Testing Tomorrow's Technology

Application
For

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

and

IC Radio Standards Specification: RSS-210

Permissive Change

For the

RFM

Model(s): WIT2492

FCC ID: HSW-2492
IC: 4492A-2492

UST Project: 13-0330
Issue Date: December 16, 2013

Total Pages in This Report: 32

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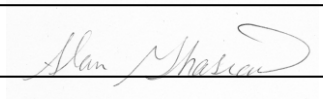
Testing Tomorrow's Technology

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: Consulting Engineer President

Date: December 16, 2013

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: RFM

MODEL(S): WIT2492

FCC ID: HSW-2492

IC ID: 4492A-2492

DATE: December 16, 2013

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

Equipment type: FHSS Transceiver 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
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1 General Information

1.1 Purpose of this Report

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Industry Canada's Radio Standards Specification RSS-210 for a Class II Permissive Change to include the use of a 2.4GHz CP beam antenna. The beam antenna information is as follows:

Manufacturer	Model	Peak Gain (dBi)	Frequency (MHz)
RF Venue	2.4 GHz CP Beam Antenna	14.0	2400-2483.5

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on December 1, 2013 in good operating condition.

1.3 Product Description

The WIT2492 radio transceiver provides reliable wireless connectivity for either point to point or multipoint applications. Frequency hopping spread spectrum technology ensures maximum resistance to noise and multipath fading and robustness in the presence of interfering signals, while operation in the 2.4GHz ISM band allows license free use and worldwide compliance. A simple serial interface supports asynchronous data up to 230400 bps. An on board 3 KB buffer and an error correcting over the air protocol provide smooth data flow and simplify the task of integration with existing applications.

1.4 Duty Cycle Correction

Maximum duty cycle for WIT2492:

5ms dwell time, 43 channels, transmission on each channel occurs once every 215ms

Base operation
Preamble 9 bytes
Sync ,ID ,control, CRC 22 bytes
Data Payload 65 bytes
Maximum packet length 96 bytes
Bit time (1/921.6 Kbps) 1.085 us
Byte time (bit time * 8) 8.68 us
Maximum packet time (byte time * 96) 833 us

Duty Cycle
833E-6/100E-3 = .00833 (.833%)

Duty Cycle Correction
20*Log (.00833) = -41.6dB

For the purposes of this test report the duty cycle correction factor used is -20 dB.

1.5 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2003, 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 Public Notice DA 00-705 released March 30, 2000 for Frequency Hopping Spread Spectrum Systems operating under section 15.247. Also, Marker-Delta Method was followed to measure the upper band-edge.

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.

1.6 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.

Table 1 - EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID	CABLES P/D
(EUT) RFM	WIT2492	Engineering Sample	HSW-2492	0.2m U D
Switching Power Supply Volgen	NP12-US0520	Production Sample	None	1.5m U P
Evaluation Board RFM	Radio Eval Board	800610	None	1.5m U P 1.5m U D

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 herewith.

Table 2 - Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	E4407B	Agilent	US41442935	11/19/13
HORN ANTENNA 1 GHz to 18 GHz	SAS-571	AH Systems	605	7/23/13
PREAMP 1 GHz to 26.5 GHz	8449B	HEWLETT-PACKARD	3008A00480	3/04/13
CALCULATION PROGRAM	N/A	N/A	Ver. 2013	N/A

Note: The calibration interval of the above test instruments is 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 2400 MHz to 2483.5 MHz, 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:

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified.

(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

For details refer to CFR 15.35 (a) and (b).

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. RFM will sell the RF Module with the following additional antenna to the original application

Table 4 - Allowed Antenna(s)

MANUFACTURER	TYPE OF ANTENNA	MODEL	REPORT REFERENCE	GAIN dB_i
RF Venue	Beam Antenna	2.4 GHz CP Beam Antenna	Antenna 1	14.0

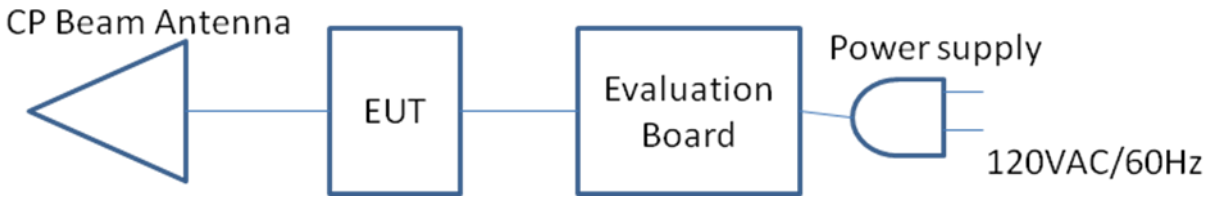


Figure 1 - Test Configuration

2.7 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 Public Notice DA 00-705, for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 12.5 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 4 through 10 below. The limit for antenna conducted power is 0.125 Watt (20.9 dBm) per 15.247 (b)(1).

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 5, 6 and 7 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. Data is shown in the tables that follow.

2 Test and Measurements (Cont'd)

2.8 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d)) (IC RSS 210, A2.9 (a)) (Cont'd).

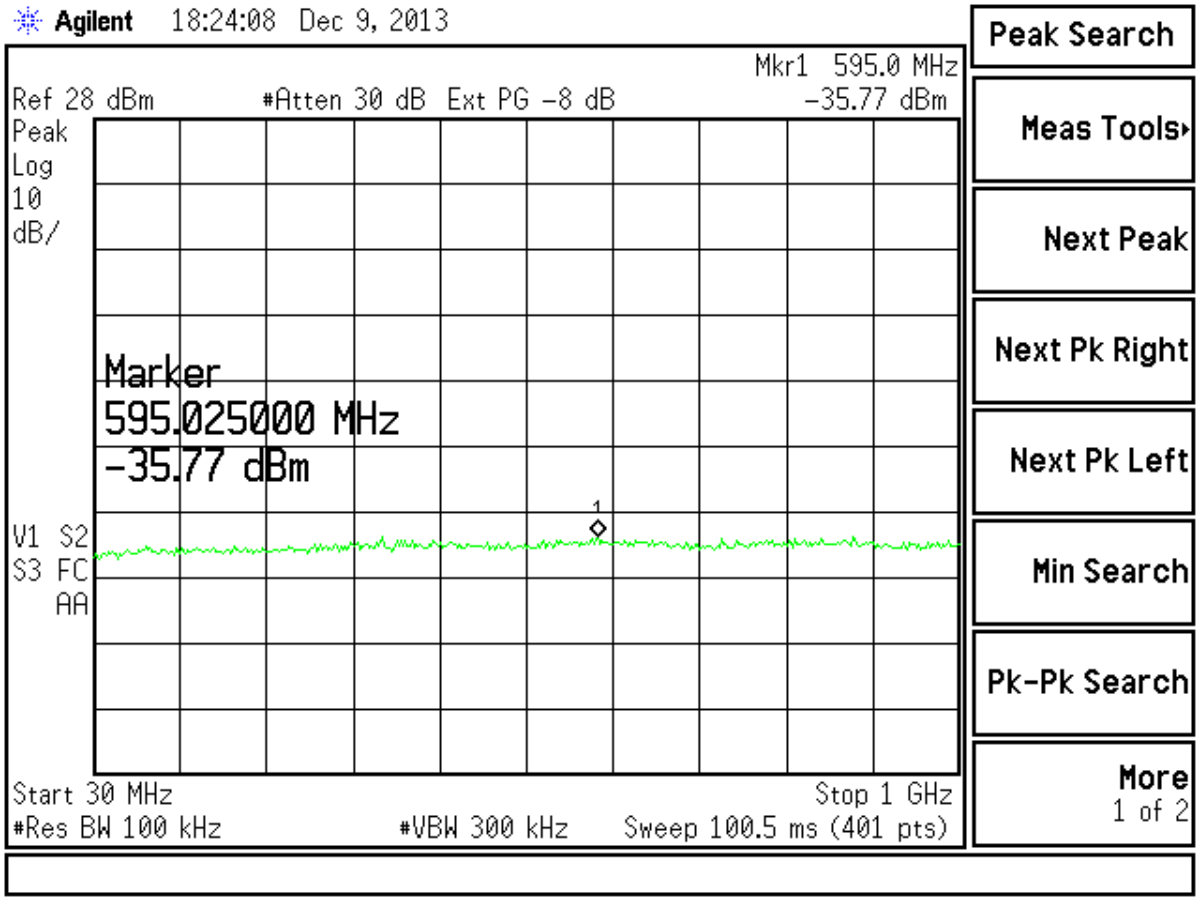


Figure 2 - Antenna Conducted Spurious Emissions – Low Channel, Part 1

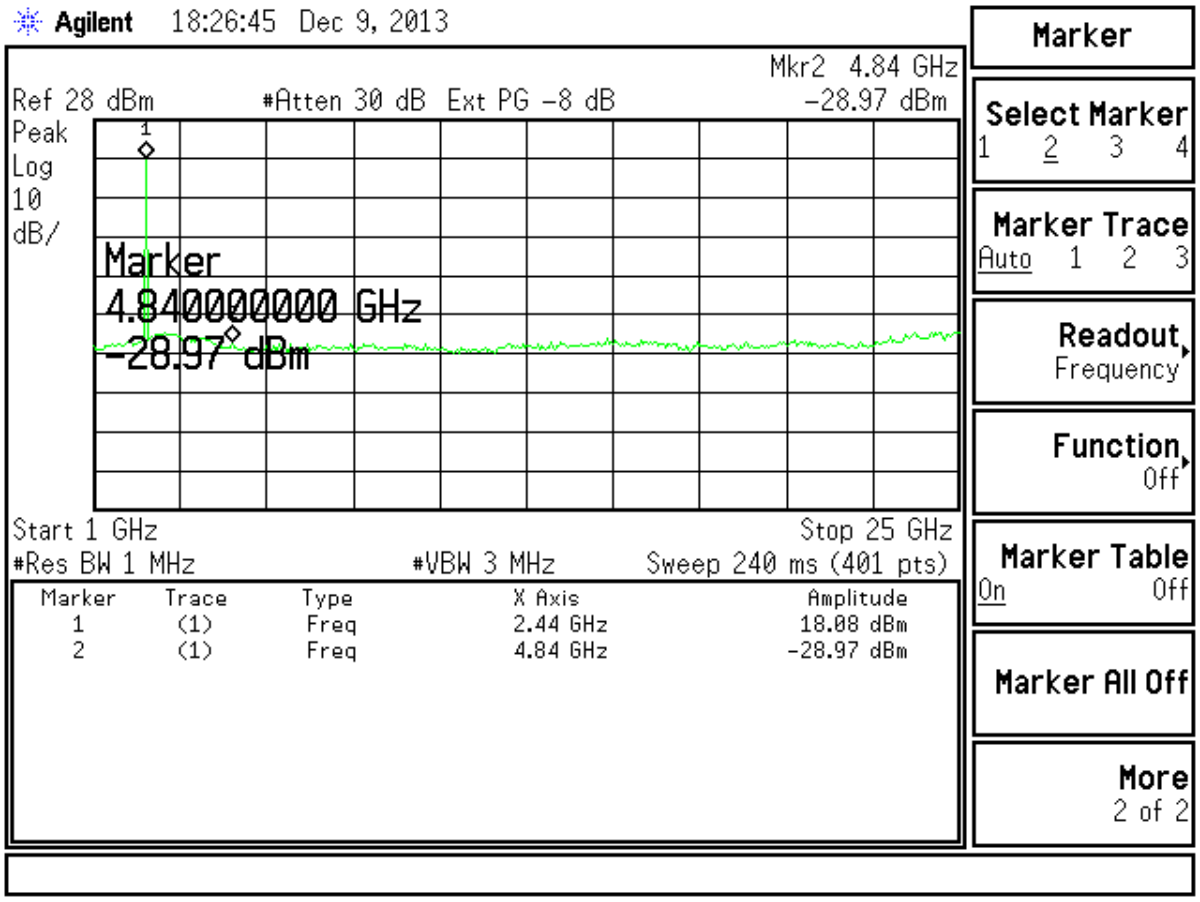


Figure 3 - Antenna Conducted Spurious Emissions – Low Channel, Part 2

Note: Large signal shown represents Fundamental Frequency

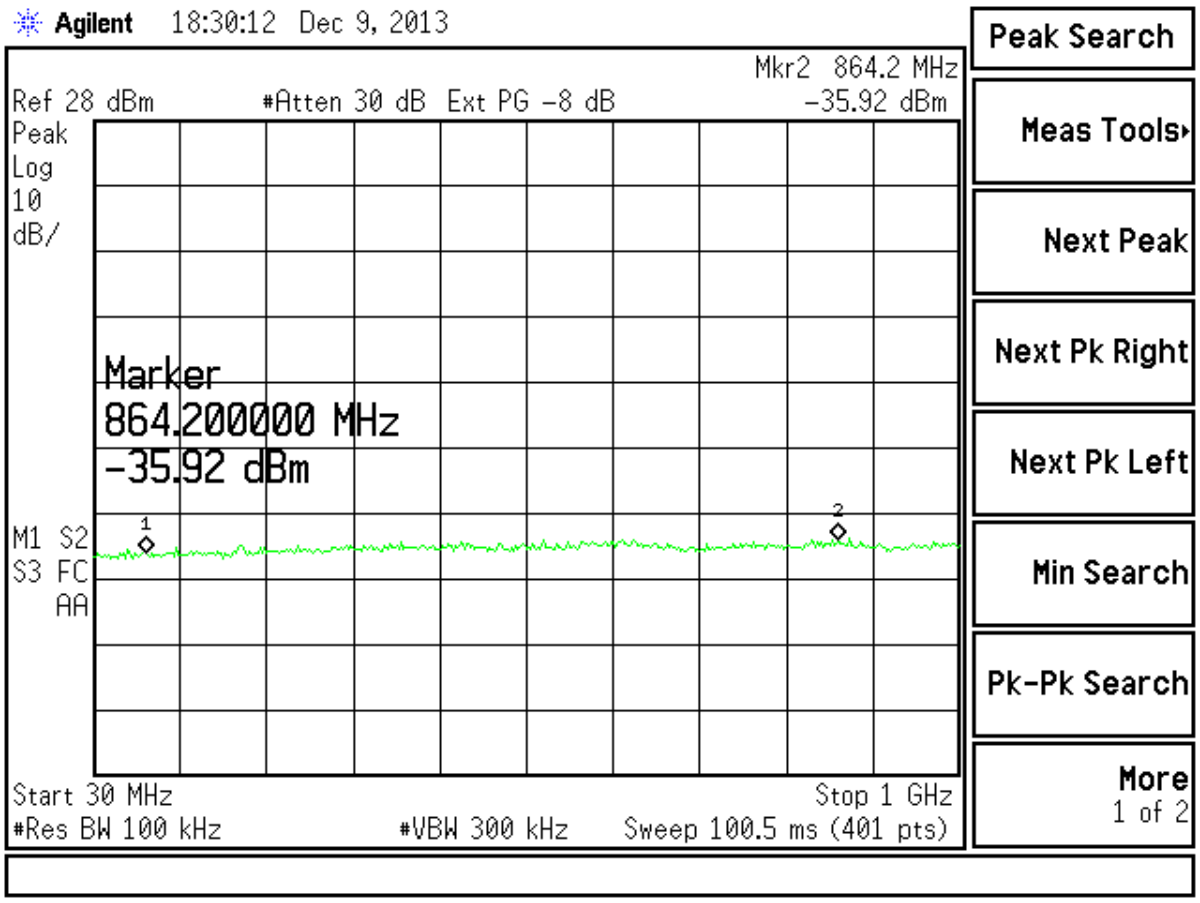


Figure 4 - Antenna Conducted Spurious Emissions - Mid Channel, Part 1

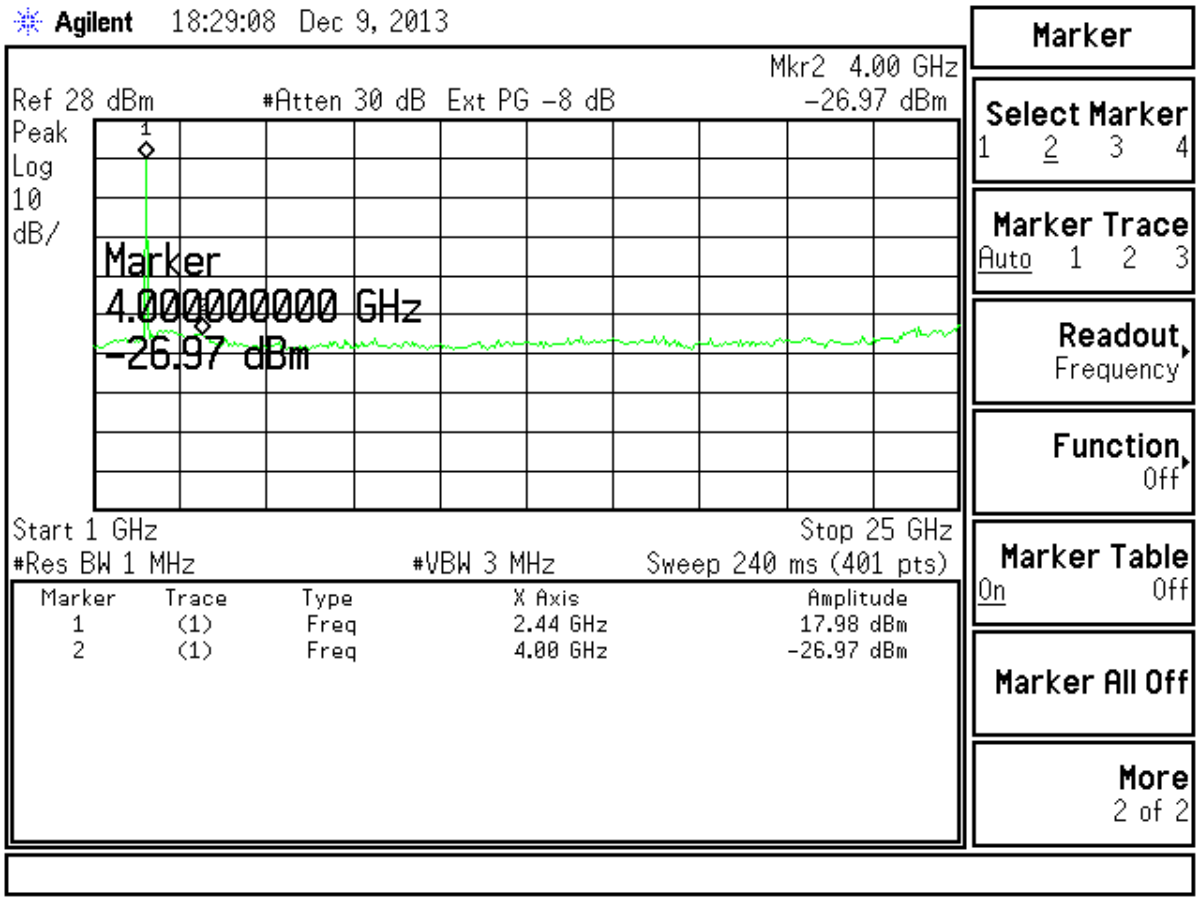


Figure 5 - Antenna Conducted Spurious Emissions – Mid Channel, Part 2

Note: Large signal shown represents Fundamental Frequency

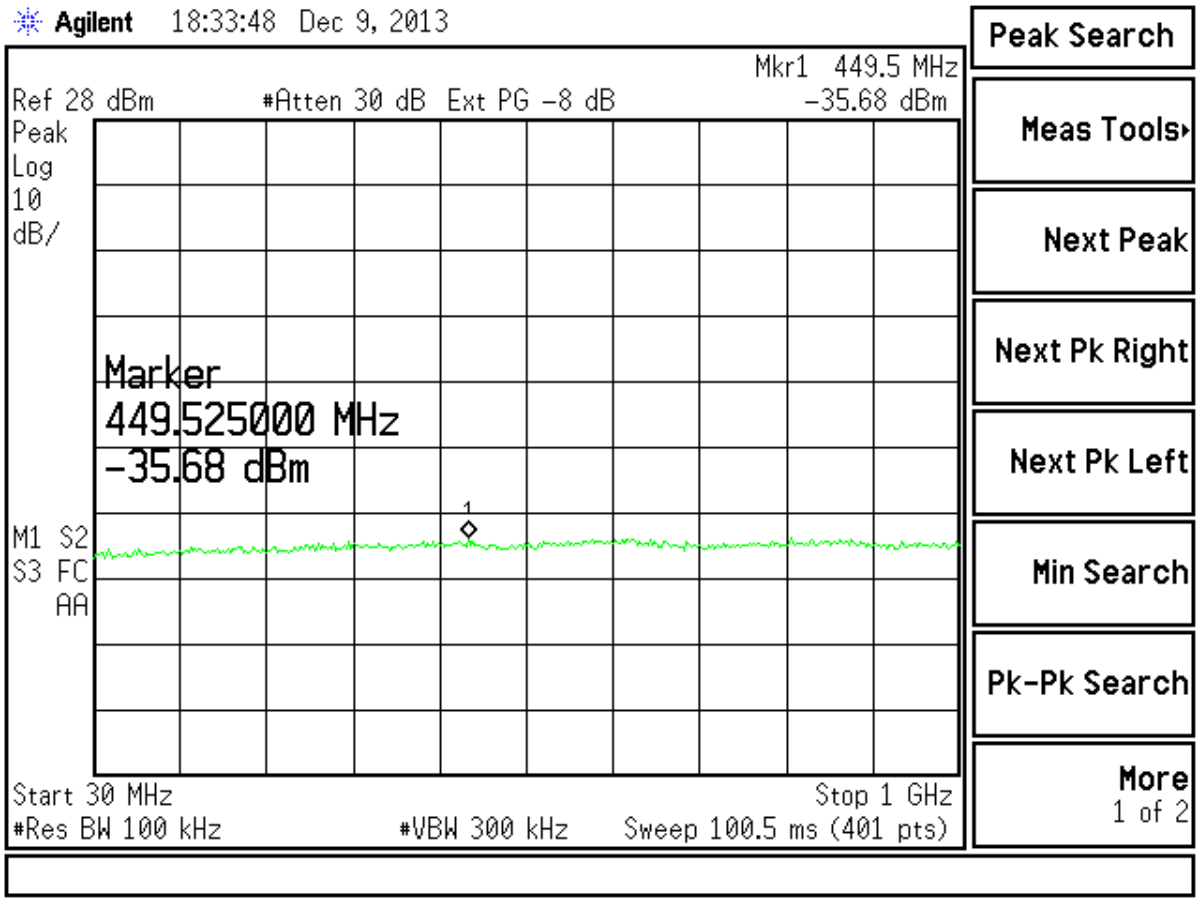


Figure 6 - Antenna Conducted Spurious Emissions – High Channel, Part 1

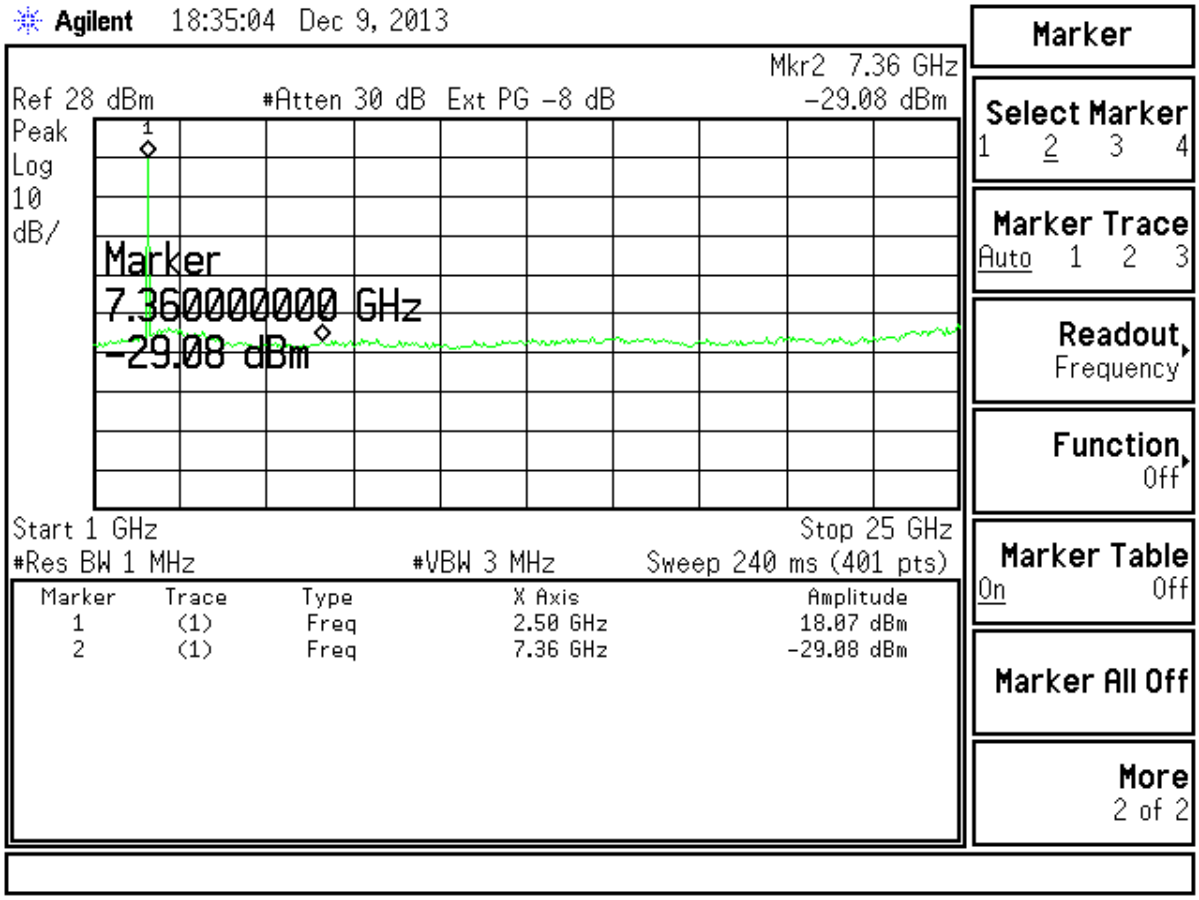


Figure 7 - Antenna Conducted Spurious Emissions - High Channel, Part 2

Note: Large signal shown represents Fundamental Frequency

Table 5 - Peak Radiated Harmonic & Spurious Emissions-Antenna 1

Radiated Harmonic and Spurious Emissions								
Tested By: GY	Test: FCC Part 15, Para 15.247(d)				Client: RFM			
	Project: 13-0330				Model: WIT2492			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**PEAK Limits (dBuV/m)**	**Distance / Polarization**	**Pass Margin (dB)**	**Detector PK / AVG**
LOW BAND - PEAK								
2402.64	85.88	--	26.96	112.84	--	3.0m./	--	**PK**
4805.28	68.99	1.50	-4.97	65.52	74.0	3.0m./	8.5	**PK**
7207.96	54.02	1.50	-4.25	51.27	74.0	3.0m./	22.7	**PK**
9610.68	51.49	1.50	8.63	61.62	74.0	3.0m./	12.4	**PK**
MID BAND- PEAK								
2441.37	87.36	--	26.86	114.22	--	3.0m./	--	**PK**
4882.51	65.04	1.50	-5.21	61.33	74.0	3.0m./	12.7	**PK**
7324.10	55.85	1.50	-4.98	52.37	74.0	3.0m./	21.6	**PK**
9764.08	50.03	1.50	8.35	59.88	74.0	3.0m./	14.1	**PK**
HIGH BAND- PEAK								
2480.06	87.57	--	27.01	114.58	--	3.0m./	--	**PK**
4959.99	63.82	1.50	-5.53	59.79	74.0	3.0m./	14.2	**PK**
7440.19	58.36	1.50	-6.07	53.79	74.0	3.0m./	20.2	**PK**
9920.28	50.33	1.50	8.13	59.96	74.0	3.0m./	14.0	**PK**

- Limits based on CFR15.209 & 20 dB relaxation of CFR 15.35(b) if applicable.
- Additional factor due to the use of filter.
- No other emissions found less than 20 dB from the limit.

SAMPLE CALCULATION:
RESULTS: At 4805.28 MHz: = 68.99 dBuV + additional factor (1.50) + (-4.97) dB/m = 65.52 dBuV/m @ 3m
Margin = (74.0 – 65.52) = 8.5 dB

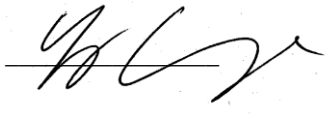
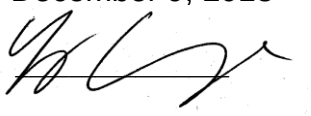
Test Date: December 9, 2013
Tested By
Signature:  Name: George Yang

Table 6 - AVG Radiated Harmonic & Spurious Emissions-Antenna 1

Radiated Harmonic and Spurious Emissions								
Tested By: GY	Test: FCC Part 15, Para 15.247(d)				Client: RFM			
	Project: 13-0330				Model: WIT2492			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Distance / Polarization**	**Pass Margin (dB)**	**Detector PK / AVG**
LOW BAND - PEAK								
2402.64	85.26	--	26.96	112.22	--	3.0m./	--	**AVG**
4805.28	67.52	-18.50	-4.97	44.05	54.0	3.0m./	9.9	**AVG**
7207.96	48.03	-18.50	-4.25	25.28	54.0	3.0m./	28.7	**AVG**
9610.68	51.49	-18.50	8.63	41.62	54.0	3.0m./	12.4	**AVG**
MID BAND- PEAK								
2441.37	86.71	--	26.86	113.57	--	3.0m./	--	**AVG**
4882.51	61.45	-18.50	-5.21	37.74	54.0	3.0m./	16.3	**AVG**
7324.10	49.77	-18.50	-4.98	26.29	54.0	3.0m./	27.7	**AVG**
9764.08	50.03	-18.50	8.35	39.88	54.0	3.0m./	14.1	**AVG**
HIGH BAND- PEAK								
2480.06	86.32	--	27.01	113.33	--	3.0m./	--	**AVG**
4959.99	54.06	-18.50	-5.53	30.03	54.0	3.0m./	24.0	**AVG**
7440.19	53.44	-18.50	-6.07	28.87	54.0	3.0m./	25.1	**AVG**
9920.28	50.33	-18.50	8.13	39.96	54.0	3.0m./	14.0	**AVG**

- Limits based on CFR15.209 & 20 dB relaxation of CFR 15.35(b) if applicable.
- Additional factor due to the use of filter and duty cycle factor.
- No other emissions found less than 20 dB from the limit.

SAMPLE CALCULATION:
RESULTS: At 4805.28 MHz: = 67.52 dBuV+ additional factor (-18.50) + (-4.97) dB/m = 44.05 dBuV/m @ 3m
Margin = (54.0 – 44.05) = 9.9 dB

Test Date: December 9, 2013
Tested By
Signature:  Name: George Yang

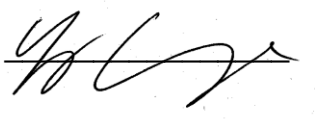
2.12 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

The WIT2492 module, the transmitter, was programmed to operate at a maximum of +18 dBm across the bandwidth.

Peak power within the band 2400-2483.5 MHz was measured per FCC KDB Publication DA 00-705 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 6 dB bandwidth of the EUT, and the VBW ≥ RBW. The loss of the short cable is <0.50 dB, and a 8.0 dB attenuator was also used. The final corrected measurements were determined by adding 8.0 dB back into the measurement. This was done using the analyzers attenuation factor settings. Peak antenna conducted output power is tabulated in Table 9 below and displayed in the figures below.

Table 9 - Peak Antenna Conducted Output Power per Part 15.247 (b)(1)

Frequency of Fundamental (MHz)	Corrected Measurement (dBm)	(mW)	FCC Limit (mW Maximum)
2402.6	18.33	68.07	125.0
2441.3	18.26	66.98	125.0
2480.0	18.04	63.67	125.0

Test Date: December 9, 2013
Tested By
Signature:  Name: George Yang

2 Test and Measurements (Cont'd)

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

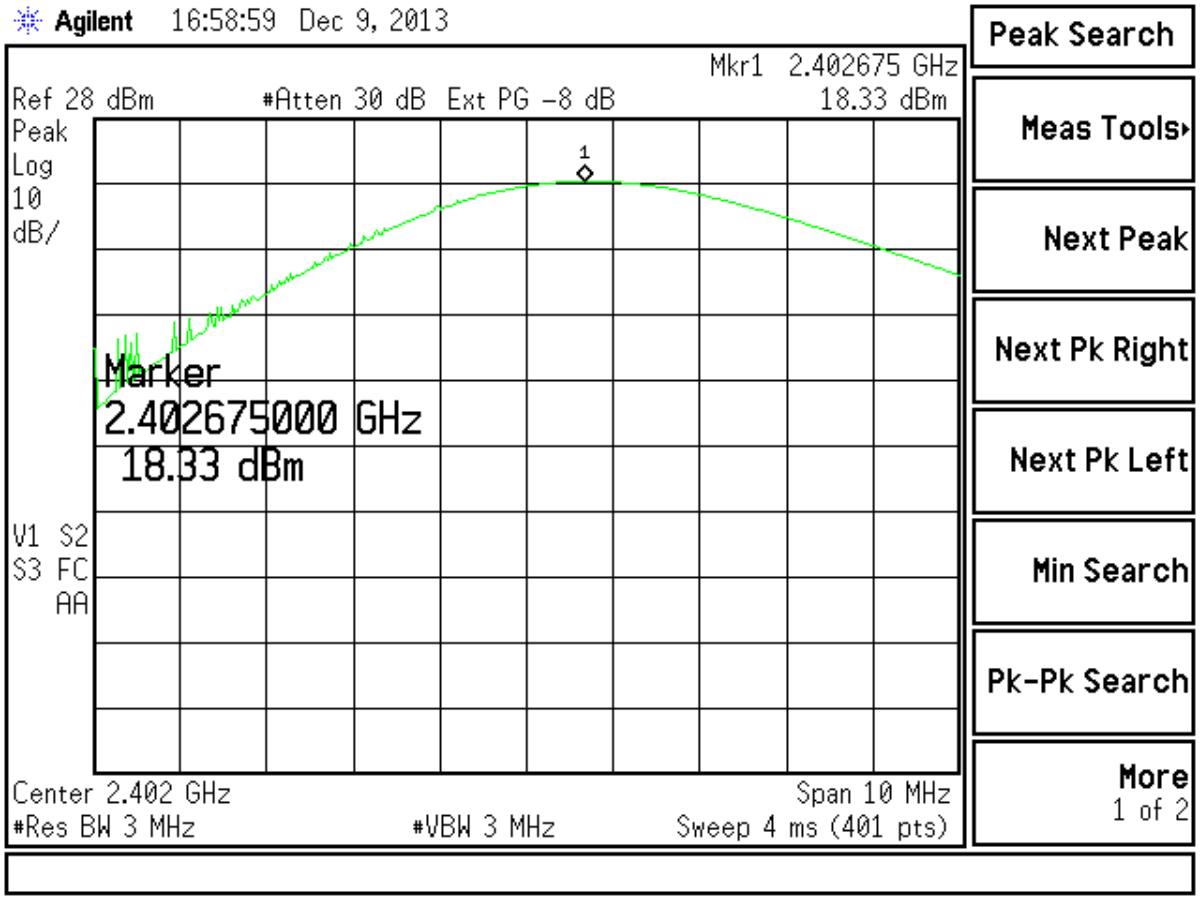


Figure 8 - Peak Antenna Conducted Output Power, Low Channel

2 Test and Measurements (Cont'd)

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

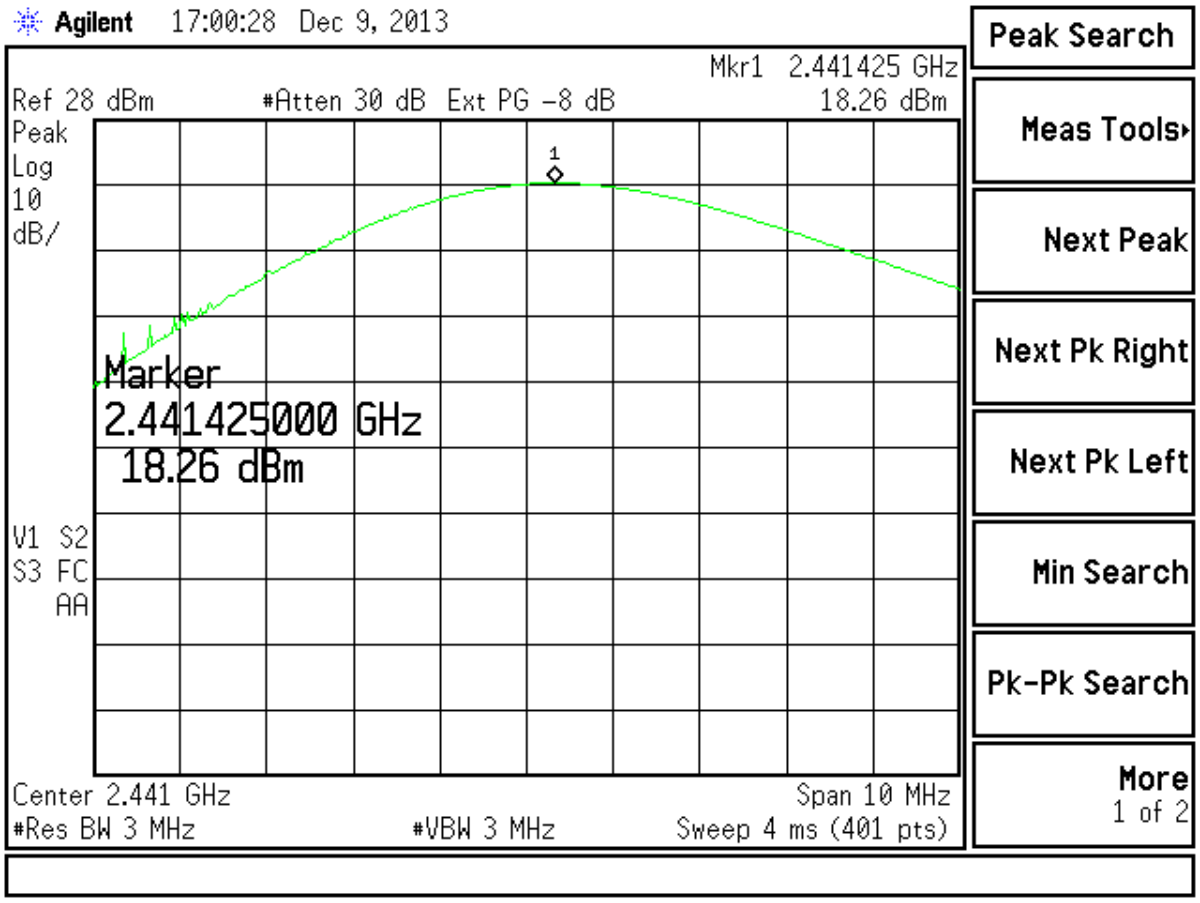


Figure 9 - Peak Antenna Conducted Output Power, Mid Channel

2 Test and Measurements (Cont'd)

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

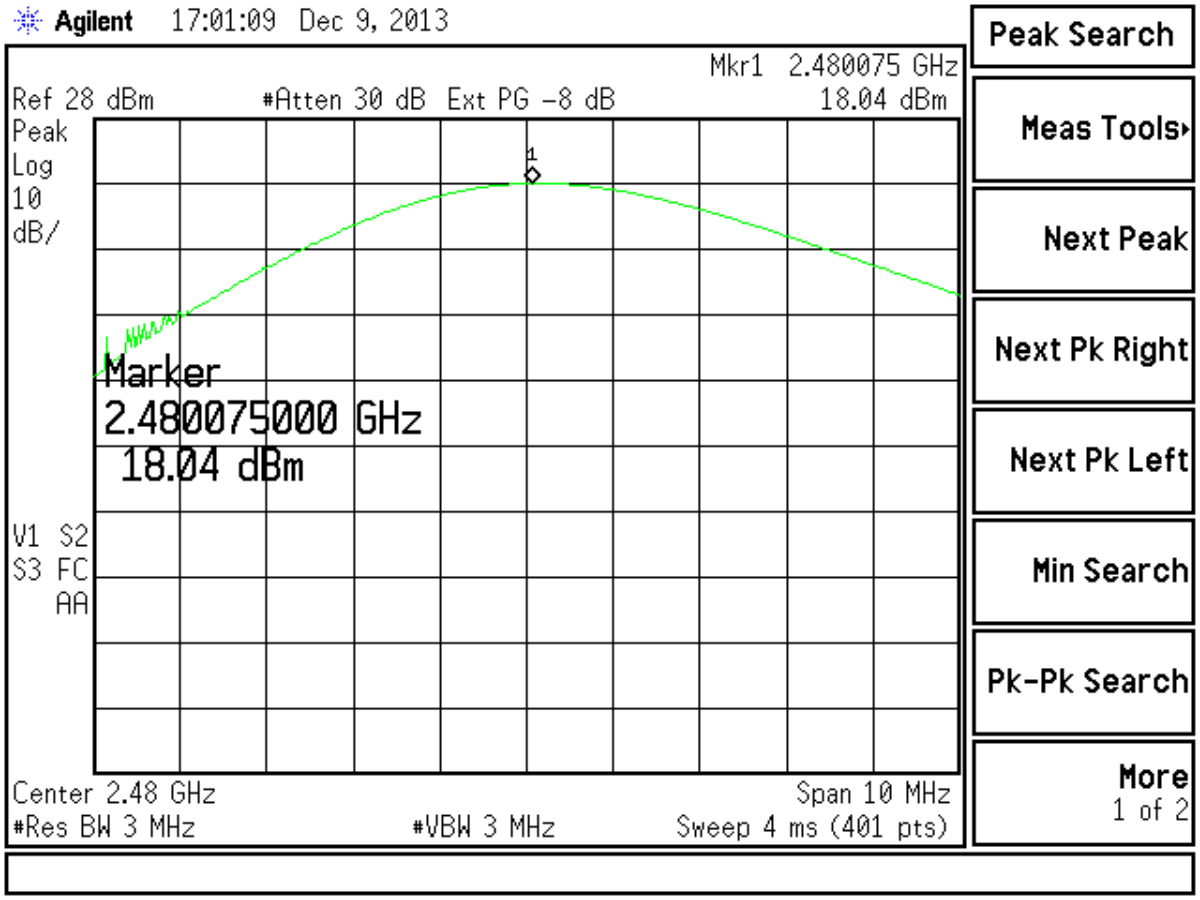


Figure 10 - Peak Antenna Conducted Output Power, High Channel

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

Band Edge measurements are made 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.

The measurement was conducted in the following manner: 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. This procedure is similar to FCC Docket # DA 00-705.

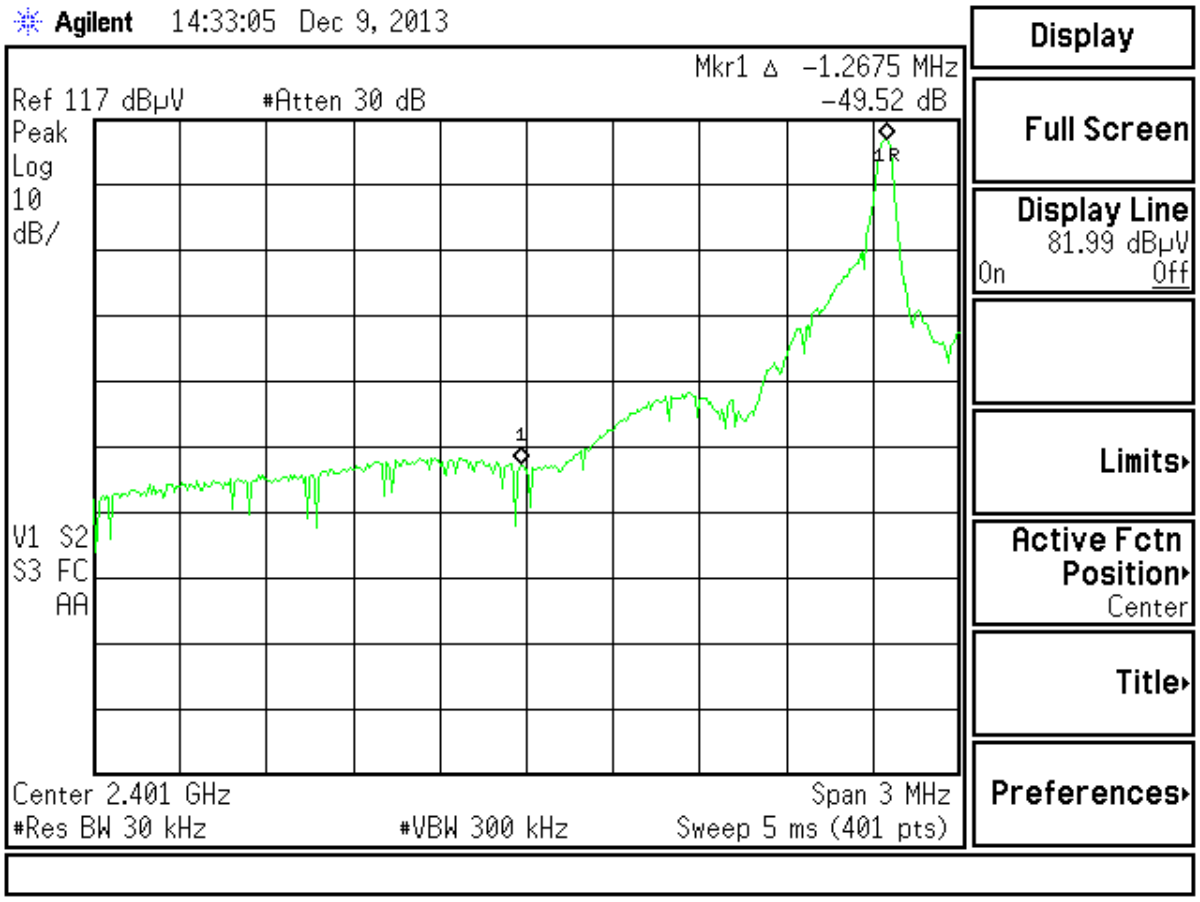


Figure 11 - Radiated Band Edge Compliance – Low Channel

Peak value:
The low channel fundamental recorded as 112.84 dBuV/m
112.84 – 49.52 = 63.32 dBuV/m; Passing Margin= 74 – 63.32 = 10.68 dB

AVG value:
The peak low channel fundamental was measured to be 112.84 dBuV/m:
Duty Cycle factor= -20.0 dB
Therefore the corrected value = 92.84
92.84 – 49.52 (peak delta) = 43.32 dBuV/m; Passing Margin= 54 – 43.32 = 10.68 dB

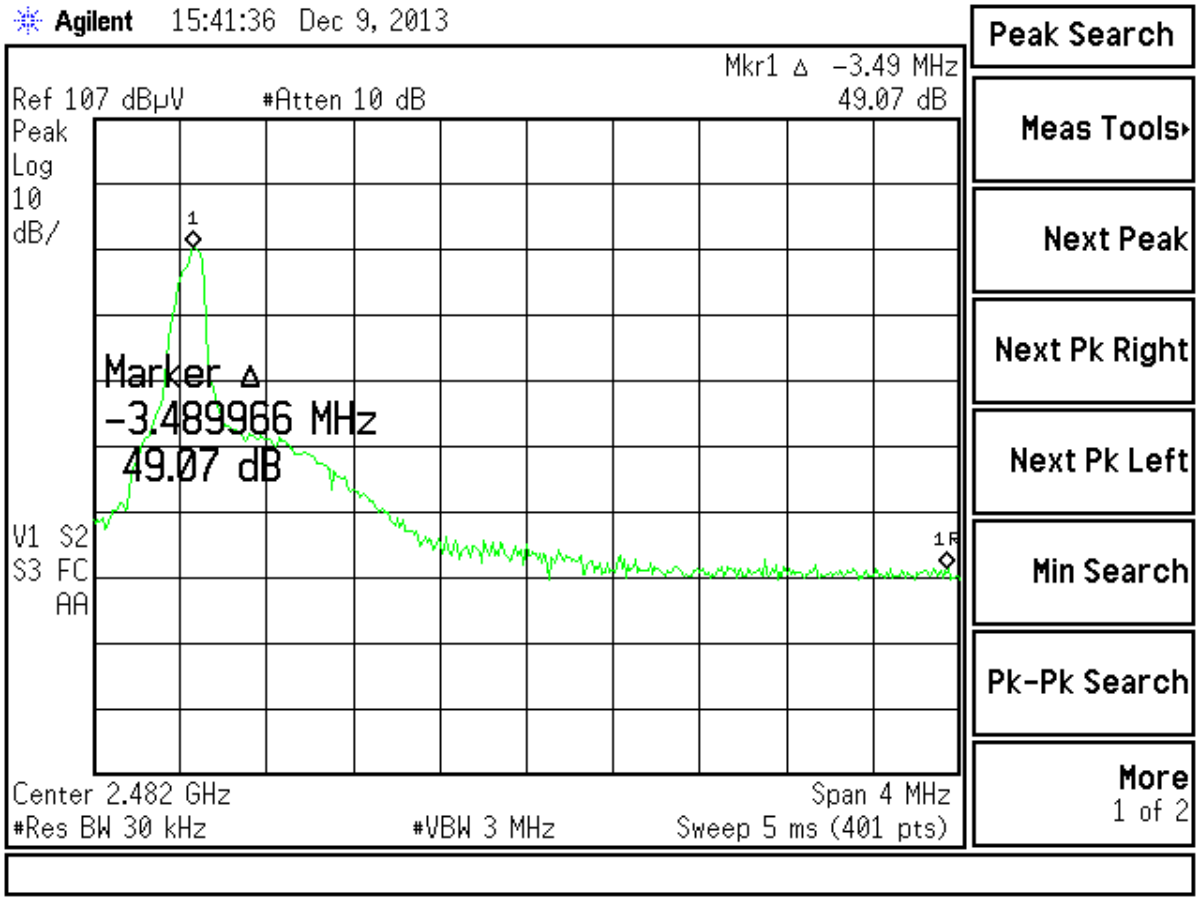


Figure 12 - Radiated Band Edge Compliance – High Channel

Peak value:
The high channel fundamental was measured to be 114.58 dBuV/m:
114.58 – 49.07dB = 65.51 dBuV/m; Passing Margin= 74 – 65.51 = 8.49 dB

AVG value:
The peak high channel fundamental was measured to be 114.58 dBuV/m:
Duty Cycle factor= -20.0 dB
Therefore the corrected value = 94.58
94.58 – 49.07 (peak delta) = 45.51 dBuV/m; Passing Margin= 54 – 45.51 = 8.49 dB

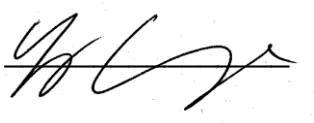
2.10 20 dB Bandwidth Measurement per CFR 15.247, (IC RSS 210, A8.1)

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 DA 00-705 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 9 and Figures 16 through 18.

Table 9 – 20dB Bandwidth Measurement

Frequency (MHz)	20 dB Bandwidth MHz
2402.6	0.3940
2441.3	0.3890
2480.0	0.3791

Test Date: December 9, 2013

Tested By
Signature: 

Name: George Yang

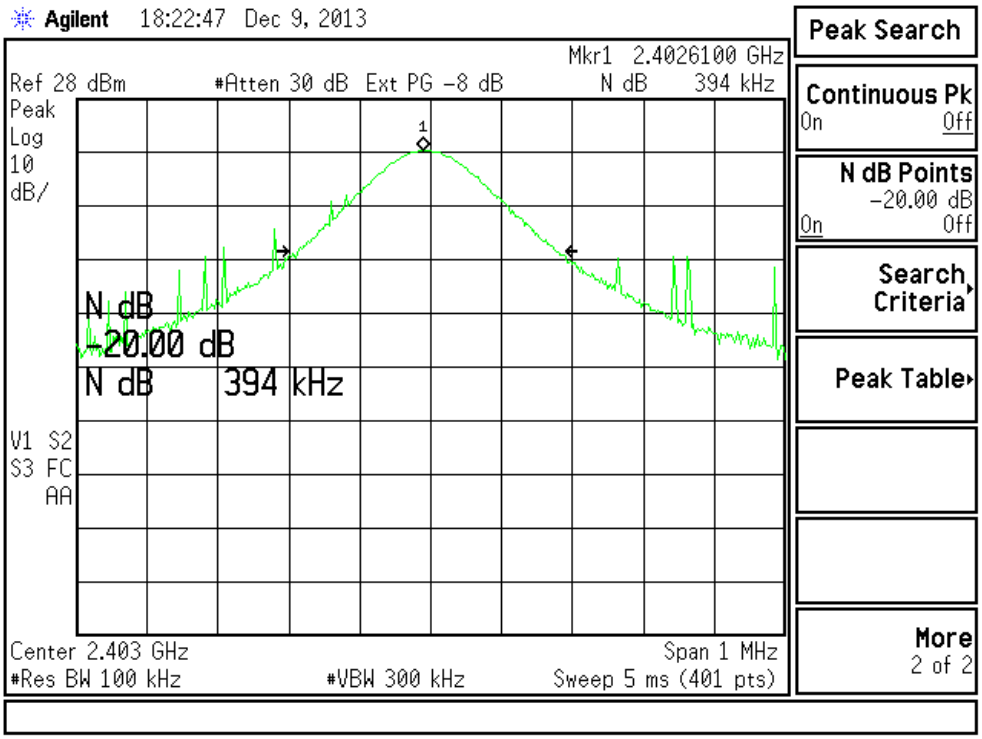


Figure 13 - Low Channel 20 dB

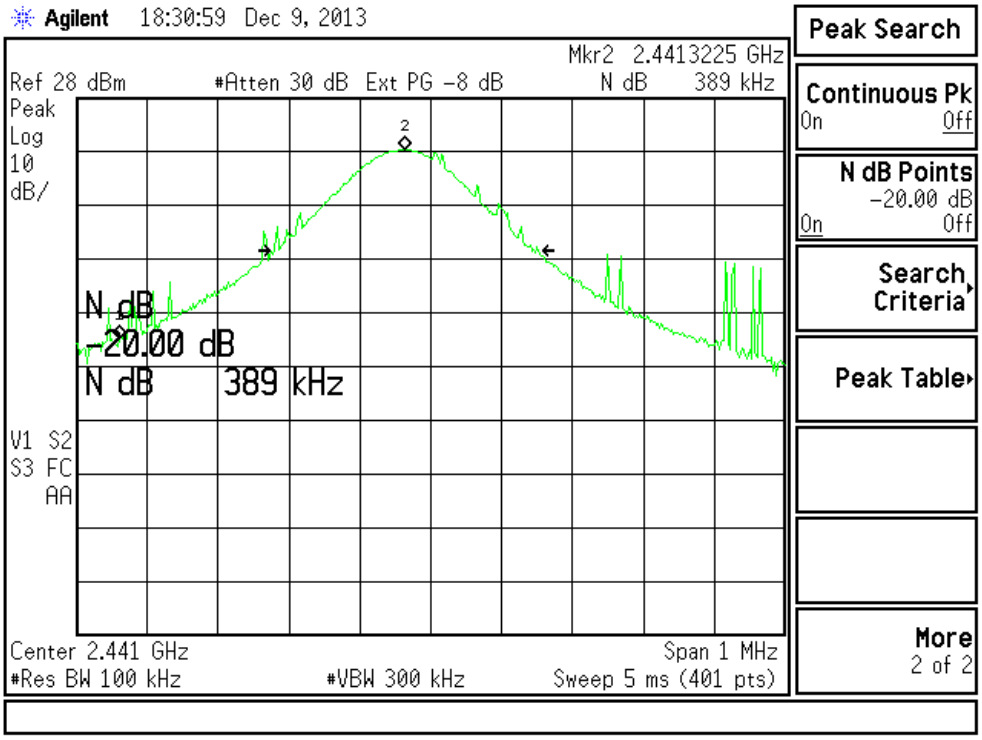


Figure 14 - Mid Channel 20 dB

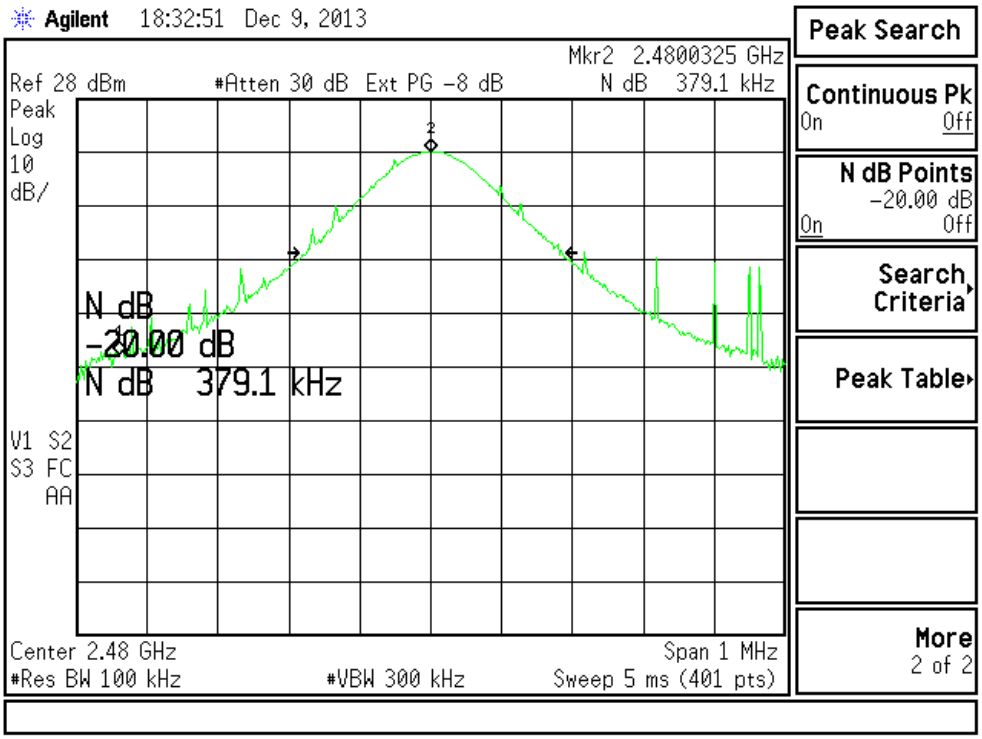


Figure 15 - High Channel 20 dB