ELEMENT WASHINGTON DC LLC
7185 Oakland Mills Road, Columbia, MD 21046 USA
Tel. 410.290.6652 / Fax 410.381.1520
http://www.element.com

MEASUREMENT REPORT
FCC PART 15.247 802.11b/g/n/ax (OFDM)

Applicant Name:
Samsung Electronics Co., Ltd.
129, Samsung-ro,
Yeongtong-gu, Suwon-si
Gyeonggi-do, 16677, Korea

Date of Testing:
11/6/2023 – 1/2/2024
Test Report Issue Date:
1/3/2024
Test Site/Location:
Element lab., Columbia, MD, USA
Test Report Serial No.:
1M2310260110-11.A3L

FCC ID:	**A3LSMA356E**
APPLICANT:	**Samsung Electronics Co., Ltd.**

Application Type:	Certification
Model:	SM-A356E/DS
Additional Model(s):	SM-A356E
EUT Type:	Portable Handset
Frequency Range:	2412 – 2472MHz
Modulation Type:	CCK, DSSS, OFDM
FCC Classification:	Digital Transmission System (DTS)
FCC Rule Part(s):	Part 15 Subpart C (15.247)
Test Procedure(s):	ANSI C63.10-2013

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. Test results reported herein relate only to the item(s) tested.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RJ Ortanez
Executive Vice President

ACCREDITED
CERT #2041.01

TABLE OF CONTENTS

Channel Bandwidth [MHz]	IEEE Mode	Tx Frequency [MHz]	MIMO			
			Avg. Conducted		Peak Conducted	
			Max. Power [mW]	Max. Power [dBm]	Max. Power [mW]	Max. Power [dBm]
20	802.11b	2412 - 2472	157.40	21.97	391.80	25.93
	802.11g	2412 - 2472	96.83	19.86	514.07	27.11
	802.11n	2412 - 2472	99.08	19.96	590.65	27.71
	802.11ax	2412 - 2472	97.27	19.88	599.29	27.78

EUT Overview

1.0 INTRODUCTION

1.1 Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and\\or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Innovation, Science and Economic Development Canada.

1.2 Element Test Location

These measurement tests were conducted at the Element laboratory located at 7185 Oakland Mills Road, Columbia, MD 21046. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014.

1.3 Test Facility / Accreditations

Measurements were performed at Element lab located in Columbia, MD 21046, U.S.A.

- Element Washington DC LLC is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.01 for Specific Absorption Rate (SAR), Hearing Aid Compatibility (HAC) testing, where applicable, and Electromagnetic Compatibility (EMC) testing for FCC and Innovation, Science, and Economic Development Canada rules.

- Element Washington DC LLC TCB is a Telecommunication Certification Body (TCB) accredited to ISO\\IEC 17065-2012 by A2LA (Certificate number 2041.03) in all scopes of FCC Rules and ISED Standards (RSS).

- Element Washington DC LLC facility is a registered (2451B) test laboratory with the site description on file with ISED.

- Element Washington DC LLC is a Recognized U.S. Certification Assessment Body (CAB # US0110) for ISED Canada as designated by NIST under the U.S. and Canada Mutual Recognition Agreements (MRAs).

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Samsung Portable Handset FCC ID: A3LSMA356E**. The test data contained in this report pertains only to the emissions due to the EUT's WLAN (DTS) transmitter.

Test Device Serial No.: 1194M, 0654M, 1199M, 0645M

2.2 Device Capabilities

This device contains the following capabilities:

850/1900 GSM/GPRS/EDGE, 850/1700/1900 WCDMA/HSPA, Multi-band LTE, Multi-band 5G NR (FR1), 802.11b/g/n/ax WLAN, 802.11a/n/ac/ax UNII (5GHz), Bluetooth (1x, EDR, LE), NFC

Ch.	Frequency (MHz)	Ch.	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442		

Table 2-1. Frequency \ Channel Operations

Notes:

1. The maximum achievable duty cycles for all modes were determined based on measurements performed on a spectrum analyzer in zero-span mode with RBW = 8MHz, VBW = 50MHz, and detector = peak per the guidance of Section 6.0 b) of ANSI C63.10-2013 and KDB 558074 D01 v05r02. The RBW and VBW were both greater than 50\T, where T is the minimum transmission duration, and the number of sweep points across T was greater than 100. The duty cycles are as follows:

802.11 Mode/Band		MIMO (1+2) Duty Cycle [%]
2.4GHz	b	98.75
	g	96.67
	n (HT20)	97.78
	ax (HE20)	95.57

Table 2-2. Measured Duty Cycles

2. The device employs MIMO technology. Below are the possible configurations.

WiFi Configurations		SISO		SDM		CDD	
		ANT1	ANT2	ANT1	ANT2	ANT1	ANT2
2.4GHz	11b	✓	✓	×	×	✓	✓
	11g	✓	✓	✓	✓	✓	✓
	11n	✓	✓	✓	✓	✓	✓
	11ax	✓	✓	✓	✓	✓	✓

Table 2-3. Antenna / Technology Configuration

✓= Support; × = NOT Support
SISO = Single Input Single Output
SDM = Spatial Diversity Multiplexing – MIMO function
CDD = Cyclic Delay Diversity - 2Tx Function

3. The device supports the following data rates (shown in Mbps):

802.11b	802.11a/g	MCS Index		Spatial Stream	OFDM (802.11n)		OFDM (802.11ax)		
20MHz	20MHz				20MHz		20MHz		
		HT	HE		0.8µs GI	0.4µs GI	0.8µs GI	1.6µs GI	3.2µs GI
1	6	0	0	1	6.5	7.2	8.6	8.1	7.3
2	9	1	1	1	13	14.4	17.2	16.3	14.6
5.5	12	2	2	1	19.5	21.7	25.8	24.4	21.9
11	18	3	3	1	26	28.9	34.4	32.5	29.3
	24	4	4	1	39	43.3	51.6	48.8	43.9
	36	5	5	1	52	57.8	68.8	65	58.5
	48	6	6	1	58.5	65	77.4	73.1	65.8
	54	7	7	1	65	72.2	86	81.3	73.1
			8	1		`	103.2	97.5	87.8
			9	1			114.7	108.3	97.5
			10	1			129	121.9	109.7
			11	1	`		143.4	135.4	121.9
1	6	8	0	2	13	14.4	17.2	16.3	14.6
2	9	9	1	2	26	28.9	34.4	32.5	29.3
5.5	12	10	2	2	39	43.3	51.6	48.8	43.9
11	18	11	3	2	52	57.8	68.8	65	58.5
	24	12	4	2	78	86.7	103.2	97.5	87.8
	36	13	5	2	104	115.6	137.6	130	117
	48	14	6	2	117	130	154.9	146.3	131.6
	54	15	7	2	130	144.4	172.1	162.5	146.3
			8	2	156	173.3	206.5	195	175.5
			9	2	N/A	N/A	229.4	216.7	195
			10	2			258.1	243.8	219.4
			11	2			286.8	270.8	243.8

Table 2-4. Supported Data Rates

2.3 Test Configuration

ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 7.7.2 for AC line conducted emissions test setups, 7.7 for radiated emissions test setups, and 7.2, 7.3, 7.4, 7.5, and 7.6 for antenna port conducted emissions test setups.

2.4 Antenna Description

The following antenna gains were used for the testing.

Frequency [GHz]	Antenna-1 Gain [dBi]	Antenna-2 Gain [dBi]	Directional Gain [dBi]
2.4	-6.55	-6.74	-3.63

Table 2-5. Antenna Peak Gain

2.5 Software and Firmware

The test was conducted with software\firmware version A356BXXU0AWJ3 installed on the EUT.

2.6 EMI Suppression Device(s) / Modifications

No EMI suppression device(s) were added and\or no modifications were made during testing.

3.0 DESCRIPTION OF TESTS

3.1 Evaluation Procedure

The measurement procedures described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2013) was used in the measurement of the EUT.

Deviation from measurement procedure…….....None

3.2 AC Line Conducted Emissions

The line-conducted facility is located inside a 10'x16'x9' shielded enclosure. The shielded enclosure is manufactured by ETS Lindgren RF EnclosuresThe line-conducted facility is located inside a 7m x 3.66m x 2.7m shielded enclosure. The shielded enclosure is manufactured by AP Americas. The shielding effectiveness of the shielded room is in accordance with MIL-Std-285 or NSA 65-5. A 1m x 1.5m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω\\50μH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. The external power line filter is an ETS Lindgren Model LPRX-4X30 (100dB Attenuation, 14kHz-18GHz) and the two EMI\\RFI filters are ETS Lindgren Model LRW-2030-S1 (100dB Minimum Insertion Loss, 14kHz – 10GHz). These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and this supply line(s) will be connected to the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference groundplane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The spectrum was scanned from 150kHz to 30MHz with a spectrum analyzer. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 10kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Once the worst case emissions have been identified, the one EUT cable configuration\\arrangement and mode of operation that produced these emissions is used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

Line conducted emissions test results are shown in Section 7.8. The EMI Receiver mode of the Agilent MXE was used to perform AC line conducted emissions testing.

3.3 Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. The test site inside the chamber is a 6m x 5.2m elliptical, obstruction-free area in accordance with Figure 5.7 of Clause 5 in ANSI C63.4-2014. Absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections for measurements above 1GHz. An 80cm tall test table made of Styrodur is placed on top of the turn table. For measurements above 1GHz, an additional Styrodur pedestal is placed on top of the test table to bring the total table height to 1.5m.

For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33 depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up was placed on top of the 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, mode of operation, turntable azimuth, and receive antenna height was noted for each frequency found.

Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, whichever produced the worst-case emissions.

All radiated measurements are performed in a chamber that meets the site requirements per ANSI C63.4-2014. Additionally, radiated emissions below 30MHz are also validated on an Open Area Test Site to assert correlation with the chamber measurements per the requirements of KDB 414788 D01 v01r01.

3.4 Environmental Conditions

The temperature is controlled within range of 15ºC to 35ºC. The relative humidity is controlled within range of 10% to 75%. The atmospheric pressure is monitored within the range 86-106kPa (860-1060mbar).

4.0 ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules\Regulations:
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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."

- The antennas of the EUT are **permanently attached.**
- There are no provisions for connections to an external antenna.

Conclusion:

The EUT unit complies with the requirement of §15.203.

5.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Contribution	Expanded Uncertainty (±dB)
Conducted Bench Top Measurements	1.13
Line Conducted Disturbance	3.09
Radiated Disturbance (<1GHz)	4.98
Radiated Disturbance (>1GHz)	5.07
Radiated Disturbance (>18GHz)	5.09

6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). Measurements antennas used during testing were calibrated in accordance to the requirements of ANSI C63.5-2017.

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
-	AP2-001	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	AP2-001
-	ETS-001	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	ETS-001
-	ETS-002	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	ETS-002
-	MD1M18-40	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	MD1M18-40
-	WL40-1	Conducted Cable Set (40GHz)	1/12/2023	Annual	1/12/2024	WL40-1
-	WL25-1	Conducted Cable Set (25GHz)	1/12/2023	Annual	1/12/2024	WL25-1
Anritsu	MA24406A	Microwave Peak Power Sensor	9/7/2023	Annual	9/7/2024	11240
Emco	3115	Horn Antenna (1-18GHz)	8/8/2022	Biennial	8/8/2024	9704-5182
Emco	3116	Horn Antenna (18 - 40GHz)	7/5/2022	Biennial	7/5/2024	9203-2178
Pastermack	MNLC-2	Line Conducted Emission Cable (NM)	1/11/2023	Annual	1/11/2024	NMLC-2
ETS-Lindgren	3816/2NM	Line Impedance Stabilization Network	8/11/2022	Biennial	8/11/2024	114451
ETS Lindgren	3116C	1-18 GHz DRG Horn Antenna	2/27/2023	Biennial	2/27/2024	00218893
ETS Lindgren	3115	Double Ridged Guide Horn	4/12/2022	Biennial	4/12/2024	82333
Com-Power	AL-130	9kHz - 30MHz Loop Antenna	4/13/2022	Biennial	4/13/2025	121034
Keysight Technologies	N9020A	MXA Signal Analyzer	3/15/2023	Annual	3/15/2024	MY54500644
Keysight Technologies	N9030A	PXA Signal Analyzer (44GHz)	3/15/2023	Annual	3/15/2024	MY52350166
Keysight Technologies	N9030A	PXA Signal Analyzer	1/31/2023	Annual	1/31/2024	MY55410501
Keysight Technologies	N9030B	PXA Signal Analyzer, Multi-touch	9/7/2023	Annual	9/7/2024	MY57141001
Rohde & Schwarz	ESU26	EMI Test Receiver (26.5GHz)	9/25/2023	Annual	9/25/2024	100342
Rohde & Schwarz	ESU40	EMI Test Receiver (40GHz)	9/11/2023	Annual	9/11/2024	100348
Rohde & Schwarz	ESW44	EMI Test Receiver 2Hz to 44 GHz	3/1/2023	Annual	3/1/2024	101716
Rohde & Schwarz	FSW67	Signal / Spectrum Analyzer	1/13/2023	Annual	1/13/2024	103200
Sunol	JB5	Bi-Log Antenna (30M - 5GHz)	2/21/2023	Biennial	2/21/2025	A051107
Sunol	JB6	LB6 Antenna	3/2/2023	Biennial	3/2/2025	A082816

Table 6-1. Annual Test Equipment Calibration Schedule

Note:

For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.

7.0 TEST RESULTS

7.1 Summary

Company Name: Samsung Electronics Co., Ltd.

FCC ID: A3LSMA356E

FCC Classification: Digital Transmission System (DTS)

FCC Part Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
15.247(a)(2)	6dB Bandwidth	The minimum 6 dB bandwidth shall be at least 500 kHz.	CONDUCTED	PASS	Section 7.2
15.247(b)(3)	Transmitter Output Power	shall not exceed 1 W		PASS	Section 7.3
N\A	e.i.r.p.	shall not exceed 4 W		PASS	Section 7.3
15.247(e)	Transmitter Power Spectral Density	shall not be greater than 8 dBm in any 3 kHz band		PASS	Section 7.4
15.247(d)	Band Edge \\ Out-of-Band Emissions	≥ 20dBc		PASS	Sections 7.5, 7.6
15.205 15.209	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209 (RSS-Gen [8.9])	RADIATED	PASS	Section 7.7
15.207	AC Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits (RSS-Gen [8.8])	LINE CONDUCTED	PASS	Section 7.8

Table 7-1. Summary of Test Results

Notes:

1) All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst-case emissions.
2) The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.
3) All antenna port conducted emissions testing was performed on a test bench with the antenna port of the EUT connected to the spectrum analyzer through calibrated cables and attenuators.
4) For conducted spurious emissions, automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance. The measurement software utilized is Element "WLAN Automation," Version 3.5.
5) For radiated band edge, automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance. The measurement software utilized is Element "Chamber Automation," Version 1.3.1.

7.2 6dB Bandwidth Measurement

Test Overview and Limit

The bandwidth at 6dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the transmitter antenna terminal of the EUT while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates were investigated and the worst case configuration results are reported in this section.

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test Procedure Used

ANSI C63.10-2013 – Section 11.8.2 Option 2

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 6dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 6. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 100kHz
3. VBW ≥ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. The trace was allowed to stabilize

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

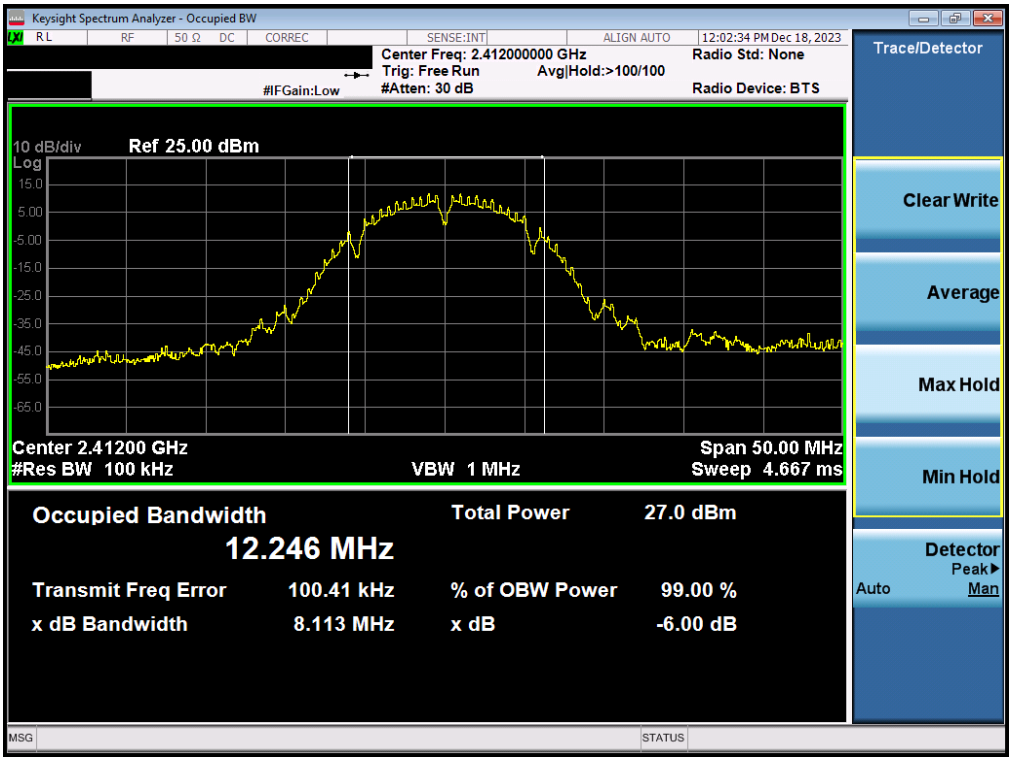
Figure 7-1. Test Instrument & Measurement Setup

Test Notes

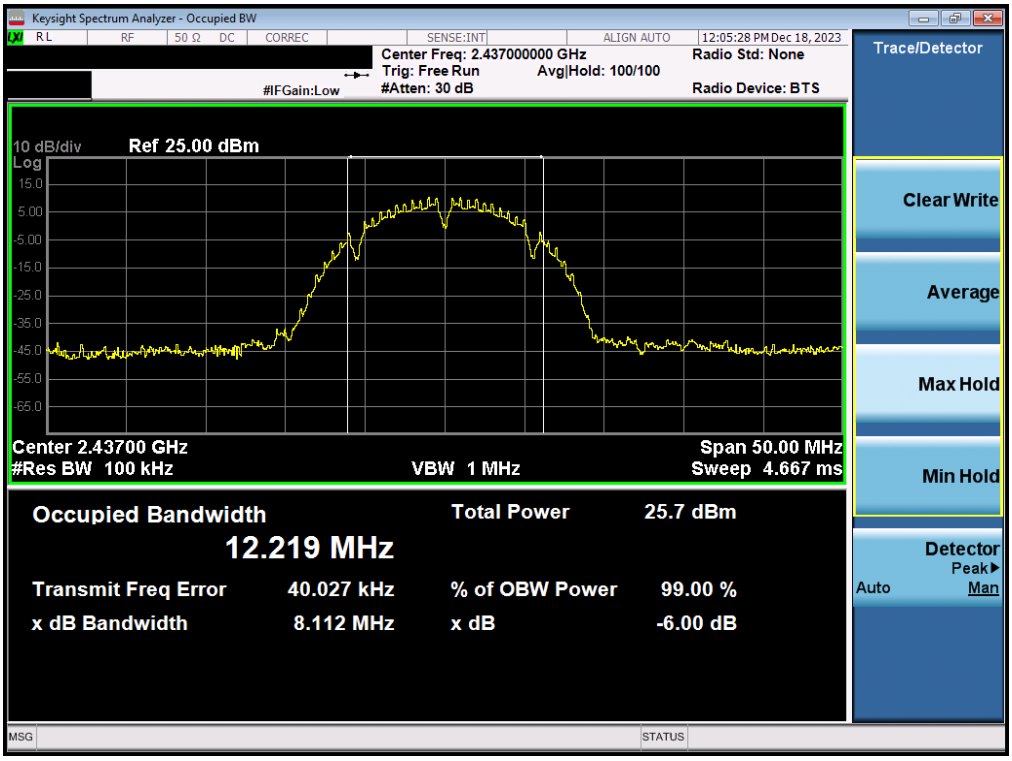
None.

Frequency [MHz]	Channel No.	802.11 Mode	Antenna-1 6dB Bandwidth [MHz]	Antenna-2 6dB Bandwidth [MHz]	Minimum Bandwidth [MHz]
2412	1	b	8.11	8.08	0.500
2437	6	b	8.11	8.13	0.500
2462	11	b	8.12	8.05	0.500
2412	1	g	16.41	16.37	0.500
2437	6	g	16.38	16.42	0.500
2462	11	g	16.42	15.78	0.500
2412	1	n	17.26	17.62	0.500
2437	6	n	17.65	17.63	0.500
2462	11	n	17.75	16.98	0.500
2412	1	ax	19.05	18.91	0.500
2437	6	ax	19.12	19.23	0.500
2462	11	ax	19.15	18.91	0.500

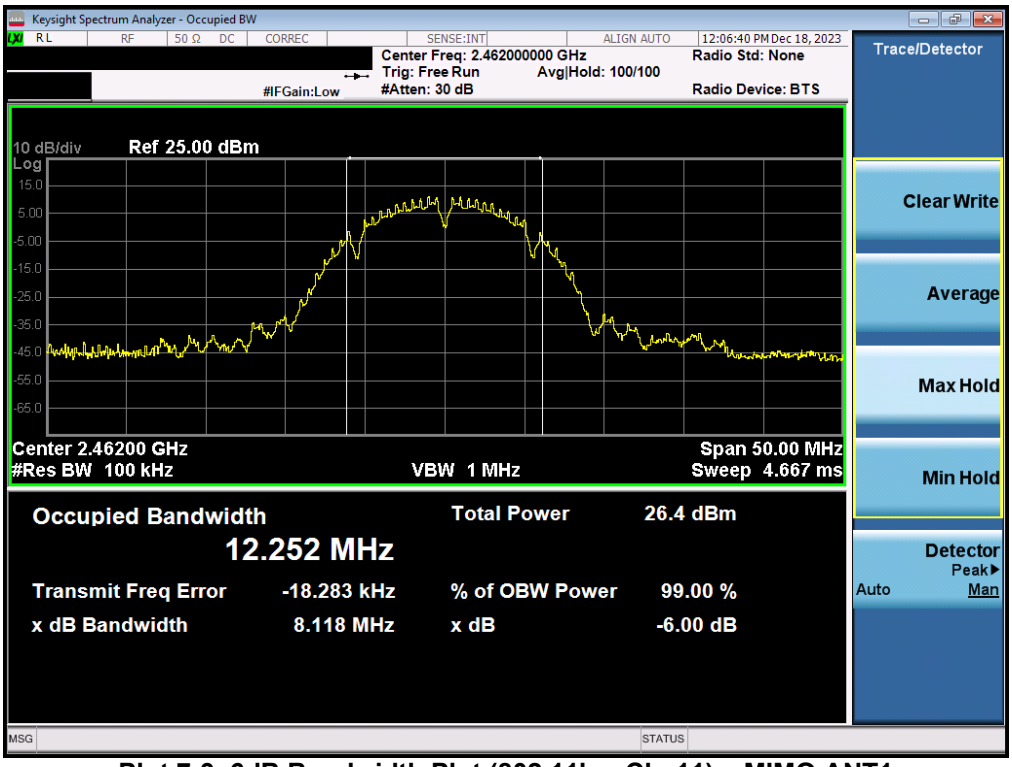
Table 7-2. Conducted 6dB Bandwidth Measurements MIMO



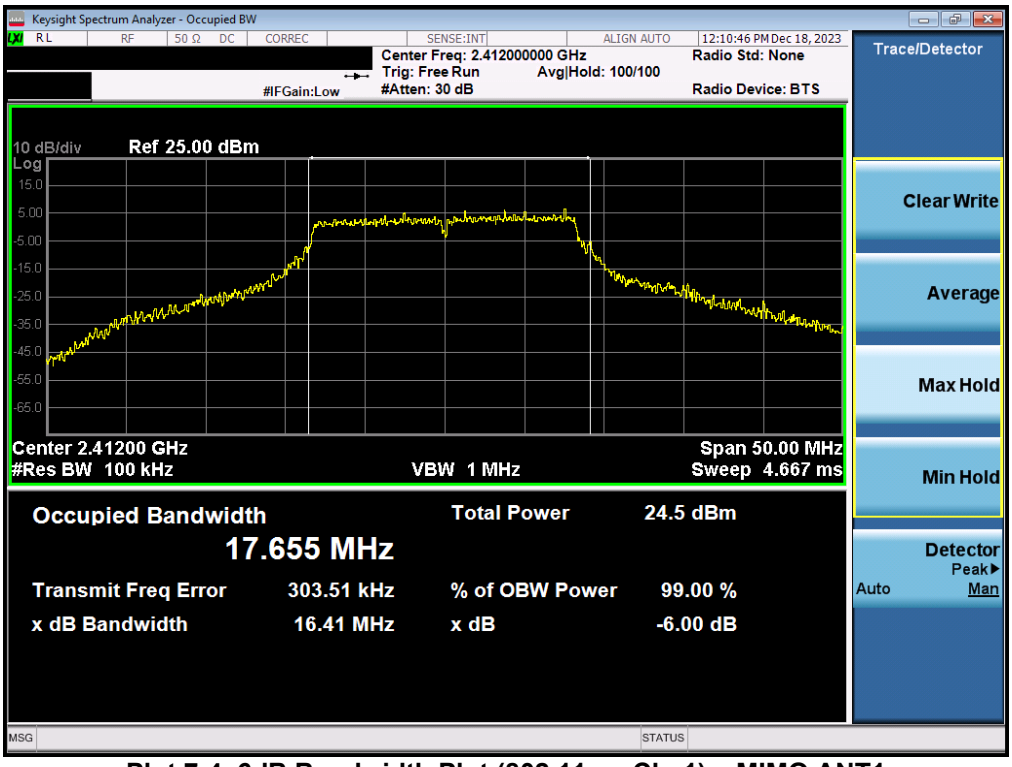
Plot 7-1. 6dB Bandwidth Plot (802.11b – Ch. 1) – MIMO ANT1



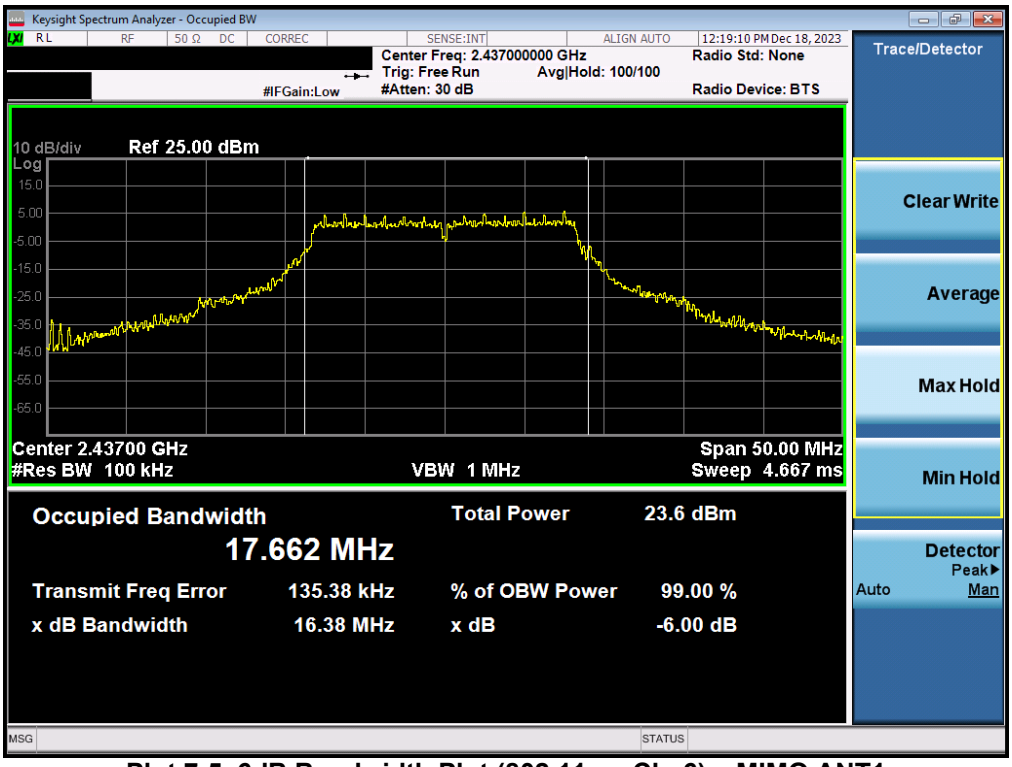
Plot 7-2. 6dB Bandwidth Plot (802.11b – Ch. 6) – MIMO ANT1



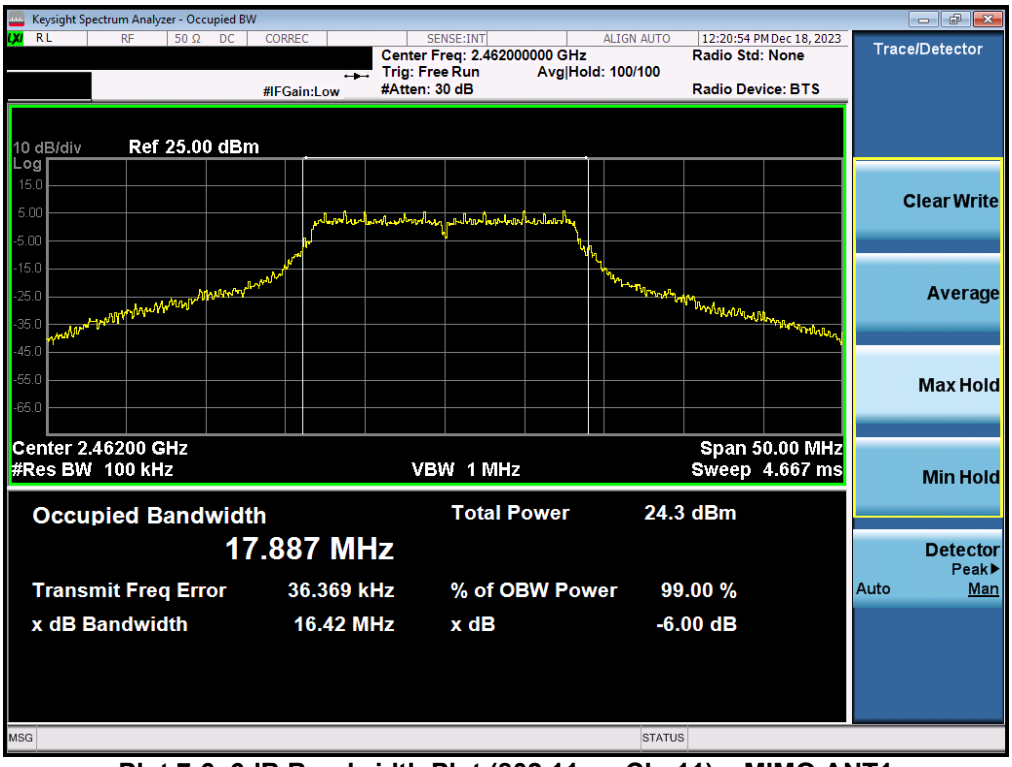
Plot 7-3. 6dB Bandwidth Plot (802.11b – Ch. 11) – MIMO ANT1



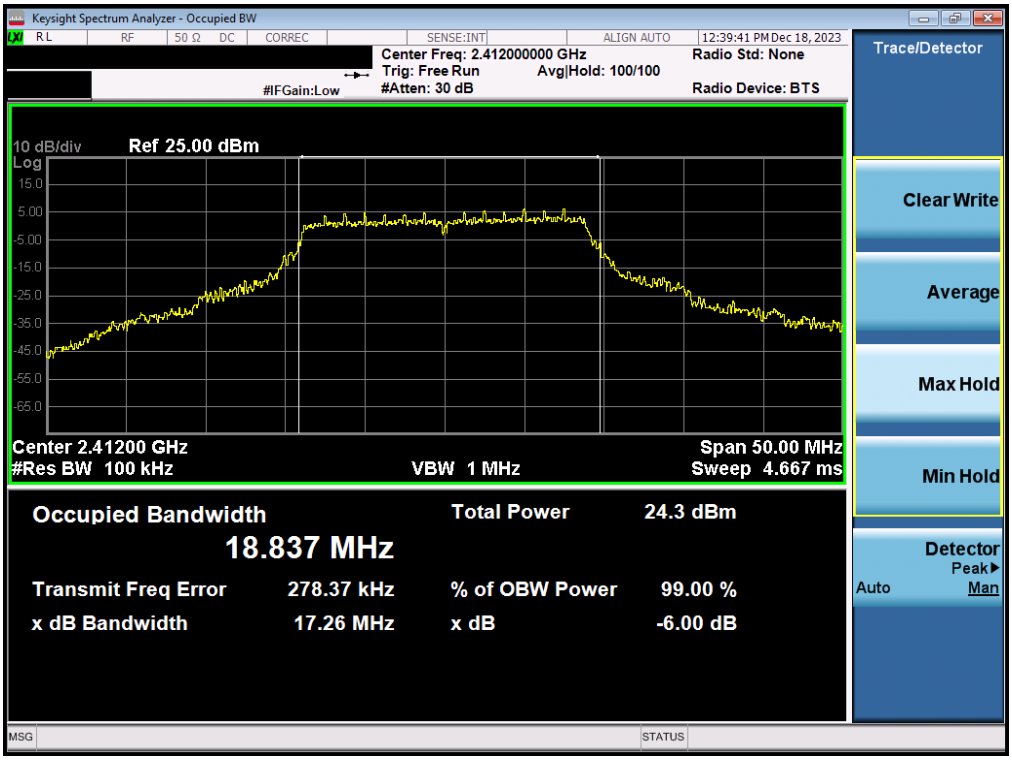
Plot 7-4. 6dB Bandwidth Plot (802.11g – Ch. 1) – MIMO ANT1



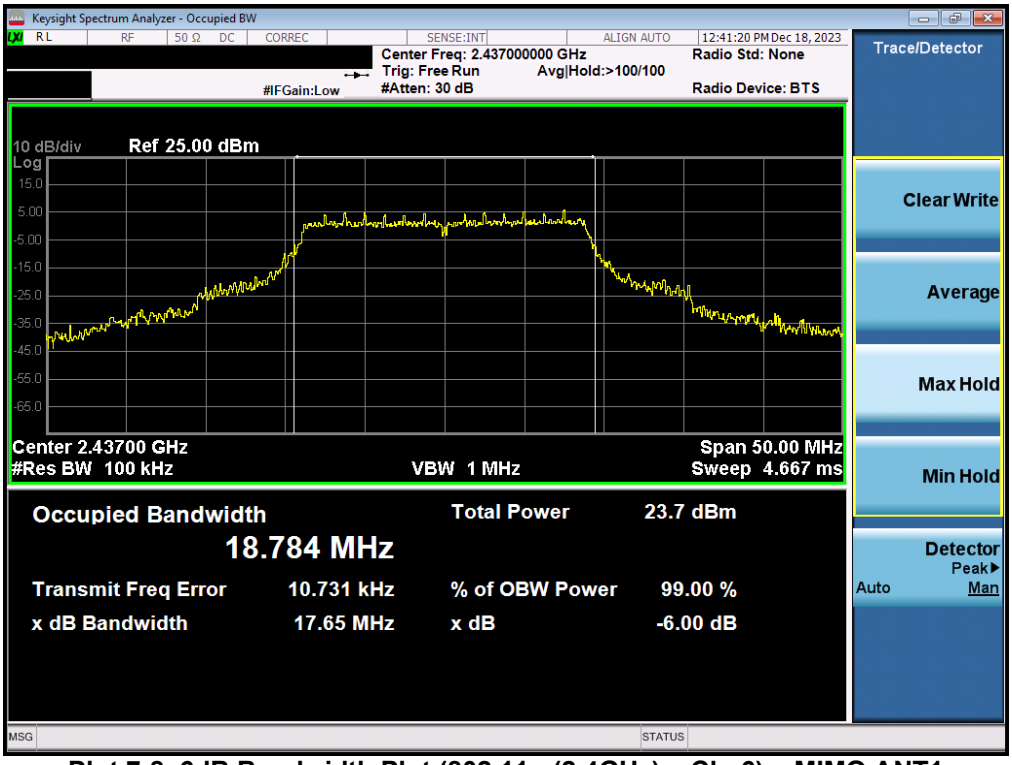
Plot 7-5. 6dB Bandwidth Plot (802.11g – Ch. 6) – MIMO ANT1



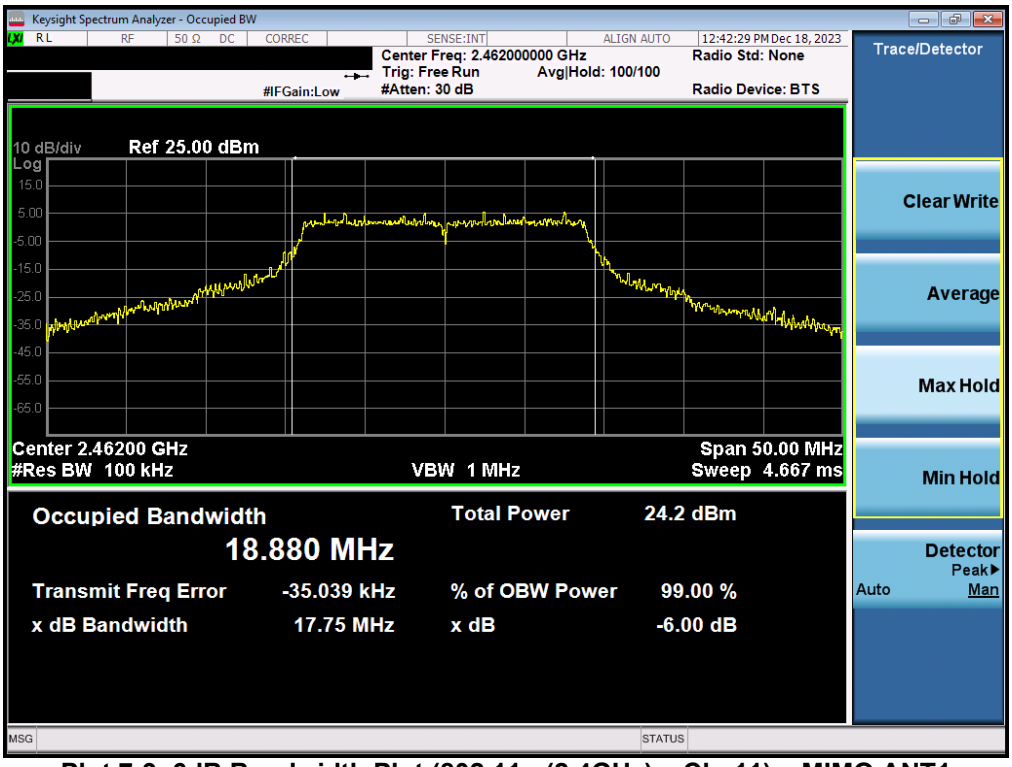
Plot 7-6. 6dB Bandwidth Plot (802.11g – Ch. 11) – MIMO ANT1



Plot 7-7. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT1

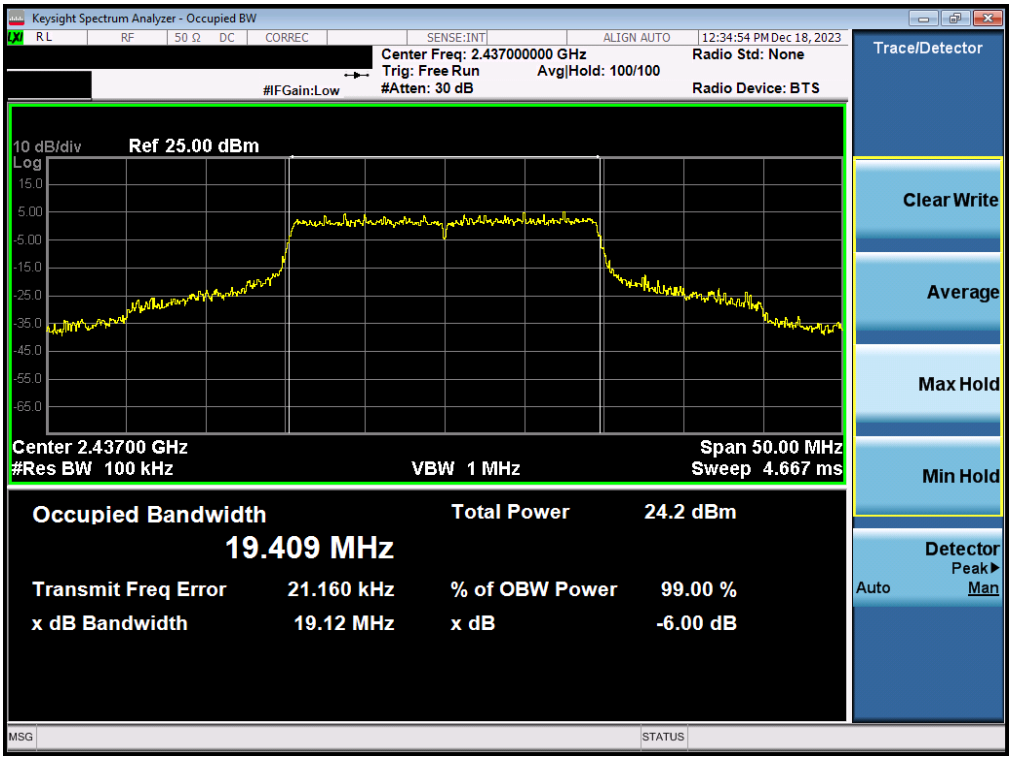


Plot 7-8. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 6) – MIMO ANT1

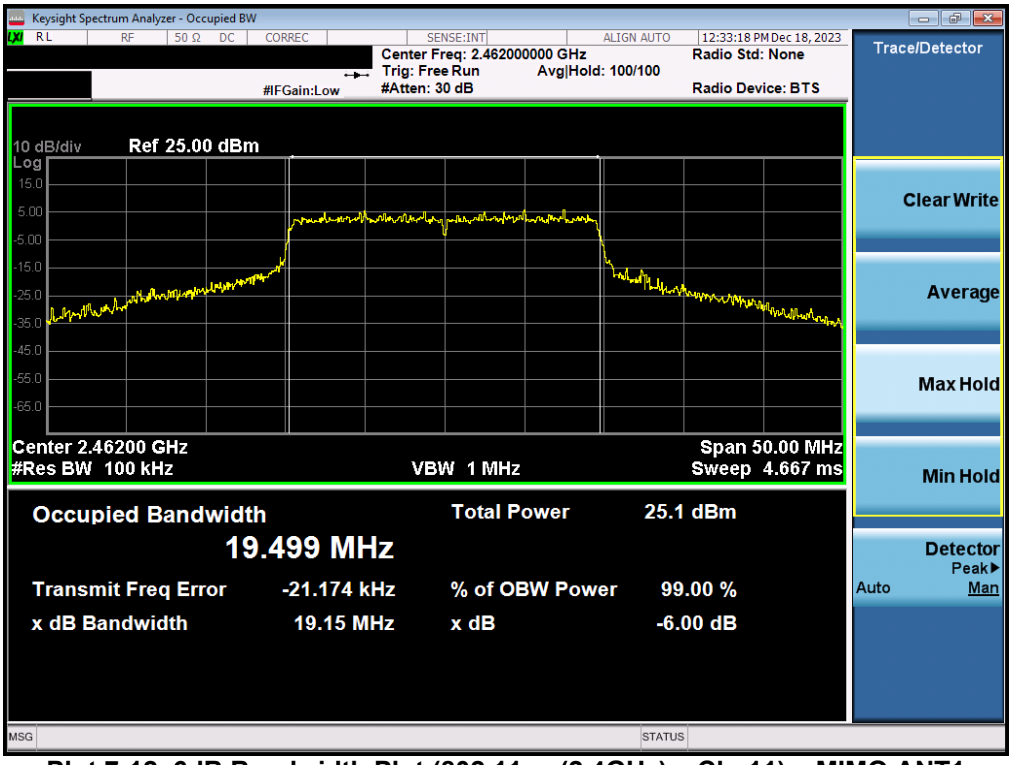


Plot 7-9. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT1

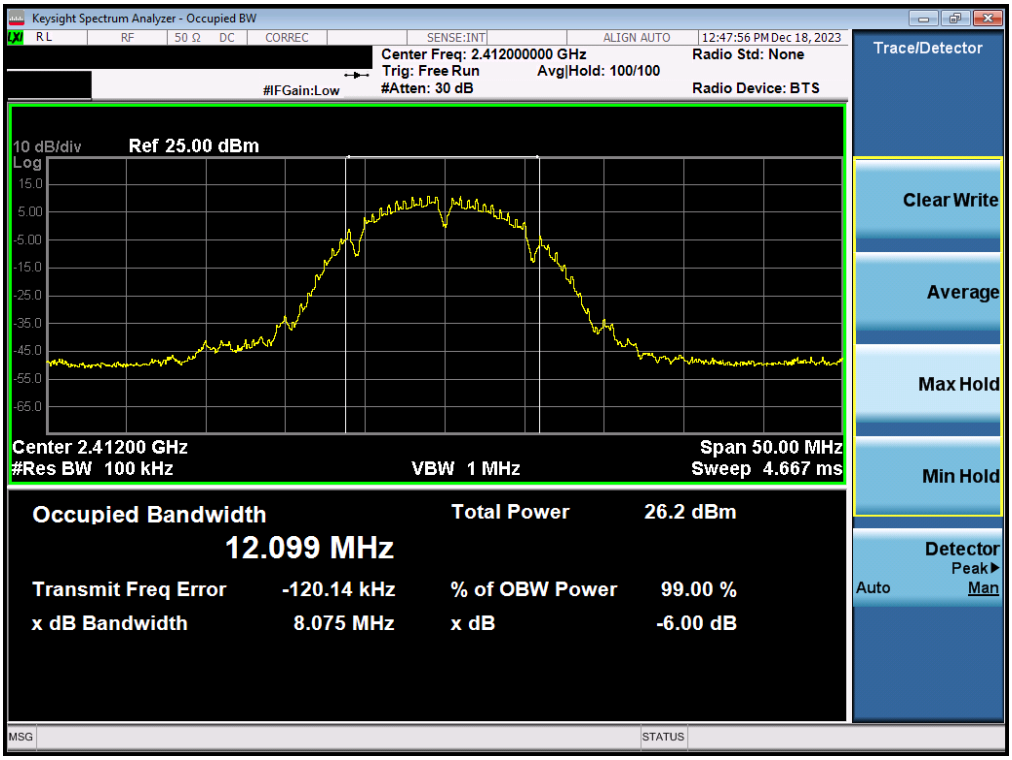
Plot 7-10. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT1



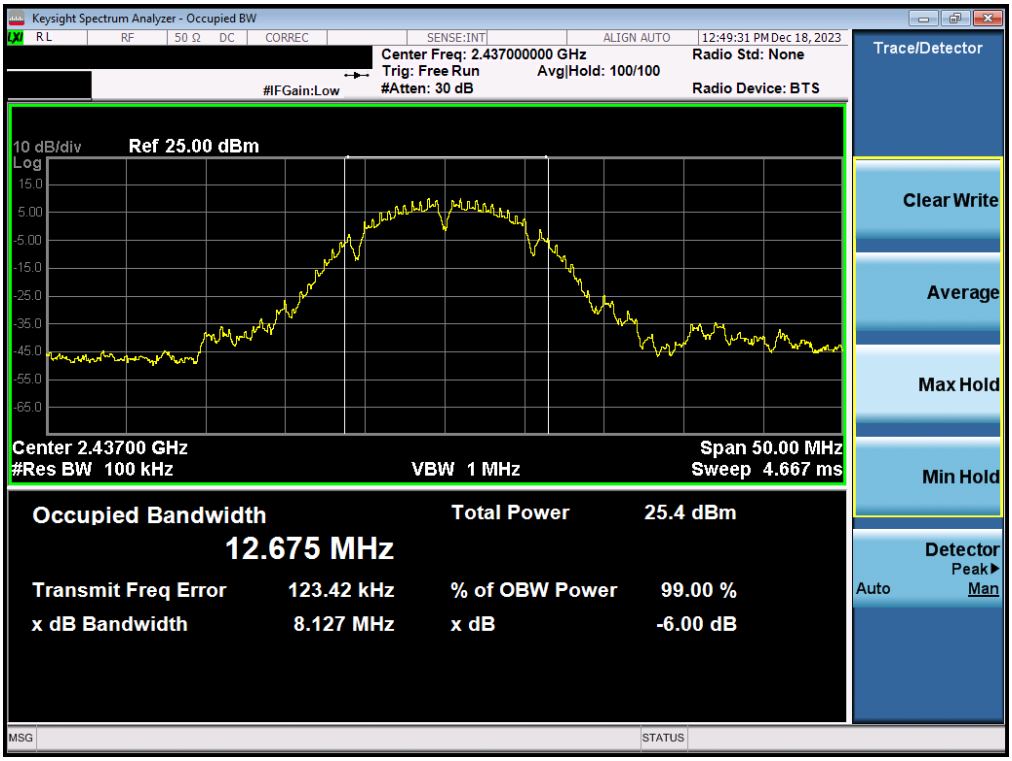
Plot 7-11. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 6) – MIMO ANT1



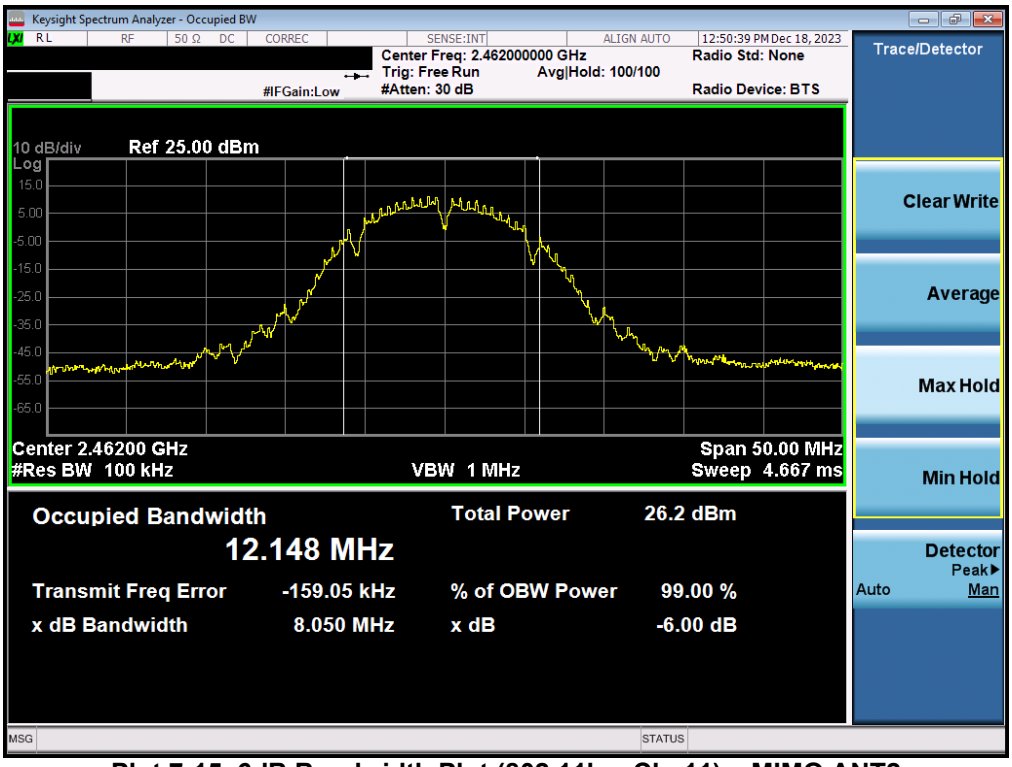
Plot 7-12. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT1



Plot 7-13. 6dB Bandwidth Plot (802.11b – Ch. 1) – MIMO ANT2

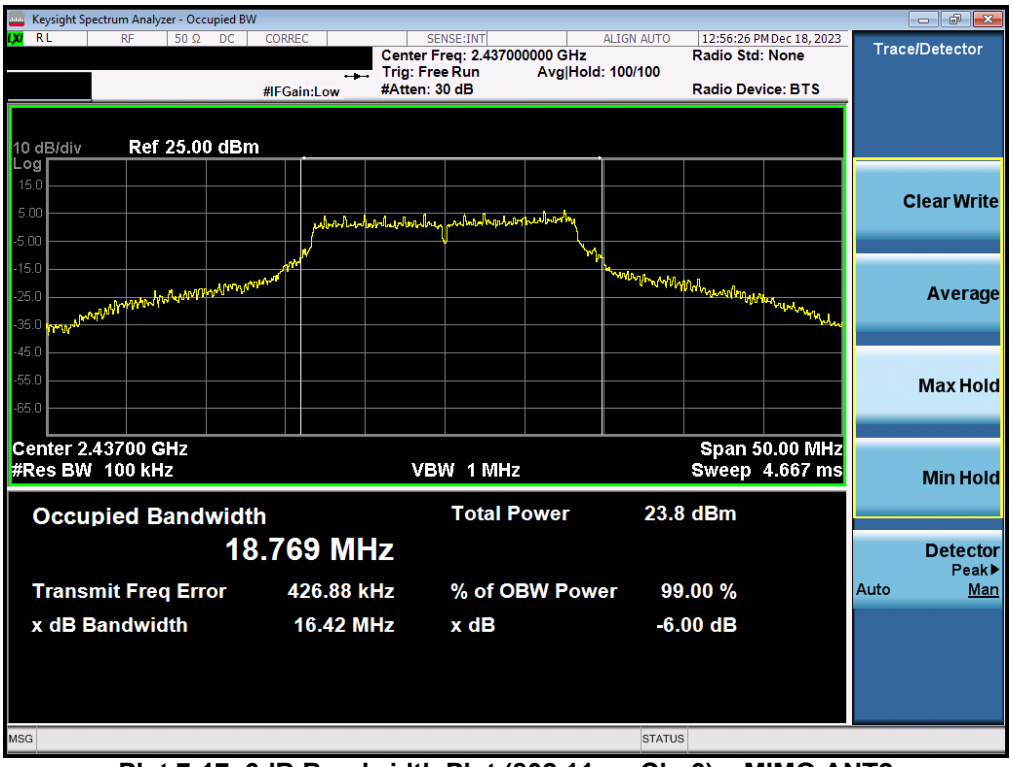


Plot 7-14. 6dB Bandwidth Plot (802.11b – Ch. 6) – MIMO ANT2

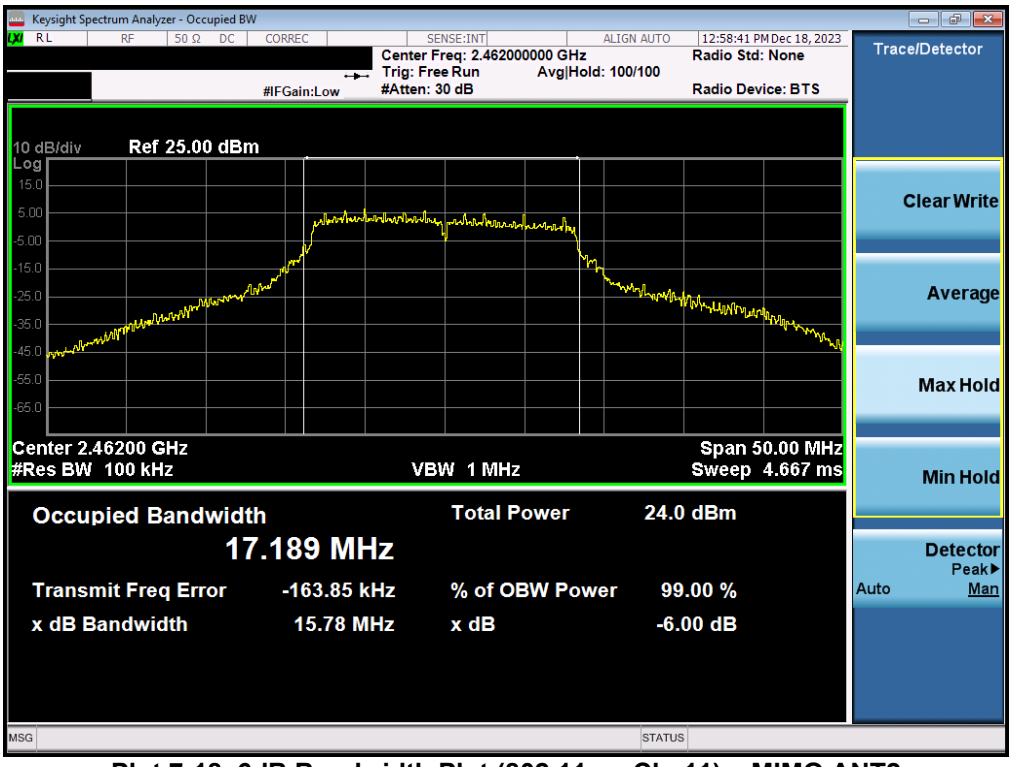


Plot 7-15. 6dB Bandwidth Plot (802.11b – Ch. 11) – MIMO ANT2

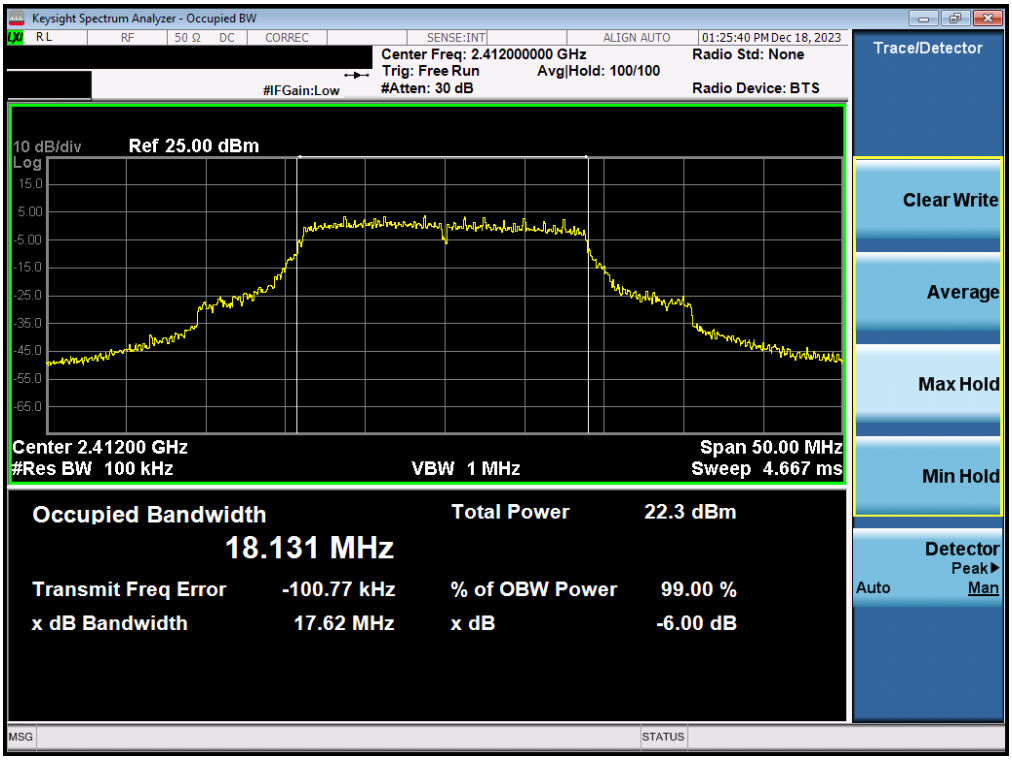
Plot 7-16. 6dB Bandwidth Plot (802.11g – Ch. 1) – MIMO ANT2



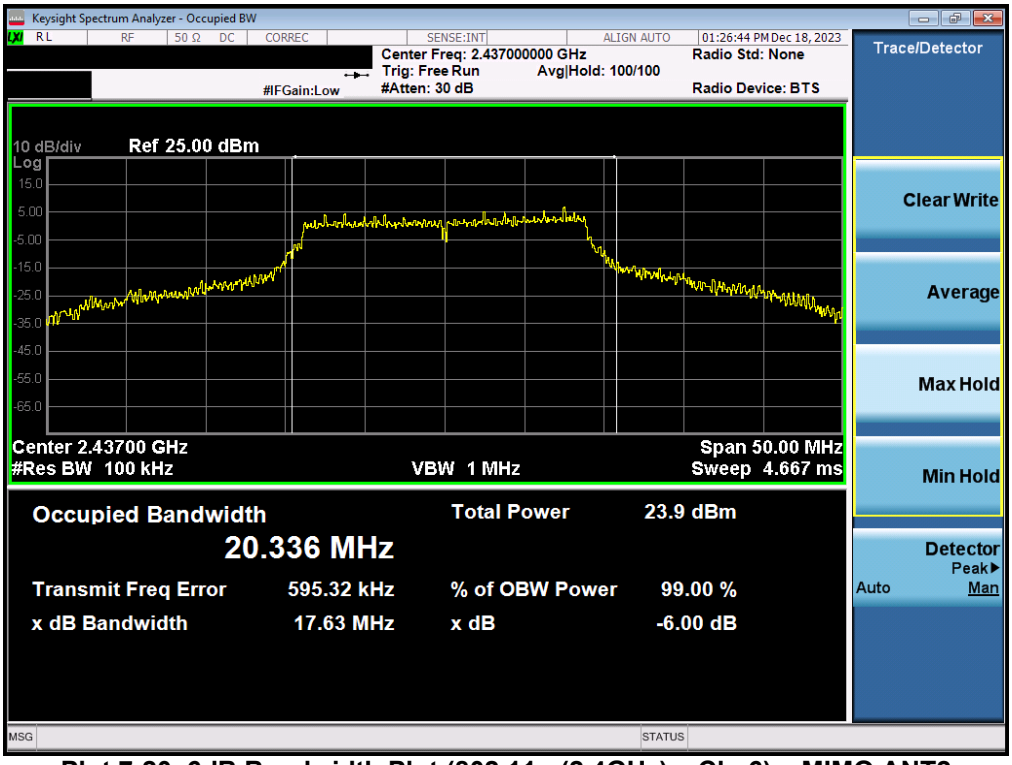
Plot 7-17. 6dB Bandwidth Plot (802.11g – Ch. 6) – MIMO ANT2



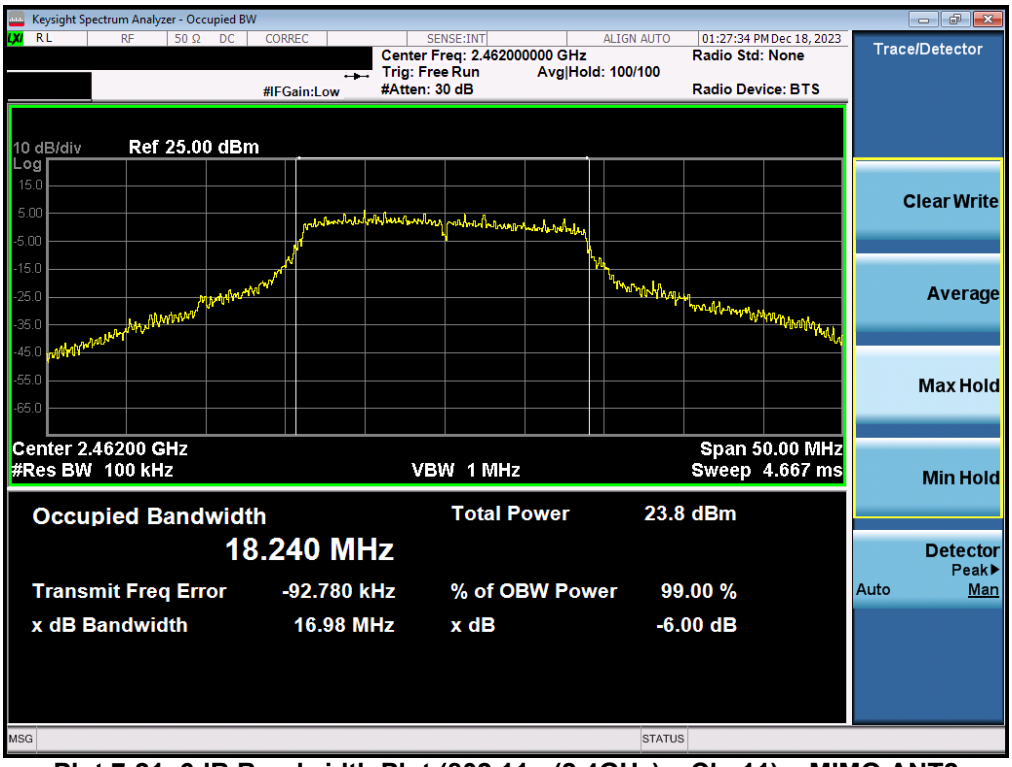
Plot 7-18. 6dB Bandwidth Plot (802.11g – Ch. 11) – MIMO ANT2



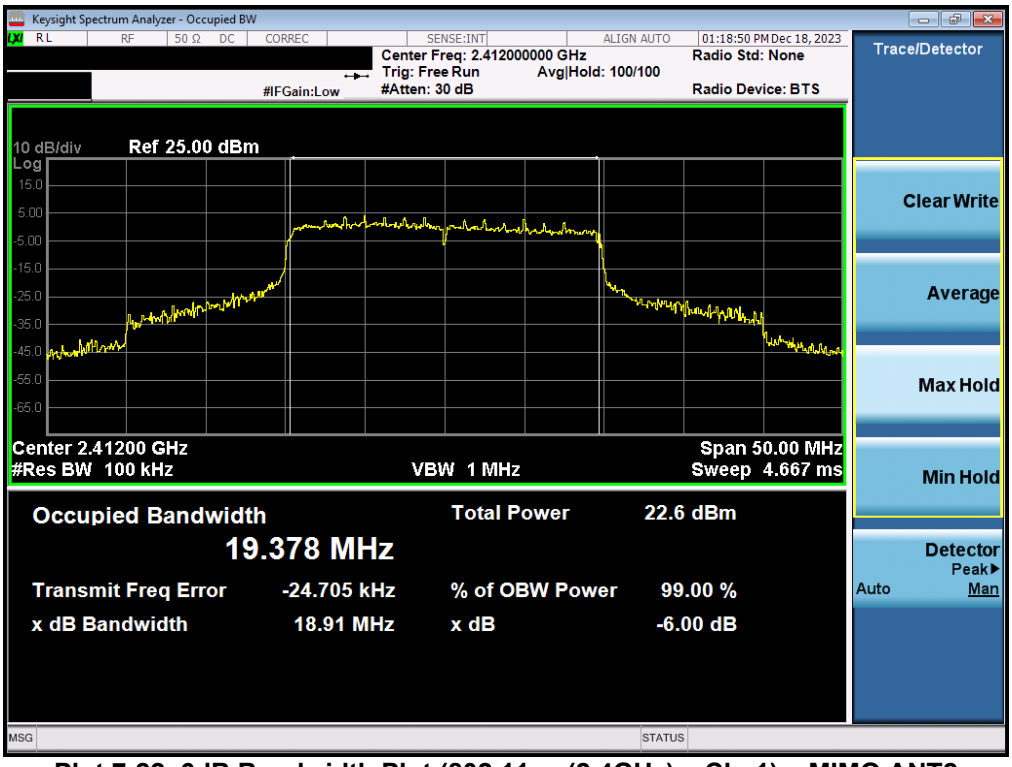
Plot 7-19. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT2



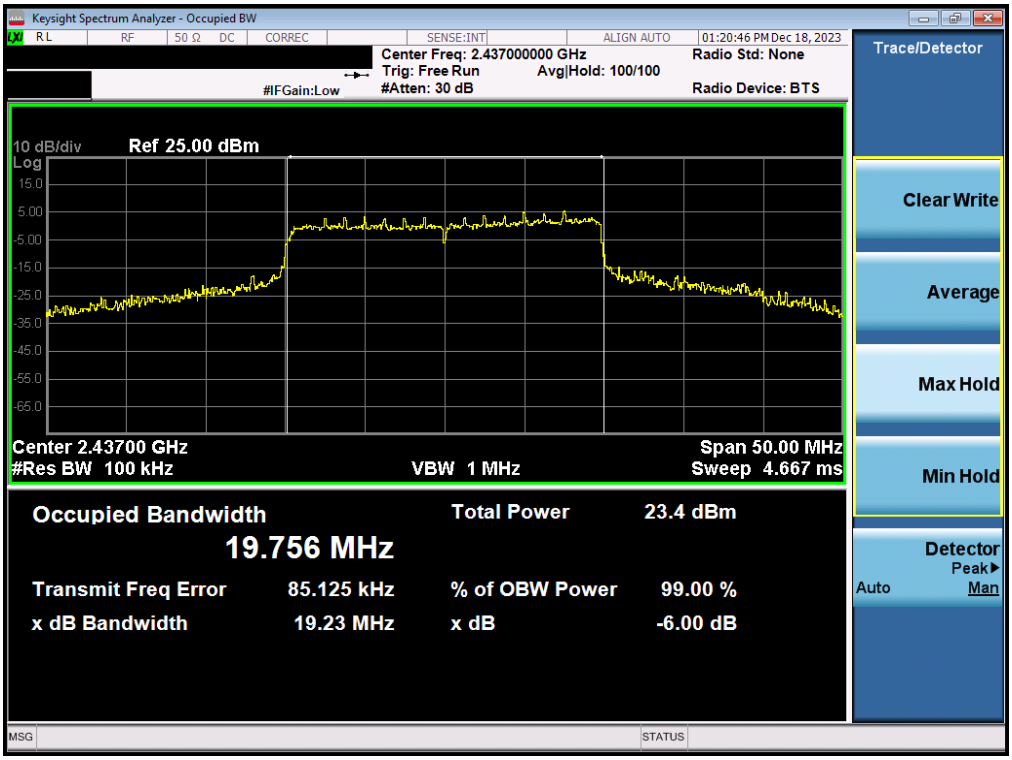
Plot 7-20. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 6) – MIMO ANT2



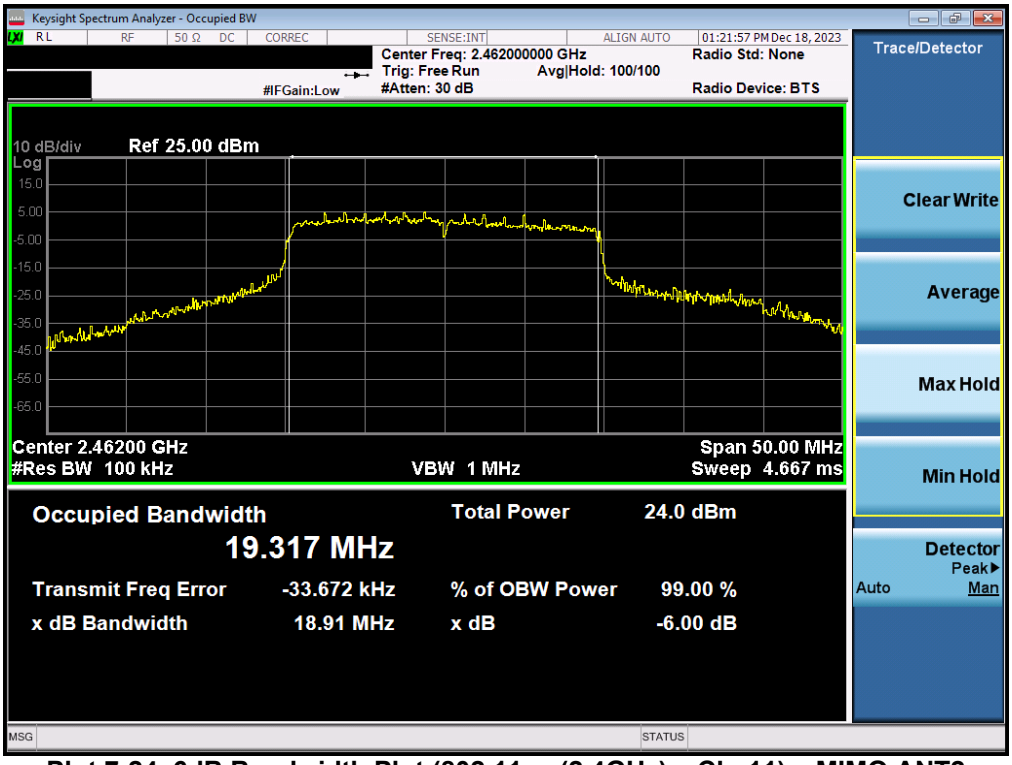
Plot 7-21. 6dB Bandwidth Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT2



Plot 7-22. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT2



Plot 7-23. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 6) – MIMO ANT2



Plot 7-24. 6dB Bandwidth Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT2

7.3 Output Power Measurement

Test Overview and Limits

A transmitter antenna terminal of EUT is connected to the input of an RF power sensor. Measurement is made using a broadband power meter capable of making peak and average measurements while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies.

The maximum permissible conducted output power is 1 Watt per 15.247.

Test Procedure Used

ANSI C63.10-2013 – Section 11.9.1.3 PKPM1 Peak Power Method
ANSI C63.10-2013 – Section 11.9.2.3.2 Method AVGPM-G
ANSI C63.10-2013 – Section 14.2 Measure-and-Sum Technique

Test Settings

Method PKPM1 (Peak Power Measurement)

Peak power measurements were performed only when the EUT was transmitting at its maximum power control level using a broadband power meter with a pulse sensor. The pulse sensor employs a VBW = 50MHz so this method was only used for signals whose DTS bandwidth was less than or equal to 50MHz.

Method AVGPM-G (Average Power Measurement)

Average power measurements were performed only when the EUT was transmitting at its maximum power control level using a broadband power meter with a pulse sensor. The power meter implemented triggering and gating capabilities which were set up such that power measurements were recorded only during the ON time of the transmitter. The trace was averaged over 100 traces to obtain the final measured average power.

Test Setup

The EUT and measurement equipment were set up as shown in the diagrams below.

Figure 7-2. Test Instrument & Measurement Setup for Power Meter Measurements

Test Notes

None.

IEEE 802.11b	2.4GHz WIFI (20MHz 802.11b MIMO)						Conducted Power Limit [dBm]	Conducted Power Margin [dB]	Directional Ant. Gain [dBi]	Max e.i.r.p [dBm]	e.i.r.p Limit [dBm]	e.i.r.p Margin [dB]
	Freq [MHz]	Channel	Detector	Conducted Power [dBm]								
				ANT1	ANT2	MIMO						
	2412	1	Average	18.92	18.99	21.97	30.00	-8.03	-3.63	18.34	36.02	-17.68
	2437	6		18.92	18.45	21.70	30.00	-8.30	-3.63	18.07	36.02	-17.95
	2462	11		18.51	18.99	21.77	30.00	-8.23	-3.63	18.14	36.02	-17.88
	2467	12		7.20	7.94	10.60	30.00	-19.40	-3.63	6.97	36.02	-29.05
	2472	13		0.99	0.87	3.94	30.00	-26.06	-3.63	0.31	36.02	-35.71
	2412	1	Peak	22.92	22.88	25.91	30.00	-4.09	-3.63	22.28	36.02	-13.74
	2437	6		23.27	22.54	25.93	30.00	-4.07	-3.63	22.30	36.02	-13.72
	2462	11		22.53	23.05	25.81	30.00	-4.19	-3.63	22.17	36.02	-13.85
	2467	12		10.03	10.74	13.41	30.00	-16.59	-3.63	9.78	36.02	-26.24
	2472	13		3.99	3.71	6.86	30.00	-23.14	-3.63	3.23	36.02	-32.79

Table 7-3. Conducted Output Power Measurements MIMO (802.11b)

IEEE 802.11g	2.4GHz WIFI (20MHz 802.11g MIMO)						Conducted Power Limit [dBm]	Conducted Power Margin [dB]	Directional Ant. Gain [dBi]	Max e.i.r.p [dBm]	e.i.r.p Limit [dBm]	e.i.r.p Margin [dB]
	Freq [MHz]	Channel	Detector	Conducted Power [dBm]								
				ANT1	ANT2	MIMO						
	2412	1	Average	15.98	15.66	18.83	30.00	-11.17	-3.63	15.20	36.02	-20.82
	2417	2		16.27	16.46	19.38	30.00	-10.62	-3.63	15.75	36.02	-20.27
	2437	6		17.38	16.25	19.86	30.00	-10.14	-3.63	16.23	36.02	-19.79
	2462	11		16.02	16.52	19.29	30.00	-10.71	-3.63	15.66	36.02	-20.36
	2467	12		6.89	7.66	10.31	30.00	-19.69	-3.63	6.68	36.02	-29.34
	2472	13		0.38	0.79	3.60	30.00	-26.40	-3.63	-0.03	36.02	-36.05
	2412	1	Peak	24.23	23.97	27.11	30.00	-2.89	-3.63	23.48	36.02	-12.54
	2437	6		24.67	22.81	26.85	30.00	-3.15	-3.63	23.21	36.02	-12.81
	2462	11		23.68	24.27	27.00	30.00	-3.00	-3.63	23.36	36.02	-12.66
	2467	12		16.11	17.05	19.62	30.00	-10.38	-3.63	15.98	36.02	-20.04
	2472	13		9.16	9.92	12.56	30.00	-17.44	-3.63	8.93	36.02	-27.09

Table 7-4. Conducted Output Power Measurements MIMO (802.11g)

IEEE 802.11n	2.4GHz WIFI (20MHz 802.11n MIMO)						Conducted Power Limit [dBm]	Conducted Power Margin [dB]	Directional Ant. Gain [dBi]	Max e.i.r.p [dBm]	e.i.r.p Limit [dBm]	e.i.r.p Margin [dB]
	Freq [MHz]	Channel	Detector	Conducted Power [dBm]								
				ANT1	ANT2	MIMO						
	2412	1	Average	15.04	15.01	18.04	30.00	-11.96	-3.63	14.41	36.02	-21.61
	2417	2		16.37	16.47	19.43	30.00	-10.57	-3.63	15.80	36.02	-20.22
	2437	6		17.34	16.52	19.96	30.00	-10.04	-3.63	16.33	36.02	-19.69
	2462	11		16.13	16.40	19.28	30.00	-10.72	-3.63	15.65	36.02	-20.37
	2467	12		6.59	7.74	10.22	30.00	-19.78	-3.63	6.59	36.02	-29.43
	2472	13		0.38	0.90	3.66	30.00	-26.34	-3.63	0.03	36.02	-35.99
	2412	1	Peak	25.18	24.17	27.71	30.00	-2.29	-3.63	24.08	36.02	-11.94
	2437	6		24.86	23.62	27.29	30.00	-2.71	-3.63	23.66	36.02	-12.36
	2462	11		24.26	24.24	27.26	30.00	-2.74	-3.63	23.63	36.02	-12.39
	2467	12		16.23	17.18	19.74	30.00	-10.26	-3.63	16.11	36.02	-19.91
	2472	13		11.03	11.23	14.14	30.00	-15.86	-3.63	10.51	36.02	-25.51

Table 7-5. Conducted Output Power Measurements MIMO (802.11n)

IEEE 802.11ax SU	2.4GHz WIFI (20MHz 802.11ax MIMO)						Conducted Power Limit [dBm]	Conducted Power Margin [dB]	Directional Ant. Gain [dBi]	Max e.i.r.p [dBm]	e.i.r.p Limit [dBm]	e.i.r.p Margin [dB]
	Freq [MHz]	Channel	Detector	Conducted Power [dBm]								
				ANT1	ANT2	MIMO						
	2412	1	Average	15.34	14.99	18.18	30.00	-11.82	-3.63	14.55	36.02	-21.47
	2417	2		16.53	16.87	19.71	30.00	-10.29	-3.63	16.08	36.02	-19.94
	2437	6		17.23	16.48	19.88	30.00	-10.12	-3.63	16.25	36.02	-19.77
	2462	11		16.07	16.35	19.22	30.00	-10.78	-3.63	15.59	36.02	-20.43
	2467	12		6.58	7.78	10.23	30.00	-19.77	-3.63	6.60	36.02	-29.42
	2472	13		-0.16	0.42	3.15	30.00	-26.85	-3.63	-0.48	36.02	-36.50
	2412	1	Peak	24.61	24.39	27.51	30.00	-2.49	-3.63	23.88	36.02	-12.14
	2437	6		24.93	23.53	27.30	30.00	-2.70	-3.63	23.66	36.02	-12.36
	2462	11		24.86	24.67	27.78	30.00	-2.22	-3.63	24.14	36.02	-11.88
	2467	12		16.24	18.12	20.29	30.00	-9.71	-3.63	16.66	36.02	-19.36
	2472	13		10.65	10.67	13.67	30.00	-16.33	-3.63	10.03	36.02	-25.99

Table 7-6. Conducted Output Power Measurements MIMO (802.11ax)

Note:

Per ANSI C63.10-2013 Section 14.2, the conducted powers at Antenna 1 and Antenna 2 were first measured separately during MIMO transmission as shown in the section above. The measured values were then summed in linear power units then converted back to dBm.

Sample MIMO Calculation:

At 2412MHz the average conducted output power was measured to be 18.92 dBm for Antenna 1 and 18.99 dBm for Antenna 2.

Antenna 1 + Antenna 2 = MIMO

(18.92 dBm + 18.99 dBm) = (77.98 mW + 79.25 mW) = 157.23mW = 21.97 dBm

7.4 Power Spectral Density

Test Overview and Limit

The peak power density is measured with a spectrum analyzer connected to the antenna terminal of the EUT while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates are investigated and the worst-case configuration results are reported in this section.

The maximum permissible power spectral density shall not be greater than 8 dBm in any 3 kHz band.

Test Procedure Used

ANSI C63.10-2013 – Section 11.10.2 Method PKPSD
ANSI C63.10-2013 – Section 14.3.1 Measure-and-Sum Technique

Test Settings

1. Analyzer was set to the center frequency of the DTS channel under investigation
2. Span = 1.5 times the DTS channel bandwidth
3. RBW = 10kHz
4. VBW = 1MHz
5. Detector = peak
6. Sweep time = auto couple
7. Trace mode = max hold
8. Trace was allowed to stabilize

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

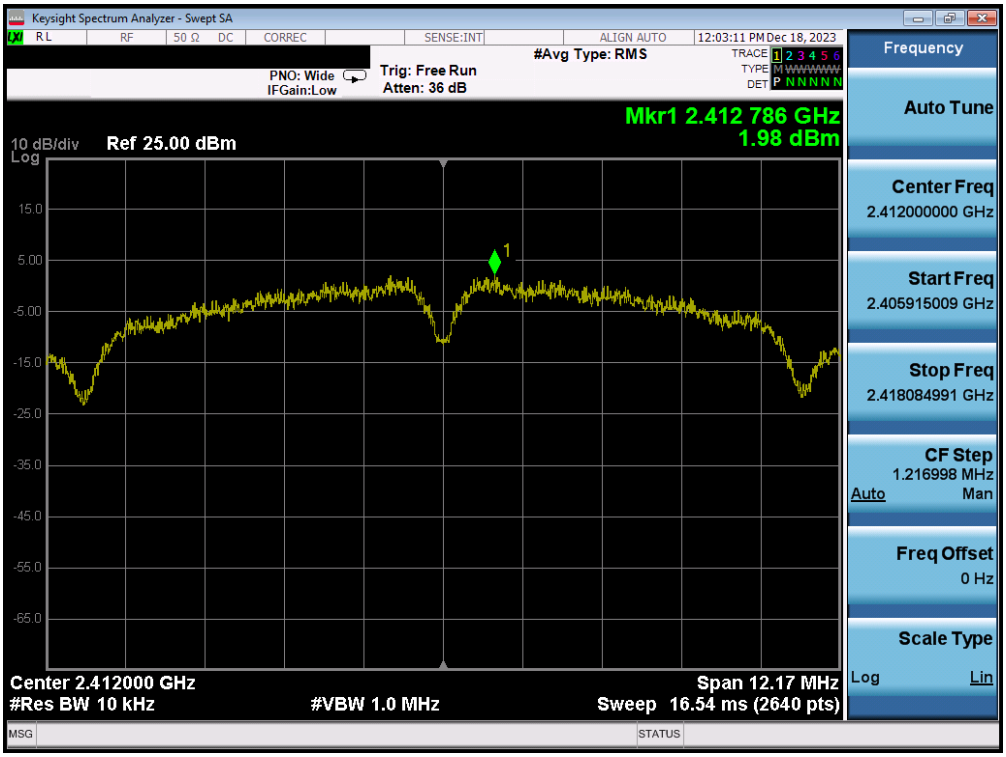
Figure 7-3. Test Instrument & Measurement Setup

Test Notes

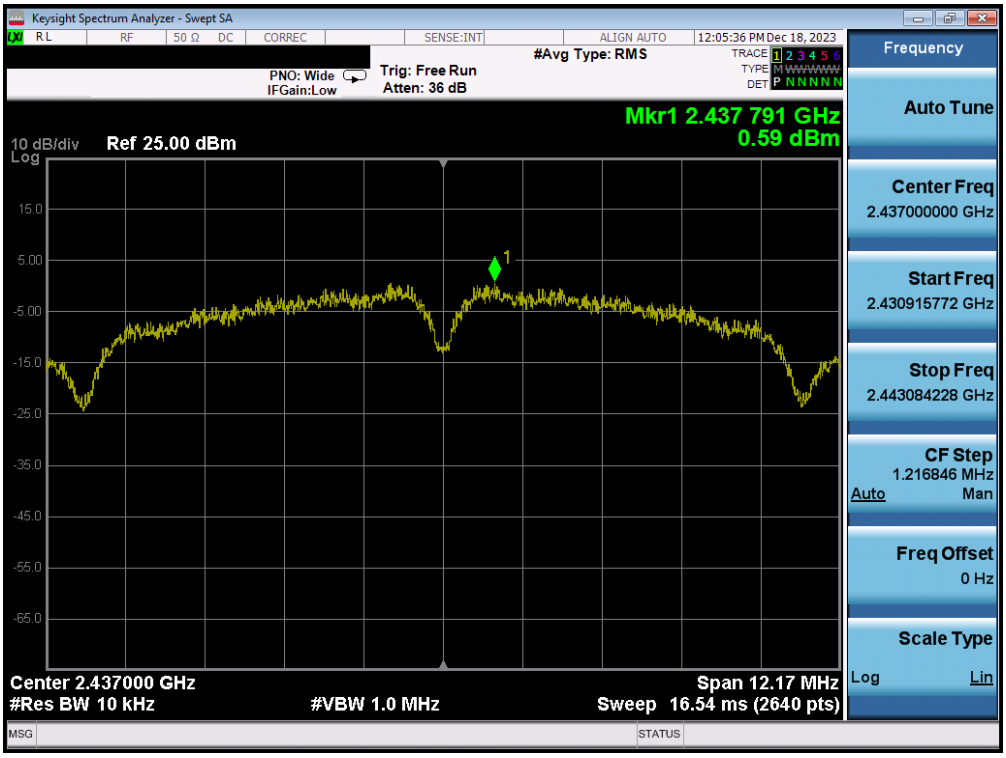
None.

Frequency [MHz]	Channel No.	802.11 Mode	ANT 1 Power Spectral Density [dBm]	ANT 2 Power Spectral Density [dBm]	Summed MIMO Power Spectral Density [dBm]	Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]	Pass / Fail
2412	1	b	1.98	1.29	4.66	8.00	-3.34	Pass
2437	6	b	0.59	0.10	3.36	8.00	-4.64	Pass
2462	11	b	1.36	1.64	4.52	8.00	-3.48	Pass
2412	1	g	-3.38	-5.45	-1.28	8.00	-9.28	Pass
2437	6	g	-5.23	-2.92	-0.91	8.00	-8.91	Pass
2462	11	g	-3.78	-4.06	-0.91	8.00	-8.91	Pass
2412	1	n	-4.10	-5.19	-1.60	8.00	-9.60	Pass
2437	6	n	-4.96	-2.77	-0.72	8.00	-8.72	Pass
2462	11	n	-4.17	-3.32	-0.71	8.00	-8.71	Pass
2412	1	ax	-4.15	-5.83	-1.90	8.00	-9.90	Pass
2437	6	ax	-5.09	-3.09	-0.97	8.00	-8.97	Pass
2462	11	ax	-4.33	-4.02	-1.16	8.00	-9.16	Pass

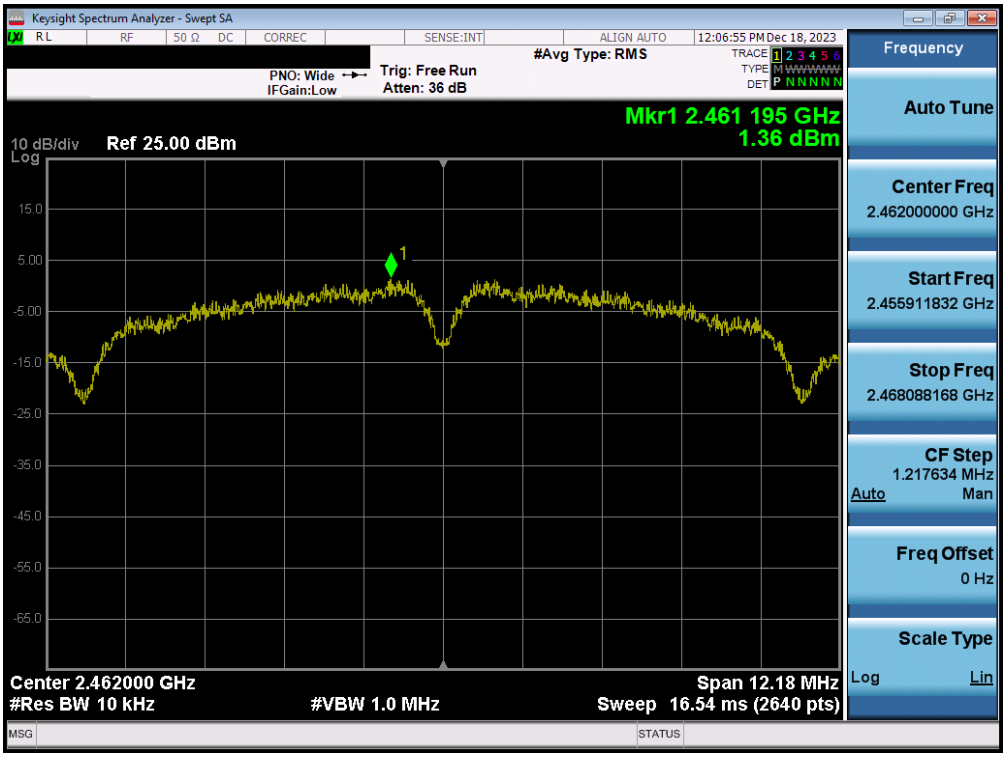
Table 7-7. MIMO Conducted Power Spectral Density Results



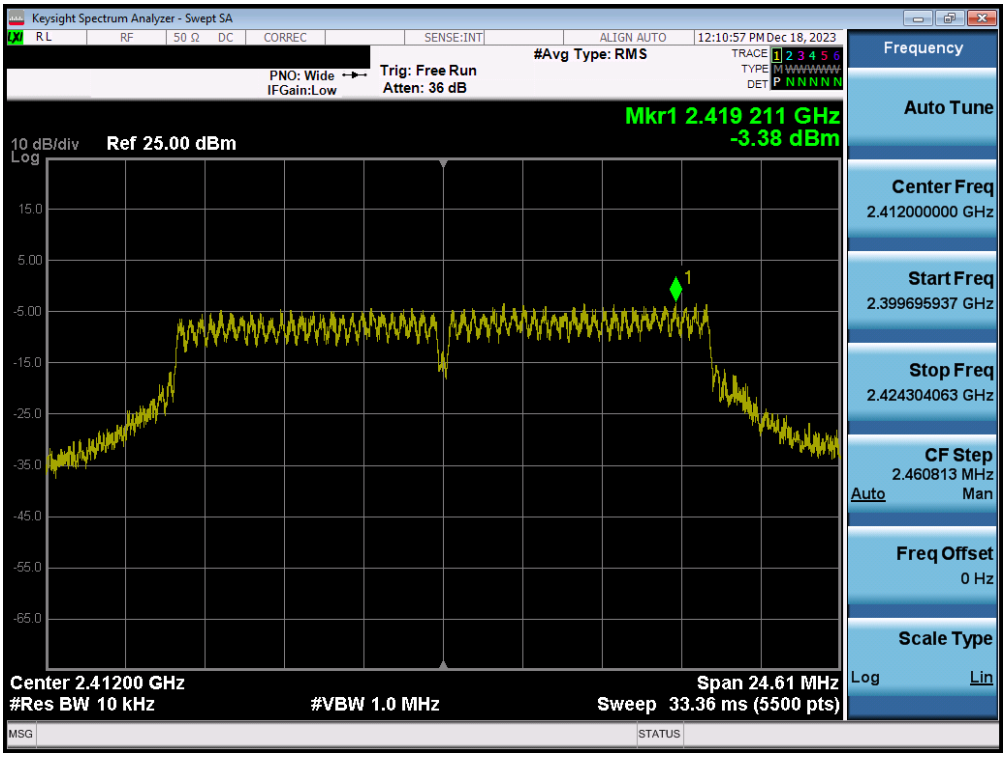
Plot 7-25. Power Spectral Density Plot (802.11b – Ch. 1) – MIMO ANT1



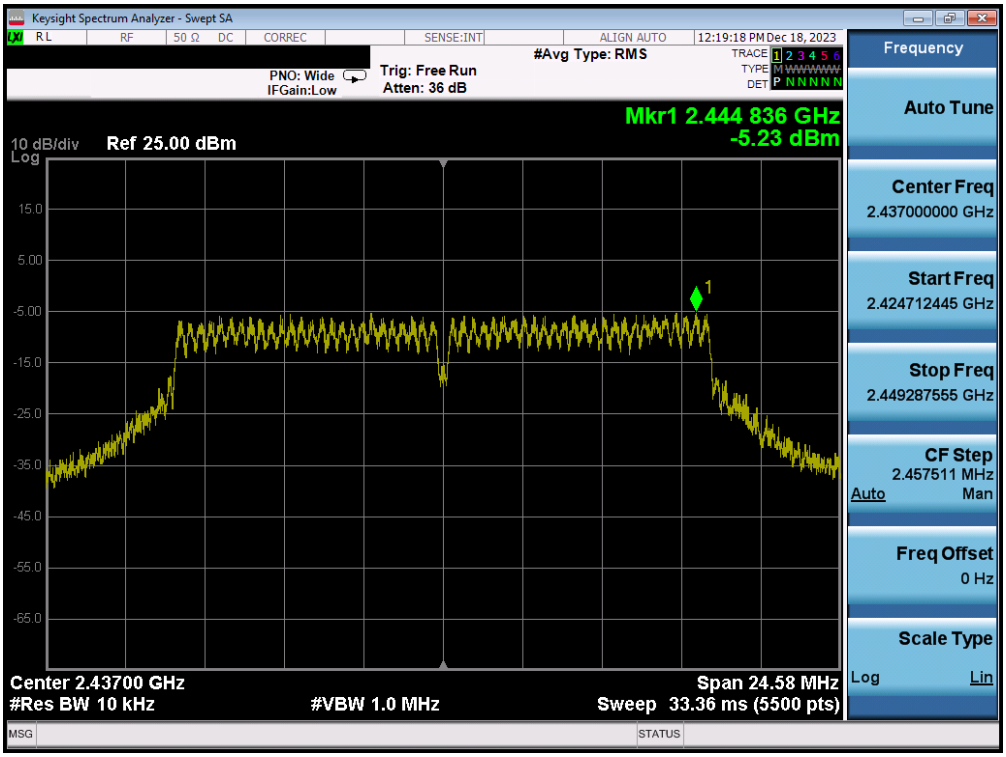
Plot 7-26. Power Spectral Density Plot (802.11b – Ch. 6) – MIMO ANT1



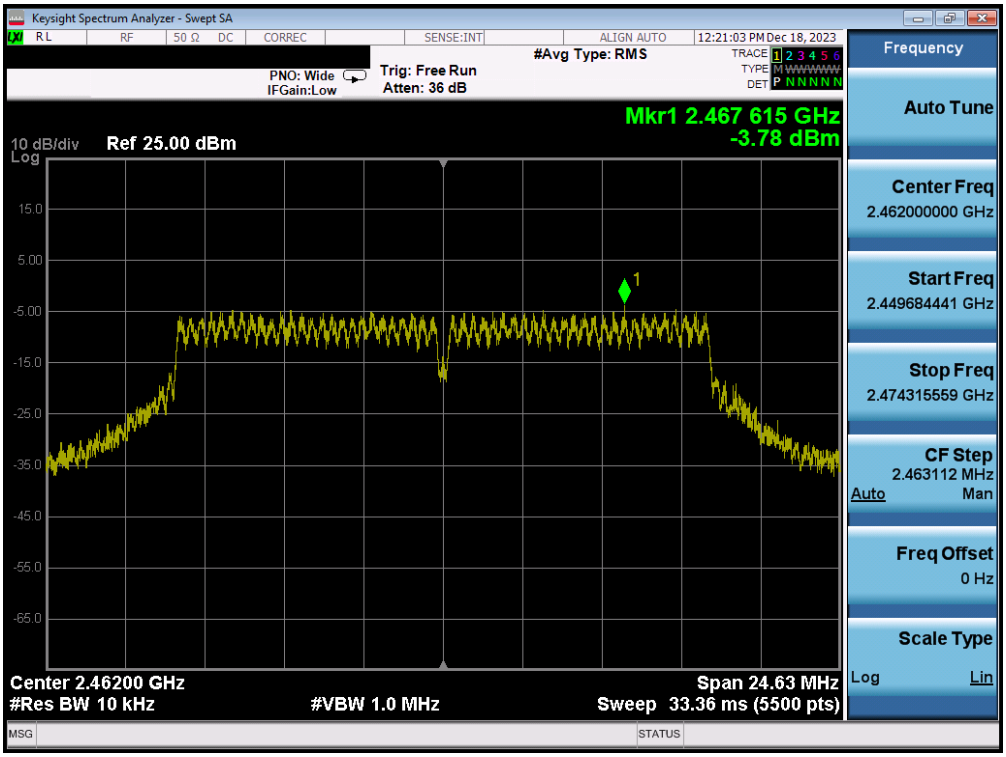
Plot 7-27. Power Spectral Density Plot (802.11b – Ch. 11) – MIMO ANT1



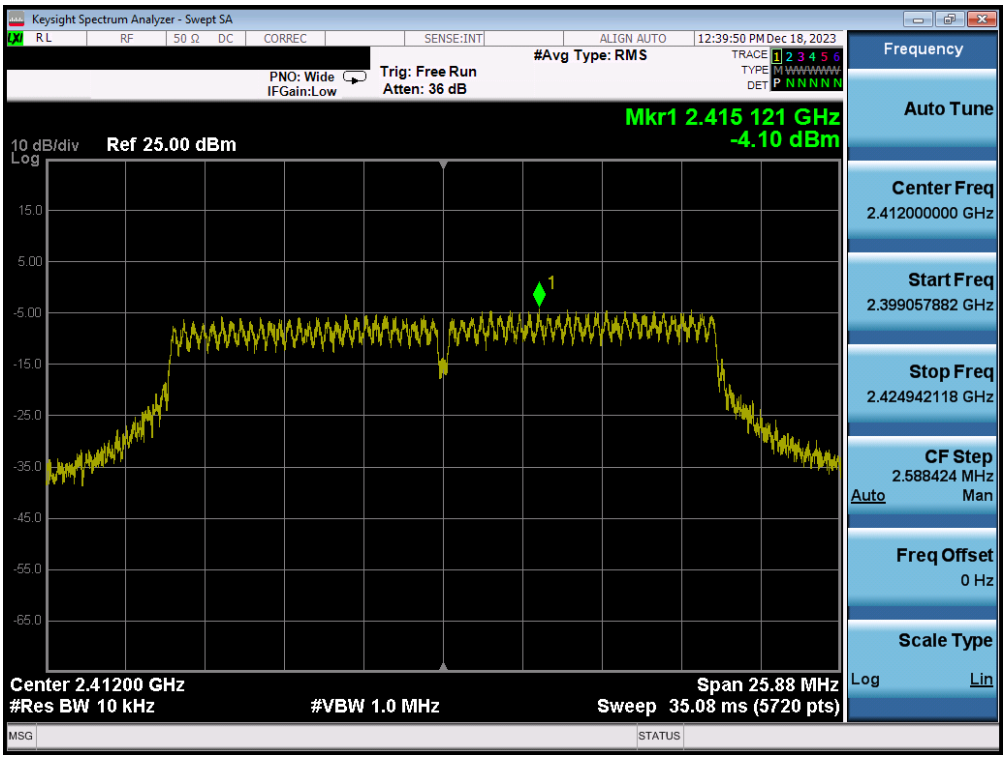
Plot 7-28. Power Spectral Density Plot (802.11g – Ch. 1) – MIMO ANT1



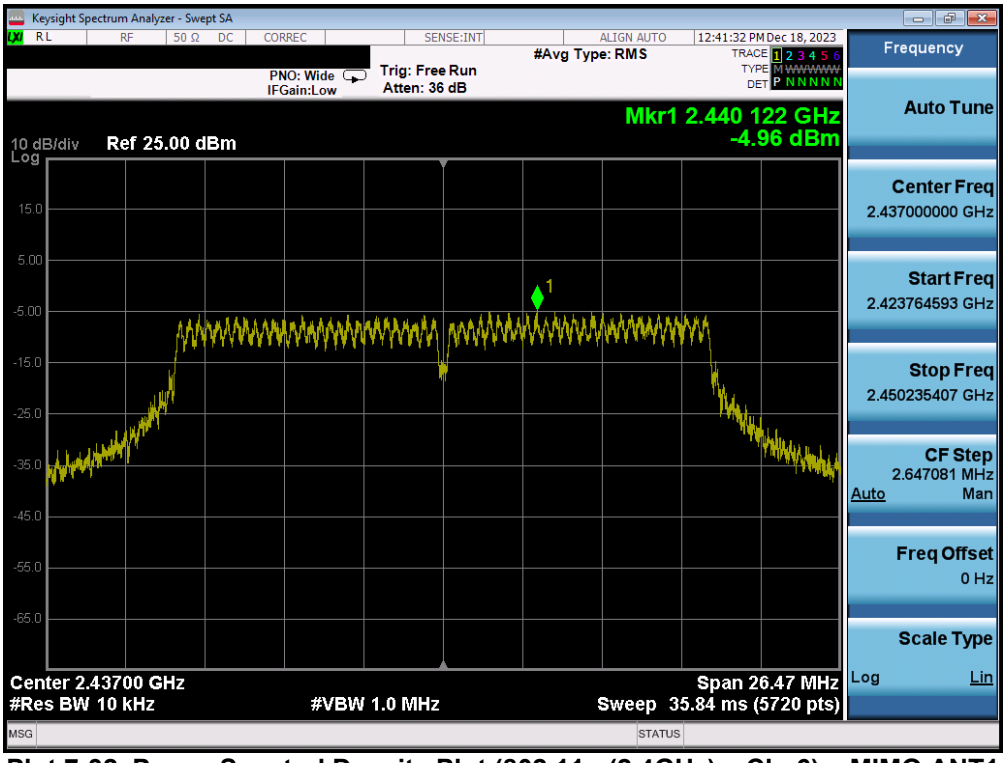
Plot 7-29. Power Spectral Density Plot (802.11g – Ch. 6) – MIMO ANT1



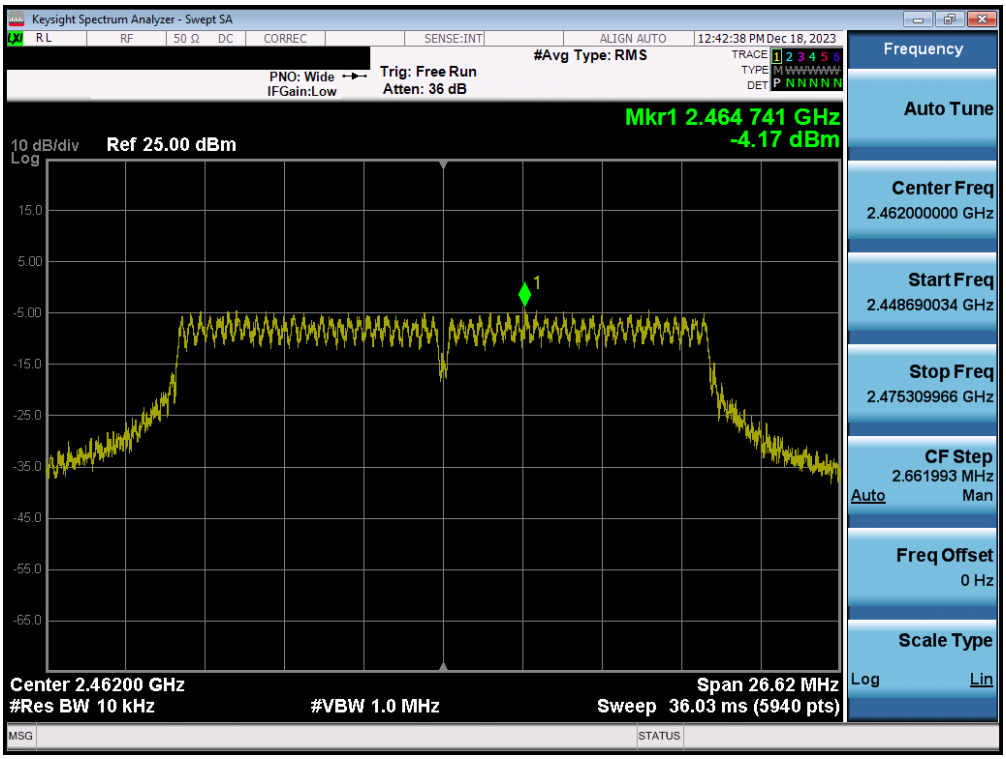
Plot 7-30. Power Spectral Density Plot (802.11g – Ch. 11) – MIMO ANT1



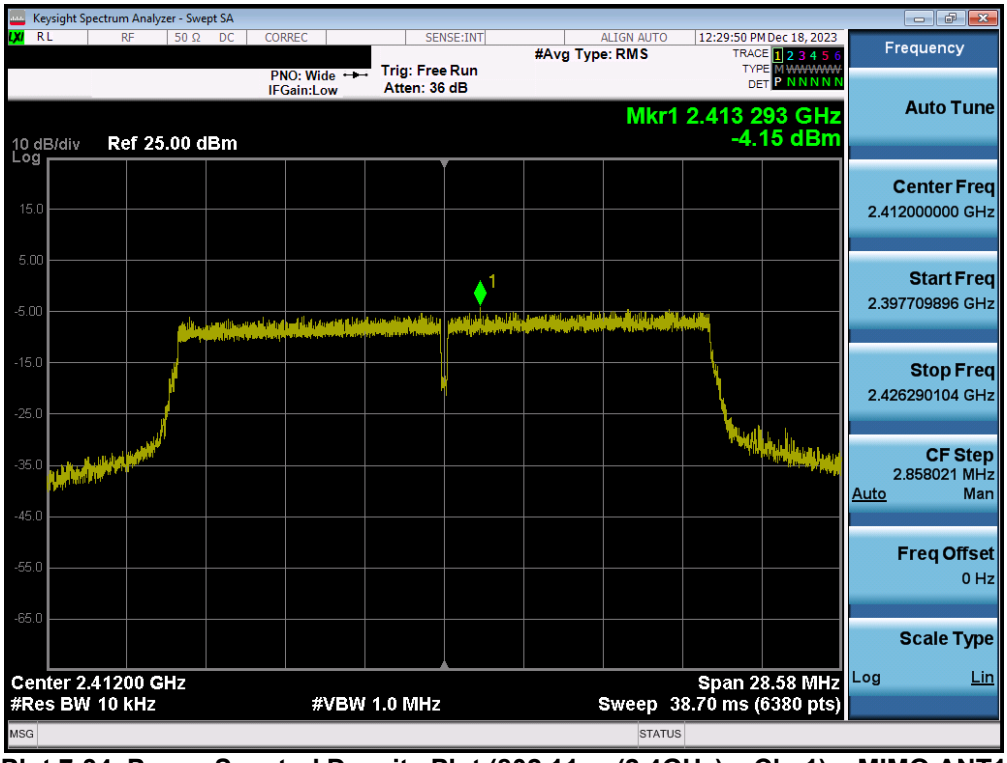
Plot 7-31. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT1



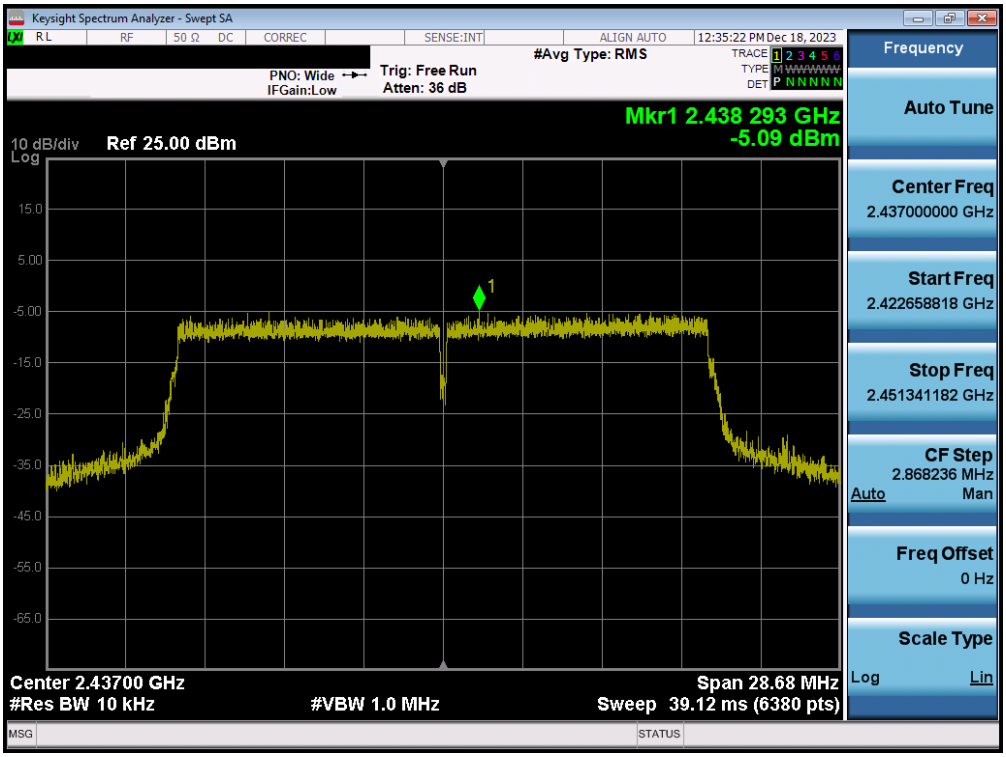
Plot 7-32. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 6) – MIMO ANT1



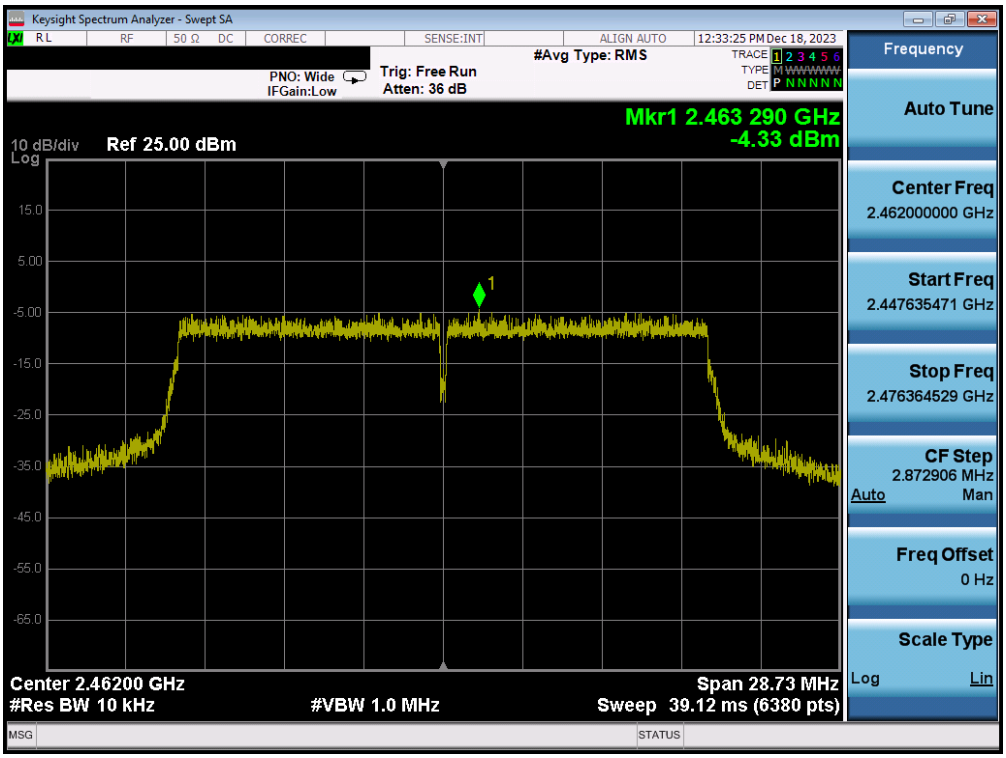
Plot 7-33. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT1



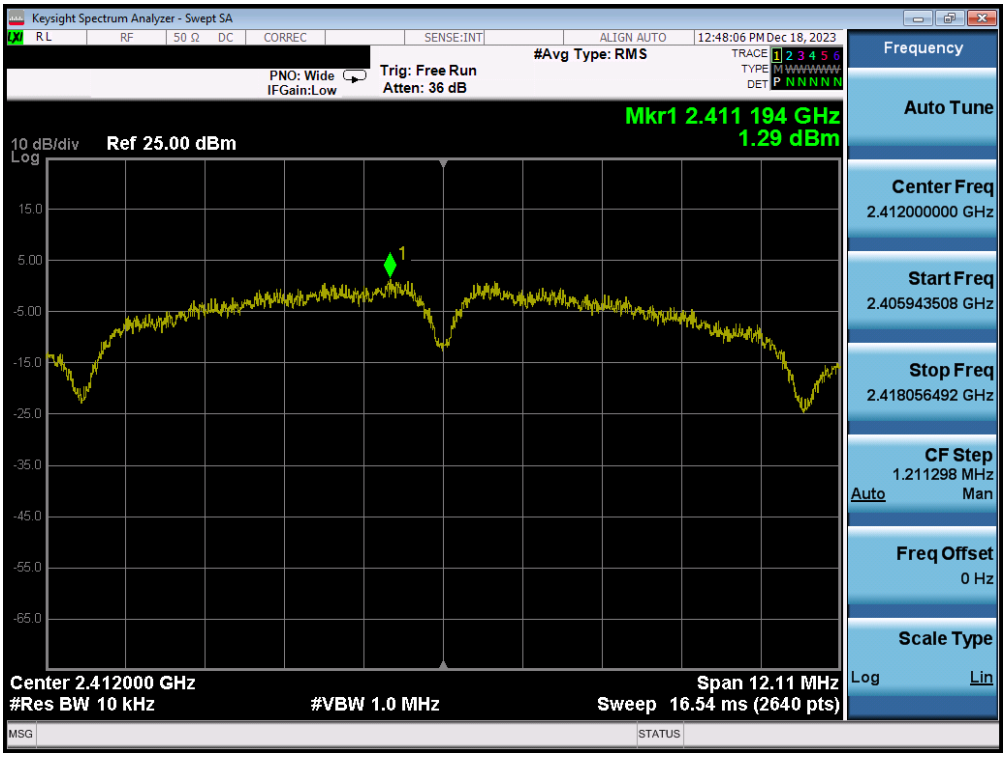
Plot 7-34. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT1



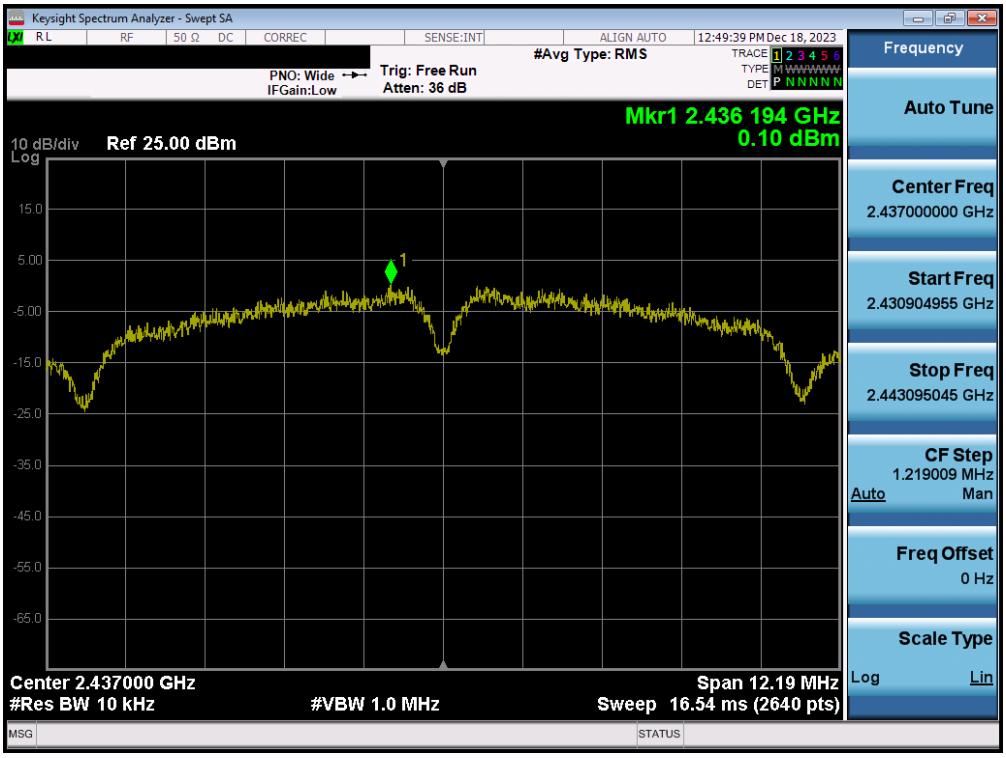
Plot 7-35. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 6) – MIMO ANT1



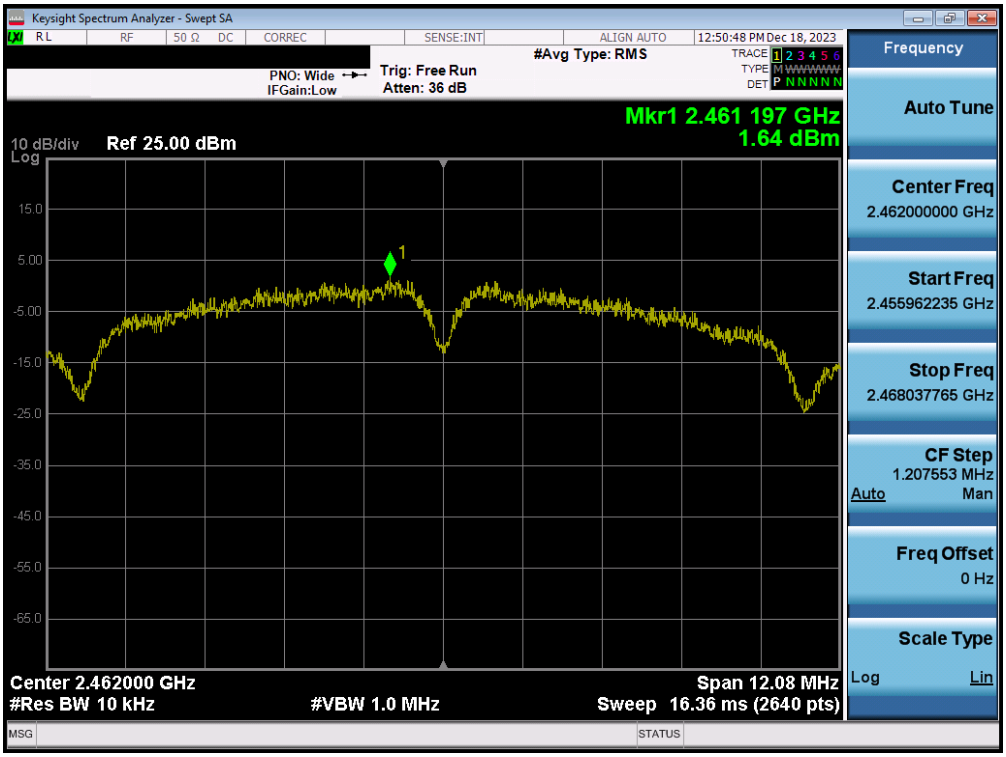
Plot 7-36. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT1



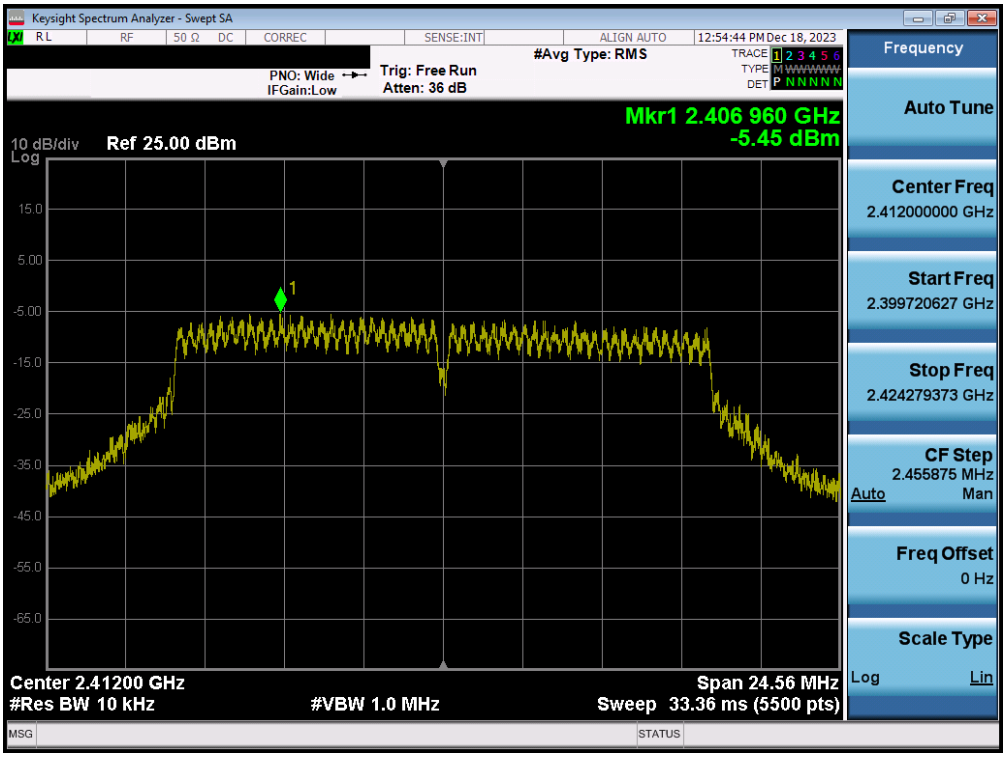
Plot 7-37. Power Spectral Density Plot (802.11b – Ch. 1) – MIMO ANT2



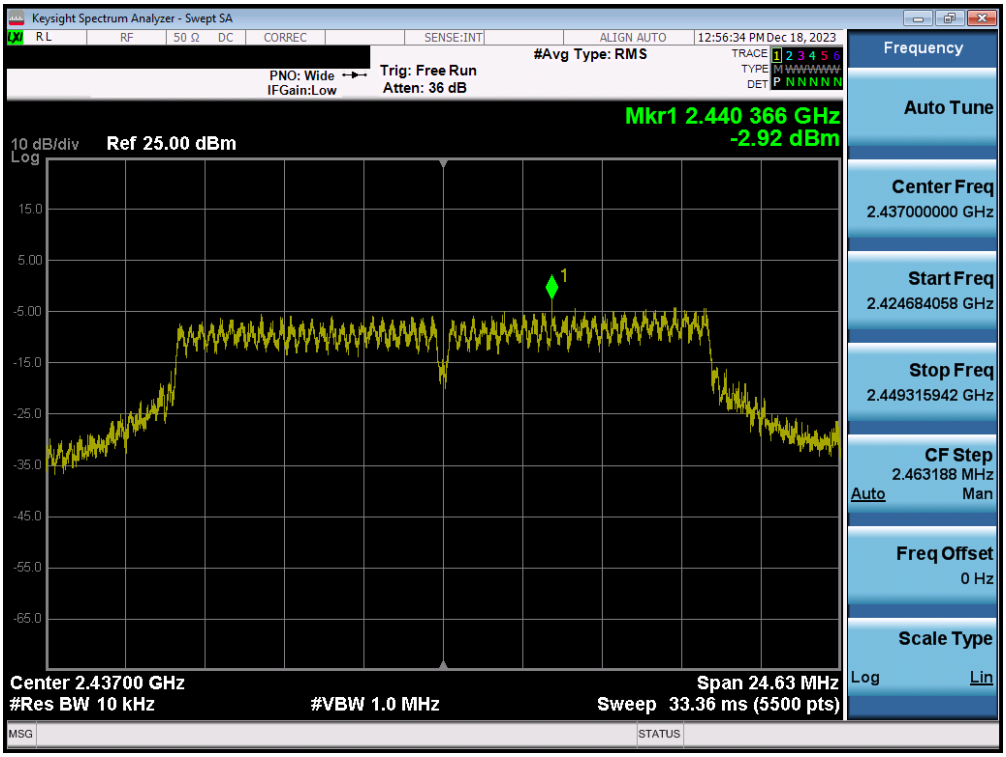
Plot 7-38. Power Spectral Density Plot (802.11b – Ch. 6) – MIMO ANT2



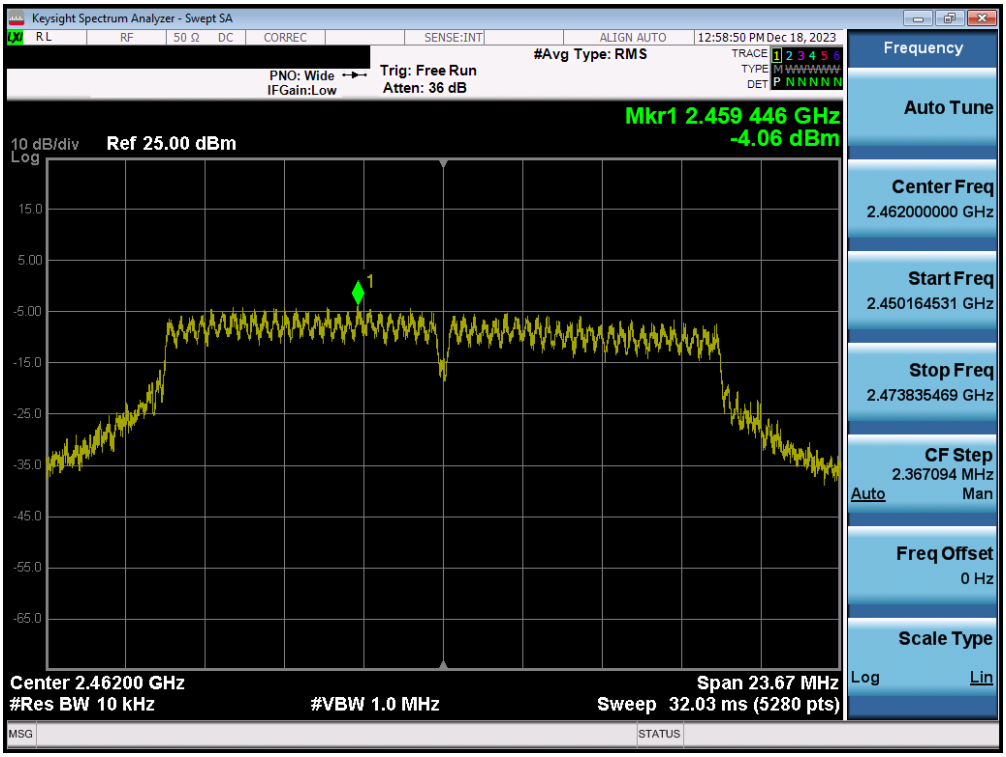
Plot 7-39. Power Spectral Density Plot (802.11b – Ch. 11) – MIMO ANT2



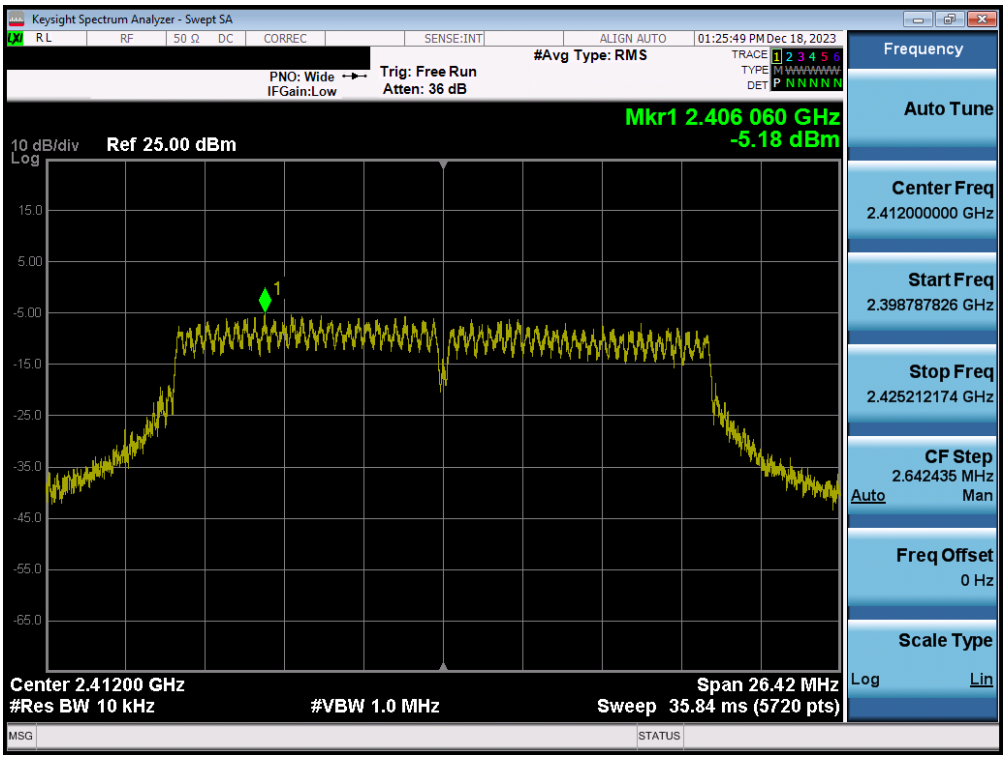
Plot 7-40. Power Spectral Density Plot (802.11g – Ch. 1) – MIMO ANT2



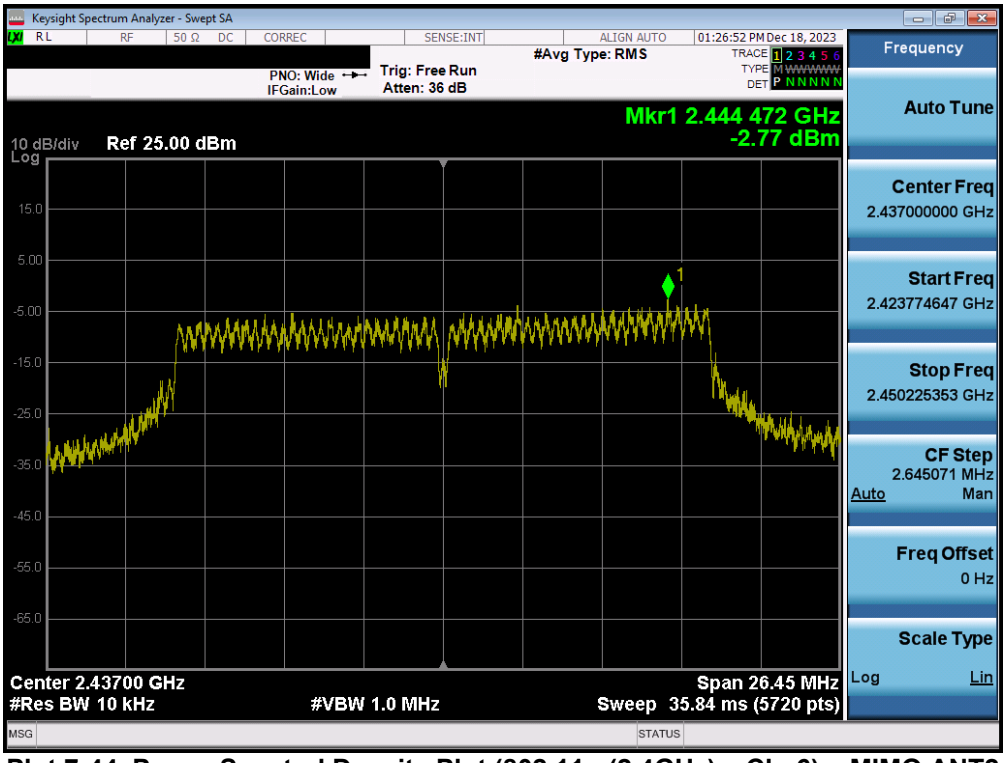
Plot 7-41. Power Spectral Density Plot (802.11g – Ch. 6) – MIMO ANT2



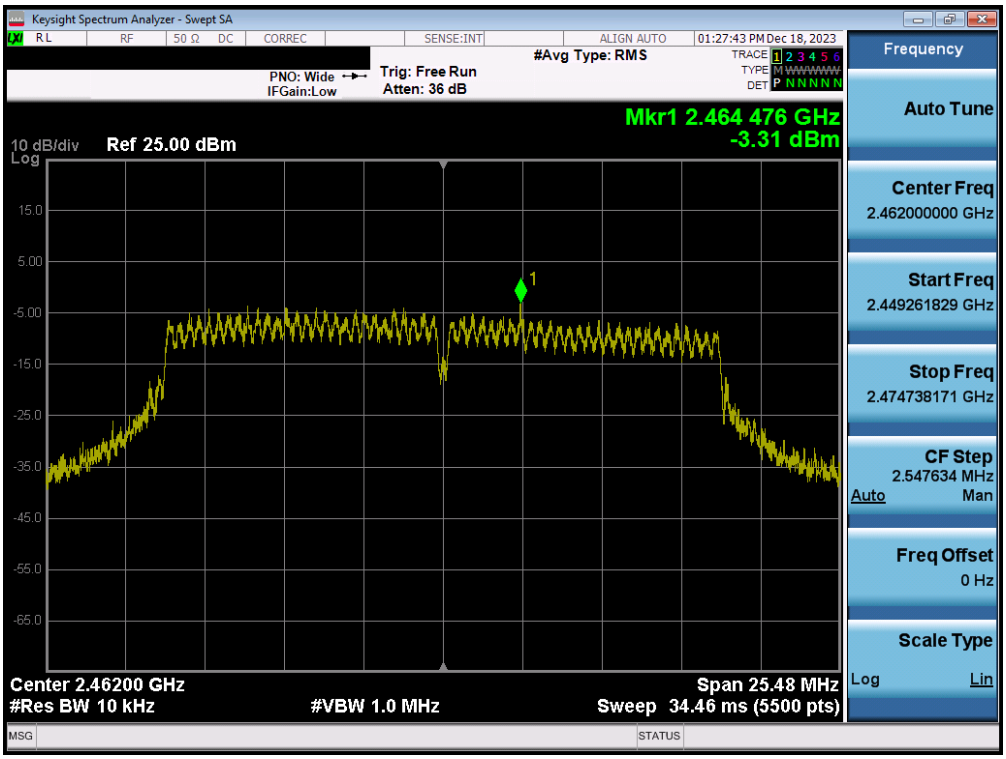
Plot 7-42. Power Spectral Density Plot (802.11g – Ch. 11) – MIMO ANT2



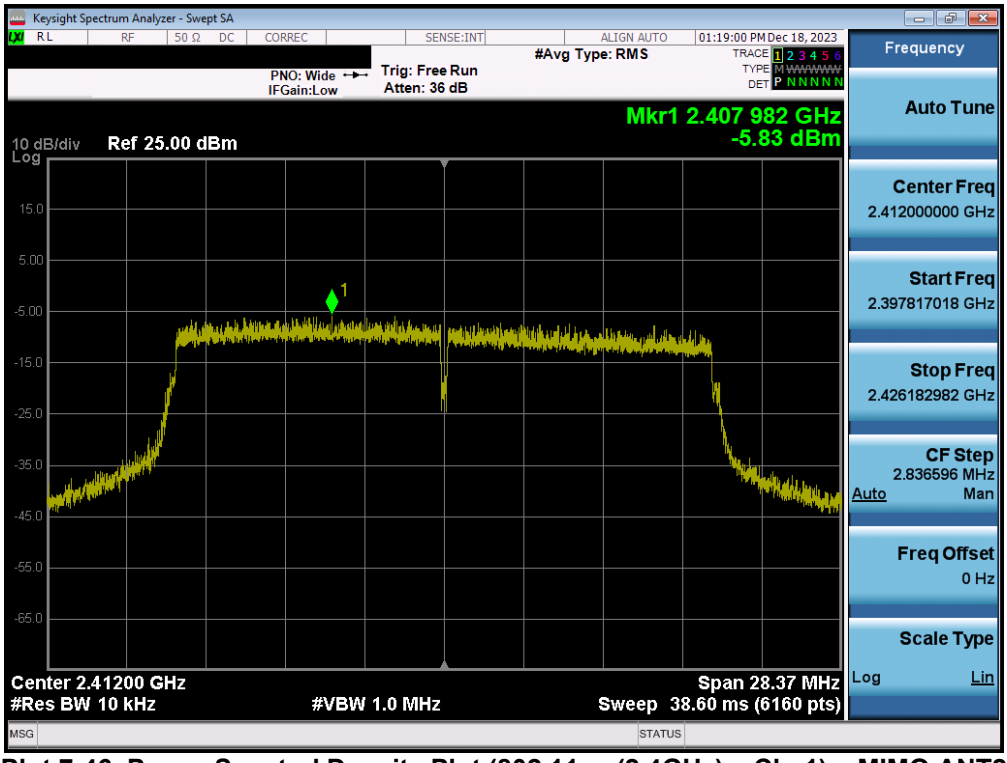
Plot 7-43. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT2



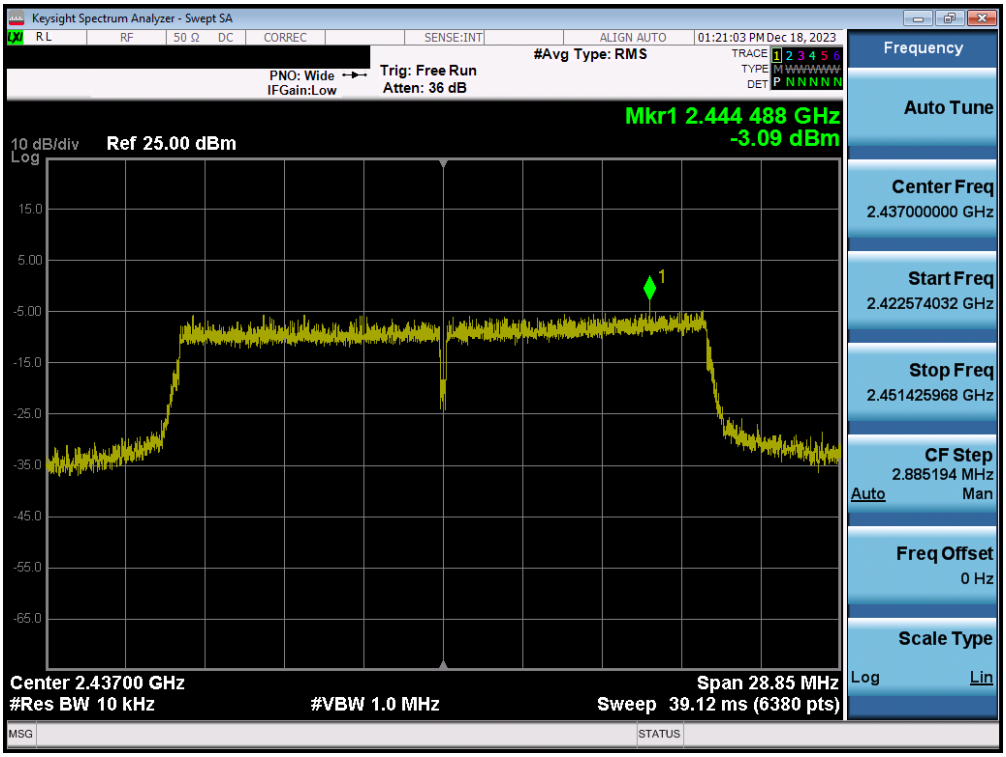
Plot 7-44. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 6) – MIMO ANT2



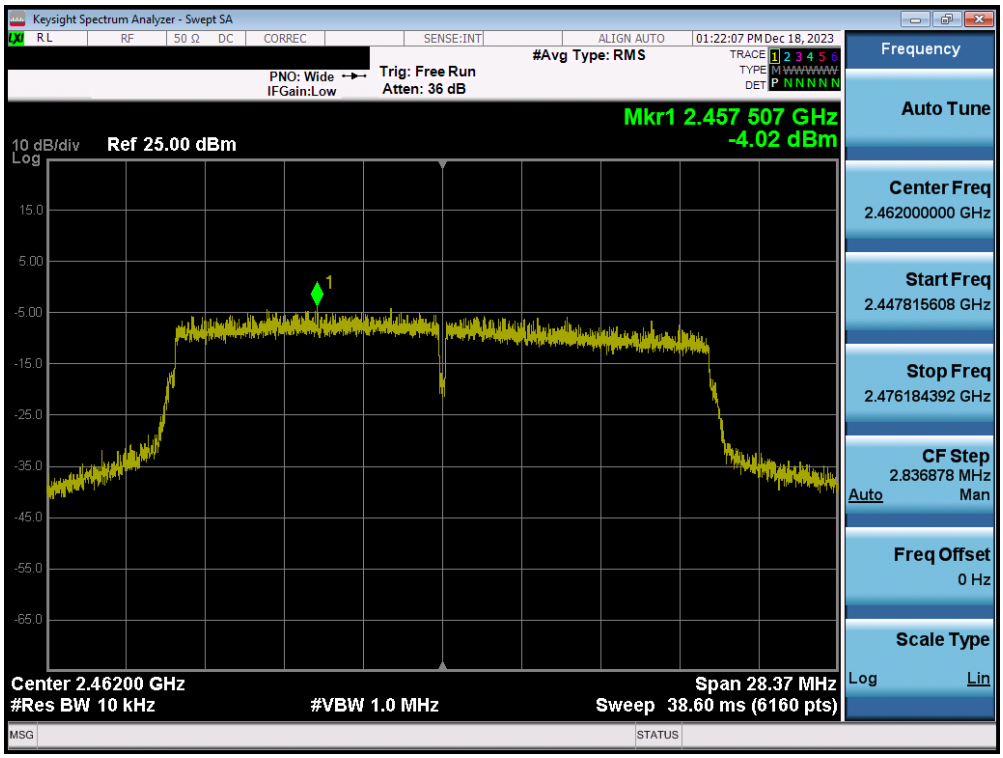
Plot 7-45. Power Spectral Density Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT2



Plot 7-46. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT2



Plot 7-47. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 6) – MIMO ANT2



Plot 7-48. Power Spectral Density Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT2

Note:

Per ANSI C63.10-2013 Section 14.3.1, the power spectral density at Antenna 1 and Antenna 2 were first measured separately as shown in the section above. The measured values were then summed in linear power units then converted back to dBm.

Sample MIMO Calculation:

At 2412MHz the average conducted power spectral density was measured to be 1.98 dBm for Antenna 1 and 1.29 dBm for Antenna 2.

Antenna 1 + Antenna 2 = MIMO

(1.98 dBm + 1.29 dBm) = (1.58 mW + 1.35 mW) = 2.93 mW = 4.66 dBm

7.5 Conducted Band Edge Emissions

Test Overview and Limit

All out of band emissions are measured with a spectrum analyzer connected to the antenna terminal of the EUT while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates were investigated to determine the worst-case configuration. For the following out of band conducted spurious emissions plots at the band edge, the EUT was set at a data rate of 1Mbps for “b” mode, 6 Mbps for “g” mode, 6.5\\7.2Mbps for “n” mode, and 8.6Mbps for “ax” mode as these settings produced the worst-case emissions.

The limit for out-of-band spurious emissions at the band edge is -20 dB below the fundamental emission level, as determined from the in-band power measurement of the DTS channel performed in a 100kHz bandwidth per the PSD procedure (Section 7.4).

Test Procedure Used

ANSI C63.10-2013 – Section 11.11.3

Test Settings

1. Start and stop frequency were set such that the band edge would be placed in the center of the plot
2. Span was set large enough so as to capture all out of band emissions near the band edge
3. RBW = 100kHz
4. VBW = 1MHz
5. Detector = Peak
6. Number of sweep points ≥ 2 x Span\\RBW
7. Trace mode = max hold
8. Sweep time = auto couple
9. The trace was allowed to stabilize

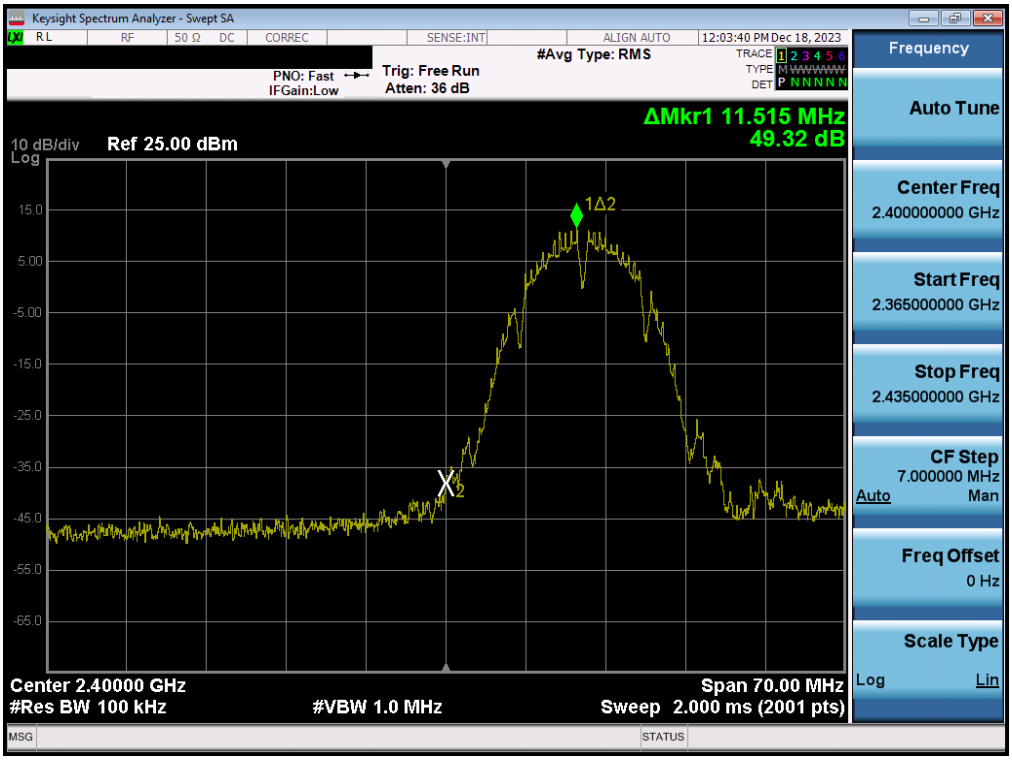
Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

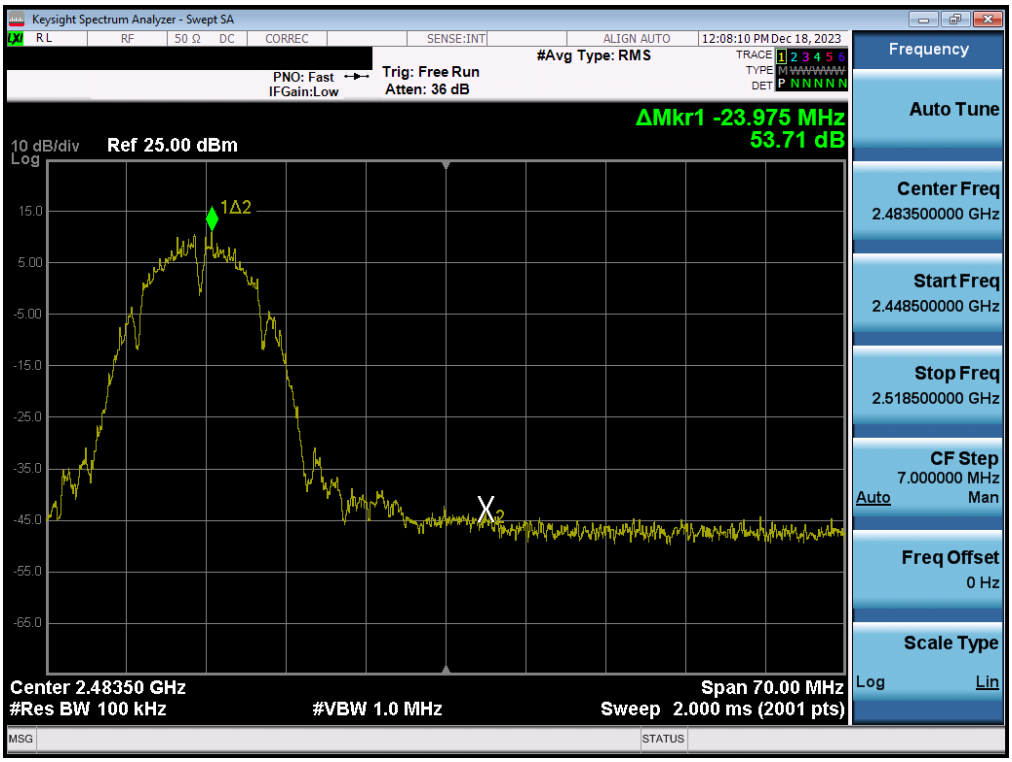
Figure 7-4. Test Instrument & Measurement Setup

Test Notes

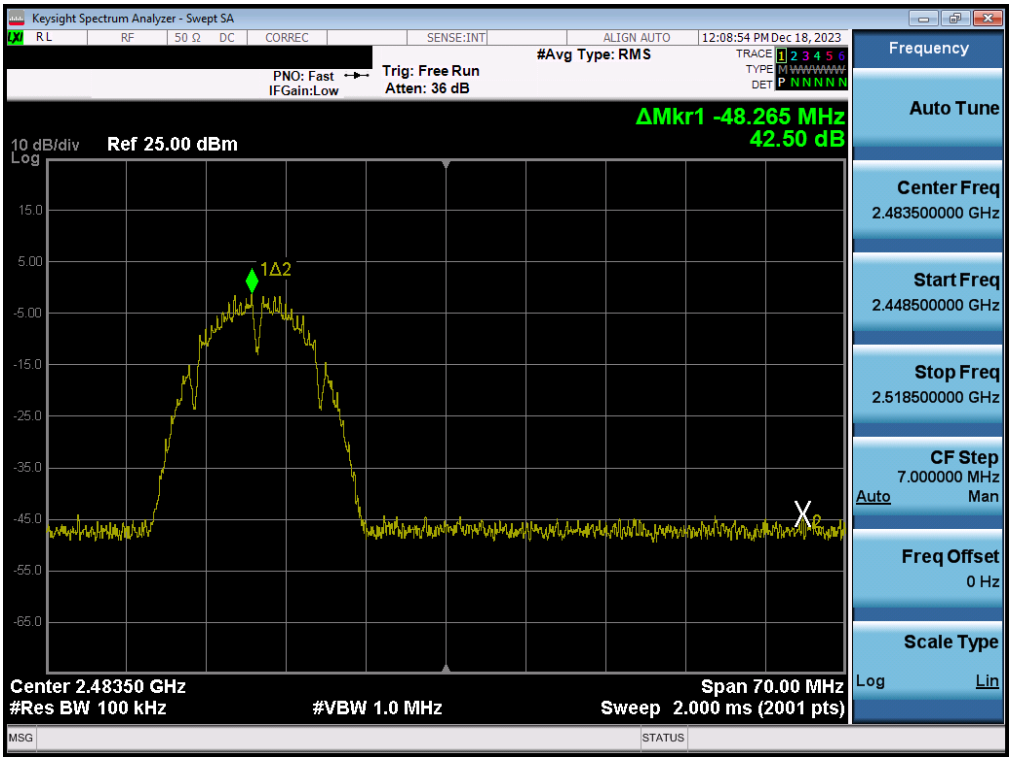
None.



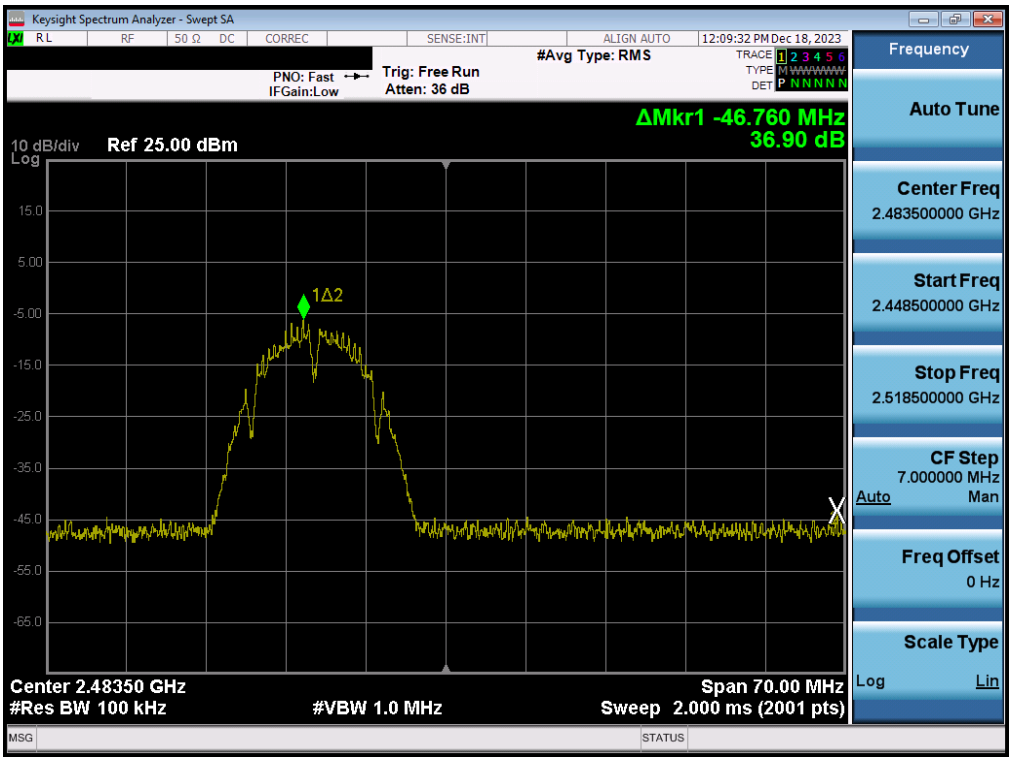
Plot 7-49. Band Edge Plot (802.11b – Ch. 1) – MIMO ANT1



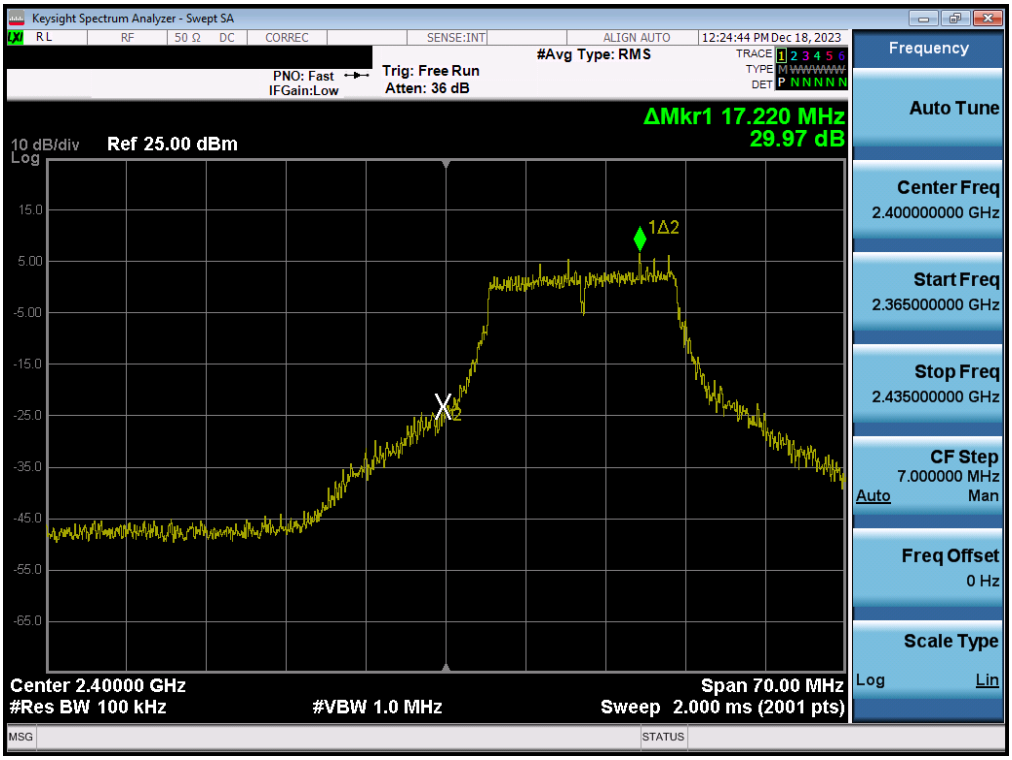
Plot 7-50. Band Edge Plot (802.11b – Ch. 11) – MIMO ANT1



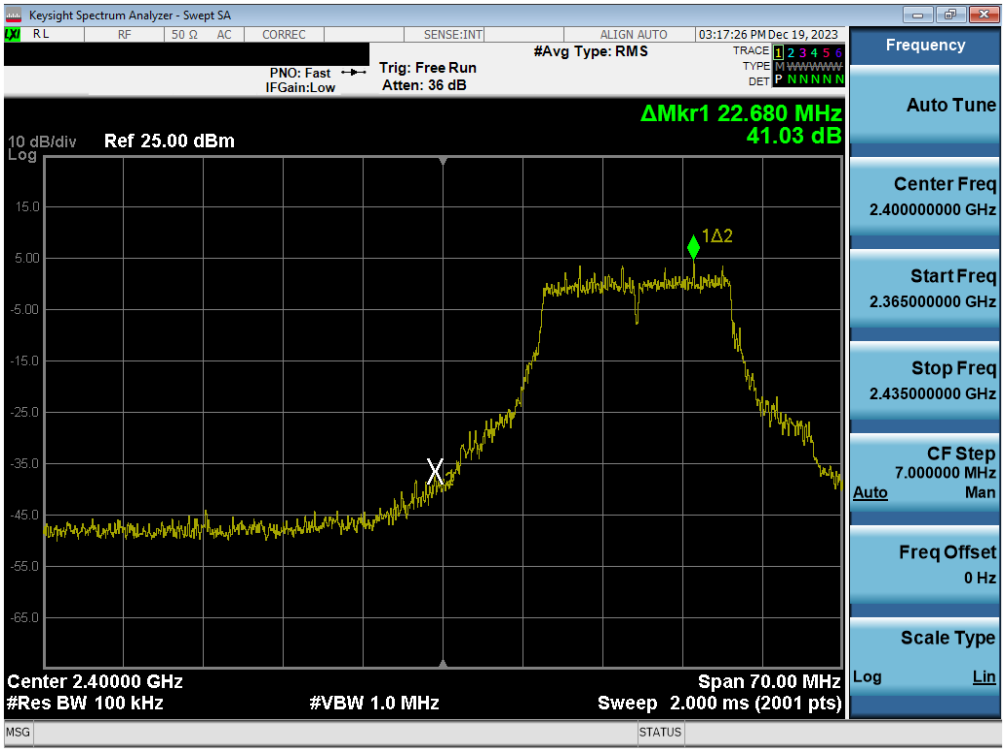
Plot 7-51. Band Edge Plot (802.11b – Ch. 12) – MIMO ANT1



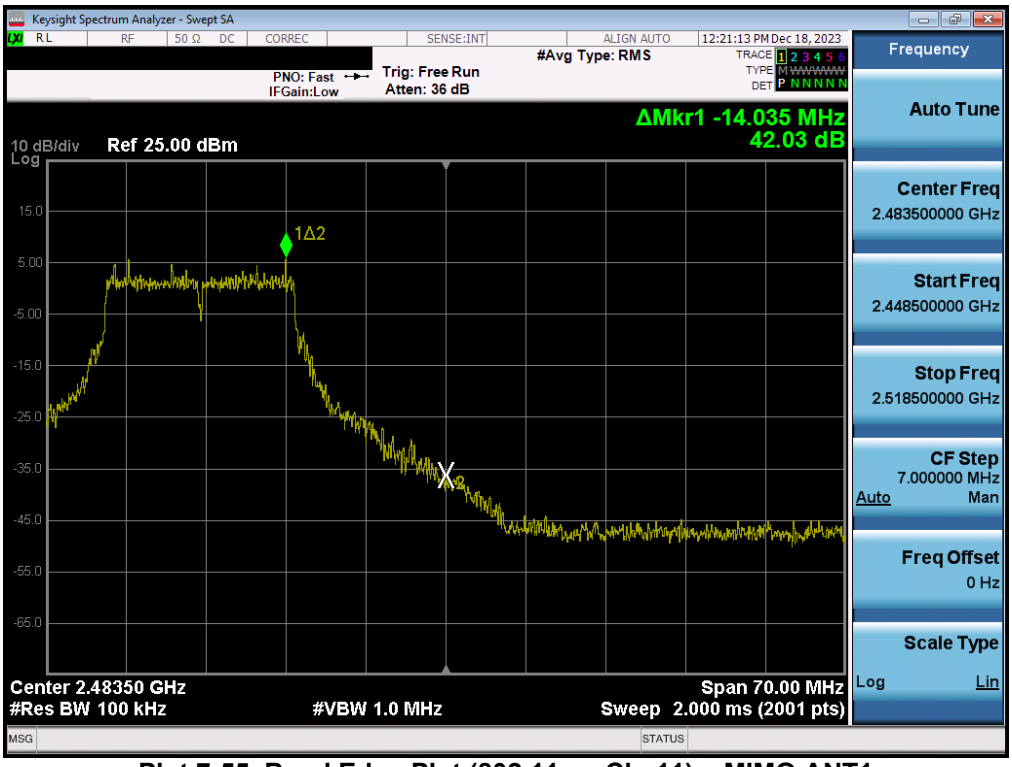
Plot 7-52. Band Edge Plot (802.11b – Ch. 13) – MIMO ANT1



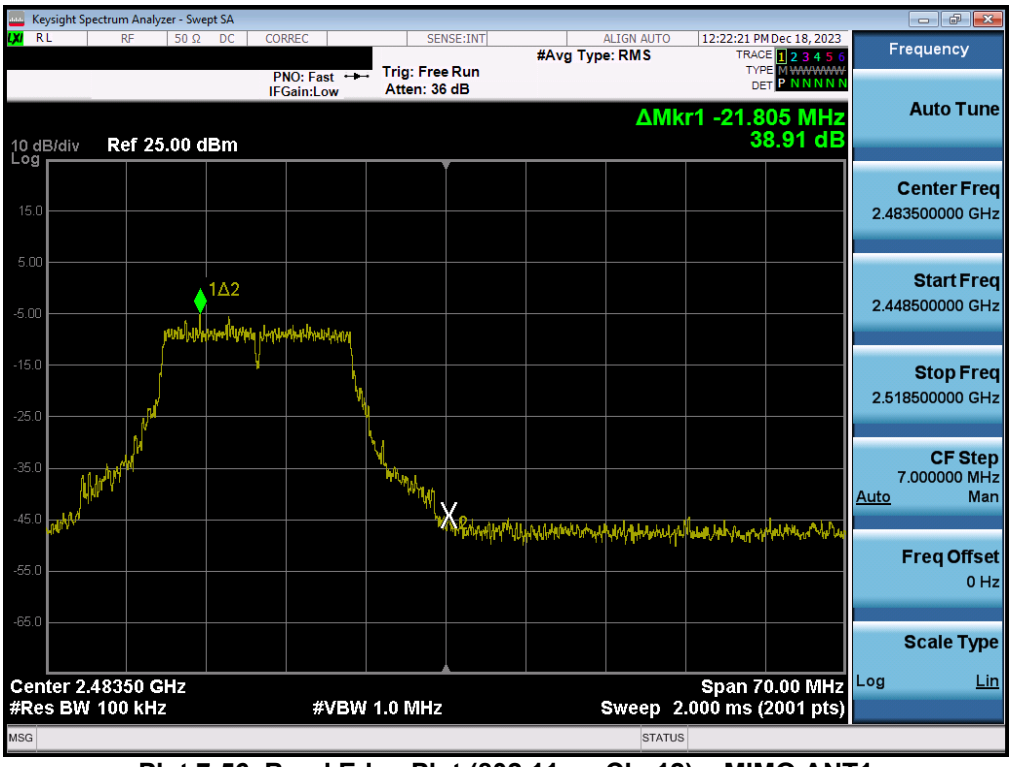
Plot 7-53. Band Edge Plot (802.11g– Ch. 1) – MIMO ANT1



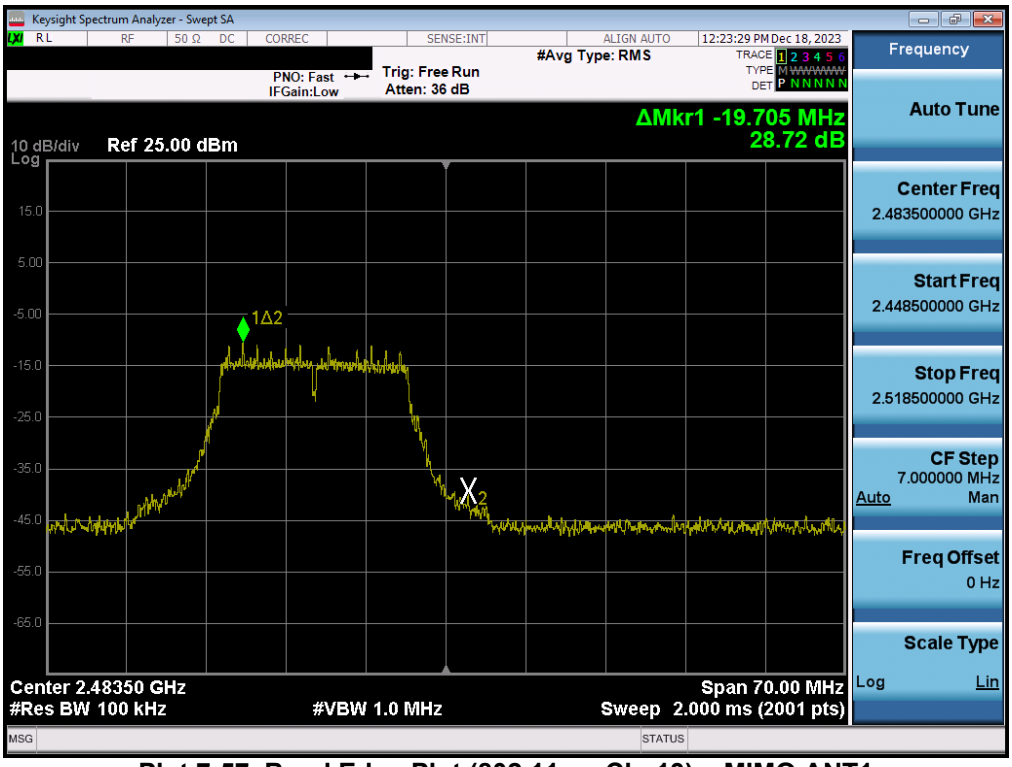
Plot 7-54. Band Edge Plot (802.11g– Ch. 2) – MIMO ANT1



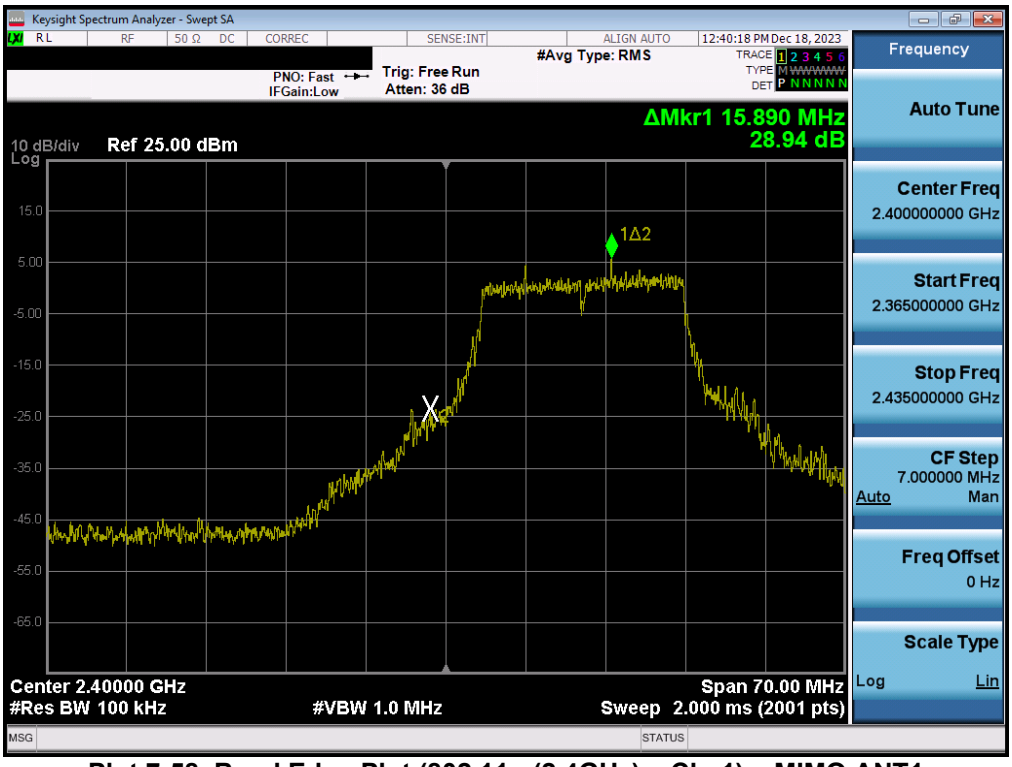
Plot 7-55. Band Edge Plot (802.11g – Ch. 11) – MIMO ANT1



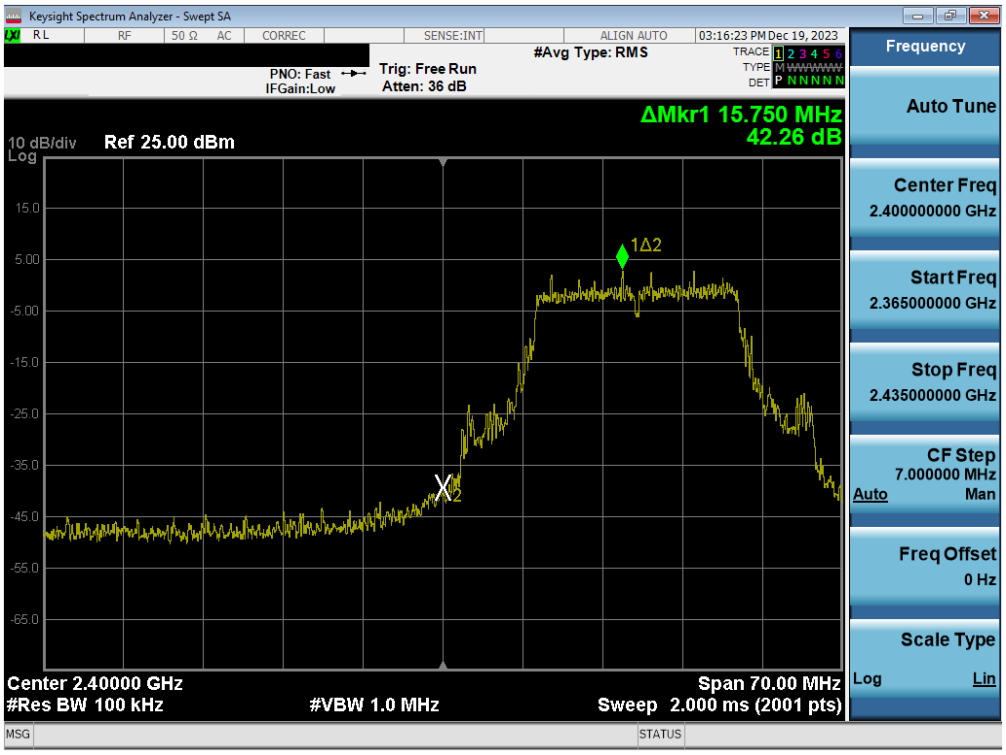
Plot 7-56. Band Edge Plot (802.11g – Ch. 12) – MIMO ANT1



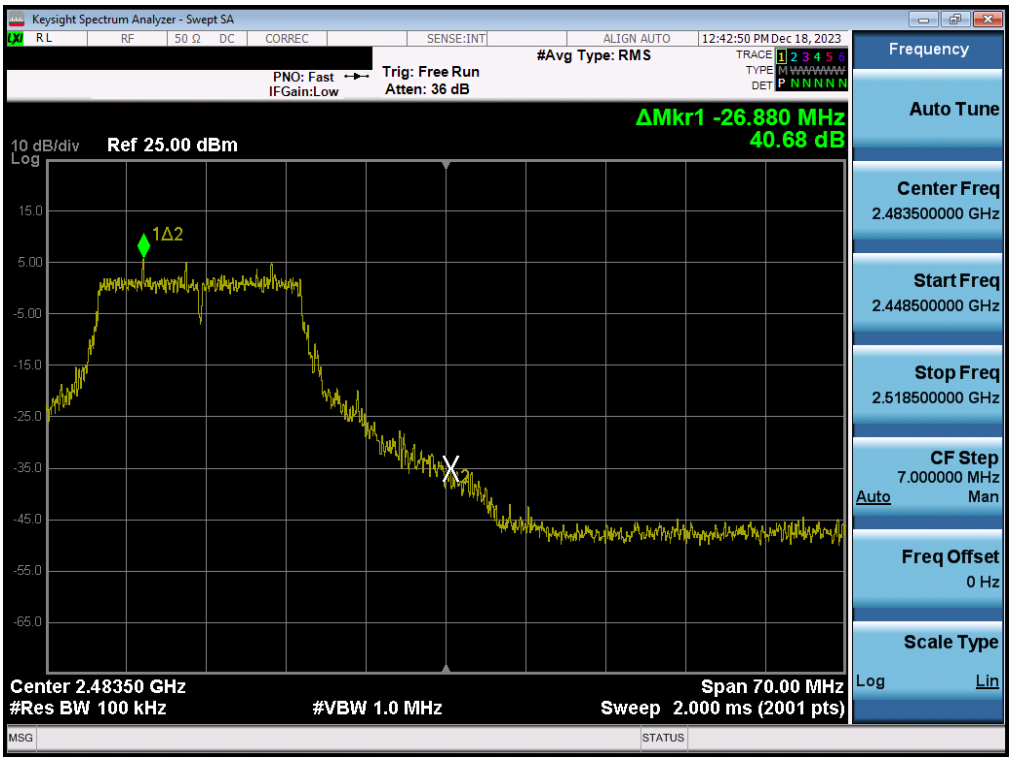
Plot 7-57. Band Edge Plot (802.11g – Ch. 13) – MIMO ANT1



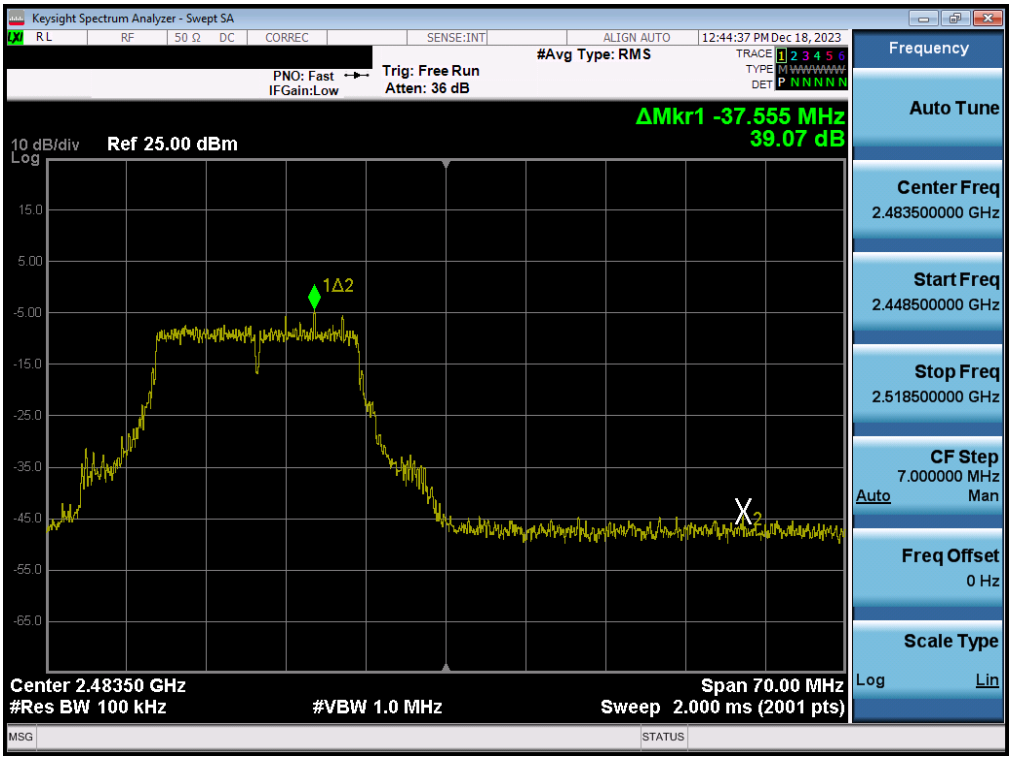
Plot 7-58. Band Edge Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT1



Plot 7-59. Band Edge Plot (802.11n (2.4GHz) – Ch. 2) – MIMO ANT1

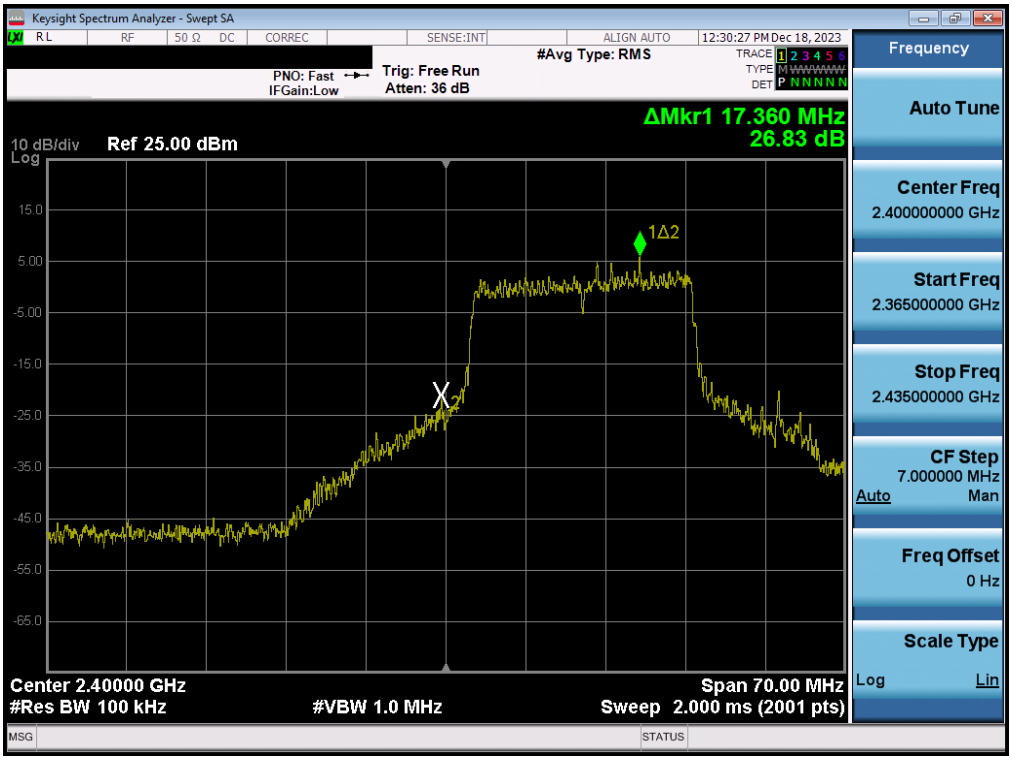


Plot 7-60. Band Edge Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT1

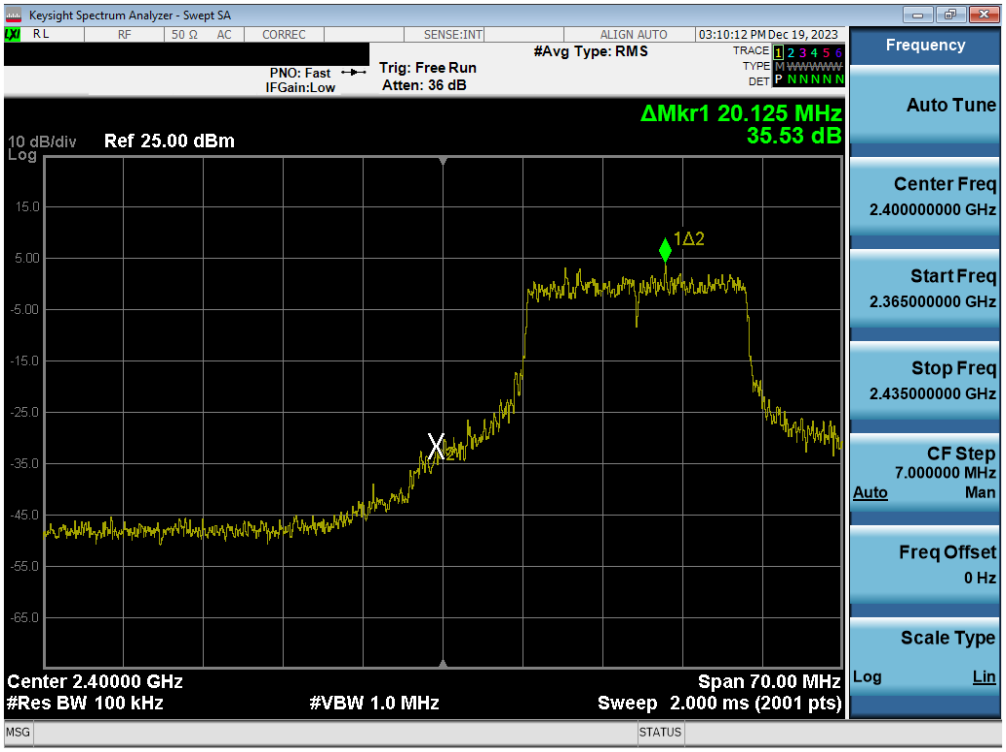


Plot 7-61. Band Edge Plot (802.11n (2.4GHz) – Ch. 12) – MIMO ANT1

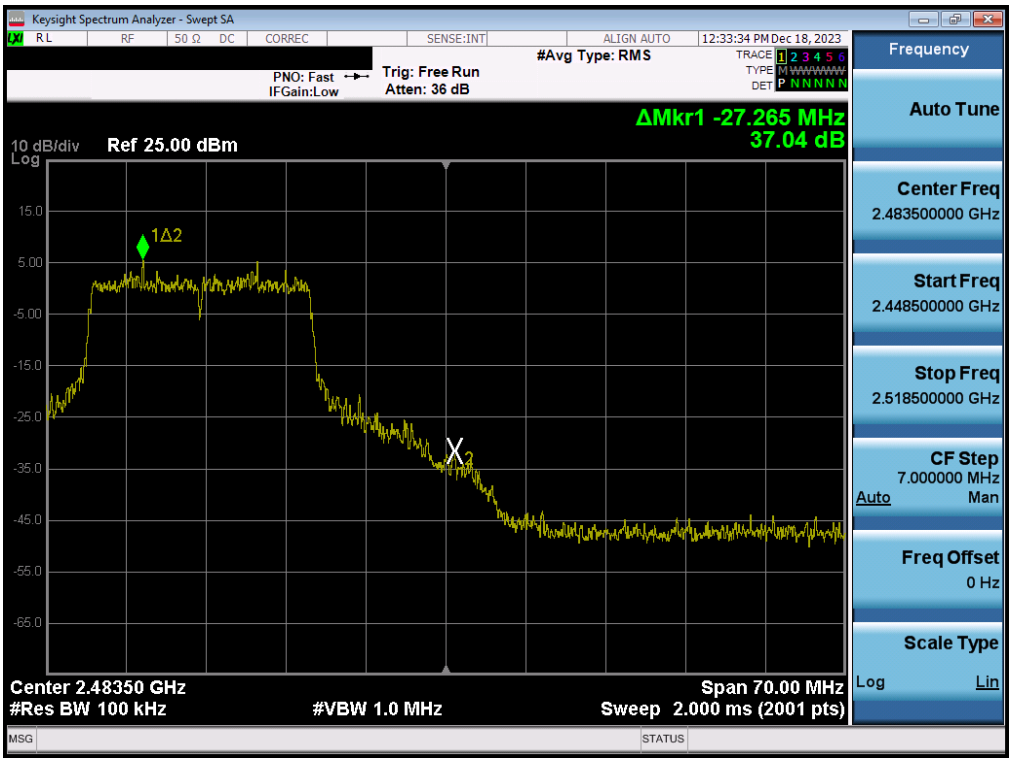
Plot 7-62. Band Edge Plot (802.11n (2.4GHz) – Ch. 13) – MIMO ANT1



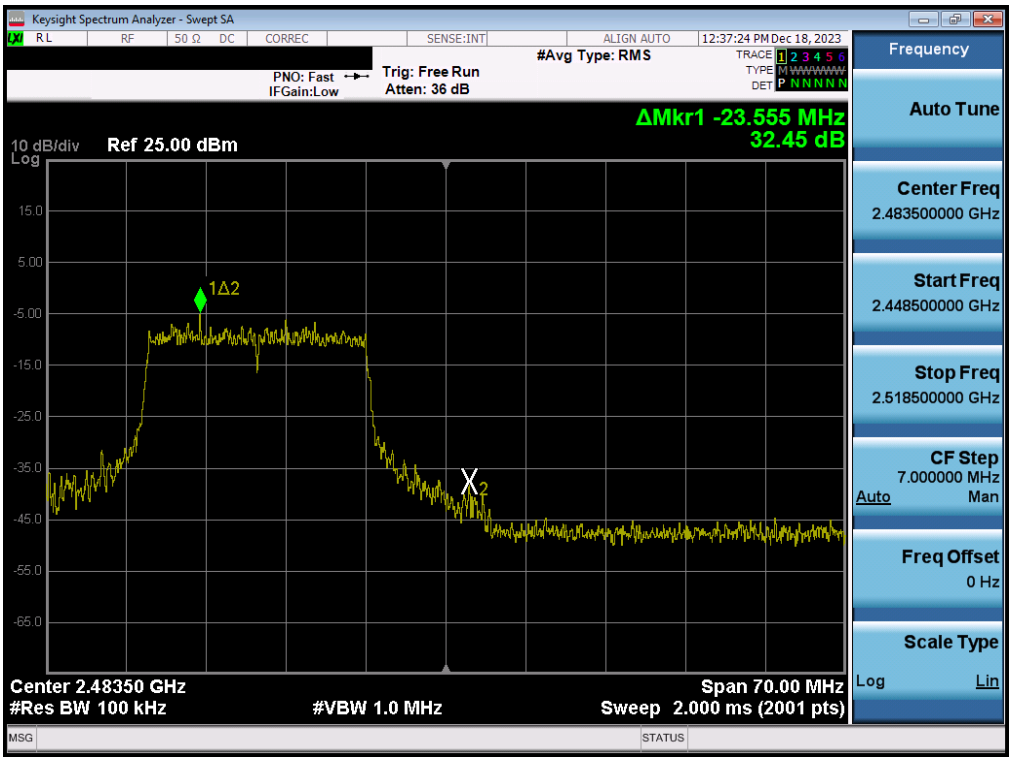
Plot 7-63. Band Edge Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT1



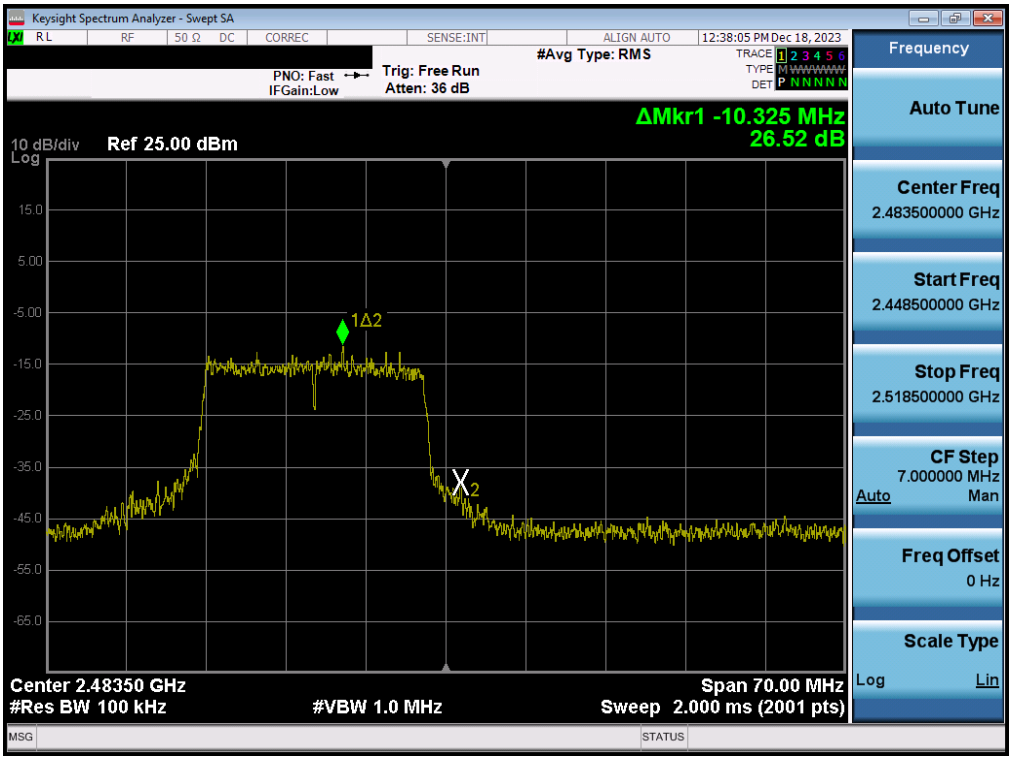
Plot 7-64. Band Edge Plot (802.11ax (2.4GHz) – Ch. 2) – MIMO ANT1



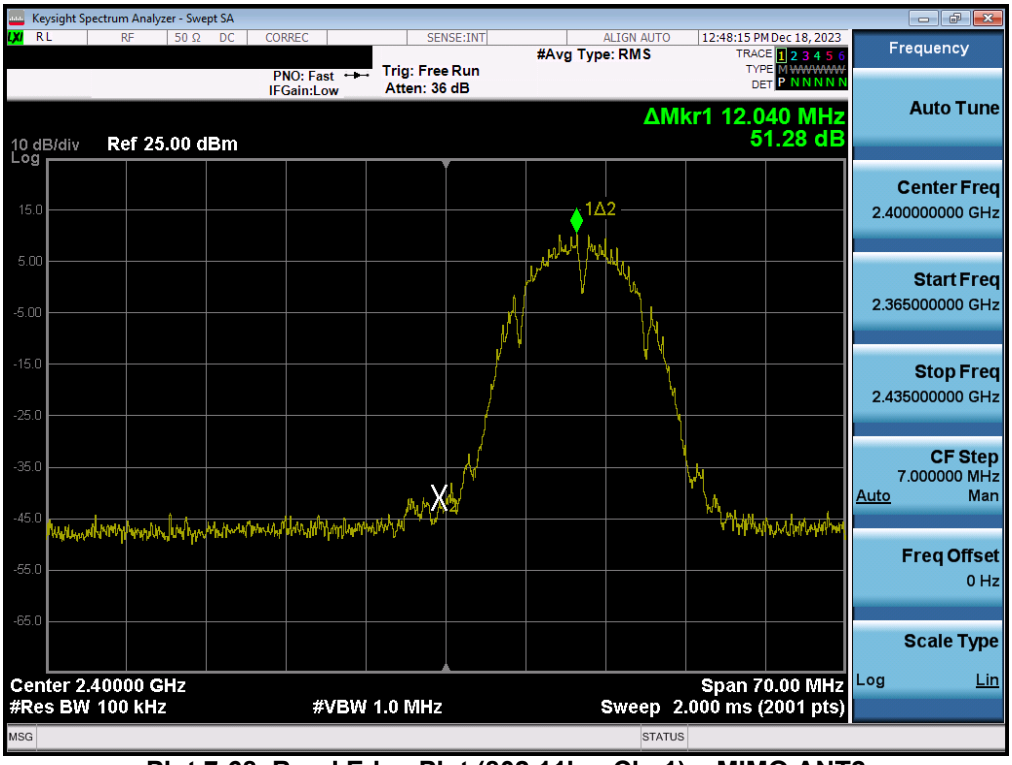
Plot 7-65. Band Edge Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT1



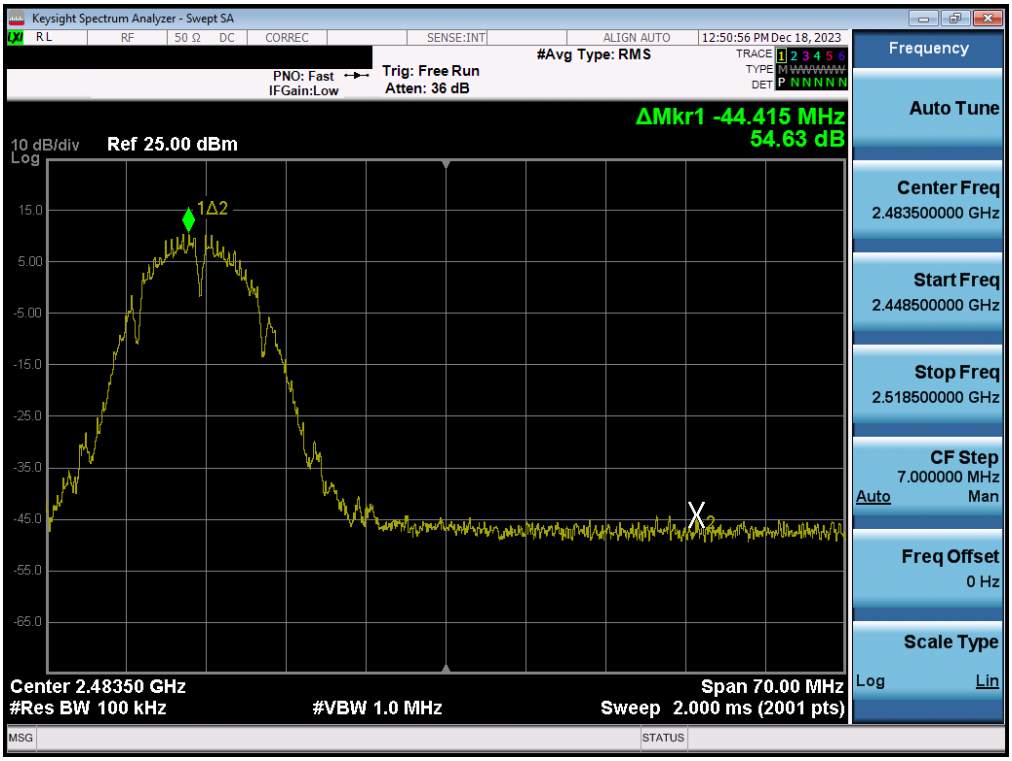
Plot 7-66. Band Edge Plot (802.11ax (2.4GHz) – Ch. 12) – MIMO ANT1



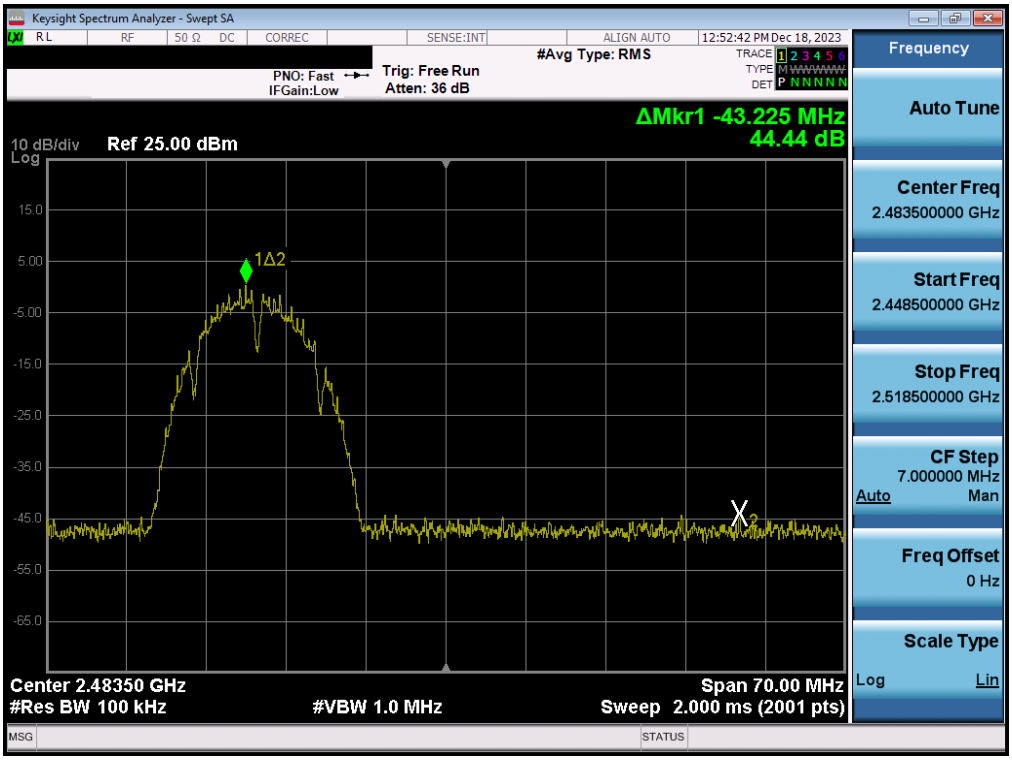
Plot 7-67. Band Edge Plot (802.11ax (2.4GHz) – Ch. 13) – MIMO ANT1



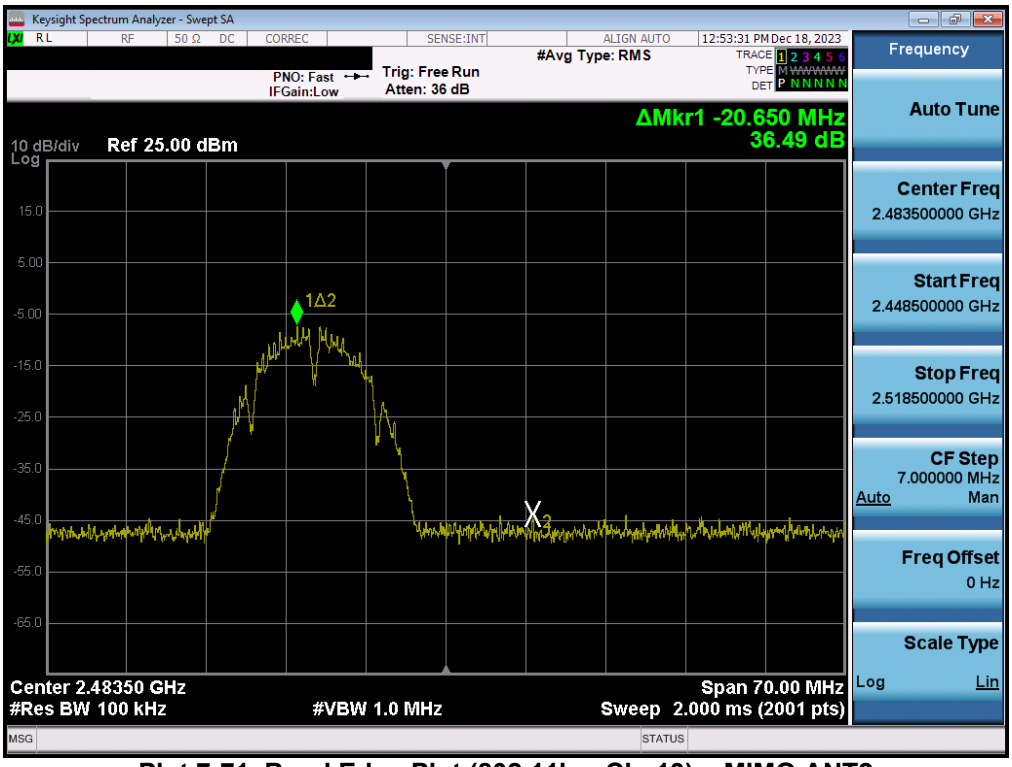
Plot 7-68. Band Edge Plot (802.11b – Ch. 1) – MIMO ANT2



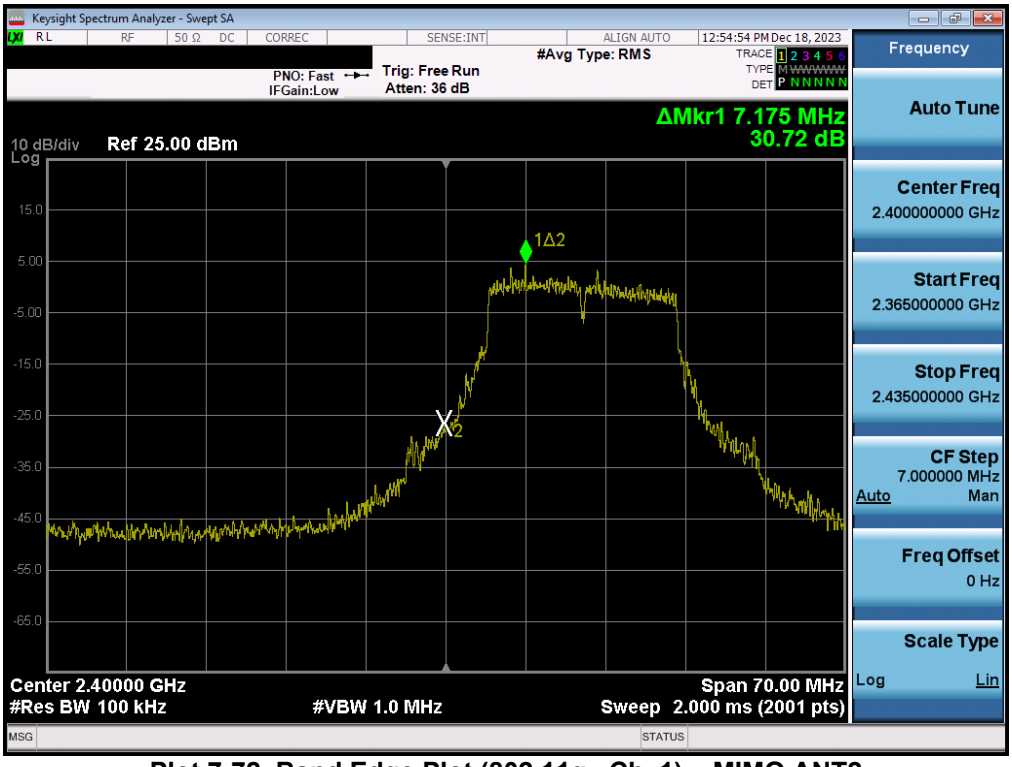
Plot 7-69. Band Edge Plot (802.11b – Ch. 11) – MIMO ANT2



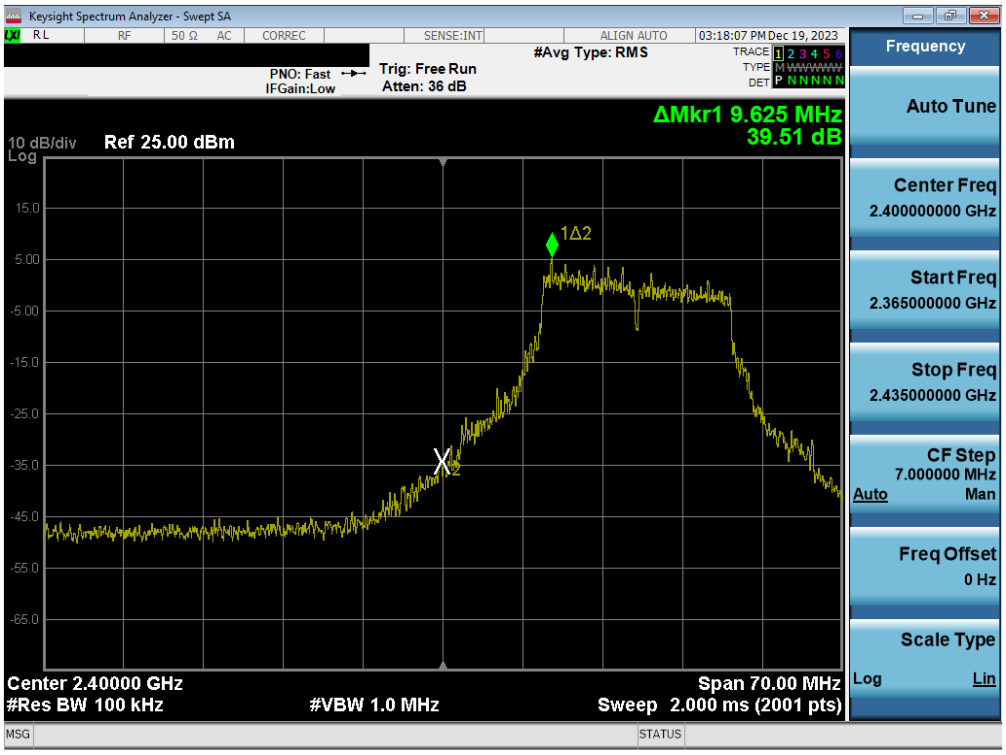
Plot 7-70. Band Edge Plot (802.11b – Ch. 12) – MIMO ANT2



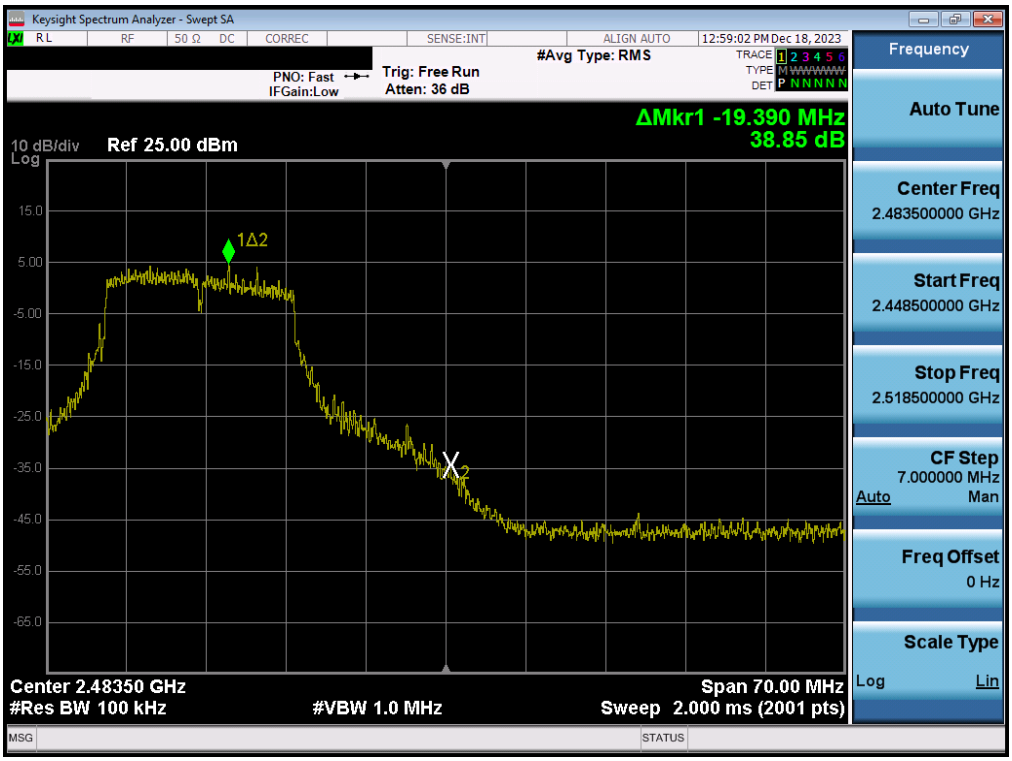
Plot 7-71. Band Edge Plot (802.11b – Ch. 13) – MIMO ANT2



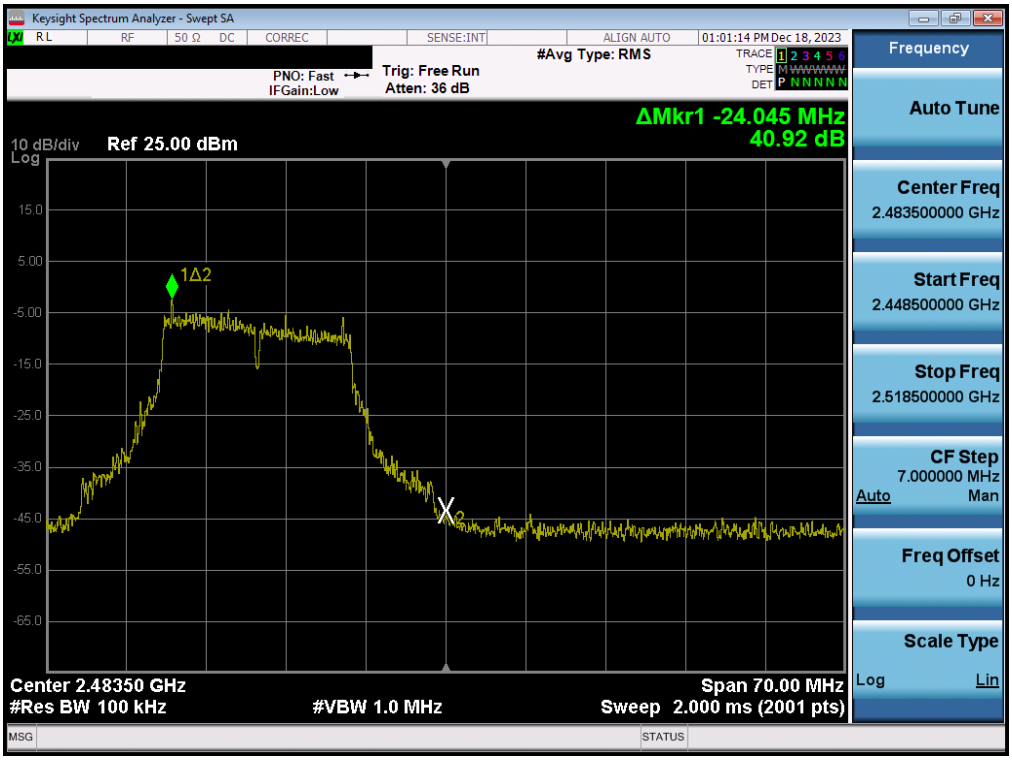
Plot 7-72. Band Edge Plot (802.11g– Ch. 1) – MIMO ANT2



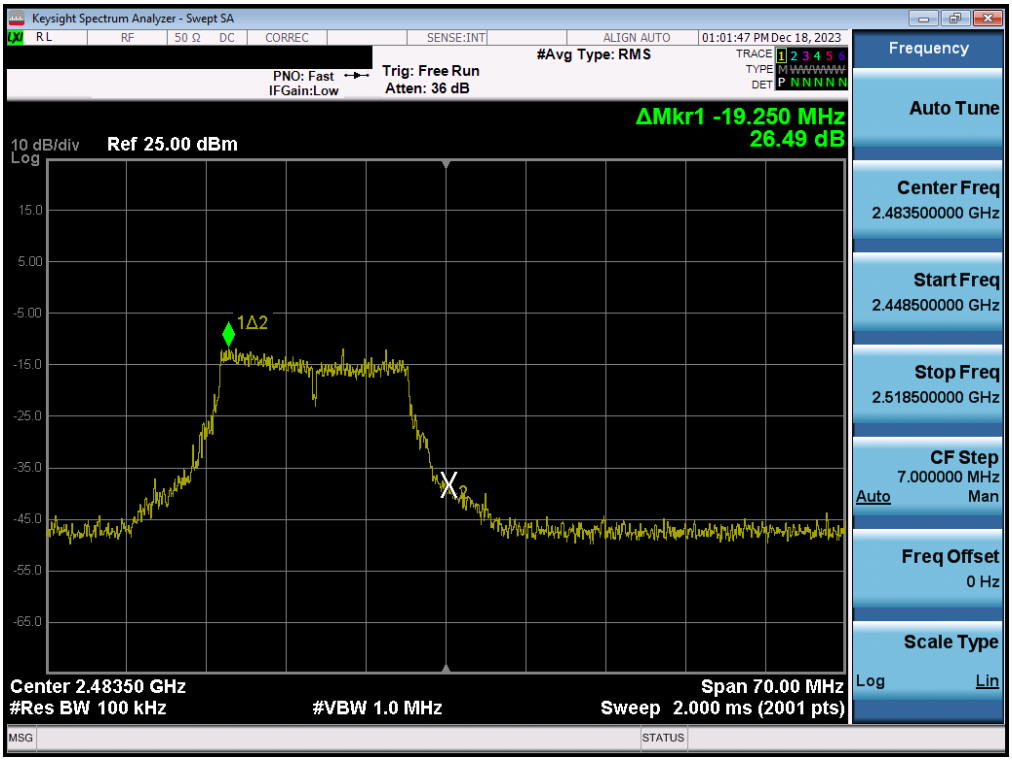
Plot 7-73. Band Edge Plot (802.11g– Ch. 2) – MIMO ANT2



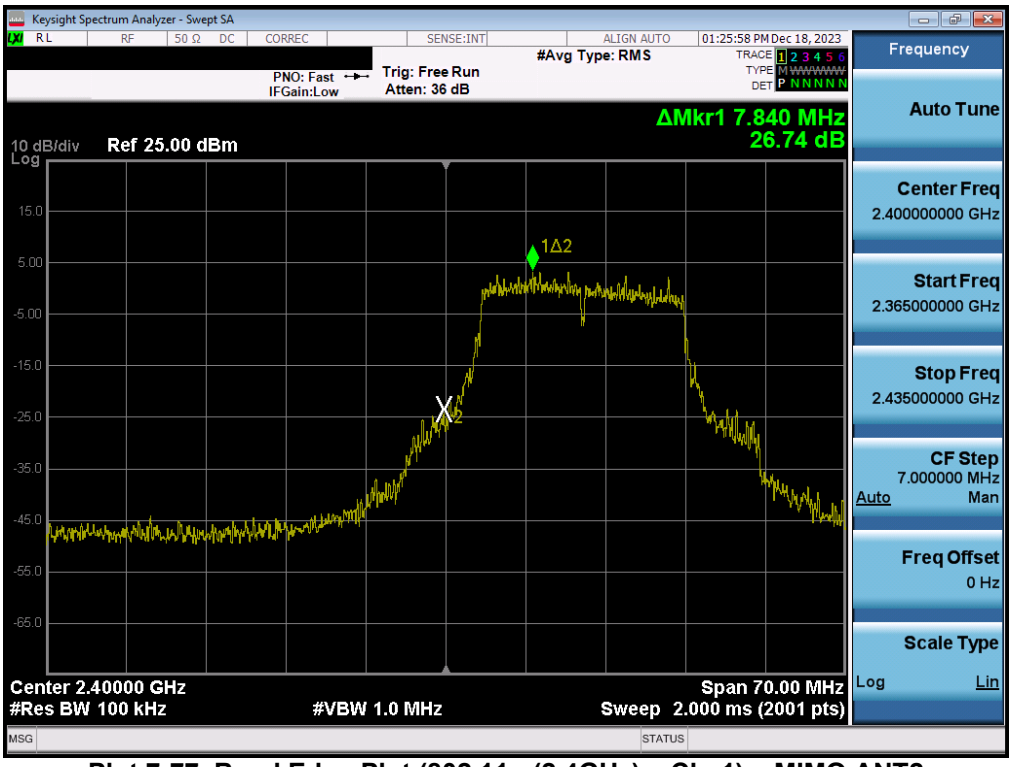
Plot 7-74. Band Edge Plot (802.11g – Ch. 11) – MIMO ANT2



Plot 7-75. Band Edge Plot (802.11g – Ch. 12) – MIMO ANT2

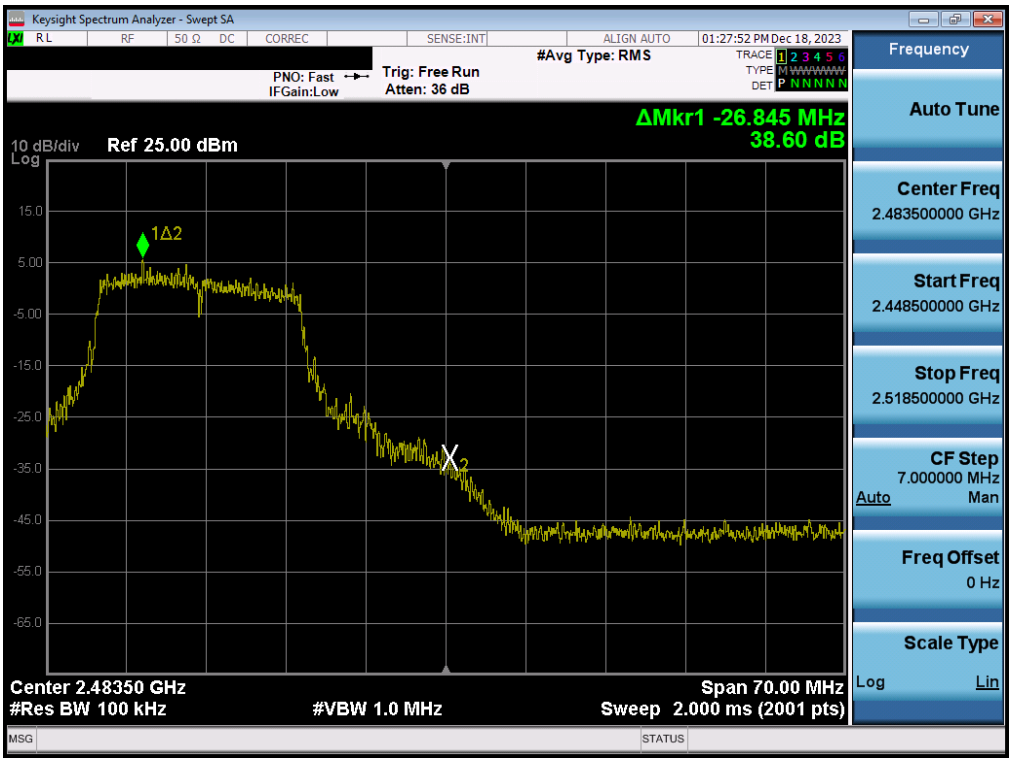


Plot 7-76. Band Edge Plot (802.11g – Ch. 13) – MIMO ANT2

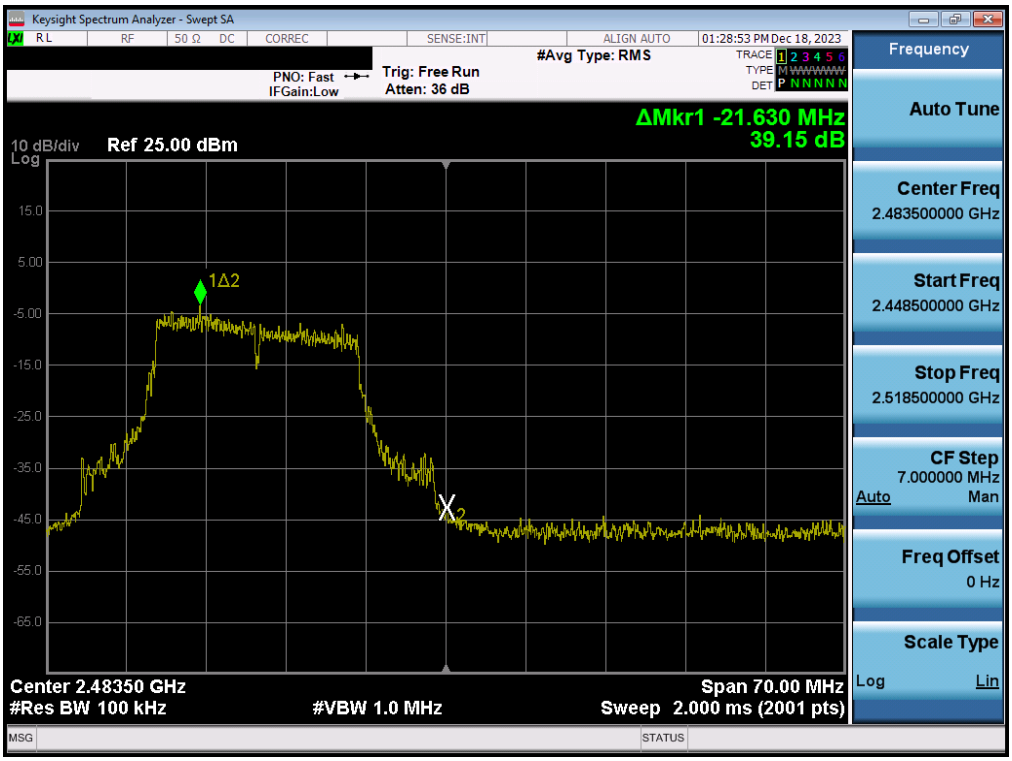


Plot 7-77. Band Edge Plot (802.11n (2.4GHz) – Ch. 1) – MIMO ANT2

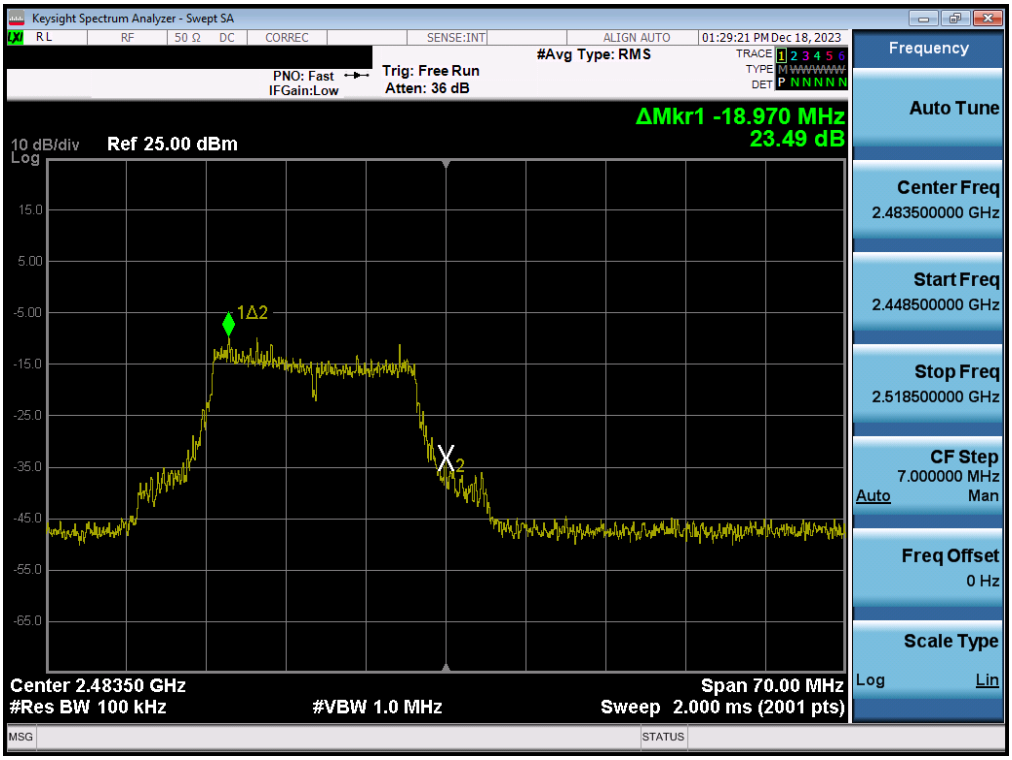
Plot 7-78. Band Edge Plot (802.11n (2.4GHz) – Ch. 2) – MIMO ANT2



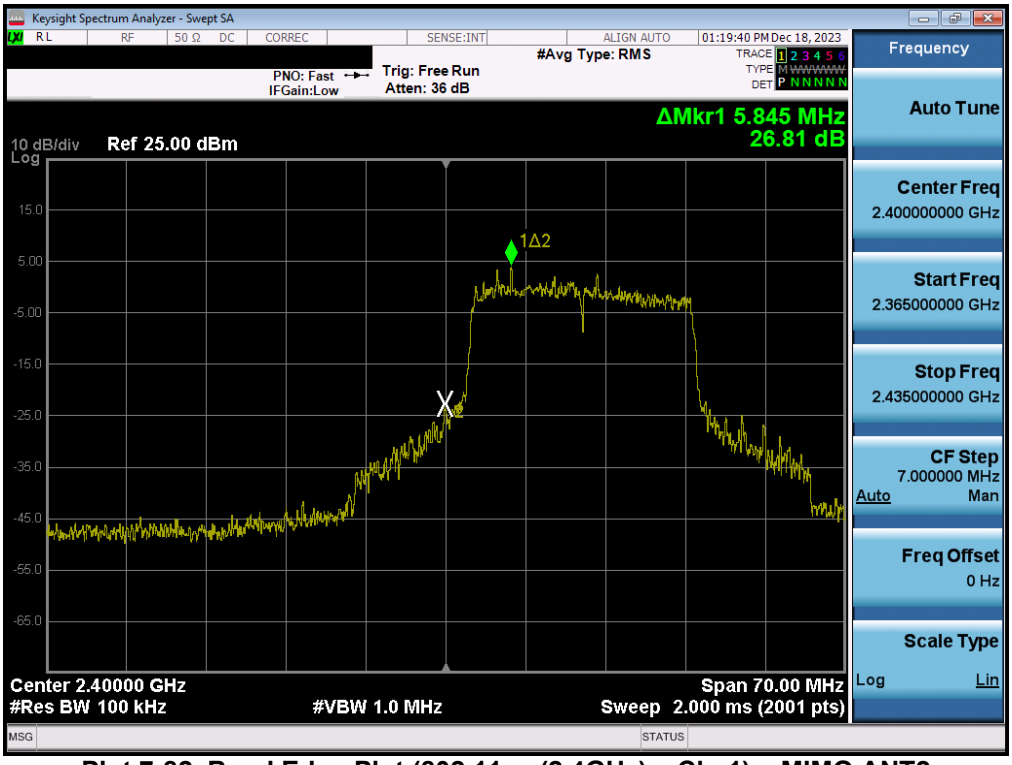
Plot 7-79. Band Edge Plot (802.11n (2.4GHz) – Ch. 11) – MIMO ANT2



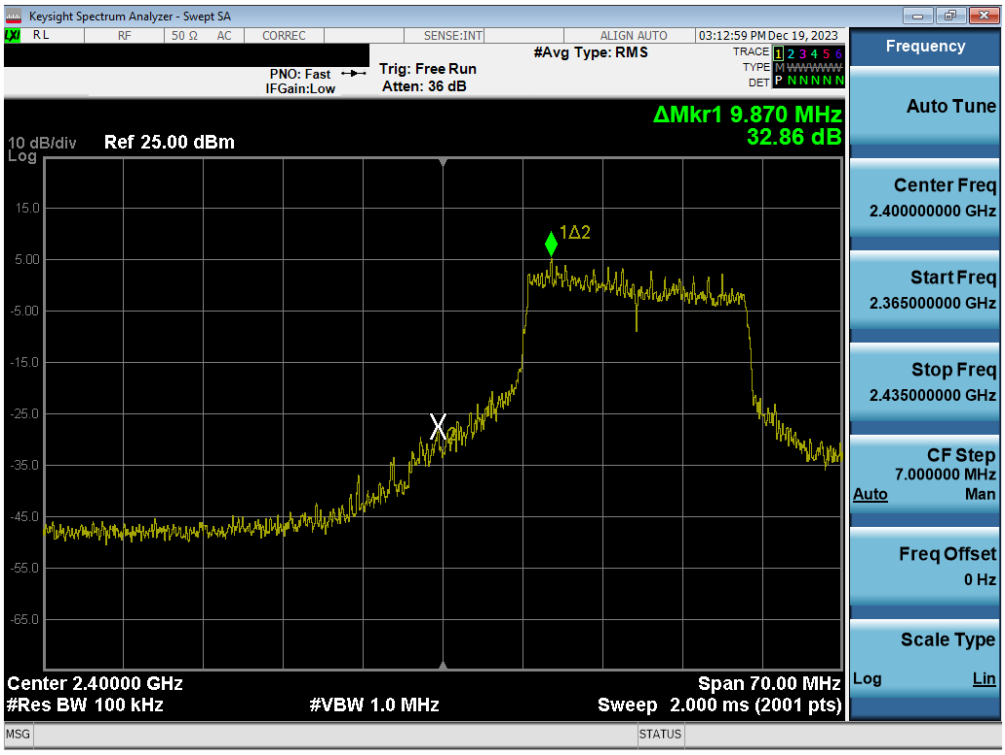
Plot 7-80. Band Edge Plot (802.11n (2.4GHz) – Ch. 12) – MIMO ANT2



Plot 7-81. Band Edge Plot (802.11n (2.4GHz) – Ch. 13) – MIMO ANT2



Plot 7-82. Band Edge Plot (802.11ax (2.4GHz) – Ch. 1) – MIMO ANT2



Plot 7-83. Band Edge Plot (802.11ax (2.4GHz) – Ch. 2) – MIMO ANT2

Plot 7-84. Band Edge Plot (802.11ax (2.4GHz) – Ch. 11) – MIMO ANT2