ELEMENT WASHINGTON DC LLC
7185 Oakland Mills Road, Columbia, MD 21046 USA
Tel. 410.290.6652 / Fax 410.290.6654
http://www.element.com

MEASUREMENT REPORT
FCC PART 15.247 Bluetooth

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

Date of Testing:
06/10/2024 – 07/30/2024
Test Report Issue Date:
08/08/2024
Test Site/Location:
ELEMENT Lab. Columbia, MD, USA
Test Report Serial No.:
1M2405140042-01.A3L

FCC ID:	**A3LSMX920**
APPLICANT:	**Samsung Electronics Co., Ltd.**

Application Type:	Certification
Model:	SM-X920
EUT Type:	Portable Tablet
Max. RF Output Power:	94.124 mW (19.74 dBm) Peak Conducted
Frequency Range:	2402 – 2480MHz
Type of Modulation:	GFSK, π/4-DQPSK, 8DPSK
FCC Classification:	FCC Part 15 Spread Spectrum Transmitter (DSS)
Test Procedure(s):	ANSI C63.10-2013, KDB 558074 D01 v05r02,

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and has been tested in accordance with the measurement procedures specified in ANSI C63.10-2013 (See Test Report). These measurements were performed with no deviation from the standards. 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

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 Innovation, Science and Economic Development Canada.

1.2 Element Test Location

These measurement tests were conducted at the Element laboratory facility 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 Engineering 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 Tablet FCC ID: A3LSMX920.** The test data contained in this report pertains only to the emissions due to the EUT's Bluetooth transmitter.

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:
  - A) The hopping sequence is pseudorandom
  - B) All channels are used equally on average
  - C) The receiver input bandwidth equals the transmit bandwidth
  - D) The receiver hops in sequence with the transmit signal
- 15.247(g): In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.
- 15.247(h): In accordance with the Bluetooth Industry Standard, the system does not coordinate its channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.
- 15.247(h): The EUT employs Adaptive Frequency Hopping (AFH) which identifies sources of interference namely devices operating in 802.11 WLAN and excludes them from the list of available channels. The process of re-mapping reduces the number of test channels from 79 channels to a minimum number of 20 channels.

Test Device Serial No.: 2026M, 2065M, 0240M

2.2 Device Capabilities

This device contains the following capabilities:

802.11b/g/n/ac/ax/be WLAN, 802.11a/n/ac/ax/be UNII (5GHz and 6GHz), Bluetooth (1x, EDR, LE), Wireless Power Transfer

Ch.	Frequency (MHz)
00	2402
:	:
39	2441
:	:
78	2480

Table 2-1. Frequency/ Channel Operations

Note: This device is capable of operating in hopping and non-hopping mode. The EUT can hop between 79 different channels in the 2400 – 2483.5MHz band.

2.3 Antenna Description

This device is only used with its integral antennas as shown in the documentation of this filing. The antenna gains for this device are as shown in the table below:

Frequency [GHz]	Antenna 1 Gain (dBi)	Antenna 2 Gain (dBi)
2.4	-5.27	-4.38

Table 2-2. Antenna Peak Gain

Note: This device is capable of operating in hopping and non-hopping mode. The EUT can hop between 79 different channels in the 2400 – 2483.5MHz band.

2.4 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013. ANSI C63.10-2013 was also used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 3.2 for AC line conducted emissions test setups, 7.9 for radiated emissions test setups, and 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, and 7.8 for antenna port conducted emissions test setups.

2.5 Software and Firmware

Testing was performed on device(s) using software/firmware version X920XXU0AXH4 installed on the EUT.

2.6 EMI Suppression Device(s)/Modifications

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

3.0 DESCRIPTION OF TESTS

3.1 Evaluation Procedure

The measurement procedure 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 SY cooperation RF Enclosures. The line-conducted facility is located inside a 7m x 3.66m x 2.7m shielded enclosure. 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 7.12. The EMI Receiver mode of the R&S ESW was used to perform AC line conducted emissions testing. Automated test software was used to perform the 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 15°C to 35°C. 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 connection to an external antenna.

Conclusion:

The EUT 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	1.95
Radiated Disturbance (<1GHz)	4.10
Radiated Disturbance (>1GHz)	4.82
Radiated Disturbance (>18GHz)	4.96

6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). Measurement 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
Agilent	N9030A	PXA Signal Analyzer	7/9/2024	Annual	7/9/2025	MY49432391
Anritsu	S820E	Cable and Antenna Analyzer	7/9/2024	Annual	7/9/2025	1839097
Anritsu	TOSLKF50A-40	Calibration Kit	N/A	-	N/A	1825024
Com-Power	AL-130R	Active Loop Antenna	10/21/2022	Biennial	10/20/2024	10160045
Fairview Microwave	FM2CP1122-10	Coupler	7/10/2024	Annual	7/10/2025	1946
Keysight Technologies	N9030B	PXA Signal Analyzer	7/8/2024	Annual	7/8/2025	MY57143276
Mini-Circuits	BW-N10W5+	Attenuator	1/11/2024	Annual	1/10/2025	TEMPNO.01-151
NARDA	180-442A-KF	Horn Antenna (Small)	1/16/2024	Annual	1/15/2025	T058701-03
Rohde & Schwarz	TS-PR1840	Preamplifier	7/10/2024	Annual	7/10/2025	100049
Rohde & Schwarz	ESW43	EMI TEST Receiver	7/9/2024	Annual	7/9/2025	101761
Rohde & Schwarz	TS-SFUNIT-Rx	Shielded Filter Unit	1/11/2024	Annual	1/10/2025	102151
Schwarzbeck	VULB9162	Broadband TRILOG Antenna	6/1/2023	Biennial	5/31/2025	9162-217
Sunol Sciences	DRH-118	Horn Antenna	7/16/2024	Biennial	7/16/2025	A102416-1
Sunol Sciences	DRH-118	Horn Antenna	1/16/2024	Biennial	1/16/2025	A060215

Table 6-1. Test Equipment

Notes:

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: A3LSMX920

Method/System: Frequency Hopping Spread Spectrum (FHSS)

Number of Channels: 79

FCC Part Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
15.247(a)(1)(iii)	20dB Bandwidth	N/A	CONDUCTED	PASS	Section 7.2
15.247(b)(1)	Peak Transmitter Output Power	< 1 Watt if ≥ 75 non-overlapping channels used		PASS	Section 7.3
15.247(a)(1)	Channel Separation	> 2/3 of 20 dB BW for systems with Output Power < 125mW		PASS	Section 7.5
15.247(a)(1)(iii)	Number of Channels	> 15 Channels		PASS	Section 7.7
15.247(a)(1)(iii)	Time of Occupancy	< 0.4 sec in 31.6 sec period		PASS	Section 7.6
15.247(d)	Band Edge / Out-of-Band Emissions	Conducted > 20dBc		PASS	Section 7.4, Section 7.8
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	RADIATED	PASS	Section 7.9, Section 7.10, Section 7.11
15.207	AC Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits	LINE CONDUCTED	PASS	Section 7.12

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, directional couplers, and attenuators used as part of the system to maintain a link between the call box and the EUT 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, attenuators, and couplers.
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 “BT Auto,” 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 “Chamber Automation,” Version 1.5.0.

7.2 20dB Bandwidth Measurement

§15.247 (a.1.iii)

Test Overview and Limit

The bandwidth at 20dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the receive antenna while the EUT is operating in transmission mode at the appropriate frequencies.

Test Procedure Used

ANSI C63.10-2013 – Section 6.9.2

Test Settings

1. The signal analyzers' automatic bandwidth measurement capability of the spectrum analyzer was used to perform the 20dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 20. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 1 – 5% OBW
3. VBW ≥ 3 x RBW
4. Reference level set to keep signal from exceeding maximum input mixer level for linear operation.
5. Detector = Peak
6. Trace mode = max hold
7. Sweep = auto couple
8. The trace was allowed to stabilize

Test Setup

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

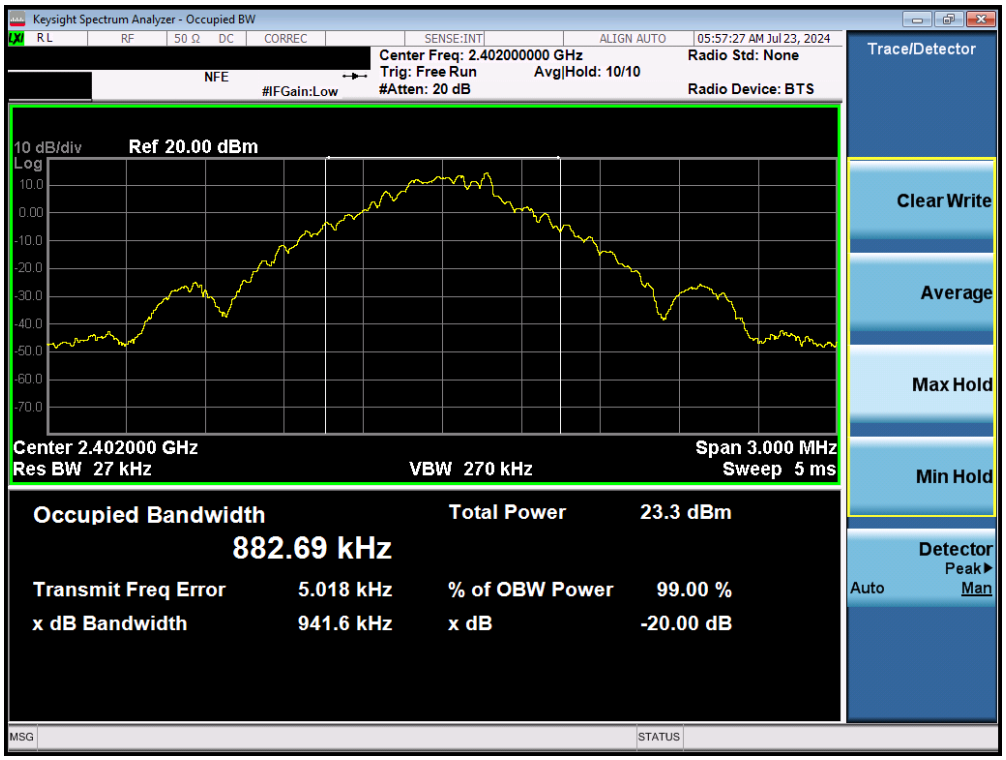
Figure 7-1. Test Instrument & Measurement Setup

Test Notes

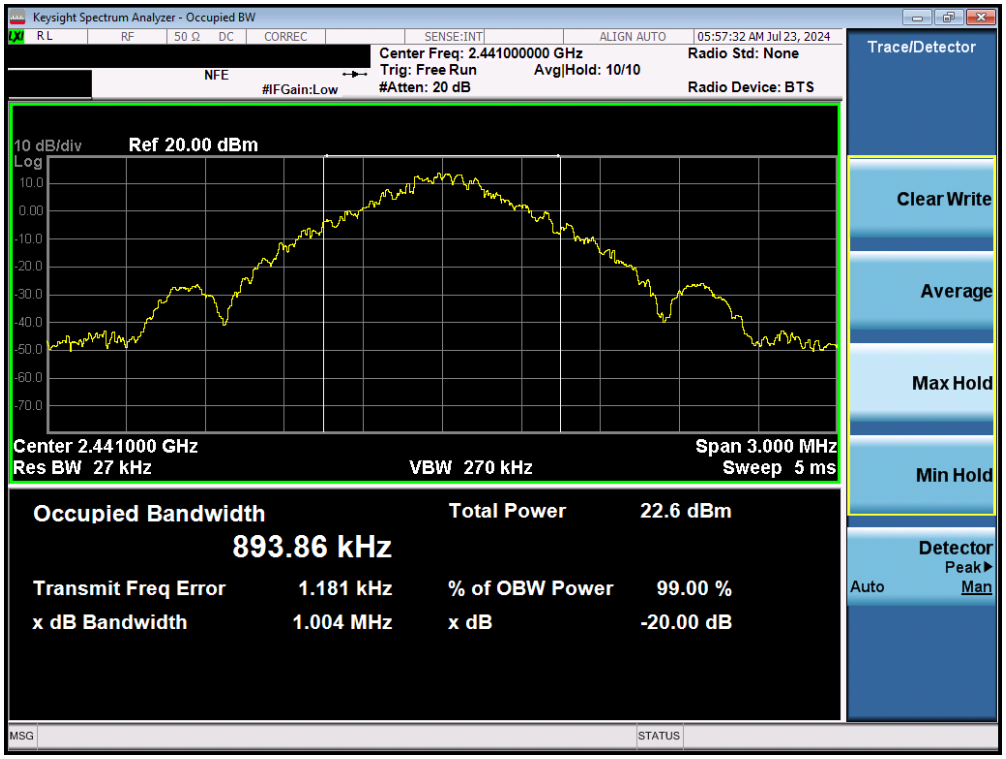
None

Frequency [MHz]	Data Rate [Mbps]	Channel No.	20dB Bandwidth Test Results [kHz]
2402	1.0	0	941.60
2441	1.0	39	1004.00
2480	1.0	78	1017.00
2402	2.0	0	1327.00
2441	2.0	39	1320.00
2480	2.0	78	1316.00
2402	3.0	0	1294.00
2441	3.0	39	1288.00
2480	3.0	78	1327.00

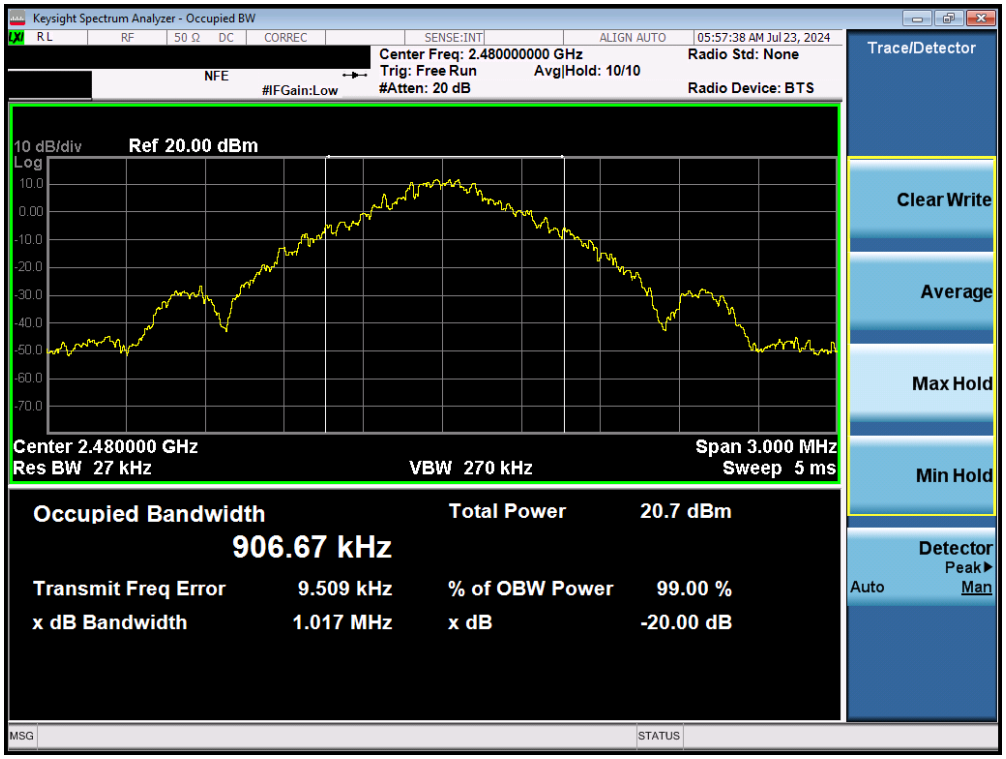
Table 7-2. Conducted 20dB Bandwidth Measurements – Ant1



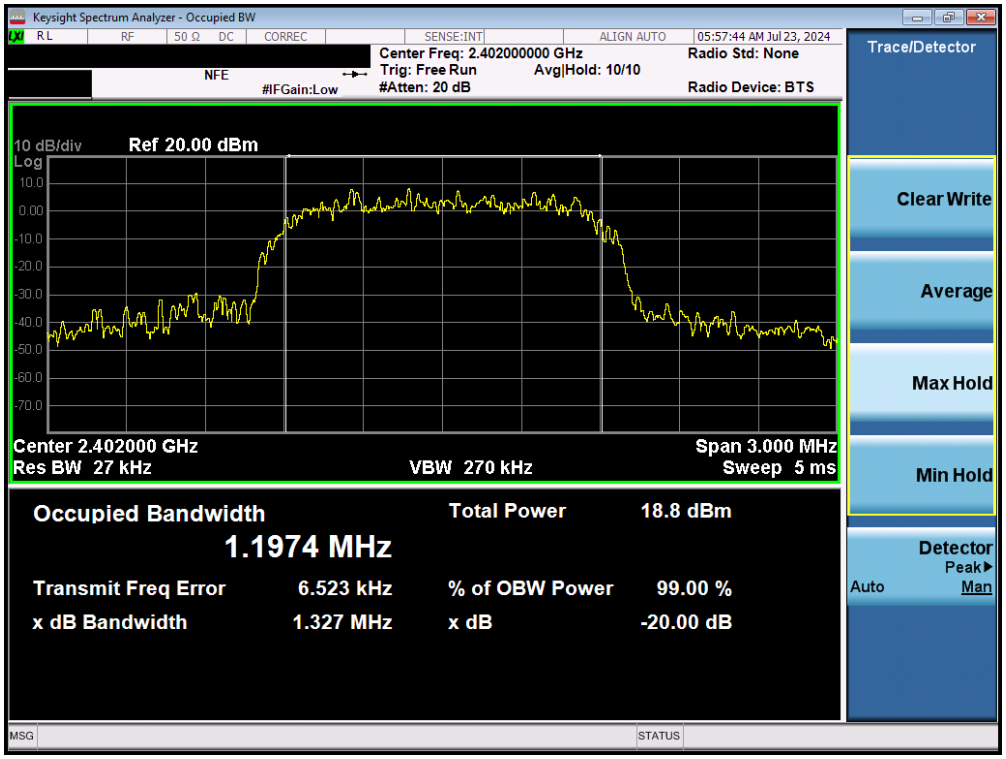
Plot 7-1. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 0) – Ant 1



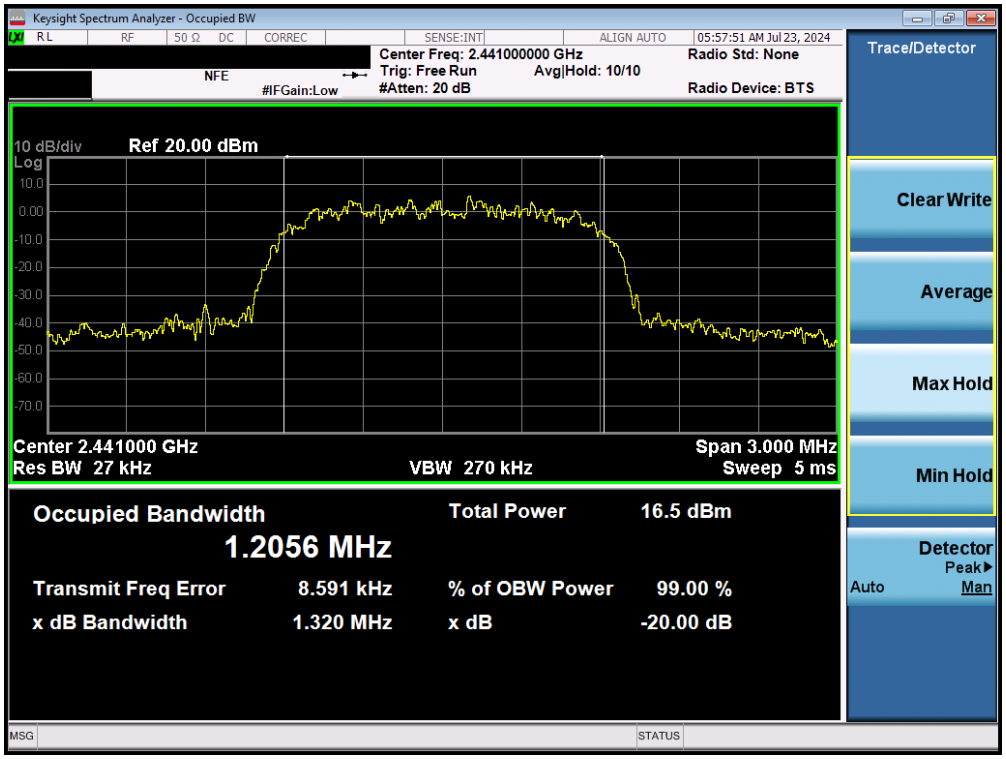
Plot 7-2. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 39) – Ant 1



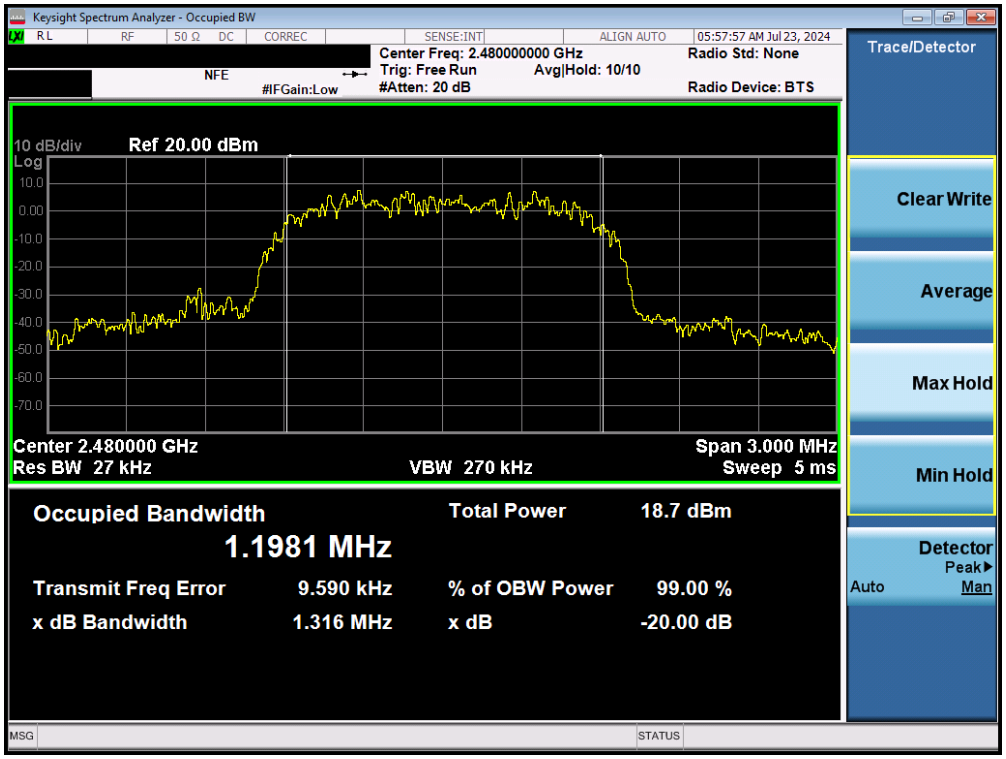
Plot 7-3. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 78) – Ant 1



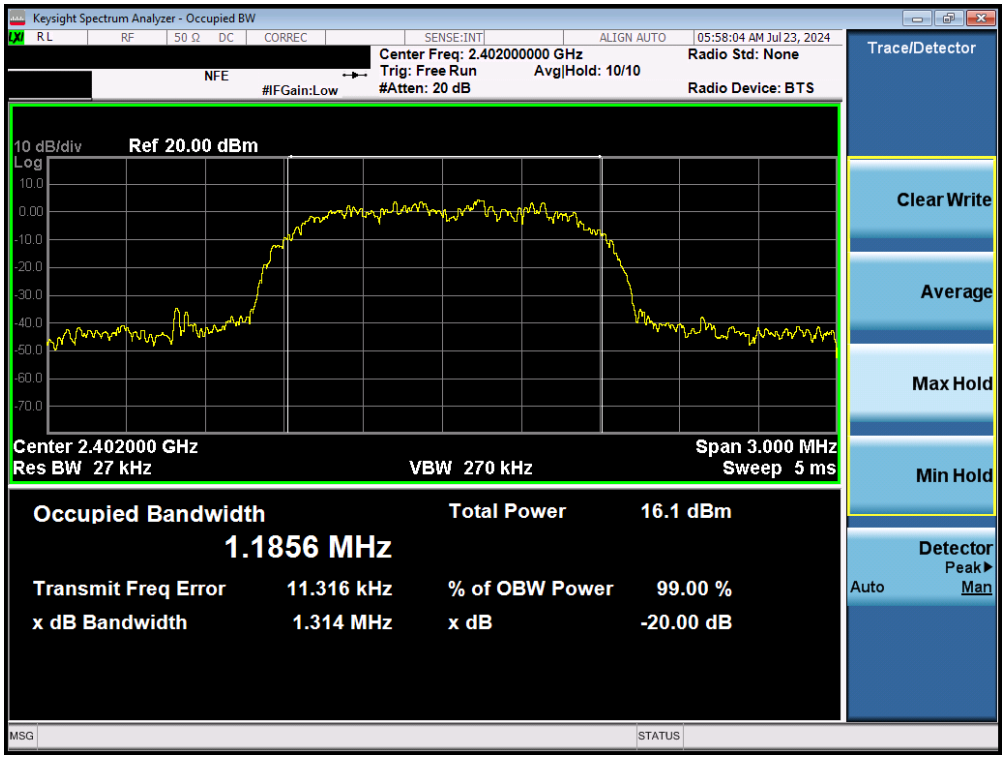
Plot 7-4. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 0) – Ant 1



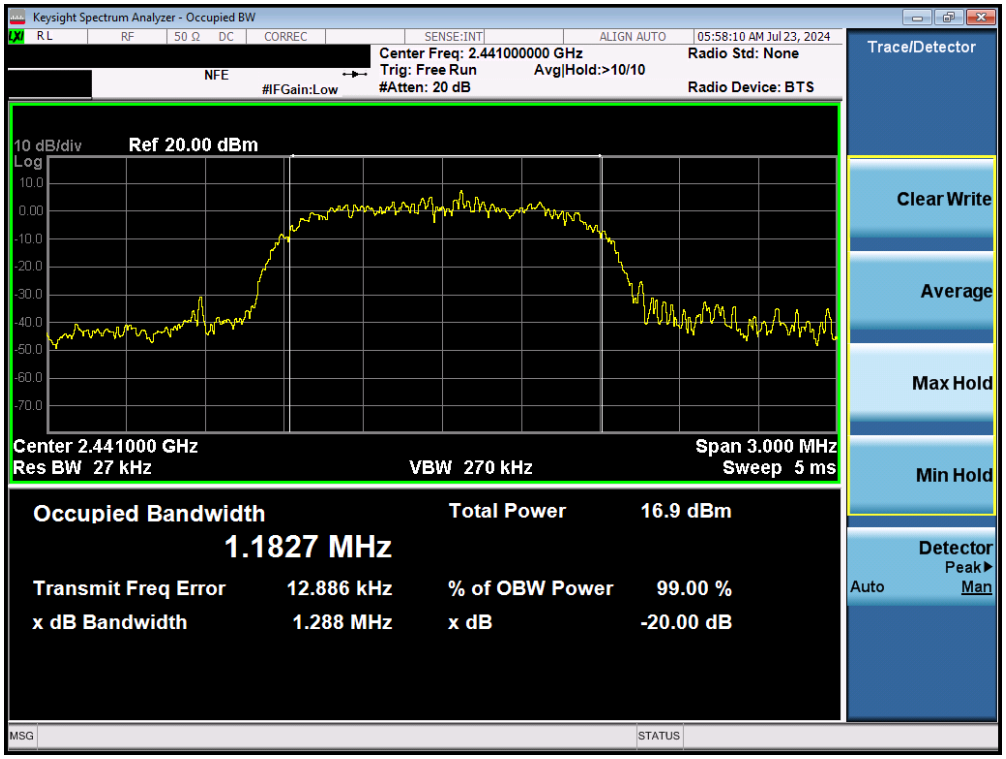
Plot 7-5. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 39) – Ant 1



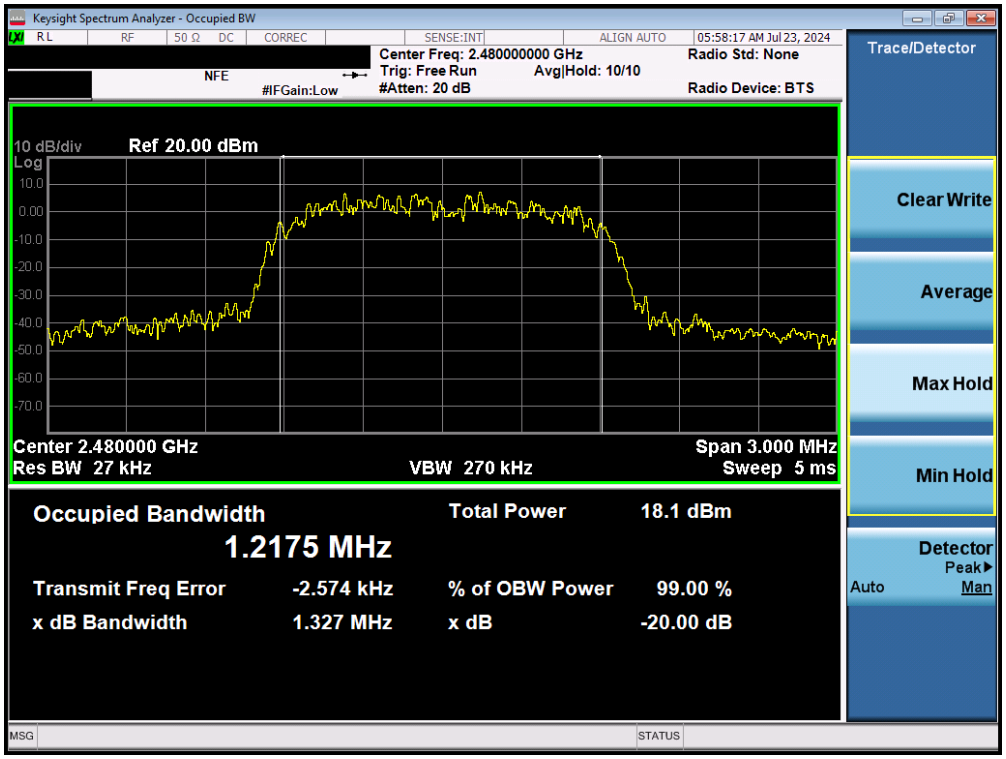
Plot 7-6. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 78) – Ant 1



Plot 7-7. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 0) – Ant 1



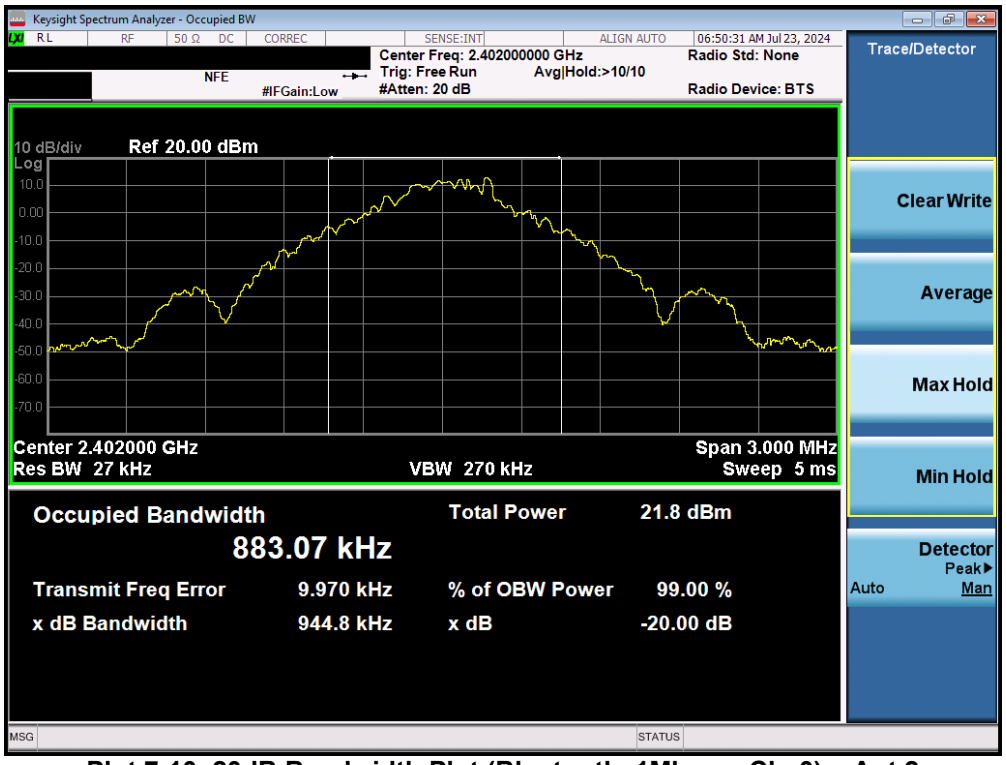
Plot 7-8. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 39) – Ant 1



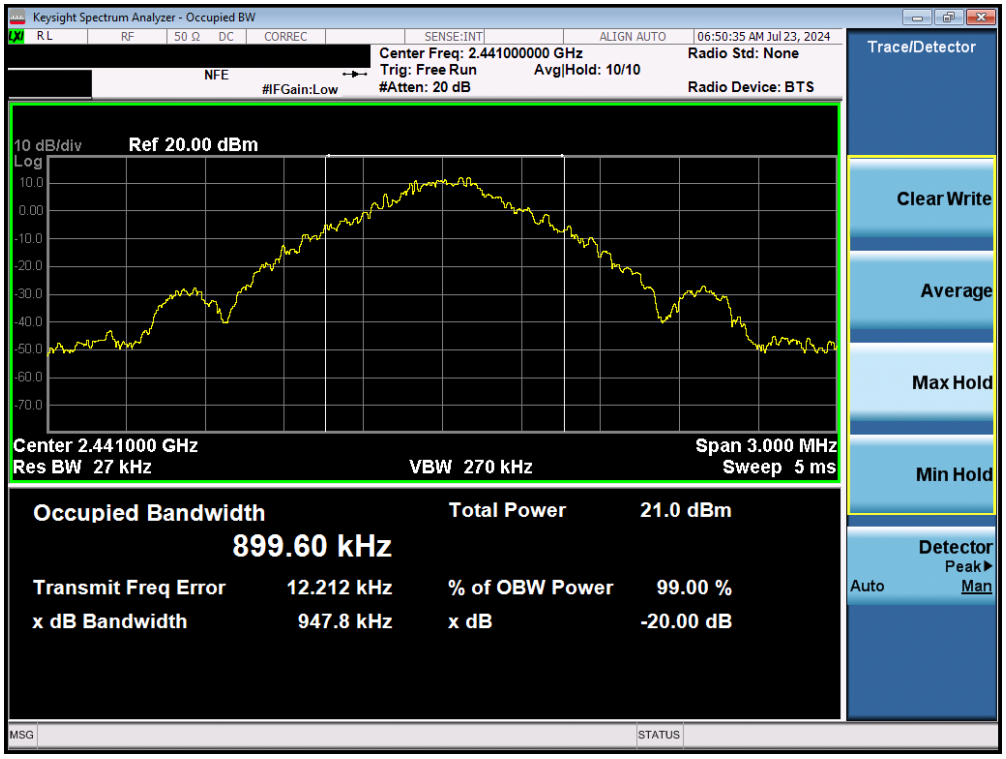
Plot 7-9. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 78) – Ant 1

Frequency [MHz]	Data Rate [Mbps]	Channel No.	20dB Bandwidth Test Results [kHz]
2402	1.0	0	944.80
2441	1.0	39	947.80
2480	1.0	78	950.70
2402	2.0	0	1306.00
2441	2.0	39	1257.00
2480	2.0	78	1274.00
2402	3.0	0	1303.00
2441	3.0	39	1283.00
2480	3.0	78	1317.00

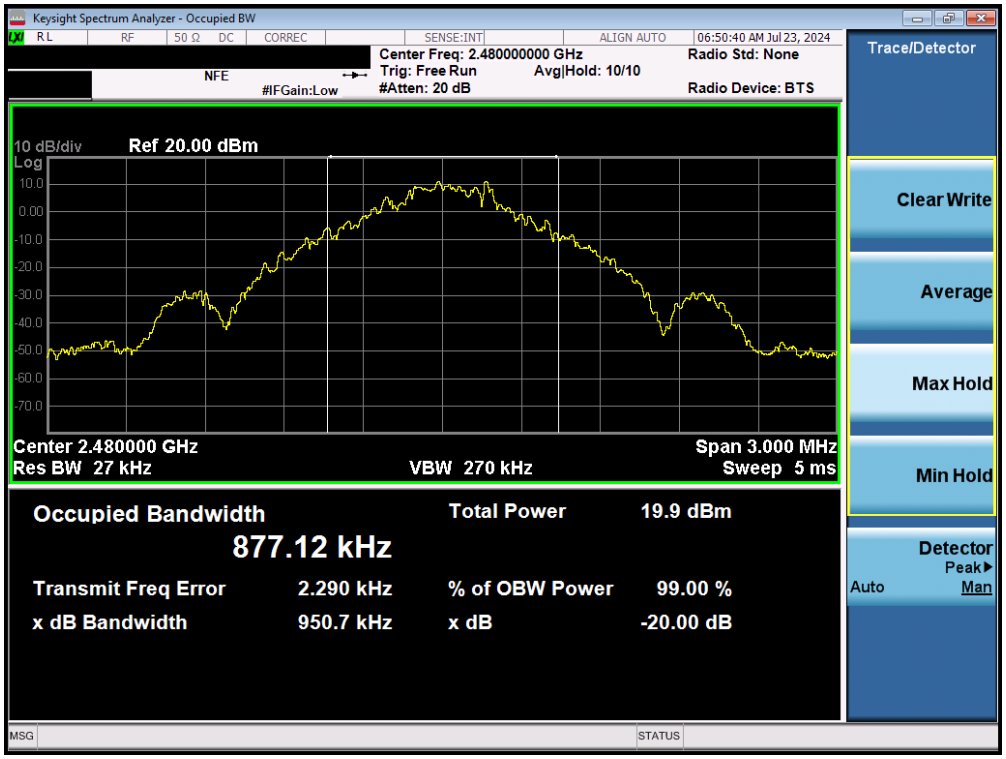
Table 7-3. Conducted 20dB Bandwidth Measurements – Ant 2



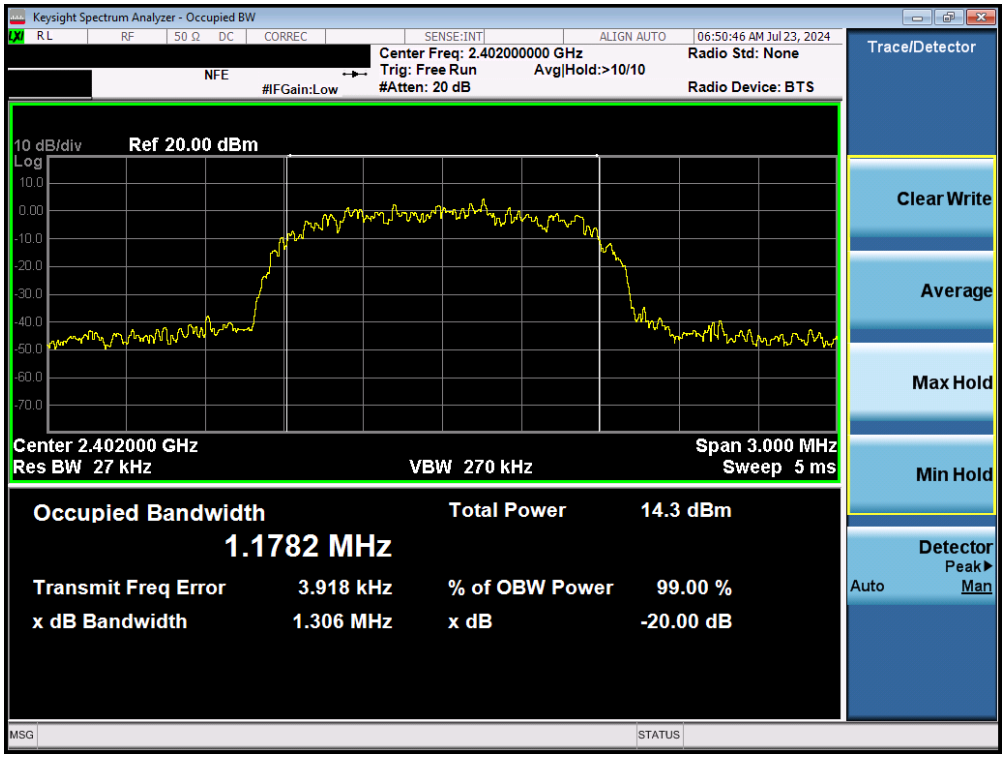
Plot 7-10. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 0) – Ant 2



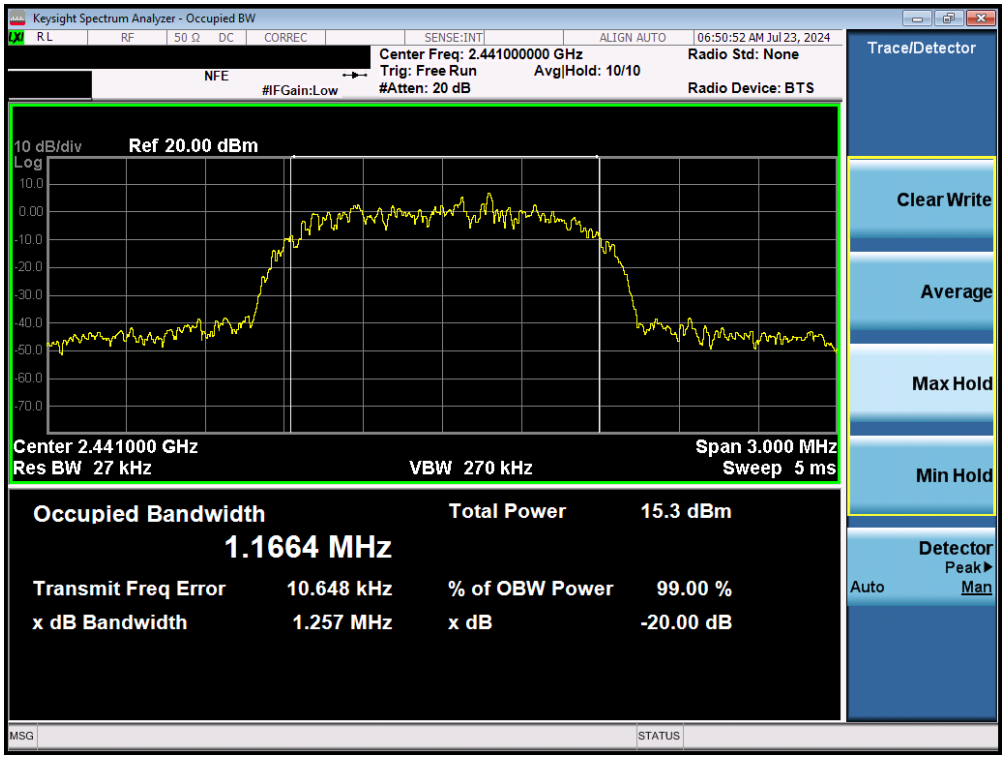
Plot 7-11. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 39) – Ant 2



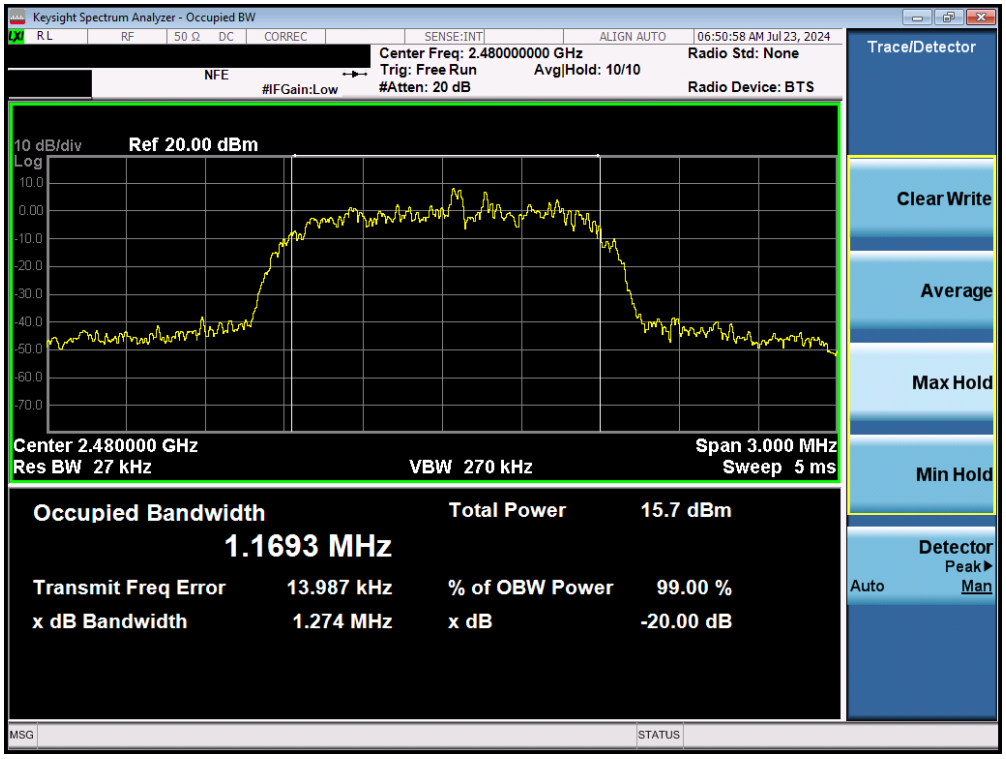
Plot 7-12. 20dB Bandwidth Plot (Bluetooth, 1Mbps – Ch. 78) – Ant 2



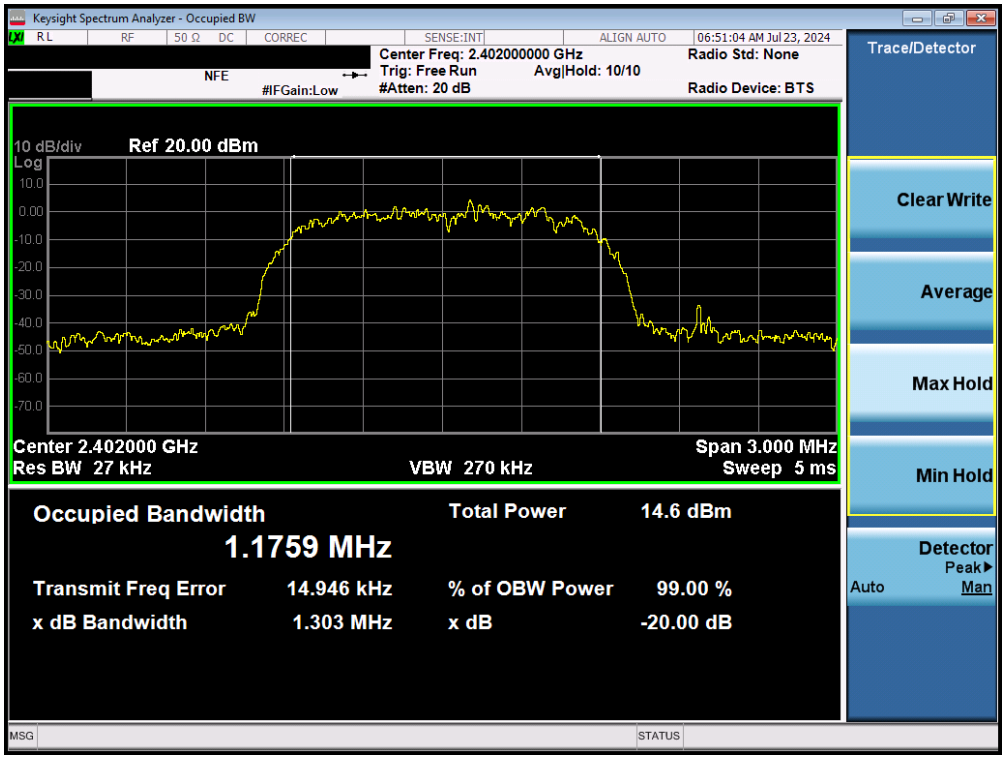
Plot 7-13. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 0) – Ant 2



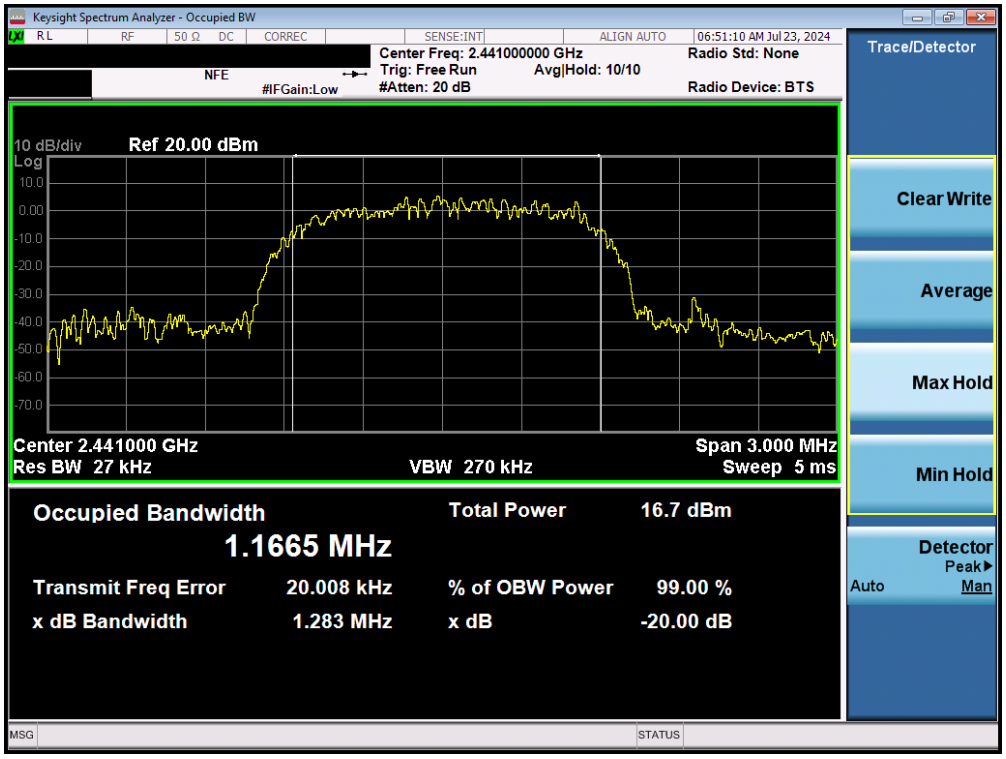
Plot 7-14. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 39) – Ant 2



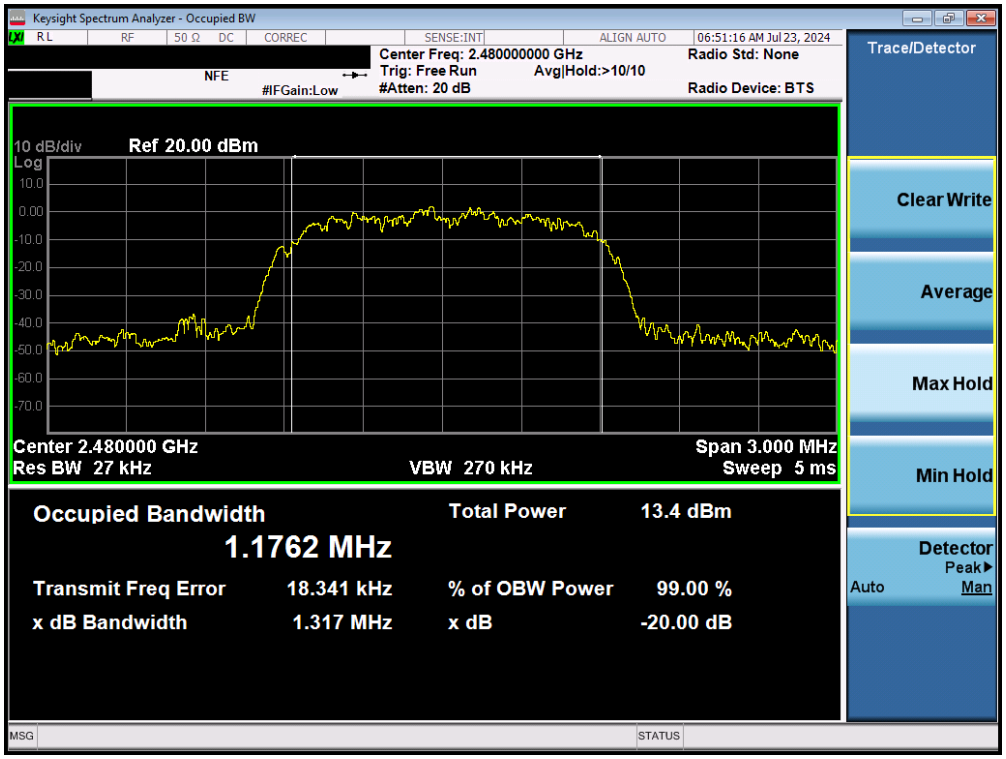
Plot 7-15. 20dB Bandwidth Plot (Bluetooth, 2Mbps – Ch. 78) – Ant 2



Plot 7-16. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 0) – Ant 2



Plot 7-17. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 39) – Ant 2



Plot 7-18. 20dB Bandwidth Plot (Bluetooth, 3Mbps – Ch. 78) – Ant 2

7.3 Output Power Measurement

§15.247 (b.1)

Test Overview and Limits

Measurement is made while the EUT is operating in non-hopping transmission mode. The powers shown below were measured using a spectrum analyzer with a Bluetooth signaling test set (Agilent Model: N4010A) used only to maintain a Bluetooth link with the EUT. Average power measurements are performed using the analyzer's "burst power" function with RBW = 3MHz. The burst power function triggers on a single set burst set to maximum power and measures the maximum average power on the on-time.

The maximum permissible output power is 1 Watt.

Test Procedure Used

ANSI C63.10-2013 – Section 7.8.5
ANSI C63.10-2013 – Section 11.9.2.3.2 method AVGPM-G

Test Settings

Peak Power Measurement

1. Span = approximately 5x 20dB bandwidth, centered on hopping channel
2. RBW > 20dB bandwidth of emission being measured
3. VBW ≥ RBW
4. Sweep = auto
5. Detector = peak
6. Trace mode = max hold
7. The trace was allowed to stabilize

Test Setup

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

Figure 7-2. Test Instrument & Measurement Setup

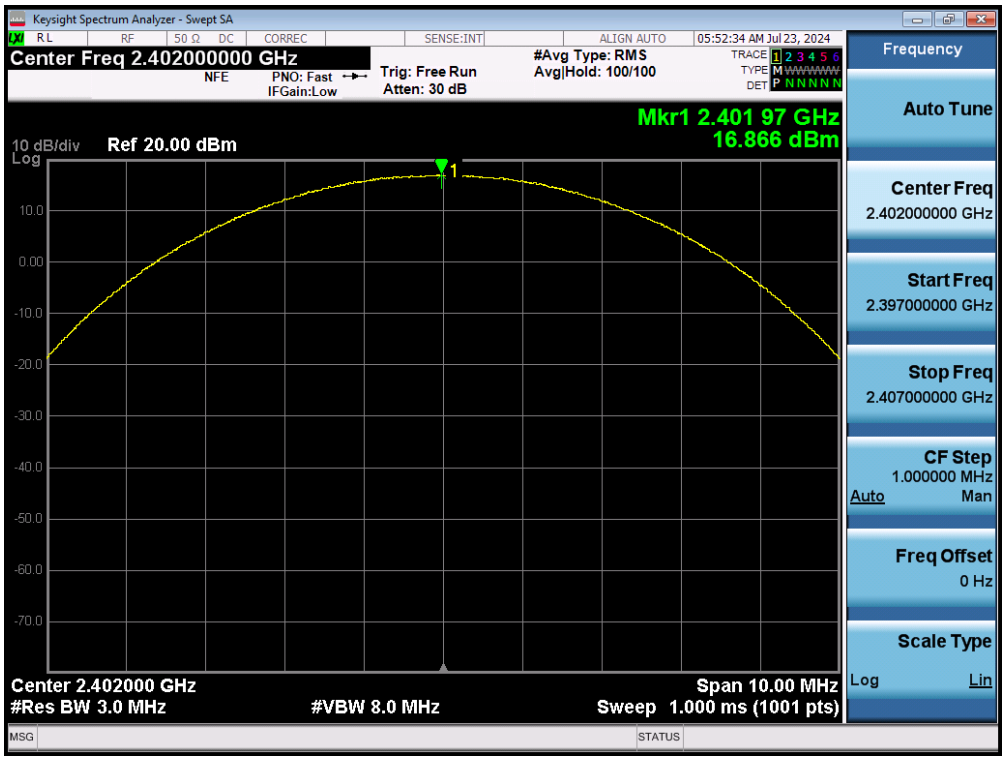
Note

Final results were obtained using calibrated couplers, attenuators, and cables. The following formula was used:

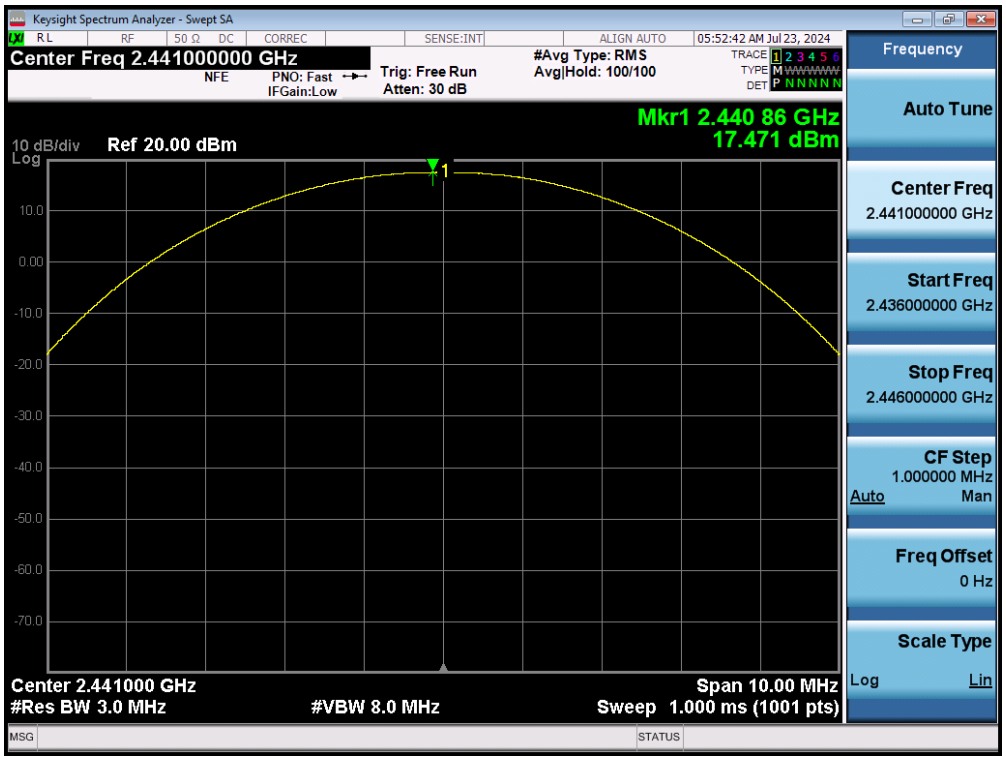
Output Power (dBm) = Raw Analyzer Level (dBm) + Cable Loss (dB) + Loss in Directional Coupler/Insertion Loss (dB)

Frequency [MHz]	Data Rate [Mbps]	Channel No.	Peak Conducted Power		Avg Conducted Power	
			[dBm]	[mW]	[dBm]	[mW]
2402	1.0	0	16.87	48.596	16.35	43.166
2441	1.0	39	17.47	55.860	16.96	49.712
2480	1.0	78	16.18	41.448	15.39	34.610
2402	2.0	0	19.74	94.124	15.36	34.362
2441	2.0	39	18.53	71.351	16.06	40.410
2480	2.0	78	18.41	69.390	14.59	28.750
2402	3.0	0	19.16	82.395	15.54	35.783
2441	3.0	39	19.69	93.197	16.14	41.089
2480	3.0	78	18.81	75.998	14.76	29.932

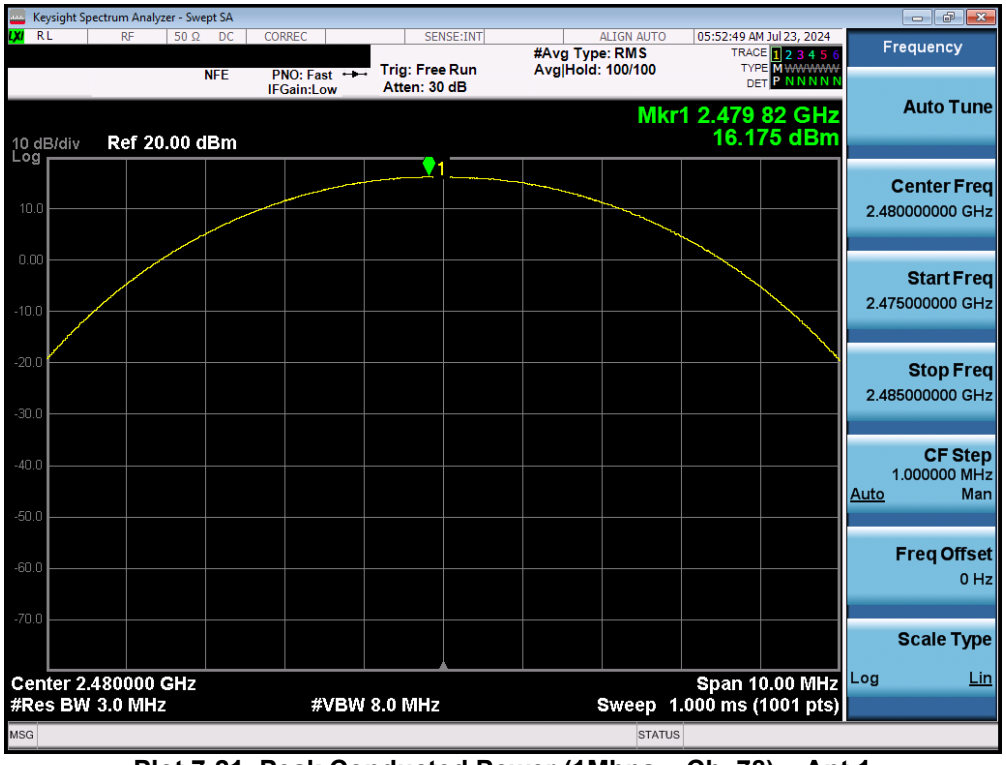
Table 7-4. Conducted Output Power Measurements– Ant 1



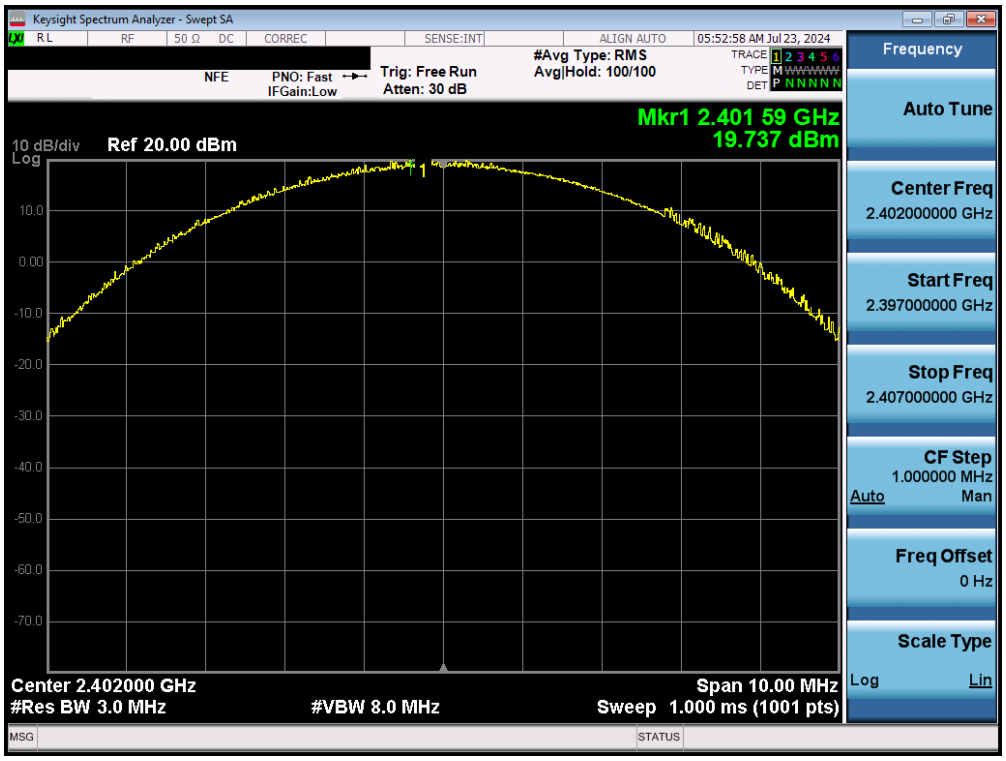
Plot 7-19. Peak Conducted Power (1Mbps – Ch. 0) – Ant 1



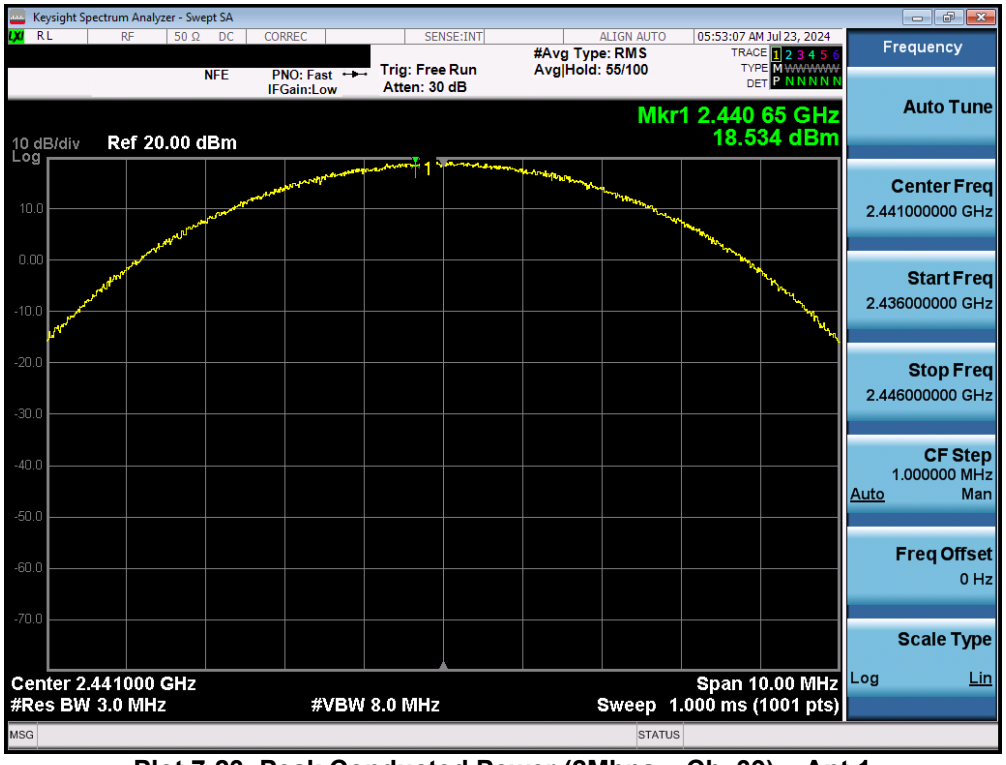
Plot 7-20. Peak Conducted Power (1Mbps – Ch. 39) – Ant 1



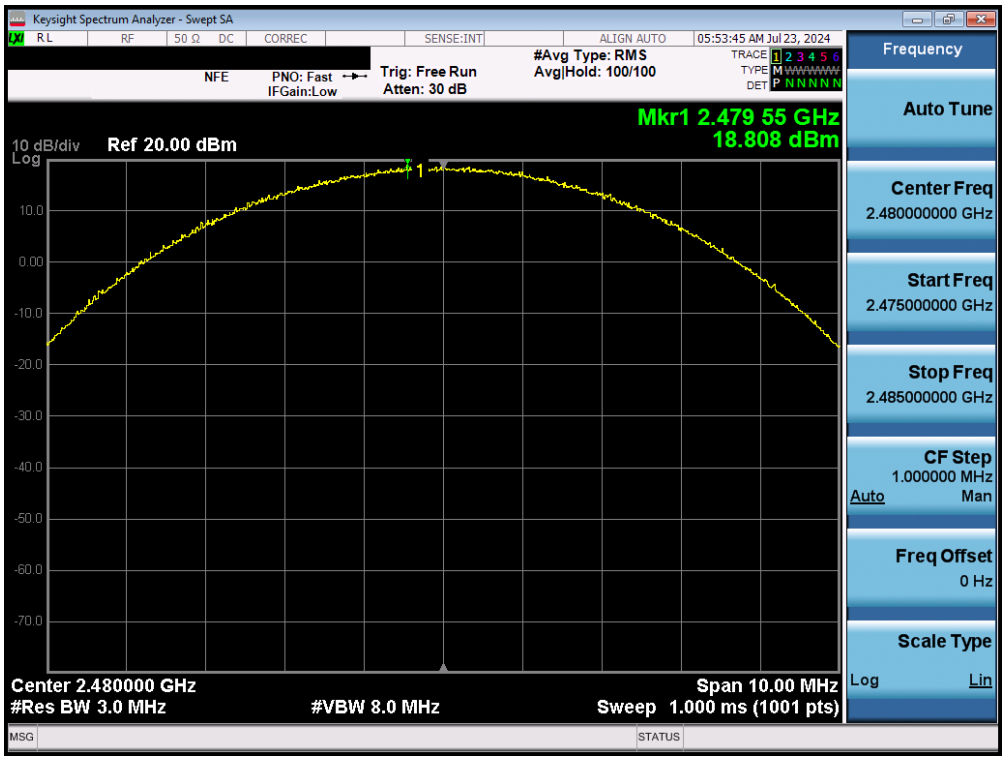
Plot 7-21. Peak Conducted Power (1Mbps – Ch. 78) – Ant 1



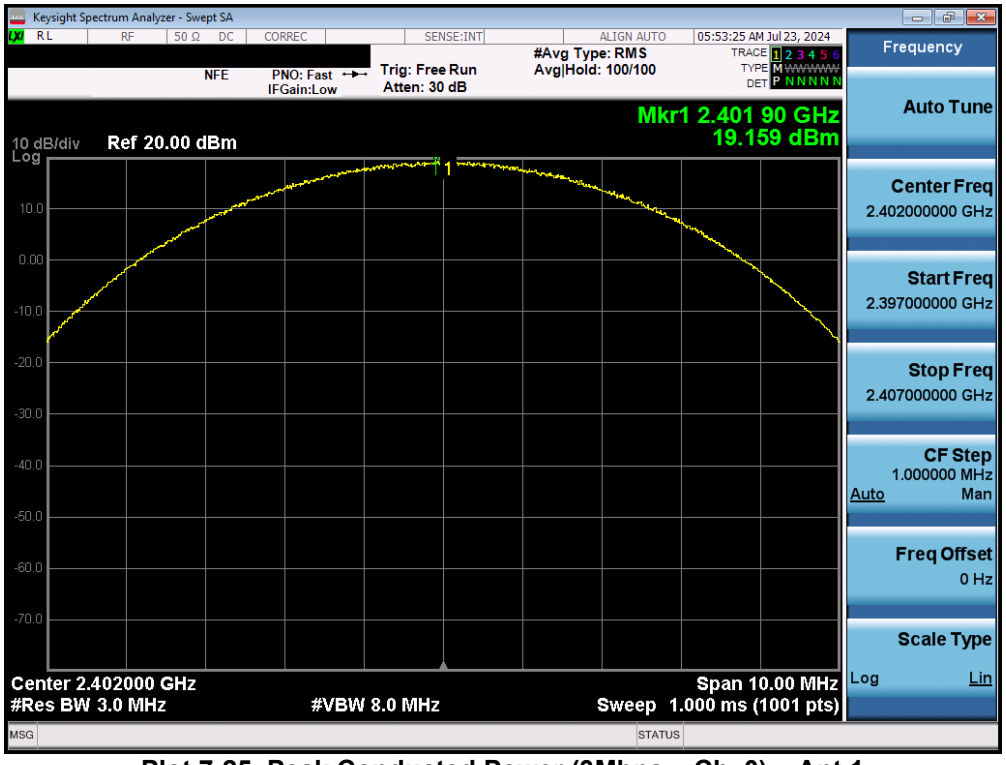
Plot 7-22. Peak Conducted Power (2Mbps – Ch. 0) – Ant 1



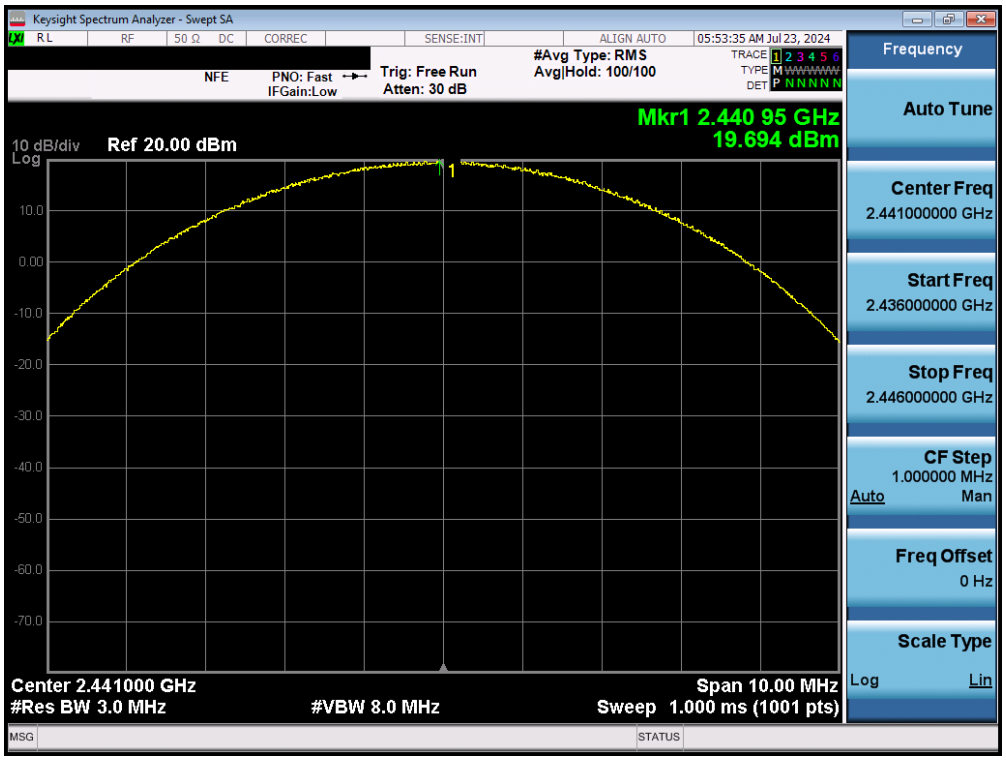
Plot 7-23. Peak Conducted Power (2Mbps – Ch. 39) – Ant 1



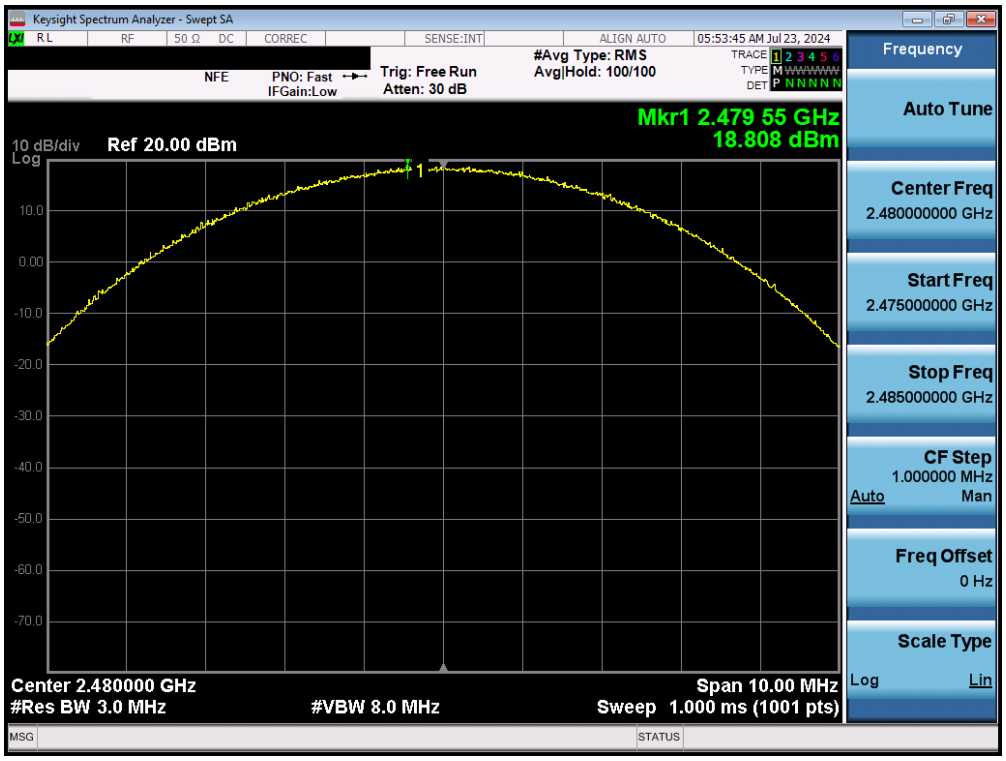
Plot 7-24. Peak Conducted Power (2Mbps – Ch. 78) – Ant 1



Plot 7-25. Peak Conducted Power (3Mbps – Ch. 0) – Ant 1

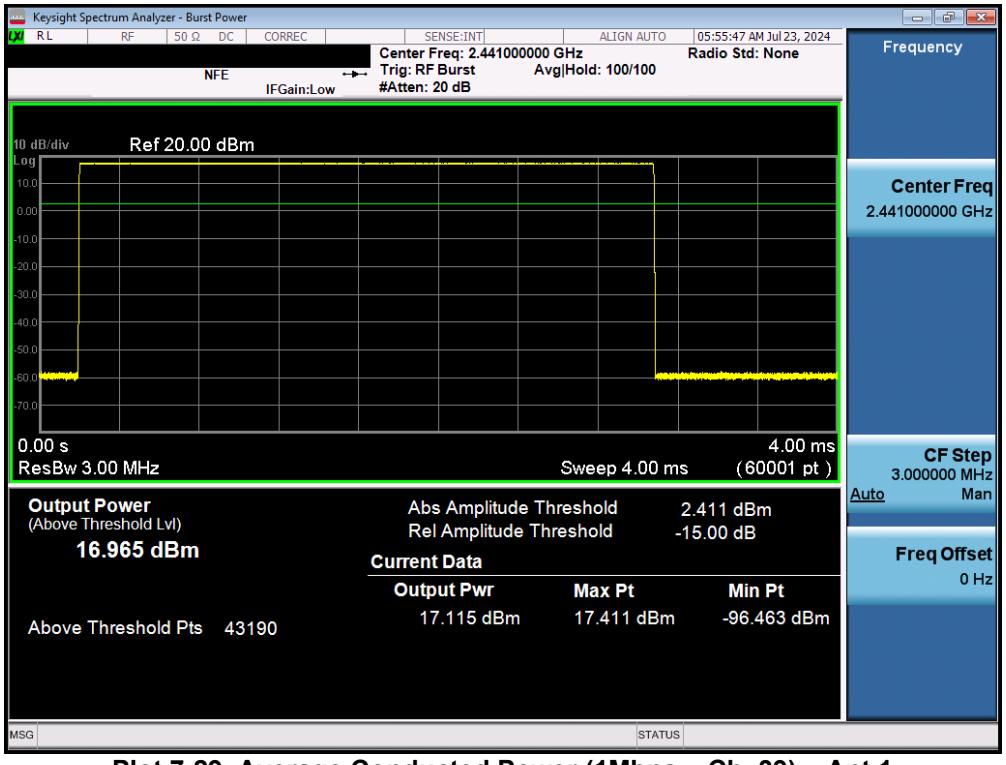


Plot 7-26. Peak Conducted Power (3Mbps – Ch. 39) – Ant 1



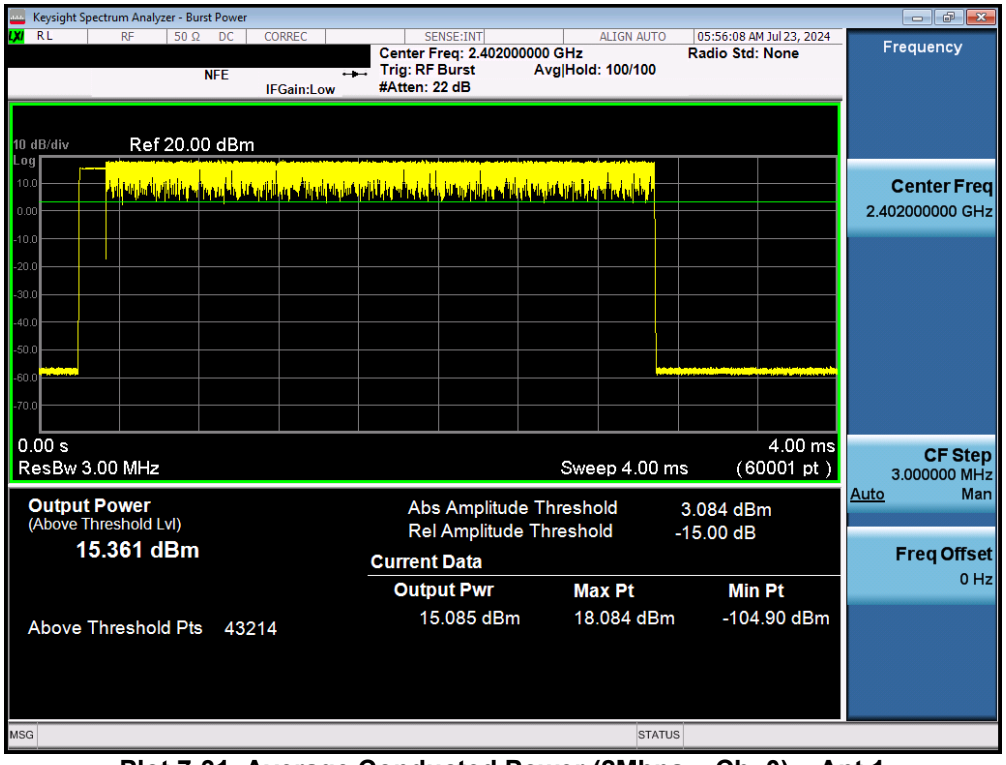
Plot 7-27. Peak Conducted Power (3Mbps – Ch. 78) – Ant 1

Plot 7-28. Average Conducted Power (1Mbps – Ch. 0) – Ant 1

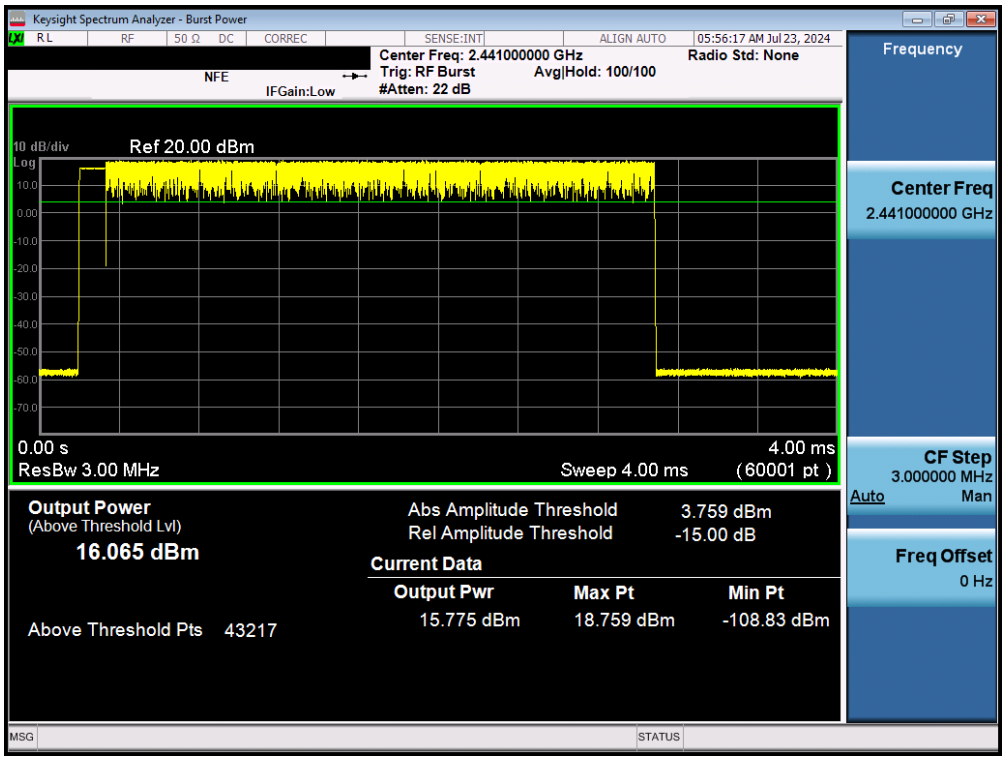


Plot 7-29. Average Conducted Power (1Mbps – Ch. 39) – Ant 1

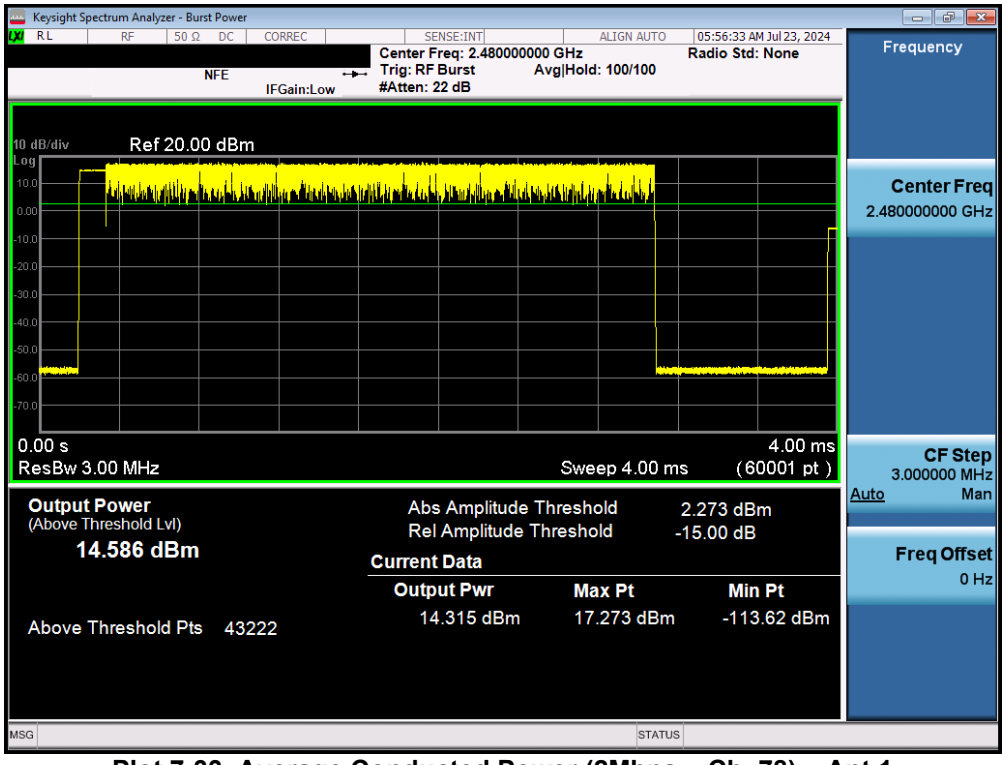
Plot 7-30. Average Conducted Power (1Mbps – Ch. 78) – Ant 1



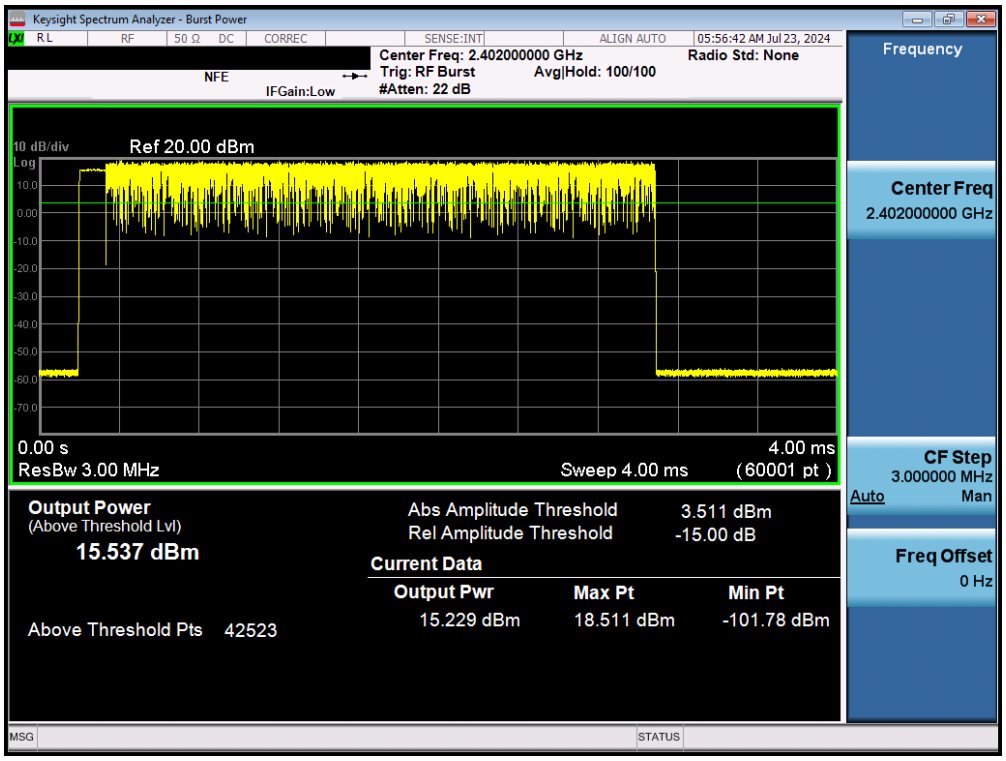
Plot 7-31. Average Conducted Power (2Mbps – Ch. 0) – Ant 1



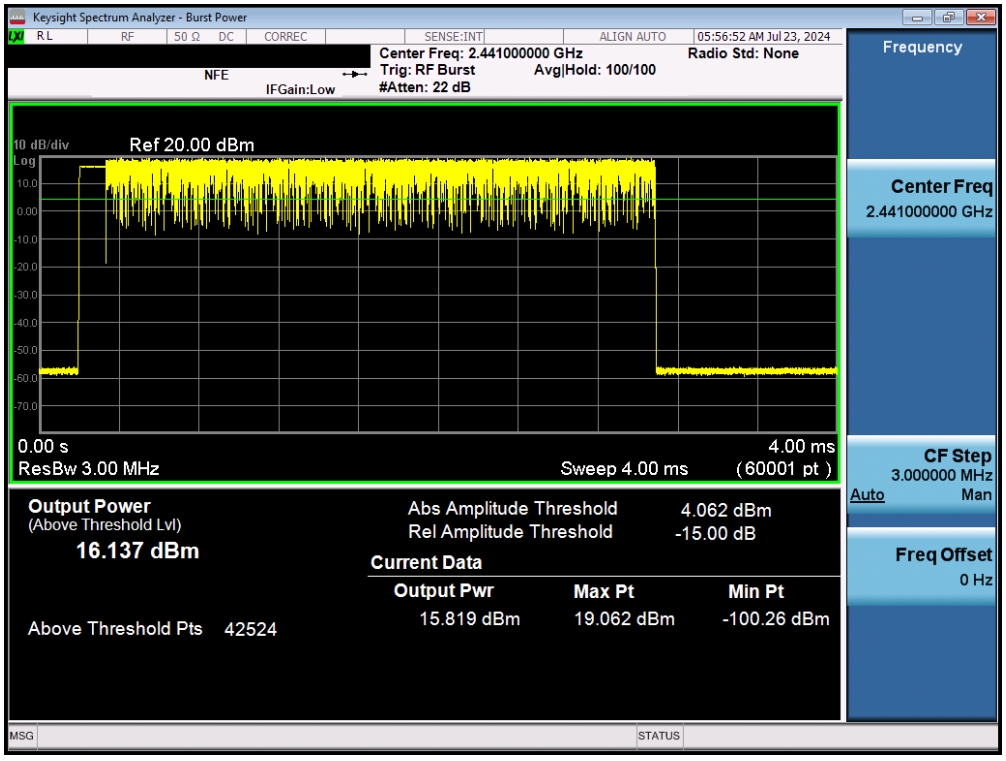
Plot 7-32. Average Conducted Power (2Mbps – Ch. 39) – Ant 1



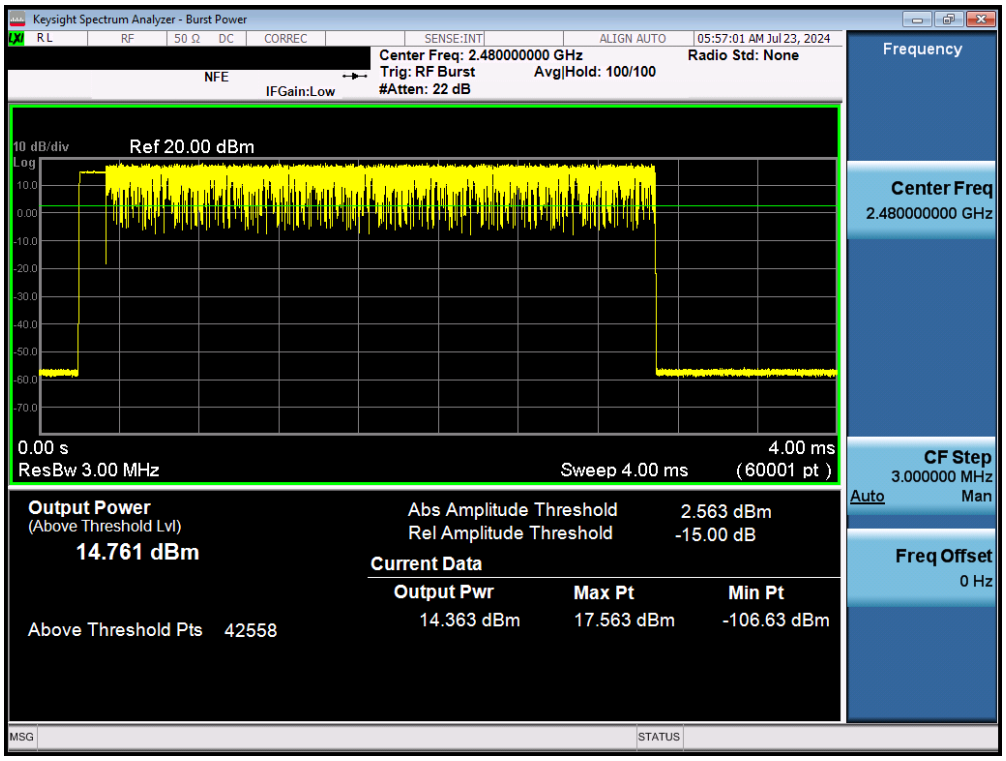
Plot 7-33. Average Conducted Power (2Mbps – Ch. 78) – Ant 1



Plot 7-34. Average Conducted Power (3Mbps – Ch. 0) – Ant 1



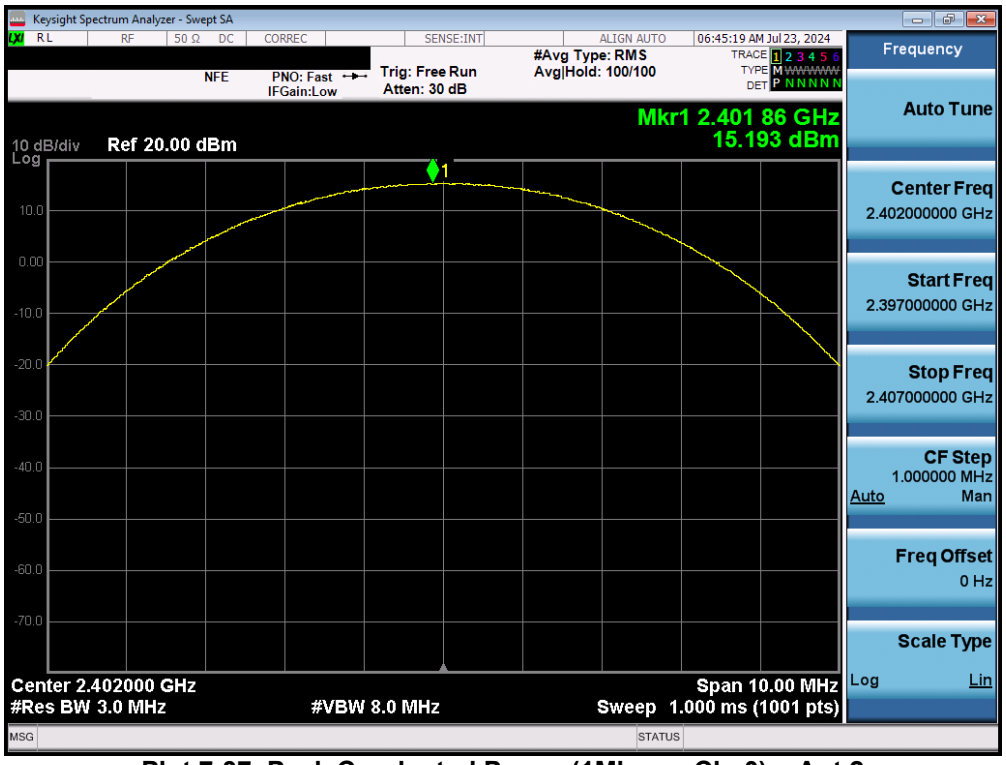
Plot 7-35. Average Conducted Power (3Mbps – Ch. 39) – Ant 1



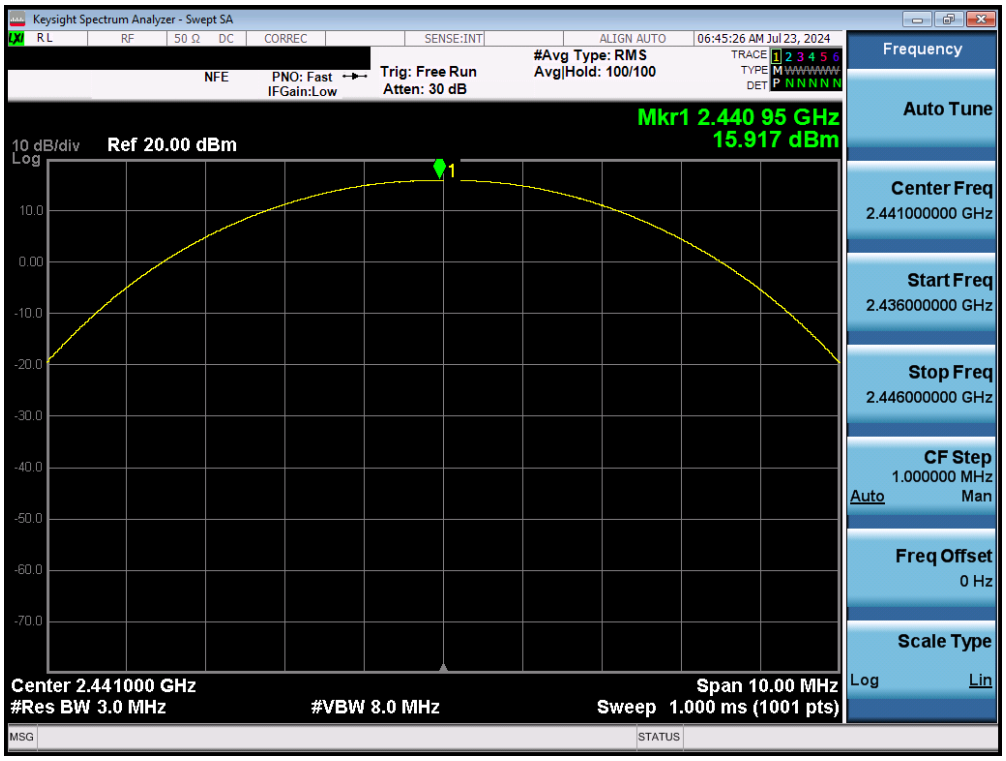
Plot 7-36. Average Conducted Power (3Mbps – Ch. 78) – Ant 1

Frequency [MHz]	Data Rate [Mbps]	Channel No.	Peak Conducted Power		Avg Conducted Power	
			[dBm]	[mW]	[dBm]	[mW]
2402	1.0	0	15.19	33.060	14.86	30.607
2441	1.0	39	15.92	39.057	15.72	37.296
2480	1.0	78	14.69	29.465	13.93	24.708
2402	2.0	0	19.37	86.457	14.10	25.679
2441	2.0	39	18.41	69.390	14.48	28.028
2480	2.0	78	16.36	43.281	13.32	21.492
2402	3.0	0	17.66	58.291	14.21	26.376
2441	3.0	39	18.07	64.077	14.57	28.642
2480	3.0	78	16.75	47.293	13.36	21.670

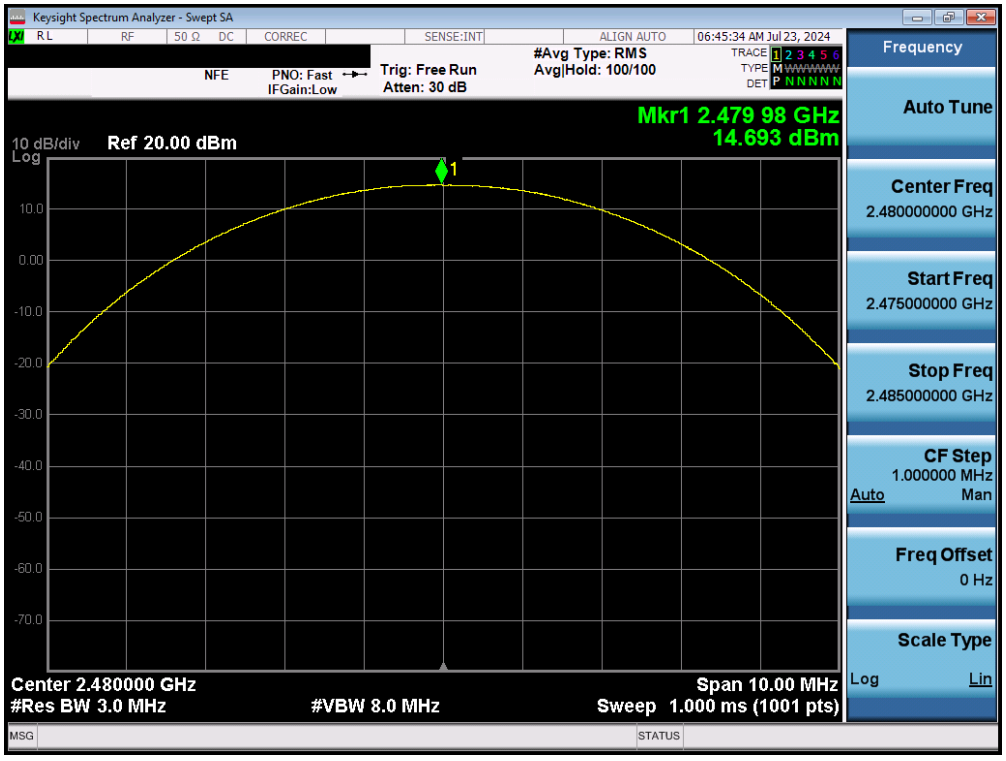
Table 7-5. Conducted Output Power Measurements– Ant 2



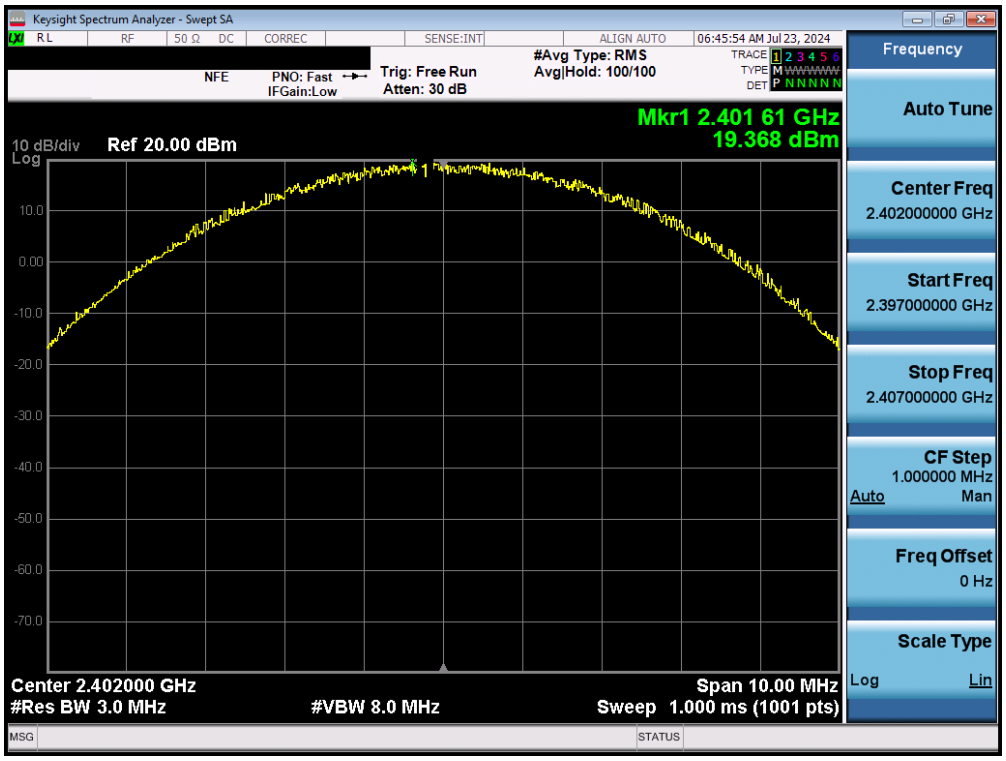
Plot 7-37. Peak Conducted Power (1Mbps – Ch. 0) – Ant 2



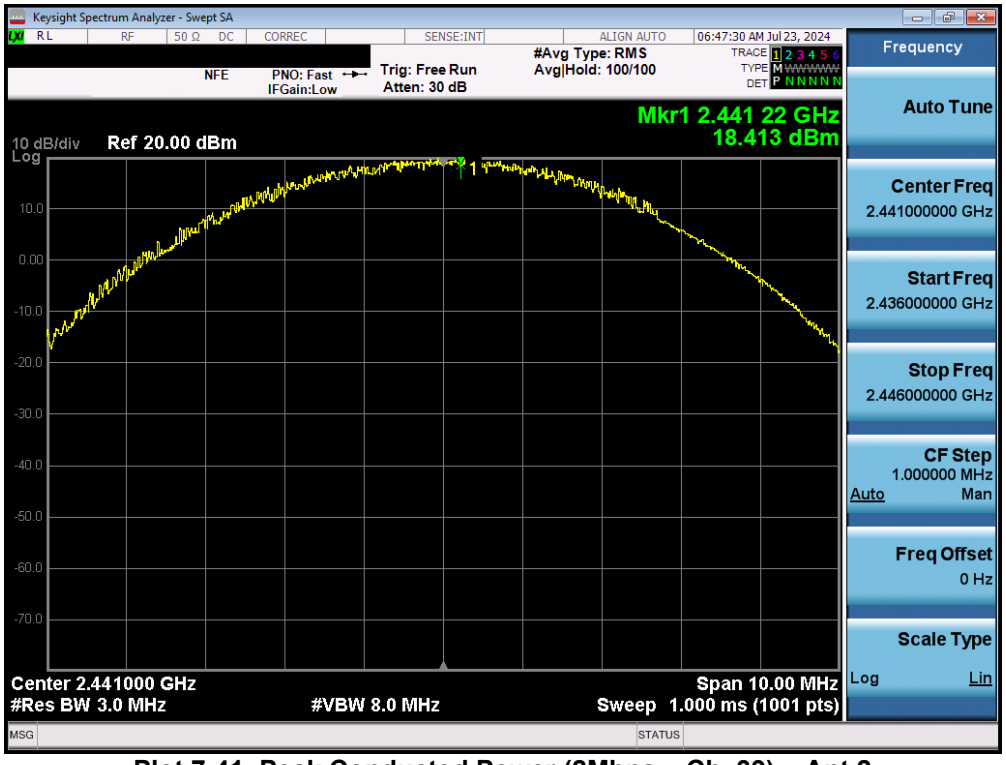
Plot 7-38. Peak Conducted Power (1Mbps – Ch. 39) – Ant 2



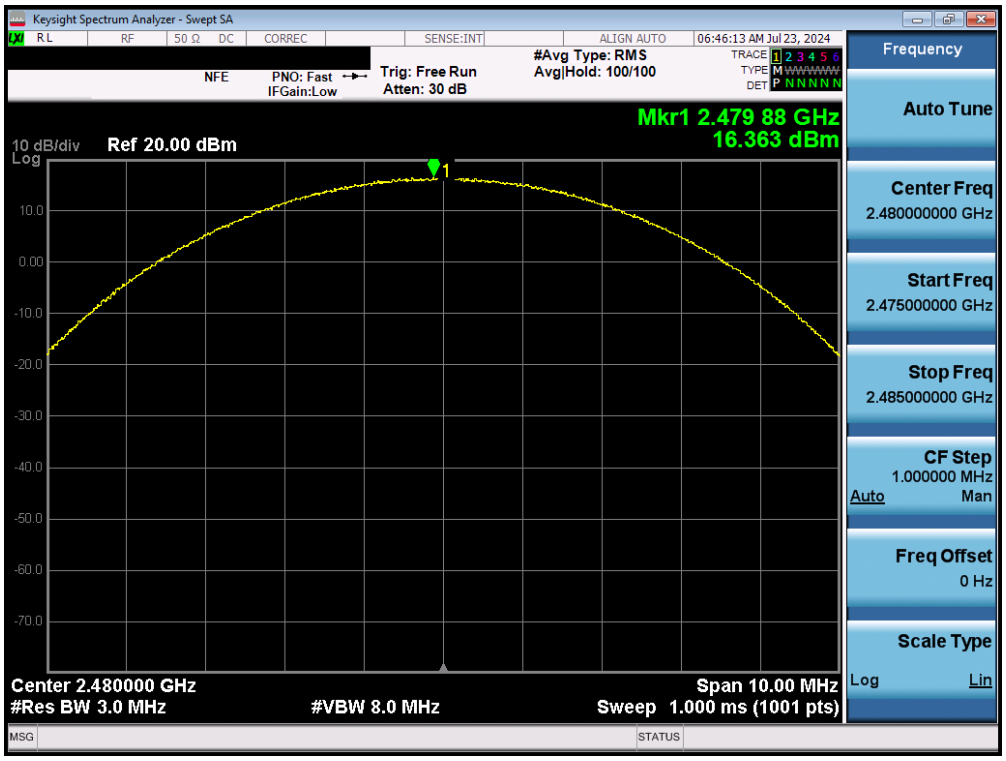
Plot 7-39. Peak Conducted Power (1Mbps – Ch. 78) – Ant 2



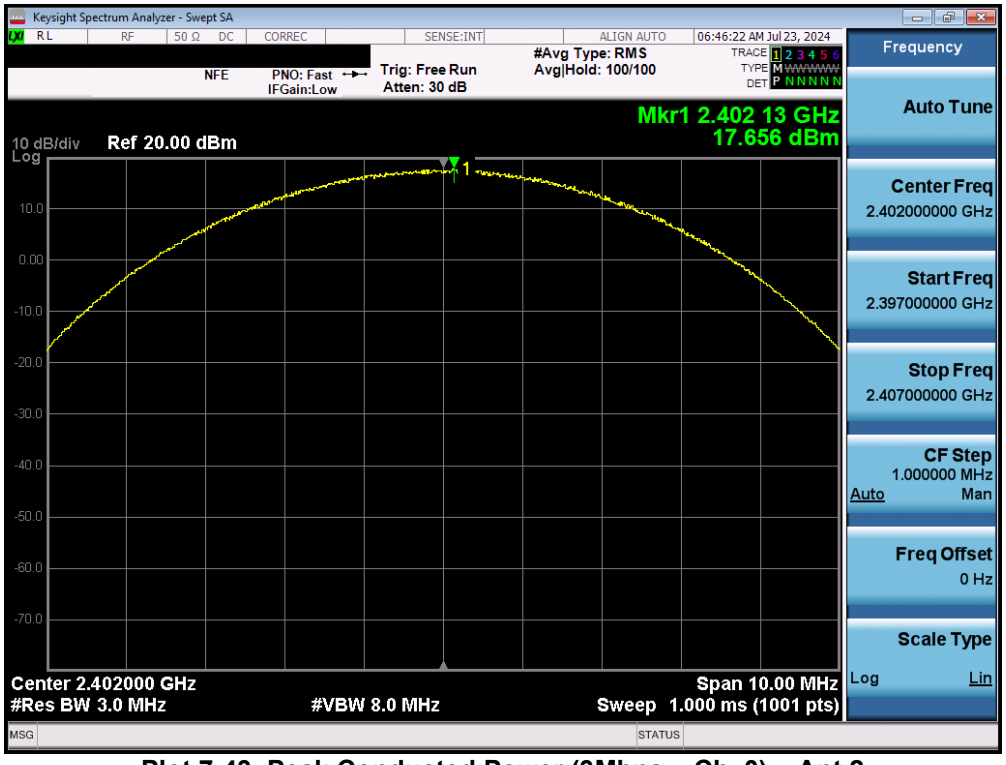
Plot 7-40. Peak Conducted Power (2Mbps – Ch. 0) – Ant 2



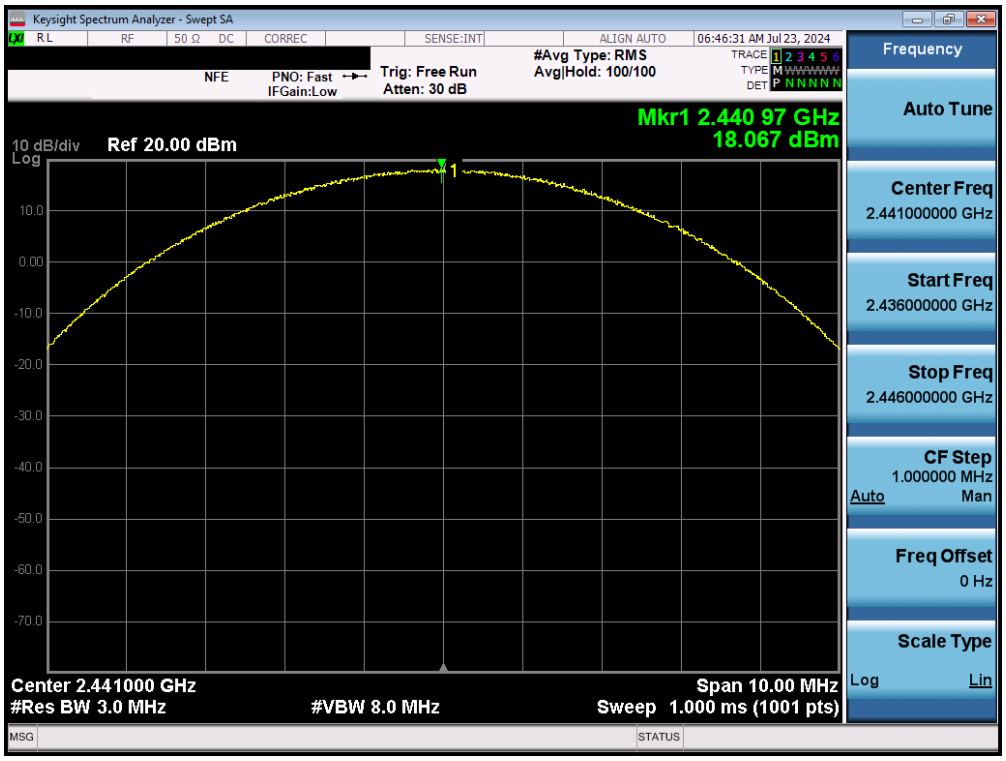
Plot 7-41. Peak Conducted Power (2Mbps – Ch. 39) – Ant 2



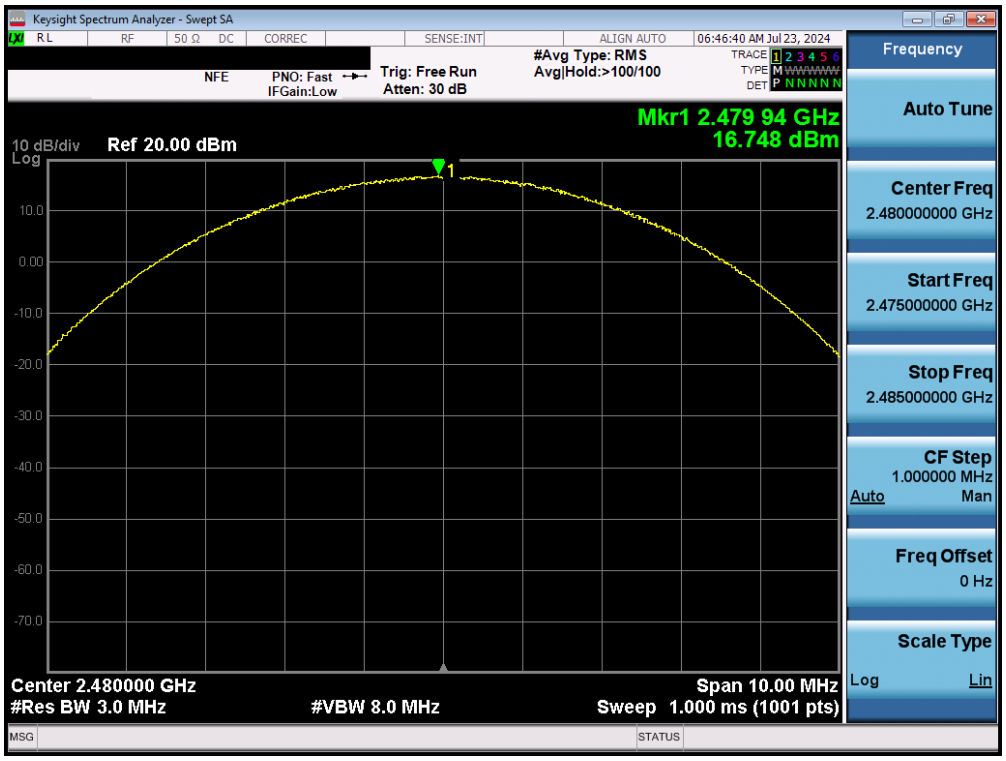
Plot 7-42. Peak Conducted Power (2Mbps – Ch. 78) – Ant 2



Plot 7-43. Peak Conducted Power (3Mbps – Ch. 0) – Ant 2



Plot 7-44. Peak Conducted Power (3Mbps – Ch. 39) – Ant 2

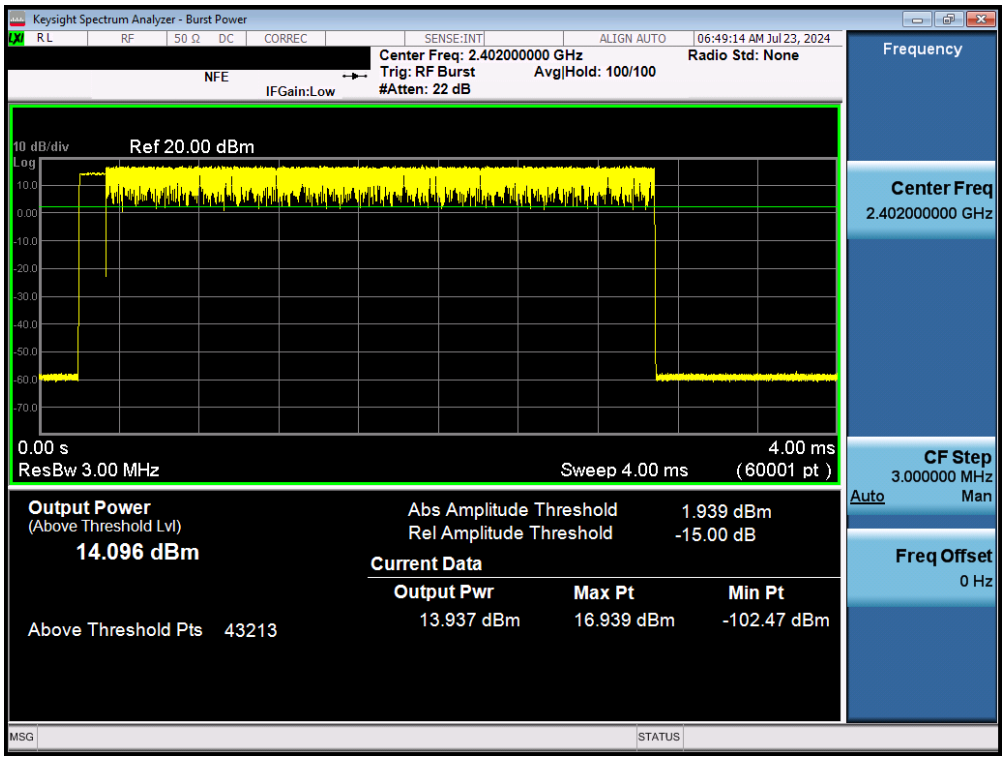


Plot 7-45. Peak Conducted Power (3Mbps – Ch. 78) – Ant 2

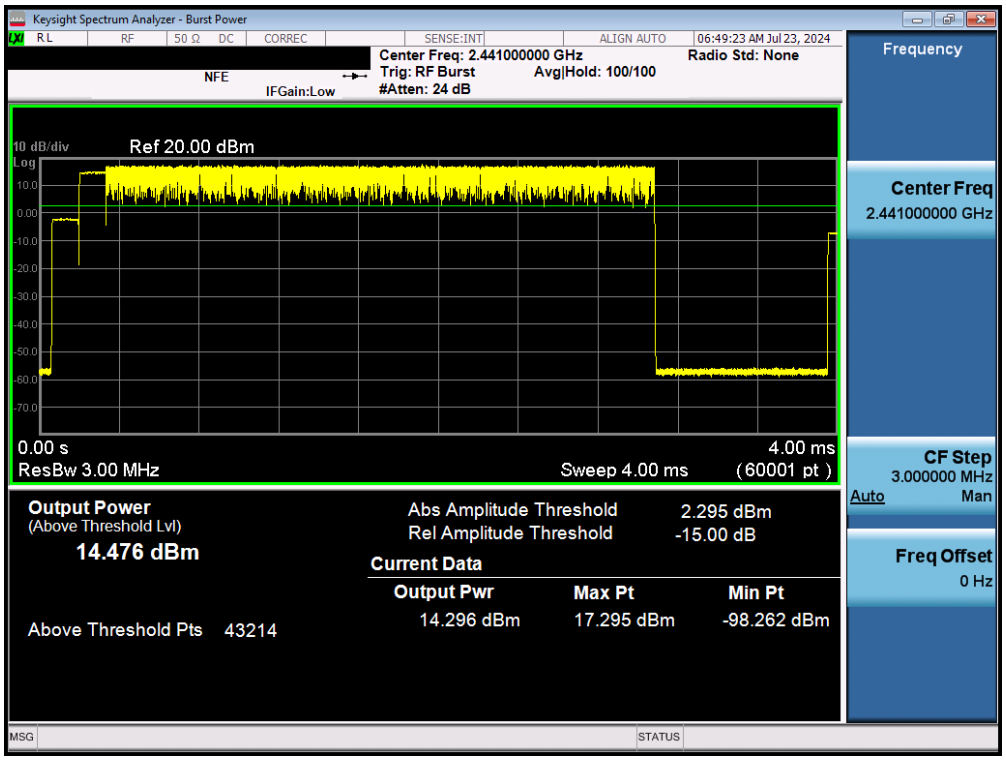
Plot 7-46. Average Conducted Power (1Mbps – Ch. 0) – Ant 2

Plot 7-47. Average Conducted Power (1Mbps – Ch. 39) – Ant 2

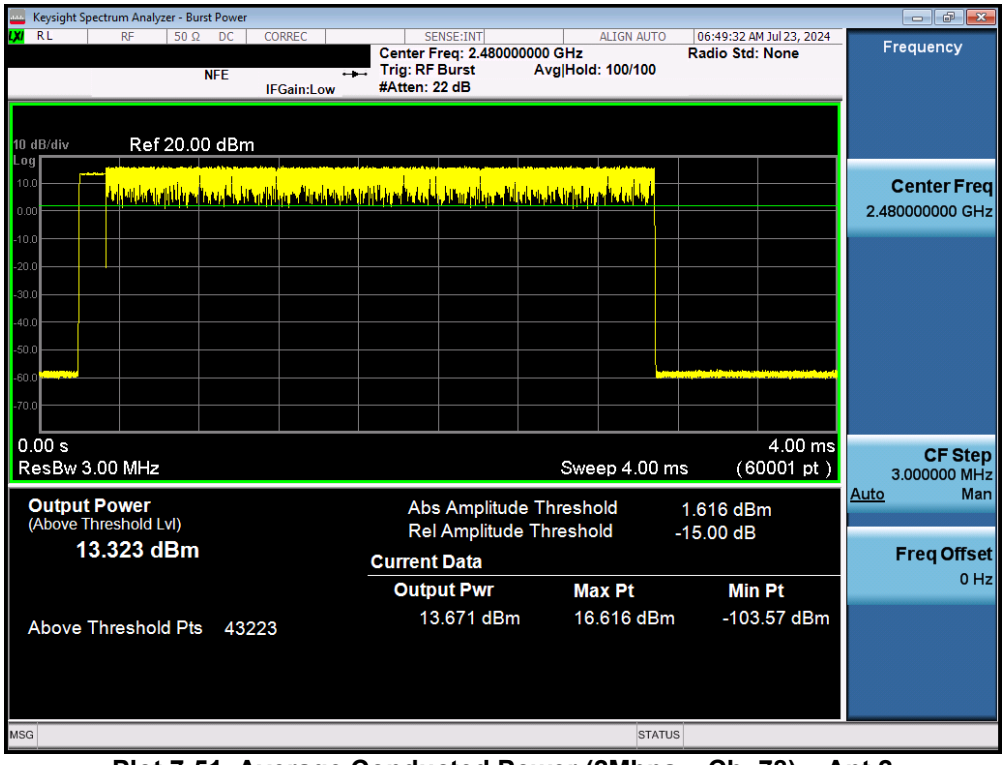
Plot 7-48. Average Conducted Power (1Mbps – Ch. 78) – Ant 2



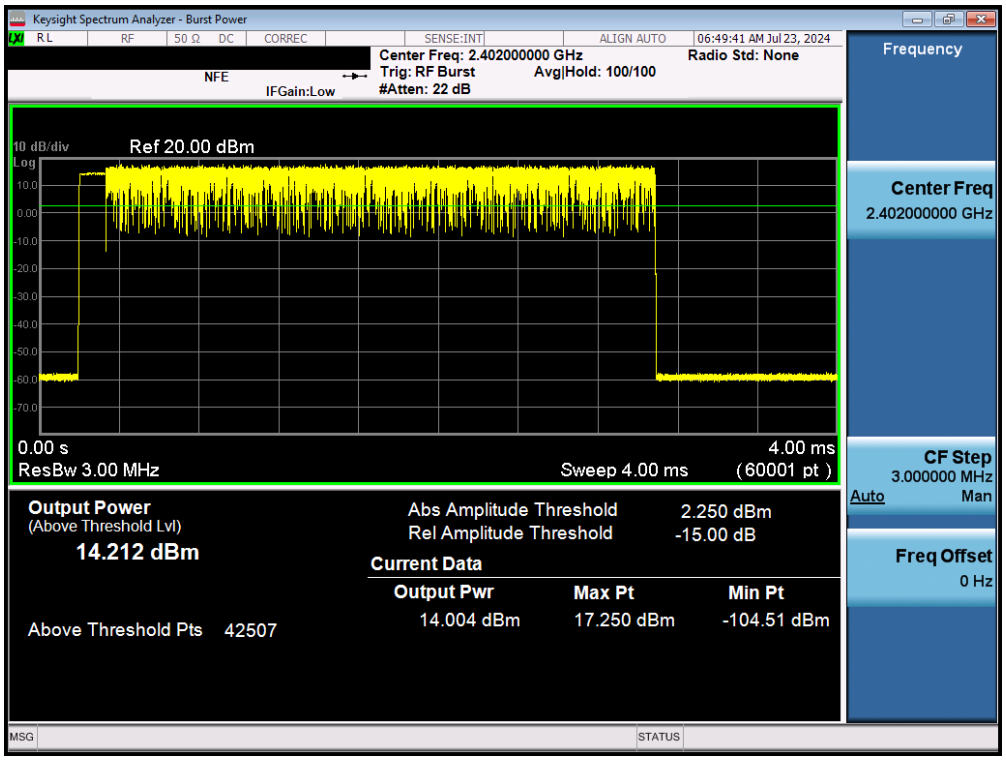
Plot 7-49. Average Conducted Power (2Mbps – Ch. 0) – Ant 2



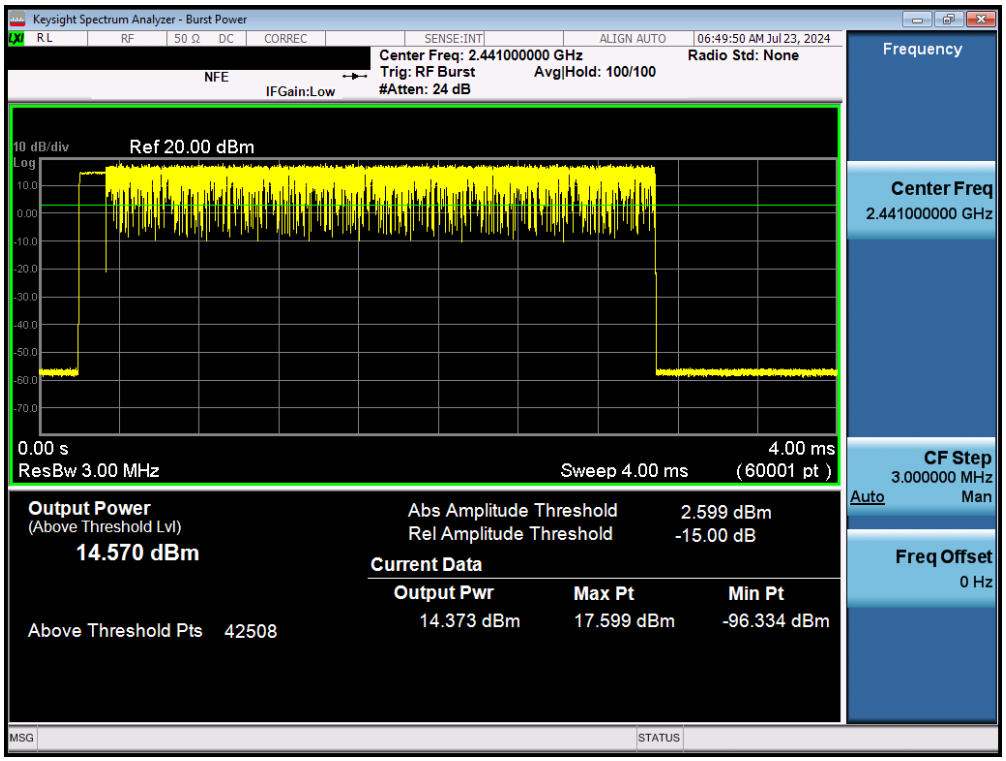
Plot 7-50. Average Conducted Power (2Mbps – Ch. 39) – Ant 2



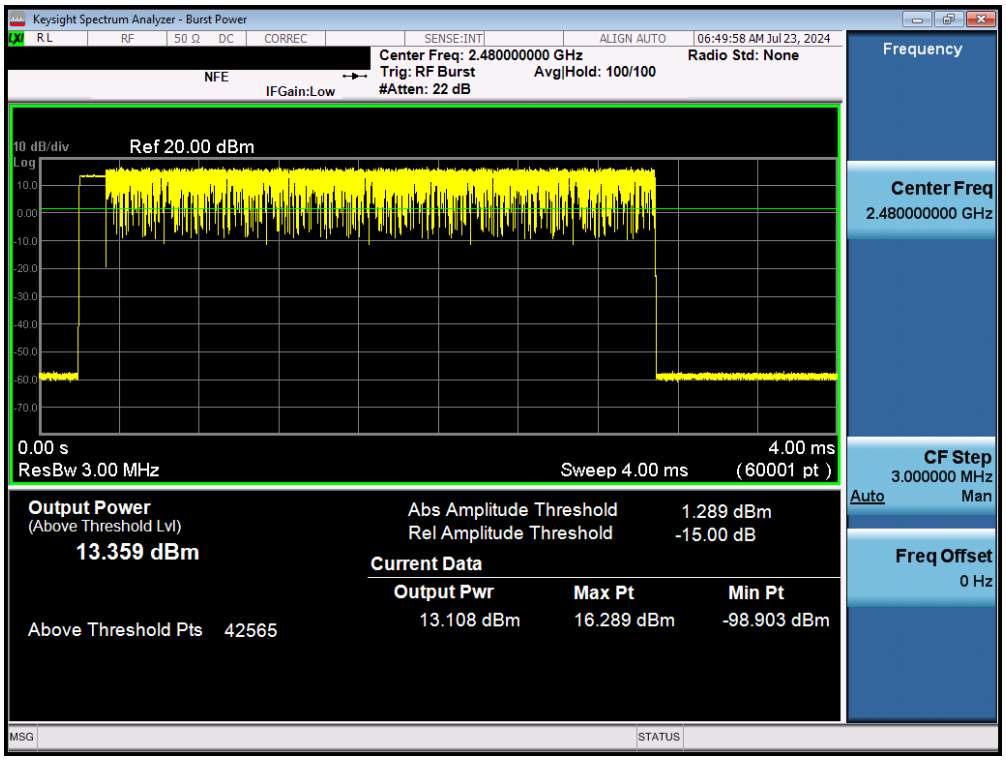
Plot 7-51. Average Conducted Power (2Mbps – Ch. 78) – Ant 2



Plot 7-52. Average Conducted Power (3Mbps – Ch. 0) – Ant 2



Plot 7-53. Average Conducted Power (3Mbps – Ch. 39) – Ant 2



Plot 7-54. Average Conducted Power (3Mbps – Ch. 78) – Ant 2

7.4 Band Edge Compliance

§15.247 (d)

Test Overview and Limits

EUT operates in hopping and non-hopping transmission mode. Measurement is taken at the highest point located outside of the emission bandwidth. ***The maximum permissible out-of-band emission level is 20 dBc.***

Test Procedure Used

ANSI C63.10-2013 – Section 6.10.4

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 = 300kHz
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

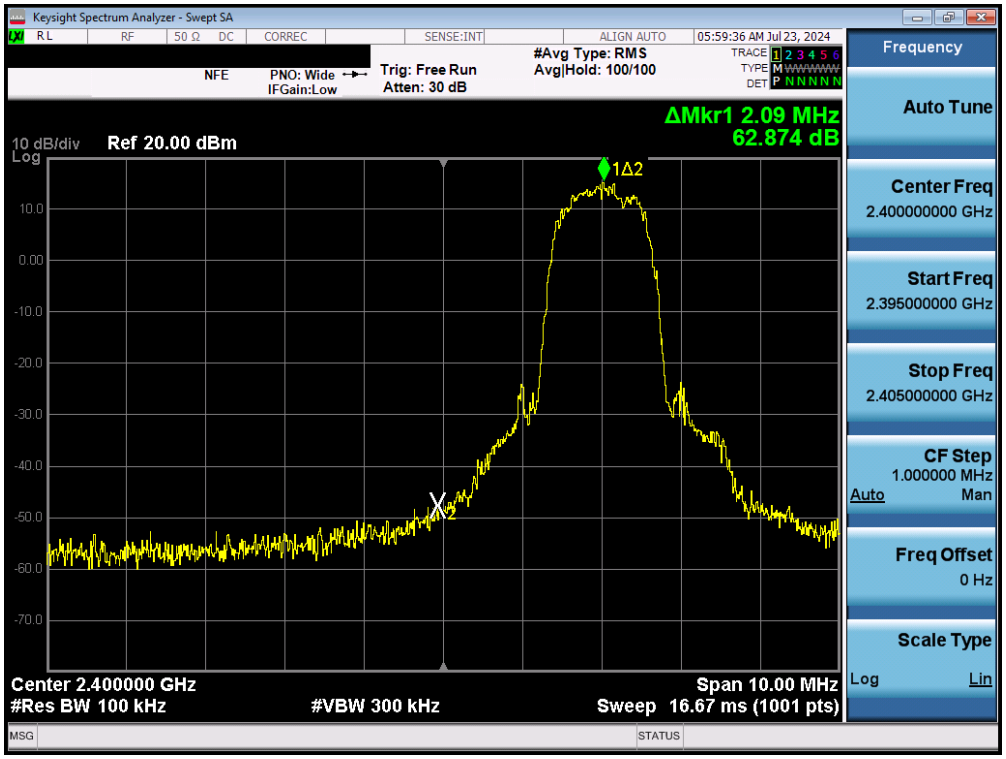
Test Setup

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

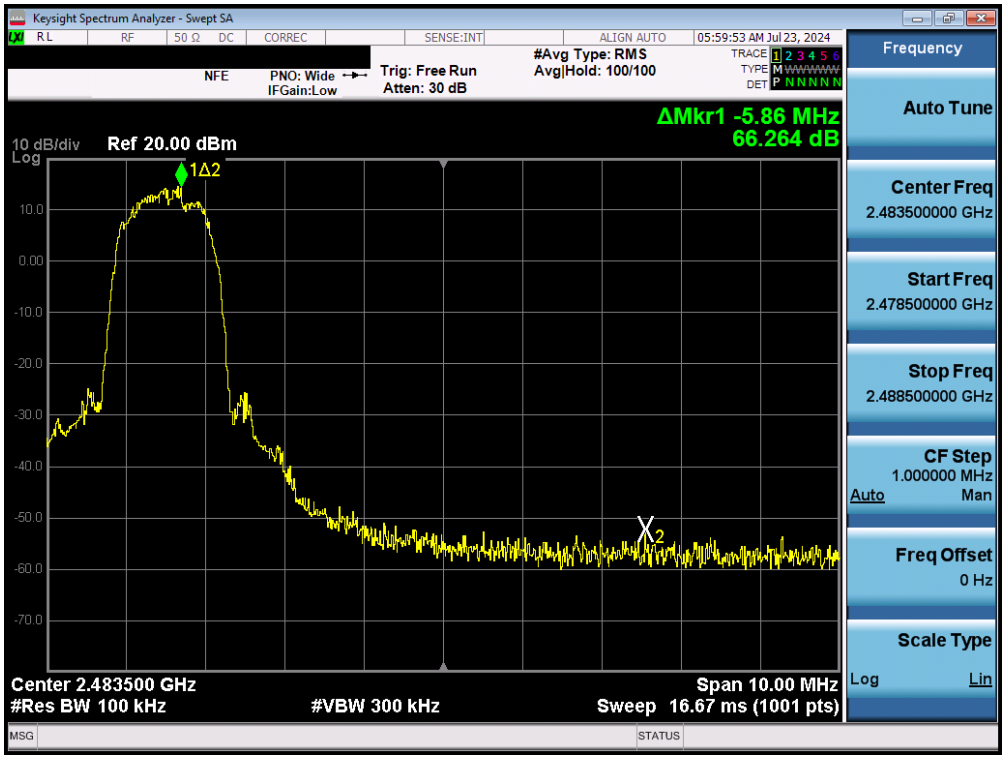
Figure 7-3. Test Instrument & Measurement Setup

Test Notes

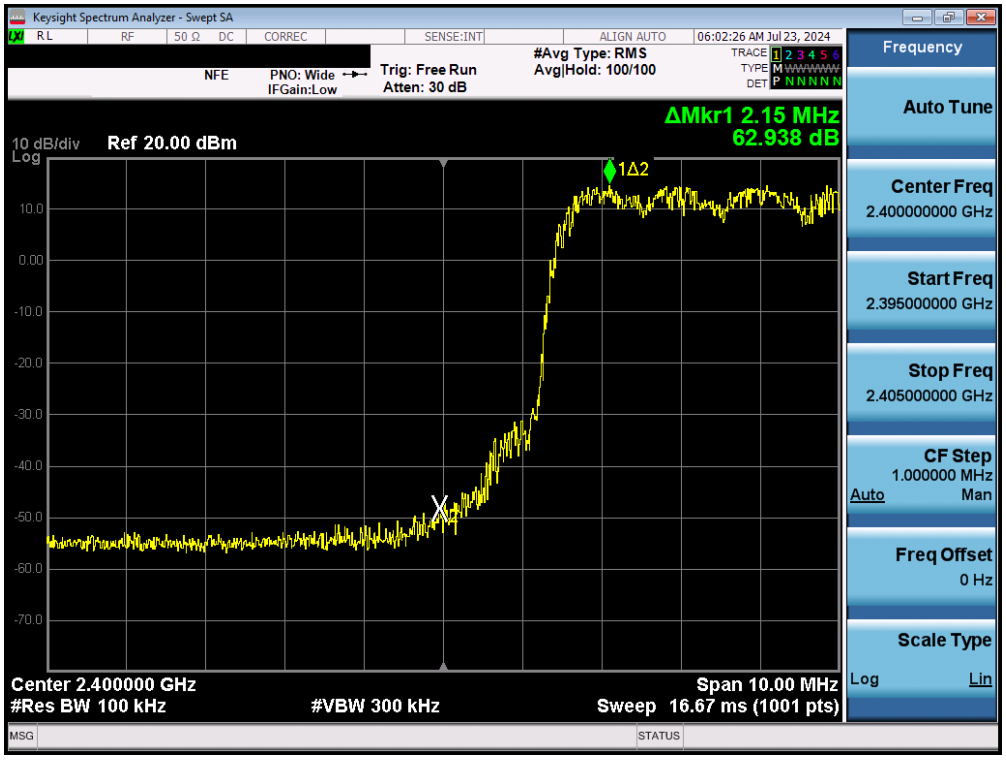
Out of band conducted spurious emissions at the band edge were investigated for all data rates in hopping and non-hopping modes. The worst case emissions were found with the EUT transmitting at 3 Mbps. Band edge emissions were also investigated with the EUT transmitting in all data rates. Plots of the worst case emissions are shown below.



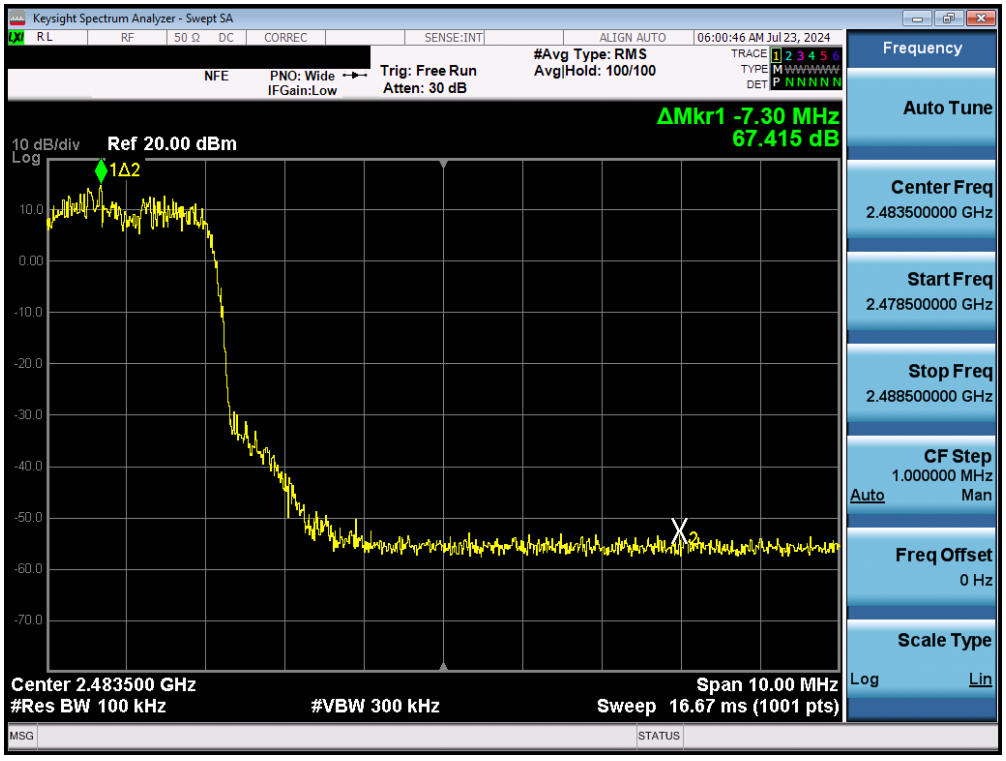
Plot 7-55. Band Edge Plot (Bluetooth with Hopping Disabled, 3 Mbps – Ch. 0) – Ant1



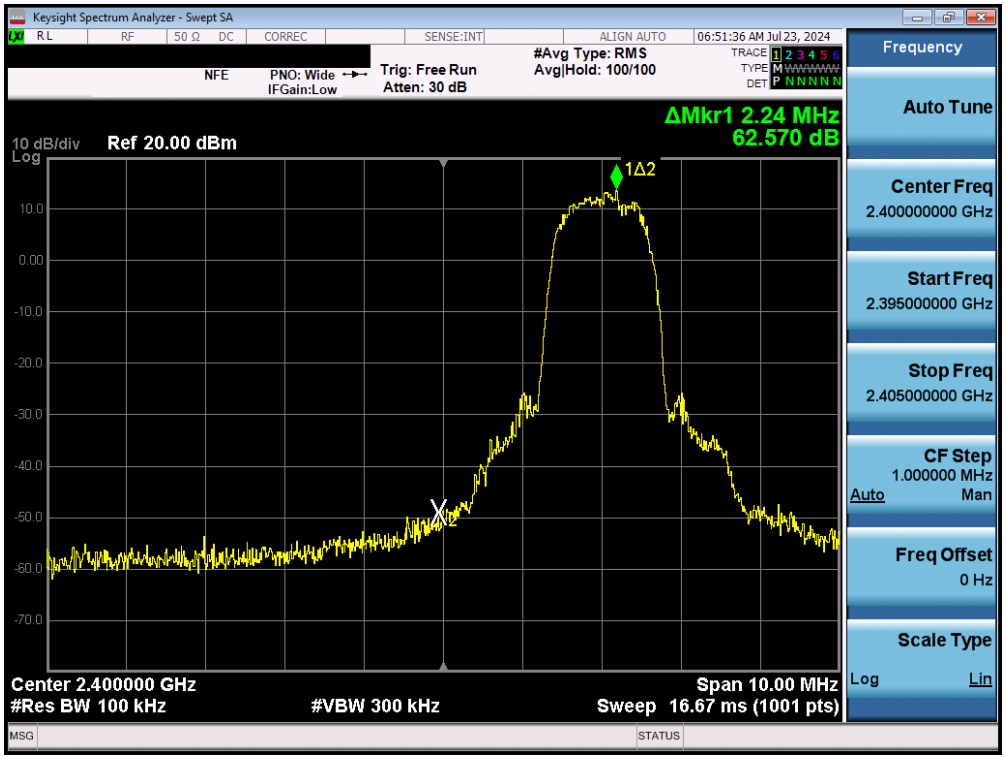
Plot 7-56. Band Edge Plot (Bluetooth with Hopping Disabled, 3 Mbps – Ch. 78) – Ant1



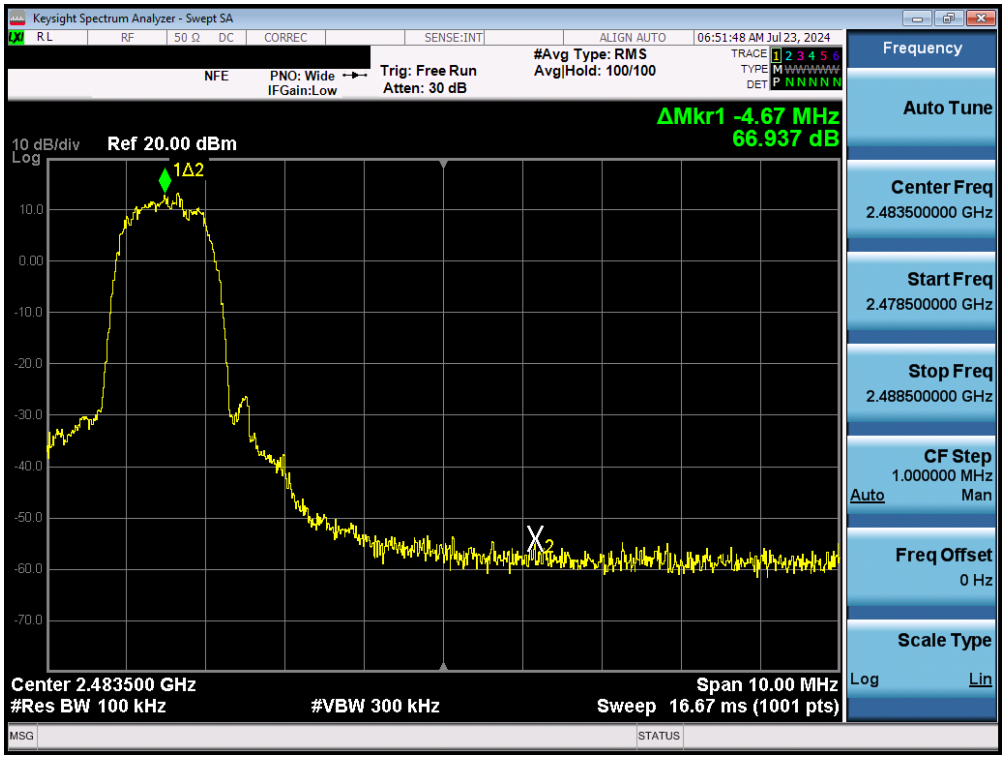
Plot 7-57. Band Edge Plot (Bluetooth with Hopping Enabled, 3 Mbps) – Ant1



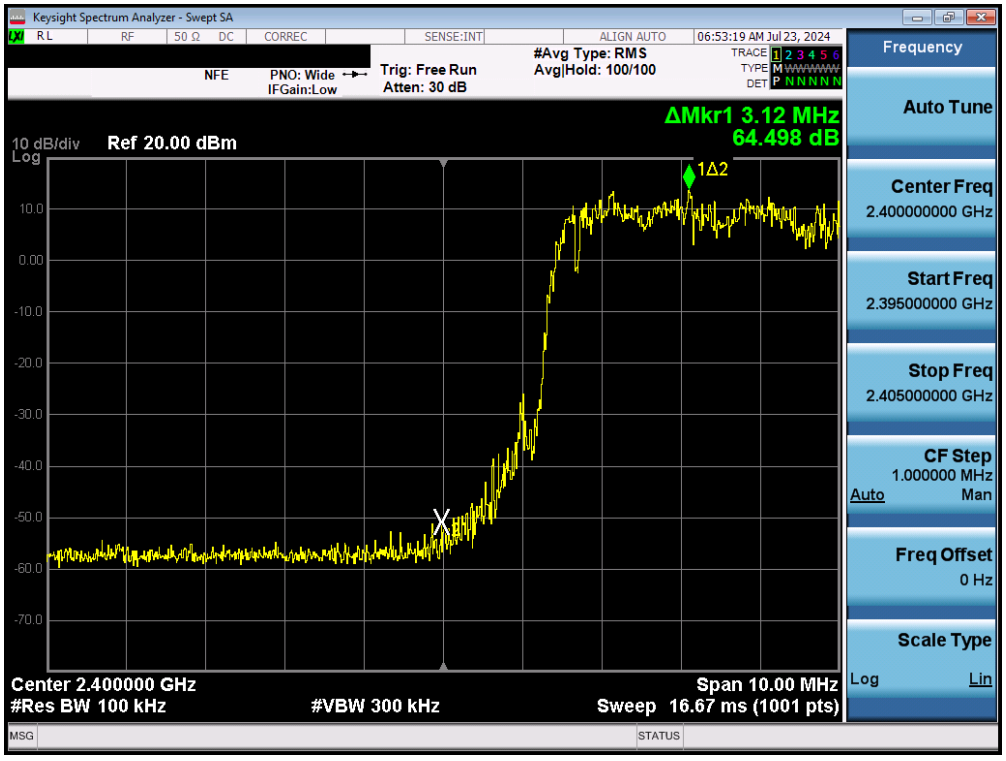
Plot 7-58. Band Edge Plot (Bluetooth with Hopping Enabled, 3 Mbps) – Ant1



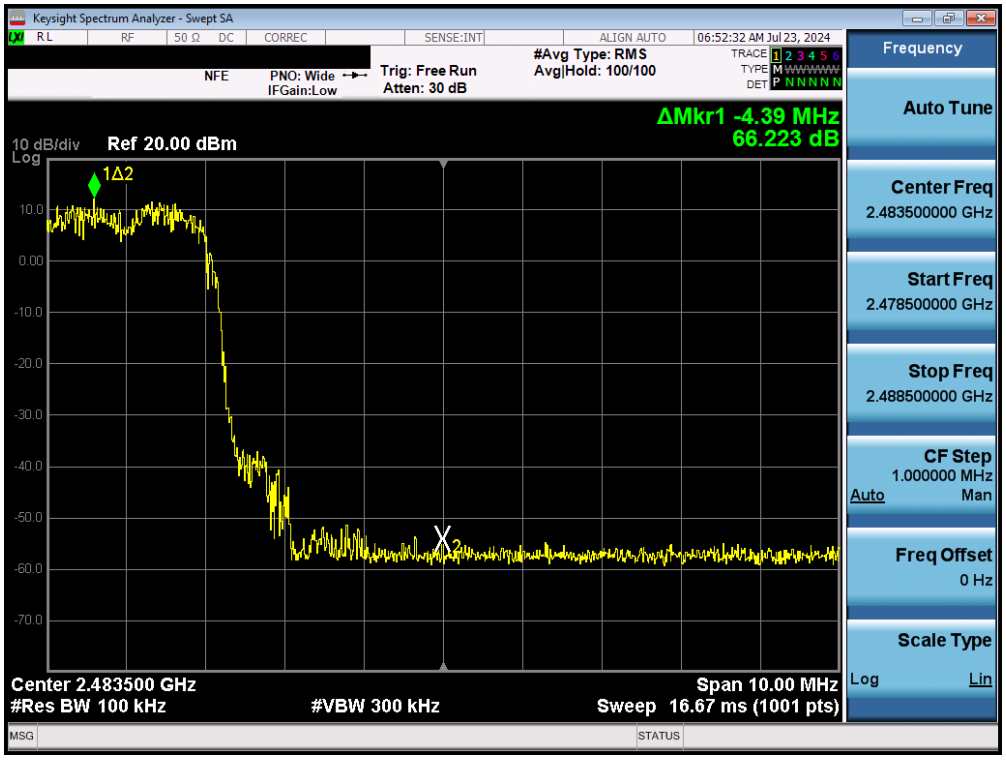
Plot 7-59. Band Edge Plot (Bluetooth with Hopping Disabled, 3 Mbps – Ch. 0) – Ant2



Plot 7-60. Band Edge Plot (Bluetooth with Hopping Disabled, 3 Mbps – Ch. 78) – Ant2



Plot 7-61. Band Edge Plot (Bluetooth with Hopping Enabled, 3 Mbps) – Ant2



Plot 7-62. Band Edge Plot (Bluetooth with Hopping Enabled, 3 Mbps) – Ant2

7.5 Carrier Frequency Separation

§15.247 (a.1)

Test Overview and Limit

Measurement is made with EUT operating in hopping mode. ***The minimum permissible channel separation for this system is 2/3 the value of the 20dB BW.***

Test Procedure Used

ANSI C63.10-2013 – Section 7.8.2

Test Settings

1. Span = Wide enough to capture peaks of two adjacent channels
2. RBW = 30% of channel spacing. Adjust as necessary to best identify center of each individual channel
3. VBW ≥ RBW
4. Sweep = Auto
5. Detector = Peak
6. Trace mode = max hold
7. The trace was allowed to stabilize.
8. Marker-delta function used to determine separation between peaks of the adjacent channels

Test Setup

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

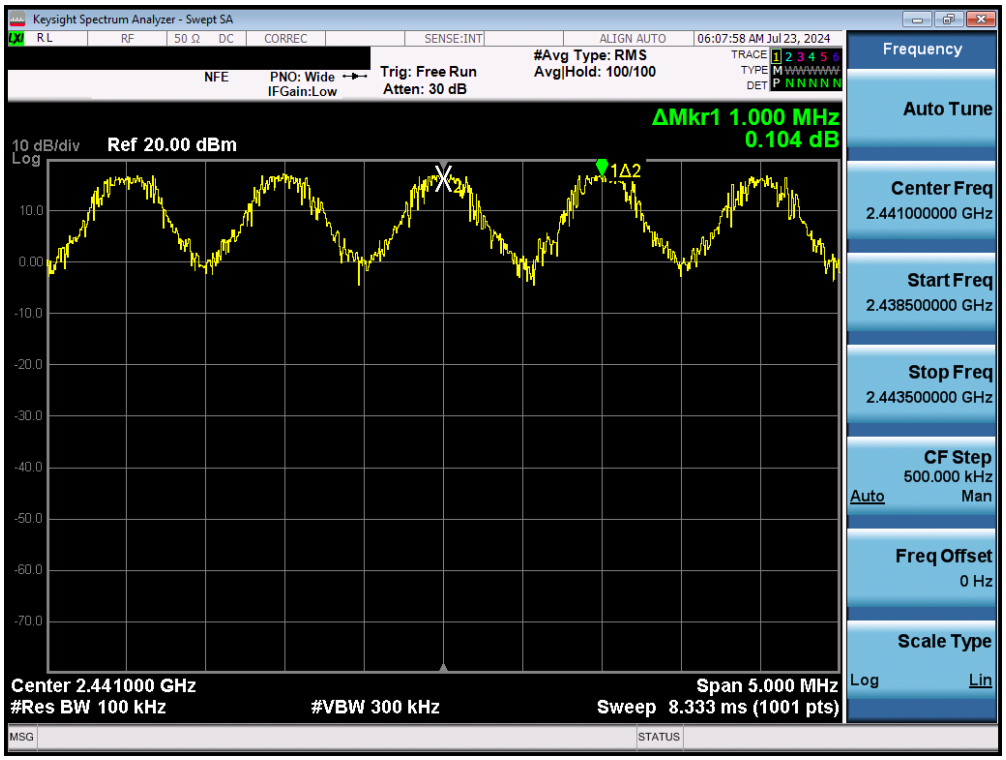
Figure 7-4. Test Instrument & Measurement Setup

Test Notes

The EUT complies with the minimum channel separation requirement when it is operating in 1x/EDR mode using 79 channels and when operating in AFH mode using 20 channels.

Frequency [MHz]	Data Rate [Mbps]	Channel No.	Min. Channel Separation [MHz]
2402	1.0	0	0.628
2441	1.0	39	0.669
2480	1.0	78	0.678
2402	2.0	0	0.885
2441	2.0	39	0.869
2480	2.0	78	0.877
2402	3.0	0	0.863
2441	3.0	39	0.849
2480	3.0	78	0.885

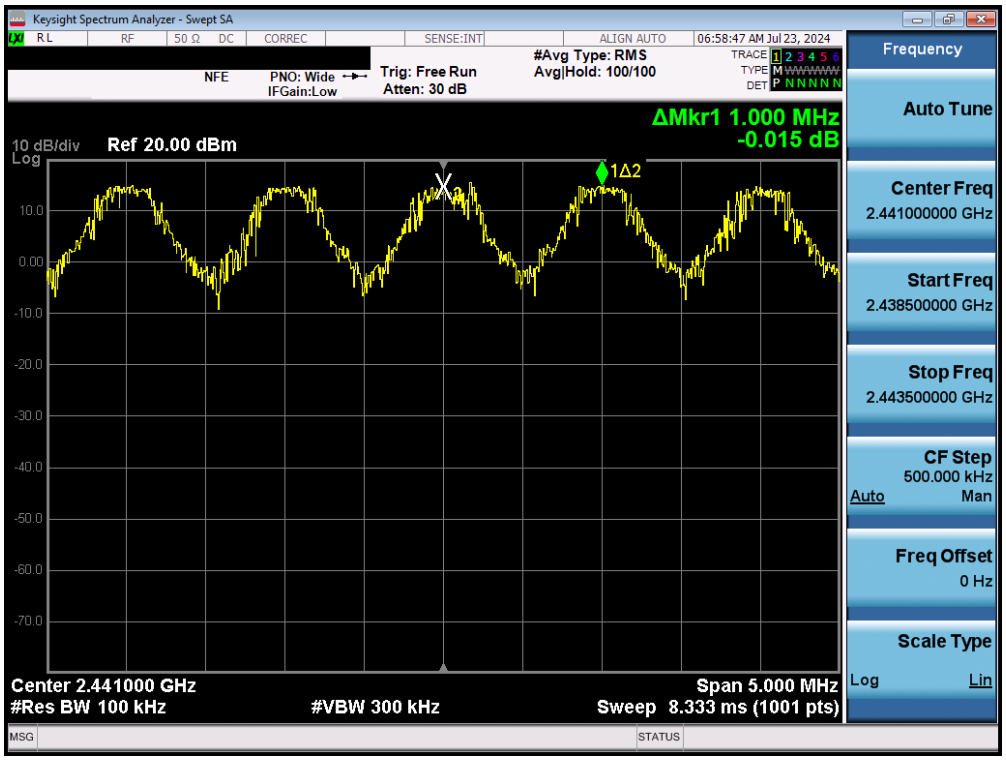
Table 7-6. Minimum Channel Separation – Ant1



Plot 7-63. Channel Spacing Plot (Bluetooth) – Ant1

Frequency [MHz]	Data Rate [Mbps]	Channel No.	Min. Channel Separation [MHz]
2402	1.0	0	0.630
2441	1.0	39	0.632
2480	1.0	78	0.634
2402	2.0	0	0.873
2441	2.0	39	0.835
2480	2.0	78	0.875
2402	3.0	0	0.884
2441	3.0	39	0.871
2480	3.0	78	0.851

Table 7-7. Minimum Channel Separation – Ant2



Plot 7-64. Channel Spacing Plot (Bluetooth) – Ant2

7.6 Time of Occupancy

§15.247 (a.1.iii)

Test Overview and Limit

Measurement is made while EUT is operating in hopping mode with the spectrum analyzer set to zero span. ***The maximum permissible time of occupancy is 400 ms within a period of 400ms multiplied by the number of hopping channels employed.***

Test Procedure Used

ANSI C63.10-2013 – Section 7.8.4

Test Settings

1. Span = zero span, centered on a hopping channel
2. RBW ≤ channel spacing and >> 1/T, where T is expected dwell time per channel
3. Sweep = as necessary to capture entire dwell time. Second plot may be required to demonstrate two successive hops on a channel
4. Trigger is set with appropriate trigger delay to place pulse near the center of the plot
5. Detector = peak
6. Trace mode = max hold
7. Marker-delta function used to determine transmit time per hop

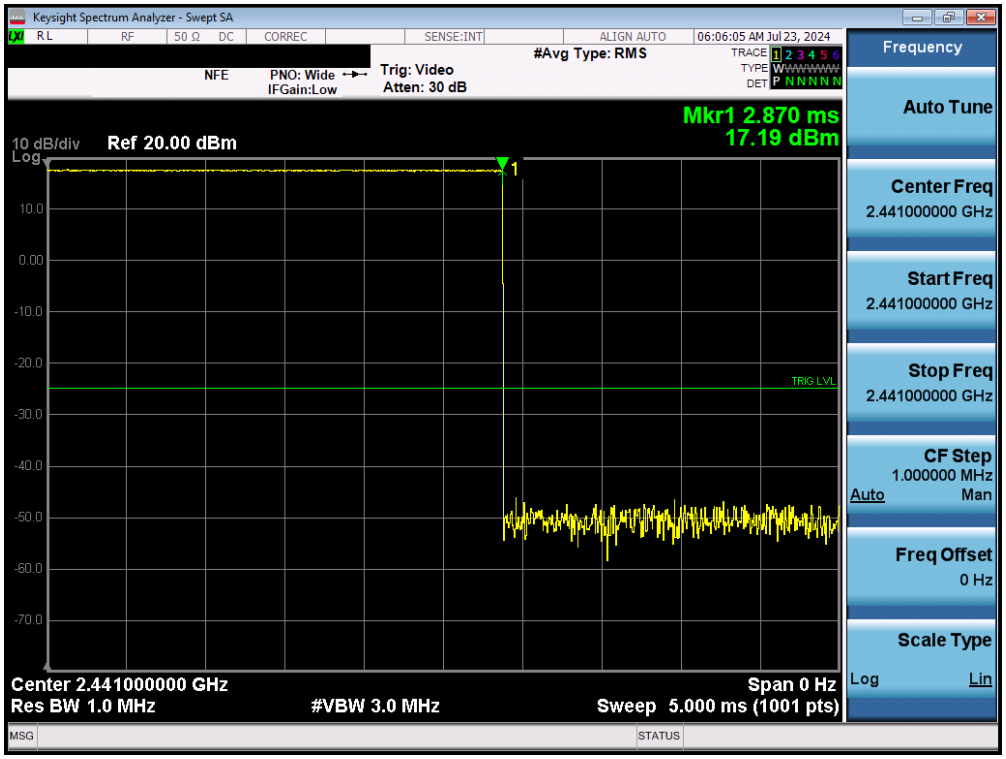
Test Setup

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

Figure 7-5. Test Instrument & Measurement Setup

Test Notes

None



Plot 7-65. Time of Occupancy Plot (Bluetooth) – Ant1

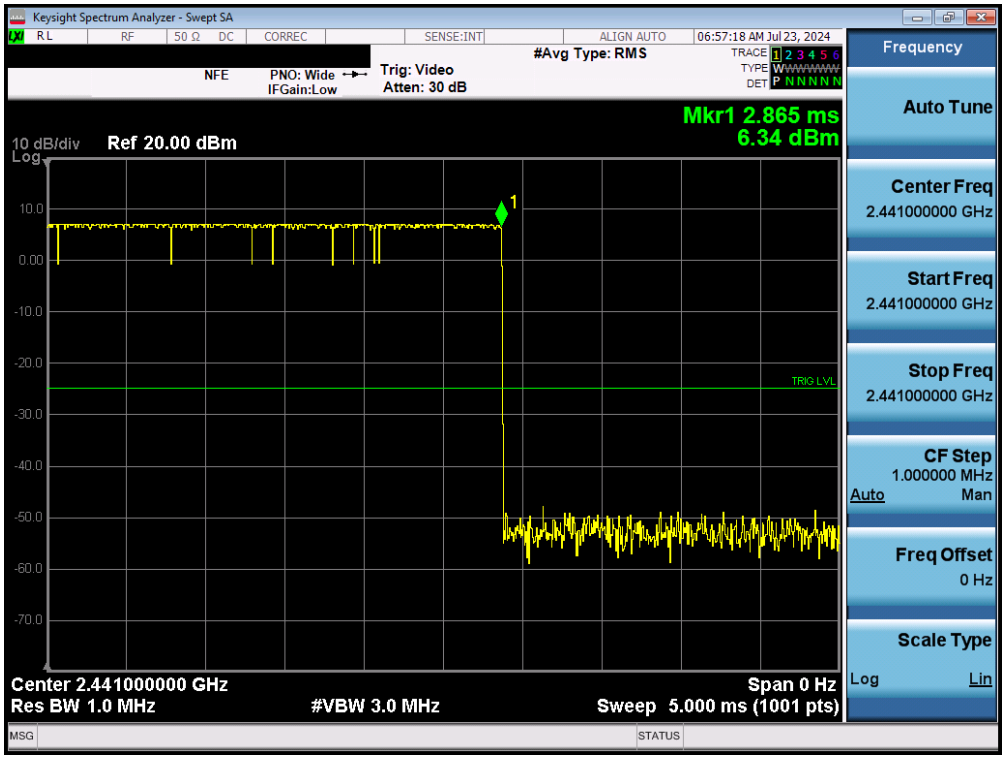
Bluetooth Time of Occupancy Calculation

Typically, Bluetooth 1x/EDR mode has a channel hopping rate of 1600 hops/s. Since 1x/EDR modes use 5 transmit and 1 receive slot, for a total of 6 slots, the Bluetooth transmitter is actually hopping at a rate of 1600 / 6 = 266.67 hops/s/slot

- 400ms x 79 hopping channels = 31.6 sec (Time of Occupancy Limit)
- Worst case BT has 266.67 hops/second (for 1x/EDR modes with DH5 operation)
- 266.67 hops/second / 79 channels = 3.38 hops/second (# of hops/second on one channel)
- 3.38 hops/second/channel x 31.6 seconds = 106.67 hops (# hops over a 31.6 second period)
- 106.67 hops x 2.870 ms/channel = 306.14 ms (worst case dwell time for one channel in 1x/EDR modes)

With AFH, the number of channels is reduced to a minimum of 20 channels and the channel hopping rate is reduced by 50% to 800 hops/s. AFH mode also uses 6 total slots so the Bluetooth transmitter hops at a rate of 800 / 6 = 133.3 hops/s/slot

- 400ms x 20 hopping channels = 8 sec (Time of Occupancy Limit)
- Worst case BT has 133.3 hops/second/slot (for AFH mode with DH5 operation)
- 133.3 hops/s / 20 channels = 6.67 hops/second (# of hops/second on one channel)
- 6.67 hops/s / channel x 8 seconds = 53.34 hops (# hops over a 8 second period)
- 53.34 hops x 2.870 ms/channel = 153.09 ms (worst case dwell time for one channel in AFH mode)



Plot 7-66. Time of Occupancy Plot (Bluetooth) – Ant2

Bluetooth Time of Occupancy Calculation

Typically, Bluetooth 1x/EDR mode has a channel hopping rate of 1600 hops/s. Since 1x/EDR modes use 5 transmit and 1 receive slot, for a total of 6 slots, the Bluetooth transmitter is actually hopping at a rate of 1600 / 6 = 266.67 hops/s/slot

- 400ms x 79 hopping channels = 31.6 sec (Time of Occupancy Limit)
- Worst case BT has 266.67 hops/second (for 1x/EDR modes with DH5 operation)
- 266.67 hops/second / 79 channels = 3.38 hops/second (# of hops/second on one channel)
- 3.38 hops/second/channel x 31.6 seconds = 106.67 hops (# hops over a 31.6 second period)
- 106.67 hops x 2.865 ms/channel = 305.61 ms (worst case dwell time for one channel in 1x/EDR modes)

With AFH, the number of channels is reduced to a minimum of 20 channels and the channel hopping rate is reduced by 50% to 800 hops/s. AFH mode also uses 6 total slots so the Bluetooth transmitter hops at a rate of 800 / 6 = 133.3 hops/s/slot

- 400ms x 20 hopping channels = 8 sec (Time of Occupancy Limit)
- Worst case BT has 133.3 hops/second/slot (for AFH mode with DH5 operation)
- 133.3 hops/s / 20 channels = 6.67 hops/second (# of hops/second on one channel)
- 6.67 hops/s / channel x 8 seconds = 53.34 hops (# hops over a 8 second period)
- 53.34 hops x 2.865 ms/channel = 152.82 ms (worst case dwell time for one channel in AFH mode)

7.7 Number of Hopping Channels

§15.247 (a.1.iii)

Test Overview and Limit

Measurement is made while EUT is operating in hopping mode. ***This frequency hopping system must employ a minimum of 15 hopping channels.***

Test Procedure Used

ANSI C63.10-2013 – Section 7.8.3

Test Settings

1. Span = frequency of band of operation (divided into two plots)
2. RBW < 30% of channel spacing or 20dB bandwidth, whichever is smaller
3. VBW ≥ RBW
4. Sweep = auto
5. Detector = peak
6. Trace mode = max hold
7. Trace was allowed to stabilize

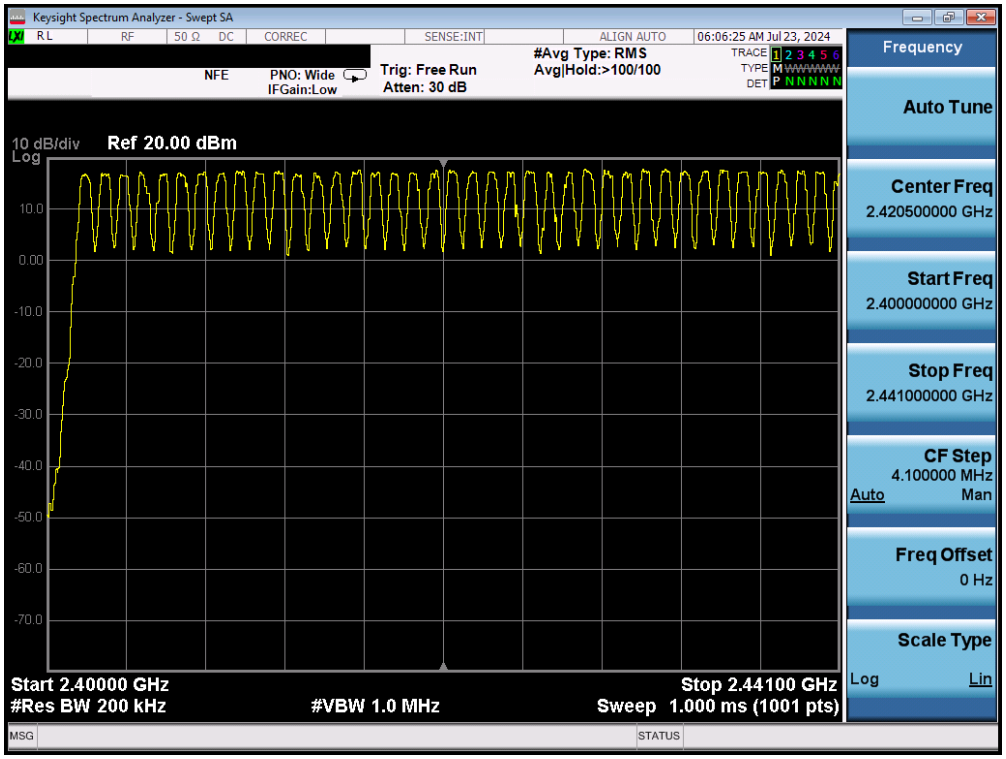
Test Setup

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

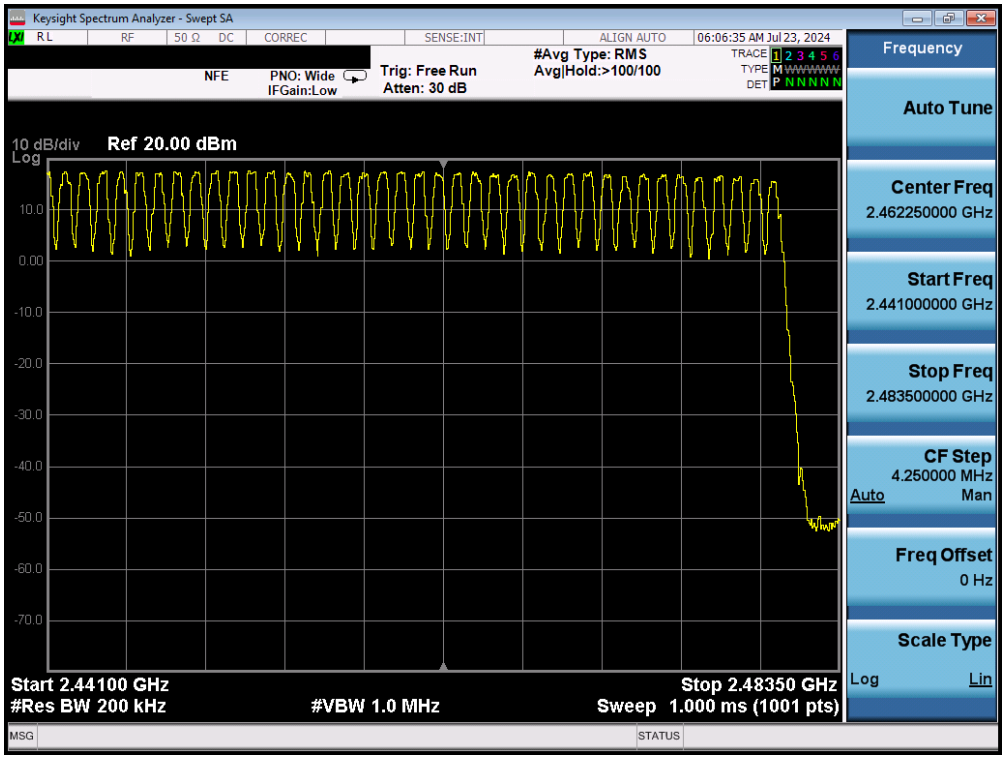
Figure 7-6. Test Instrument & Measurement Setup

Test Notes

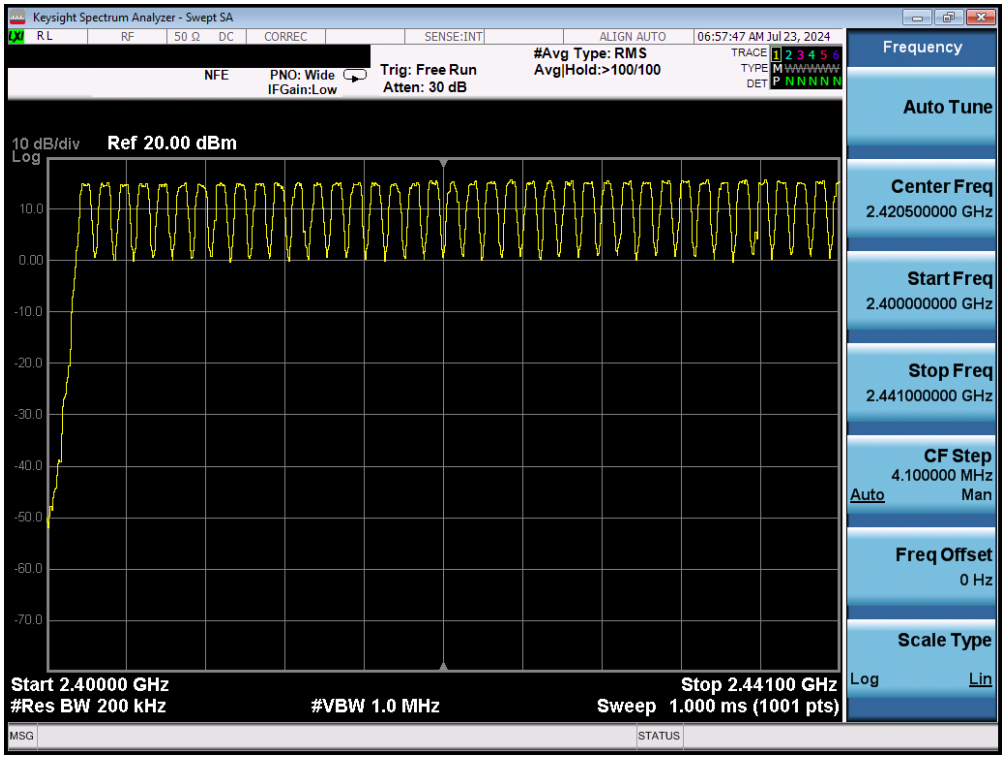
The frequency spectrum was broken up into two sub-ranges to clearly show all the hopping frequencies. In AFH mode, this device operates using 20 channels so the requirement for minimum number of hopping channels is satisfied.



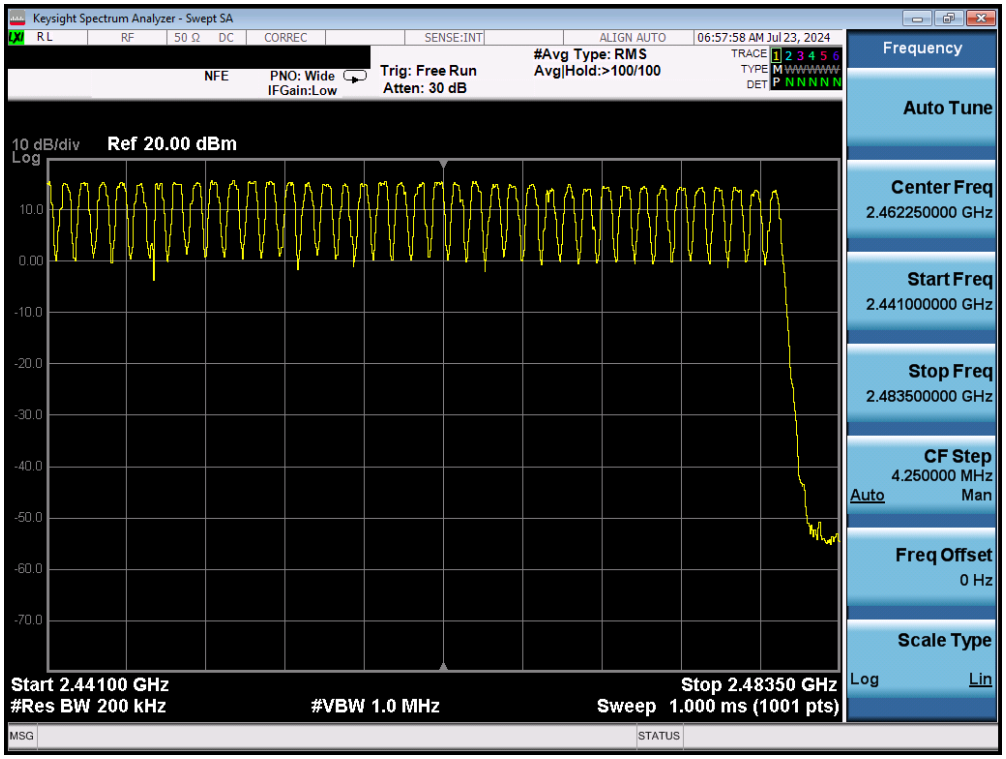
Plot 7-67. Low End Spectrum Channel Hopping Plot (Bluetooth) – Ant1



Plot 7-68. High End Spectrum Channel Hopping Plot (Bluetooth) – Ant1



Plot 7-69. Low End Spectrum Channel Hopping Plot (Bluetooth) – Ant2



Plot 7-70. High End Spectrum Channel Hopping Plot (Bluetooth) – Ant2

7.8 Conducted Spurious Emissions

§15.247 (d)

Test Overview and Limit

Conducted out-of-band spurious emissions were investigated from 30MHz up to 25GHz to include the 10th harmonic of the fundamental transmit frequency. ***The maximum permissible out-of-band emission level is 20 dBc.***

Test Procedure Used

ANSI C63.10-2013 – Section 7.8.8

Test Settings

1. Start frequency was set to 30MHz and stop frequency was set to 25GHz (separated into two plots per channel)
2. RBW = 1MHz* (See note below)
3. VBW = 3MHz
4. Detector = Peak
5. Trace mode = max hold
6. Sweep time = auto couple
7. The trace was allowed to stabilize

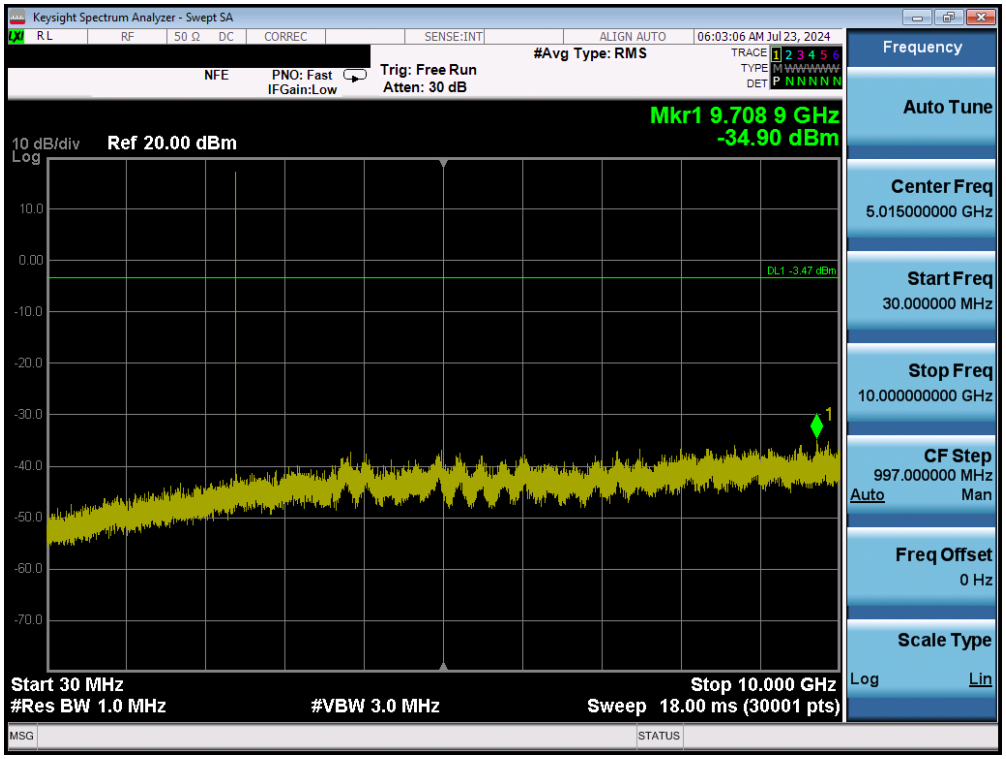
Test Setup

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

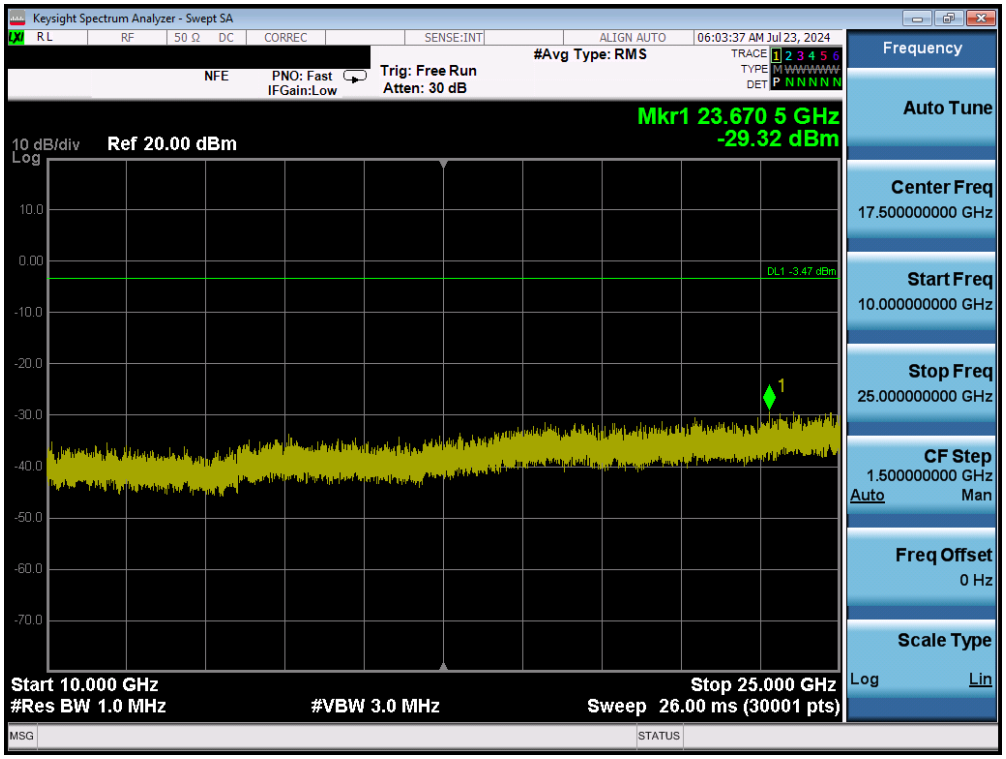
Figure 7-7. Test Instrument & Measurement Setup

Test Notes

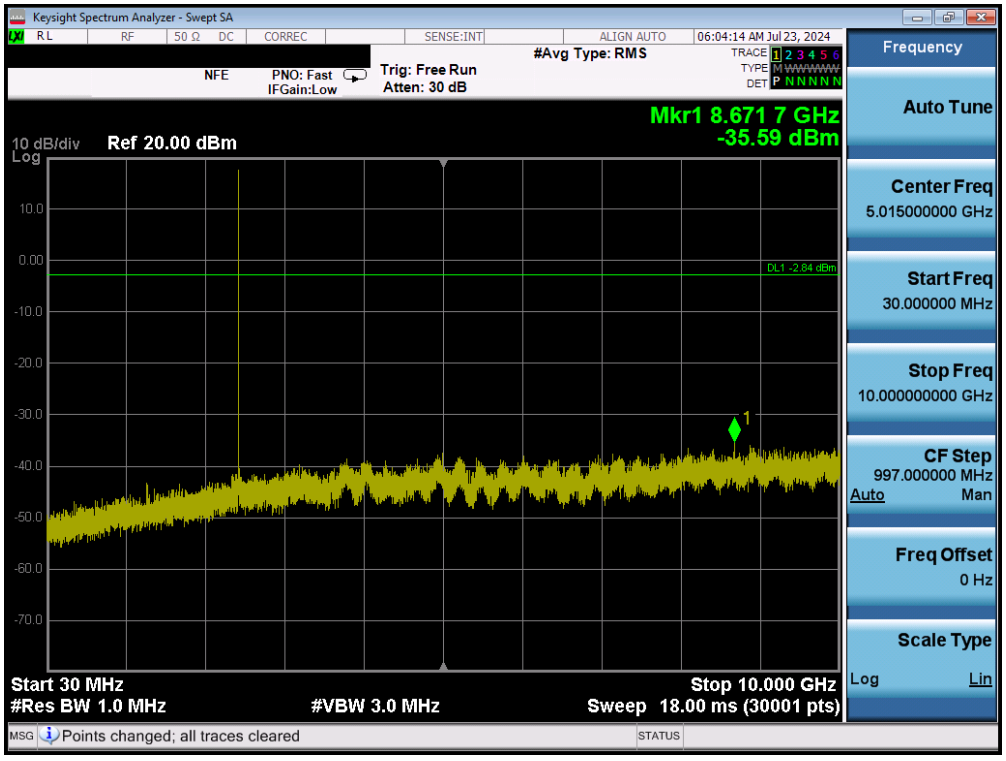
Out-of-band conducted spurious emissions were investigated for all data rates and the worst-case emissions were found with the EUT transmitting at 1Mbps. The display line shown in the following plots is the limit at 20dB below the fundamental emission level measured in a 100kHz bandwidth. However, the traces in the following plots are measured with a 1MHz RBW to reduce test time, so the display line may not necessarily appear to be 20dB below the level of the fundamental in a 1MHz bandwidth.



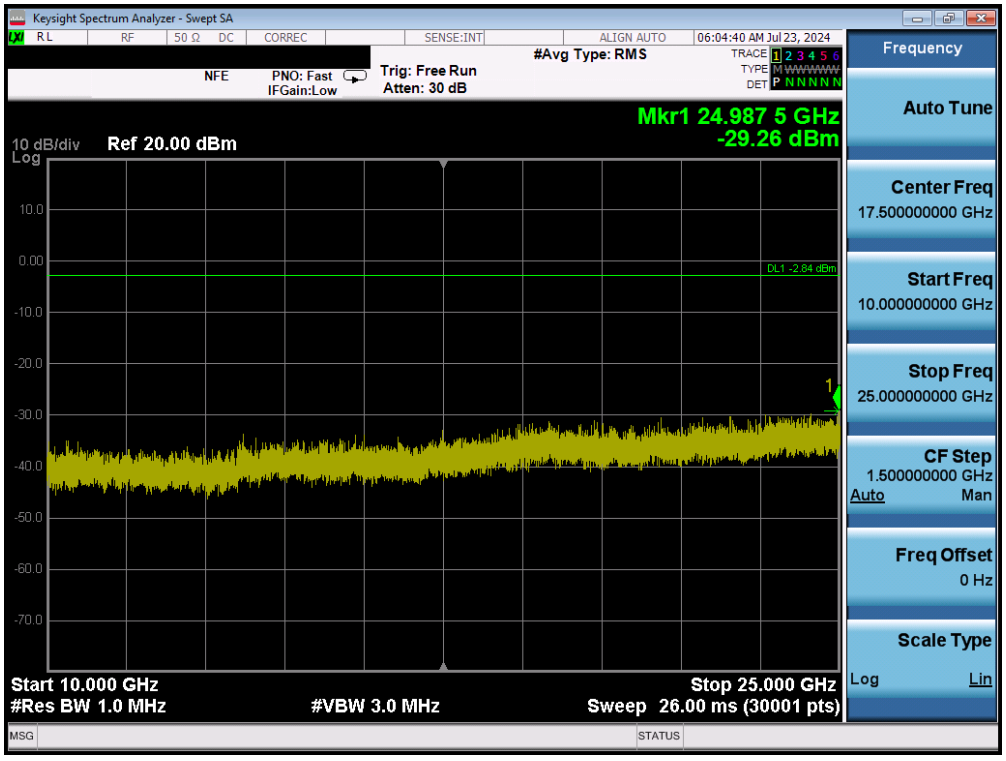
Plot 7-71. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 0) – Ant1



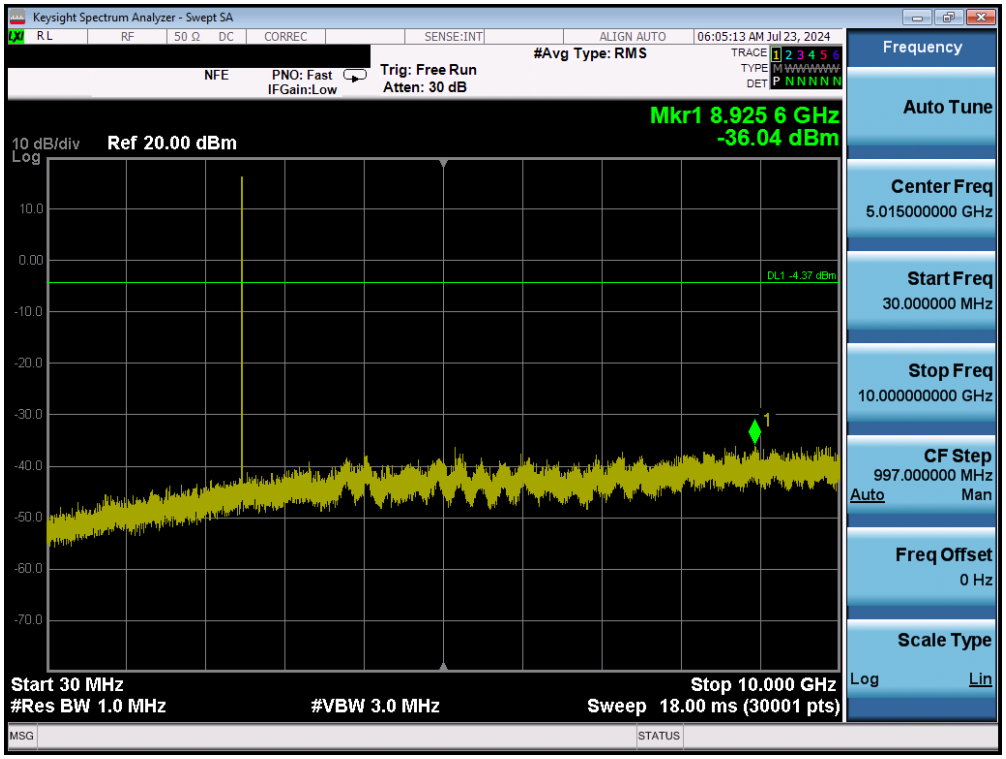
Plot 7-72. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 0) – Ant1



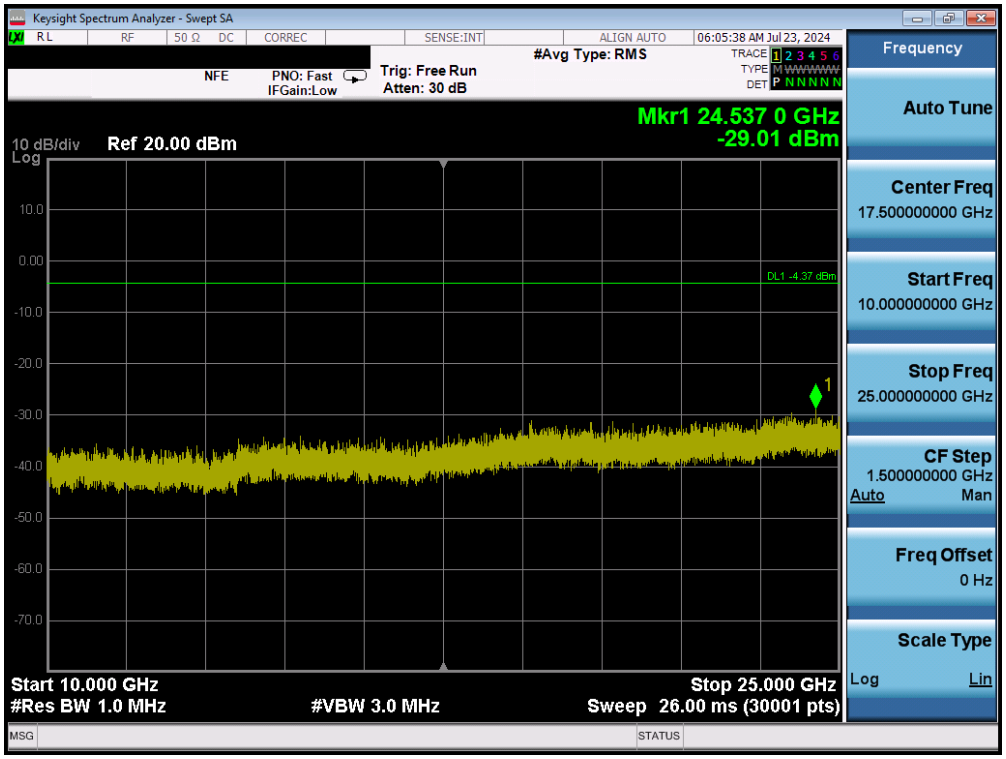
Plot 7-73. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 39) – Ant1



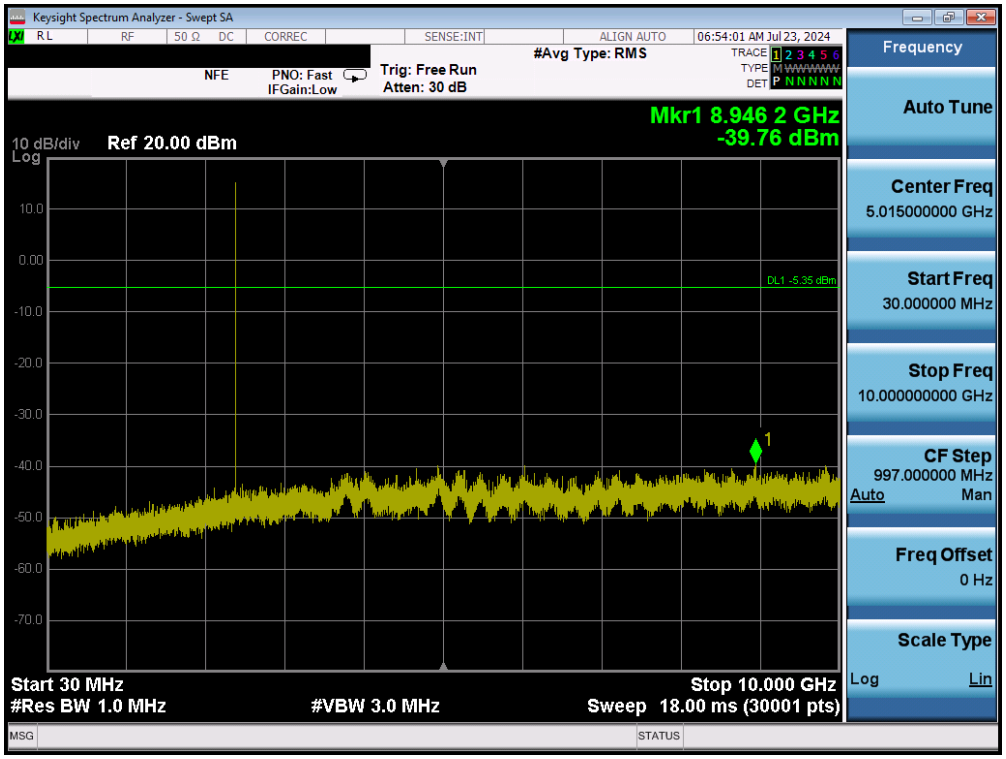
Plot 7-74. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 39) – Ant1



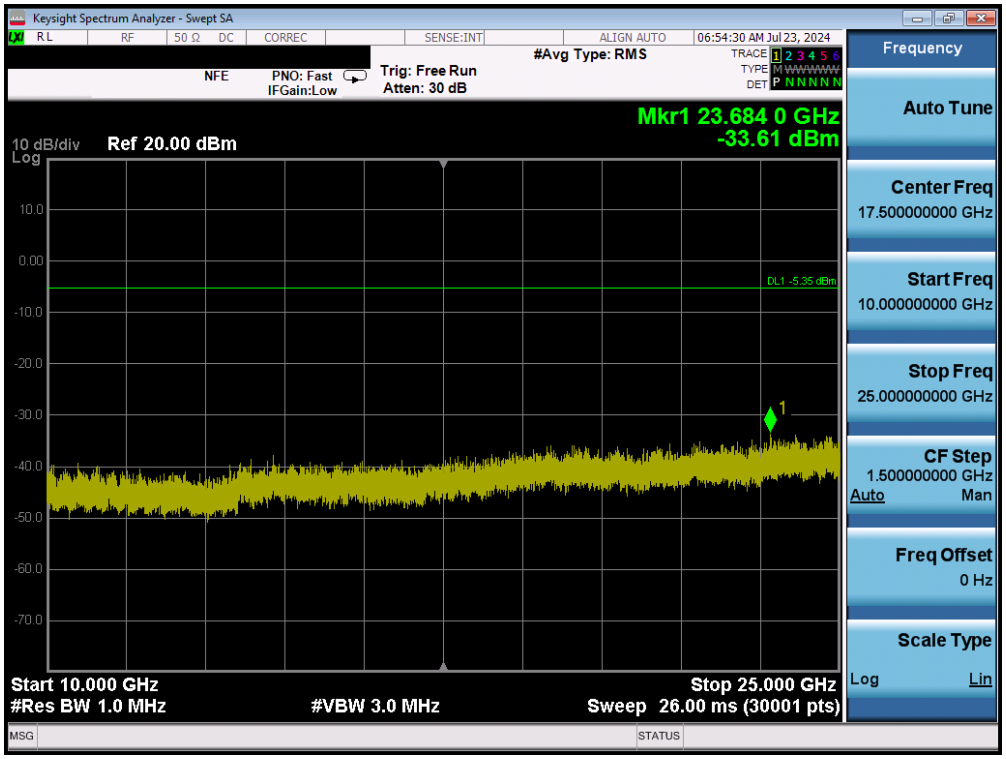
Plot 7-75. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 78) – Ant1



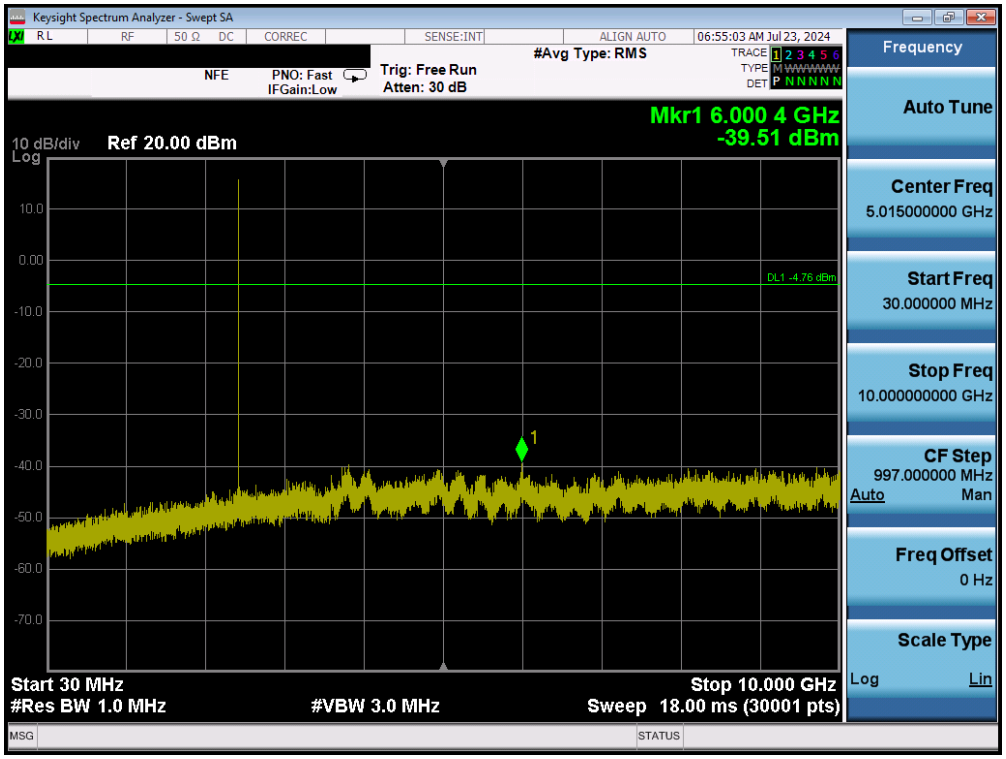
Plot 7-76. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 78) – Ant1



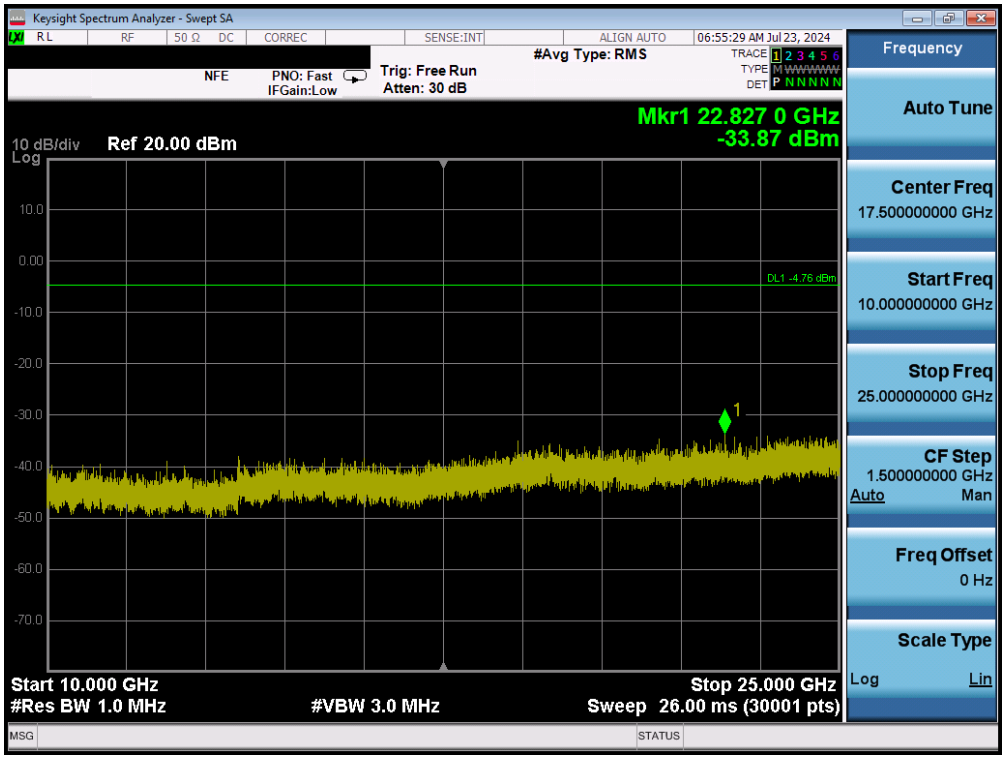
Plot 7-77. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 0) – Ant2



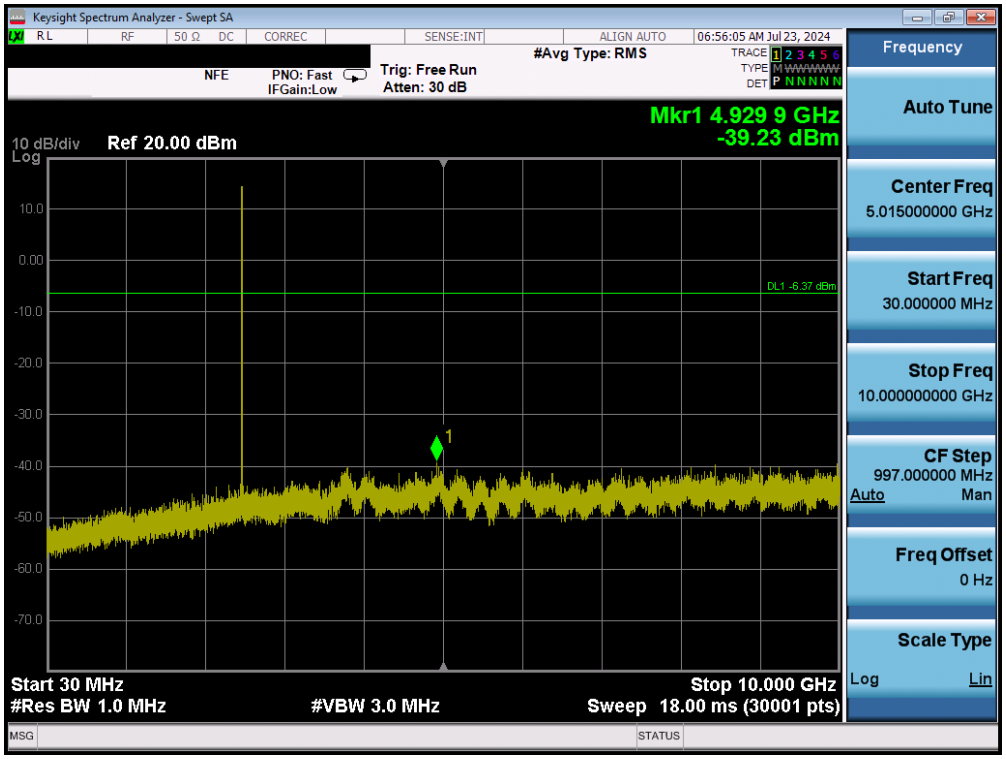
Plot 7-78. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 0) – Ant2



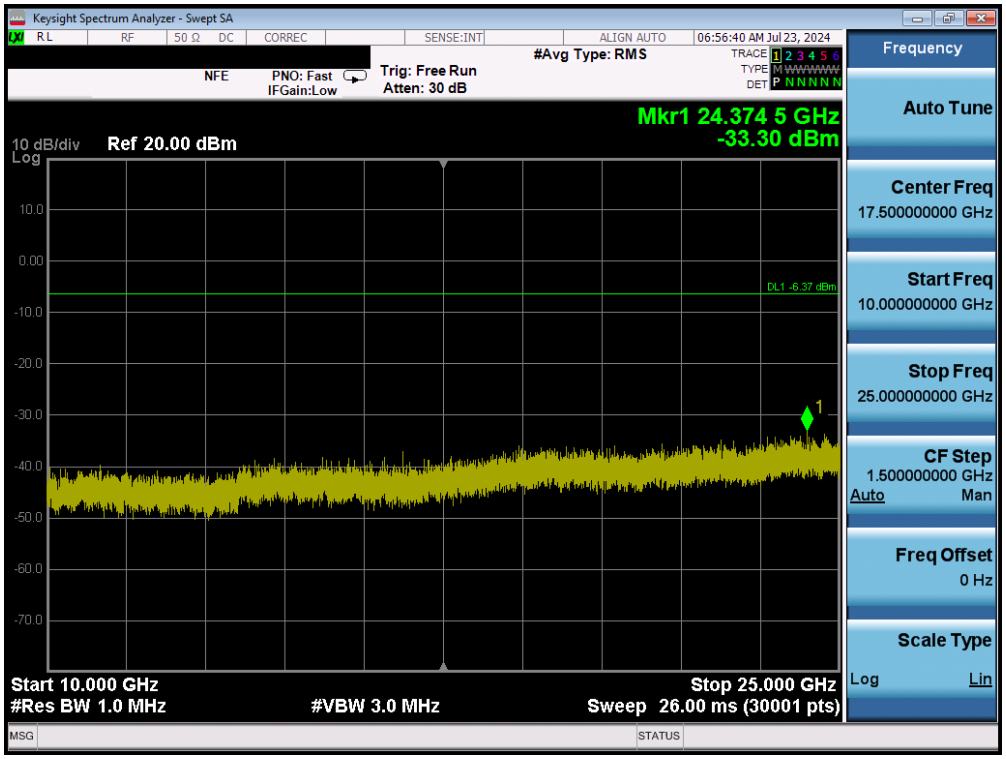
Plot 7-79. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 39) – Ant2



Plot 7-80. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 39) – Ant2



Plot 7-81. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 78) – Ant2



Plot 7-82. Conducted Spurious Plot (Bluetooth, 1Mbps – Ch. 78) – Ant2

7.9 Radiated Spurious Emission Measurements – Above 1GHz

§15.205 §15.209 §15.247 (d)

Test Overview and Limit

All out of band radiated spurious emissions are measured with a spectrum analyzer connected to a receive antenna while the EUT is operating at maximum power and at the appropriate frequencies. Only the radiated emissions of the configuration that produced the worst-case emissions are reported in this section.

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47 CFR must not exceed the limits shown below per Section 15.209.

Frequency	Field Strength [μV/m]	Measured Distance [Meters]
Above 960.0 MHz	500	3

Table 7-8. Radiated Limits

Test Procedure Used

ANSI C63.10-2013 – Section 6.6.4.3

Test Settings

Average Field Strength Measurements per Section 4.1.4.2.3 of ANSI C63.10-2013

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 1kHz ≥ 1/τ Hz, where τ = pulse width in seconds
4. Averaging type was set to RMS to ensure that video filtering was applied in the power domain
5. Detector = peak
6. Sweep time = auto
7. Trace mode = max hold
8. Trace was allowed to stabilize

Peak Field Strength Measurements per Section 4.1.4.2.2 of ANSI C63.10-2013

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW is set depending on measurement frequency, as specified in Table 7-9 below
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Frequency	RBW
9 – 150kHz	200 – 300Hz
0.15 – 30MHz	9 – 10kHz
30 – 1000MHz	100 – 120kHz
> 1000MHz	1MHz

Table 7-9. RBW as a Function of Frequency

Test Setup

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

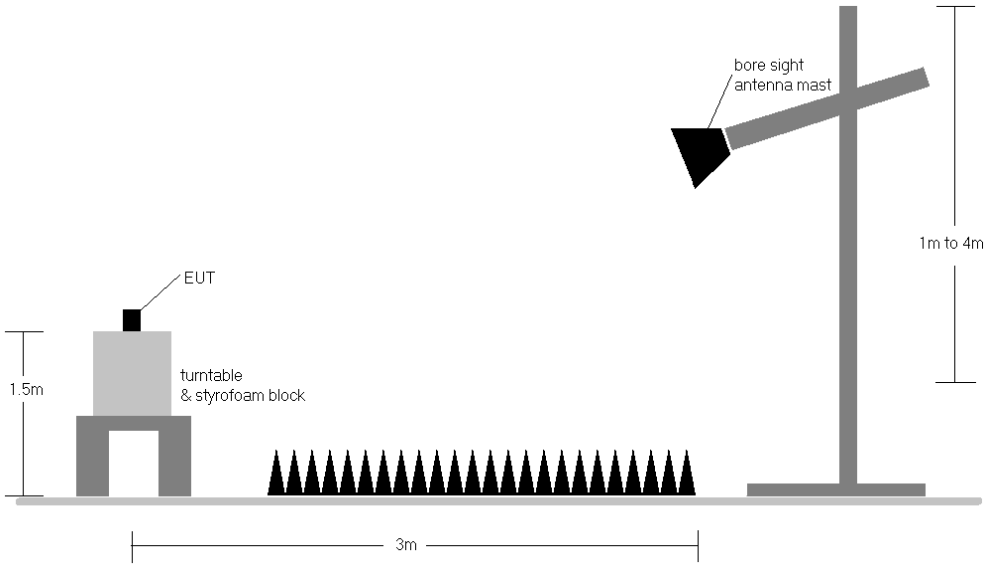


Figure 7-8. Radiated Test Setup >1GHz

Test Notes

1. All emissions lying in restricted bands specified in §15.205 is below the limit shown in §15.209.
2. No significant radiated emissions were found in the 2310 - 2390MHz restricted band.
3. The antenna is manipulated through typical positions, polarity, and length during the tests. The EUT is manipulated through three orthogonal planes.
4. This unit was tested with its standard battery.
5. The spectrum is measured from 9kHz to the 10th harmonic and the worst-case emissions are reported.
6. The duty cycle correction factor was not applied to noise floor measurements.
7. The wide spectrum spurious emissions plots shown on the following pages are used only for the purpose of emission identification. Any emissions found to be within 20dB of the limit are fully investigated and the results are shown in this section.
8. The "-" shown in the following RSE tables is used to denote a noise floor measurement.

Sample Calculation

- Field Strength Level $_{[dB\mu V/m]}$ = Analyzer Level $_{[dBm]}$ + 107 + AFCL $_{[dB/m]}$ + Duty Cycle Correction $_{[dB]}$
- AFCL $_{[dB/m]}$ = Antenna Factor $_{[dB/m]}$ + Cable Loss $_{[dB]}$
- Margin $_{[dB]}$ = Field Strength Level $_{[dB\mu V/m]}$ – Limit $_{[dB\mu V/m]}$

Duty Cycle Correction Factor Calculation

- Channel hop rate = 800 hops/second (AFH Mode)
- Adjusted channel hop rate for DH5 mode **=** 133.33 hops/second
- Time per channel hop **=** 1 / 133.33 hops/second = 7.50 ms
- Time to cycle through all channels = 7.50 x 20 channels = 150 ms
- Number of times transmitter hits on one channel = 100 ms / 150 ms = 1 time(s)
- Worst case dwell time = 7.5 ms
- Duty cycle correction factor = $20\log_{10}(7.5ms/100ms)$ = -22.5 dB