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, paragraphs 15.207, 15.209 and 15.247

And

IC Radio Standards Specification: RSS-210, RSS-Gen I4

Permissive Change Report
For the

RFM

Model: DNT24P, DNT24PA, DNT24C, DNT24CA

FCC ID: HSW-DNT24
IC:4492A-DNT24

UST Project: 15-0010
Issue Date: January 19, 2015

Total Pages in This Report: 60

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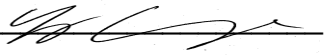
I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: George Yang

Name: 

Title: Laboratory Manager

Date February 11, 2015

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: RFM

MODEL: DNT24P, DNT24PA, DNT24C, DNT24CA

FCC ID: HSW-DNT24

IC: 4492A-DNT24

DATE: January 19, 2015

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

Equipment type: 2406-2475 MHz 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
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Table of Contents

List of Figures

Figures **Title** **Page**

List of Tables

Table **Title** **Page**

List of Attachments

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

1 General Information

1.1 Purpose of this Report

The purpose of this report is to demonstrate compliance with FCC Part 15 Subpart C of the FCC's Code of Federal Regulations and Industry Canada's Radio Standards Specification RSS-210, and RSS-Gen I4 for a Class II Permissive Change to replace an obsolete power amplifier, Skyworks model: PA2423L with a new power amplifier, Skyworks model: SE2433T. The functionality will remain unchanged, but the parts are not pin for pin compatible; thus we are requesting a Class II Permissive change. The output power of the new design is set at production to match that of the original grant. No additional changes are being made to the RF circuitry.

Based on the changes above the output power level was retested along with other radio conducted measurements. As long as measurements were no more than 0.5 dB above the previously measurement maximum values the data was deemed acceptable. Please see the test report for test results.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on January 15, 2015 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the RFM Model DNT24, which is a 2.4 GHz Transmitter Module. The EUT is a wireless transceiver designed for use in industrial monitoring and control application and comes in 4 variants. The only difference between them is that model is either pinned or castellated and either has a permanent antenna on connecter installed.

Model Number:	Variant:
DNT24P	Pinned with connector
DNT24PA	Pinned with antenna
DNT24C	Castellated with connector
DNT24CA	Castellated with antenna

The EUT is plugged in to an evaluation board which requires an external 9 V power supply and provides a regulated source of 5 VDC to the module. A Laptop PC with RFM propriety software is needed to communicate with the device in its test mode state.

The module provides general purpose analog and digital I/O for use by the applications board (see module schematic). The module firmware implements RFM proprietary protocols.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2009, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2009)* for FCC subpart A Digital equipment Verification requirements and per FCC KDB Publication number 558074 v03r02 for Digital Transmission Systems Operating Under section 15.247. Also, FCC, KDB Publication No. 558074 v03r02 was used as a test procedure guide.

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 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 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

1.6.1 The EUT is subject to the following FCC authorizations:

a) Certification under section 15.247 as a transmitter.
b) Verification under 15.101 as a digital device and receiver.

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

1.6.2 Verification of the Digital apparatus

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report (part 15.107 and 15.109) for the EUT is included herein.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
RFM	DNT24	Engineering Sample	FCC ID: HSW-DNT24 IC: 4492A-DNT24	1 m UP
Antenna See antenna details	--	--	--	--
DC Power Supply GlobTek, Inc	GT-21088-0909-W2	00221511/04	None	1 m UP
Dell Laptop	Various	CND	CND	1 m UP

U= Unshielded
S= Shielded
P= Power
D= Data
CND= Could Not Determine

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2410A00109	2/03/2014 Extended 90 days
SPECTRUM ANALYZER	E4407B	Agilent	US41442935	1/28/2015
PREAMP	8449B	HEWLETT-PACKARD	3008A00480	12/05/2014
PREAMP	8447D	HEWLETT-PACKARD	1937A02980	12/04/2014
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/12/2013 2 yr
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	7/08/2014 2 yr
LISN x 2	8028-50-TS24-BNC	Solar Electronics	955824 & 955825	12/30/20145/9/2013

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 physical 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 below.

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 at 2406 MHz to 2475 MHz, 3 test frequencies were 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 10th 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 5 times the highest internal clock frequency.

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 be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

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)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Fractus	Fractus Antenna	Chip	FR05-S1-N-0-104	1.7	Permanently attached
Patch	RFM	Patch	PA2412	12	MMCX
Omni	Mobile Mark	Omni	OD12-2400	12	Reverse N or Reverse TNC

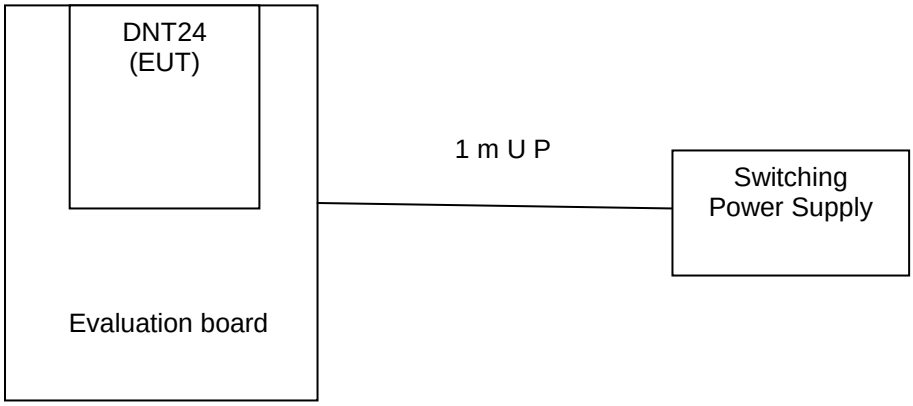

Figure 1. Test Configuration

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 2.1

2.8 Transmitter Duty Cycle (CFR 35 (c))

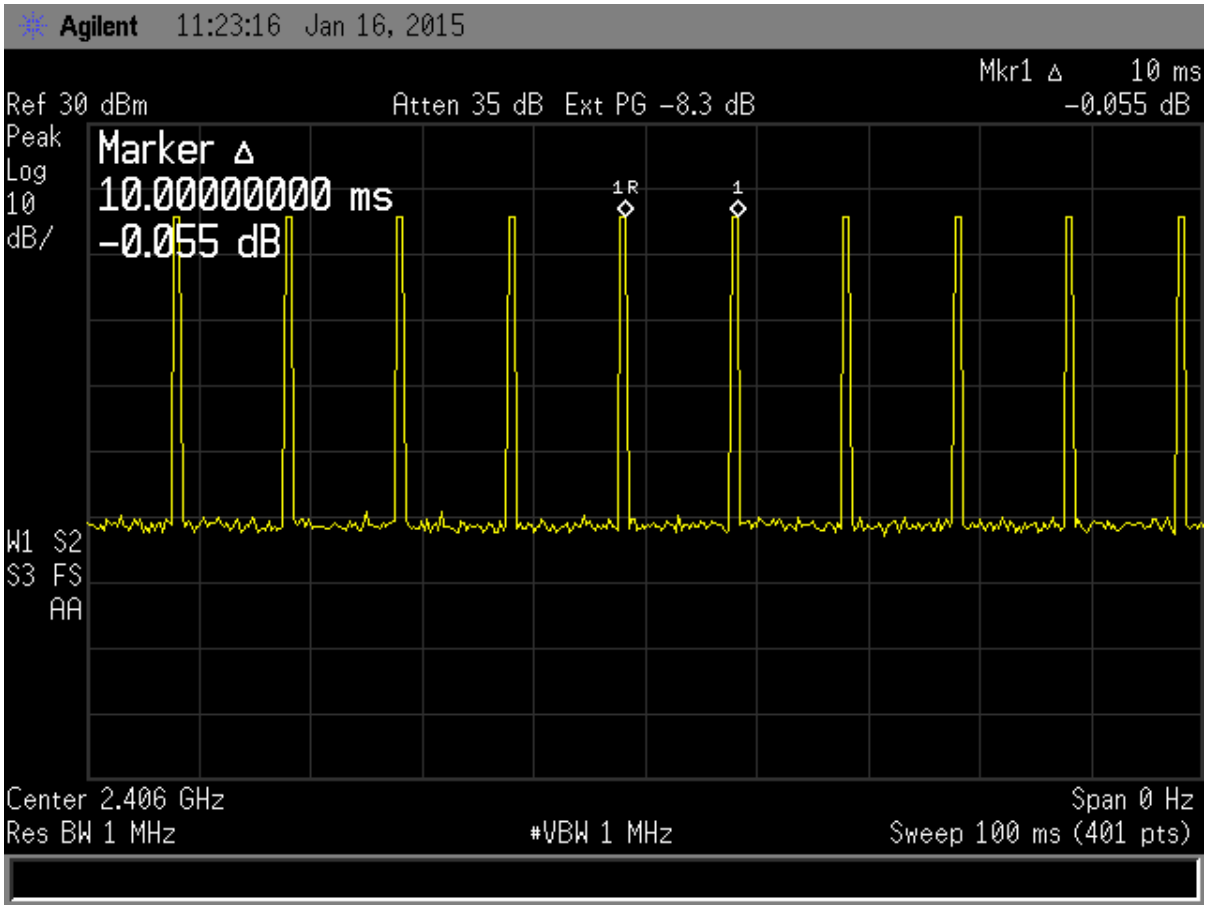

Figure 2. Duty Cycle 100ms Sweep

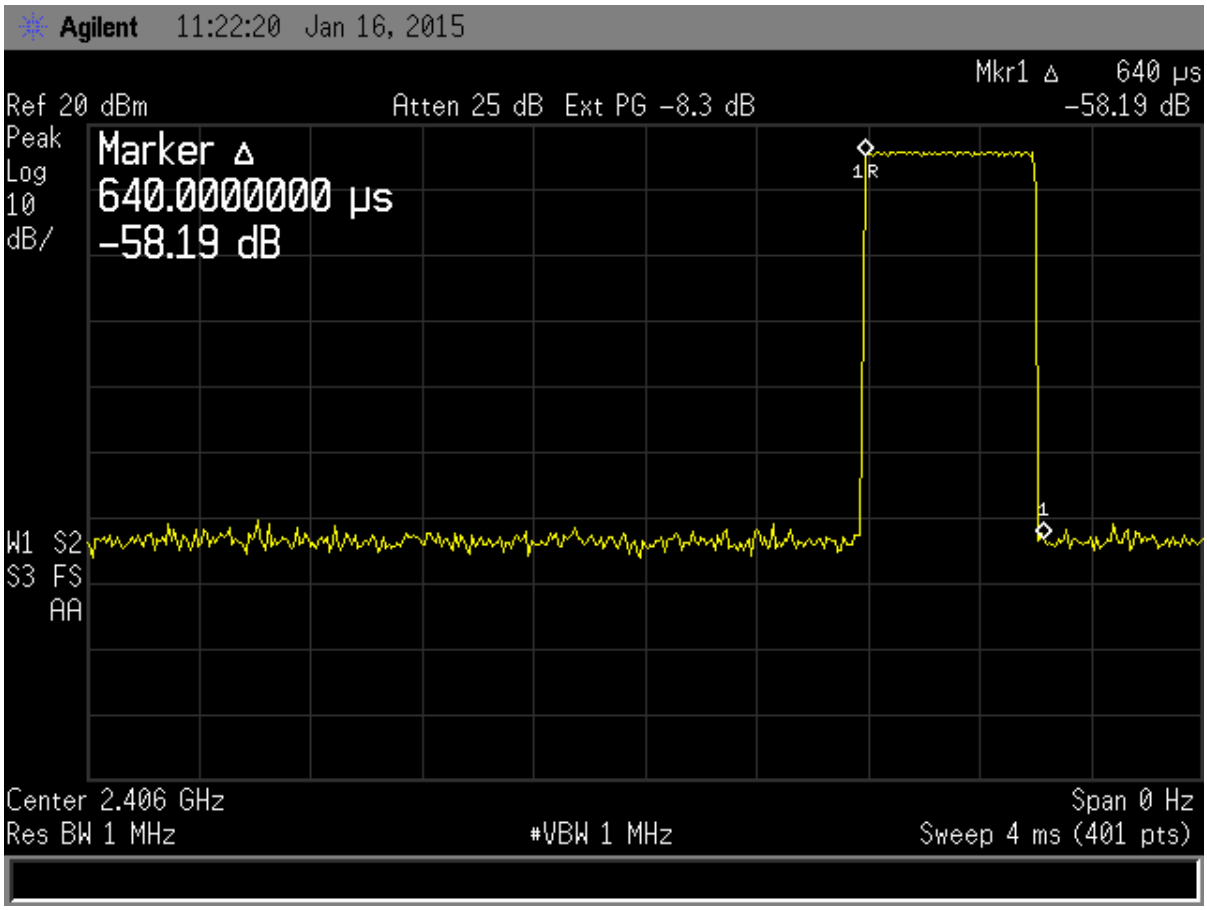

Figure 3. Transmitter Pulse Width

Total Time On from Figure 3 = .640 ms (Transmitter Pulse Width)
Total Pulse Train from Figure 2 = 10 (Pulse Train)

(6.40 ms Total Time On)/(100 ms Total Pulse Train) = .064 Numeric Duty Cycle
Duty Cycle = 20 Log (.064) = -23.88 dB

Duty Cycle applied for this test report is **-20 dB**.

NOTE: The transmitter was programmed to transmit at >98% duty cycle, therefore wherever applicable (where the detection mode was AVG) the duty cycle factor calculated above will be applied.

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

Power line conducted emissions testing was performed to ensure that with the EUT in operation (exercising all transmitter functions), the complete system continues to meet the applicable requirements for CFR 15.207. These measurements were completed and are displayed along with the 15.107 power line test data in the sections below.

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

Radiated Spurious measurements: the EUT was placed into a continuous transmit mode of operation (>98% duty cycle) and tested per FCC KDB Publication 558074 v03r02 and ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the device. To obtain worse case results the EUT was tested in X, Y, and Z axes or in the orientation of normal operation if the device is designed to operation in a fixed position.

Radiated measurements were then conducted between the frequency range of 9KHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). In the band below 30 MHz a resolution bandwidth (RBW) of 9 kHz was used, emissions below 1 GHz were tested with a RBW of 120 KHz and emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value.

For this permissive change, for radiated emissions, the EUT was investigated to CFR 15.209, general requirements for unwanted spurious emissions, see section 2.18 below. The conducted spurious method as described below was use to investigate all other emissions emanating from the antenna port.

Conducted Spurious measurements: the EUT was put into a continuous-transmit mode of operation (>98% duty cycle) and tested per FCC KDB Publication 558074 v03r02 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.

The conducted output power (in dBm) was recorded. The maximum transmit antenna gain in dBi was added to determine the EIRP level. The appropriate maximum ground reflection factor to the EIRP level, 6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz – 1000 MHz, and 0 dB for frequencies > 1000 MHz, was also added to the EIRP calculation. The resultant EIRP level was then converted to an equivalent electric field strength using the following relationship:

$$E = EIRP - 20\log D + 104.8$$

Where:

E= electric field strength in dBuV/m
EIRP= equivalent isotropic radiated power in dBm
D= specified measurement distance in meters

The results are displayed in the plots below. Radiated emissions per CFR 15.209 was performed with the antenna port terminated to address the concerns of unwanted emissions that may radiate from the EUT cabinet, control circuits, or power leads. The results for this test can be found in section 2.18 below.

Note 1: The results below are compared to Peak limits. Average limits are met when the duty cycle factor, -20 dB, is applied to the peak recorded value.

Note 2: For emissions levels below 1000 MHz, the restricted band limits were applied to show worst case emissions levels, else the limit is 20 dB below the fundamental level.

2.10.1 Conducted Spurious Emissions Data

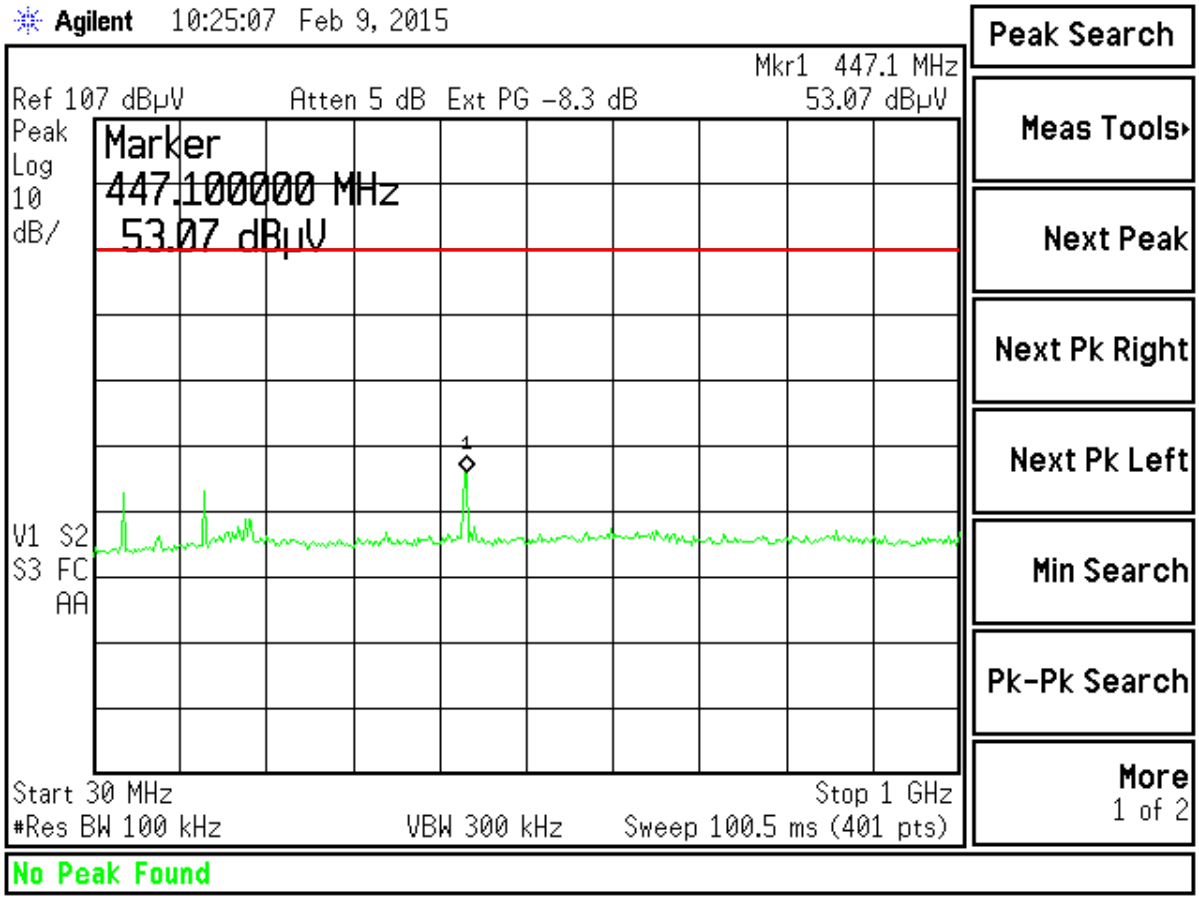


Figure 4. Antenna Conducted Emissions Low, Part 1

EIRP= 53.07 dBuV(-53.93 dBm) + 12 dBi (max antenna gain) + 4.7 dB (ground reflection factor)= -37.23 dBm

E= EIRP – 20log D +104.8= -37.23 – (20log (3))+104.8= 58.02 dBuV/m

Limit = 20 dB below fundamental (fundamental displayed in Figure 5 below)

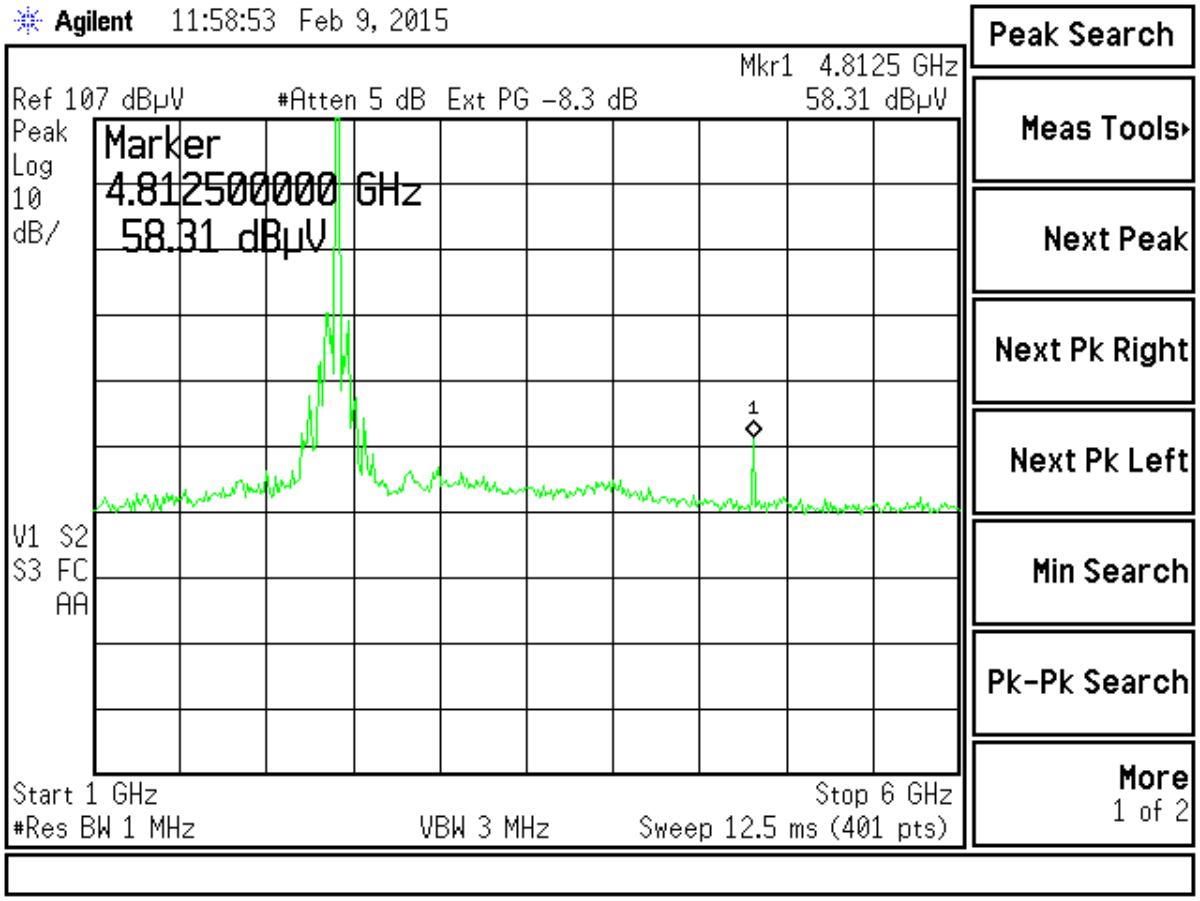


Figure 5. Antenna Conducted Emissions Low, Part 2

Note: Large signal show is fundamental frequency.

EIRP= 58.31 dBuV(-48.69 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -36.69 dBm

E= EIRP – 20log D +104.8= -36.69 – (20log (3))+104.8= 58.56 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 58.59 dBuV/m= 15.41 dB

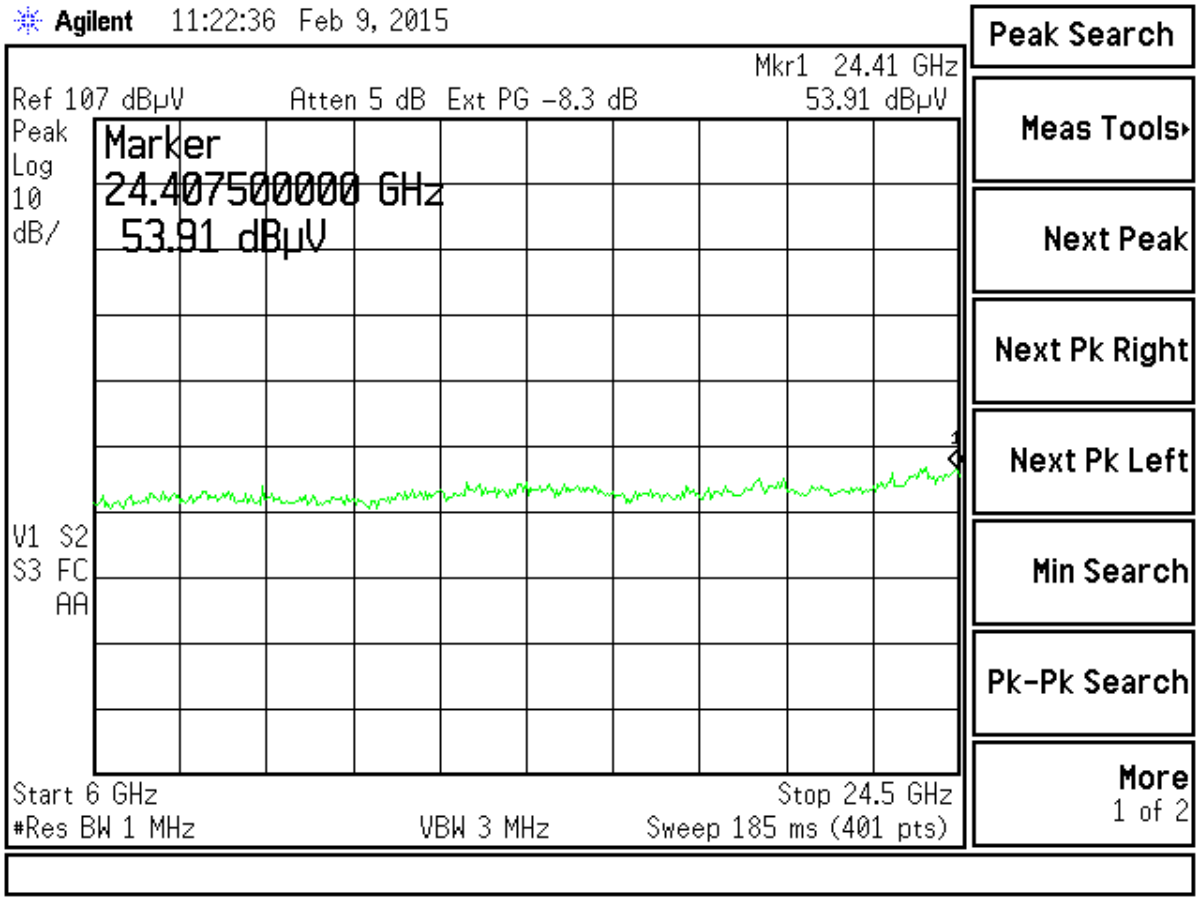


Figure 6. Antenna Conducted Emissions Low, Part 3

EIRP= 53.91 dBuV(-53.09 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -41.09 dBm

E= EIRP – 20log D +104.8= -41.09 – (20log (3))+104.8= 54.17 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 54.17 dBuV/m= 19.83 dB

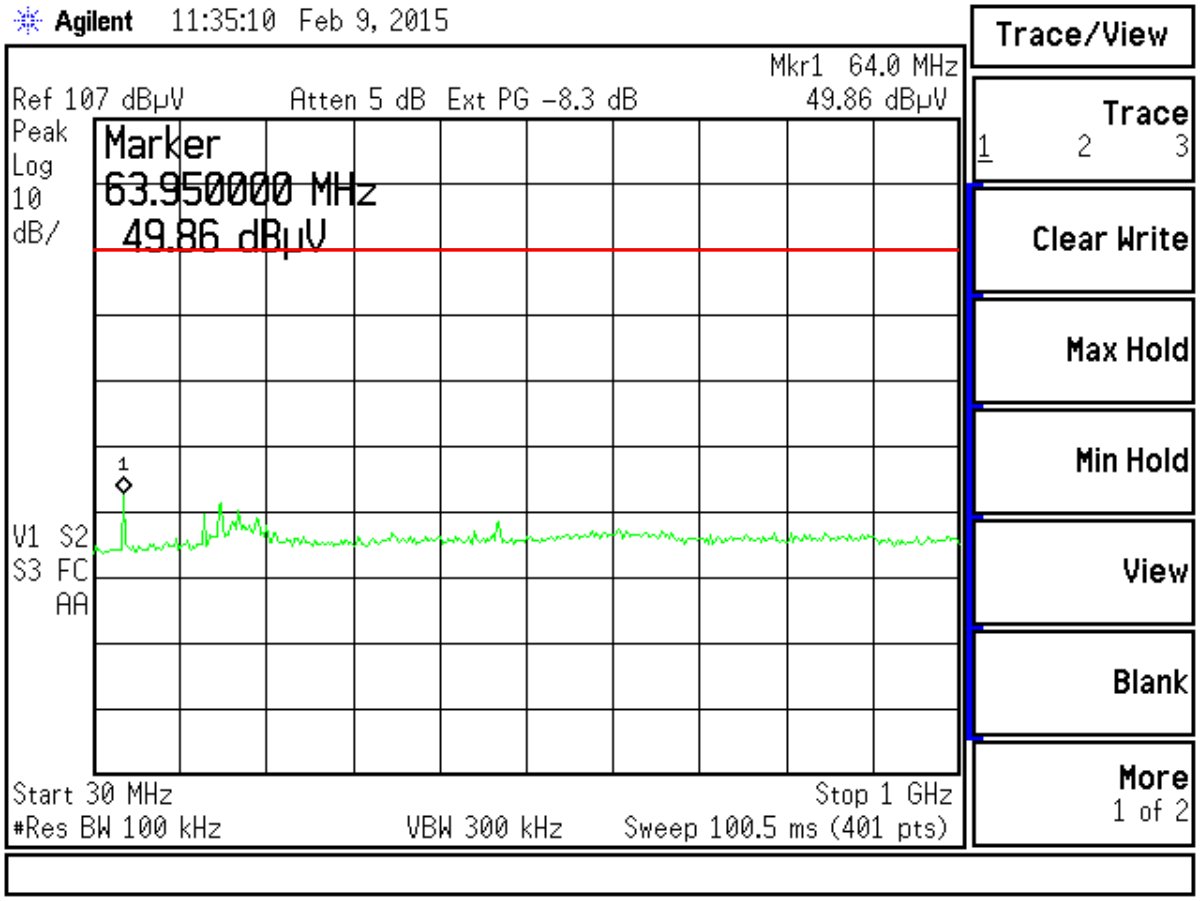


Figure 7. Antenna Conducted Emissions Mid, Part 1

EIRP= 49.86 dBuV(-57.14 dBm) + 12 dBi (max antenna gain) + 4.7 dB (ground reflection factor)= -40.44 dBm

E= EIRP – 20log D +104.8= -40.44 – (20log (3))+104.8= 54.81 dBuV/m

Limit = 20 dB below fundamental (fundamental displayed in Figure 8 below)

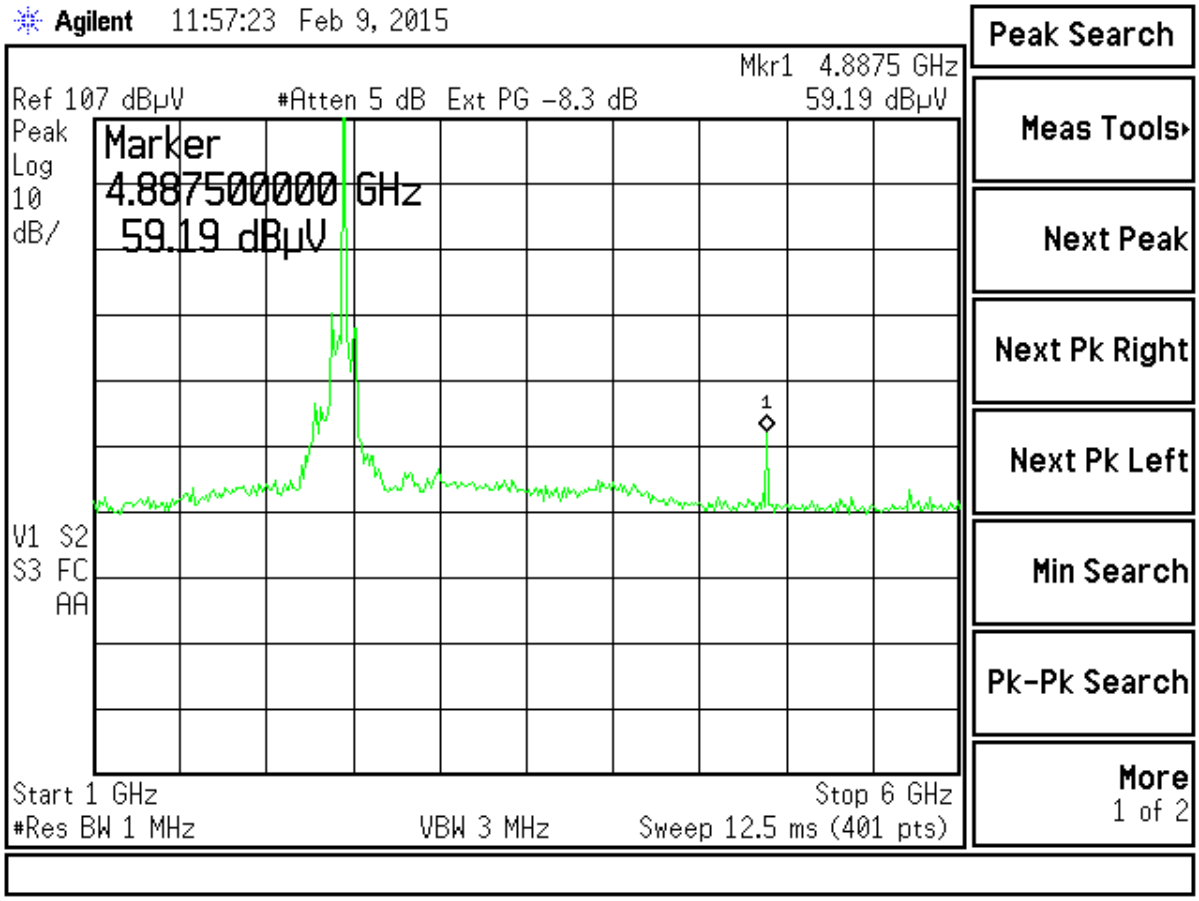


Figure 8. Antenna Conducted Emissions Mid, Part 2

Note: Large signal show is fundamental frequency.

EIRP= 59.19 dBuV(-47.81 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -35.81 dBm

E= EIRP – 20log D +104.8= -35.81 – (20log (3))+104.8= 59.44 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 59.44 dBuV/m= 14.56 dB

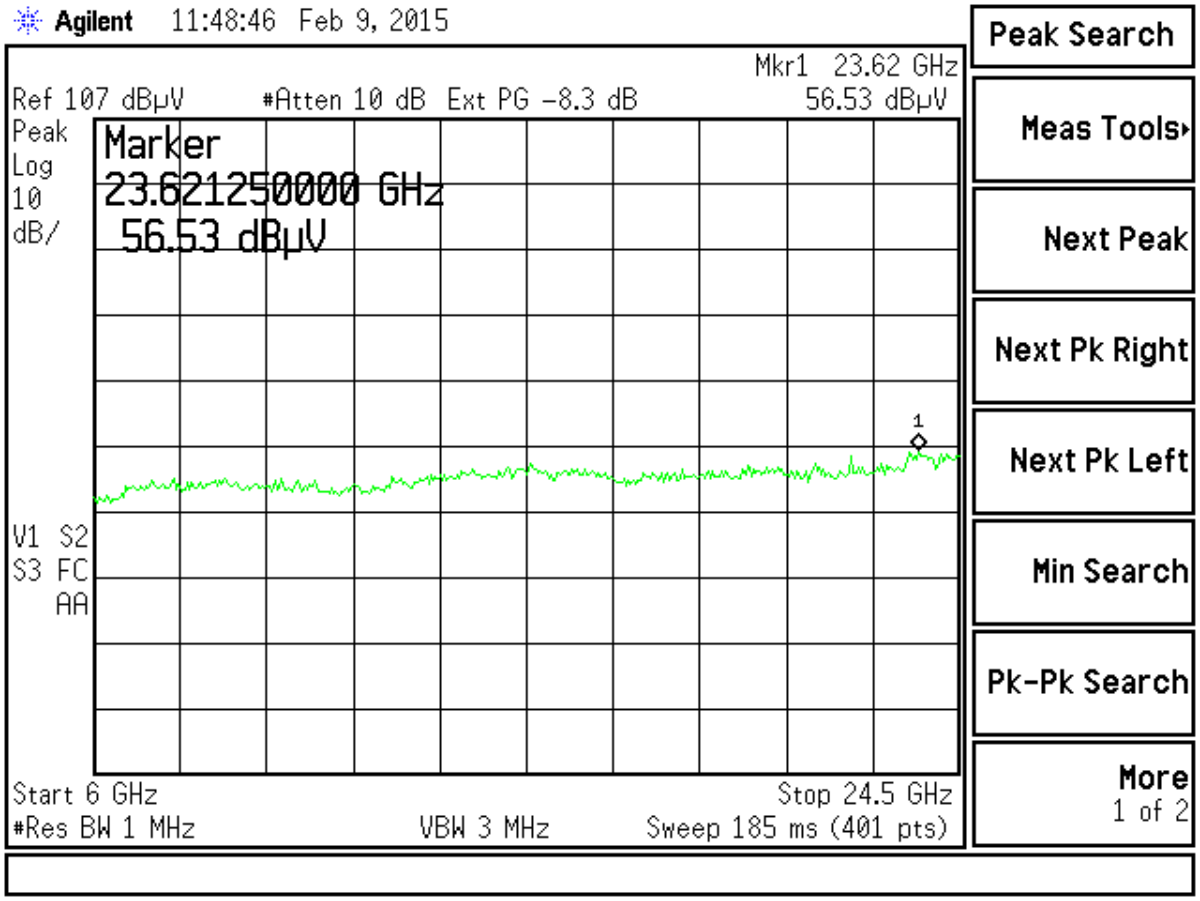


Figure 9. Antenna Conducted Emissions Mid, Part 3

EIRP= 56.53 dBuV(-50.47 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -38.47 dBm

E= EIRP – 20log D +104.8= -38.47 – (20log (3))+104.8= 56.78 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 56.78 dBuV/m= 17.21 dB

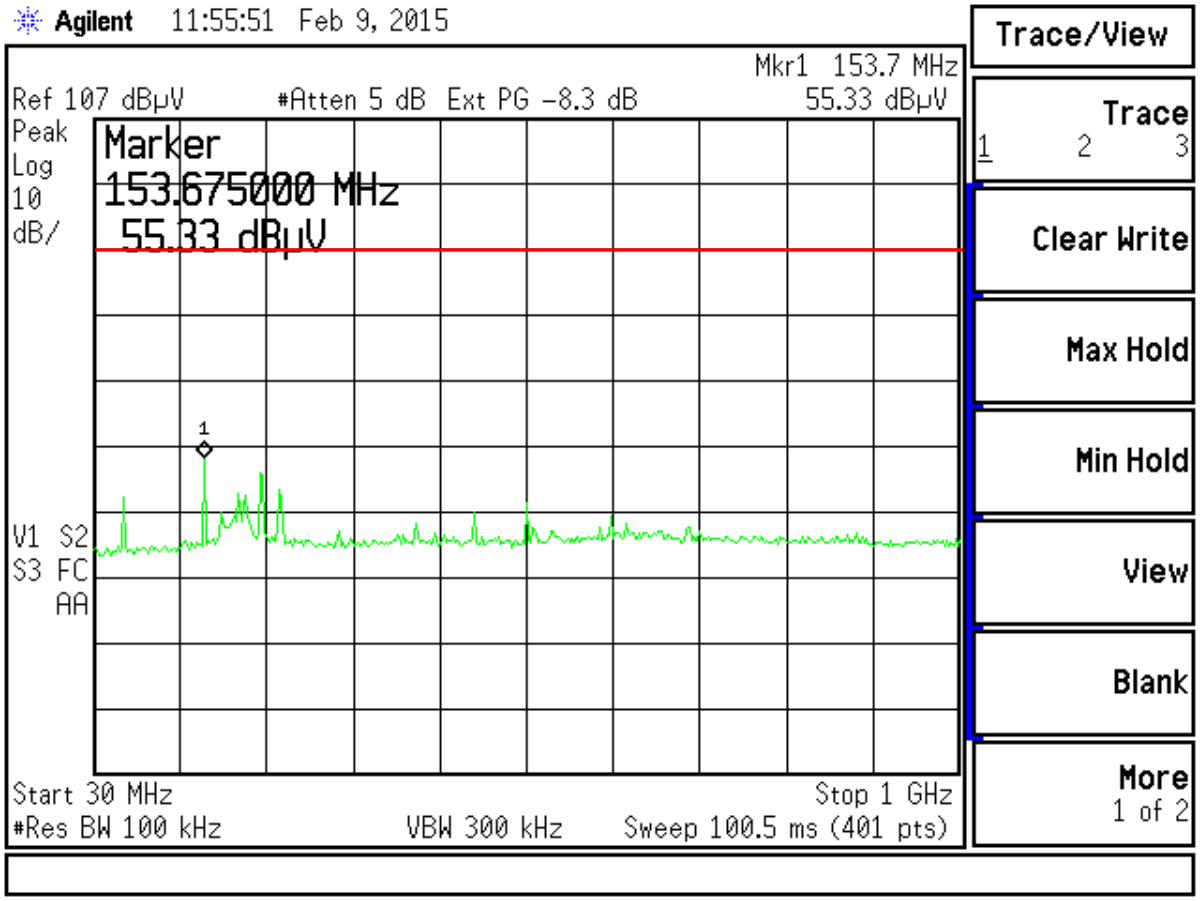


Figure 10. Antenna Conducted Emissions High, Part 1

EIRP= 55.33 dBuV(-51.67 dBm) + 12 dBi (max antenna gain) + 4.7 dB (ground reflection factor)= -34.97 dBm

E= EIRP – 20log D +104.8= -34.97 – (20log (3))+104.8= 60.29 dBuV/m

Limit = 20 dB below fundamental (fundamental displayed in Figure 11 below)

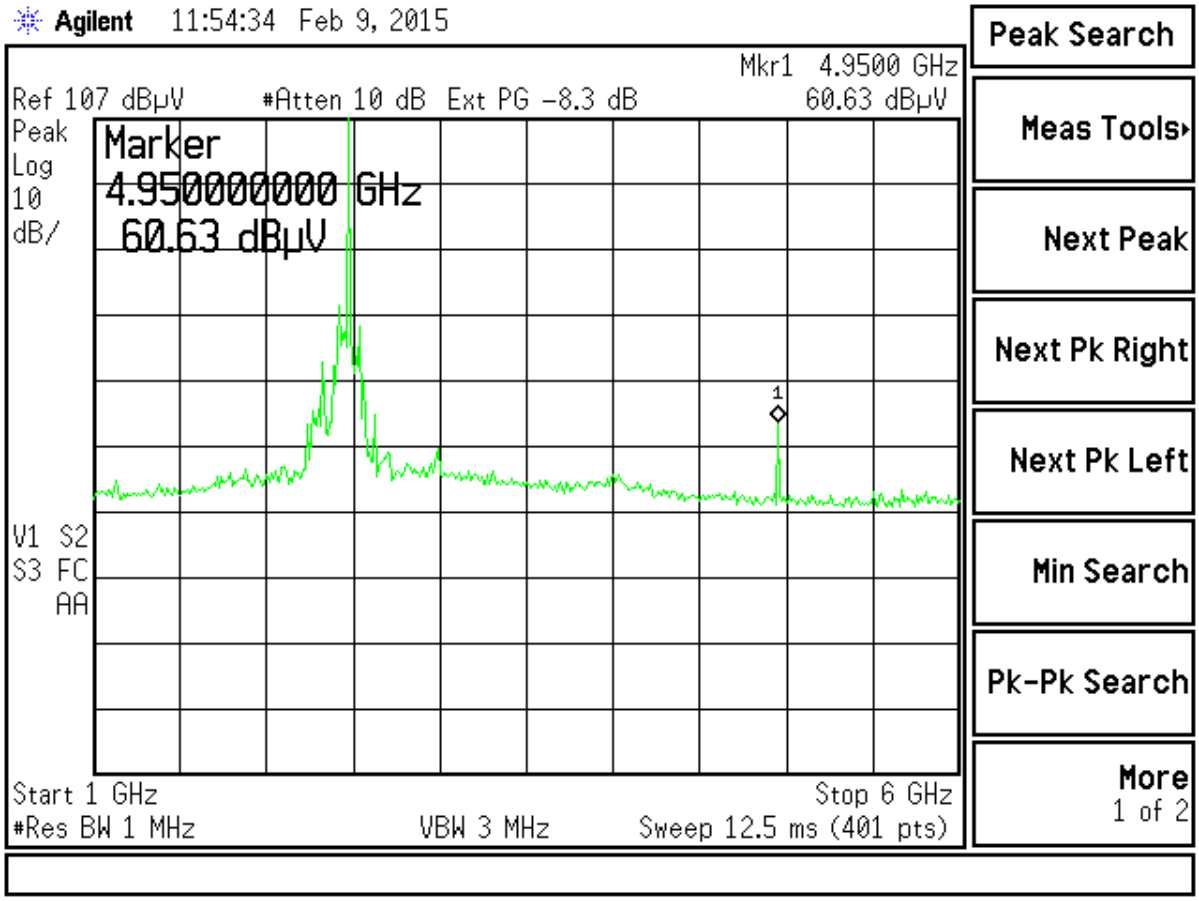


Figure 11. Antenna Conducted Emissions High, Part 2

Note: Large signal show is fundamental frequency.

EIRP= 60.63 dBuV(-46.37 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -34.37 dBm

E= EIRP – 20log D +104.8= -34.37 – (20log (3))+104.8= 60.88 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 60.88 dBuV/m= 13.11 dB

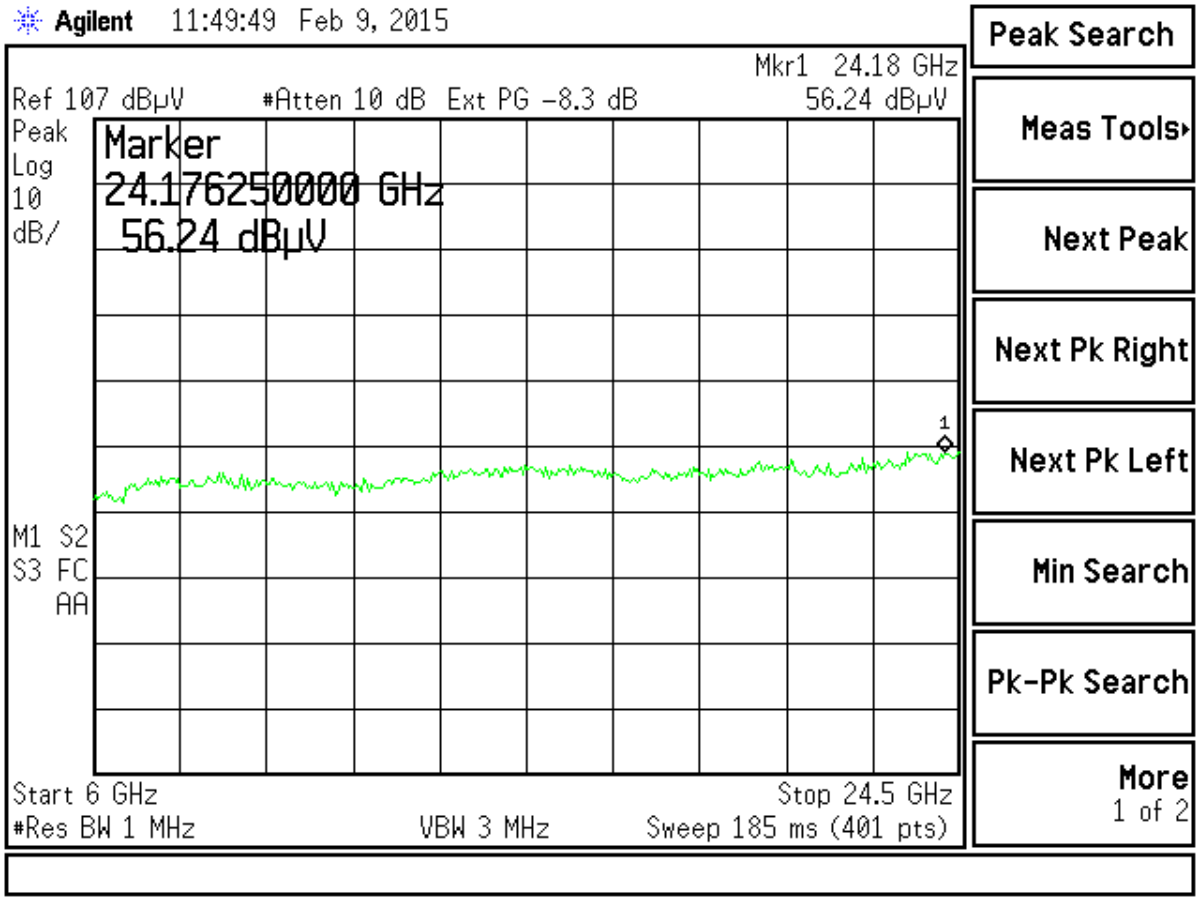


Figure 12. Antenna Conducted Emissions High, Part 3

EIRP= 56.24 dBuV(-50.76 dBm) + 12 dBi (max antenna gain) + 0 dB (ground reflection factor)= -38.76 dBm

E= EIRP – 20log D +104.8= -38.76 – (20log (3))+104.8= 56.49 dBuV/m

Limit = 74 dBuV/m (Peak)

Margin= 74 dBuV/m – 56.49 dBuV/m= 17.50 dB

2.10.2 Radiated Spurious Emissions Data

The EUT was evaluated for spurious radiated emission in the range from 30 MHz-1000 MHz in addition to the conducted spurious emissions evaluations performed above.

A prescan was performed using each of the approved antennas listed in Table 4 above to determine which of the antennas would likely generate the highest emissions. Once that antenna was determined, the EUT was set up on the OATS and radiated spurious emissions testing was performed.

In this case, the 12 dBi Omni antenna was determined to be the highest emitting antenna. The EUT was connected to that antenna, placed in continuous transmit mode and spurious emissions testing in the range of 30 MHz to 1000 MHz was performed.

Table 5. Radiated Spurious Emissions (30 MHz – 1000 MHz)

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
156.90	42.54	-6.85	35.69	43.5	3m./HORZ	7.8	**PK**
170.68	40.95	-5.52	35.43	43.5	3m./VERT	8.1	**PK**
156.72	40.58	-5.85	34.73	43.5	3m./VERT	8.8	**PK**
73.41	48.34	-11.46	36.88	40.0	3m./VERT	3.1	**PK**
73.41	39.08	-11.46	27.62	40.0	3m./VERT	12.4	**QP**
37.79	44.57	-7.97	36.60	40.0	3m./VERT	3.4	**PK**
37.79	38.80	-7.97	30.83	40.0	3m./VERT	9.2	**QP**
406.45	40.45	-2.50	37.95	46.0	3m./HORZ	8.0	**PK**
408.76	41.08	-2.50	38.58	46.0	3m./HORZ	7.4	**PK**
All other emissions are greater than 20 dB from the limit.							

Sample Calculation: at 159.90 MHz, 42.54 dBuV + (-6.85) dB/m = 35.69 dBuV/m

Test Date: March 3, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

Table 6. Peak Radiated Fundamental & Harmonic Spurious Emissions

Test: FCC Part 15, Para 15.247(d)				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
The test was not re-evaluated because the EUT conducted output power levels are within 0.5 dB of the originally recorded level. Additional conducted spurious emissions were performed in the restricted bands and found to meet the applicable limits.							

Sample Calculation: N/A

Test Date: January 16, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

Table 7. Average Radiated Fundamental & Harmonic Spurious Emissions

Test: FCC Part 15, Para 15.247(d)				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
The test was not re-evaluated because the EUT conducted output power levels are within 0.5 dB of the originally recorded level. Additional conducted spurious emissions were performed in the restricted bands and found to meet the applicable limits.							

Sample Calculation: N/A

Test Date: January 16, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

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

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 v03r02 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).

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 figures and calculations below for more detail.

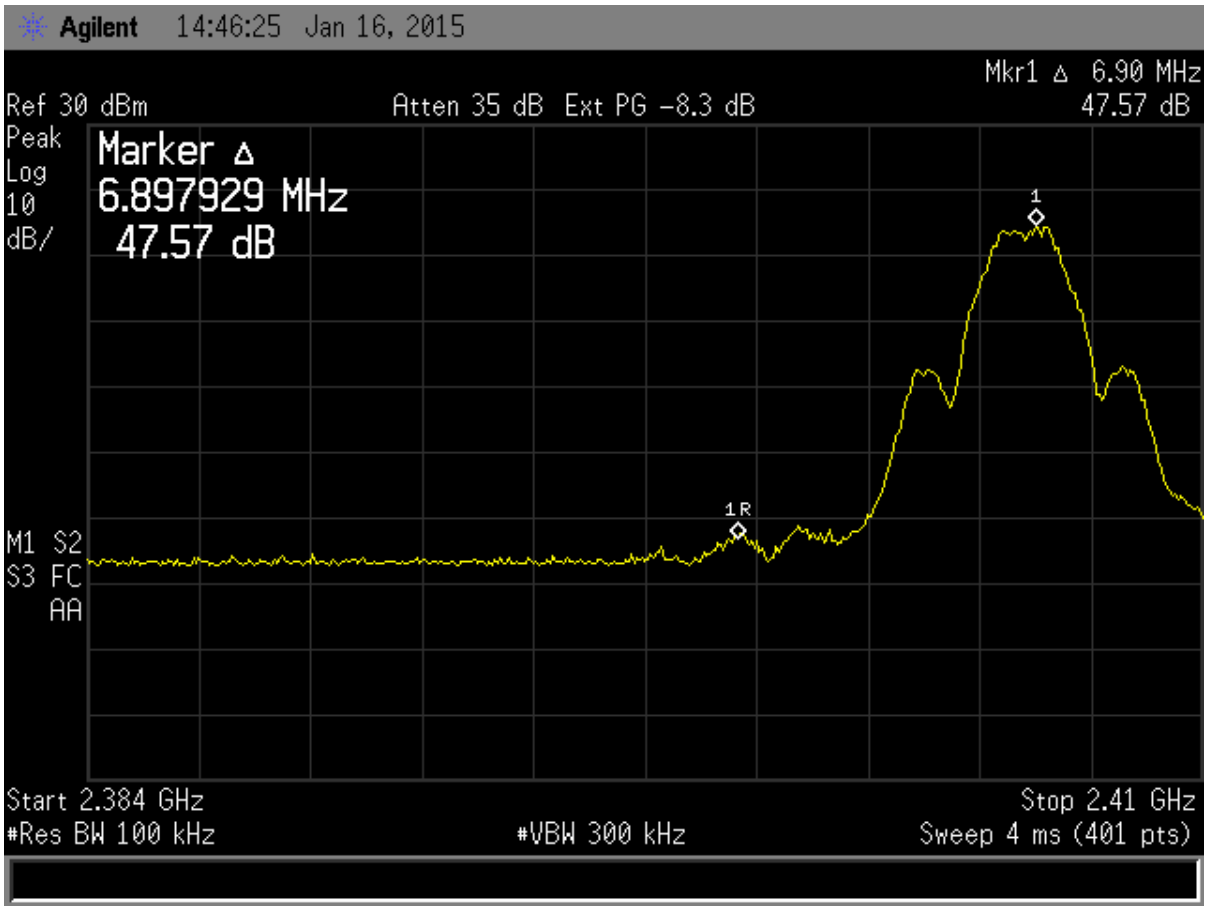


Figure 13. Band Edge Compliance, Low Channel Delta - Peak

Calculation of worst case lower band edge measurement:

Measured Delta (from Figure 13)	47.57	dB
-limit	20.00	dB
Margin	27.57	dB

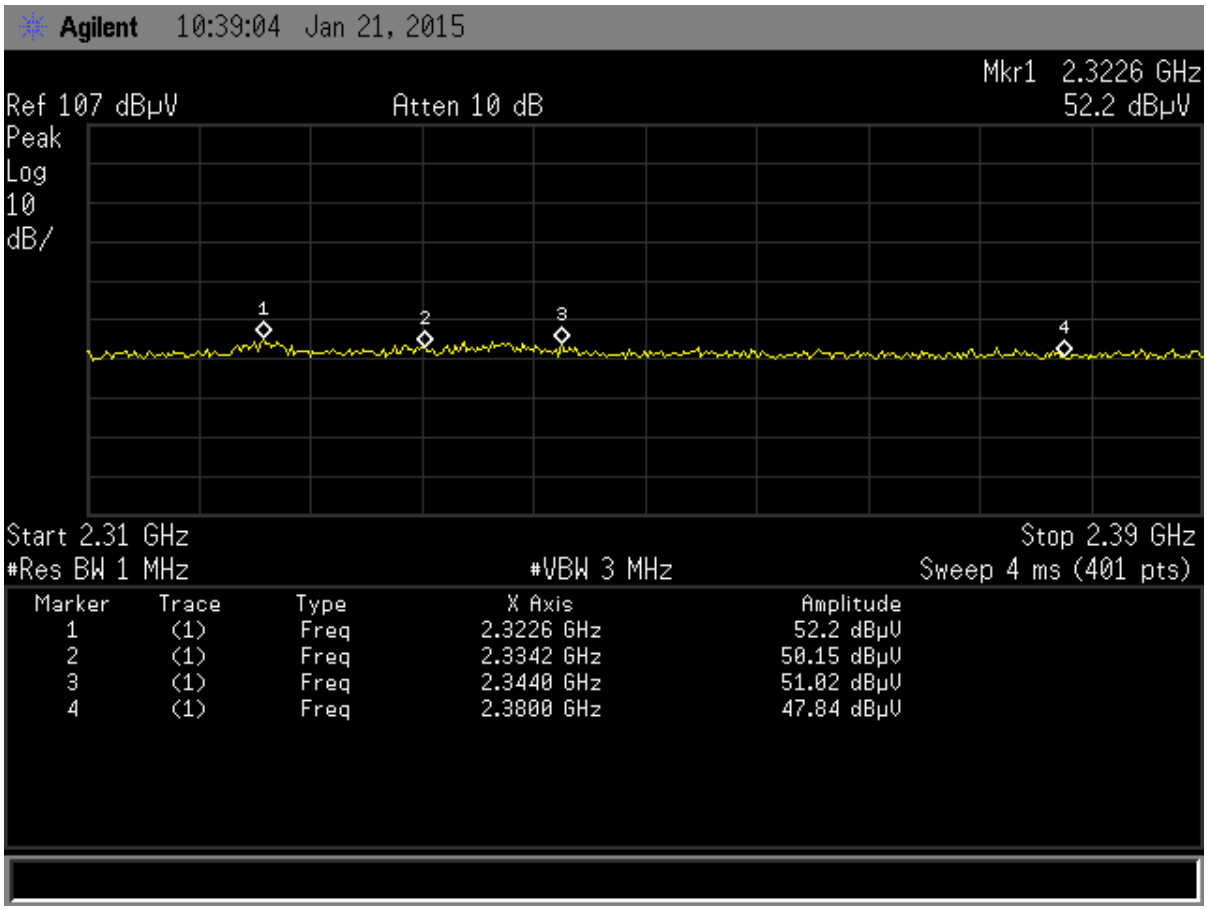


Figure 14. Radiated Restricted Band Measurements PK, 2.31 GHz to 2.39 GHz

Table 8. Radiated Restricted Band Measurements PK, 2.31 GHz to 2.39 GHz

Test By: CF	**Client:** RFM	
	Project: 15-0010	**Model:** DNT24

Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Peak Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK / AVG**
2332.6	52.2	-4.75	47.45	74.0	3m./HORZ	26.6	**PK**
2334.2	50.15	-4.75	45.40	74.0	3m./HORZ	28.6	**PK**
2344.0	51.02	-4.75	46.27	74.0	3m./HORZ	27.7	**PK**
2380.0	47.84	-4.65	43.19	74.0	3m./HORZ	30.8	**PK**

Sample Calculation at 2332.6 MHz:

Magnitude of Measured Frequency	52.2	dBuV
+Correction Factors	-4.75	dB/m
Corrected Result	47.45	dBuV/m

Test Date: January 21, 2015

Tested by
Signature: _____ Name: Carrie Fincannon

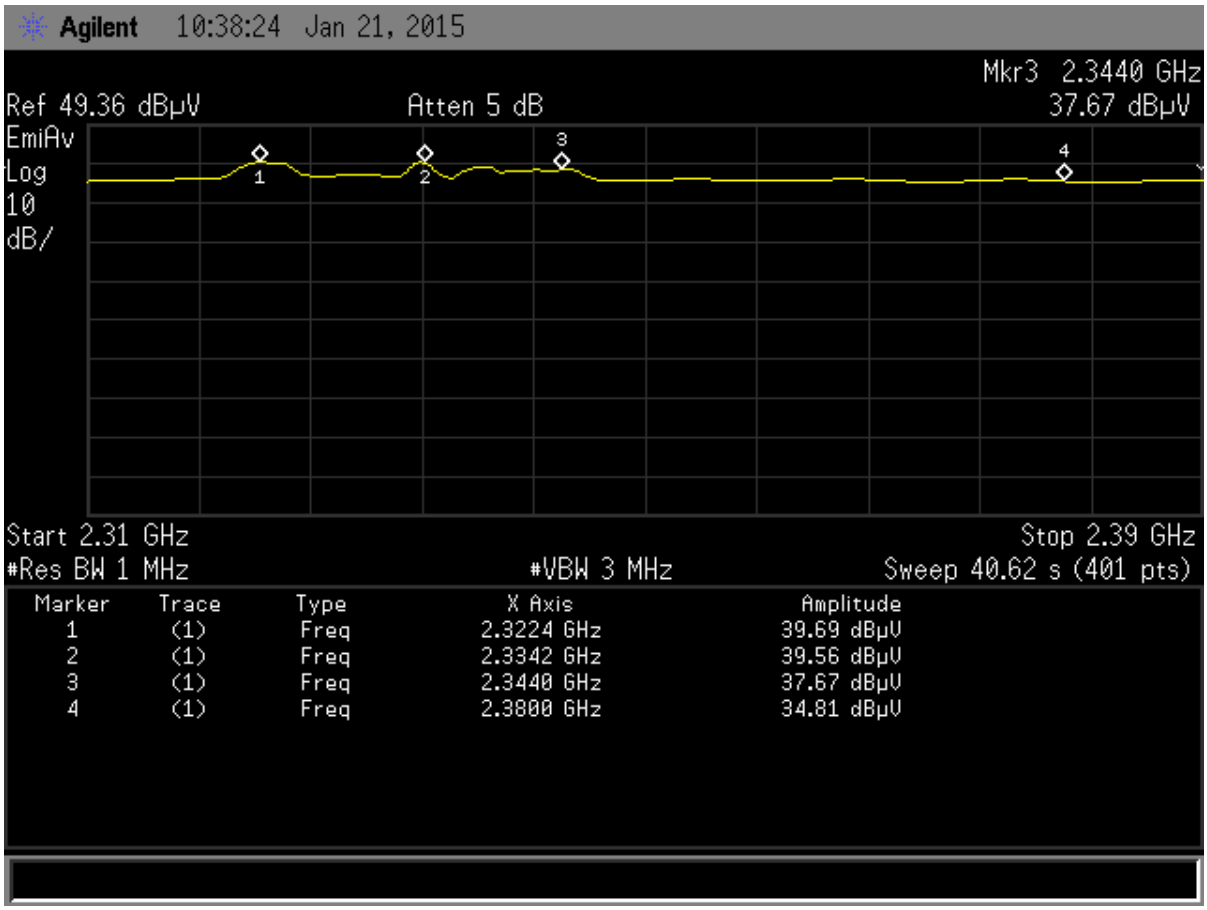


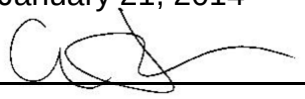
Figure 15. Radiated Restricted Band Measurements AVG, 2.31 GHz to 2.39 GHz

Table 9. Radiated Restricted Band Measurements AVG, 2.31 GHz to 2.39 GHz

Test By: CF	**Client:** RFM						
	Project: 15-0010			**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK / AVG**
2322.4	39.69	-4.75	34.94	54.0	3m./HORZ	19.1	**AVG**
2334.2	39.56	-4.75	34.81	54.0	3m./HORZ	19.2	**AVG**
2344.0	37.67	-4.75	32.92	54.0	3m./HORZ	21.1	**AVG**
2380.0	34.81	-4.65	30.16	54.0	3m./HORZ	23.8	**AVG**

Sample Calculation at 2322.4 MHz:

Magnitude of Measured Frequency	39.69	dBuV
+Correction Factors	-4.75	dB/m
Corrected Result	34.94	dBuV/m

Test Date: January 21, 2014
Tested by
Signature:  Name: Carrie Fincannon

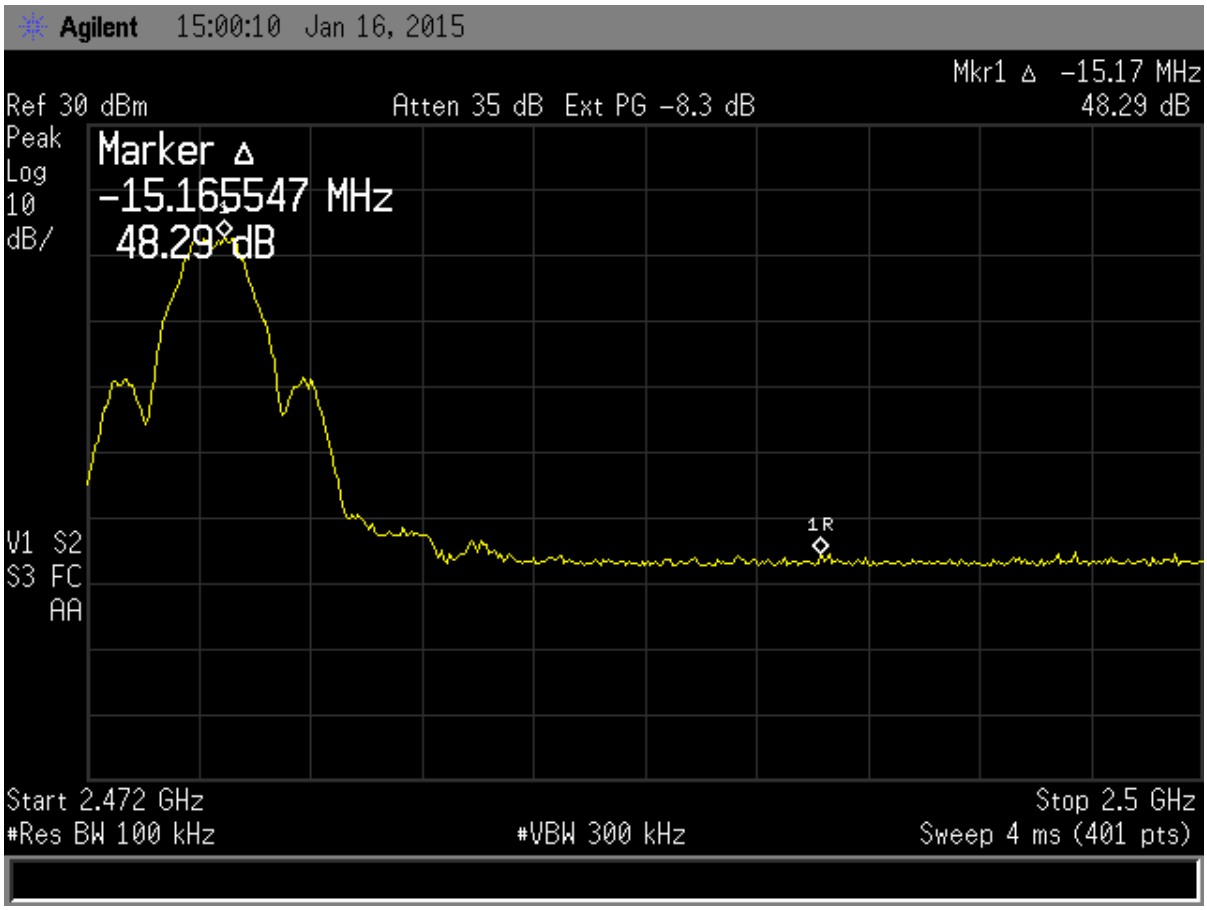


Figure 16. Band Edge Compliance, High Channel Delta – Peak

Calculation of worst case upper band edge peak measurement:

High Channel Corrected Measured Value from report 11-0197	120.56	dBuV
High Channel Band Edge Delta from Figure 16	48.29	dB
Calculated Result	72.27	dBuV/m
Band Edge Limit	74.00	dBuV/m
Calculated Result	72.27	dBuV/m
Band Edge Margin	1.73	dBuV/m

Calculation of worst case upper band edge average measurement:

High Channel Corrected Measured Value from report 11-0197	120.56	dBuV
-High Channel Band Edge Delta from Figure 16	48.29	dB
Calculated Result	72.27	dBuV/m
Calculated Result	72.27	dBuV/m
-Duty Cycle Correction	20.00	dBuV/m
Duty Cycle Calculated Result	52.27	dBuV/m
Band Edge Limit	54.00	dBuV/m
Calculated Result	52.27	dBuV/m
Band Edge Margin	1.73	dBuV/m

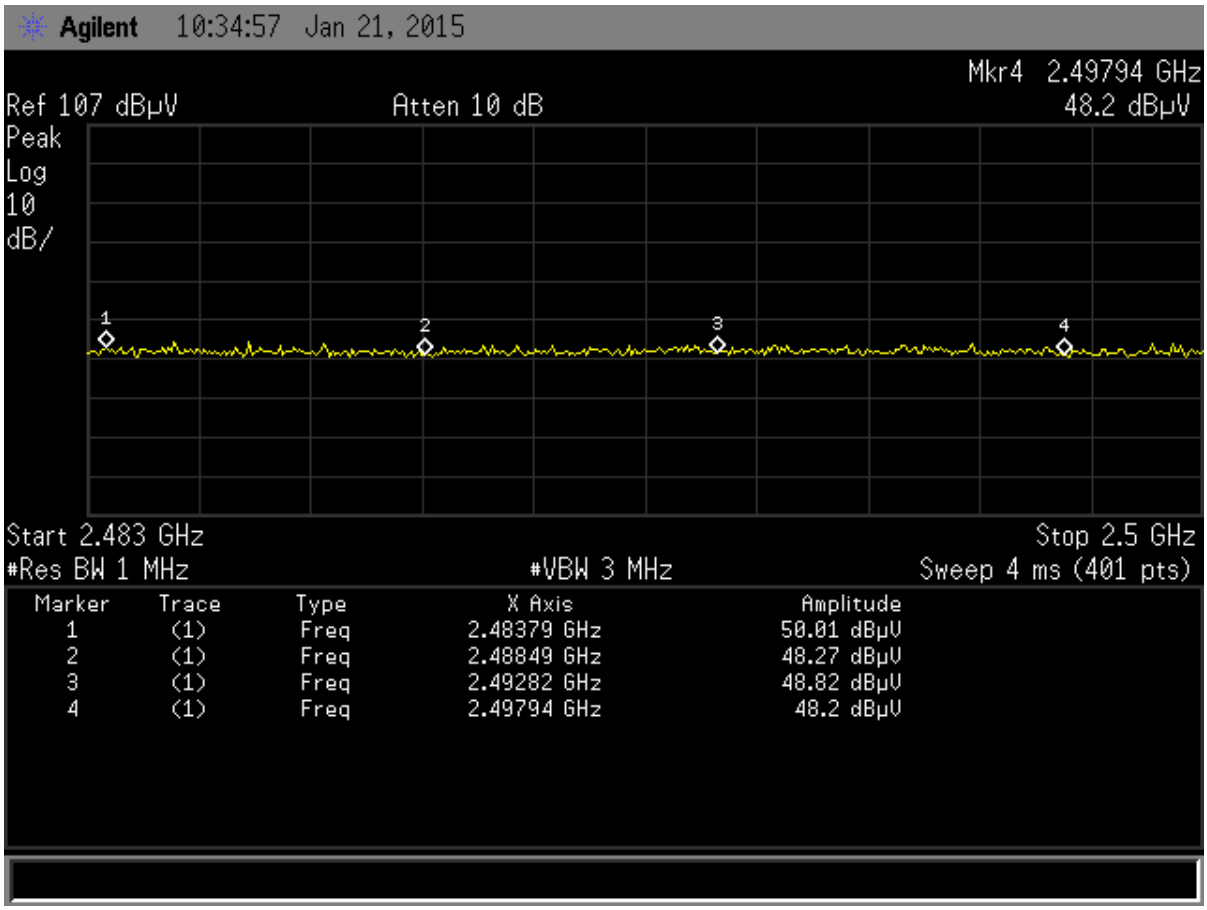


Figure 17. Radiated Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz

Table 10. Radiated Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz

Test By: CF	**Client:** RFM	
	Project: 15-0010	**Model:** DNT24

Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**PK Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK / AVG**
2483.8	50.01	-4.43	45.58	74.0	3m./HORZ	28.4	**PK**
2488.5	48.27	-4.43	43.84	74.0	3m./HORZ	30.2	**PK**
2492.8	48.82	-4.43	44.39	74.0	3m./HORZ	29.6	**PK**
2497.9	48.2	-4.43	43.77	74.0	3m./HORZ	30.2	**PK**

Sample Calculation at 2483.8 MHz:

Magnitude of Measured Frequency	50.01 dBuV
+Correction Factors	-4.43 dB/m
Corrected Result	45.58 dBuV/m

Test Date: January 21, 2014

Tested by
Signature: _____ Name: Carrie Fincannon

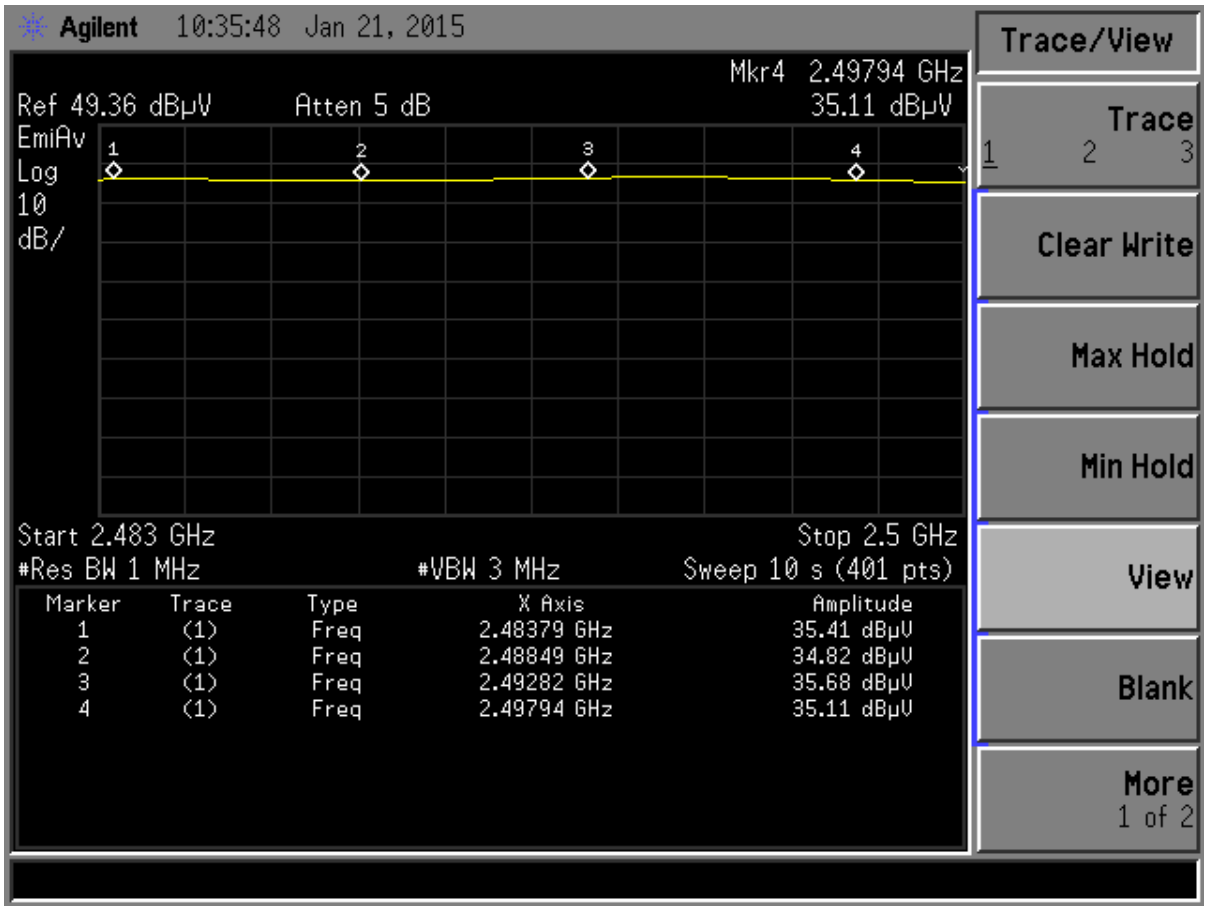


Figure 18. Radiated Restricted Band Measurements AVG, 2.4835 GHz to 2.5 GHz

Table 11. Radiated Restricted Band Measurements AVG, 2.4835 GHz to 2.5 GHz

Test By: CF	**Client:** RFM	
	Project: 15-0010	**Model:** DNT24

Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK / AVG**
2493.8	35.41	-4.43	30.98	54.0	3m./HORZ	23.0	**AVG**
2488.5	34.82	-4.43	30.39	54.0	3m./HORZ	23.6	**AVG**
2492.8	35.68	-4.43	31.25	54.0	3m./HORZ	22.8	**AVG**
2497.9	35.11	-4.43	30.68	54.0	3m./HORZ	23.3	**AVG**

Sample Calculation at 2493.8 MHz:

Magnitude of Measured Frequency	35.41	dBuV
+Correction Factors	-4.43	dB/m
Corrected Result	30.98	dBuV/m

Test Date: January 21, 2014

Tested by
Signature: _____ Name: Carrie Fincannon

2.12 Six (6) dB Bandwidth per CFR 15.247(a)(2),

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 v03r02 for a bandwidth of 6 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 the table below and figures below.

Table 12. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
2406	1.67	0.500
2442	1.66	0.500
2475	1.65	0.500

Test Date: January 16, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

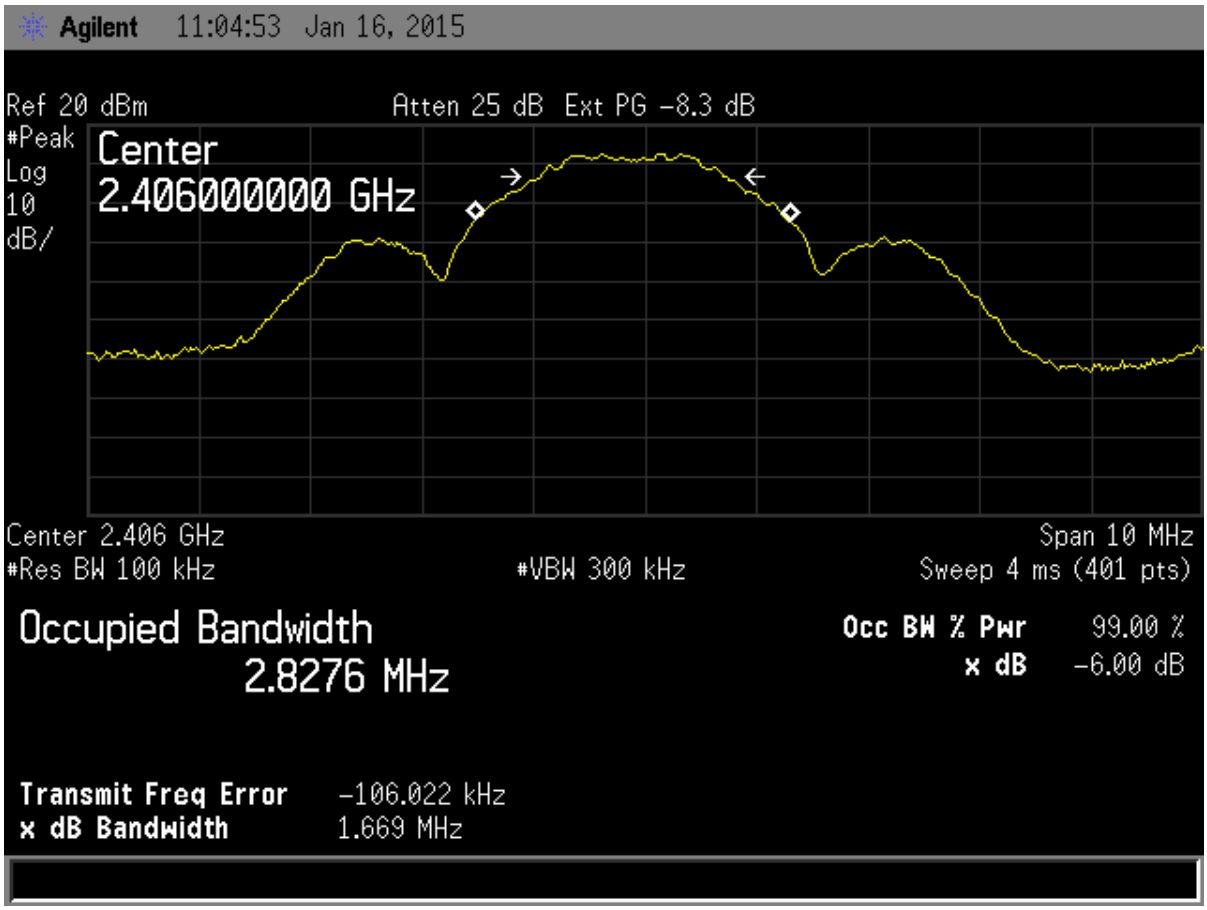


Figure 19. Six dB Bandwidth - 15.247 - Low Channel

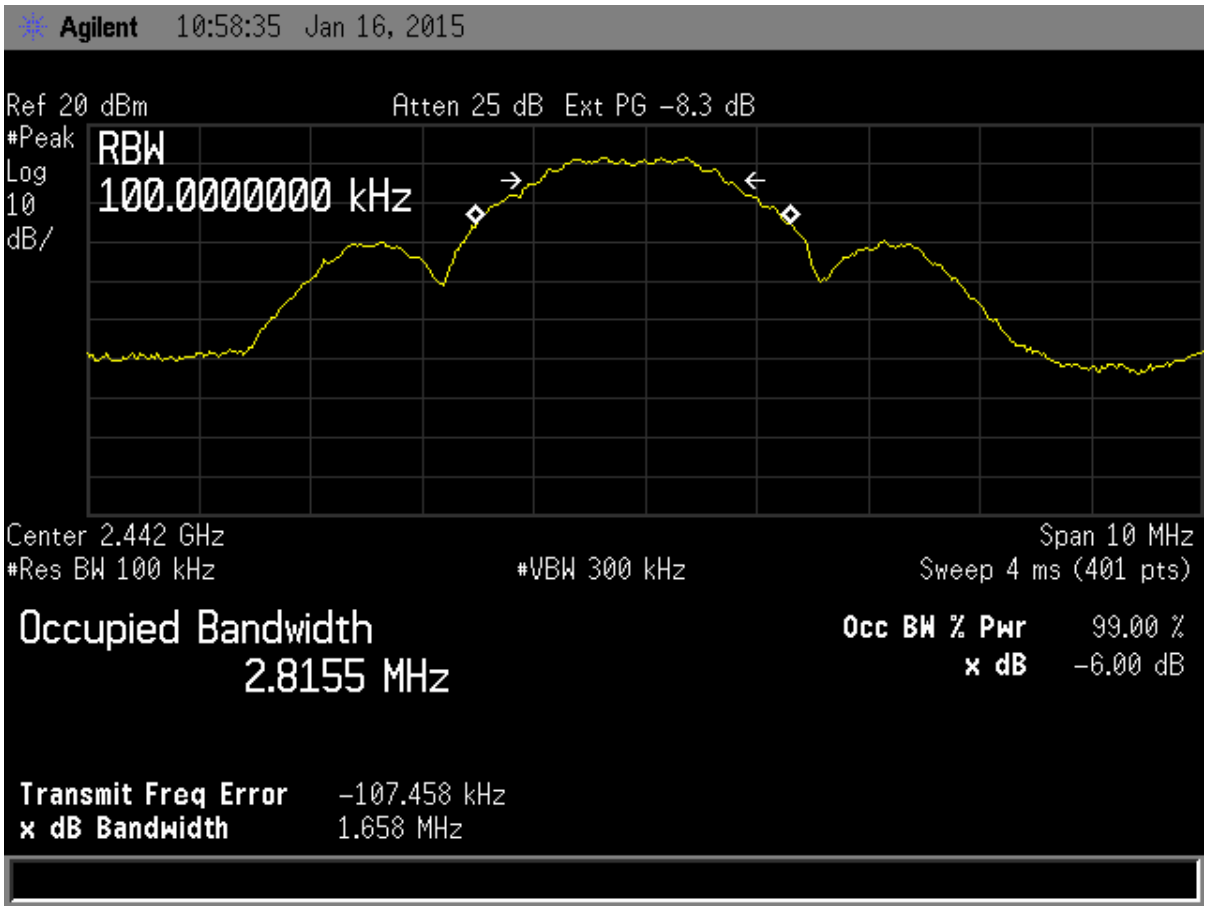


Figure 20. Six dB Bandwidth - 15.247 - Mid Channel

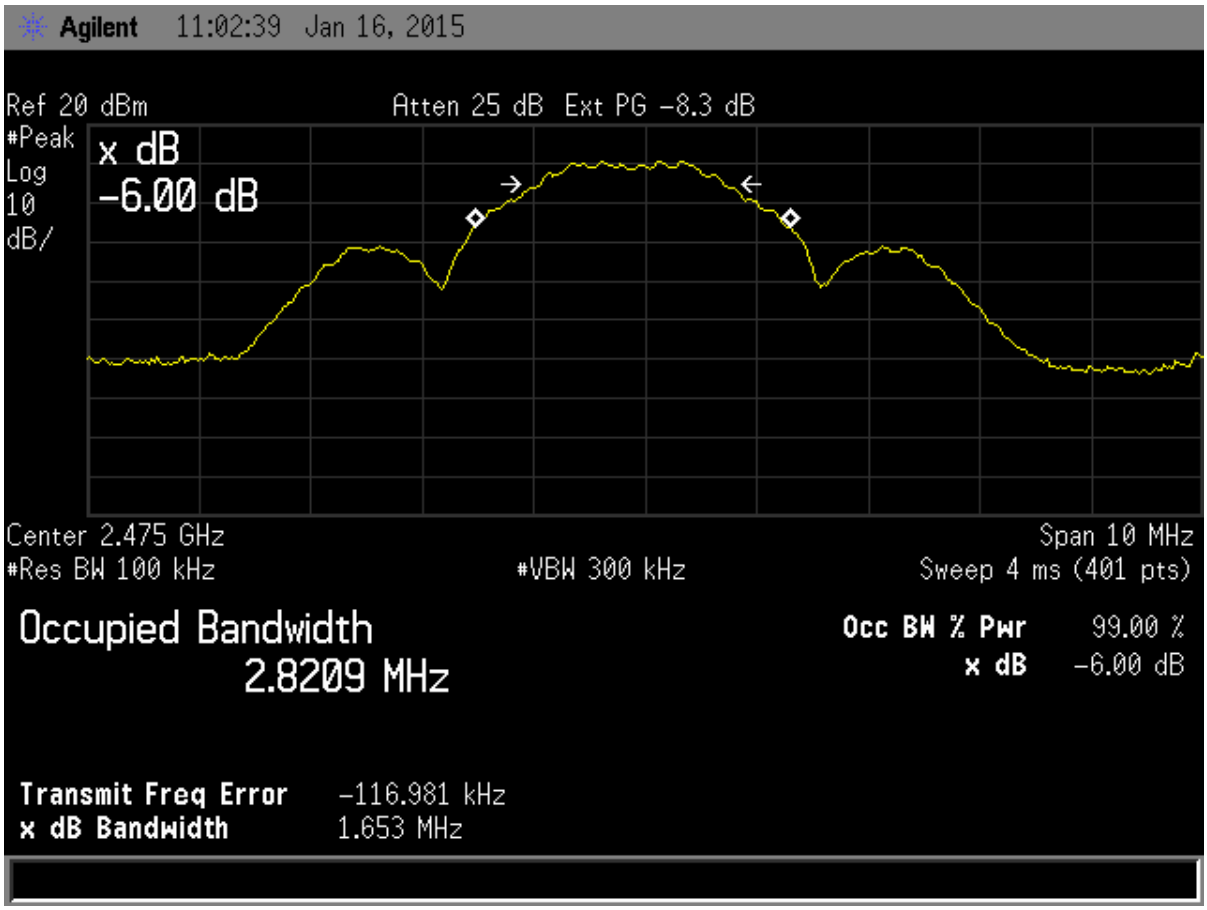


Figure 21. Six dB Bandwidth - 15.247 - High Channel

2.13 99% Occupied Bandwidth (IC RSS 210, A8.1)

These measurements were performed while the EUT was in a constant transmit mode. A method similar to the marker delta method was used to capture the points. 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 13 below and Figures 19 - 21 in the section above.

Table 13. 99% Occupied Bandwidth

Frequency (MHz)	99% Occupied Bandwidth (MHz)
2406	2.83
2442	2.82
2475	2.82

Test Date: January 16, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

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

The transmitter was programmed to operate at a maximum output power across the bandwidth.

Peak power within the band 2406 MHz to 2475 MHz was measured per FCC KDB Publication 558074 v03r02 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators 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. Peak antenna conducted output power is tabulated in the table below.

Table 14. Peak Antenna Conducted Output Power per Part 15.247 (b) (3)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
2406	17.71	59.02	1000
2442	17.13	51.64	1000
2475	16.27	42.36	1000

Test Date: January 16, 2015
Tested By
Signature: _____ Name: Carrie Fincannon

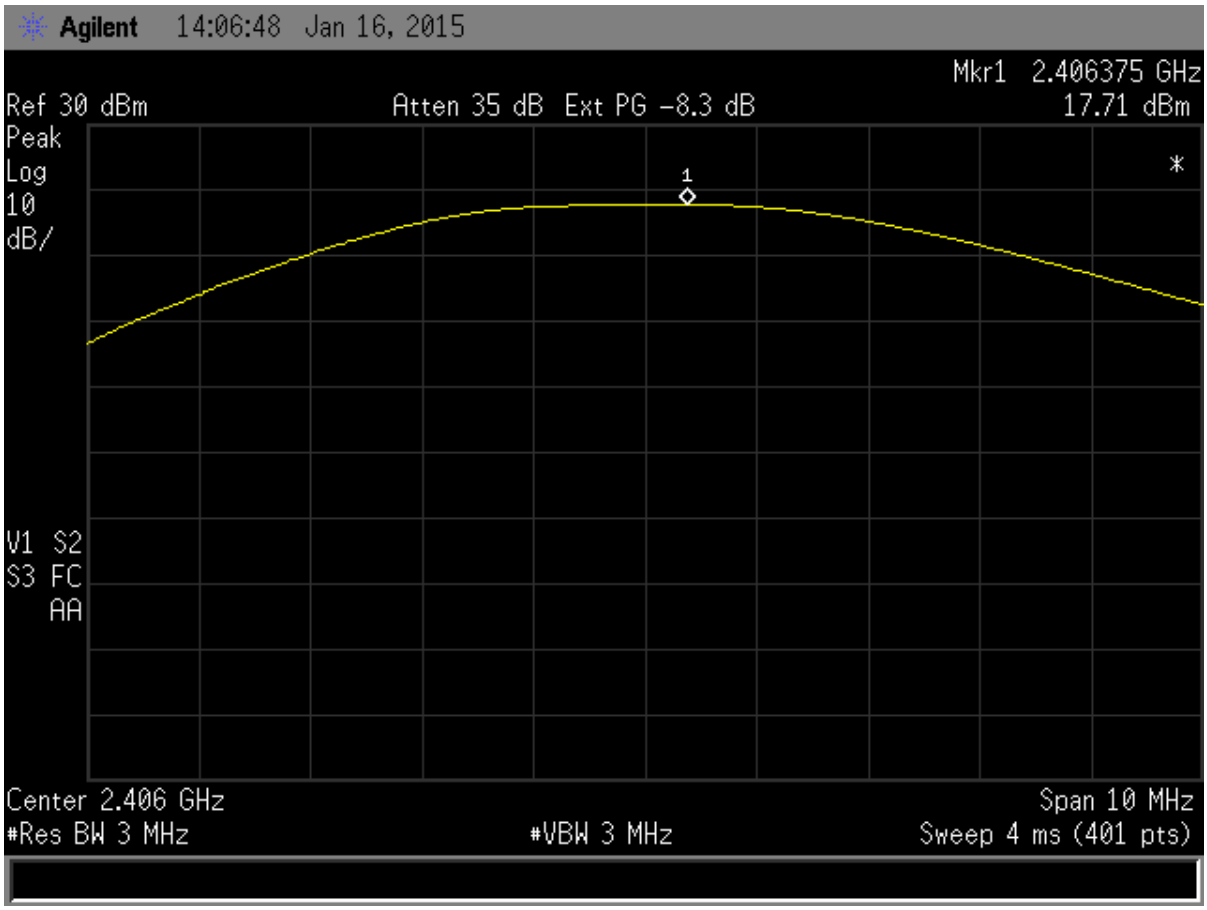


Figure 22. Peak Antenna Conducted Output Power, Low Channel

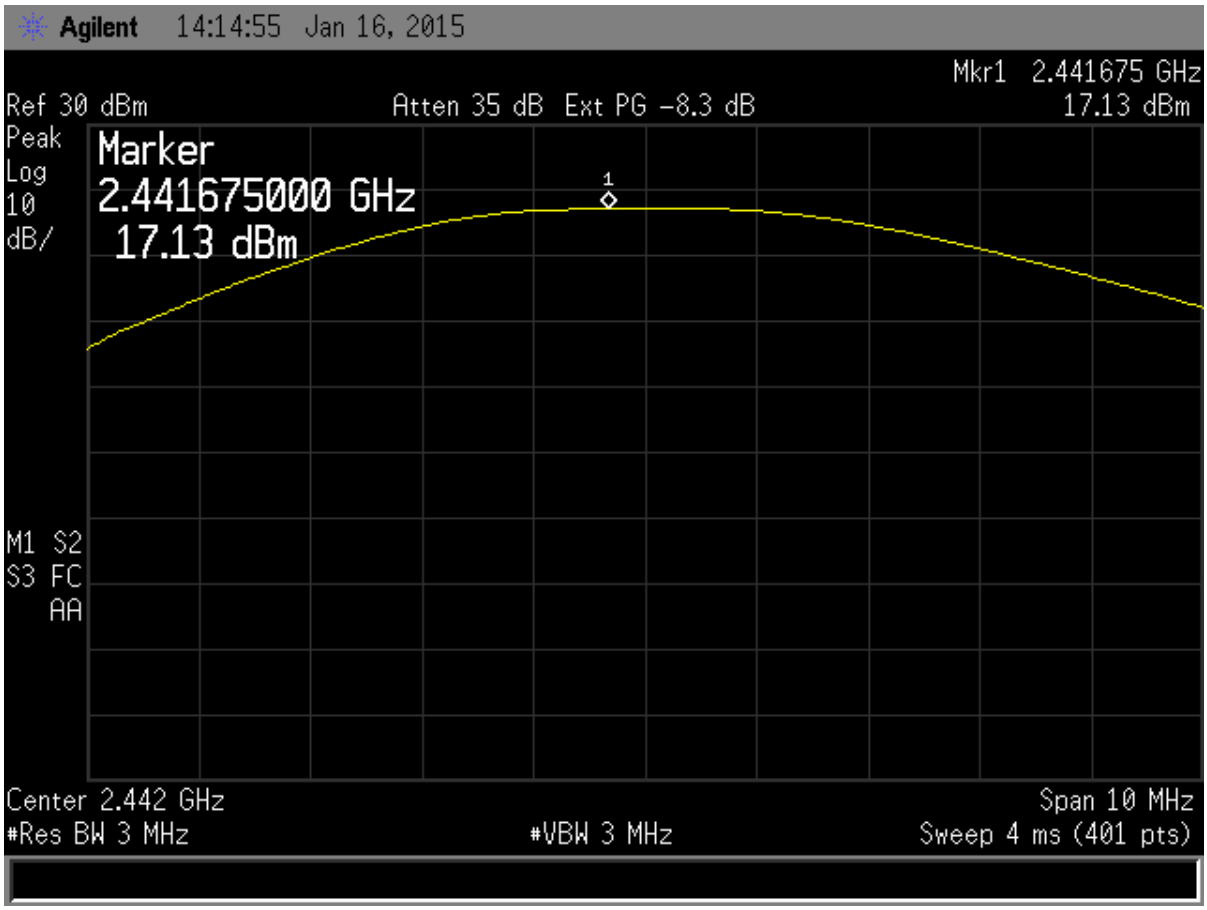


Figure 23. Peak Antenna Conducted Output Power, Mid Channel

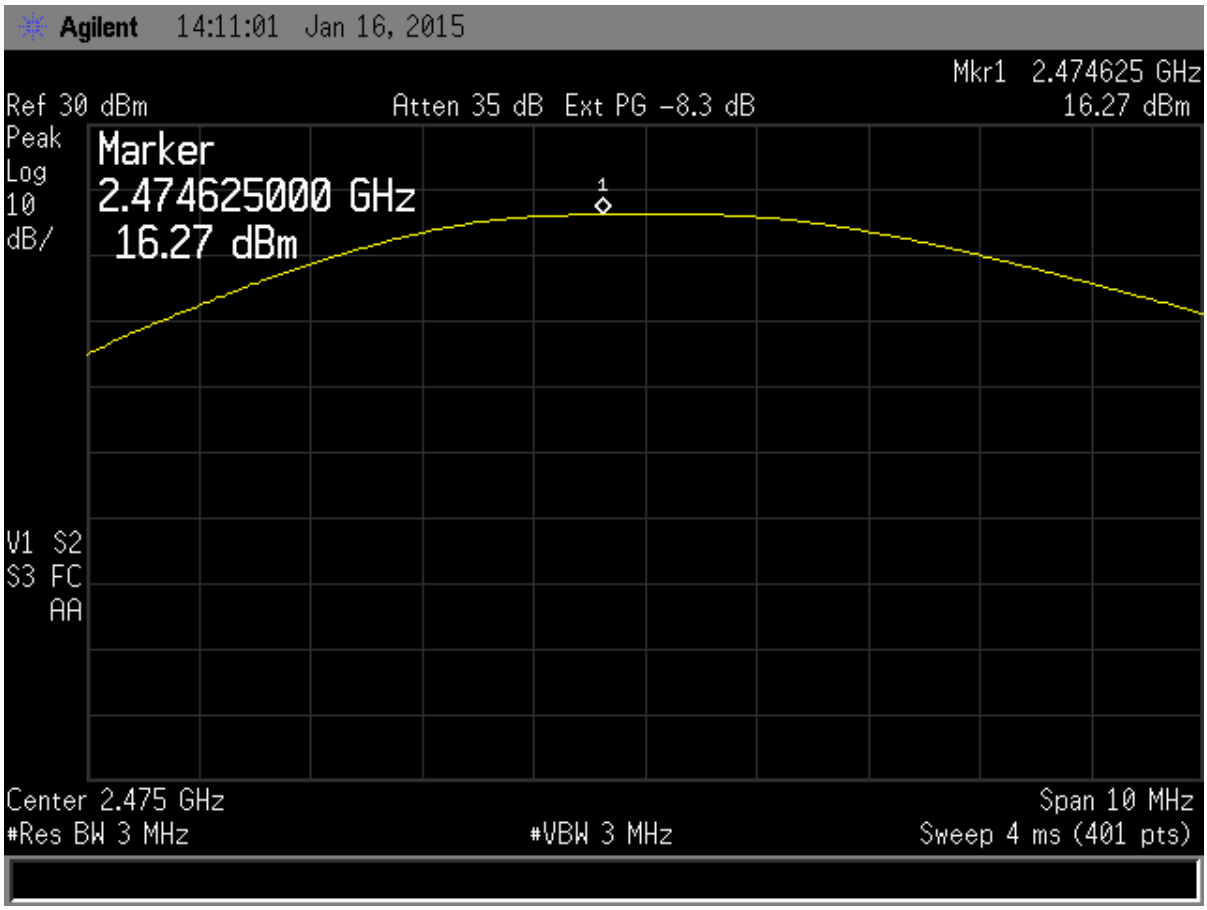


Figure 24. Peak Antenna Conducted Output Power, High Channel

2.15 Power Spectral Density (CFR 15.247(e)) (IC RSS 210 A8.5)

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 558074 v03r02 section 10.2 Method PKPSD 9peak PSD). This method was used since the maximum peak conducted output power was used to demonstrate compliance.

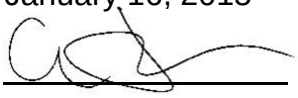
The center frequency was set to a DTS channel, low, mid, and high. The span was set to at least 1.5 times the DTS bandwidth. The RBW was set to 3 kHz ≤ RBW ≤ 100 kHz. The VBW was set to 3 x RBW. The detector was set to Peak, sweep time was set to auto couple and trace was set to Max hold. The trace was allowed to fully stabilize before the emission was recorded. If the measured value exceeds the limit the RBW was reduce (no less than 3 kHz) and repeated.

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

The following results show that all are less than +8 dBm per 3 kHz band.

Table 15. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Test Data (dBm/3 KHz)	Results (dBm/3 kHz)	FCC Limit (dBm/3 kHz)
2406	2.94	2.94	+8.0
2442	2.12	2.12	+8.0
2475	1.16	1.16	+8.0

Test Date: January 16, 2015
Tested By
Signature:  Name: Carrie Fincannon

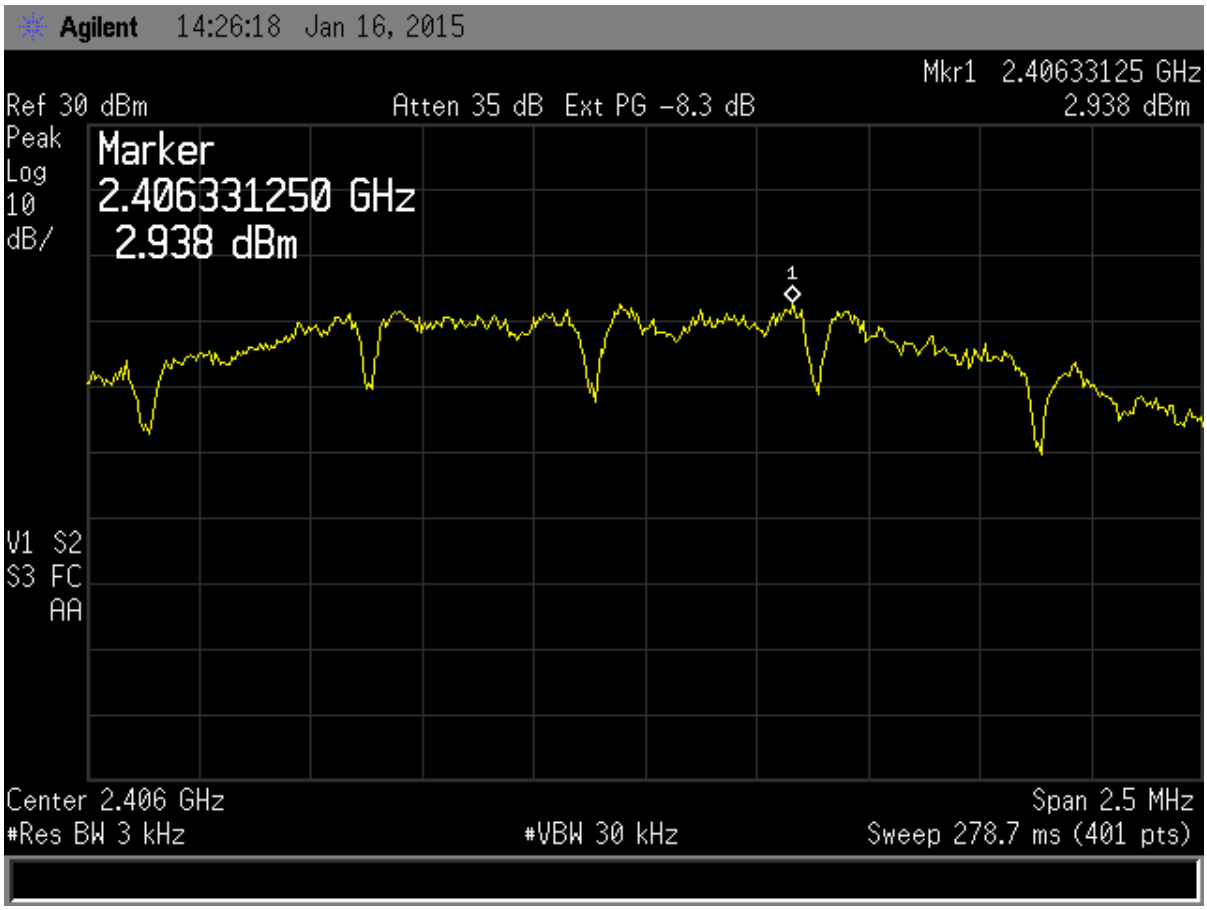


Figure 25. Peak Power Spectral Density, Low Channel

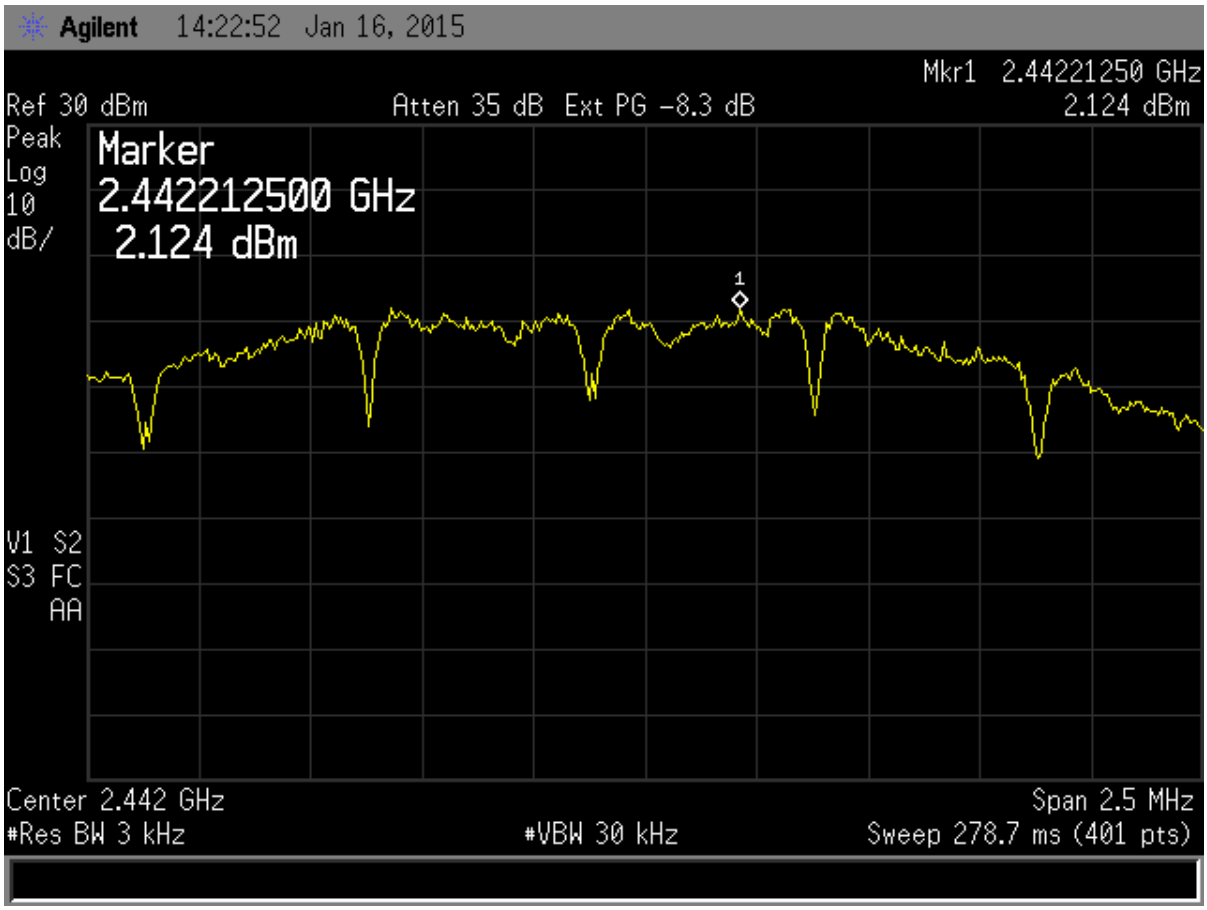


Figure 26. Peak Power Spectral Density, Mid Channel

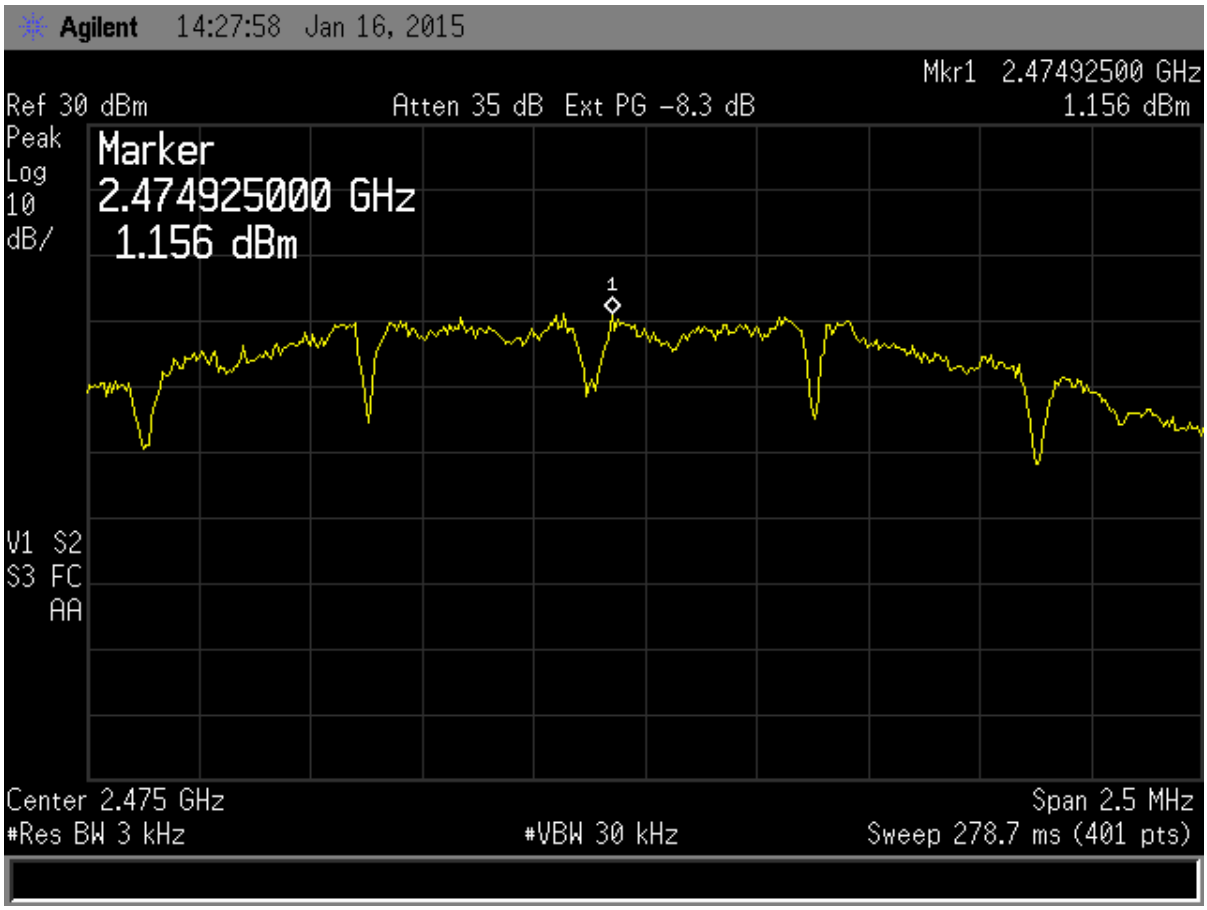


Figure 27. Peak Power Spectral Density, High Channel

2.16 Intentional Radiator, Powerline Emissions (CFR 15.207)

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in Part 15.207(a), as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal.

The testing was carried out in accordance with CFR 15.207 and ANSI C63.4:2009, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into normal use mode.

The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement occurred on the phase line at 0.2500 MHz. The emission level was 13.0 dB from the applicable limit. All other emissions were at least 13.5 dB from the limit. Those results are given in the tables following below.

Table 16. Transmitter Power Line Conducted Emissions Test Data (CFR 15.207)

150KHz to 30 MHz with Class B Limits						
Test: Power Line Conducted Emissions				**Client:** RFM		
Project: 15-0010				**Model:** DNT24		
Frequency (MHz)	**Test Data (dBuv)**	**LISN+CL-PA (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
120 VAC, 60 Hz Phase						
0.25	37.8	0.87	38.67	51.6	13.0	**PK**
0.57	31.2	0.44	31.64	46.0	14.4	**PK**
2.10	31.7	0.40	32.10	46.0	13.9	**PK**
8.78	30.3	0.51	30.81	50.0	19.2	**PK**
10.11	28.2	0.53	28.73	50.0	21.3	**PK**
24.00	22.7	0.72	23.42	50.0	26.6	**PK**
120VAC, 60 Hz Neutral						
0.19	33.4	1.15	34.55	54.0	19.5	**PK**
0.58	27.1	0.46	27.56	46.0	18.4	**PK**
2.28	32.1	0.39	32.49	46.0	13.5	**PK**
8.72	30.6	0.59	31.19	50.0	18.8	**PK**
10.04	27.4	0.62	28.02	50.0	22.0	**PK**
22.31	20.6	1.16	21.76	50.0	28.2	**PK**

SAMPLE CALCULATION at 0.25 MHz:

Magnitude of Measured Frequency	37.80	dBuV
+ Cable Loss+ LISN Loss	0.87	dB
=Corrected Result	38.67	dBuV
Limit	51.60	dBuV
-Corrected Result	38.67	dBuV
Margin	13.00	dB

Test Date: January 19, 2014

Tested By
Signature:  Name: Carrie Fincannon

2.17 Intentional Radiator, Radiated Emissions (CFR 15.209)

Radiated emissions disturbance measurements were performed per C63.10:2013 with an instrument having both peak and quasi-peak detectors over the frequency range of 150 kHz to 25 GHz. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

The worst-case results for radiated emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement occurred at 7225.00 MHz. The emission level was 0.7 dB from the applicable limit. All other emissions were at least 6.8 dB from the limit. Those results are given in the tables below.

Table 17 . Intentional Radiator, Peak Radiated Emissions (CFR 15.209), .150 MHz to 30 MHz

.150 MHz to 30 MHz							
Test: Radiated Emissions				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
All other emissions seen were 20 dB or more from the limit.							

Tested from .150 MHz to 30 MHz

SAMPLE CALCULATION: N/A

Test Date: January 19, 2014

Tested By
Signature: _____ Name: Carrie Fincannon

Table 18 . Intentional Radiator, Peak Radiated Emissions (CFR 15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz							
Test: Radiated Emissions				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
178.03	46.41	-13.41	33.00	43.5	3m./HORZ	10.5	**PK**
178.23	45.67	-12.61	33.06	43.5	3m./VERT	10.4	**PK**
All other emissions seen were 20 dB or more from the limit.							

Tested from 30 MHz to 1 GHz

SAMPLE CALCULATION: at 178.03 MHz, 46.41 dBuV + (-13.41) dB/m = 33.00 dBuV/m

Test Date: January 19, 2014

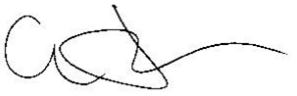
Tested By
Signature:  Name: Carrie Fincannon

Table 19 . Intentional Radiator, Peak Radiated Emissions (CFR 15.209), 1 GHz to 25 GHz

1 GHz to 25 GHz							
Test: Radiated Emissions				**Client:** RFM			
Project: 15-0010				**Model:** DNT24			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
1738.00	48.26	-7.20	41.06	54.0[2]	3.0m./VERT	12.9	**PK**
4800.00	46.90	1.83	48.73	54.0[2]	3.0m./VERT	5.27	**PK**
7225.00	66.53	6.76	73.29	74.0	3.0m./VERT	0.7	**PK**
7225.00[1]	46.53	6.79	53.32	54.0[2]	3.0m./VERT	0.7	**AVG**
1738.00	50.04	-7.10	42.94	54.0[2]	3.0m./HORZ	11.1	**PK**
4817.00	48.32	2.12	50.44	54.0[2]	3.0m./HORZ	3.6	**PK**
7237.00	60.47	6.78	67.25	74.0	3.0m./HORZ	6.8	**PK**
7237.00[1]	40.47	6.78	47.25	54.0[2]	3.0m./HORZ	6.8	**AVG**
All other emissions seen were 20 dB or more from the limit.							

Note (1): peak value corrected using Duty cycle factor (-20 dB) and compared to AVG limit.
Note (2): AVG limit used

Tested from 1 GHz to 25 GHz

SAMPLE CALCULATION: at 1738.00 MHz, 48.26 dBuV + (-7.20) dB/m = 41.06 dBuV/m

Test Date: January 19, 2014

Tested By
Signature: _____ Name: Carrie Fincannon

2.18 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.18.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.

2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.