Testing Tomorrow's Technology

Application
For

Title 47 USC, Part 2, Subpart J, Paragraph 2.902, Equipment Authorization of Verification for an Unintentional Radiator per Part 15, Subpart B, Paragraphs 15.107 and 15.109

And

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraph 15.247

For the

Georgia Institute of Technology
Model: 2

FCC ID: VDU-416D79

UST Project: 12-0302
Issue Date: July 2, 2012

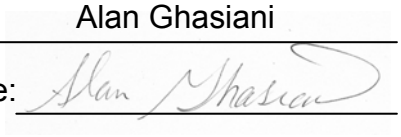
Total Pages: 50

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date July 2, 2012

This report shall not be reproduced except in full. This report may be copied in part only with the prior written approval of US Tech. The results contained in this report are subject to the adequacy and representative character of the sample provided.

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Georgia Institute of Technology

MODEL: 2

FCC ID: VDU-416D79

DATE: July 2, 2012

This report concerns (check one): Original grant [X]
Class II change

Equipment type: 2.4 GHz Transmitter Module

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No X

If yes, defer until: _____N/A_____
date
agrees to notify the Commission by N/A
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
Fax Number: (770) 740-1508

Table of Contents

List of Figures

Figures **Title** **Page**

List of Tables

Table **Title** **Page**

List of Attachments

Attachments

Agency Agreement
Application Forms
Letter of Confidentiality
Equipment Label
Block Diagram(s)
Schematic(s)
Test Configuration Photographs
Internal Photographs
Theory of Operation
RF Exposure
User's Manual

1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on June 26, 2012 in good operating condition.

1.3 Product Description

The Equipment Under Test (EUT) is the Georgia Institute Of Technology's IPRE Fluke Model 2, which is a 2.4 GHZ Transmitter Module. The Fluke robot upgrade module is a device by which low-cost robots are reprogrammed to support advanced educational software such as Microsoft Robotics studio or IPRE Myro. The Fluke module also includes a camera and IR sensors which expand the capabilities of low-cost robot bases. Once attached to the robot the module uploads the device server into the robot's internal program memory and then provides a wireless link between the student's computer and the robot. The Fluke module bypasses the robot's onboard computer and allows direct robot control from a desktop computer.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2003)* for FCC subpart B Digital equipment Verification requirements and per FCC KDB Publication number 558074 for Digital Transmission Systems Operating Under section 15.247. Also, FCC, KDB Publication No. 558074 was used as a test procedure guide.

Digital RF conducted and radiated Verification emissions data (FCC 15.107 and 109) below 1 GHz were taken with the measuring receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1.0 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5117. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 2982A-1.

1.6 Related Submittal(s)/Grant(s)

The EUT will be used to wirelessly send/receive data. The transceiver presented in this report will be used with other like transceivers:

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter (with modular approval), see test data presented herein.
b) Verification as a class B digital device.

The manufacturer desires to seek a modular approval on this device.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
2.4 GHz radio Georgia Institute of Technology (EUT)	2	Engineering Sample	Pending: VDU-416D79	NA
Antenna, Please see Antenna description	--	--	None	N/A

2 Tests and Measurements

2.1 Test Equipment

Table 2 below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are included herein.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MFG.	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8593E	HEWLETT-PACKARD	3205A00124	10/26/2011
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2410A00109	11/4/2011
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	1937A02980	10/06/2011
LOOP ANTENNA	SAS-200/562	AH Systems	142	08/09/2011
BICONICAL ANTENNA 25 MHz to 200 MHz	BIA-25	Electro-Metrics	2451	6/4/2012 2 Year
LOG PERIODIC 100 MHz to 1000 MHz	3146	EMCO	3110-3236	11/22/2011 2 Year
HORN ANTENNA 1 GHz to 18 GHz	3115	EMCO	9107-3723	8/10/2011 2 Year
HORN ANTENNA 18 GHz to 40 GHz	3116	EMCO	9505-2255	Performance verified with HP 8593E before test and antenna calibrated on 8/9/12 with no significant change to antenna factors at applicable frequencies.
PREAMP 1 GHz to 26.5 GHz	8449B	HEWLETT-PACKARD	3008A00480	11/15/2011
CALCULATION PROGRAM	N/A	N/A	Ver. 6.0	N/A

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 as follows:

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the device operates	Number of Frequencies	Location in the Range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates over 2.4 GHz to 2.4835 GHz, 3 test frequencies will be used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10^{th} harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to the range specified in 2.4.1 above, whichever is the higher range of investigation.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may also be expressed logarithmically in dB. Please section 2.8 herein for details.

2.6 EUT Antenna Requirements (CFR 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. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

MANUFACTURER	TYPE OF ANTENNA	MODEL	REPORT REFERENCE	GAIN dB_i	TYPE OF CONNECTOR
Georgia Institute of Technology	Trace	Engineering Sample	Dipole	1	Permanently attached

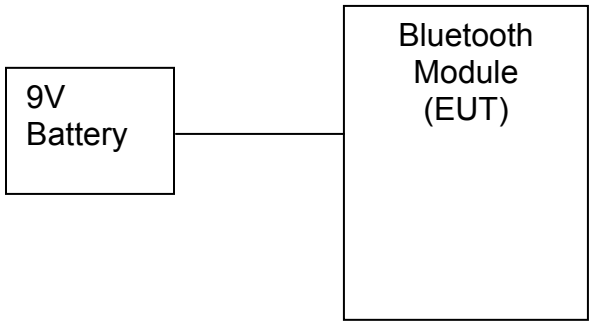


Figure 1. Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other Spurious are examined for this requirement see paragraph 2.10.

2.8 Transmitter Duty Cycle (CFR 35 (c))

The duty cycle de-rating factor used in the calculation of average radiated limits (per CFR 15.209 and 15.35(c)) is described below. This factor was calculated by first determining the worst case scenario for system operation. DH% pocket type was found to be worse case scenario.

The worst-case scenario in any 100 ms timeslot, along with all transmission lengths, will be as follows:

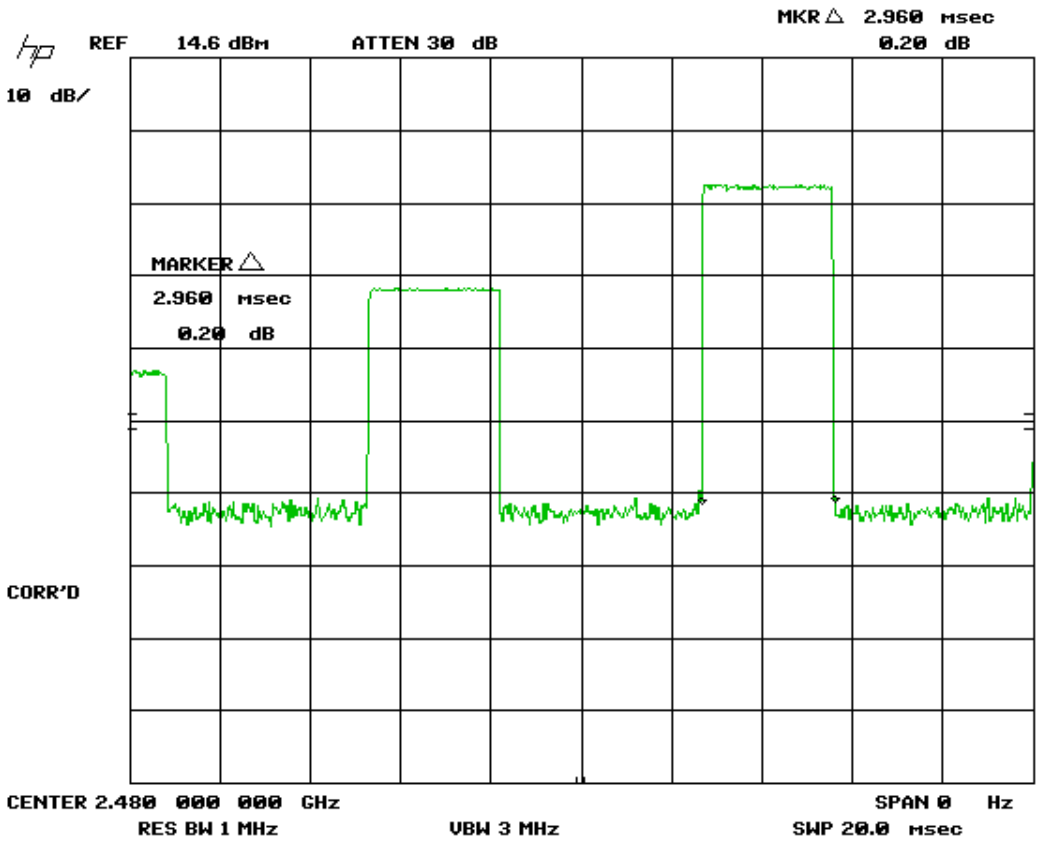
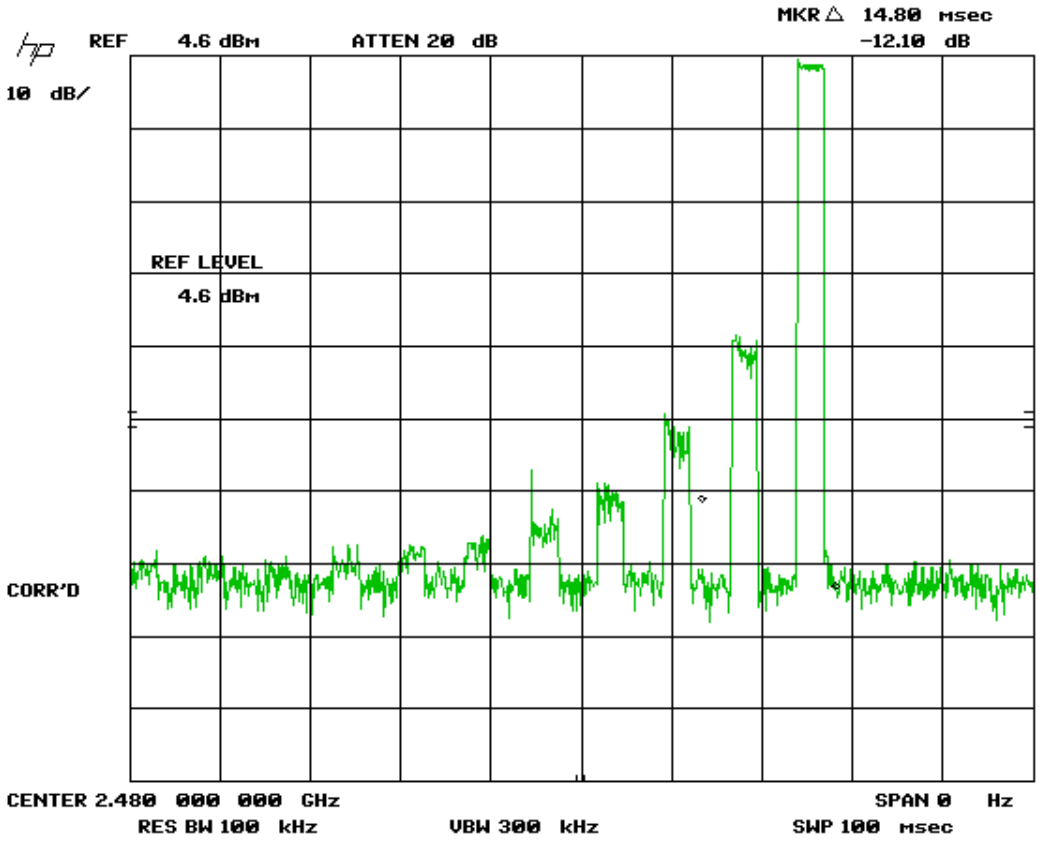
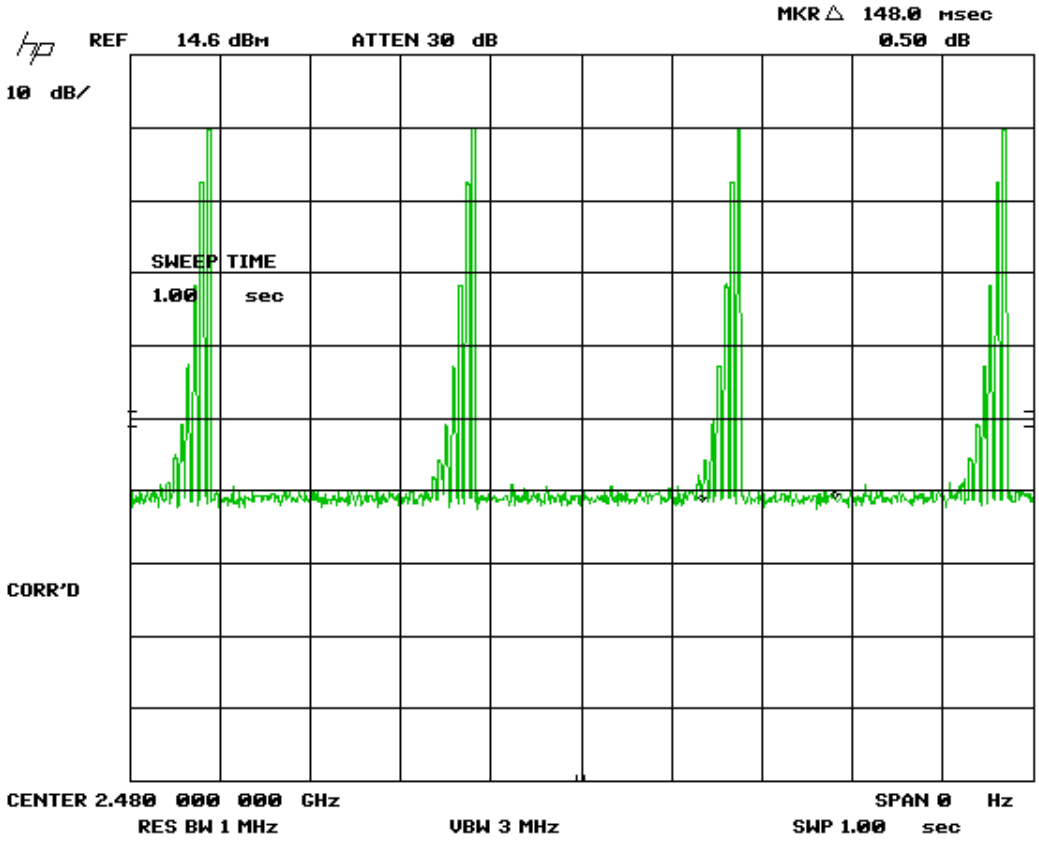


Figure 2. Pulse Width



Note: There are seven(7) discernable pulses.

Figure 3. Pulse Count



Note: There are four(4) burst per second.

Figure 4. Burst Pattern

The duty cycle is computed as follows (in any 100 ms period):

Time On = Pulse Width * Pulse Count* Number of Burst
Time On = 2.96 mS * 8 * 4
Time On = 94.72 mS
Duty Cycle = Time On/ Total Time
Duty Cycle = (94.72/1000) = 0.09472
Correction Factor = $20\log_{10}(0.09472)$ = **-20.47 dB**

2.9 Intentional Radiator, Power Lines Conducted Emissions (CFR 15.207)

The power line conducted voltage emission measurements are not done because the EUT is powered by a 9 volt battery.

Table 5. Transmitter Power Line Conducted Emissions Test Data, Part 15.207

CONDUCTED EMISSIONS 150 kHz to 30 MHz						
Tested By: JCW	**Specification Requirement: FCC Part 15.207 Class B**		**Project No.: 12-0302**	**Manufacturer/Model: Georgia Institute Of Technology Model 2**		
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL-PA (dB)**	**Corrected Results (dBuV)**	**Avg Limits (dBuV)**	**Margin (dB)**	**Detector**
The EUT is powered by a 9V battery; this test is not applicable.						

2.10 Intentional Radiator, Radiated Emissions (Antenna Conducted) (CFR 15.209, 15.247(d)) (IC RSS 210, A2.9 (a))

The EUT was put into a continuous-transmit mode of operation and tested per FCC KDB Publication 558074 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 25 GHz. A conducted scan was performed on the EUT to identify and record spurious signals that were related to the transmitter. Antenna Conducted Emissions of a significant magnitude that fell within restricted bands were then measured as radiated emissions on the OATS. The conducted emissions graphs are found in figures below.

For radiated measurements, the EUT was set into a continuous transmission mode. Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW ≥ RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 6 below.

For Average Voltage measurements above 1 GHz, the emissions were measured using RBW = 1 MHz and VBW = 10 Hz. For a pulse-modulated transmitter, the EUT's average emissions are further modified by adding to them the worst-case duty cycle, determined by adding the EUT's total pulse widths (on time) over a 100 ms period and dividing by 100 ms.

On the OATS, the EUT was mounted on top of a non-conductive table, 80 cm above the floor, by placing it in the X-Z plane along the Z axis with its bottom cover in parallel with the ground. The front of the EUT faced the measurement antenna located 3 meters away. Each signal measured was maximized by raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display (with channel A in the Clear-Write mode and channel B in the Max-Hold mode) for the largest signal visible. That exact antenna height where the signal was maximized was recorded for reproducibility purposes. Also, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

The test data is detailed below in for this section. Several radiated emissions above 1 GHz were measured at a distance of 1 meter. The measured value at 1 meter was then extrapolated to the resultant at 3 meters using an inverse distance extrapolation factor of -20 dB/decade. There were no test failures.

2.10.1 Conducted Emissions

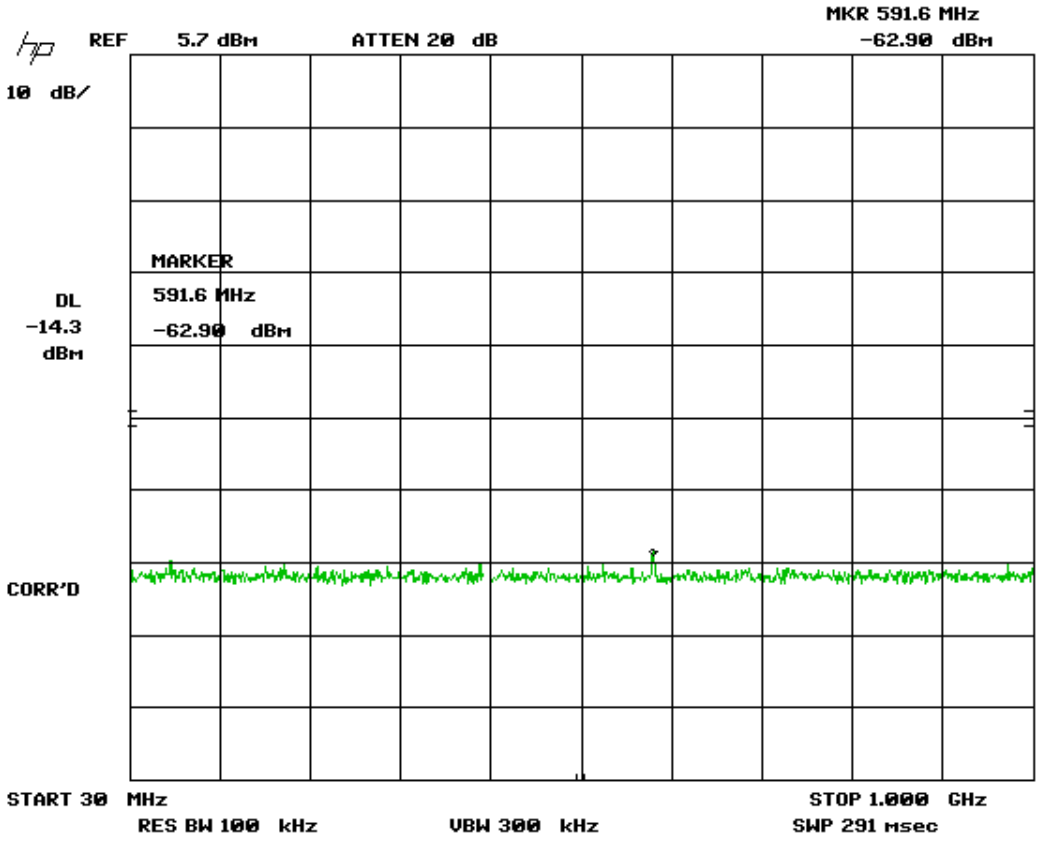


Figure 5. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Low Channel, Part 1

Note: Large Signal shown is Fundamental Frequency

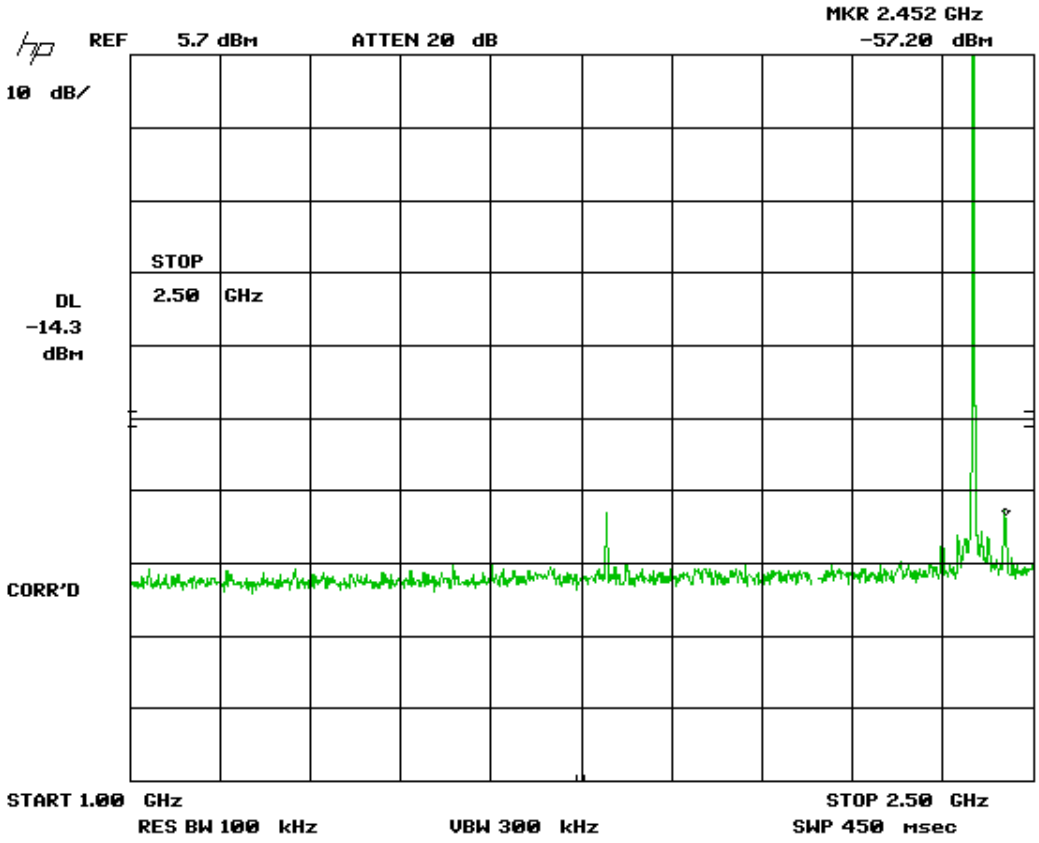


Figure 6. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Low Channel, Part 2

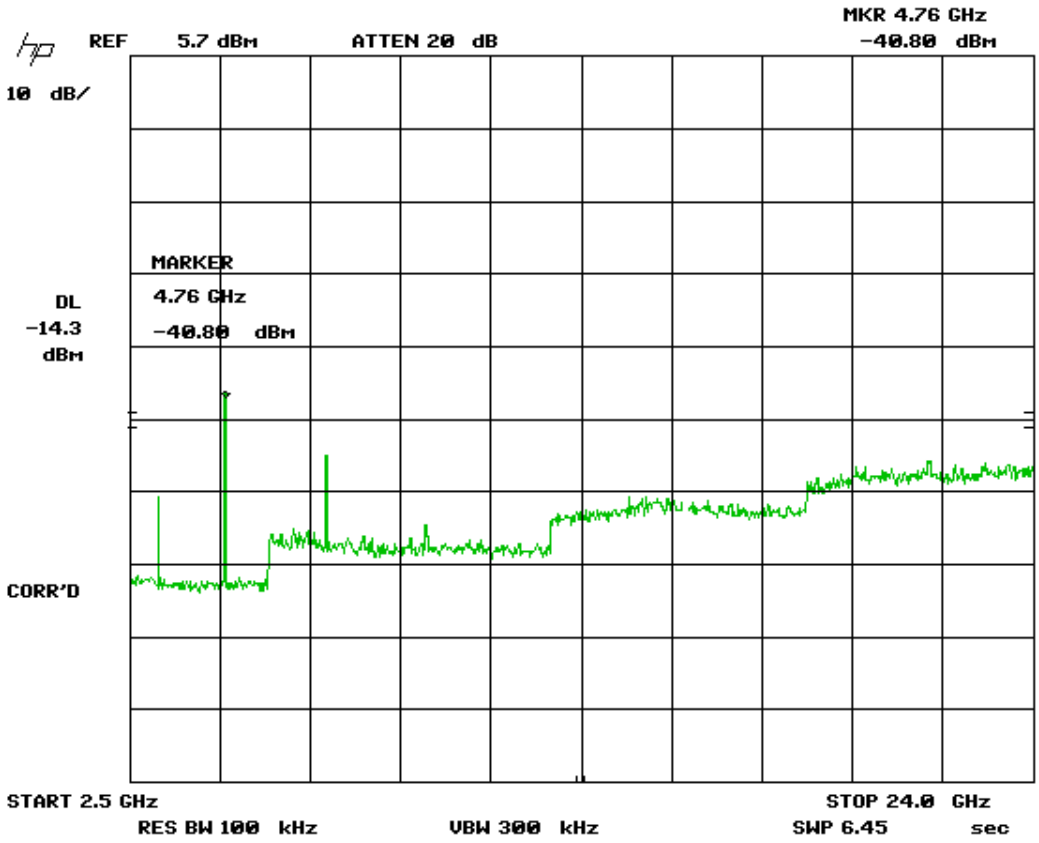


Figure 7. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Low Channel, Part 3

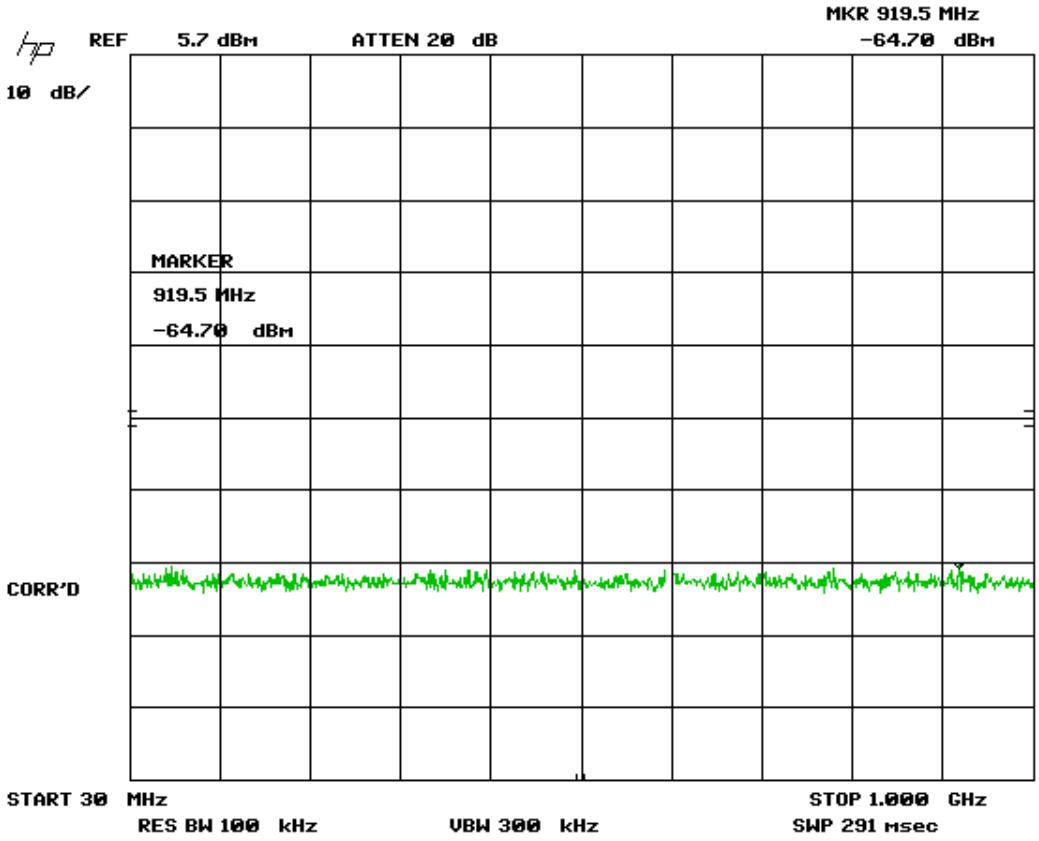


Figure 8. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Mid Channel, Part 1

Note: Signal shown represents Fundamental Frequency

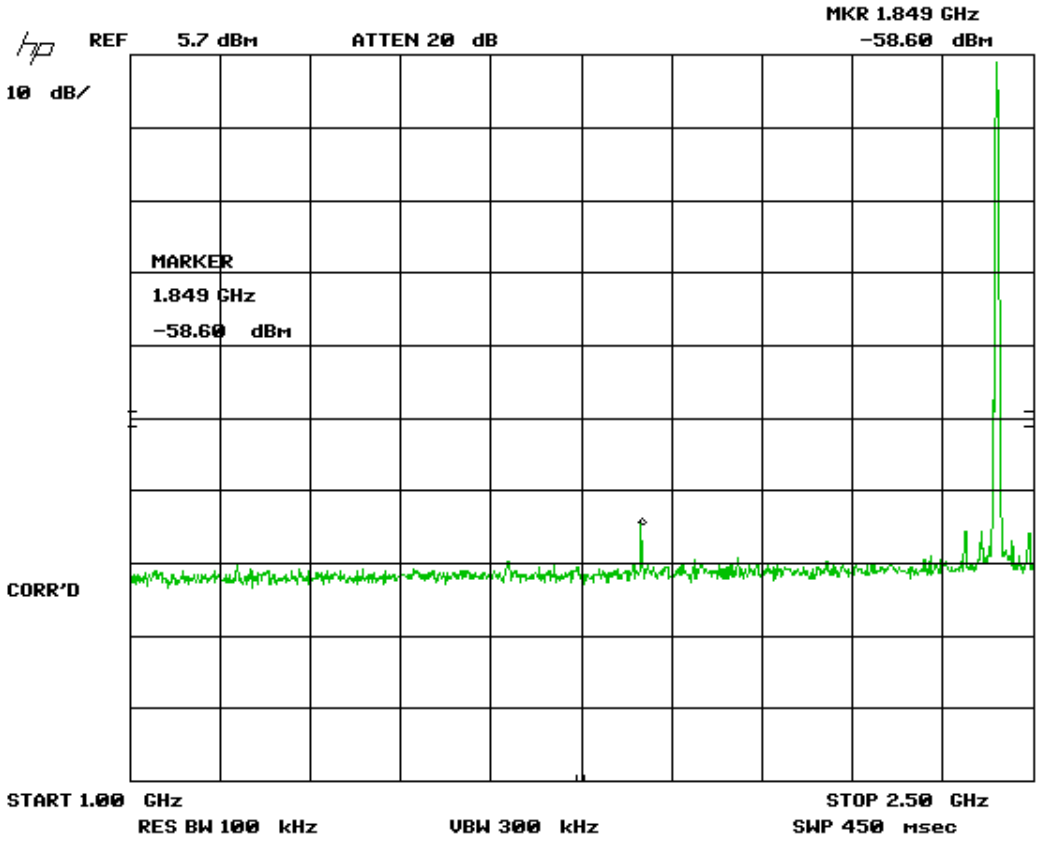


Figure 9. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Mid Channel, Part 2

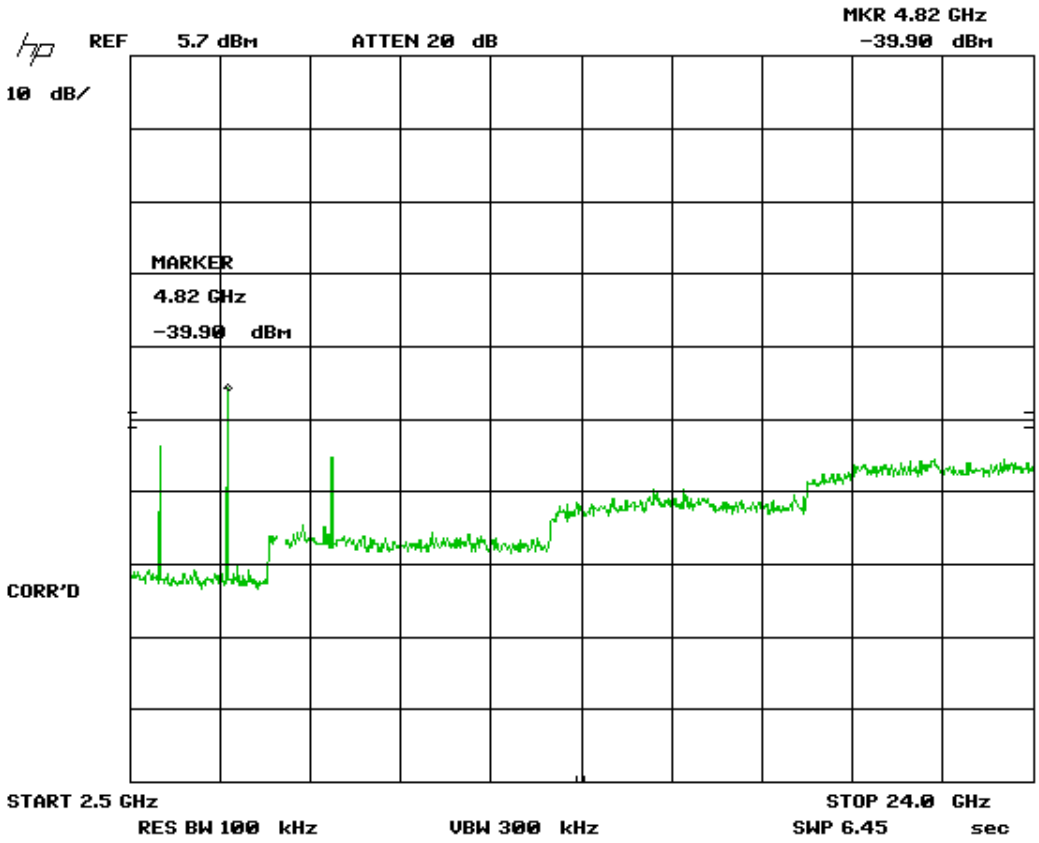


Figure 10. Antenna Conducted Spurious Emissions – CFR 15.247 (d) - Mid Channel, Part 3

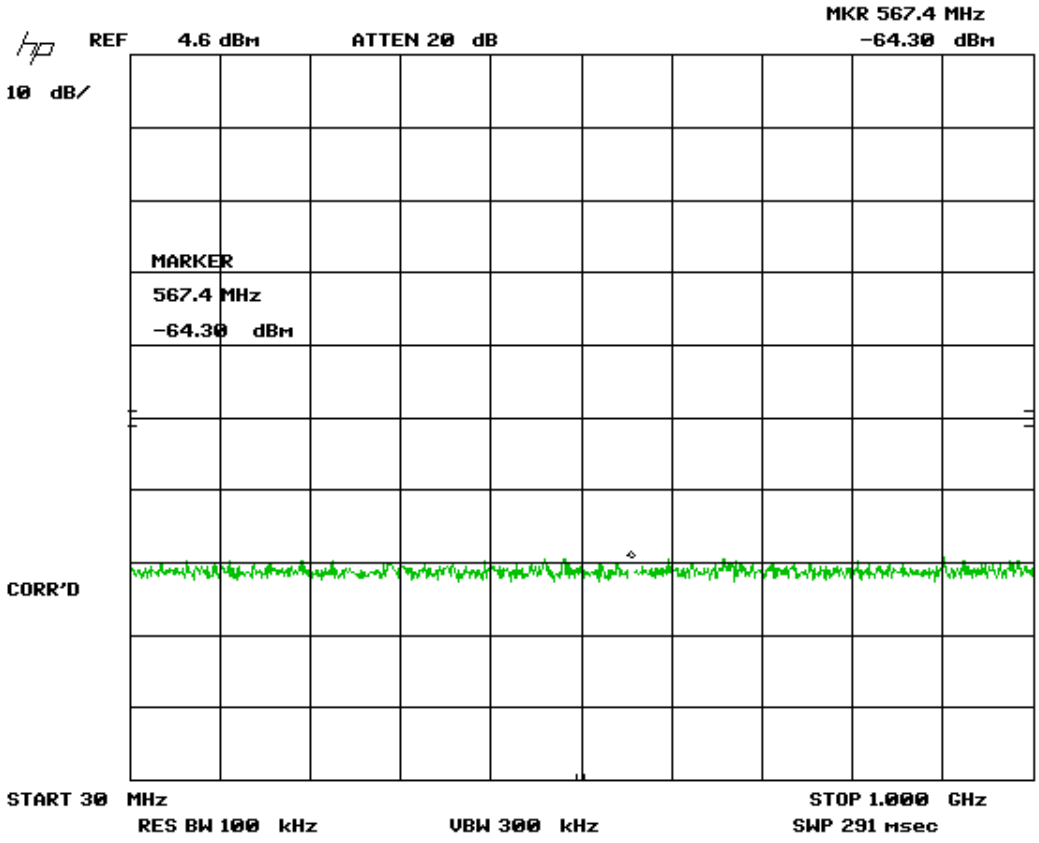


Figure 11. Antenna Conducted Spurious Emissions – CFR 15.247 (b) - High Channel, Part 1

Note: Large Signal shown is Fundamental Frequency

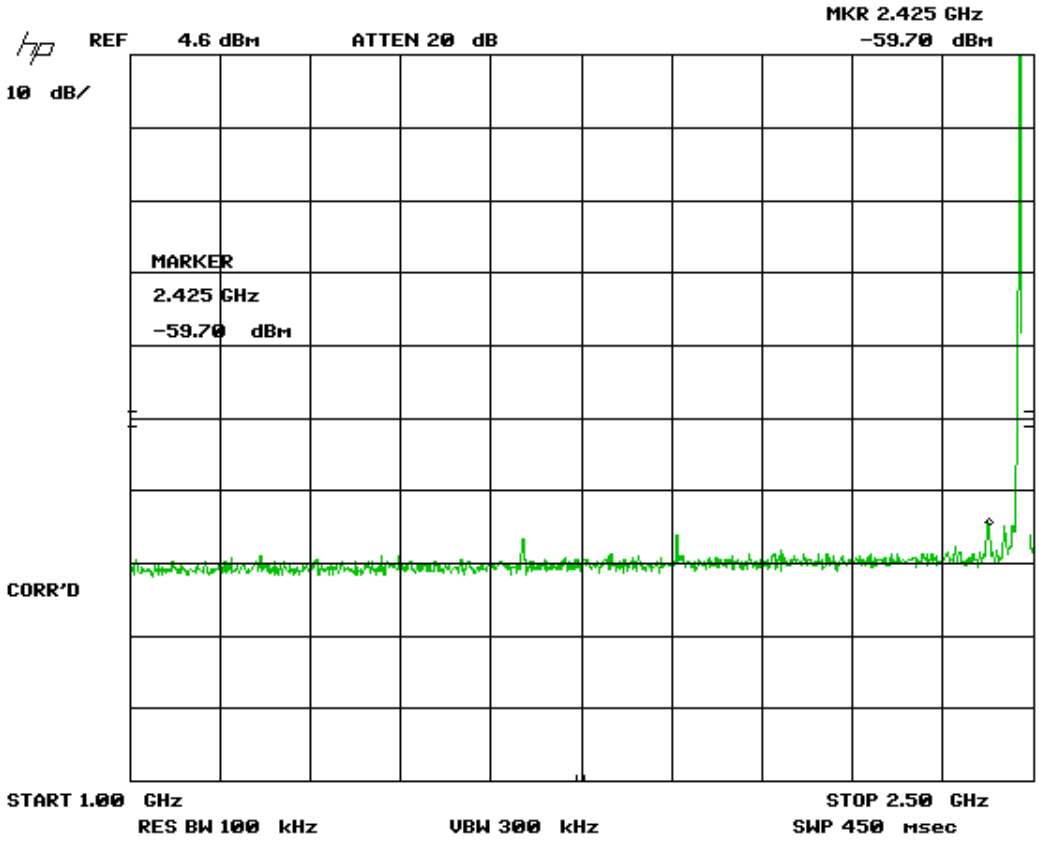


Figure 12. Antenna Conducted Spurious Emissions - CFR 15.247 (d), High Channel, Part 2

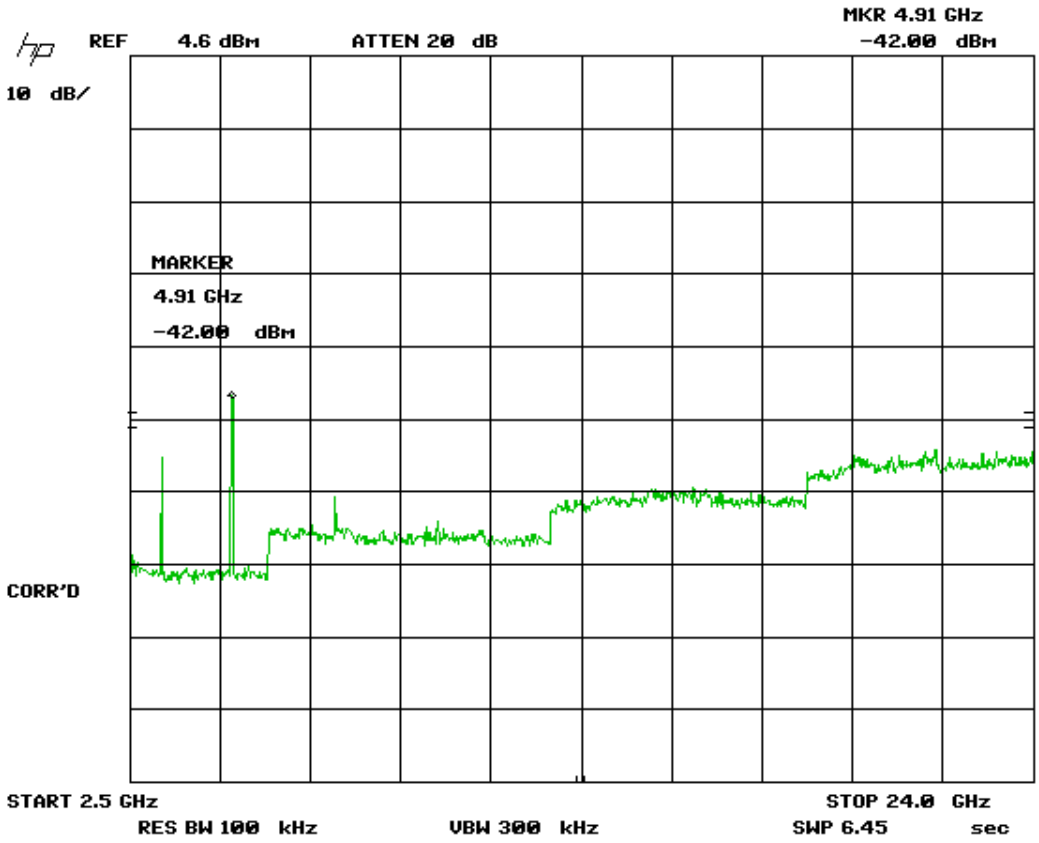


Figure 13. Antenna Conducted Spurious Emissions - CFR 15.247 (d), High Channel, Part 3

2.10.2 Intentional Radiated Emissions

Table 6. Peak Fundamental and Harmonic Measurements

Radiated Harmonic and Harmonic Emissions, Tested from 30 MHz – 25 GHz						
Tested By: JCW	**Test: FCC Part 15, Para 15.247(d)**			**Client: Georgia Institute Of Technology**		
	Project: 12-0302			**Model: 2**		
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Pass Margin (dB)**
LOW BAND - PEAK						
2401.91	70.27	31.34	101.61		3.0m./	
4803.94	68.18	4.7	72.88	74.0	3.0m./	1.1
MID BAND- PEAK						
2440.92	72.56	31.42	103.98		3.0m./	
4881.95	66.22	4.76	70.88	74.0	3.0m./	3.1
7322.8	49.47	1.82	51.29	74.0	1.0m./	22.7
HIGH BAND- PEAK						
2479.88	69.06	31.72	100.78		3.0m./	
4959.95	65.64	5.0	70.63	74.0	3.0m./	3.4

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation of CFR 15.35.
2. ND = No other signals detected within 20 dB of specification limit.
SAMPLE CALCULATION:
3. Measurements taken at 1 meter distance were extrapolated to 3 meter using a factor of (-9.5 dB).
4. 1.5 dB loss factor is added for all measurement using the high pass filter.
RESULTS: At 4881.95 MHz: = 66.22 dBuV+ (1.5 dB high pass filter loss) + 3.26 dB/m = 70.88 dBuV/m @ 3m
Margin = (74.0 – 70.88) = 3.1 dB

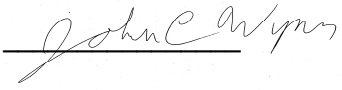
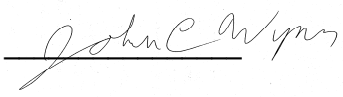
Test Date: June 27, 2012
Tested By
Signature:  Name: John C. Wynn

Table 7. Average Fundamental and Harmonic Measurements

Radiated Harmonic and Harmonic Emissions, Tested from 30 MHz – 25 GHz						
Tested By:	**Test: FCC Part 15, Para 15.247(d)**			**Client: Georgia Institute Of Technology**		
JCW	**Project: 12-0302**			**Model: 2**		
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Pass Margin (dB)**
LOW BAND - AVERAGE						
2401.913	69.81	31.34	101.15		3.0m./	
4803.94	67.18	16.93	50.25	54.0	3.0m./	3.75
MID BAND - AVERAGE						
2440.92	72.37	31.42	103.79		3.0m./	
4881.95	65.81	-16.97	48.84	54.0	3.0m./	5.16
7322.80	43.93	29.88	24.12	54.0	1.0m./	29.88
HIGH BAND - AVERAGE						
2479.88	68.81	31.72	100.53		3.0m./	
4959.95	65.34	-16.64	48.70	54.0	3.0m./	5.3

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation of CFR 15.35.
2. ND = No other signals detected within 20 dB of specification limit.
SAMPLE CALCULATION:
3. Measurements taken at 1 meter distance were extrapolated to 3 meter using a factor of (-9.5 dB).
4. 1.5 dB loss factor is added for all measurement using the high pass filter.
RESULTS: At 4881.952 MHz: = 65.81 dBuV+ (1.5 dB high pass filter loss) (-20.0 duty cycle offset) + 3.26 dB/m = 48.84 dBuV/m @ 3m
Margin = (54.0 – 48.84) = 5.16 dB

Test Date: June 27, 2012
Tested By
Signature:  Name: John C. Wynn

2.11 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

For the Model 2 module, the transmitter was programmed to operate at a maximum of 6.3 dBm across the bandwidth.

Peak power within the band 2400 MHz to 2483.5 MHz was measured per FCC KDB Publication 558074 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set greater than the 20 dB bandwidth of the EUT, and the VBW ≥ RBW. The loss of the short cable is 0.3 dB. The raw data measured values are found in Figures 17 to 19. Peak antenna conducted output power is tabulated in Table 9 below.

Antenna Conducted Output Power was measured at Low Channel, Mid Channel and High Channel frequencies. See Figures 17 to 19 below. The 0.3 dB loss for the RF wire is taken into consideration here (Corrected Measurement column).

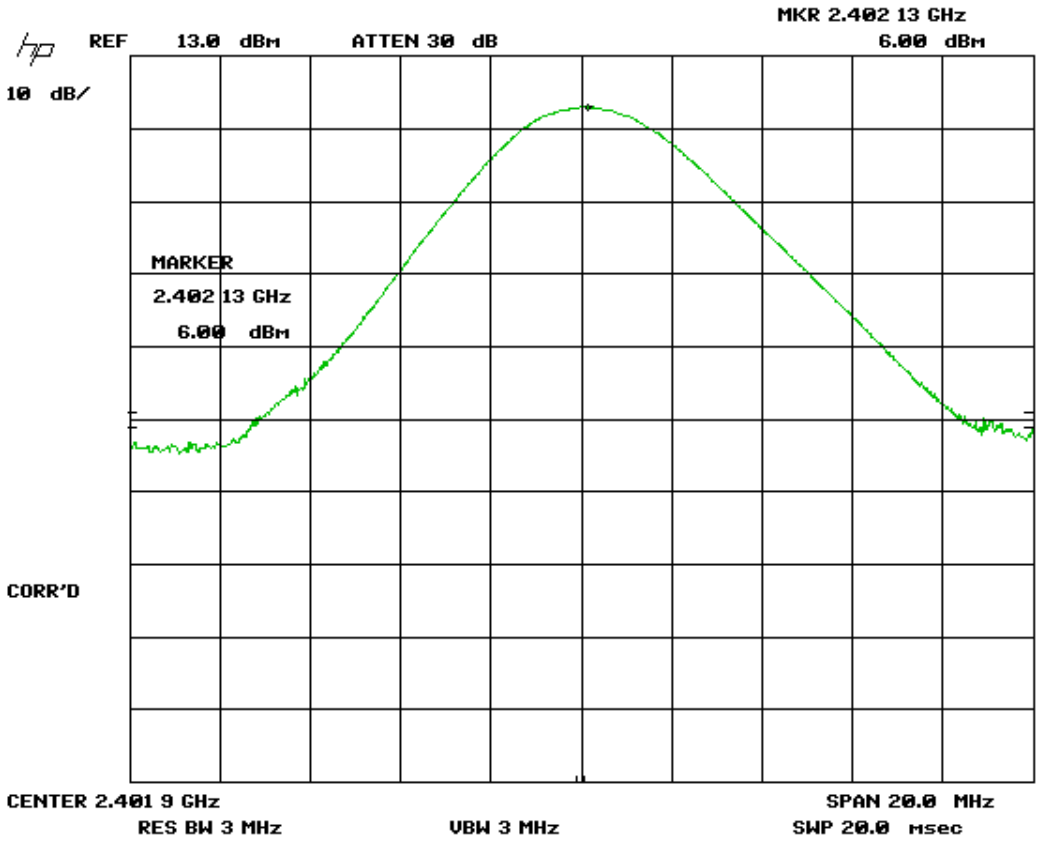
Table 8. Peak Antenna Conducted Output Power per Part 15.247 (b) (3) (Same as EIRP)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Corrected Measurement (dBm)	(mW)	FCC Limit (mW Maximum)
Low Band (ch00) 2401	6.00	6.30	4.27	1000
Mid Band (ch40) 2441	5.70	6.00	3.98	1000
High Band (ch79) 2480	4.90	5.20	3.31	1000

Note: reference adjusted for correction factor, 0.3 dB for attenuator and cable loss.

Test Date: June 26, 2012
Tested By
Signature: _____ Name: Keyvan Muvahhid

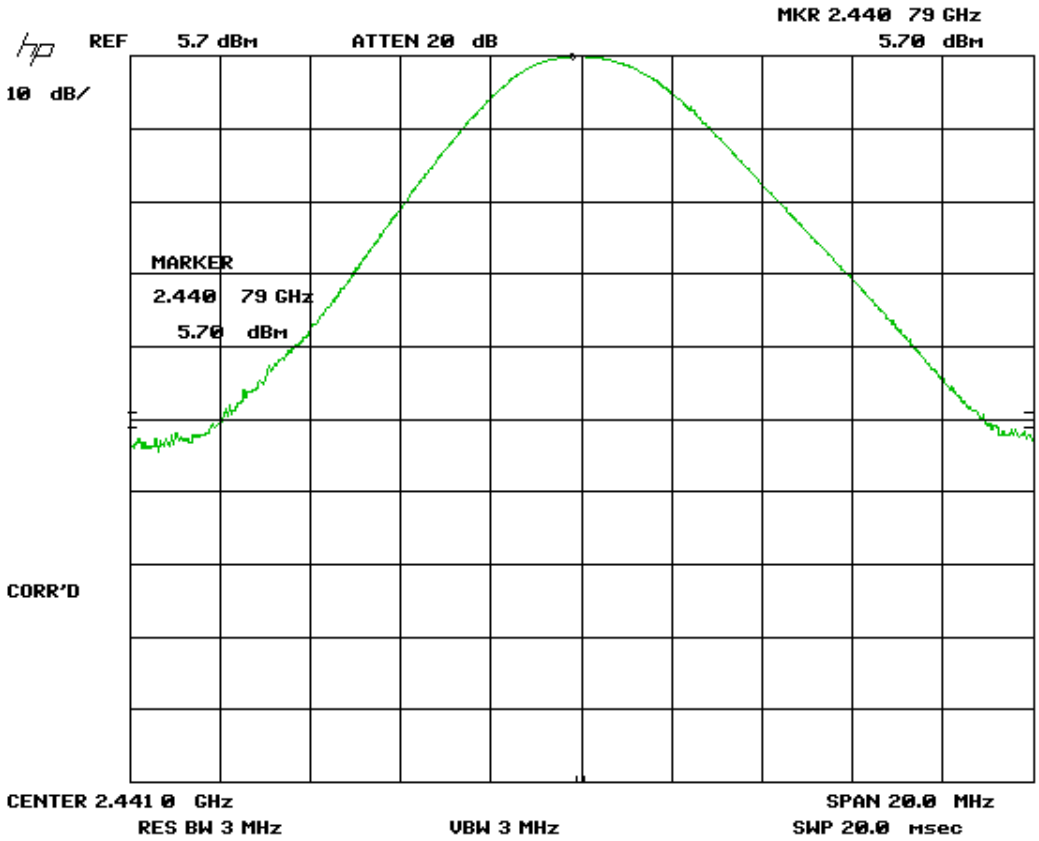
2.12 Peak Power Output (CFR 15.247 (b)(3))



Note: reference adjusted for correction factor.

Figure 14. Peak Antenna Conducted Output Power, Low Channel

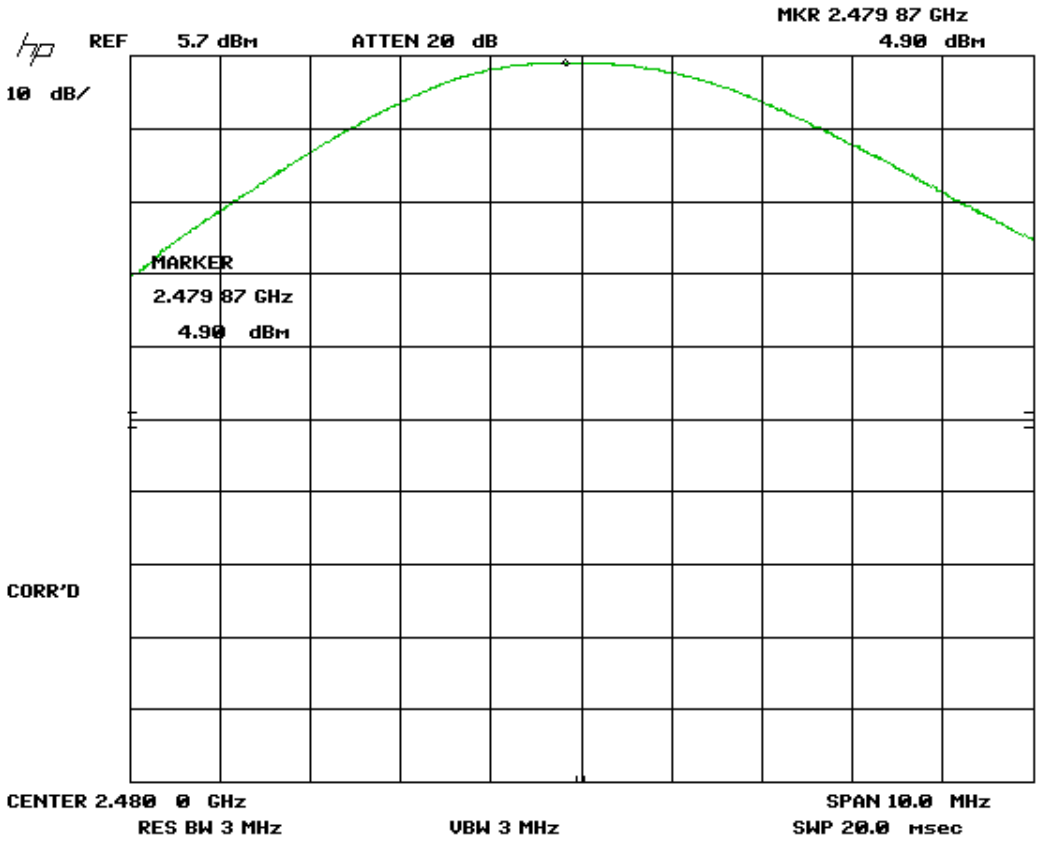
2.12 Peak Power Output (CFR 15.247 (b)(3))



Note: reference adjusted for correction factor.

Figure 15. Peak Antenna Conducted Output Power, Mid Channel

2.12 Peak Power Output (CFR 15.247 (b)(3))



Note: reference adjusted for correction factor.

Figure 16. Peak Antenna Conducted Output Power, High Channel

2.12 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band). Because these frequencies occur above 1000 MHz they have both a peak and average requirement.

To capture the band edge set the Spectrum Analyzer frequency span large enough (usually around 10 MHz) to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW ≥1% of the frequency span. In all cases, the VBW is set ≥ RBW. See Figure 23 and 24 below.

Table 9. Upper Band Edge - Radiated Emissions

Peak Radiated Higher Band Edge Measurements							
Test By: KM	**Test: FCC Part 15.247**			**Client: Georgia Institute Of Technology**			
	Project: 12-0302	**Class: B**		**Model: 2**			
Frequency (MHz)	**AF Table**	**Test data (dBuV)**	**AF+CA-AMP+DC (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Margin (dB)**	**Detector PK / AVG**
Fund. 2479.88	1HN3mV	69.06	31.72	100.78	--	--	**PK**
Band Edge 2484.03	--	(100.78-56.4)	--	44.38	74.0	29.62 See calculation below	**PK**
Fund. 2479.88	1HN3mV	68.81	31.72-20 dB	80.53	--	--	**AVG**
Band Edge 2484.03	--	(80.53-56.4)	--	24.13	54.0	29.87 See calculation below	**AVG**

The limit for the average value of radiated emissions in a Restricted Band is 54 dBuV/m. To compute the average values of the band edge emissions, the duty cycle correction factor of -20.00 dB is applied to the values in the Corrected Results column. After this correction the EUT is found to have met the restrictions placed on average radiated emissions in Restricted Bands. The worst-case measurement is computed below.

CALCULATION OF WORST-CASE AVERAGE UPPER BAND EDGE MEASUREMENT:
Results = Peak Corrected Results + Duty Cycle Correction Factor- Delta
Results = 100.53 + (-20.0) + (-56.4) = 24.13 dBuV/m
Margin = Limit – Results = 54 – 24.13 = 29.87 dB

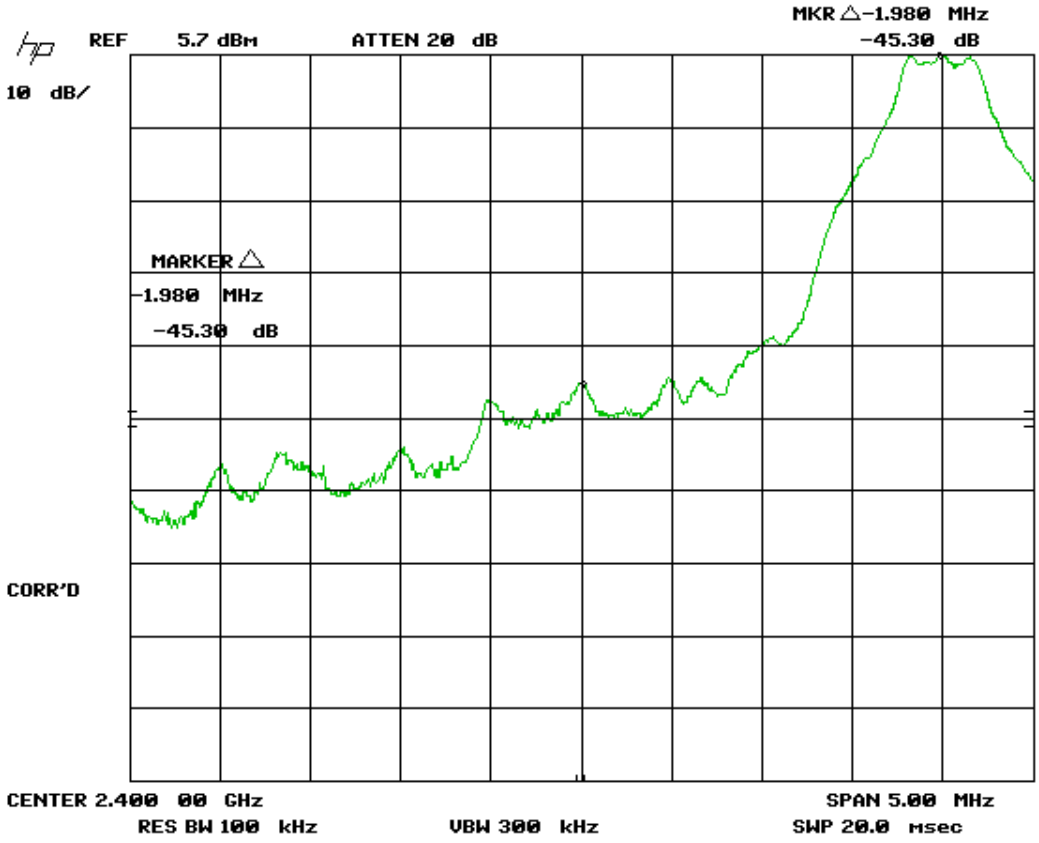


Figure 17. Band Edge Compliance – Low Channel Delta - Peak
Note: conducted emission shown here as this is the worst case.

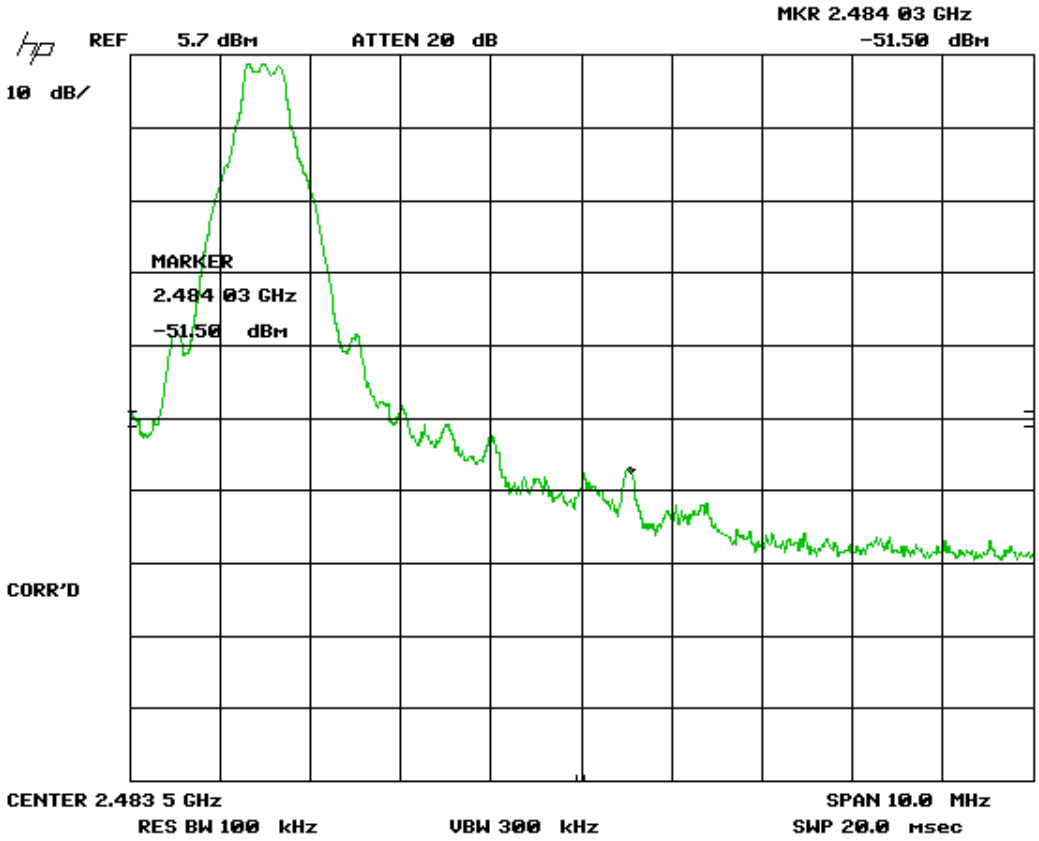


Figure 18. Band Edge Compliance – High Channel Delta - Peak

Note: conducted emission shown here as this is the worst case.
Delta = 4.9dBm (fundamental from Figure 19) – (-51.50 dBm) = 56.4 dB

2.13 20 dB Bandwidth Measurement per CFR 15.247, 99% Occupied Bandwidth (IC RSS 210, A8.1)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 for a bandwidth of 20 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table 12 and Figures 25 through 27.

Table 10. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	20 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2401.99	1.105	1.105
2441.0	1.110	1.110
2480.0	1.125	1.125

Test Date: June 27, 2012

Tested By
Signature: Keyvan Muvahhid Name: Keyvan Muvahhid

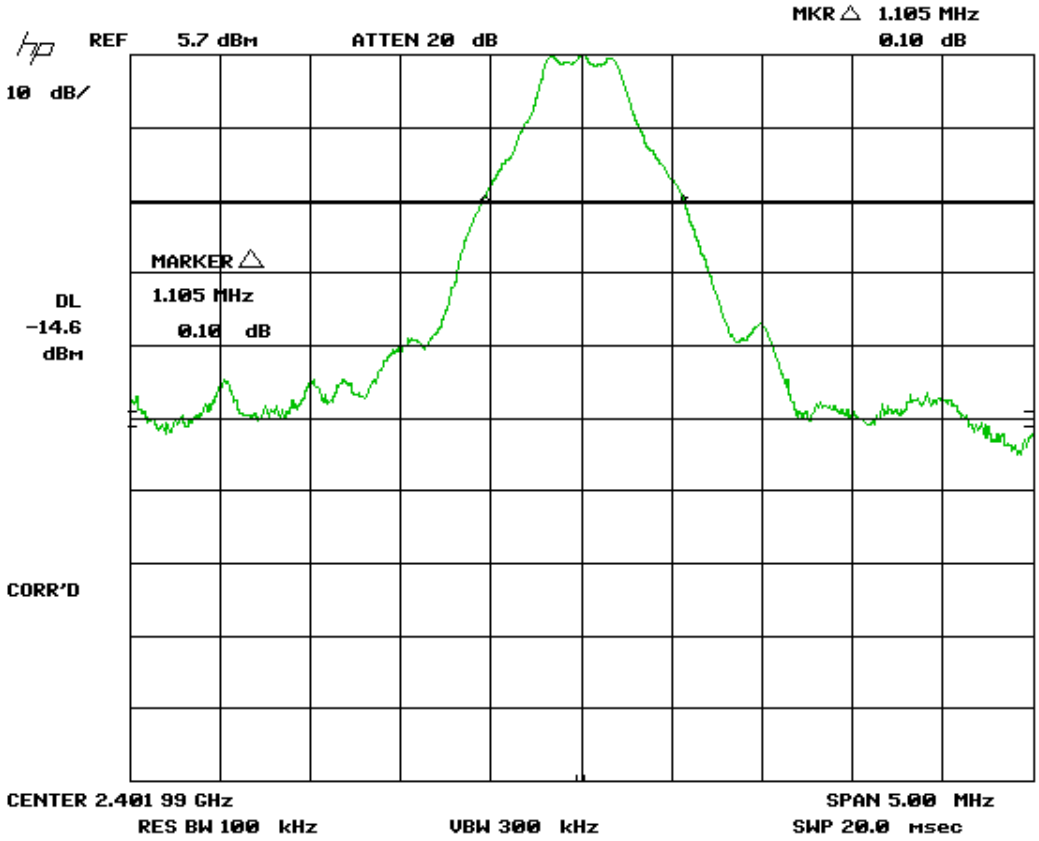


Figure 19. Low Channel 99% Bandwidth

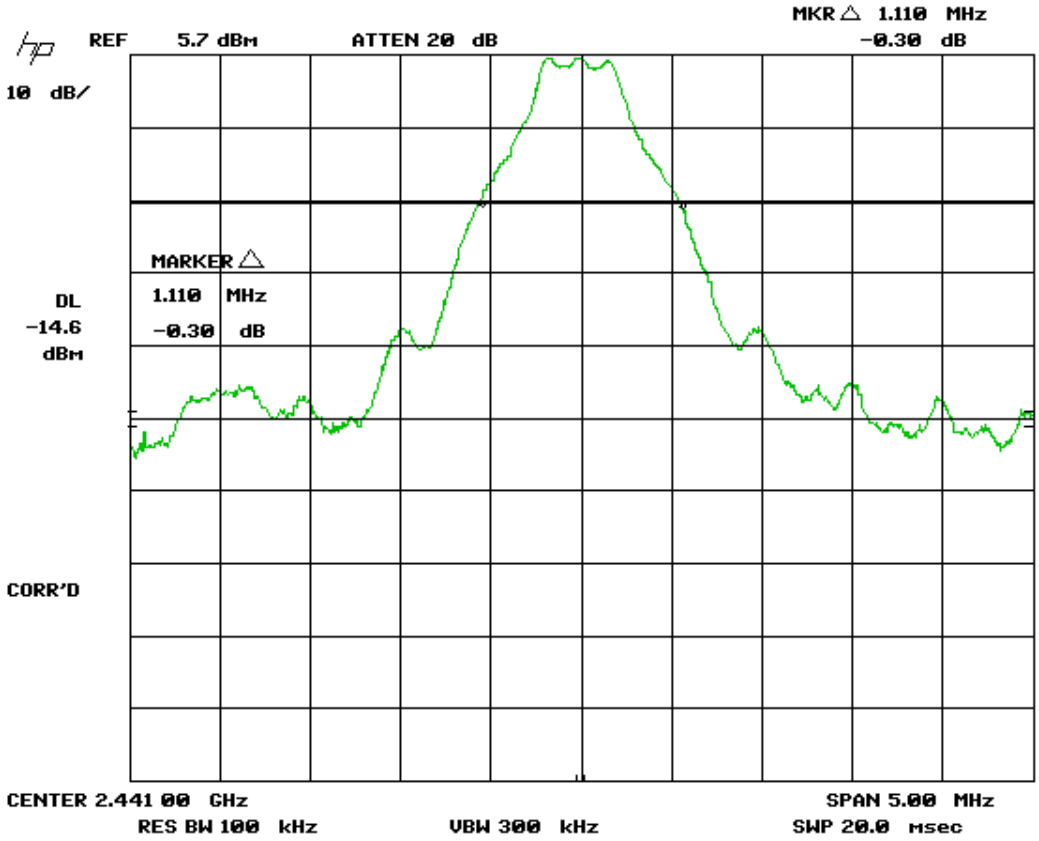


Figure 20. Mid Channel 99% Bandwidth

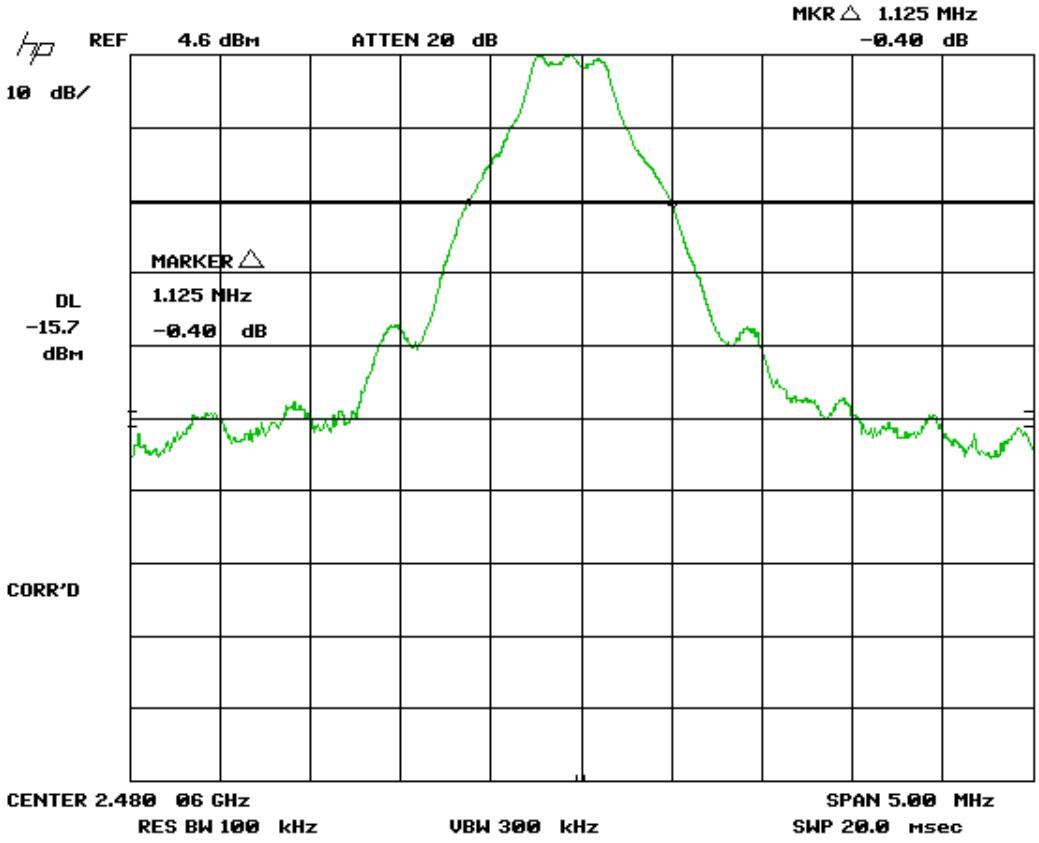


Figure 21. High Channel 99% Bandwidth

2.14 Frequency Separation (CRF 15.247(a)(1))

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

The test procedures outlined in FCC Public Notice DA 00-705 was used to conduct measurements.

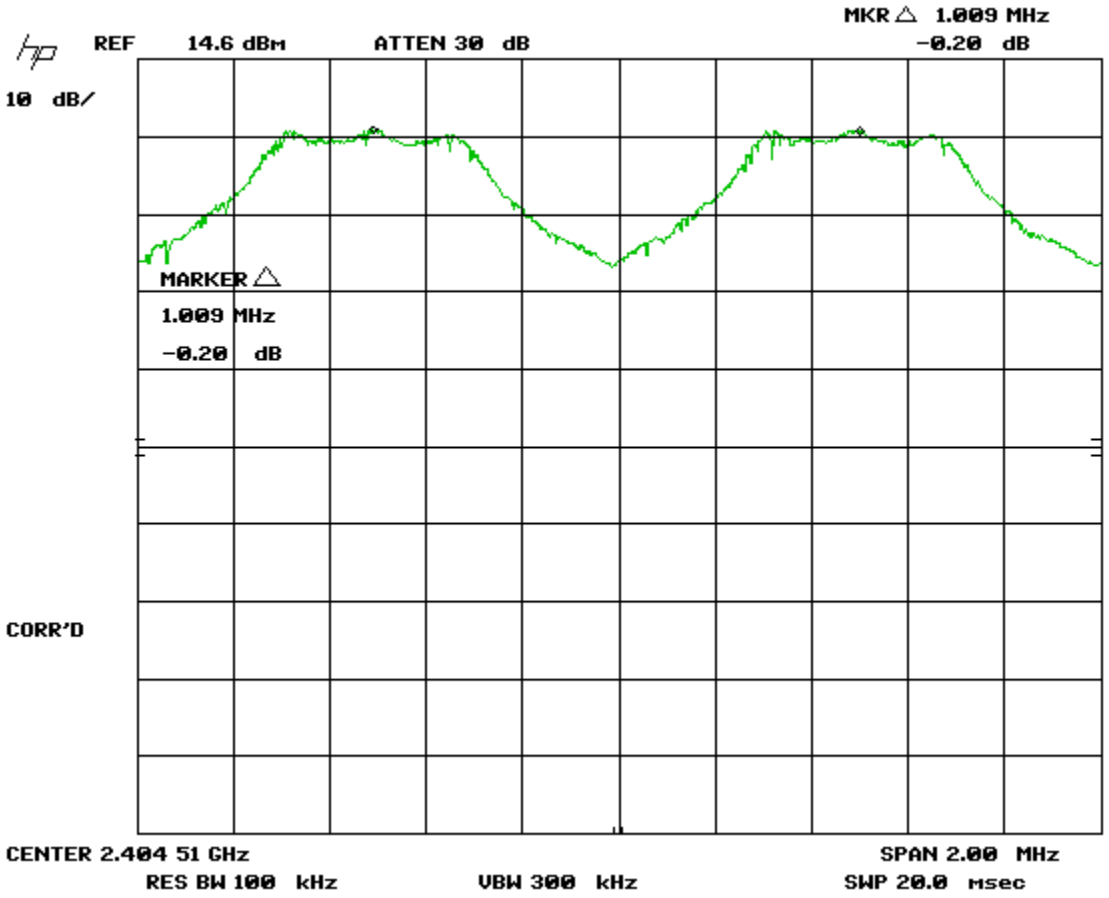


Figure 22. Channel spacing

2.15 Number of Hopping Frequencies (CFR 15.247(a)(1)(iii))(CRF 15.247(b)(1))

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

The EUT employs at 75 non-overlapping hopping channels therefore the maximum allowed output power is 1 watt.

The test procedures outlined in FCC Public Notice DA 00-705 was used to conduct measurements.

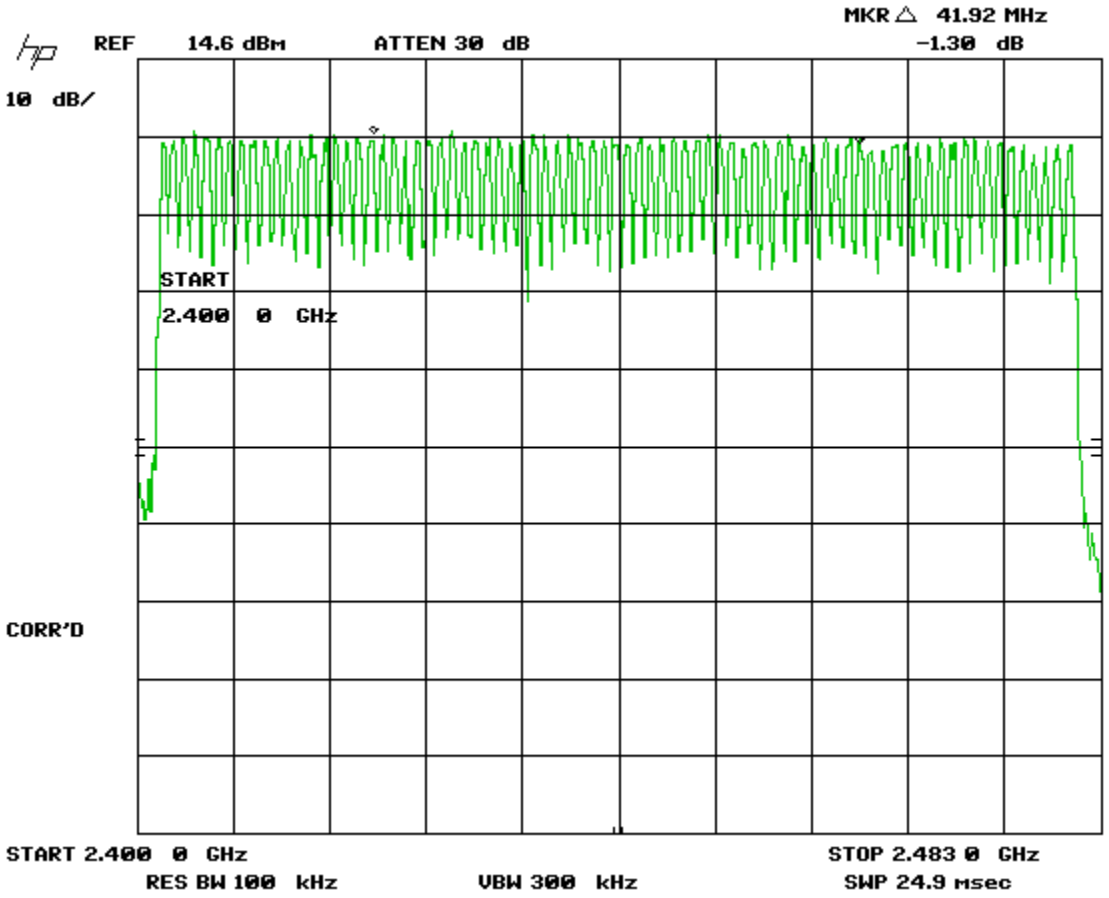


Figure 23. Number of hopping channels

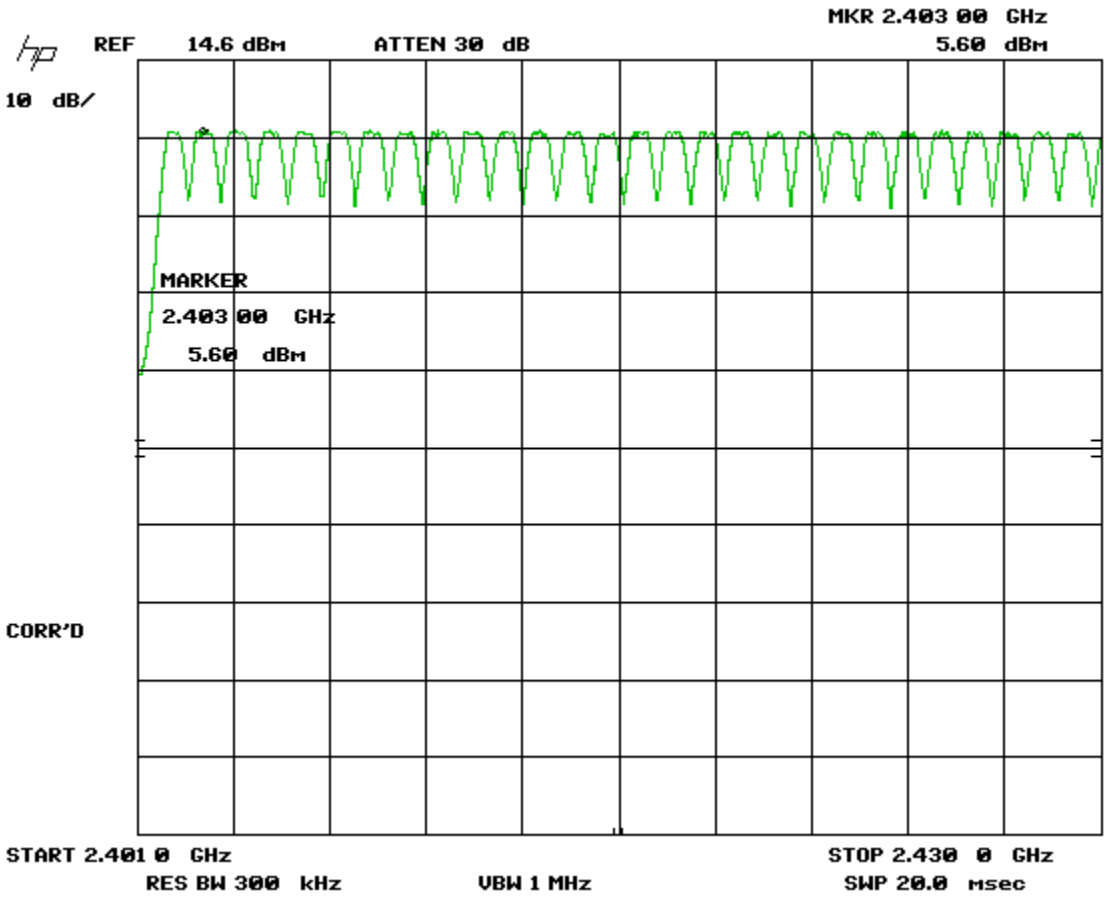


Figure 24. Number of hopping channels Part 1

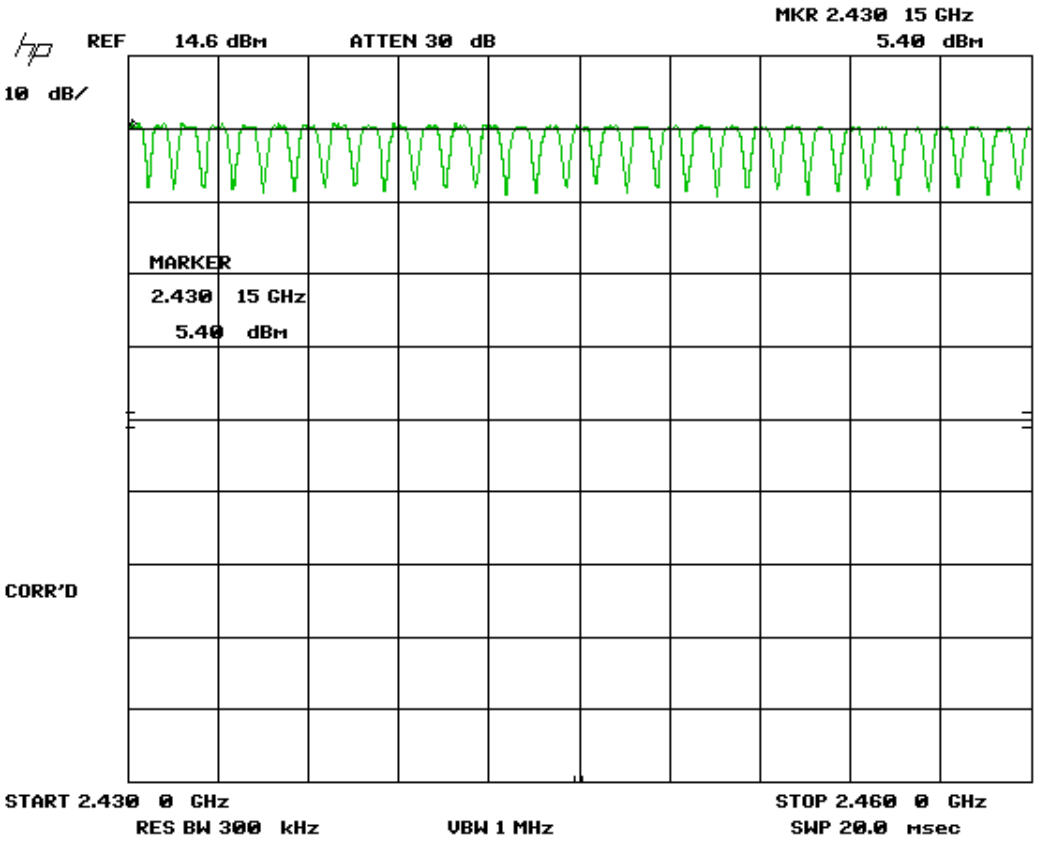


Figure 25. Number of hopping channels Part 2

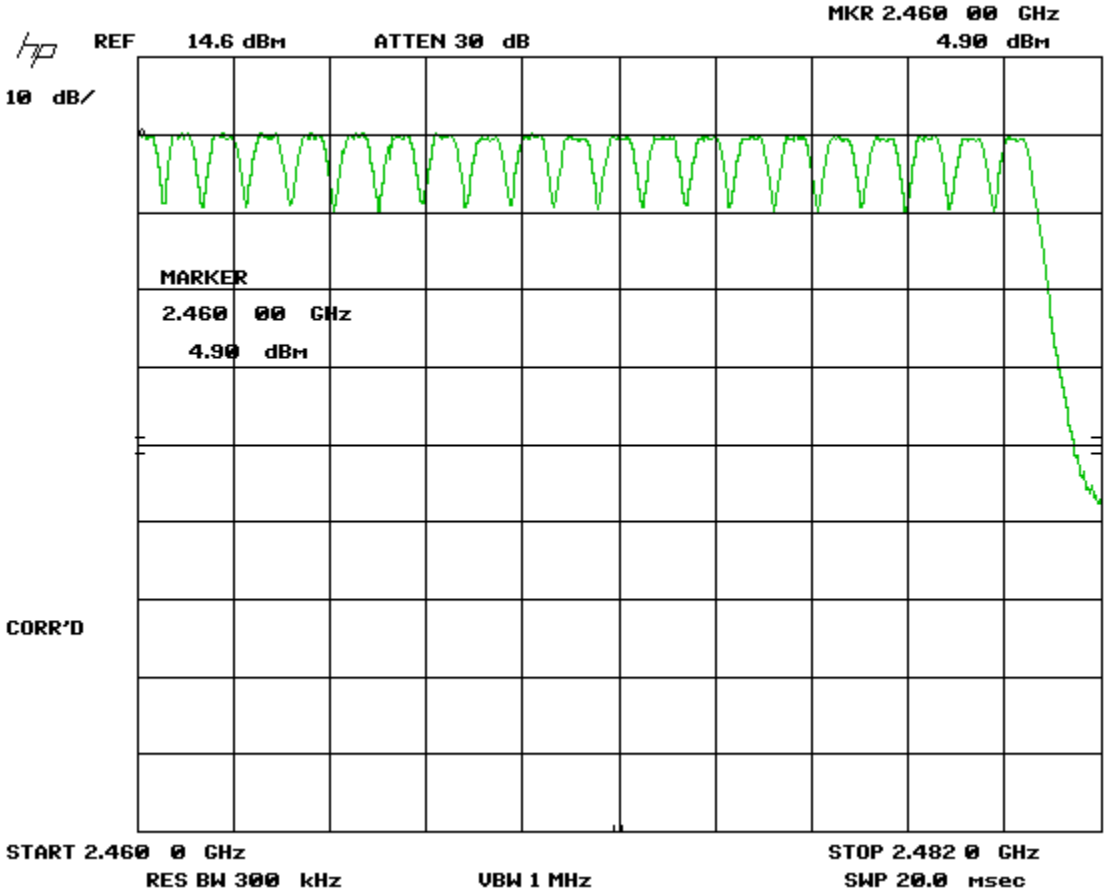


Figure 26. Number of hopping channels Part 3

2.16 Unintentional Radiator Power Lines Conducted Emissions (CFR 15.107)

The test data provided herein is to support the Verification requirement for the digital apparatus. The power line conducted voltage measurements for Receiver and Digital Devices have been carried out in accordance with CFR 15.107 and ANSI C63.4, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into an idle condition or a continuous mode of receive (non-transmitting). Please refer to the results as shown in the table below.

The EUT is powered by 9VDC battery, therefore this test in not applicable.

Table 11. Power Line Conducted Emissions Data, Class B Part 15.107, Peak Measurement vs. Avg. Limits

CONDUCTED EMISSIONS						
Tested By: JCW	Specification Requirement: FCC Part 15, Para 15.107 Class B		Project No.: 12-0302	Manufacturer/Model: Georgia Institute Of Technology Model 2		
Frequency (MHz)	Test Data (dBuV)	LISN+CL-PA (dB)	Corrected Results (dBuV)	Avg Limits (dBuV)	Margin (dB)	Detector
This test is not applicable.						

2.17 Unintentional Radiator, Radiated Emissions (CFR 15.109, 15.209)

The test data provided herein is to support the verification requirement for digital devices. Radiated emissions coming from the EUT in a non-transmit state per 15.109 were evaluated from 30 MHz to 25 GHz as well as radiated emission coming for the EUT in a transmitting state per 15.209 and were investigated from 9kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.4:2003, Paragraph 8. The worst case is presented herein.

Radiated emissions within the band of 9 kHz to 30 MHz were investigated using a calibrated Loop Antenna and per the requirements of ANSI C63.4:2003.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure. All measured signals were at least 0.5 dB below the specification limit. The results are shown in Table 12 below.

These test data are provided herein to support the Verification requirement for digital devices. Radiated emissions coming from the EUT in a transmitting mode were evaluated from 30 MHz to 25.0 GHz per 15.209 and were tested as detailed in ANSI C63.4:2003, Paragraph 8. The worst case is presented herein.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure. The results are shown in the table below.

Table 12. Unintentional Radiator, Radiated Emissions

Unintentional Radiator, Radiated Emissions							
Test By: JCW	**Test: FCC Part 15.109, 15.209**			**Client: Georgia Institute Of Technology**			
	Project: 12-0302 Class: B			**Model: 2**			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP**
15.93	35.10	3.80	38.90	70.0	3m./LOOP	31.1	**PK**
137.42	42.10	-12.99	29.11	43.5	3m./Hor	14.4	**PK**
81.45	47.30	-19.01	28.29	40.0	3m./Ver	11.7	**PK**
144.15	44.80	-12.23	32.57	43.5	3m./Ver	10.9	**PK**
180.00	28.30	-7.89	20.41	43.5	3m./Ver	23.1	**PK**
180.00	30.40	-8.49	21.91	43.5	3m./Hor	21.6	**PK**
225.00	39.40	-12.35	27.06	46.0	3m./Hor	18.9	**PK**
270.00	51.00	-10.00	41.00	46.0	3m./Hor	5.0	**PK**
292.48	40.30	-9.36	30.94	46.0	3m./Hor	15.1	**PK**
314.99	51.00	-8.13	42.87	46.0	3m./Hor	3.1	**QP**
337.51	43.80	-8.73	35.07	46.0	3m./Hor	10.9	**PK**
224.99	35.50	-12.89	22.61	46.0	3m./Ver	23.4	**PK**
270.02	42.70	-10.30	32.40	46.0	3m./Ver	13.6	**PK**
314.99	45.70	-8.33	37.37	46.0	3m./Ver	8.6	**PK**
337.49	39.00	-9.03	29.97	46.0	3m./Ver	16.0	**PK**
382.49	38.10	-8.25	29.86	46.0	3m./Ver	16.1	**PK**
427.51	36.80	-7.93	28.87	46.0	3m./Ver	17.1	**PK**

No other emissions detected within 20 dB of the FCC Part 15.209 limits
AF is antenna factor. CL is cable loss. PA is preamplifier gain
SAMPLE CALCULATION: At 81.45 MHz: = 47.3 + (-19.01) = 28.29 dBuV/m @ 3m
Margin = (40.0 – 28.29) = 11.7 dB

Test Date: June 27, 2012

Tested By Signature:  Name: John C. Wynn