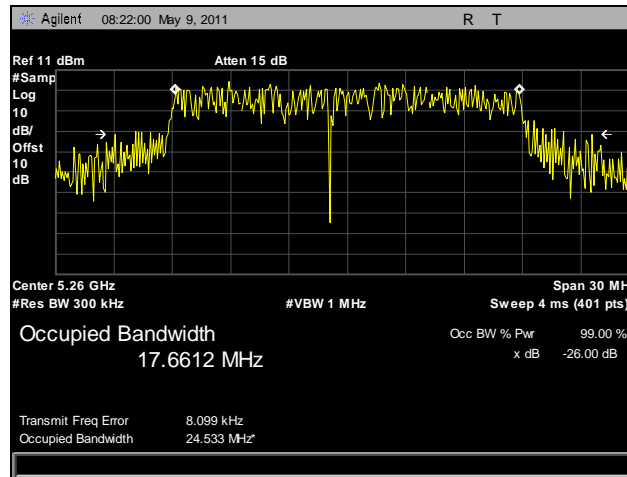


Plot 7. 26 dB Occupied Bandwidth, 5580 MHz, HT20

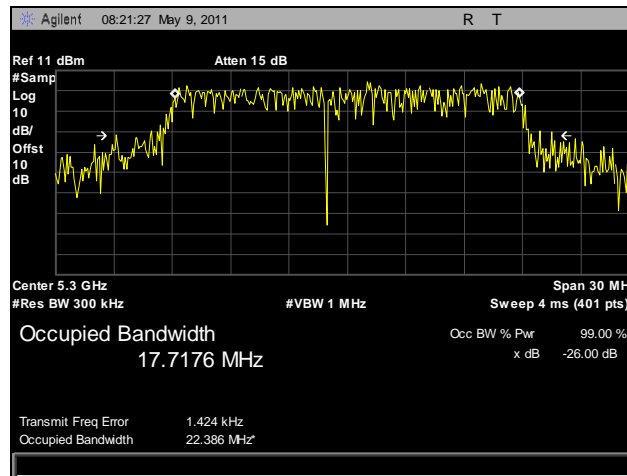


Plot 8. 26 dB Occupied Bandwidth, 5700 MHz, HT20

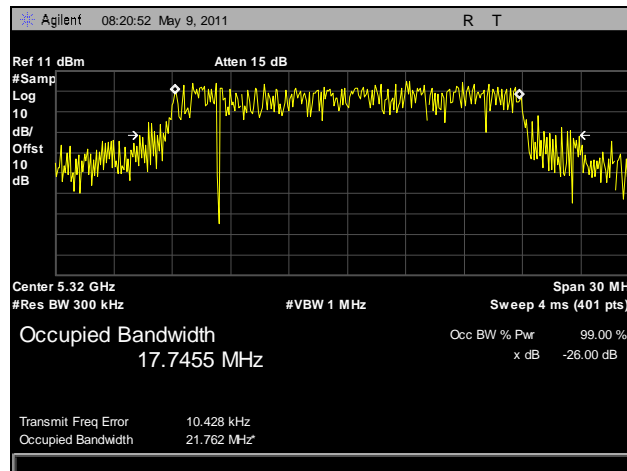
99% Occupied Bandwidth Test Results, HT20



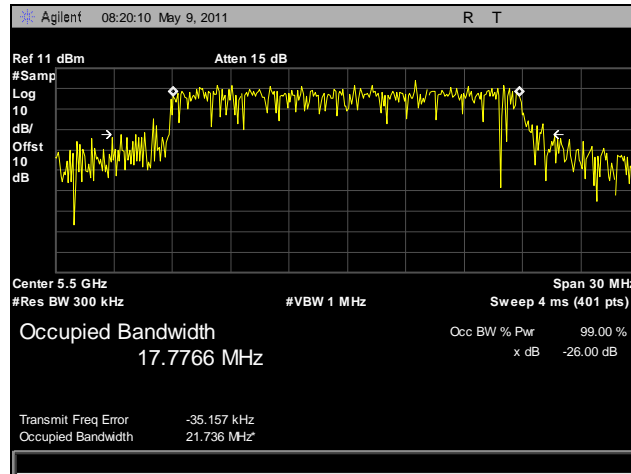
Plot 9. 99% Occupied Bandwidth, 5260 MHz, HT20



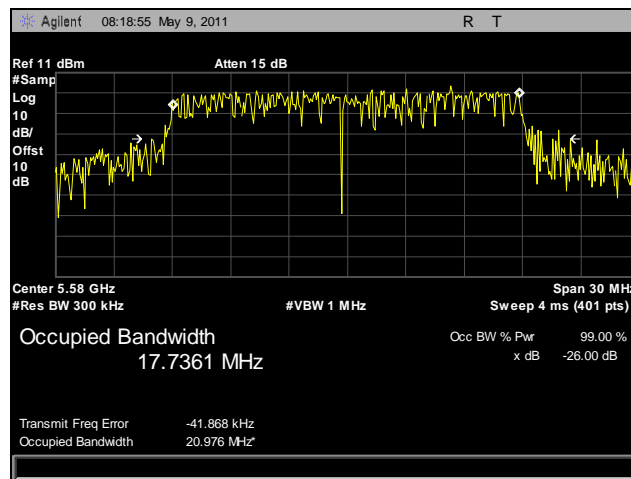
Plot 10. 99% Occupied Bandwidth, 5300 MHz, HT20



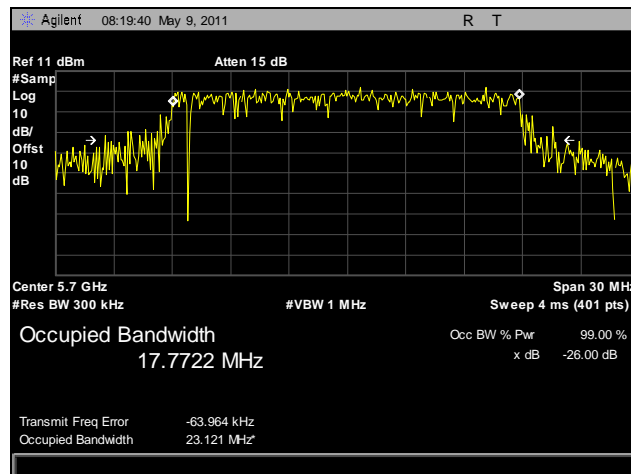
Plot 11. 99% Occupied Bandwidth, 5320 MHz, HT20



Plot 12. 99% Occupied Bandwidth, 5500 MHz, HT20



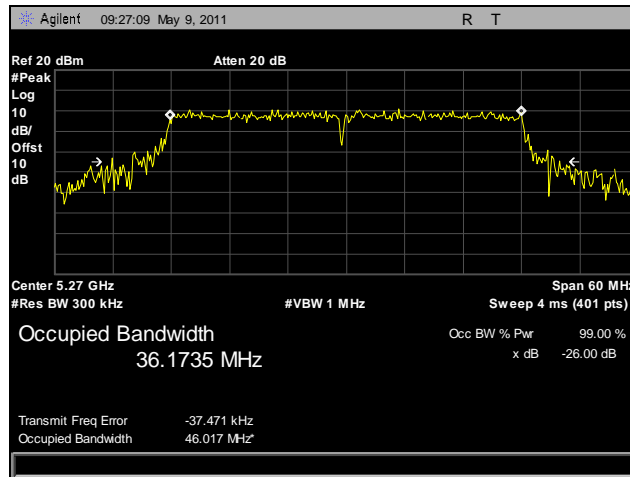
Plot 13. 99% Occupied Bandwidth, 5580 MHz, HT20



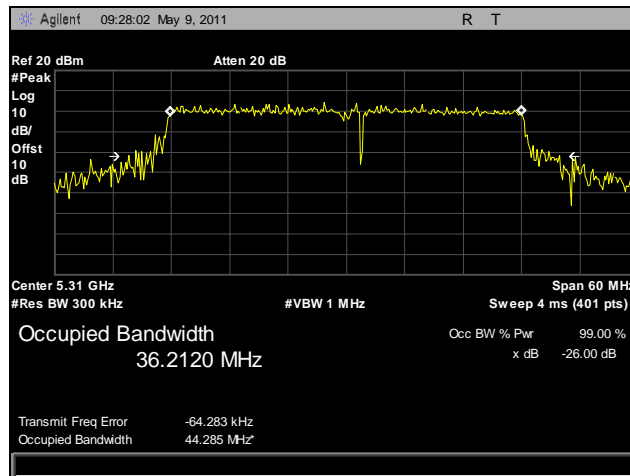
Plot 14. 99% Occupied Bandwidth, 5700 MHz, HT20



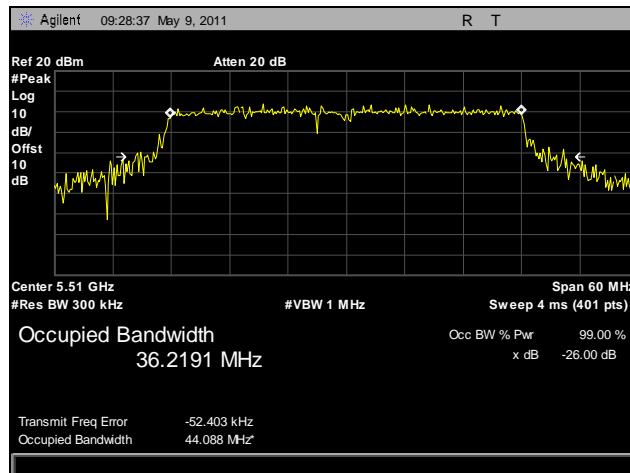
26 dB Occupied Bandwidth Test Results, HT40



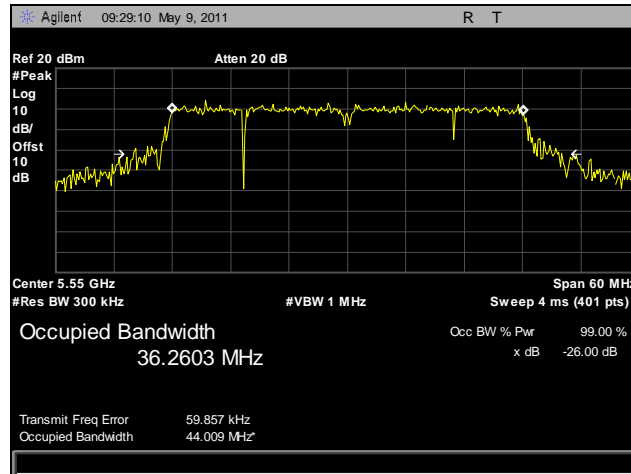
Plot 15. 26 dB Occupied Bandwidth, 5270 MHz, HT40



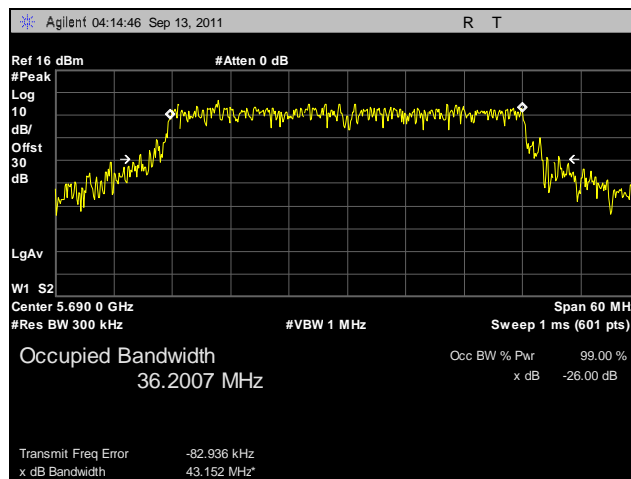
Plot 16. 26 dB Occupied Bandwidth, 5310 MHz, HT40



Plot 17. 26 dB Occupied Bandwidth, 5510 MHz, HT40



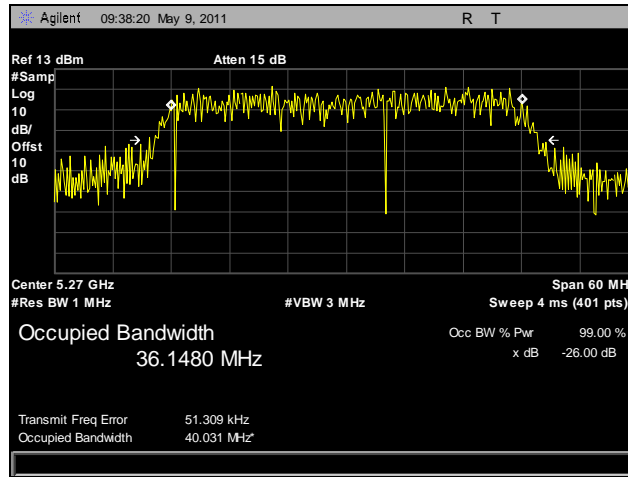
Plot 18. 26 dB Occupied Bandwidth, 5550 MHz, HT40



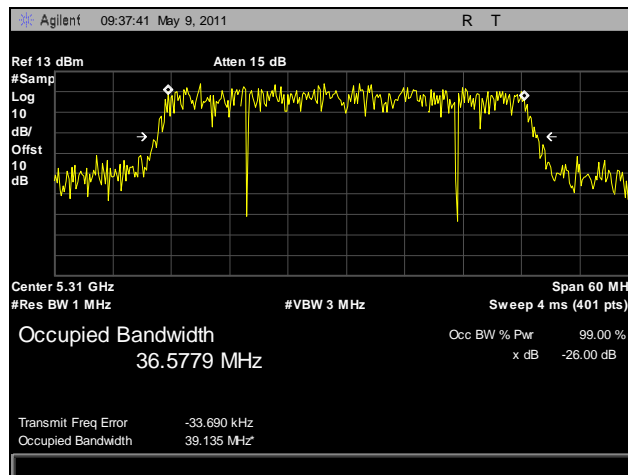
Plot 19. 26 dB Occupied Bandwidth, 5690 MHz, HT40



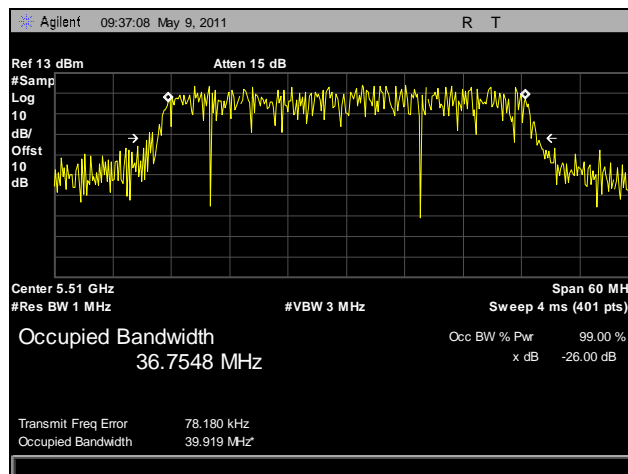
99% Occupied Bandwidth Test Results, HT40



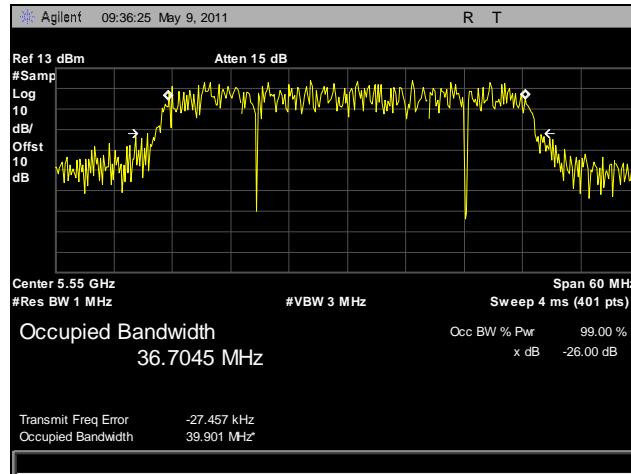
Plot 20. 99% Occupied Bandwidth, 5270 MHz, HT40



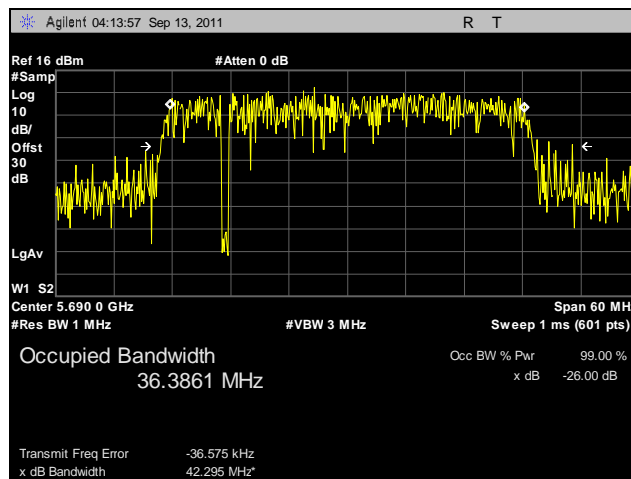
Plot 21. 99% Occupied Bandwidth, 5310 MHz, HT40



Plot 22. 99% Occupied Bandwidth, 5510 MHz, HT40



Plot 23. 99% Occupied Bandwidth, 5550 MHz, HT40



Plot 24. 99% Occupied Bandwidth, 5670 MHz, HT40

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 407(a)(2) RF Power Output

Test Requirements: §15.407(a) (2): The maximum output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit
5150-5250	50mW
5250-5350	250mW
5470-5725	250mW
5725-5825	1W

Table 12. Output Power Requirements from §15.407

§15.407(a) (2): For the band 5.725–5.825 GHz, the maximum conducted output power over the frequency band of operation shall not exceed the lesser of 1 W or $17 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz.

Test Procedure: The EUT was connected to a Spectrum Analyzer. The power was measured on three channels.

Test Results: Equipment was compliant with the Peak Power Output limits of § 15.401(a)(2).

Test Engineer(s): Jeff Pratt and Dusmantha Tennakoon

Test Date(s): 04/20/11 and 05/09/11

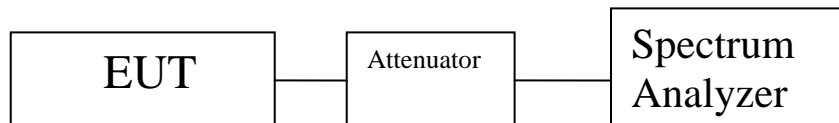


Figure 2. Power Output Test Setup



Frequency (MHz)	Conducted Power (dBm)	Conducted Power (mW)	Limit (mW)
5260	13.36	21.68	250
5300	16.41	43.75	250
5320	15.56	35.97	250
5500	16.08	40.55	250
5580	15.50	35.48	250
5700	15.87	38.64	250

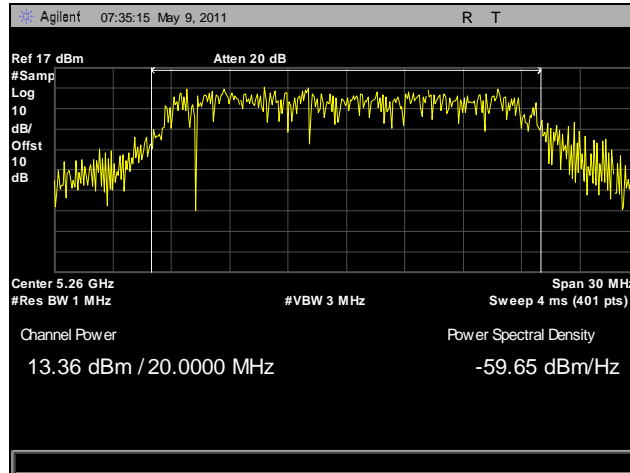
Table 13. RF Power Output, Test Results, HT20

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (mW)	Limit (mW)
5270	13.35	21.63	250
5310	15.65	36.73	250
5510	15.73	37.41	250
5550	15.39	34.59	250
5670	15.94	39.26	250

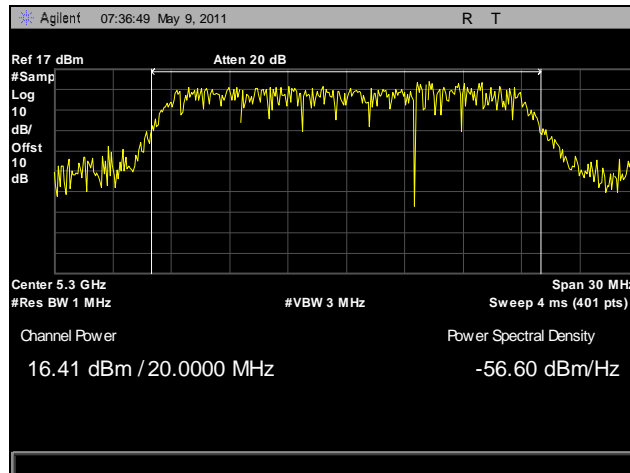
Table 14. RF Power Output, Test Results, HT40



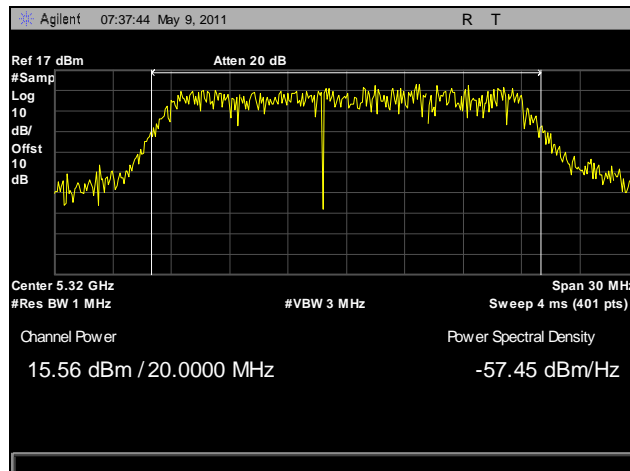
RF Output Power Test Results, HT20



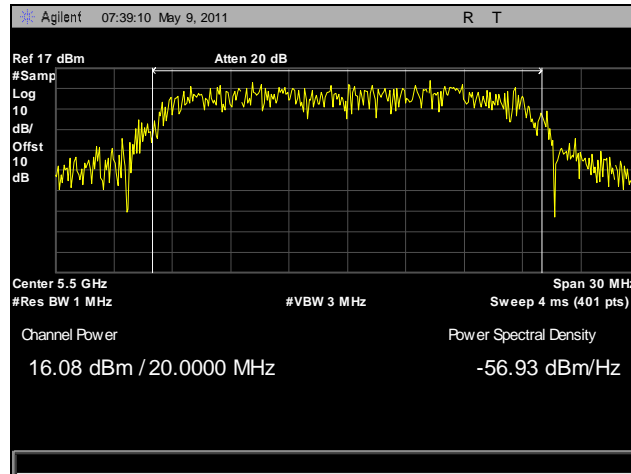
Plot 25. RF Power Output, 5260 MHz, HT20



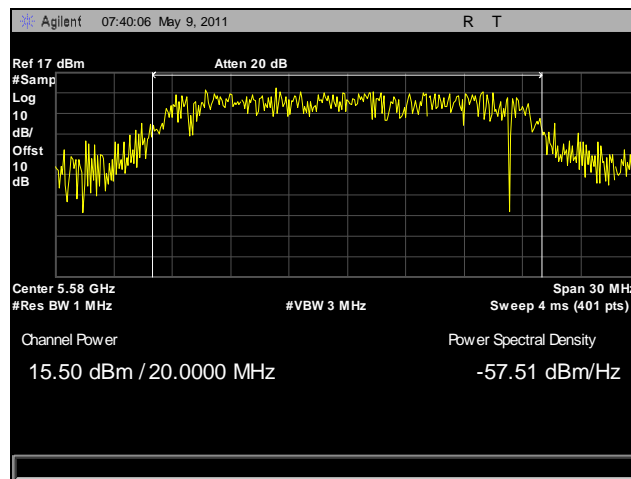
Plot 26. RF Power Output, 5300 MHz, HT20



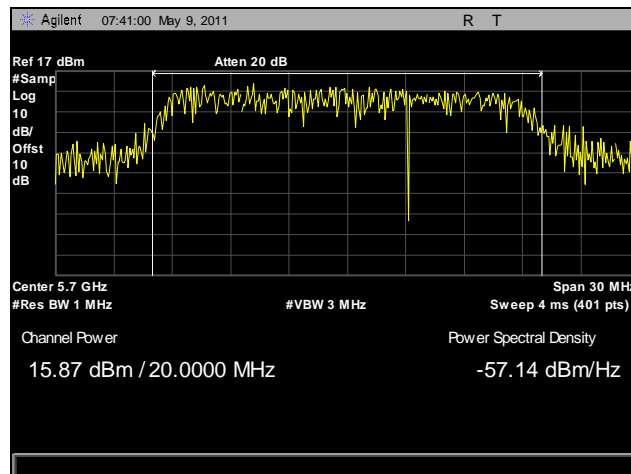
Plot 27. RF Power Output, 5320 MHz, HT20



Plot 28. RF Power Output, 5500 MHz, HT20



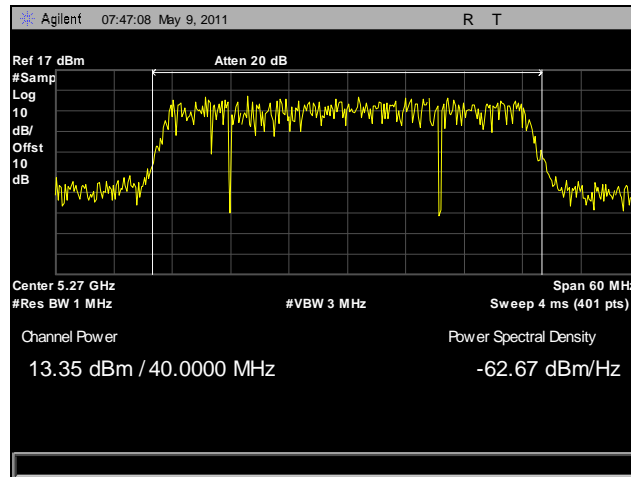
Plot 29. RF Power Output, 5580 MHz, HT20



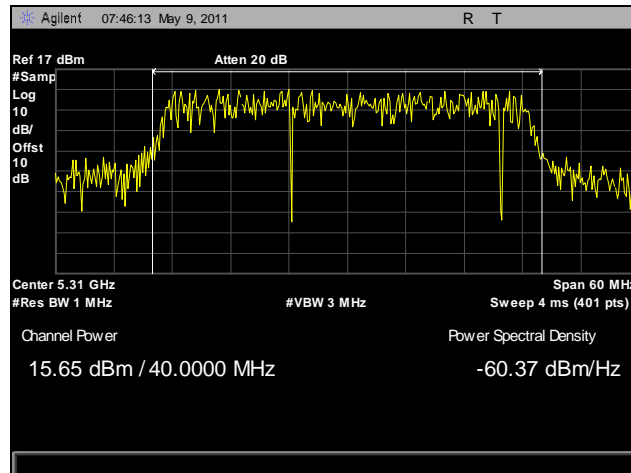
Plot 30. RF Power Output, 5700 MHz, HT20



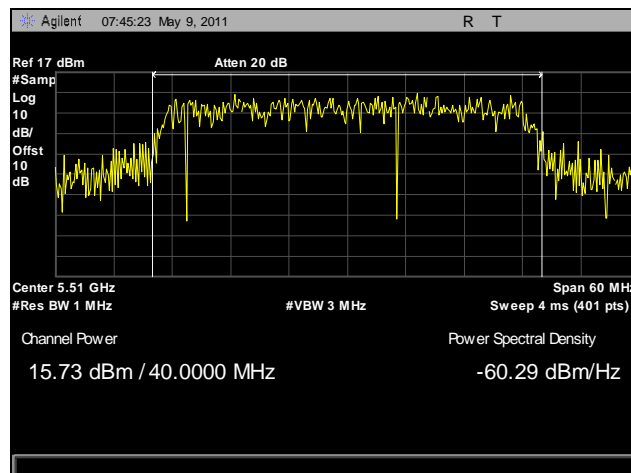
RF Output Power Test Results, HT40



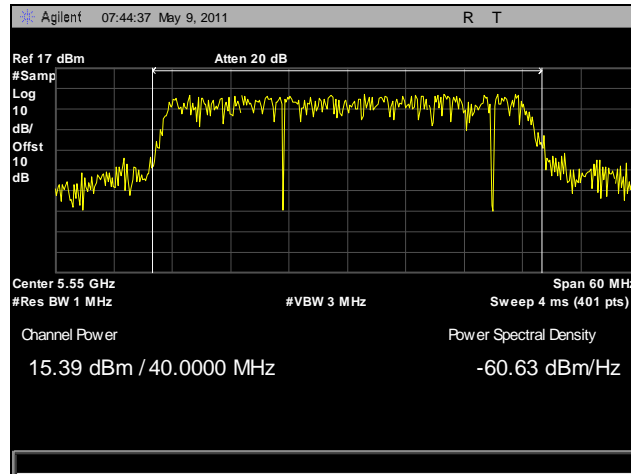
Plot 31. RF Power Output, 5270 MHz, HT40



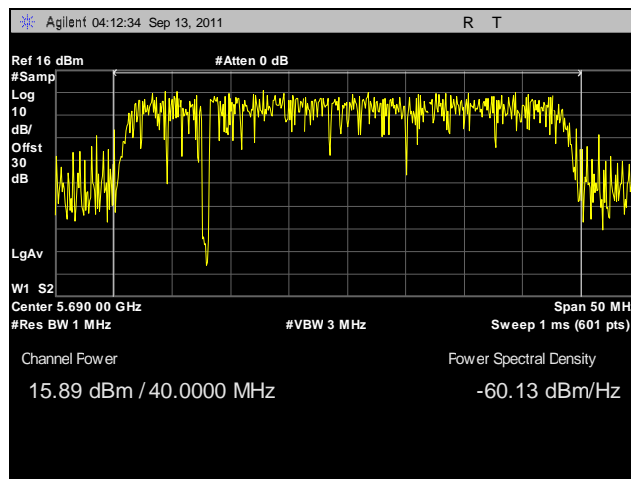
Plot 32. RF Power Output, 5310 MHz, HT40



Plot 33. RF Power Output, 5510 MHz, HT40



Plot 34. RF Power Output, 5550 MHz, HT40



Plot 35. RF Power Output, 5670 MHz, HT40

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(a)(3) Peak Power Spectral Density

Test Requirements: § 15.407(a)(3): The peak power spectral density shall not exceed 17 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. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain up to 23dBi without any corresponding reduction in the transmitter peak output power or peak power spectral density. For fixed, point-to-point U-NII transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in peak transmitter power and peak power spectral density for each 1 dB of antenna gain in excess of 23 dBi would be required. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, Omni directional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level on the EUT. The RBW was set to 1MHz and the VBW was set to 3MHz. The method of measurement SA-2 from 789033 D01 General UNII Test Procedures was used.

Test Results: Equipment was compliant with the peak power spectral density limits of § 15.407 (a)(2). The peak power spectral density was determined from plots on the following page(s).

Test Engineer(s): Dusmantha Tennakoon

Test Date(s): 05/09/11

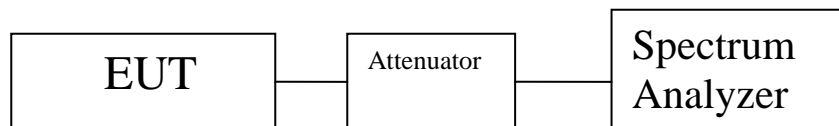


Figure 3. Power Spectral Density Test Setup



Frequency (MHz)	PSD (dBm/MHz)
5260	0.097
5300	3.818
5320	3.021
5500	3.596
5580	3.235
5700	3.415

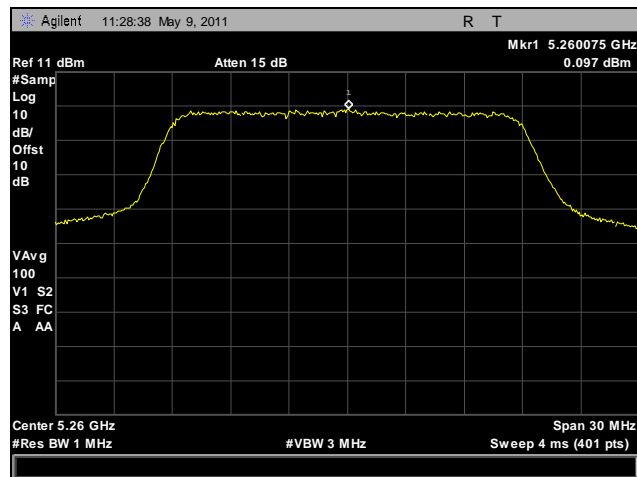
Table 15. Power Spectral Density, Test Results, HT20

Frequency (MHz)	PSD (dBm/MHz)
5270	-2.529
5310	0.167
5510	0.331
5550	0.024
5670	-0.15

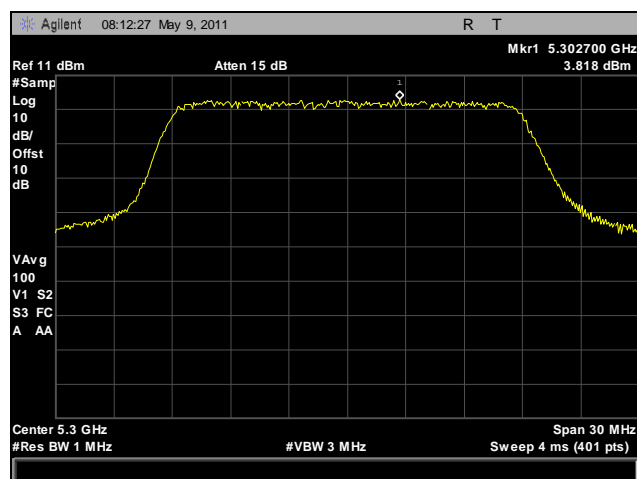
Table 16. Power Spectral Density, Test Results, HT40



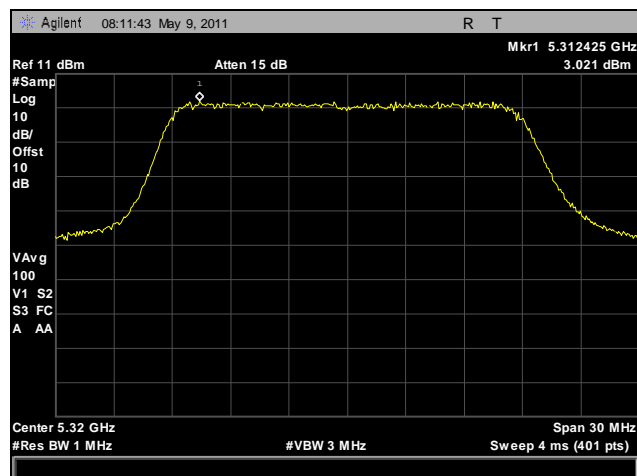
Power Spectral Density Test Results, HT20



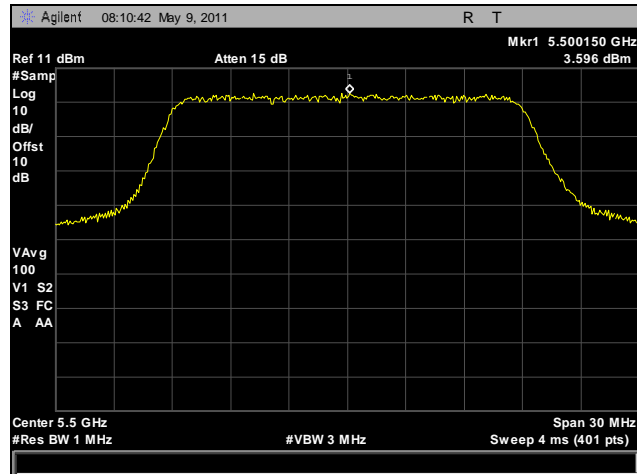
Plot 36. Power Spectral Density, 5260 MHz, HT20



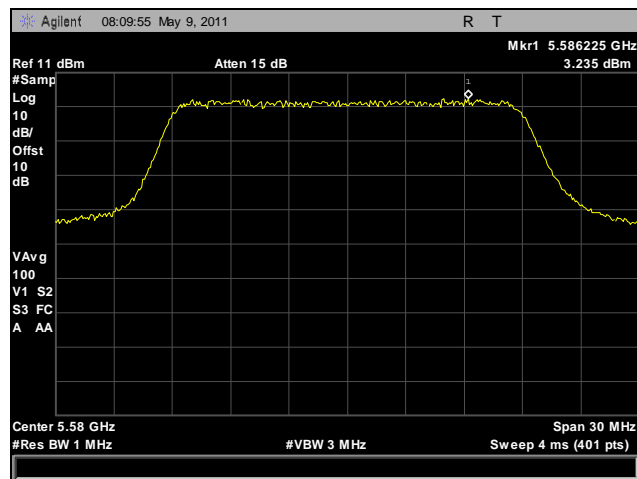
Plot 37. Power Spectral Density, 5300 MHz, HT20



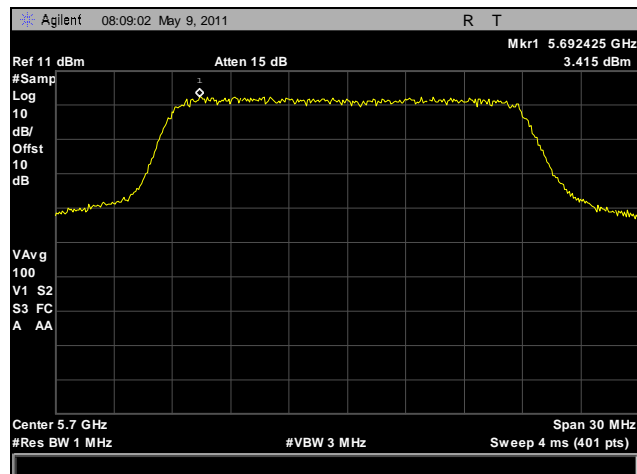
Plot 38. Power Spectral Density, 5320 MHz, HT20



Plot 39. Power Spectral Density, 5500 MHz, HT20



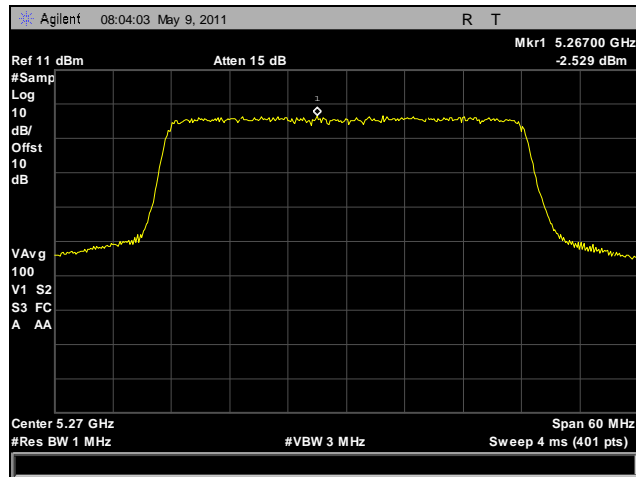
Plot 40. Power Spectral Density, 5580 MHz, HT20



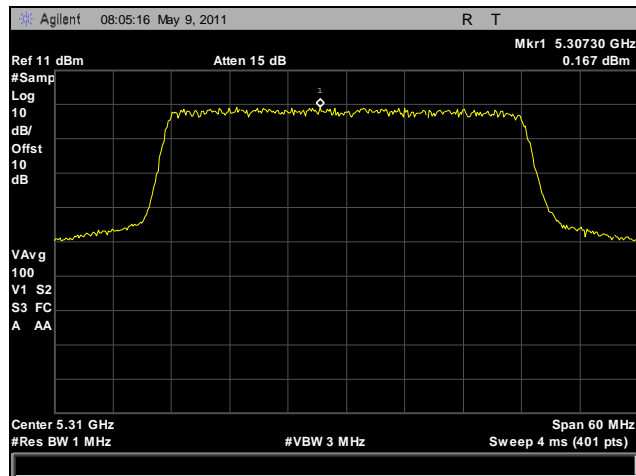
Plot 41. Power Spectral Density, 5700 MHz, HT20



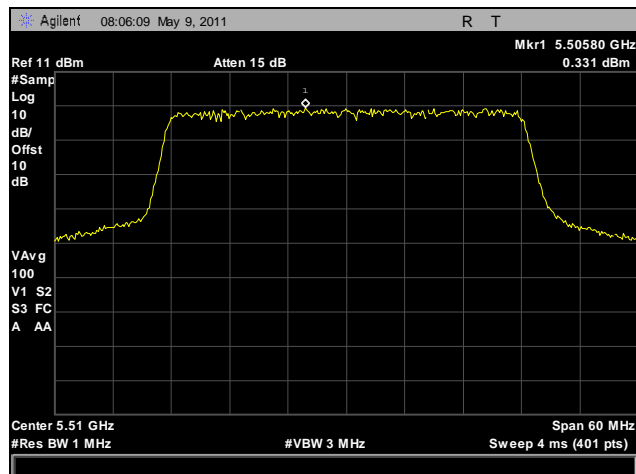
Power Spectral Density Test Results, HT40



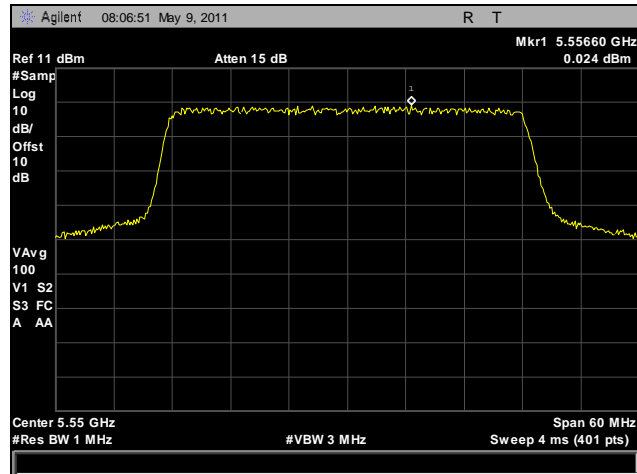
Plot 42. Power Spectral Density, 5270 MHz, HT40



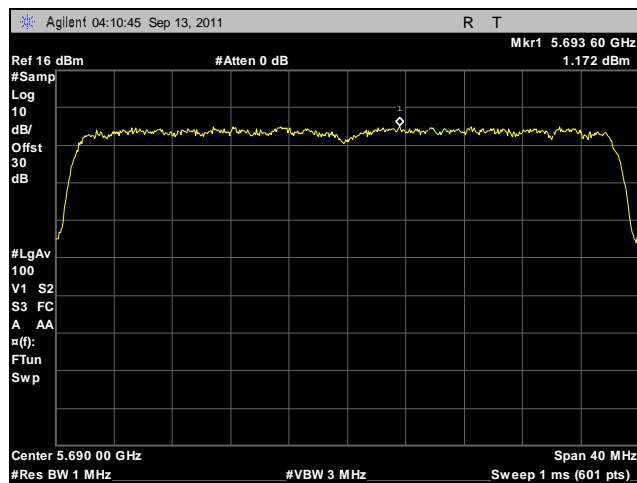
Plot 43. Power Spectral Density, 5310 MHz, HT40



Plot 44. Power Spectral Density, 5510 MHz, HT40



Plot 45. Power Spectral Density, 5550 MHz, HT40



Plot 46. Power Spectral Density, 5690 MHz, HT40

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(a)(6) Peak Excursion Ratio

Test Requirements:	§ 15.407(a)(6): The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the maximum conducted output power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.
Test Procedure:	The EUT was connected directly to the spectrum analyzer through cabling and attenuation. The 1 st trace on the spectrum analyzer was set to RBW=1MHz, VBW=3MHz. The peak detector mode was used and the trace max held. The 2 nd trace on the spectrum analyzer was set according to measurement method SA-2 from 789033 D01 General UNII Test Procedures for conducted power measurements.
Test Results:	Equipment was compliant with the peak excursion ratio limits of § 15.407(a)(6). The peak excursion ratio was determined from plots on the following page(s).
Test Engineer(s):	Dusmantha Tennakoon
Test Date(s):	05/09/11

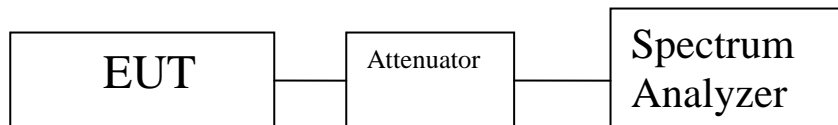
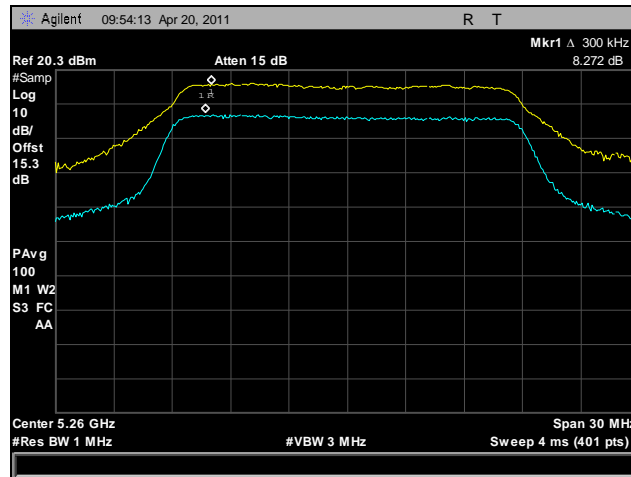
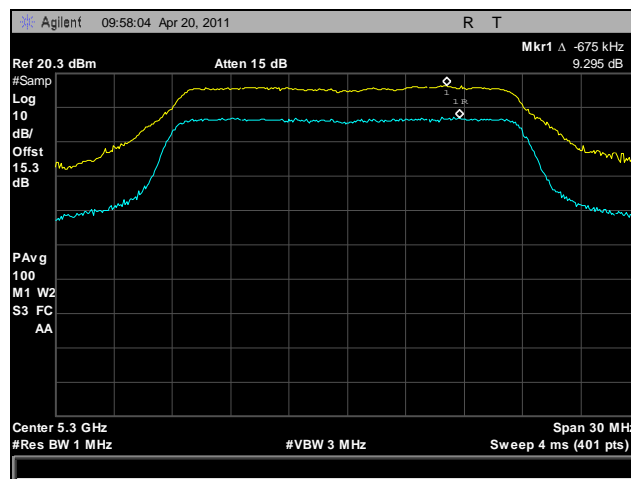


Figure 4. Peak Excursion Ration Test Setup

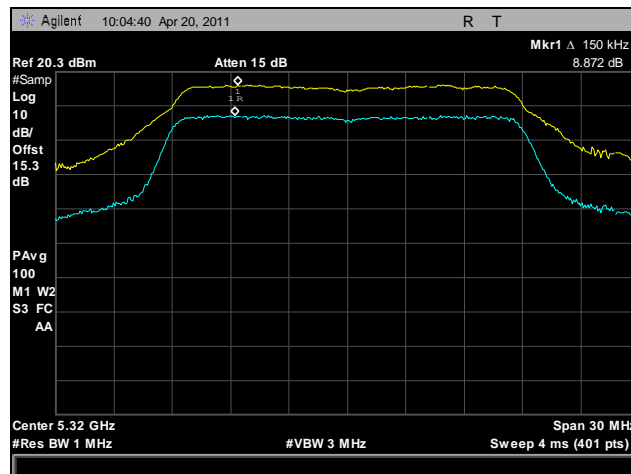
Peak Excursion Test Results, HT20



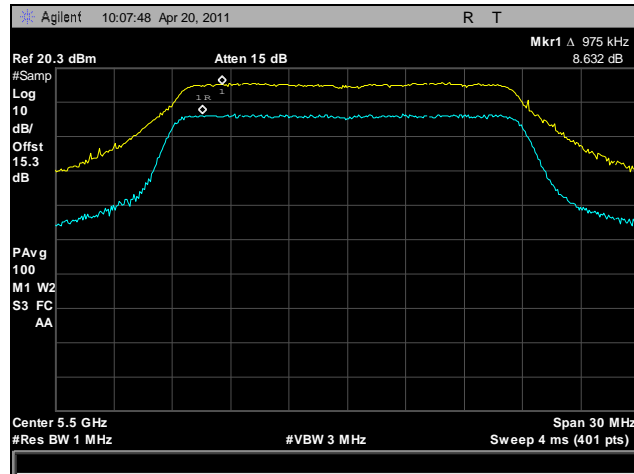
Plot 47. Peak Excursion Ratio, 5260 MHz, HT20



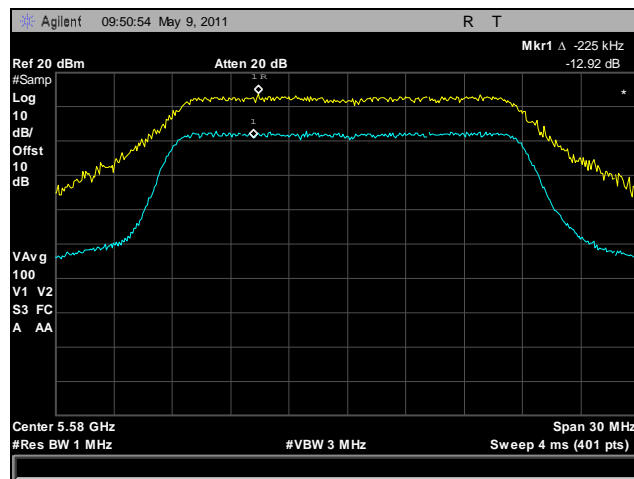
Plot 48. Peak Excursion Ratio, 5300 MHz, HT20



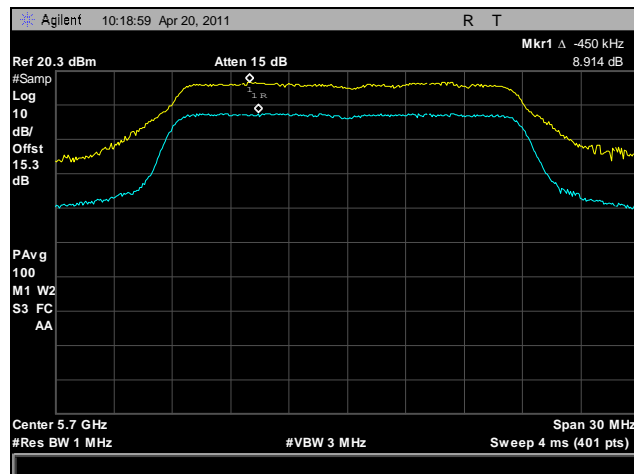
Plot 49. Peak Excursion Ratio, 5320 MHz, HT20



Plot 50. Peak Excursion Ratio, 5500 MHz, HT20

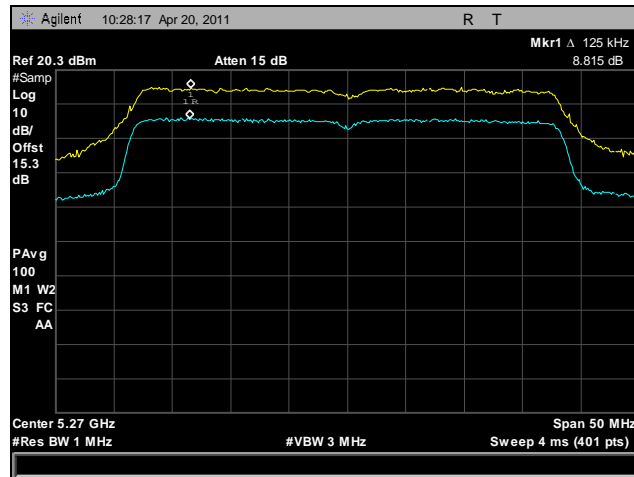


Plot 51. Peak Excursion Ratio, 5580 MHz, HT20

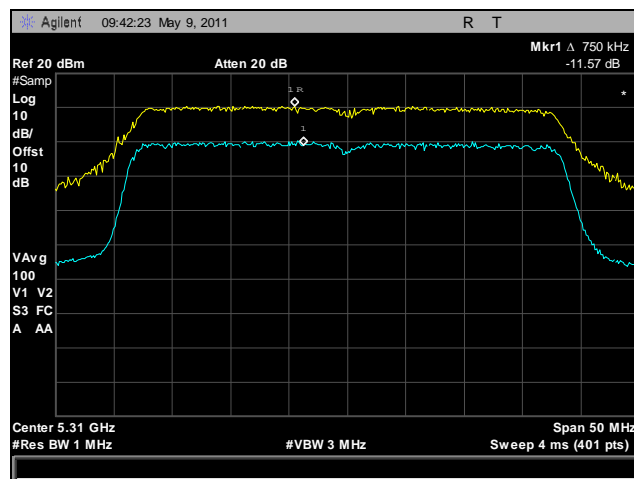


Plot 52. Peak Excursion Ratio, 5700 MHz, HT20

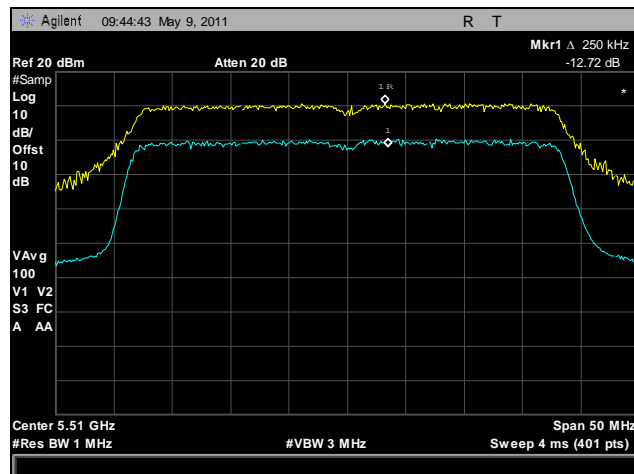
Peak Excursion Test Results, HT40



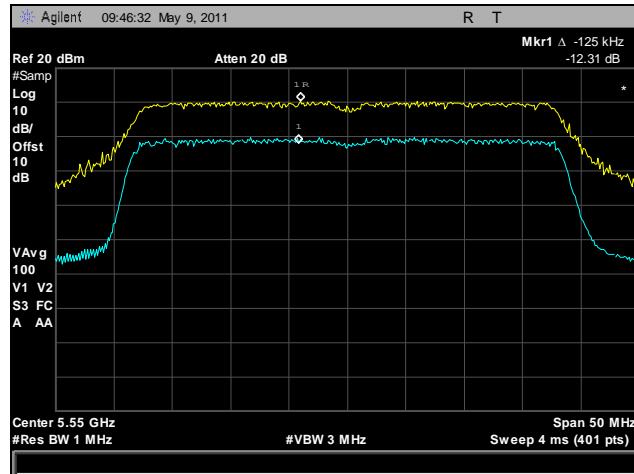
Plot 53. Peak Excursion Ratio, 5270 MHz, HT40



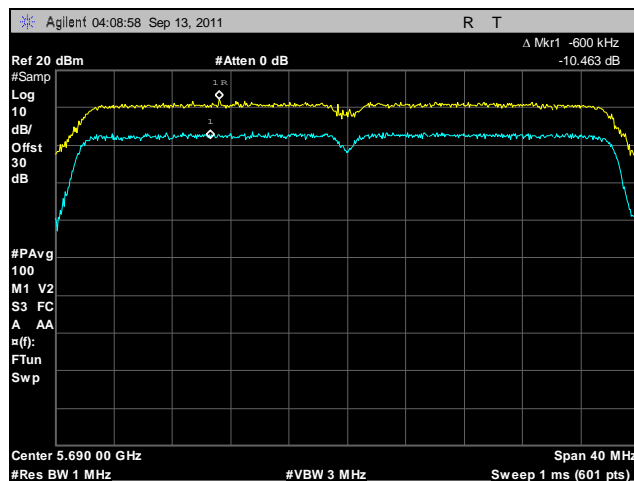
Plot 54. Peak Excursion Ratio, 5310 MHz, HT40



Plot 55. Peak Excursion Ratio, 5510 MHz, HT40



Plot 56. Peak Excursion Ratio, 5550 MHz, HT40



Plot 57. Peak Excursion Ratio, 5670 MHz, HT40



Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(b) Undesirable Emissions

Test Requirements: § 15.407(b)(4), (b)(6), (b)(7), §15.205: Emissions outside the frequency band.

§ 15.407(b)(4): For transmitters operating in the 5.725–5.825 GHz band: all emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an EIRP of –17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an EIRP of –27 dBm/MHz.

§ 15.407(b)(6): Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in Section 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in Section 15.207.

§ 15.407(b)(7): The provisions of Section 15.205 of this part apply to intentional radiators operating under this section.

Test Procedure: The transmitter was placed on an acrylic stand inside in a semi-anechoic chamber. Measurements were performed with the EUT rotated 360 degrees and varying the adjustable antenna mast height to determine worst case orientation for maximum emissions.

For frequencies from 30 MHz to 1 GHz, measurements were made using a quasi-peak detector with a 120 kHz bandwidth.

For measurements above 1 GHz, measurements were made with a Peak detector with 1 MHz resolution bandwidth. Where the spurious emissions fell into a restricted band, measurements were also made with an average detector to make sure they complied with 15.209 limits. Emissions were explored up to 40 GHz.

The equation, $EIRP = E + 20 \log D - 104.8$ was used to convert an EIRP limit to a field strength limit.

E = field strength (dBuV/m)

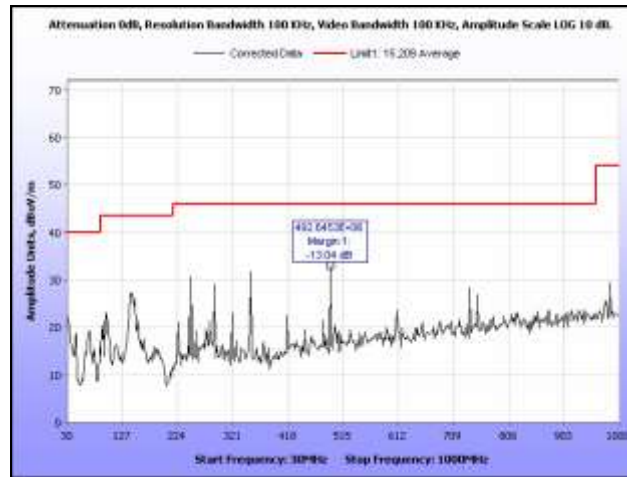
D = Reference measurement distance (m)

Test Results: The EUT was compliant with the Radiated Emission limits for Intentional Radiators. See following pages for detailed test results.

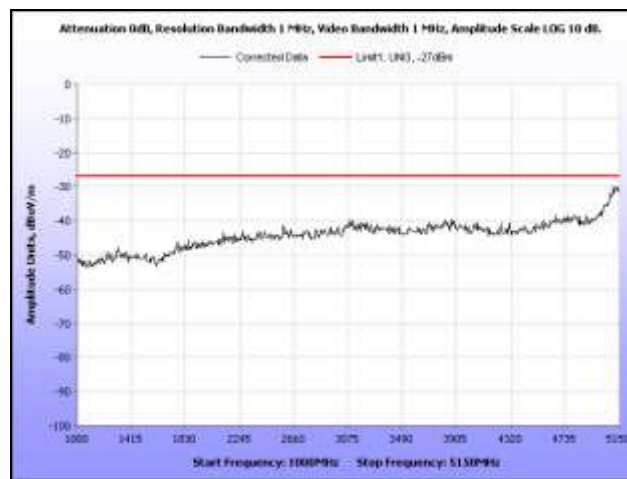
Test Engineer(s): Dusmantha Tennakoon

Test Date(s): 05/09/11

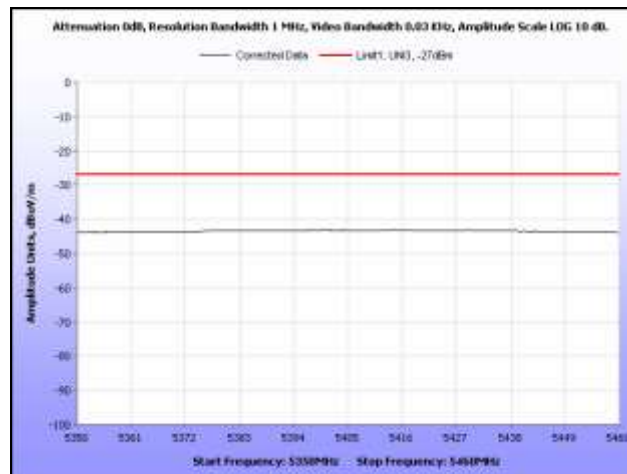
Radiated Spurious Emissions Test Results, HT20



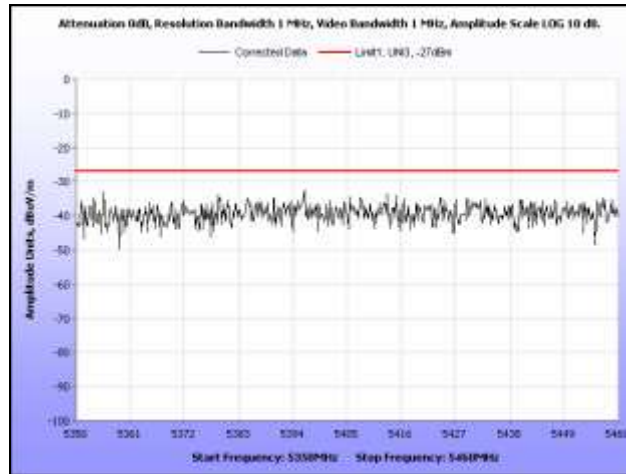
Plot 58. Radiated Spurious Emissions, 5260 MHz, 30 MHz – 1 GHz, HT20



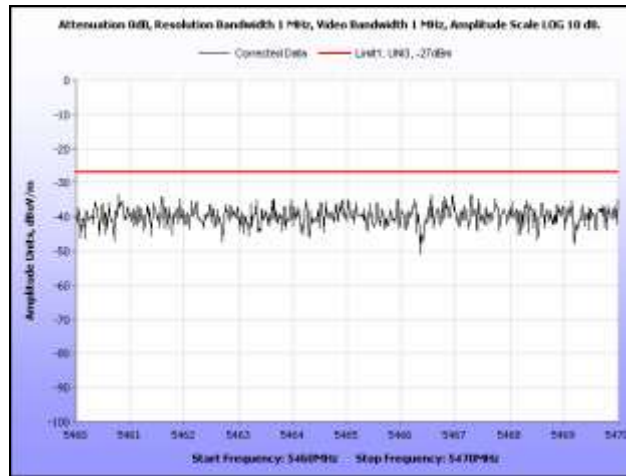
Plot 59. Radiated Spurious Emissions, 5260 MHz, 1 GHz – 5.15 GHz, HT20



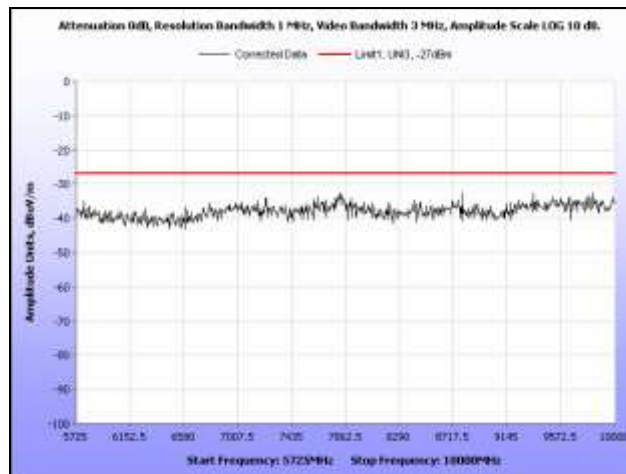
Plot 60. Radiated Spurious Emissions, 5260 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



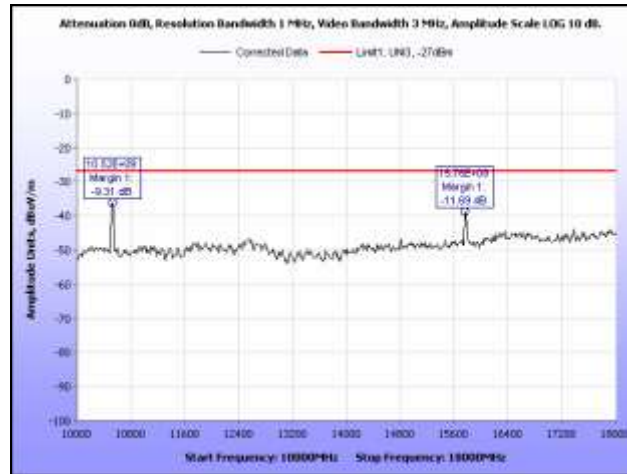
Plot 61. Radiated Spurious Emissions, 5260 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



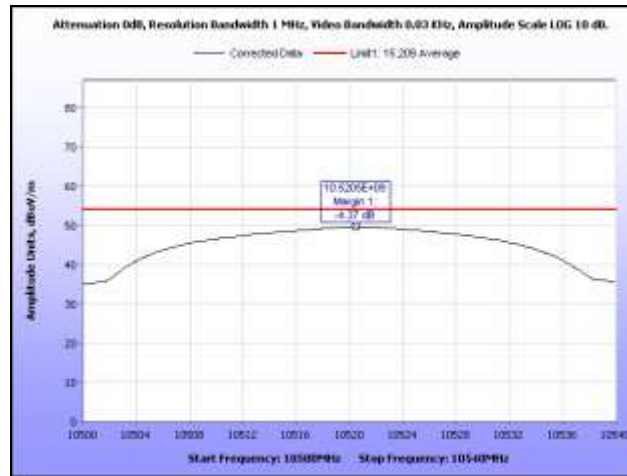
Plot 62. Radiated Spurious Emissions, 5260 MHz, 5.46 GHz – 5.47 GHz, HT20



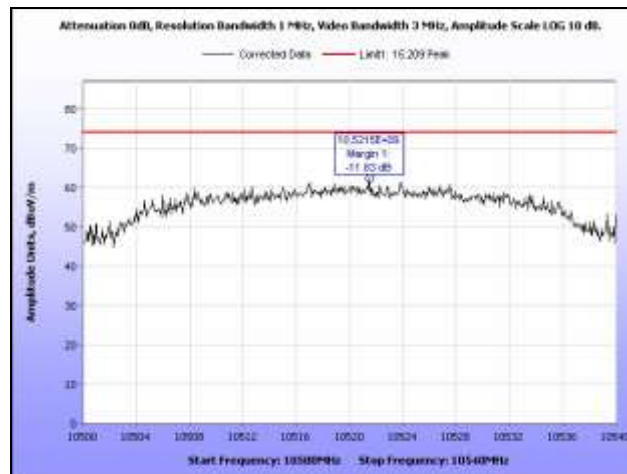
Plot 63. Radiated Spurious Emissions, 5260 MHz, 5.47 GHz – 10 GHz, HT20



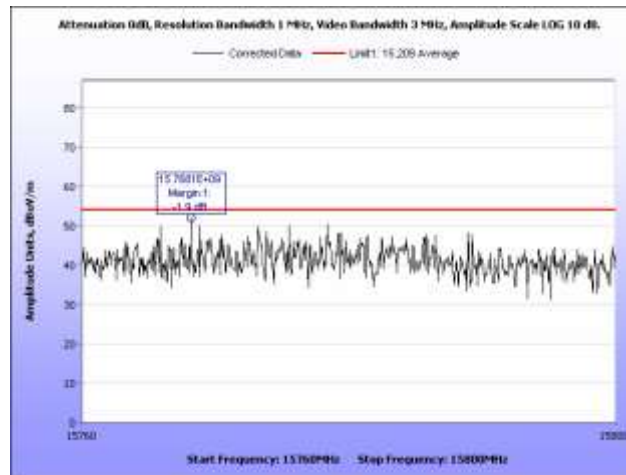
Plot 64. Radiated Spurious Emissions, 5260 MHz, 10 GHz – 18 GHz, HT20



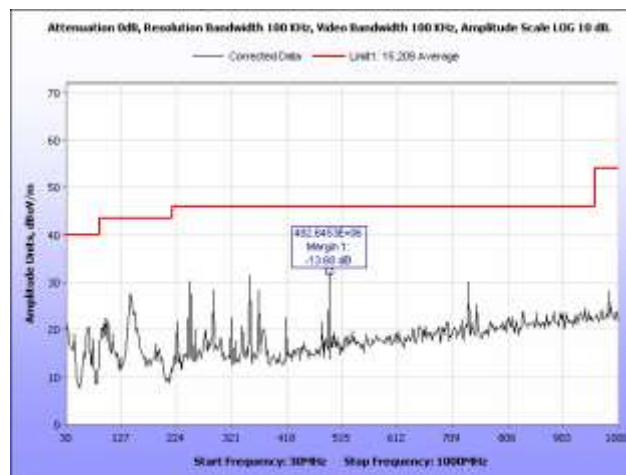
Plot 65. Radiated Spurious Emissions, 5260 MHz, 2nd Harmonic, Average



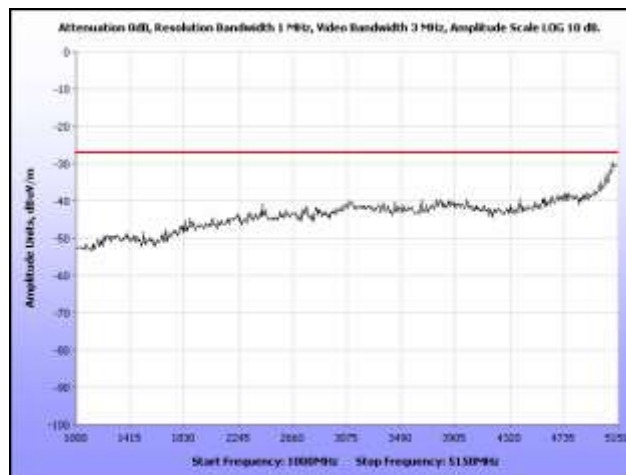
Plot 66. Radiated Spurious Emissions, 5260 MHz, 2nd Harmonic, Peak



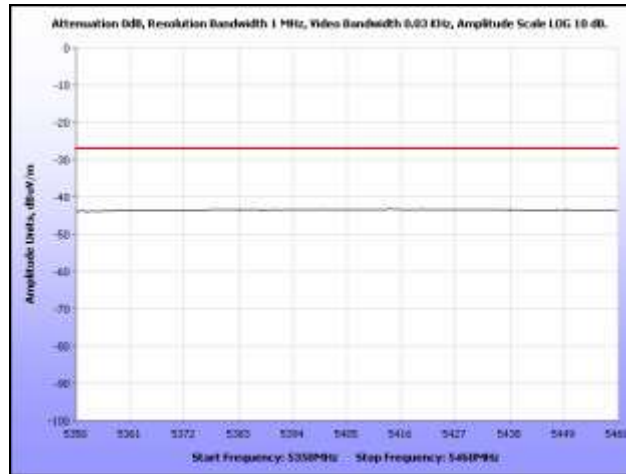
Plot 67. Radiated Spurious Emissions, 5260 MHz, 3rd Harmonic, Average Limit with Peak Detector



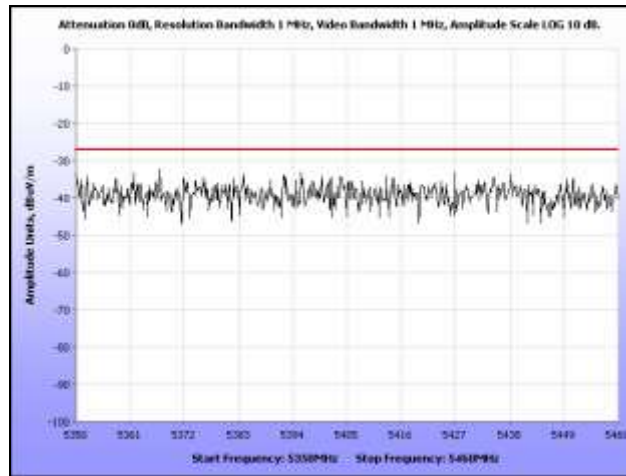
Plot 68. Radiated Spurious Emissions, 5300 MHz, 30 MHz – 1 GHz, HT20



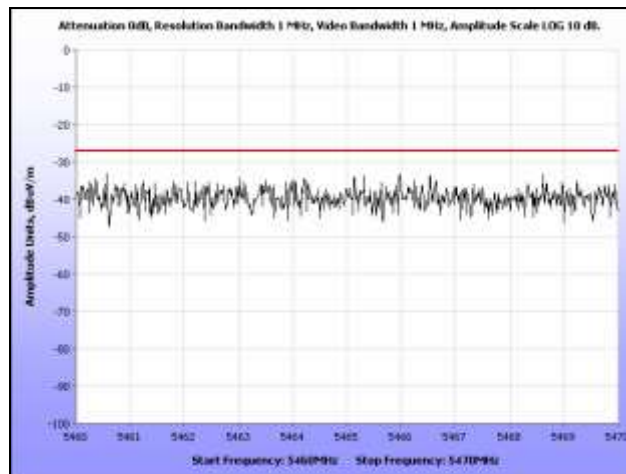
Plot 69. Radiated Spurious Emissions, 5300 MHz, 1 GHz – 5.15 GHz



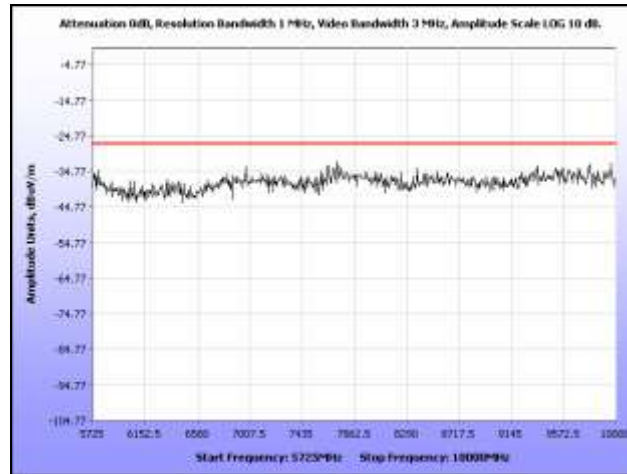
Plot 70. Radiated Spurious Emissions, 5300 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



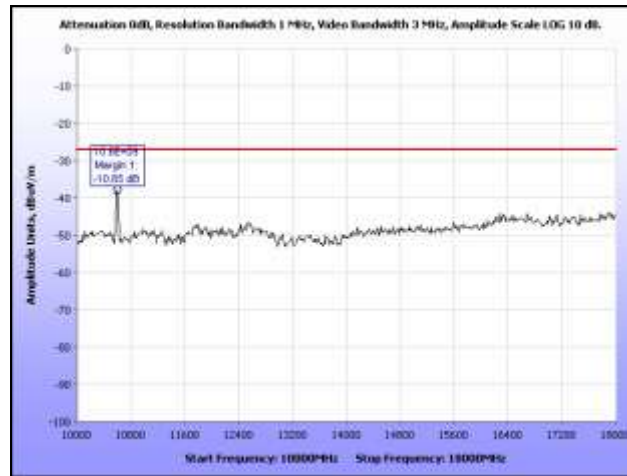
Plot 71. Radiated Spurious Emissions, 5300 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



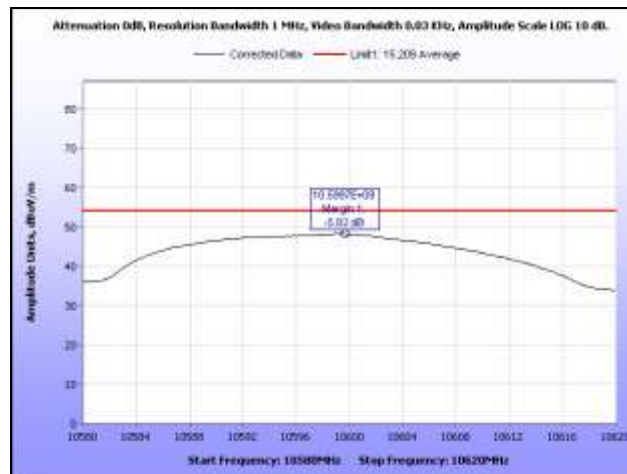
Plot 72. Radiated Spurious Emissions, 5300 MHz, 5.46 GHz – 5.47 GHz, HT20



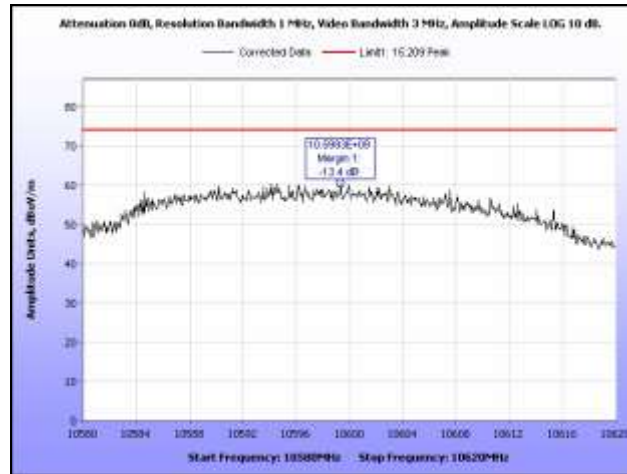
Plot 73. Radiated Spurious Emissions, 5300 MHz, 5.47 GHz – 10 GHz, HT20



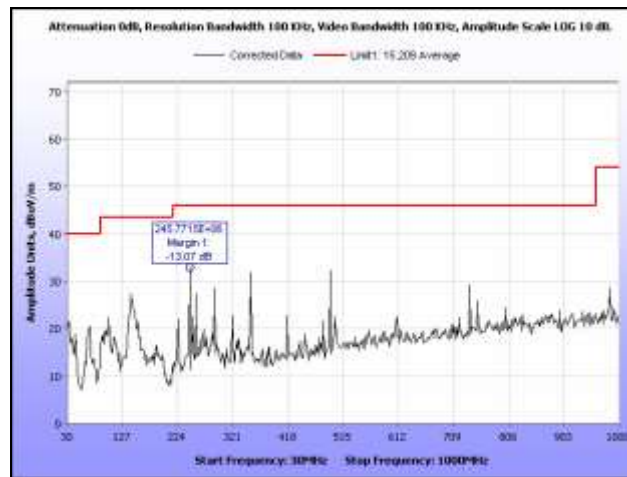
Plot 74. Radiated Spurious Emissions, 5300 MHz, 10 GHz – 18 GHz, HT20



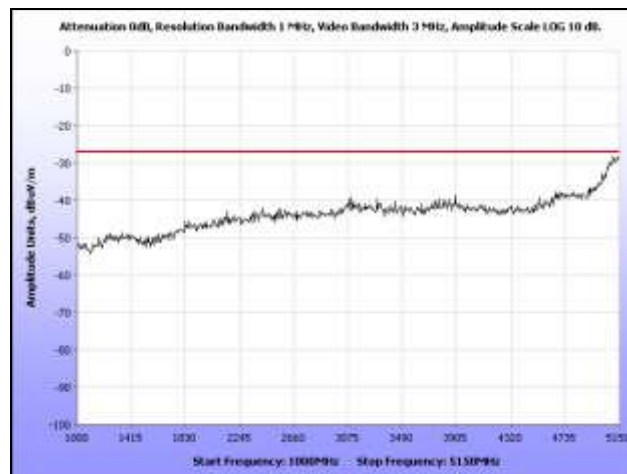
Plot 75. Radiated Spurious Emissions, 5300 MHz, 2nd Harmonic, Average



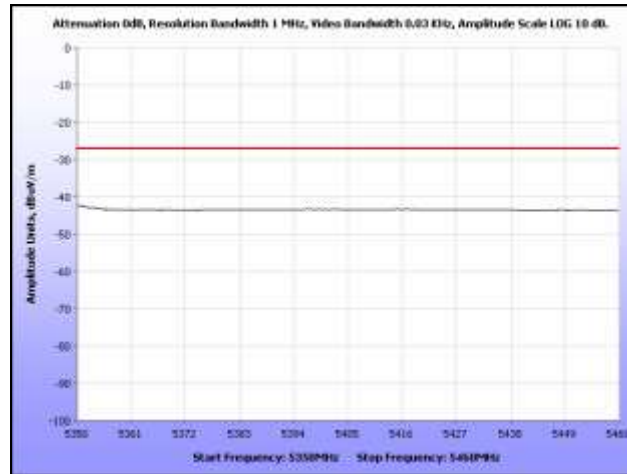
Plot 76. Radiated Spurious Emissions, 5300 MHz, 2nd Harmonic, Peak



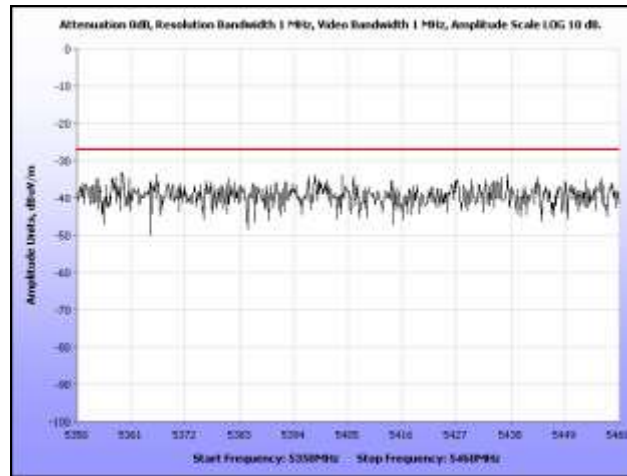
Plot 77. Radiated Spurious Emissions, 5320 MHz, 30 MHz – 1 GHz, HT20



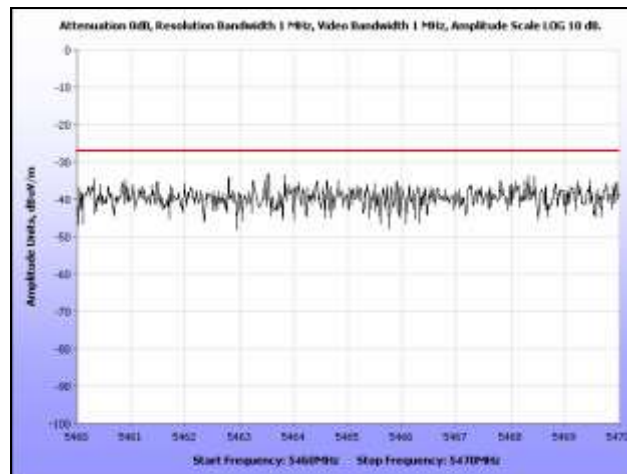
Plot 78. Radiated Spurious Emissions, 5320 MHz, 1 GHz – 5.15 GHz



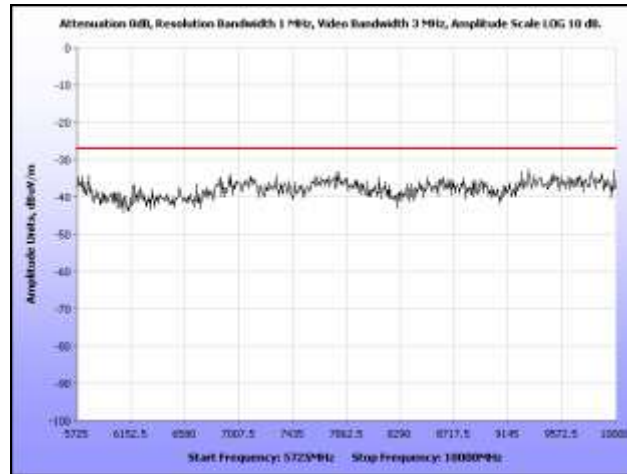
Plot 79. Radiated Spurious Emissions, 5320 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



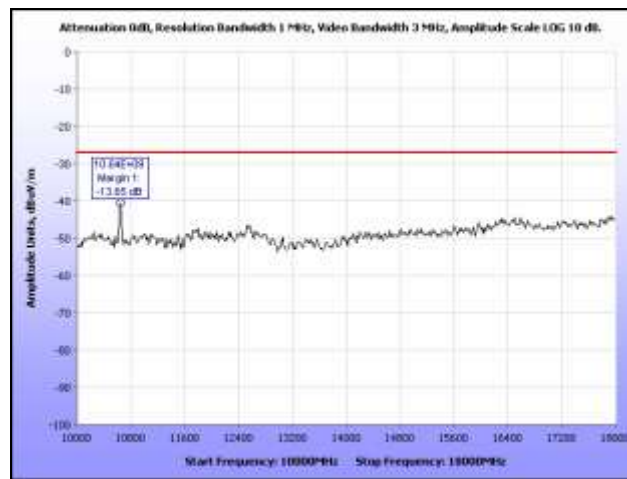
Plot 80. Radiated Spurious Emissions, 5320 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



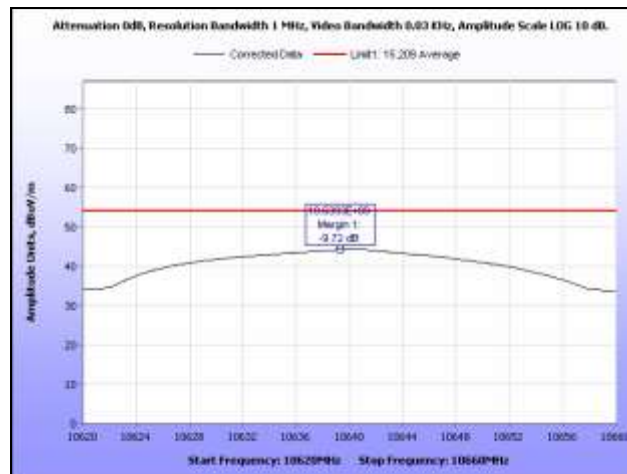
Plot 81. Radiated Spurious Emissions, 5320 MHz, 5.46 GHz – 5.47 GHz, HT20



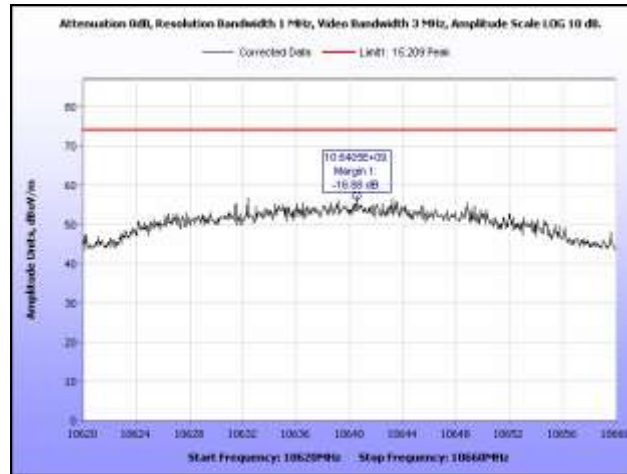
Plot 82. Radiated Spurious Emissions, 5320 MHz, 5.47 GHz – 10 GHz, HT20



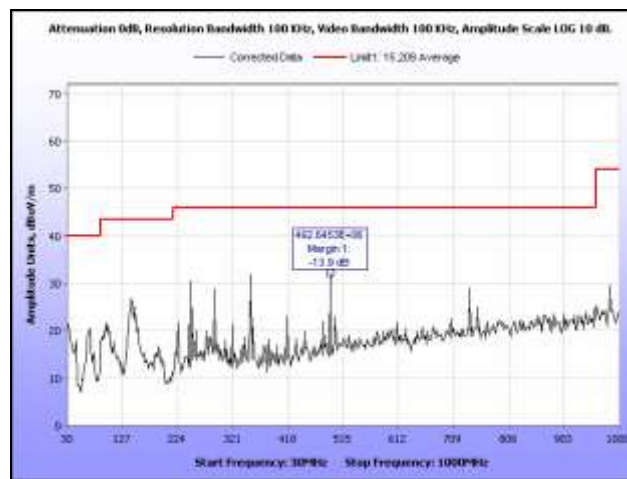
Plot 83. Radiated Spurious Emissions, 5320 MHz, 10 GHz – 18 GHz, HT20



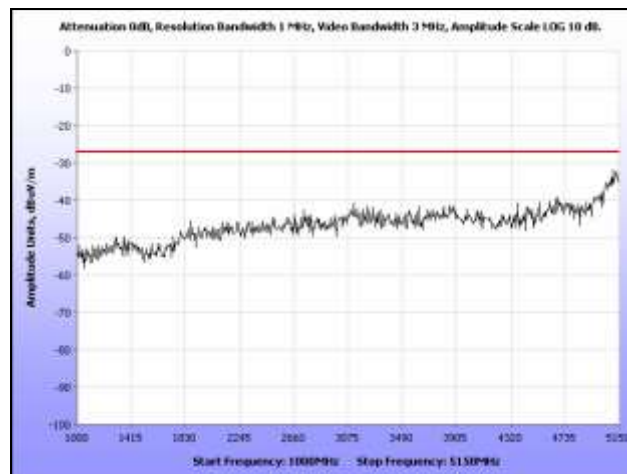
Plot 84. Radiated Spurious Emissions, 5320 MHz, 2nd Harmonic, Average



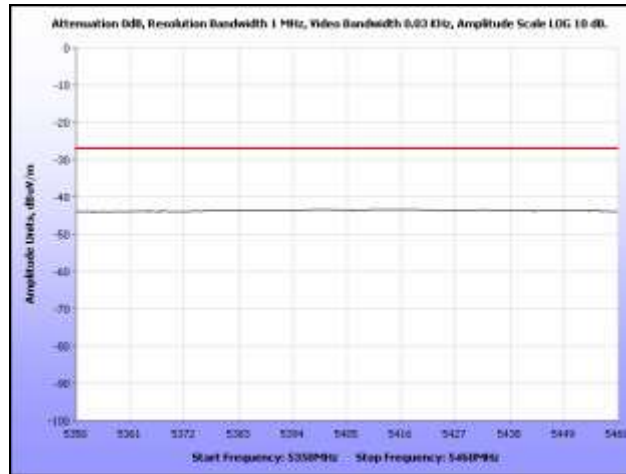
Plot 85. Radiated Spurious Emissions, 5320 MHz, 2nd Harmonic, Peak



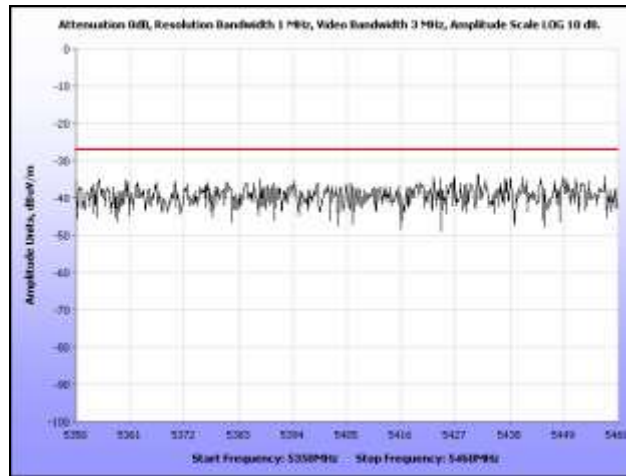
Plot 86. Radiated Spurious Emissions, 5500 MHz, 30 MHz – 1 GHz, HT20



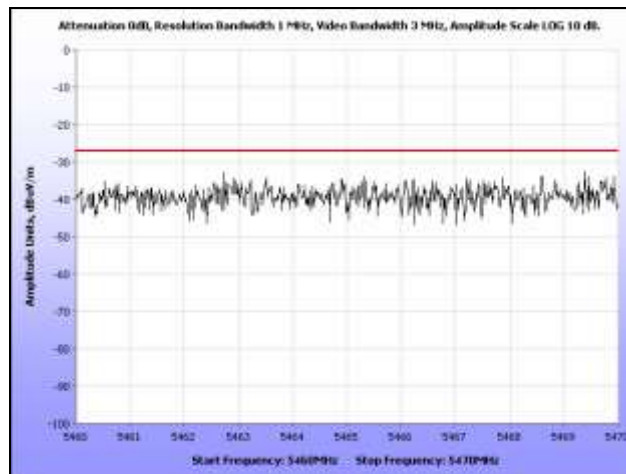
Plot 87. Radiated Spurious Emissions, 5500 MHz, 1 GHz – 5.15 GHz, HT20



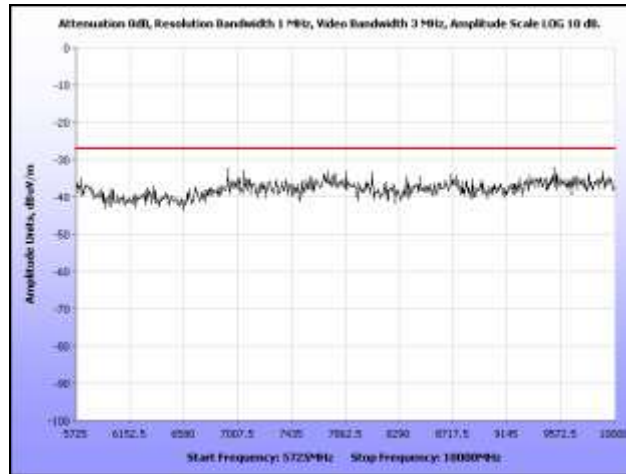
Plot 88. Radiated Spurious Emissions, 5500 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



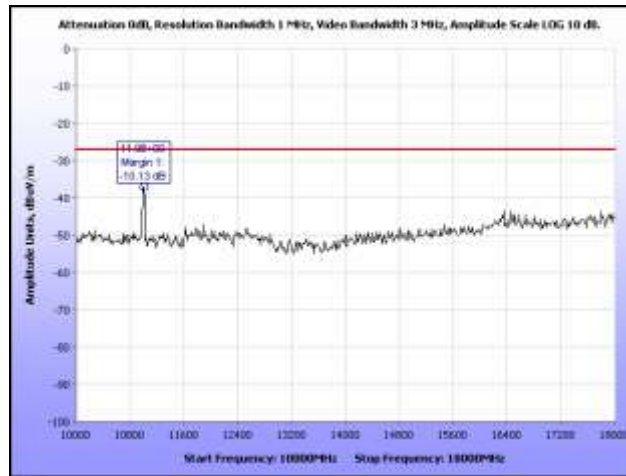
Plot 89. Radiated Spurious Emissions, 5500 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



Plot 90. Radiated Spurious Emissions, 5500 MHz, 5.46 GHz – 5.47 GHz, HT20



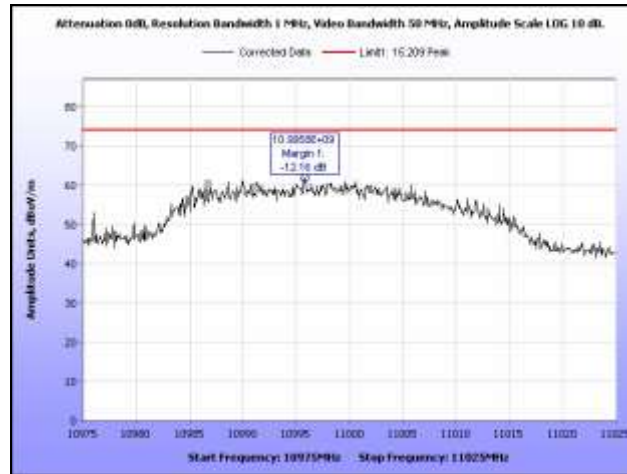
Plot 91. Radiated Spurious Emissions, 5500 MHz, 5.725 GHz – 10 GHz, HT20



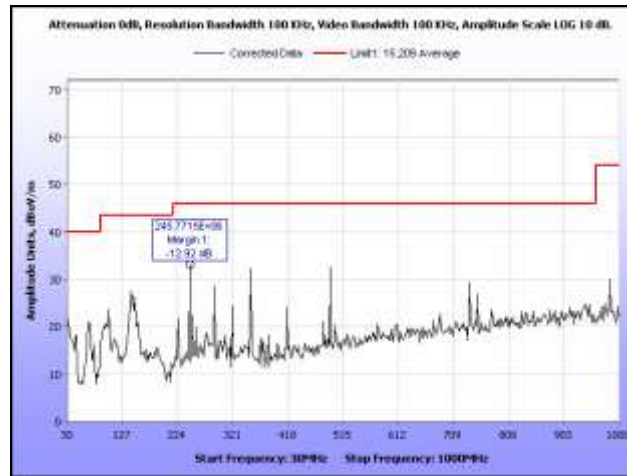
Plot 92. Radiated Spurious Emissions, 5500 MHz, 10 GHz – 18 GHz, HT20



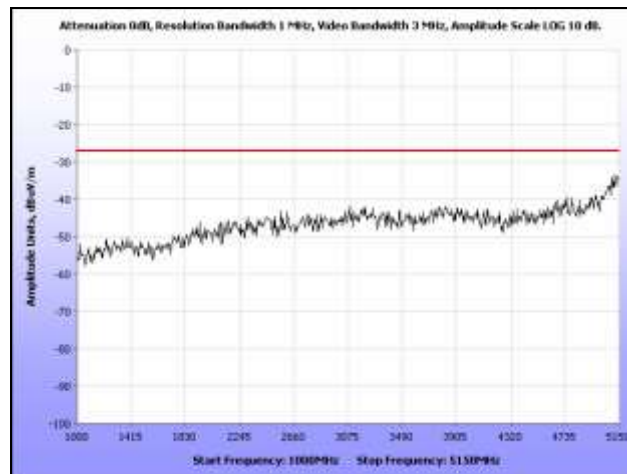
Plot 93. Radiated Spurious Emissions, 5500 MHz, 2nd Harmonic, Average



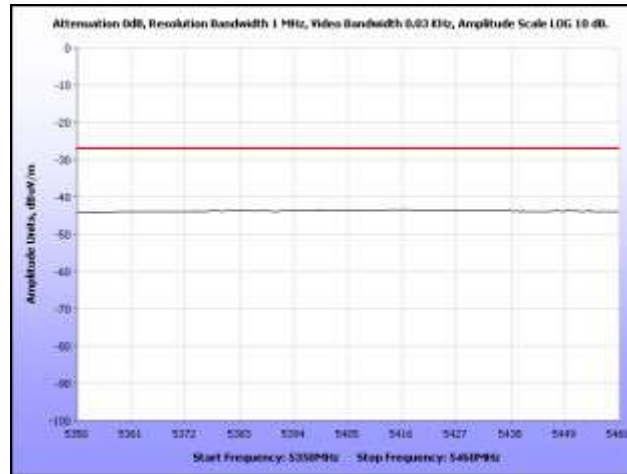
Plot 94. Radiated Spurious Emissions, 5500 MHz, 2nd Harmonic, Peak



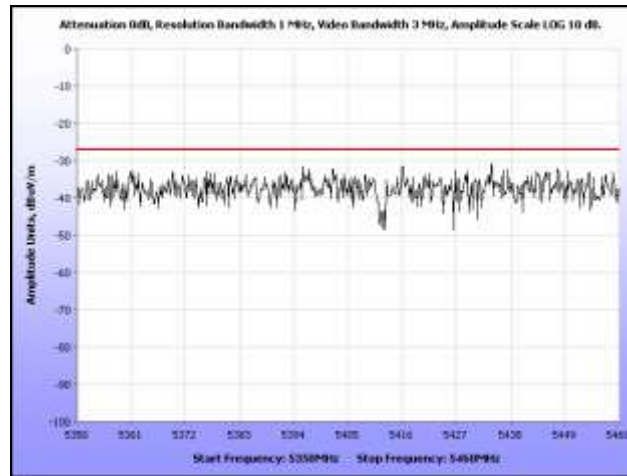
Plot 95. Radiated Spurious Emissions, 5580 MHz, 30 MHz – 1 GHz, HT20



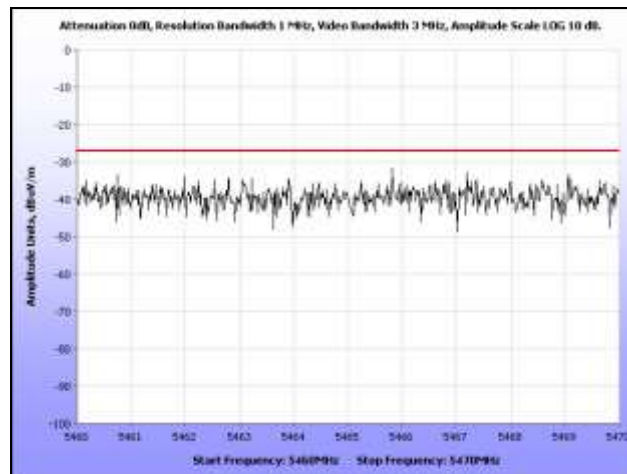
Plot 96. Radiated Spurious Emissions, 5580 MHz, 1 GHz – 5.15 GHz, HT20



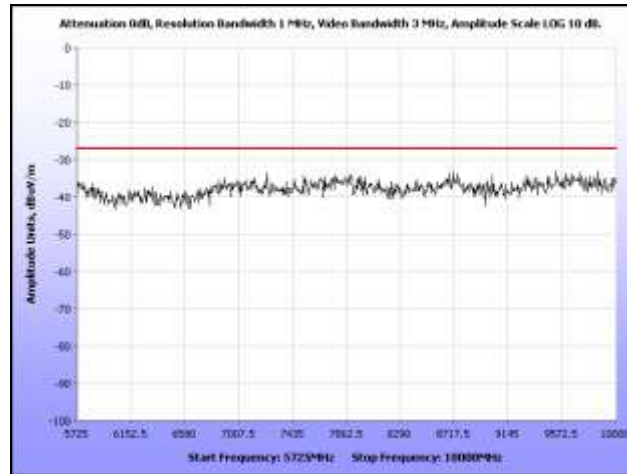
Plot 97. Radiated Spurious Emissions, 5580 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



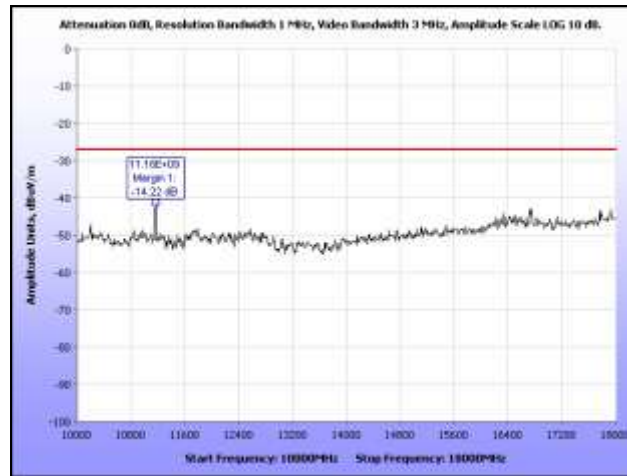
Plot 98. Radiated Spurious Emissions, 5580 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



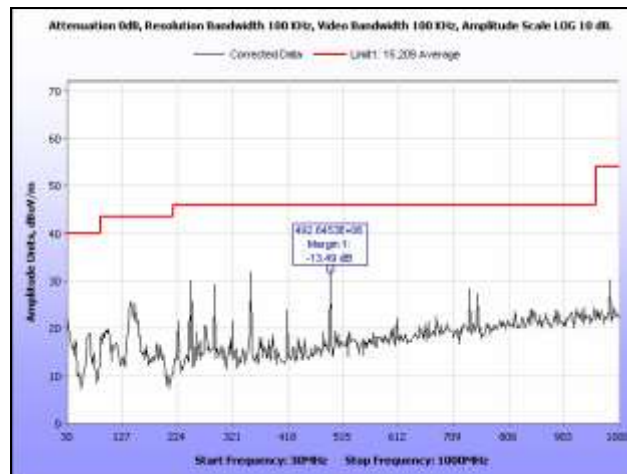
Plot 99. Radiated Spurious Emissions, 5580 MHz, 5.46 GHz – 5.47 GHz, HT20



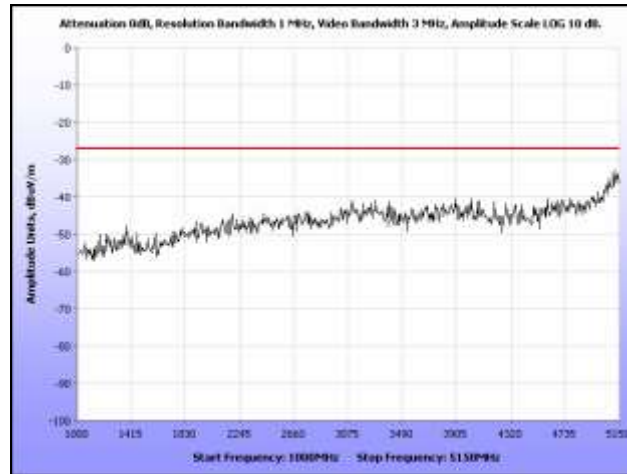
Plot 100. Radiated Spurious Emissions, 5580 MHz, 5.725 GHz – 10 GHz, HT20



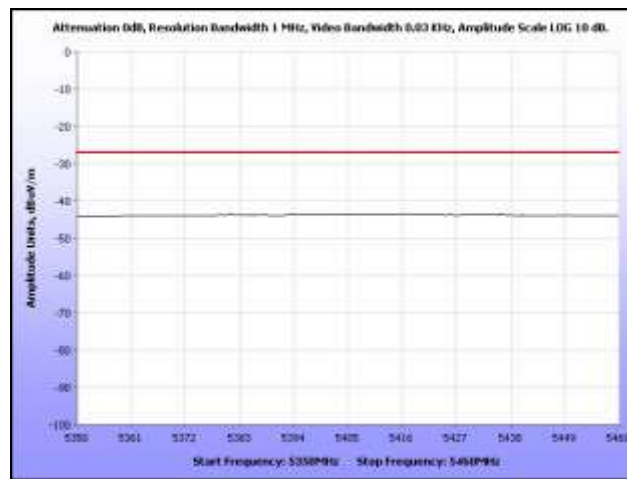
Plot 101. Radiated Spurious Emissions, 5580 MHz, 10 GHz – 18 GHz, HT20



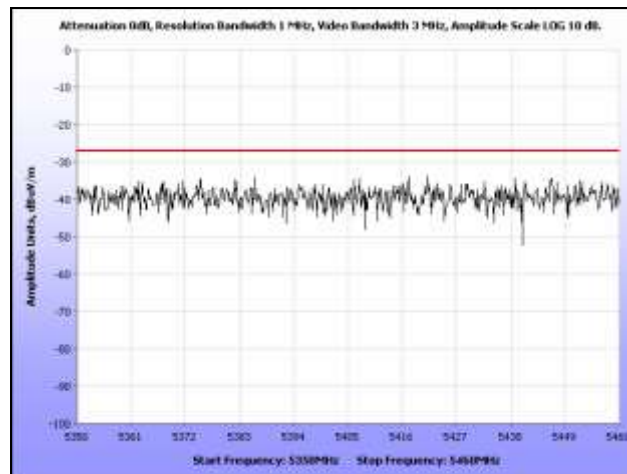
Plot 102. Radiated Spurious Emissions, 5700 MHz, 30 MHz – 1 GHz, HT20



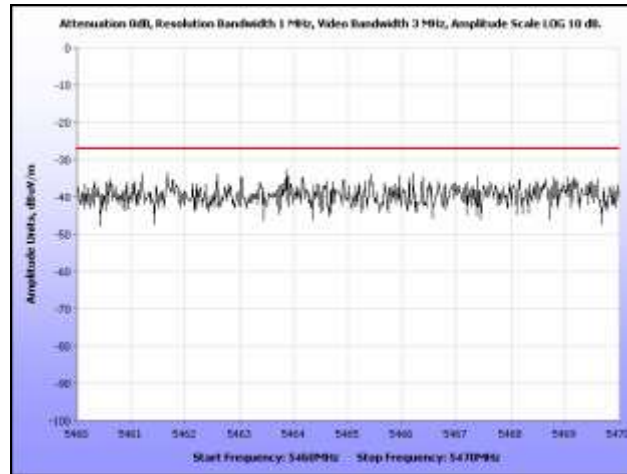
Plot 103. Radiated Spurious Emissions, 5700 MHz, 1 GHz – 5.15 GHz, HT20



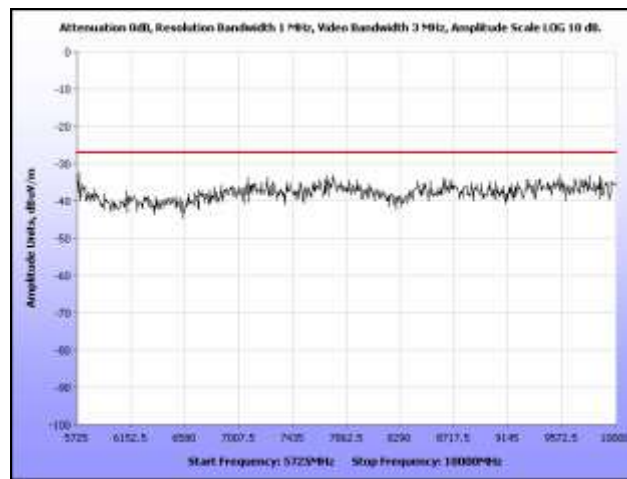
Plot 104. Radiated Spurious Emissions, 5700 MHz, 5.35 GHz – 5.46 GHz, Average, HT20



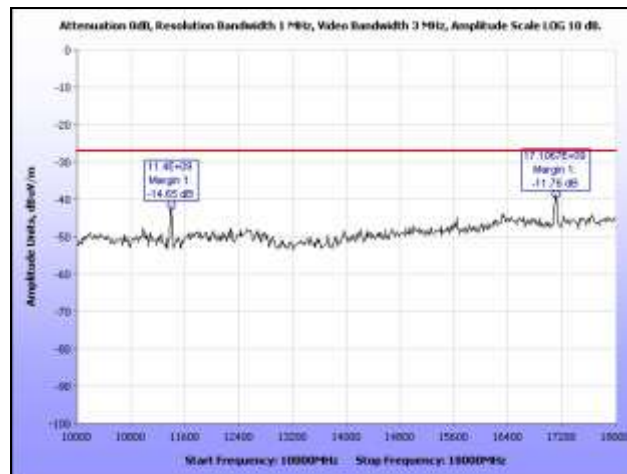
Plot 105. Radiated Spurious Emissions, 5700 MHz, 5.35 GHz – 5.46 GHz, Peak, HT20



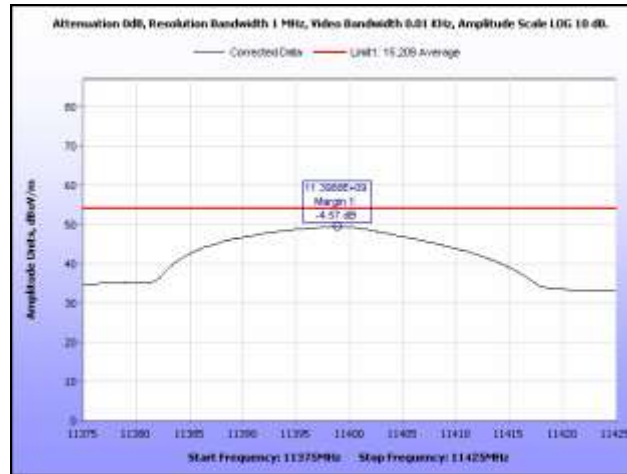
Plot 106. Radiated Spurious Emissions, 5700 MHz, 5.46 GHz – 5.47 GHz, HT20



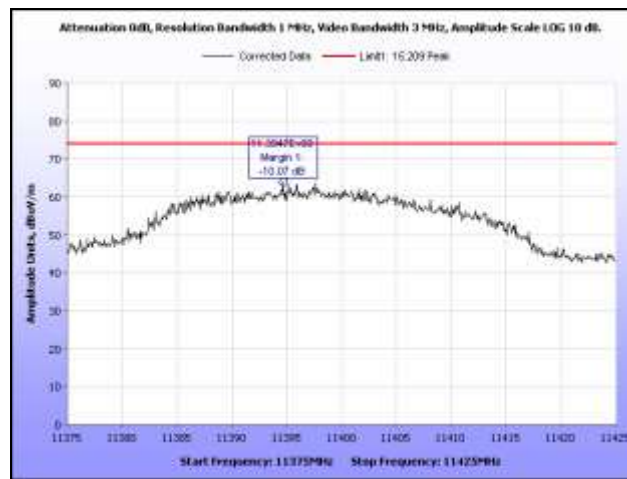
Plot 107. Radiated Spurious Emissions, 5700 MHz, 5.725 GHz – 10 GHz, HT20



Plot 108. Radiated Spurious Emissions, 5700 MHz, 10 GHz – 18 GHz, HT20



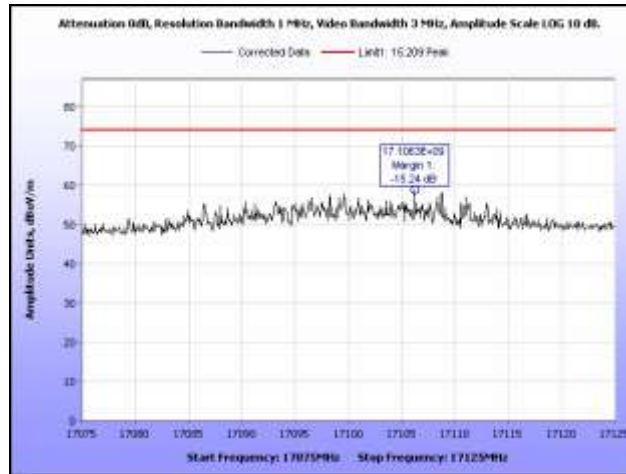
Plot 109. Radiated Spurious Emissions, 5700 MHz, 2nd Harmonic, Average



Plot 110. Radiated Spurious Emissions, 5700 MHz, 2nd Harmonic, Peak

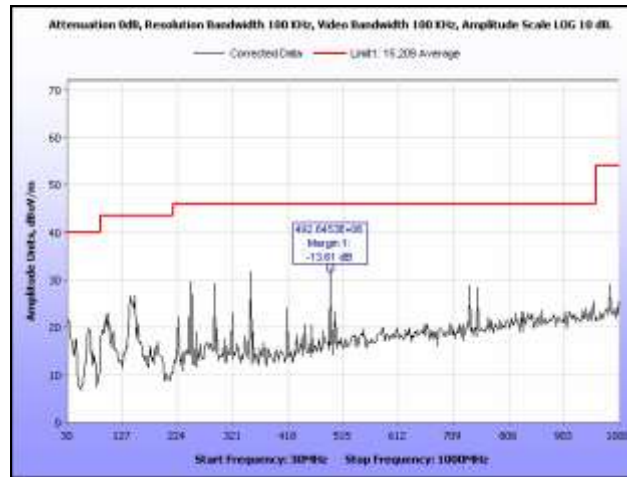


Plot 111. Radiated Spurious Emissions, 5700 MHz, 3rd Harmonic, Average

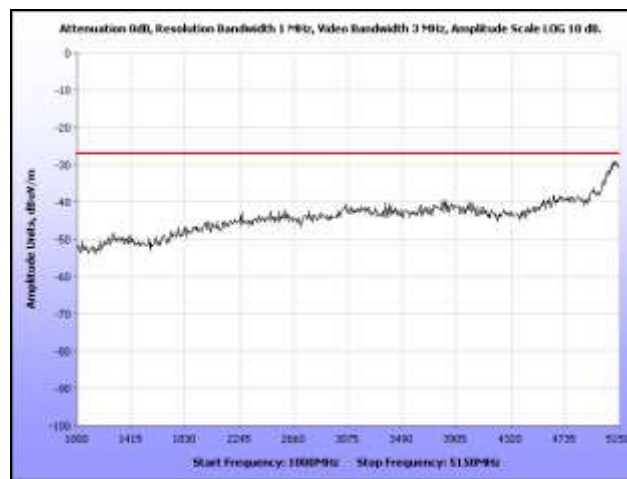


Plot 112. Radiated Spurious Emissions, 5700 MHz, 3rd Harmonic, Peak

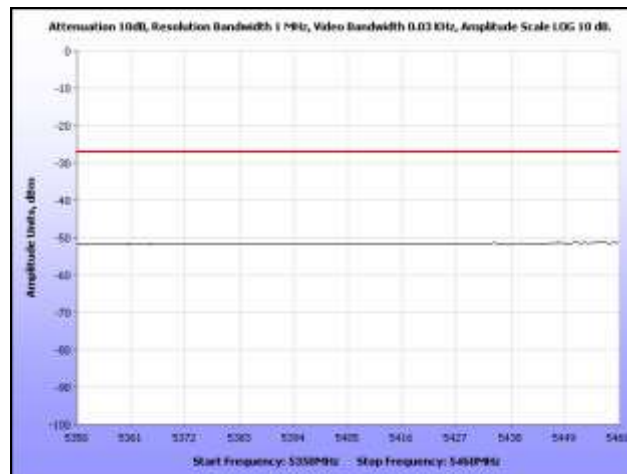
Radiated Spurious Emissions Test Results, HT40



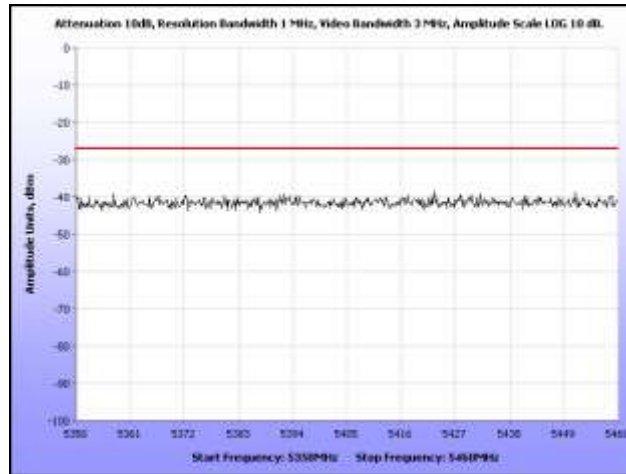
Plot 113. Radiated Spurious Emissions, 5270 MHz, 30 MHz – 1 GHz, HT40



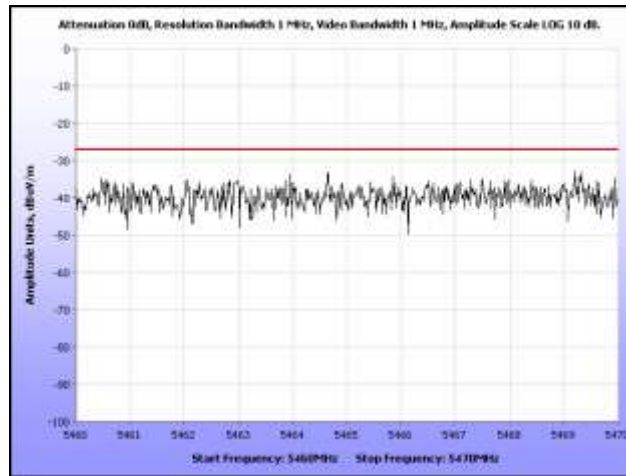
Plot 114. Radiated Spurious Emissions, 5270 MHz, 1 GHz – 5.15 GHz, HT40



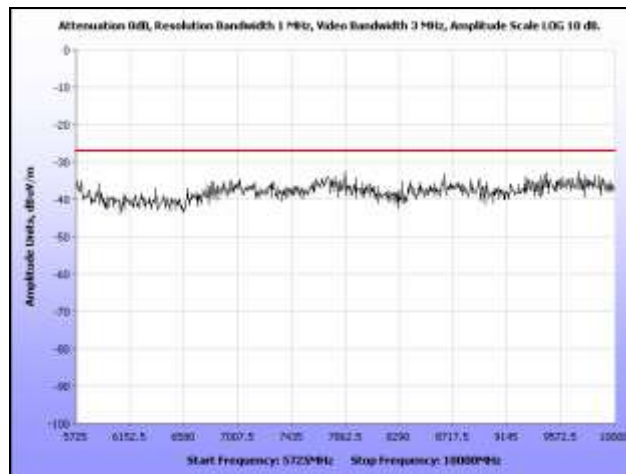
Plot 115. Radiated Spurious Emissions, 5270 MHz, 5.35 GHz – 5.46 GHz, Average, HT40



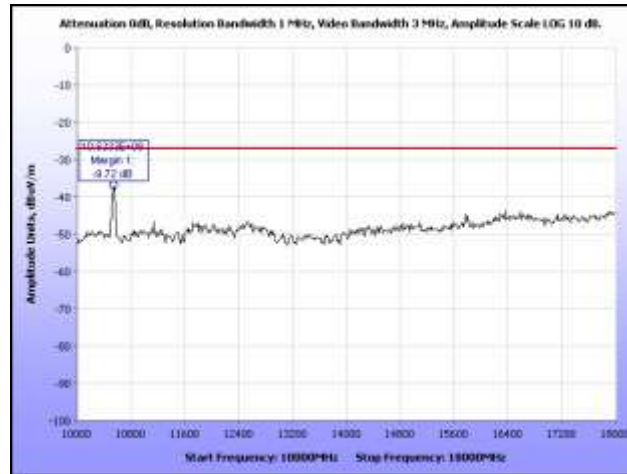
Plot 116. Radiated Spurious Emissions, 5270 MHz, 5.35 GHz – 5.46 GHz, Peak, HT40



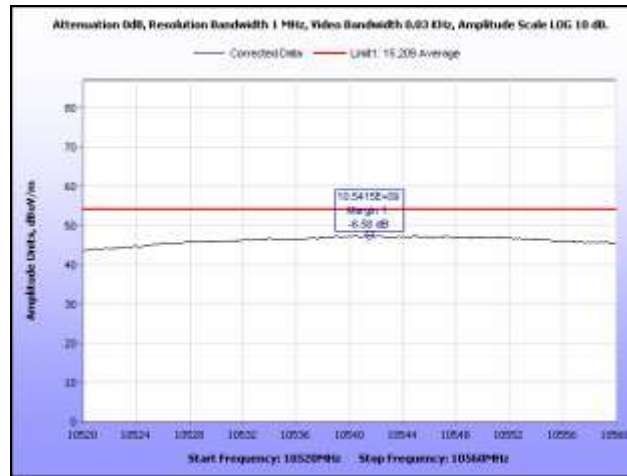
Plot 117. Radiated Spurious Emissions, 5270 MHz, 5.46 GHz – 5.47 GHz, HT40



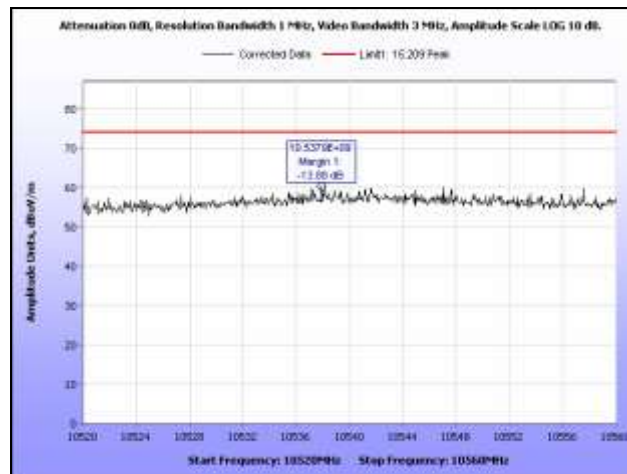
Plot 118. Radiated Spurious Emissions, 5270 MHz, 5.47 GHz – 10 GHz, HT40



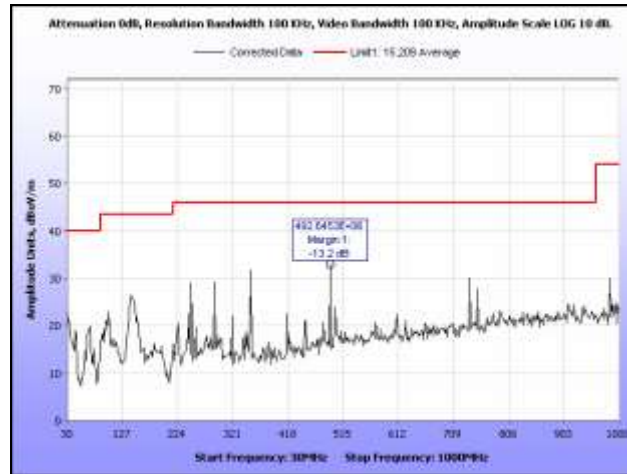
Plot 119. Radiated Spurious Emissions, 5270 MHz, 10 GHz – 18 GHz, HT40



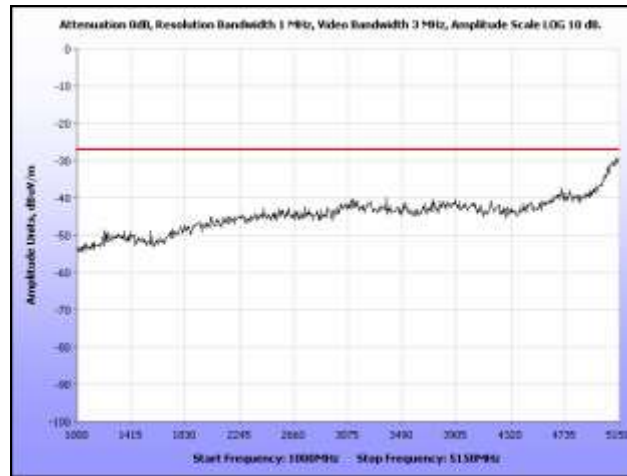
Plot 120. Radiated Spurious Emissions, 5270 MHz, 2nd Harmonic, Average



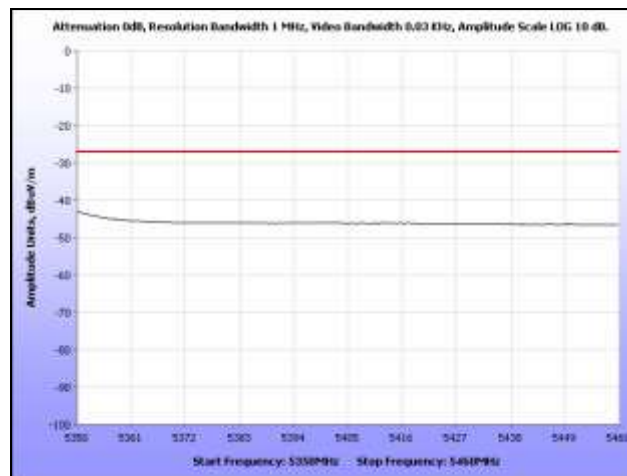
Plot 121. Radiated Spurious Emissions, 5270 MHz, 2nd Harmonic, Peak



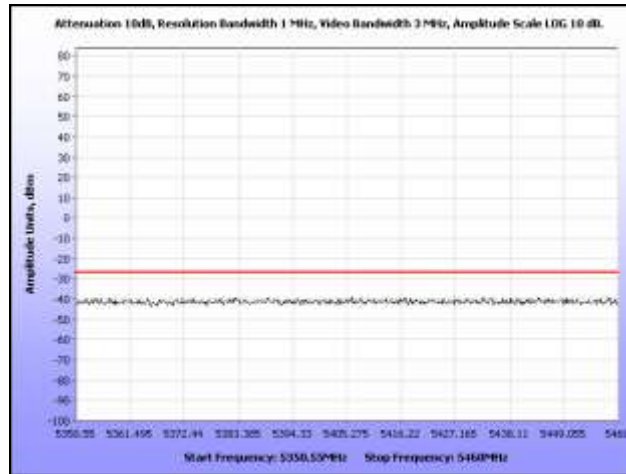
Plot 122. Radiated Spurious Emissions, 5310 MHz, 30 MHz – 1 GHz, HT40



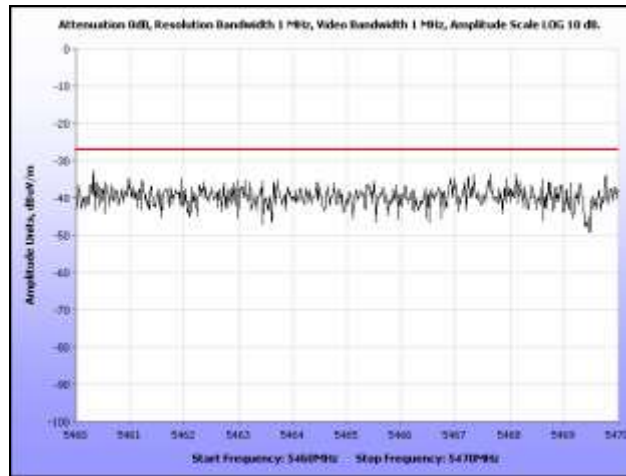
Plot 123. Radiated Spurious Emissions, 5310 MHz, 1 GHz – 5.15 GHz, HT40



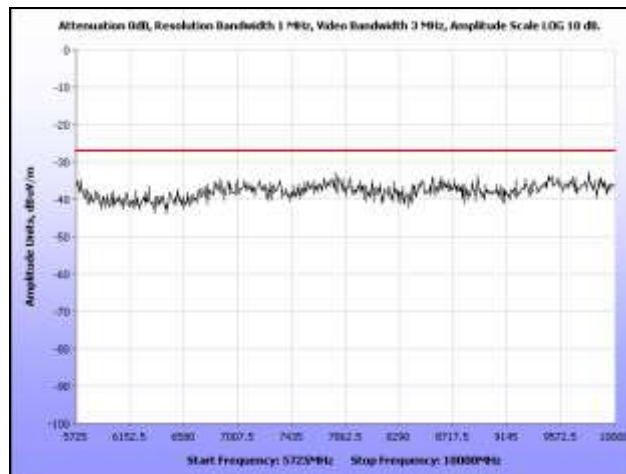
Plot 124. Radiated Spurious Emissions, 5310 MHz, 5.35 GHz – 5.46 GHz, Average, HT40



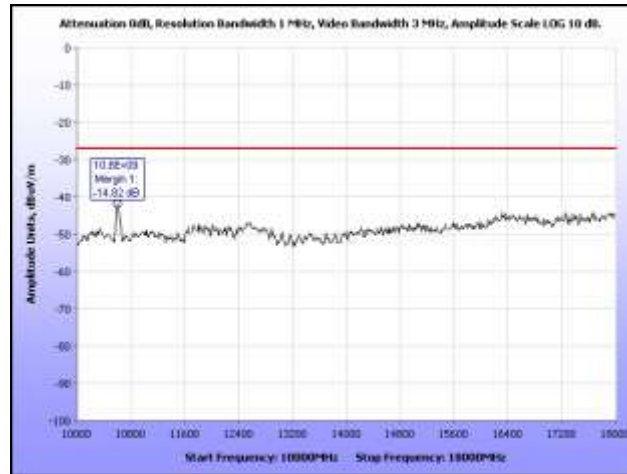
Plot 125. Radiated Spurious Emissions, 5310 MHz, 5.35 GHz – 5.46 GHz, Peak, HT40



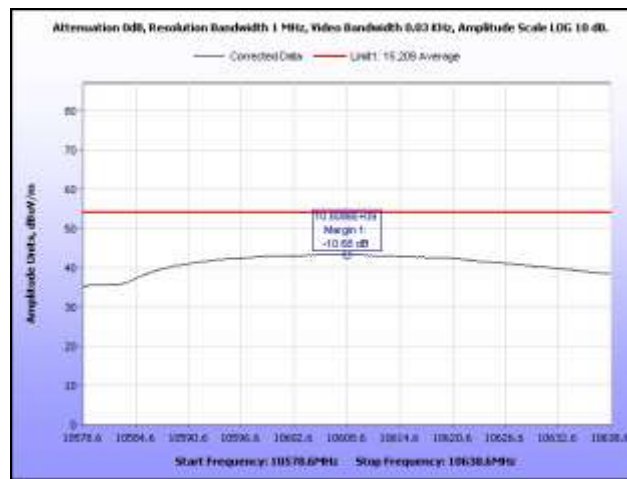
Plot 126. Radiated Spurious Emissions, 5310 MHz, 5.46 GHz – 5.47 GHz, HT40



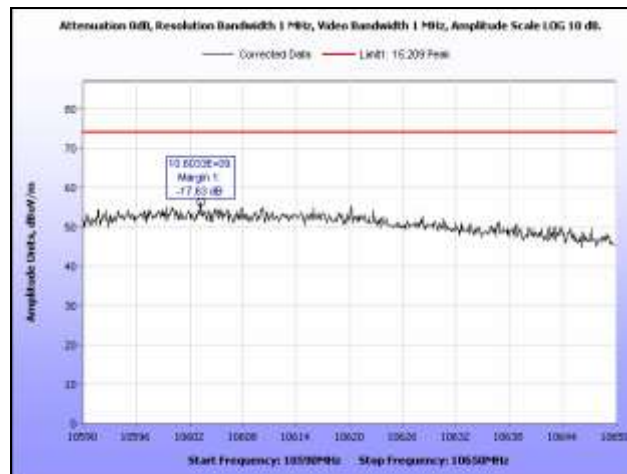
Plot 127. Radiated Spurious Emissions, 5310 MHz, 5.47 GHz – 10 GHz, HT40



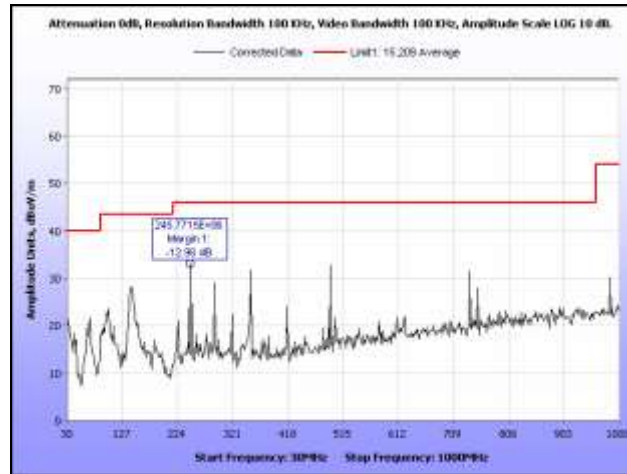
Plot 128. Radiated Spurious Emissions, 5310 MHz, 10 GHz – 18 GHz, HT40



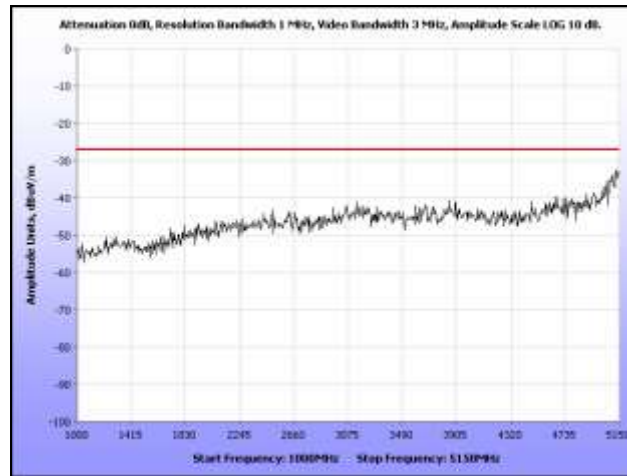
Plot 129. Radiated Spurious Emissions, 5310 MHz, 2nd Harmonic, Average



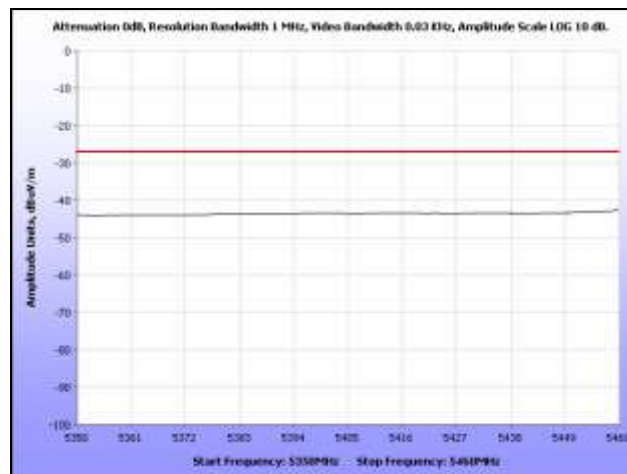
Plot 130. Radiated Spurious Emissions, 5310 MHz, 2nd Harmonic, Peak



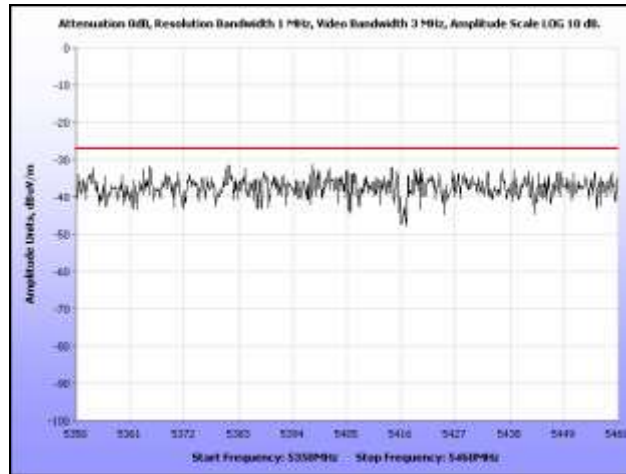
Plot 131. Radiated Spurious Emissions, 5510 MHz, 30 MHz – 1 GHz, HT40



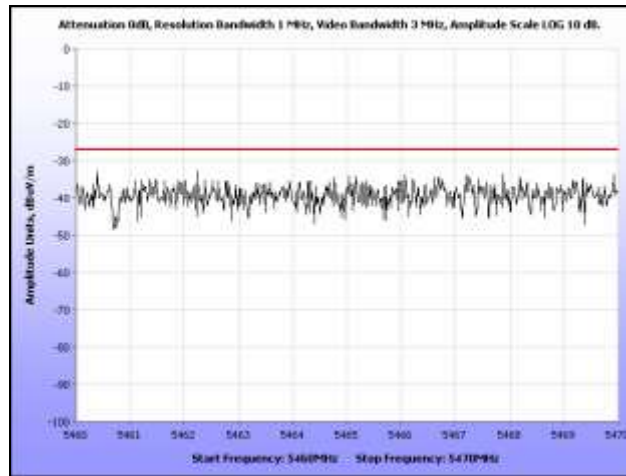
Plot 132. Radiated Spurious Emissions, 5510 MHz, 1 GHz – 5.15 GHz, HT40



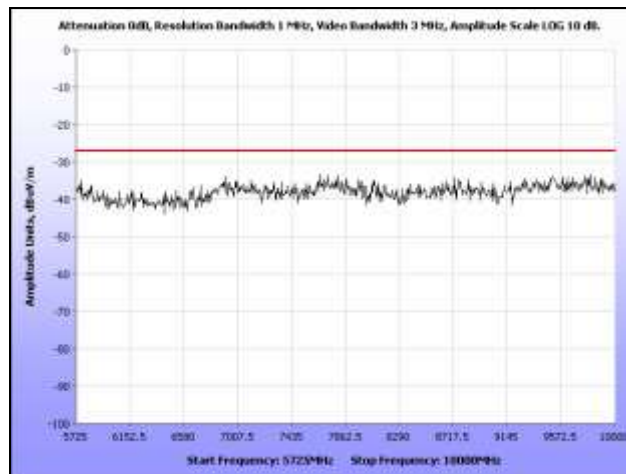
Plot 133. Radiated Spurious Emissions, 5510 MHz, 5.35 GHz – 5.46 GHz, Average, HT40



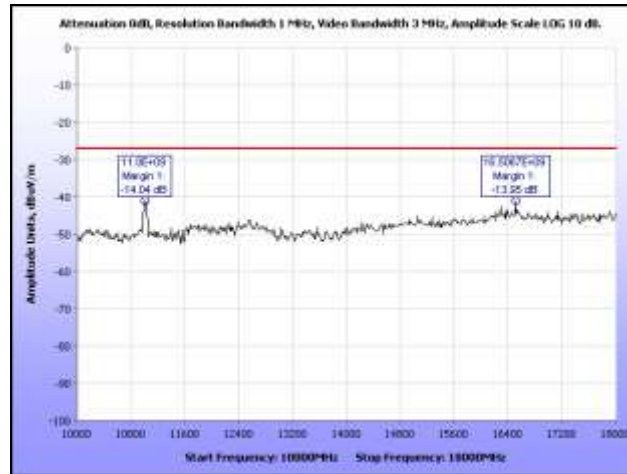
Plot 134. Radiated Spurious Emissions, 5510 MHz, 5.35 GHz – 5.46 GHz, Peak, HT40



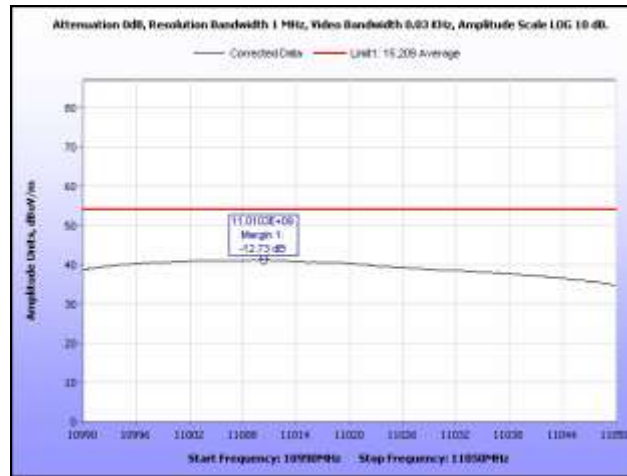
Plot 135. Radiated Spurious Emissions, 5510 MHz, 5.46 GHz – 5.47 GHz, HT40



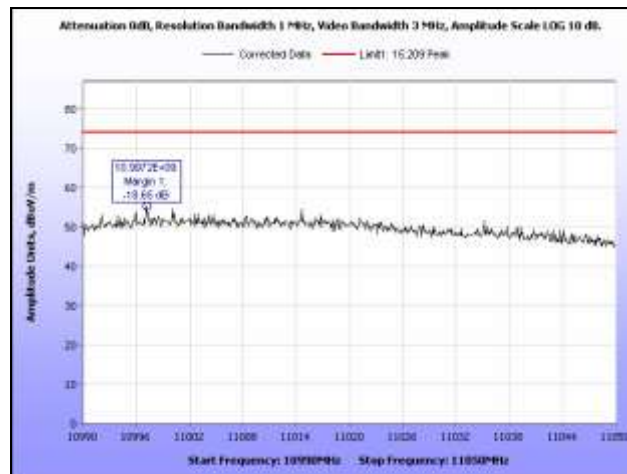
Plot 136. Radiated Spurious Emissions, 5510 MHz, 5.47 GHz – 10 GHz, HT40



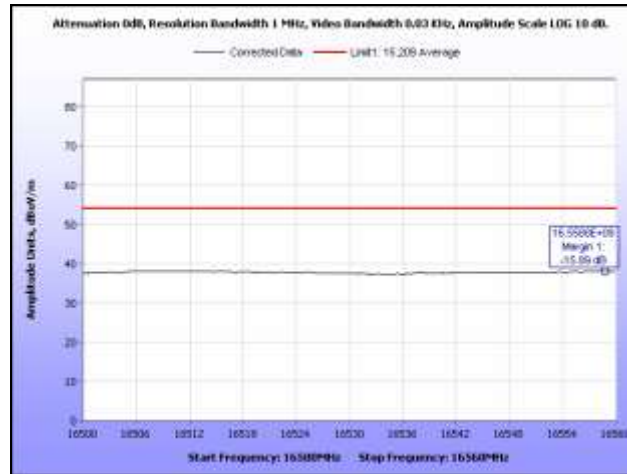
Plot 137. Radiated Spurious Emissions, 5510 MHz, 10 GHz – 18 GHz, HT40



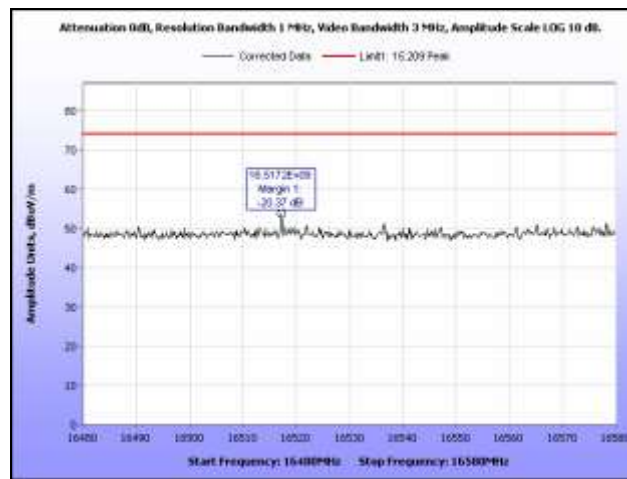
Plot 138. Radiated Spurious Emissions, 5510 MHz, 2nd Harmonic, Average



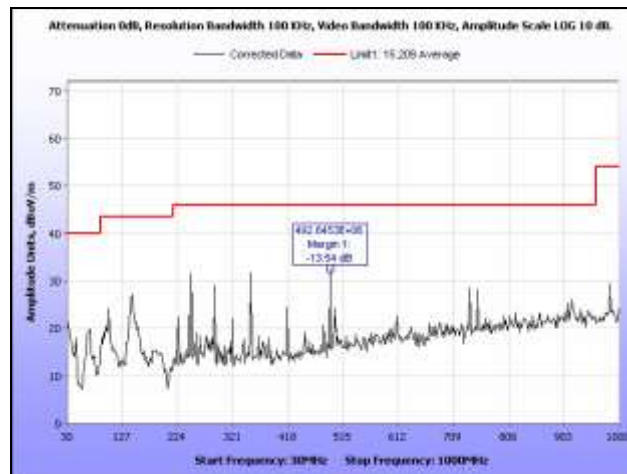
Plot 139. Radiated Spurious Emissions, 5510 MHz, 2nd Harmonic, Peak



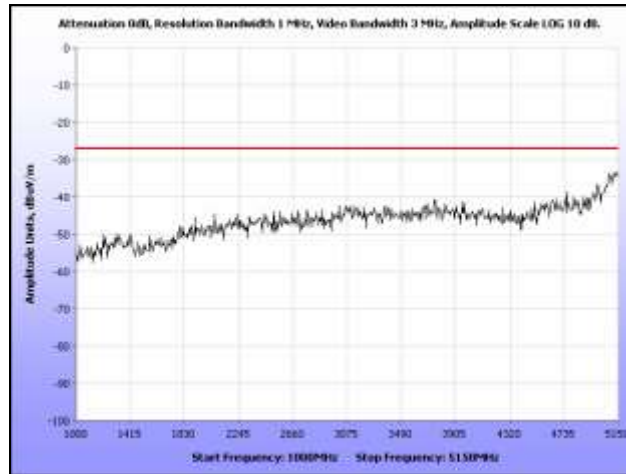
Plot 140. Radiated Spurious Emissions, 5510 MHz, 3rd Harmonic, Average



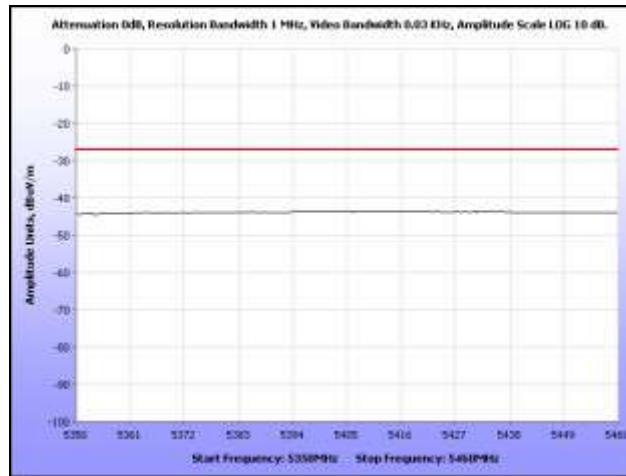
Plot 141. Radiated Spurious Emissions, 5510 MHz, 3rd Harmonic, Peak



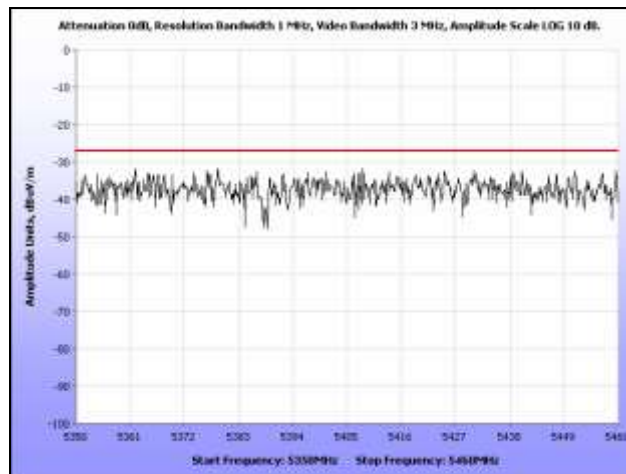
Plot 142. Radiated Spurious Emissions, 5550 MHz, 30 MHz – 1 GHz, HT40



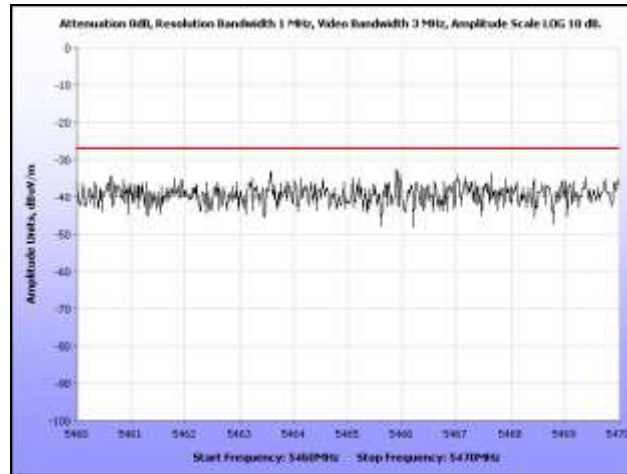
Plot 143. Radiated Spurious Emissions, 5550 MHz, 1 GHz – 5.15 GHz, HT40



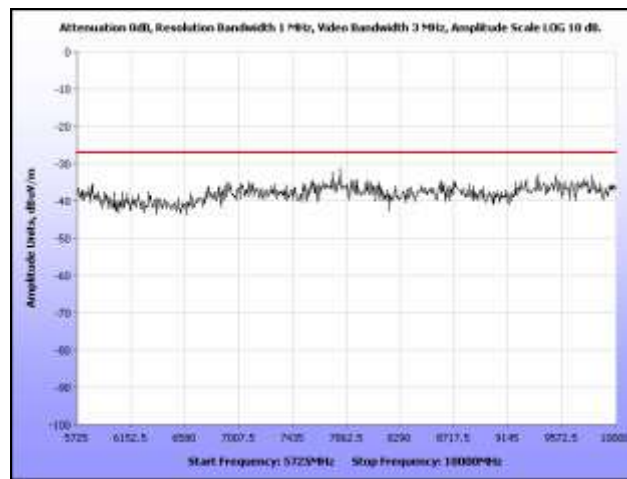
Plot 144. Radiated Spurious Emissions, 5550 MHz, 5.35 GHz – 5.46 GHz, Average, HT40



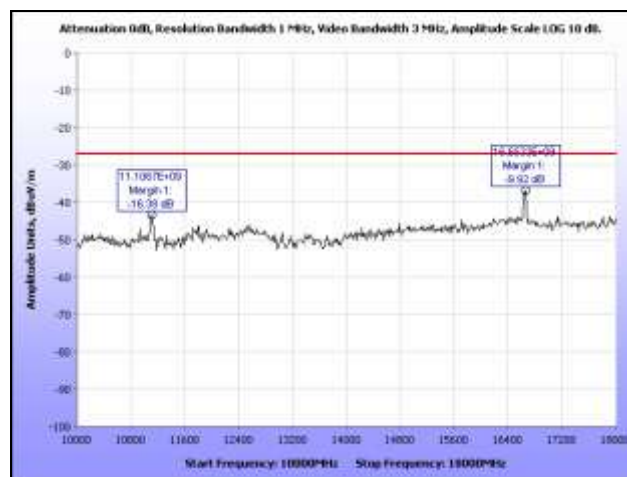
Plot 145. Radiated Spurious Emissions, 5550 MHz, 5.35 GHz – 5.46 GHz, Peak, HT40



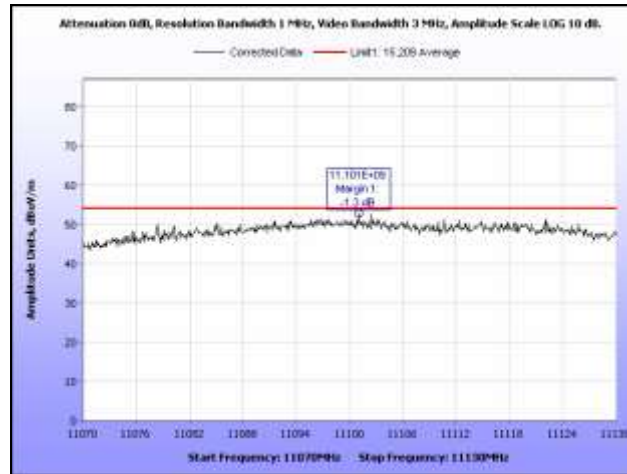
Plot 146. Radiated Spurious Emissions, 5550 MHz, 5.46 GHz – 5.47 GHz, HT40



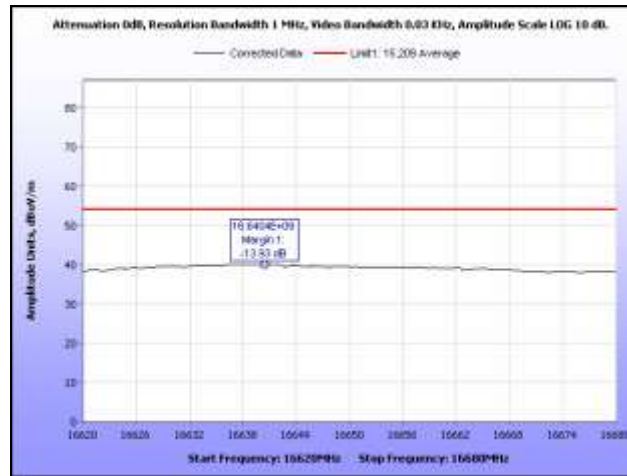
Plot 147. Radiated Spurious Emissions, 5550 MHz, 5.725 GHz – 10 GHz, HT40



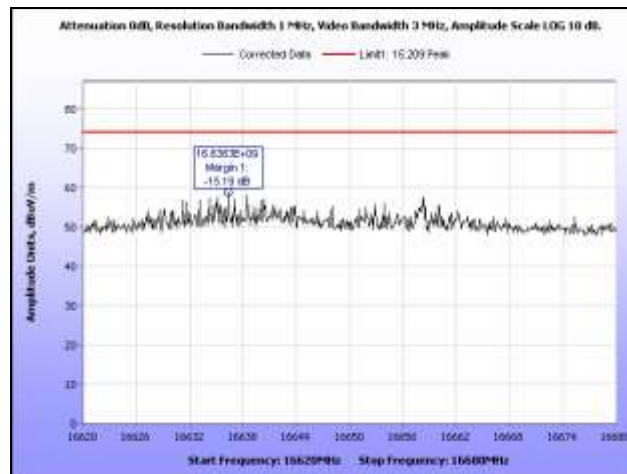
Plot 148. Radiated Spurious Emissions, 5550 MHz, 10 GHz – 18 GHz, HT40



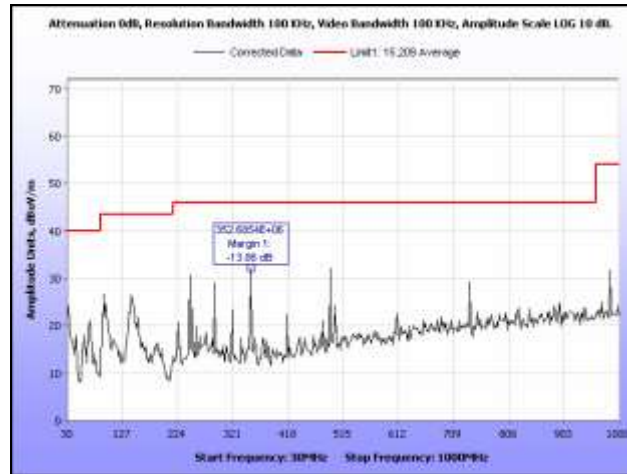
Plot 149. Radiated Spurious Emissions, 5550 MHz, 2nd Harmonic, Average Limit with Peak Detector



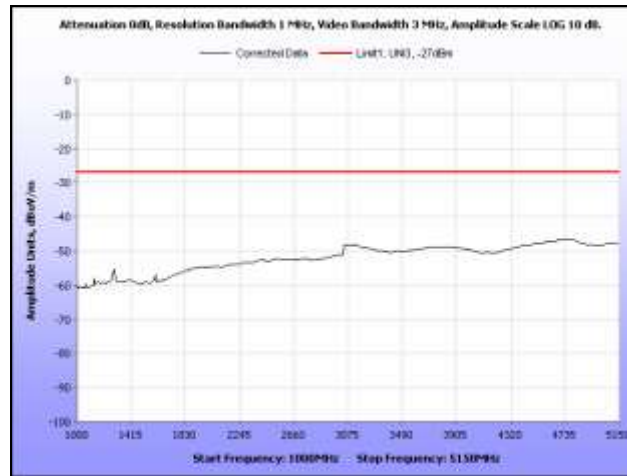
Plot 150. Radiated Spurious Emissions, 5550 MHz, 3rd Harmonic, Average



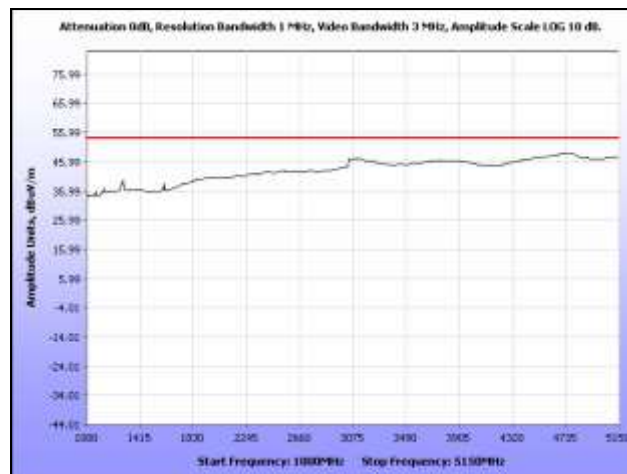
Plot 151. Radiated Spurious Emissions, 5550 MHz, 3rd Harmonic, Peak



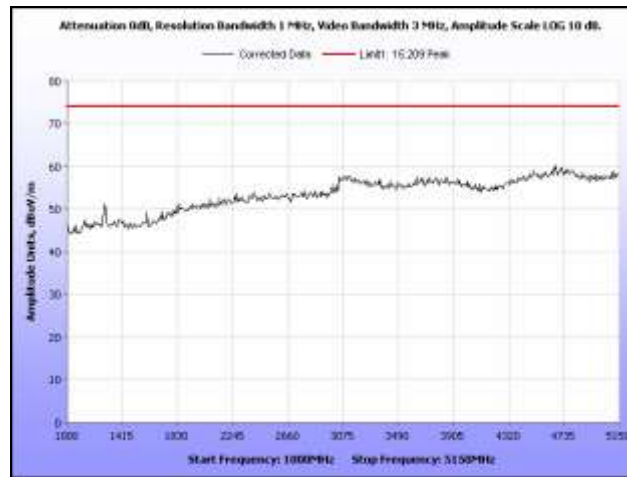
Plot 152. Radiated Spurious Emissions, 5690 MHz, 30 MHz – 1 GHz, HT40



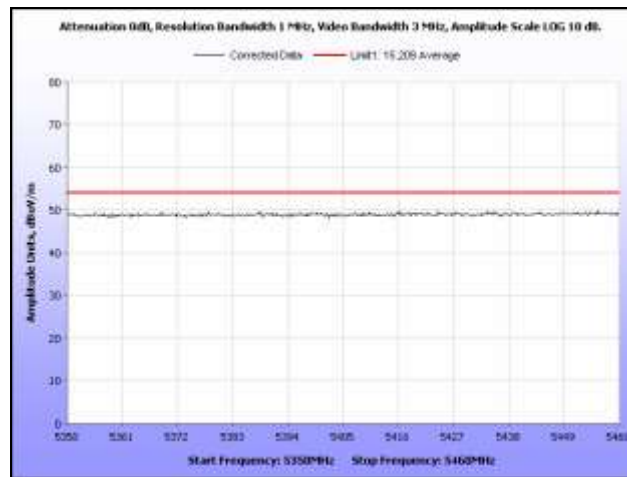
Plot 153. Radiated Spurious Emissions, 5690 MHz, 1 GHz – 5.15 GHz, HT40



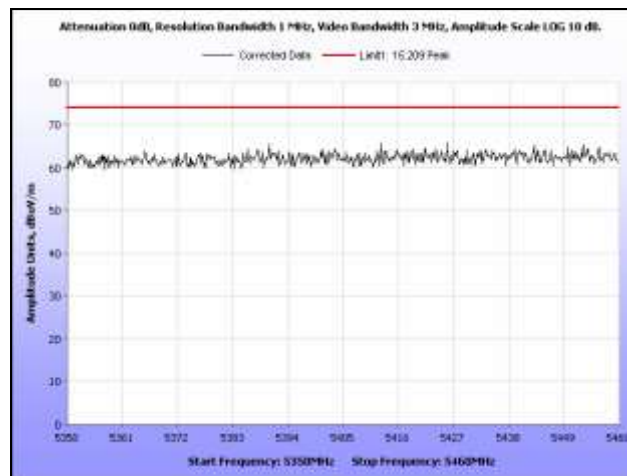
Plot 154. Radiated Spurious Emissions, 5690 MHz, 1 GHz – 5.15 GHz, Average HT40



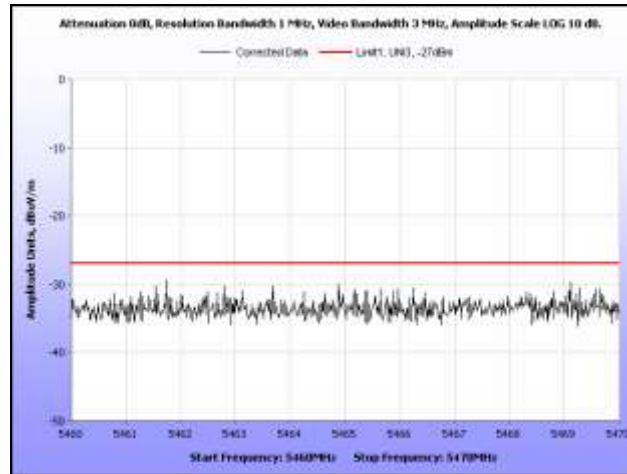
Plot 155. Radiated Spurious Emissions, 5690 MHz, 1 GHz – 5.15 GHz, Peak HT40



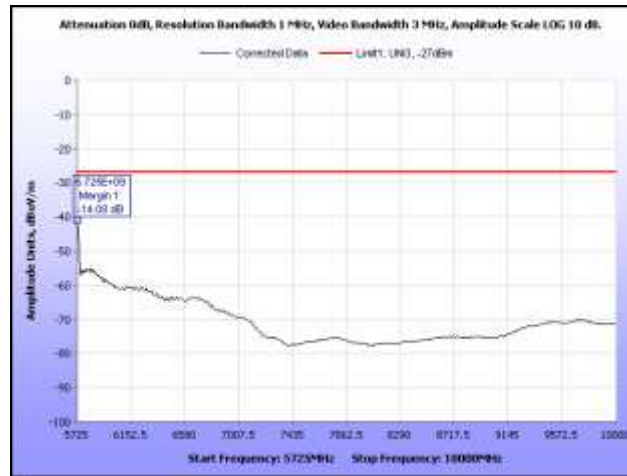
Plot 156. Radiated Spurious Emissions, 5690 MHz, 5.35 GHz – 5.46 GHz, Average, HT40



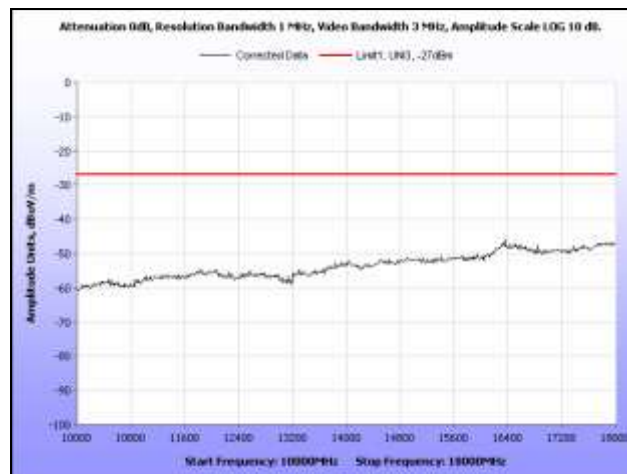
Plot 157. Radiated Spurious Emissions, 5690 MHz, 5.35 GHz – 5.46 GHz, Peak, HT40



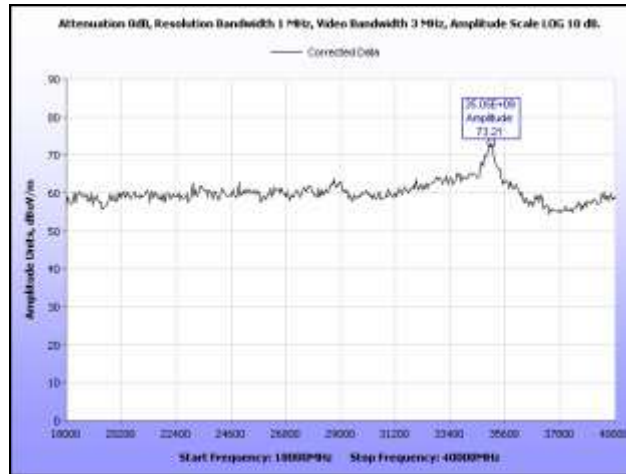
Plot 158. Radiated Spurious Emissions, 5690 MHz, 5.46 GHz – 5.47 GHz, HT40



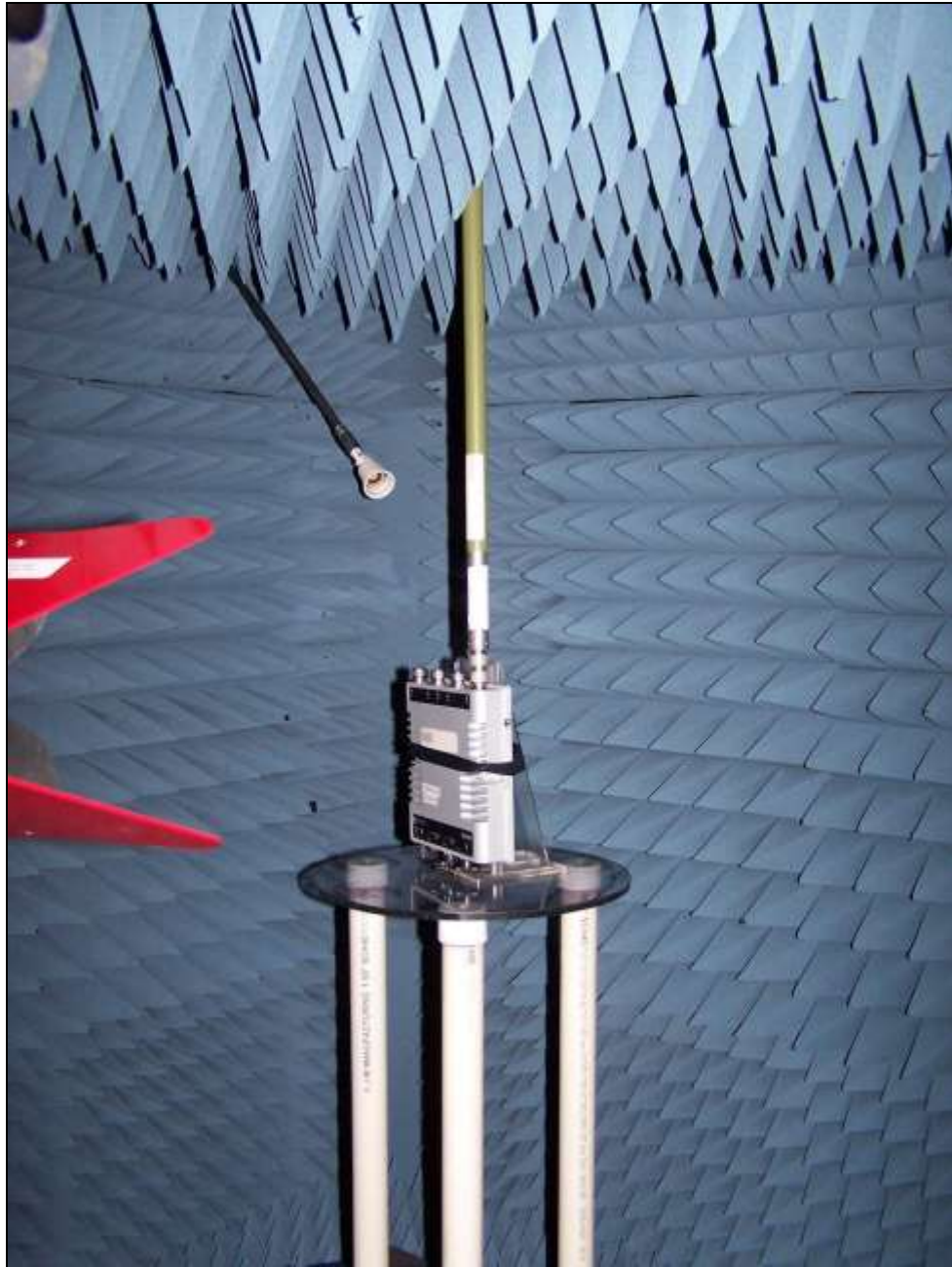
Plot 159. Radiated Spurious Emissions, 5690 MHz, 5.725 GHz – 10 GHz, HT40



Plot 160. Radiated Spurious Emissions, 5690 MHz, 10 GHz – 18 GHz, HT40



Plot 161. Radiated Spurious Emissions, 5690 MHz, 18 GHz - 40 GHz, HT40



Photograph 4. Radiated Emissions, Test Setup



Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(f) RF Exposure

RF Exposure Requirements: §1.1307(b)(1) and §1.1307(b)(2): Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: §1.1310: As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Equation from page 18 of OET 65, Edition 97-01

$$S = P G / 4\pi R^2$$

where,

S = Power Density mW/m²

P = Power (mW)

R = Distance to the center of radiation of the antenna

G = Maximum antenna gain

Maximum antenna gain for EUT = 9 dBi = 7.9

M5 Radio:

MPE Limit Calculation: EUT's operating frequency is 5745 - 5805 MHz; Highest conducted power = 34.3 mW (i.e. 15.35 dBm). Therefore, **Limit for Uncontrolled exposure: 1 mW/cm²**.

P = 34.3 mW

R = 20 cm

G = 7.9

$$S1 = 34.3 * 7.9 / 4(3.1416)(20)^2$$

$$S1 = 0.054 \text{ mW/cm}^2$$

Therefore, EUT meets the Uncontrolled Exposure limit at 20cm.



M5 Radio:

MPE Limit Calculation: EUT's operating frequency is 5745 - 5805 MHz;. Highest conducted power = 60.4 mW (i.e. 17.81 dBm). Therefore, **Limit for Uncontrolled exposure: 1 mW/cm²**.

$$P = 60.4 \text{ mW}$$

$$R = 20 \text{ cm}$$

$$G = 7.9$$

$$S_2 = 60.4 * 7.9 / 4(3.1416)(20)^2$$

$$S_2 = 0.095 \text{ mW/cm}^2$$

Therefore, EUT meets the Uncontrolled Exposure limit at 20cm.

Co-location:

S	Power density (mW/cm ²)	General Population Limit (mW/cm ²)	S as a fraction of the limit (%)
S1	0.054	1	5.4
S2	0.095	1	9.5

The total percentages do not exceed 100 % per OET 65 requirements when the spectral power density is calculated at least 20cm away from the unit.



Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(g) Frequency Stability

Test Requirements: § 15.407(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.

Test Procedure: The EUT was connected directly to a spectrum analyzer through a attenuator. The resolution band width of the spectrum analyzer was set to 10 KHz. The 1st trace of the Spectrum Analyzer was used as a reference at 20°C. A 2nd trace was used to show the drift of the carrier at extreme conditions. A delta marker was used to find the drift at a given extreme condition.

Test Results: The EUT was compliant with the requirements of §15.407(g).

Test Engineer(s): Dusmantha Tennakoon

Test Date(s): 12/22/09

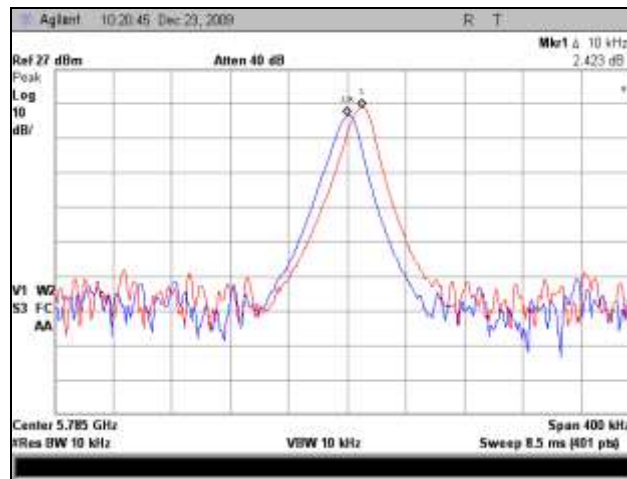
Temperature (centigrade)	Drift (kHz)	Drift (ppm)
55	130.0	22.5
50	124.0	21.4
40	84.0	14.5
30	45.0	7.8
20	ref	ref
10	6.0	1
0	-3.0	-0.5
-10	5.0	0.9
-20	10.0	1.7

Table 17. Frequency Stability, Reference 5785 MHz at 20°C, Test Results

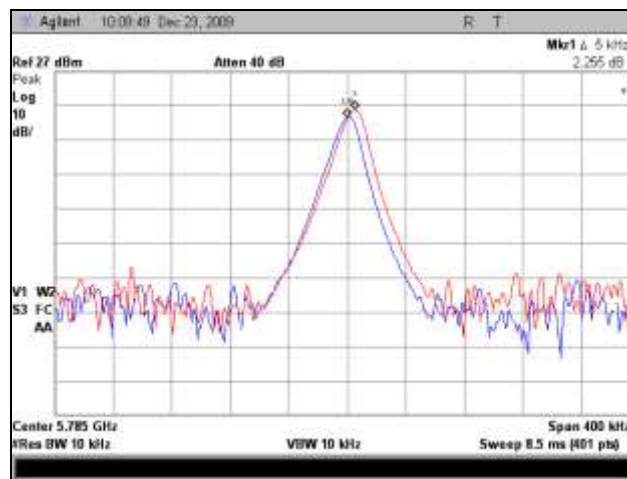
Voltage variation		
Voltage (VAC)	Drift (kHz)	Drift (ppm)
102	1	0.2
138	2	0.4

Table 18. Frequency Stability, Reference 5785 MHz at 120 VAC and 20°C, Test Results

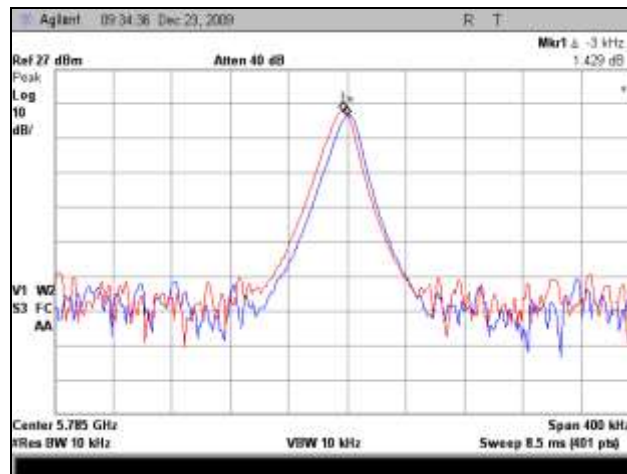
Frequency Stability Test Results



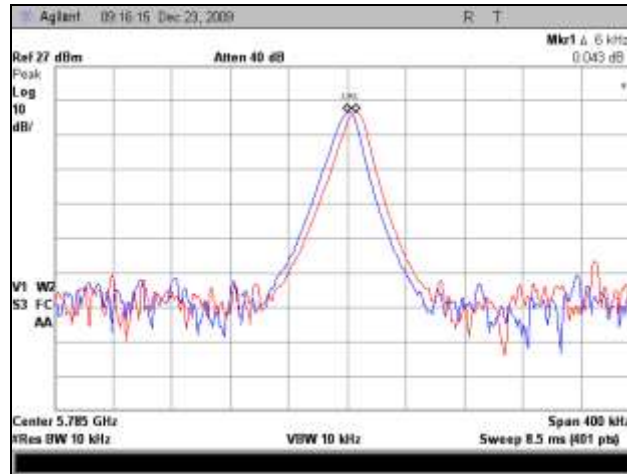
Plot 162. Frequency Stability, -20°C



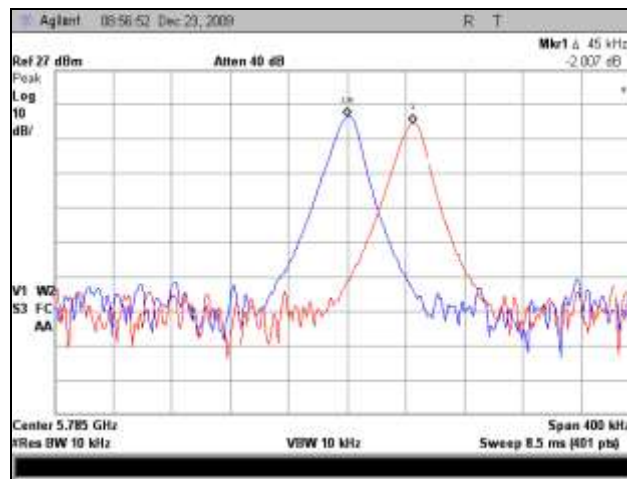
Plot 163. Frequency Stability, -10°C



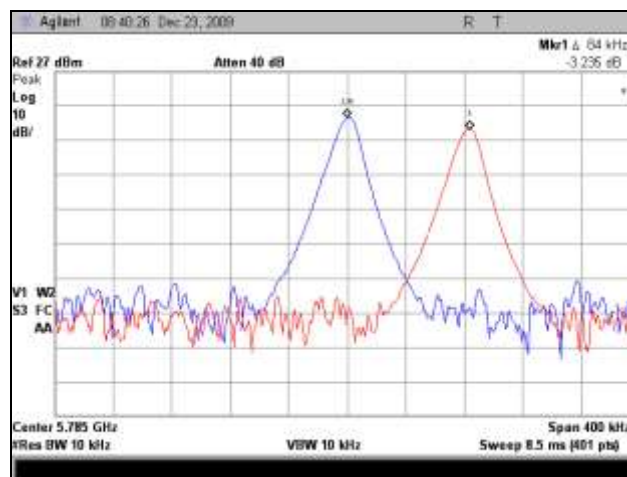
Plot 164. Frequency Stability, 0°C



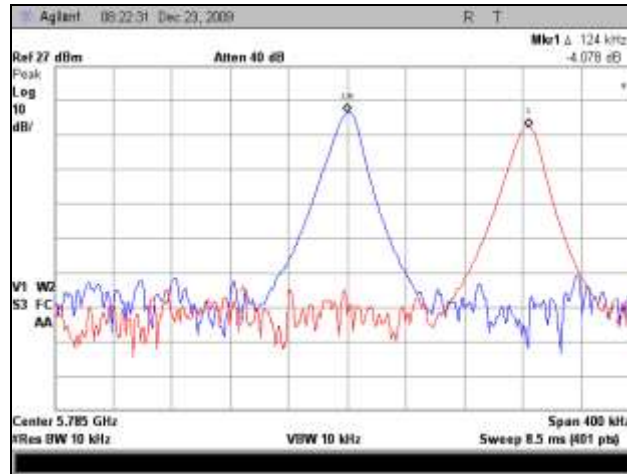
Plot 165. Frequency Stability, 10°C



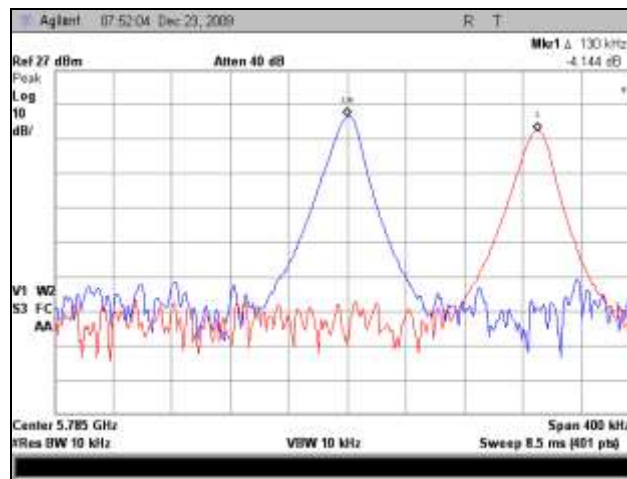
Plot 166. Frequency Stability, 30°C



Plot 167. Frequency Stability, 40°C



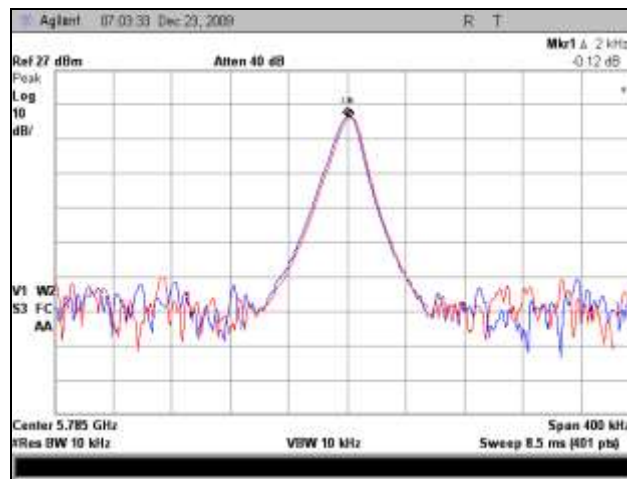
Plot 168. Frequency Stability, 50°C



Plot 169. Frequency Stability, 55°C



Plot 170. Frequency Stability, 102VAC



Plot 171. Frequency Stability, 138VAC



Photograph 5. Extreme Test Conditions, M5 Radio

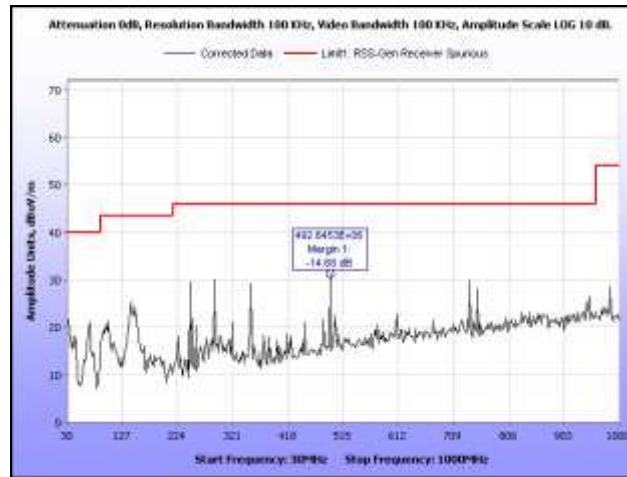


Electromagnetic Compatibility Criteria for Intentional Radiators

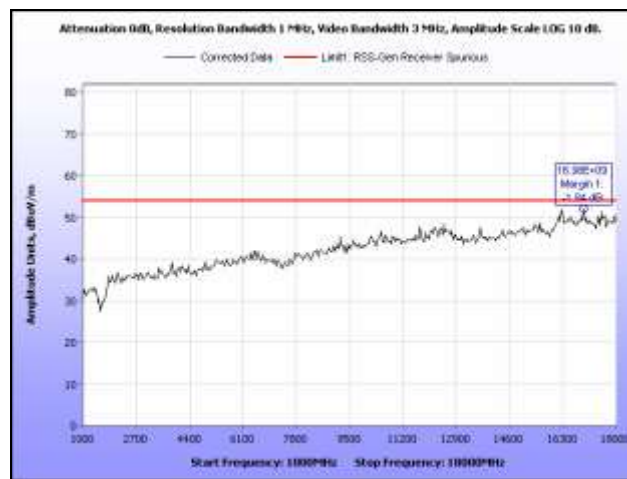
RSS-GEN Receiver Spurious – M5

Test Requirement:	<p>If the device has a detachable antenna of known antenna impedance, then the antenna conducted method is permitted in lieu of a radiated measurement.</p> <p>If a conducted measurement is made, no spurious output signals appearing at the antenna terminals shall exceed 2 nanowatts per any 4 kHz spurious frequency in the band 30 – 1000 MHz, or 5 nanowatts above 1 GHz.</p>
Test Procedure:	<p>The EUT was directly connected to a spectrum analyzer. Testing was performed when the EUT was receiving on channel 5785 MHz. Testing was performed conducted.</p>
Results:	<p>The EUT as tested is compliant with the requirements of RSS-GEN.</p>
Test Engineer(s):	<p>Dusmantha Tennakoon</p>
Test Date(s):	<p>05/10/11 – 05/11/11</p>

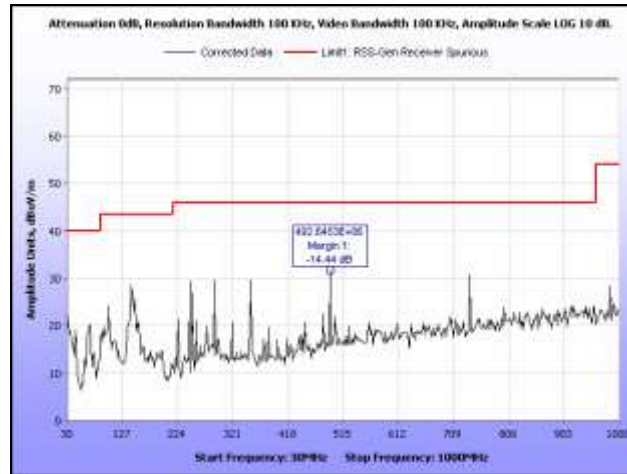
Receiver Spurious Emissions Test Results, HT20



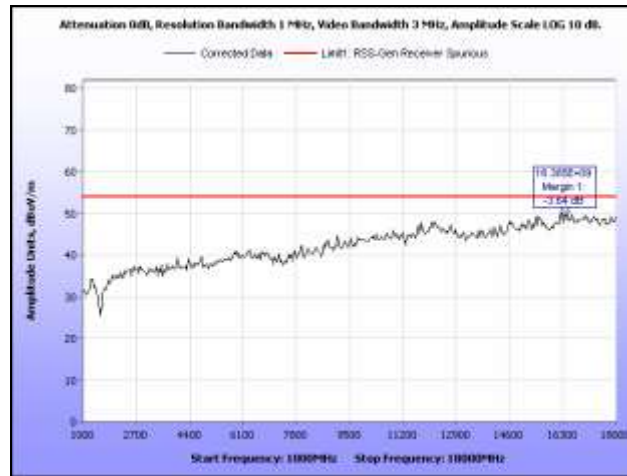
Plot 172. Receiver Spurious Emission, 5300 MHz, 30 MHz – 1 GHz, HT20



Plot 173. Receiver Spurious Emission, 5300 MHz, 1 GHz – 18 GHz, HT20

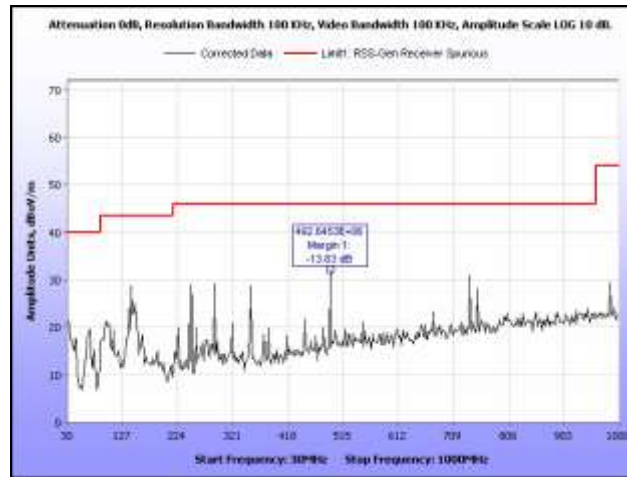


Plot 174. Receiver Spurious Emission, 5580 MHz, 30 MHz – 1 GHz, HT20

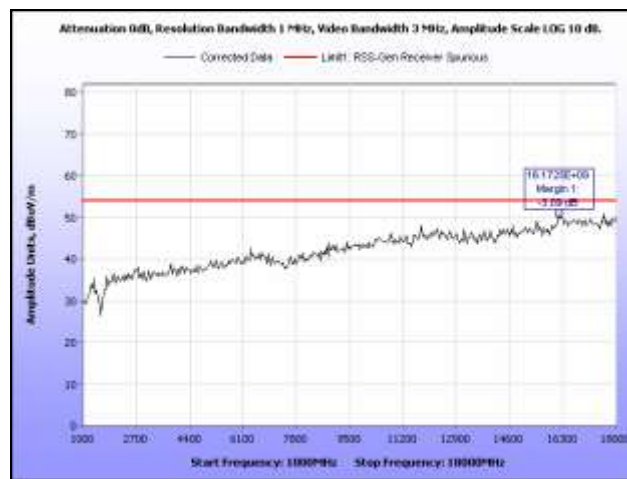


Plot 175. Receiver Spurious Emission, 5580 MHz, 1 GHz – 18 GHz, HT20

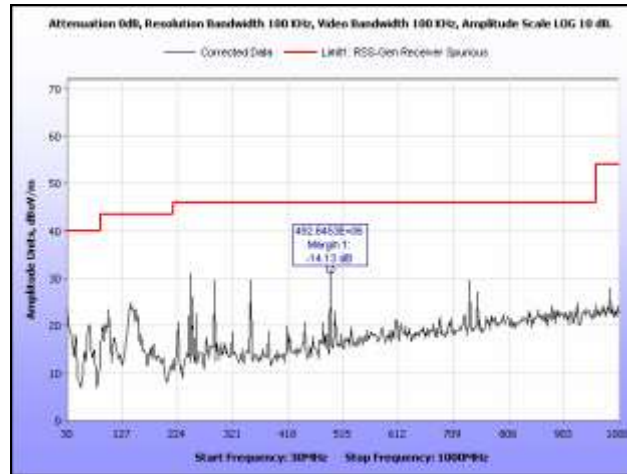
Receiver Spurious Emissions Test Results, HT40



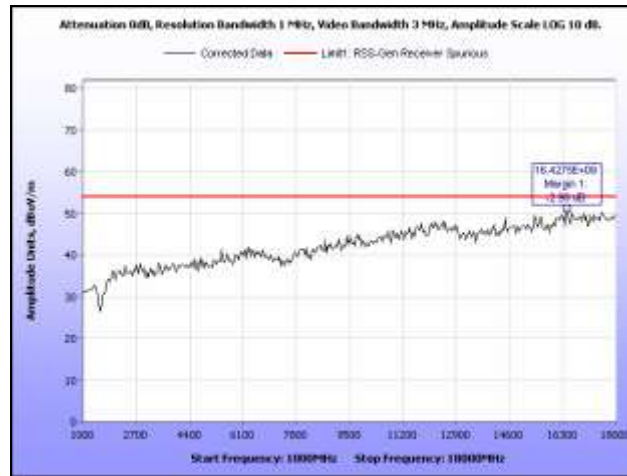
Plot 176. Receiver Spurious Emission, 5270 MHz, 30 MHz – 1 GHz, HT40



Plot 177. Receiver Spurious Emission, 5270 MHz, 1 GHz – 18 GHz, HT40



Plot 178. Receiver Spurious Emission, 5550 MHz, 30 MHz – 1 GHz, HT40



Plot 179. Receiver Spurious Emission, 5550 MHz, 1 GHz – 18 GHz, HT40



IV. DFS Requirements and Radar Waveform Description & Calibration



A. DFS Requirements

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
<i>Non-Occupancy Period</i>	Yes	Not required	Yes
<i>DFS Detection Threshold</i>	Yes	Not required	Yes
<i>Channel Availability Check Time</i>	Yes	Not required	Not required
<i>Uniform Spreading</i>	Yes	Not required	Not required
<i>U-NII Detection Bandwidth</i>	Yes	Not required	Yes

Table 19. Applicability of DFS Requirements Prior to Use of a Channel

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
<i>DFS Detection Threshold</i>	Yes	Not required	Yes
<i>Channel Closing Transmission Time</i>	Yes	Yes	Yes
<i>Channel Move Time</i>	Yes	Yes	Yes
<i>U-NII Detection Bandwidth</i>	Yes	Not required	Yes

Table 20. Applicability of DFS Requirements During Normal Operation

Maximum Transmit Power	Value
≥ 200 milliwatt	-64 dBm
< 200 milliwatt	-62 dBm
Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.	

Table 21. DFS Detection Thresholds for Master or Client Devices Incorporating DFS



Parameter	Value
<i>Non-occupancy period</i>	Minimum 30 minutes
<i>Channel Availability Check Time</i>	60 seconds
<i>Channel Move Time</i>	10 seconds See Note 1
<i>Channel Closing Transmission Time</i>	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2
<i>U-NII Detection Bandwidth</i>	Minimum 80% of the 99% power bandwidth. See Note 3.
<p>Note 1: The instant that the <i>Channel Move Time</i> and the <i>Channel Closing Transmission Time</i> begins is as follows:</p> <ul style="list-style-type: none">• For the Short pulse radar Test Signals this instant is the end of the <i>Burst</i>.• For the Frequency Hopping radar Test Signal, this instant is the end of the last radar <i>Burst</i> generated.• For the Long Pulse radar Test Signal this instant is the end of the 12 second period defining the radar transmission. <p>Note 2: The <i>Channel Closing Transmission Time</i> is comprised of 200 milliseconds starting at the beginning of the <i>Channel Move Time</i> plus any additional intermittent control signals required facilitating <i>Channel</i> changes (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.</p> <p>Note 3: During the <i>U-NII Detection Bandwidth</i> detection test, radar type 1 is used and for each frequency step the minimum percentage of detection is 90%. Measurements are performed with no data traffic.</p>	

Table 22. DFS Response Requirement Values



B. Radar Test Waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance. Step intervals of 0.1 microsecond for Pulse Width, 1 microsecond for PRI, 1 MHz for chirp width and 1 for the number of pulses will be utilized for the random determination of specific test waveforms.

Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Trials
1	1	1428	18	60%	30
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120

A minimum of 30 unique waveforms are required for each of the short pulse radar types 2 through 4. For short pulse radar type 1, the same waveform is used a minimum of 30 times. If more than 30 waveforms are used for short pulse radar types 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms. The aggregate is the average of the percentage of successful detections of short pulse radar types 1-4.

Long Pulse Radar Test Waveform

Radar Type	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	Number of Pulses per Bursts	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse radar test signal. If more than 30 waveforms are used for the Long Pulse radar test signal, then each additional waveform must also be unique and not repeated from the previous waveforms.



Each waveform is defined as follows:

- 1) The transmission period for the Long Pulse Radar test signal is 12 seconds.
- 2) There are a total of 8 to 20 Bursts in the 12 second period, with the number of Bursts being randomly chosen. This number is Burst_Count.
- 3) Each Burst consists of 1 to 3 pulses, with the number of pulses being randomly chosen. Each Burst within the 12 second sequence may have a different number of pulses.
- 4) The pulse width is between 50 and 100 microseconds, with the pulse width being randomly chosen. Each pulse within a Burst will have the same pulse width. Pulses in different Bursts may have different pulse widths.
- 5) Each pulse has a linear FM chirp between 5 and 20 MHz, with the chirp width being randomly chosen. Each pulse within a Burst will have the same chirp width. Pulses in different Bursts may have different chirp widths. The chirp is centered on the pulse. For example, with radar frequency of 5300 MHz and a 20 MHz chirped signal, the chirp starts at 5290 MHz and ends at 5310 MHz.
- 6) If more than one pulse is present in a Burst, the time between the pulses will be between 1000 and 2000 microseconds, with the time being randomly chosen. If three pulses are present in a Burst, the time between the first and second pulses is chosen independently of the time between the second and third pulses.
- 7) The 12 second transmission period is divided into even intervals. The number of intervals is equal to Burst_Count. Each interval is of length $(12,000,000 / \text{Burst_Count})$ microseconds. Each interval contains one Burst. The start time for the Burst, relative to the beginning of the interval, is between 1 and $[(12,000,000 / \text{Burst_Count}) - (\text{Total Burst Length}) + (\text{One Random PRI Interval})]$ microseconds, with the start time being randomly chosen. The step interval for the start time is 1 microsecond. The start time for each Burst is chosen independently.

A representative example of a Long Pulse radar test waveform:

- 1) The total test signal length is 12 seconds.
- 2) 8 Bursts are randomly generated for the Burst_Count.
- 3) Burst 1 has 2 randomly generated pulses.
- 4) The pulse width (for both pulses) is randomly selected to be 75 microseconds.
- 5) The PRI is randomly selected to be at 1213 microseconds.
- 6) Bursts 2 through 8 are generated using steps 3 – 5.
- 7) Each Burst is contained in even intervals of 1,500,000 microseconds. The starting location for Pulse 1, Burst 1 is randomly generated (1 to 1,500,000 minus the total Burst 1 length + 1 random PRI interval) at the 325,001 microsecond step. Bursts 2 through 8 randomly fall in successive 1,500,000 microsecond intervals (i.e. Burst 2 falls in the 1,500,001 – 3,000,000 microsecond range).

Graphical Representation of a Long Pulse radar Test Waveform

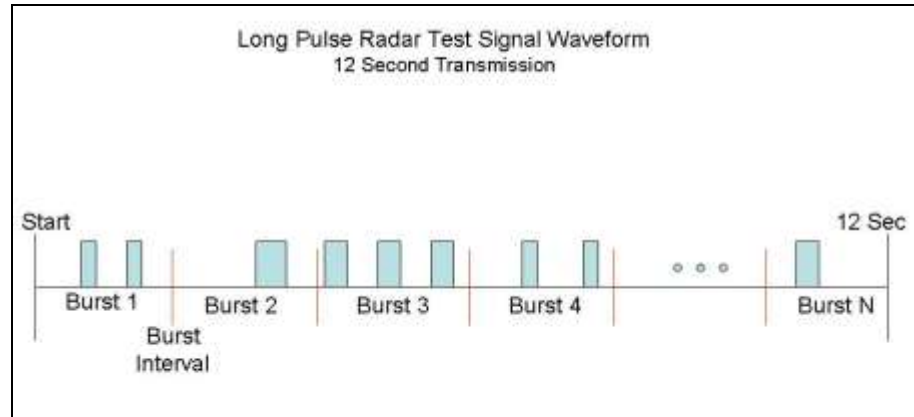


Figure 5. Long Pulse Radar Test Signal Waveform

Frequency Hopping Radar Test Waveform

Radar Type	Pulse Width (μsec)	PRI (μsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	9	.333	300	70%	30

For the Frequency Hopping Radar Type, the same *Burst* parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected¹ from the hopping sequence defined by the following algorithm:

The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set. For selection of a random frequency, the frequencies remaining within the group are always treated as equally likely.

C. Radar Waveform Calibration

The following equipment setup was used to calibrate the radiated Radar Waveform. A spectrum analyzer was used to establish the test signal level for each radar type. During this process there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) mode at the frequency of the Radar Waveform generator. Peak detection was utilized. The spectrum analyzer's resolution bandwidth (RBW) was set to 3 MHz and the video bandwidth (VBW) was set to 3 MHz. The calibration setup is diagrammed in Figure 6, and the radar test signal generator is shown in Photograph 6.

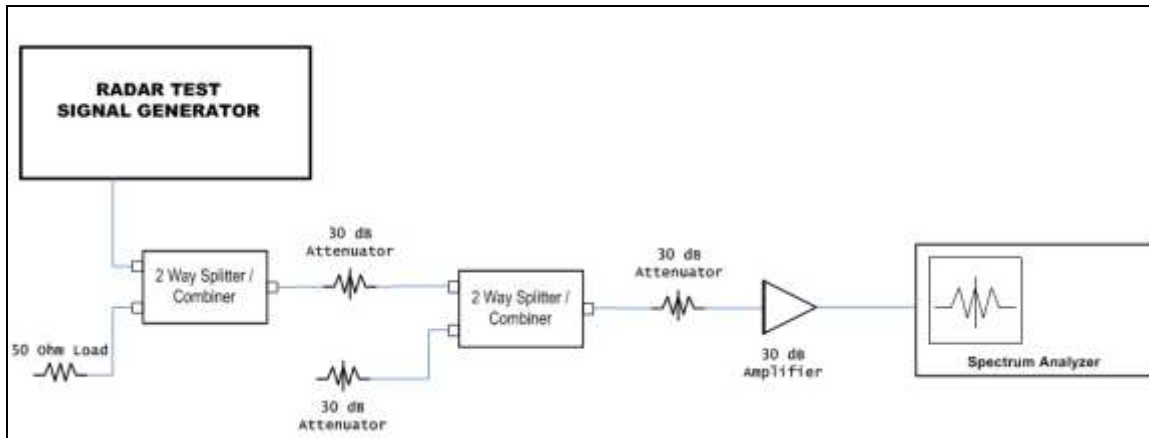


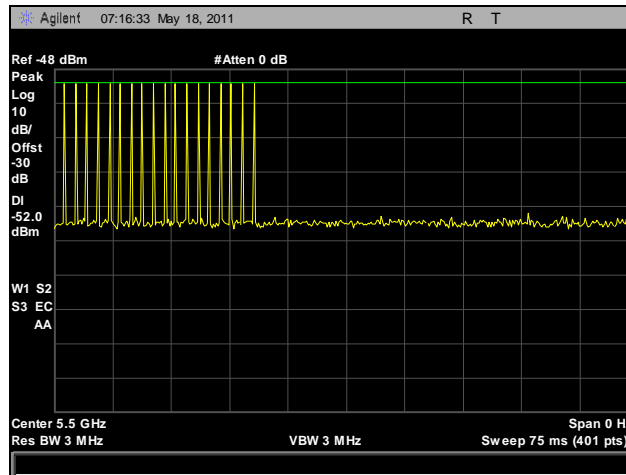
Figure 6. Calibration Test setup



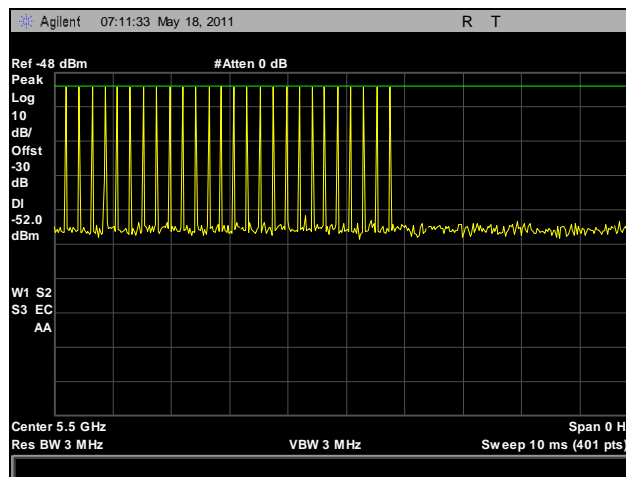
Photograph 6. DFS Radar Test Signal Generator



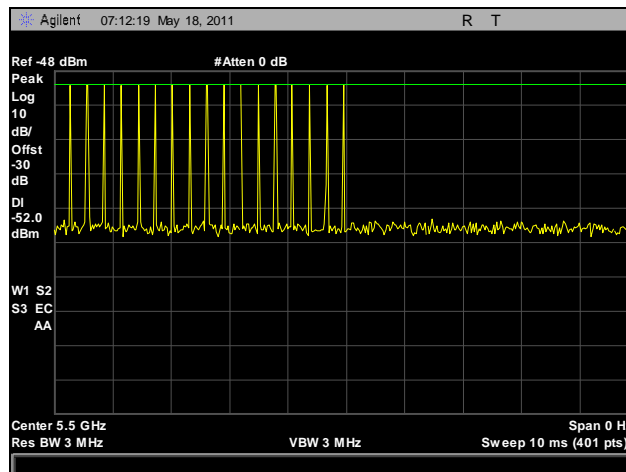
Radar Waveform Calibration



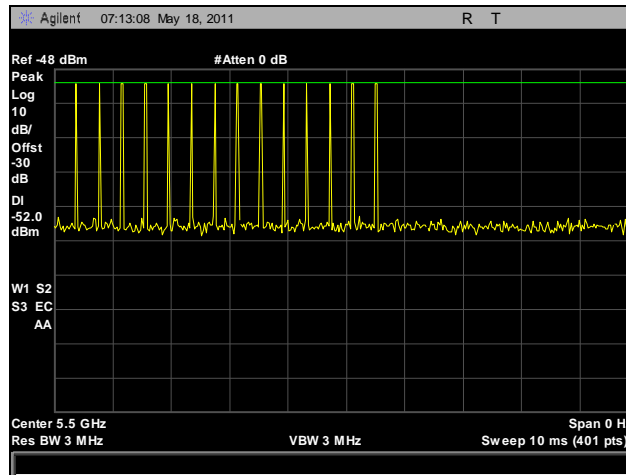
Plot 180. Radar Type 1 Calibration, 5500 MHz



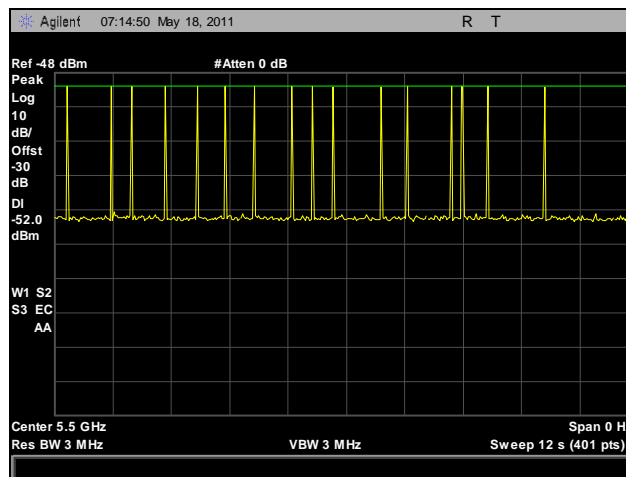
Plot 181. Radar Type 2 Calibration, 5500 MHz



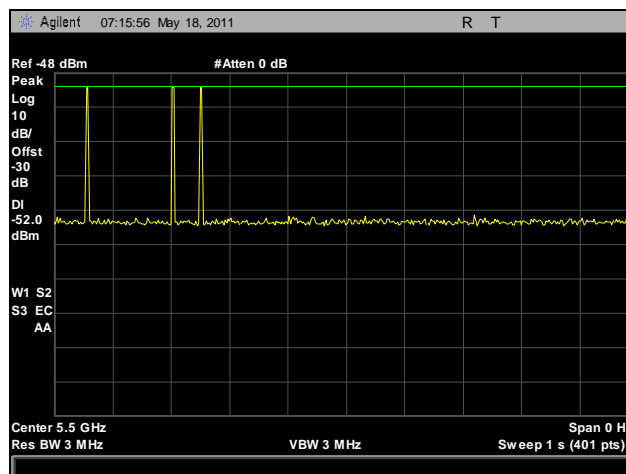
Plot 182. Radar Type 3 Calibration, 5500 MHz



Plot 183. Radar Type 4 Calibration, 5500 MHz



Plot 184. Radar Type 5 Calibration, 5500 MHz



Plot 185. Radar Type 6 Calibration, 5500 MHz



V. DFS Test Procedure and Test Results

A. DFS Test Setup

The 5600 – 5650 MHz bands were disabled.

1. A spectrum analyzer is used as a monitor to verify that the Unit Under Test (UUT) has vacated the Channel within the Channel Closing Transmission Time and Channel Move Time, and does not transmit on a Channel during the Non-Occupancy Period after the detection and subsequent Channel move. It is also used to monitor UUT transmissions during the Channel Availability Check Time.
2. The test setup, which consists of test equipment and equipment under test (EUT), is diagrammed in Figure 7 and pictured in Photograph 7

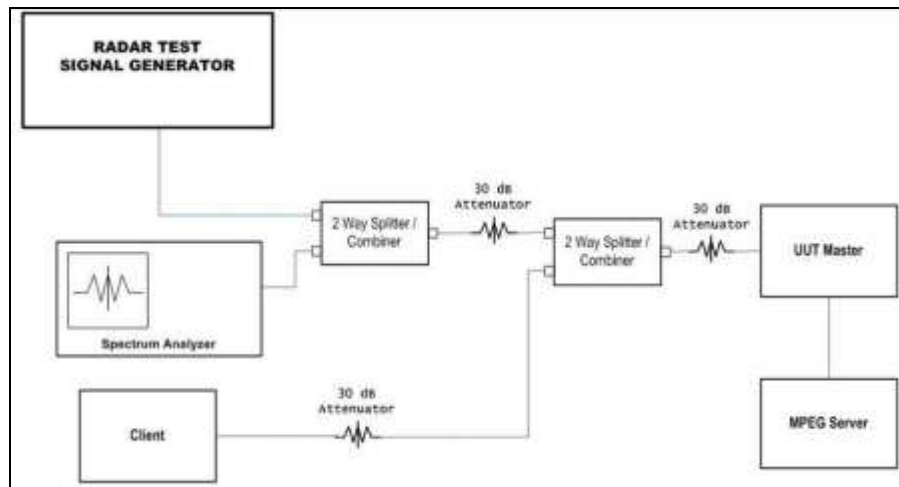
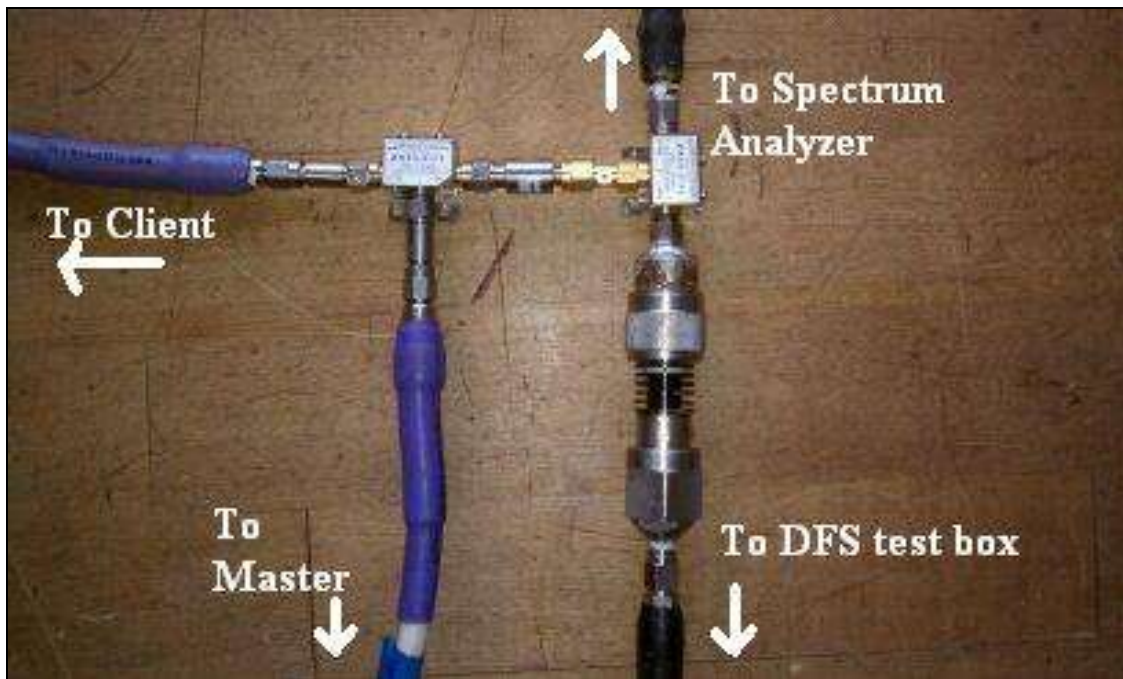


Figure 7. Test Setup Diagram



Photograph 7. DFS Test Setup Photo



Photograph 8. DFS Cables Test Setup Photo



B. Description of Master Device

1. Operating Frequency Range – 5260-5320 MHz and 5500-5700 MHz
2. Modes of Operation – Master Device
3. Highest and Lowest EIRP – Highest = 16.84 dBm;
4. Antenna gain – Omni, 9dBi
5. Antenna impedance – 50 Ohms
6. Antenna gain verification – Use antenna datasheet
7. Test file that is transmitted is the designated MPEG test file that streams full motion video at 30 frames per second from the Master to the Client
8. TPC not required for UNII devices with less than 500 mW EIRP
9. Time for master to complete its power-on-cycle is about 3min
10. The EUT's uniform channel spreading is as follows: The master uses a simple incrementing algorithm: if radar is detected, the next sequential channel is used. For example, if one is on channel 100 and radar is detected, then it will be changed to 104. If radar is then detected on 104, it is changed to 108. When the last channel is reached, we start again at the beginning in a circular fashion.



C. UNII Detection Bandwidth

Test Requirement(s): § 15.407 A minimum 80% of the UNII 99% transmission power bandwidth is required.

Test Procedure: All UNII channels for this device have identical channel bandwidths.

A single burst of the short pulse radar type 1 is produced at 5580 MHz, at the -63dBm test level. The UUT is set up as a standalone device (no associated client, and no data traffic).

A single radar burst is generated for a minimum of 10 trials, and the response of the UUT is recorded. The UUT must detect the radar waveform 90% or more of the time.

The radar frequency is increased in 1 MHz steps, repeating the above test sequence, until the detection rate falls below 90%. The highest frequency at which detection is greater than or equal to 90% is denoted F_H .

The radar frequency is decreased in 1 MHz steps, repeating the above test sequence, until the detection rate falls below 90%. The lowest frequency at which detection is greater than or equal to 90% is denoted F_L .

The U-NII Detection Bandwidth is calculated as follows:

$$\text{U-NII Detection Bandwidth} = F_H - F_L$$

Test Engineer: Jeff Pratt

Test Date: 07/06/11



UNII Detection Bandwidth – Test Results

EUT Frequency- 5510MHz											
Radar Frequency (MHz)	DFS Detection Trials (1=Detection, 0= No Detection)										Detection Rate (%)
	1	2	3	4	5	6	7	8	9	10	
5490	1	1	1	1	1	1	1	1	1	1	100
5491	1	1	1	1	1	1	1	1	1	1	100
5492	1	1	1	1	1	1	1	1	1	1	100
5493	1	1	1	1	1	1	1	1	1	1	100
5494	1	1	1	1	1	1	1	1	1	1	100
5495	1	1	1	1	1	1	1	1	1	1	100
5496	1	1	1	1	1	1	1	1	1	1	100
5497	1	1	1	1	1	1	1	1	1	1	100
5498	1	1	1	1	1	1	1	1	1	1	100
5499	1	1	1	1	1	1	1	1	1	1	100
5500	1	1	1	1	1	1	1	1	1	1	100
5501	1	1	1	1	1	1	1	1	1	1	100
5502	1	1	1	1	1	1	1	1	1	1	100
5503	1	1	1	1	1	1	1	1	1	1	100
5504	1	1	1	1	1	1	1	1	1	1	100
5505	1	1	1	1	1	1	1	1	1	1	100
5506	1	1	1	1	1	1	1	1	1	1	100
5507	1	1	1	1	1	1	1	1	1	1	100
5508	1	1	1	1	1	1	1	1	1	1	100
5509	1	1	1	1	1	1	1	1	1	1	100
5510	1	1	1	1	1	1	1	1	1	1	100
5511	1	1	1	1	1	1	1	1	1	1	100
5512	1	1	1	1	1	1	1	1	1	1	100
5513	1	1	1	1	1	1	1	1	1	1	100
5514	1	1	1	1	1	1	1	1	1	1	100
5515	1	1	1	1	1	1	1	1	1	1	100
5516	1	1	1	1	1	1	1	1	1	1	100
5517	1	1	1	1	1	1	1	1	1	1	100
5518	1	1	1	1	1	1	1	1	1	1	100
5519	1	1	1	1	1	1	1	1	1	1	100
5520	1	1	1	1	1	1	1	1	1	1	100
5521	1	1	1	1	1	1	1	1	1	1	100
5522	1	1	1	1	1	1	1	1	1	1	100
5523	1	1	1	1	1	1	1	1	1	1	100
5524	1	1	1	1	1	1	1	1	1	1	100
5525	1	1	1	1	1	1	1	1	1	1	100
5526	1	1	1	1	1	1	1	1	1	1	100
5527	1	1	1	1	1	1	1	1	1	1	100
5528	1	1	1	1	1	1	1	1	1	1	100
Overall Detection Percentage											100%
Detection Bandwidth = $f_h - f_l = 5530\text{MHz} - 5490\text{MHz} = 40\text{MHz}$											
EUT 99% Bandwidth = 36.75MHz											
OBW* 80% = 29.40MHz											

Table 23. UNII Detection Bandwidth, Test Results, 5510 MHz



D. Initial Channel Availability Check Time

Test Requirements: § 15.407 The Initial Channel Availability Check Time tests that the UUT does not emit beacon, control, or data signals on the test channel until the power-up sequence has been completed and the U-NII device has checked for radar waveforms, for one minute, on the test channel. This test does not use any of the radar waveforms and only needs to be performed once.

The UUT should not make any transmissions over the test channel, for at least 1 minute after completion of its power-on cycle.

Test Procedure: The U-NII device is powered on and instructed to operate at 5580 MHz. At the same time the UUT is powered on, the spectrum analyzer is set to 5580MHz with a zero span and a 200 sec. sweep time. The analyzer is triggered at the same time power is applied to the U-NII device.

Test Results: Marker 1R on Plot 186 indicates the start of the channel availability check time. Initial beacon/data transmission is indicated by marker 1.

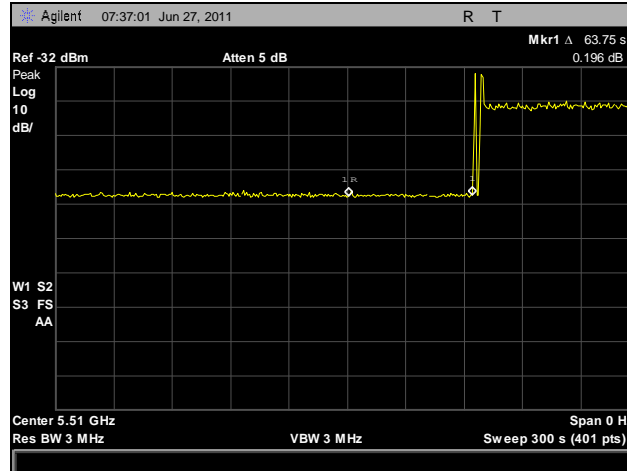
The Equipment was compliant with § 15.407 Initial Channel Availability Check Time.

Test Engineer: Jeff Pratt

Test Date: 07/06/11



Initial Channel Availability Check Time Test Results



Plot 186. Initial Channel Availability Check Time



E. Radar Burst at the Beginning of Channel Availability Check Time

Test Requirements: § 15.407 A Radar Burst at the Beginning of the Channel Availability Check Time tests that the UUT does not emit beacon, control, or data signals on the test Channel if it has detected a radar burst during that time period until the power-up sequence has been completed and the U-NII device checks for Radar Waveforms for one minute on the test Channel. The steps below define the procedure to verify successful radar detection on the selected Channel during a period equal to the Channel Availability Check Time and avoidance of operation on that Channel when a radar Burst with a level equal to the DFS Detection Threshold + 1 dB occurs at the beginning of the Channel Availability Check Time.

Test Procedure: The UUT is powered on at T0. T1 denotes the instant when the UUT has completed its power-up sequence. The Channel Availability Check Time commences at instant T1 and will end no sooner than T1 + 60 seconds.

A single Burst of short pulse radar type 1 will commence within a 6 second window starting at T1.

Visual indication of the UUT of successful detection of the radar Burst will be recorded and reported. Observation of transmission at 5580MHz will continue for 2.5 minutes after the radar Burst has been generated.

Verify that during the 2.5 minute measurement window, no UUT transmissions occur at 5580MHz.

Test Results Plot 187 below indicates that there were no UUT transmissions during the 2.5 minute measurement window when a radar burst was injected 6 seconds into the CACT. Therefore, the UUT detected the presence of a radar during the CACT and moved away from that channel.

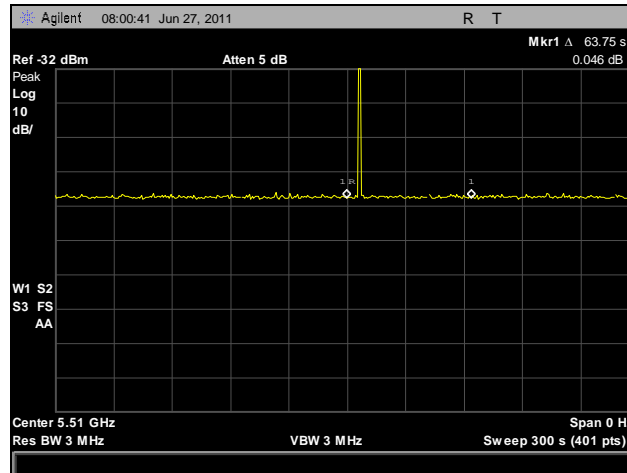
The equipment was compliant with § 15.407 Radar Burst at the Beginning of the Channel Availability Check Time.

Test Engineer: Jeff Pratt

Test Date: 07/06/11



Radar Burst at the Beginning of Channel Availability Check Time Test Results



Plot 187. Radar Burst at the Beginning of CACT



F. Radar Burst at the End of Channel Availability Check Time

Test Requirements: § 15.407 A Radar Burst at the End of the Channel Availability Check Time tests that the UUT does not emit beacon, control, or data signals on the test Channel if it has detected a radar burst during that time period until the power-up sequence has been completed and the U-NII device checks for Radar Waveforms for one minute on the test Channel. The steps below define the procedure to verify successful radar detection on the selected Channel during a period equal to the Channel Availability Check Time and avoidance of operation on that Channel when a radar Burst with a level equal to the DFS Detection Threshold + 1 dB occurs at the end of the Channel Availability Check Time.

Test Procedure: The steps below define the procedure to verify successful radar detection on the selected Channel during a period equal to the Channel Availability Check Time and avoidance of operation on that Channel when a radar Burst with a level equal to the DFS Detection Threshold + 1 dB occurs at the end of the Channel Availability Check Time.

The UUT is powered on at T0. T1 denotes the instant when the UUT has completed its power-up sequence. The Channel Availability Check Time commences at instant T1 and will end no sooner than T1 + 60 seconds.

A single Burst of short pulse of radar type 1 will commence within a 6 second window starting at T1 + 54 seconds.

Visual indication on the UUT of successful detection of the radar Burst will be recorded and reported. Observation of emissions at 5580MHz will continue for 2.5 minutes after the radar Burst has been generated.

Verify that during the 2.5 minute measurement window no UUT transmissions occurred at 5580MHz.

Test Results: Plot 188 indicates that no UUT transmissions occurred during the 2.5 minute measurement window when a radar burst was injected 6 seconds before the end of the CACT. Therefore, the UUT detected the presence of a radar and moved away from that channel.

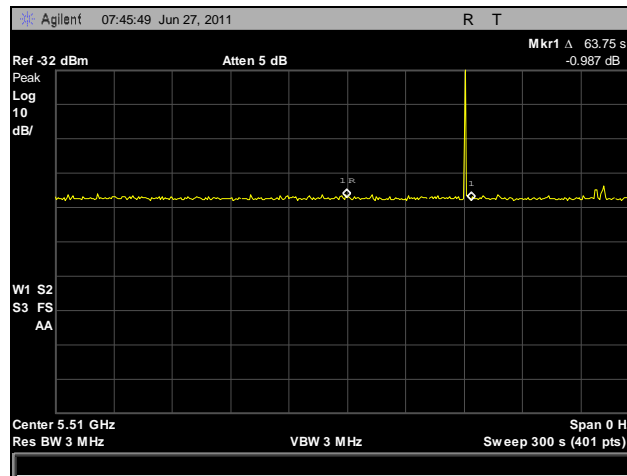
The equipment was compliant with § 15.407 Radar Burst at the End of the Channel Availability Check Time.

Test Engineer: Jeff Pratt

Test Date: 07/06/11



Radar Burst at the End of Channel Availability Check Time Test Results



Plot 188. Radar Burst at the End of CACT, 54 sec (5580MHz)



G. In-Service Monitoring for Channel Move Time, Channel Closing Transmission Time, and Non-Occupancy Period – M5

Test Requirements: § 15.407 (Refer to DFS Response Requirement Values table in section III-A of this report.) The UUT shall continuously monitor for radar transmissions in the operating test channel. When a radar burst occurs in the test channel, it has 10 seconds to move to another channel. This 10 second window is termed Channel Move Time (CMT).

When a radar burst occurs, the UUT has 200 milliseconds, plus an aggregate of 60 milliseconds, to cease transmission in the operating test channel. This 200 ms + 60 ms requirement is termed Channel Closing Transmission Time (CCT).

After radar burst and subsequent move to another channel, the UUT shall not resume transmission, on the channel it moved from, for a period of 30 minutes. This requirement is termed Non-Occupancy Period (NOP).

Test Procedure: These tests define how the following DFS parameters are verified during In-Service Monitoring: Channel Closing Transmission Time, Channel Move Time, and Non-Occupancy Period.

The steps below define the procedure to determine the above mentioned parameters when a radar Burst with a level equal to the DFS Detection Threshold + 1dB is generated on the Operating Channel of the U-NII device.

A U-NII device operating as a Client Device will associate with the UUT (Master) at 5580 MHz. Stream the MPEG test file from the Master Device to the Client Device on the selected Channel for the entire period of the test.

At time T0 the Radar Waveform generator sends a Burst of pulses for each of the radar types.

Observe the transmissions of the UUT at the end of the radar Burst on the Operating Channel for duration greater than 10 seconds. Measure and record the transmissions from the UUT during the observation time (Channel Move Time). Compare the Channel Move Time and Channel Closing Transmission Time results to the limits defined in the *DFS Response Requirement Values table*.

Test Results: The EUT was compliant with § 15.407 In-Service Monitoring for Channel Move Time, Channel Closing Transmission Time, and Non-Occupancy Period. The results were as follows:

Channel Move Time	412.5 ms.
Channel Closing Transmission Time	48.8 ms
Channel Non-Occupancy Period	> 30 minutes.

Test Engineer: Jeff Pratt

Test Date: 07/06/11



Radar Type	Trial #	Pulses per Burst	Pulse Width (μsec)	PRI (μsec)	Detection
					1 = Yes, 0 = No
1	1	18	1	1428	1
	2	18	1	1428	1
	3	18	1	1428	1
	4	18	1	1428	1
	5	18	1	1428	1
	6	18	1	1428	1
	7	18	1	1428	0
	8	18	1	1428	1
	9	18	1	1428	1
	10	18	1	1428	1
	11	18	1	1428	1
	12	18	1	1428	1
	13	18	1	1428	1
	14	18	1	1428	1
	15	18	1	1428	1
	16	18	1	1428	1
	17	18	1	1428	1
	18	18	1	1428	1
	19	18	1	1428	1
	20	18	1	1428	1
	21	18	1	1428	1
	22	18	1	1428	1
	23	18	1	1428	1
	24	18	1	1428	1
	25	18	1	1428	1
	26	18	1	1428	1
	27	18	1	1428	1
	28	18	1	1428	1
	29	18	1	1428	1
	30	18	1	1428	1
Detection Percentage					97% (> 60%)

Table 24. In-Service Monitoring, Radar Type 1



Radar Type	Trial #	Pulse Width 1 to 5 μ sec	PRI 150 to 230 μ sec	Pulses per Burst 23 to 29	Detection
					1 = Yes, 0 = No
2	1	1	1.9	165	24
	2	2	5	208	25
	3	3	3.3	228	29
	4	4	3.9	180	28
	5	5	4.3	206	25
	6	6	4.9	227	27
	7	7	1.3	182	28
	8	8	3.4	170	28
	9	9	4.9	162	29
	10	10	5	201	28
	11	11	2	216	29
	12	12	3.7	183	23
	13	13	4.8	191	24
	14	14	5	199	23
	15	15	3.3	206	26
	16	16	3.1	155	23
	17	17	1.9	228	27
	18	18	2.5	186	24
	19	19	1.2	172	24
	20	20	2.9	185	26
	21	21	2.5	177	29
	22	22	2.2	228	28
	23	23	1.3	200	23
	24	24	3.9	190	29
	25	25	4.7	168	25
	26	26	1.2	223	24
	27	27	3.2	166	27
	28	28	4.1	226	29
	29	29	2.5	205	28
	30	30	4	183	27
Detection Percentage					90% (> 60%)

Table 25. In-Service Monitoring, Radar Type 2



Radar Type	Trial #	Pulse Width 6 to 10 μ sec	PRI 200 to 500 μ sec	Pulses per Burst 16 to 18	Detection
					1 = Yes, 0 = No
3	1	7.9	428	16	1
	2	8.4	287	17	1
	3	7.3	468	16	0
	4	6.4	252	16	1
	5	8	395	17	1
	6	9.1	207	18	1
	7	9.1	356	18	0
	8	8.4	330	17	1
	9	8.2	290	16	0
	10	7.1	341	17	1
	11	6.4	337	17	1
	12	7.3	430	16	1
	13	8.4	267	17	1
	14	8.8	430	18	1
	15	6.6	321	18	1
	16	8.2	268	17	1
	17	8	490	18	1
	18	7.3	266	18	1
	19	8.7	466	16	1
	20	8.5	419	16	1
	21	7.1	253	17	1
	22	9.4	201	18	1
	23	8.3	339	18	1
	24	7.6	324	16	1
	25	8.2	200	18	0
	26	8	252	16	0
	27	9.1	318	18	0
	28	7.8	459	16	0
	29	7.4	250	18	0
	30	7.9	208	17	0
Detection Percentage					70% (> 60%)

Table 26. In-Service Monitoring, Radar Type 3



Radar Type	Trial #	Pulse Width 11 to 20 μ sec	PRI 200 to 500 μ sec	Pulses per Burst 12 to 16	Detection
					1 = Yes, 0 = No
4	1	15.9	323	14	1
	2	15.7	231	16	1
	3	18.6	378	14	1
	4	16	206	16	0
	5	11	226	12	1
	6	11.1	444	15	1
	7	15.3	253	12	1
	8	14.8	471	12	1
	9	17.2	234	13	1
	10	11.9	490	13	1
	11	18.1	273	15	1
	12	14.7	237	15	1
	13	17	219	14	1
	14	11.9	320	14	1
	15	15.7	324	16	1
	16	11	384	15	1
	17	14	308	13	1
	18	17.9	335	12	1
	19	16	491	13	1
	20	11.9	383	12	1
	21	17.6	244	16	1
	22	18.1	272	16	1
	23	18.8	316	12	1
	24	12.4	325	12	0
	25	19.9	290	12	1
	26	15.1	396	14	0
	27	13	221	12	1
	28	15.1	435	16	1
	29	15.7	487	12	1
	30	19.7	388	15	0
Detection Percentage					87% (> 60%)

Table 27. In-Service Monitoring, Radar Type 4



Radar Type	Trial #	Filename*	Detection
			1 = Yes, 0 = No
5	1	bin5set620wav1	1
	2	bin5set620wav2	1
	3	bin5set620wav3	1
	4	bin5set620wav4	1
	5	bin5set620wav5	1
	6	bin5set620wav6	1
	7	bin5set620wav7	1
	8	bin5set620wav8	1
	9	bin5set620wav9	0
	10	bin5set620wav10	1
	11	bin5set620wav11	1
	12	bin5set620wav12	1
	13	bin5set620wav13	1
	14	bin5set620wav14	1
	15	bin5set620wav15	1
	16	bin5set620wav16	1
	17	bin5set620wav17	1
	18	bin5set620wav18	1
	19	bin5set620wav19	1
	20	bin5set620wav20	0
	21	bin5set620wav21	1
	22	bin5set620wav22	1
	23	bin5set620wav23	1
	24	bin5set620wav24	1
	25	bin5set620wav25	1
	26	bin5set620wav26	1
	27	bin5set620wav27	1
	28	bin5set620wav28	0
	29	bin5set620wav29	1
	30	bin5set620wav30	1
Detection Percentage			90% (> 80%)

Table 28. In-Service Monitoring, Radar Type 5

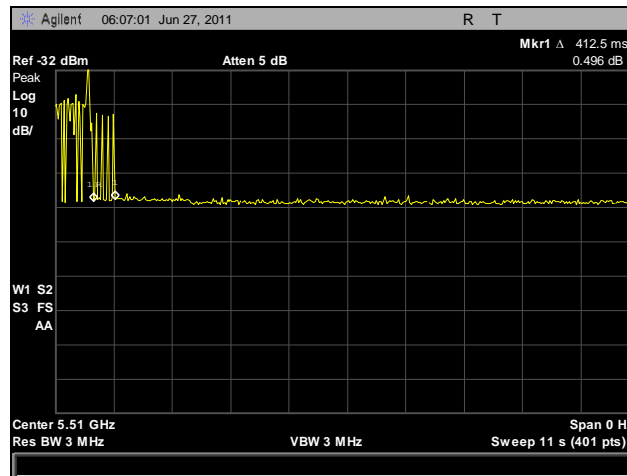


Radar Type	Trial #	Frequency (MHz)	Pulses/Hop	Pulse Width (µsec)	PRI (µsec)	Detection
						1 = Yes, 0 = No
6	1	5510	9	1	333	1
	2	5510	9	1	333	1
	3	5510	9	1	333	1
	4	5510	9	1	333	1
	5	5510	9	1	333	1
	6	5510	9	1	333	1
	7	5510	9	1	333	1
	8	5510	9	1	333	1
	9	5510	9	1	333	1
	10	5510	9	1	333	1
	11	5510	9	1	333	1
	12	5510	9	1	333	1
	13	5510	9	1	333	1
	14	5510	9	1	333	1
	15	5510	9	1	333	1
	16	5510	9	1	333	1
	17	5510	9	1	333	1
	18	5510	9	1	333	1
	19	5510	9	1	333	1
	20	5510	9	1	333	1
	21	5510	9	1	333	1
	22	5510	9	1	333	1
	23	5510	9	1	333	1
	24	5510	9	1	333	1
	25	5510	9	1	333	1
	26	5510	9	1	333	1
	27	5510	9	1	333	1
	28	5510	9	1	333	1
	29	5510	9	1	333	1
	30	5510	9	1	333	1
Detection Percentage						100% (> 60%)

Table 29. In-Service Monitoring, Radar Type 6



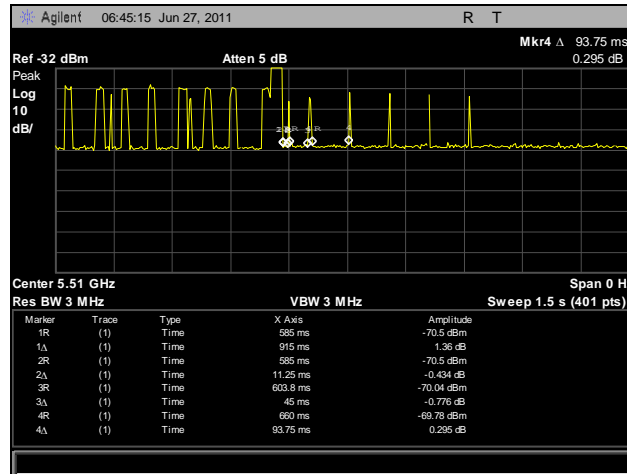
Channel Move Time Test Results



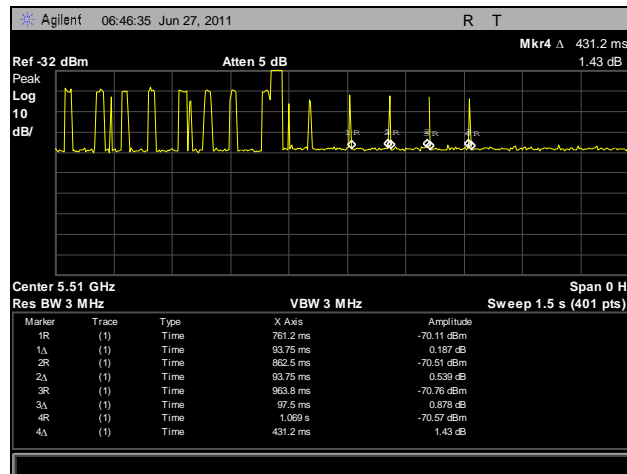
Plot 189. Channel Move Time



Channel Closing Transmission Time Test Results



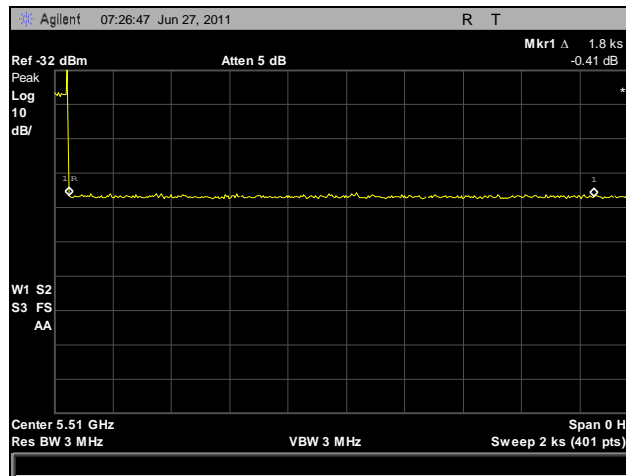
Plot 190. Channel Closing Transmission Time, 1



Plot 191. Channel Closing Transmission Time, 2



Non-Occupancy Period



Plot 192. Non-Occupancy Period, 30minutes



H. Statistical Performance Check

Test Requirements: § 15.407 During In-Service Monitoring, the EUT requires a minimum percentage of successful radar detections from all required radar waveforms at a level equal to the DFS Detection Threshold + 1dB.

Test Procedure: Stream the MPEG test file from the Master Device to the Client Device on the selected Channel for the entire period of the test. The Radar Waveform generator sends the individual waveform for each of the radar types 1-6 at -63dbm. Statistical data is gathered to determine the ability of the device to detect the radar test waveforms. The device can utilize a test mode to demonstrate when detection occurs to prevent the need to reset the device between trial runs. The percentage of successful detection is calculated by:

$$\frac{TotalWaveformDetections}{TotalWaveformTrials} \times 100$$

The Minimum number of trails, minimum percentage of successful detection and the average minimum percentage of successful detection are found in the Radar Test Waveforms section.

Test Results: The equipment was compliant with § 15.407 Statistical Performance Check. The aggregate detection percentage of radar types 1-4 is greater than 80%. The Detection Percentage was 86%.

Test Engineer: Jeff Pratt

Test Date: 07/06/2011



VI. Test Equipment



Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ANSI/NCSL Z540-1-1994 and ANSI/ISO/IEC 17025:2000.

MET Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1T4564	LISN (24 AMP)	SOLAR ELECTRONICS	9252-50-R-24-BNC	10/06/2010	10/06/2011
1T4621	ESA-E SERIES SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4402B	05/31/2011	5/31/2012
1T4612	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	09/27/2010	09/27/2011
1T4681	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4448A	01/27/2011	01/27/2012
1T4751	ANTENNA - BILOG	SUNOL SCIENCES	JB6	11/03/2010	11/3/2011
1T4483	ANTENNA; HORN	ETS-LINDGREN	3117	06/08/2010	06/08/2011
1T4442	PREAMPLIFIER, MICROWAVE	MITEQ	AFS42-01001800-30-10P	SEE NOTE	
1T4752	PREAMPLIFIER	MITEQ	JS44-18004000-35-8P	SEE NOTE	
1T4505	TEMPERATURE CHAMBER	TEST EQUITY	115	11/29/2010	11/29/2011
1T4409	EMI RECEIVER	ROHDE & SCHWARZ	ESIB7	06/14/2011	06/14/2012

Table 30. Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.



VII. Certification & User's Manual Information



Certification & User's Manual Information

K. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

- (a) The various types of radio communication transmitting devices described throughout this chapter.
- (b) *The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*
- (c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.
- (d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

- (a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:
 - (1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or
 - (2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.
- (d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.



- (e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:
- (i) *Compliance testing;*
 - (ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or
 - (v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.
- (e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.
- (f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.



Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

- (a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.¹ *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.*
- (b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

- (a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.
- (b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

¹ In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.



Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

- (a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.
 - (1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.
 - (i) *If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*
 - (ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.
 - (2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.



Certification & User's Manual Information

Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) *In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

- (1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- (2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

- (3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- (4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

- (5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.



Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

- (a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

- (b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.