

Testing Tomorrow's Technology

Class II Permissive Change Application

For

**Certification for an Intentional Radiator per
Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247
and
Innovation Science and Economic Development Canada
Certification per
RSS-Gen General Requirements for Radio Apparatus
and
RSS-247 Spread Spectrum Transmitter (DSS), Frequency Hopping Systems
(FHSS) and License-Exempt Local Area Network (LE-LAN) Devices**

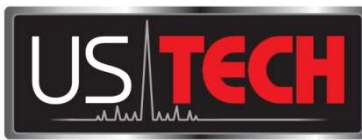
For the

**Murata Electronics North America
Model: WIT2450**

**FCC ID: HSW-2450
IC: 4492A-2450
UST Project: 17-0308
Issue Date: April 24, 2018**

Total Pages in This Report: 59

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PH: 770-740-0717 Fax: 770-740-1508
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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: Compliance Engineer – President

Date April 24, 2018



TESTING
NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANYS NAME: Murata Electronics North America

MODEL: WIT2450

FCC ID: HSW-2450

IC: 4492A-2450

DATE: April 24, 2018

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

Equipment type: FHSS 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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Alpharetta, GA 30004

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1 General Information

1.1 Purpose of this Report

The reason for the Class II permissive change is due to the following:

- Previous driver amplifier with gain control (DA_AGC) has been substituted to a separate amplifier and an analog attenuator to achieve gain control.
- Component values changes and reorganization.
- Shielding completely soldered along the seams to improved radiated performance.

All other circuitry remains the same; no other changes have been implemented.

The number of antennas used has also been reduced to include only the following:

- Dipole 9 dBi
- Corner Reflector 9 dBi
- Patch 6 dBi

Due to the changes, the following tests were performed to show that the EUT continues to comply with the relevant subpart:

- Spurious conducted emissions
- Intentional radiator spurious radiated emissions
- Band-edge measurements
- Restricted band measurements
- Conducted output power
- Occupied Bandwidth

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on March 20, 2018 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Murata Model WIT2450. The EUT is a modular Frequency Hopping Spread Spectrum (FHSS) 2.4 GHz transceiver radio module. The EUT was originally approved under FCC ID: HSW-2450 by the FCC on 12/28/2004.

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1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* as well as FCC subpart C of Part 15 Under section 15.247.

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 under registration number US5301. 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.

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.

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Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID and IC Number	CABLES P/D
Murata Electronics North America (EUT)	WIT2450	12	FCC ID: HSW-2450 IC: 4492A-2450	9 inch U P D
Antenna See antenna details in Table 4	--	--	--	--
Radio Evaluation Board Murata Electronics	800610	N/A	N/A	6 ft D
Power Supply CUI Inc	EPAS-101W-05	N/A	N/A	6 ft U P
Laptop computer Dell	D630	Various		

U= Unshielded
 S= Shielded
 P= Power
 D= Data

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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	CALIBRATION DUE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	6/22/2018
HORN ANTENNA	3115	EMCO	9107-3723	9/22/2018 2 yr.
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	12/1/2018

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 from 2401 MHz to 2474 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The EUT was evaluated to Fundamental and harmonic emissions to ensure that these intentional emissions remain compliant with the requirements of Part 15.247 and RSS-247. The module was investigated up to the 10th harmonic of the fundamental frequency.

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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.

For the radiated emissions testing to the average limit, the EUT duty cycle was reduced to the highest level that would be used during normal operation (<15%) and the EMC average function of the spectrum analyzer was enabled.

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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	PART NO.	GAIN dBi	TYPE OF CONNECTOR
Antenna 1	Mobile Mark	Dipole	OMNI249	9 dBi	N
Antenna 2	Mobile Mark	Corner Reflector, Directional	CORNER249	9 dBi	N
Antenna 3	Cirronet	Patch	PA2400	6 dBi	MMCX

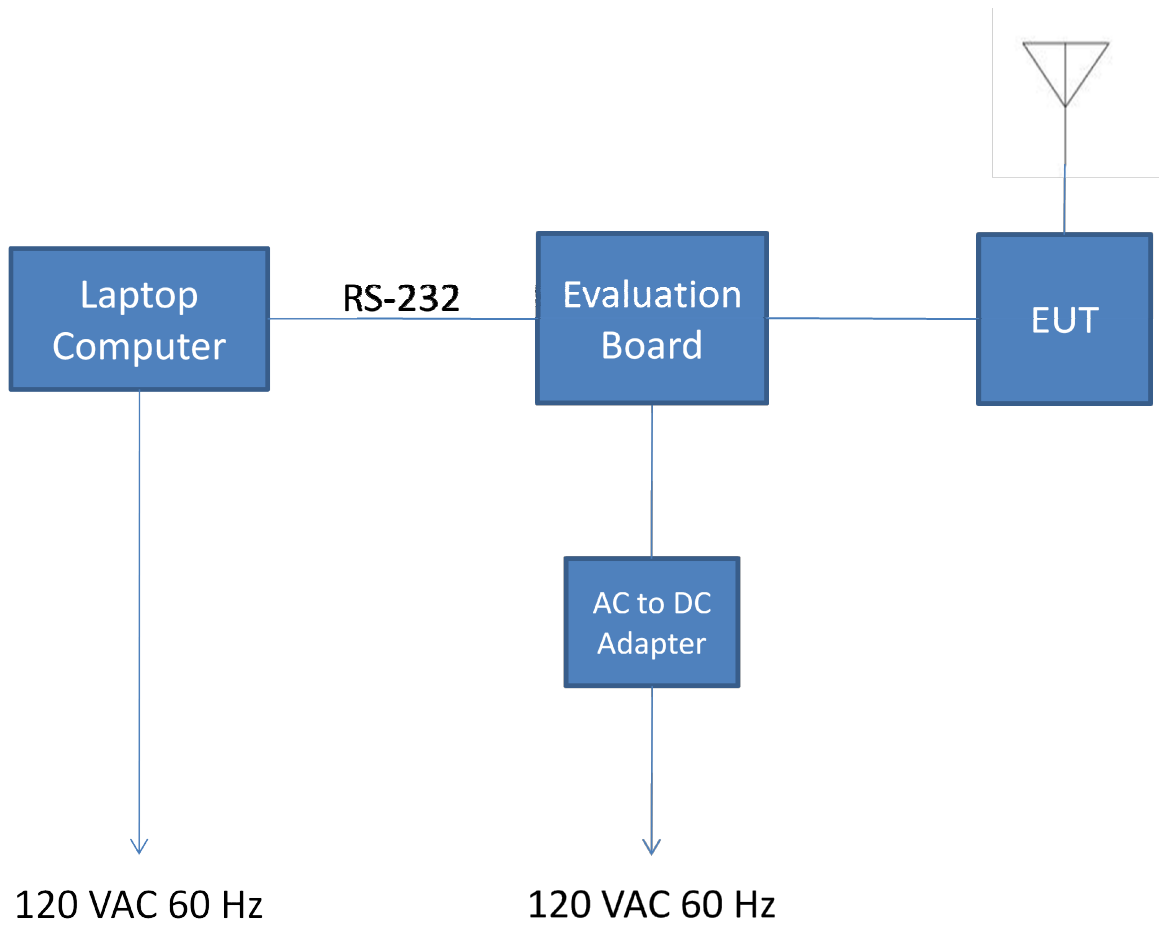


Figure 1. Block Diagram of Test Configuration

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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 2.8

2.8 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d)) (IC RSS 247 5.1 & 5.2)

Radiated Spurious measurements: The EUT was placed into a continuous transmit mode of operation using a duty cycle representative of normal operation and tested per ANSI C63.10:2013.

Radiated measurements were then conducted between the frequency range of 9 kHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). Emissions below 1 GHz were tested with a RBW of 100 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.

The EUT was investigated to CFR 15.209, General requirements for unwanted spurious emissions. The conducted spurious method as described below was used to investigate all other emissions emanating from the antenna port.

Conducted Spurious measurements: The EUT was put into a single frequency (non-hopping) transmit mode of operation (<15% duty cycle) and tested per ANSI C63.10-2013 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to ten times the highest clock frequency. A conducted scan was performed on the EUT to identify and record the spurious signals that were related to the transmitter.

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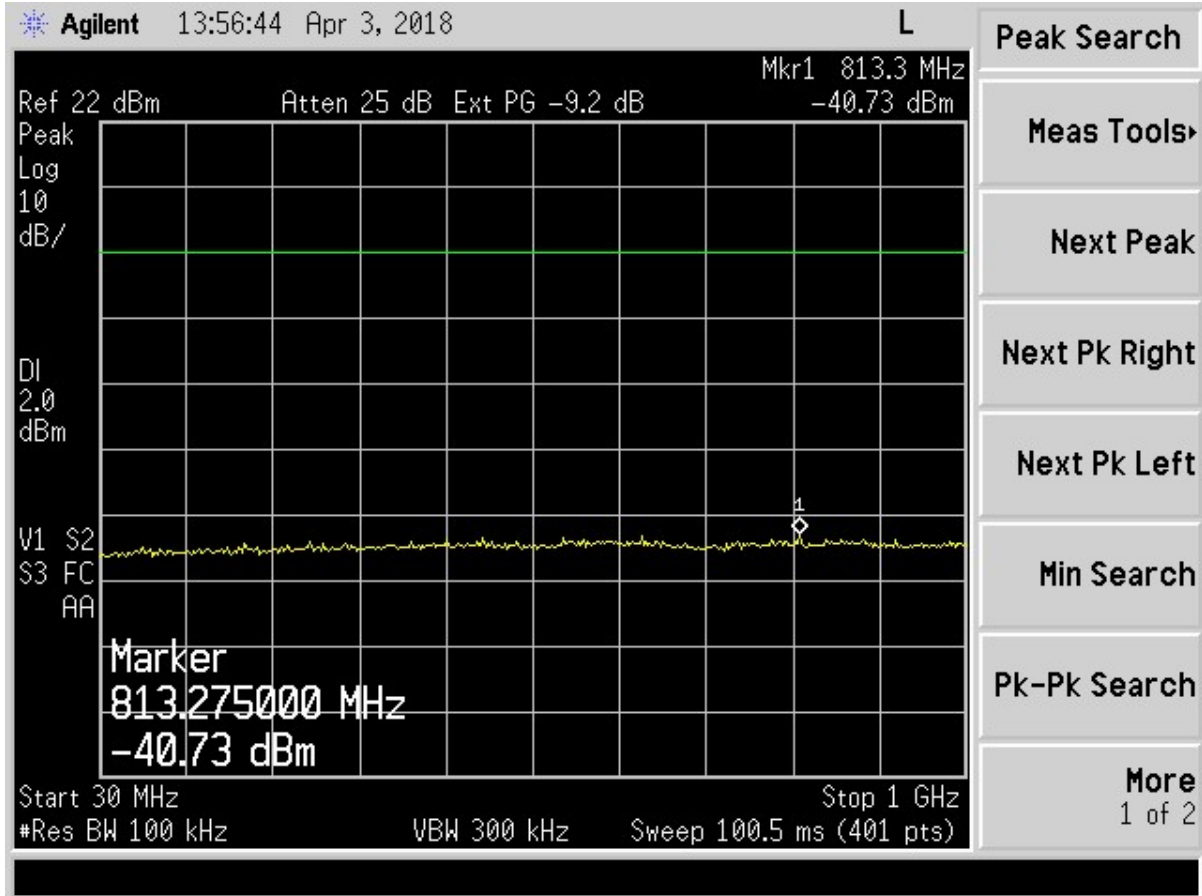


Figure 2. Antenna Conducted Emissions Low, Part 1

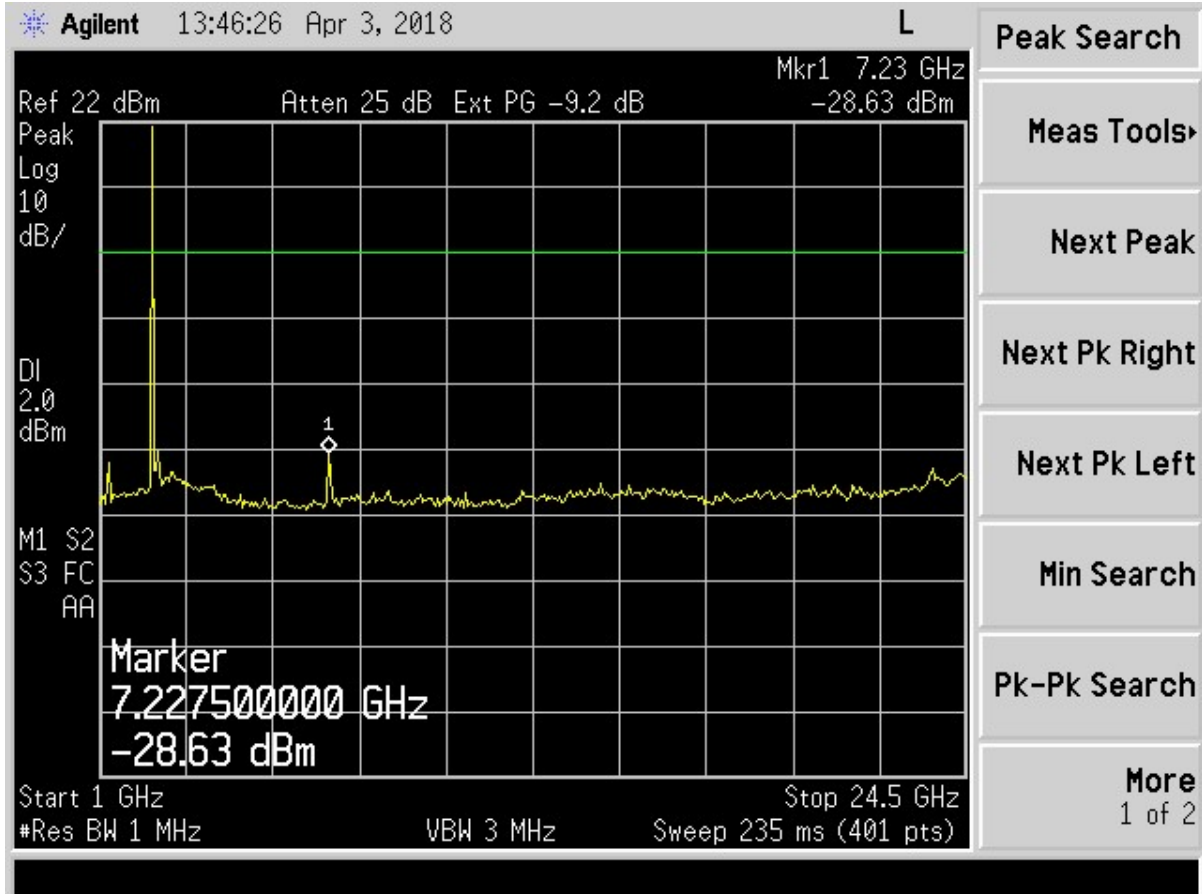


Figure 3. Antenna Conducted Emissions Low, Part 2

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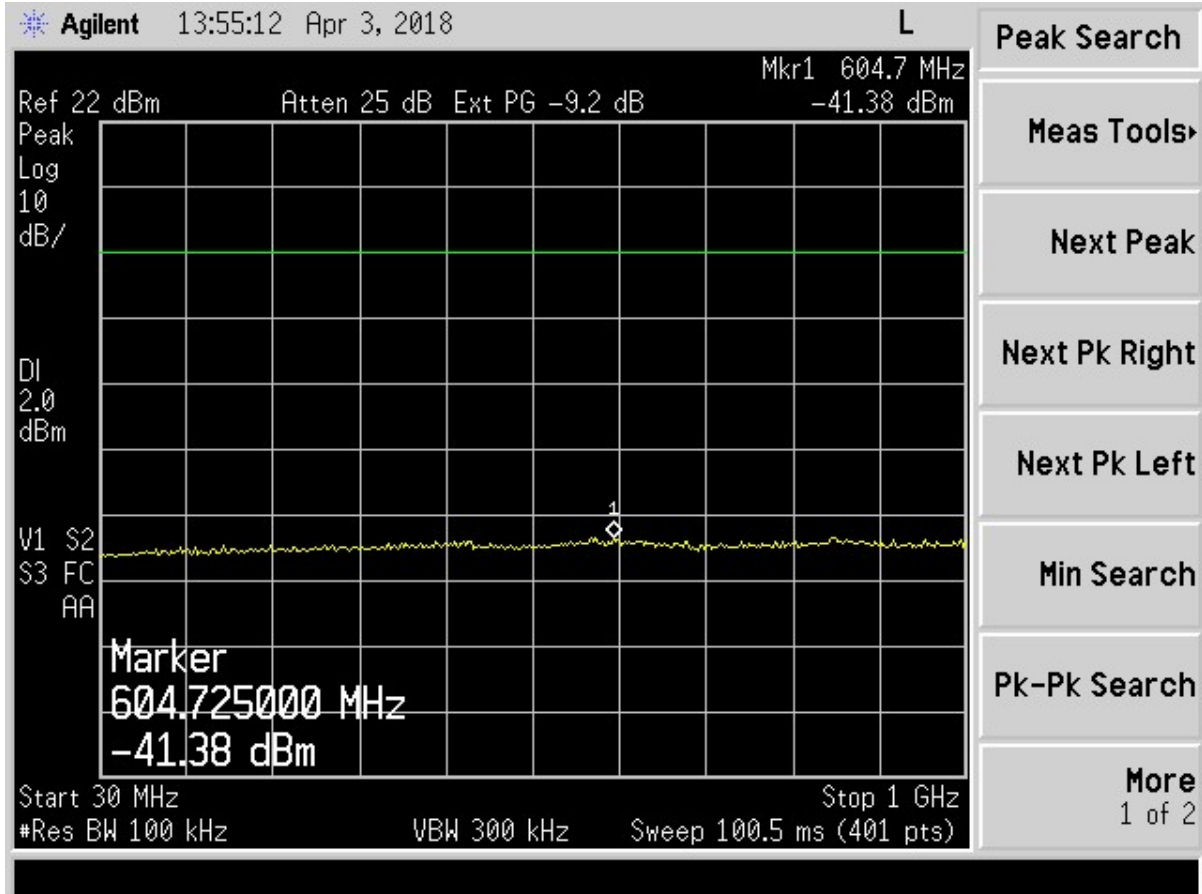


Figure 4. Antenna Conducted Emissions Mid, Part 1

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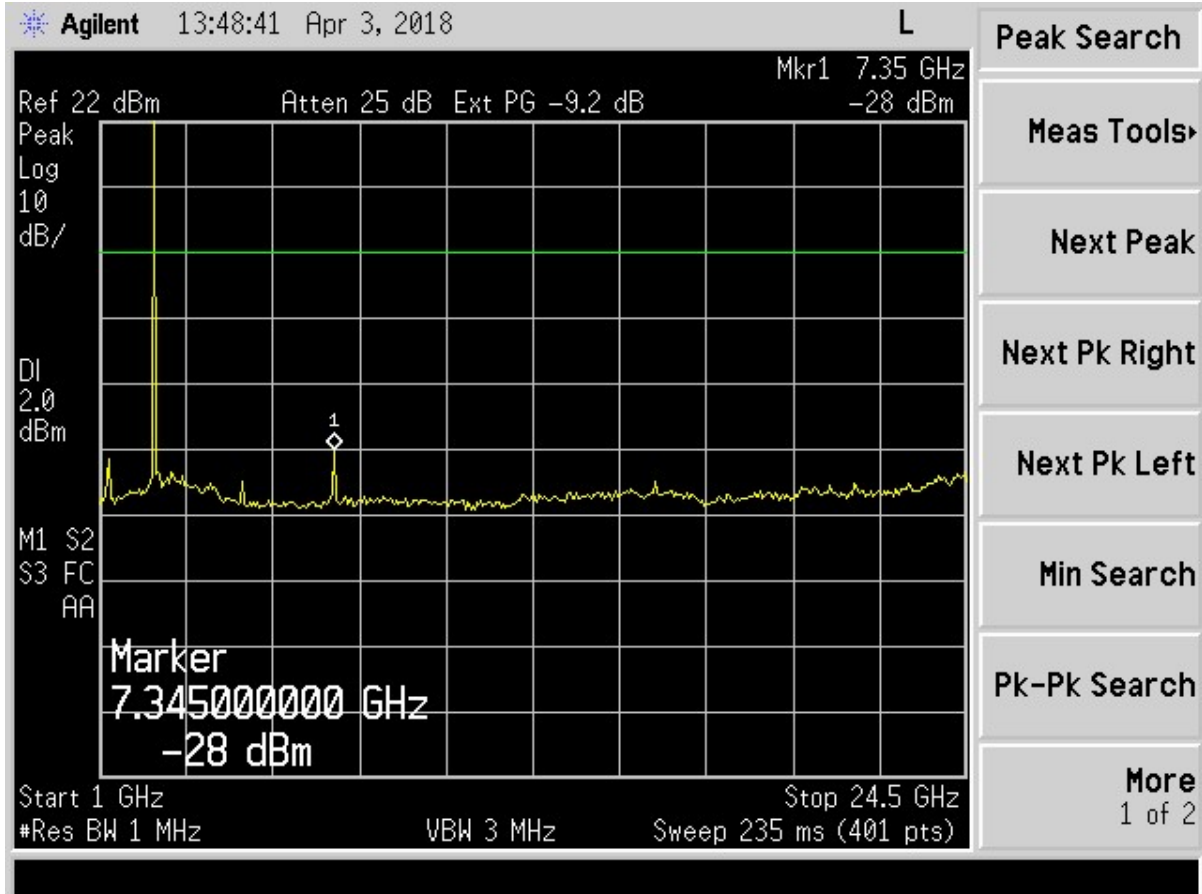


Figure 5. Antenna Conducted Emissions Mid, Part 2

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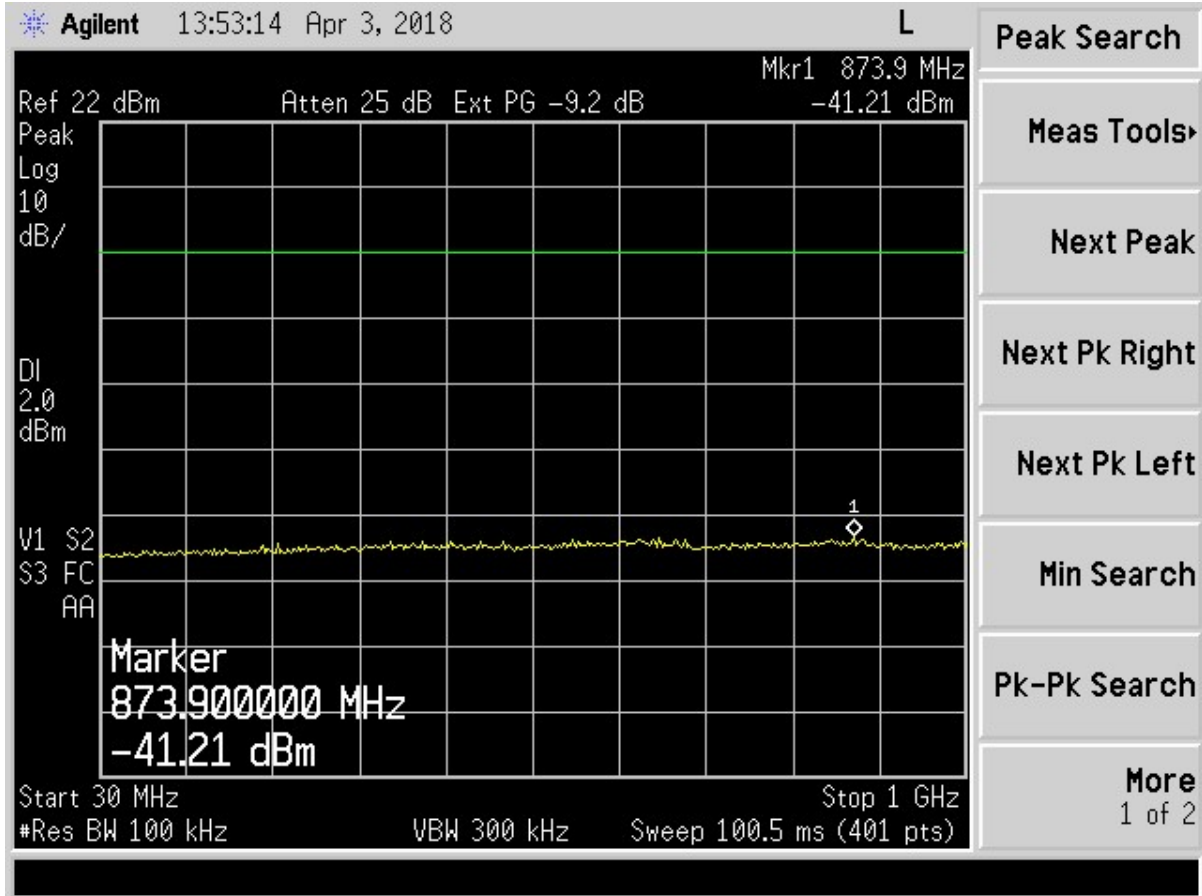


Figure 6. Antenna Conducted Emissions High, Part 1

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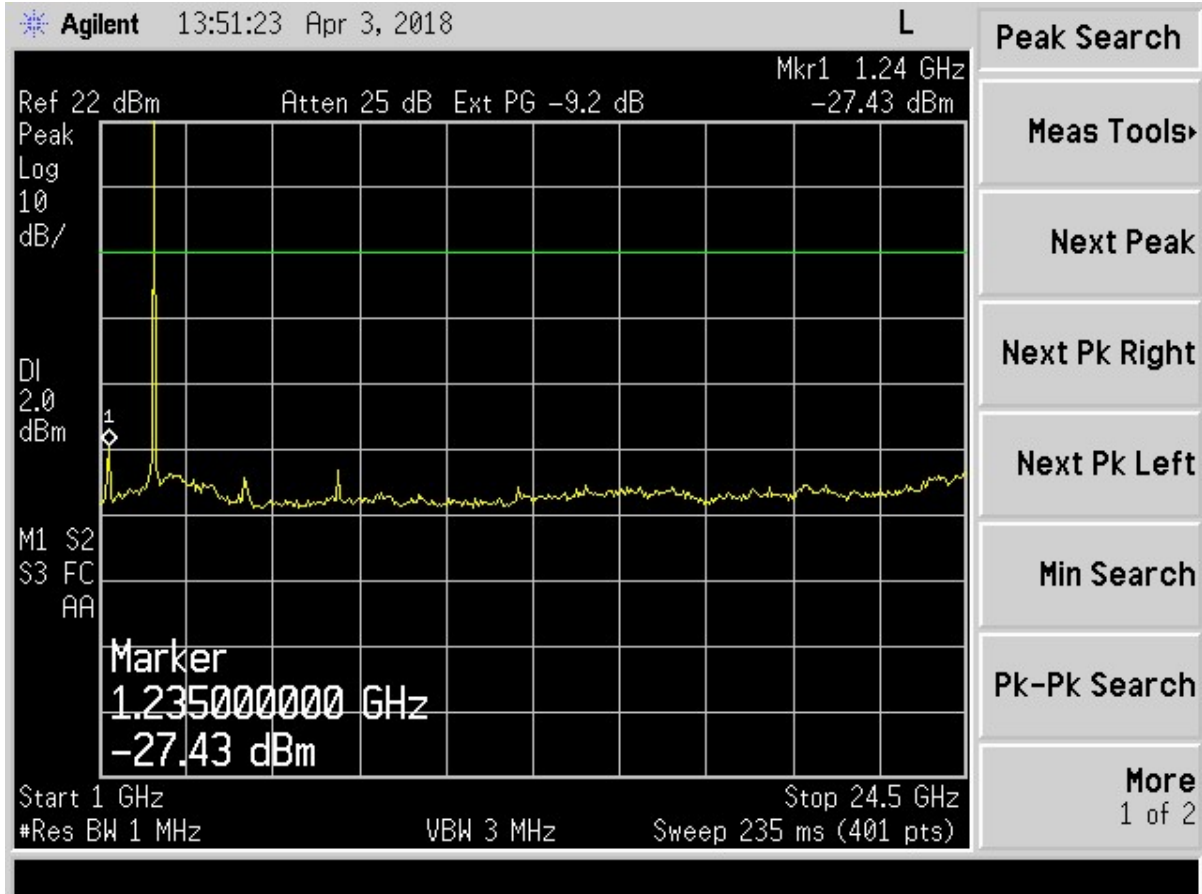


Figure 7. Antenna Conducted Emissions High, Part 2

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Table 5. Peak Radiated Fundamental & Harmonic Emissions (Antenna 1)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - PK								
2401.04	87.89		35.00	122.89	--	3.0m./VERT		PK
4801.95*	58.75		9.71	68.46	74.0*	3.0m./VERT	5.5	PK
7203.54	63.84	-9.50~	16.98	71.32	102.9	1.0m./VERT	31.6	PK
9604.44	55.62	-9.50~	19.23	65.35	102.9	1.0m./VERT	37.5	PK
Mid Channel - PK								
2438.25	91.22		34.95	126.17	--	3.0m./VERT		PK
4876.30*	56.17		9.32	65.49	74.0*	3.0m./VERT	8.5	PK
7314.80*	63.92	-9.50~	18.38	72.80	74.0*	1.0m./VERT	1.2	PK
9753.20	54.27	-9.50~	19.59	64.36	106.2	1.0m./VERT	41.8	PK
High Channel - PK								
2476.61	90.32		35.08	125.40	--	3.0m./VERT		PK
4948.64*	57.37		10.99	68.36	74.0*	3.0m./VERT	5.6	PK
7423.65*	62.14	-9.50~	18.72	71.36	74.0*	1.0m./VERT	2.6	PK
9897.51	51.55	-9.50~	20.97	63.02	105.4	1.0m./VERT	42.4	PK

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9604.44 MHz:

Magnitude of Measured Frequency	55.62	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	19.23	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	65.35	dBuV/m

Test Date: March 29, 2018

Tested By: 

Name: Bruce Arnold

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Table 6. Average Radiated Fundamental & Harmonic Emissions (Antenna 1)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - AVERAGE								
2401.15	39.18		35.00	74.18	--	3.0m./VERT		AVG
4802.09*	33.47		9.71	43.18	54.0*	3.0m./VERT	10.8	AVG
7203.20	33.16	-9.50~	16.98	40.64	54.2	1.0m./VERT	13.5	AVG
9604.20	32.69	-9.50~	19.23	42.42	54.2	1.0m./VERT	11.8	AVG
Mid Channel - AVERAGE								
2438.31	40.54		34.95	75.49	--	3.0m./VERT		AVG
4876.58*	32.93		9.32	42.25	54.0*	3.0m./VERT	11.7	AVG
7314.62*	31.88	-9.50~	18.38	40.76	54.0*	1.0m./VERT	13.2	AVG
9753.00	31.01	-9.50~	19.59	41.10	55.5	1.0m./VERT	14.4	AVG
High Channel - AVERAGE								
2474.59	40.11		35.08	75.19	--	3.0m./VERT		AVG
4949.04*	33.45		10.99	44.44	54.0*	3.0m./VERT	9.6	AVG
7423.65*	30.13	-9.50~	18.72	39.35	54.0*	1.0m./VERT	14.7	AVG
9898.08	31.92	-9.50~	20.97	43.39	55.2	1.0m./VERT	11.8	AVG

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9604.2 MHz:

Magnitude of Measured Frequency	32.69	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	19.23	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	42.42	dBuV/m

Test Date: March 29, 2018

Tested By

Signature: 

Name: Bruce Arnold

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 247
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 Murata Electronics North America
 WIT2450

Table 7. Peak Radiated Fundamental & Harmonic Emissions (Antenna 2)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - PK								
2401.10	89.01		35.00	124.01		3.0m./VERT		PK
4802.05*	55.84		9.71	65.55	74.0*	3.0m./VERT	8.5	PK
7203.50	64.86	-9.50~	17.01	72.37	104.0	1.0m./HORZ	31.6	PK
9603.40	50.39	-9.50~	19.17	60.06	104.0	1.0m./HORZ	43.9	PK
Mid Channel - PK								
2438.09	90.99		34.95	125.94		3.0m./VERT		PK
4876.32*	57.04		9.32	66.36	74.0*	3.0m./VERT	7.6	PK
7314.81*	63.90	-9.50~	18.29	72.69	74.0*	1.0m./HORZ	1.3	PK
9754.20	49.50	-9.50~	19.53	59.53	105.9	1.0m./HORZ	46.4	PK
High Channel - PK								
2474.34	91.47		35.08	126.55		3.0m./VERT		PK
4948.86*	58.65		10.99	69.64	74.0*	3.0m./VERT	4.4	PK
7423.30*	61.36	-9.50~	18.68	70.54	74.0*	1.0m./HORZ	3.5	PK
9898.00	50.56	-9.50~	20.94	62.00	106.6	1.0m./HORZ	44.5	PK

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9603.4 MHz:

Magnitude of Measured Frequency	50.39	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	19.17	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	60.06	dBuV/m

Test Date: March 29, 2018

Tested By: 

Name: Bruce Arnold

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

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Table 8. Average Radiated Fundamental & Harmonic Emissions (Antenna 2)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - AVERAGE								
2401.10	36.45		35.00	71.45		3.0m./VERT		AVG
4802.08*	32.29		9.71	42.00	54.0*	3.0m./VERT	12.0	AVG
7203.20	33.55	-9.50~	17.01	41.06	54.0	1.0m./HORZ	12.9	AVG
9604.20	30.30	-9.50~	19.17	39.97	54.0	1.0m./HORZ	14.0	AVG
Mid Channel - AVERAGE								
2438.12	38.05		34.95	73.00		3.0m./VERT		AVG
4876.49*	32.42		9.32	41.74	54.0*	3.0m./VERT	12.3	AVG
7314.58*	32.62	-9.50~	18.29	41.41	54.0*	1.0m./HORZ	12.6	AVG
9752.90	31.04	-9.50~	19.53	41.07	54.0	1.0m./HORZ	12.9	AVG
High Channel - AVERAGE								
2474.64	38.21		35.08	73.29		3.0m./VERT		AVG
4949.08*	33.00		10.99	43.99	54.0*	3.0m./VERT	10.0	AVG
7423.60*	31.59	-9.50~	18.68	40.77	54.0*	1.0m./HORZ	13.2	AVG
9898.20	30.49	-9.50~	20.94	41.93	54.0	1.0m./HORZ	12.1	AVG

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9604.2 MHz:

Magnitude of Measured Frequency	30.30	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	19.17	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	39.97	dBuV/m

Test Date: March 29, 2018

Tested By

Signature: 

Name: Bruce Arnold

US Tech Test Report:
 FCC ID:
 IC:
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 Customer:
 Model:

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Table 9. Peak Radiated Fundamental & Harmonic Emissions (Antenna 3)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - PK								
2401.16	86.20		34.82	121.02		3.0m./HORZ		PK
4802.10	56.59*		9.71	66.30	74.0*	3.0m./VERT	7.7	PK
7202.96	52.62		15.99	68.61	101.0	3.0m./VERT	32.4	PK
9604.50	56.26	-9.50~	19.78	66.54	101.0	1.0m./VERT	34.5	PK
Mid Channel - PK								
2438.00	88.74		34.77	123.51		3.0m./HORZ		PK
4876.30	58.52*		9.32	67.84	74.0*	3.0m./VERT	6.2	PK
7314.54	54.43*		17.41	71.84	74.0*	3.0m./VERT	2.2	PK
9753.10	53.44	-9.50~	19.92	63.86	103.5	1.0m./VERT	39.7	PK
High Channel - PK								
2474.40	86.14		34.90	121.04		3.0m./HORZ		PK
4949.00	58.52*		10.99	69.51	74.0*	3.0m./VERT	4.5	PK
7423.70	53.08*		17.94	71.02	74.0*	3.0m./VERT	3.0	PK
9898.80	53.74	-9.50~	21.22	65.46	101.0	1.0m./HORZ	35.6	PK

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9604.5 MHz:

Magnitude of Measured Frequency	56.26	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	19.78	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	66.54	dBuV/m

Test Date: March 30, 2018

Tested By
 Signature: 

Name: Bruce Arnold

US Tech Test Report:
 FCC ID:
 IC:
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 Model:

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Table 10. Average Radiated Fundamental & Harmonic Emissions (Antenna 3)

Test: FCC Part 15, Para 15.209, 15.247(d)					Client: Murata			
Project: 17-0308					Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low Channel - AVERAGE								
2401.26	35.02		34.82	69.84		3.0m./HORZ		AVG
4802.30*	32.90		9.71	42.61	54.0*	3.0m./VERT	11.4	AVG
7203.26	30.97		15.99	46.96	54.0	3.0m./VERT	7.0	AVG
9604.32	31.66	-9.50~	19.78	41.94	54.0	1.0m./VERT	12.1	AVG
Mid Channel - AVERAGE								
2438.41	36.68		28.18	64.86		3.0m./HORZ		AVG
4876.68*	32.92		9.32	42.24	54.0*	3.0m./VERT	11.8	AVG
7314.79*	30.71		17.43	48.14	54.0*	3.0m./HORZ	5.9	AVG
9763.00	31.19	-9.50~	19.92	41.61	54.0	1.0m./VERT	12.4	AVG
High Channel - AVERAGE								
2474.75	34.96		34.90	69.86		3.0m./HORZ		AVG
4949.18*	33.04		10.99	44.03	54.0*	3.0m./VERT	10.0	AVG
7423.45*	29.70		17.94	47.64	54.0*	3.0m./VERT	6.4	AVG
9898.20	31.33	-9.50~	21.24	43.07	54.0	1.0m./VERT	10.9	AVG

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
- (~) Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
- The EUT was placed in its normal operating position and the transmitter was in constant broadcast (test) mode, with a duty cycle simulating normal duty cycle. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 9604.32 MHz:

Magnitude of Measured Frequency	31.66	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	19.78	dB/m
1 meter to 3 meter extrapolation	-9.50	dB
Corrected Result	41.94	dBuV/m

Test Date: March 30, 2018

Tested By
 Signature: 

Name: Bruce Arnold

US Tech Test Report:
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2.9 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made, following the guidelines in ANSI C63.10-2013 for the FHSS modulation, with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Radiated measurements are performed for each antenna 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 2 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. Radiated measurements are performed with RBW = 100 kHz. In all cases, the VBW is set \geq RBW. See figure and calculations below for more detail.

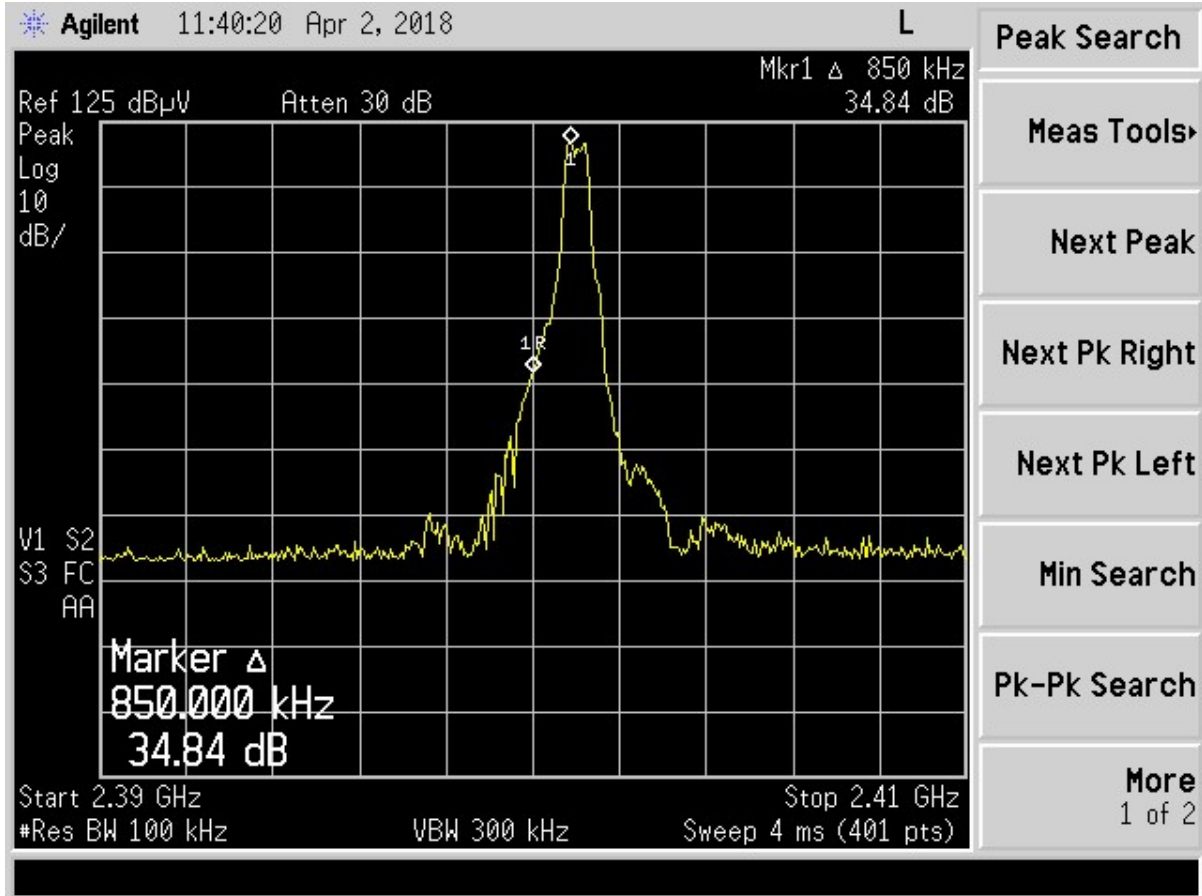


Figure 8. Band Edge Compliance, Low Channel Delta - Antenna 1

Calculation of worst case lower band edge measurement:

Measured Delta (from Figure 8)	34.84	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	14.84	dB

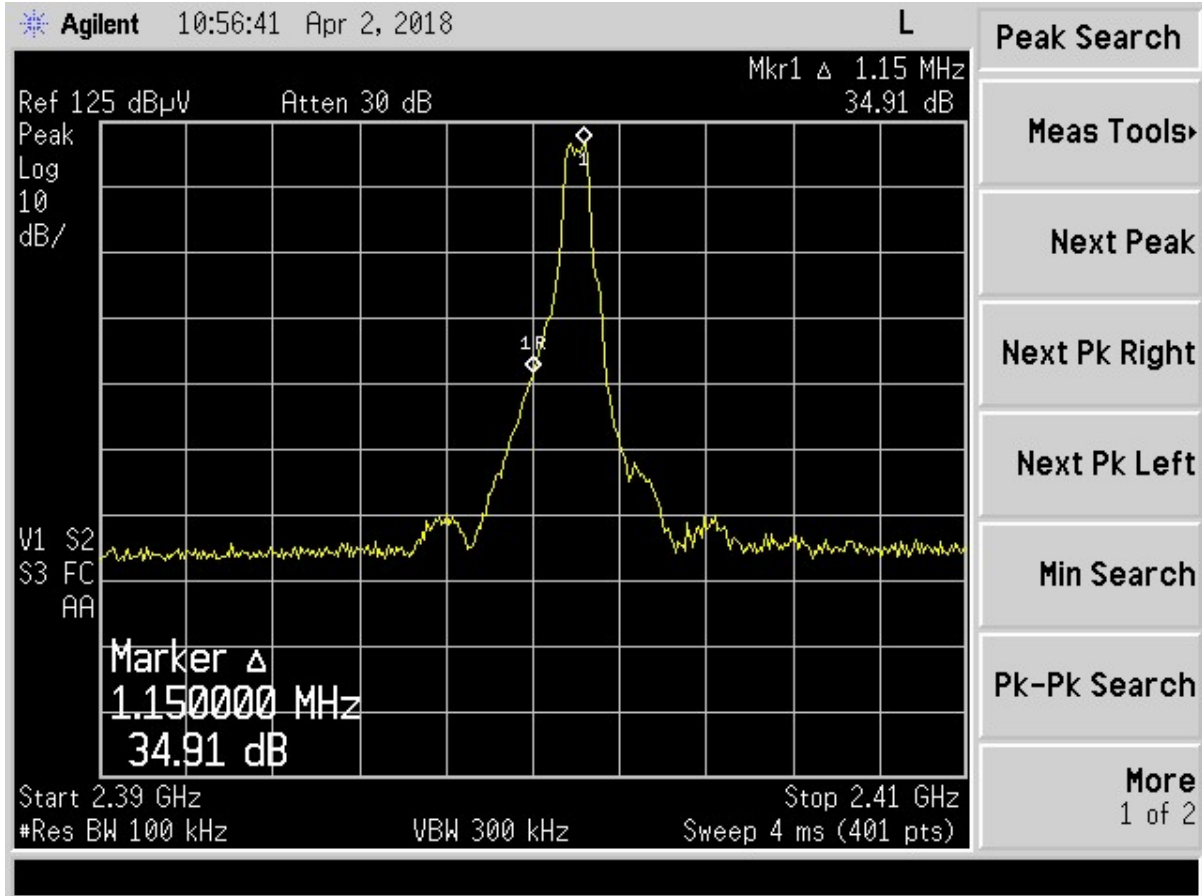


Figure 9. Band Edge Compliance, Low Channel Delta - Antenna 2

Calculation of worst case lower band edge measurement:

Measured Delta (from Figure 9)	34.91	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	14.91	dB

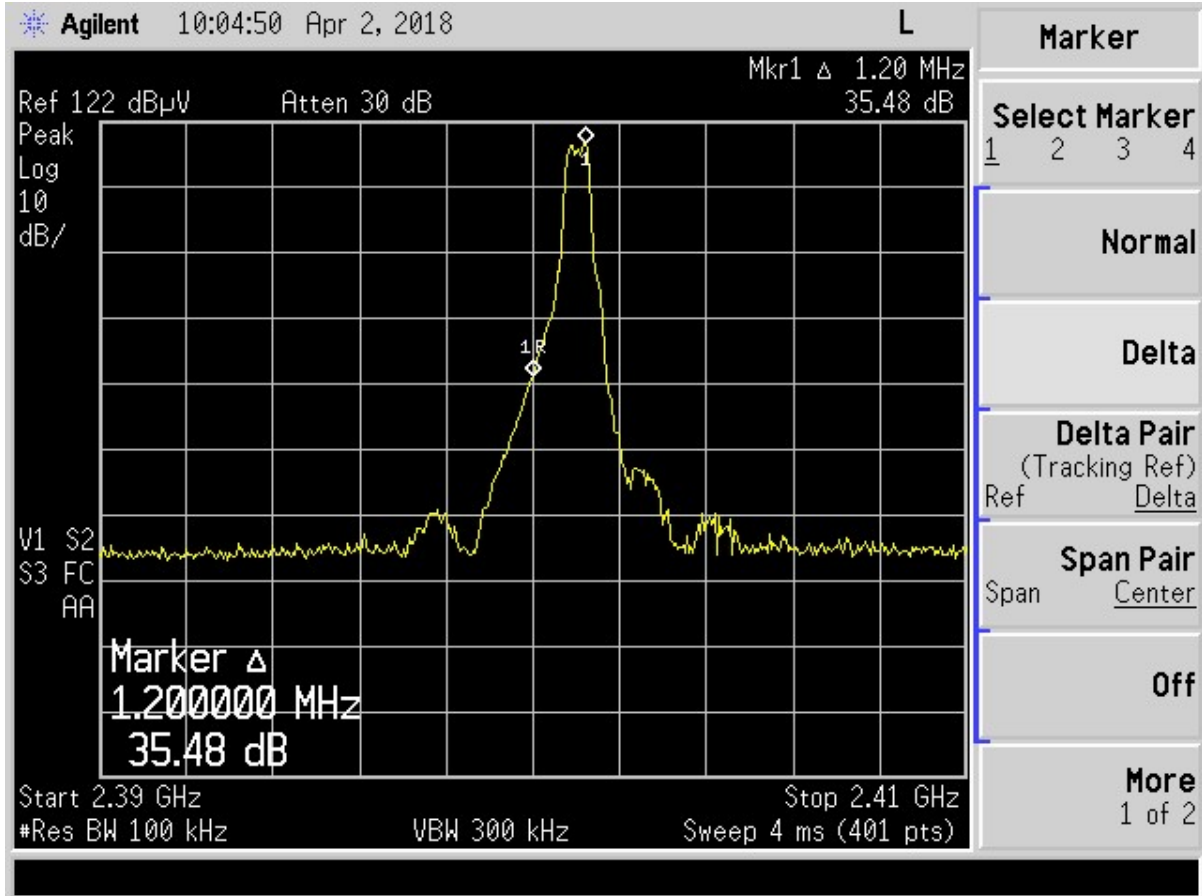


Figure 10. Band Edge Compliance, Low Channel Delta – Antenna 3

Calculation of worst case lower band edge measurement:

Measured Delta (from Figure 10)	35.48	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	15.48	dB

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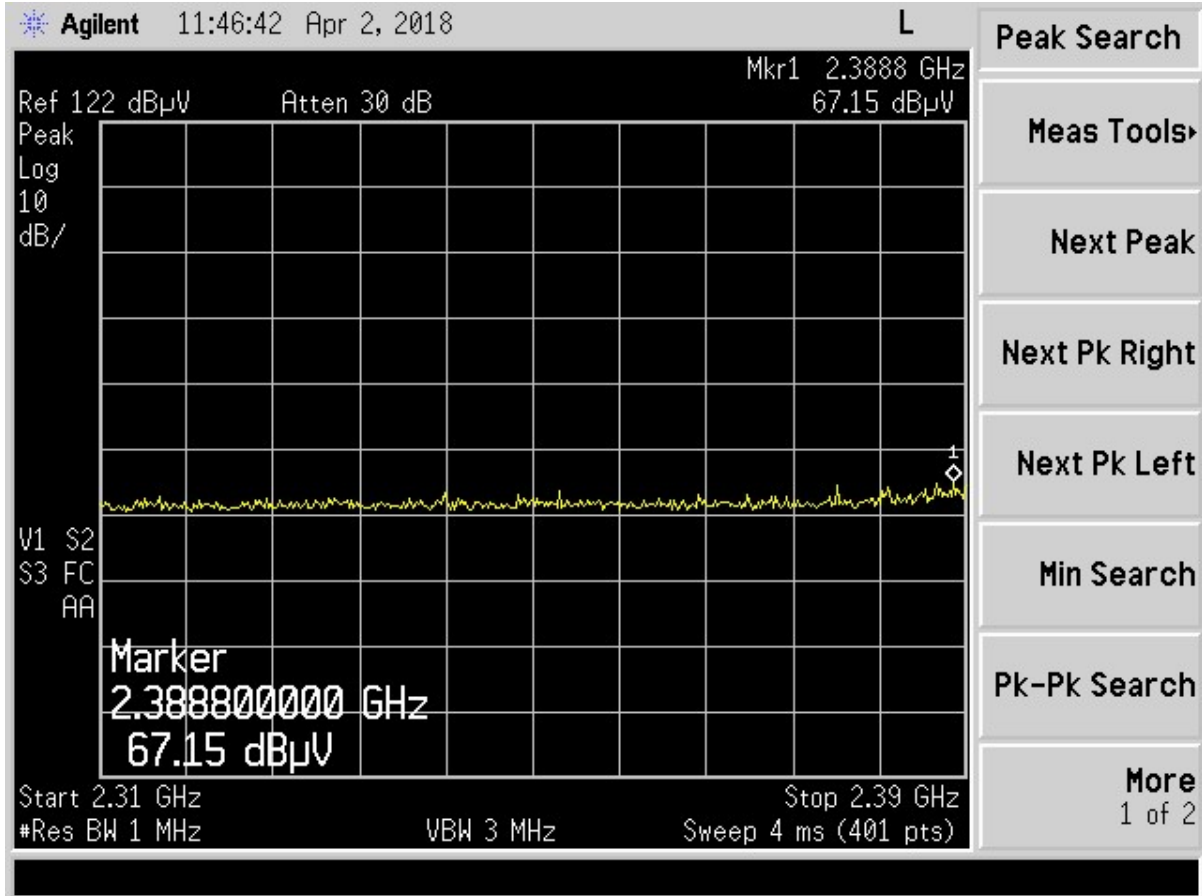


Figure 11. Restricted Band Emissions PK, 2.31 to 2.39 GHz – Antenna 1

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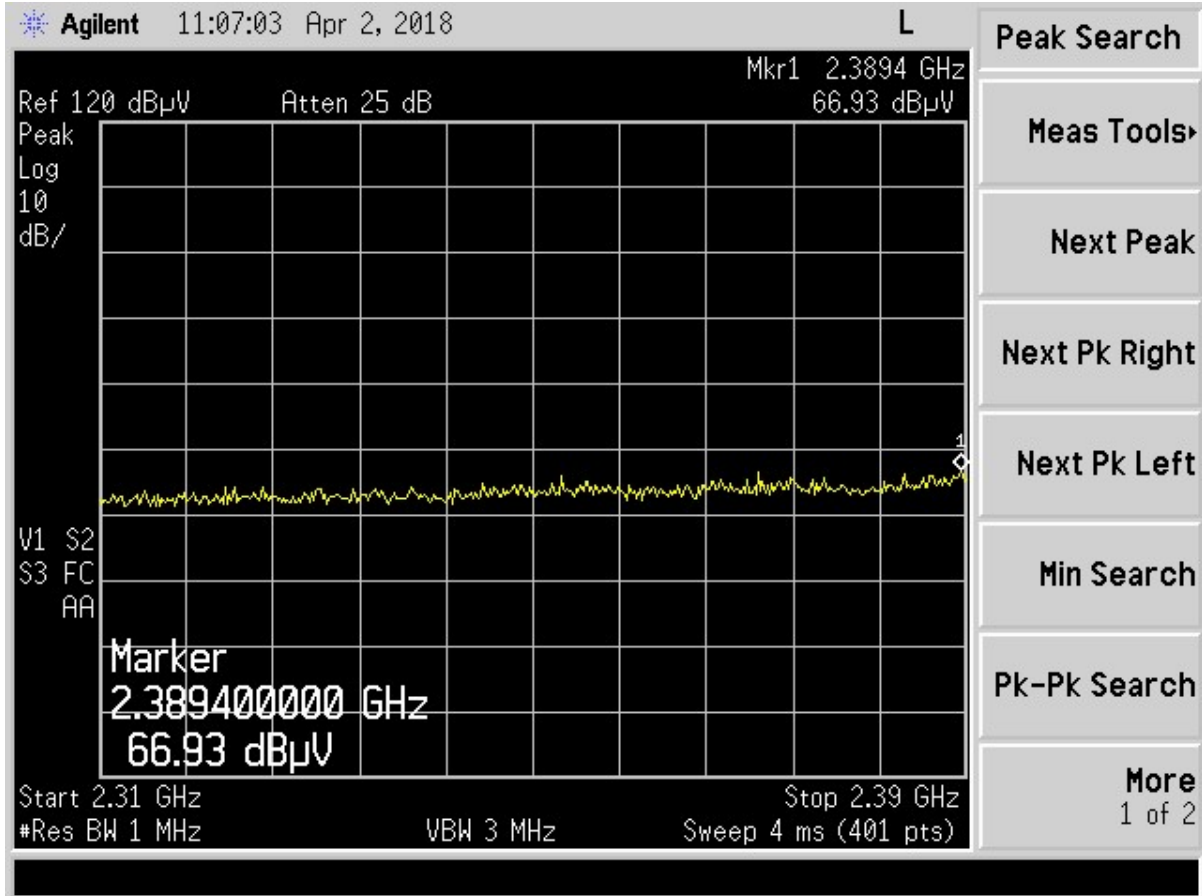


Figure 12. Restricted Band Emissions PK, 2.31 to 2.39 GHz – Antenna 2

US Tech Test Report:
FCC ID:
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Customer:
Model:

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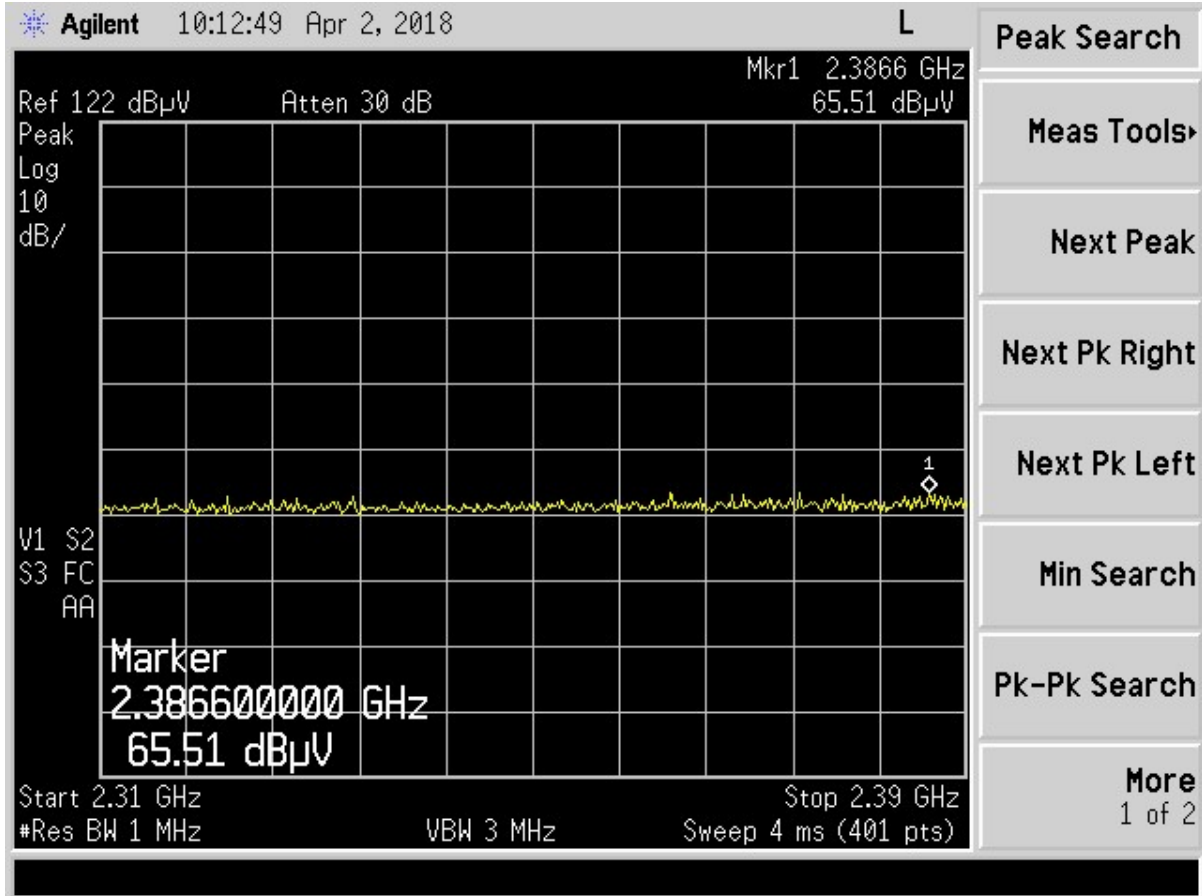


Figure 13. Restricted Band Emissions PK, 2.31 to 2.39 GHz – Antenna 3

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Table 11. Radiated Restricted Band Measurements PK, 2.31 GHz to 2.39 GHz

Test: FCC Part 15, Restricted Bands				Client: Murata			
Project: 17-0308				Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
2388.80	67.15	-1.28	65.87	74.0	3.0m./VERT	8.1	PK
2389.40	66.93	-1.28	65.65	74.0	3.0m./VERT	8.3	PK
2386.60	65.51	-1.15	64.36	74.0	3.0m./HORZ	9.6	PK

Sample Calculation at 2388.8 MHz:

Magnitude of Measured Frequency	67.15 dBuV
+Correction Factors	-1.28 dB/m
Corrected Result	65.87 dBuV/m

Test Date: April 2, 2018

Tested by
 Signature: 

Name: Bruce Arnold

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

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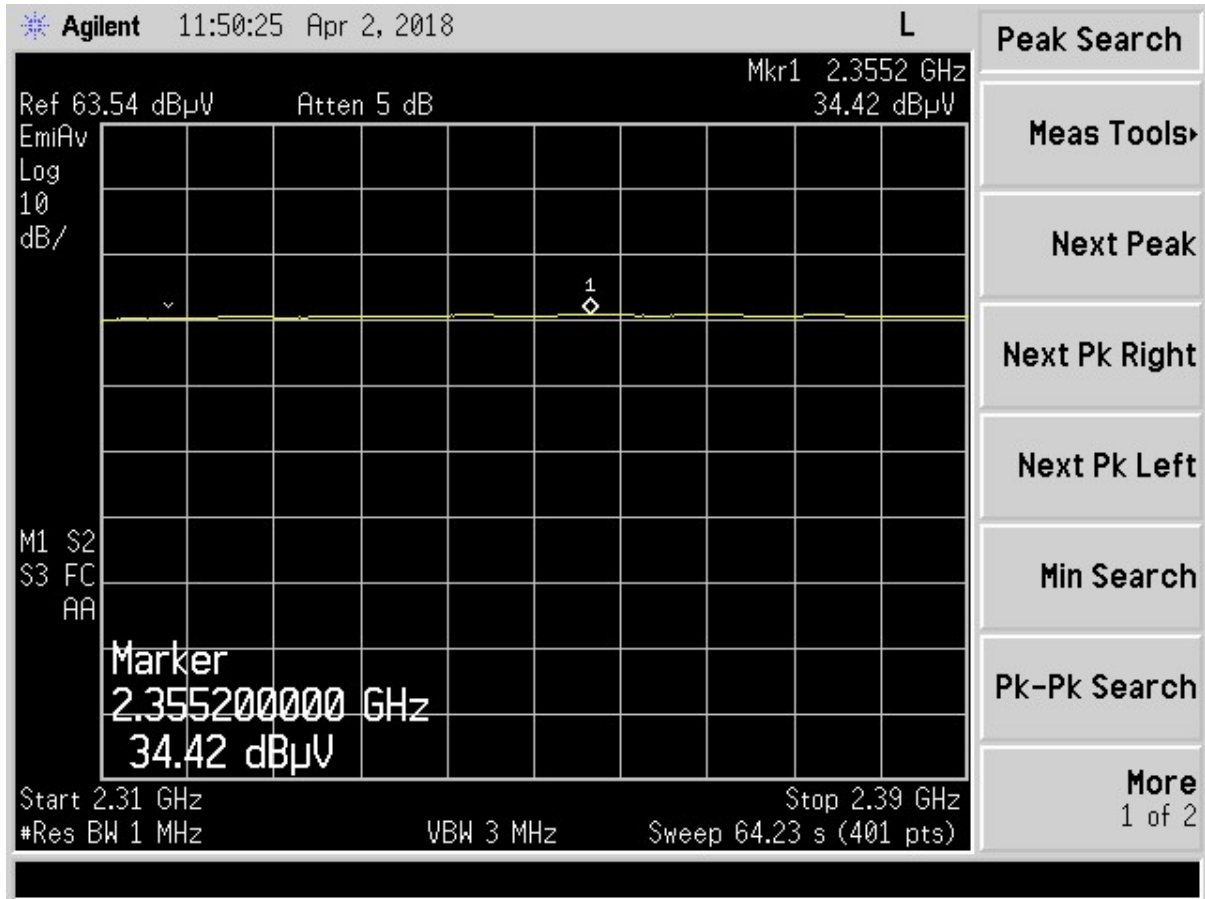


Figure 14. Restricted Band Emissions AVG, 2.31 to 2.39 GHz – Antenna 1

US Tech Test Report:
FCC ID:
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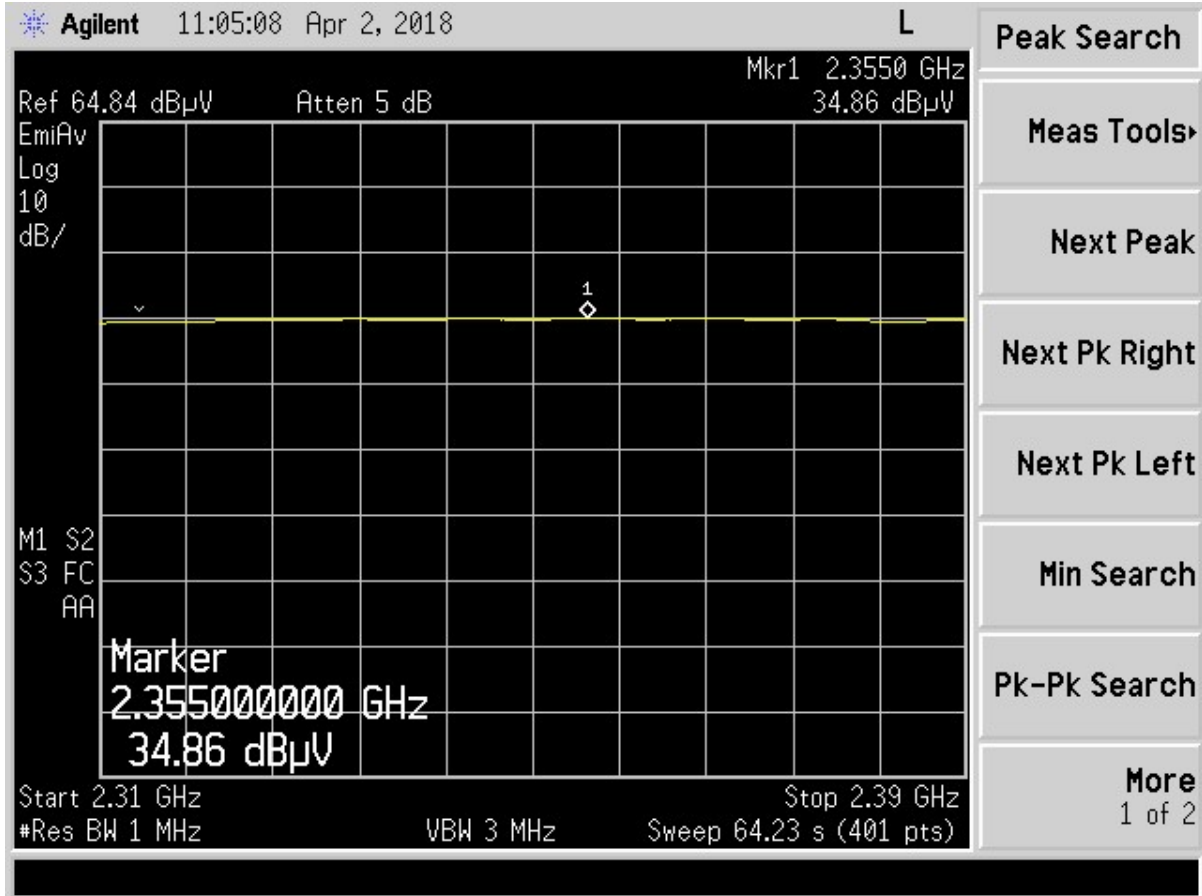


Figure 15. Restricted Band Emissions AVG, 2.31 to 2.39 GHz – Antenna 2

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Customer:
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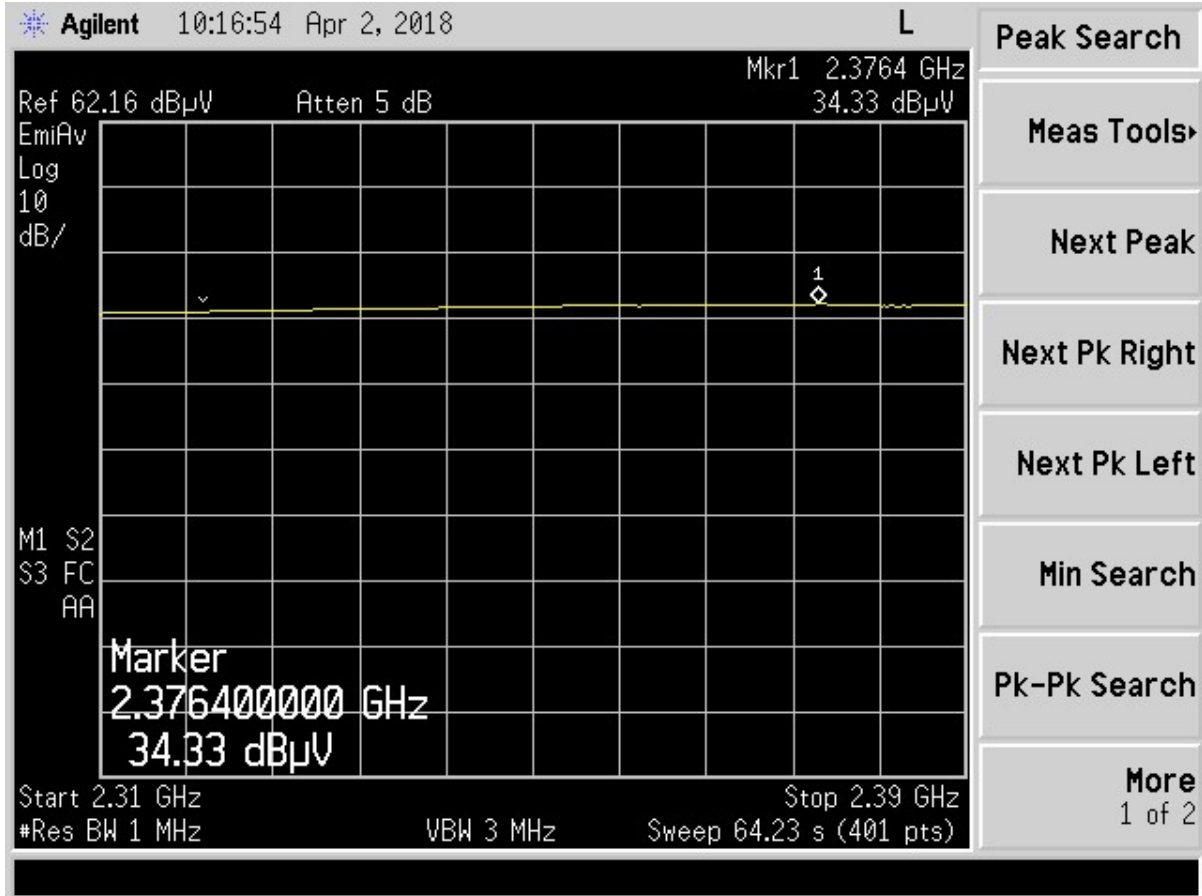


Figure 16. Restricted Band Emissions AVG, 2.31 to 2.39 GHz – Antenna 3

US Tech Test Report:
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Table 12. Radiated Restricted Band Measurements AVG, 2.31 GHz to 2.39 Ghz

Test: FCC Part 15, Restricted Bands				Client: Murata			
Project: 17-0308				Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
2355.20	34.42	-1.28	33.14	54.0	3.0m./VERT	20.9	AVG
2355.00	34.86	-1.28	33.58	54.0	3.0m./VERT	20.4	AVG
2376.40	34.33	-1.15	33.18	54.0	3.0m./HORZ	20.8	AVG

Sample Calculation at 2355.2 MHz:

Magnitude of Measured Frequency	34.42 dBuV
+Correction Factors	-1.28 dB/m
Corrected Result	33.14 dBuV/m

Test Date: April 2, 2018

Tested by
 Signature: 

Name: Bruce Arnold

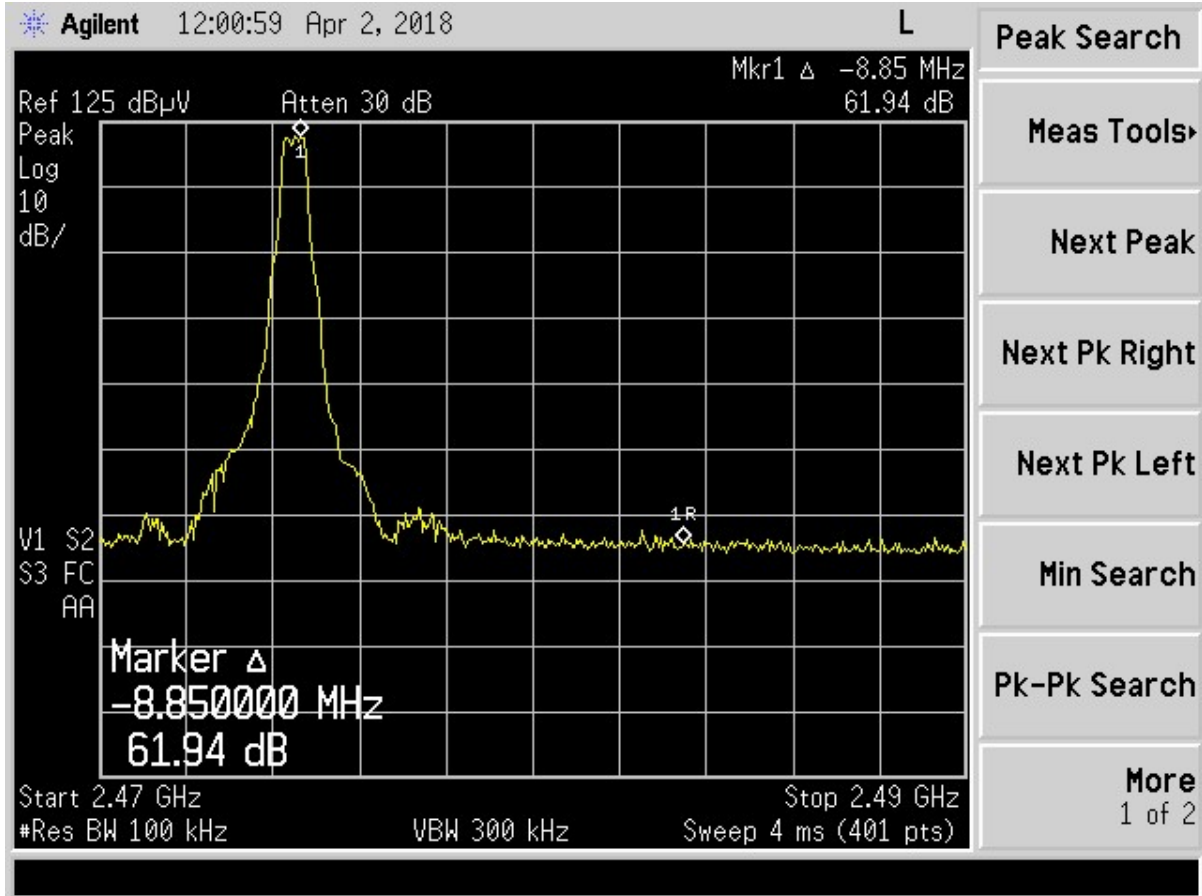


Figure 17. Band Edge Compliance, High Channel Delta - Antenna 1

Calculation of worst case upper band edge measurement:

Measured Delta (from Figure 10)	61.94	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	41.94	dB

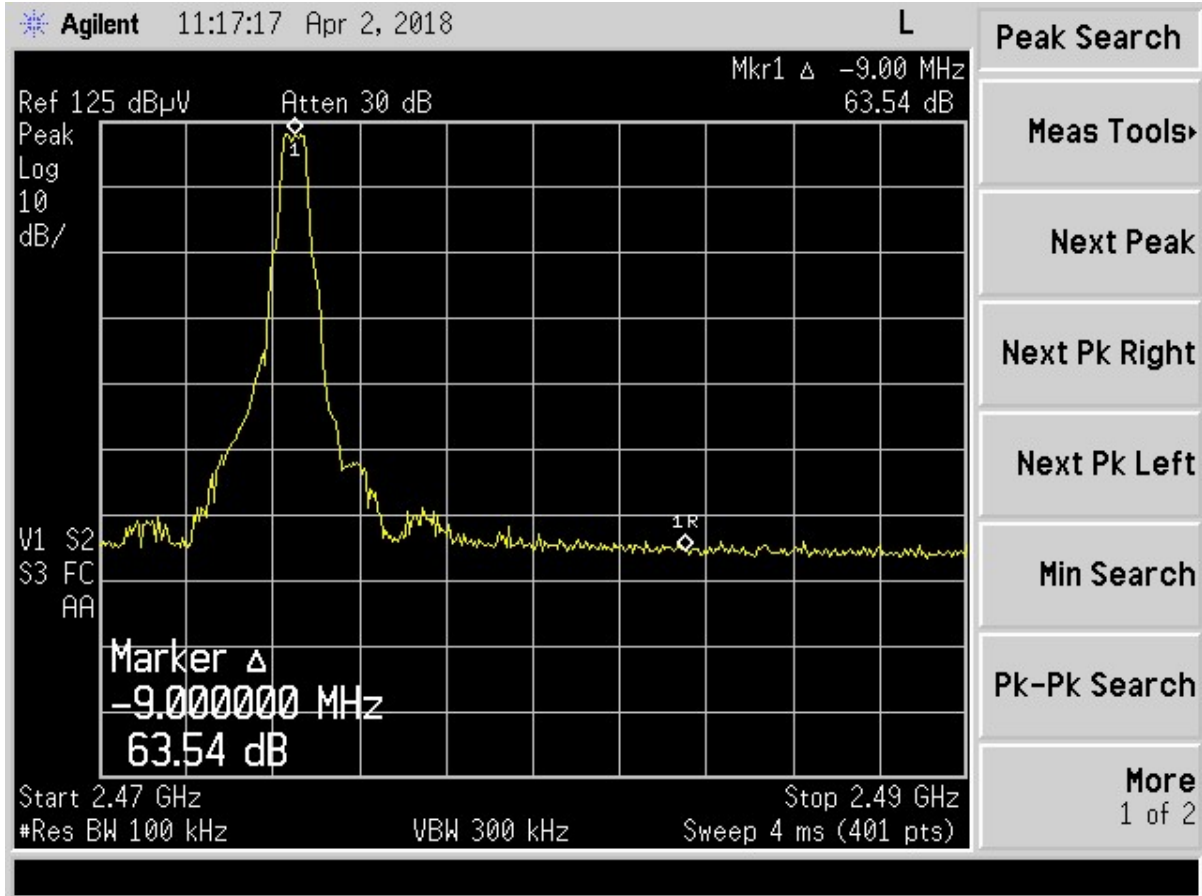


Figure 18. Band Edge Compliance, High Channel Delta - Antenna 2

Calculation of worst case upper band edge measurement:

Measured Delta (from Figure 10)	63.54	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	43.54	dB

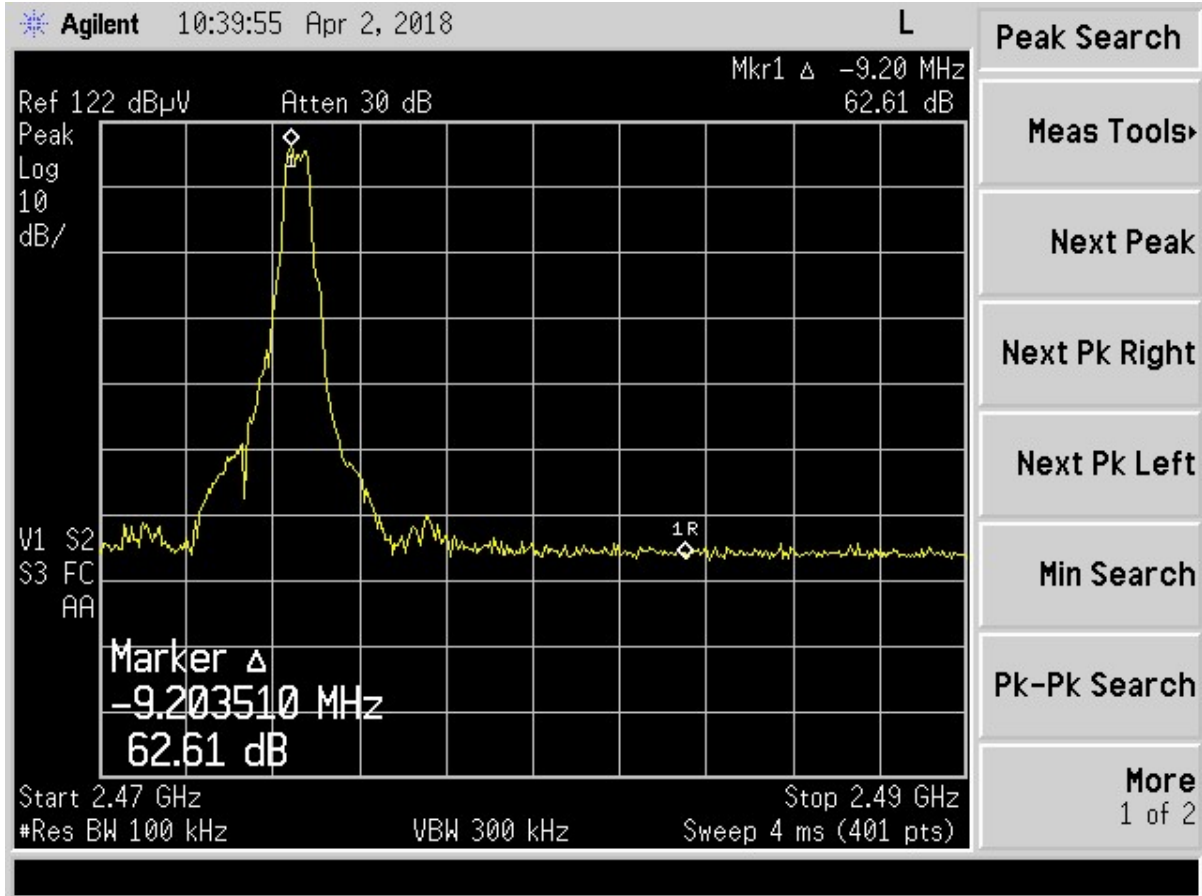


Figure 19. Band Edge Compliance, High Channel Delta - Antenna 3

Calculation of worst case upper band edge measurement:

Measured Delta (from Figure 10)	62.61	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	42.61	dB

dBuV/m

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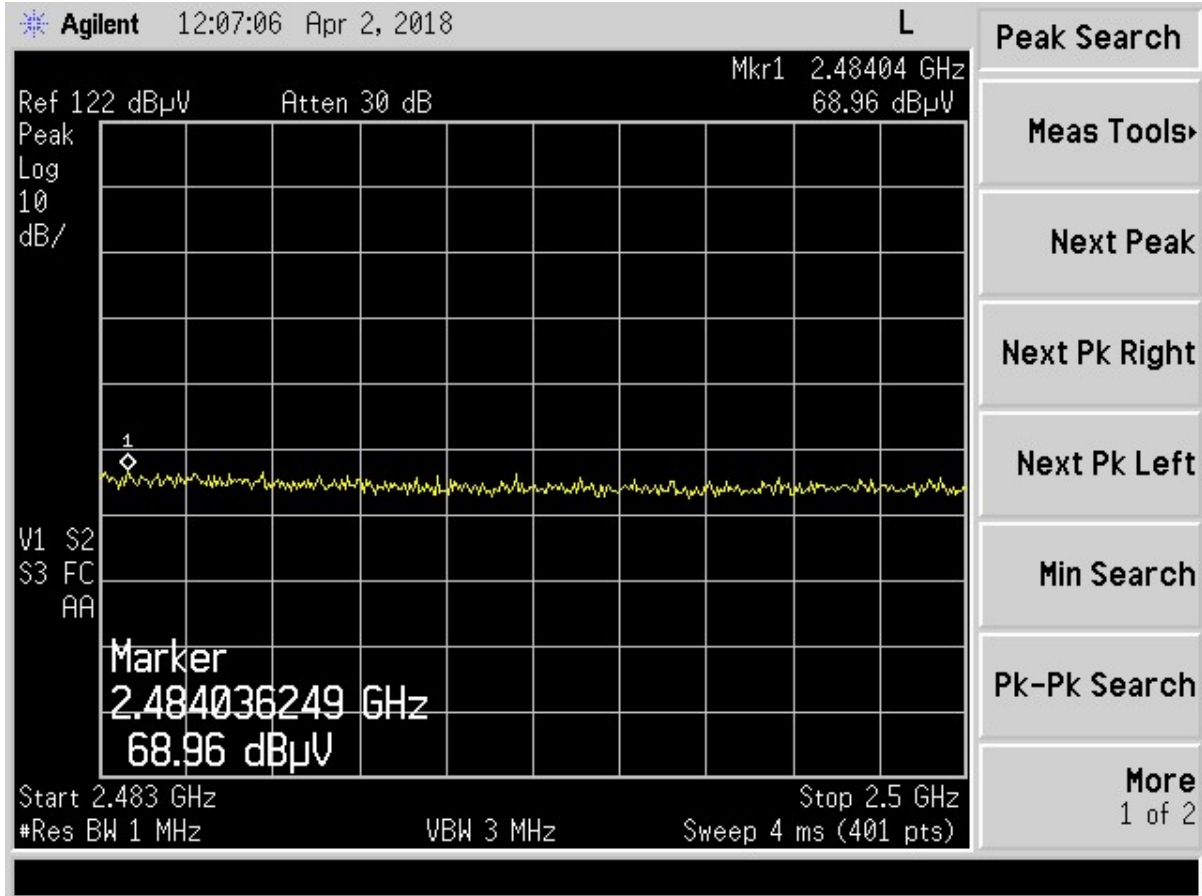


Figure 20. Restricted Band Emissions PK, 2.4835 to 2.5 GHz – Antenna 1

US Tech Test Report:
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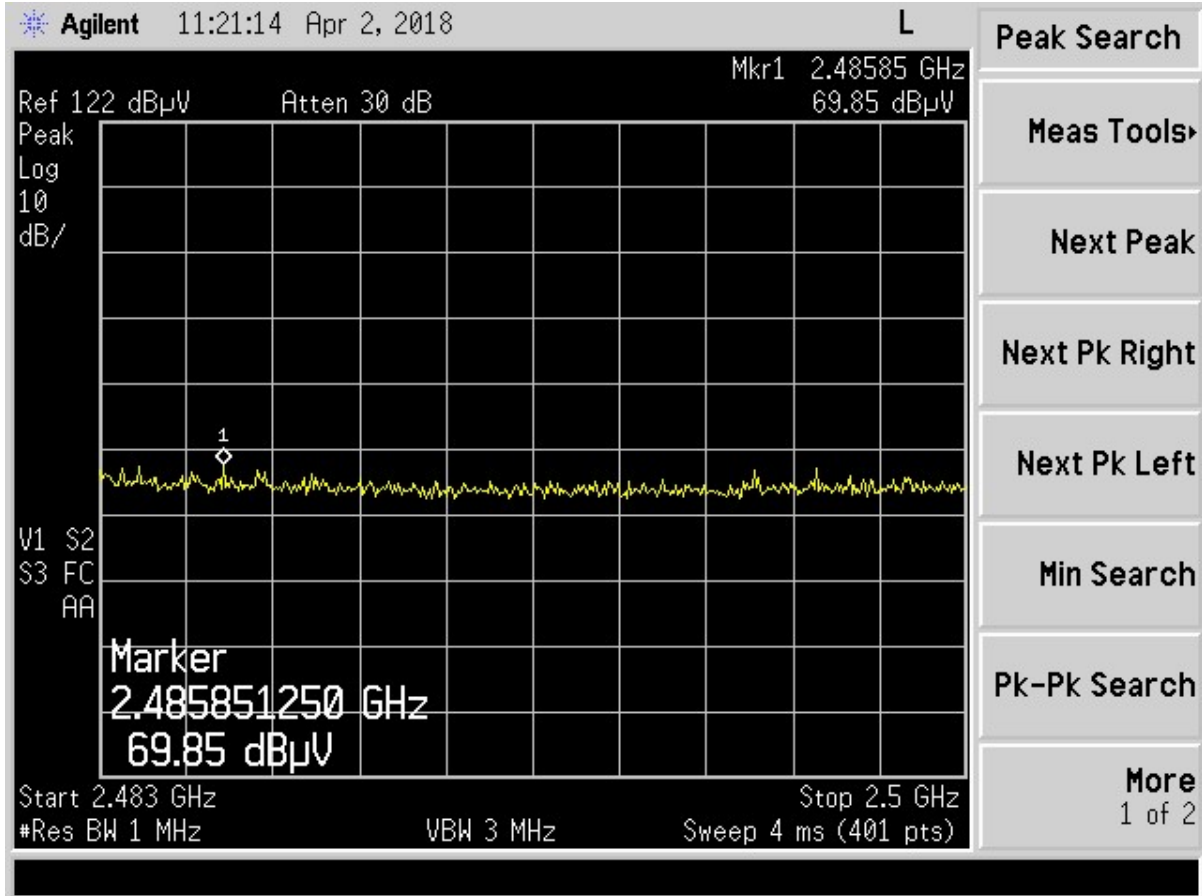


Figure 21. Restricted Band Emissions PK, 2.4835 to 2.5 GHz – Antenna 2

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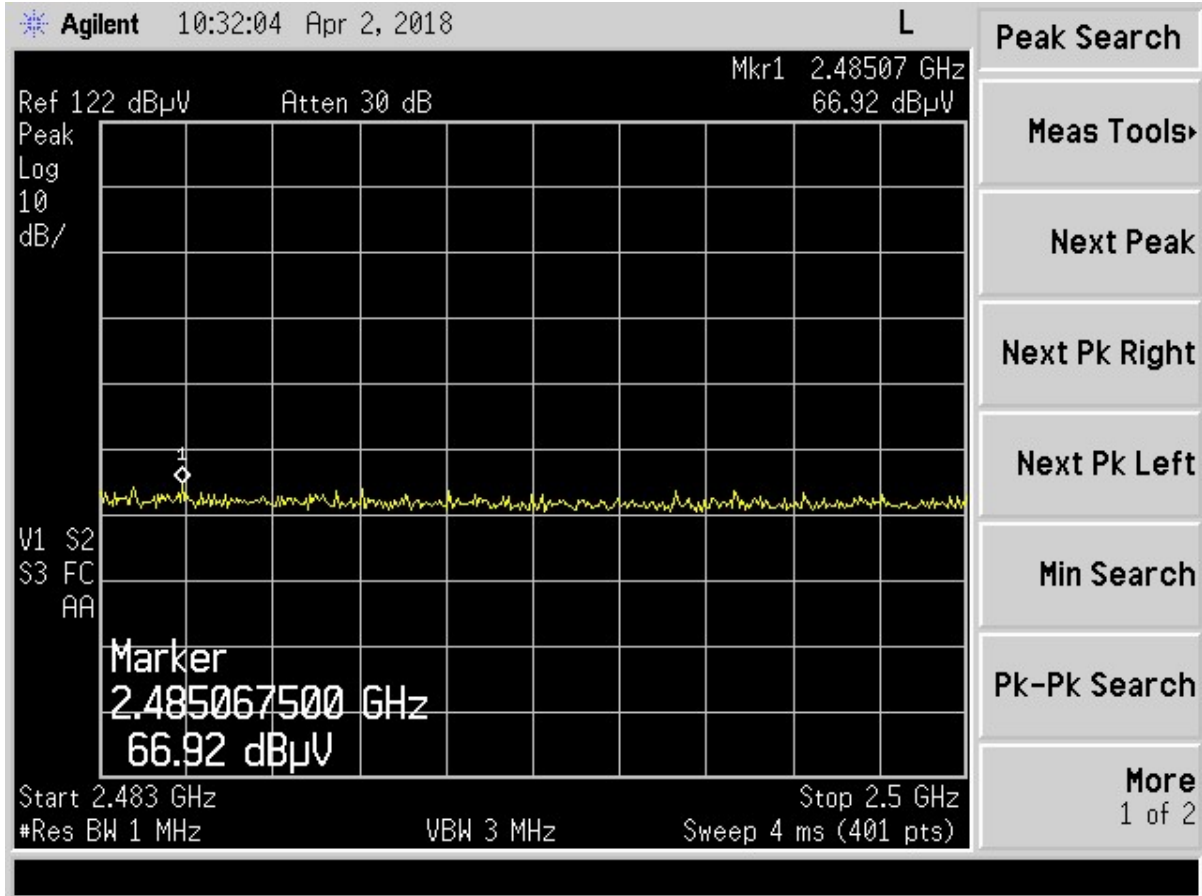


Figure 22. Restricted Band Emissions PK, 2.4835 to 2.5 GHz – Antenna 3

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 Model:

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Table 13. Radiated Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz

Test: FCC Part 15, Restricted Bands				Client: Murata			
Project: 17-0308				Model: WIT2450			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
2484.04	68.96	0.48	69.44	74.0	3.0m./VERT	4.6	PK
2485.85	69.85	0.48	70.33	74.0	3.0m./VERT	3.7	PK
2485.07	66.92	0.29	67.21	74.0	3.0m./HORZ	6.8	PK

Sample Calculation at 2484.04 MHz:

Magnitude of Measured Frequency	68.96 dBuV
+Correction Factors	0.48 dB/m
Corrected Result	69.44 dBuV/m

Test Date: April 2, 2018

Tested by
 Signature: 

Name: Bruce Arnold

US Tech Test Report:
FCC ID:
IC:
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Issue Date:
Customer:
Model:

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HSW-2450
4492A-2450
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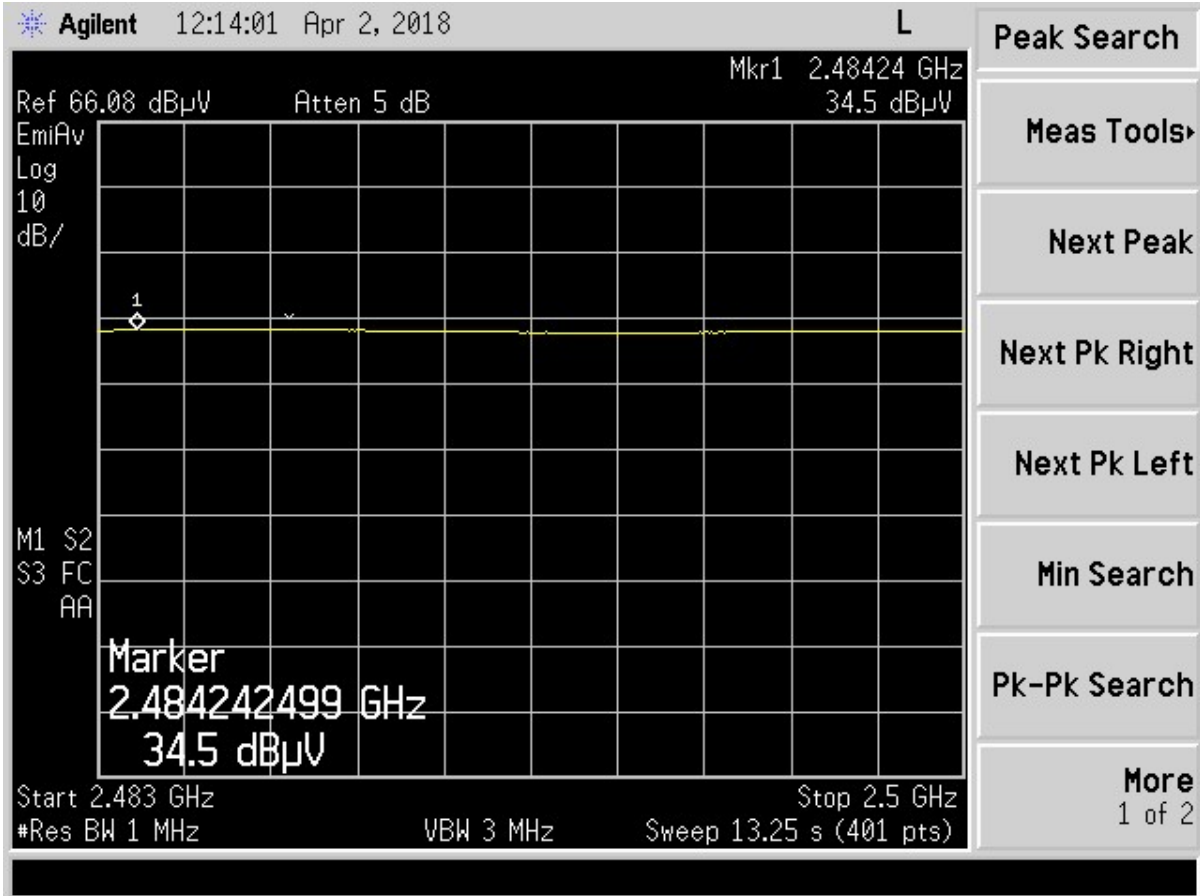


Figure 23. Restricted Band Emissions AVG, 2.4835 to 2.5 GHz – Antenna 1

US Tech Test Report:
FCC ID:
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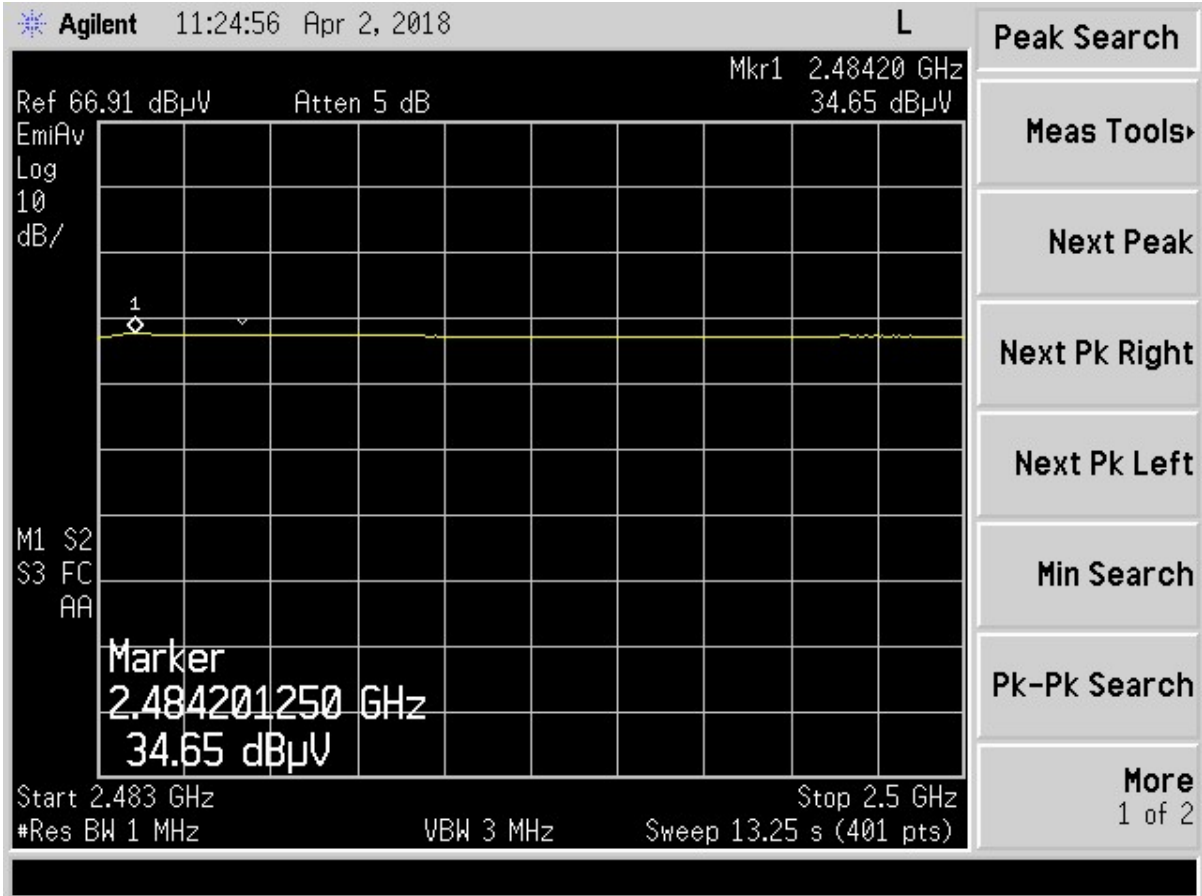


Figure 24. Restricted Band Emissions AVG, 2.4835 to 2.5 GHz – Antenna 2

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Issue Date:
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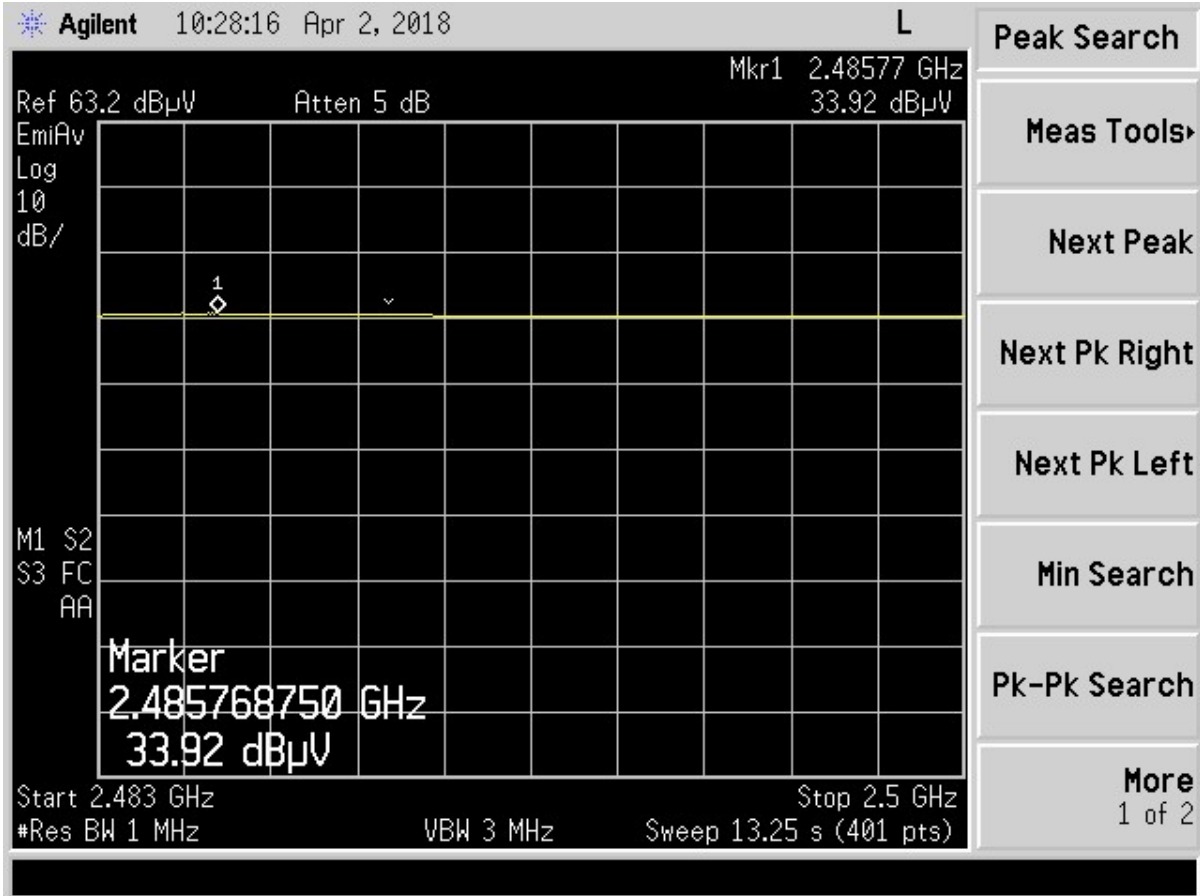


Figure 25. Restricted Band Emissions AVG, 2.4835 to 2.5 GHz – Antenna 3

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

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Table 14. Radiated Restricted Measurements AVG, 2.4835 GHz to 2.5 GHz

Test: FCC Part 15, Restricted Bands				Client: Company's Name			
Project: 14-0XXX				Model: Modelx			
Frequency (MHz)	Test Data (dBuv)	AF+CA-AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
2484.24	34.50	0.48	34.98	54.0	3.0m./VERT	19.0	AVG
2484.20	34.65	0.48	35.13	54.0	3.0m./VERT	18.9	AVG
2485.77	33.92	0.29	34.21	54.0	3.0m./HORZ	19.8	AVG

Sample Calculation at 2484.24 MHz:

Magnitude of Measured Frequency	34.50 dBuV
+Correction Factors	0.48 dB/m
Corrected Result	34.98 dBuV/m

Test Date: April 2, 2018

Tested by
 Signature: 

Name: Bruce Arnold

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

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

For frequency hopping systems in the 2400-2483.5 MHz band with at least 75 non-overlapping hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed 1 watt. Since the EUT has 86 hopping channels, the maximum peak conducted output power shall not exceed 1 W.

Peak power within the band X MHz to Y MHz was measured per ANSI C63.10-2013 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 \geq RBW. Peak antenna conducted output power is tabulated in the table below.

Table 15. 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)
2401.156	21.15	130.3167	501.12
2438.308	22.80	190.5461	501.12
2474.396	21.94	156.3148	501.12

Note: Maximum Antenna gain exceeds 6.0 dBi by a maximum value of 3.0 dB, therefore the output power limit is reduced by 3.0 dB per Part 15.247(b)(4), the limit reduces to 27 dBm or 501.12 mW.

Test Date: April 3, 2018

Tested By
Signature: 

Name: Bruce Arnold

US Tech Test Report:
FCC ID:
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Model:

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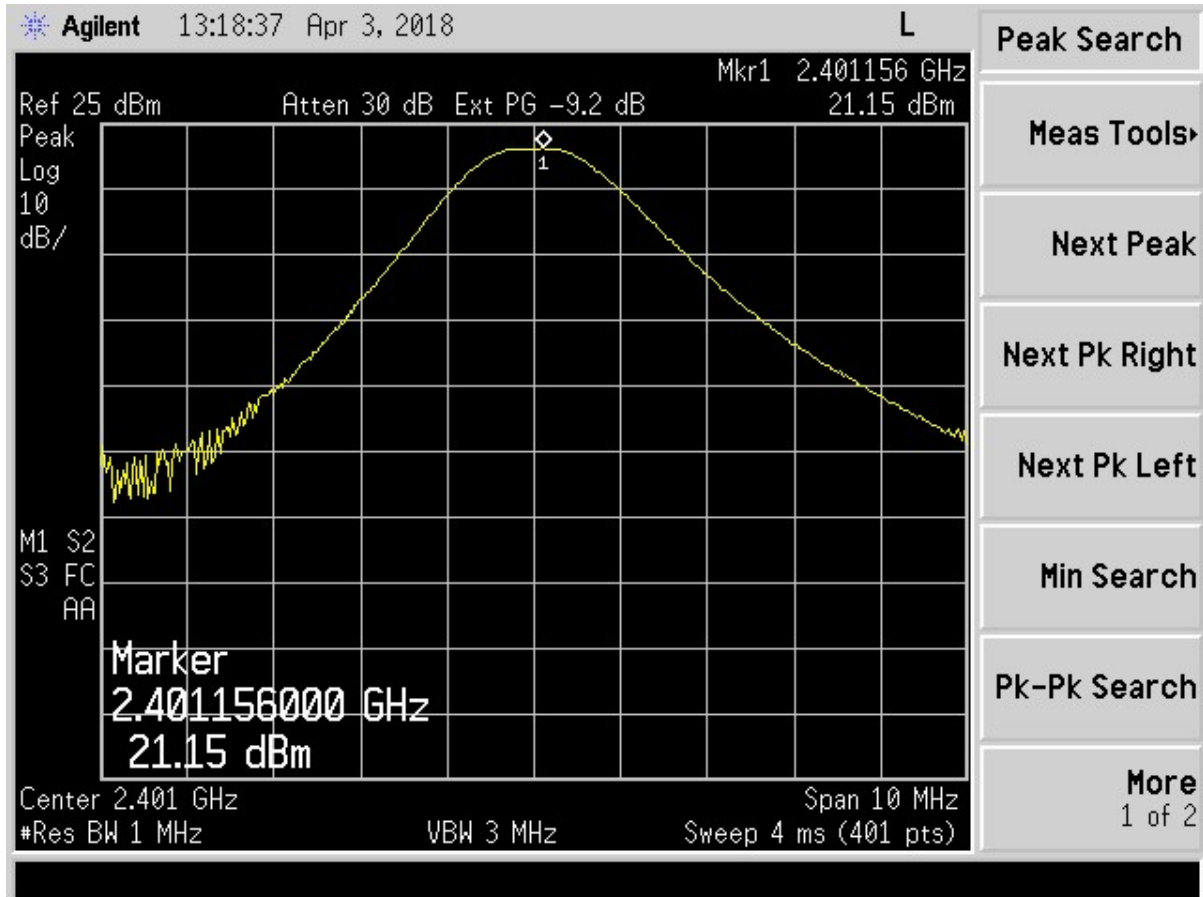


Figure 26. Peak Antenna Conducted Output Power, Low Channel

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Model:

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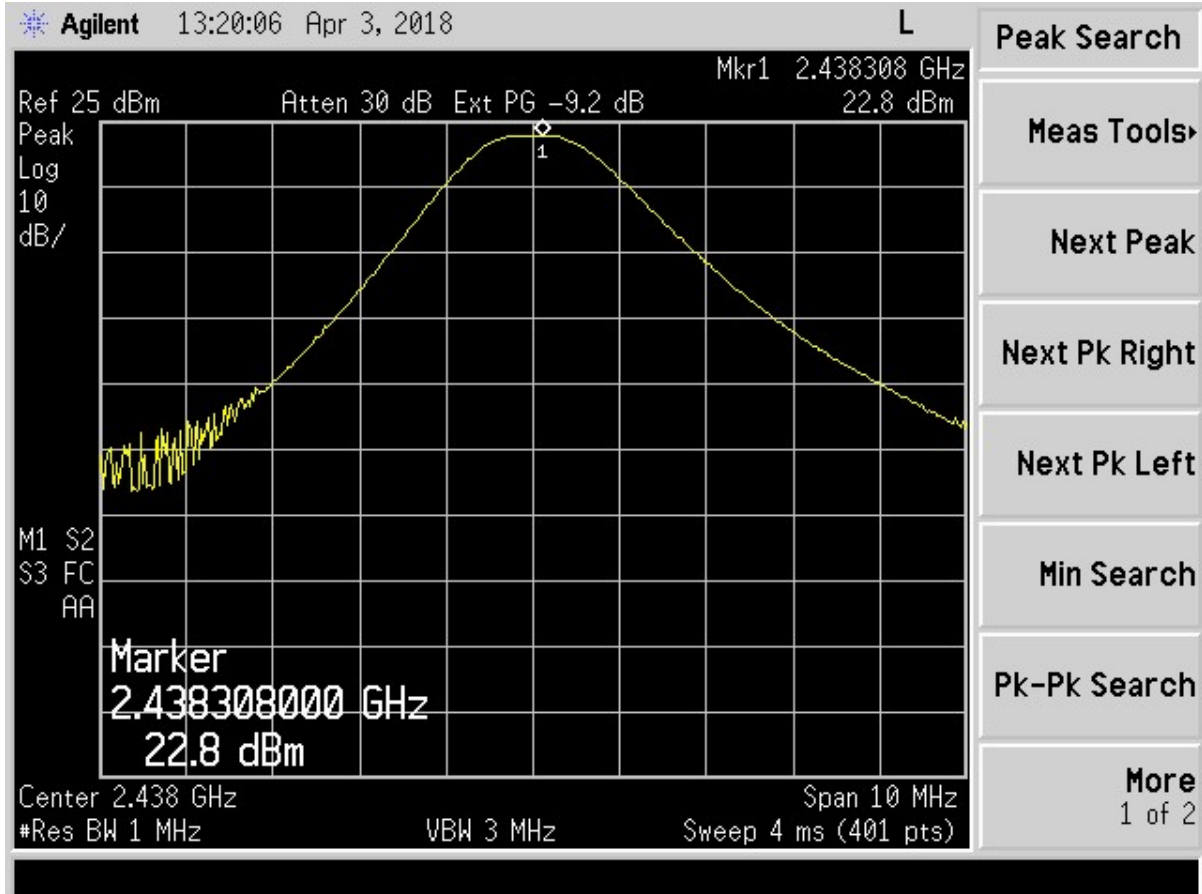


Figure 27. Peak Antenna Conducted Output Power, Mid Channel

US Tech Test Report:
FCC ID:
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Model:

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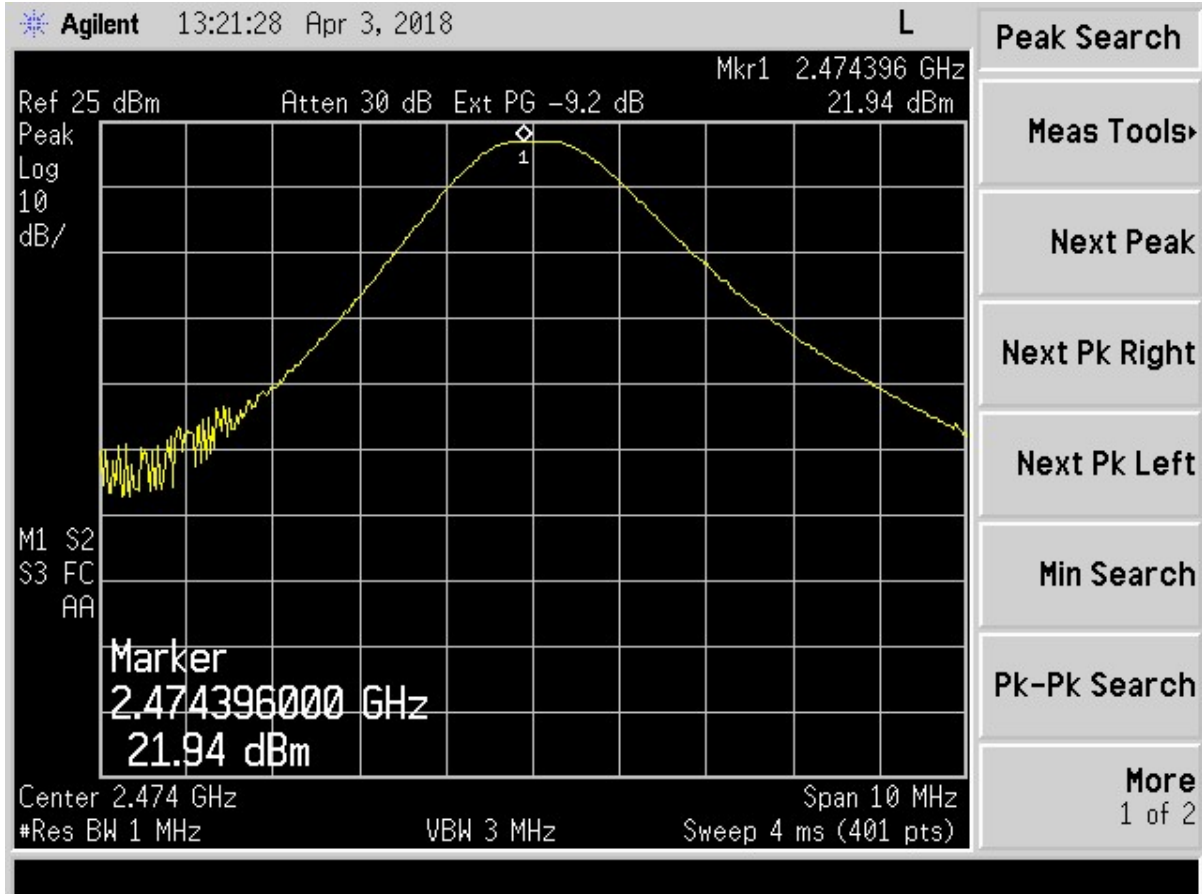


Figure 28. Peak Antenna Conducted Output Power, High Channel

US Tech Test Report:
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2.11 99% Occupied Bandwidth (CFR 15.247 (a) (1))

For frequency hopping systems shall have hopping channel carrier frequencies separated by the 20 dB bandwidth of the hopping channel. For this radio the maximum allowed 20 dB bandwidth is 864 kHz.


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 \geq RBW. The results of this test are given in Table 16 and Figures 29-31.

Table 16. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	20 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2401.056	594.8	618.2
2438.208	576.2	612.7
2474.496	761.5	702.2

Test Date: April 23, 2018

Tested By

Signature: 

Name: Bruce Arnold

US Tech Test Report:
 FCC ID:
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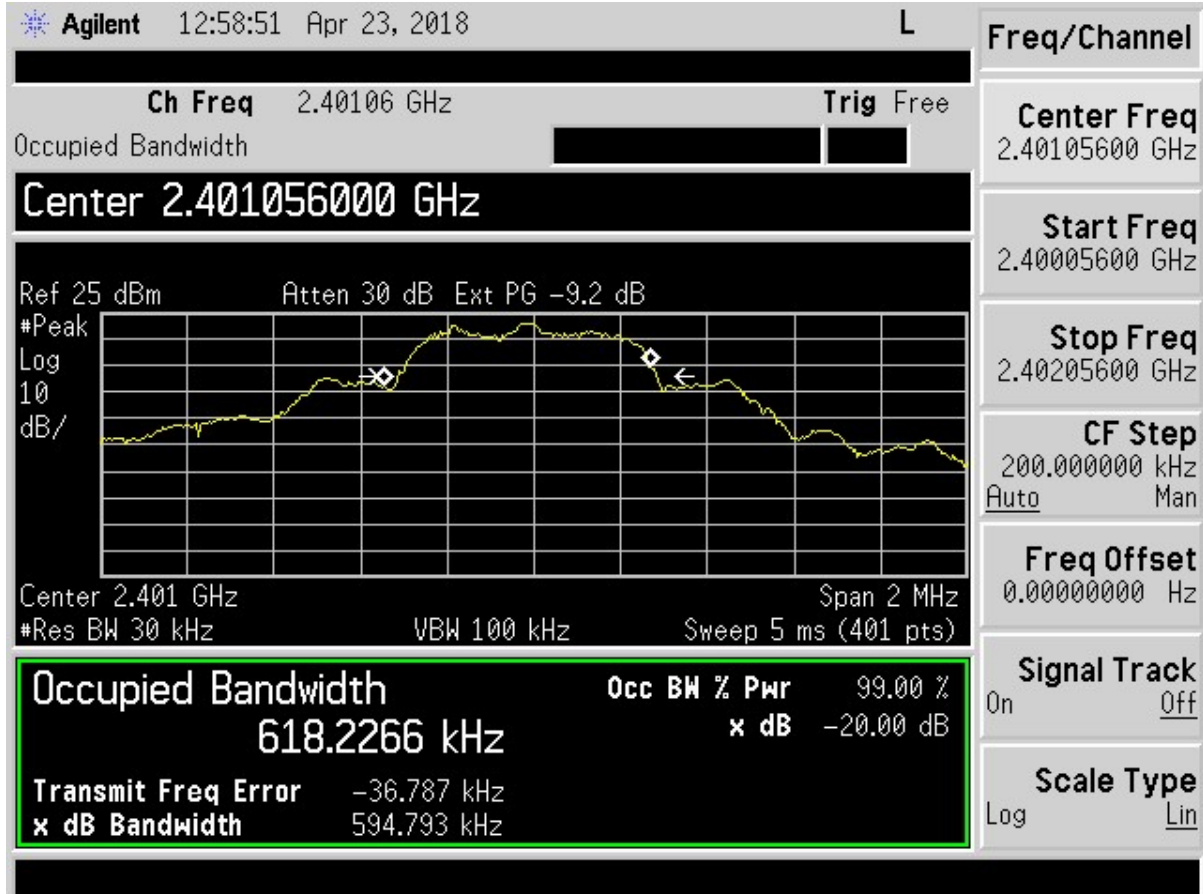


Figure 29. 20dB / 99% Bandwidth, Low

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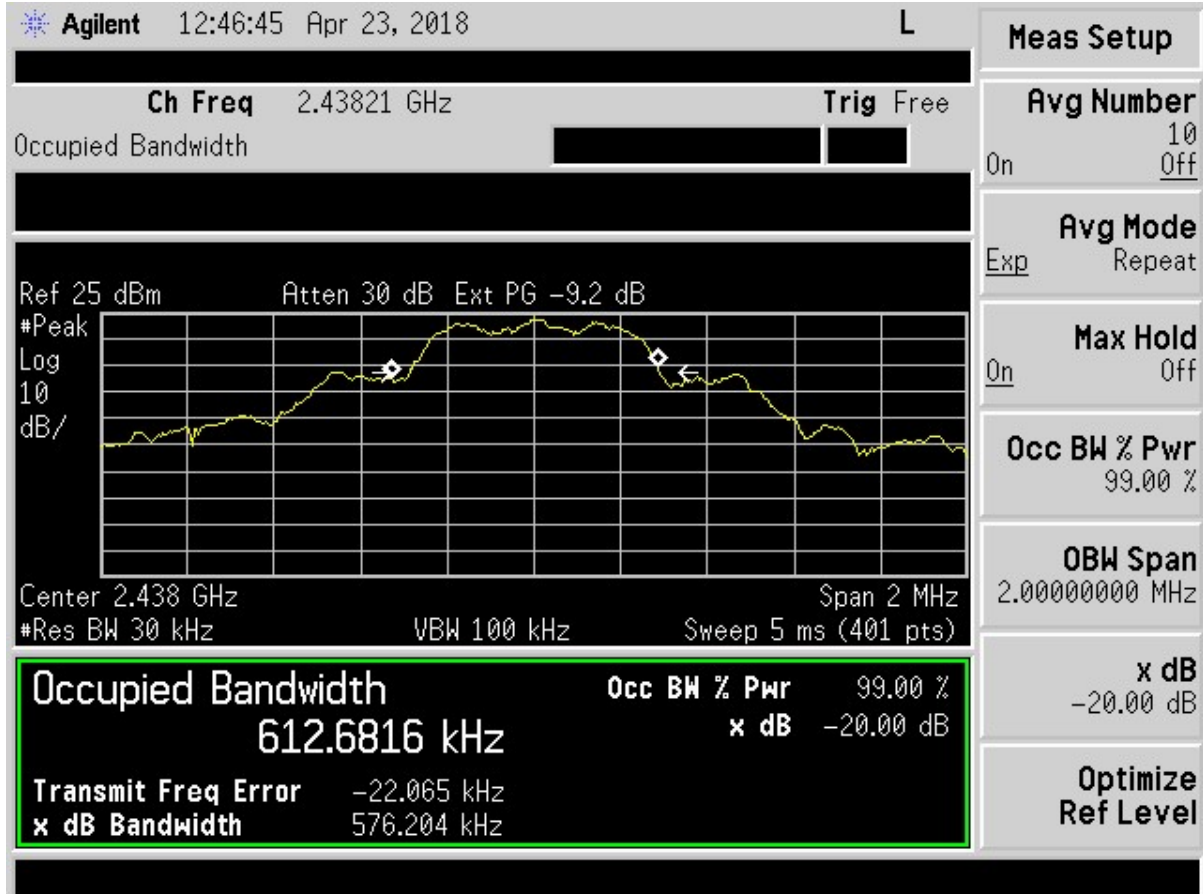


Figure 30. 20dB / 99% Bandwidth, Mid

US Tech Test Report:
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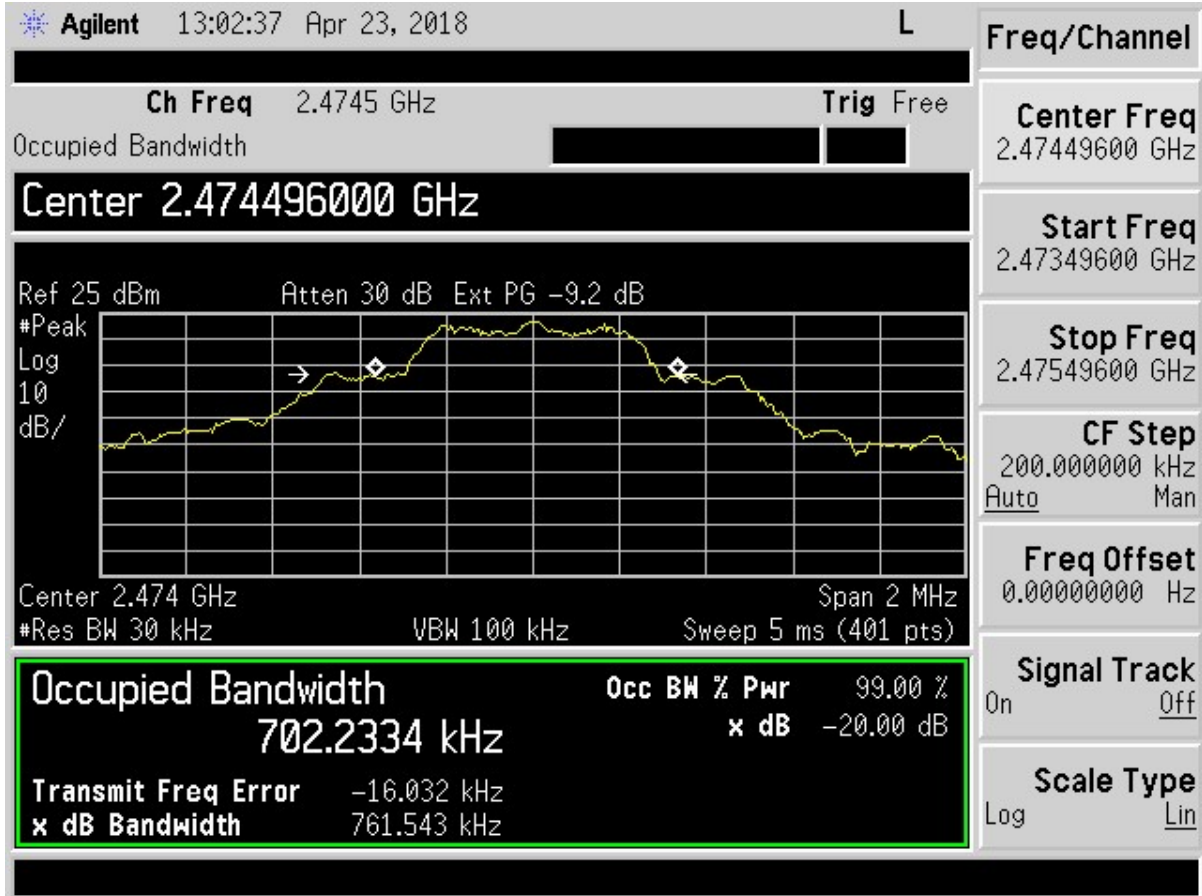


Figure 31. 20dB / 99% Bandwidth, High

US Tech Test Report:
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2.12 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%.

2.12.1 Conducted Emissions Measurement Uncertainty

Conducted emissions measurements not performed for this report.

2.12.2 Radiated Emissions Measurement Uncertainty

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is $\pm 5.21\text{dB}$.

The data listed in this test report does not have sufficient margin to negate the effects of uncertainty. Therefore, the EUT conditionally meets this requirement.