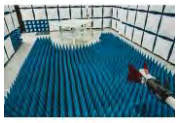
PCTEST
18855 Adams Court, Morgan Hill, CA 95037 USA
Tel. 410.290.6652 / Fax 410.290.6654
http://www.pctest.com



MEASUREMENT REPORT
FCC PART 15.247 / ISED RSS-247 Bluetooth (Low Energy)

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

Date of Testing:
12/10/2019 - 02/21/2020
Test Site/Location:
PCTEST Morgan Hill, CA, USA
Test Report Serial No.:
1C1912170050-05.BCG

FCC ID:	**BCGA2228**
IC:	**579C-A2228**
APPLICANT:	**Apple Inc.**

Application Type:	Certification
Model/HVIN:	A2228
EUT Type:	Tablet Device
Max. RF Output Power:	97.724 mW (19.90 dBm) Peak Conducted
Frequency Range:	2402 – 2480MHz
FCC Classification:	Digital Transmission System (DTS)
FCC Rule Part(s):	Part 15 Subpart C (15.247)
ISED Specification:	RSS-247 Issue 2
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 was tested in accordance with the measurement procedures specified in ANSI C63.10-2013 and KDB 558074 D01 v05r02. 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.

Randy Ortanez
President

ACCREDITED
TESTING CERT#2041.02

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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 PCTEST Test Location

These measurement tests were conducted at the PCTEST 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 PCTEST located in Morgan Hill, CA 95037, U.S.A.

- PCTEST is an ISO 17025-2005 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.

- PCTEST 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).

- PCTEST 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: BCGA2228**. The data found in this test report was taken with the EUT operating in Bluetooth low energy mode. While in low energy mode, the Bluetooth transmitter hops pseudo-randomly between 40 channels, three of which are “advertising channels”. When the transmitter is hopping only between the three advertising channels, the EUT does not fall under the category of a “hopper” as defined in 15.247(a)(iii) which states that a “frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.” As operation on only the advertising channels does not qualify the EUT as a hopper, the EUT is certified as a DTS device in this mode. The data found in this report is representative of the device when it transmits on its advertising channels. Typical Bluetooth operation is covered under the DSS report found with this application.

Test Device Serial No.: DLXZR006P7FJ, DLXZR034P7FJ

2.2 Device Capabilities

This device contains the following capabilities:

802.11b/g/n/ax WLAN, 802.11a/n/ac/ax UNII, Bluetooth (1x, EDR, LE, HDR4, HDR8)

Ch.	Frequency (MHz)
0	2402
:	:
19	2440
:	:
39	2480

Table 2-1. Frequency / Channel Operations

Measured Duty Cycles				
BTLE Mode		Duty Cycle (%)		
		Ant WF8	Ant WF7	TxBF
1Mbps	ePA	100.0	100.0	100.0
	iPA	100.0	100.0	100.0
2Mbps	ePA	100.0	100.0	100.0
	iPA	100.0	100.0	100.0

Table 2-2. Measured Duty Cycles

1. This device supports Bluetooth LE operations with 1Mbps and 2Mbps.
2. This device supports BT Beamforming

2.3 Antenna Description

Following antennas were used for the testing.

Frequency [GHz]	Antenna Gain (dBi)	
	Ant WF8	Ant WF7
2.4	0.3	-3.2

Table 2-3. Highest Antenna Gain

Note: This device is capable of operating in hopping and non-hopping mode. The EUT can hop between 40 different channels in the 2400 – 2483.5MHz band.

2.4 Test Support Equipment

1	Apple MacBook	Model:	A1398	S/N:	C2QKP008F6F3
	w/ AC/DC Adapter	Model:	A1435	S/N:	C04325505K1F288BG
2	Apple USB-C Cable	Model:	Chimp	S/N:	304523
3	USB-C Cable	Model:	A1997	S/N:	N/A
	w / AC/DC Adapter	Model:	A1720	S/N:	C3D9274B06YLHDAE
4	Apple Pencil	Model:	A2051	S/N:	GQXYGSXCJKM9
5	DC Power Supply	Model:	KPS3010D	S/N	N/A

Table 2-4. Test Support Equipment Used

2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013 and KDB 558074 D01 v05r02. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 3.2 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 channel and the worst case configuration.

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 worst case was reported.

- 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

2.6 Software and Firmware

The test was conducted with firmware version 17E228 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 558074 D01 v05r02 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 7.10. Automated test software was used to perform the AC line conducted emissions testing. Automated measurement software utilized is Rohde & Schwarz EMC32, Version 10.35.04.

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 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 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 C63.10-2013. 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	1.29
Conducted Disturbance	2.48
Radiated Disturbance (<1GHz)	4.15
Radiated Disturbance (>1GHz)	4.70
Radiated Disturbance (>18GHz)	5.01

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	3/13/2019	Annual	3/13/2020	MY49430244
Anritsu	ML2496A	Power Meter	10/29/2019	Annual	10/29/2020	184005
Anritsu	MA2411B	Pulse Power Sensor	10/29/2019	Annual	10/29/2020	1726261
Anritsu	MA2411B	Pulse Power Sensor	10/29/2019	Annual	10/29/2020	1726262
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna	10/29/2019	Annual	10/29/2020	T058701-02
COM-POWER	LIN-120A	LISN	3/13/2019	Annual	3/13/2020	241297
ETS-Lindgren	3142E–PA	Pre-Amplifier (30MHz - 6GHz)	9/19/2019	Annual	9/19/2020	213236
ETS-Lindgren	3142E	BiConiLog Antenna (30MHz - 6GHz)	8/14/2019	Annual	8/14/2020	224569
ETS-Lindgren	3117	Double Ridged Guide Antenna (1-18 GHz)	3/12/2019	Annual	3/12/2020	205956
Rohde & Schwarz	ESW26	EMI Test Receiver	5/21/2019	Annual	5/21/2020	101299
Rohde & Schwarz	ESW44	EMI Test Receiver	7/27/2019	Annual	7/27/2020	101668
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz - 40GHz)	9/19/2019	Annual	9/19/2020	100051
Rohde & Schwarz	TC-TA18	Cross Polarized Vivaldi Antenna (400MHz-18GHz)	11/14/2019	Annual	11/14/2020	101057
Rohde & Schwarz	HFH2-Z2	Loop Antenna	3/21/2019	Annual	3/21/2020	100519

Table 6-1. Annual Test Equipment Calibration Schedule

Note:

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

7.0 TEST RESULTS

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCGA2228

FCC Classification: Digital Transmission System (DTS)

Number of Channels: 40

FCC Part Section(s)	RSS Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
15.247(a)(2)	RSS-247 [5.2]	6dB Bandwidth	> 500kHz	CONDUCTED	PASS	Section 7.2
15.247(b)(3)	RSS-247 [5.4(d)]	Transmitter Output Power	< 1 Watt		PASS	Sections 7.3
15.247(e)	RSS-247 [5.2]	Transmitter Power Spectral Density	< 8dBm / 3kHz Band		PASS	Section 7.4
15.247(d)	RSS-247 [5.5]	Band Edge / Out-of-Band Emissions	≥ 20dBc		PASS	Sections 7.5, 7.6
15.205 15.209	RSS-Gen [8.9]	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209 (RSS-Gen [8.9])	RADIATED	PASS	Sections 7.7, 7.8
15.207	RSS-Gen [8.8]	AC Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits (RSS-Gen[8.8])	LINE CONDUCTED	PASS	Section 7.9

Table 7-1. Summary of Test Results

Notes:

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

7.2 6dB Bandwidth Measurement – Bluetooth (LE)

§15.247(a.2); RSS-247 [5.2]

Test Overview and Limit

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

The minimum permissible 6dB bandwidth is 500 kHz.

Test Procedure Used

ANSI C63.10-2013 – Section 11.8.2 Option 2
KDB 558074 D01 v05r02 – Section 8.2

Test Settings

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

Test Setup

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

Figure 7-1. Test Instrument & Measurement Setup

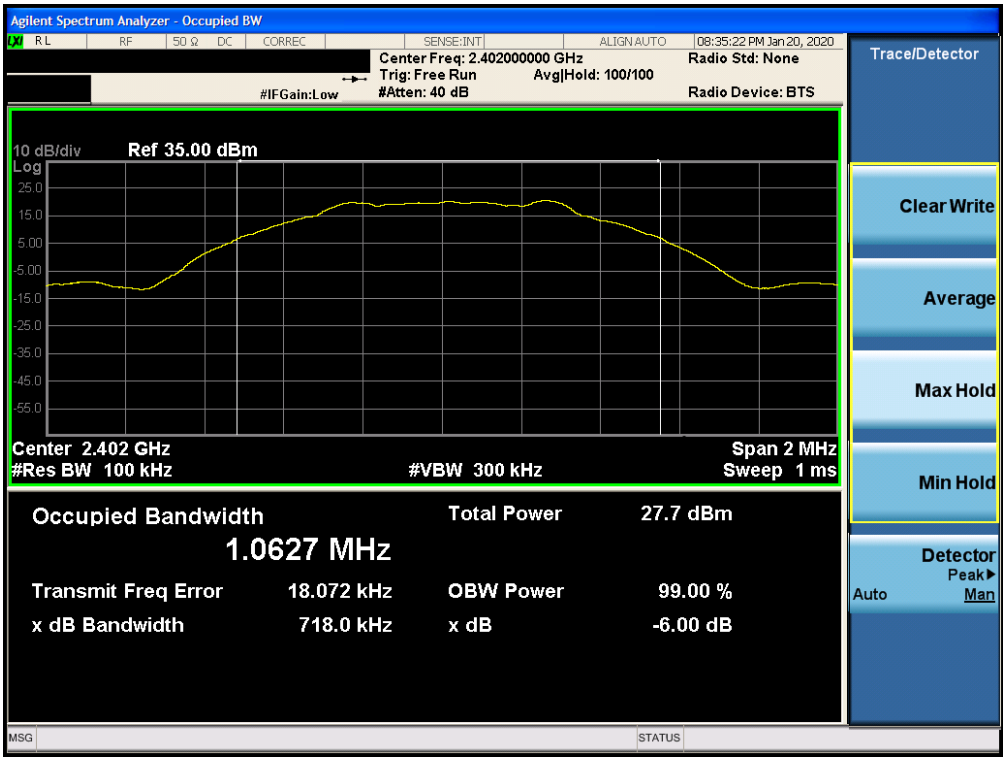
Test Notes

Both power schemes were investigated, and only the worst case is reported

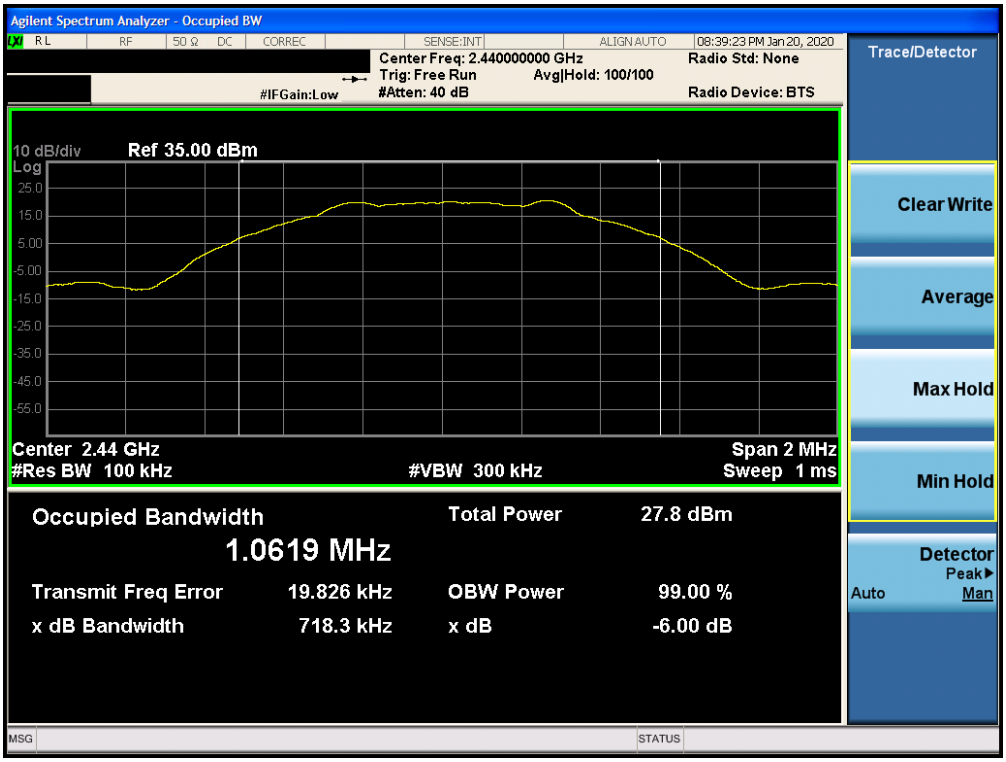
Antenna WF8

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Measured Bandwidth [kHz]	Minimum Bandwidth [kHz]	Pass / Fail
2402	1.0	ePA	0	718.0	500	Pass
2440	1.0	ePA	19	718.3	500	Pass
2480	1.0	ePA	39	718.0	500	Pass
2404	2.0	ePA	1	1325.0	500	Pass
2440	2.0	ePA	19	1325.0	500	Pass
2478	2.0	ePA	38	1325.0	500	Pass

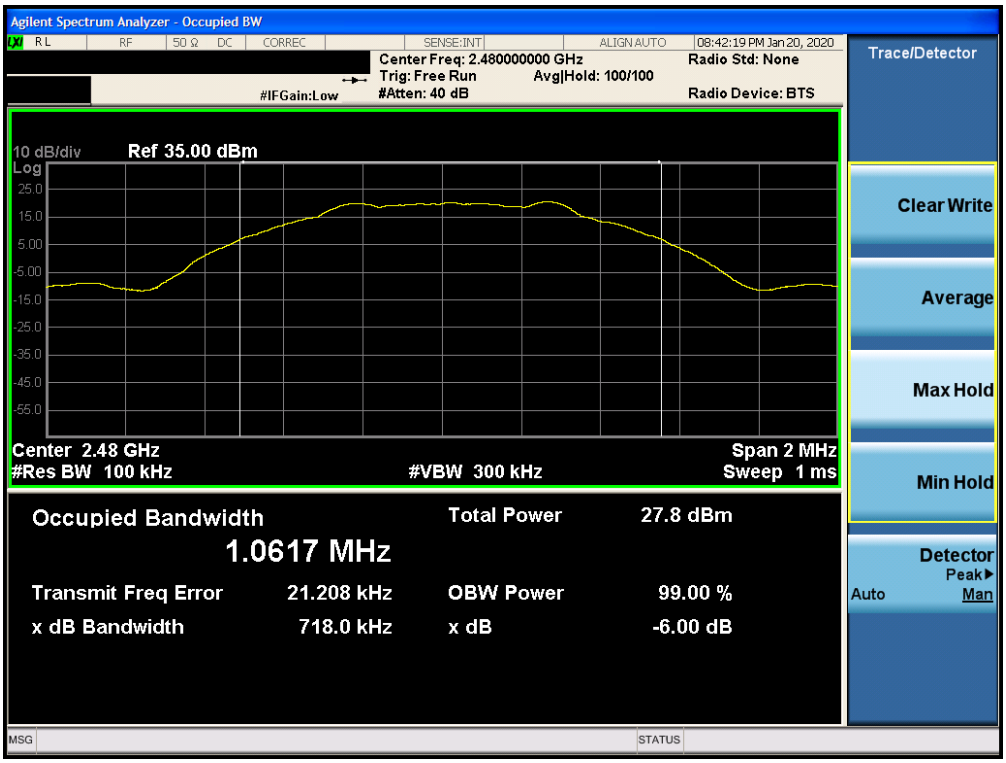
Table 7-2. Conducted Bandwidth Measurements Ant WF8



Plot 7-1. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



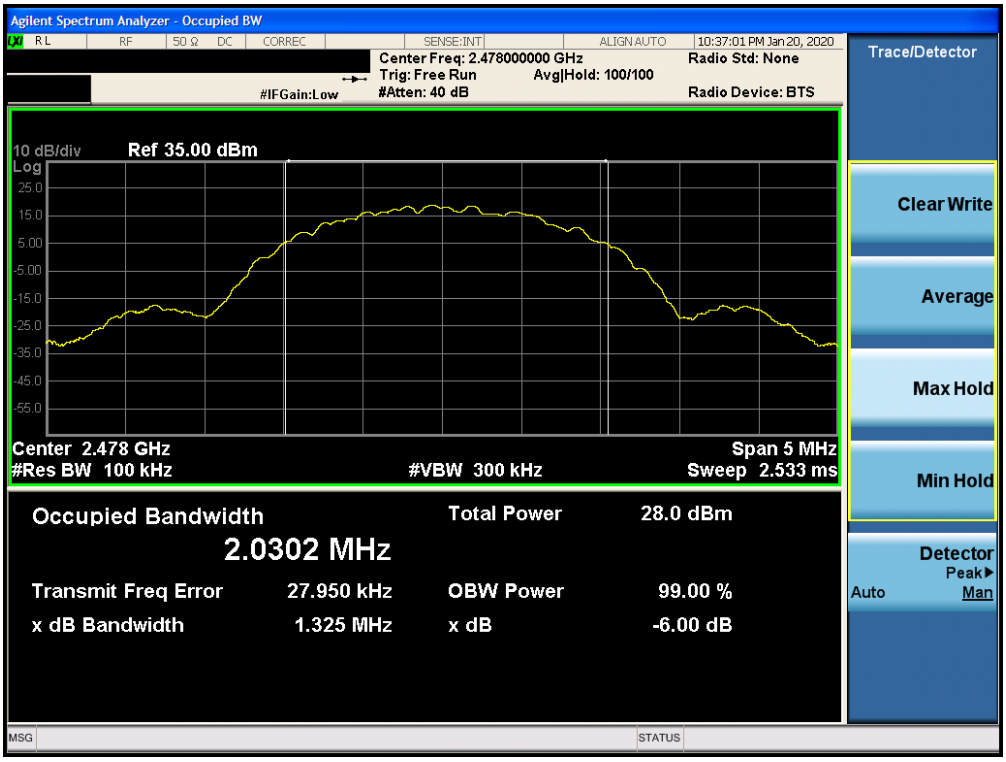
Plot 7-2. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



Plot 7-3. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)

Plot 7-4. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 1)

Plot 7-5. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)

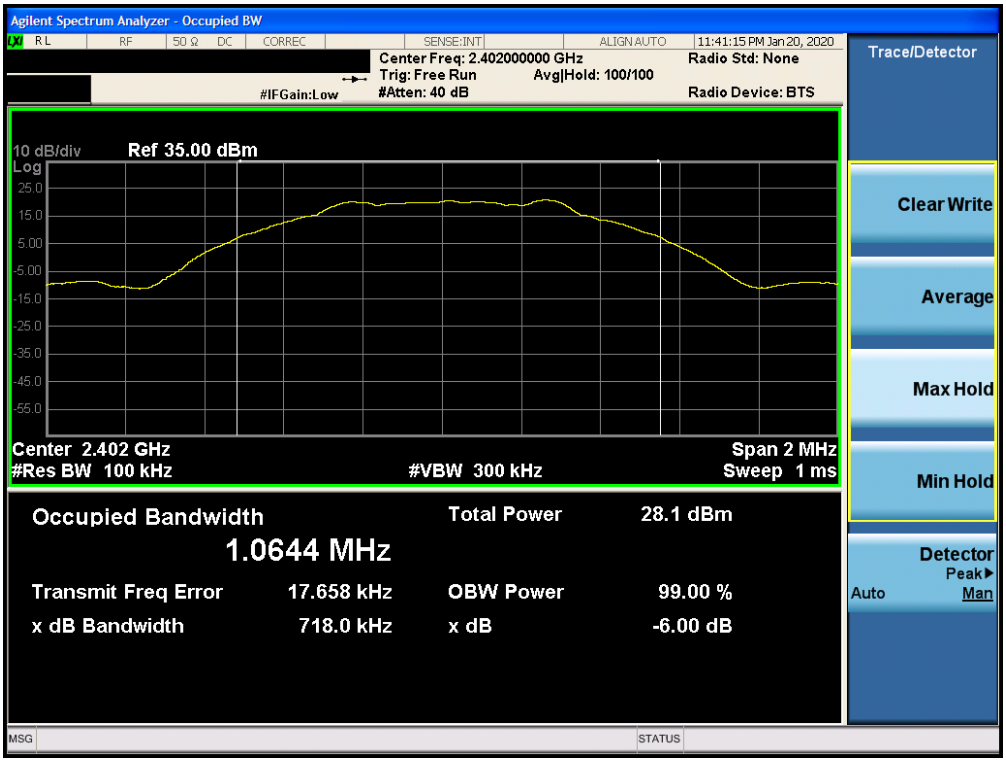


Plot 7-6. 6dB Bandwidth Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 38)

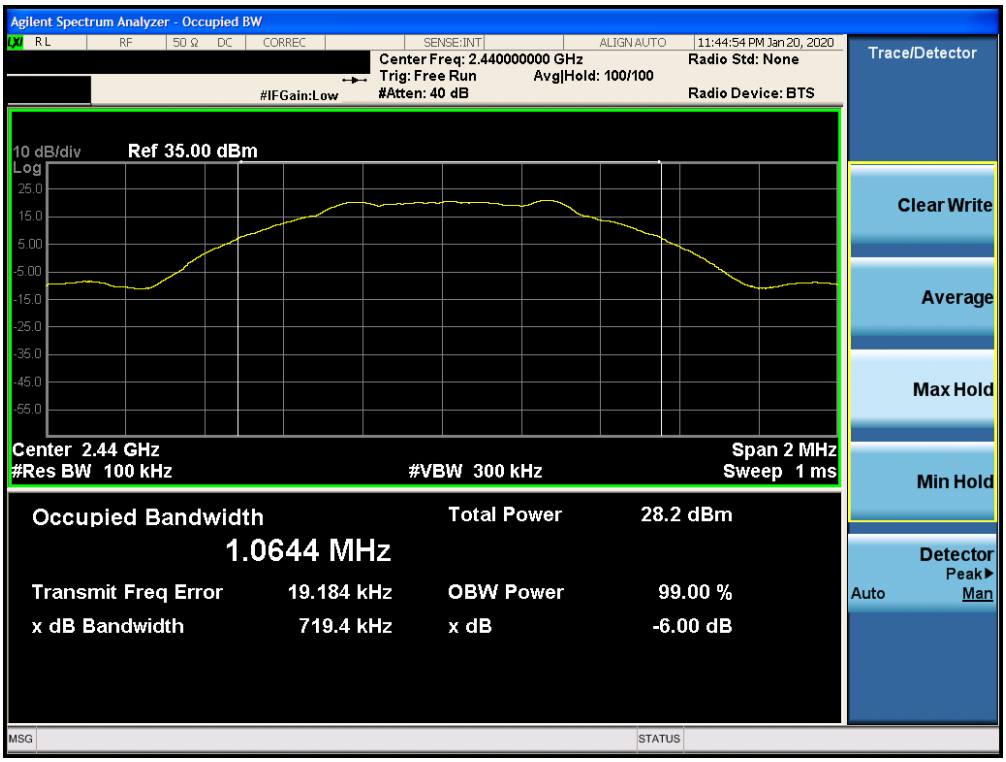
Antenna WF7

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Measured Bandwidth [kHz]	Minimum Bandwidth [kHz]	Pass / Fail
2402	1.0	ePA	0	718.0	500	Pass
2440	1.0	ePA	19	719.4	500	Pass
2480	1.0	ePA	39	719.2	500	Pass
2404	2.0	ePA	1	1329.0	500	Pass
2440	2.0	ePA	19	1329.0	500	Pass
2478	2.0	ePA	38	1328.0	500	Pass

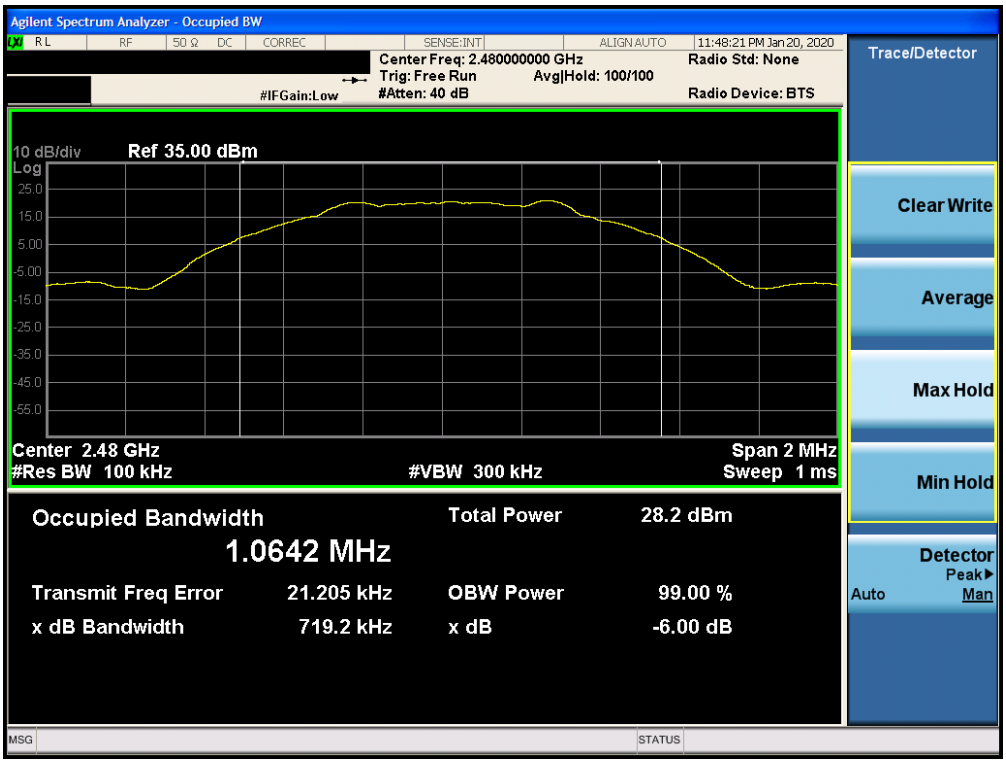
Table 7-3. Conducted Bandwidth Measurements Ant WF7



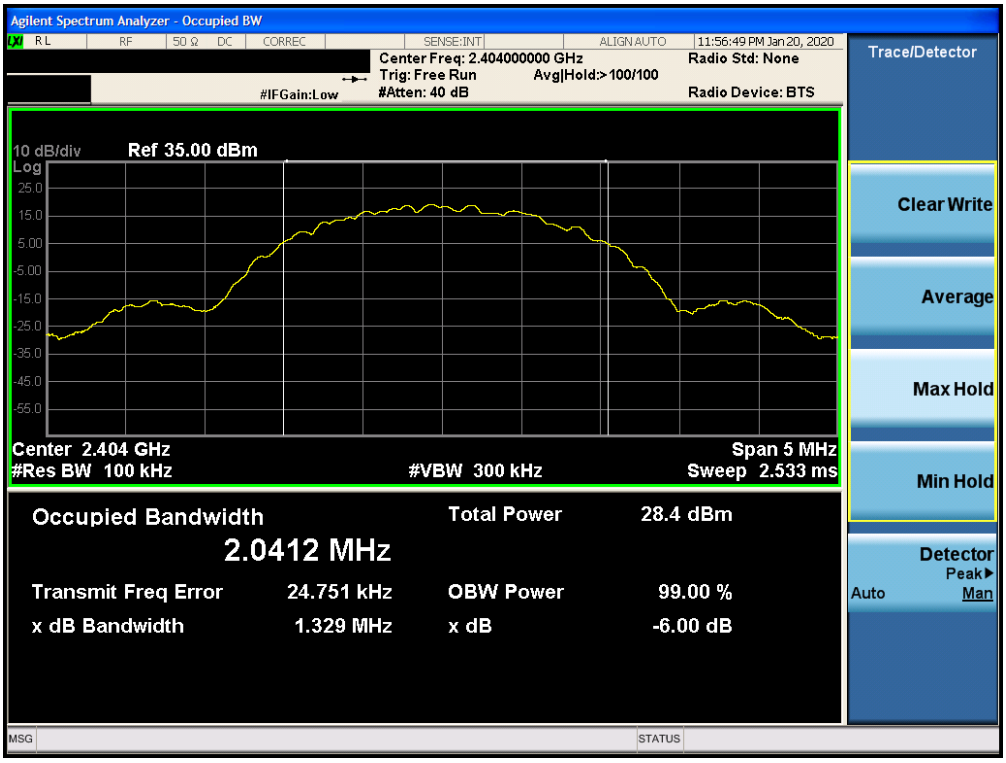
Plot 7-7. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



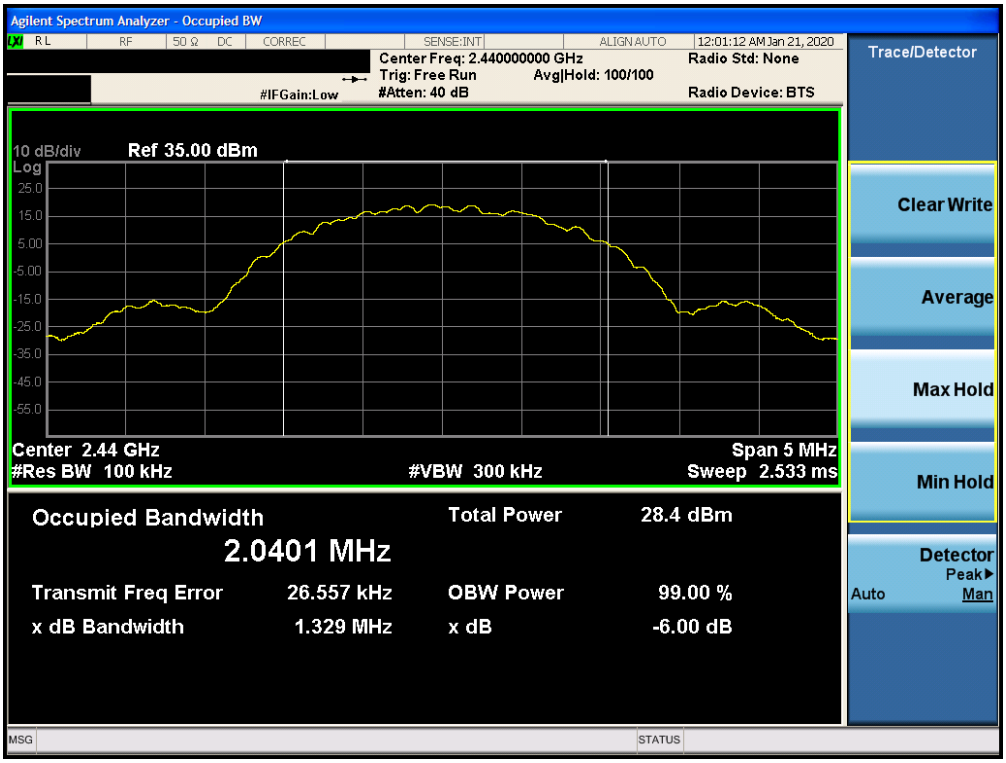
Plot 7-8. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



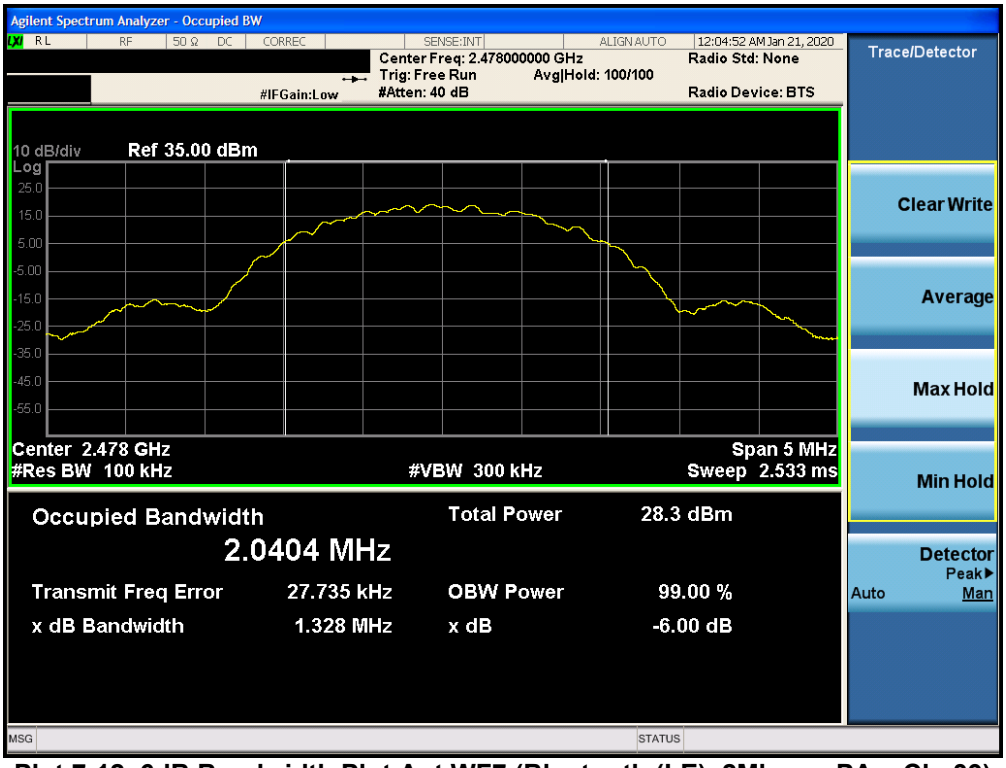
Plot 7-9. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



Plot 7-10. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 0)



Plot 7-11. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)



Plot 7-12. 6dB Bandwidth Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 39)

7.3 Output Power Measurement – Bluetooth (LE)

§15.247(b.3); RSS-247 [5.4(d)]

Test Overview and Limits

The transmitter antenna terminal of the EUT is connected to the input of a spectrum analyzer. Measurements are made while the EUT is operating at maximum power and at the appropriate frequencies.

The maximum permissible conducted output power is 1 Watt.

Test Procedure Used

ANSI C63.10-2013 – Section 11.9.1.3
ANSI C63.10-2013 – Section 11.9.2.3.2
KDB 558074 D01 v05r02 – Section 8.3.1.3
ANSI C63.10-2013 – Section 14.2 Measure-and-Sum Technique
KDB 662911 D01 v02r01 – Section E)1) Measure-and-Sum Technique

Test Settings

Method PKPM1 (Peak Power Measurement)

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

Method AVGPM-G (Average Power Measurement)

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

Test Setup

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

Figure 7-2. Test Instrument & Measurement Setup for Peak and Average Power Measurement

Test Notes

None

7.3.1 Peak Output Power Measurement - Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Peak Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				[dBm]	[mW]				
2402	1.0	ePA	0	17.88	61.376	0.30	18.18	36.02	-17.84
2440	1.0	ePA	19	17.72	59.156	0.30	18.02	36.02	-18.00
2480	1.0	ePA	39	17.48	55.976	0.30	17.78	36.02	-18.24
2402	1.0	iPA	0	13.81	24.044	0.30	14.11	36.02	-21.91
2440	1.0	iPA	19	13.84	24.210	0.30	14.14	36.02	-21.88
2480	1.0	iPA	39	13.64	23.121	0.30	13.94	36.02	-22.08
2404	2.0	ePA	1	17.96	62.517	0.30	18.26	36.02	-17.76
2440	2.0	ePA	19	18.00	63.096	0.30	18.30	36.02	-17.72
2478	2.0	ePA	38	18.15	65.313	0.30	18.45	36.02	-17.57
2404	2.0	iPA	1	13.83	24.155	0.30	14.13	36.02	-21.89
2440	2.0	iPA	19	13.86	24.322	0.30	14.16	36.02	-21.86
2478	2.0	iPA	38	13.67	23.281	0.30	13.97	36.02	-22.05

Table 7-4. Ant WF8 Peak Conducted Output Power Measurements (Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Peak Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				[dBm]	[mW]				
2402	1.0	ePA	0	18.20	66.069	-3.20	15.00	36.02	-21.02
2440	1.0	ePA	19	18.27	67.143	-3.20	15.07	36.02	-20.95
2480	1.0	ePA	39	17.94	62.230	-3.20	14.74	36.02	-21.28
2402	1.0	iPA	0	13.84	24.210	-3.20	10.64	36.02	-25.38
2440	1.0	iPA	19	13.88	24.434	-3.20	10.68	36.02	-25.34
2480	1.0	iPA	39	13.75	23.714	-3.20	10.55	36.02	-25.47
2404	2.0	ePA	1	18.29	67.453	-3.20	15.09	36.02	-20.93
2440	2.0	ePA	19	18.37	68.707	-3.20	15.17	36.02	-20.85
2478	2.0	ePA	38	18.72	74.473	-3.20	15.52	36.02	-20.50
2404	2.0	iPA	1	13.89	24.491	-3.20	10.69	36.02	-25.33
2440	2.0	iPA	19	13.90	24.547	-3.20	10.70	36.02	-25.32
2478	2.0	iPA	38	13.77	23.823	-3.20	10.57	36.02	-25.45

Table 7-5. Ant WF7 Peak Conducted Output Power Measurements (Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Peak Conducted Power						Directional Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				Ant WF8		Ant WF8		Summed					
				[dBm]	[mW]	[dBm]	[mW]	[dBm]	[mW]				
2402	1.0	ePA	0	16.77	47.534	16.54	45.082	19.67	92.683	1.74	18.51	36.02	-17.52
2440	1.0	ePA	19	16.68	46.559	16.65	46.238	19.68	92.897	1.74	18.42	36.02	-17.61
2480	1.0	ePA	39	16.30	42.658	16.83	48.195	19.58	90.782	1.74	18.04	36.02	-17.99
2402	1.0	iPA	0	14.29	26.853	13.66	23.227	17.00	50.119	1.74	16.03	36.02	-20.00
2440	1.0	iPA	19	14.98	31.477	13.83	24.155	17.45	55.590	1.74	16.72	36.02	-19.31
2480	1.0	iPA	39	14.83	30.409	13.90	24.547	17.40	54.954	1.74	16.57	36.02	-19.46
2404	2.0	ePA	1	16.97	49.774	16.81	47.973	19.90	97.724	1.74	18.71	36.02	-17.32
2440	2.0	ePA	19	16.56	45.290	16.74	47.206	19.66	92.470	1.74	18.30	36.02	-17.73
2478	2.0	ePA	38	16.28	42.462	16.83	48.195	19.57	90.573	1.74	18.02	36.02	-18.01
2404	2.0	iPA	1	14.61	28.907	14.00	25.119	17.33	54.075	1.74	16.35	36.02	-19.68
2440	2.0	iPA	19	14.96	31.333	13.80	23.988	17.43	55.335	1.74	16.70	36.02	-19.33
2478	2.0	iPA	38	14.65	29.174	13.86	24.322	17.28	53.456	1.74	16.39	36.02	-19.64

Table 7-6. TXBF Peak Conducted Output Power Measurements (Bluetooth (LE)

7.3.2 Average Output Power Measurement - Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Average Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				[dBm]	[mW]				
2402	1.0	ePA	0	17.50	56.234	0.30	17.80	36.02	-18.22
2440	1.0	ePA	19	17.47	55.847	0.30	17.77	36.02	-18.25
2480	1.0	ePA	39	17.28	53.456	0.30	17.58	36.02	-18.44
2402	1.0	iPA	0	13.70	23.442	0.30	14.00	36.02	-22.02
2440	1.0	iPA	19	13.75	23.714	0.30	14.05	36.02	-21.97
2480	1.0	iPA	39	13.54	22.594	0.30	13.84	36.02	-22.18
2404	2.0	ePA	1	17.42	55.208	0.30	17.72	36.02	-18.30
2440	2.0	ePA	19	17.48	55.976	0.30	17.78	36.02	-18.24
2478	2.0	ePA	38	17.50	56.234	0.30	17.80	36.02	-18.22
2404	2.0	iPA	1	13.67	23.281	0.30	13.97	36.02	-22.05
2440	2.0	iPA	19	13.71	23.496	0.30	14.01	36.02	-22.01
2478	2.0	iPA	38	13.52	22.491	0.30	13.82	36.02	-22.20

Table 7-7. Ant WF8 Average Conducted Output Power Measurements (Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Average Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				[dBm]	[mW]				
2402	1.0	ePA	0	17.97	62.661	-3.20	14.77	36.02	-21.25
2440	1.0	ePA	19	18.00	63.096	-3.20	14.80	36.02	-21.22
2480	1.0	ePA	39	17.73	59.293	-3.20	14.53	36.02	-21.49
2402	1.0	iPA	0	13.72	23.550	-3.20	10.52	36.02	-25.50
2440	1.0	iPA	19	13.78	23.878	-3.20	10.58	36.02	-25.44
2480	1.0	iPA	39	13.67	23.281	-3.20	10.47	36.02	-25.55
2404	2.0	ePA	1	17.73	59.293	-3.20	14.53	36.02	-21.49
2440	2.0	ePA	19	17.81	60.395	-3.20	14.61	36.02	-21.41
2478	2.0	ePA	38	18.00	63.096	-3.20	14.80	36.02	-21.22
2404	2.0	iPA	1	13.71	23.496	-3.20	10.51	36.02	-25.51
2440	2.0	iPA	19	13.75	23.714	-3.20	10.55	36.02	-25.47
2478	2.0	iPA	38	13.62	23.014	-3.20	10.42	36.02	-25.60

Table 7-8. Ant WF7 Average Conducted Output Power Measurements (Bluetooth (LE)

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Average Conducted Power						Directional Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
				[dBm]	[mW]	[dBm]	[mW]	[dBm]	[mW]				
2402	1.0	ePA	0	16.50	44.668	16.30	42.658	19.41	87.297	1.74	18.24	36.02	-17.79
2440	1.0	ePA	19	16.49	44.566	16.47	44.361	19.49	88.920	1.74	18.23	36.02	-17.80
2480	1.0	ePA	39	16.24	42.073	16.50	44.668	19.38	86.696	1.74	17.98	36.02	-18.05
2402	1.0	iPA	0	13.98	25.003	13.64	23.121	16.82	48.084	1.74	15.72	36.02	-20.31
2440	1.0	iPA	19	14.00	25.119	13.82	24.099	16.92	49.204	1.74	15.74	36.02	-20.29
2480	1.0	iPA	39	13.99	25.061	13.88	24.434	16.95	49.545	1.74	15.73	36.02	-20.30
2404	2.0	ePA	1	16.35	43.152	16.22	41.879	19.30	85.114	1.74	18.09	36.02	-17.94
2440	2.0	ePA	19	16.49	44.566	16.50	44.668	19.51	89.331	1.74	18.23	36.02	-17.80
2478	2.0	ePA	38	16.23	41.976	16.49	44.566	19.37	86.497	1.74	17.97	36.02	-18.06
2404	2.0	iPA	1	14.00	25.119	13.94	24.774	16.98	49.888	1.74	15.74	36.02	-20.29
2440	2.0	iPA	19	13.99	25.061	13.77	23.823	16.89	48.865	1.74	15.73	36.02	-20.30
2478	2.0	iPA	38	13.97	24.946	13.81	24.044	16.90	48.978	1.74	15.71	36.02	-20.32

Table 7-9. TXBF Average Conducted Output Power Measurements (Bluetooth (LE)

7.4 Power Spectral Density – Bluetooth (LE)

§15.247(e); RSS-247 [5.2]

Test Overview and Limit

The peak power density is measured with a spectrum analyzer connected to the antenna terminal of the EUT while the EUT is operating at maximum power and at the appropriate frequencies.

The maximum permissible power spectral density is 8 dBm in any 3 kHz band.

Test Procedure Used

ANSI C63.10-2013 – Section 11.10.2 Method PKPSD
KDB 558074 D01 v05r02 – Section 8.4 DTS Maximum Power Spectral Density level in the fundamental emission
ANSI C63.10-2013 – Section 14.3.2.2 Measure-and-Sum Technique
KDB 662911 D01 v02r01 – Section E)2) Measure-and-Sum Technique

Test Settings

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

Test Setup

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

Figure 7-3. Test Instrument & Measurement Setup

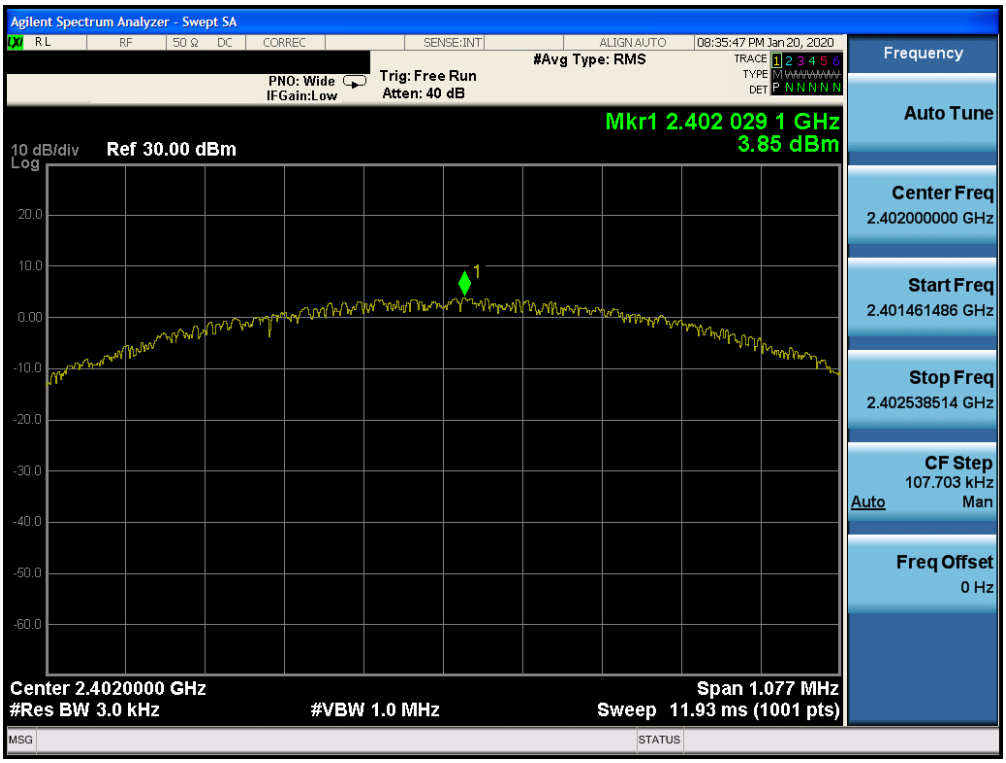
Test Notes

None

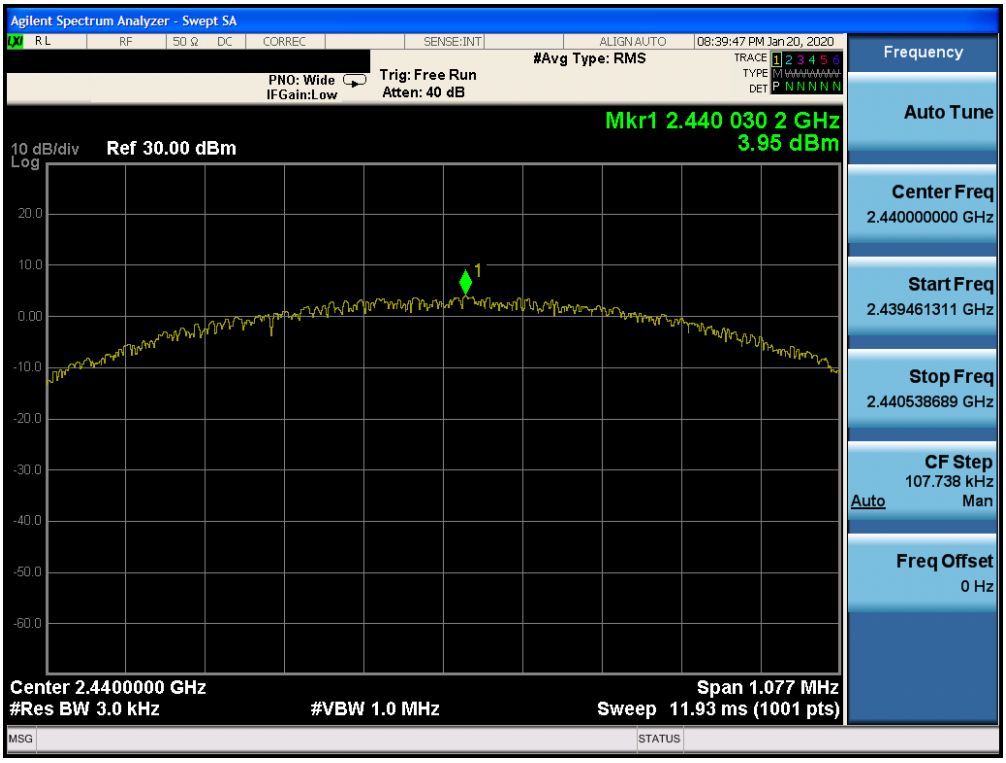
Antenna WF8

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Measured Power Spectral Density [dBm/3kHz]	Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]
2402	1.0	ePA	0	3.85	8.0	-4.15
2440	1.0	ePA	19	3.95	8.0	-4.05
2480	1.0	ePA	39	3.96	8.0	-4.04
2402	1.0	iPA	0	-6.09	8.0	-14.09
2440	1.0	iPA	19	-5.89	8.0	-13.89
2480	1.0	iPA	39	-5.90	8.0	-13.90
2404	2.0	ePA	1	-1.60	8.0	-9.60
2440	2.0	ePA	19	-1.55	8.0	-9.55
2478	2.0	ePA	38	-1.52	8.0	-9.52
2404	2.0	iPA	1	-11.10	8.0	-19.10
2440	2.0	iPA	19	-11.14	8.0	-19.14
2478	2.0	iPA	38	-11.05	8.0	-19.05

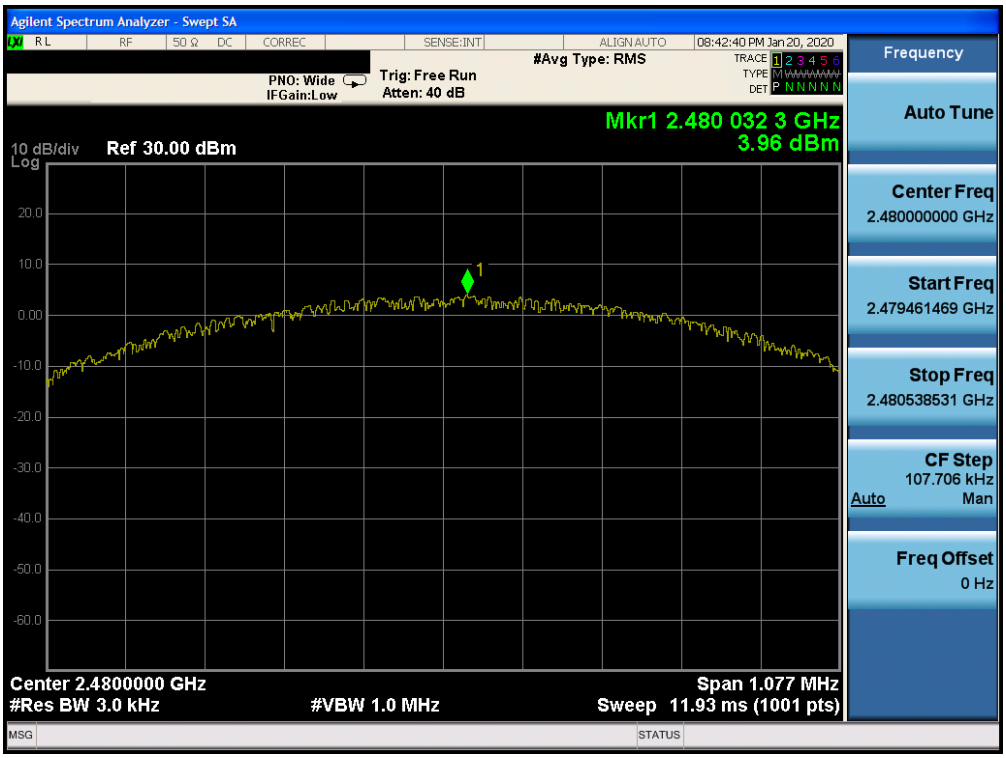
Table 7-10. Conducted Power Density Measurements Ant WF8



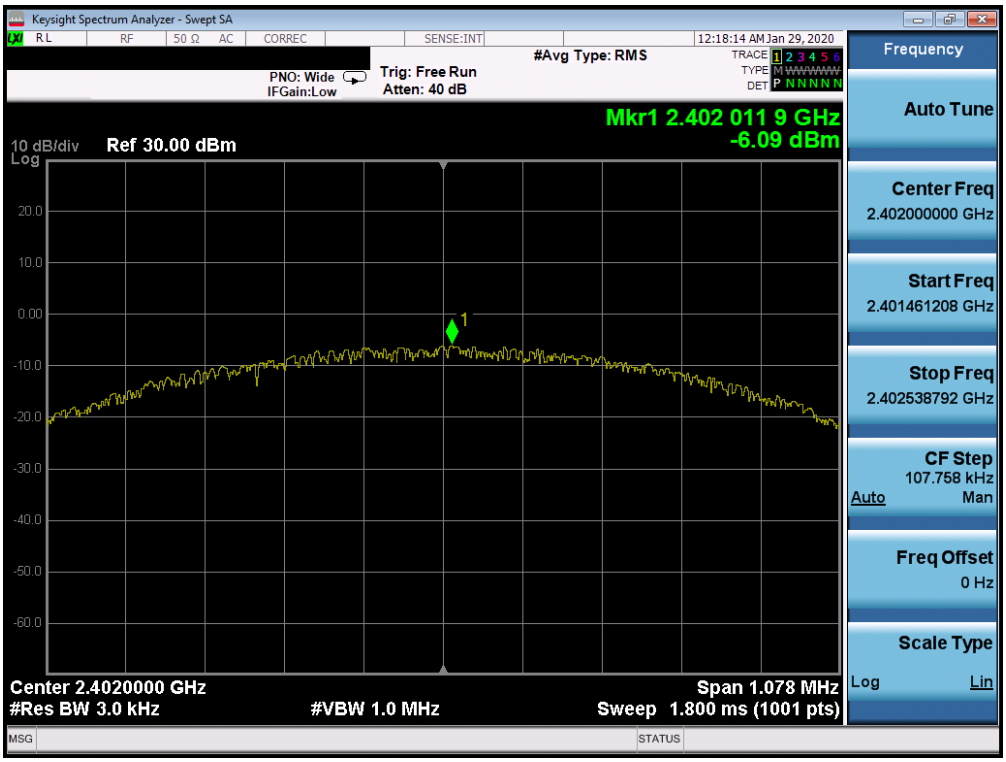
Plot 7-13. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



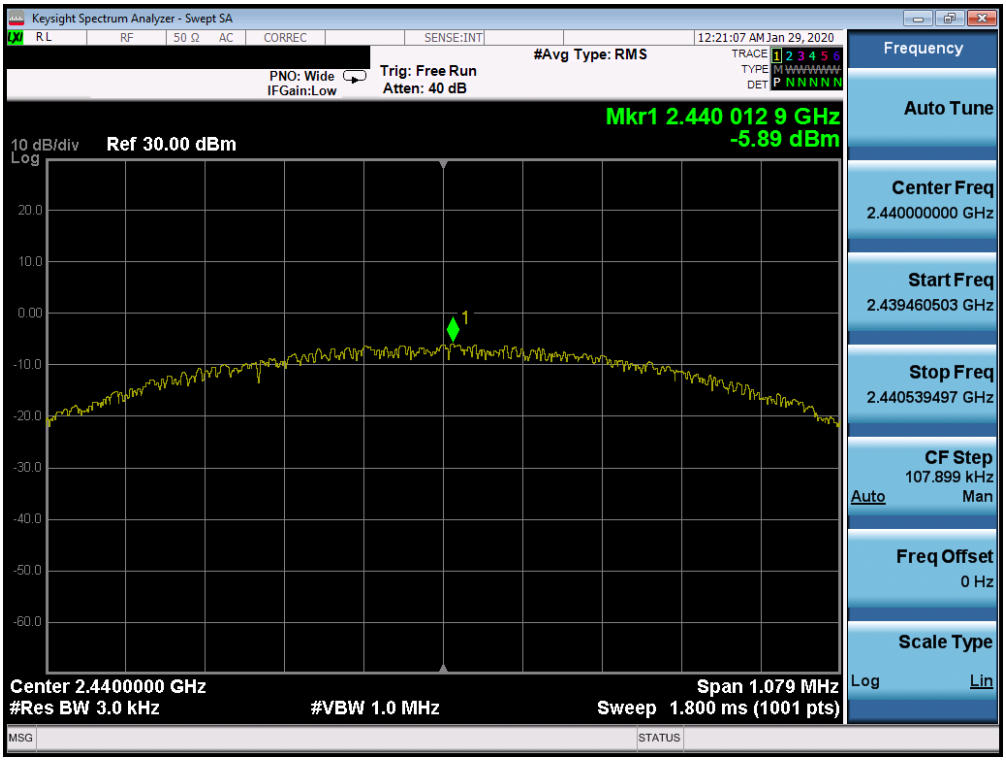
Plot 7-14. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



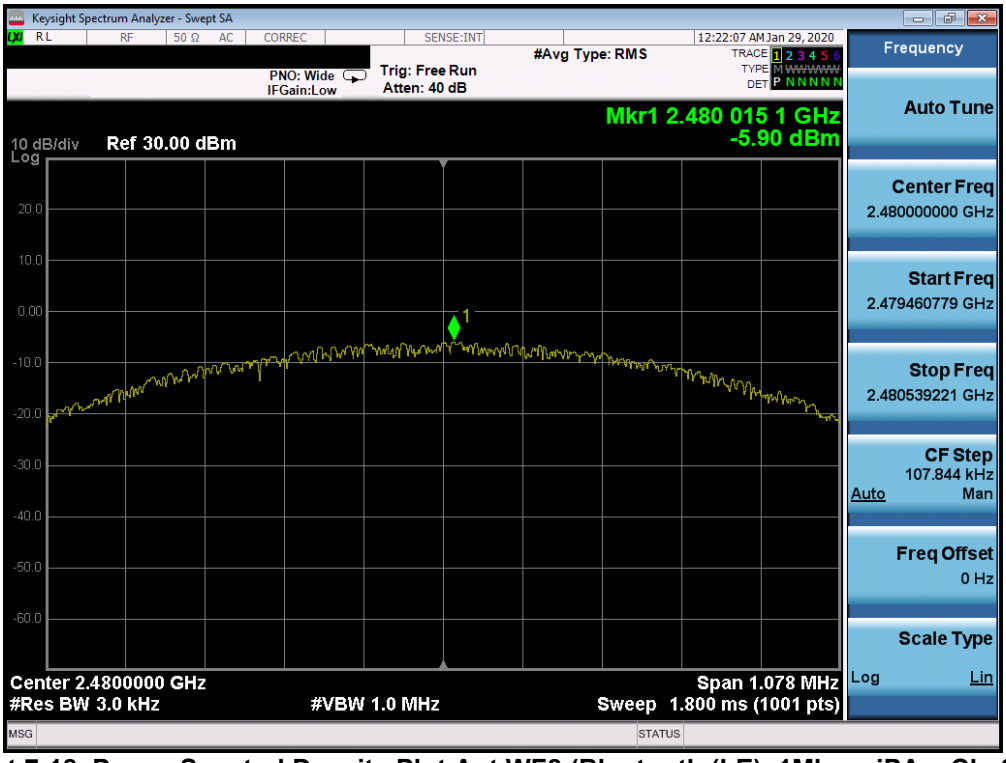
Plot 7-15. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



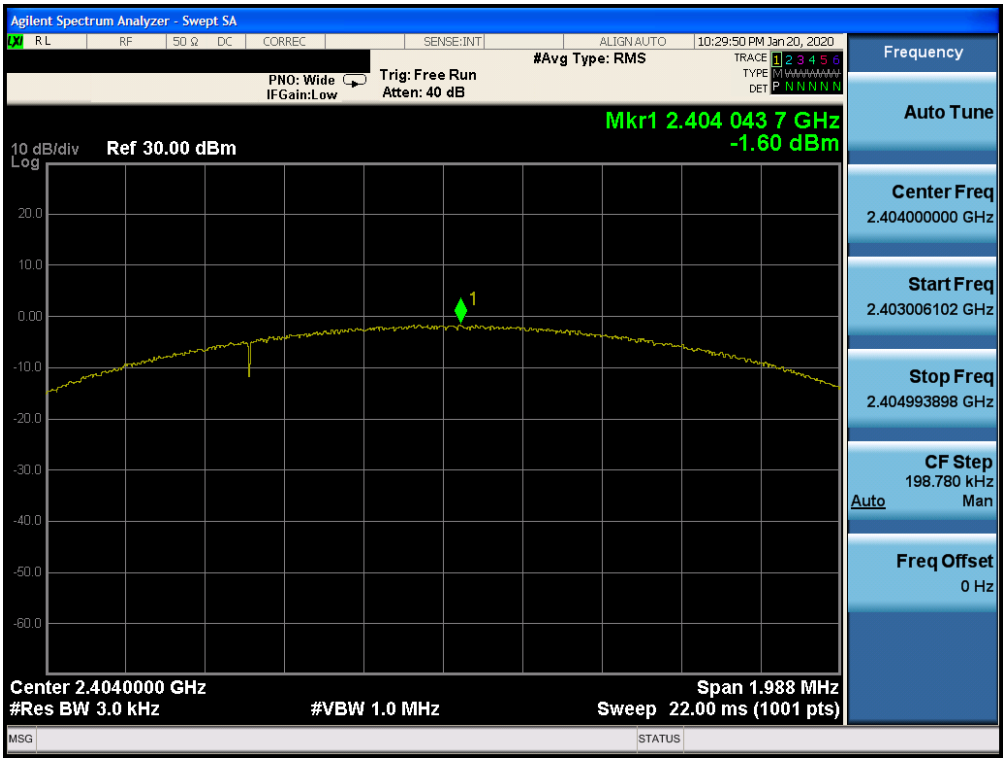
Plot 7-16. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 0)



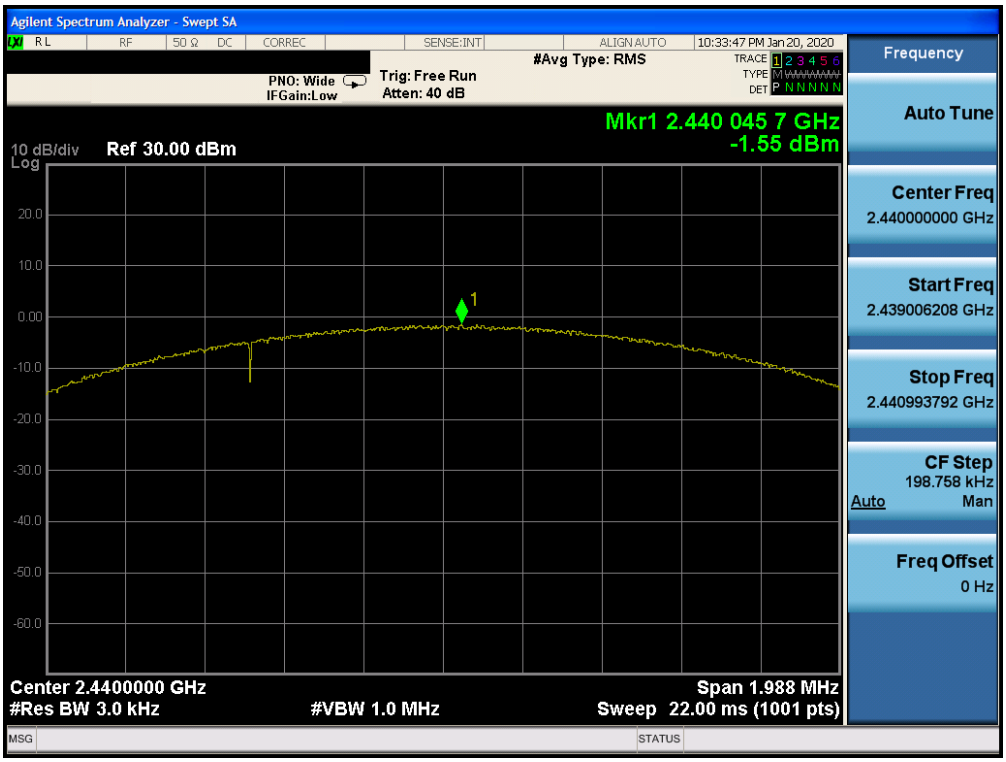
Plot 7-17. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 19)



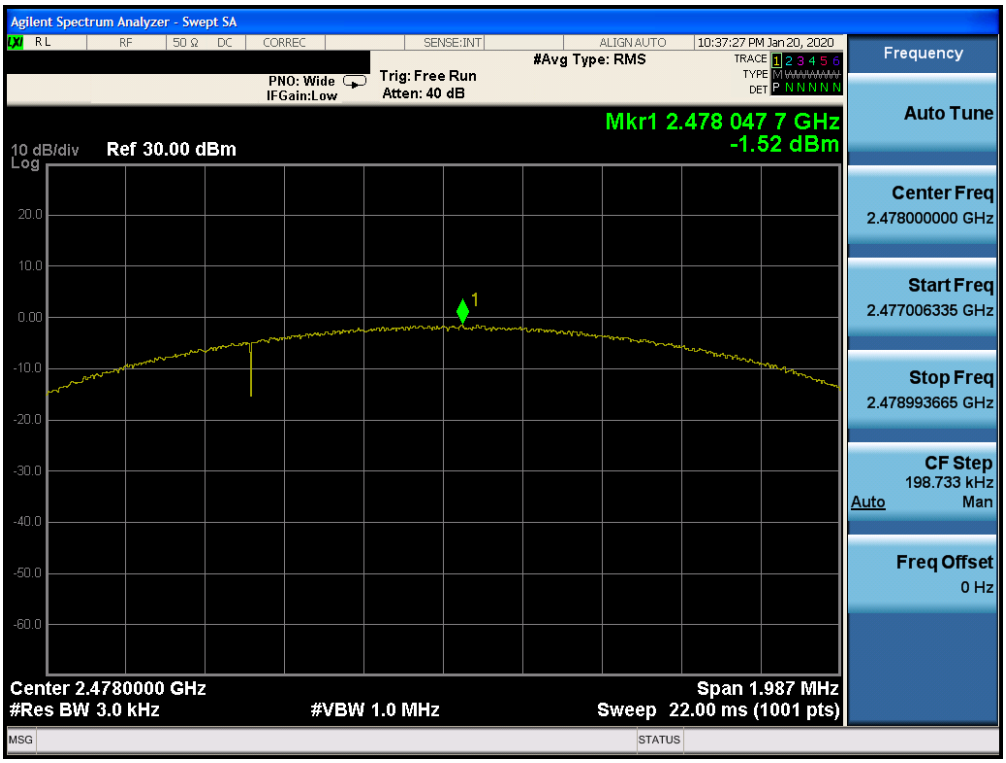
Plot 7-18. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 39)



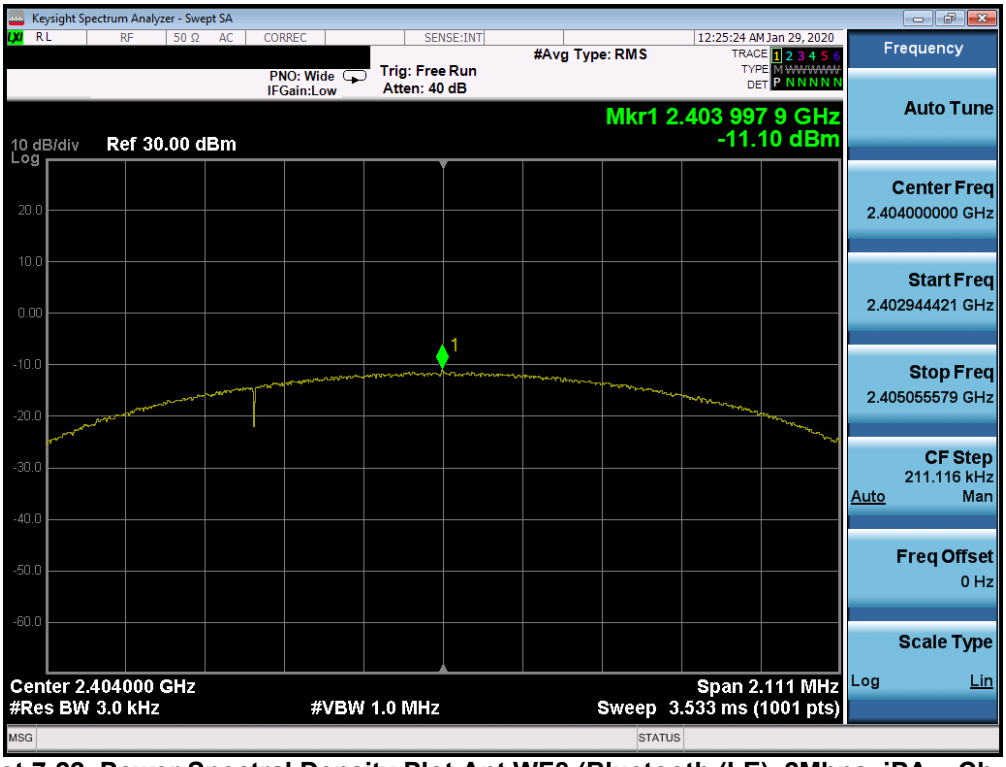
Plot 7-19. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 1)



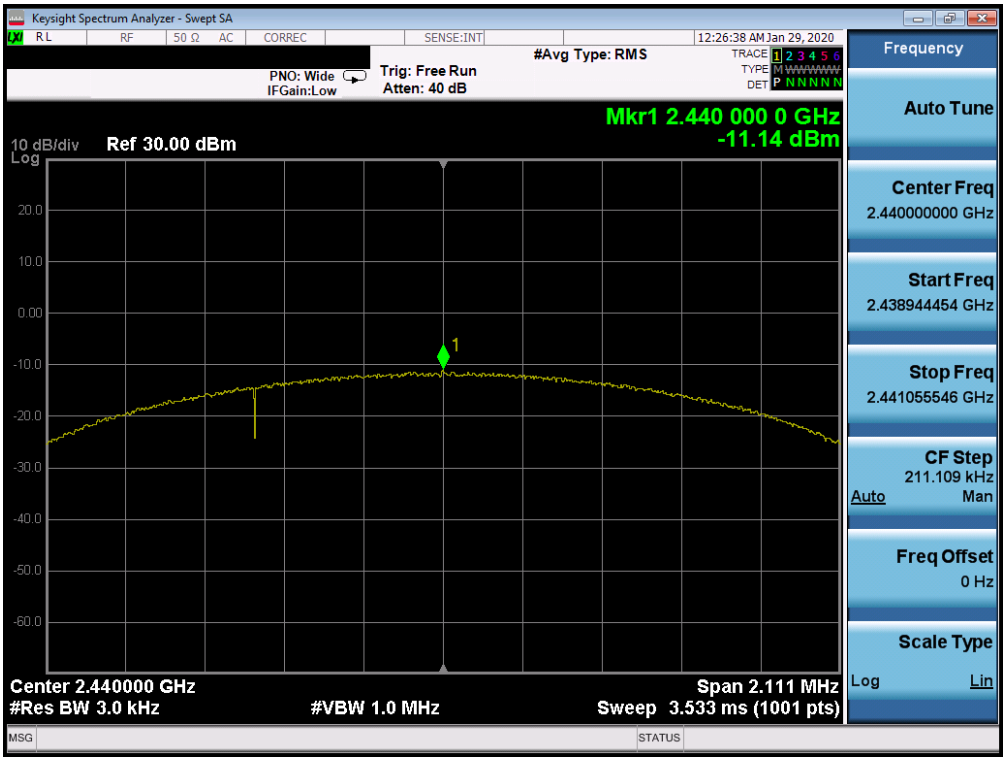
Plot 7-20. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)



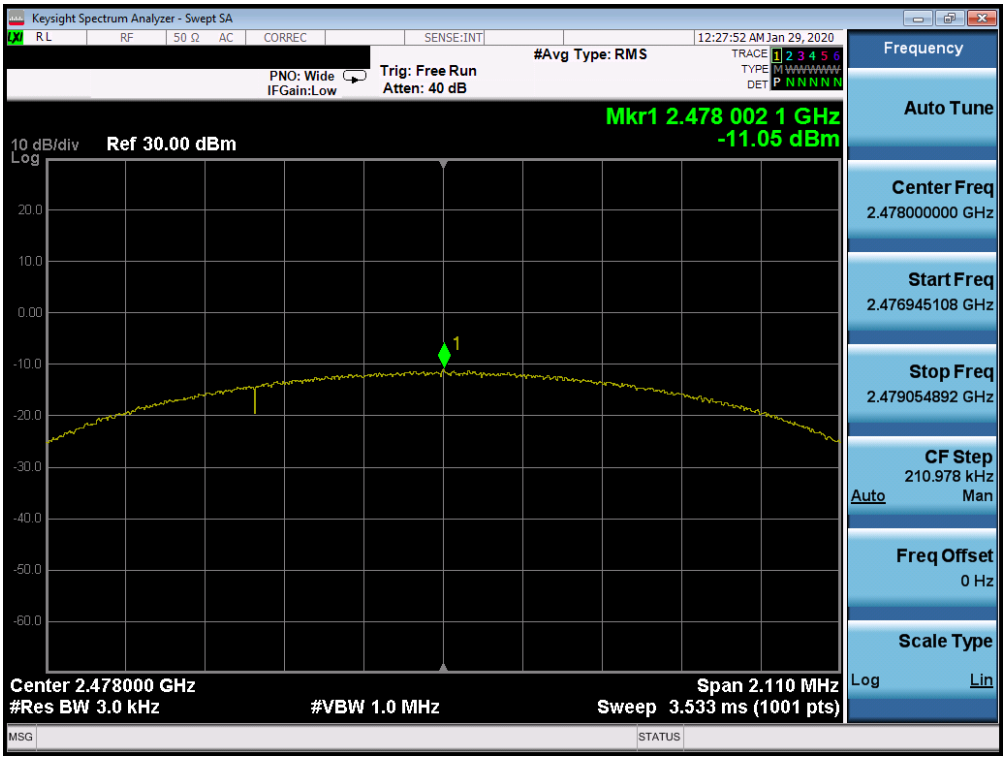
Plot 7-21. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 38)



Plot 7-22. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 1)



Plot 7-23. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 19)

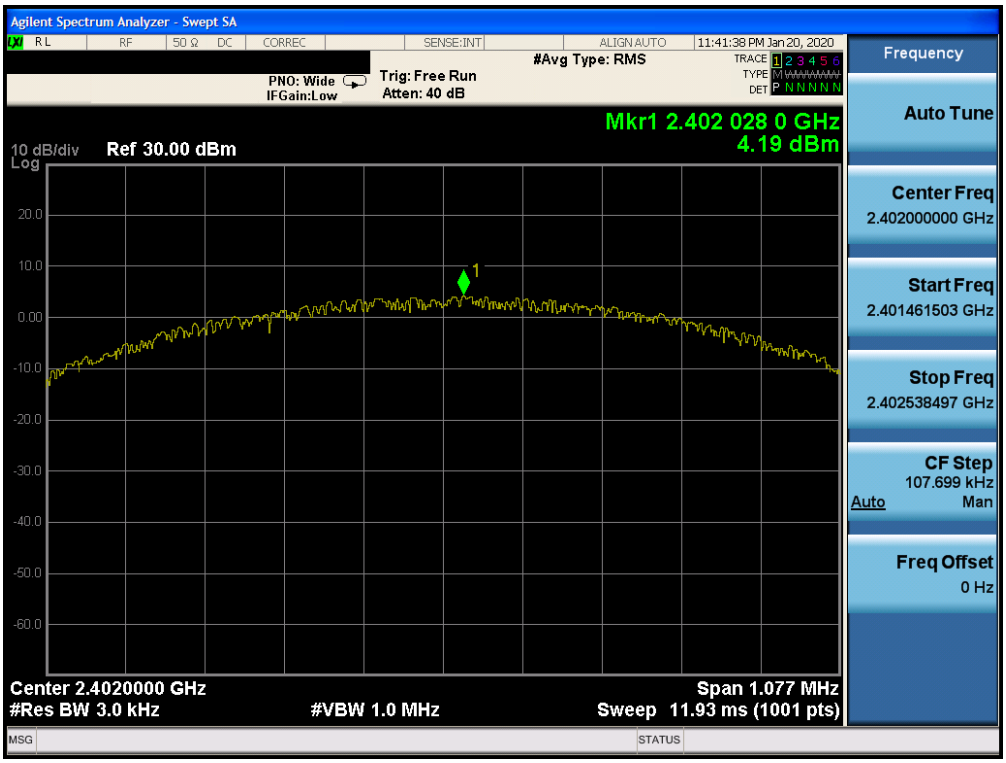


Plot 7-24. Power Spectral Density Plot Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 38)

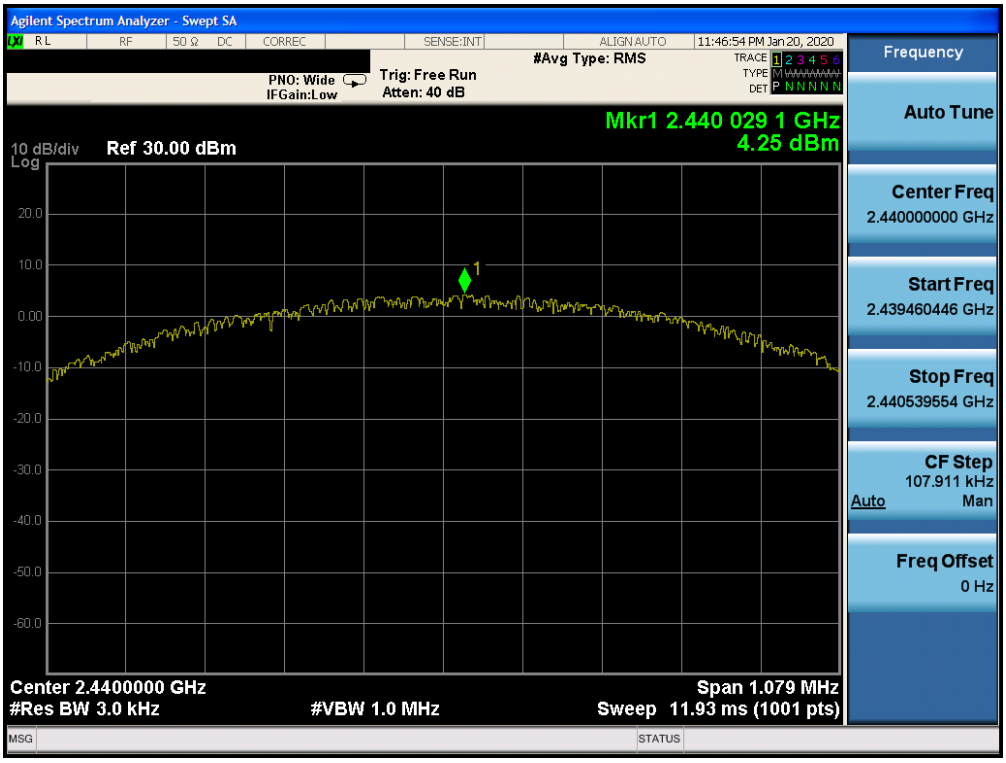
Antenna WF7

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Measured Power Spectral Density [dBm/3kHz]	Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]
2402	1.0	ePA	0	4.19	8.0	-3.81
2440	1.0	ePA	19	4.25	8.0	-3.75
2480	1.0	ePA	39	4.27	8.0	-3.73
2402	1.0	iPA	0	-5.85	8.0	-13.85
2440	1.0	iPA	19	-5.72	8.0	-13.72
2480	1.0	iPA	39	-6.06	8.0	-14.06
2404	2.0	ePA	1	-1.23	8.0	-9.23
2440	2.0	ePA	19	-1.17	8.0	-9.17
2478	2.0	ePA	38	-1.21	8.0	-9.21
2404	2.0	iPA	1	-11.18	8.0	-19.18
2440	2.0	iPA	19	-11.33	8.0	-19.33
2478	2.0	iPA	38	-11.36	8.0	-19.36

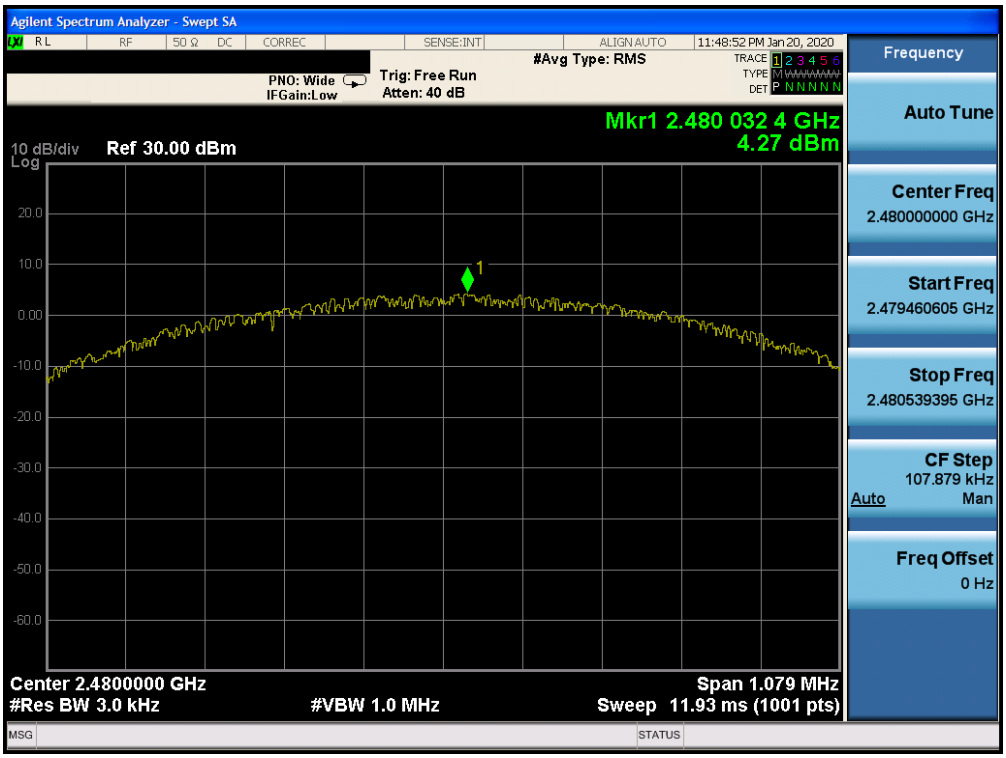
Table 7-11. Conducted Power Density Measurements Ant WF7



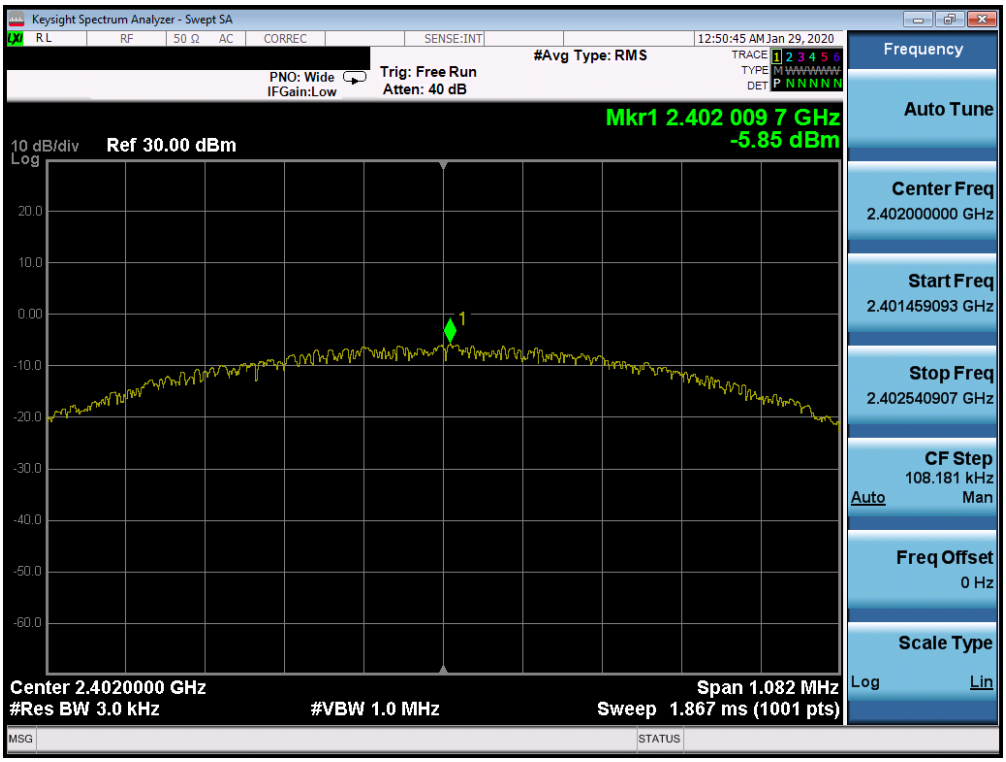
Plot 7-25. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



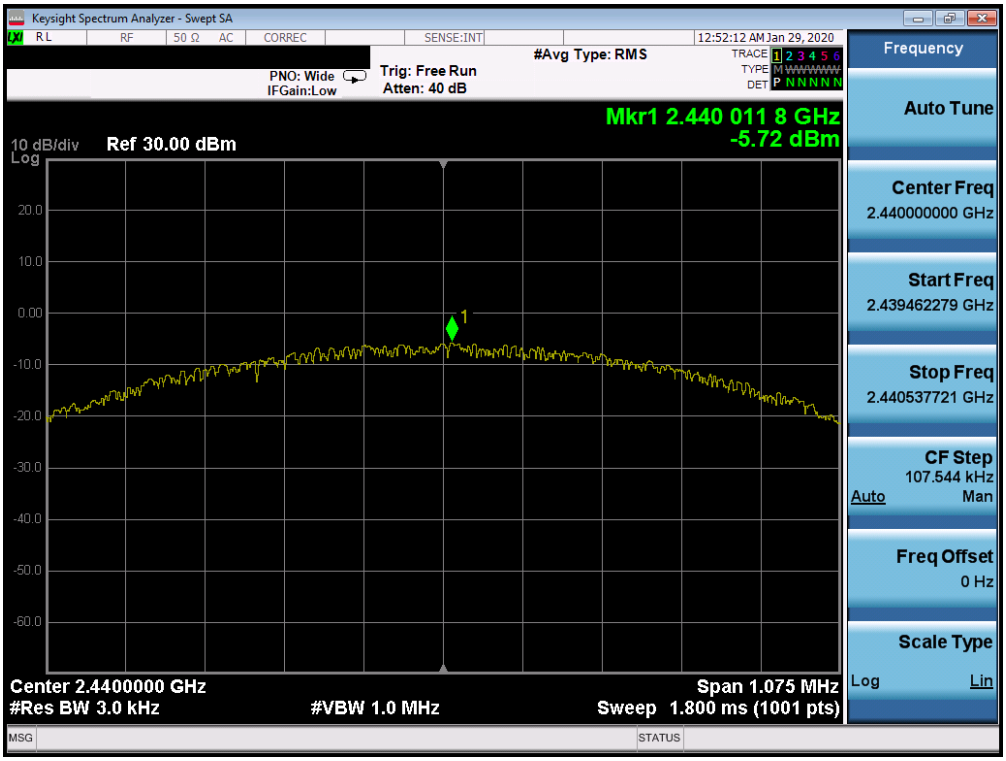
Plot 7-26. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



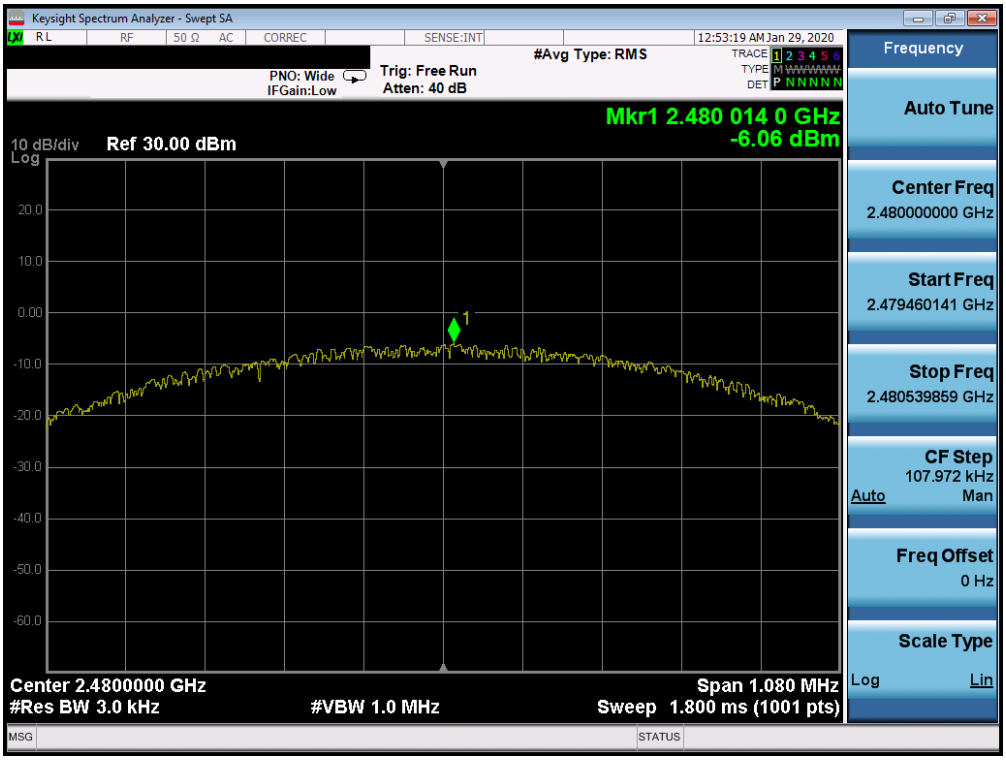
Plot 7-27. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



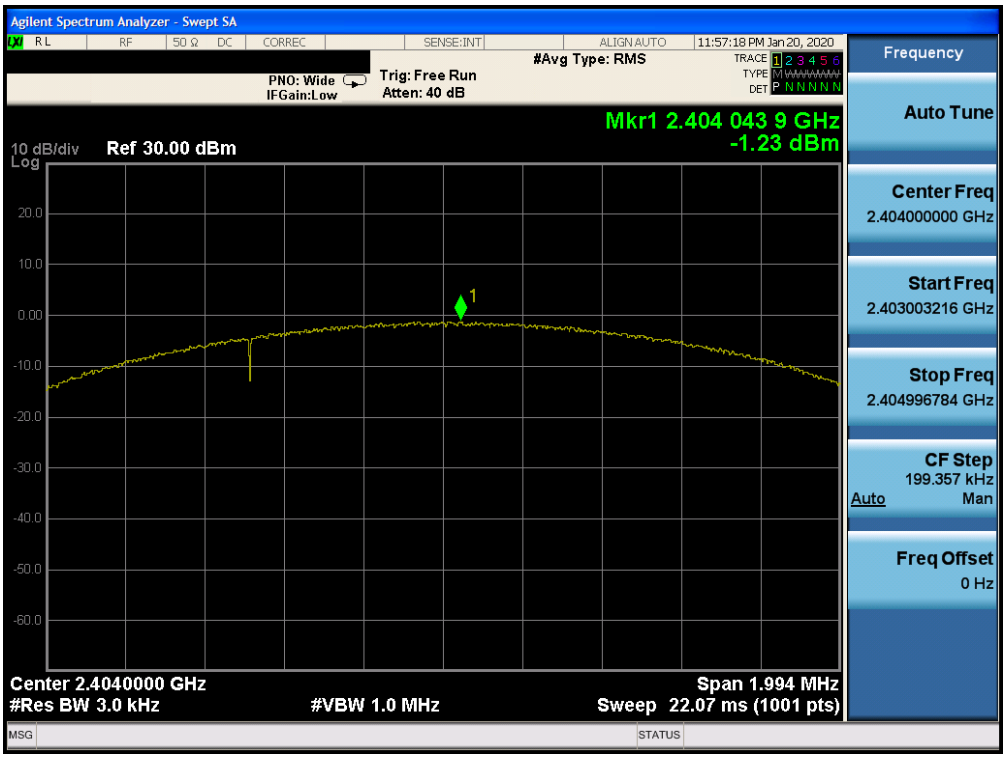
Plot 7-28. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 0)



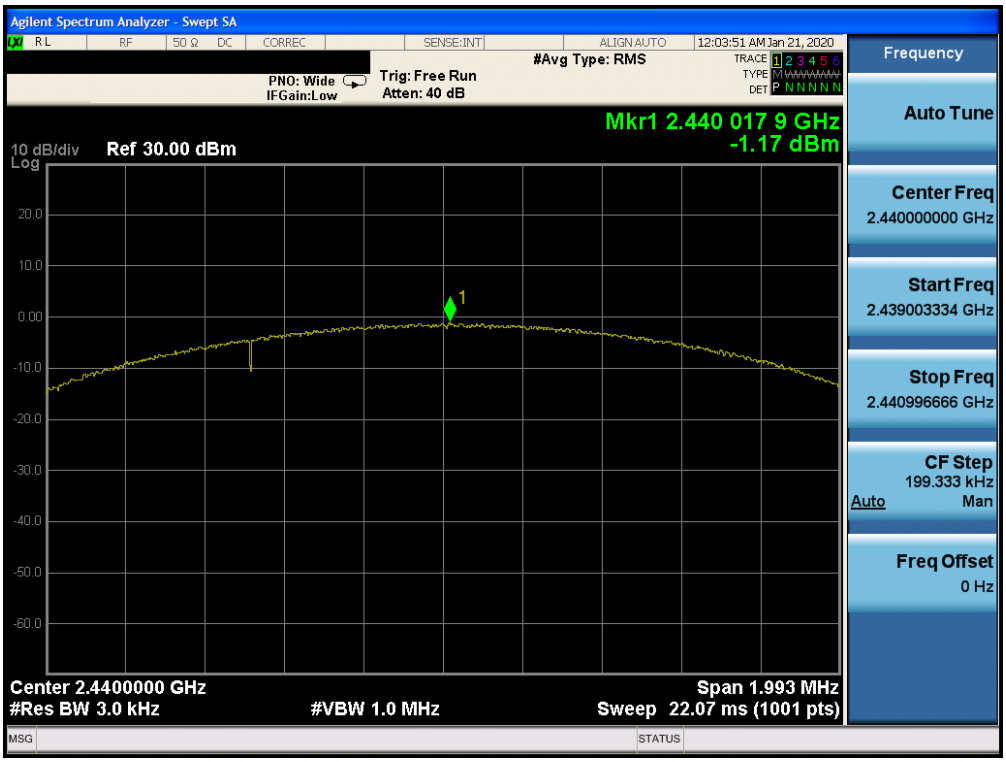
Plot 7-29. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 19)



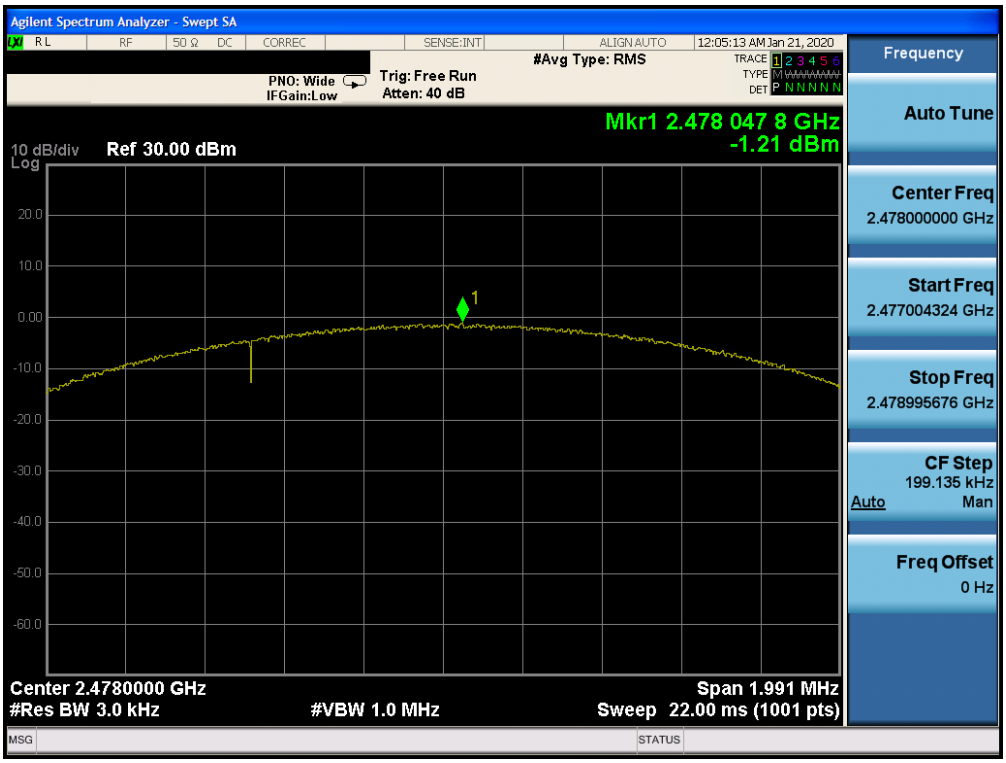
Plot 7-30. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 39)



Plot 7-31. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 1)

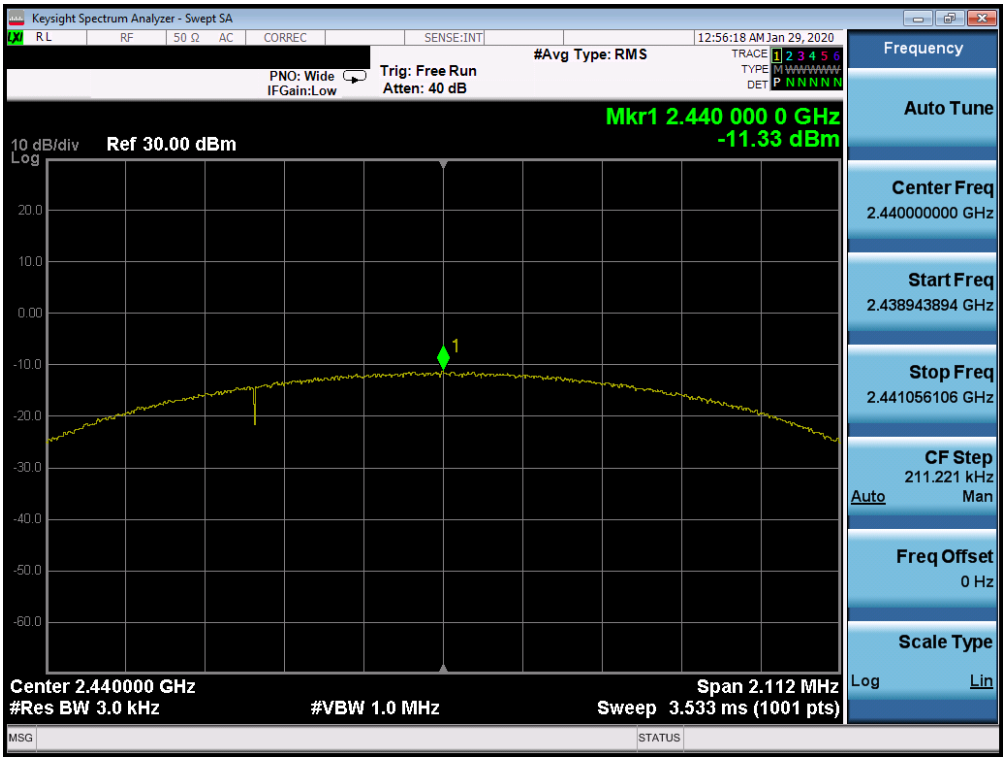


Plot 7-32. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)

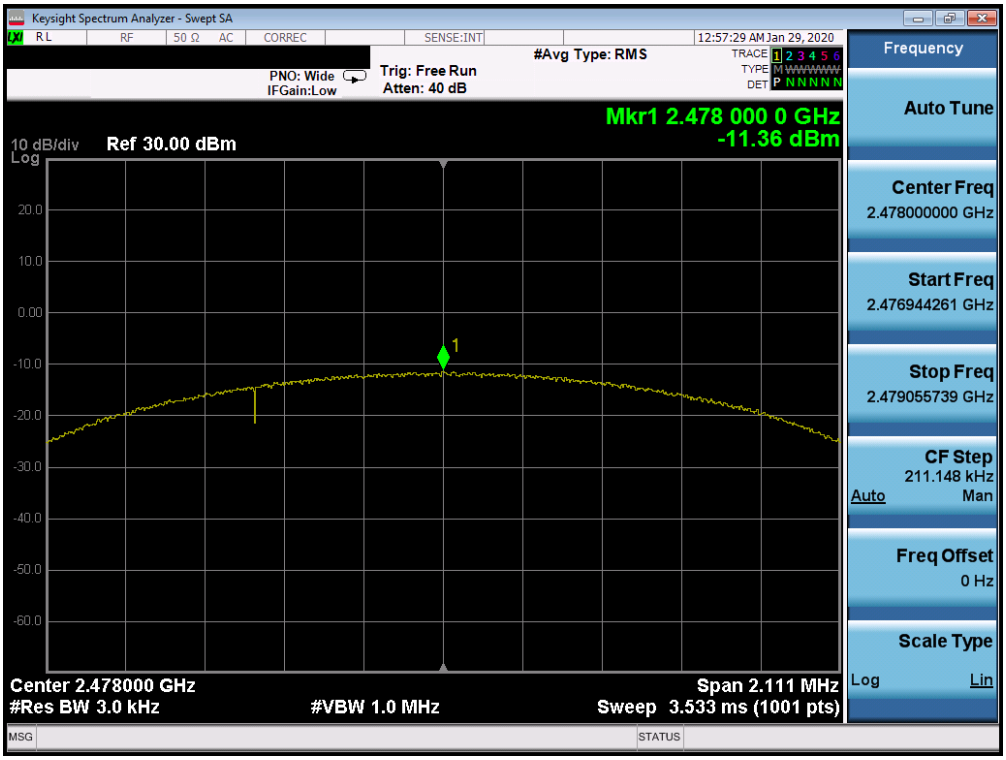


Plot 7-33. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 38)

Plot 7-34. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 1)



Plot 7-35. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 19)

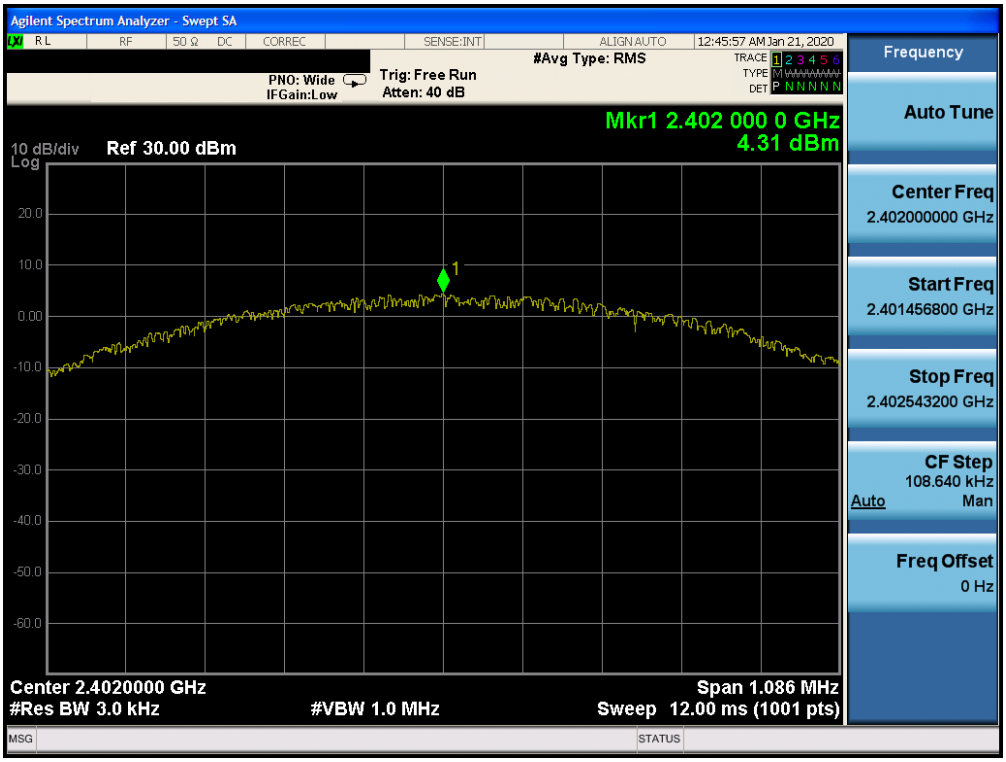


Plot 7-36. Power Spectral Density Plot Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 38)

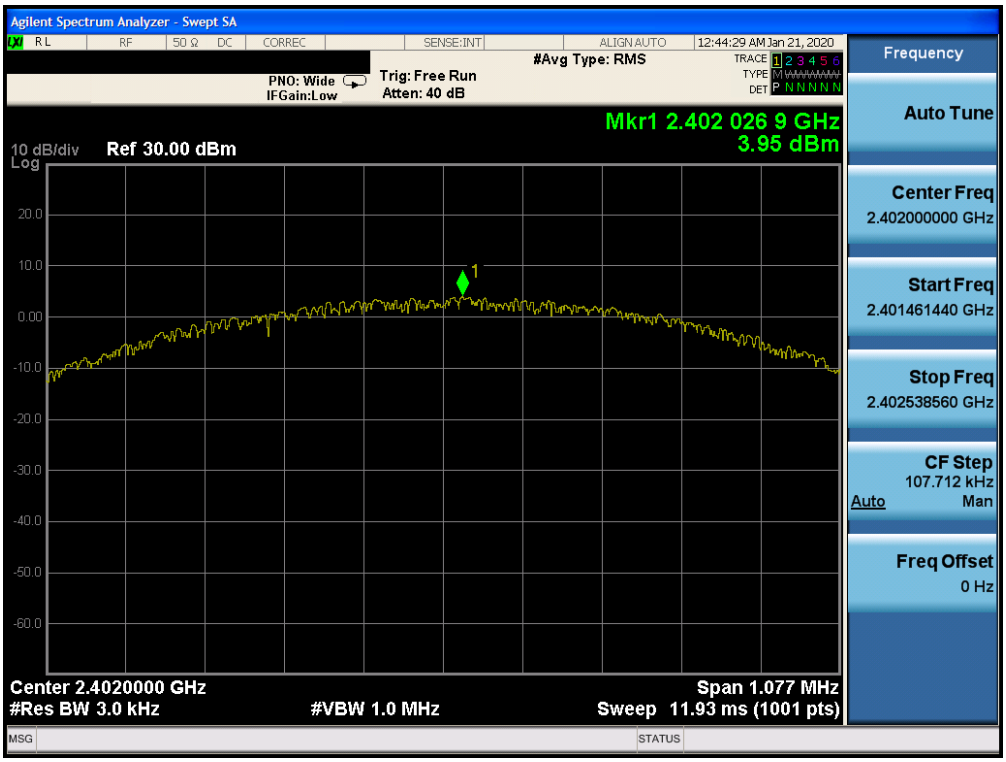
TxBF

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Measured Power Spectral Density [dBm/3kHz]			Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]
				Ant WF8	Ant WF7	Summed		
2402	1.0	ePA	0	4.31	3.95	7.14	8.0	-0.86
2440	1.0	ePA	19	4.15	4.13	7.15	8.0	-0.85
2480	1.0	ePA	39	4.09	4.04	7.08	8.0	-0.92
2402	1.0	iPA	0	2.03	2.01	5.03	8.0	-2.97
2440	1.0	iPA	19	1.63	1.96	4.81	8.0	-3.19
2480	1.0	iPA	39	1.18	2.21	4.74	8.0	-3.26
2404	2.0	ePA	1	-1.16	-1.59	1.64	8.0	-6.36
2440	2.0	ePA	19	-1.36	-1.27	1.70	8.0	-6.30
2478	2.0	ePA	38	-1.35	-1.46	1.61	8.0	-6.39
2404	2.0	iPA	1	-5.02	-3.14	-0.97	8.0	-8.97
2440	2.0	iPA	19	-5.53	-3.68	-1.50	8.0	-9.50
2478	2.0	iPA	38	-5.43	-3.19	-1.16	8.0	-9.16

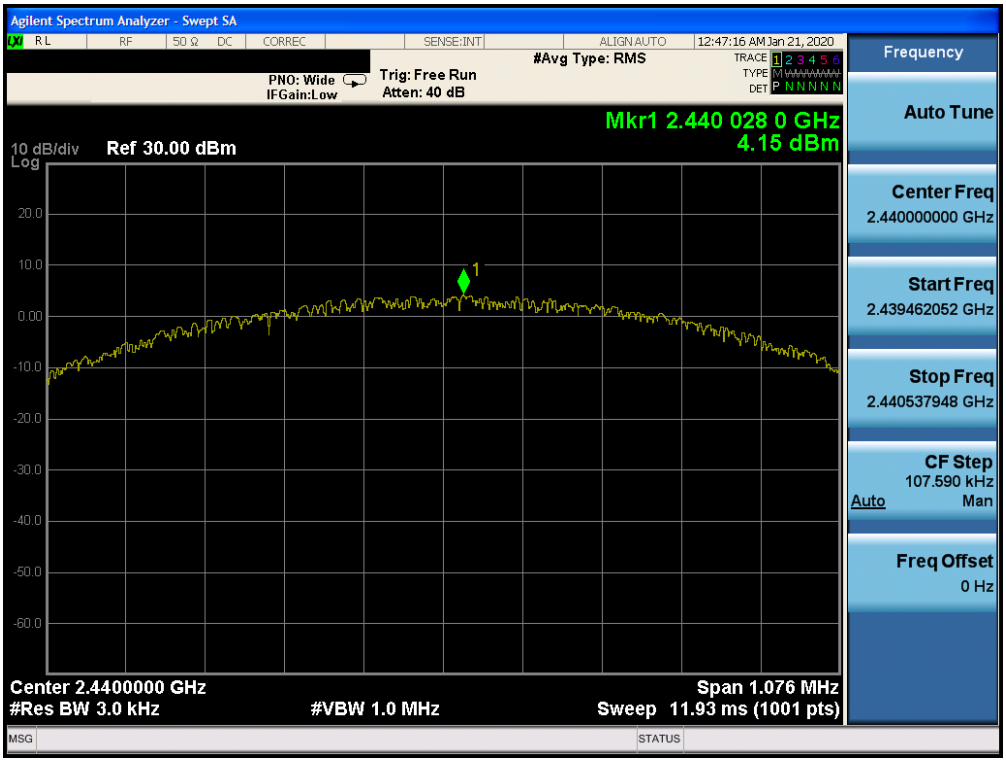
Table 7-12. Conducted Power Density Measurements TxBF



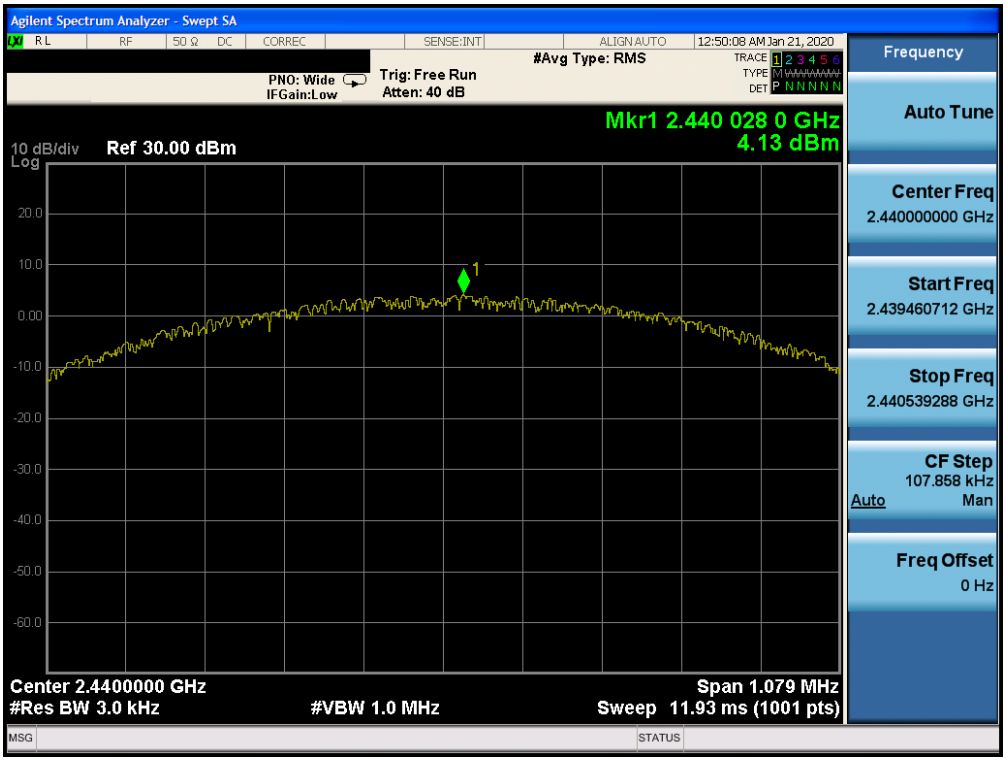
Plot 7-37. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



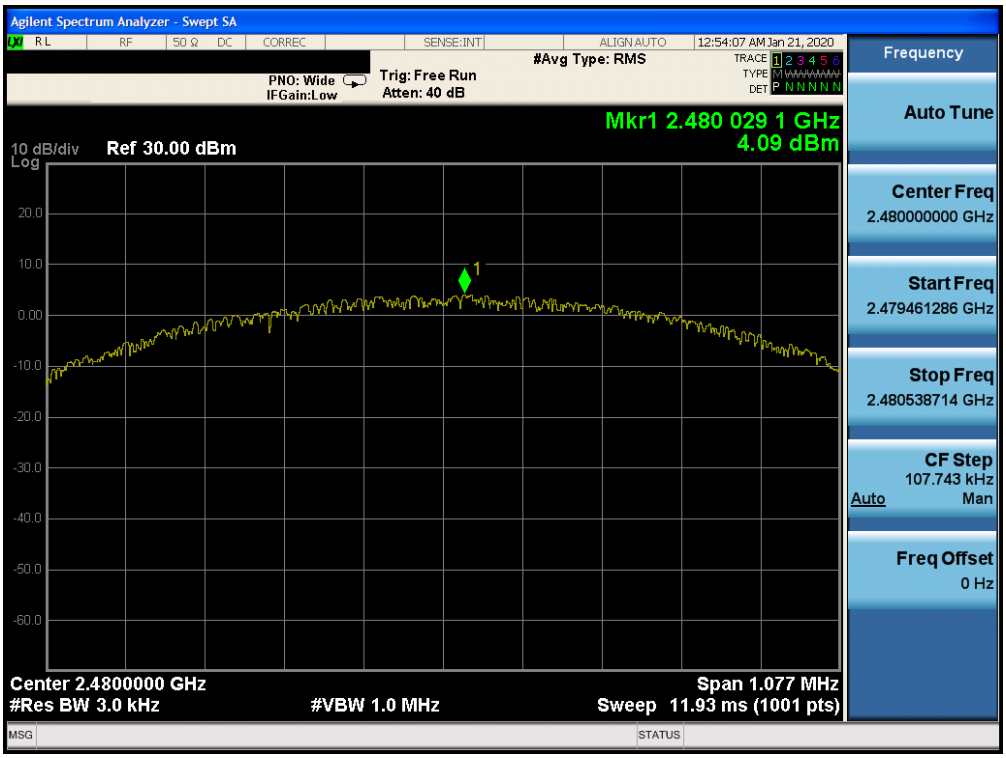
Plot 7-38. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



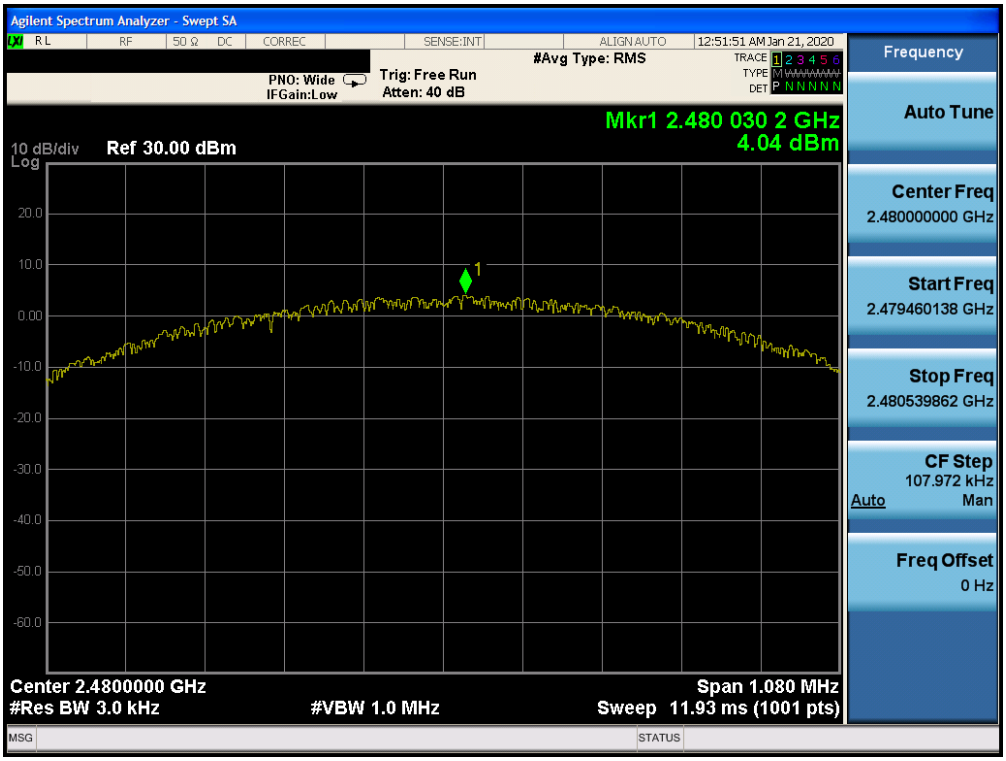
Plot 7-39. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



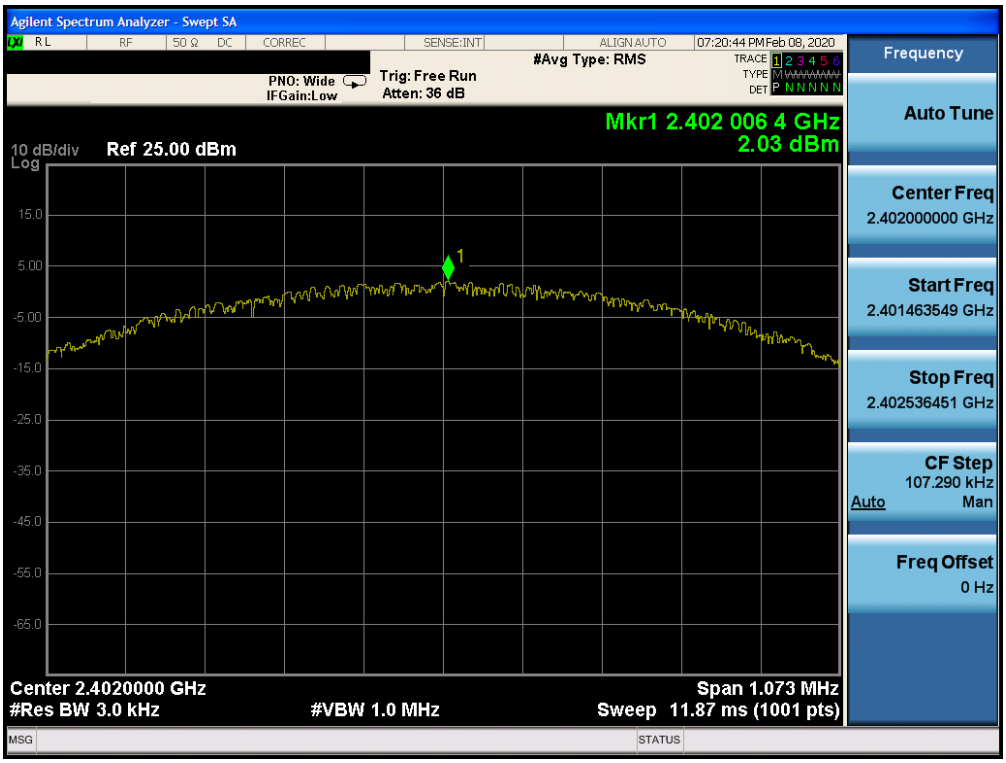
Plot 7-40. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



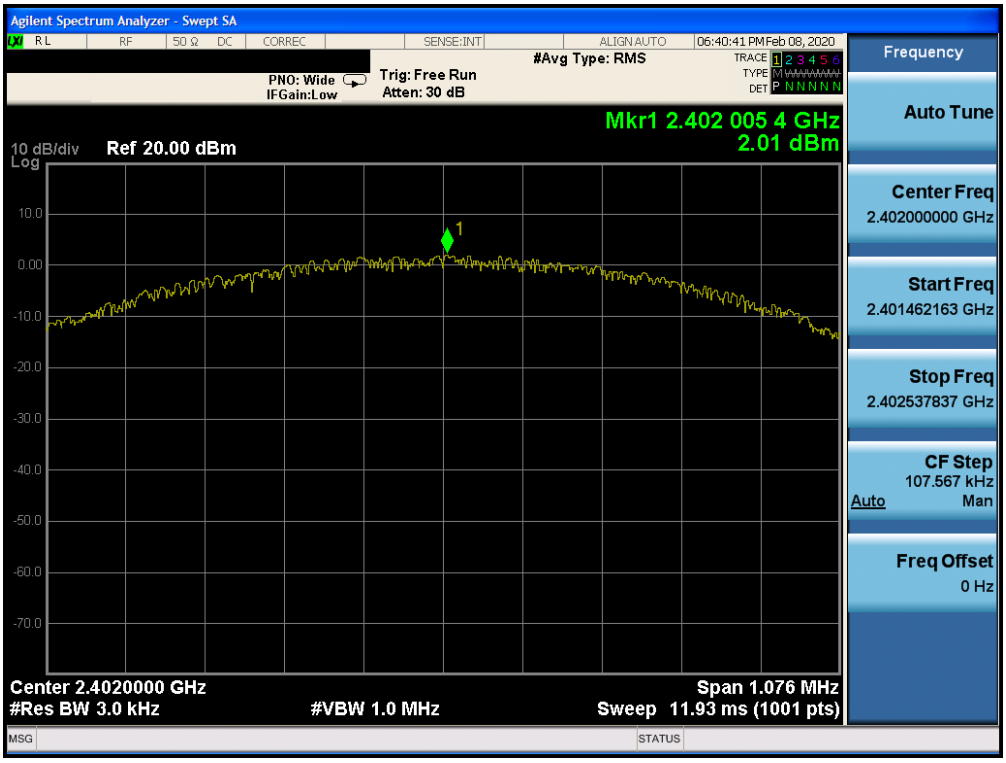
Plot 7-41. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



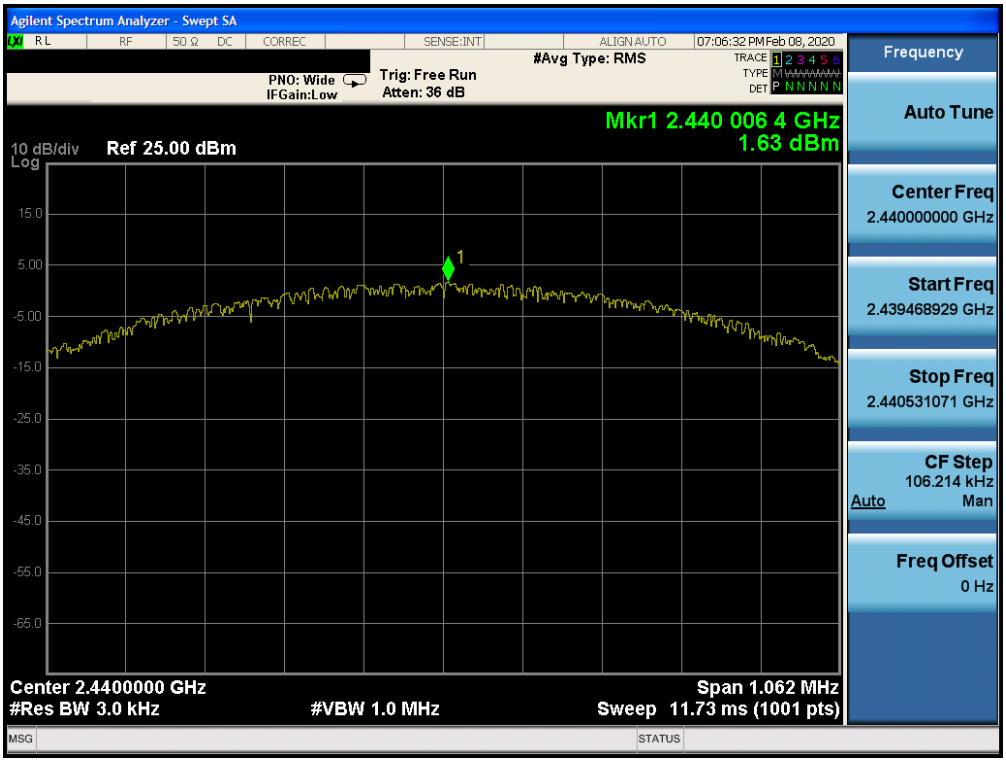
Plot 7-42. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



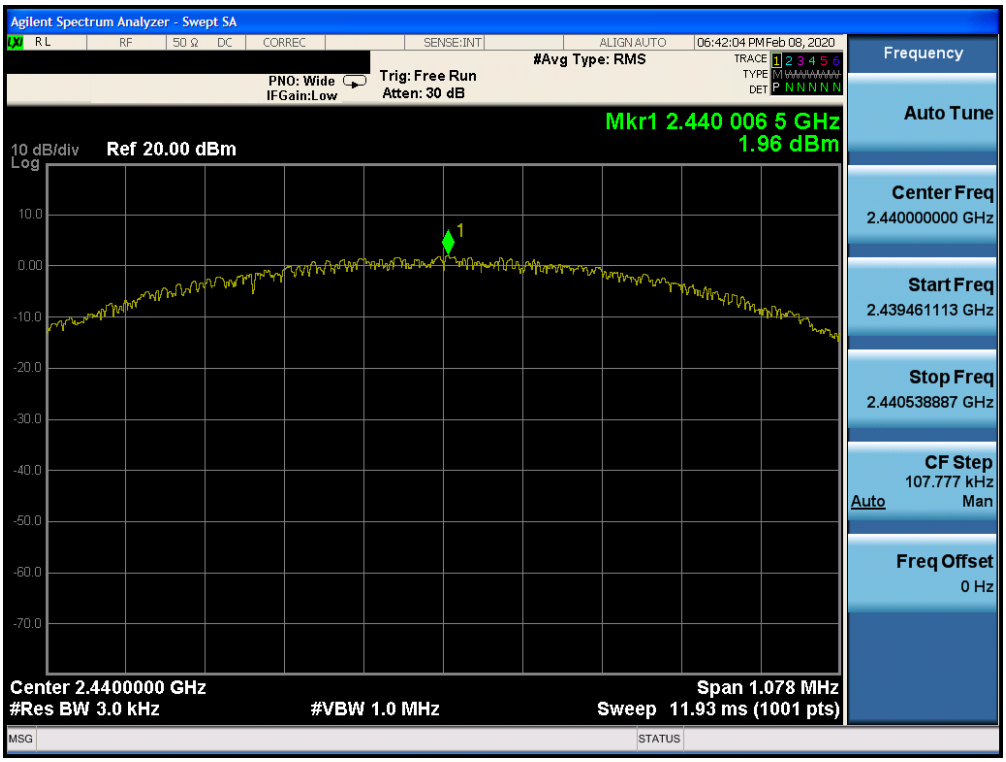
Plot 7-43. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 0)



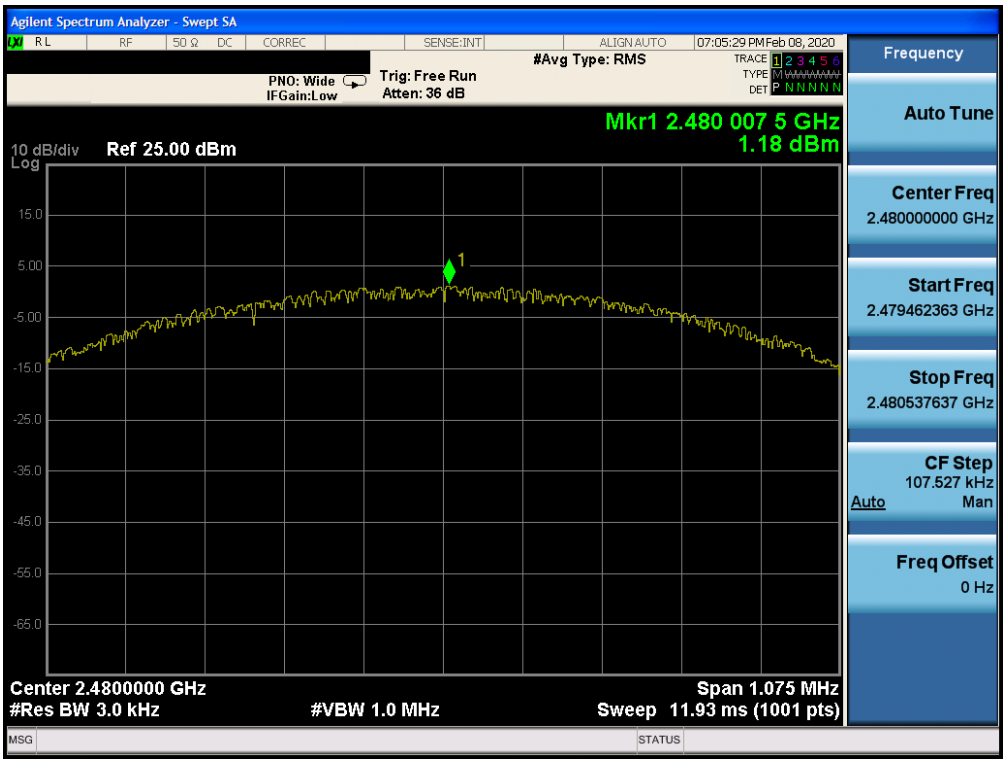
Plot 7-44. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 0)



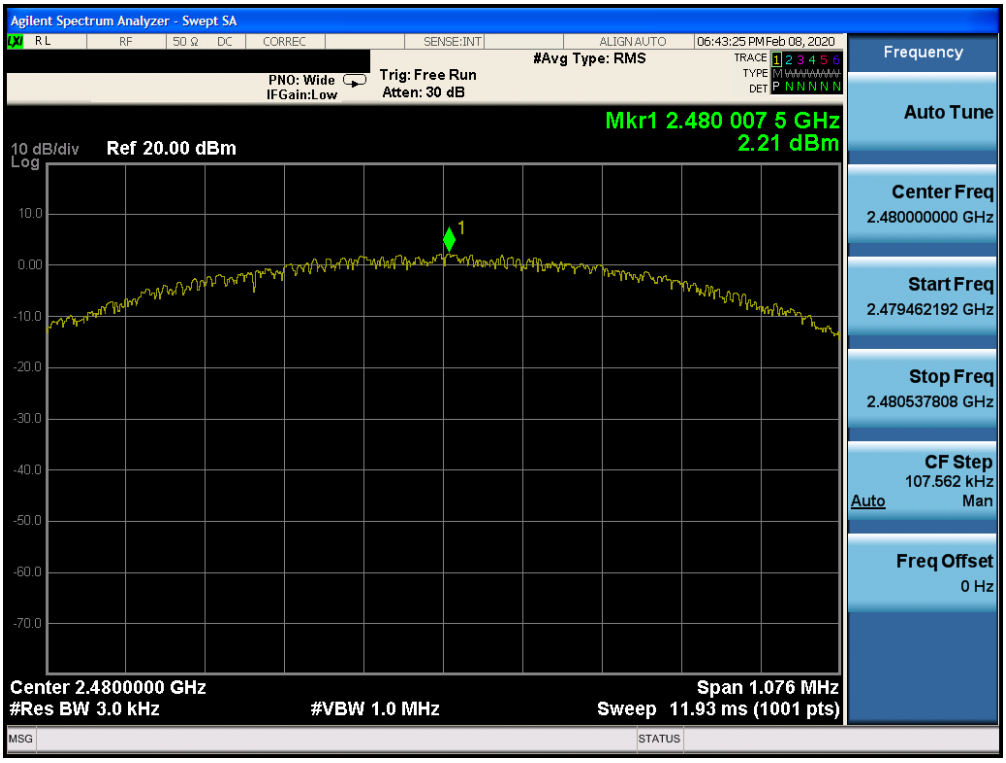
Plot 7-45. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 19)



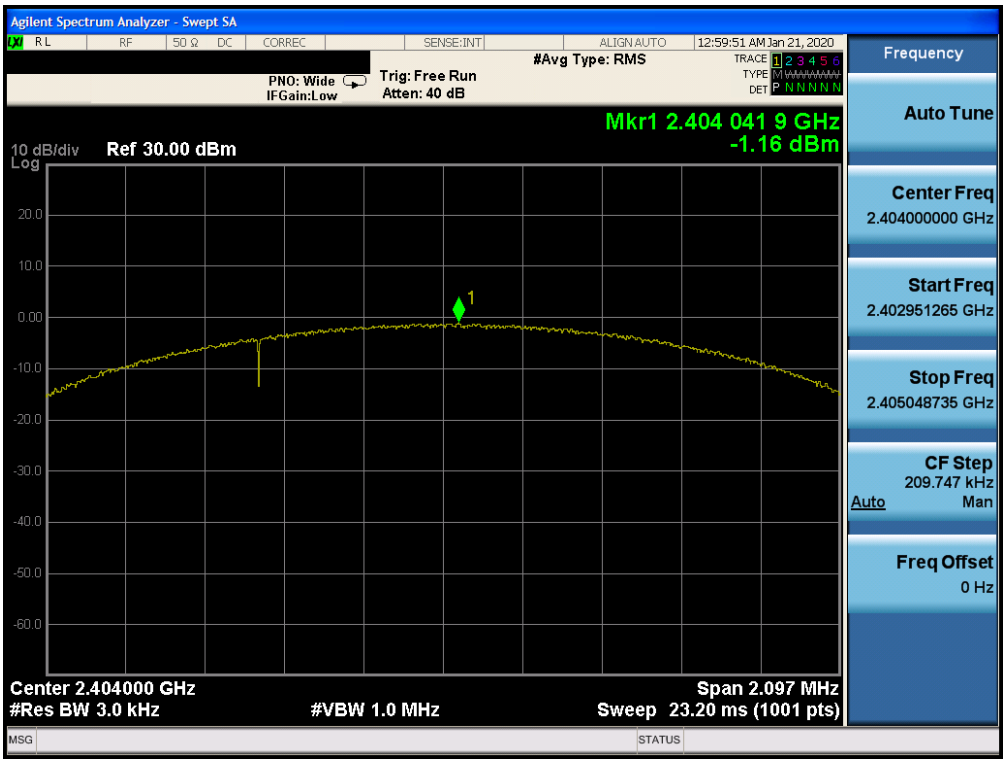
Plot 7-46. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 19)



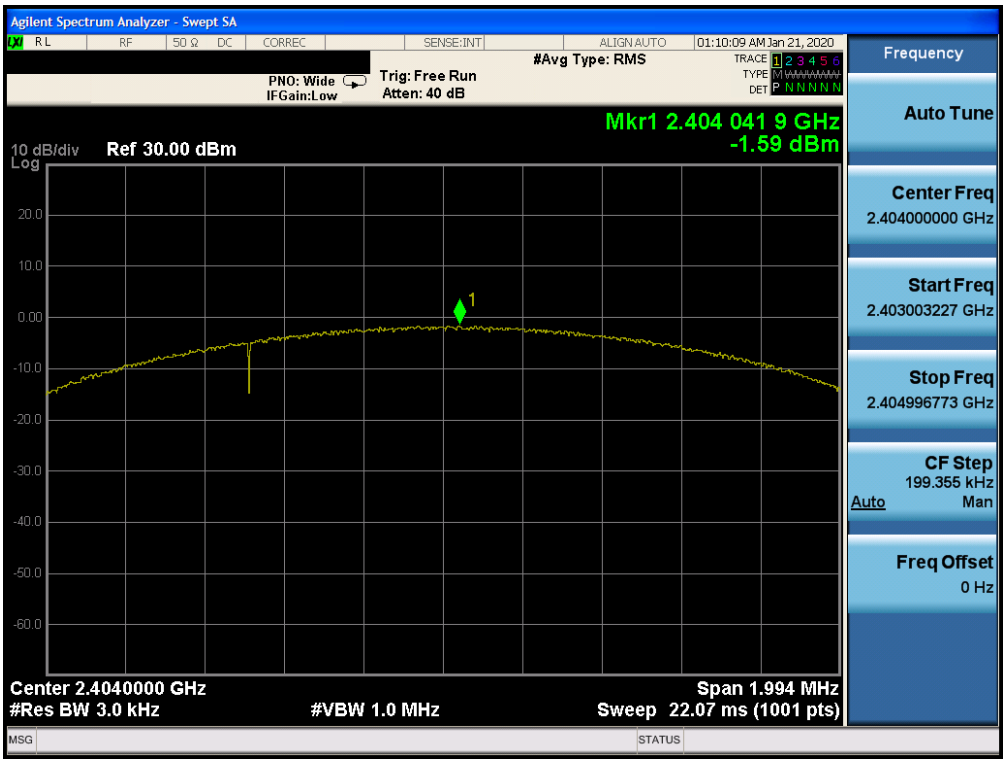
Plot 7-47. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 1Mbps, iPA – Ch. 39)



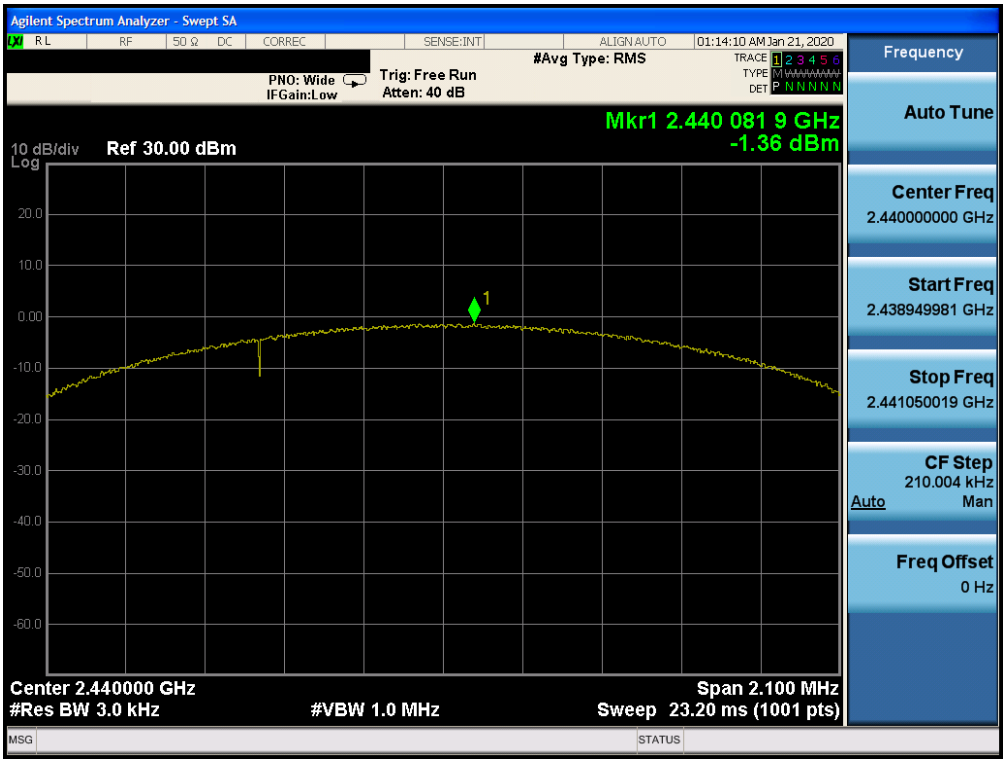
Plot 7-48. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 1Mbps, iPA – Ch. 39)



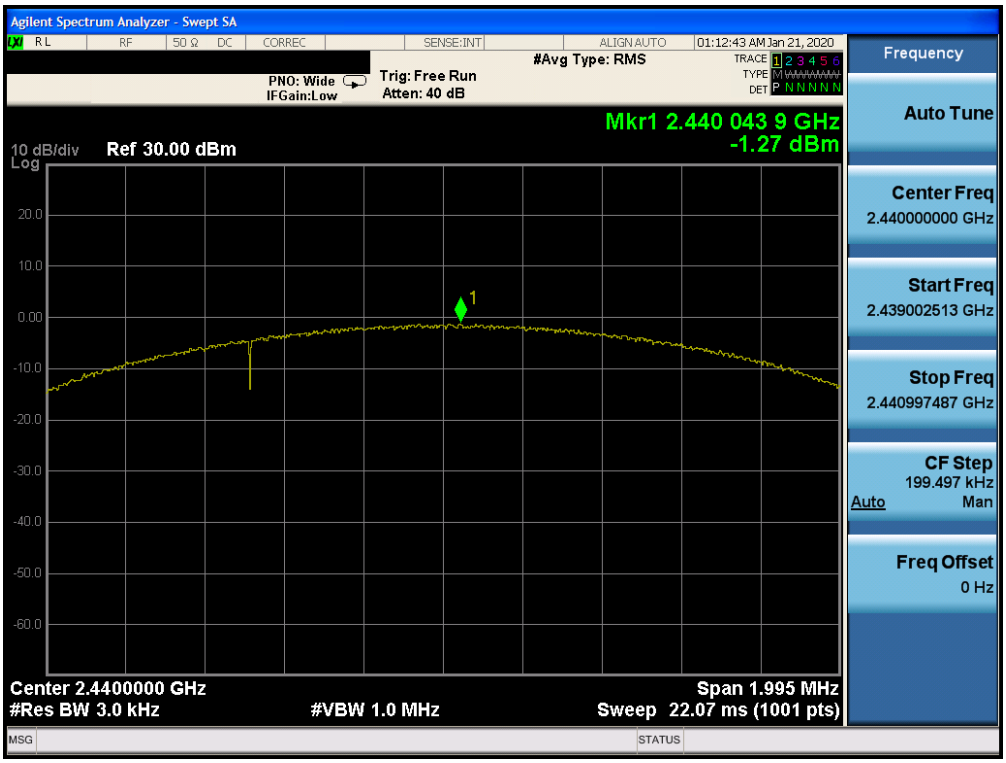
Plot 7-49. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 1)



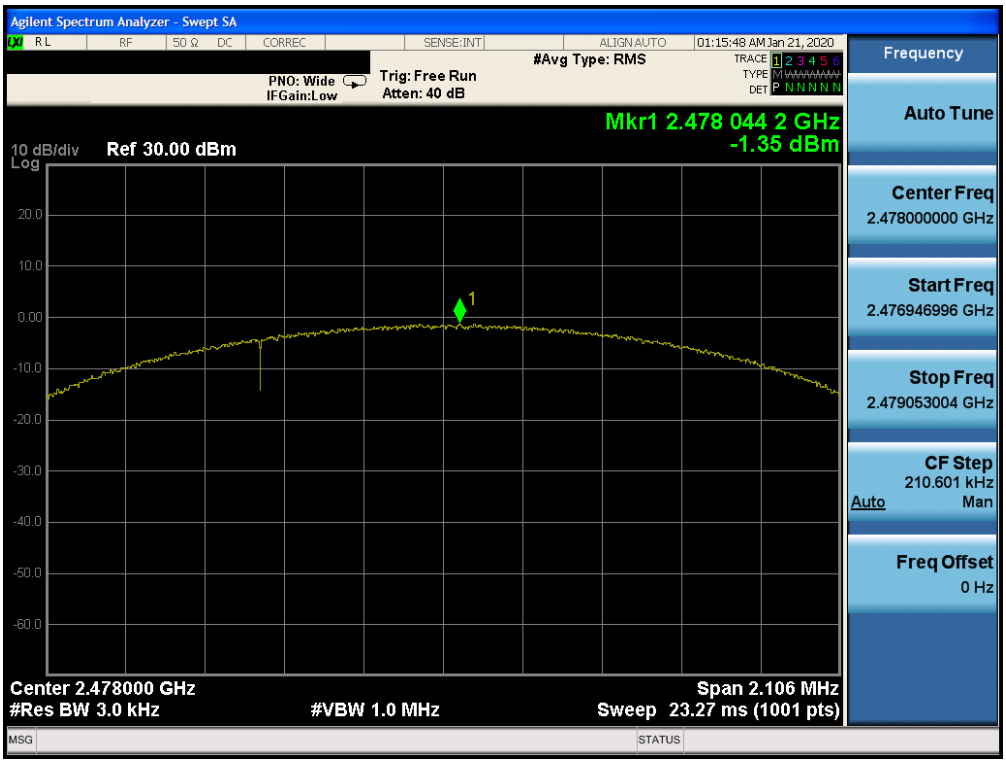
Plot 7-50. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 1)



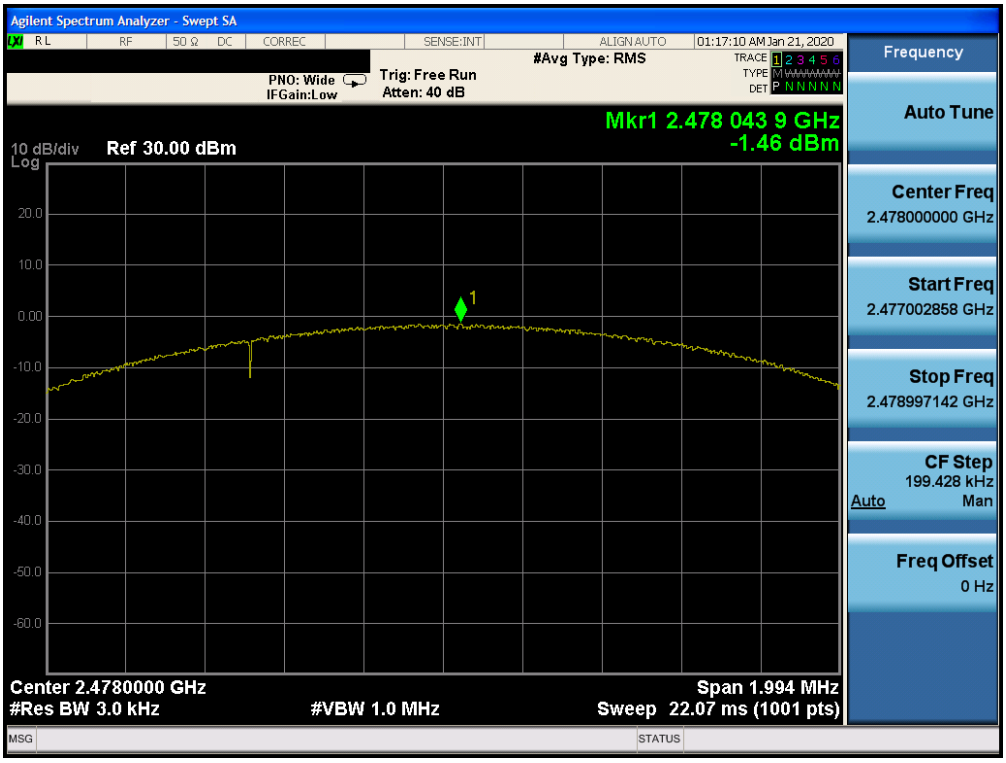
Plot 7-51. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)



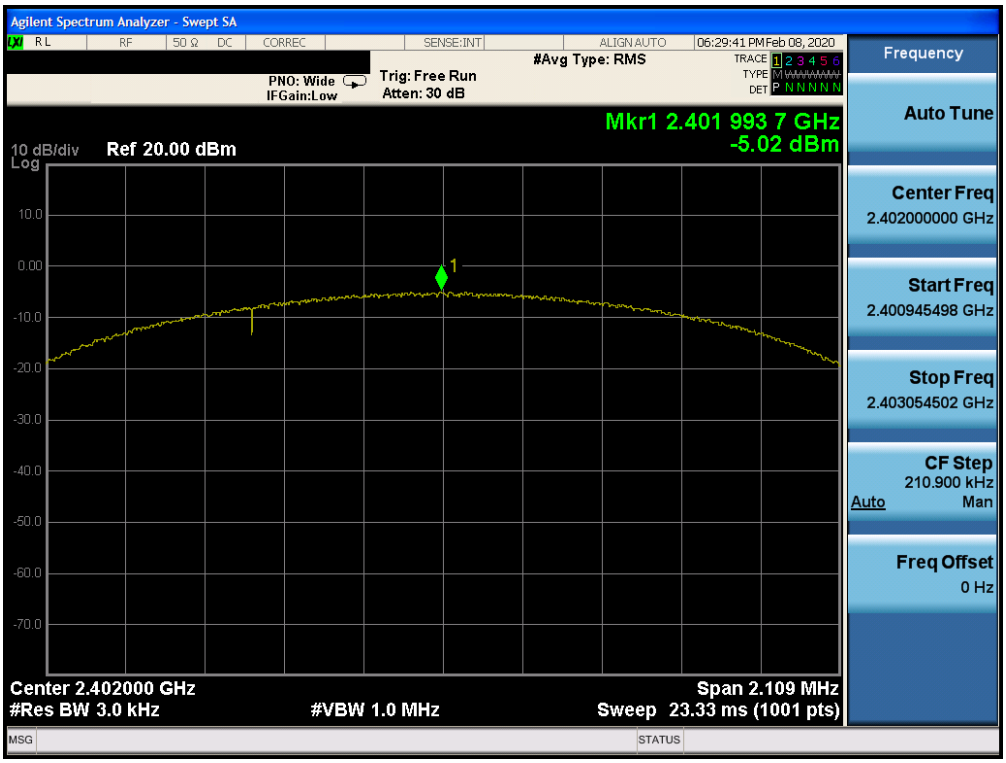
Plot 7-52. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 19)



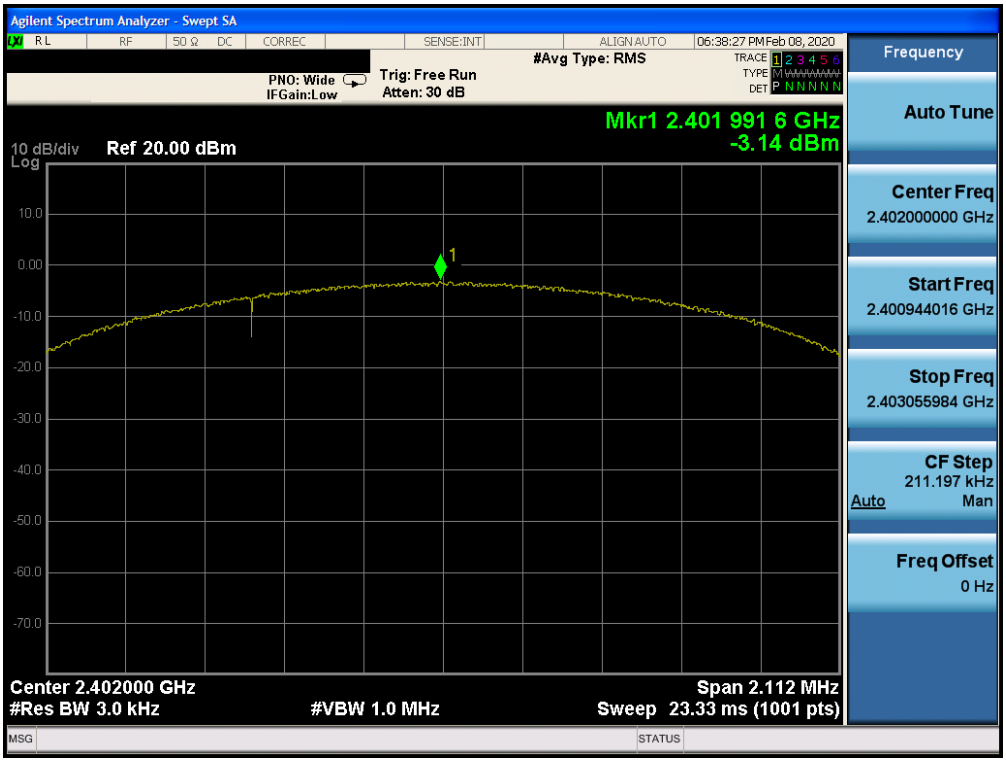
Plot 7-53. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, ePA – Ch. 38)



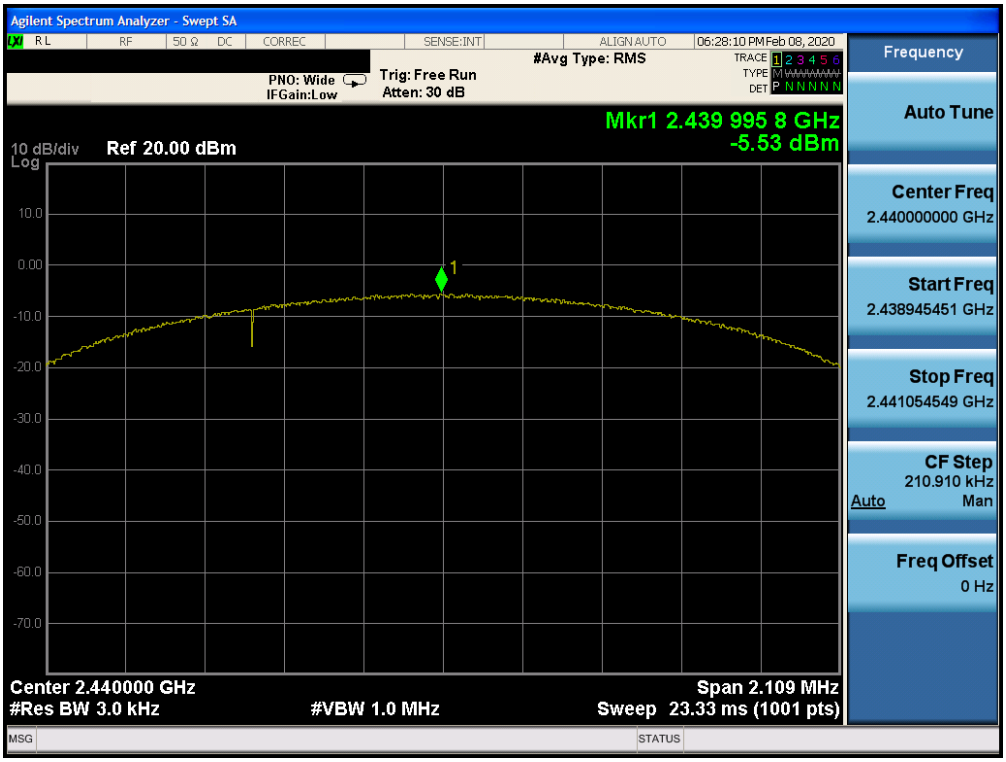
Plot 7-54. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, ePA – Ch. 38)



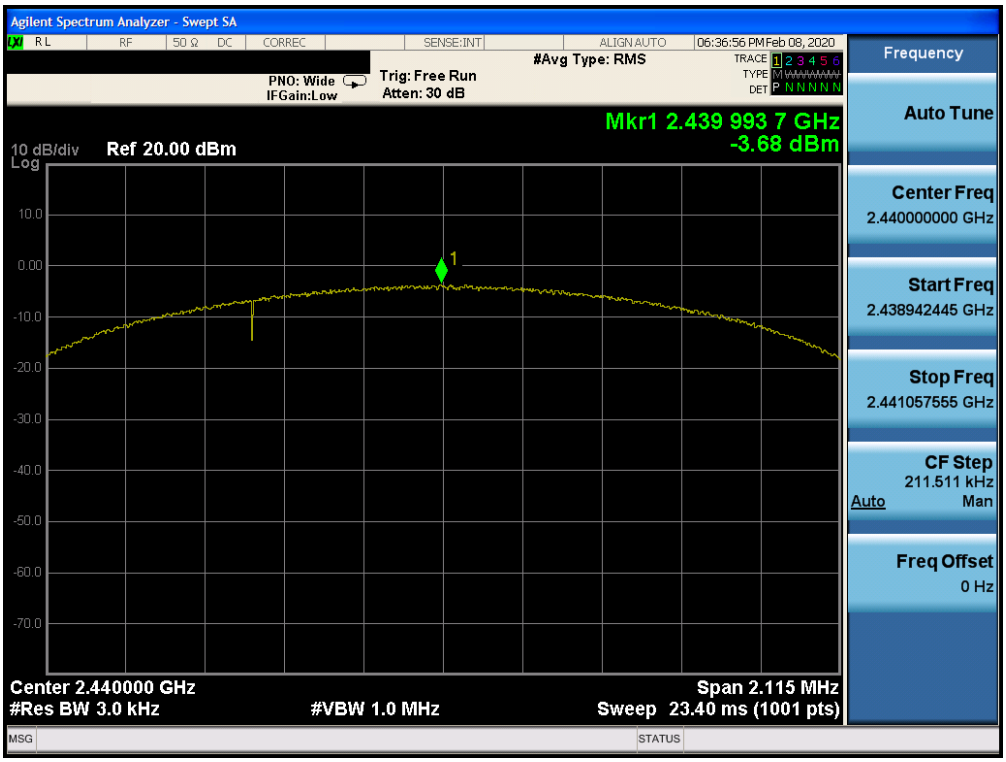
Plot 7-55. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 1)



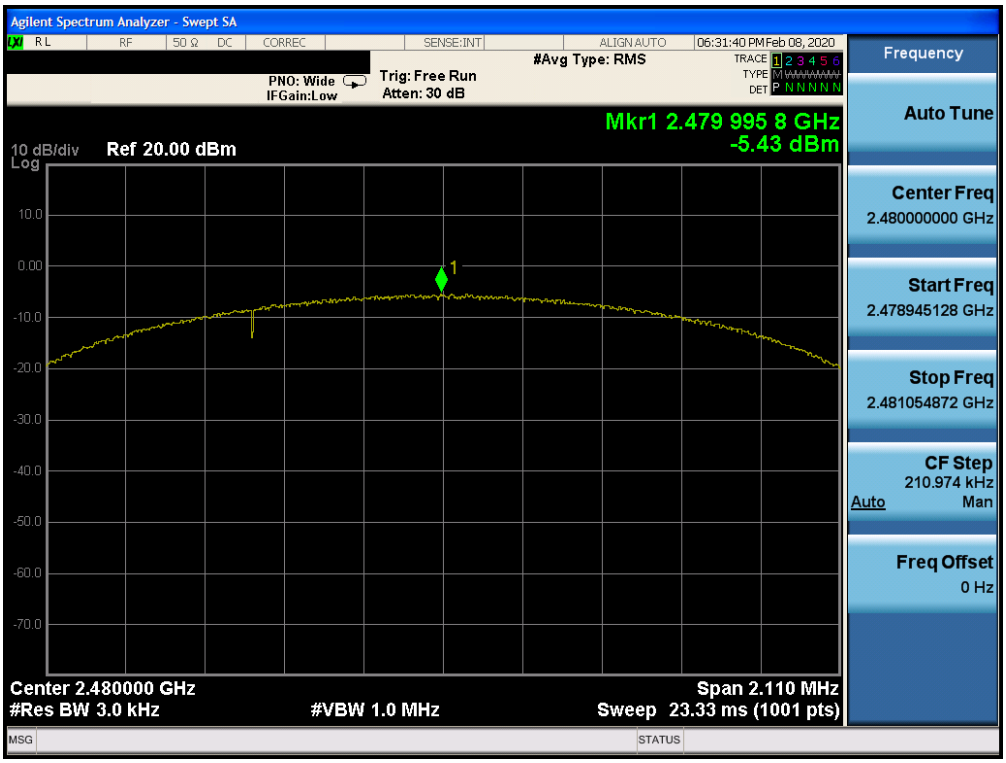
Plot 7-56. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 1)



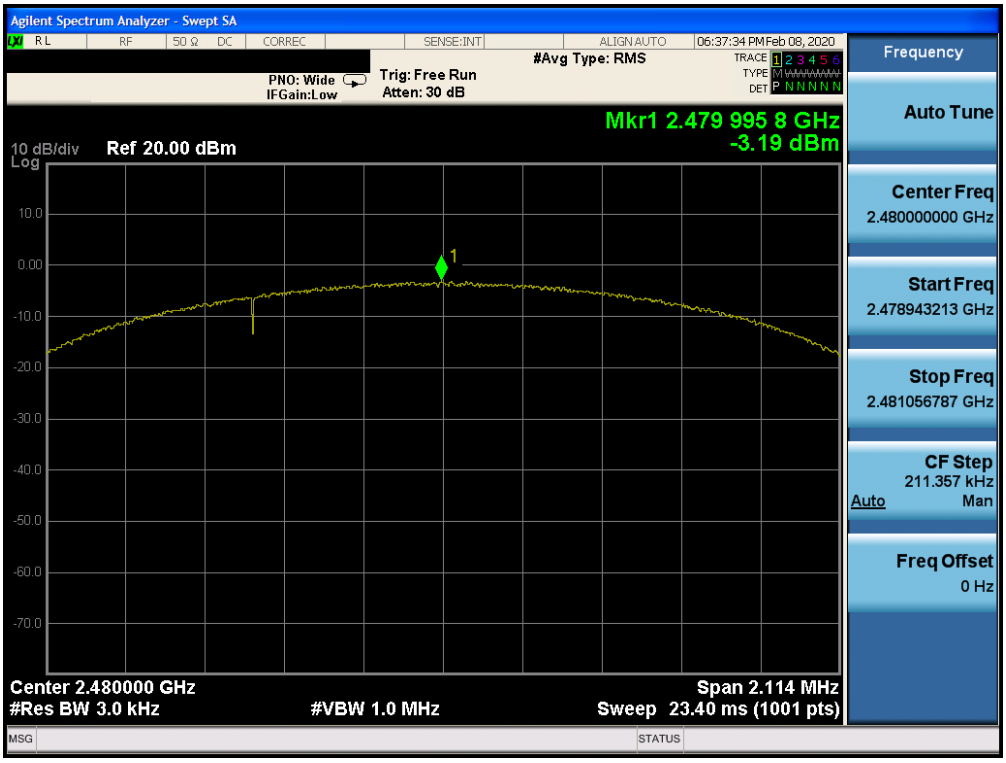
Plot 7-57. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 19)



Plot 7-58. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 19)



Plot 7-59. Power Spectral Density Plot TxBF Ant WF8 (Bluetooth (LE), 2Mbps, iPA – Ch. 38)



Plot 7-60. Power Spectral Density Plot TxBF Ant WF7 (Bluetooth (LE), 2Mbps, iPA – Ch. 38)

7.5 Conducted Emissions at the Band Edge

§15.247(d); RSS-247 [5.5]

Test Overview and Limit

For the following out of band conducted spurious emissions plots at the band edge, the EUT was set to transmit at maximum power with the largest packet size available. These settings produced the worst-case emissions.

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

Test Procedure Used

ANSI C63.10-2013 – Section 11.11.3
KDB 558074 D01 v05r02 – Section 8.7.2

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

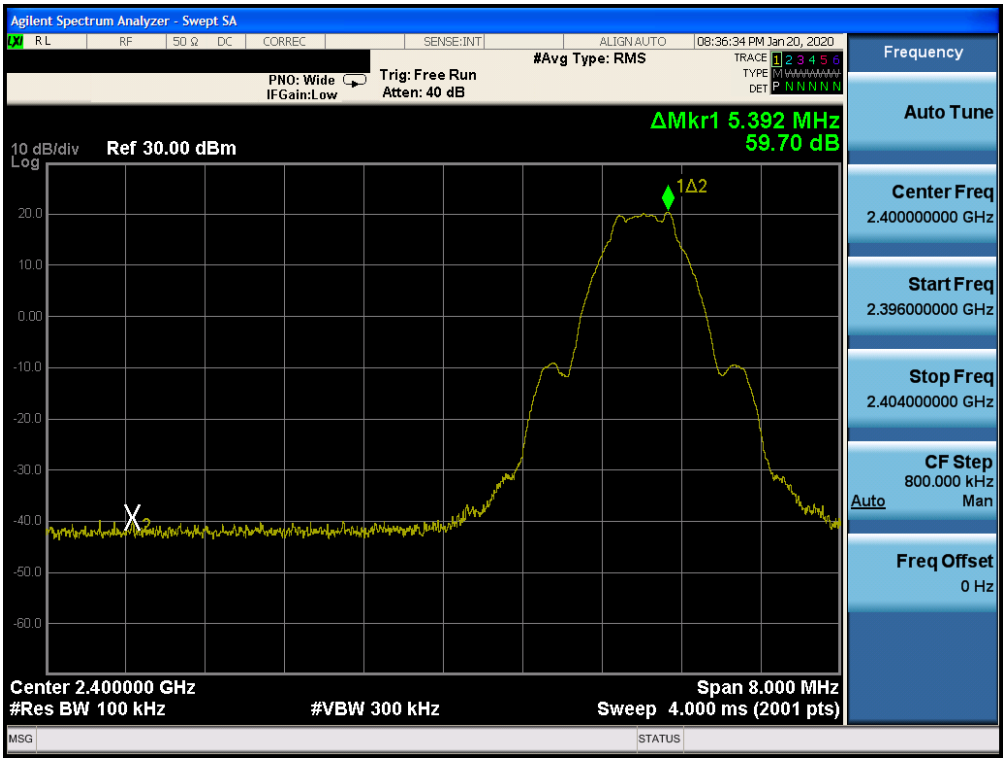
Test Setup

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

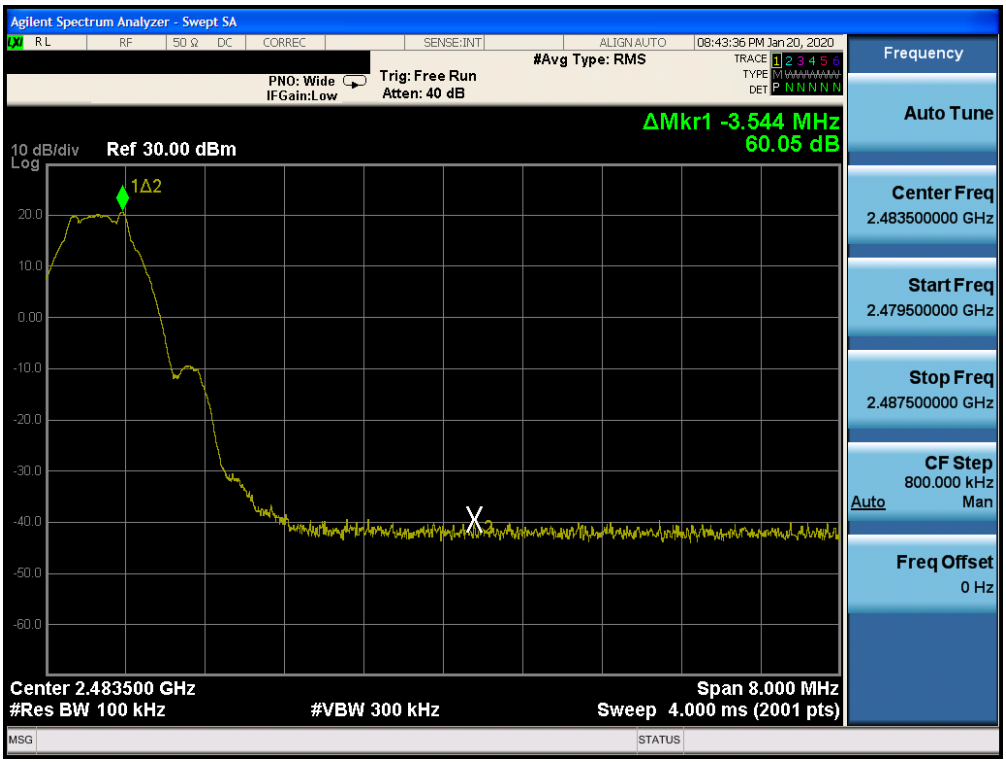
Figure 7-4. Test Instrument & Measurement Setup

Test Notes

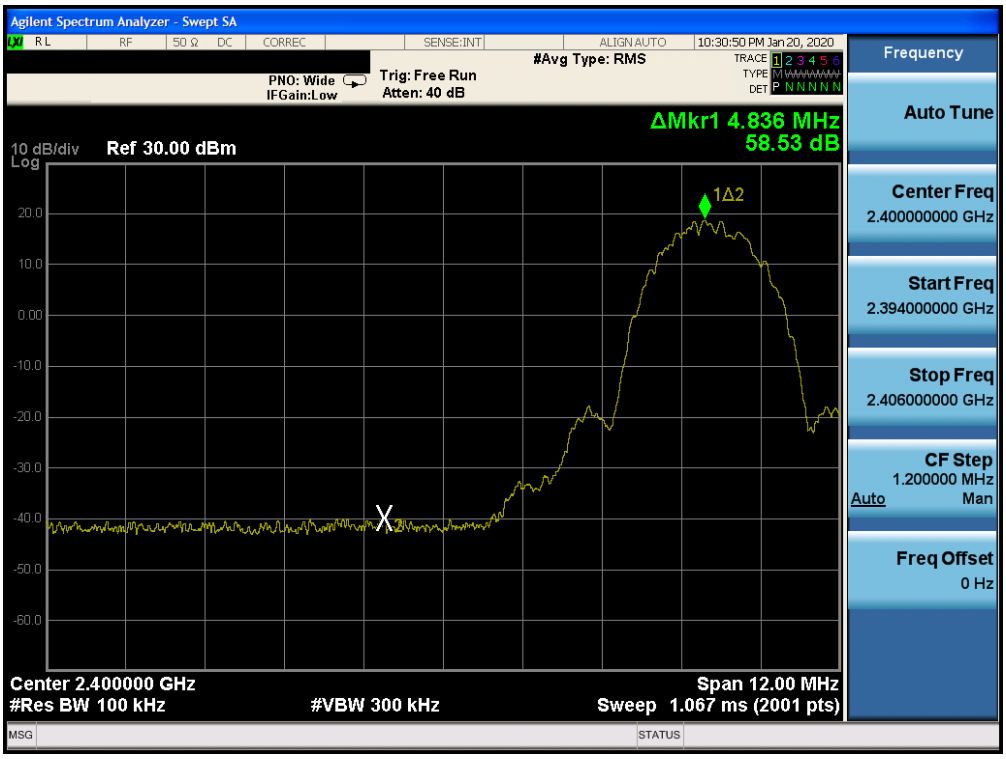
Both power schemes were investigated, and only the worst case is reported.



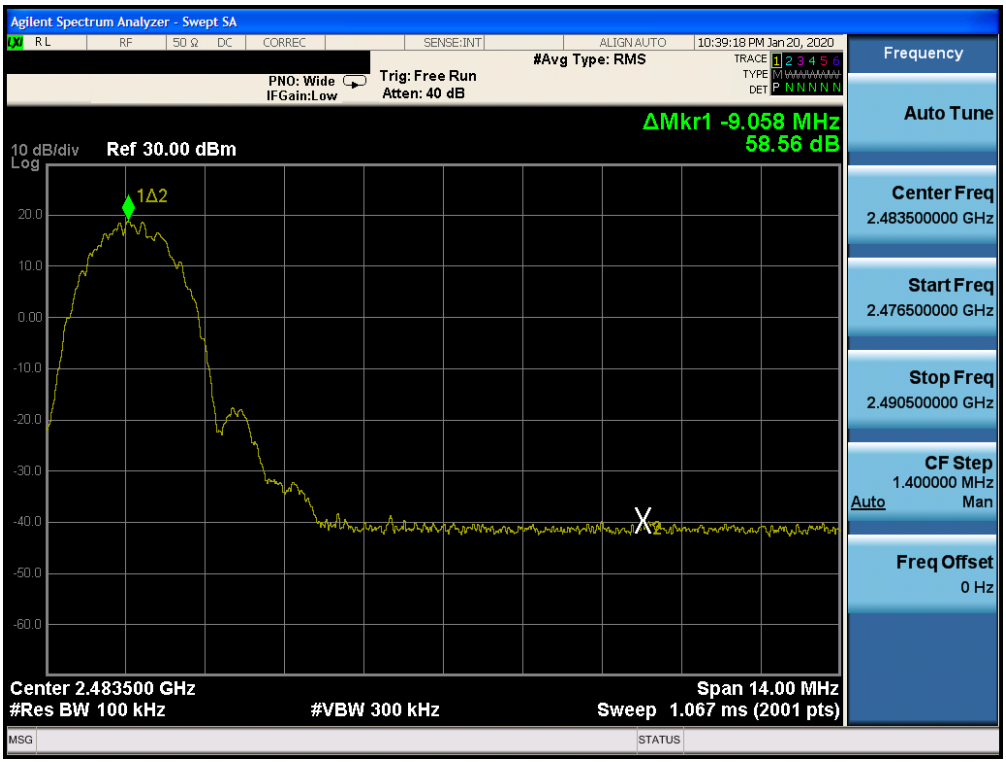
Plot 7-61. Band Edge Plot Ant WF8 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



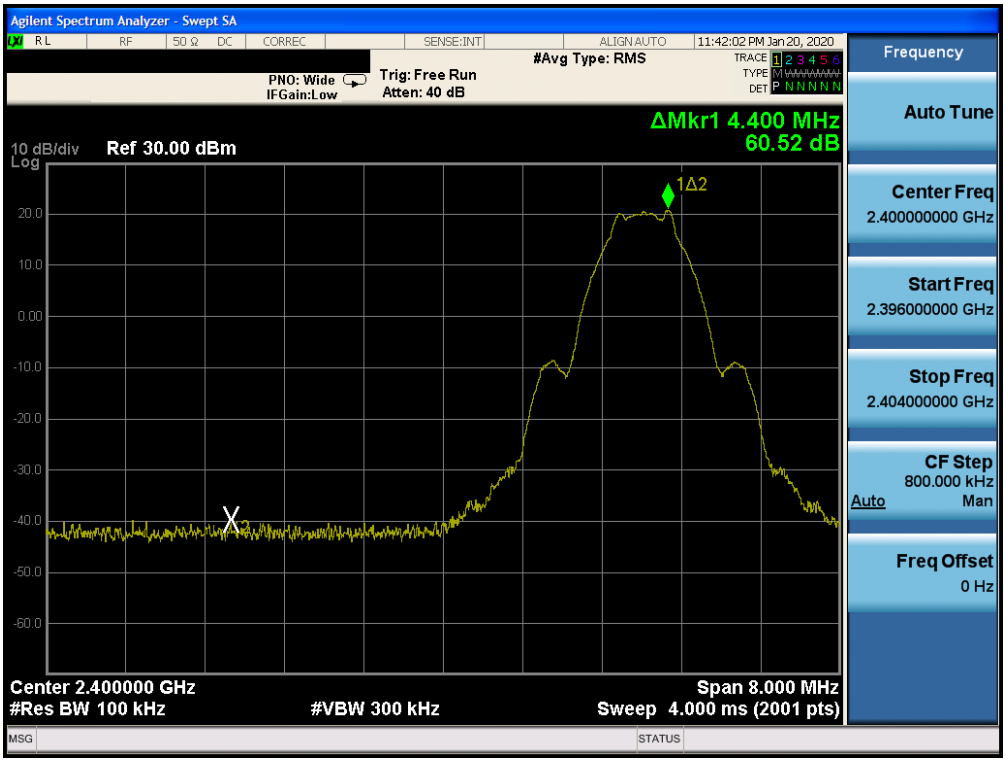
Plot 7-62. Band Edge Plot Ant WF8 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



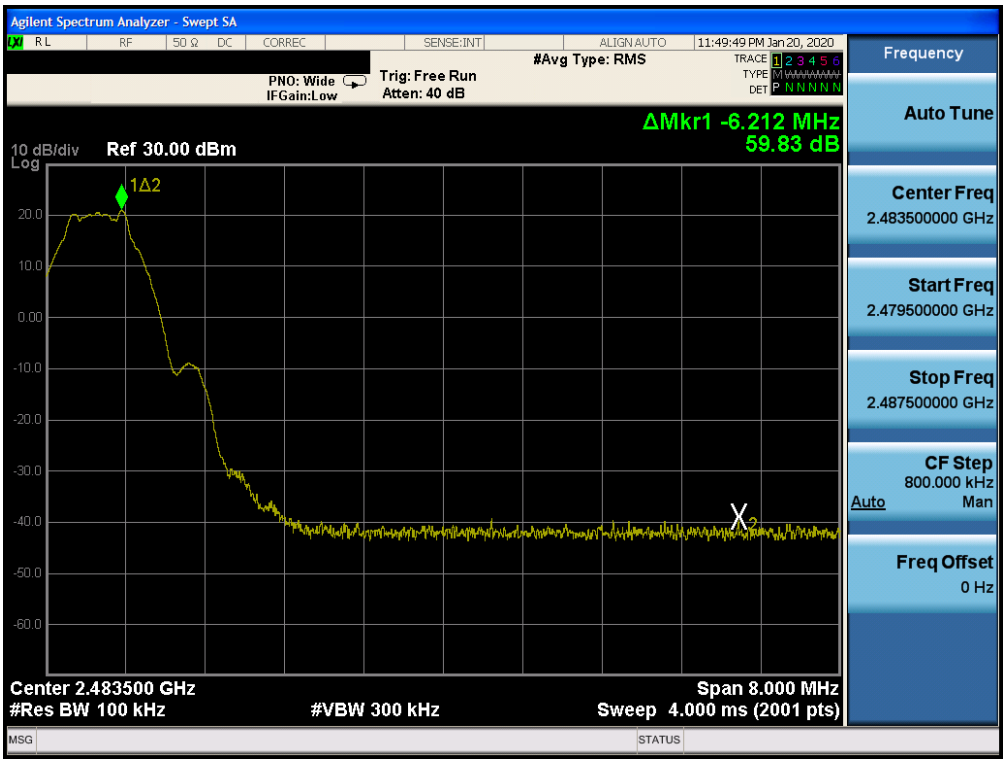
Plot 7-63. Band Edge Plot Ant WF8 (Bluetooth (LE), 2Mbps ePA – Ch. 1)



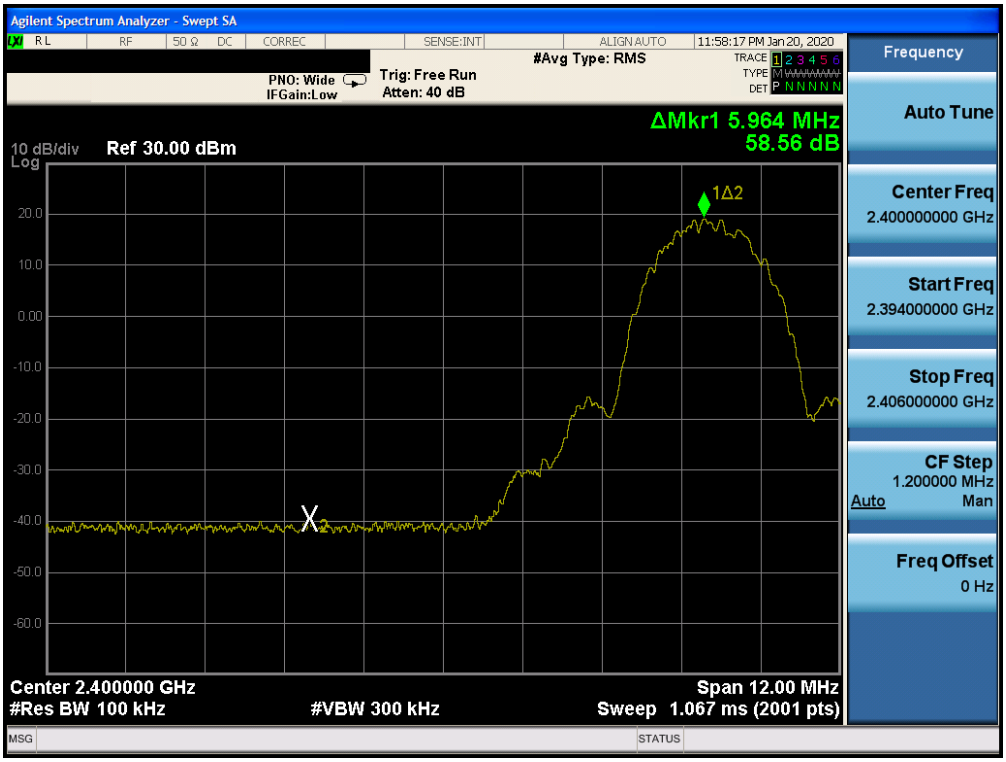
Plot 7-64. Band Edge Plot Ant WF8 (Bluetooth (LE), 2Mbps ePA – Ch. 38)



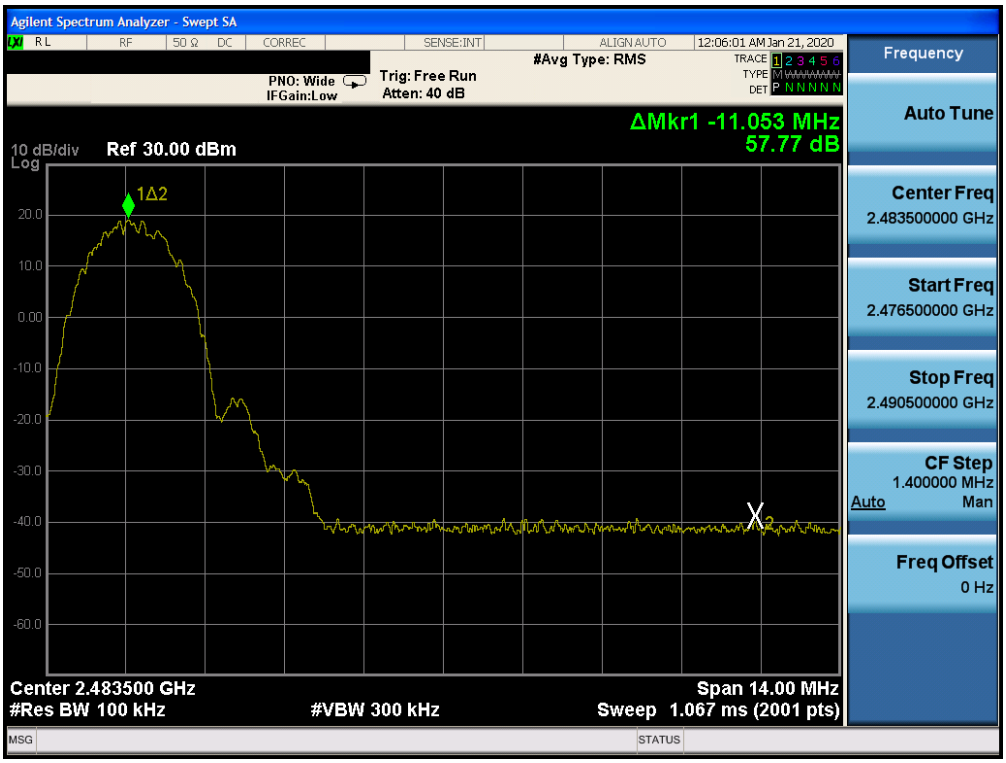
Plot 7-65. Band Edge Plot Ant WF7 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



Plot 7-66. Band Edge Plot Ant WF7 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



Plot 7-67. Band Edge Plot Ant WF7 (Bluetooth (LE), 2Mbps ePA – Ch. 1)



Plot 7-68. Band Edge Plot Ant WF7 (Bluetooth (LE), 2Mbps ePA – Ch. 38)

7.6 Conducted Spurious Emissions

§15.247(d); RSS-247 [5.5]

Test Overview and Limit

For the following out of band conducted spurious emissions plots, the EUT was set to transmit at maximum power with the largest packet size available. The worst case spurious emissions were found in this configuration.

The limit for out-of-band spurious emissions at the band edge is 20dB below the fundamental emission level, as determined from the in-band power measurement of the DTS channel performed in a 100kHz bandwidth per the procedure in Section 8.5 of KDB 558074 D01 v05r02 and Section 11.11 of ANSI C63.10-2013.

Test Procedure Used

ANSI C63.10-2013 – Section 11.11.3
KDB 558074 D01 v05r02 – Section 8.5

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
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 7-5. Test Instrument & Measurement Setup

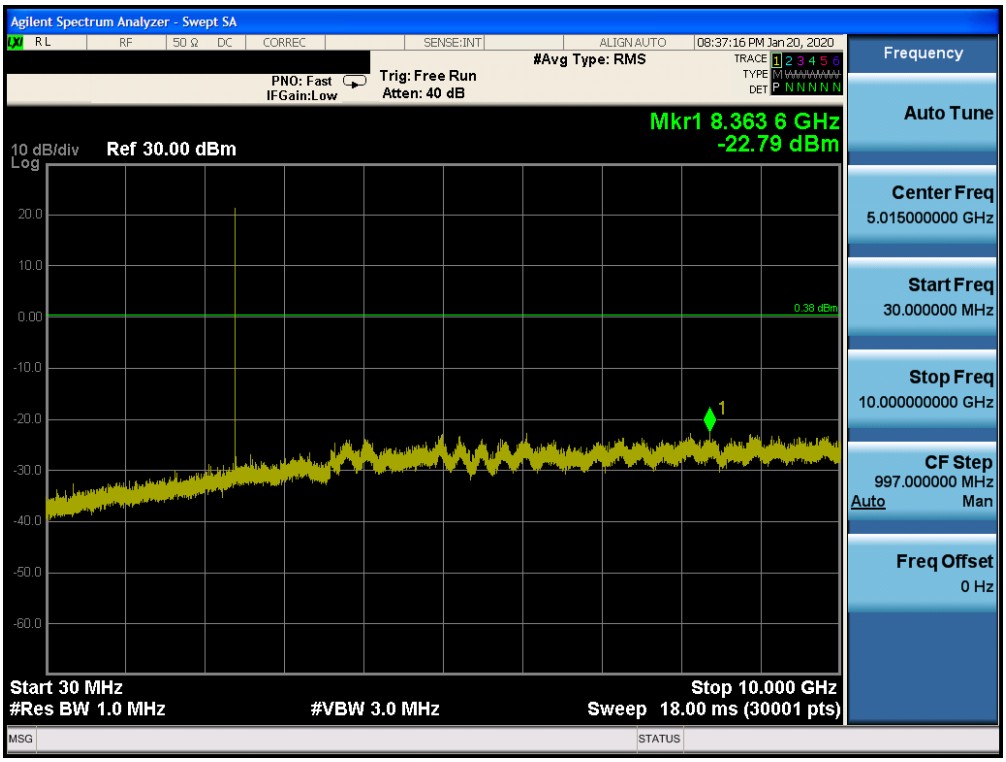
Test Notes

1. RBW was set to 1MHz rather than 100kHz in order to increase the measurement speed.

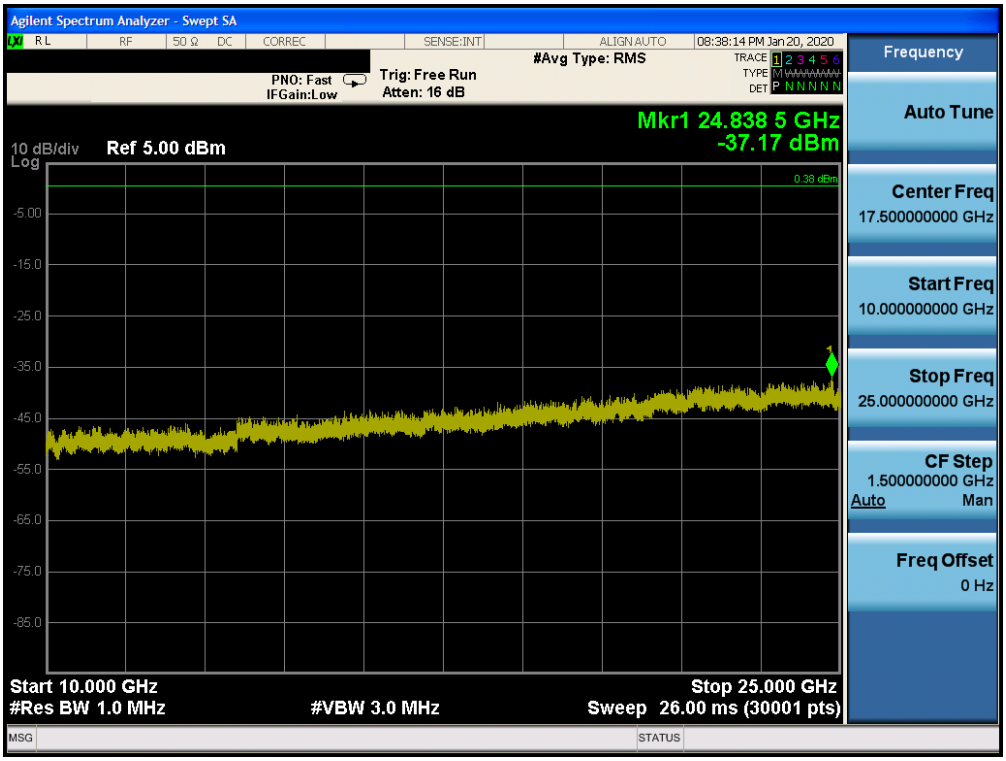
2. The display line shown in the following plots denotes the limit at 20dB below the fundamental emission level measured in a 100kHz bandwidth. However, since the traces in the following plots are measured with a 1MHz RBW, the display line may not necessarily appear to be 20dB below the level of the fundamental in a 1MHz bandwidth.

3. For plots showing conducted spurious emissions near the limit, the frequencies were investigated with a reduced RBW to ensure that no emissions were present.

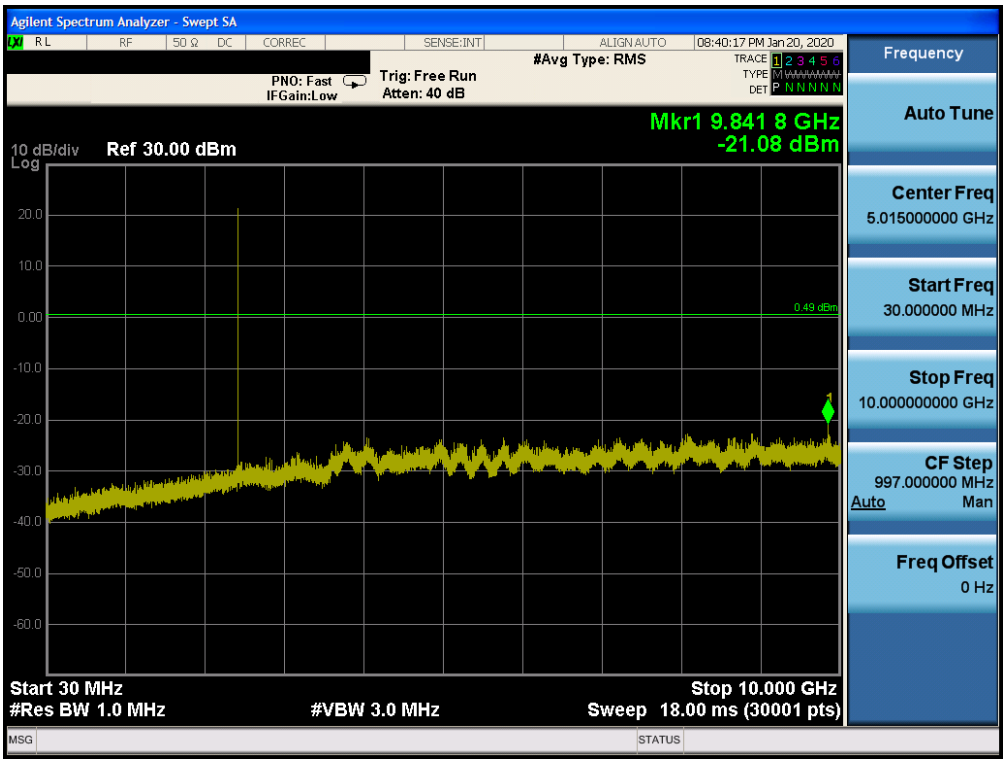
4. The unit was tested with all possible mode and power schemes and only the highest emission is reported.



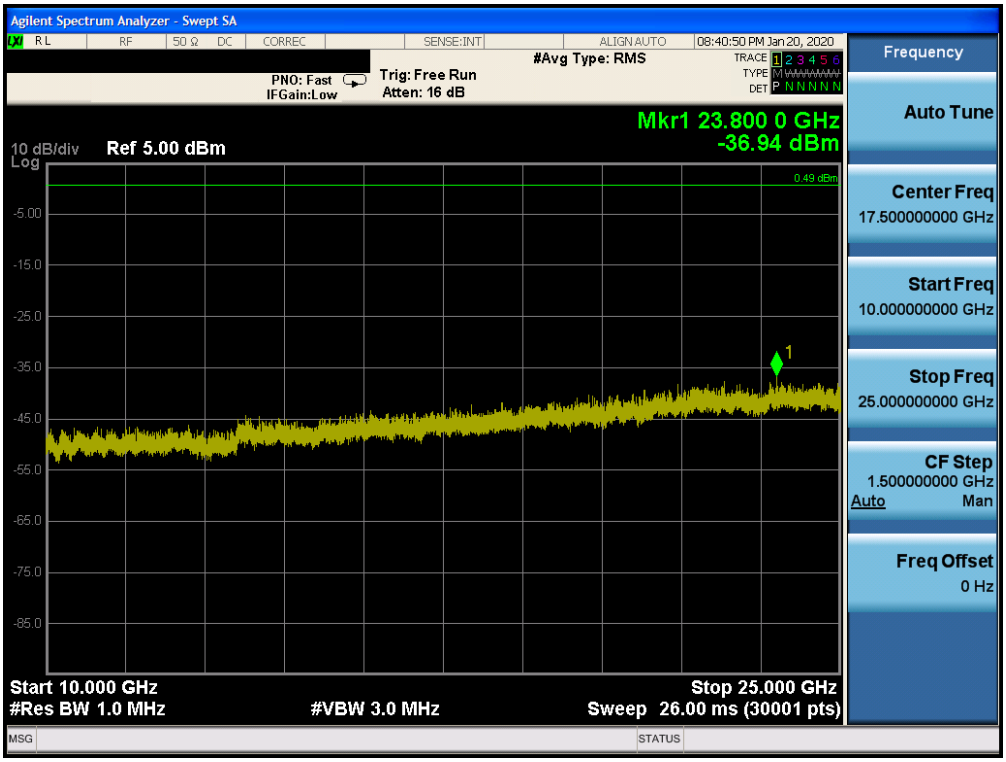
Plot 7-69. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



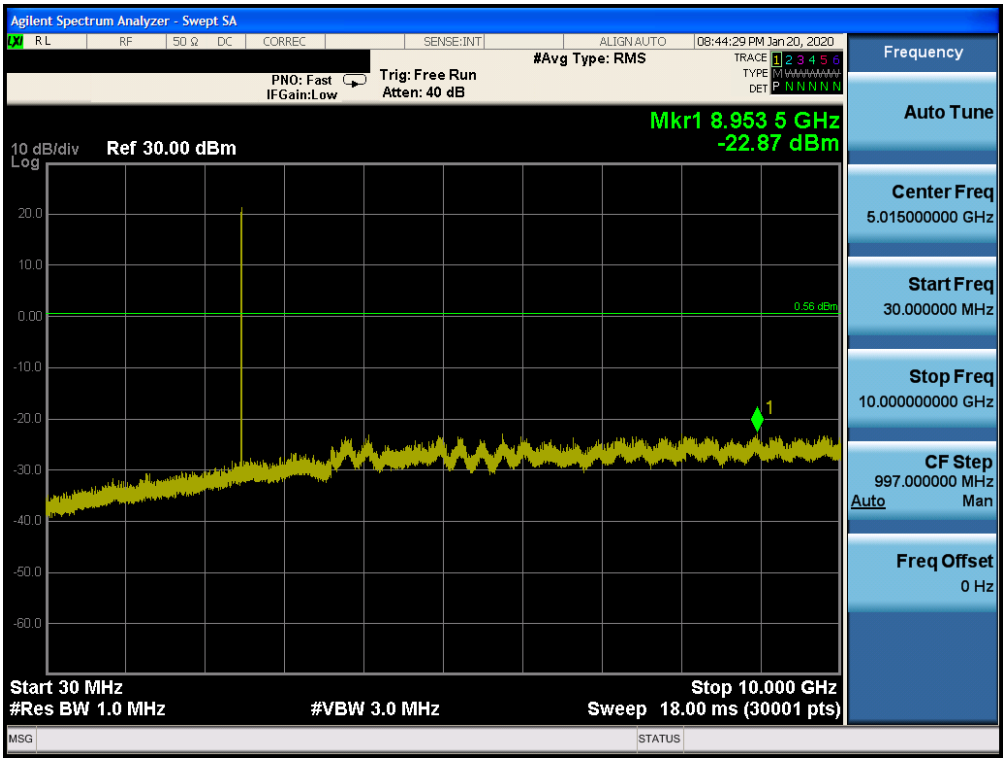
Plot 7-70. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



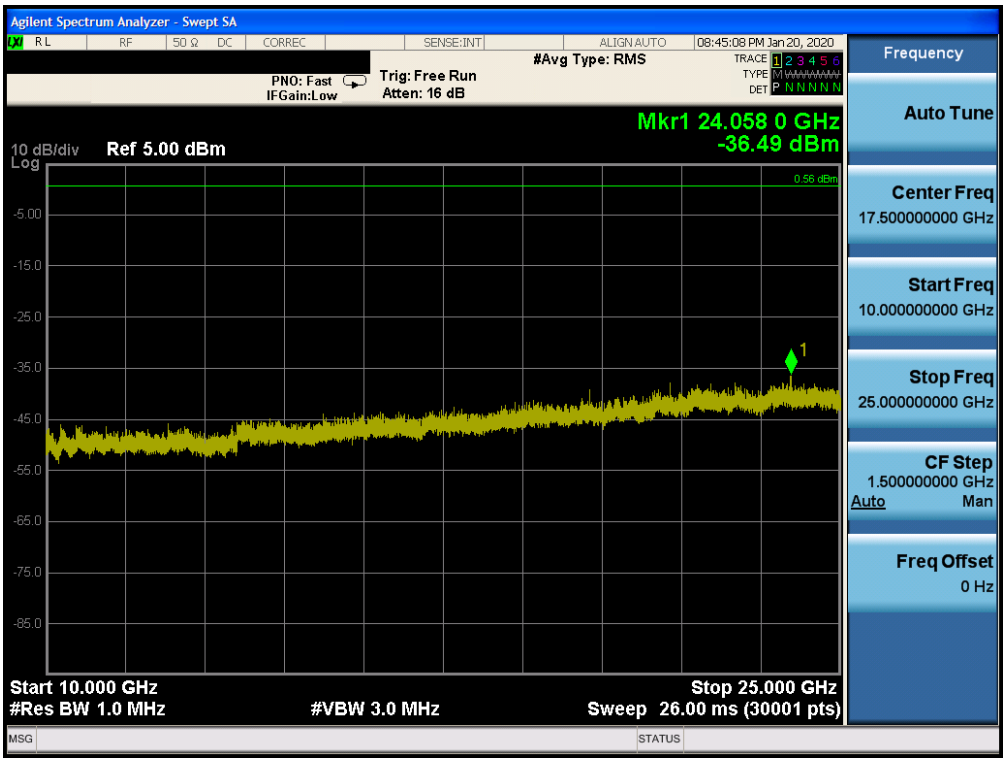
Plot 7-71. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



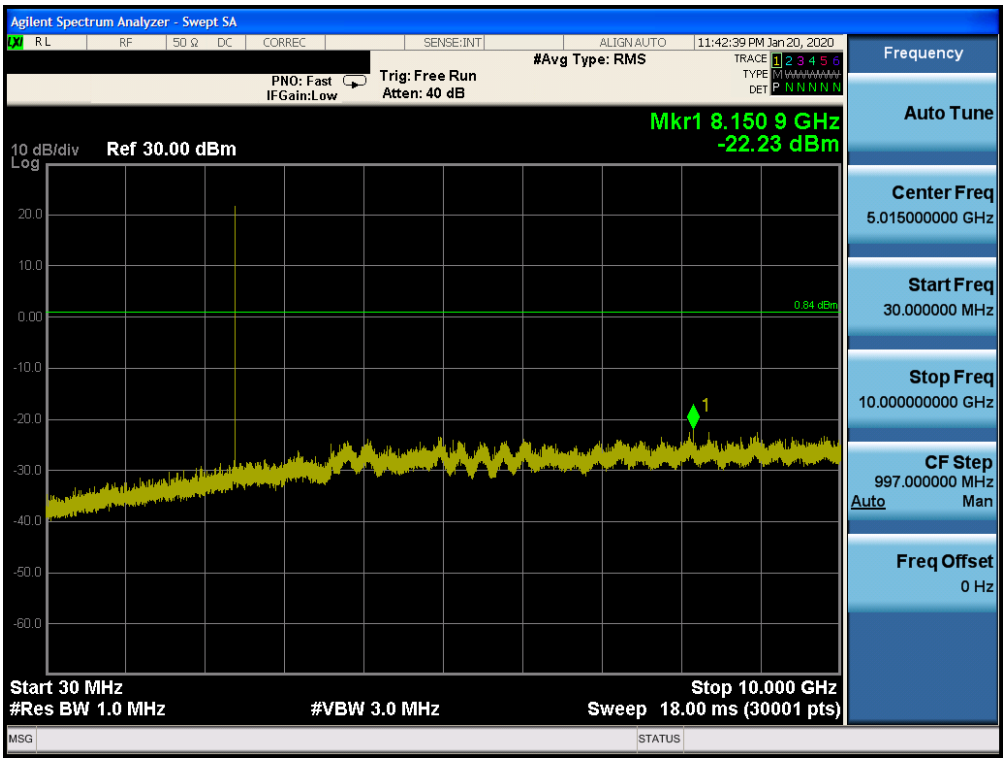
Plot 7-72. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



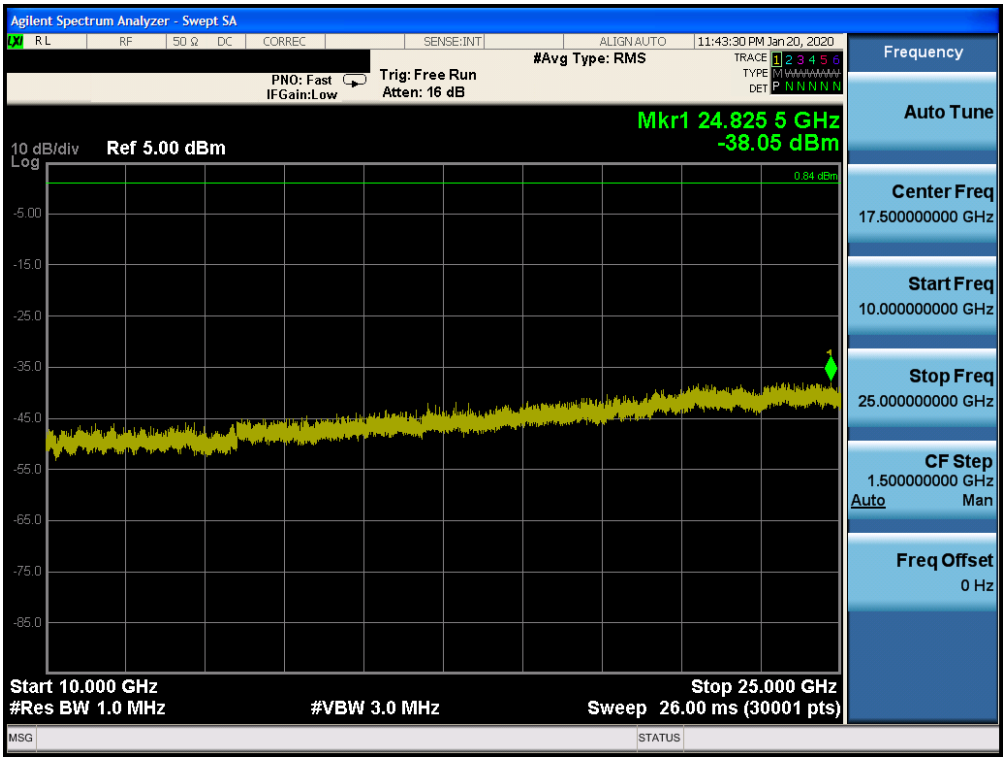
Plot 7-73. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



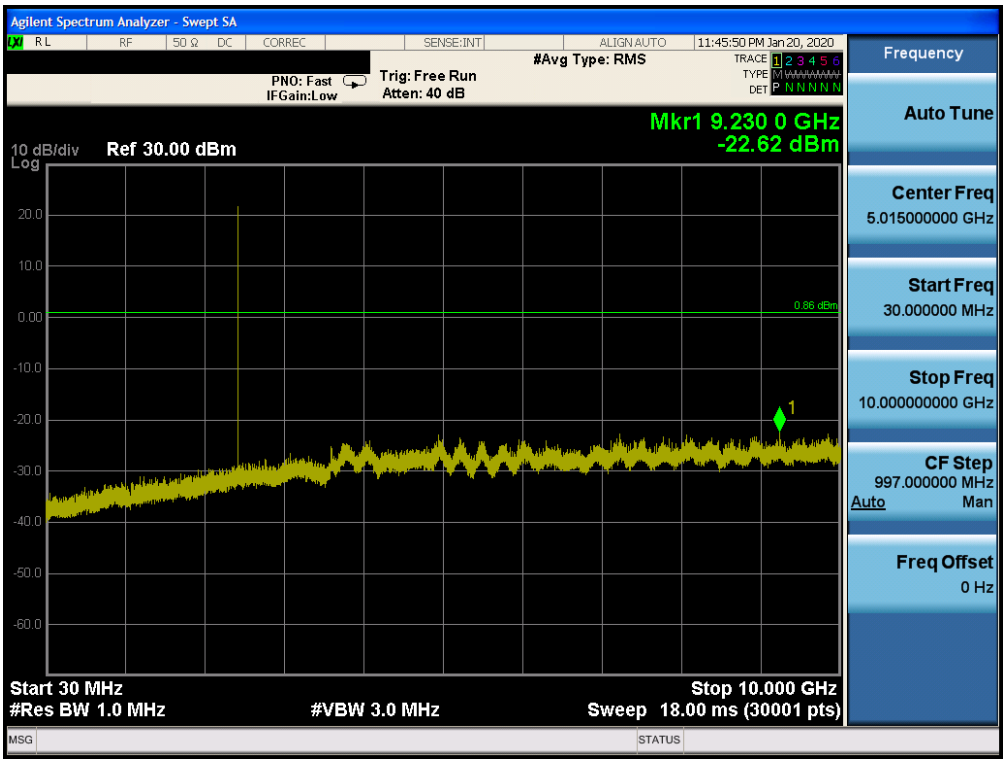
Plot 7-74. Conducted Spurious Plot Ant WF8 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



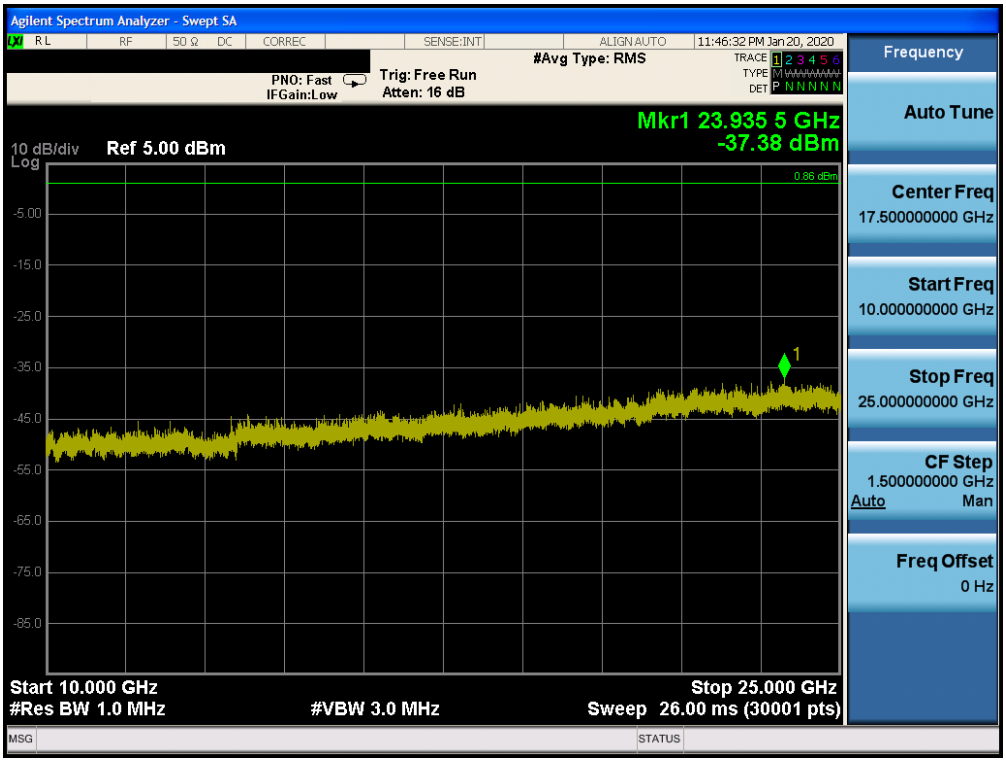
Plot 7-75. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



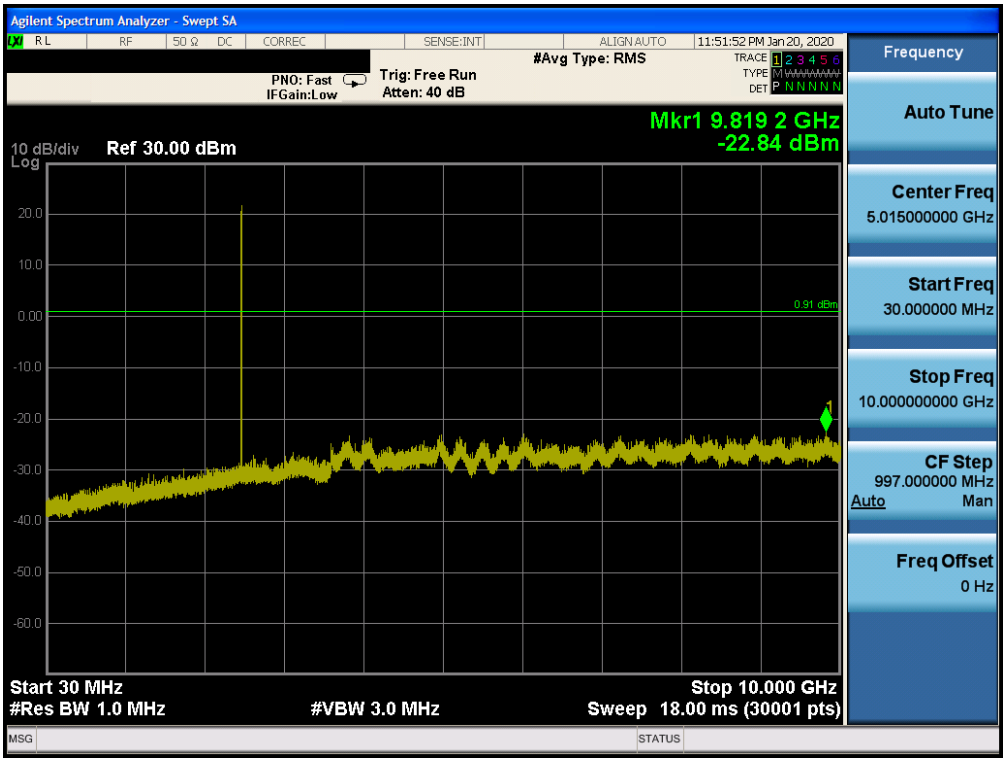
Plot 7-76. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 0)



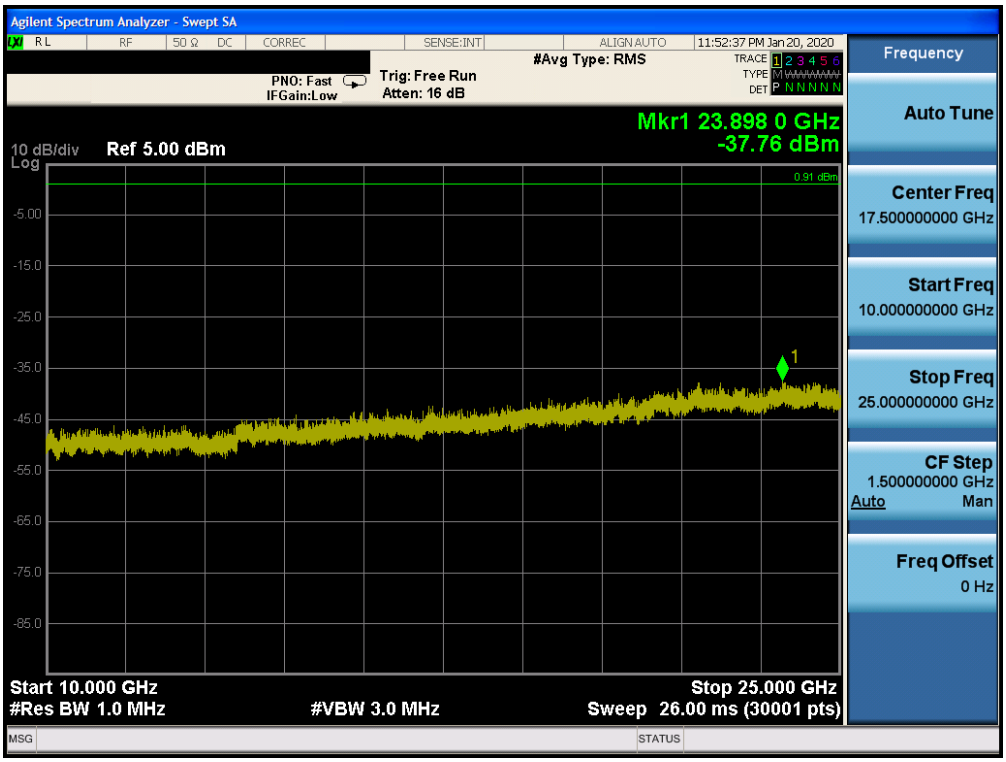
Plot 7-77. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



Plot 7-78. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 19)



Plot 7-79. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)



Plot 7-80. Conducted Spurious Plot Ant WF7 (Bluetooth (LE), 1Mbps, ePA – Ch. 39)

7.7 Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

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 and Table 7 of RSS-Gen (8.10) must not exceed the limits shown in Table 7-13 per Section 15.209 and RSS-Gen (8.9).

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

Table 7-13. Radiated Limits

Test Procedures Used

ANSI C63.10-2013 – Section 6.6.4.3

KDB 558074 D01 v05r02 – Section 8.6, 8.7

Test Settings

Average Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = power average (RMS)
5. Number of measurement points = 1001 (Number of points must be ≥ 2 x span/RBW)
6. Sweep time = auto
7. Trace (RMS) averaging was performed over at least 100 traces

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
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.

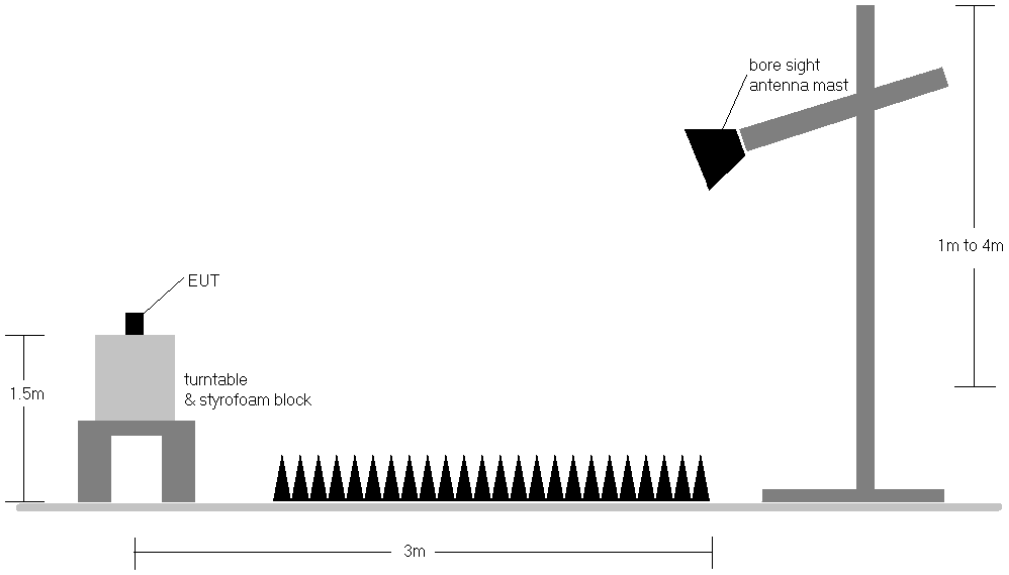


Figure 7-6. Radiated Test Setup >1GHz

Test Notes

1. The optional test procedures for antenna port conducted measurements of unwanted emissions per the guidance of KDB 558074 D01 v05r02 were not used to evaluate this device for compliance to radiated limits. All radiated spurious emissions levels were measured in a radiated test setup.
2. All emissions lying in restricted bands specified in §15.205 and Section 8.10 of RSS-Gen are below the limit shown in Table 7-13.
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 of the fundamental frequency of the transmitter using CISPR quasi peak detector below 1GHz. Above 1 GHz, average and peak measurements were taken using linearly polarized horn antennas. The worst-case emissions are reported however emissions whose levels were not within 20dB of the respective limits were not reported.
6. Emissions below 18GHz were measured at a 3 meter test distance while emissions above 18GHz were measured at a 1 meter test distance with the application of a distance correction factor.
7. The "-" shown in the following RSE tables are used to denote a noise floor measurement.
8. The unit was tested with all possible mode and power schemes and only the highest emission is reported.

Sample Calculations

Determining Spurious Emissions Levels

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

Radiated Band Edge Measurement Offset

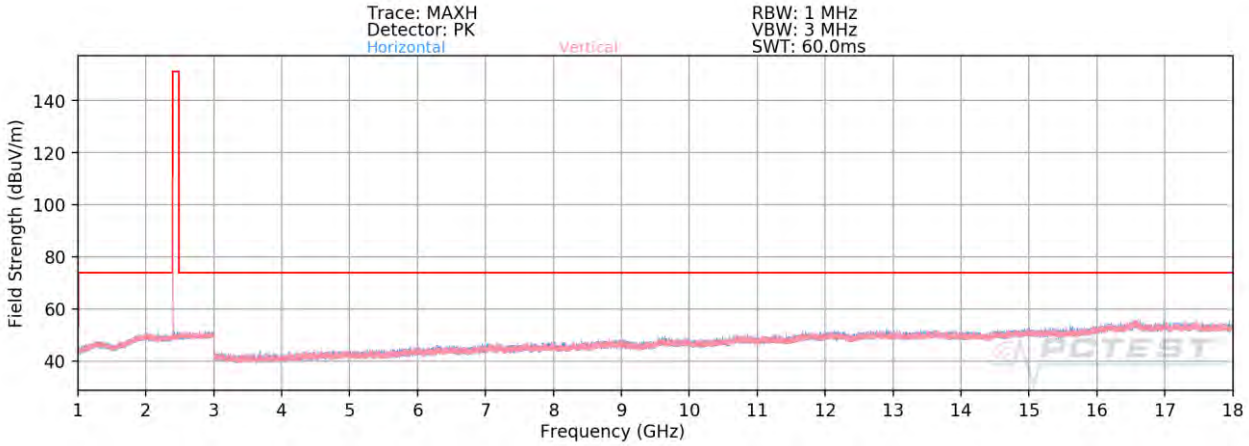
- The amplitude offset shown in the radiated restricted band edge plots in Section 7.8 was calculated using the formula:

  Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

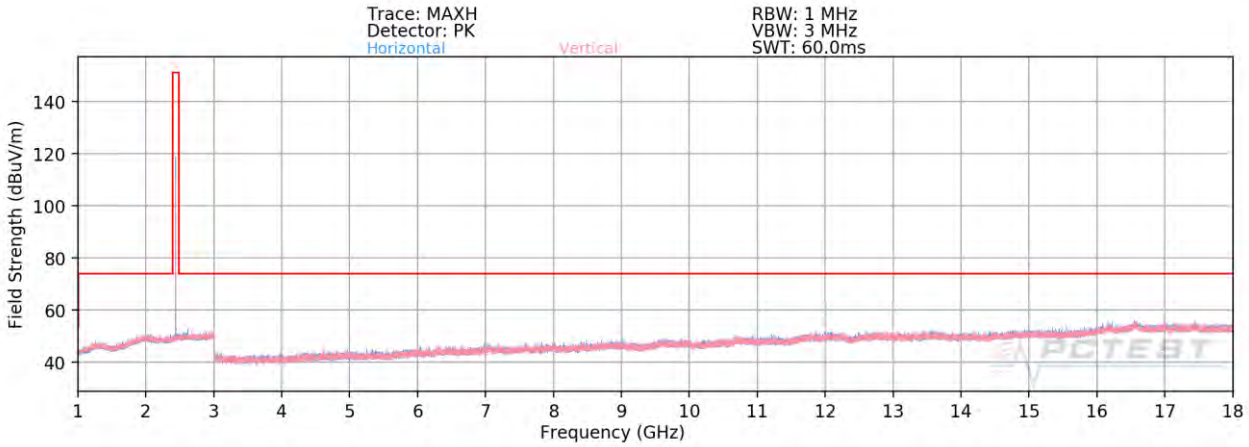
Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

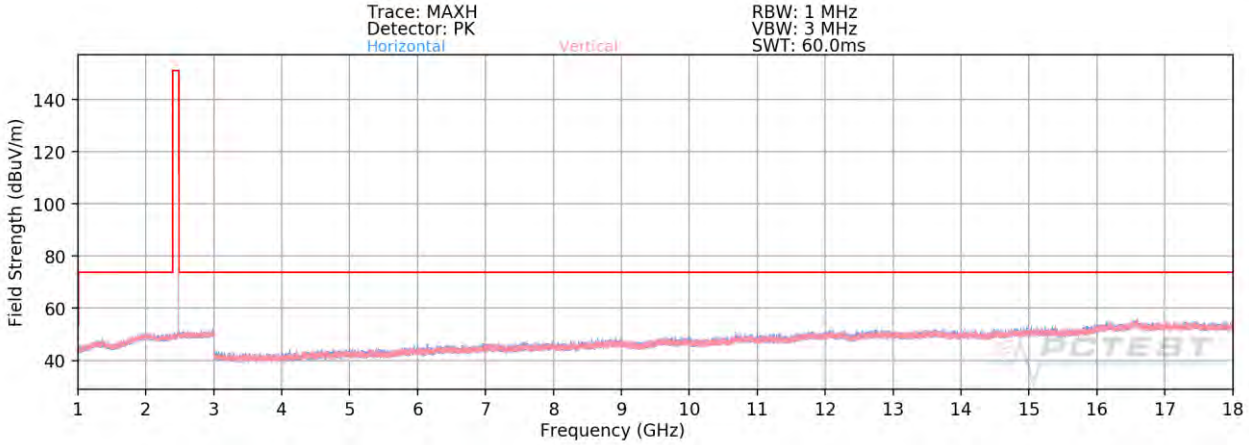
Antenna WF8



Plot 7-81. Radiated Spurious Plot Above 1GHz Ant WF8 (1Mbps, ePA – Ch. 0)

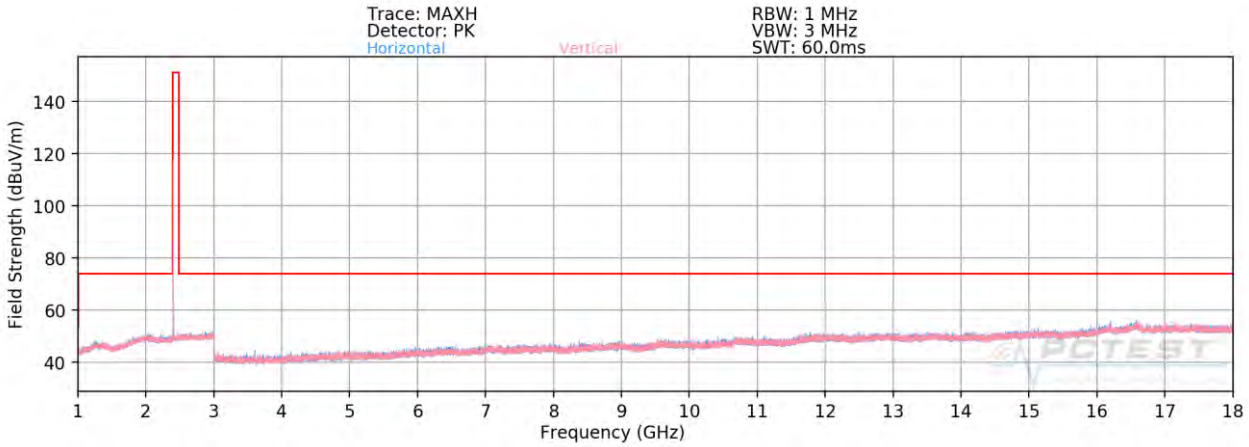


Plot 7-82. Radiated Spurious Plot Above 1GHz Ant WF8 (1Mbps, ePA – Ch. 19)

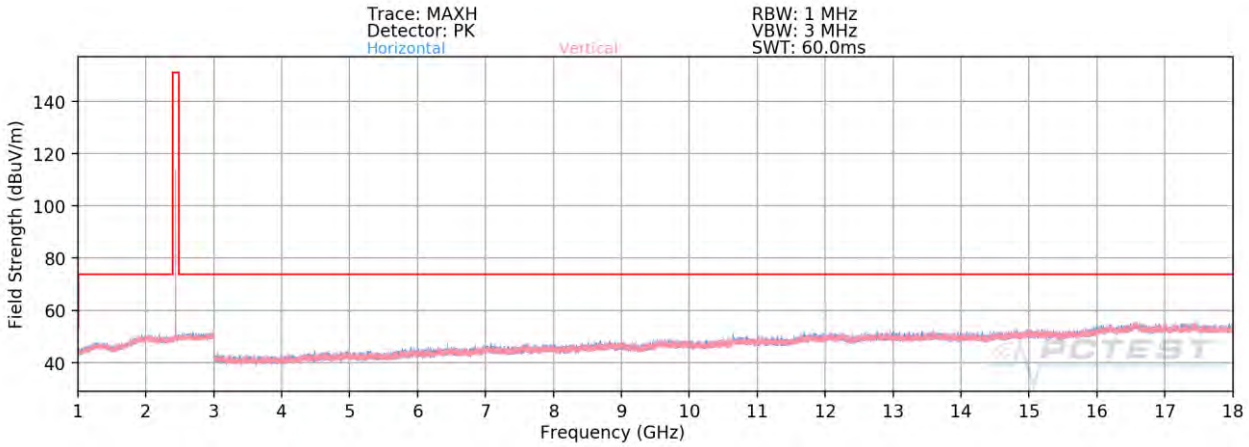


Plot 7-83. Radiated Spurious Plot Above 1GHz Ant WF8 (1Mbps, ePA – Ch. 39)

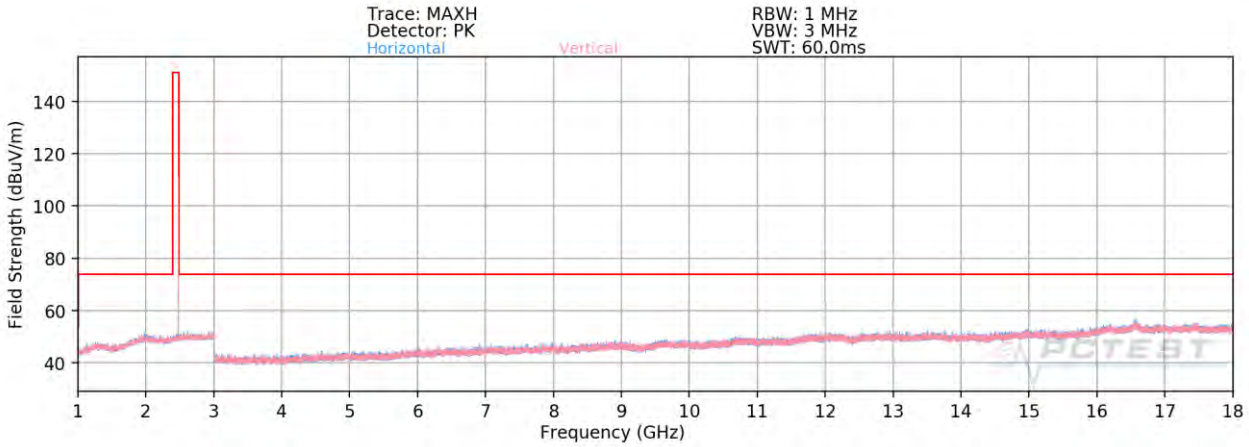
Antenna WF7



Plot 7-84. Radiated Spurious Plot Above 1GHz Ant WF7 (1Mbps, ePA – Ch. 0)



Plot 7-85. Radiated Spurious Plot Above 1GHz Ant WF7 (1Mbps, ePA – Ch. 19)

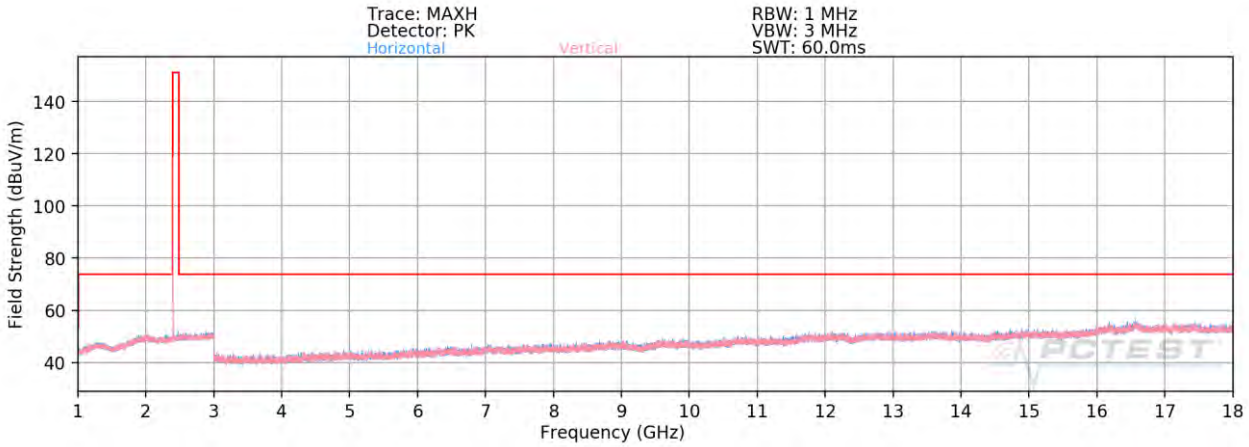


Plot 7-86. Radiated Spurious Plot Above 1GHz Ant WF7 (1Mbps, ePA – Ch. 39)

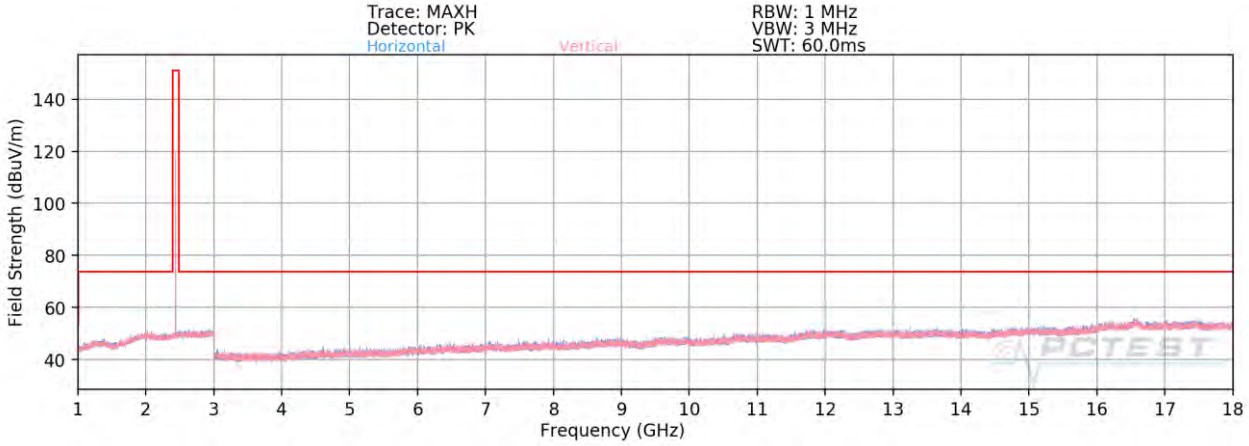
Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

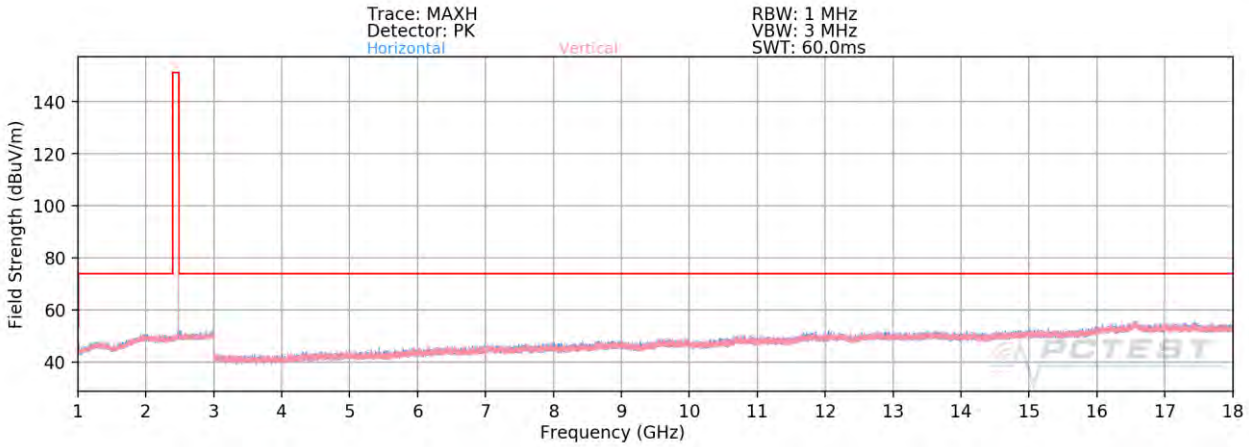
TxBF



Plot 7-87. Radiated Spurious Plot Above 1GHz TXBF (1Mbps, ePA – Ch. 0)



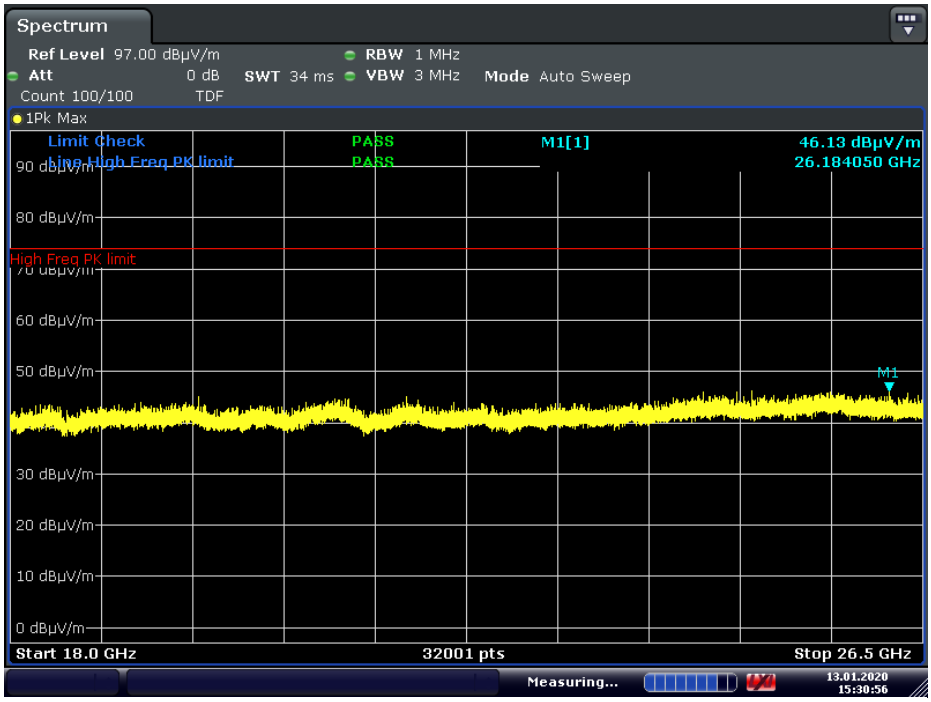
Plot 7-88. Radiated Spurious Plot Above 1GHz TXBF (1Mbps, ePA – Ch. 19)



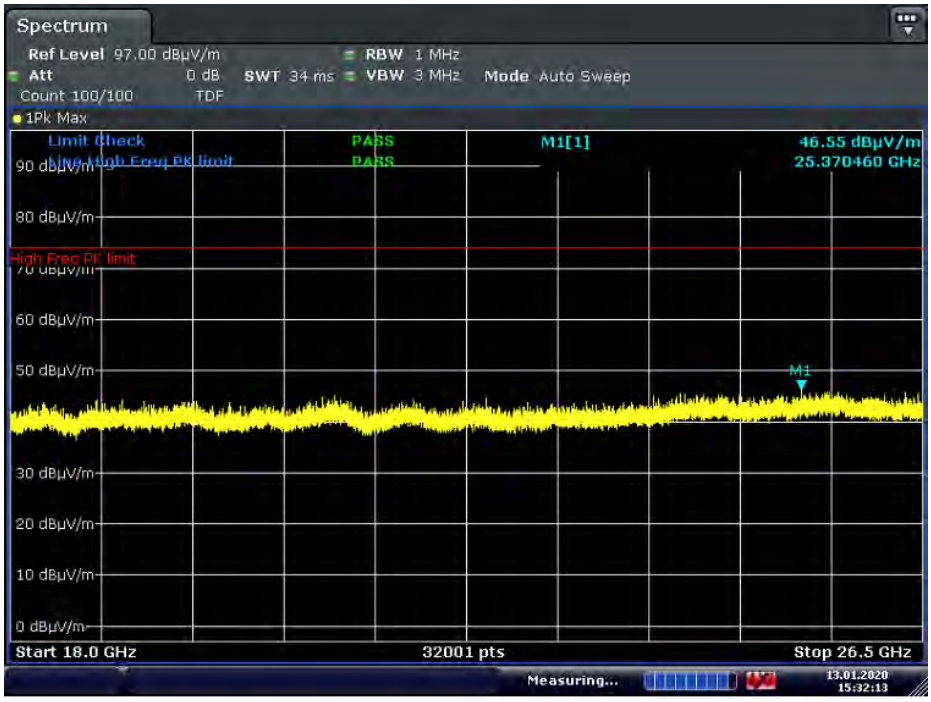
Plot 7-89. Radiated Spurious Plot Above 1GHz TXBF (1Mbps, ePA – Ch. 39)

Radiated Spurious Emission Measurements (Above 18GHz)

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]



Plot 7-90. Radiated Spurious Plot Above 18GHz TxBF (1Mbps, ePA, Ant. Pol. H)



Plot 7-91. Radiated Spurious Plot Above 18GHz TxBF (1Mbps, ePA, Ant. Pol. V)

Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

Antenna WF8

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2402MHz
Channel: 0

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]
4804.00	Avg	H	-	-	-79.76	5.39	32.63	53.98	-21.35
4804.00	Peak	H	-	-	-68.03	5.39	44.36	73.98	-29.62
12010.00	Avg	H	-	-	-82.85	14.50	38.65	53.98	-15.33
12010.00	Peak	H	-	-	-70.93	14.50	50.57	73.98	-23.41

Table 7-14. Radiated Measurements

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2440MHz
Channel: 19

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]
4880.00	Avg	H	-	-	-79.74	5.46	32.72	53.98	-21.26
4880.00	Peak	H	-	-	-68.68	5.46	43.78	73.98	-30.20
7320.00	Avg	H	-	-	-81.10	9.01	34.91	53.98	-19.07
7320.00	Peak	H	-	-	-69.61	9.01	46.40	73.98	-27.58
12200.00	Avg	H	-	-	-82.55	14.91	39.36	53.98	-14.62
12200.00	Peak	H	-	-	-70.76	14.91	51.15	73.98	-22.83

Table 7-15. Radiated Measurements

Bluetooth Mode:	LE
Distance of Measurements:	3 Meters
Operating Frequency:	2480MHz
Channel:	39

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]
4960.00	Avg	H	-	-	-80.06	6.16	33.10	53.98	-20.88
4960.00	Peak	H	-	-	-68.07	6.16	45.09	73.98	-28.89
7440.00	Avg	H	-	-	-81.65	9.86	35.21	53.98	-18.77
7440.00	Peak	H	-	-	-70.00	9.86	46.86	73.98	-27.12
12400.00	Avg	H	-	-	-83.47	14.54	38.07	53.98	-15.91
12400.00	Peak	H	-	-	-71.99	14.54	49.55	73.98	-24.43

Table 7-16. Radiated Measurements

Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

Antenna WF7

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2402MHz
Channel: 0

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]
4804.00	Avg	V	-	-	-79.71	5.39	32.68	53.98	-21.30
4804.00	Peak	V	-	-	-68.44	5.39	43.95	73.98	-30.03
12010.00	Avg	V	-	-	-82.82	14.50	38.68	53.98	-15.30
12010.00	Peak	V	-	-	-71.68	14.50	49.82	73.98	-24.16

Table 7-17. Radiated Measurements

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2440MHz
Channel: 19

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]
4880.00	Avg	V	-	-	-79.74	5.46	32.72	53.98	-21.26
4880.00	Peak	V	-	-	-68.11	5.46	44.35	73.98	-29.63
7320.00	Avg	V	-	-	-81.22	9.01	34.79	53.98	-19.19
7320.00	Peak	V	-	-	-69.84	9.01	46.17	73.98	-27.81
12200.00	Avg	V	-	-	-82.63	14.91	39.28	53.98	-14.70
12200.00	Peak	V	-	-	-70.92	14.91	50.99	73.98	-22.99

Table 7-18. Radiated Measurements

Bluetooth Mode:	LE
Distance of Measurements:	3 Meters
Operating Frequency:	2480MHz
Channel:	39

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]
4960.00	Avg	V	-	-	-80.15	6.16	33.01	53.98	-20.97
4960.00	Peak	V	-	-	-68.65	6.16	44.51	73.98	-29.47
7440.00	Avg	V	-	-	-81.79	9.86	35.07	53.98	-18.91
7440.00	Peak	V	-	-	-70.37	9.86	46.49	73.98	-27.49
12400.00	Avg	V	-	-	-83.43	14.54	38.11	53.98	-15.87
12400.00	Peak	V	-	-	-71.52	14.54	50.02	73.98	-23.96

Table 7-19. Radiated Measurements

Radiated Spurious Emission Measurements

§15.205 §15.209 §15.247(d); RSS-Gen [8.9]

TxBF

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2402MHz
Channel: 0

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]
4804.00	Avg	V	-	-	-79.60	5.39	32.79	53.98	-21.19
4804.00	Peak	V	-	-	-67.83	5.39	44.56	73.98	-29.42
12010.00	Avg	V	-	-	-82.81	14.50	38.69	53.98	-15.29
12010.00	Peak	V	-	-	-71.25	14.50	50.25	73.98	-23.73

Table 7-20. Radiated Measurements

Bluetooth Mode: LE
Distance of Measurements: 3 Meters
Operating Frequency: 2440MHz
Channel: 19

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]
4880.00	Avg	V	-	-	-79.92	5.46	32.54	53.98	-21.44
4880.00	Peak	V	-	-	-68.02	5.46	44.44	73.98	-29.54
7320.00	Avg	V	-	-	-81.21	9.01	34.80	53.98	-19.18
7320.00	Peak	V	-	-	-69.55	9.01	46.46	73.98	-27.52
12200.00	Avg	V	-	-	-82.58	14.91	39.33	53.98	-14.65
12200.00	Peak	V	-	-	-71.50	14.91	50.41	73.98	-23.57

Table 7-21. Radiated Measurements

Bluetooth Mode:	LE
Distance of Measurements:	3 Meters
Operating Frequency:	2480MHz
Channel:	39

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]
4960.00	Avg	V	-	-	-80.11	6.16	33.05	53.98	-20.93
4960.00	Peak	V	-	-	-69.03	6.16	44.13	73.98	-29.85
7440.00	Avg	V	-	-	-81.78	9.86	35.08	53.98	-18.90
7440.00	Peak	V	-	-	-70.44	9.86	46.42	73.98	-27.56
12400.00	Avg	V	-	-	-83.55	14.54	37.99	53.98	-15.99
12400.00	Peak	V	-	-	-71.99	14.54	49.55	73.98	-24.43

Table 7-22. Radiated Measurements

7.8 Radiated Restricted Band Edge Measurements

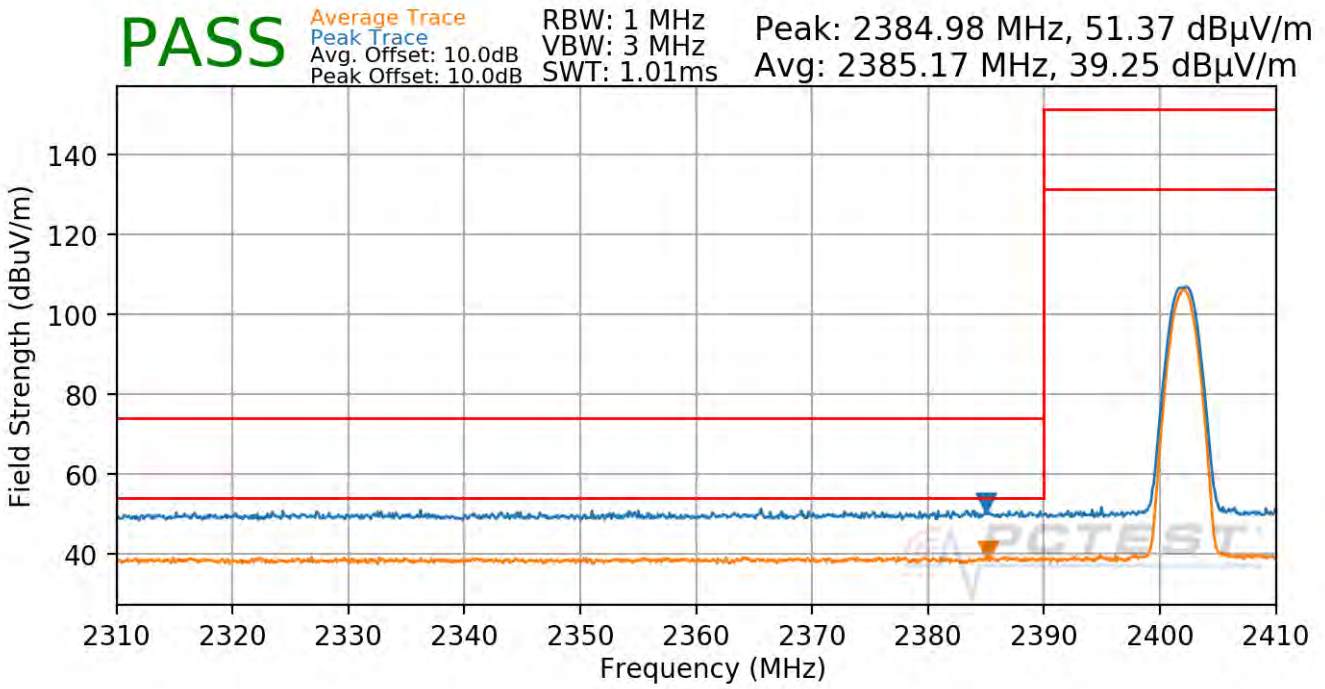
§15.205 §15.209; RSS-Gen [8.9]

The radiated restricted band edge measurements are measured with an EMI test receiver connected to the receive antenna while the EUT is transmitting.

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2402MHz
Channel:	0



Plot 7-92. Radiated Restricted Lower Band Edge Measurement Ant WF8 (Average & Peak)

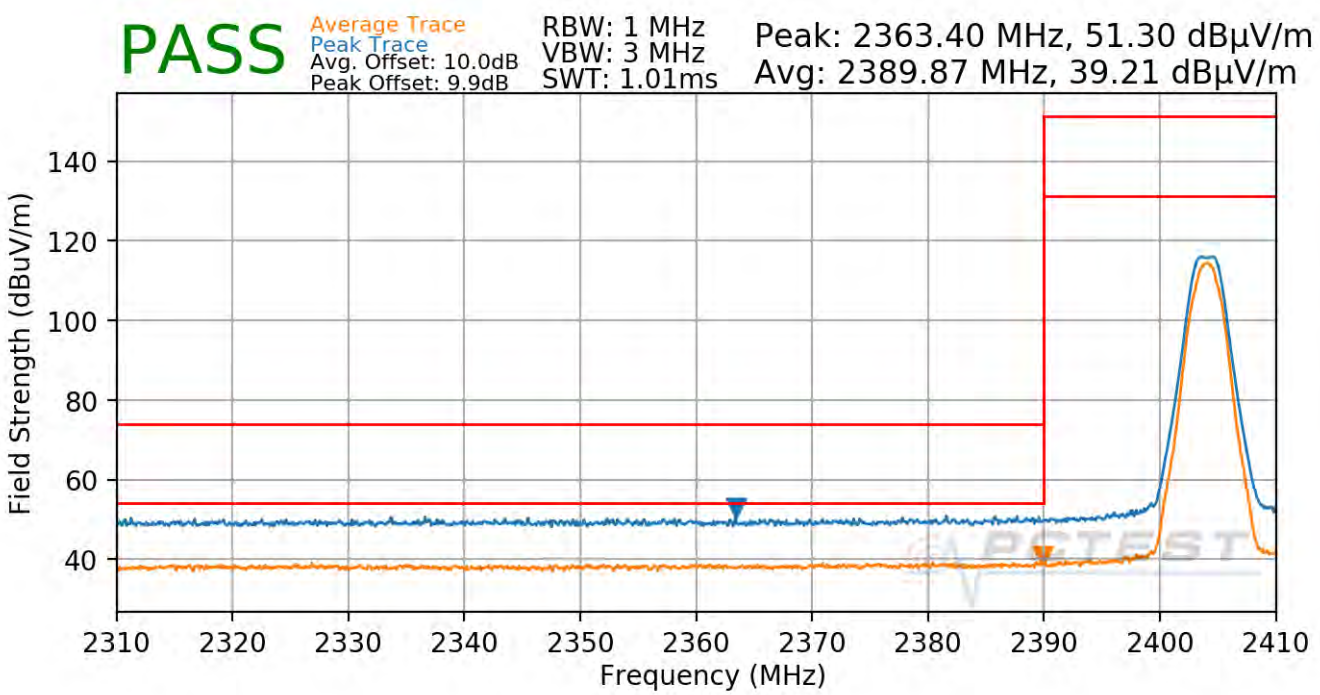
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2404MHz
Channel:	1



Plot 7-93. Radiated Restricted Lower Band Edge Measurement Ant WF8 (Average & Peak)

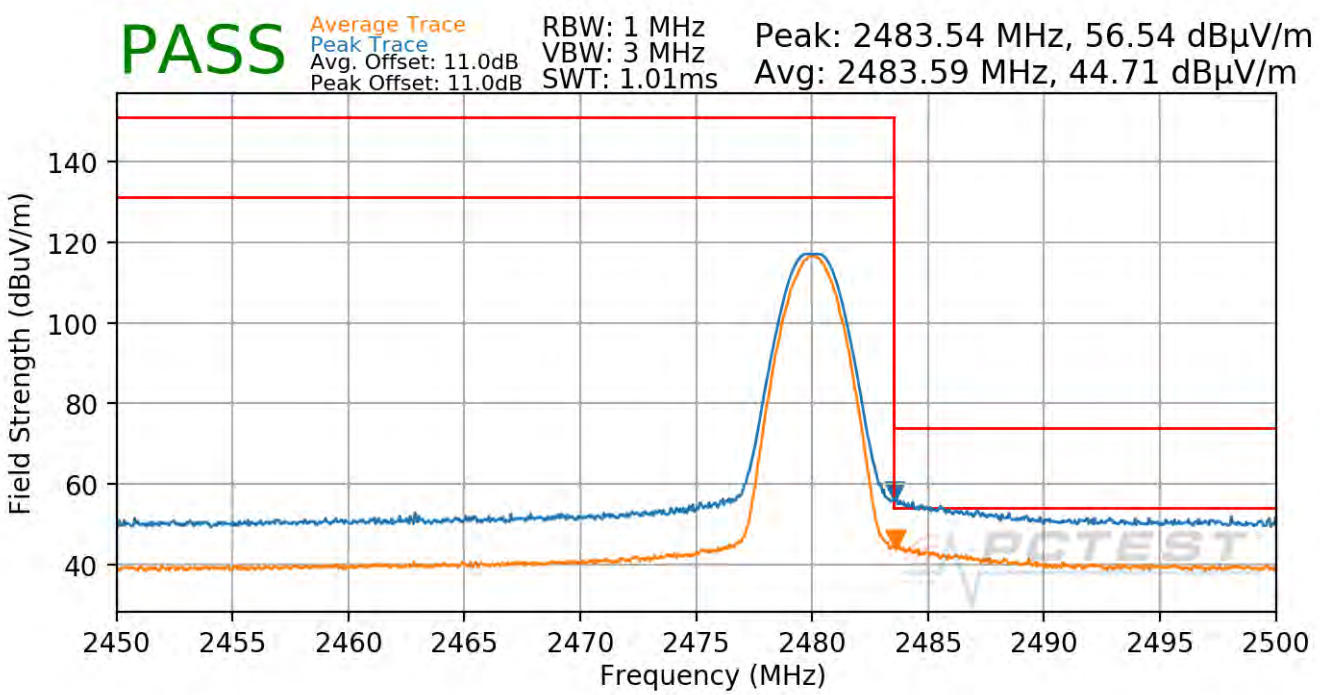
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2480MHz
Channel:	39



Plot 7-94. Radiated Restricted Upper Band Edge Measurement Ant WF8 (Average & Peak)

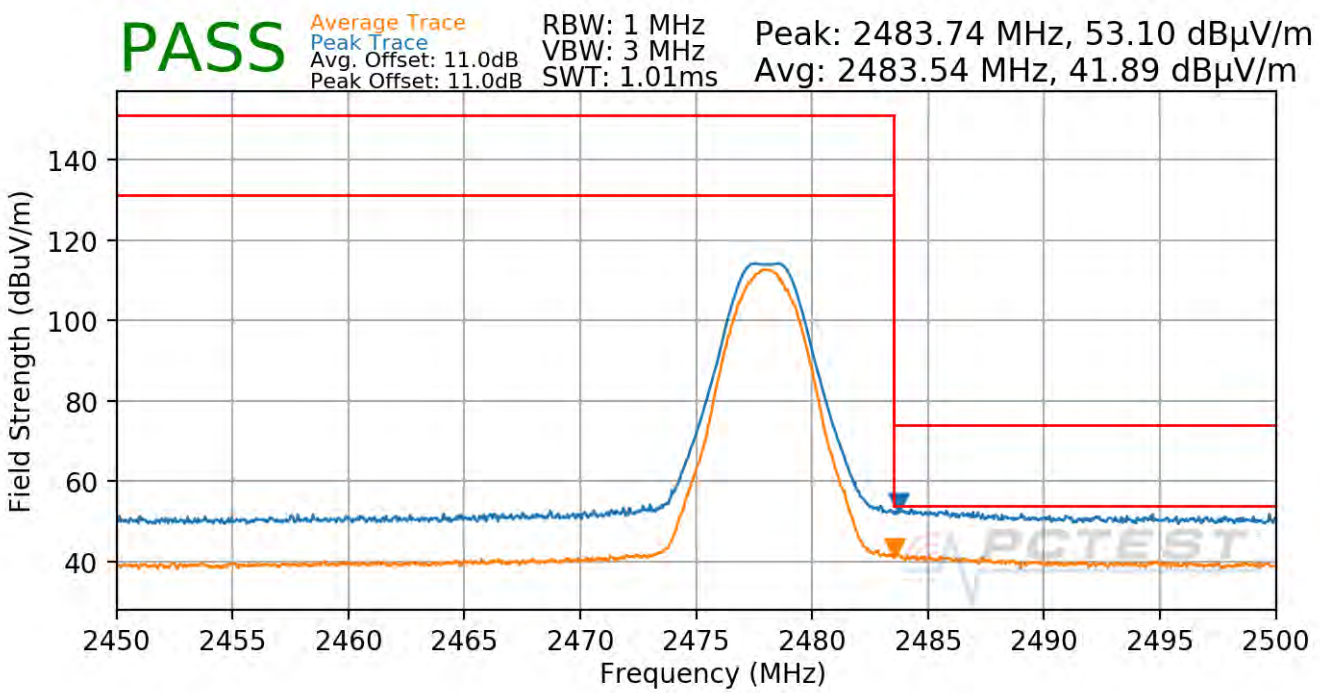
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2478MHz
Channel:	38



Plot 7-95. Radiated Restricted Upper Band Edge Measurement Ant WF8 (Average & Peak)

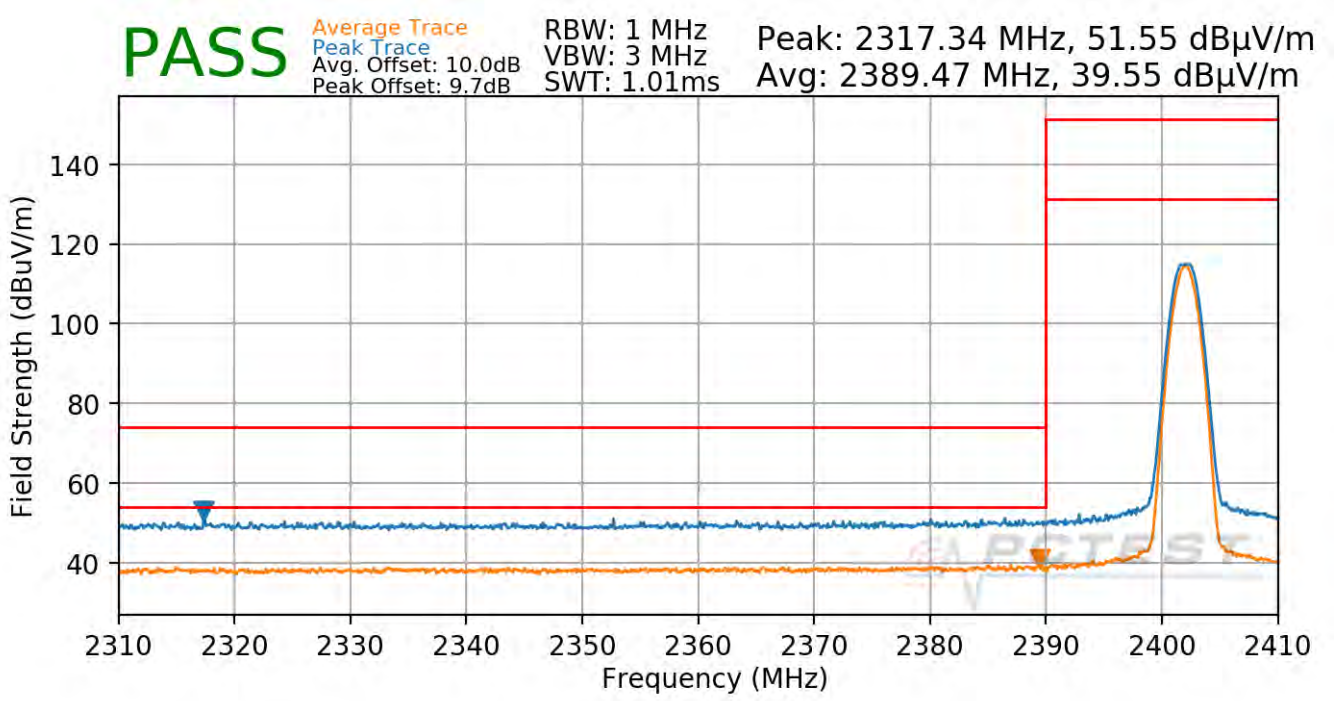
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2402MHz
Channel:	0



Plot 7-96. Radiated Restricted Lower Band Edge Measurement Ant WF7 (Average & Peak)

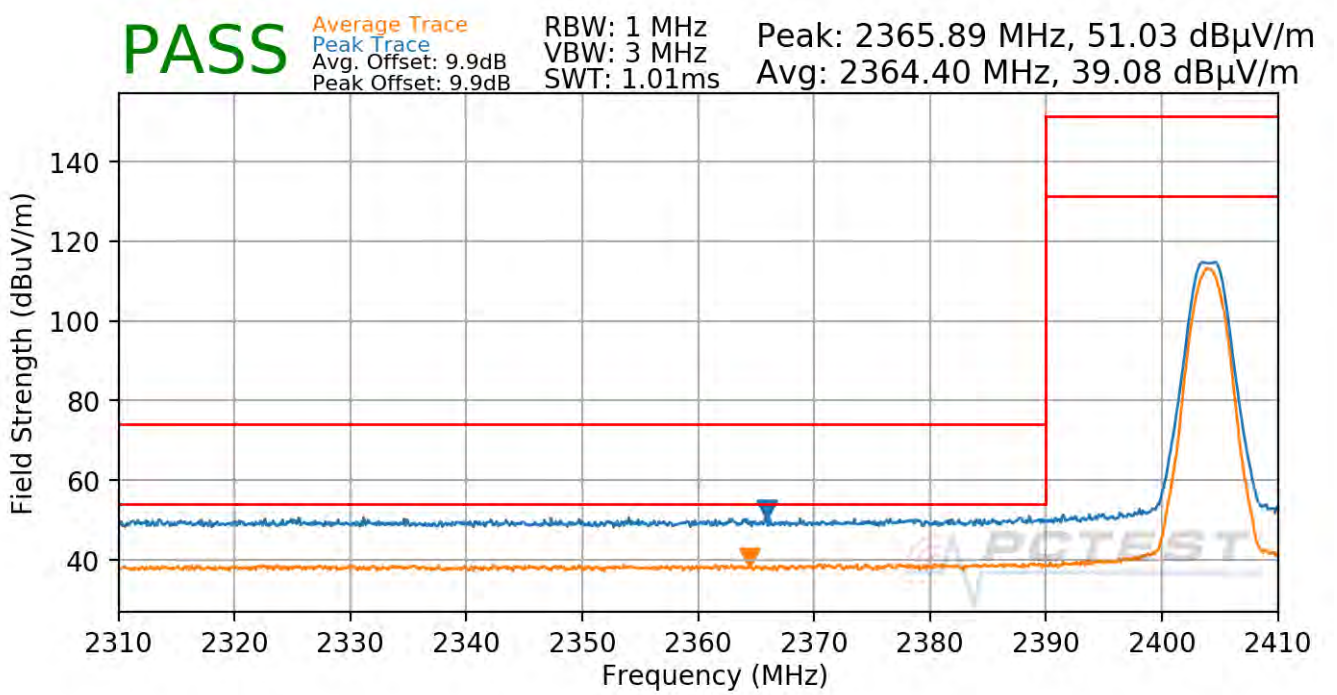
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2404MHz
Channel:	1



Plot 7-97. Radiated Restricted Lower Band Edge Measurement Ant WF7 (Average & Peak)

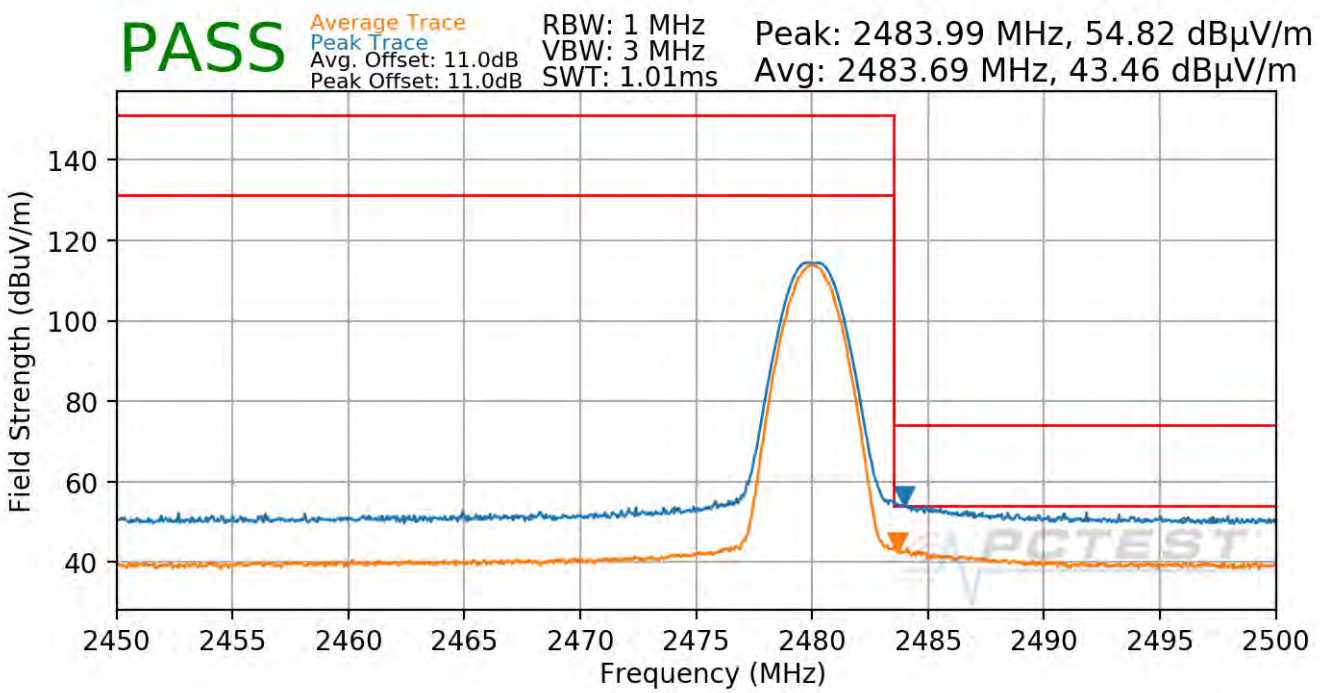
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2480MHz
Channel:	39



Plot 7-98. Radiated Restricted Upper Band Edge Measurement Ant WF7 (Average & Peak)

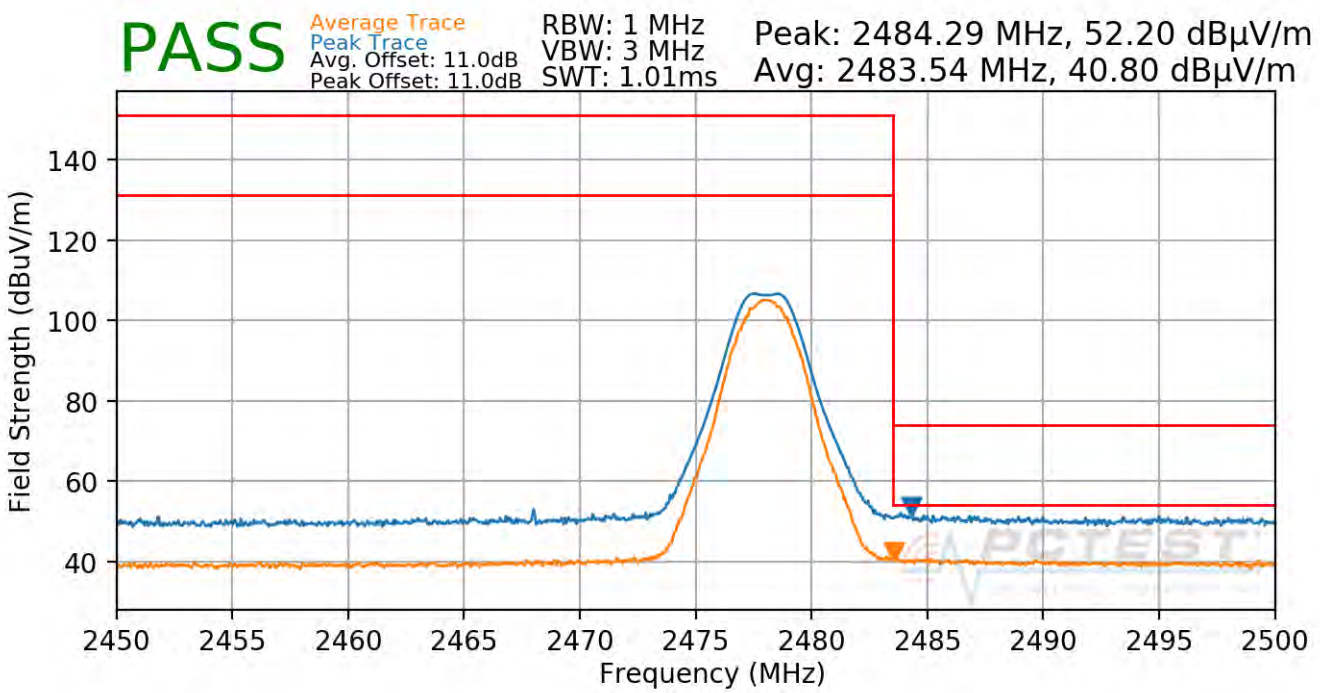
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2478MHz
Channel:	38



Plot 7-99. Radiated Restricted Upper Band Edge Measurement Ant WF7 (Average & Peak)

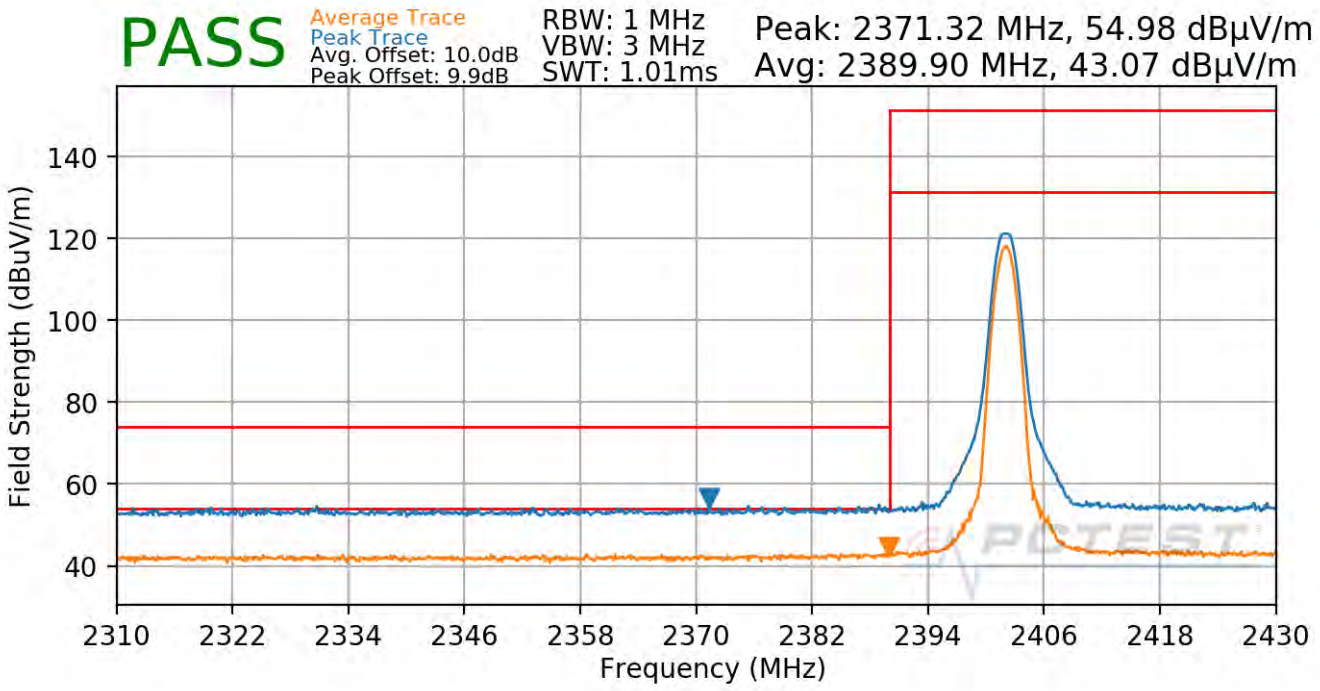
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2402MHz
Channel:	0



Plot 7-100. Radiated Restricted Lower Band Edge Measurement TXBF (Average & Peak)

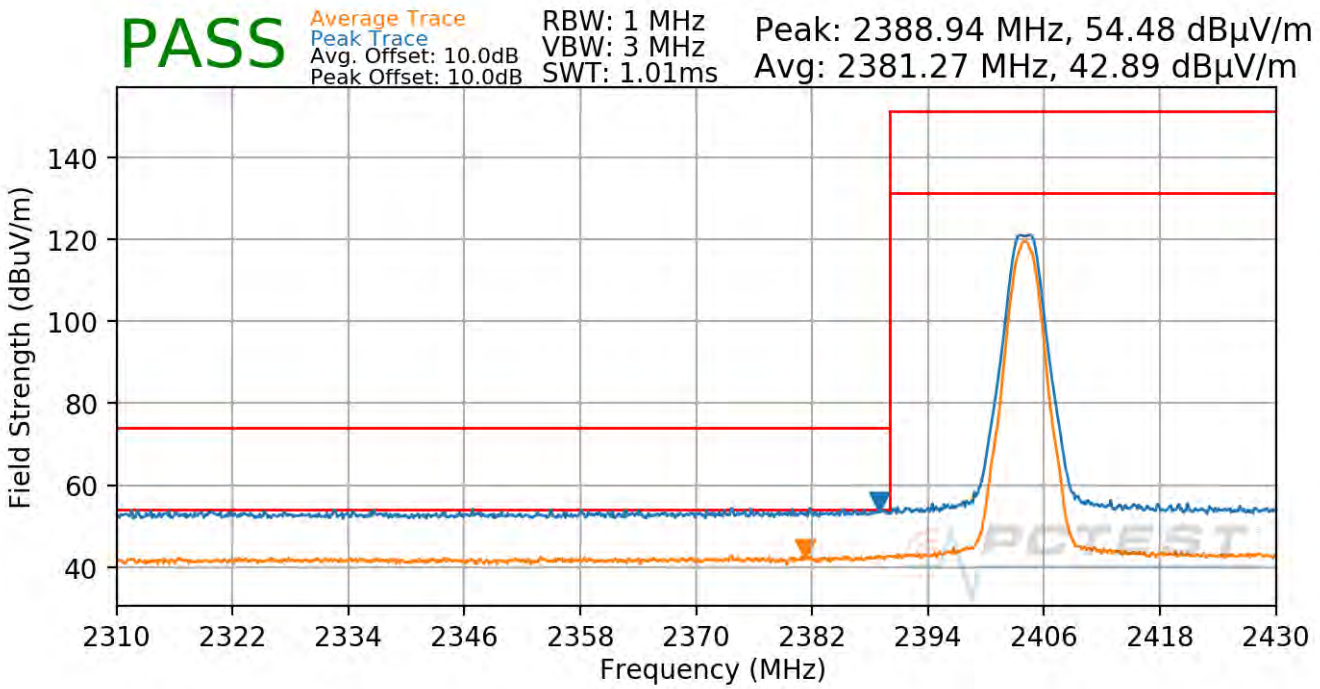
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2404MHz
Channel:	1



Plot 7-101. Radiated Restricted Lower Band Edge Measurement TXBF (Average & Peak)

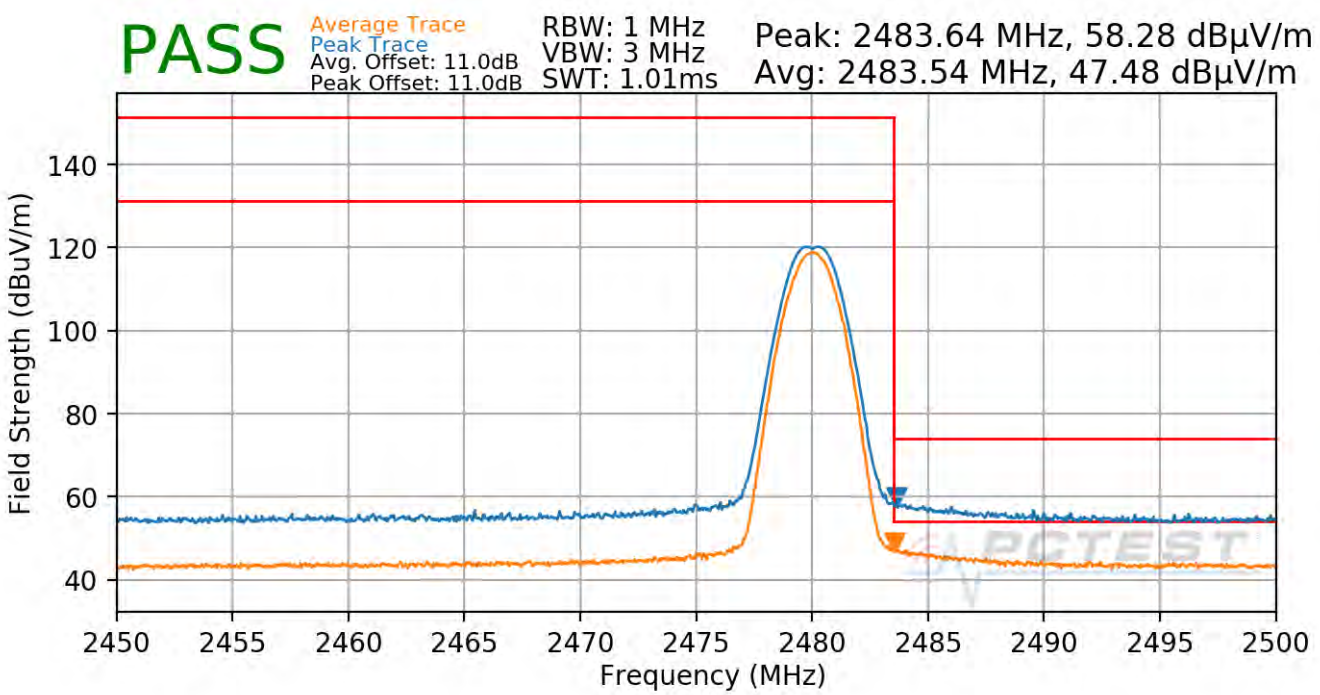
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	1 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2480MHz
Channel:	39



Plot 7-102. Radiated Restricted Upper Band Edge Measurement TXBF (Average & Peak)

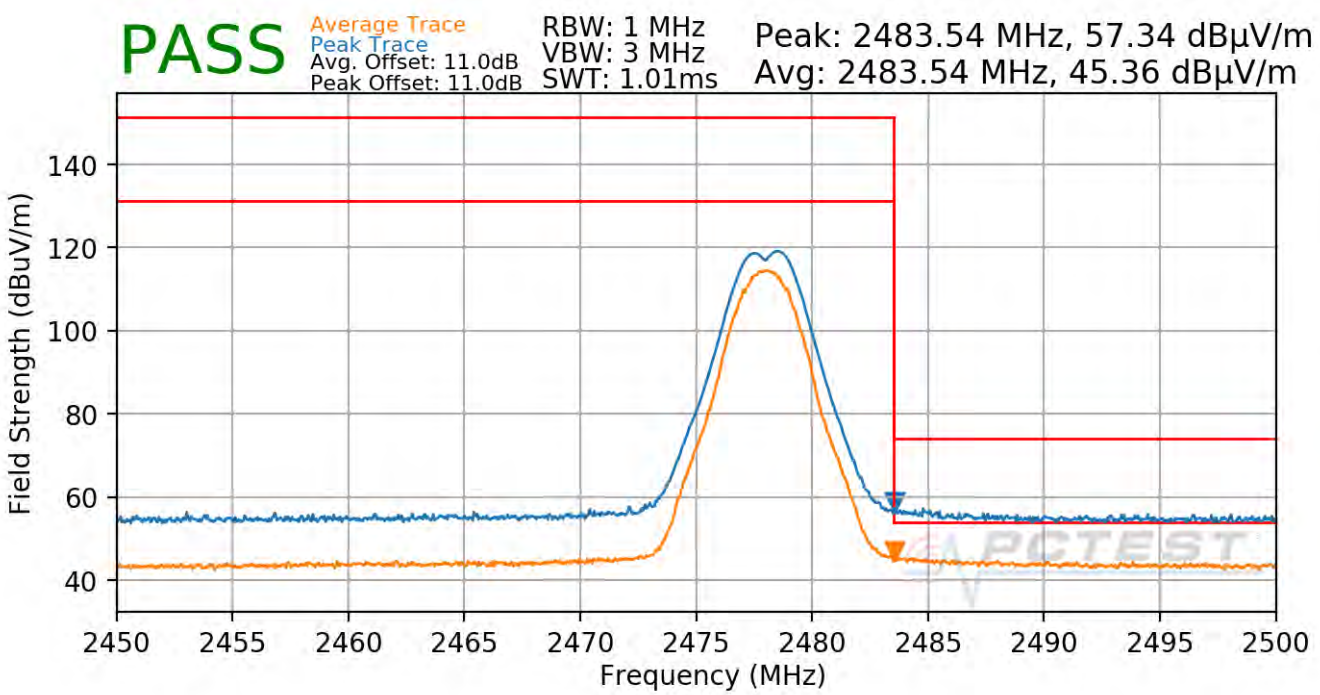
Radiated Restricted Band Edge Measurements

§15.205 §15.209; RSS-Gen [8.9]

The amplitude offset shown in the following plots for average measurements was calculated using the formula:

Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain

Bluetooth Mode:	LE
Modulation:	GFSK
Data Rate:	2 Mbps
Measurement Distance:	3 Meters
Operating Frequency:	2478MHz
Channel:	38



Plot 7-103. Radiated Restricted Upper Band Edge Measurement TXBF (Average & Peak)

7.9 Radiated Spurious Emissions Measurements – Below 1GHz

§15.209; RSS-Gen [8.9]

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 its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates and modes were investigated for radiated spurious emissions. 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 and Table 7 of RSS-Gen (8.10) must not exceed the limits shown in Table 7-10 per Section 15.209 and RSS-Gen (8.9).

Frequency	Field Strength [μV/m]	Measured Distance [Meters]
0.009 – 0.490 MHz	2400/F (kHz)	300
0.490 – 1.705 MHz	24000/F (kHz)	30
1.705 – 30.00 MHz	30	30
30.00 – 88.00 MHz	100	3
88.00 – 216.0 MHz	150	3
216.0 – 960.0 MHz	200	3
Above 960.0 MHz	500	3

Table 7-23. Radiated Limits

Test Procedures Used

ANSI C63.10-2013

Test Settings

Quasi-Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 120kHz (for emissions from 30MHz – 1GHz)
3. Detector = quasi-peak
4. Sweep time = auto couple
5. Trace mode = max hold
6. Trace was allowed to stabilize

Quasi-Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 120kHz (for emissions from 30MHz – 1GHz)
3. VBW = 300kHz
4. Detector = quasi-peak
5. Sweep time = auto couple
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 diagrams below.

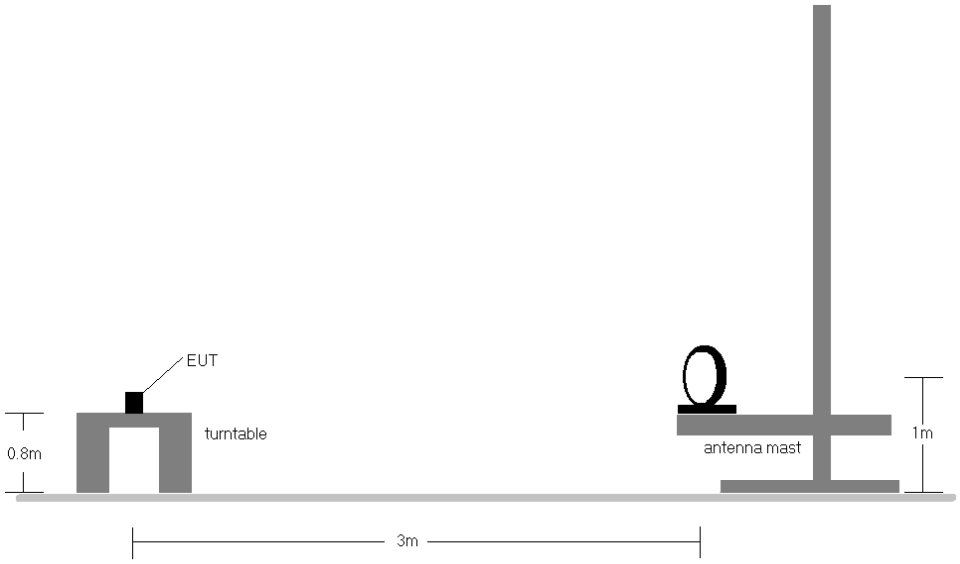


Figure 7-7. Radiated Test Setup < 30MHz

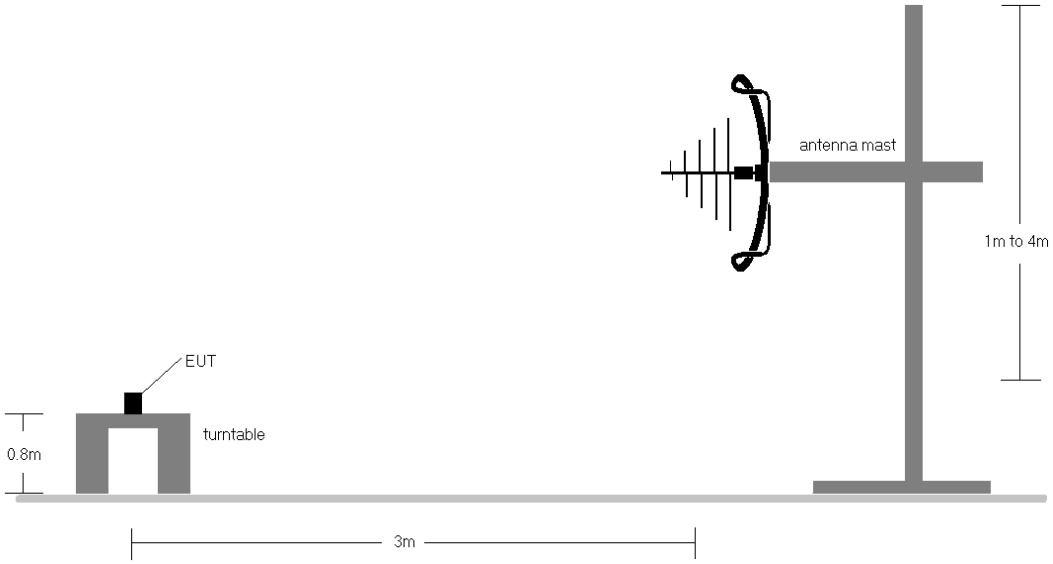


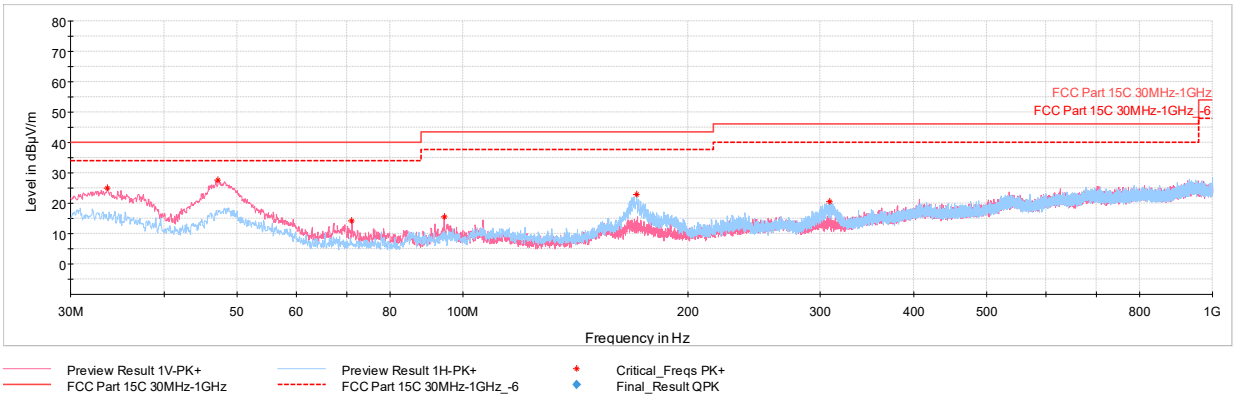
Figure 7-8. Radiated Test Setup < 1GHz

Test Notes

1. All emissions lying in restricted bands specified in §15.205 are below the limit shown in Table 7-23.
2. The broadband receive antenna is manipulated through vertical and horizontal polarizations during the tests. The EUT is manipulated through three orthogonal planes.
3. This unit was tested with its standard battery.
4. The spectrum is investigated using a peak detector and final measurements are recorded using CISPR quasi peak detector on emissions within 6dB of the limit. The worst-case emissions are reported however emissions whose levels were not within 20dB of the respective limits were not reported.
5. Emissions were measured at a 3 meter test distance.
6. Emissions are investigated while operating on the center channel of the mode, band, and modulation that produced the worst case results during the transmitter spurious emissions testing.
7. No spurious emissions were detected within 20dB of the limit below 30MHz.
8. The results recorded using the broadband antenna is known to correlate with the results obtained by using a tuned dipole with an acceptable degree of accuracy. The VSWR for the measurement antenna was found to be less than 2:1.
9. The wide spectrum spurious emissions plots shown on the following pages are used only for the purpose of emission identification. There were no emissions detected in the 30MHz – 1GHz frequency range, as shown in the subsequent plots.
10. The unit was tested with all possible mode and power schemes and only the highest emission is reported.

Radiated Spurious Emissions Measurements (Below 1GHz)

§15.209; RSS-Gen [8.9]



Plot 7-104. Radiated Spurious Plot below 1GHz (1Mbps, ePA Ch.19 with AC/DC Adapter)

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]
33.59	Max Peak	V	100	237	-68.09	-13.79	25.12	40.00	-14.88
47.22	Max Peak	V	100	305	-58.51	-20.76	27.73	40.00	-12.27
71.18	Max Peak	V	100	102	-72.00	-20.85	14.15	40.00	-25.85
94.51	Max Peak	V	100	68	-71.16	-20.40	15.44	43.52	-28.08
170.55	Max Peak	H	100	93	-66.59	-17.54	22.87	43.52	-20.65
308.83	Max Peak	H	100	243	-73.21	-13.31	20.48	46.02	-25.54

Table 7-24. Radiated Spurious Emissions Below 1GHz (1Mbps, ePA Ch.19 with AC/DC Adapter)

7.10 AC Line-Conducted Test Data

§15.207; RSS-Gen [8.8]

Test Overview and Limit

All AC line conducted spurious emissions are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates and modes were investigated for conducted spurious emissions. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.

All conducted emissions must not exceed the limits shown in the table below, per Section 15.207 and RSS-Gen (8.8).

Frequency of emission (MHz)	Conducted Limit (dBμV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

Table 7-25. Conducted Limits

*Decreases with the logarithm of the frequency.

Test Procedures Used

ANSI C63.10-2013, Section 6.2

Test Settings

Quasi-Peak Field Strength Measurements

8. Analyzer center frequency was set to the frequency of the spurious emission of interest
9. RBW = 9kHz (for emissions from 150kHz – 30MHz)
10. Detector = quasi-peak
11. Sweep time = auto couple
12. Trace mode = max hold
13. Trace was allowed to stabilize

Average Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the spurious emission of interest
2. RBW = 9kHz (for emissions from 150kHz – 30MHz)
3. Detector = RMS
4. Sweep time = auto couple
5. Trace mode = max hold
6. Trace was allowed to stabilize

Test Setup

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

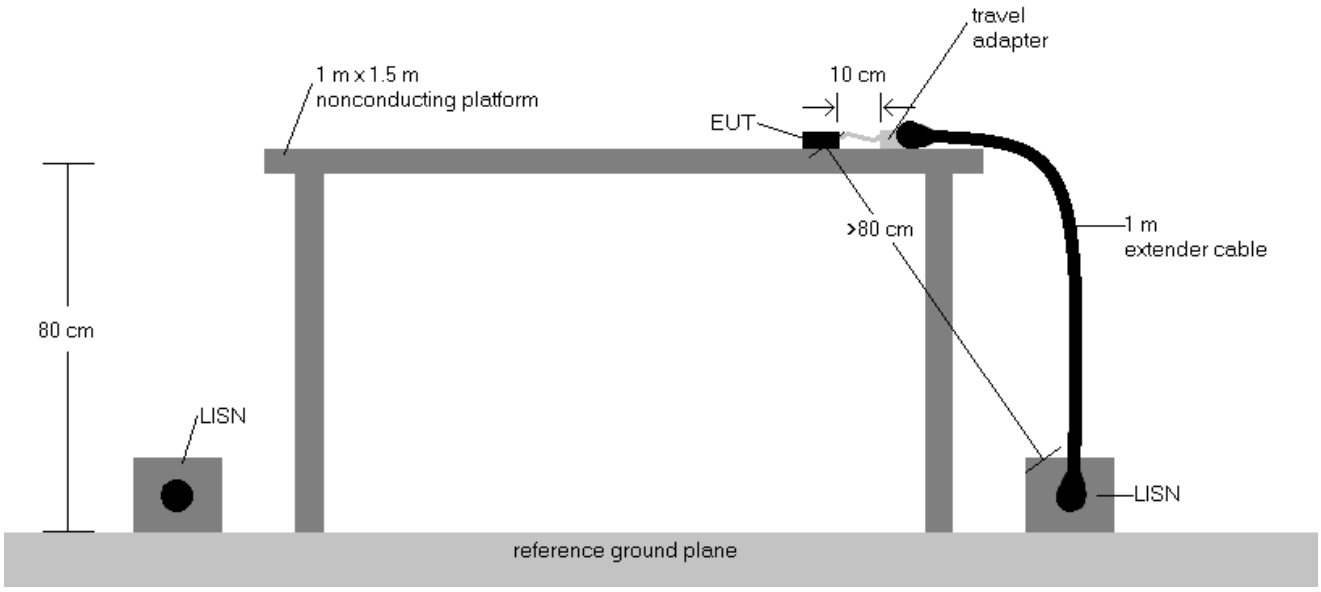
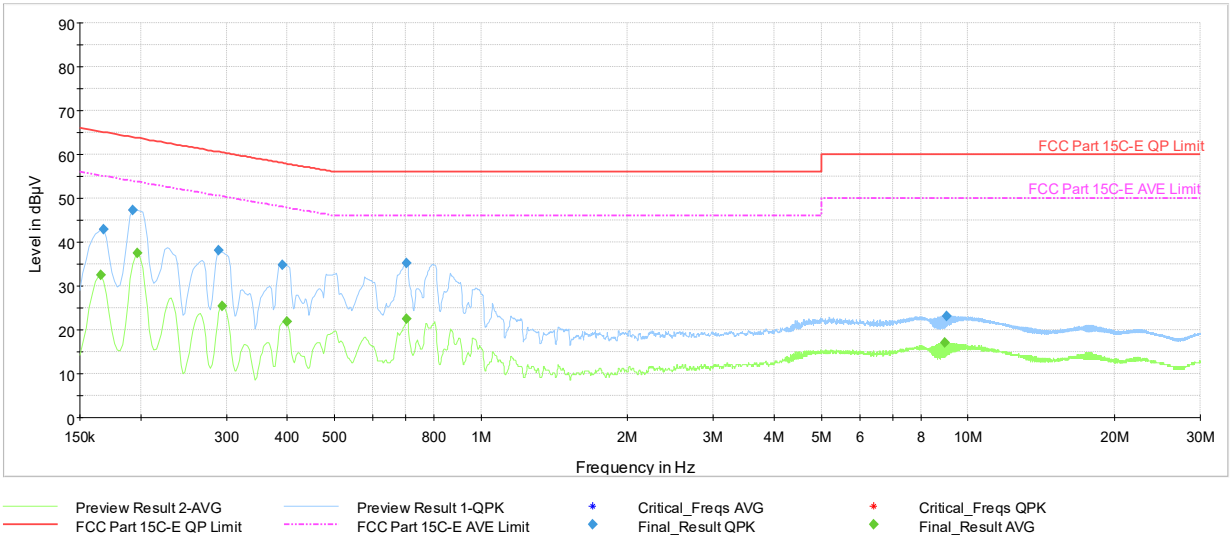


Figure 7-9. Test Instrument & Measurement Setup

Test Notes

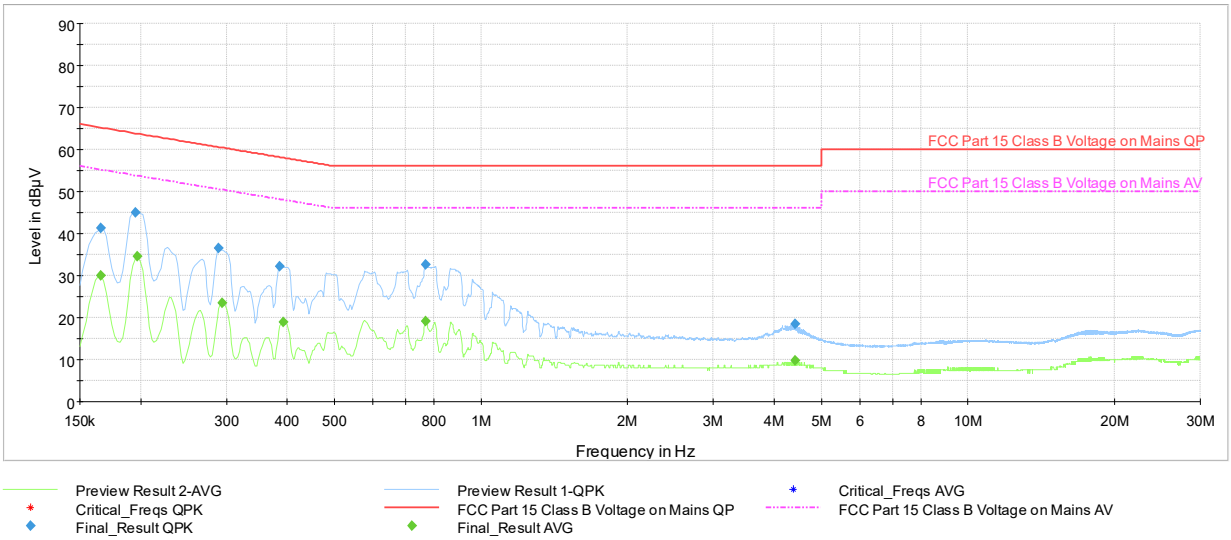
1. All modes of operation were investigated and the worst-case emissions are reported using mid channel. The emissions found were not affected by the choice of channel used during testing.
2. The limit for an intentional radiator from 150kHz to 30MHz are specified in Part 15.207 and RSS-Gen (8.8).
3. Corr. (dB) = Cable loss (dB) + LISN insertion factor (dB)
4. QP/AV Level (dBμV) = QP/AV Analyzer/Receiver Level (dBμV) + Corr. (dB)
5. Margin (dB) = QP/AV Limit (dBμV) - QP/AV Level (dBμV)
6. Traces shown in plot are made using a quasi-peak and average detector.
7. Deviations to the Specifications: None.



Plot 7-105. Line Conducted Plot with Bluetooth LE (L1 – 1Mbps, ePA, Ch.19, with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.166	FINAL	—	32.40	55.17	-22.77	L1	GND
0.168	FINAL	42.94	—	65.06	-22.12	L1	GND
0.193	FINAL	47.35	—	63.92	-16.57	L1	GND
0.197	FINAL	—	37.41	53.73	-16.31	L1	GND
0.290	FINAL	38.17	—	60.54	-22.37	L1	GND
0.294	FINAL	—	25.41	50.41	-25.00	L1	GND
0.391	FINAL	34.71	—	58.05	-23.34	L1	GND
0.400	FINAL	—	21.80	47.86	-26.06	L1	GND
0.704	FINAL	—	22.55	46.00	-23.45	L1	GND
0.704	FINAL	35.23	—	56.00	-20.77	L1	GND
8.970	FINAL	—	17.12	50.00	-32.88	L1	GND
9.038	FINAL	23.14	—	60.00	-36.86	L1	GND

Table 7-26. Line Conducted Measurements with Bluetooth LE (L1 – 1Mbps, ePA, Ch.19, with AC/DC Adapter)



Plot 7-106. Line Conducted Plot with Bluetooth LE (N – 1Mbps, ePA, Ch.19 with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.166	FINAL	41.20	—	65.17	-23.97	N	GND
0.166	FINAL	—	30.03	55.17	-25.15	N	GND
0.195	FINAL	45.02	—	63.82	-18.80	N	GND
0.197	FINAL	—	34.57	53.73	-19.15	N	GND
0.290	FINAL	36.42	—	60.54	-24.12	N	GND
0.294	FINAL	—	23.56	50.41	-26.85	N	GND
0.386	FINAL	32.14	—	58.14	-26.00	N	GND
0.393	FINAL	—	18.84	48.00	-29.16	N	GND
0.769	FINAL	—	19.22	46.00	-26.78	N	GND
0.769	FINAL	32.68	—	56.00	-23.32	N	GND
4.416	FINAL	18.39	—	56.00	-37.61	N	GND
4.418	FINAL	—	9.86	46.00	-36.14	N	GND

Table 7-27. Line Conducted Measurements with Bluetooth LE (N – 1Mbps, ePA, Ch.19, with AC/DC Adapter)

8.0 CONCLUSION

The data collected relate only the item(s) tested and show that the **Apple Tablet Device FCC ID: BCGA2228** is in compliance with Part 15 Subpart C (15.247) of the FCC Rules and RSS-247 of the Innovation, Science and Economic Development Canada Rules.