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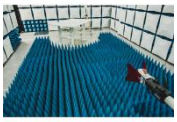

DATA REFERENCE REPORT

FCC PART 15.407 / ISED RSS-248 UNII 802.11a/ax OFDM WIFI 6E

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
05/30/2022 - 09/16/2022
Test Report Issue Date:
05/23/2023
Test Site/Location:
Element Materials Technology Morgan Hill, CA, USA
Test Report Serial No.:
1C2205090029-20-R1.BCG

FCC ID:	**BCGA2437**
IC:	**579C-A2437**
APPLICANT:	**Apple Inc.**

Reference Model/HVIN:	A2764
Variant Model/HVIN:	A2437 (A2766)
EUT Type:	Tablet Device
Frequency Range:	5955 – 7115MHz
Modulation Type:	OFDM
FCC Classification:	15E 6GHz Low Power Dual Client (6CD)
FCC Rule Part(s):	Part 15 Subpart E (15.407)
ISED Specification:	RSS-248 Issue 2
Test Procedure(s):	ANSI C63.10-2013, KDB 789033 D02 v02r01 KDB 662911 D01 v02r01, KDB 987594 D02 v01r01 KDB 987594 D04 v01

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 and KDB 789033 D02 v02r01. Test results reported herein relate only to the item(s) tested.

This revised Test Report (S/N: 1C2205090029-20-R1.BCG) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

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 #2041.02

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1.0 INTRODUCTION

1.1 Scope

Per manufacturer declaration, there are two tablet device models, A2764 and A2437 (A2766), with high degree of similarity, reference model FCC ID: BCGA2764 / IC: 579C-A2764 and variant model **FCC ID: BCGA2437 / IC: 579C-A2437**. The reference models support mmWave operations, while the variant models have the mmWave components/antennas removed. Both models share the same material, form factor, circuit design, and components, including antennas and their locations. The reference and variant models use the same power tables and have same tune-up tolerances.

Per FCC/ISED approved Data Referencing Test Plan, testing was done fully on the reference model FCC ID: BCGA2764 / IC: 579C-A2764, while radiated and conducted spot-check verification has been performed on variant model **FCC ID: BCGA2437 / IC: 579C-A2437**. Spot-check measurements were conducted, all measurements were investigated and found to be within acceptable tolerance.

Equipment Class	Reference Model FCC ID & IC	Reference Report	Report Title
6CD	BCGA2764 579C-A2764	1C2205090028-21-R3.BCG	RF UNII 6E OFDM Test Report

Table 1-1. Reference Model Details

Reference model FCC ID: BCGA2764 / IC: 579C-A2764 test report has been included in Appendix A.

1.2 Element Materials Technology Test Location

These measurement tests were conducted at the Element Materials Technology facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at Element Materials Technology located in Morgan Hill, CA 95037, U.S.A.

- Element Materials Technology is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 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 Materials Technology facility is a registered (22831) test laboratory with the site description on file with ISED.

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Tablet Device FCC ID: BCGA2437** and **IC: 579C-A2437**. The test data contained in this report pertains only to the emissions due to the EUT's UNII transmitter while operating in the 6GHz band.

Test Device Serial No.: VT04VPHP2V, HHQXGXDW0V

2.2 Device Capabilities

This device contains the following capabilities:

850/1700/1900 WCDMA/HSPA, Multi-band LTE, 5G NR (FR1), 802.11b/g/n/ax WLAN, 802.11a/n/ac/ax UNII, 802.11a/ax WIFI 6E, Bluetooth (1x, EDR, LE1M, LE2M, HDR4, HDR8), WPT, NB UNII (1x, HDR4, HDR8).

This device supports BT Beamforming

Band 5		Band 6		Band 7		Band 8	
Ch.	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**
1	5955	97	6435	117	6535	189	6895
:	:	:	:	:	:	:	:
45	6175	105	6475	149	6695	209	6995
:	:	:	:	:	:	:	:
93	6415	113	6515	185	6875	233	7115

Table 2-1. 802.11a / 802.11ax (20MHz) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**
3	5965	99	6445	123	6565	187	6885
:	:	:	:	:	:	:	:
43	6165	107	6485	155	6725	211	7005
:	:	:	:	:	:	:	:
91	6405	115	6525	179	6845	227	7085

Table 2-2. 802.11ax (40MHz BW) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)
7	5985	103	6465	119	6545	199	6945
:	:			:	:	:	:
39	6145			151	6705	215	7025
:	:			:	:		
87	6385			183	6865		

Table 2-3. 802.11ax (80MHz BW) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)
15	6025	111	6505	143	6665	207	6985
:	:			:	:		
47	6185			175	6825		
:	:						
79	6345						

Table 2-4. 802.11ax (160MHz BW) Frequency / Channel Operations

Notes:

1. 6GHz NII operation is possible in 20MHz, 40MHz, 80MHz, and 160MHz channel bandwidths. 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 B)2)b) KDB 789033 D02 v02r01 and ANSI C63.10-2013. 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		Duty Cycle [%]		
		Antenna 5b	Antenna 4a	SDM
6GHz	11a (20MHz) (Low Rate)	98.1	98.1	-
	11a (20MHz) (Mid Rate)	96.4	95.9	-
	11a (20MHz) (High Rate)	92.5	92.1	-
	11ax(SU) (20MHz) (Low Rate)	96.5	96.2	96.1
	11ax(SU) (20MHz) (Mid Rate)	94.2	93.9	93.5
	11ax(SU) (20MHz) (High Rate)	88.2	87.4	87.9
	11ax(SU) (40MHz) (Low Rate)	93.5	93.7	92.4
	11ax(SU) (40MHz) (Mid Rate)	89.4	89.8	89.9
	11ax(SU) (40MHz) (High Rate)	83.1	82.6	83.3
	11ax(SU) (80MHz) (Low Rate)	89.4	89.4	89.4
	11ax(SU) (80MHz) (Mid Rate)	85.1	84.7	84.9
	11ax(SU) (80MHz) (High Rate)	80.1	80.1	80.2
	11ax(SU) (160MHz) (Low Rate)	84.9	85.2	84.8
	11ax(SU) (160MHz) (Mid Rate)	81.2	81.4	81.0
	11ax(SU) (160MHz) (High Rate)	77.6	76.8	77.5

Table 2-5. Measured Duty Cycles

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

WiFi Configurations		SISO		CDD		SDM		STBC	
		Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a
5GHz	11a	✓	✓	×	×	×	×	×	×
	11ax(SU) (20MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (40MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (80MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (160MHz)	✓	✓	✓	✓	✓	✓	✓	✓

Table 2-6. WIFI Configurations

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

Data Rate(s) Tested: 6, 9, 12, 18, 24, 36, 48, 54Mbps (802.11a)

8/8.6, 16/17.2, 24/25.8, 33/34.4, 49/51.6, 65/68.8, 73/77.4, 81/86.0, 98/103.2, 108/114.7, 122/129.0, 135/143.4 (ax – 20MHz)
16/17.2, 33/34.4, 49/51.6, 65/68.8, 98/103.2, 130/137.6, 146/154.9, 163/172.1, 195/206.5, 217/229.4, 244/258.1, 271/286.8 (ax – 40MHz BW)
34/36.0, 68/72.1, 102/108.1, 136/144.1, 204/216.2, 272/288.2, 306/324.4, 340/360.3, 408/432.4, 453/480.4, 510/540.4, 567/600.5 (ax – 80MHz BW)
68.1/72.1, 136.1/144.1, 204.2/216.2, 272.2/288.2, 408.3/432.4, 544.4/576.5, 612.5/648.5, 680.6/720.6, 816.7/864.7, 907.4/960.8, 1020.8/1080.9, 1134.3/1201 (ax – 160Mhz BW)
16.3/17.2, 32.5/34.4, 48.8/51.6, 65/68.8, 97.5/103.2, 130/137.6, 146.3/154.9, 162.5/172.1, 195/206.5, 216.7/229.4, 243.8/258.1, 270.8/286.8 (MIMO ax – 20MHz)
32.5/34.4, 65/68.8, 97.5/103.2, 130/137.6, 195/206.5, 260/275.3, 292.5/309.7, 325/344.1, 390/412.9, 433.3/458.8, 487.5/516.2, 541.7/573.5 (MIMO ax – 40MHz BW)
68.1/72.1, 136.1/144.1, 204.2/216.2, 272.2/288.2, 408.3/432.4, 544.4/576.5, 612.5/648.5, 680.6/720.6, 816.7/864.7, 907.4/960.8, 1020.8/1080.9, 1134.3/1201 (MIMO ax – 80MHz BW)
136.1/144.1, 272.2/288.2, 408.3/432.4, 544.4/576.5, 816.7/864.7, 1088.9/1152.9, 1225/1297.1, 1361.1/1441.2, 1633.3/1729.4, 1814.8/1921.6, 2041.7/2161.8, 2268.5/2402 (MIMO ax – 160MHz BW)

3. This device supports simultaneous transmission operations, which allows for multiple transmitters to transmit simultaneously on the same antenna. The table below shows all configurations possible.

Antenna	Simultaneous Tx Config	WiFi 2.4GHz	Bluetooth	NB UNII	WiFi 5GHz	WiFi 6GHz	LTE / FR1 NR
		802.11 b/g/n/ax	BDR, EDR, HDR4/8, LE1/2M	BDR, HDR4/8	802.11 a/n/ac/ax	802.11 a/ax	Ultra High Band
2a	Config 1	✓	×	×	×	×	✓
2a	Config 2	×	✓	×	×	×	✓
4a	Config 3	✓	×	✓	×	×	×
4a	Config 4	×	✓	×	✓	×	×

Table 2-7. Simultaneous Transmission Configurations

✓ = Support; × = Not Support

4. All the above simultaneous transmission configurations have been tested and the worst-case configuration was found to be Config 2 and reported in Bluetooth and Part 96 RF test reports.

5. Wi-Fi 2.4GHz and Bluetooth 2.4 GHz can transmit simultaneously on separate antennas. Specific 2.4 GHz Wi-Fi antenna that can only transmit simultaneously with 2.4 GHz Bluetooth antenna is listed in the SAR test report. For BT (2.4 GHz) in connected mode and Wi-Fi (2.4 GHz) – Wi-Fi max power will not exceed minimum of (13.5dBm, SAR max cap, Reg max cap) power. For BT (2.4 GHz) in disconnected mode and Wi-Fi (2.4 GHz) – BT will be using iPA only and Wi-Fi max power will not exceed minimum of (SAR max cap, Reg max cap) power.

2.3 Antenna Description

Following antenna gains were provided by the manufacturer.

Frequency (MHz)	Antenna Gain (dBi)			
	Antenna 5b		Antenna 4a	
	H	V	H	V
5955	3	1.2	-1.5	0.1
6075	3.9	1.1	-1.5	1.7
6110	3.8	0.4	-1	1.3
6135	3.8	0.4	-1	1.3
6185	3.8	0.4	-1.5	-0.9
6215	3.8	0.4	-1.5	-0.9
6255	4.1	0.5	-1.5	-0.9
6260	4.1	0.5	-1.5	-0.9
6375	4.6	1.2	-0.3	1.4
6430	4.6	1.2	-0.3	1.4
6435	4.3	1.5	0.5	1.8
6455	4.2	-0.2	1.1	0.6
6505	4.2	-0.2	1.1	0.6
6555	4.2	-0.2	1.1	0.6
6580	4.2	-0.2	0.6	0
6590	4.2	-0.2	0.6	0
6665	4.2	-0.2	0.6	0
6675	4	0	0.6	0
6695	4	0	0.7	-0.8
6735	4	1.2	0.7	-0.8
6740	4	1.2	-1	-2.9
6855	3.3	1.4	-1	-2.9
6910	2.3	0.3	-2	-4.5
6935	2.3	0.3	-2	-4.5
6975	2.3	0.3	-2	-4.5
6985	2.1	0.1	-3.3	-4.9
7035	2.1	0.1	-3.3	-4.9
7060	2.1	0.1	-3	-5.1
7115	2.3	1	-3	-5.1

Table 2-8. Antenna Gains

2.4 Test Support Equipment

1	Apple MacBook Pro	Model:	A2141	S/N:	C02DV7VKMD6T
	w/AC/DC Adapter	Model:	A2166	S/N:	N/A
2	Apple USB-C Cable	Model:	Spartan	S/N:	000MKTR02U
3	USB-C Cable	Model:	A246	S/N:	N/A
	w/ AC Adapter	Model:	A2305	S/N:	N/A
4	Apple Pencil	Model:	N/A	S/N:	GQXGSXBJKM9
5	DC Power Supply	Model:	KPS3010D	S/N:	N/A
6	Netgear Nighthawk	Model :	RAXE450	S/N:	6JX215GA10A5

Table 2-9. Test Support Equipment List

2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013, KDB 789033 D02 v02r01 and KDB 987594 D02 v01r01. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions. See Section 3.2 for radiated emissions test setups.

There are two vendors of the WiFi/Bluetooth radio modules, variant 1 and variant 2. Both radio modules have the same mechanical outline, same on-board antenna matching circuit, identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances. The worst case configuration was found between the two variants. The EUT was also investigated with and without charger.

For emissions from 1GHz – 18GHz, low, mid, and high channels were tested with highest power and worst case configuration. The emissions below 1GHz and above 18GHz were tested with the highest transmitting power and the worst case channel.

The EUT was manipulated through three orthogonal planes of X-orientation (flatbed), Y-orientation (landscape), and Z-orientation (portrait) during the testing. Only the worst case emissions were reported in this test report.

Per FCC/ISED Approved Data Referencing Test Plan, spot-check measurements have been conducted and reported. Spot-Check Test Plan can be referred to below Table 2-10.

Technology	Test Case	FCC ID: BCGA2437 IC: 579C-A2437	
		Mode	Channel
WiFi 6E (802.11ax)	Radiated Spurious Emissions	MIMO Max Power WiFi 6E (UNII 5/6/7/8): 11ax 20MHz SU	M

Table 2-10. FCC/ISED Approved Spot-Check Test Plan

Output powers were measured and confirmed to be consistent between Reference and Variant models prior to testing.

2.6 Software and Firmware

The test was conducted with firmware version 20A8359 installed on the EUT.

2.7 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) and the guidance provided in KDB 789033 D02 v02r01 were used in the measurement of the EUT**.**

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

3.2 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.

Per KDB 414788, radiated emission test sites other than open-field test sites (e.g., shielded anechoic chambers), may be employed for emission measurements below 30MHz if characterized so that the measurements correspond to those obtained at an open-field test site. To determine test site equivalency, a reference sample transmitting at 149kHz was measured on an open field test site (asphalt with no ground plane) and then measured in the 3m semi-anechoic chamber. A calibrated 60cm loop antenna was rotated about its vertical axis
while the reference device was rotated through the X, Y and Z axis in order to capture the worst case level. A maximum deviation of 2.77dB at 149kHz was measured when comparing the 3 meter semi-anechoic chamber to the open field site.

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.

3.3 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 antenna(s) 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 C63.23-2012. 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)
Radiated Disturbance (<30MHz)	4.38
Radiated Disturbance (30MHz - 1GHz)	4.75
Radiated Disturbance (1 - 18GHz)	5.20
Radiated Disturbance (>18GHz)	4.72

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 Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	6/10/2022	Annual	6/10/2023	MY49430244
Agilent Technologies	N9020A	MXA Signal Analyzer	4/26/2022	Annual	4/26/2023	MY56470202
Anritsu	ML2496A	Power Meter	11/29/2021	Annual	11/29/2022	1840005
Anritsu	MA2411B	Pulse Power Sensor	11/30/2021	Annual	11/30/2022	1726261
Anritsu	MA2411B	Pulse Power Sensor	11/30/2021	Annual	11/30/2022	1726262
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna	1/19/2022	Annual	1/19/2023	T058701-02
Com-Power Corporation	LIN-120A	Line Impedance Stabilization Network (LISN)	3/7/2022	Annual	3/7/2023	241296
ETS-Lindgren	3142E	Biconilog Antenna (26-6000MHz)	10/21/2021	Annual	10/21/2022	208204
ETS-Lindgren	3117	Double Ridged Guide Horn Antenna (1-18GHz)	10/25/2021	Annual	10/25/2022	227597
Keysight Technology	N9040B	UXA Signal Analyzer	2/8/2022	Annual	2/8/2023	MY57212015
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz-6GHz)	1/6/2022	Annual	1/6/2023	102328
Rohde & Schwarz	ESW26	EMI Test Receiver	5/19/2022	Annual	5/19/2023	101299
Rohde & Schwarz	ESW44	EMI Test Receiver	12/2/2021	Annual	12/2/2022	101570
Rohde & Schwarz	FSV40	Signal Analyzer (10Hz-40GHz)	3/4/2022	Annual	3/4/2023	101619
Rohde & Schwarz	FSVA3044	Signal Analyzer (up to 44 GHz)	5/12/2022	Annual	5/12/2023	101098
Rohde & Schwarz	HFH2-Z2	Loop Antenna	4/3/2022	Annual	4/3/2023	100546
Rohde & Schwarz	SMB100A	Signal Generator 100KHz-40GHz	1/10/2022	Annual	1/10/2023	180080
Rohde & Schwarz	TC-TA18	Cross-Polarized Antenna 400MHz-18GHz	1/25/2022	Annual	1/25/2023	101063
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz-18GHz)	1/6/2022	Annual	1/6/2023	101639
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz-40GHz)	4/18/2022	Annual	4/18/2023	100050

Table 6-1. Test Equipment List

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 (SPOT-CHECK DATA)

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCGA2437

IC: 579C-A2437

FCC Classification: 15E 6GHz Low Power Dual Client (6CD)

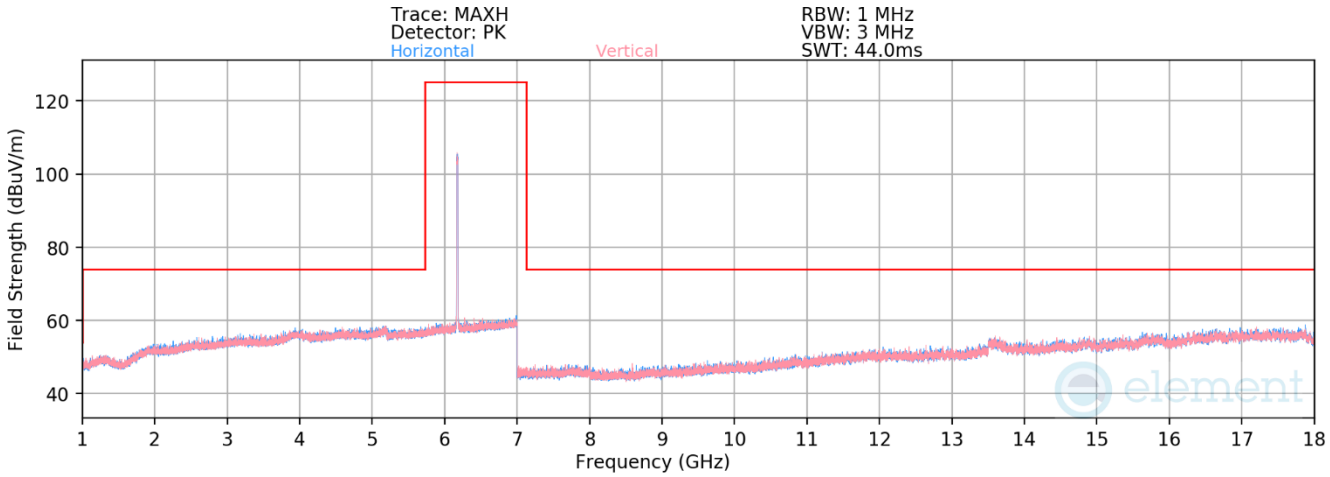
Technology	Test Configurations			Reference Model		Variant Model		Delta	
	Test Description	Channel	Measurement Frequency [MHz]	FCC ID: BCGA2764 IC: 579C-A2764		FCC ID: BCGA2437 IC: 579C-A2437			
				Peak [dBµV/m]	Average [dBµV/m]	Peak [dBµV/m]	Average [dBµV/m]	Peak [dB]	Average [dB]
WiFi 6E 802.11ax	Radiated Spurious Emissions	45	12350	51.50	40.67	53.00	41.35	1.50	0.68
		105	12950	-	41.59	-	41.95	-	0.36
		149	13390	52.15	40.76	52.77	42.38	0.62	1.62
		209	13990	-	41.04	-	41.63	-	0.59

Table 7-1. Worst Case Spot-check Results

Spot-checks were conducted, all measurements were investigated and found to be within acceptable tolerance in accordance with FCC/ISED Approved Data Referencing Test Plan.

7.2 Radiated Spurious Emissions

§15.407(b) §15.205 §15.209; RSS-Gen [8.9]

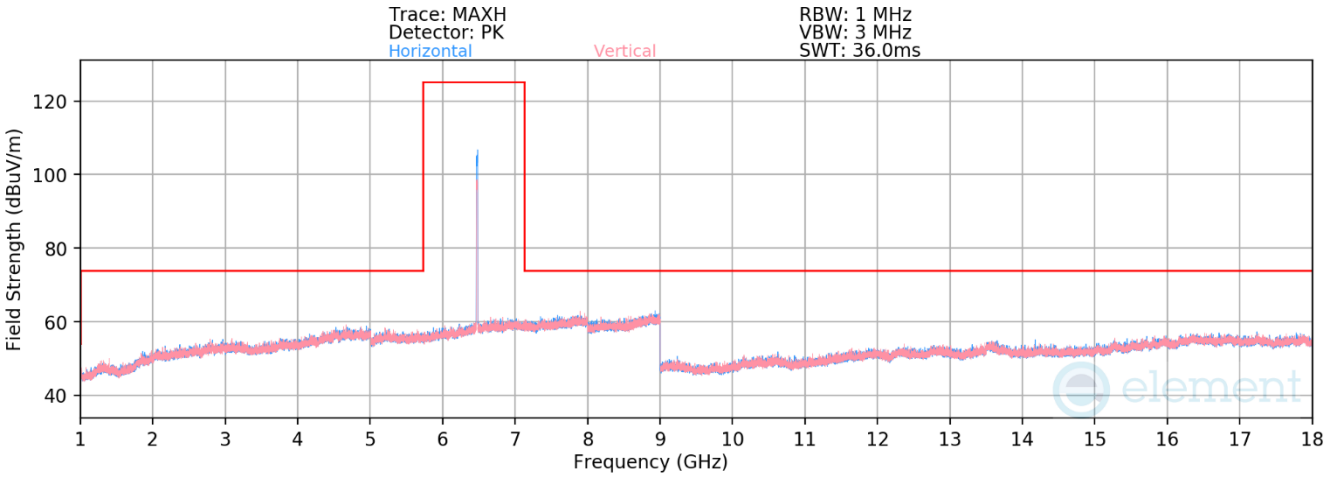


Plot 7-1. Radiated Spurious Emissions above 1GHz SDM (802.11ax – Ch. 45, MCS2)

Mode:	802.11ax
Data Rate:	MCS2
Distance of Measurements:	3 Meters
Operating Frequency:	6175MHz
Channel:	45

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
12350.00	Peak	H	-	-	-72.47	18.47	53.00	73.98	-20.99
12350.00	Average	H	-	-	-84.12	18.47	41.35	53.98	-12.63

Table 7-2. Radiated Spurious Emission Measurements SDM

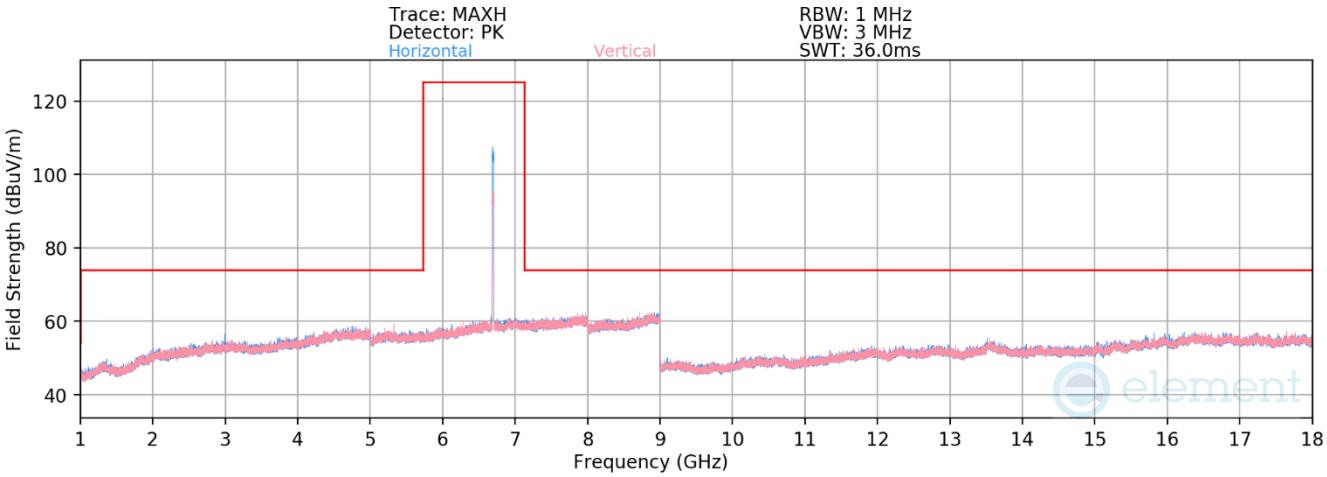


Plot 7-2. Radiated Spurious Emissions above 1GHz SDM (802.11ax – Ch. 105, MCS2)

Mode:	802.11ax
Data Rate:	MCS2
Distance of Measurements:	3 Meters
Operating Frequency:	6475MHz
Channel:	105

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
12950.00	Average	H	-	-	-83.72	18.67	41.95	68.20	-26.25

Table 7-3. Radiated Spurious Emission Measurements SDM

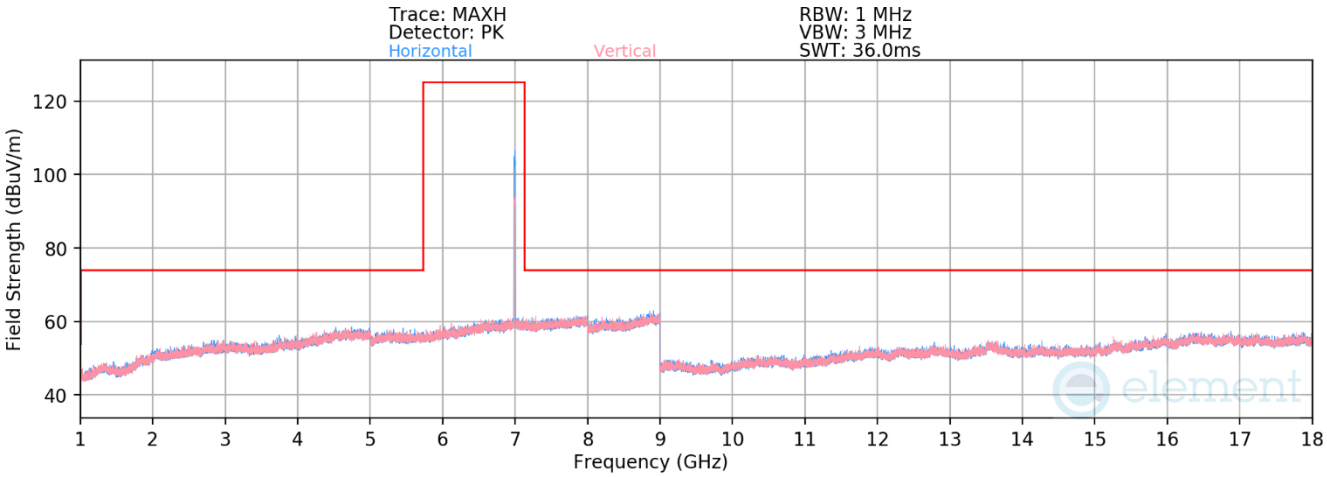


Plot 7-3. Radiated Spurious Emissions above 1GHz SDM (802.11ax – Ch. 149, MCS2)

Mode:	802.11ax
Data Rate:	MCS2
Distance of Measurements:	3 Meters
Operating Frequency:	6695MHz
Channel:	149

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
13390.00	Peak	H	-	-	-72.53	18.30	52.77	73.98	-21.21
13390.00	Average	H	-	-	-82.92	18.30	42.38	53.98	-11.60

Table 7-4. Radiated Spurious Emission Measurements SDM



Plot 7-4. Radiated Spurious Emissions above 1GHz SDM (802.11ax – Ch. 209, MCS2)

Mode:	802.11ax
Data Rate:	MCS2
Distance of Measurements:	3 Meters
Operating Frequency:	6995MHz
Channel:	209

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
13990.00	Average	H	-	-	-83.22	17.85	41.63	68.20	-26.57

Table 7-5. Radiated Spurious Emission Measurements SDM

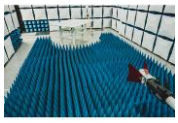
8.0 CONCLUSION

The spot-check data measured for variant model **FCC ID: BCGA2437 / IC: 579C-A2437** is in tolerance with reference model FCC ID: BCGA2764 / IC: 579C-A2764 per FCC/ISED Approved Data Referencing Test Plan.

9.0 APPENDIX A: REFERENCE MODEL TEST REPORT

Attached is the test report (1C2205090028-21-R3.BCG) from reference model FCC ID: BCGA2764 / IC: 579C-A2764, which includes referenced data results.

ELEMENT MATERIALS TECHNOLOGY
(formerly PTEST)
18855 Adams Court, Morgan Hill, CA 95037 USA
Tel. 408.538.5600
http://www.element.com



MEASUREMENT REPORT

FCC PART 15.407 / ISED RSS-248 UNII 802.11a/ax OFDM WIFI 6E

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
5/30/2022 - 9/16/2022
Test Report Issue Date:
05/22/2023
Test Site/Location:
Element Morgan Hill, CA, USA
Test Report Serial No.:
1C2205090028-21-R3.BCG

FCC ID:	**BCGA2764**
IC:	**579C-A2764**
APPLICANT:	**Apple Inc.**

Application Type:	Certification
Model/HVIN:	A2436
EUT Type:	Tablet Device
Frequency Range:	5955 – 7115MHz
Modulation Type:	OFDM
FCC Classification:	15E 6GHz Low Power Dual Client (6CD)
FCC Rule Part(s):	Part 15 Subpart E (15.407)
ISED Specification:	RSS-248 Issue 2
Test Procedure(s):	ANSI C63.10-2013, KDB 789033 D02 v02r01 KDB 662911 D01 v02r01, KDB 987594 D02 v01r01 KDB 987594 D04 v01

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 and KDB 789033 D02 v02r01. Test results reported herein relate only to the item(s) tested.

This revised Test Report (S/N: 1C2205090028-21-R3.BCG) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

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 #2041.02

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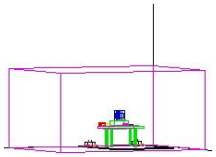
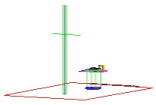


MEASUREMENT REPORT



UNII Band	Channel Bandwidth (MHz)	Mode	Tx Frequency (MHz)	SISO				SDM	
				Antenna WF5t		Antenna WF5b		Summed	
				Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)
5	20	802.11a/ax	5955 - 6415	5.433	7.35	3.296	5.18	5.493	7.40
6		802.11a/ax	6435 - 6515	5.370	7.30	2.979	4.74	5.505	7.41
7		802.11a/ax	6535 - 6875	5.483	7.39	2.723	4.35	5.446	7.36
8		802.11a/ax	6895 - 7115	7.244	8.60	2.512	4.00	7.786	8.91
5	40	802.11ax	5965 - 6405	10.544	10.23	5.058	7.04	10.443	10.19
6		802.11ax	6445 - 6525	10.715	10.30	5.888	7.70	11.034	10.43
7		802.11ax	6565 - 6845	10.715	10.30	5.260	7.21	10.817	10.34
8		802.11ax	6885 - 7085	10.233	10.10	3.945	5.96	10.670	10.28
5	80	802.11ax	5985 - 6385	21.577	13.34	10.965	10.40	20.689	13.16
6		802.11ax	6465	21.086	13.24	11.376	10.56	21.615	13.35
7		802.11ax	6545 - 6865	21.135	13.25	9.772	9.90	20.375	13.09
8		802.11ax	6945 - 7025	20.045	13.02	7.943	9.00	21.144	13.25
5	160	802.11ax	6025 - 6345	53.456	17.28	25.823	14.12	52.581	17.21
6		802.11ax	6505	51.523	17.12	25.586	14.08	50.477	17.03
7		802.11ax	6665 - 6825	46.881	16.71	21.429	13.31	44.612	16.49
8		802.11ax	6985	47.206	16.74	17.298	12.38	47.009	16.72

EUT Overview (Low Rate)

UNII Band	Channel Bandwidth (MHz)	Mode	Tx Frequency (MHz)	SISO				SDM	
				Antenna WF5t		Antenna WF5b		Summed	
				Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)
5	20	802.11a/ax	5955 - 6415	5.058	7.04	2.831	4.52	5.245	7.20
6		802.11a/ax	6435 - 6515	5.370	7.30	3.013	4.79	5.442	7.36
7		802.11a/ax	6535 - 6875	5.495	7.40	2.685	4.29	5.384	7.31
8		802.11a/ax	6895 - 7115	7.129	8.53	2.483	3.95	7.840	8.94
5	40	802.11ax	5965 - 6405	10.765	10.32	5.188	7.15	10.637	10.27
6		802.11ax	6445 - 6525	10.715	10.30	5.821	7.65	10.783	10.33
7		802.11ax	6565 - 6845	11.015	10.42	5.333	7.27	10.792	10.33
8		802.11ax	6885 - 7085	10.495	10.21	3.855	5.86	10.524	10.22
5	80	802.11ax	5985 - 6385	20.941	13.21	10.280	10.12	20.789	13.18
6		802.11ax	6465	20.797	13.18	11.995	10.79	21.615	13.35
7		802.11ax	6545 - 6865	20.845	13.19	10.162	10.07	20.469	13.11
8		802.11ax	6945 - 7025	20.989	13.22	7.551	8.78	21.487	13.32
5	160	802.11ax	6025 - 6345	52.966	17.24	25.704	14.10	51.384	17.11
6		802.11ax	6505	50.350	17.02	24.378	13.87	50.129	17.00
7		802.11ax	6665 - 6825	46.345	16.66	20.749	13.17	44.305	16.46
8		802.11ax	6985	45.920	16.62	17.378	12.40	47.226	16.74

EUT Overview (Mid Rate)

UNII Band	Channel Bandwidth (MHz)	Mode	Tx Frequency (MHz)	SISO				SDM	
				Antenna WF5t		Antenna WF5b		Summed	
				Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)	Max. e.i.r.p (mW)	Max. e.i.r.p (dBm)
5	20	802.11a/ax	5955 - 6415	5.358	7.29	2.972	4.73	5.209	7.17
6		802.11a/ax	6435 - 6515	5.370	7.30	2.965	4.72	5.530	7.43
7		802.11a/ax	6535 - 6875	5.458	7.37	2.716	4.34	5.471	7.38
8		802.11a/ax	6895 - 7115	7.129	8.53	2.512	4.00	7.401	8.69
5	40	802.11ax	5965 - 6405	10.814	10.34	5.012	7.00	10.491	10.21
6		802.11ax	6445 - 6525	10.715	10.30	5.998	7.78	10.808	10.34
7		802.11ax	6565 - 6845	10.889	10.37	5.164	7.13	10.792	10.33
8		802.11ax	6885 - 7085	10.593	10.25	3.873	5.88	10.744	10.31
5	80	802.11ax	5985 - 6385	21.330	13.29	10.257	10.11	21.273	13.28
6		802.11ax	6465	20.941	13.21	11.722	10.69	21.664	13.36
7		802.11ax	6545 - 6865	20.749	13.17	10.000	10.00	20.469	13.11
8		802.11ax	6945 - 7025	20.749	13.17	7.816	8.93	20.901	13.20
5	160	802.11ax	6025 - 6345	53.456	17.28	25.942	14.14	52.099	17.17
6		802.11ax	6505	50.582	17.04	24.434	13.88	50.944	17.07
7		802.11ax	6665 - 6825	45.290	16.56	21.528	13.33	44.102	16.44
8		802.11ax	6985	45.709	16.60	17.061	12.32	48.998	16.90

EUT Overview (High Rate)

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 Materials Technology Test Location

These measurement tests were conducted at the Element Materials Technology facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at Element Materials Technology located in Morgan Hill, CA 95037, U.S.A.

- Element Materials Technology is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 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 Materials Technology facility is a registered (22831) test laboratory with the site description on file with ISED.

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Tablet Device FCC ID: BCGA2764** and **IC: 579C-A2764**. The test data contained in this report pertains only to the emissions due to the EUT's UNII transmitter while operating in the 6GHz band.

Test Device Serial No.: YH3MJ964TK, DLX2237005M22Y21Z, LJFR9N4G07, KH6MVRP0C3

2.2 Device Capabilities

This device contains the following capabilities:

850/1700/1900 WCDMA/HSPA, Multi-band LTE, 5G NR (FR1/FR2), 802.11b/g/n/ax WLAN, 802.11a/n/ac/ax UNII, Bluetooth (1x, EDR, LE1M, LE2M, HDR4, HDR8), WPT

This device supports BT Beamforming

Band 5		Band 6		Band 7		Band 8	
Ch.	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**
1	5955	97	6435	117	6535	189	6895
:	:	:	:	:	:	:	:
45	6175	105	6475	149	6695	209	6995
:	:	:	:	:	:	:	:
93	6415	113	6515	185	6875	233	7115

Table 2-1. 802.11a / 802.11ax (20MHz) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**	**Ch.**	**Frequency (MHz)**
3	5965	99	6445	123	6565	187	6885
:	:	:	:	:	:	:	:
43	6165	107	6485	155	6725	211	7005
:	:	:	:	:	:	:	:
91	6405	115	6525	179	6845	227	7085

Table 2-2. 802.11ax (40MHz BW) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)
7	5985	103	6465	119	6545	199	6945
:	:			:	:	:	:
39	6145			151	6705	215	7025
:	:			:	:		
87	6385			183	6865		

Table 2-3. 802.11ax (80MHz BW) Frequency / Channel Operations

Band 5		Band 6		Band 7		Band 8	
Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)	Ch.	Frequency (MHz)
15	6025	111	6505	143	6665	207	6985
:	:			:	:		
47	6185			175	6825		
:	:						
79	6345						

Table 2-4. 802.11ax (160MHz BW) Frequency / Channel Operations

Notes:

1. 6GHz NII operation is possible in 20MHz, 40MHz, 80MHz, and 160MHz channel bandwidths. 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 B)2)b) KDB 789033 D02 v02r01 and ANSI C63.10-2013. 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		Duty Cycle [%]		
		Antenna 5b	Antenna 4a	SDM
6GHz	11a (20MHz) (Low Rate)	98.1	98.1	-
	11a (20MHz) (Mid Rate)	96.4	95.9	-
	11a (20MHz) (High Rate)	92.5	92.1	-
	11ax(SU) (20MHz) (Low Rate)	96.5	96.2	96.1
	11ax(SU) (20MHz) (Mid Rate)	94.2	93.9	93.5
	11ax(SU) (20MHz) (High Rate)	88.2	87.4	87.9
	11ax(SU) (40MHz) (Low Rate)	93.5	93.7	92.4
	11ax(SU) (40MHz) (Mid Rate)	89.4	89.8	89.9
	11ax(SU) (40MHz) (High Rate)	83.1	82.6	83.3
	11ax(SU) (80MHz) (Low Rate)	89.4	89.4	89.4
	11ax(SU) (80MHz) (Mid Rate)	85.1	84.7	84.9
	11ax(SU) (80MHz) (High Rate)	80.1	80.1	80.2
	11ax(SU) (160MHz) (Low Rate)	84.9	85.2	84.8
	11ax(SU) (160MHz) (Mid Rate)	81.2	81.4	81.0
	11ax(SU) (160MHz) (High Rate)	77.6	76.8	77.5

Table 2-5. Measured Duty Cycles

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

WiFi Configurations		SISO		CDD		SDM		STBC	
		Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a	Antenna 5b	Antenna 4a
5GHz	11a	✓	✓	×	×	×	×	×	×
	11ax(SU) (20MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (40MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (80MHz)	✓	✓	✓	✓	✓	✓	✓	✓
	11ax(SU) (160MHz)	✓	✓	✓	✓	✓	✓	✓	✓

Table 2-6. WIFI Configurations

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

Data Rate(s) Tested: 6, 9, 12, 18, 24, 36, 48, 54Mbps (802.11a)

8/8.6, 16/17.2, 24/25.8, 33/34.4, 49/51.6, 65/68.8, 73/77.4, 81/86.0, 98/103.2, 108/114.7, 122/129.0, 135/143.4 (ax – 20MHz)
16/17.2, 33/34.4, 49/51.6, 65/68.8, 98/103.2, 130/137.6, 146/154.9, 163/172.1, 195/206.5, 217/229.4, 244/258.1, 271/286.8 (ax – 40MHz BW)
34/36.0, 68/72.1, 102/108.1, 136/144.1, 204/216.2, 272/288.2, 306/324.4, 340/360.3, 408/432.4, 453/480.4, 510/540.4, 567/600.5 (ax – 80MHz BW)
68.1/72.1, 136.1/144.1, 204.2/216.2, 272.2/288.2, 408.3/432.4, 544.4/576.5, 612.5/648.5, 680.6/720.6, 816.7/864.7, 907.4/960.8, 1020.8/1080.9, 1134.3/1201 (ax – 160Mhz BW)
16.3/17.2, 32.5/34.4, 48.8/51.6, 65/68.8, 97.5/103.2, 130/137.6, 146.3/154.9, 162.5/172.1, 195/206.5, 216.7/229.4, 243.8/258.1, 270.8/286.8 (MIMO ax – 20MHz)
32.5/34.4, 65/68.8, 97.5/103.2, 130/137.6, 195/206.5, 260/275.3, 292.5/309.7, 325/344.1, 390/412.9, 433.3/458.8, 487.5/516.2, 541.7/573.5 (MIMO ax – 40MHz BW)
68.1/72.1, 136.1/144.1, 204.2/216.2, 272.2/288.2, 408.3/432.4, 544.4/576.5, 612.5/648.5, 680.6/720.6, 816.7/864.7, 907.4/960.8, 1020.8/1080.9, 1134.3/1201 (MIMO ax – 80MHz BW)
136.1/144.1, 272.2/288.2, 408.3/432.4, 544.4/576.5, 816.7/864.7, 1088.9/1152.9, 1225/1297.1, 1361.1/1441.2, 1633.3/1729.4, 1814.8/1921.6, 2041.7/2161.8, 2268.5/2402 (MIMO ax – 160MHz BW)

3. This device supports simultaneous transmission operations, which allows for multiple transmitters to transmit simultaneously on the same antenna. The table below shows all configurations possible.

Antenna	Simultaneous Tx Config	WiFi 2.4GHz	Bluetooth	NB UNII	WiFi 5GHz	WiFi 6GHz	LTE / FR1 NR
		802.11 b/g/n/ax	BDR, EDR, HDR4/8, LE1/2M	BDR, HDR4/8	802.11 a/n/ac/ax	802.11 a/ax	Ultra High Band
2a	Config 1	✓	×	×	×	×	✓
2a	Config 2	×	✓	×	×	×	✓
4a	Config 3	✓	×	✓	×	×	×
4a	Config 4	×	✓	×	✓	×	×

Table 2-7. Simultaneous Transmission Configurations

✓ = Support; × = Not Support

4. All the above simultaneous transmission configurations have been tested and the worst-case configuration was found to be Config 2 and reported in Bluetooth and Part 96 RF test reports.

5. Wi-Fi 2.4GHz and Bluetooth 2.4 GHz can transmit simultaneously on separate antennas. Specific 2.4 GHz Wi-Fi antenna that can only transmit simultaneously with 2.4 GHz Bluetooth antenna is listed in the SAR test report. For BT (2.4 GHz) in connected mode and Wi-Fi (2.4 GHz) – Wi-Fi max power will not exceed minimum of (13.5dBm, SAR max cap, Reg max cap) power. For BT (2.4 GHz) in disconnected mode and Wi-Fi (2.4 GHz) – BT will be using iPA only and Wi-Fi max power will not exceed minimum of (SAR max cap, Reg max cap) power.

2.3 Antenna Description

Following antenna gains were provided by the manufacturer.

Frequency (MHz)	Antenna Gain (dBi)			
	Antenna 5b		Antenna 4a	
	H	V	H	V
5955	3	1.2	-1.5	0.1
6075	3.9	1.1	-1.5	1.7
6110	3.8	0.4	-1	1.3
6135	3.8	0.4	-1	1.3
6185	3.8	0.4	-1.5	-0.9
6215	3.8	0.4	-1.5	-0.9
6255	4.1	0.5	-1.5	-0.9
6260	4.1	0.5	-1.5	-0.9
6375	4.6	1.2	-0.3	1.4
6430	4.6	1.2	-0.3	1.4
6435	4.3	1.5	0.5	1.8
6455	4.2	-0.2	1.1	0.6
6505	4.2	-0.2	1.1	0.6
6555	4.2	-0.2	1.1	0.6
6580	4.2	-0.2	0.6	0
6590	4.2	-0.2	0.6	0
6665	4.2	-0.2	0.6	0
6675	4	0	0.6	0
6695	4	0	0.7	-0.8
6735	4	1.2	0.7	-0.8
6740	4	1.2	-1	-2.9
6855	3.3	1.4	-1	-2.9
6910	2.3	0.3	-2	-4.5
6935	2.3	0.3	-2	-4.5
6975	2.3	0.3	-2	-4.5
6985	2.1	0.1	-3.3	-4.9
7035	2.1	0.1	-3.3	-4.9
7060	2.1	0.1	-3	-5.1
7115	2.3	1	-3	-5.1

Table 2-8. Antenna Gains

Some antenna gains in the table were chosen from the worst between two frequencies as confirmed by manufacturer

2.4 Test Support Equipment

1	Apple MacBook Pro	Model:	A2141	S/N:	C02DV7VKMD6T
	w/AC/DC Adapter	Model:	A2166	S/N:	N/A
2	Apple USB-C Cable	Model:	Spartan	S/N:	000MKTR02U
3	USB-C Cable	Model:	A246	S/N:	N/A
	w/ AC Adapter	Model:	A2305	S/N:	N/A
4	Apple Pencil	Model:	N/A	S/N:	GQXGSXBJKM9
5	DC Power Supply	Model:	KPS3010D	S/N:	N/A

Table 2-9. Test Support Equipment List

2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013, KDB 789033 D02 v02r01 and KDB 987594 D02 v01r01. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 3.3 for AC line conducted emissions test setups, 3.3 for radiated emissions test setups, and 7.2, 7.3, 7.4, 7.5 and 7.6 for antenna port conducted emissions test setups.

There are two vendors of the WiFi/Bluetooth radio modules, variant 1 and variant 2. Both radio modules have the same mechanical outline, same on-board antenna matching circuit, identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances. The worst case configuration was found between the two variants. The EUT was also investigated with and without charger.

For emissions from 1GHz – 18GHz, low, mid, and high channels were tested with highest power and worst case configuration. The emissions below 1GHz and above 18GHz were tested with the highest transmitting power and the worst case channel.

The EUT was manipulated through three orthogonal planes of X-orientation (flatbed), Y-orientation (landscape), and Z-orientation (portrait) during the testing. Only the worst case emissions were reported in this test report.

For AC line conducted and radiated test below 1GHz, following configuration were investigated and EUT powered by AC/DC was the worst case.

- EUT powered by AC/DC adaptor via USB-C cable with wire charger
- EUT powered by host PC via USB-C cable with wire charger

802.11ax HE20/40/80 2TX SDM mode test data provided in this report covers 802.11ax HE20/40/80 2TX STBC mode.

For 802.11ax-RU test results, see separate UNII 6E OFDMA report, 1C2205090028-22.BCG.

The data rates have been classified into three different groups; low data rate, middle data rate, and high data rate. All three groups of data rate have been investigated and only the worst case data rate per group is reported. The worst case data rate for each group per mode are as follows:

- 802.11a:
  - Low Data Rate: 12Mbps
  - Mid Data Rate: 24Mbps
  - High Data Rate: 54Mbps
- 802.11ax(SU) HE20/HE40/HE80/HE160
  - Low Data Rate: MCS2
  - Mid Data Rate: MCS4
  - High Data Rate: MCS11

2.6 Software and Firmware

The test was conducted with firmware version 20A8359 installed on the EUT.

2.7 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) and the guidance provided in KDB 789033 D02 v02r01 were 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 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 65-6. 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 EPCOS 2X60A Power Line Filter (100dB Attenuation, 14kHz-18GHz) and the two EPCOs 2X48A filters (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 ground plane. 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 7.9. Automated test software was used to perform the AC line conducted emissions testing. Automated measurement software utilized is Rohde & Schwarz EMC32, Version 10.50.40.

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.

Per KDB 414788, radiated emission test sites other than open-field test sites (e.g., shielded anechoic chambers), may be employed for emission measurements below 30MHz if characterized so that the measurements correspond to those obtained at an open-field test site. To determine test site equivalency, a reference sample transmitting at 149kHz was measured on an open field test site (asphalt with no ground plane) and then measured in the 3m semi-anechoic chamber. A calibrated 60cm loop antenna was used while the reference device was rotated through the X, Y and Z axis in order to capture the worst case level. A maximum deviation of 2.77dB at 149kHz was measured when comparing the 3 meter semi-anechoic chamber to the open field site.

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.

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 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 C63.23-2012. 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	1.77
Line Conducted Disturbance	2.70
Radiated Disturbance (<30MHz)	4.38
Radiated Disturbance (30MHz - 1GHz)	4.75
Radiated Disturbance (1 - 18GHz)	5.20
Radiated Disturbance (>18GHz)	4.72

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
Agilent Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	6/10/2022	Annual	6/10/2023	MY49430244
Agilent Technologies	N9020A	MXA Signal Analyzer	4/26/2022	Annual	4/26/2023	MY56470202
Anritsu	ML2496A	Power Meter	11/29/2021	Annual	11/29/2022	1840005
Anritsu	MA2411B	Pulse Power Sensor	11/30/2021	Annual	11/30/2022	1726261
Anritsu	MA2411B	Pulse Power Sensor	11/30/2021	Annual	11/30/2022	1726262
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna	1/19/2022	Annual	1/19/2023	T058701-02
Com-Power Corporation	LIN-120A	Line Impedance Stabilization Network (LISN)	3/7/2022	Annual	3/7/2023	241296
ETS-Lindgren	3142E	Biconilog Antenna (26-6000MHz)	10/21/2021	Annual	10/21/2022	208204
ETS-Lindgren	3117	Double Ridged Guide Horn Antenna (1-18GHz)	10/25/2021	Annual	10/25/2022	227597
Keysight Technology	N9040B	UXA Signal Analyzer	2/8/2022	Annual	2/8/2023	MY57212015
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz-6GHz)	1/6/2022	Annual	1/6/2023	102328
Rohde & Schwarz	ESW26	EMI Test Receiver	5/19/2022	Annual	5/19/2023	101299
Rohde & Schwarz	ESW44	EMI Test Receiver	12/2/2021	Annual	12/2/2022	101570
Rohde & Schwarz	FSV40	Signal Analyzer (10Hz-40GHz)	3/4/2022	Annual	3/4/2023	101619
Rohde & Schwarz	FSVA3044	Signal Analyzer (up to 44 GHz)	5/12/2022	Annual	5/12/2023	101098
Rohde & Schwarz	HFH2-Z2	Loop Antenna	4/3/2022	Annual	4/3/2023	100546
Rohde & Schwarz	SMB100A	Signal Generator 100KHz-40GHz	1/10/2022	Annual	1/10/2023	180080
Rohde & Schwarz	TC-TA18	Cross-Polarized Antenna 400MHz-18GHz	1/25/2022	Annual	1/25/2023	101063
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz-18GHz)	1/6/2022	Annual	1/6/2023	101639
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz-40GHz)	4/18/2022	Annual	4/18/2023	100050

Table 6-1. Test Equipment List

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: Apple Inc.
FCC ID: BCGA2764
IC: 579C-A2764
FCC Classification: 15E 6GHz Low Power Dual Client (6CD)

FCC Part Section(s)	RSS Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
2.1049, 15.407(a)(10)	RSS Gen [6.7], RSS-248 [4.4]	Occupied Bandwidth/ 26dB Bandwidth	99% of the occupied bandwidth of any channel must be contained within each of its respective U-NII sub bands < 320MHz (5.925 - 7.125GHz)	CONDUCTED	PASS	Section 7.2
15.407(a)(8)	RSS-248 [4.6.3]	Maximum Power Spectral Density	< -1dBm/MHz e.i.r.p.		PASS	Section 7.4
15.407(a)(8)	RSS-248 [4.6]	Maximum Radiated Output Power	< 24dBm over the frequency band of operation		PASS	Section 7.3
15.407(b)(7)	RSS-248 [4.7.2]	In-Band Emissions	EUT must meet the limits detailed in 15.407(b)(7) and RSS-248 [4.7.2]b)		PASS	Section 7.5
15.407(d)(6)	RSS-248 [4.8]	Contention Based Protocol	EUT must detect AWGN signal with 90% (or better) certainty		PASS	Section 7.6
15.407(b)(6)	RSS-248 [4.7.2]	Undesirable Emissions	< -27dBm/MHz e.i.r.p. outside of the 5.925 – 7.125GHz band	RADIATED	PASS	Section 7.7
15.205, 15.209	RSS-248 [4.7]	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209		PASS	Section 7.7, 7.8
15.407(b)(8)	RSS-248 [4.7]	AC Conducted Emissions (150kHz – 30MHz)	< FCC 15.207 & RSS-Gen [8.8] limits	LINE CONDUCTED	PASS	Section 7.9

Table 7-1. Summary of Test Results

Notes:

1) All channels, modes, and modulations/data rates were investigated among all UNII bands. 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 EMC Software Tool v1.2.
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 1.3.2.

7.2 26dB & 99% Bandwidth Measurement – 802.11a/ax(SU)

§2.1049; §15.407; RSS-Gen [6.7]

Test Overview and Limit

The bandwidth at 26dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the antenna terminal while the EUT is operating at its maximum duty cycle, at its maximum power control level, as defined in ANSI C63.10-2013 and KDB 789033 D02 v02r01, and at the appropriate frequencies. The spectrum analyzer's bandwidth measurement function is configured to measure the 26dB bandwidth.

Test Procedure Used

ANSI C63.10-2013 – Section 12.4
KDB 789033 D02 v02r01 – Section C

Test Settings

1. The signal analyzers' automatic bandwidth measurement capability was used to perform the 26dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 26. The automatic bandwidth measurement function also has the capability of simultaneously measuring the 99% occupied bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = approximately 1% of the emission bandwidth
3. VBW $\geq$ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold

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

1. All antenna configurations and data rates were investigated and only the worst case are reported.
2. The data rates have been classified into three different groups; Low Data Rate, Middle Data Rate, and High Data Rate. All three data rate groups of data rate have been investigated and only the worst case data rate per group is reported.
3. Low, mid, and high channels were tested and tabular data has been reported. Only mid channel bandwidth plots have been reported.

7.2.1 Antenna 5b 26dB & 99% Bandwidth Measurements

	Frequency [MHz]	Channel	802.11 MODE	Data Rate [Mbps]	Measured 99% Occupied Bandwidth [MHz]	Measured 26dB Bandwidth [MHz]	Maximum Bandwidth Limit [MHz]	Pass / Fail
Band 5	5955	1	a	12	16.59	20.77	320	Pass
	6175	45	a	12	16.61	20.84	320	Pass
	6415	93	a	12	16.57	20.75	320	Pass
	5955	1	ax (20MHz)	24/25.8 (MCS2)	19.04	21.24	320	Pass
	6175	45	ax (20MHz)	24/25.8 (MCS2)	19.08	21.34	320	Pass
	6415	93	ax (20MHz)	24/25.8 (MCS2)	19.02	21.14	320	Pass
	5965	3	ax (40MHz)	49/51.6 (MCS2)	37.90	41.67	320	Pass
	6165	43	ax (40MHz)	49/51.6 (MCS2)	37.93	41.24	320	Pass
	6405	91	ax (40MHz)	49/51.6 (MCS2)	37.92	41.45	320	Pass
	5985	7	ax (80MHz)	102/108.1 (MCS2)	77.23	82.18	320	Pass
	6145	39	ax (80MHz)	102/108.1 (MCS2)	77.23	81.41	320	Pass
	6385	87	ax (80MHz)	102/108.1 (MCS2)	77.13	81.69	320	Pass
	6025	15	ax (160MHz)	183.8/216.2 (MCS2)	156.17	166.40	320	Pass
	6185	47	ax (160MHz)	183.8/216.2 (MCS2)	156.57	166.22	320	Pass
	6345	79	ax (160MHz)	183.8/216.2 (MCS2)	156.13	166.50	320	Pass
Band 6	6435	97	a	12	16.69	20.78	320	Pass
	6475	105	a	12	16.59	20.75	320	Pass
	6515	113	a	12	16.61	20.68	320	Pass
	6435	97	ax (20MHz)	24/25.8 (MCS2)	19.03	21.10	320	Pass
	6475	105	ax (20MHz)	24/25.8 (MCS2)	18.98	21.31	320	Pass
	6515	113	ax (20MHz)	24/25.8 (MCS2)	18.99	21.19	320	Pass
	6445	99	ax (40MHz)	49/51.6 (MCS2)	37.89	41.53	320	Pass
	6485	107	ax (40MHz)	49/51.6 (MCS2)	37.97	41.68	320	Pass
	6525	115	ax (40MHz)	49/51.6 (MCS2)	37.94	41.56	320	Pass
	6465	103	ax (80MHz)	102/108.1 (MCS2)	77.23	81.72	320	Pass
	6505	111	ax (160MHz)	183.8/216.2 (MCS2)	156.55	167.33	320	Pass
Band 7	6535	117	a	12	16.57	20.81	320	Pass
	6695	149	a	12	16.63	20.84	320	Pass
	6875	185	a	12	16.59	20.81	320	Pass
	6535	117	ax (20MHz)	24/25.8 (MCS2)	19.03	21.36	320	Pass
	6695	149	ax (20MHz)	24/25.8 (MCS2)	19.06	21.34	320	Pass
	6875	185	ax (20MHz)	24/25.8 (MCS2)	19.05	21.34	320	Pass
	6565	123	ax (40MHz)	49/51.6 (MCS2)	37.87	41.20	320	Pass
	6725	155	ax (40MHz)	49/51.6 (MCS2)	37.97	41.74	320	Pass
	6845	179	ax (40MHz)	49/51.6 (MCS2)	37.92	41.45	320	Pass
	6545	119	ax (80MHz)	102/108.1 (MCS2)	77.16	82.09	320	Pass
	6705	151	ax (80MHz)	102/108.1 (MCS2)	77.06	81.40	320	Pass
	6865	183	ax (80MHz)	102/108.1 (MCS2)	77.23	82.09	320	Pass
	6665	143	ax (160MHz)	183.8/216.2 (MCS2)	155.97	166.62	320	Pass
	6825	175	ax (160MHz)	183.8/216.2 (MCS2)	156.91	166.90	320	Pass
Band 8	6895	189	a	12	16.60	20.93	320	Pass
	6995	209	a	12	16.65	20.86	320	Pass
	7115	233	a	12	16.64	20.87	320	Pass
	6895	189	ax (20MHz)	24/25.8 (MCS2)	19.07	21.37	320	Pass
	6995	209	ax (20MHz)	24/25.8 (MCS2)	18.98	21.31	320	Pass
	7115	233	ax (20MHz)	24/25.8 (MCS2)	19.06	21.31	320	Pass
	6885	187	ax (40MHz)	49/51.6 (MCS2)	37.95	41.28	320	Pass
	7005	211	ax (40MHz)	49/51.6 (MCS2)	37.91	41.50	320	Pass
	7085	227	ax (40MHz)	49/51.6 (MCS2)	37.91	41.28	320	Pass
	6945	199	ax (80MHz)	102/108.1 (MCS2)	77.10	81.84	320	Pass
	7025	215	ax (80MHz)	102/108.1 (MCS2)	77.09	81.57	320	Pass
	6985	207	ax (160MHz)	183.8/216.2 (MCS2)	156.12	166.10	320	Pass

Table 7-2. Conducted Bandwidth Measurements Antenna 5b (Low Data Rate)

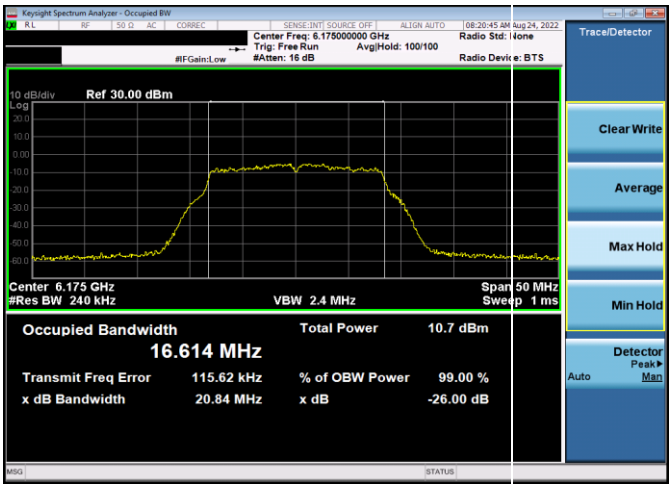
	Frequency [MHz]	Channel	802.11 MODE	Data Rate [MHz]	Measured 99% Occupied Bandwidth [MHz]	Measured 26dB Bandwidth [MHz]	Maximum Bandwidth Limit [MHz]	Pass / Fail
Band 5	5955	1	a	24	16.57	20.49	320	Pass
	6175	45	a	24	16.58	20.45	320	Pass
	6415	93	a	24	16.56	20.20	320	Pass
	5955	1	ax (20MHz)	49/51.6 (MCS4)	19.02	21.29	320	Pass
	6175	45	ax (20MHz)	49/51.6 (MCS4)	19.03	21.28	320	Pass
	6415	93	ax (20MHz)	49/51.6 (MCS4)	19.03	21.24	320	Pass
	5965	3	ax (40MHz)	98/103.2 (MCS4)	37.92	41.46	320	Pass
	6165	43	ax (40MHz)	98/103.2 (MCS4)	37.88	41.69	320	Pass
	6405	91	ax (40MHz)	98/103.2 (MCS4)	37.89	41.64	320	Pass
	5985	7	ax (80MHz)	204/216.2 (MCS4)	77.16	81.54	320	Pass
	6145	39	ax (80MHz)	204/216.2 (MCS4)	77.14	81.74	320	Pass
	6385	87	ax (80MHz)	204/216.2 (MCS4)	77.18	81.60	320	Pass
	6025	15	ax (160MHz)	367.5/432.4 (MCS4)	156.32	164.56	320	Pass
	6185	47	ax (160MHz)	367.5/432.4 (MCS4)	156.53	165.50	320	Pass
	6345	79	ax (160MHz)	367.5/432.4 (MCS4)	156.05	164.64	320	Pass
Band 6	6435	97	a	24	16.52	20.46	320	Pass
	6475	105	a	24	16.54	20.32	320	Pass
	6515	113	a	24	16.57	20.49	320	Pass
	6435	97	ax (20MHz)	49/51.6 (MCS4)	19.01	21.24	320	Pass
	6475	105	ax (20MHz)	49/51.6 (MCS4)	19.01	21.12	320	Pass
	6515	113	ax (20MHz)	49/51.6 (MCS4)	19.04	21.13	320	Pass
	6445	99	ax (40MHz)	98/103.2 (MCS4)	37.89	41.54	320	Pass
	6485	107	ax (40MHz)	98/103.2 (MCS4)	37.94	41.59	320	Pass
	6525	115	ax (40MHz)	98/103.2 (MCS4)	37.93	41.63	320	Pass
	6465	103	ax (80MHz)	204/216.2 (MCS4)	77.21	81.61	320	Pass
	6505	111	ax (160MHz)	367.5/432.4 (MCS4)	156.51	166.63	320	Pass
Band 7	6535	117	a	24	16.56	20.43	320	Pass
	6695	149	a	24	16.56	20.41	320	Pass
	6875	185	a	24	16.58	20.56	320	Pass
	6535	117	ax (20MHz)	49/51.6 (MCS4)	19.03	21.14	320	Pass
	6695	149	ax (20MHz)	49/51.6 (MCS4)	19.02	21.18	320	Pass
	6875	185	ax (20MHz)	49/51.6 (MCS4)	19.02	21.25	320	Pass
	6565	123	ax (40MHz)	98/103.2 (MCS4)	37.86	41.62	320	Pass
	6725	155	ax (40MHz)	98/103.2 (MCS4)	37.90	41.57	320	Pass
	6845	179	ax (40MHz)	98/103.2 (MCS4)	37.94	41.71	320	Pass
	6545	119	ax (80MHz)	204/216.2 (MCS4)	77.20	81.34	320	Pass
	6705	151	ax (80MHz)	204/216.2 (MCS4)	77.26	81.54	320	Pass
	6865	183	ax (80MHz)	204/216.2 (MCS4)	77.09	81.72	320	Pass
	6665	143	ax (160MHz)	367.5/432.4 (MCS4)	155.96	164.94	320	Pass
	6825	175	ax (160MHz)	367.5/432.4 (MCS4)	156.69	165.88	320	Pass
Band 8	6895	189	a	24	16.56	20.46	320	Pass
	6995	209	a	24	16.54	20.39	320	Pass
	7115	233	a	24	18.99	21.27	320	Pass
	6895	189	ax (20MHz)	49/51.6 (MCS4)	19.03	21.32	320	Pass
	6995	209	ax (20MHz)	49/51.6 (MCS4)	19.02	21.04	320	Pass
	7115	233	ax (20MHz)	49/51.6 (MCS4)	18.99	21.20	320	Pass
	6885	187	ax (40MHz)	98/103.2 (MCS4)	37.92	41.42	320	Pass
	7005	211	ax (40MHz)	98/103.2 (MCS4)	37.92	41.25	320	Pass
	7085	227	ax (40MHz)	98/103.2 (MCS4)	37.95	41.25	320	Pass
	6945	199	ax (80MHz)	204/216.2 (MCS4)	77.18	81.26	320	Pass
	7025	215	ax (80MHz)	204/216.2 (MCS4)	77.16	81.74	320	Pass
	6985	207	ax (160MHz)	367.5/432.4 (MCS4)	156.18	165.68	320	Pass

Table 7-3. Conducted Bandwidth Measurements Antenna 5b (Mid Data Rate)

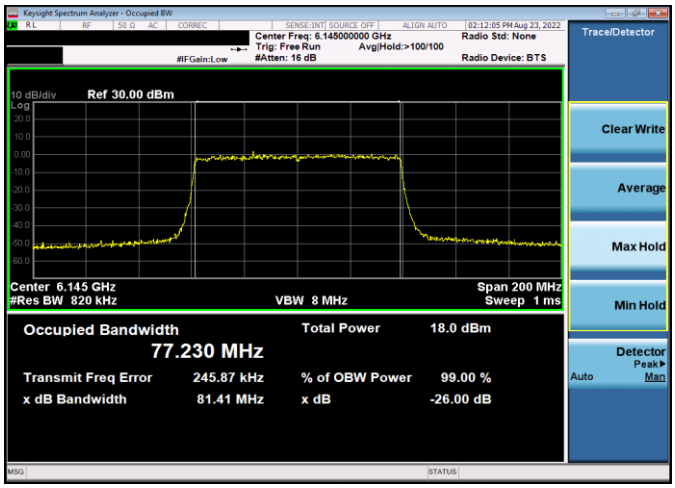
	Frequency [MHz]	Channel	802.11 MODE	Data Rate [MHz]	Measured 99% Occupied Bandwidth [MHz]	Measured 26dB Bandwidth [MHz]	Maximum Bandwidth Limit [MHz]	Pass / Fail
Band 5	5955	1	a	54	16.67	20.57	320	Pass
	6175	45	a	54	16.65	20.67	320	Pass
	6415	93	a	54	16.67	20.72	320	Pass
	5955	1	ax (20MHz)	135/143.4 (MCS11)	19.02	21.17	320	Pass
	6175	45	ax (20MHz)	135/143.4 (MCS11)	19.07	21.31	320	Pass
	6415	93	ax (20MHz)	135/143.4 (MCS11)	19.01	21.31	320	Pass
	5965	3	ax (40MHz)	271/286.8 (MCS11)	37.85	41.12	320	Pass
	6165	43	ax (40MHz)	271/286.8 (MCS11)	37.90	41.40	320	Pass
	6405	91	ax (40MHz)	271/286.8 (MCS11)	37.89	41.19	320	Pass
	5985	7	ax (80MHz)	567/600.5 (MCS11)	77.00	81.22	320	Pass
	6145	39	ax (80MHz)	567/600.5 (MCS11)	77.19	81.12	320	Pass
	6385	87	ax (80MHz)	567/600.5 (MCS11)	77.13	81.68	320	Pass
	6025	15	ax (160MHz)	1020.8/1201 (MCS11)	156.40	165.87	320	Pass
	6185	47	ax (160MHz)	1020.8/1201 (MCS11)	156.13	164.83	320	Pass
	6345	79	ax (160MHz)	1020.8/1201 (MCS11)	156.47	165.13	320	Pass
Band 6	6435	97	a	54	16.67	20.66	320	Pass
	6475	105	a	54	16.68	20.79	320	Pass
	6515	113	a	54	16.69	20.55	320	Pass
	6435	97	ax (20MHz)	135/143.4 (MCS11)	19.06	21.31	320	Pass
	6475	105	ax (20MHz)	135/143.4 (MCS11)	19.02	21.13	320	Pass
	6515	113	ax (20MHz)	135/143.4 (MCS11)	19.04	21.23	320	Pass
	6445	99	ax (40MHz)	271/286.8 (MCS11)	37.93	41.16	320	Pass
	6485	107	ax (40MHz)	271/286.8 (MCS11)	37.92	41.32	320	Pass
	6525	115	ax (40MHz)	271/286.8 (MCS11)	37.85	41.47	320	Pass
	6465	103	ax (80MHz)	567/600.5 (MCS11)	77.13	81.52	320	Pass
	6505	111	ax (160MHz)	1020.8/1201 (MCS11)	156.76	166.06	320	Pass
Band 7	6535	117	a	54	16.68	20.72	320	Pass
	6695	149	a	54	16.65	20.68	320	Pass
	6875	185	a	54	16.69	20.49	320	Pass
	6535	117	ax (20MHz)	135/143.4 (MCS11)	19.01	21.24	320	Pass
	6695	149	ax (20MHz)	135/143.4 (MCS11)	19.04	21.26	320	Pass
	6875	185	ax (20MHz)	135/143.4 (MCS11)	19.06	21.06	320	Pass
	6565	123	ax (40MHz)	271/286.8 (MCS11)	37.94	41.53	320	Pass
	6725	155	ax (40MHz)	271/286.8 (MCS11)	37.85	41.01	320	Pass
	6845	179	ax (40MHz)	271/286.8 (MCS11)	37.92	41.31	320	Pass
	6545	119	ax (80MHz)	567/600.5 (MCS11)	77.13	81.19	320	Pass
	6705	151	ax (80MHz)	567/600.5 (MCS11)	77.17	81.49	320	Pass
	6865	183	ax (80MHz)	567/600.5 (MCS11)	77.07	81.24	320	Pass
	6665	143	ax (160MHz)	1020.8/1201 (MCS11)	156.16	165.70	320	Pass
	6825	175	ax (160MHz)	1020.8/1201 (MCS11)	156.68	165.33	320	Pass
Band 8	6895	189	a	54	19.11	21.24	320	Pass
	6995	209	a	54	16.66	20.65	320	Pass
	7115	233	a	54	16.67	20.60	320	Pass
	6895	189	ax (20MHz)	135/143.4 (MCS11)	19.06	21.41	320	Pass
	6995	209	ax (20MHz)	135/143.4 (MCS11)	19.08	21.49	320	Pass
	7115	233	ax (20MHz)	135/143.4 (MCS11)	19.05	21.33	320	Pass
	6885	187	ax (40MHz)	271/286.8 (MCS11)	37.88	41.50	320	Pass
	7005	211	ax (40MHz)	271/286.8 (MCS11)	37.85	41.17	320	Pass
	7085	227	ax (40MHz)	271/286.8 (MCS11)	37.91	41.16	320	Pass
	6945	199	ax (80MHz)	567/600.5 (MCS11)	76.99	81.45	320	Pass
	7025	215	ax (80MHz)	567/600.5 (MCS11)	77.03	81.63	320	Pass
	6985	207	ax (160MHz)	1020.8/1201 (MCS11)	156.38	165.96	320	Pass

Table 7-4. Conducted Bandwidth Measurements Antenna 5b (High Data Rate)

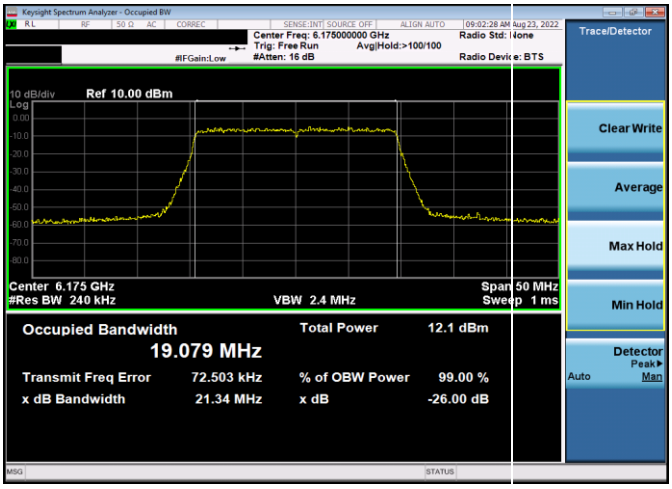
Low Data Rate



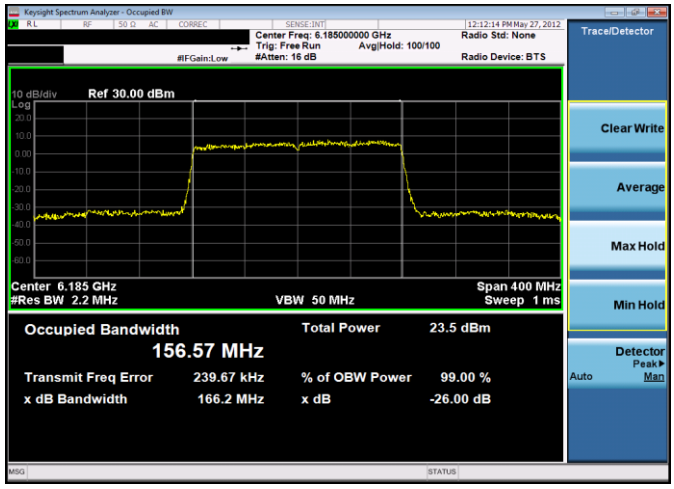
Plot 7-1. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 5) – Ch. 45, MCS2)



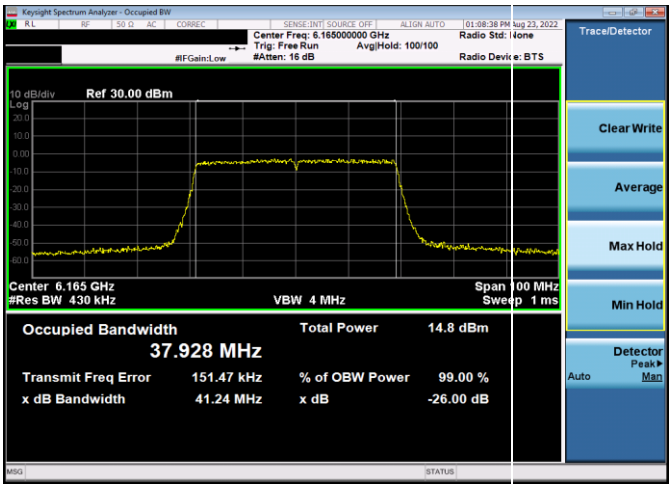
Plot 7-4. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 5) – Ch. 39, MCS2)



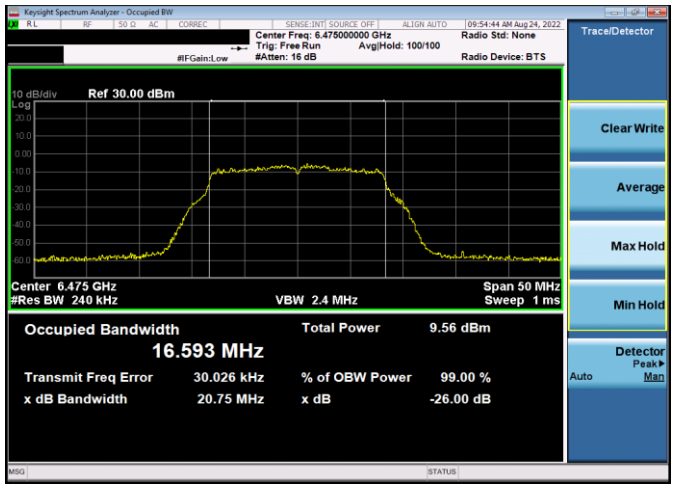
Plot 7-2. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 5) – Ch. 45, MCS2)



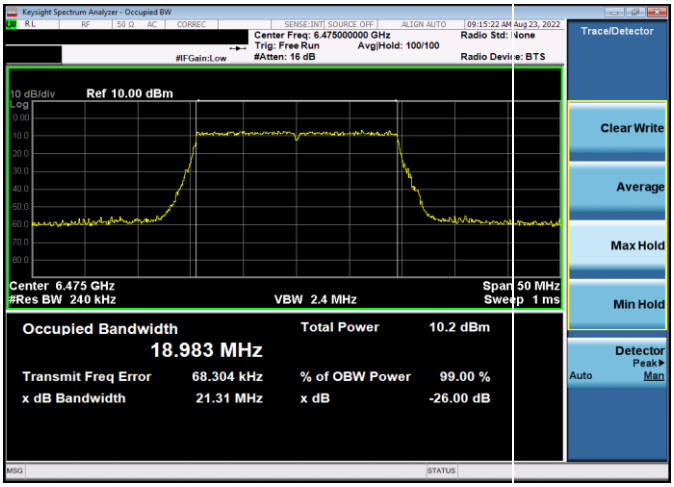
Plot 7-5. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 5) – Ch. 47, MCS2)



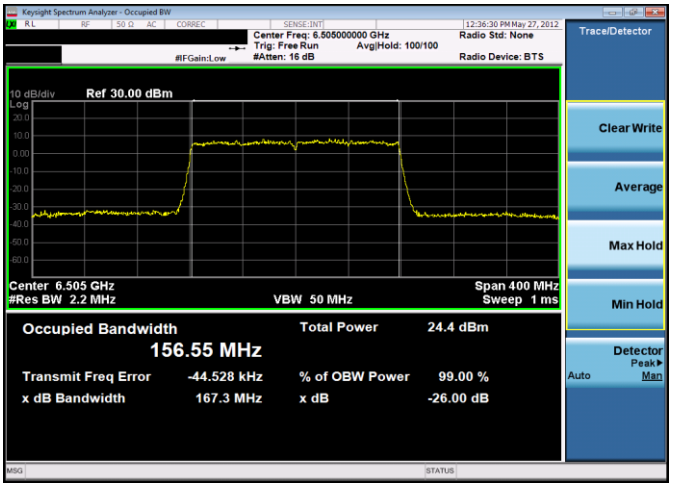
Plot 7-3. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 5) – Ch. 43, MCS2)



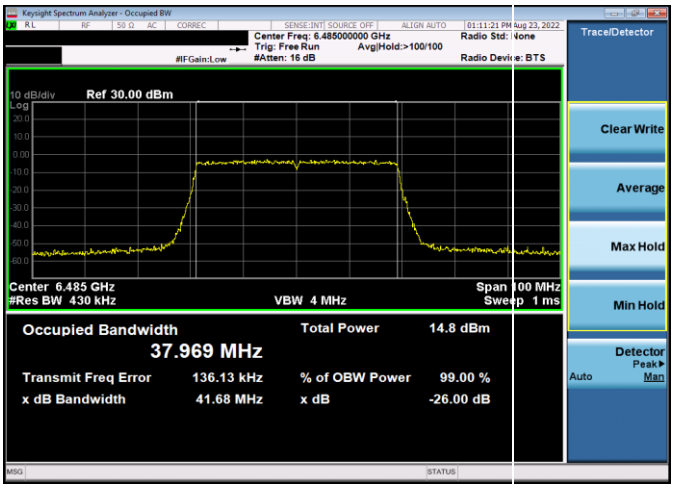
Plot 7-6. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 6) – Ch. 105, MCS2)



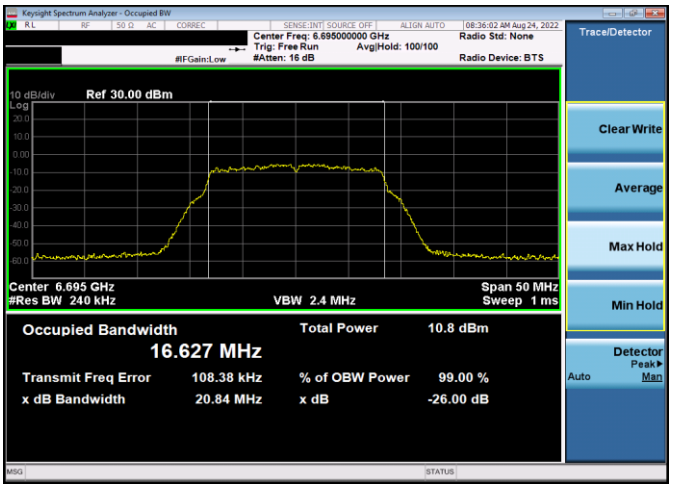
Plot 7-7. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 6) – Ch. 105, MCS2)



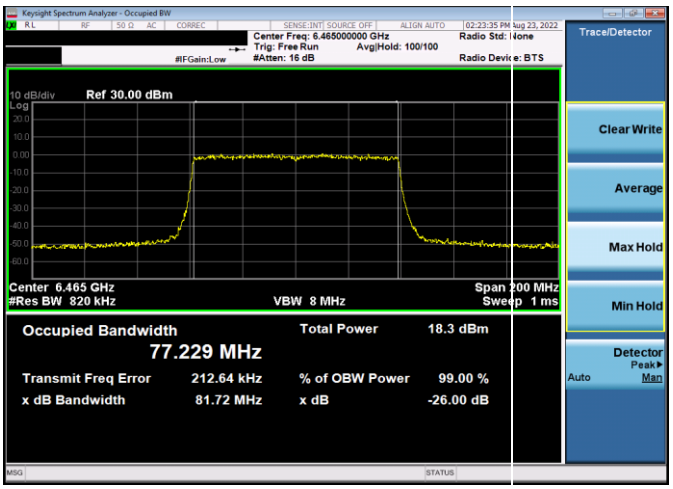
Plot 7-10. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 6) – Ch. 111, MCS2)



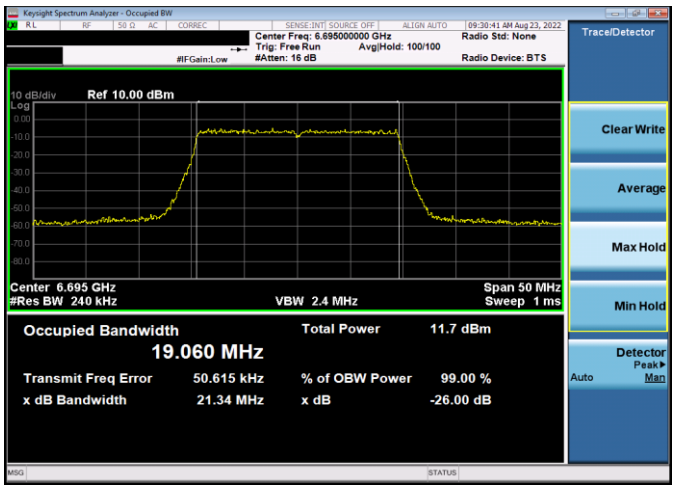
Plot 7-8. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 6) – Ch. 107, MCS2)



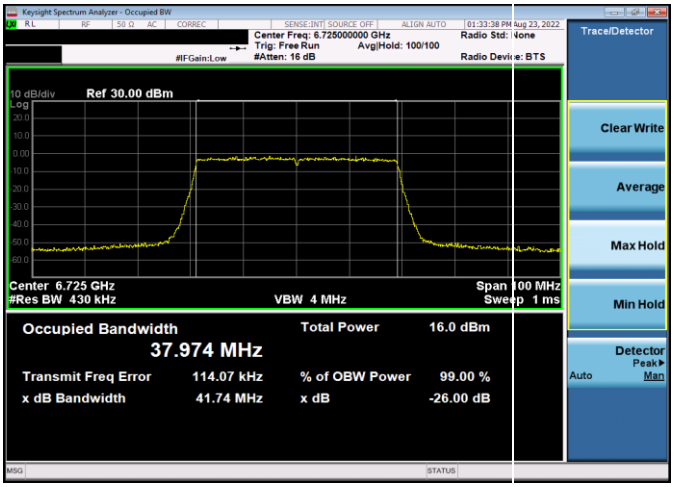
Plot 7-11. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 7) – Ch. 149, MCS2)



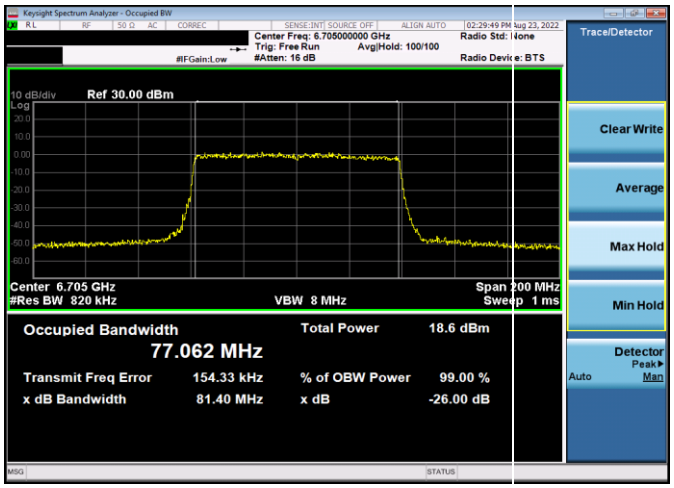
Plot 7-9. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 6) – Ch. 103, MCS2)



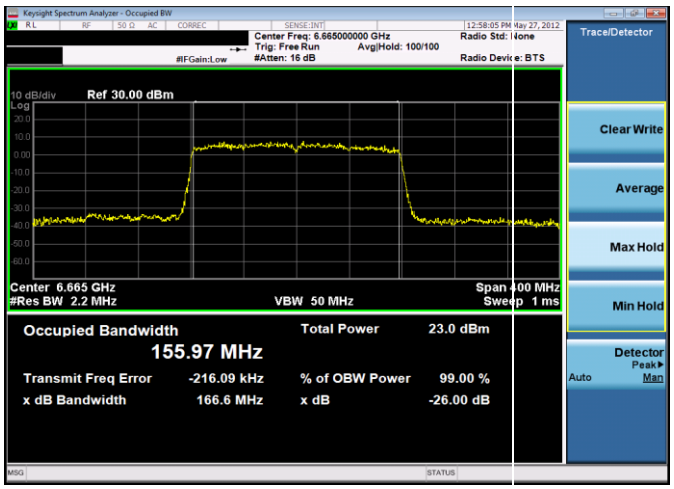
Plot 7-12. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 7) – Ch. 149, MCS2)



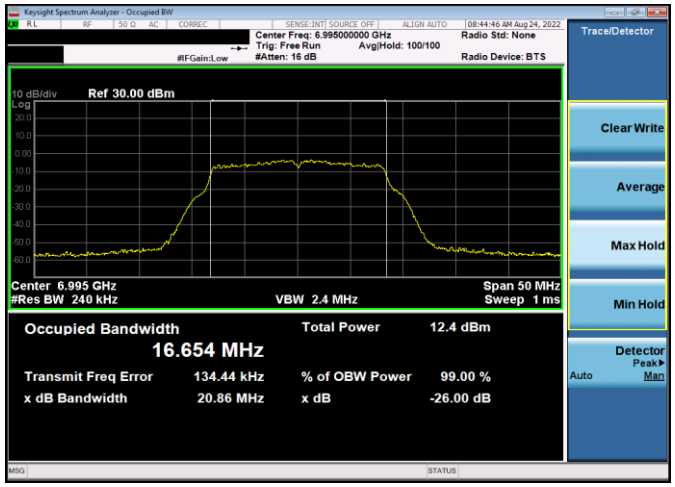
Plot 7-13. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 7) – Ch. 155, MCS2)



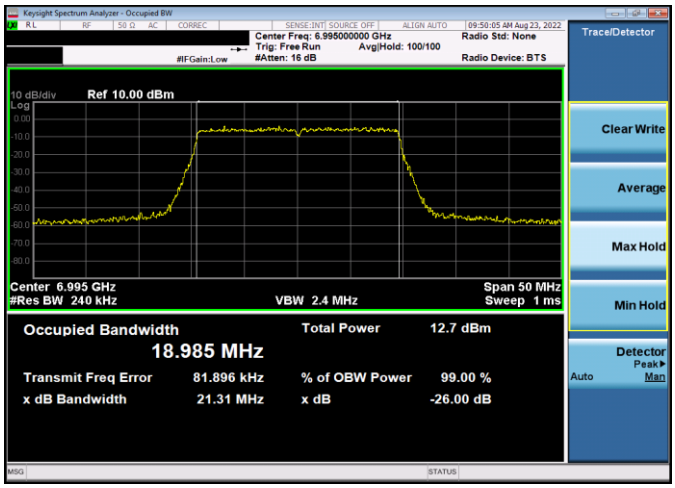
Plot 7-14. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 7) – Ch. 151, MCS2)



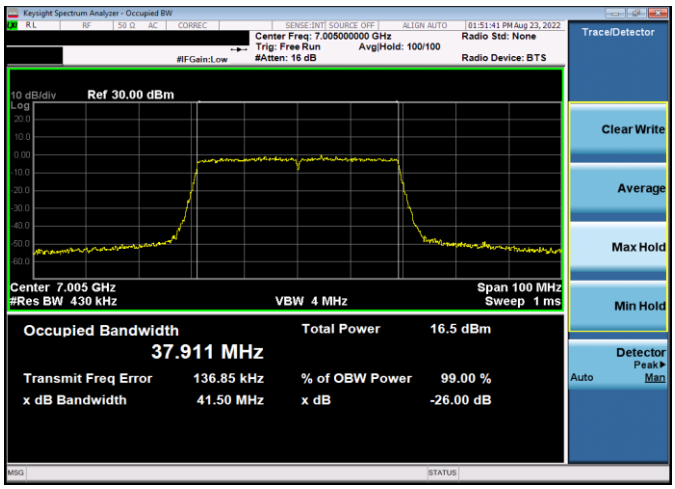
Plot 7-15. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 7) – Ch. 143, MCS2)



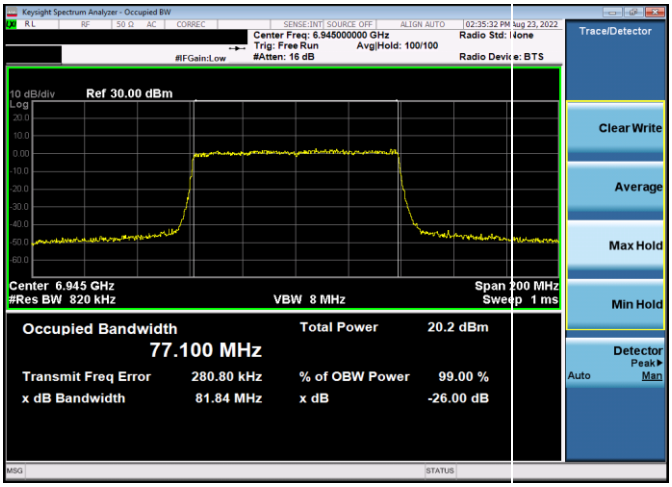
Plot 7-16. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 8) – Ch. 209, MCS2)



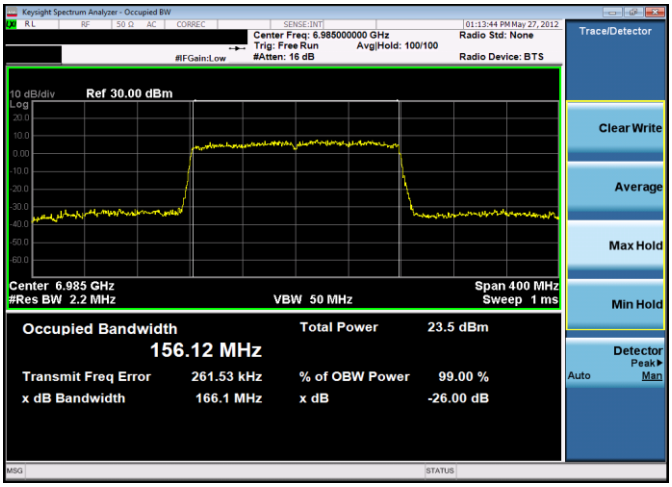
Plot 7-17. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 8) – Ch. 209, MCS2)



Plot 7-18. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 8) – Ch. 211, MCS2)

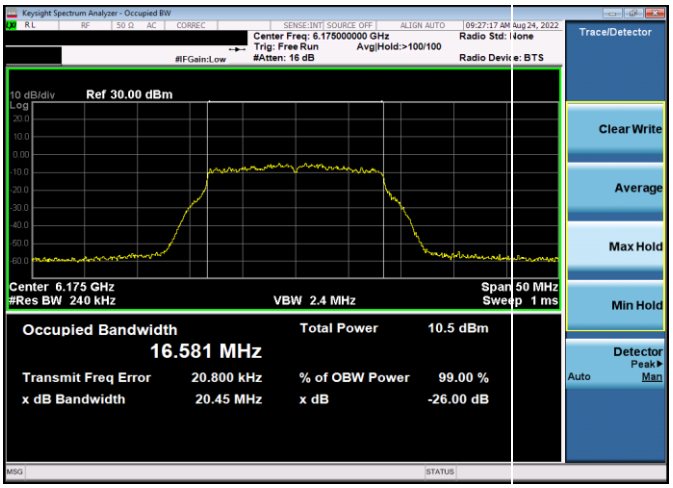


Plot 7-19. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 8) – Ch. 199, MCS2)

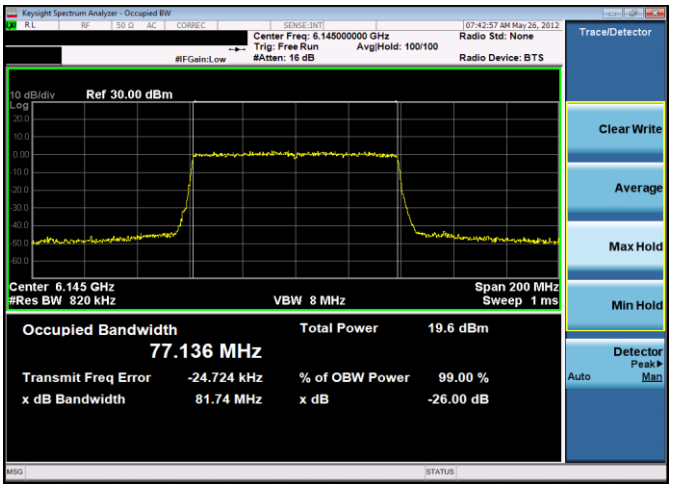


Plot 7-20. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 8) – Ch. 207, MCS2)

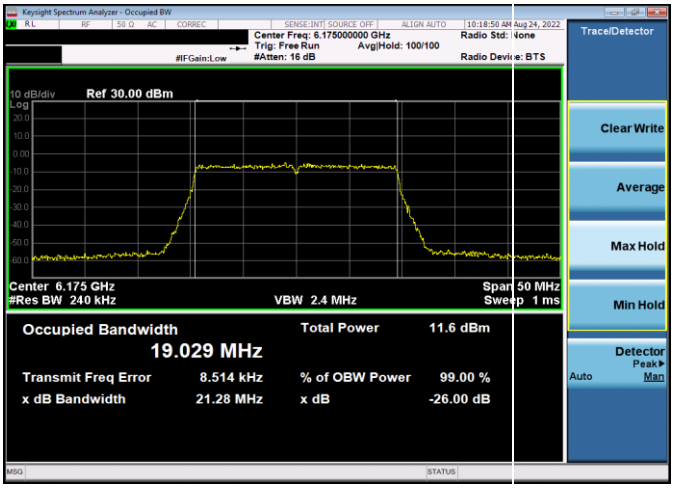
Mid Data Rate



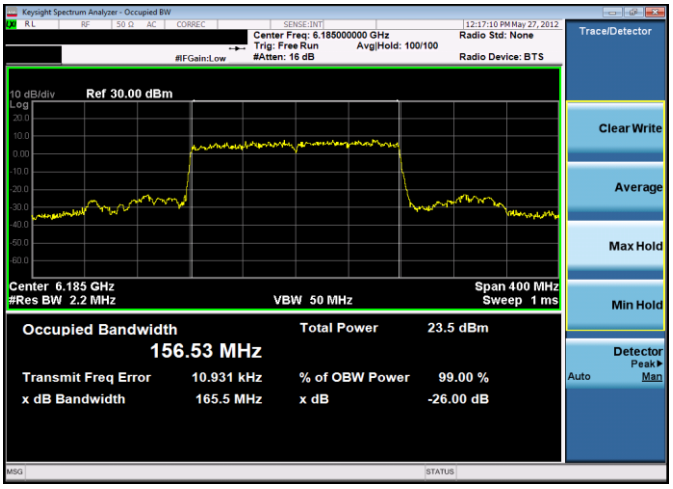
Plot 7-21. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 5) – Ch. 45, MCS4)



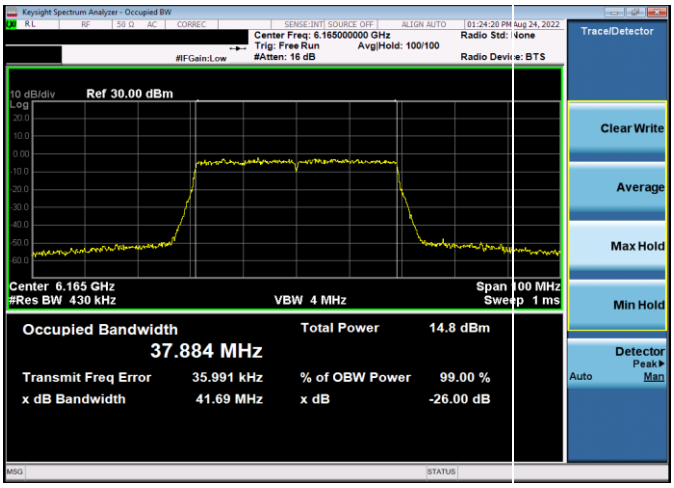
Plot 7-24. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 5) – Ch. 39, MCS4)



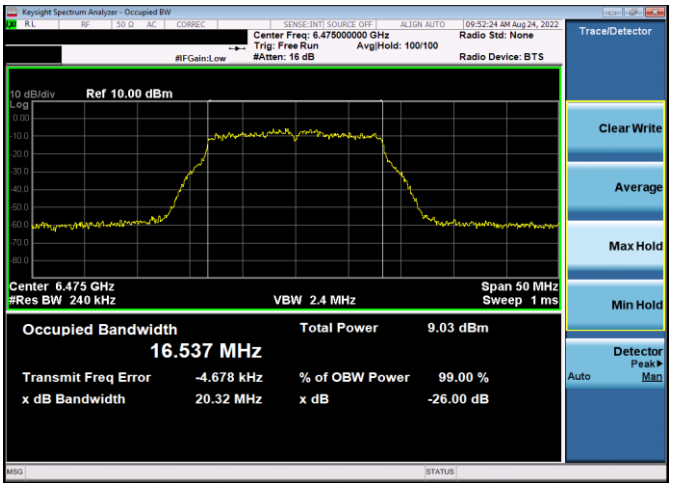
Plot 7-22. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 5) – Ch. 45, MCS4)



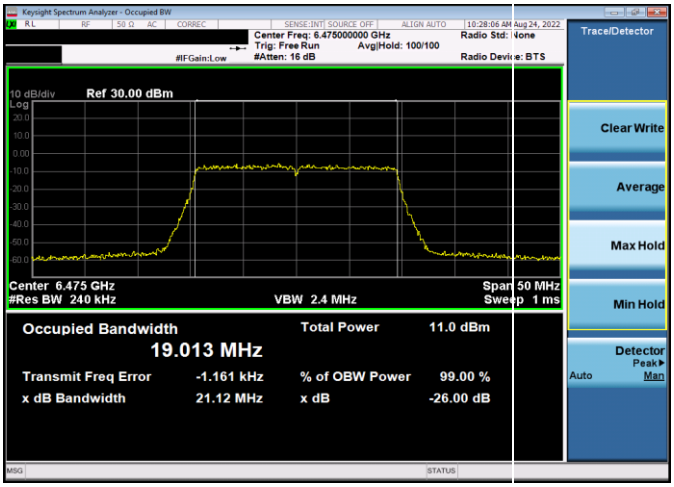
Plot 7-25. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 5) – Ch. 47, MCS4)



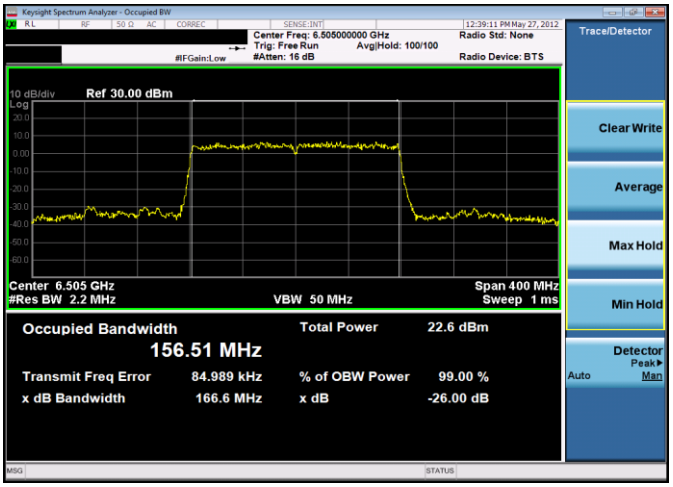
Plot 7-23. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 5) – Ch. 43, MCS4)



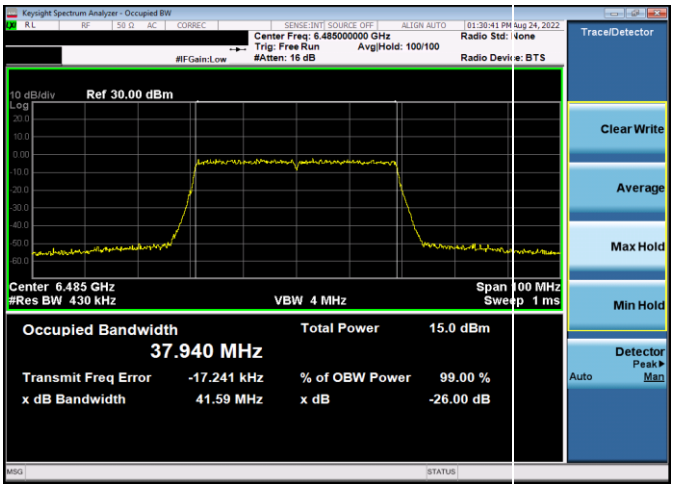
Plot 7-26. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 6) – Ch. 105, MCS4)



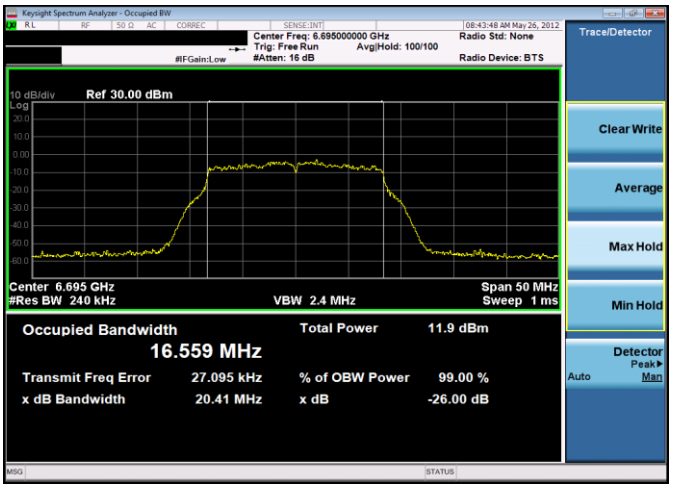
Plot 7-27. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 6) – Ch. 105, MCS4)



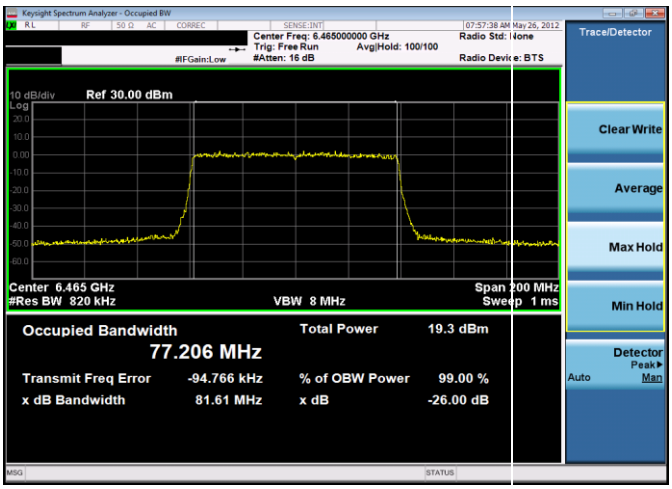
Plot 7-30. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 6) – Ch. 111, MCS4)



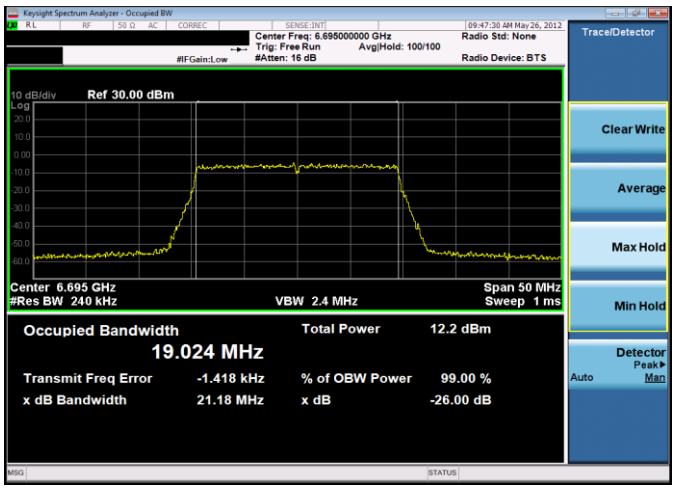
Plot 7-28. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 6) – Ch. 107, MCS4)



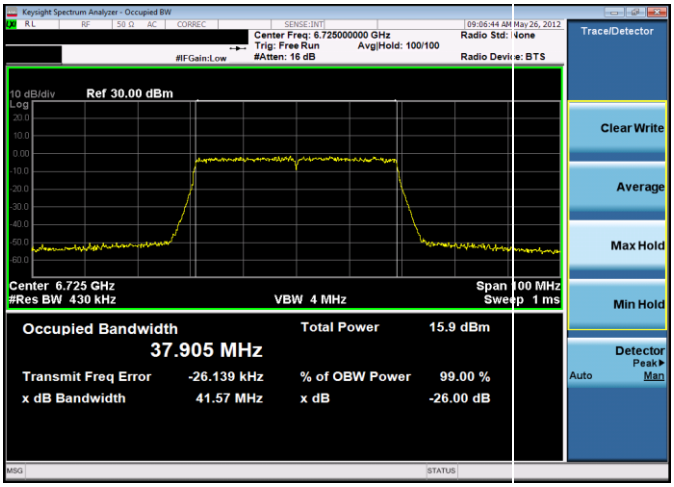
Plot 7-31. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 7) – Ch. 149, MCS4)



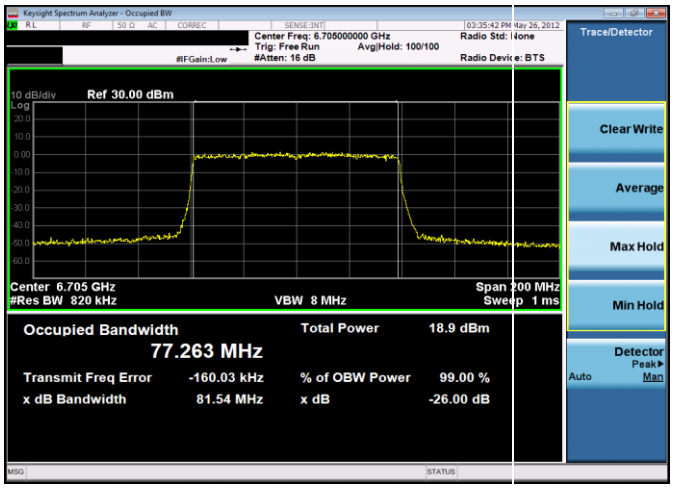
Plot 7-29. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 6) – Ch. 103, MCS4)



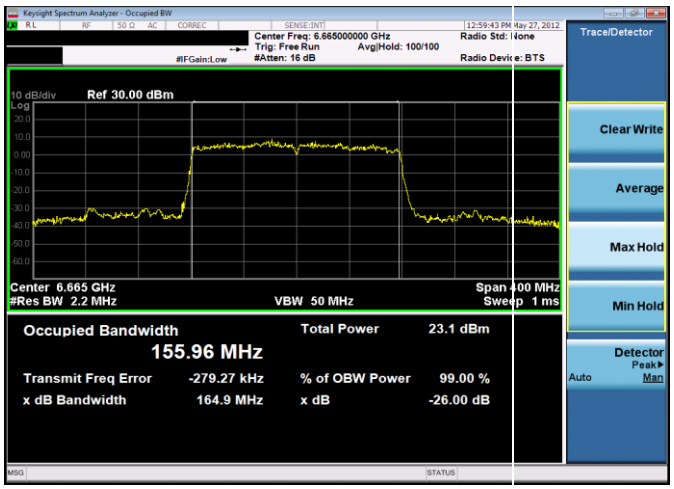
Plot 7-32. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 7) – Ch. 149, MCS4)



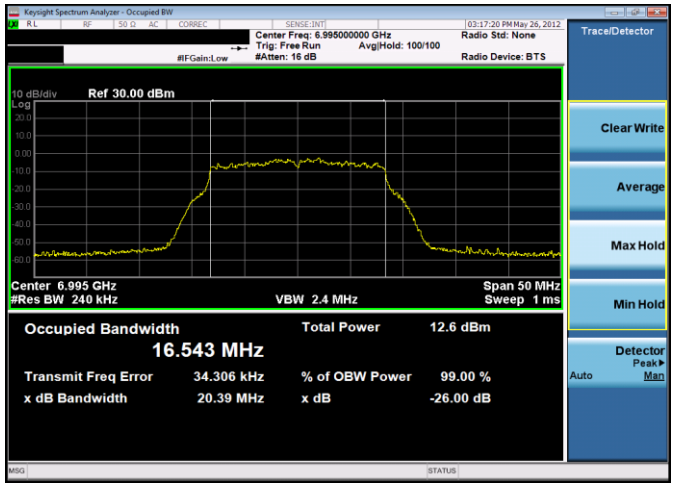
Plot 7-33. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 7) – Ch. 155, MCS4)



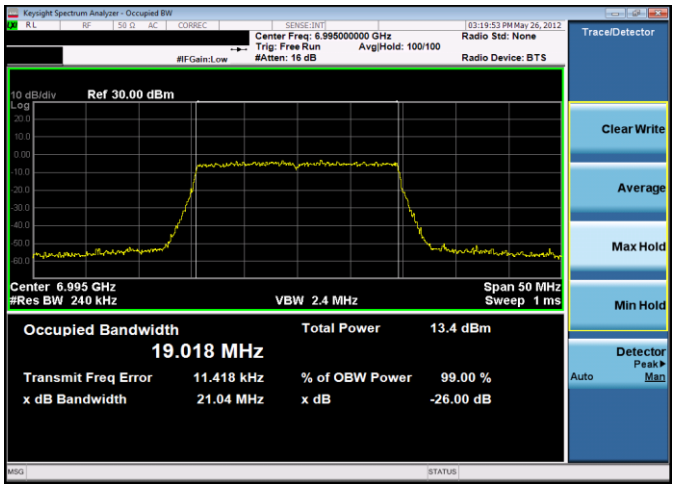
Plot 7-34. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 7) – Ch. 151, MCS4)



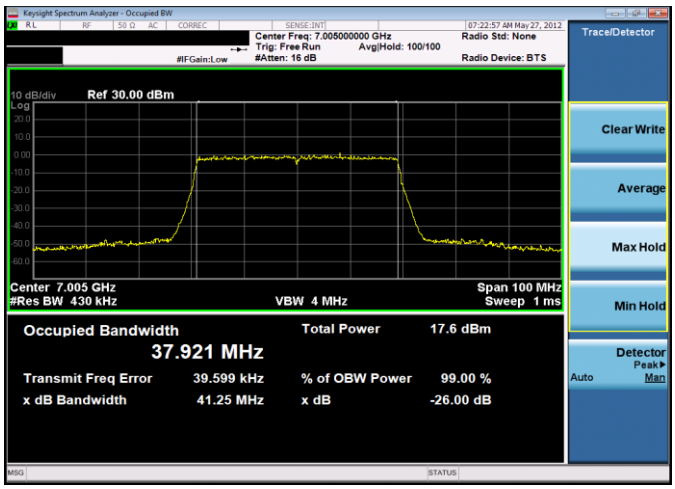
Plot 7-35. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 7) – Ch. 143, MCS4)



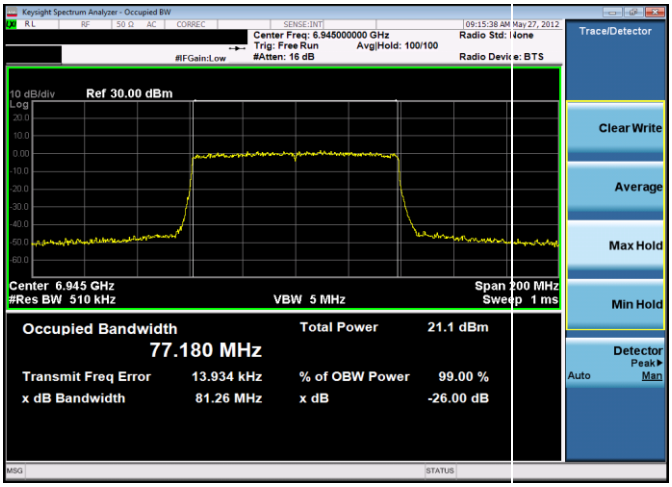
Plot 7-36. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11a (UNII Band 8) – Ch. 209, MCS4)



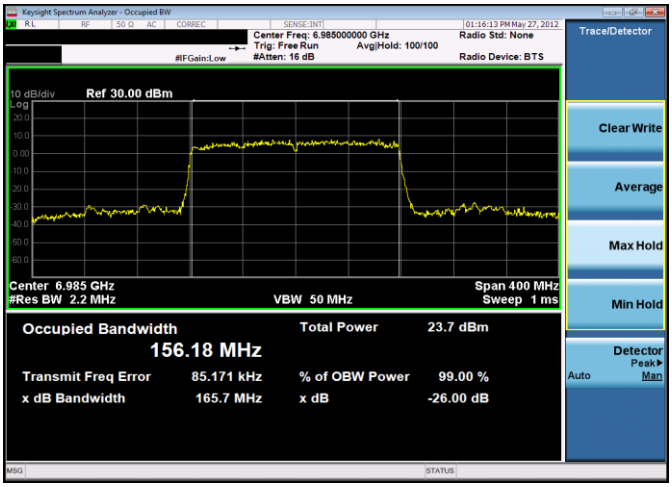
Plot 7-37. 26dB & 99% Bandwidth Plot Antenna 5b (20MHz 802.11ax (UNII Band 8) – Ch. 209, MCS4)



Plot 7-38. 26dB & 99% Bandwidth Plot Antenna 5b (40MHz 802.11ax (UNII Band 8) – Ch. 211, MCS4)



Plot 7-39. 26dB & 99% Bandwidth Plot Antenna 5b (80MHz 802.11ax (UNII Band 8) – Ch. 199, MCS4)



Plot 7-40. 26dB & 99% Bandwidth Plot Antenna 5b (160MHz 802.11ax (UNII Band 8) – Ch. 207, MCS4)