FCC Part 15 Subpart C
Transmitter Certification

Direct Sequence Spread Spectrum Transmitter

Test Report

FCC ID: HSW-ZN241

FCC Rule Part: 15.247

ACS Report Number: 05-0173-15C

Manufacturer: Cirronet Inc.
Model: ZN241

Test Begin Date: July 20, 2005
Test End Date: July 21, 2005

Report Issue Date: July 28, 2005

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612

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ACS, Inc.

This report contains 25 pages

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1.0 GENERAL

1.1 Purpose
The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description

1.2.1 General
The ZN241 Radio network is designed for Point of Service (POS) transactions. The network consists of a server (ZN241-S) and many clients (ZN241-C). Both models use the same hardware with different software. One option for the server is two antenna outputs provided by a 2-way splitter with each output 3 dBm lower in RF power.

The ZN241 utilizes a Zigbee standard hardware module. The software is Cirronet's networking POS system.

Detailed photographs of the EUT are filed separately with this filing.

1.2.2 Intended Use
The intended use of the ZN241 Radio network is for Point of Service (POS) transactions.

2.0 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following address:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications

The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment. In addition, ACS is compliant to ISO 17025 as certified by the National Institute of Standards and Technology under their National Voluntary Laboratory Accreditation Program. The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 89450
Industry Canada Lab Code: IC 4175
VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

NVLAP Lab Code: 200612

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 150cm in diameter and is located 160cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chases from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

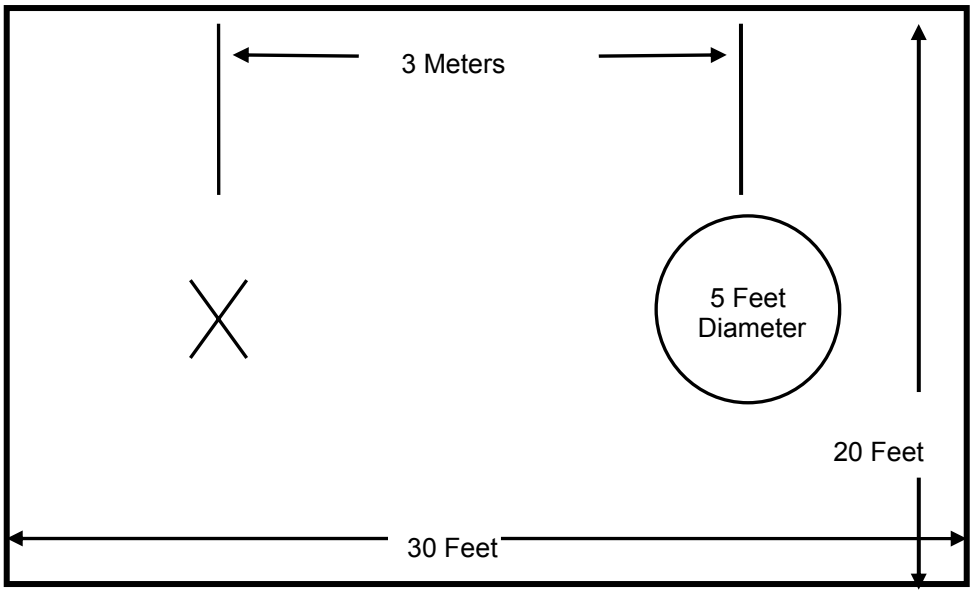

Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 2.3-2 below:

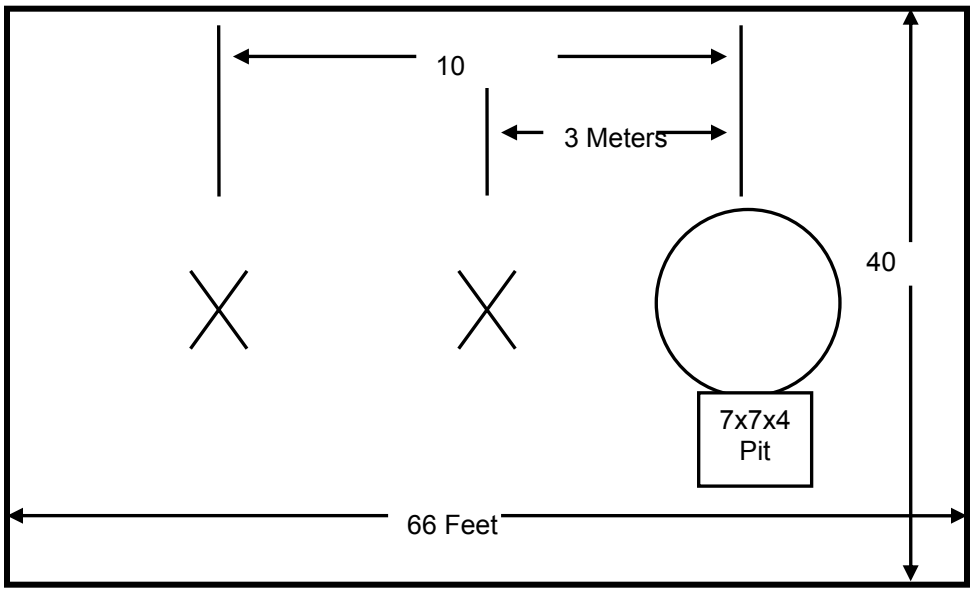

Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description
The AC mains conducted EMI site is a shielded room with the following dimensions:

- Height: 3.0 Meters
- Width: 3.6 Meters
- Length: 4.9 Meters

The room is manufactured by Rayproof Corporation and installed by Panashield, Inc. Earth ground is provided to the room via an 8' copper ground rod. Each panel of the room is connected electrically at intervals of 4".

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 1B42-60P manufactured by Rayproof Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 2.4-1:

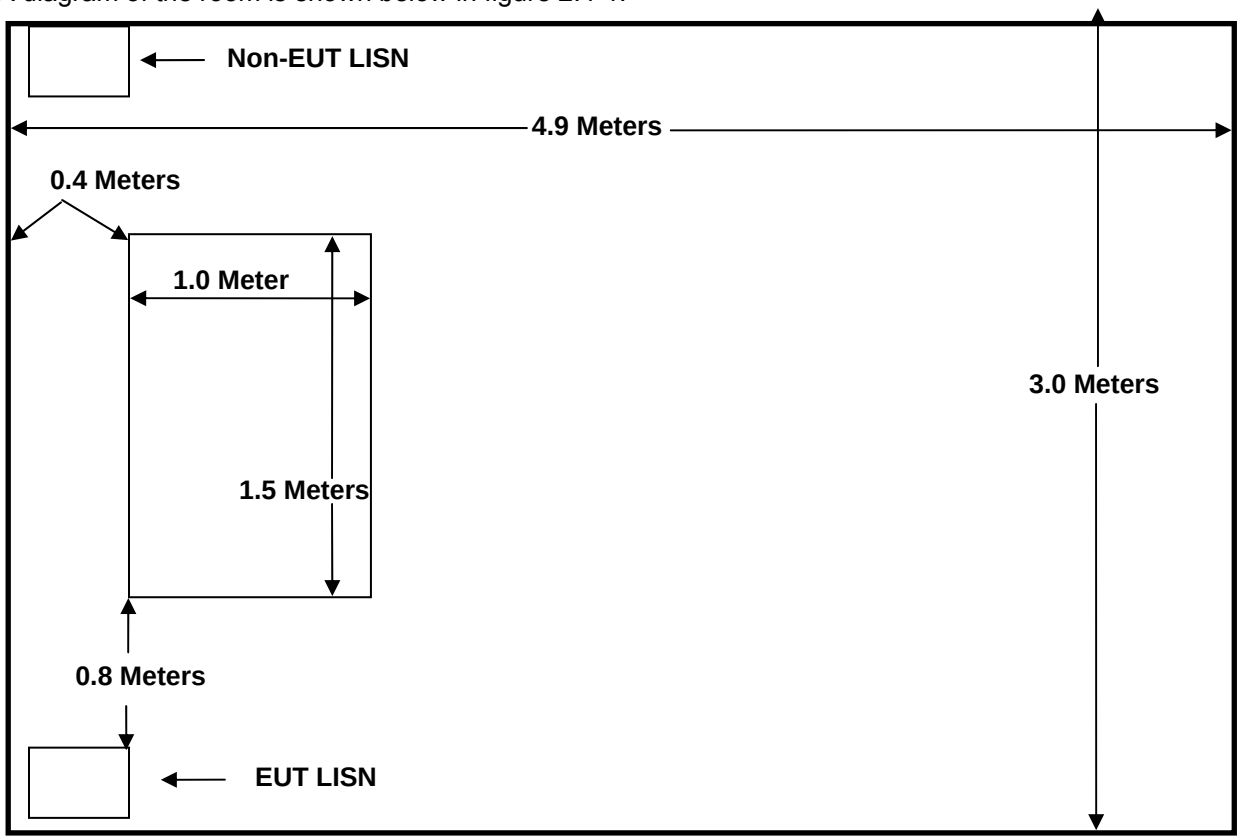

Figure 2.4-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES
The following standards were used:

1 - ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the 9 KHz to 40GHz
2 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2004)
3 - FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Table 4.0-1: Test Equipment

Equipment Calibration Information					
ACS#	**Mfg.**	**Eq. type**	**Model**	**S/N**	**Cal. Due**
☒ 26	Chase	Bi-Log Antenna	CBL6111	1044	10/15/05
☒ 153	EMCO	LISN	3825/2	9411-2268	12/20/05
☒ 193	ACS	OATS Cable Set	RG8	193	01/07/06
☒ 225	Andrew	OATS RF cable	Heliax	225	01/06/06
☒ 165	ACS	Conducted EMI Cable Set	RG8	165	01/06/06
☒ 22	Agilent	Pre-Amplifier	8449B	3008A00526	05/06/06
☒ 73	Agilent	Pre-Amplifier	8447D	272A05624	05/18/06
☒ 30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	05/09/06
☒ 105	Microwave Circuits	High Pass Filter	H1G810G1	2123-01 DC0225	06/09/06
☒ 1	Rohde & Schwarz	Receiver Display	804.8932.52	833771/007	03/07/06
☒ 2	Rohde & Schwarz	ESMI Receiver	1032.5640.53	839587/003	03/07/06
☒ 3	Rohde & Schwarz	Receiver Display	804.8932.52	839379/011	12/15/05
☒ 4	Rohde & Schwarz	ESMI Receiver	1032.5640.53	833827/003	12/15/05
☒ ---	Agilent	Spectrum Analyzer	E7402A	US41110277	11/10/05
☒ 168	Hewlett Packard	Pulse Limiter	11947A	3107A02268	01/06/06
☒ 6	Harbour Industries	HF RF Cable	LL-335	00006	03/16/06
☒ 7	Harbour Industries	HF RF Cable	LL-335	00007	03/16/06
☒ 167	ACS	Chamber EMI Cable Set	RG6	167	12/29/05
☒ 204	ACS	Chamber EMI RF cable	RG8	204	01/07/06

5.0 SUPPORT EQUIPMENT

Table 5.0-1: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number	FCC ID
1	Laptop PC	Dell	PP10L	CN-OH2049-48643-46F-1251	NA
2	PC Power Supply	Dell	PA-1650-05D	CN-05U092-71615-45L-3A83	NA
3	Power Supply	CUI, Inc.	EPAS-101W-12	DPS120100UPS-P5P-SZ	NA

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

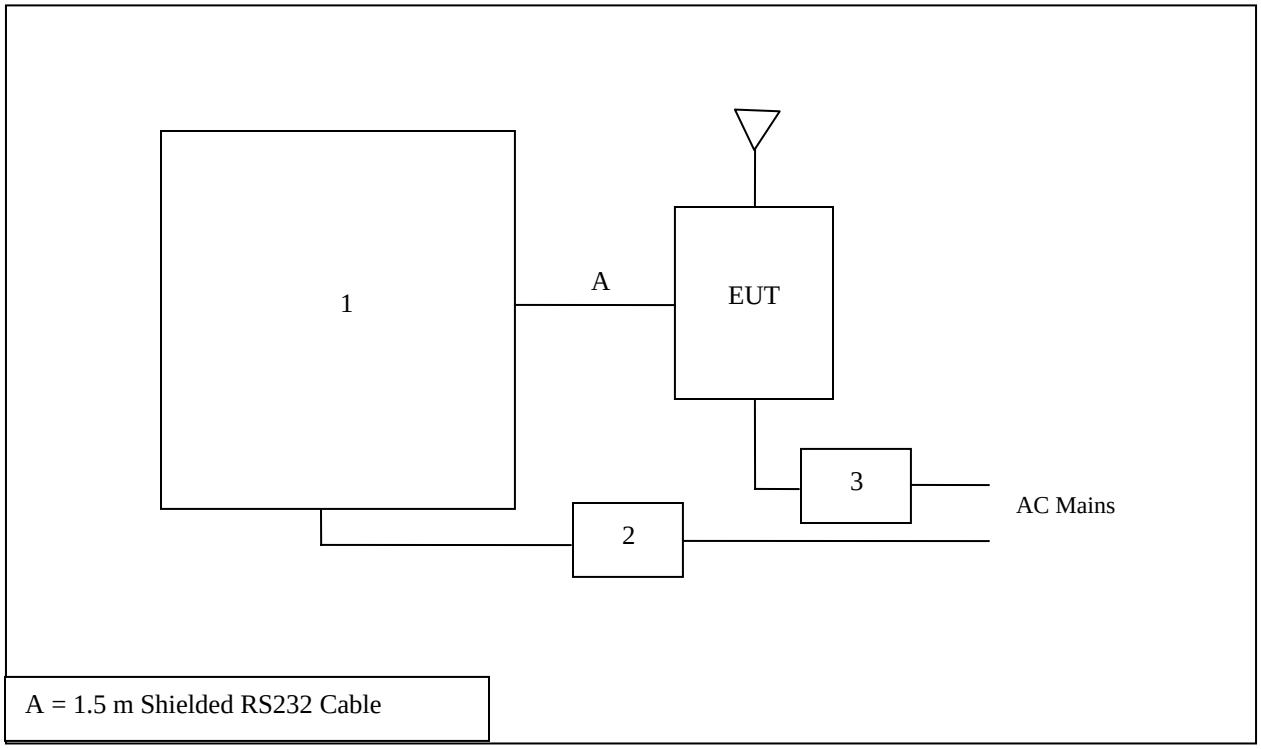

Figure 6.0-1: EUT Test Setup

7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement - FCC Section 15.203

The EUT employs a detachable antenna that utilizes a reverse SMA RF connector which meets the requirements of Part 15.203.

7.2 Power Line Conducted Emissions - FCC Section 15.207

7.2.1 Test Methodology

Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Corrected Reading – Applicable Limit

Results of the test are shown below in and Tables 7.2.2-1 through 7.2.2-4 and Figure 7.2.2-1 through 7.2.2-2

7.2.2 Test Results

Table 7.2.2-1: Line 1 Conducted EMI Results (Quasi-Peak)

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.372	44.3	9.9	58.4	14.0	L1	GND
0.744	44.0	9.9	56	11.9	L1	GND
1.116	40.6	10	56	15.4	L1	GND
1.494	35.6	10	56	20.3	L1	GND
1.866	30.4	10	56	25.5	L1	GND
2.238	39.0	10	56	17.0	L1	GND
2.610	39.3	10	56	16.7	L1	GND
2.982	35.0	10	56	20.9	L1	GND
3.726	29.8	10	56	26.2	L1	GND
4.098	26.1	10	56	29.8	L1	GND

Table 7.2.2-2: Line 1 Conducted EMI Results (Average)

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.372	43.8	9.9	48.4	4.6	L1	GND
0.744	42.4	9.9	46	3.5	L1	GND
1.116	38.4	10	46	7.5	L1	GND
1.488	33.5	10	46	12.4	L1	GND
1.866	27.7	10	46	18.2	L1	GND
2.232	34.8	10	46	11.1	L1	GND
2.610	34.6	10	46	11.3	L1	GND
2.982	30.4	10	46	15.5	L1	GND
3.732	21.1	10	46	24.8	L1	GND
4.104	18.0	10	46	28.0	L1	GND

Table 7.2.2-3: Line 2 Conducted EMI Results (Quasi-Peak)

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.372	42.9	9.9	58.4	15.4	L2	GND
0.744	44.7	9.9	56	11.2	L2	GND
1.116	41.1	10	56	14.8	L2	GND
1.494	38.3	10	56	17.6	L2	GND
1.866	31.9	10	56	24.0	L2	GND
2.238	40.9	10	56	15.0	L2	GND
2.610	41.6	10	56	14.3	L2	GND
2.988	37.2	10	56	18.7	L2	GND
3.726	31.0	10	56	25.0	L2	GND
4.098	28.7	10	56	27.2	L2	GND

Table 7.2.2-4: Line 2 Conducted EMI Results (Average)

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.372	43.4	9.9	48.4	4.9	L2	GND
0.744	44.4	9.9	46	1.5	L2	GND
1.122	41.3	10	46	4.6	L2	GND
1.494	37.2	10	46	8.7	L2	GND
1.866	30.2	10	46	15.7	L2	GND
2.238	38.6	10	46	7.3	L2	GND
2.610	38.9	10	46	7.0	L2	GND
2.988	31.1	10	46	14.8	L2	GND
3.732	26.2	10	46	19.7	L2	GND
4.110	22.8	10	46	23.1	L2	GND

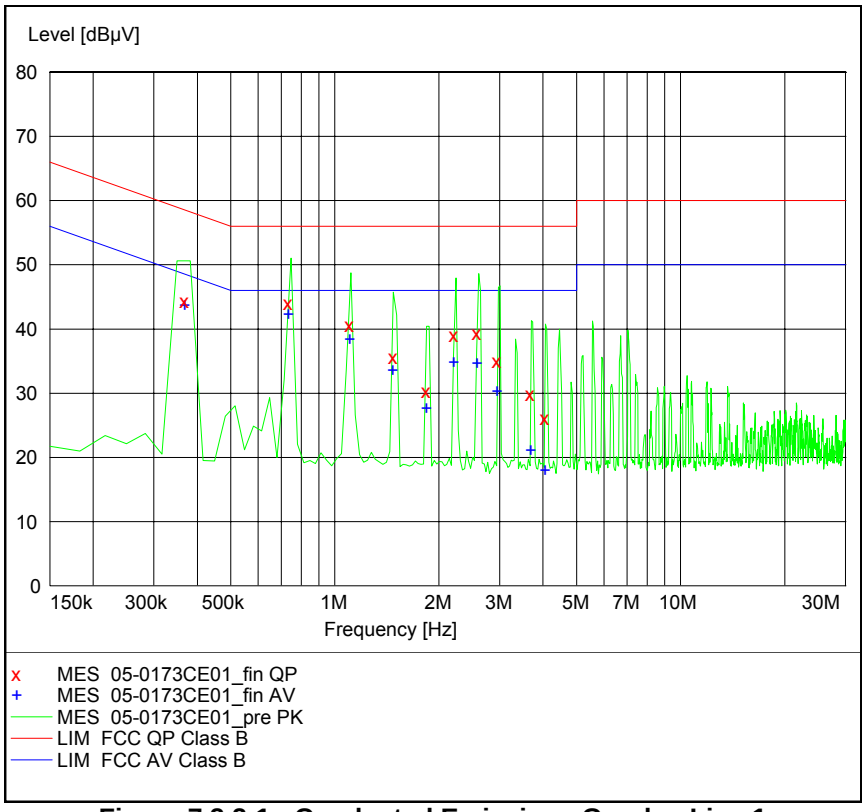

Figure 7.2.2-1: Conducted Emissions Graph – Line 1

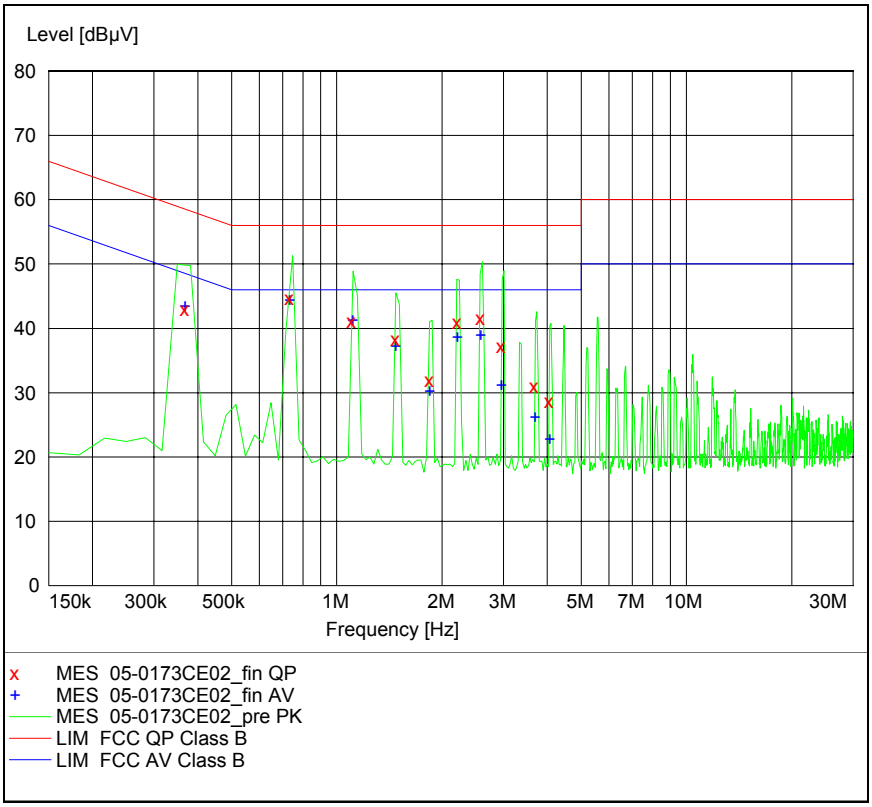

Figure 7.2.2-2: Conducted Emissions Graph – Line 2

7.3 Radiated Emissions - FCC Section 15.109(Unintentional Radiation)

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 1 GHz. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120 KHz for measurements above 30MHz. Average measurements are taken with the RBW and VBW were set to 1MHz and 10 Hz respectively for measurements above 1000MHz.

7.3.2 Test Results

Results of the test are given below in Table 7.3.2-1 and Figure 7.3.2-1:

Table 7.3.2-1: Radiated Emissions

Frequency (MHz)	Polarization	Height (cm)	Azimuth (deg)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
30.40	VERTICAL	107	14	13.3	40	26.7
40.08	VERTICAL	99	144	34.8	40	5.2
54.16	VERTICAL	158	13	24.5	40	15.5
66.32	VERTICAL	110	289	25.5	40	14.5
100.40	VERTICAL	110	24	18.3	43.5	25.2
133.60	VERTICAL	100	200	15.5	43.5	28.0
198.88	HORIZONTAL	170	263	19.6	43.5	23.9
431.04	VERTICAL	100	211	20.2	46	25.8
698.56	VERTICAL	350	255	22.1	46	23.9
958.64	VERTICAL	270	0	25.6	46	20.4

* Note: All emissions above 958.64 MHz were attenuated at least 20 dB below the permissible limit.

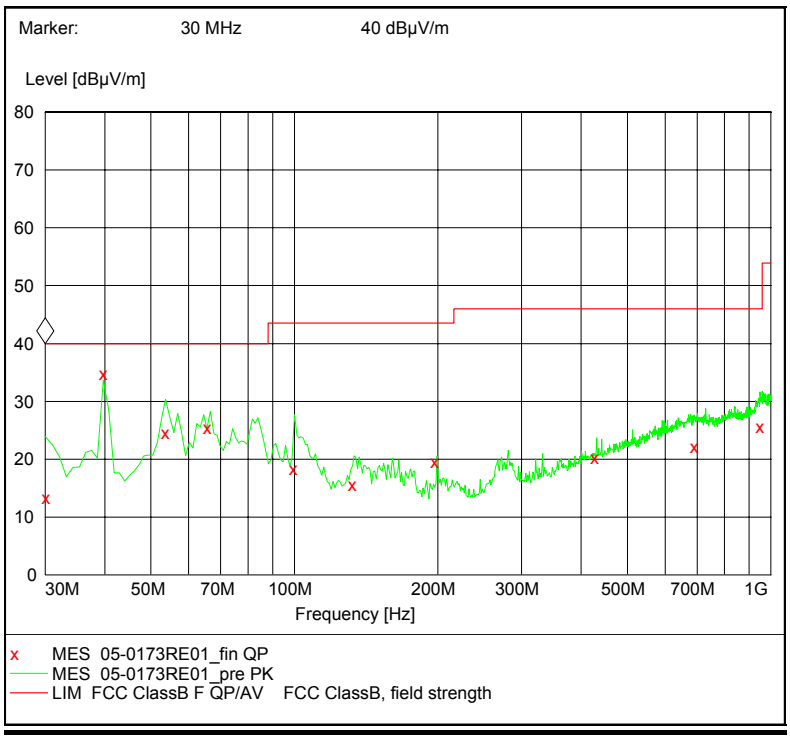

Figure 7.3.2-1: Radiated Emissions

7.4 6dB Bandwidth – FCC Section 15.247(a)

7.4.1 Test Methodology

The 6dB bandwidth was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247". The RBW of the spectrum analyzer was set to 100 kHz and VBW 100 kHz. Span was set large enough to capture the entire emissions and >> RBW.

7.4.2 Test Results

Results are shown below in table 7.4.2-1 and figure 7.4.2-1 through 7.4.2-3:

Table 7.4.2-1: 6dB Bandwidth

Frequency [MHz]	Bandwidth [MHz]	Limit	Result
2405	1.54	≥ 500 kHz	PASS
2440	1.57	≥ 500 kHz	PASS
2475	1.54	≥ 500 kHz	PASS

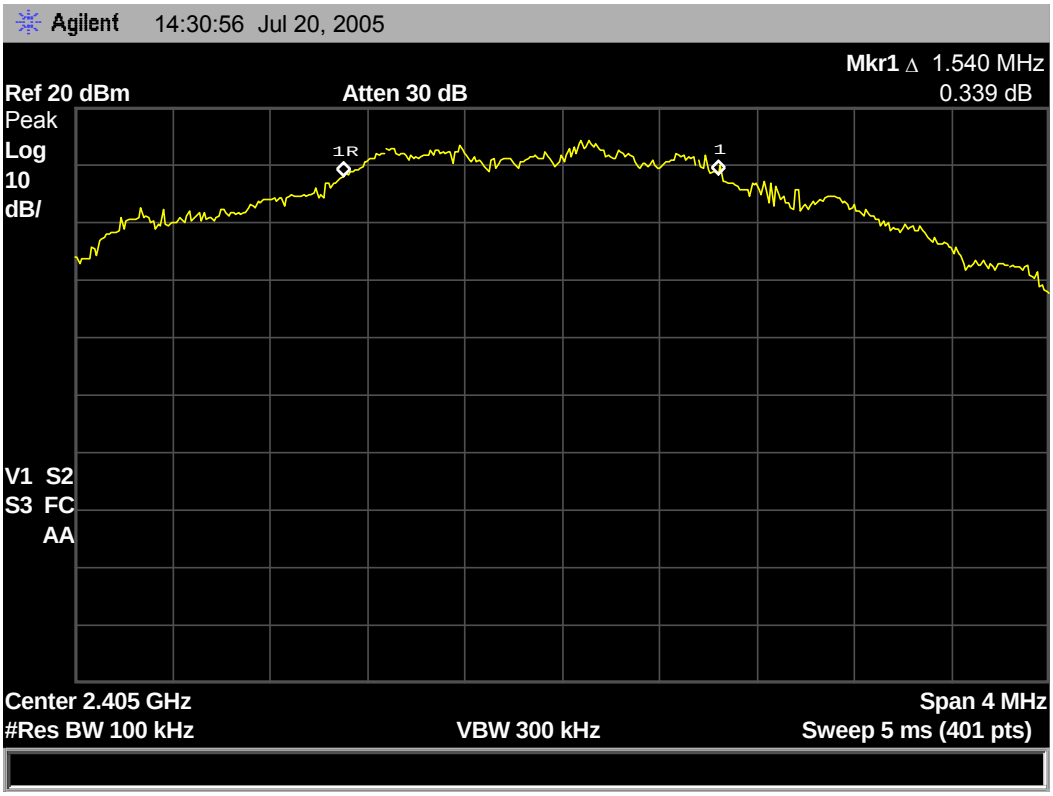

Figure 7.4.2-1: 6dB Bandwidth Plot Low Channel

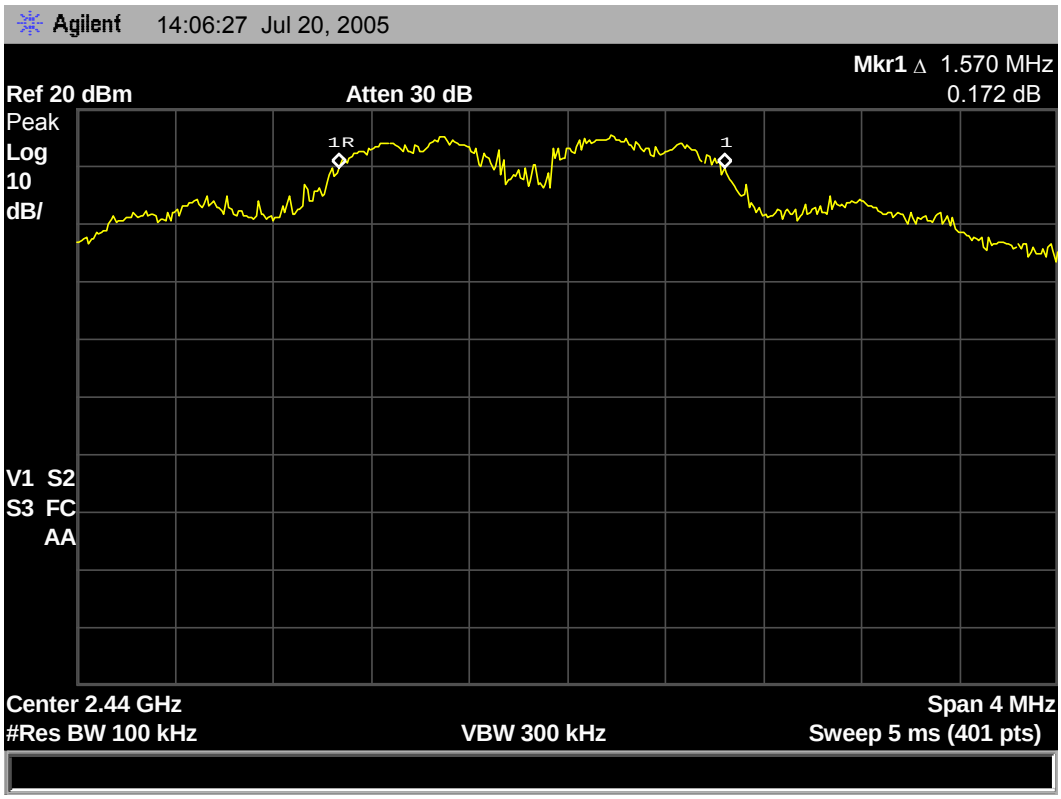

Figure 7.4.2-2: 6dB Bandwidth Plot Mid Channel

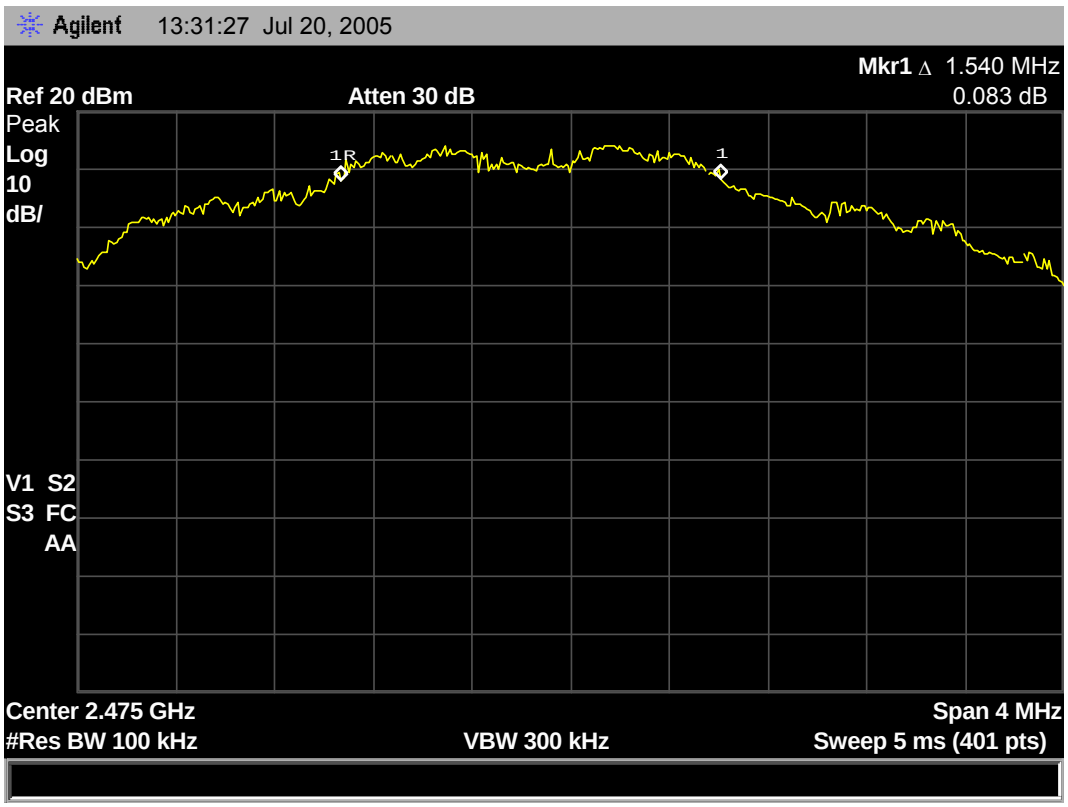

Figure 7.4.2-3: 6dB Bandwidth Plot High Channel

7.5 Peak Output Power Requirement - FCC Section 15.247(b)

7.5.1 Test Methodology

The Peak Output Power was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247" Power Option 1. The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer. The resolution and video bandwidths of the spectrum analyzer were set at sufficient levels, >> emission bandwidth, to produce accurate results. The analyzer was set for Max Hold using a peak detector.
Data was collected with the EUT operating at maximum power and in continuous transmit operation.

7.5.2 Test Results

Results are shown below in Table 7.5.2-1 and Figures 7.5.2-1 through 7.5.2-3:

Table 7.5.2-1: Peak Output Power

Frequency (MHz)	Output Power (dBm)
2045	18.25
2440	18.67
2475	18.40

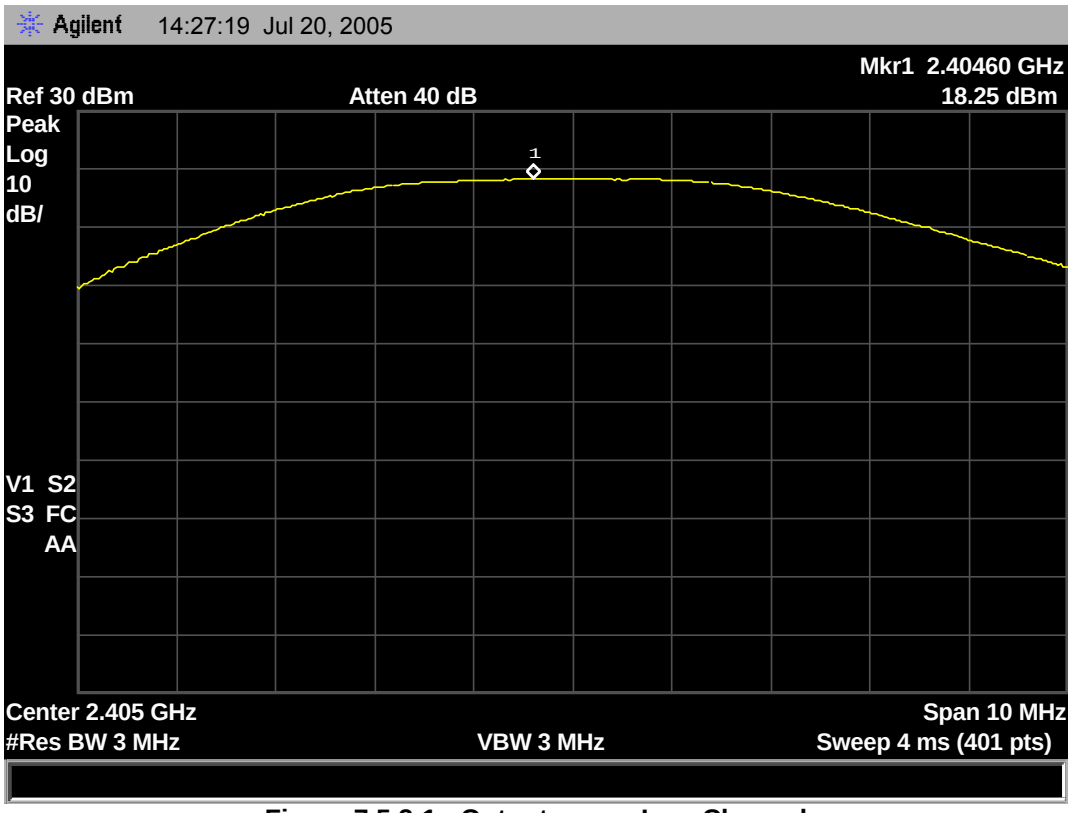

Figure 7.5.2-1: Output power Low Channel

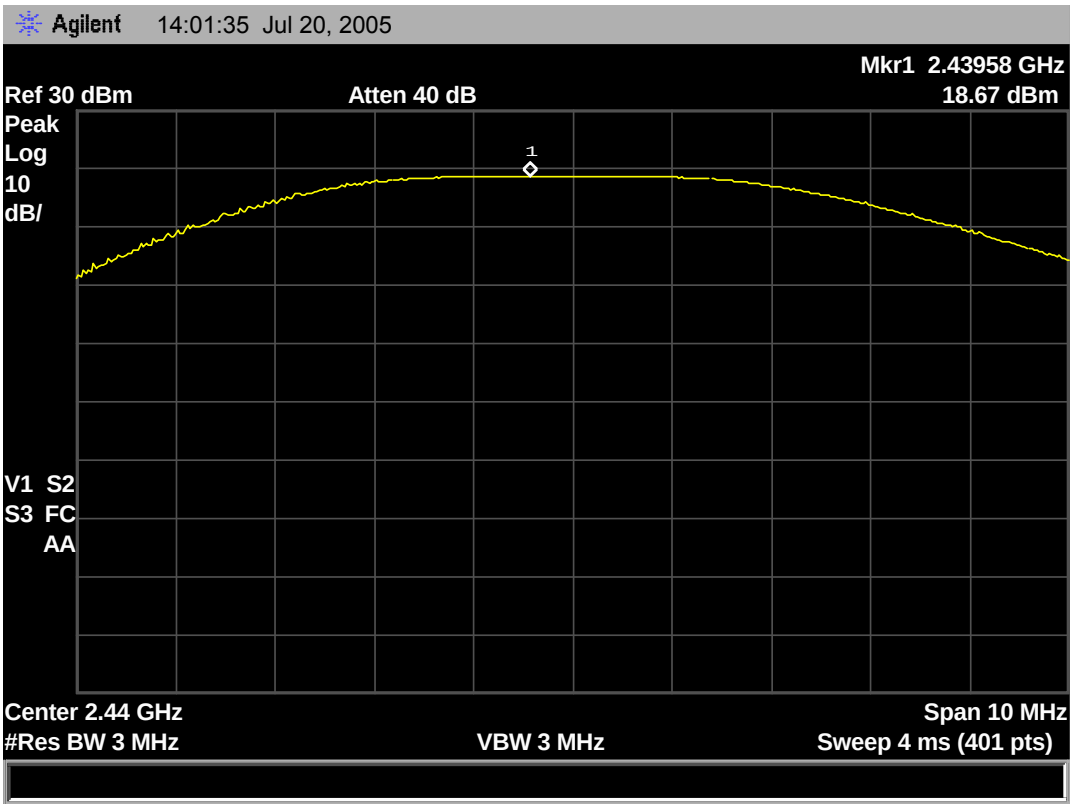

Figure 7.5.2-2: Output power Mid Channel

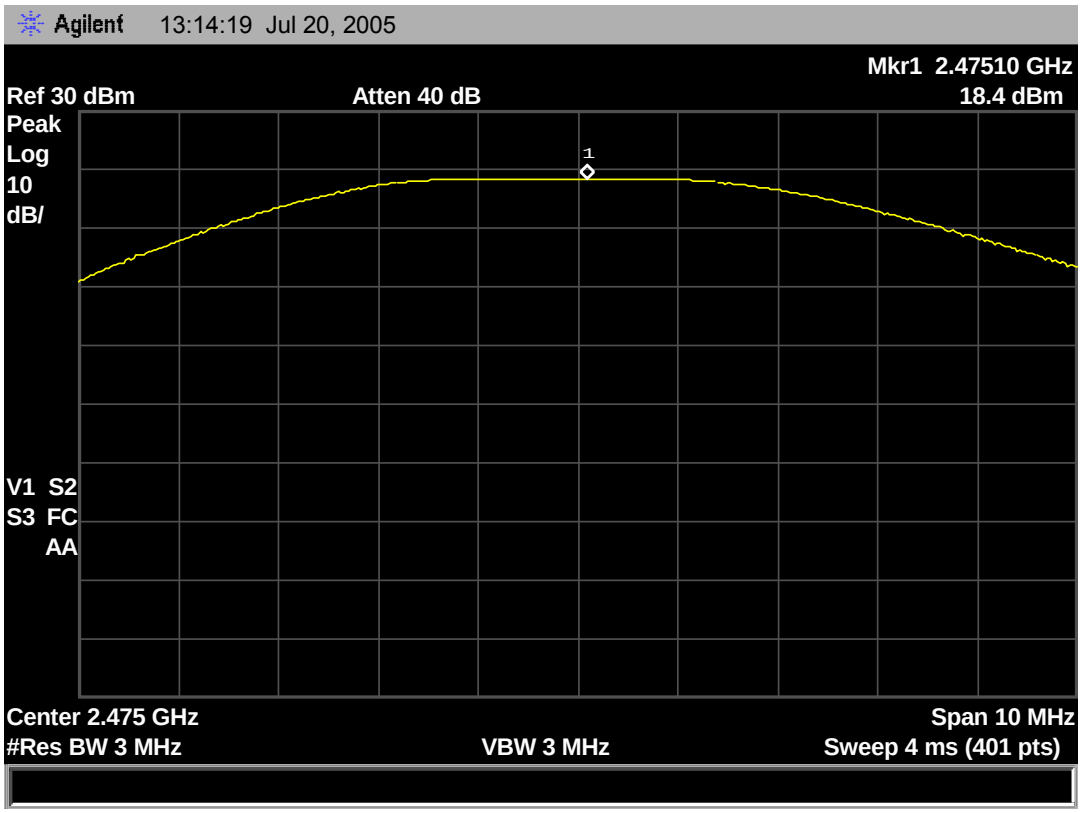

Figure 7.5.2-3: Output power High Channel

7.6 Band-Edge Compliance and Spurious Emissions - FCC Section 15.247(d)

7.6.1 Band-Edge Compliance of RF Emissions

7.6.1.1 Test Methodology

The EUT was investigated at the lowest and highest available channels to determine band-edge compliance. For this measurement the spectrum analyzer's RBW and VBW was set to 100 kHz.

7.6.1.2 Test Results

In a 100 kHz bandwidth at the lower and upper band-edge, the radio frequency power that was produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. Band-edge compliance is displayed in Figure 7.6.1.2-1 and Figure 7.6.1.2-2.

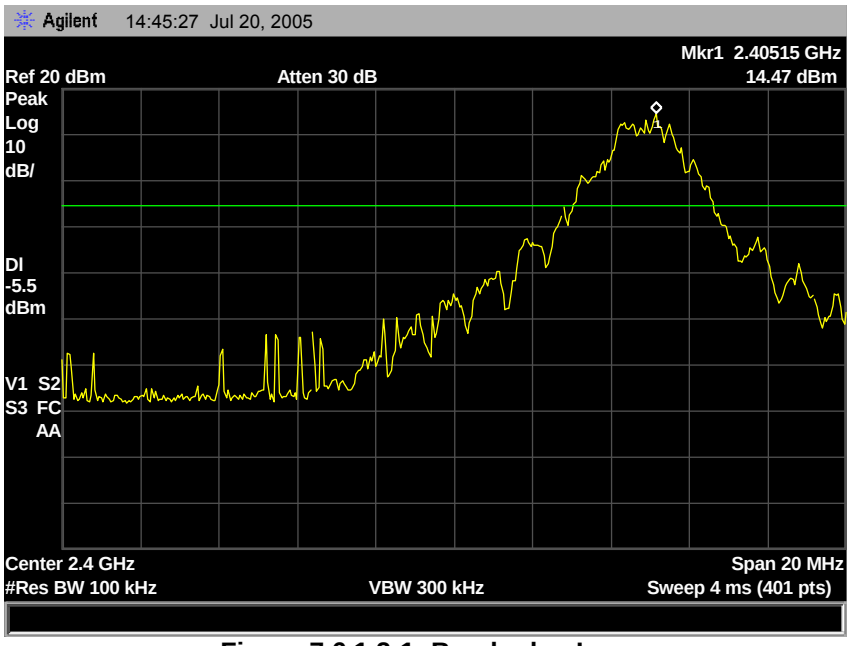

Figure 7.6.1.2-1: Band-edge Low

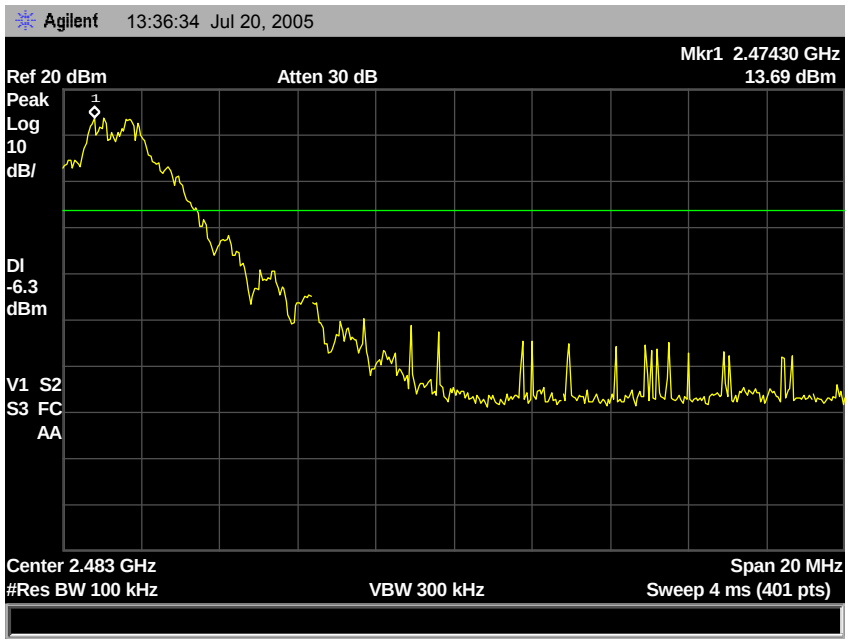

Figure 7.6.1.2-2: Band-edge High

7.6.2 RF Conducted Spurious Emissions

7.6.2.1 Test Methodology

The RF Conducted Spurious Emissions were measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247". The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer. The EUT was investigated for conducted spurious emissions from 30MHz to 25GHz, 10 times the highest fundamental frequency. For each measurement, the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz. The peak detector and Max Hold function of the analyzer were utilized.

7.6.2.2 Test Results

In a 100 kHz bandwidth, the radio frequency power that was produced by the EUT emissions is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. RF Conducted Emissions are displayed in Figures 7.6.2.2-1 through 7.6.2.2-9.

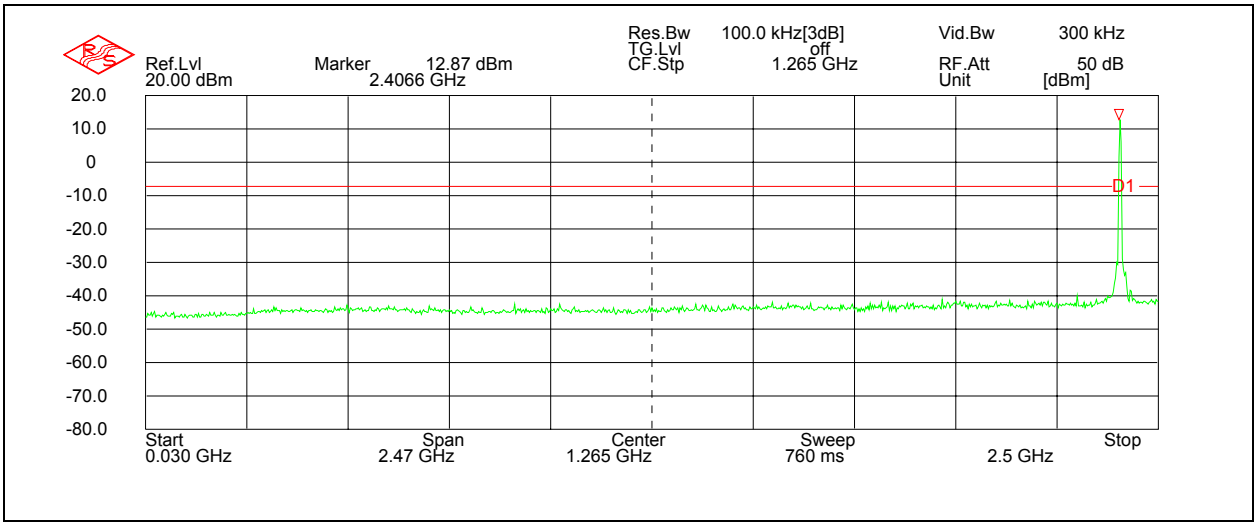

Figure 7.6.2.2-1: RF Conducted Spurious Emission 30 MHz – 2.5 GHz – Low Channel

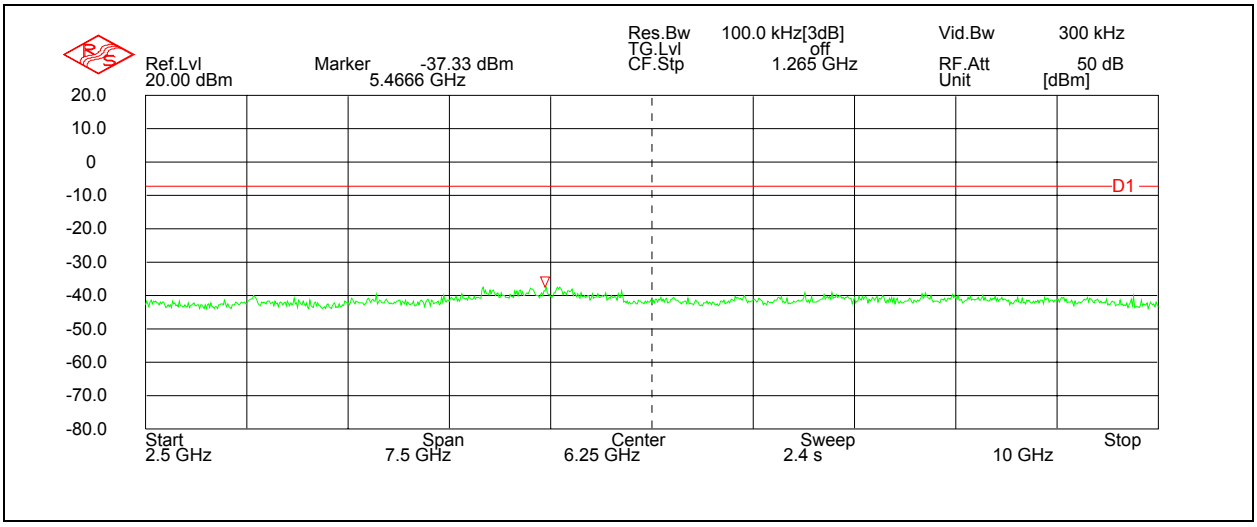

Figure 7.6.2.2-2: RF Conducted Spurious Emission 2.5 GHz – 10 GHz – Low Channel

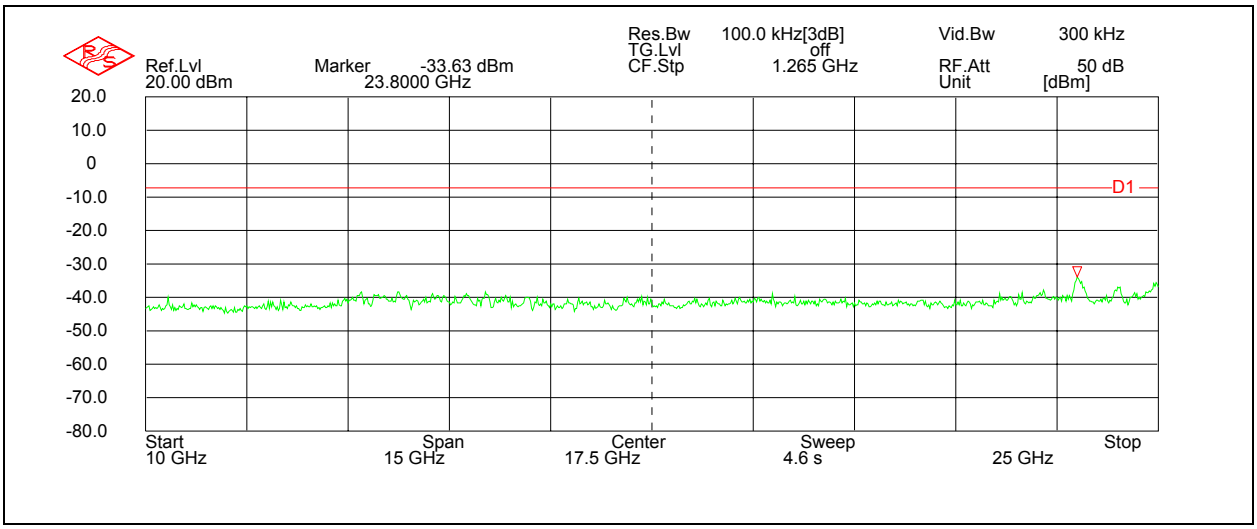

Figure 7.6.2.2-3: RF Conducted Spurious Emission 10 GHz – 25 GHz – Low Channel

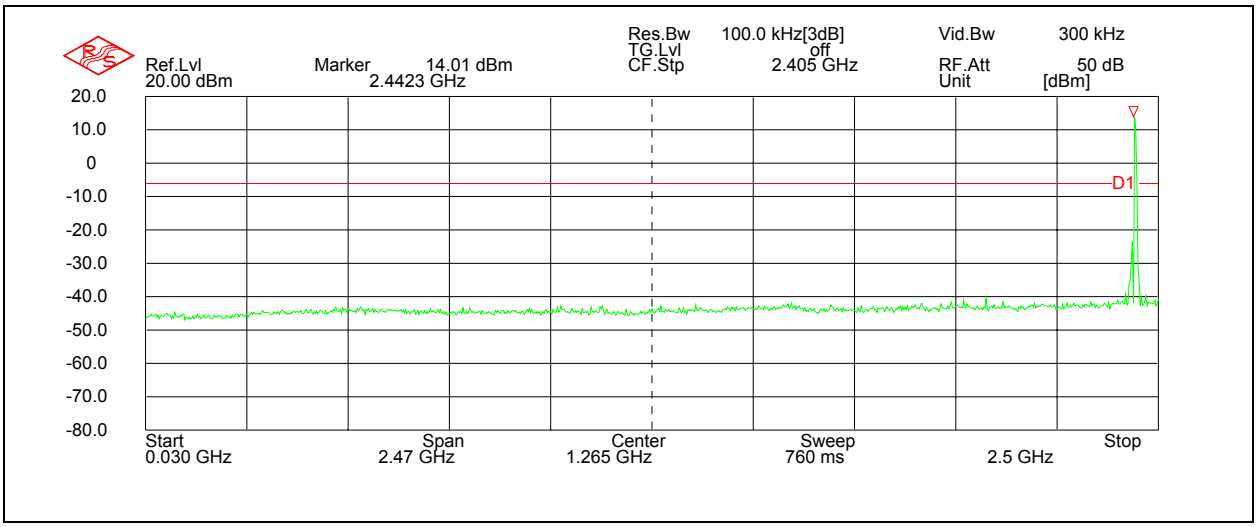

Figure 7.6.2.2-4: RF Conducted Spurious Emission 30 MHz – 2.5 GHz – Mid Channel

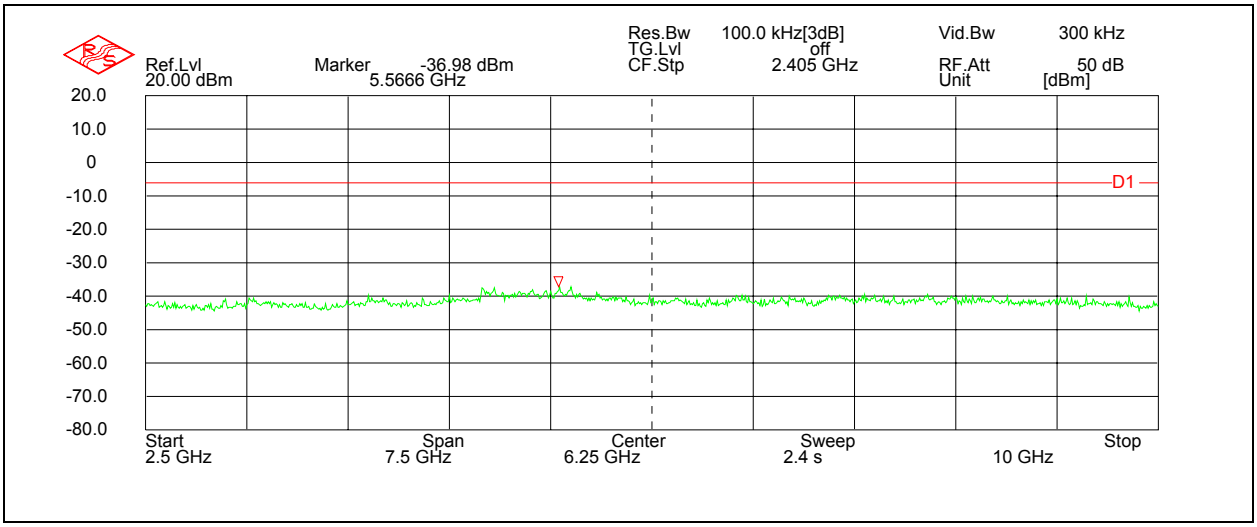

Figure 7.6.2.2-5: RF Conducted Spurious Emission 2.5 GHz – 10 GHz – Mid Channel

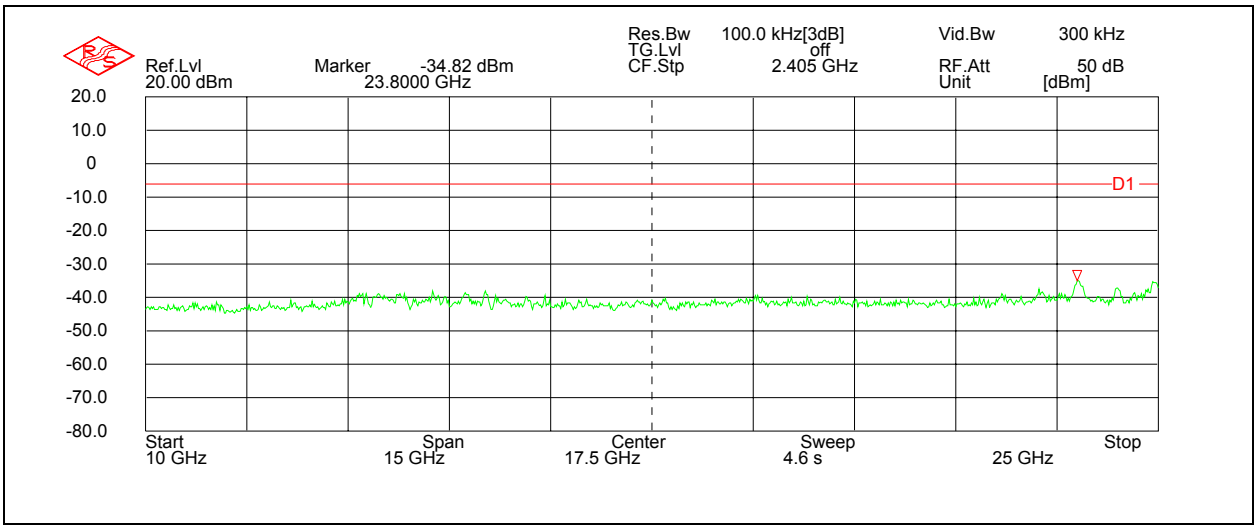

Figure 7.6.2.2-6: RF Conducted Spurious Emission 10 GHz – 25 GHz – Mid Channel

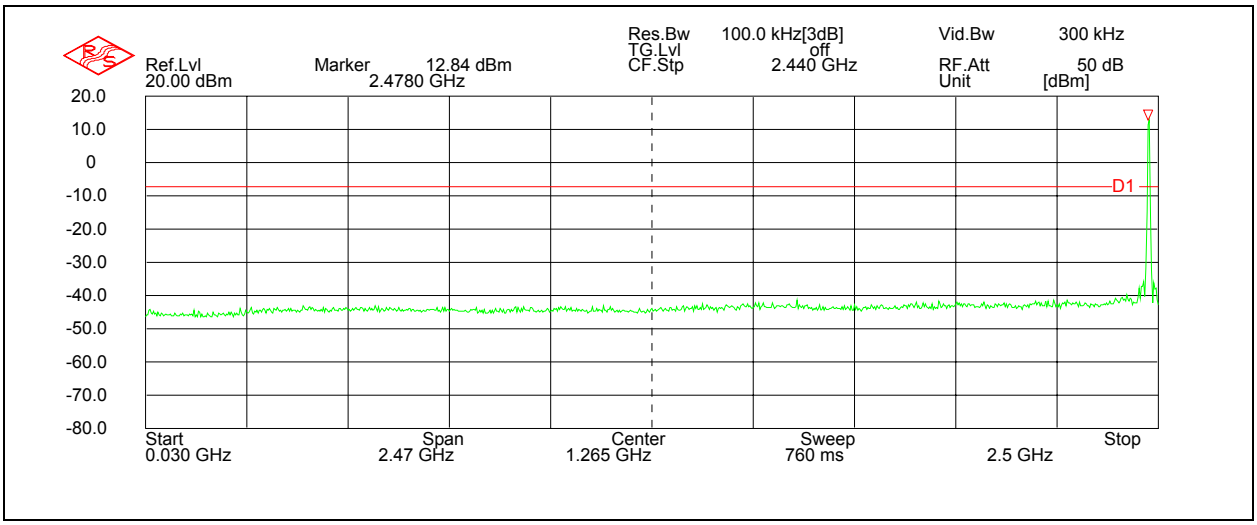

Figure 7.6.2.2-7: RF Conducted Spurious Emission 30 MHz – 2.5 GHz – High Channel

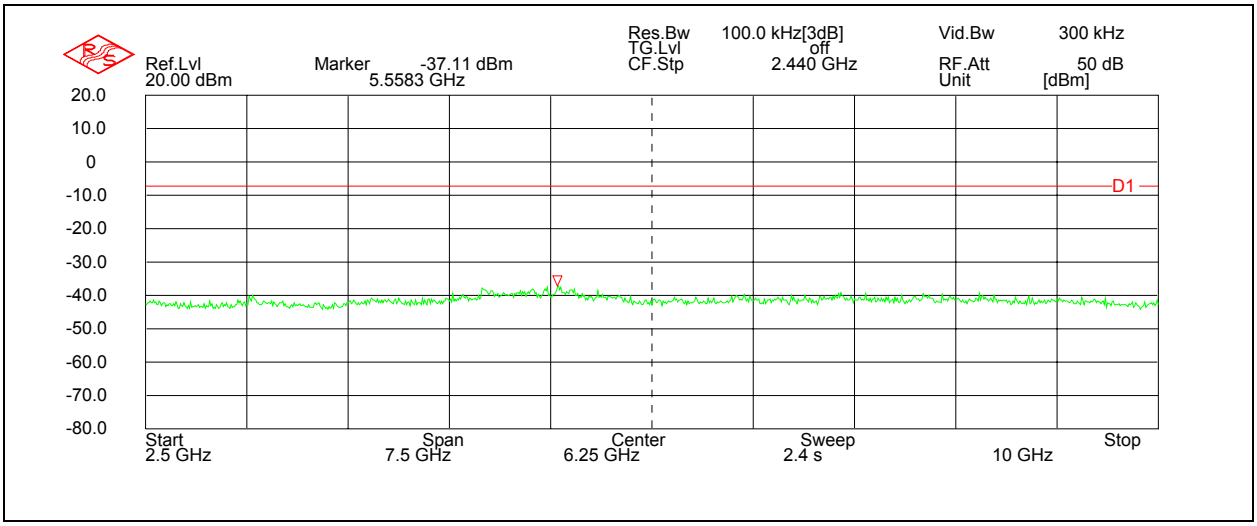

Figure 7.6.2.2-8: RF Conducted Spurious Emission 2.5 GHz – 10 GHz – High Channel

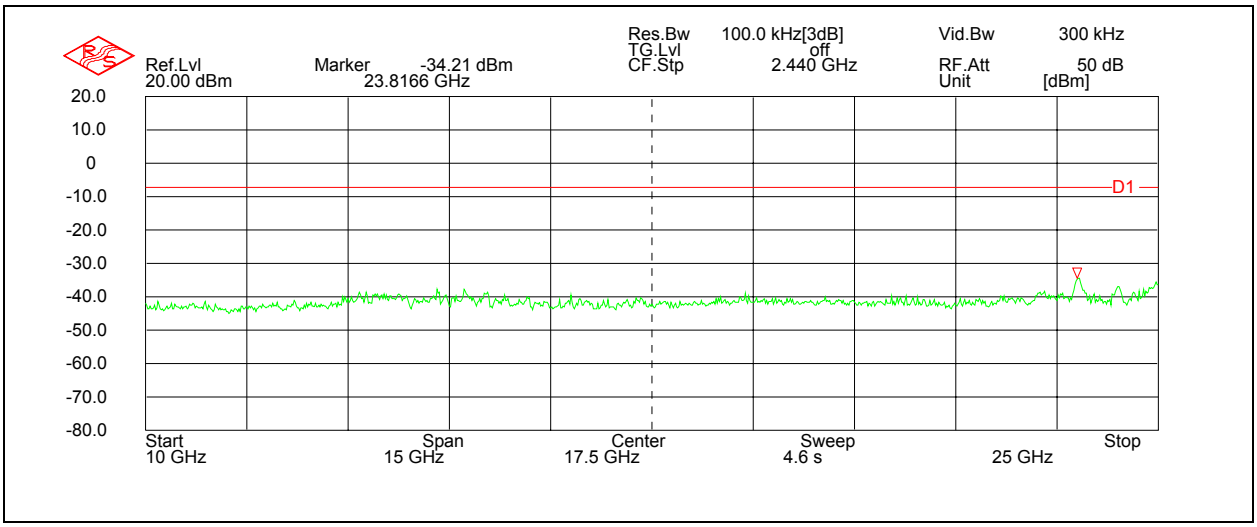

Figure 7.6.2.2-9: RF Conducted Spurious Emission 10 GHz – 25 GHz – High Channel

7.6.3 Radiated Spurious Emissions (Restricted Bands) - FCC Section 15.205

7.6.3.1 Test Methodology

Radiated emissions tests were made over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000MHz, average measurements were calculated based on the peak measurements made with RBW of 1 MHz and a VBW of 1 MHz. The average emissions were calculated by applying the duty cycle correction of the EUT to the peak measurements for comparison to the average limit.

7.6.3.2 Duty Cycle Correction

For average radiated measurements, the measured level was reduced by a factor 17.08dB to account for the duty cycle of the EUT. The duty cycle was determined to be 14% or 14ms with a 100ms period. The duty cycle correction factor is determined using the formula: 20log (0.14) = -17.08dB.

7.6.3.3 Test Results

Radiated spurious emissions found in the band of 30MHz to 25GHz are reported in Table 7.6.3.2-1. Each emission found to be in a restricted band as defined by section 15.205, was compared to the radiated emission limits as defined in section 15.209.

Table 7.6.3.2-1: Radiated Spurious Emissions

Frequency (MHz)	Level (pk)	Antenna Polarity (H/V)	Correction Factors (dB)	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
				pk	avg	pk	avg	pk	avg
Low Channel									
4810	49.12	H	8.91	58.03	40.96	74	54	15.97	13.04
4810	49.04	V	8.91	57.95	40.88	74	54	16.05	13.12
Mid Channel									
4880	47.44	H	9.22	56.66	39.59	74	54	17.34	14.41
4880	48.76	V	9.22	57.98	40.91	74	54	16.02	13.09
7320	45.00	V	15.67	60.67	43.59	74	54	13.33	10.41
High Channel									
4950	48.00	H	9.53	57.53	40.46	74	54	16.47	13.54
4950	49.78	V	9.53	59.31	42.24	74	54	14.69	11.76

7.6.3.4 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T = Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U = Uncorrected Reading
R_C = Corrected Level
AF = Antenna Factor
CA = Cable Attenuation
AG = Amplifier Gain
DC = Duty Cycle Correction Factor

Example Calculation: Peak

Corrected Level: 49.12 + 8.91 = 58.03 dBuV
Margin: 74dBuV – 58.03 dBuV = 15.97 dB

Example Calculation: Average

Corrected Level: 49.12 + 8.91 -17.08 = 40.96 dBuV
Margin: 54dBuV – 40.96 dBuV = 13.04 dB

7.7 Peak Power Spectral Density- FCC Section 15.247(d)

7.7.1 Test Methodology

The power spectral density was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247". The emission peaks within the pass band were located and zoomed in on. The spectrum analyzer RBW was set to 3 kHz and VBW 10 kHz. Span was adjusted to 500 kHz and the sweep time was calculated to be 167s (Span/3 kHz).

7.7.2 Test Results

Results are shown below in table 7.7.2-1 and figures 7.7.2-1 through 7.7.2-3:

Table 7.7.2-1: Peak Power Spectral Density

Frequency [MHz]	Level [dBm]	Limit [dBm]	Result
2405	7.24	8	PASS
2440	7.81	8	PASS
2475	6.81	8	PASS

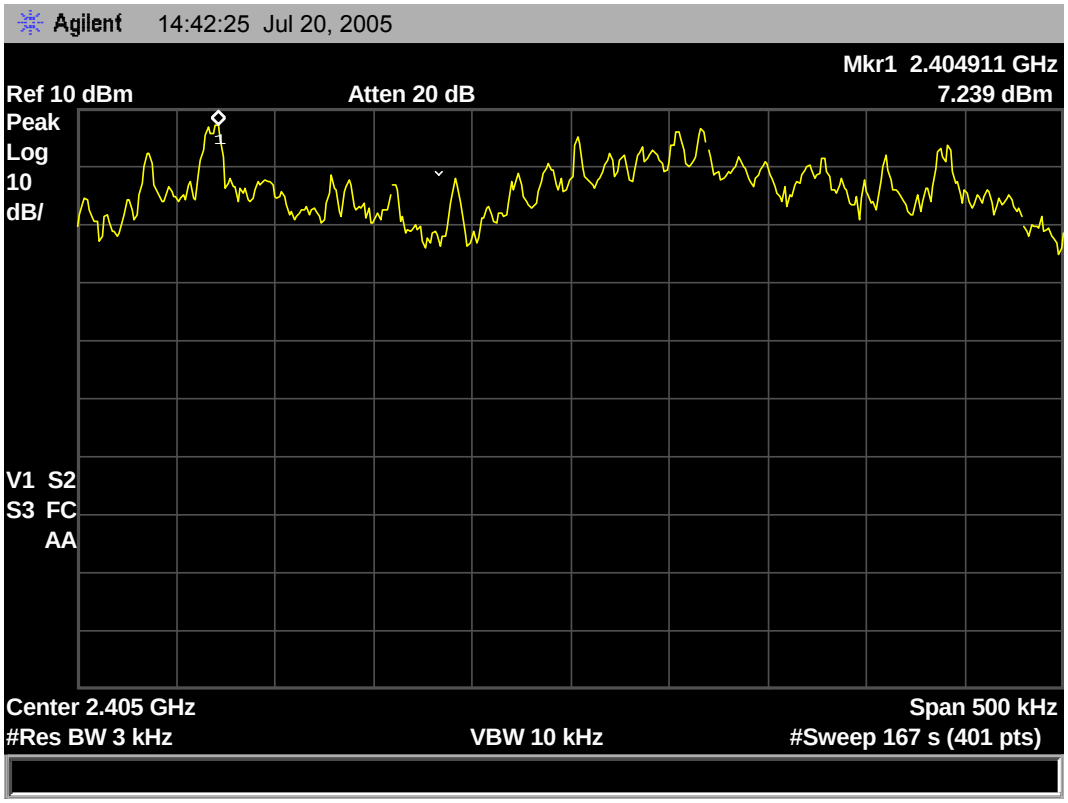

Figure 7.7.2-1: Peak Power Spectral Density – Low Channel

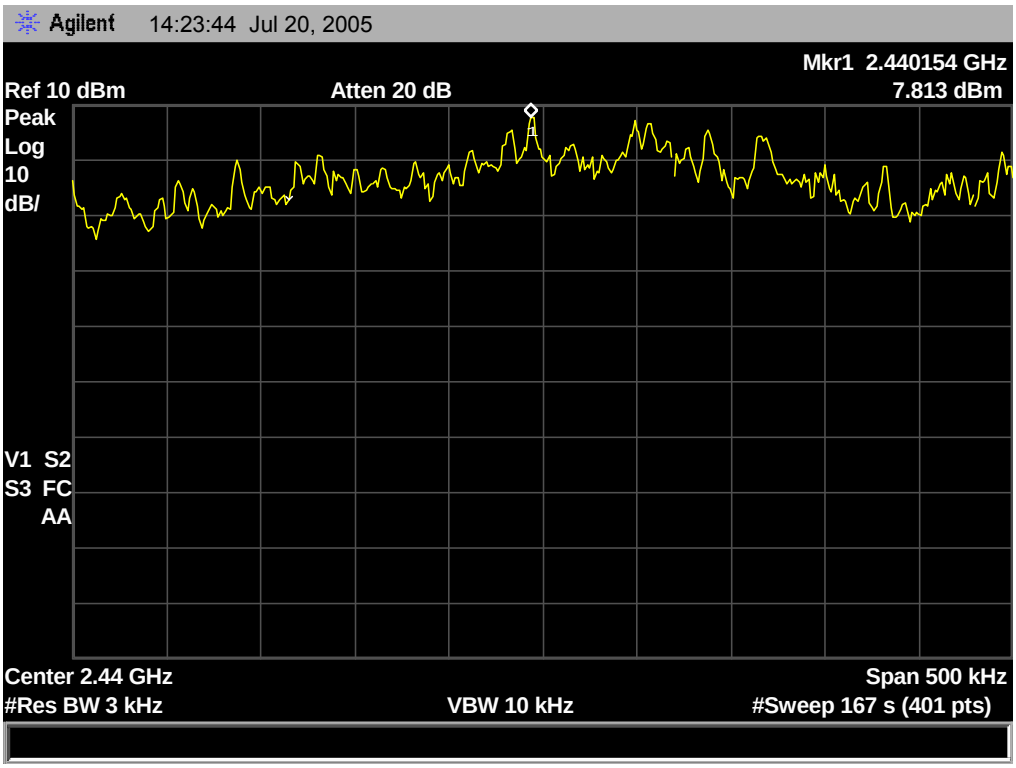

Figure 7.7.2-2: Peak Power Spectral Density – Mid Channel

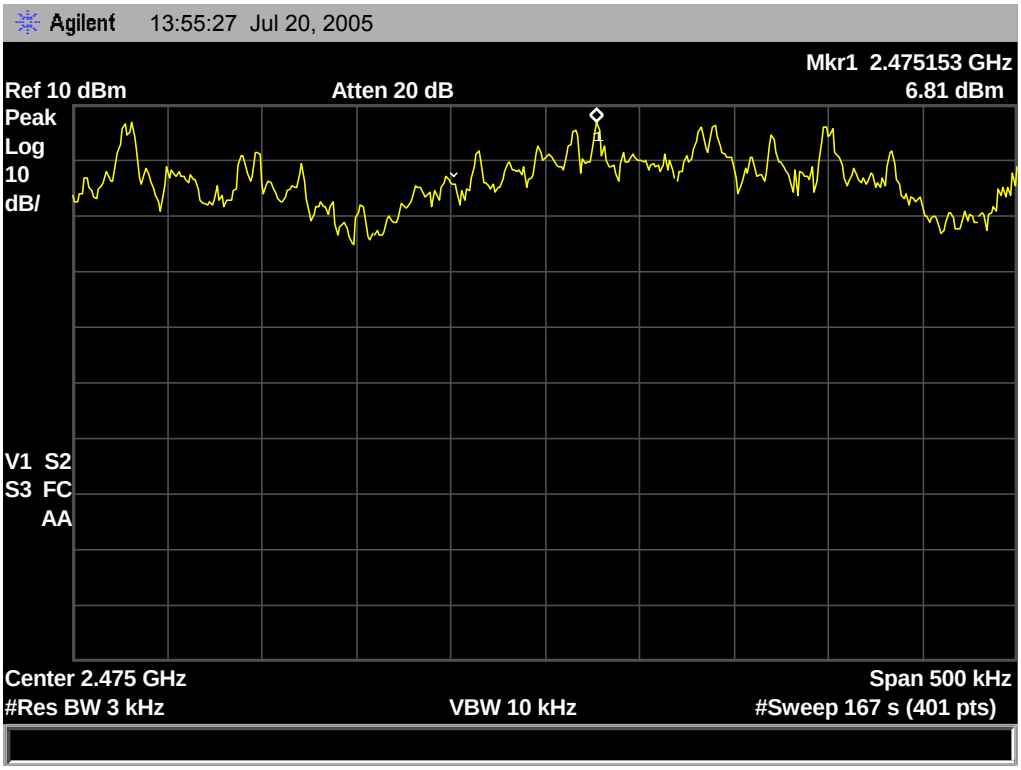

Figure 7.7.2-3: Peak Power Spectral Density – High Channel

8.0 CONCLUSION

In the opinion of ACS, Inc. the ZN241 manufactured by Cirronet, Inc, does meet the requirements of FCC Part 15 subpart C.