



**MET Laboratories, Inc.** *Safety Certification - EMI - Telecom Environmental Simulation*  
914 W. PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

September 2, 2008

LigoWave  
1440 Dutch Valley Place  
Atlanta, GA 30324

Dear Matt Hardy,

Enclosed is the EMC Wireless test report for compliance testing of the LigoWave, LigoPTP 3-N, tested to the requirements of Title 47 of the Code of Federal Regulations (CFR), Part 90 Subpart Z for Land Mobile Radio Services and Part 15 Subpart B for a Class B Digital Device.

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.

Jennifer Warnell  
Documentation Department

Reference: (\LigoWave\EMC25159-FCC90 Rev. 1)

Certificates and reports shall not be reproduced except in full, without the written permission of MET Laboratories, Inc.



**MET Laboratories, Inc.** *Safety Certification - EMI - Telecom Environmental Simulation*  
914 W. PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

## **Electromagnetic Compatibility Criteria Test Report**

For the

**LigoWave  
Model LigoPTP 3-N**

Tested under

**The FCC Verification Rules  
Contained in Title 47 of the CFR, Part 90, Subpart Z  
for Private Land Mobile Radio Services  
and Part 15, Subpart B for a Class B Digital Device**

**MET Report: EMC25159-FCC90 Rev. 1**

September 2, 2008

**Prepared For:  
LigoWave  
1440 Dutch Valley Place  
Atlanta, GA 30324**

**Prepared By:  
MET Laboratories, Inc.  
914 W. Patapsco Ave.  
Baltimore, MD 21230**



LigoWave  
LigoPTP 3-N

Electromagnetic Compatibility  
Cover Page  
CFR Title 47 Part 90 Subpart Y & Part 15 Subpart B

## Electromagnetic Compatibility Criteria Test Report

For the

**LigoWave  
Model LigoPTP 3-N**

Tested under

**The FCC Verification Rules  
Contained in Title 47 of the CFR, Part 90, Subpart Z  
for Private Land Mobile Radio Services  
and Part 15, Subpart B for a Class B Digital Device**

**MET Report: EMC25159-FCC90 Rev. 1**

Dusmantha Tennakoon  
Electromagnetic Compatibility Lab

Jennifer Warnell  
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 / is not capable of operation in accordance with the requirements of Part 90, Subpart Z and Part 15, Subpart B of the FCC Rules under normal use and maintenance.

Shawn McMillen, Wireless Manager  
Electromagnetic Compatibility Lab



LigoWave  
LigoPTP 3-N

Electromagnetic Compatibility  
Report Status  
CFR Title 47 Part 90 Subpart Z & Part 15 Subpart B

## Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	September 2, 2008	Initial Issue.
1	September 3, 2008	Customer correction.



## Table of Contents

<b>1. Executive Summary .....</b>	<b>1</b>
1.1. Testing Summary .....	2
<b>2. Equipment Configuration.....</b>	<b>3</b>
2.1. Overview .....	4
2.2. Test Site .....	5
2.3. Description of Test Sample .....	5
2.4. Equipment Configuration .....	5
2.5. Support Equipment .....	5
2.6. Ports and Cabling Information .....	6
2.7. Mode of Operation .....	8
2.8. Modifications .....	8
2.8.1. Modifications to EUT .....	8
2.8.2. Modifications to Test Standard .....	8
2.9. Disposition of EUT .....	8
<b>3. Electromagnetic Compatibility Criteria for Unintentional Radiators .....</b>	<b>9</b>
3.1. Conducted Emissions Limits .....	10
3.2. Radiated Emissions Limits .....	13
<b>4. Electromagnetic Compatibility Criteria for Intentional Radiators .....</b>	<b>18</b>
4.1. Peak Power Output .....	24
<b>5. Electromagnetic Compatibility Occupied Bandwidth Requirements.....</b>	<b>29</b>
5.1. Occupied Bandwidth (Emission Masks) .....	29
<b>6. Electromagnetic Compatibility Spurious Emissions at Antenna Terminal Requirements .....</b>	<b>34</b>
6.1. Spurious Emissions at Antenna Terminals .....	34
<b>7. Electromagnetic Compatibility Radiated Emissions Requirements .....</b>	<b>42</b>
7.1. Radiated Emissions (Substitution Method) .....	42
<b>8. Frequency Stability .....</b>	<b>44</b>
<b>9. RF Exposure Requirements .....</b>	<b>45</b>
<b>10. Test Equipment .....</b>	<b>46</b>
<b>11. Certification Label &amp; User's Manual Information .....</b>	<b>47</b>
11.1. Verification Information .....	48
11.2. Label and User's Manual Information .....	52

All references to section numbers are taken directly from the standard/specification used. Only sections requiring testing or evaluation are included.



## List of Tables

Table 1. Equipment Configuration .....	5
Table 2. Support Equipment.....	5
Table 3. Ports and Cabling Information .....	6
Table 4. Conducted Limits for Radio Frequency Devices calculated from FCC Part 15 Section 15.107(a) (b) .....	10
Table 5. Conducted Emissions - Voltage, AC Power, Phase Line 120VAC, 60Hz .....	11
Table 6. Conducted Emissions - Voltage, AC Power, Neutral Line 120VAC, 60Hz.....	12
Table 7. Radiated Emissions Limits calculated from FCC Part 15, §15.109 (a) (b) .....	13
Table 8. Radiated Emissions Limits Test Results .....	14
Table 9. Temperature Vs. Frequency Test Results.....	44
Table 10. Frequency vs. Voltage Test Results .....	44

## List of Figures

Figure 1. Block Diagram of Test Configuration.....	6
Figure 2. Picture of EUT .....	7



## List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB $\mu$ A	Decibels above one microamp
dB $\mu$ V	Decibels above one microvolt
dB $\mu$ A/m	Decibels above one microamp per meter
dB $\mu$ V/m	Decibels above one microvolt per meter
DC	Direct Current $\mu$
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GR-1089-CORE	( <i>GR</i> ) General Requirement(s) imposed by the NEBS standard, ( <i>CORE</i> ) Central Office Recovery Express (AT&T), ( <i>1089</i> ) specifies various parts of the General Requirements under Bellcore Technical Standard, Requirements for Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment
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
$\mu$ H	microhenry
$\mu$	microfarad
$\mu$ s	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane



# Executive Summary





## 1. Testing Summary

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 90, Subpart Z. All tests were conducted using measurement procedure ANSI TIA/EIA-603-A-2004.

Title 47 of the CFR, Part 90, Subpart Z, Reference and Test Description	Conformance			Comments
	Yes	No	N/A	
	Yes - Equipment complies with the Requirement No - Equipment does not comply with the Requirement N/A - Not applicable to the equipment under tests			
2.1046; 90.1215(a) Peak Power Output	√			Compliant
2.1046; 90.1215(a) Peak Power Spectral Density	√			Compliant
2.1049 Occupied Bandwidth	√			Compliant
2.1051 Spurious Emissions at Antenna Terminals	√			Compliant
2.1053; 90.210(M) Radiated Spurious Emissions	√			Compliant
RF exposure 90.1335	√			Compliant
15.107 AC Power Line Conducted Emissions for unintentional radiators	√			Compliant
15.109 Radiated Spurious Emissions for unintentional radiators	√			Compliant



# Equipment Configuration



## 2. Equipment Configuration

### 2.1. Overview

MET Laboratories, Inc. was contracted by LigoWave to perform testing on the LigoPTP 3-N under purchase order number 1037.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the LigoWave., LigoPTP 3-N.

An EMC evaluation to determine compliance of the TB 4.9 with the requirements of Part 90, Subpart Z, was conducted. (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 TB4.9. LigoWave. should retain a copy of this document and it should be kept on file for at least five years after the manufacturing of the EUT has been **permanently** discontinued. The results obtained relate only to the item(s) tested.

<b>Model(s) Tested:</b>	LigoPTP 3-N	
<b>Model(s) Covered:</b>	LigoPTP 3-N and LigoPTP 3-18	
<b>EUT Specifications:</b>	Primary Power Source: 18V (POE)	
	FCC ID: V2V-PTP3	
	Type of Modulations:	OFDM
	Emission Designators:	5MHz: 4M14D7D
		10MHz: 8M25D7D
		20MHz: 16M7D7D
	Modulated Average Output Power:	5MHz: 36.27 dBm (EIRP)
		10MHz: 39.30 dBm (EIRP)
		20MHz: 41.71 dBm (EIRP)
<b>Analysis:</b>	Equipment Code:	TNB
	EUT Frequency Ranges:	3655 – 3670MHz
	The results obtained relate only to the item(s) tested.	
<b>Environmental Test Conditions:</b>	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
<b>Evaluated by:</b>	Dusmantha Tennakoon	
<b>Date(s):</b>	September 2, 2008	



## 2.2. 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 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.

## 2.3. Description of Test Sample

The LigoPTP 3-N and LigoPTP 3-18 are complete systems operating from 3.300GHz – 3.700GHz. The intended use of this product is fixed point to point and fixed point to multi-point wireless applications. T

The LigoPTP 3-N is a connectorized model that can be used with different antennas.

The LigoPTP 3-18 is an integrated model that has a built in 18dBi antenna.

## 2.4. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. 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	3.65GHZ OUTDOOR RADIO UNIT	LIGOPTP 3-N	N/A
2	POE POWER SUPPLY	A5-S20S18-V	R00081100022

Table 1. Equipment Configuration

## 2.5. Support Equipment

LigoWave supplied support equipment necessary for the operation and testing of the LigoPTP 3-N. All support equipment supplied is listed in the following Support Equipment List.

Ref. ID	Name / Description	Manufacturer	Model Number
3	DESKTOP PC	LG	N/A

Table 2. Support Equipment

## 2.6. Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty.	Length (m)	Shielded?	Termination Box ID & Port ID
4	POWER + DATA	CAT 5	1	1	N	N/A
5	DATA IN	CAT 5	1	2	N	PC

Table 3. Ports and Cabling Information

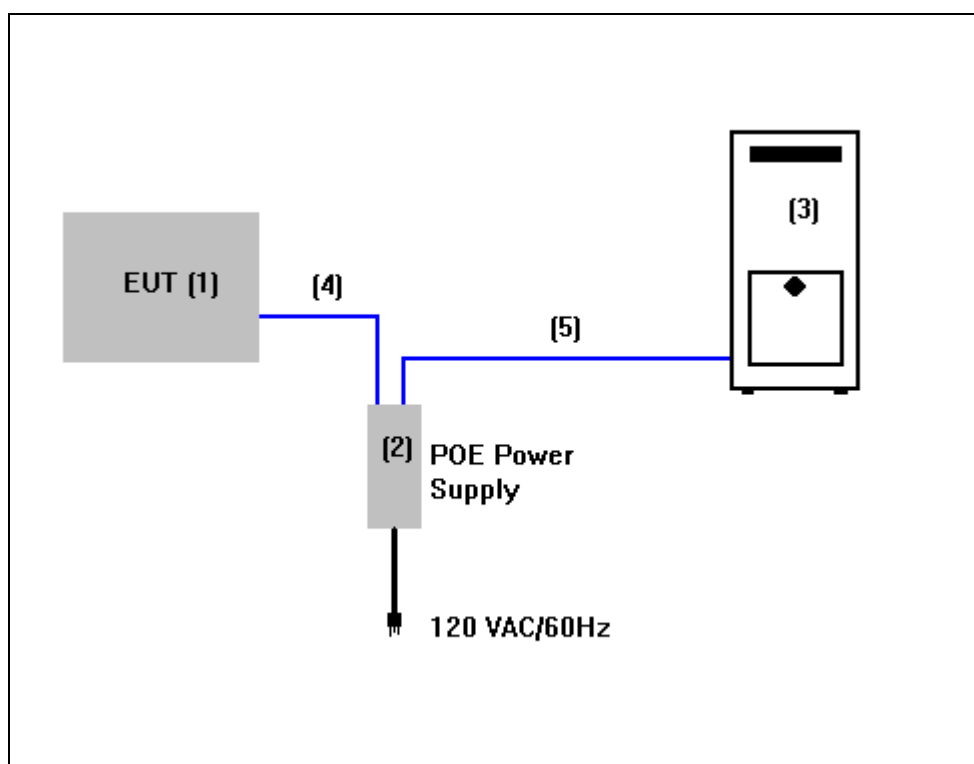


Figure 1. Block Diagram of Test Configuration



Figure 2. Picture of EUT



## **2.7. Mode of Operation**

The EUT is a 3.65GHz radio unit. This radio will be loaded and controlled by an external computer. This device provides seven transmitting speeds, 6, 9, 12, 24, 36, 48 and 54Mbps. The device of RF carrier is BPSK, QPSK, 16QAM and 64QAM. ART software running on the laptop was used to control the radio.

## **2.8. Modifications**

### **2.8.1. Modifications to EUT**

No modifications were made to the EUT.

### **2.8.2. Modifications to Test Standard**

No modifications were made to the EUT.

## **2.9. Disposition of EUT**

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



### **III. Electromagnetic Compatibility Criteria for Unintentional Radiators**





### 3. Electromagnetic Compatibility Criteria for Unintentional Radiators

#### 3.1. Conducted Emissions Limits

**Test Requirement(s):** **15.107 (a)** “Except for Class A digital devices, for equipment 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 30 MHz shall not exceed the limits in Table 4. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.”

**15.107 (b)** “For a Class A digital device 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 30 MHz shall not exceed the limits in Table 4. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals. The lower limit applies at the band edges.”

Frequency range (MHz)	15.107(b), Class A Limits (dBμV)		15.107(a), Class B Limits (dBμV)	
	Quasi-Peak	Average	Quasi-Peak	Average
0.15- 0.5	79	66	66 - 56	56 - 46
0.5 – 5.0	73	60	56	46
5.0 - 30	73	60	60	50
Note — The lower limit shall apply at the transition frequencies.				

**Table 4. Conducted Limits for Radio Frequency Devices calculated from FCC Part 15 Section 15.107(a) (b)**

**Test Procedures:** The EUT was placed on a 0.8m-high wooden table inside a screen room. The method of testing, test conditions, and test procedures of ANSI C63.4 were used. The EUT was powered through a 50Ω/50μH LISN. An EMI receiver, connected to the measurement port of the LISN, scanned the frequency range from 150 kHz to 30 MHz in order to find the peak conducted emissions. All peak emissions within 6 dB of the limit were re-measured using a quasi-peak and/or average detector as appropriate.

**Test Results:** The EUT was found compliant with the Class B requirement(s) of this section. Measured emissions below applicable limits.

**Test Engineer(s):** Dusmantha Tennakoon

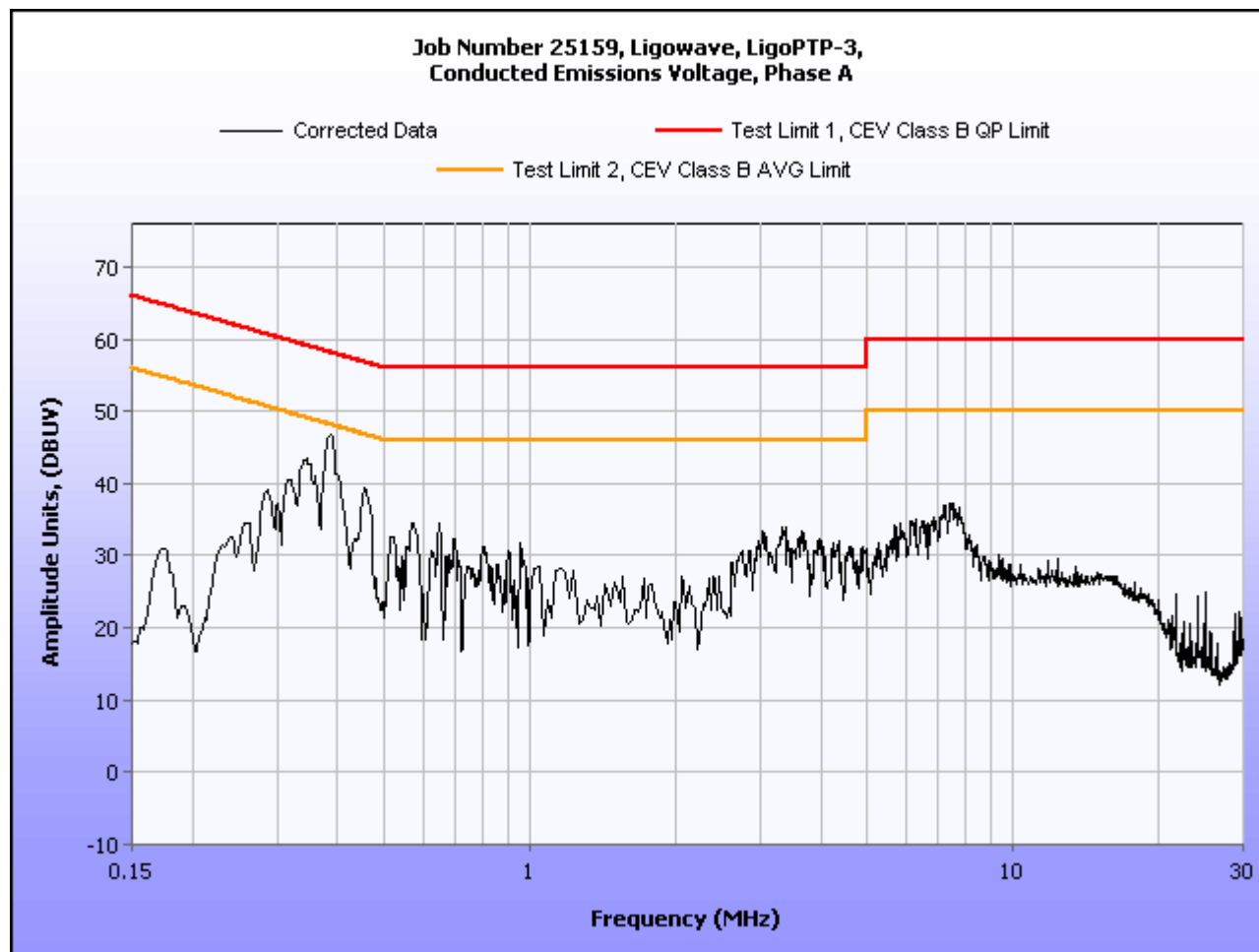
**Test Date(s):** 08/19/2008



## Conducted Emissions - Voltage, AC Power

FREQ. (MHz)	Corrected Amplitude (dBuV) QP	Limit (dBuV) QP	Margin (dB) QP	Corrected Amplitude (dBuV) AVG	Limit (dBuV) AVG	Margin (dB) AVG
0.2569	34.5	61.53	-27.03	29.17	51.53	-22.36
0.3218	39.3	59.66	-20.36	32.94	49.66	-16.72
0.3854	46.37	58.16	-11.79	39.49	48.16	-8.67
3.467	32.48	56	-23.52	31.05	46	-14.95
7.643	33.424293	60	-26.5757	29.474293	50	-20.5257
25	29.92	60	-30.08	29.93	50	-20.07

Table 5. Conducted Emissions - Voltage, AC Power, Phase Line 120VAC, 60Hz

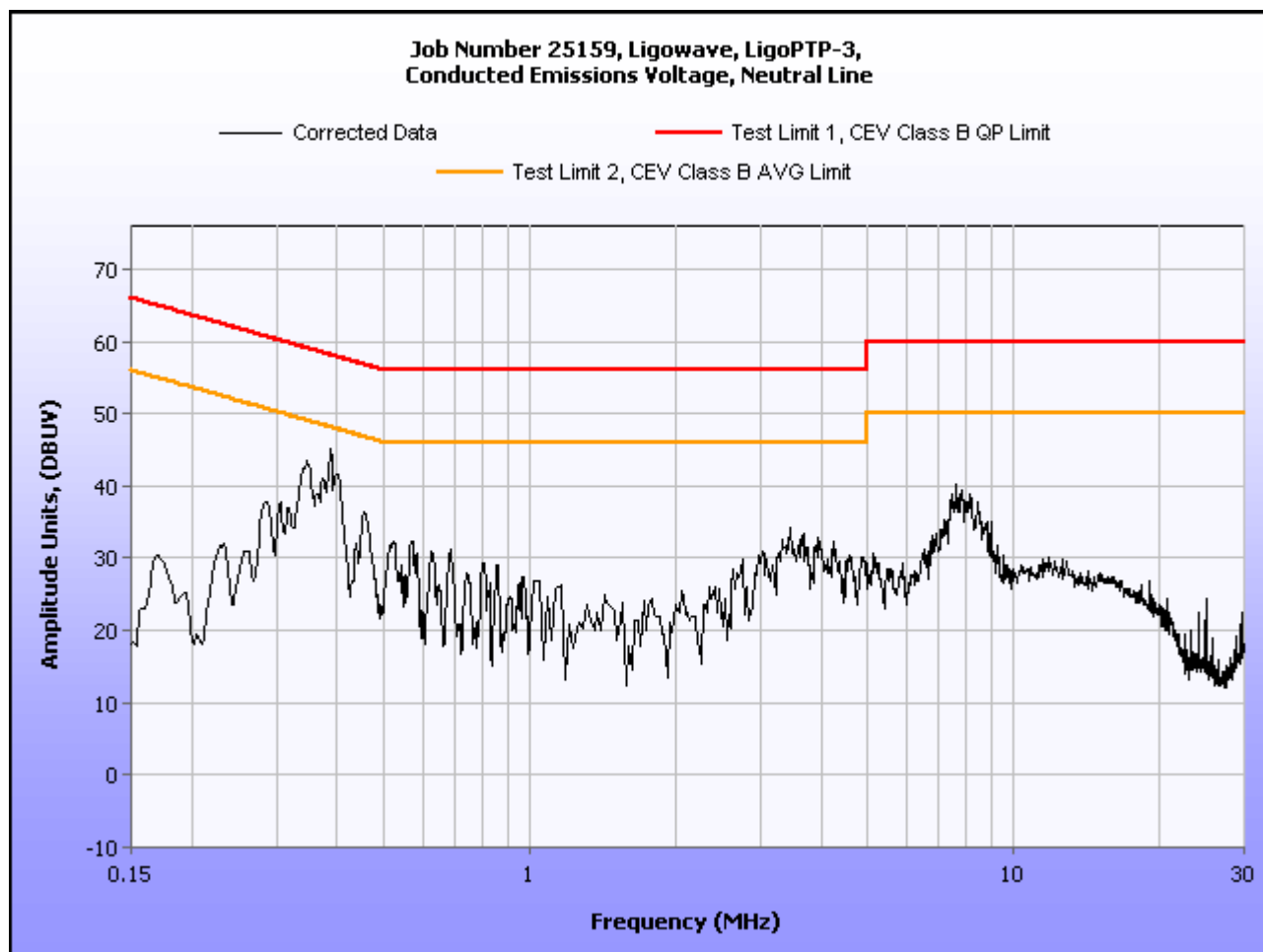


Plot 1. Conducted Emission, Phase Line Plot



FREQ. (MHz)	Corrected Amplitude (dBuV) QP	Limit (dBuV) QP	Margin (dB) QP	Corrected Amplitude (dBuV) AVG	Limit (dBuV) AVG	Margin (dB) AVG
0.2568	32.14	61.53	-29.39	20.35	51.53	-31.18
0.3238	35.92	59.61	-23.69	23.2	49.61	-26.41
0.3889	40.29	58.09	-17.8	30.77	48.09	-17.32
3.726	32.74	56	-23.26	31.21	46	-14.79
7.843	34.76496	60	-25.235	28.70496	50	-21.295
25	29.7	60	-30.3	29.74	50	-20.26

Table 6. Conducted Emissions - Voltage, AC Power, Neutral Line 120VAC, 60Hz



Plot 2. Conducted Emission, Neutral Line Plot



### 3.2. Radiated Emissions Limits

**Test Requirement(s):** **15.109 (a)** Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the Class B limits expressed in Table 7.

**15.109 (b)** The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the Class A limits expressed in Table 7.

Frequency (MHz)	Field Strength (dB $\mu$ V/m)	
	§15.109 (b), Class A Limit (dB $\mu$ V) @ 10m	§15.109 (a), Class B Limit (dB $\mu$ V) @ 3m
30 - 88	39.00	40.00
88 - 216	43.50	43.50
216 - 960	46.40	46.00
Above 960	49.50	54.00

**Table 7. Radiated Emissions Limits calculated from FCC Part 15, §15.109 (a) (b)**

**Test Procedures:** The EUT was placed inside a semi-anechoic chamber. The method of testing and test conditions of ANSI C63.4 were used. An antenna was located 3 m from the EUT on an adjustable mast. A pre-scan was first performed in order to find prominent radiated emissions. For final emissions measurements at each frequency of interest, the EUT was rotated and the antenna height was varied between 1 m and 4 m in order to maximize the emission. Measurements in both horizontal and vertical polarities were made and the data was recorded. Unless otherwise specified, measurements were made using a quasi-peak detector with a 120 kHz bandwidth.

**Test Results:** The EUT was found compliant with the Class B requirement(s) of this section. Measured emissions below applicable limits.

**Test Engineer(s):** Dusmantha Tennakoon

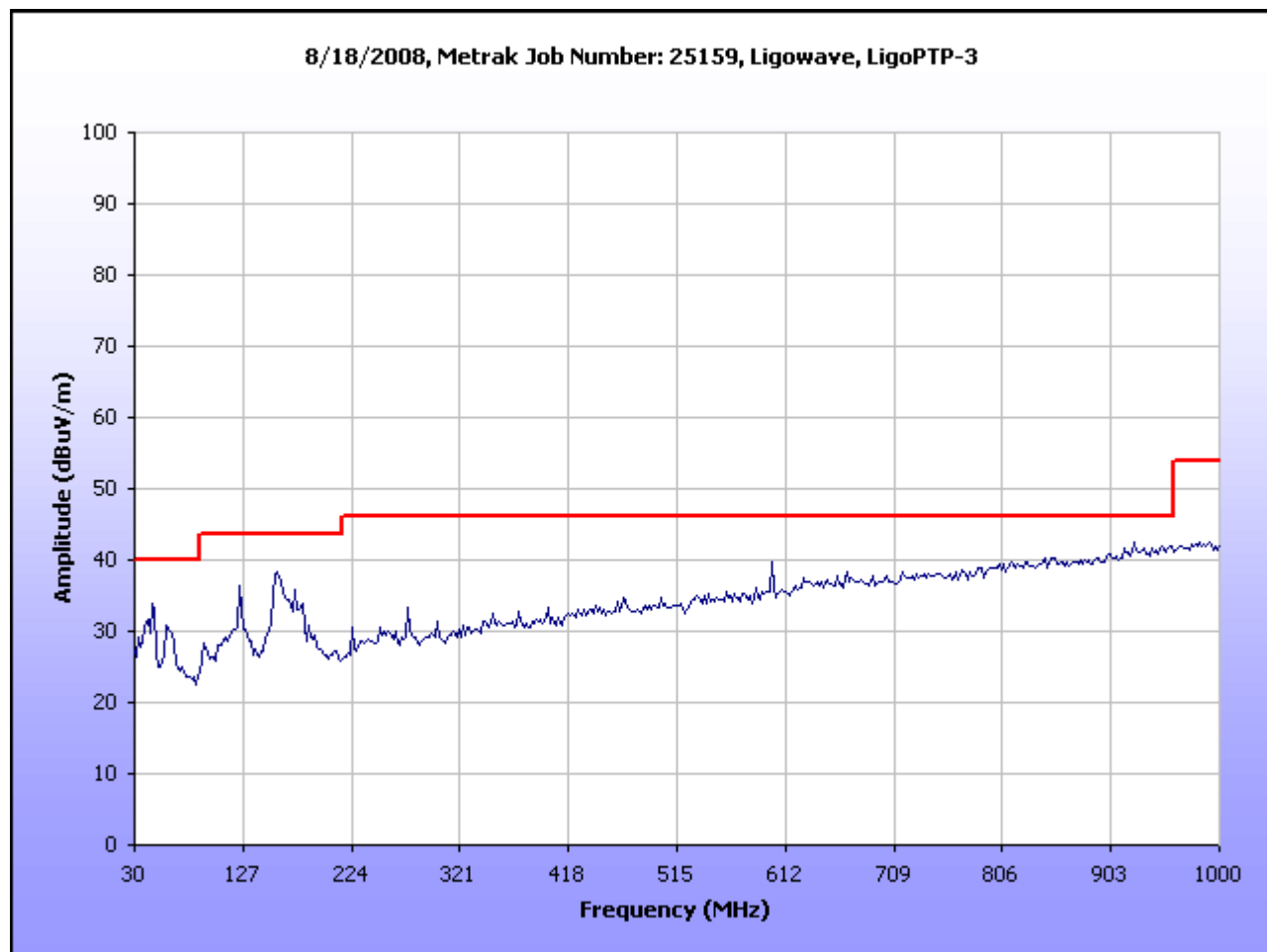
**Test Date(s):** 08/18/2008



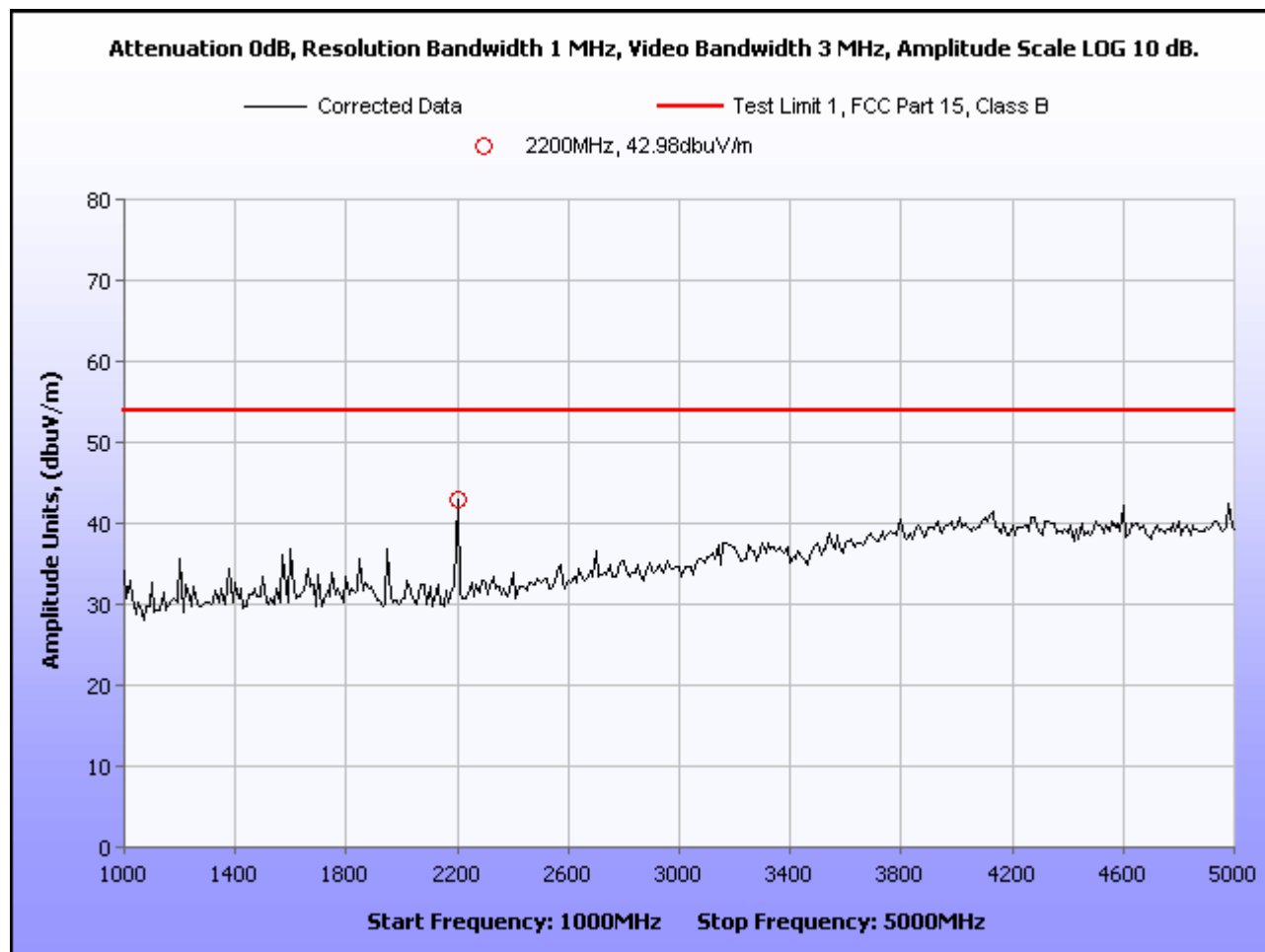
## Radiated Emissions Limits Test Results, Class B

Frequency (MHz)	Antenna Polarity (H/V)	EUT Azimuth (Degrees)	Antenna Height (m)	Uncorrected Amplitude QP Detector (dBuv)	Antenna Correction Factor (dB/m) (+)	Cable Loss (dB) (+)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
46.559	H	316	1.00	5.72	9.59	0.98	16.30	40.00	-23.70
46.559	V	167	1.00	21.58	9.22	0.98	31.78	40.00	-8.22
61.337	H	360	1.00	5.50	10.43	1.06	16.98	40.00	-23.02
61.337	V	12	1.00	17.59	10.10	1.06	28.75	40.00	-11.25
124.996	H	57	1.00	17.50	7.40	1.31	26.21	43.50	-17.29
124.996	V	320	1.00	26.78	7.90	1.31	35.99	43.50	-7.51
158.236	H	146	1.43	20.39	8.16	1.31	29.86	43.50	-13.64
158.236	V	276	1.00	27.54	8.26	1.31	37.11	43.50	-6.39
599.584	H	296	1.00	10.50	18.78	2.28	31.56	46.00	-14.44
599.584	V	274	1.33	18.87	18.79	2.28	39.94	46.00	-6.06
899.904	H	34	1.00	5.80	22.50	2.67	30.97	46.00	-15.03
899.904	V	360	1.00	6.16	22.10	2.67	30.93	46.00	-15.07

Table 8. Radiated Emissions Limits Test Results

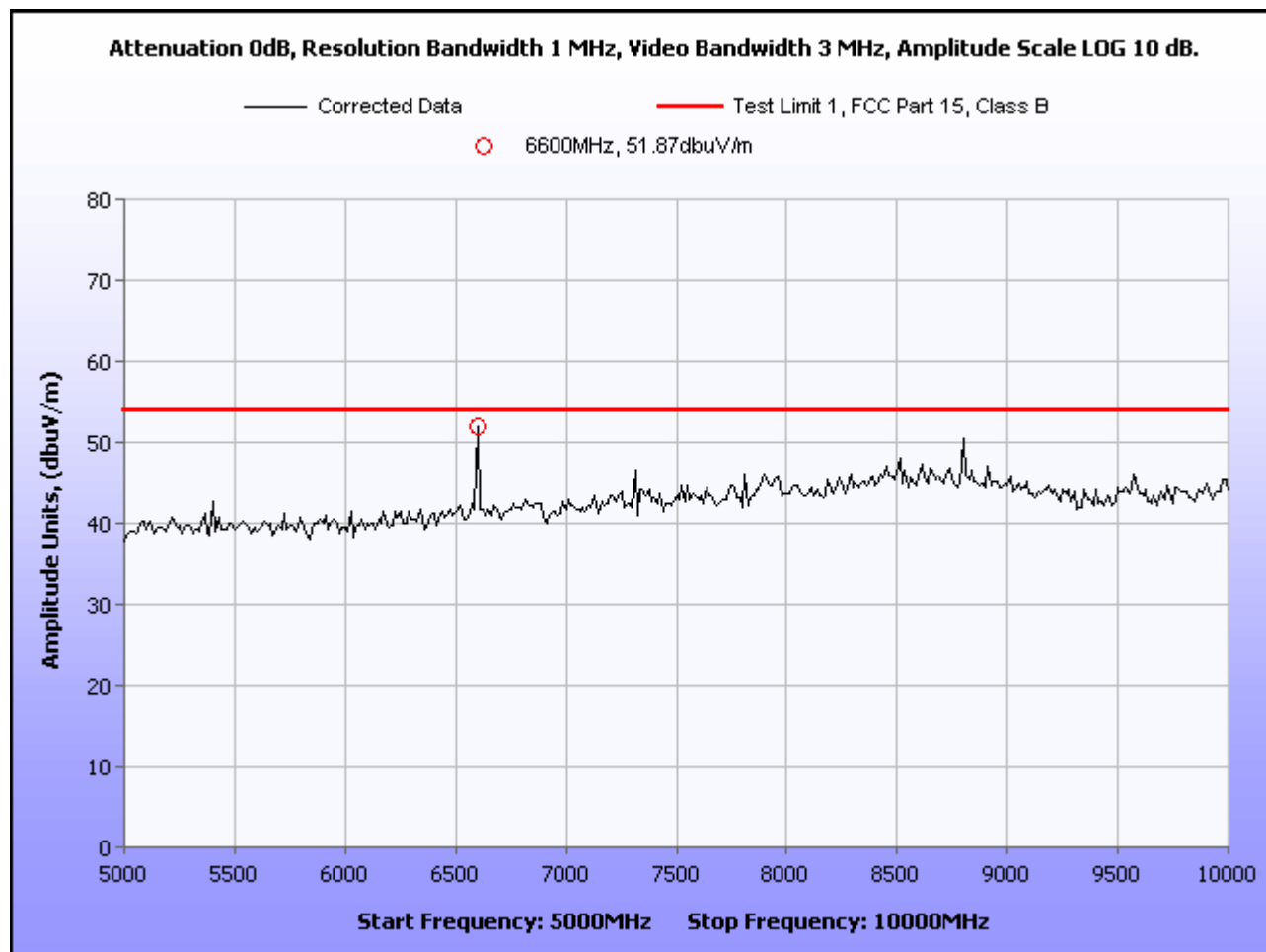


Plot 3. Radiated Emissions, Pre-Scan



Plot 4. Radiated Emissions, 1GHz – 5GHz

Emissions in the plot have been corrected for distance, cable loss, antenna correction factor, and preamp.



**Plot 5. Radiated Emissions, 5GHz – 10GHz**

Emissions in the plot have been corrected for distance, cable loss, antenna correction factor, and preamp.





## **IV. Electromagnetic Compatibility Criteria for Intentional Radiators**



#### 4. Electromagnetic Compatibility RF Power Output Requirements

##### 4.1. RF Power Output

**Test Requirement(s):** §2.1046 and §90.1321 (a)

**Test Procedures:** As required by 47 CFR 2.1046, *RF power output measurements* were made at the RF output terminals using a Spectrum Analyzer.

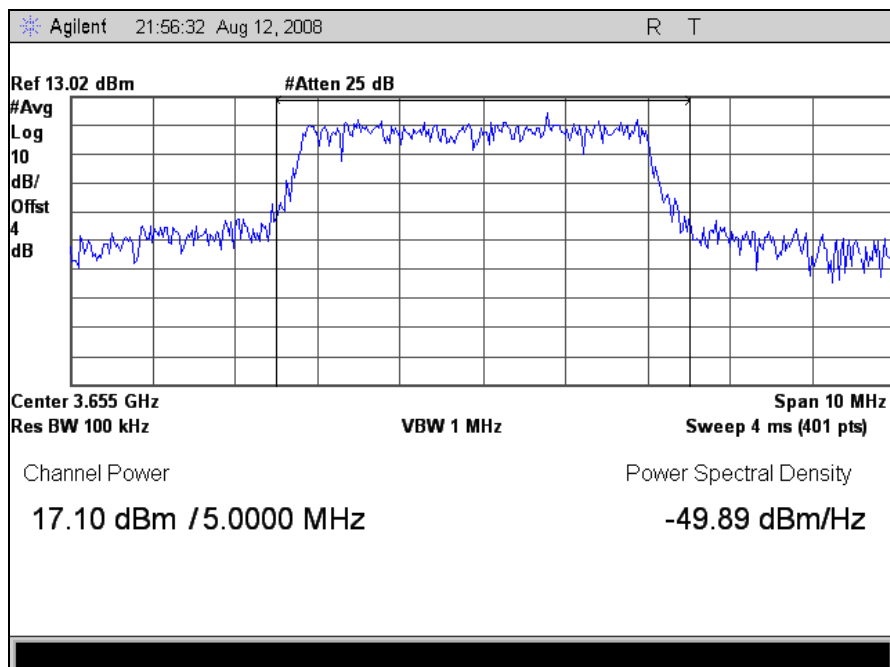
Art software was used to control the power level on the radio. Measurements were made at 6Mbps data rate. All cable corrections have been programmed into spectrum analyzer.

**Test Results:** Equipment complies with 47CFR 2.1046 and 90.1321(a).

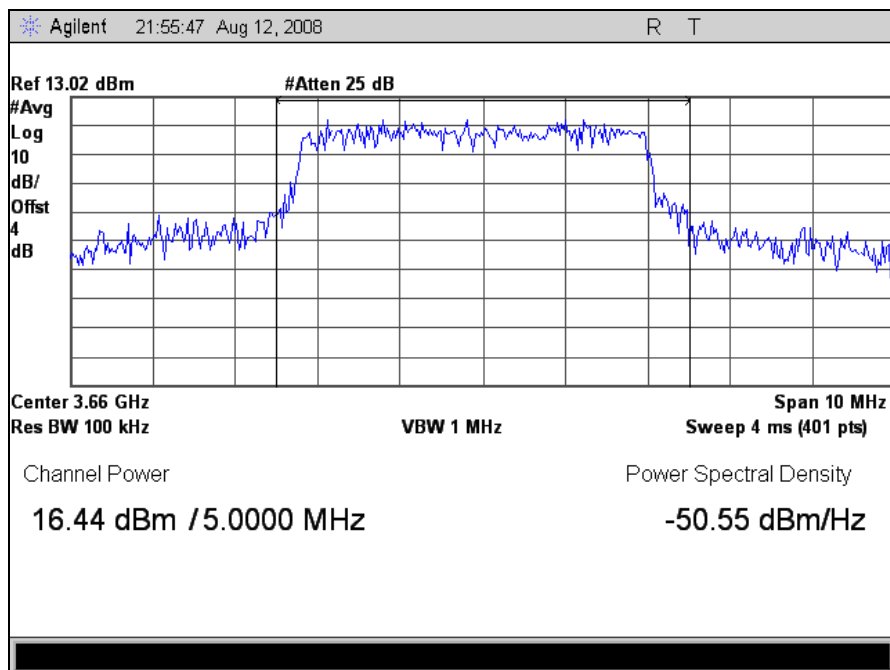
Channel Bandwidth (MHz)	Frequency (GHz)	Conducted Power (dBm) - Average	Max Antenna Gain (dBi)	EIRP (dBm)	Limit (dBm)
5	3.655	17.1	19	36.10	37
	3.660	16.44	19	35.44	37
	3.665	17.27	19	36.27	37
	3.670	16.72	19	35.72	37
10	3.660	20.36	18.5	38.86	40
	3.665	20.8	18.5	39.30	40
20	3.660	18.02	23.5	41.52	43
	3.665	18.21	23.5	41.71	43

**Test Engineer(s):** Dusmantha Tennakoon

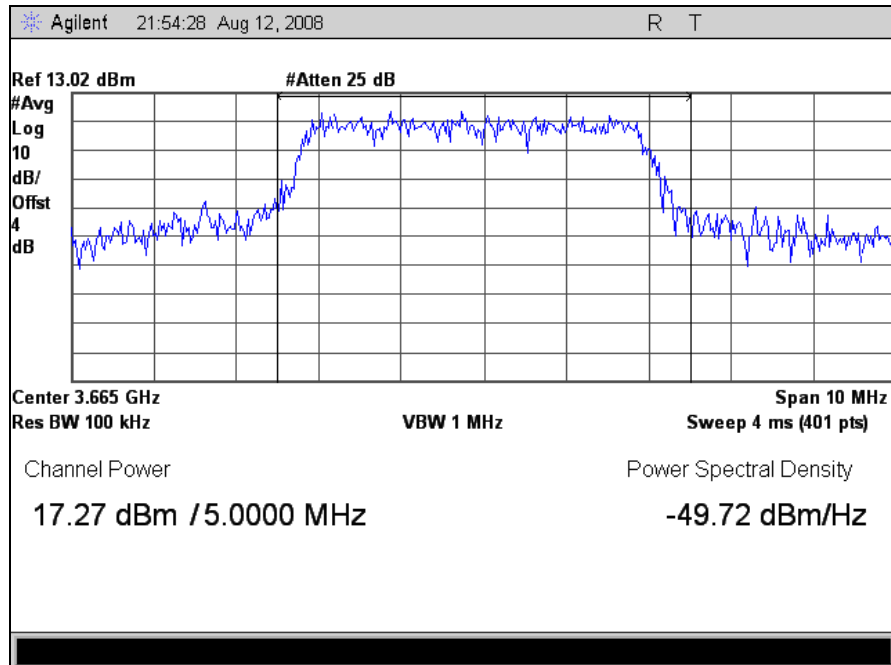
**Test Date(s):** 08/19/2008



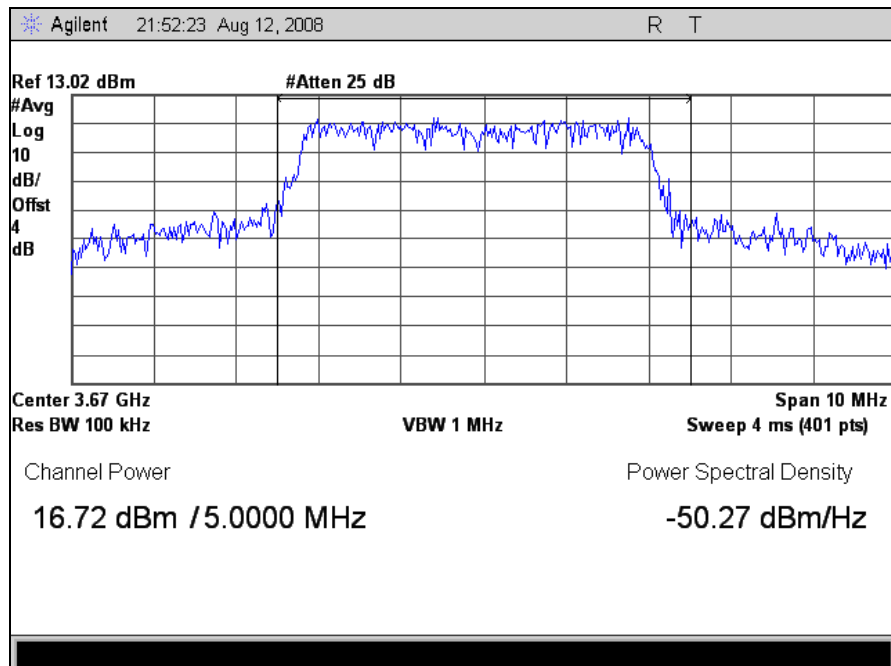
Plot 6. RF Power Output, 3655MHz (5MHz)



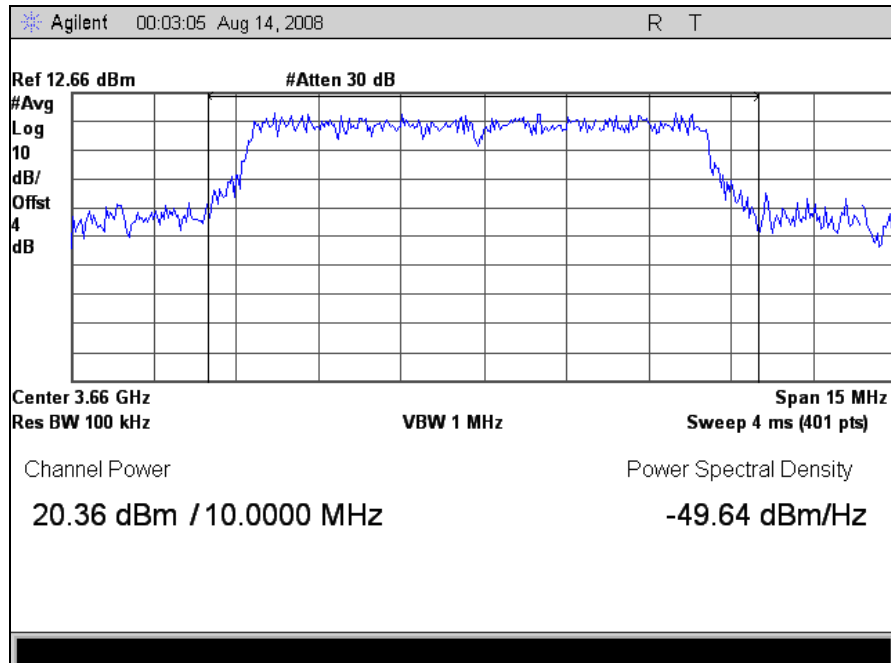
Plot 7. RF Power Output, 3660MHz (5MHz)



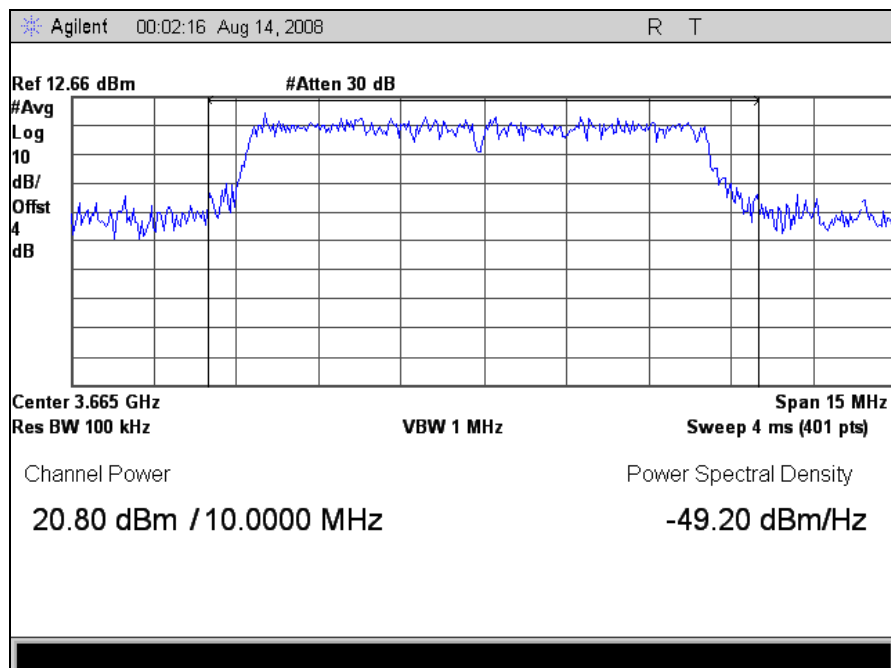
Plot 8. RF Power Output, 3665MHz (5MHz)



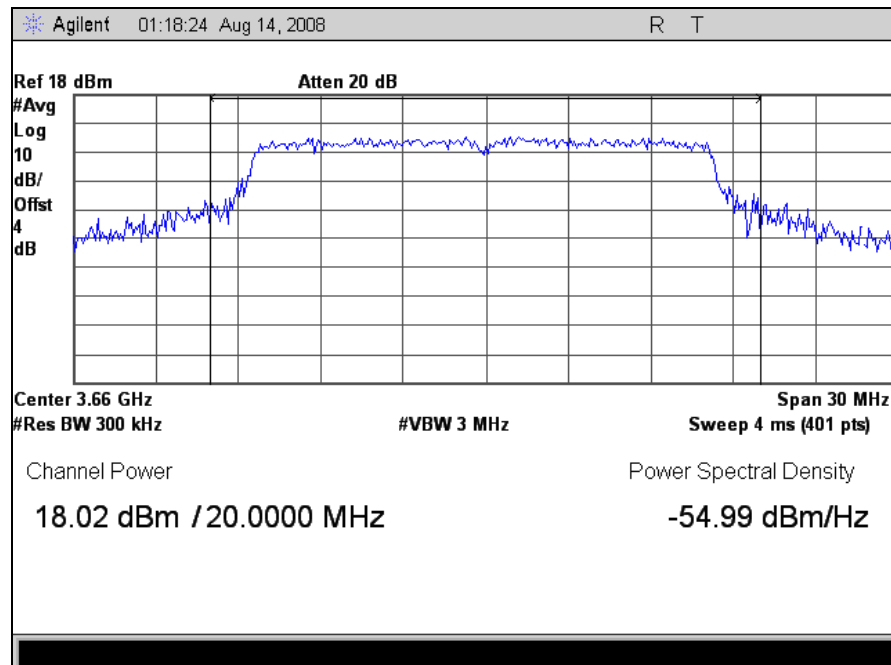
Plot 9. RF Power Output, 3670MHz (5MHz)



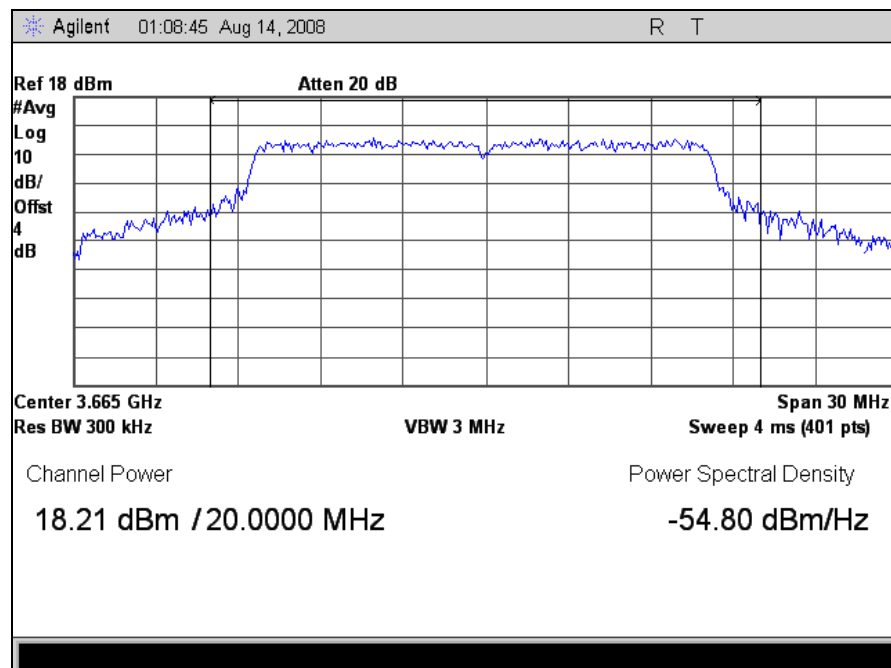
Plot 10. RF Power Output, 3660MHz (10MHz)



Plot 11. RF Power Output, 3665MHz (10MHz)



Plot 12. RF Power Output, 3660MHz (20MHz)



Plot 13. RF Power Output, 3665MHz (20MHz)



## 4.2. Peak Power Spectral Density

**Test Requirement(s):** §90.1321(a) check docket

**Test Procedures:** As required by §90.1321(a), *power spectral density measurements* were made at the RF output terminals using a Spectrum Analyzer.

Measurements were made at 6 Mbps data rate. All cable corrections have been programmed into spectrum analyzer.

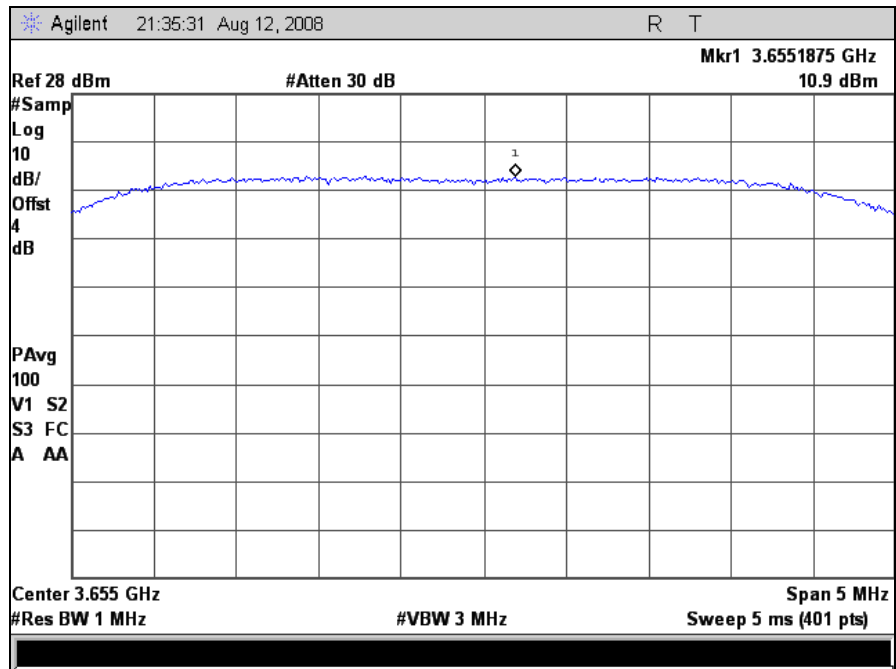
**Test Results:** Equipment complies with 47 CFR 2.1046 and 90.1321(a).

The following pages show measurements of Peak Power Spectral Density plots which is recorded below:

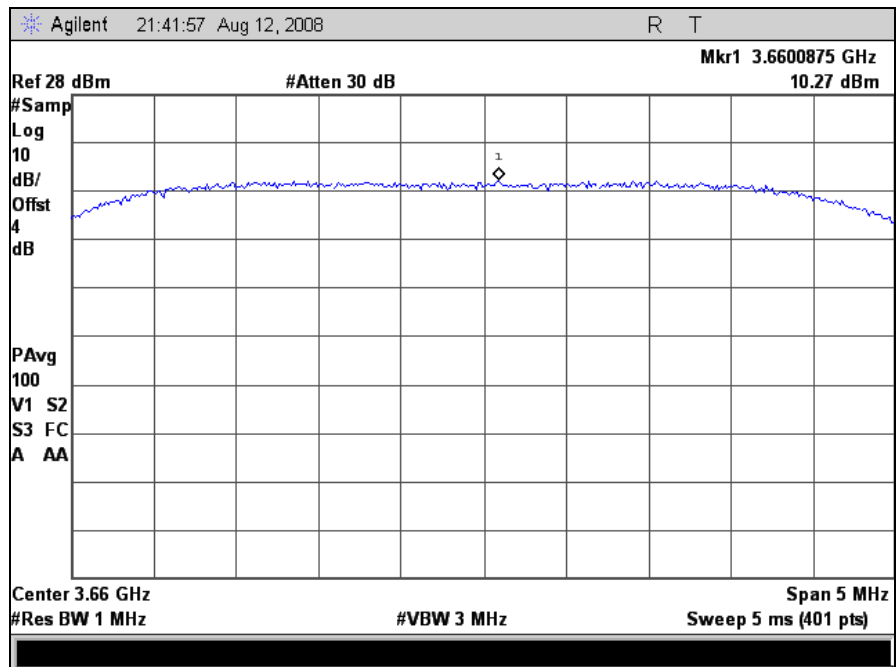
Channel Bandwidth (MHz)	Frequency (GHz)	PSD (dBm)	Max Antenna Gain (dBi)	EIRP (dBm)	Limit (dBm)
5	3.655	10.90	19	29.90	30
	3.660	10.27	19	29.27	30
	3.665	10.50	19	29.50	30
	3.670	10.35	19	29.35	30
10	3.660	11.27	18.5	29.77	30
	3.665	11.49	18.5	29.99	30
20	3.660	6.46	23.5	29.96	30
	3.665	6.00	23.5	29.50	30

**Test Engineer(s):** Dusmantha Tennakoon

**Test Date(s):** 08/19/2008

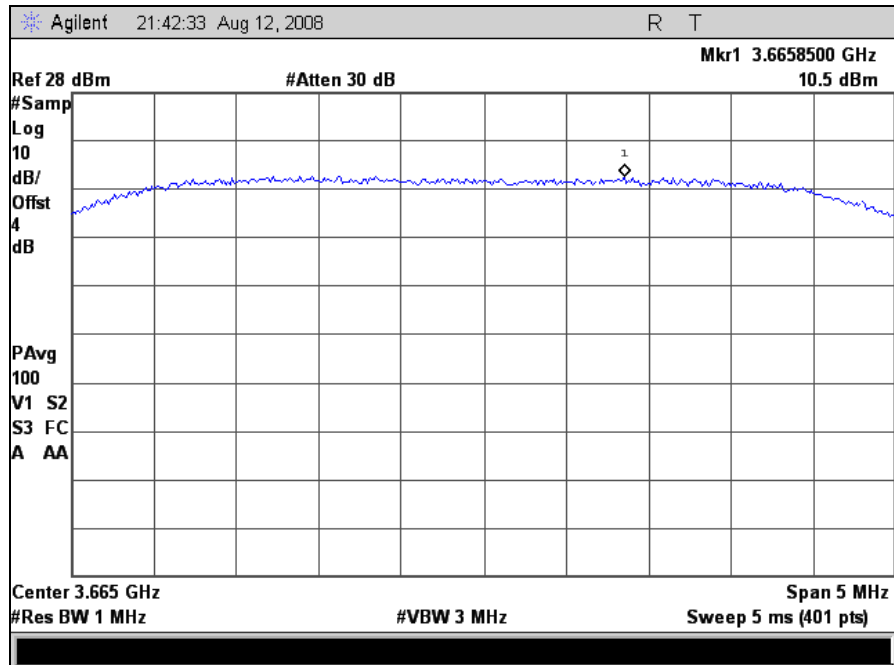


Plot 14. Peak Power Spectral Density, 3655MHz (5MHz)

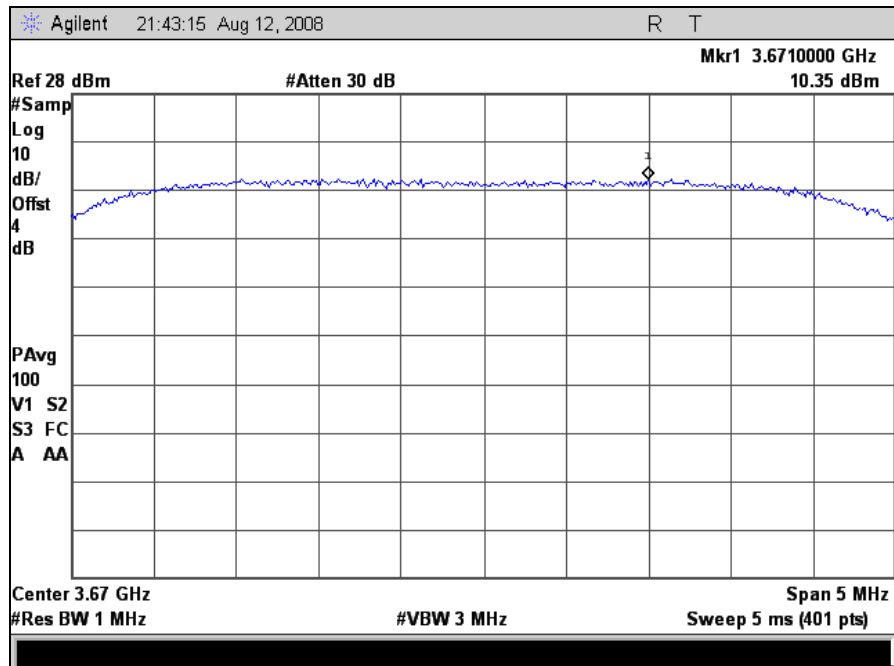


Plot 15. Peak Power Spectral Density, 3660MHz (5MHz)

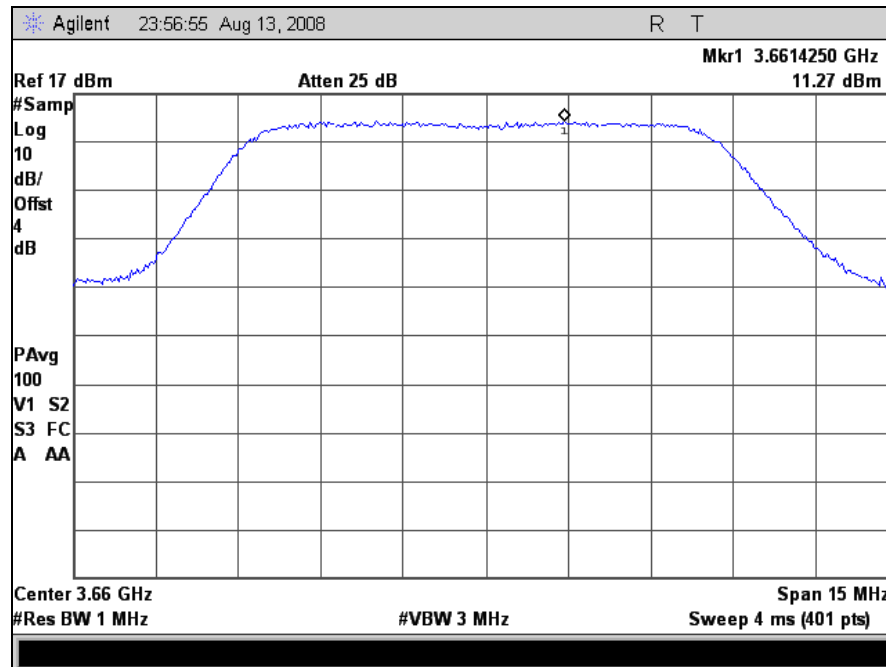




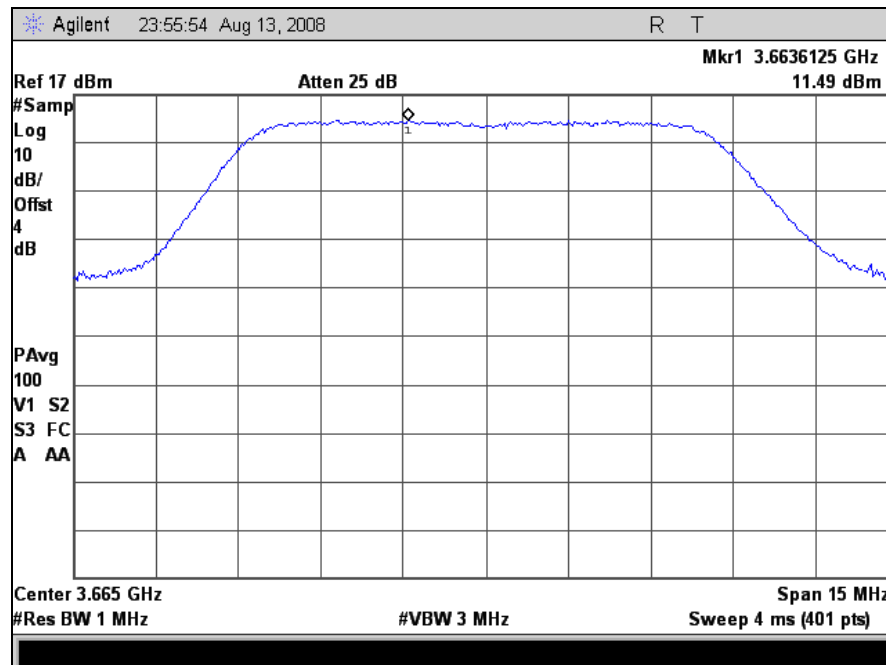
Plot 16. Peak Power Spectral Density, 3665MHz (5MHz)



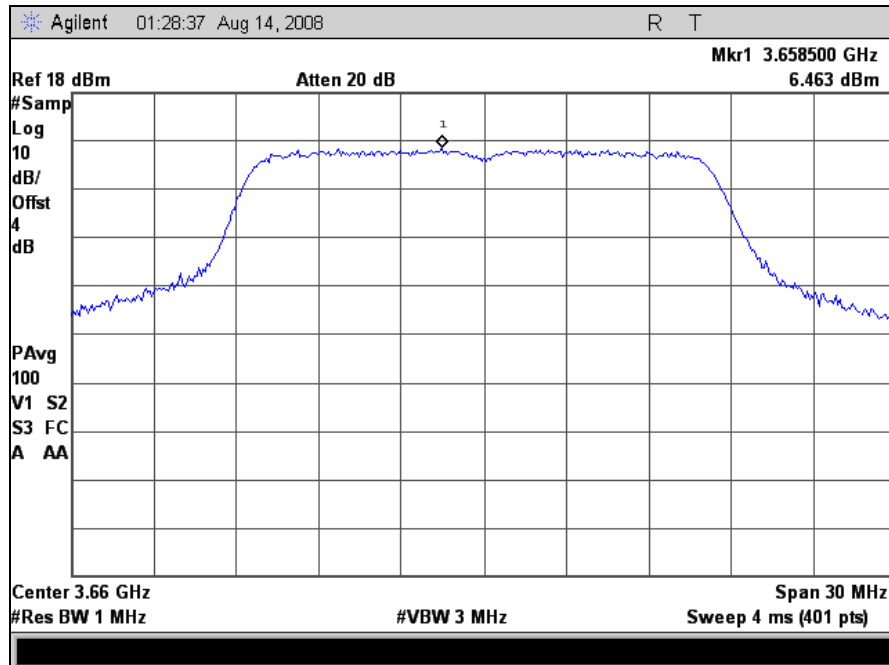
Plot 17. Peak Power Spectral Density, 3670MHz (5MHz)



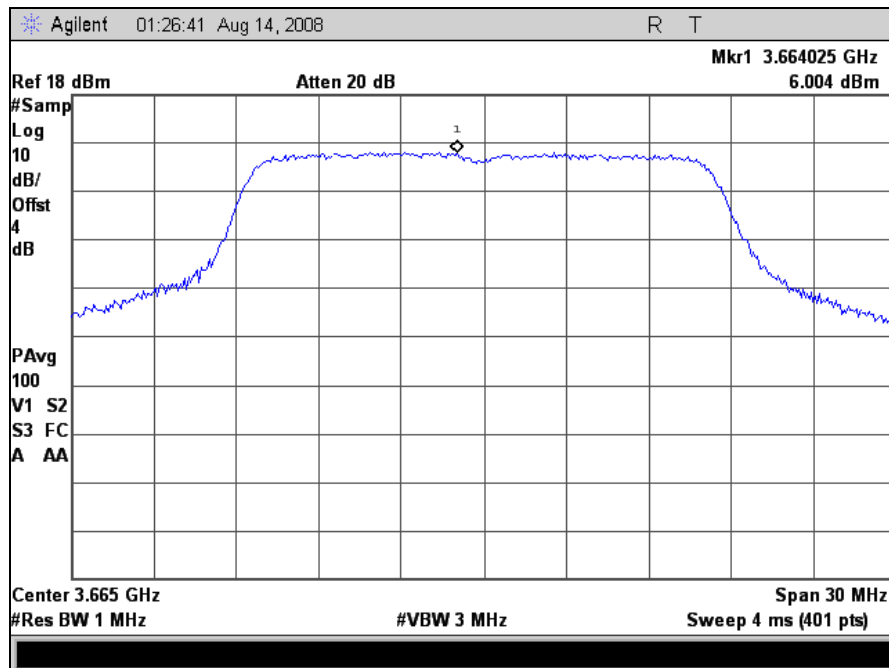
Plot 18. Peak Power Spectral Density, 3660MHz (10MHz)



Plot 19. Peak Power Spectral Density, 3665MHz (10MHz)



Plot 20. Peak Power Spectral Density, 3660MHz (20MHz)



Plot 21. Peak Power Spectral Density, 3665MHz (20MHz)



## 5. Electromagnetic Compatibility Occupied Bandwidth Requirements

### 5.1. Occupied Bandwidth

**Test Requirement(s):** §2.1049

**Test Procedures:** As required by 47 CFR 2.1049, *occupied bandwidth measurements* were made at the RF output terminals using a Spectrum Analyzer.

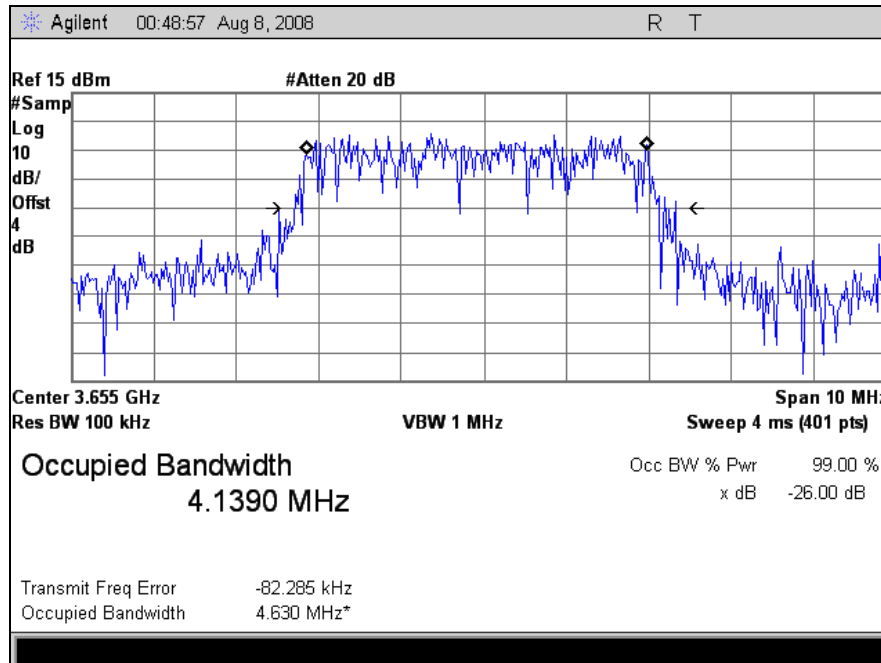
The RBW of the Spectrum Analyzer was set to at least 1% of the channel bandwidth. Measurements were made at 6Mbps data rate.

**Test Results:** Equipment complies with Section 2.1049

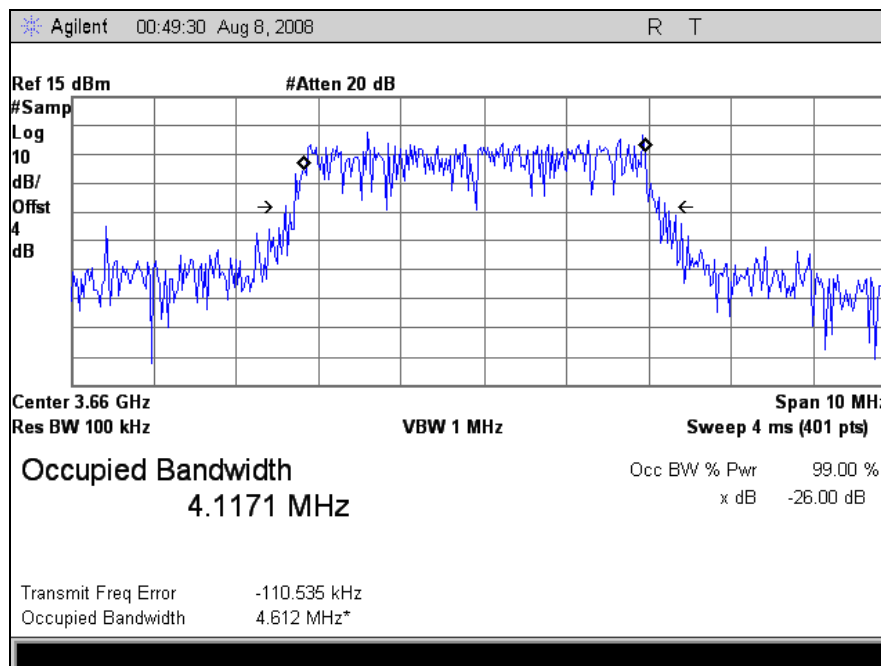
The following pages show measurements of occupied band width.

**Test Engineer(s):** Dusmantha Tennakoon

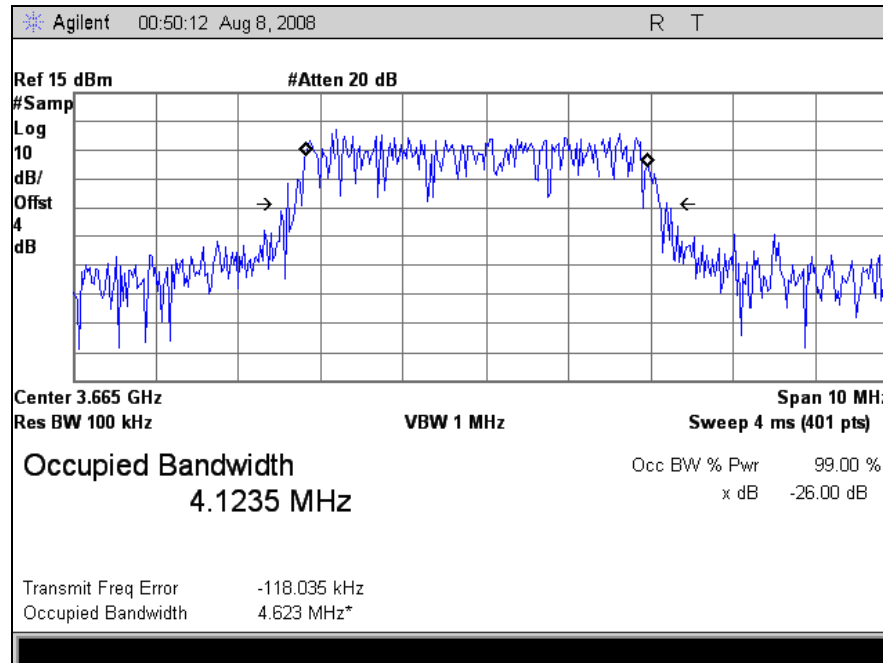
**Test Date(s):** 08/19/2008



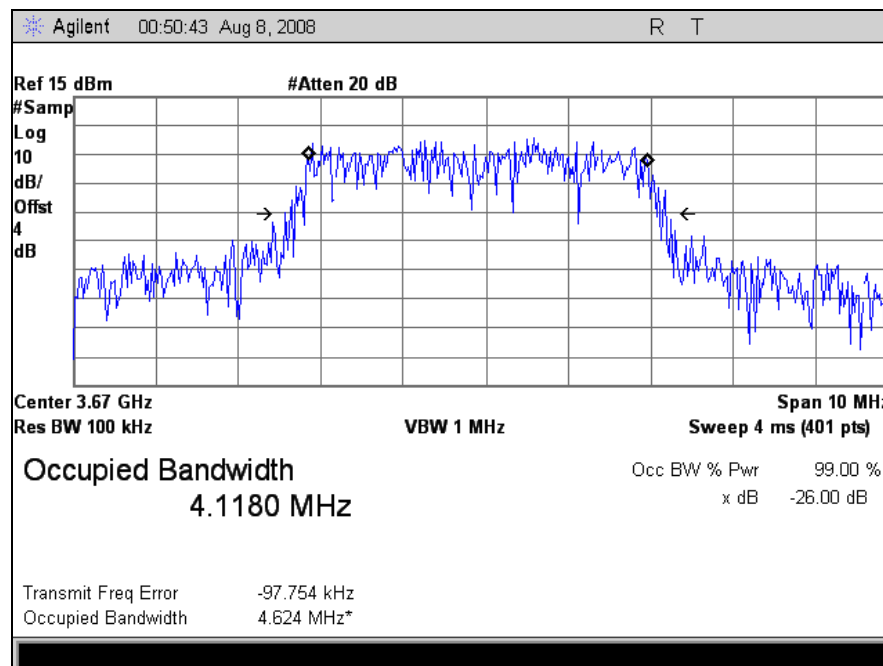
Plot 22. Occupied Bandwidth, 3655MHz (5MHz)



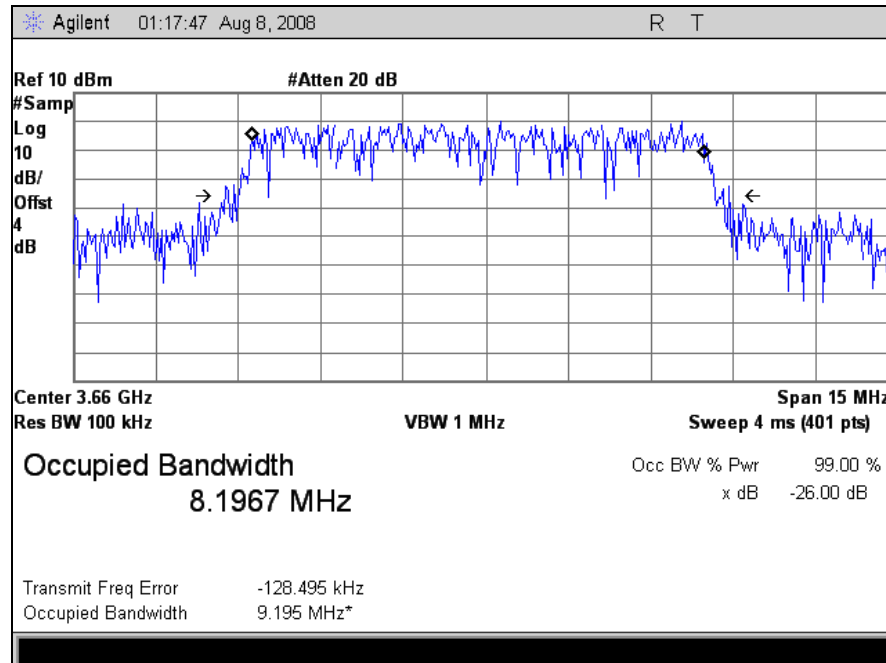
Plot 23. Occupied Bandwidth, 3660MHz (5MHz)



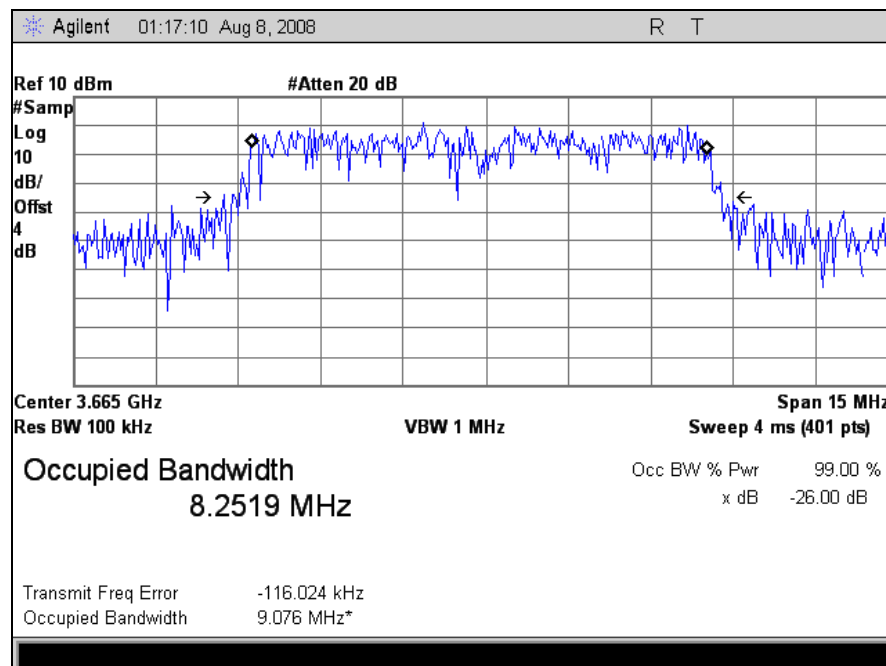
Plot 24. Occupied Bandwidth, 3665MHz (5MHz)



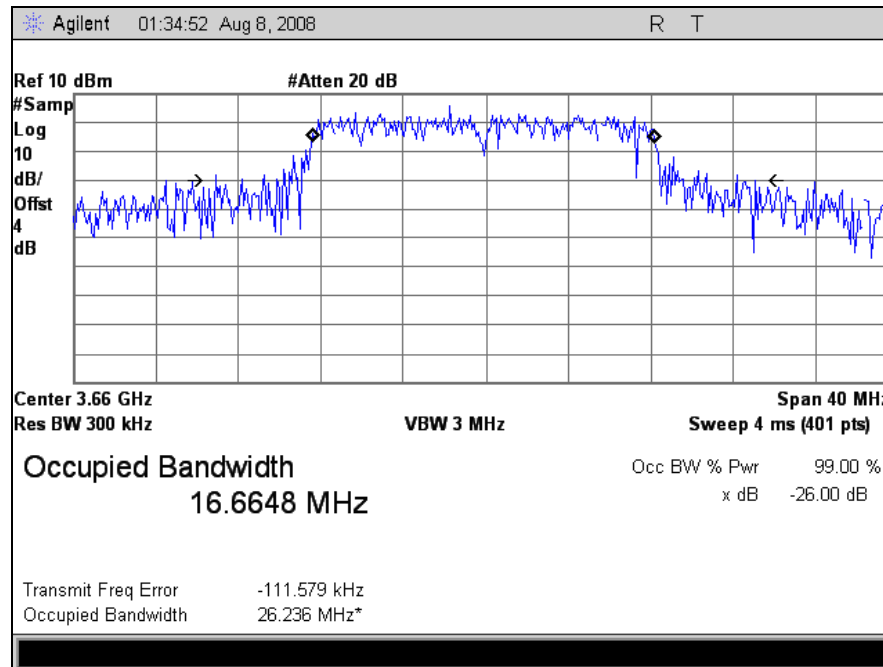
Plot 25. Occupied Bandwidth, 3670MHz (5MHz)



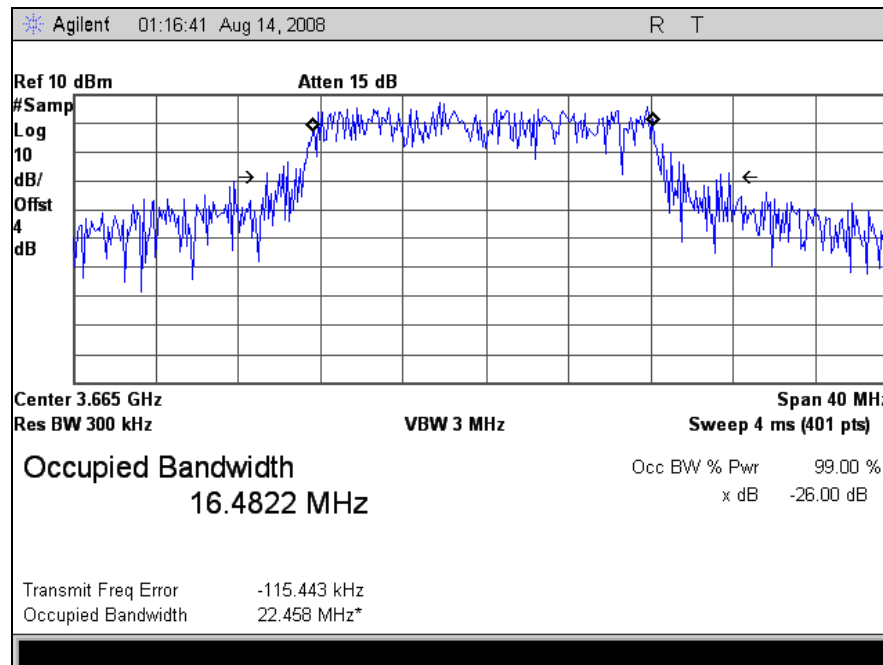
Plot 26. Occupied Bandwidth, 3660MHz (10MHz)



Plot 27. Occupied Bandwidth, 3665MHz (10MHz)



Plot 28. Occupied Bandwidth, 3660MHz (20MHz)



Plot 29. Occupied Bandwidth, 3665MHz (20MHz)





## 6. Electromagnetic Compatibility Spurious Emissions at Antenna Terminal Requirements

### 6.1. Spurious Emissions at Antenna Terminals

**Test Requirement(s):** §2.1051 and §90.1323(a)

**Test Procedures:** As required by 47 CFR 2.1051, *spurious emissions at antenna terminal measurements* were made at the RF output terminals using a Spectrum Analyzer.

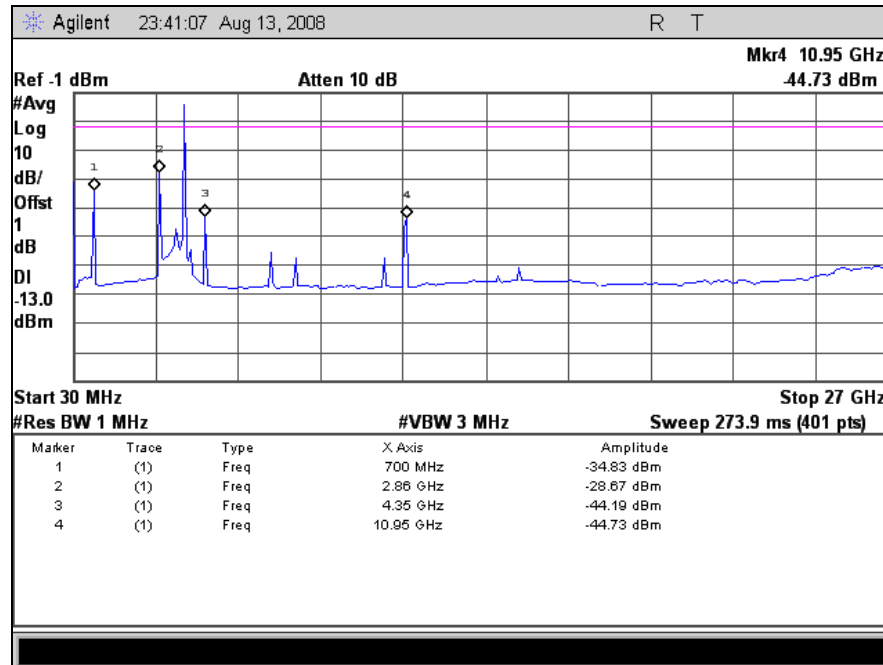
A laptop was connected to EUT to control the RF power output and frequency channel. The EUT was connected to a Spectrum Analyzer. The Spectrum Analyzer was set to sweep from 30 MHz up to 27GHz. Only noise floor was observed between 27 – 40 GHz

The Conducted Spurious Emissions are shown in the following pages.

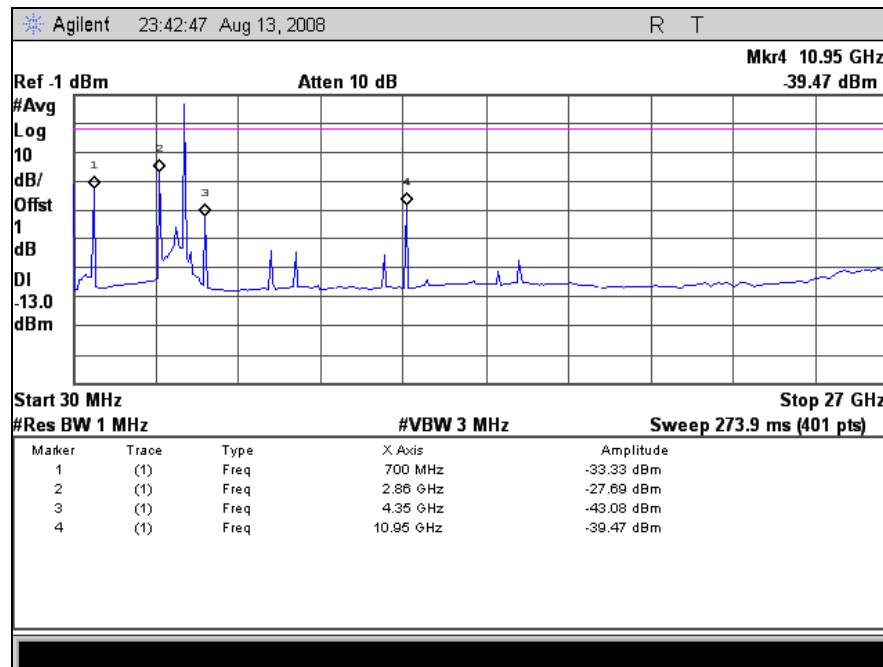
**Test Results:** Equipment complies with Section 2.1051 and 90.1323(a).

**Test Engineer(s):** Dusmantha Tennakoon

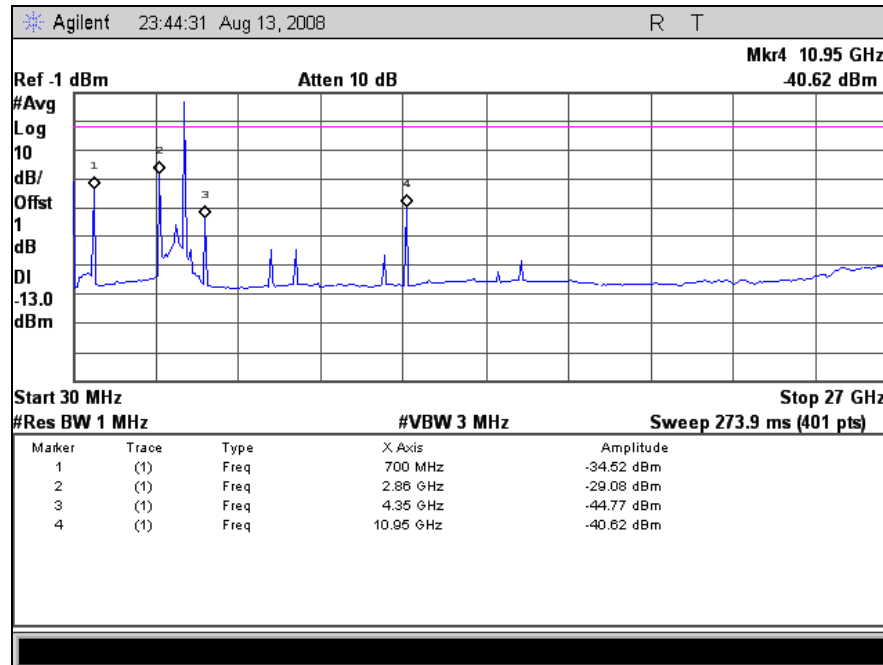
**Test Date(s):** 08/19/2008



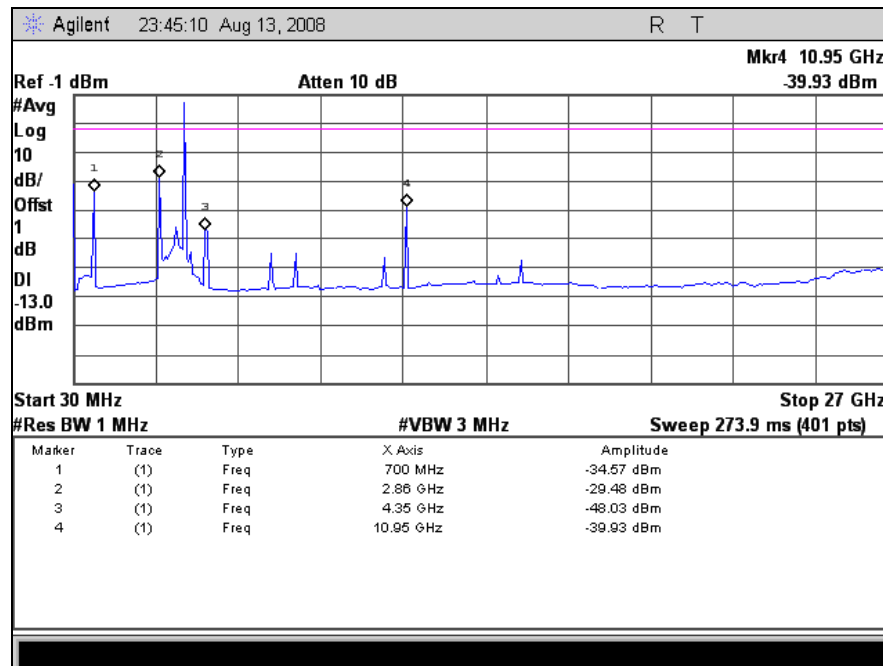
Plot 30. Conducted Spurious Emissions, 3655MHz (5MHz)



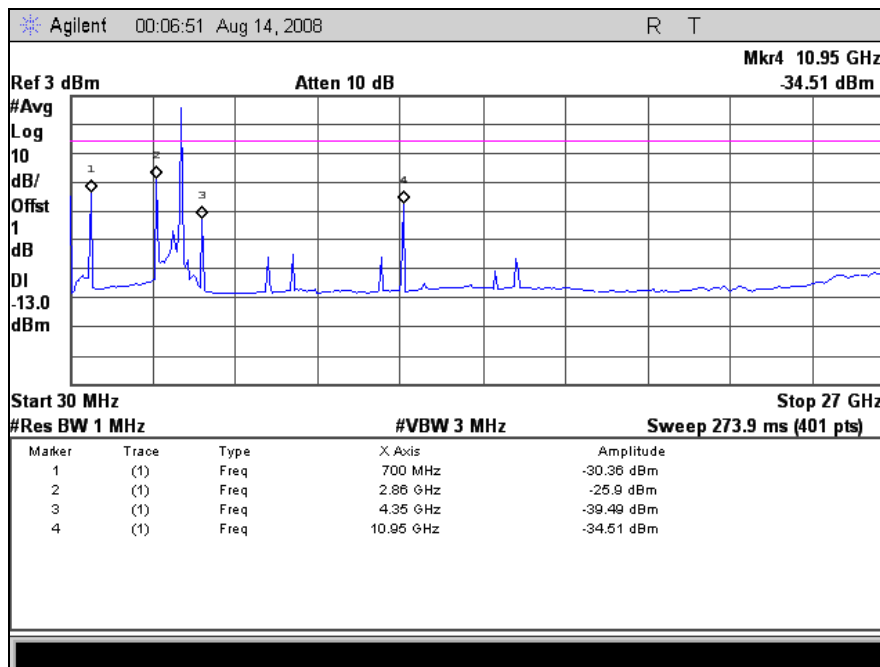
Plot 31. Conducted Spurious Emissions, 3660MHz (5MHz)



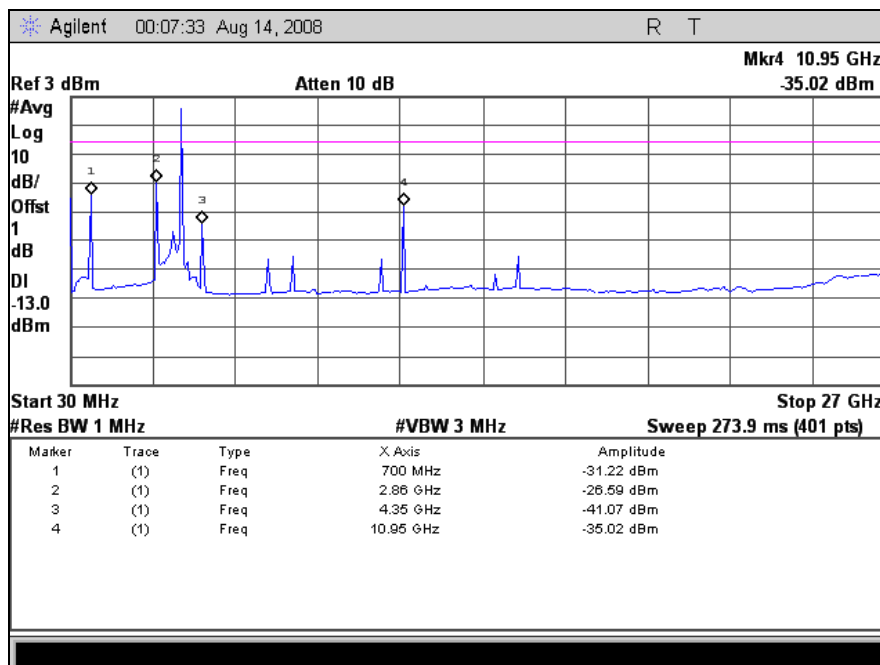
Plot 32. Conducted Spurious Emissions, 3665MHz (5MHz)



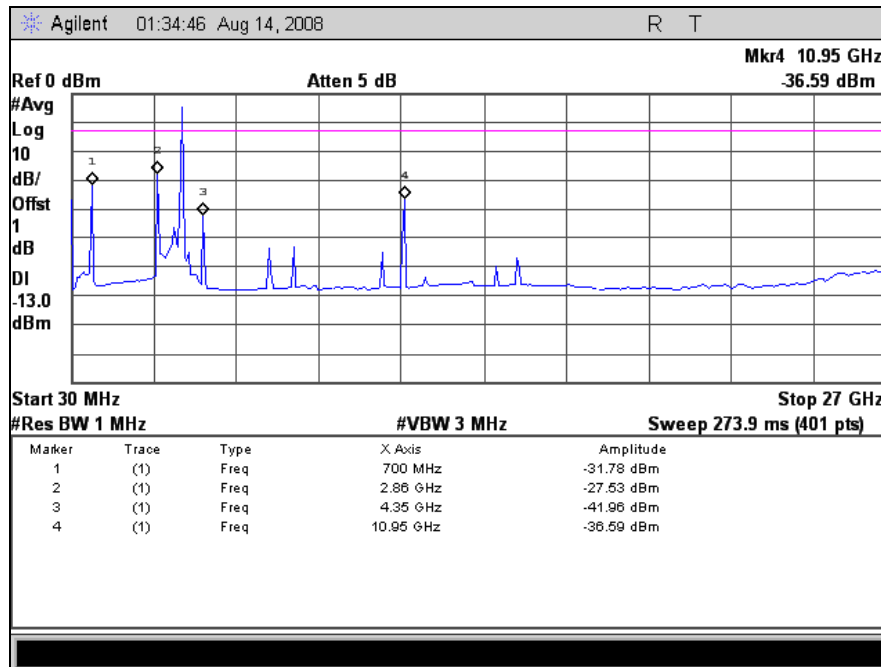
Plot 33. Conducted Spurious Emissions, 3670MHz (5MHz)



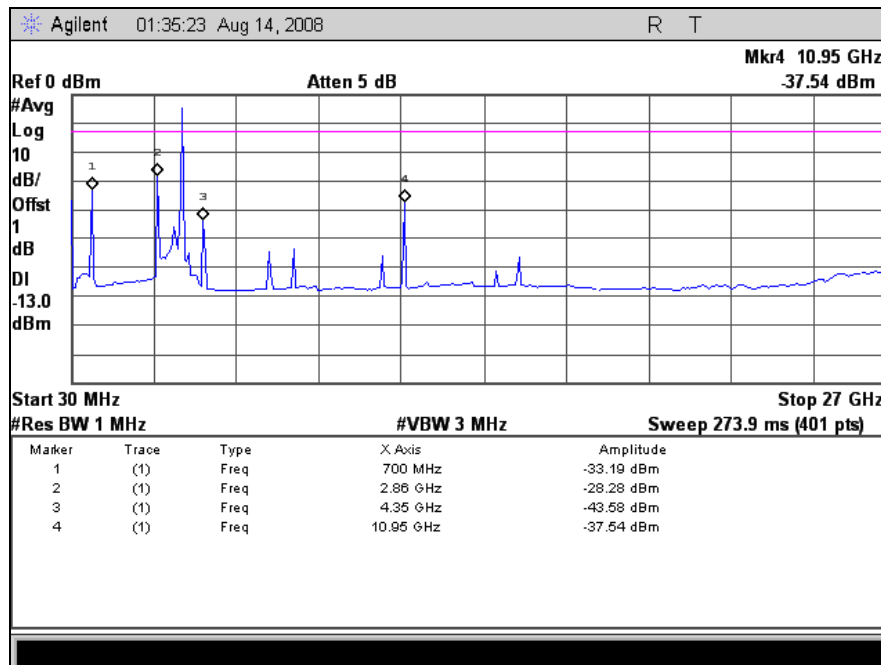
Plot 34. Conducted Spurious Emissions, 3660MHz (10MHz)



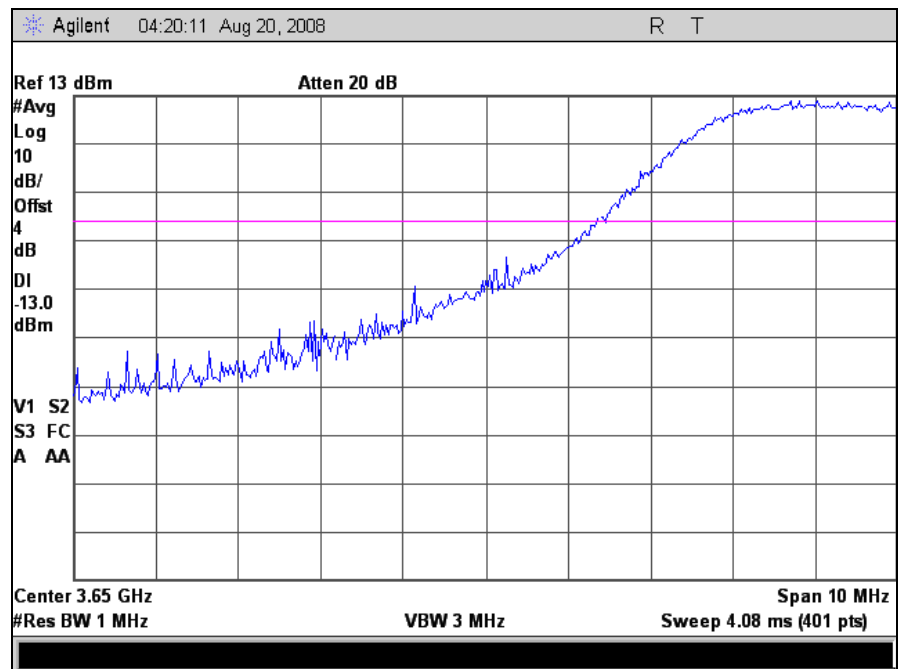
Plot 35. Conducted Spurious Emissions, 3665MHz (10MHz)



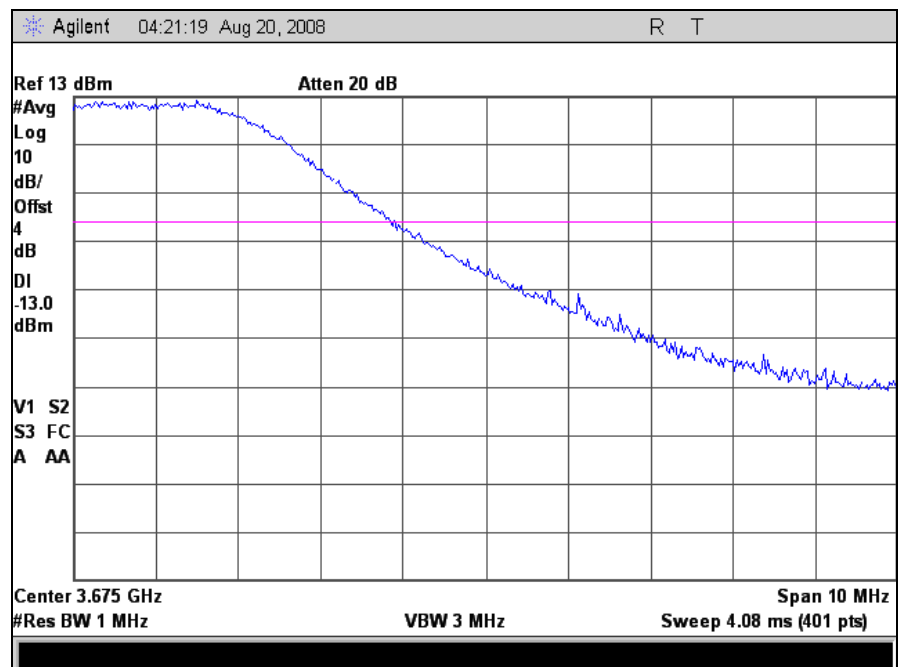
Plot 36. Conducted Spurious Emissions, 3660MHz (20MHz)



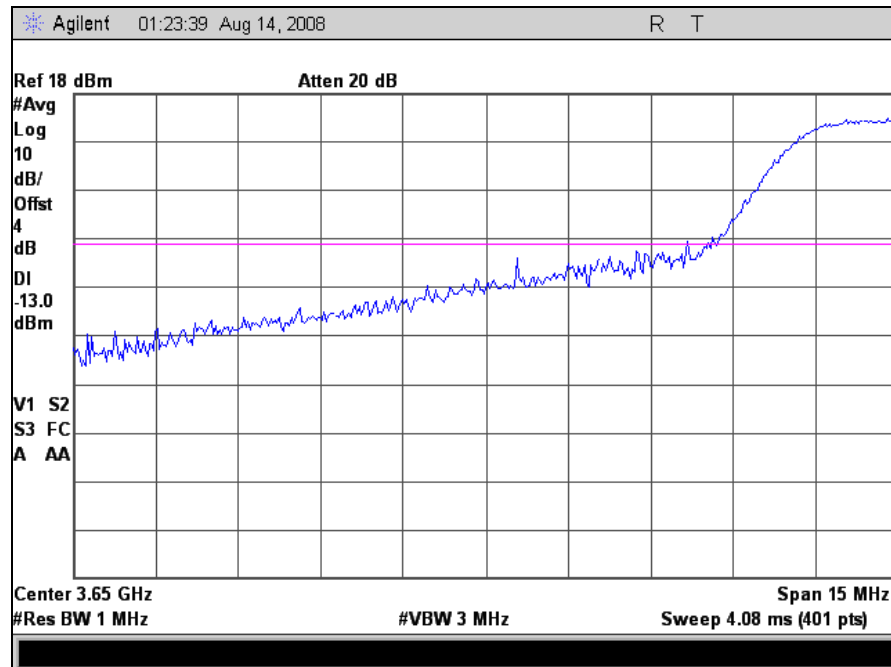
Plot 37. Conducted Spurious Emissions, 3665MHz (20MHz)



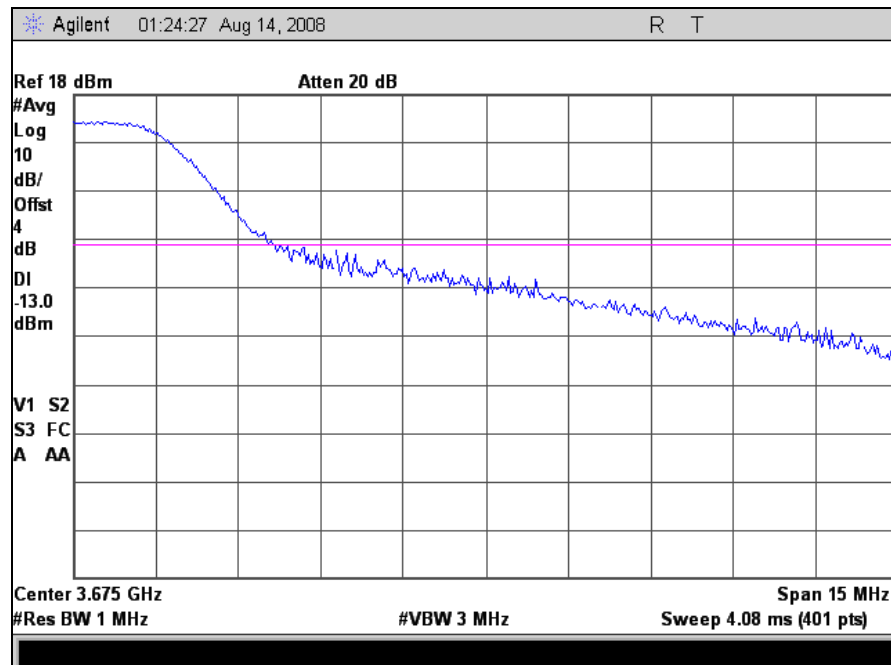
Plot 38. Band Edge, Low Channel, 5MHz



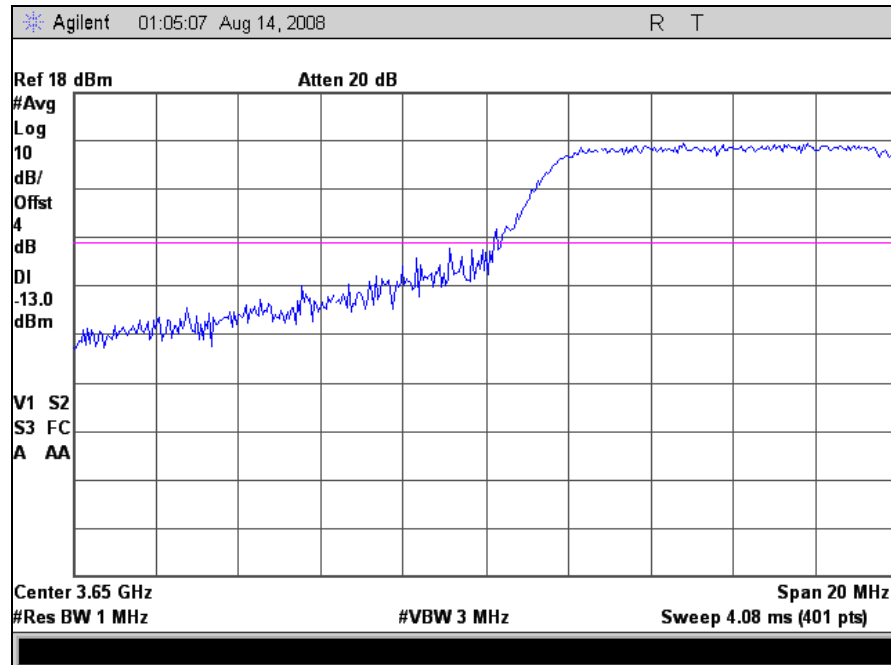
Plot 39. Band Edge, High Channel, 5MHz



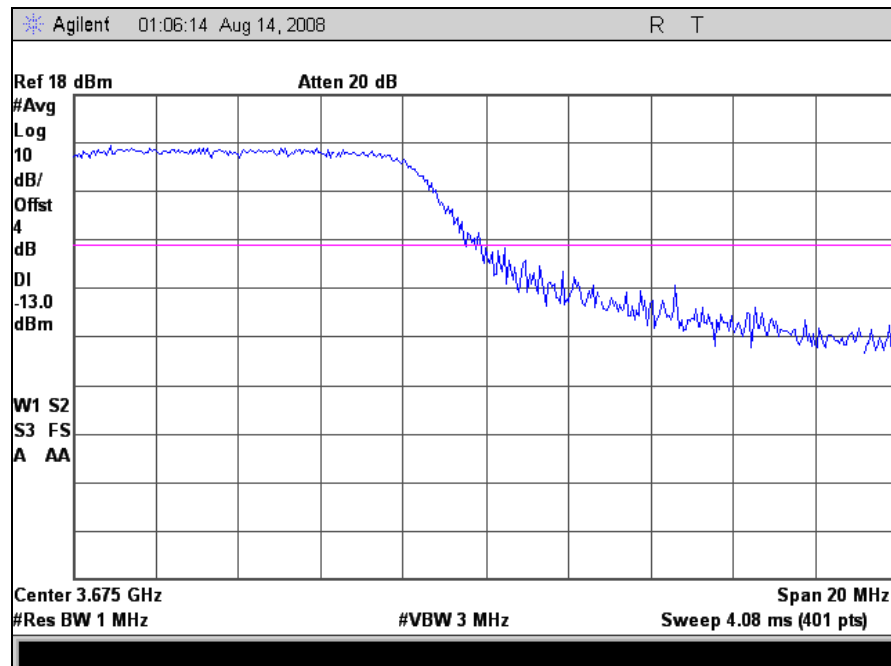
Plot 40. Band Edge, Low Channel, 10MHz



Plot 41. Band Edge, High Channel, 10MHz



Plot 42. Band Edge, Low Channel, 20MHz



Plot 43. Band Edge, High Channel, 20MHz





## Electromagnetic Compatibility Radiated Emissions Requirements

### 6.2. Radiated Emissions (Substitution Method)

**Test Requirement(s):** §2.1053 and TIA/EIA-603-A-2001, and §90.210(d)

**Test Procedures:** As required by 47 CFR 2.1053, *field strength of radiated spurious measurements* were made in accordance with the procedures of TIA/EIA-603-A-2001 "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards".

Radiated emission measurements were performed inside a 3 meter semi-anechoic chamber. The EUT was set at a distance of 1m from the receiving antenna. The EUT's RF ports were terminated to 50ohm load. The EUT was set to transmit at the low, mid and high channels of the transmitter frequency range at its maximum power level. The EUT was rotated about 360<sup>0</sup> and the receiving antenna scanned from 1-4m in order to capture the maximum emission. A calibrated antenna source was positioned in place of the EUT and the previously recorded signal was duplicated. The maximum EIRP of the emission was calculated by adding the forward power to the calibrated source plus its appropriate gain value. These steps were carried out with the receiving antenna in both vertical and horizontal polarization. Harmonic emissions up to the 10<sup>th</sup> or 40GHz, which ever was the lesser, were investigated.

**Test Results:** Equipment complies with Section 2.1053 and TIA/EIA-603-A-2001 and 90.210(d).

**Test Engineer(s):** Dusmantha Tennakoon

**Test Date(s):** 08/19/2008



## Radiated Emissions (Substitution Method) Test Results

Channel Bandwidth (MHz)	Frequency (GHz)	Power into Substitution antenna (dBm)	Gain of substitution antenna (dBi)	Measured EIRP (dBm)	Limit (dBm)
5	7.308	-51.54	11.5	-40.04	-13
	10.969	-40.1	12.6	-27.5	-13
	14.62	-52.3	13.5	-38.8	-13
	3.655 GHz channel				
	7.32	-50.3	11.6	-38.7	-13
	10.977	-42.1	12.6	-29.5	-13
	14.637	-46.8	13.5	-33.3	-13
	3.660 GHz channel				
	7.339	-47	11.6	-35.4	-13
	11.008	-40.3	12.6	-27.7	-13
	14.675	-55.9	13.6	-42.3	-13
	3.670 GHz channel				
10	7.32	-60.9	11.7	-49.2	-13
	10.979	-47.7	12.6	-35.1	-13
	3.660 GHz channel				
	7.33	-63.5	11.7	-51.8	-13
	10.998	-50.3	12.6	-37.7	-13
20	3.665 GHz channel				
	7.322	-68.6	11.7	-56.9	-13
	10.986	-49.5	12.6	-36.9	-13
3.660 GHz channel					

Notes: All other emissions were measured at the noise floor of the spectrum analyzer.



## 7. Frequency Stability

**Test Requirement(s):** §2.1055 and §90.213

**Test Procedures:** As required by 47 CFR 2.1055, *Frequency Stability measurements* were made at the RF output terminals using a Spectrum Analyzer.

The EUT was placed in the Environmental Chamber and support equipments outside the chamber on a table. The EUT was set to transmit on a channel corresponding to 5MHz BW. The frequency drift was investigated for every 10°C increment until the unit is stabilized then recorded the reading in tabular format with the temperature range of -30 to 50°C.

Voltage supplied to EUT is 120 VAC, reference temperature was done at 20°C. The voltage was varied by ± 15 % of nominal

**Test Results:** Equipment complies with Section 2.1055 and 90.213

**Test Engineer(s):** Dusmantha Tennakoon

**Test Date(s):** 08/19/2008

**Reference Freq.:** 3.660000GHz at 20°C

Temperature (centigrade)	Drift (ppm)
50	20.5
40	20.5
30	13.7
20	Ref
10	3.4
0	3.4
-10	6.8
-20	6.8
-30	3.4

**Table 9. Temperature Vs. Frequency Test Results**

**Reference:** 3.660000 at 120 VAC and 20°C

Measured voltage (+/- 15% of nominal)	Drift (ppm)
102	6.8
138	6.8

**Table 10. Frequency vs. Voltage Test Results**



## 8. RF Exposure Requirements

**RF Exposure Requirements:** §90.1335, §1.1307(b), 2.1091, 2.1093: 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:** §1.1307: 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.

MPE Limit Calculation: EUT's operating frequencies between 3655 and 3670 MHz. Highest radiated power (EIRP) = 41.71 dBm. Therefore, **Limit for Uncontrolled exposure: 1 mW/cm<sup>2</sup>.**

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

$$R = \sqrt{\{EIRP / 4\pi S\}}$$

where,

S = Power Density mW/m<sup>2</sup> = 1

EIRP = Equivalent Isotropic Radiated Power

R = Distance to the center of radiation of the antenna

$$EIRP = 14860.4 \text{ mW}$$

$$R = \sqrt{(EIRP/4\pi S)}$$

$$R = 2.1 \text{ m}$$

Therefore, a separation distance of 2.1m is required to meet the limit for uncontrolled exposure.



## 9. 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.

Test: Conducted Emissions			Test Dates: 08/19/2008		
MET Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1T4627	THERMO/HYGROMETER	CONTROL COMPANY	S6-627-9	09/25/2007	09/25/2009
1T4612	ESA-E SERIES SPECTRUM ANALYZER	AGILENT	E4407B	01/04/2008	01/04/2009
1T4503	SHIELDED ROOM	UNIVERSAL SHIELDING CORP	N/A	06/01/2006	06/01/2007
1T4563	LISN (10 AMP)	SOLAR ELECTRONICS	9322-50-R-10-BNC	09/10/2007	09/10/2008
Test: Radiated Emissions			Test Dates: 08/18/2008		
1T4568	RADIATING NOISE SOURCE	MET LABORATORIES	N/A	SEE NOTE	
1T4300	SEMI-ANECHOIC CHAMBER # 1	EMC TEST SYSTEMS	NONE	02/17/2006	01/17/2009
1T4303	ANTENNA; BILOG	SCHAFNER - CHASE EMC	CBL6140A	07/07/2008	07/07/2009
1T4409	EMI RECEIVER	ROHDE & SCHWARZ	ESIB7	04/18/2008	04/18/2009
Test: RF Output Power			Test Dates: 08/18/2008		
1T4612	ESA-E SERIES SPECTRUM ANALYZER	AGILENT	E4407B	01/04/2008	01/04/2009
Test: Spurious Radiated Emissions			Test Dates: 08/18/2008		
1T4483	DOUBLE RIDGE WAVEGUIDE HORN	ETS LINDGREN	3117	05/07/2008	05/07/2009
1T2665	HORN ANTENNA	EMCO	3115	05/07/2008	05/07/2009
1T4612	ESA-E SERIES SPECTRUM ANALYZER	AGILENT	E4407B	01/04/2008	01/04/2009
1T4354	SIGNAL GENERATOR	HEWLETT PACKARD	83752A	05/08/2008	05/08/2009
1T4300	SEMI-ANECHOIC CHAMBER # 1	EMC TEST SYSTEMS	NONE	02/17/2006	01/17/2009
1T4442	PRE-AMPLIFIER, MICROWAVE	MITEQ	AFS42-01001800-30-10P	SEE NOTE	
1T4592	RF FILTER KIT	VARIOUS	N/A	SEE NOTE	
Test: Frequency Stability			Test Dates: 08/18/2008		
1T4612	ESA-E SERIES SPECTRUM ANALYZER	AGILENT	E4407B	01/04/2008	01/04/2009
1T4505	TEMPERATURE CHAMBER	TEST EQUITY	115	08/19/2007	08/19/2008
1T4548	AC POWER SOURCE	CALIFORNIA INSTRUMENTS	1251P	SEE NOTE	

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



LigoWave  
LigoPTP 3-N

Electromagnetic Compatibility  
Certification & User's Manual Information  
CFR Title 47 Part 90 Subpart Z & Part 15 Subpart B

---

# Certification & User's Manual Information



## 10. Certification Label & User's Manual Information

### 10.1. 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 provision that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.





**The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart Y — 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.<sup>1</sup> *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, whichever is applicable.

**§ 2.902 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.

---

<sup>1</sup> 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.



**§ 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.



## 10.2. 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.

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 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.



LigoWave  
LigoPTP 3-N

Electromagnetic Compatibility  
End of Report  
CFR Title 47 Part 90 Subpart Z & Part 15 Subpart B

---

# End of Report