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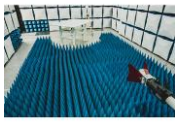

MEASUREMENT REPORT
FCC PART 15.247 / ISED RSS-247 Bluetooth (Low Energy)

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

Date of Testing:
11/09/2018-02/06/2019
Test Site/Location:
PCTEST Lab. Morgan Hill, CA, USA
Test Report Serial No.:
1C1811080028-07.BCG

FCC ID:	**BCGA2153**
IC:	**579C-A2153**
APPLICANT:	**Apple Inc.**

Application Type:	Certification
Model/HVIN:	A2153
EUT Type:	Tablet Device
Max. RF Output Power:	108.893 mW (20.37 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 v05r01

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 v05r01. 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 Engineering Laboratory, Inc. 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 v01.

1.3 Test Facility / Accreditations

Measurements were performed at PCTEST Engineering Lab 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: BCGA2153**. 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.: DLXXT033LT65, DLXXT00SLT65

2.2 Device Capabilities

This device contains the following capabilities:

850/1900 GSM/GPRS/EDGE, 850/1700/1900 WCDMA/HSPA, Multi-band LTE, 802.11b/g/n WLAN, 802.11a/n/ac UNII, Bluetooth (HDR4, HDR8, 1x, EDR, LE)

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

Table 2-1. Frequency / Channel Operations

Maximum Achievable Duty Cycles		
BLE Mode		Duty Cycle (%)
1M	ePA	100.0
	iPA	100.0
2M	ePA	100.0
	iPA	100.0

Table 2-2. Measured Duty Cycles

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

2.3 Antenna Description

Following antenna was used for the testing.

Frequency [GHz]	Antenna Gain [dBi]	
	Antenna 0	Antenna 1
2.4	1.00	-0.01

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 Lightning Cable	Model:	Kanzi	S/N:	3252E9
3	USB Lightning Cable	Model:	N/A	S/N:	N/A
	w/ AC Adapter	Model:	A1385	S/N:	D292066H2NLDHLHAE
4	Apple Pencil	Model:	A1603	S/N:	G64TG0FEGWTJ
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 v05r01. 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.

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 cable with wire charger
- EUT powered by host PC via USB cable with wire charger

Throughout the report, Antenna 0 is correlating to Antenna WF1 and Antenna 1 is correlating to Antenna WF2.

2.6 Software and Firmware

The test was conducted with firmware version 16E31520i 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 v05r01 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 groundplane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

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

Line conducted emissions test results are shown in Section 7.10. Automated test software was used to perform the AC line conducted emissions testing. Automated measurement software utilized is Rohde & Schwarz EMC32, Version 10.20.01.

3.3 Radiated Emissions

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

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

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

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
Line 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
Anritsu	ML2496A	Power Meter	10/22/2018	Annual	10/22/2019	184005
Anritsu	MA2411B	Pulse Power Meter	10/22/2018	Annual	10/22/2019	1726261
Anritsu	MA2411B	Pulse Power Meter	10/22/2018	Annual	10/22/2019	1726262
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna	3/13/2018	Annual	3/13/2019	T058601-02
COM-POWER	LIN-120A	LISN	3/7/2018	Annual	3/7/2019	241296
Keysight Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	2/27/2018	Annual	2/27/2019	MY49430244
Rohde & Schwarz	ESW26	EMI Test Receiver	7/19/2018	Annual	7/19/2019	101299
Rohde & Schwarz	ESW44	EMI Test Receiver	11/20/2018	Annual	11/20/2019	101570
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz - 40GHz)	6/11/2018	Annual	6/11/2019	100051
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz - 8GHz)	1/25/2018	Annual	1/25/2019	102333
Rohde & Schwarz	HL562E	Ultra Broadband Antenna (30MHz - 6GHz)	6/8/2018	Annual	6/8/2019	100810
Rohde & Schwarz	TC-TA18	Cross Polarized Vivaldi Antenna (400MHz-18GHz)	11/21/2018	Annual	11/21/2019	101057
Rohde & Schwarz	TC-TA18	Cross Polarized Vivaldi Antenna (400MHz-18GHz)	12/7/2018	Annual	12/7/2019	101063
Rohde & Schwarz	HFH2-Z2	Loop Antenna	3/13/2018	Annual	3/13/2019	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: BCGA2153

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, 7.9
15.207	RSS-Gen [8.8]	AC Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits (RSS-Gen[8.8])	LINE CONDUCTED	PASS	Section 7.10

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 3.1.
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 1.3.0.

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 v05r01 – 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

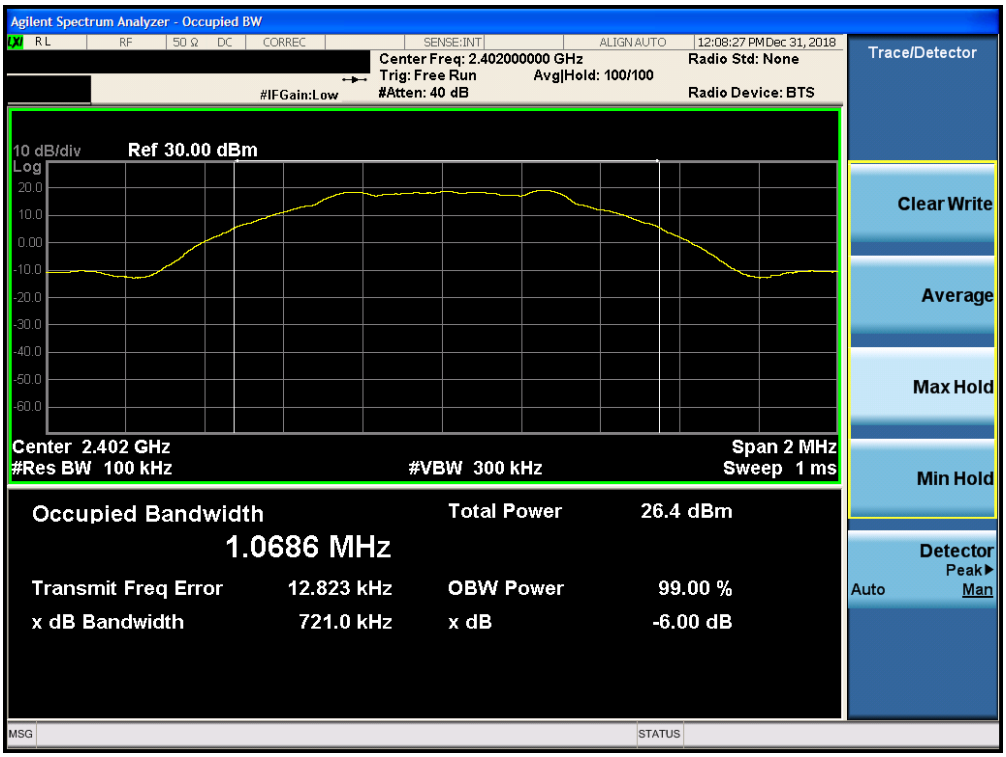
Test Notes

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

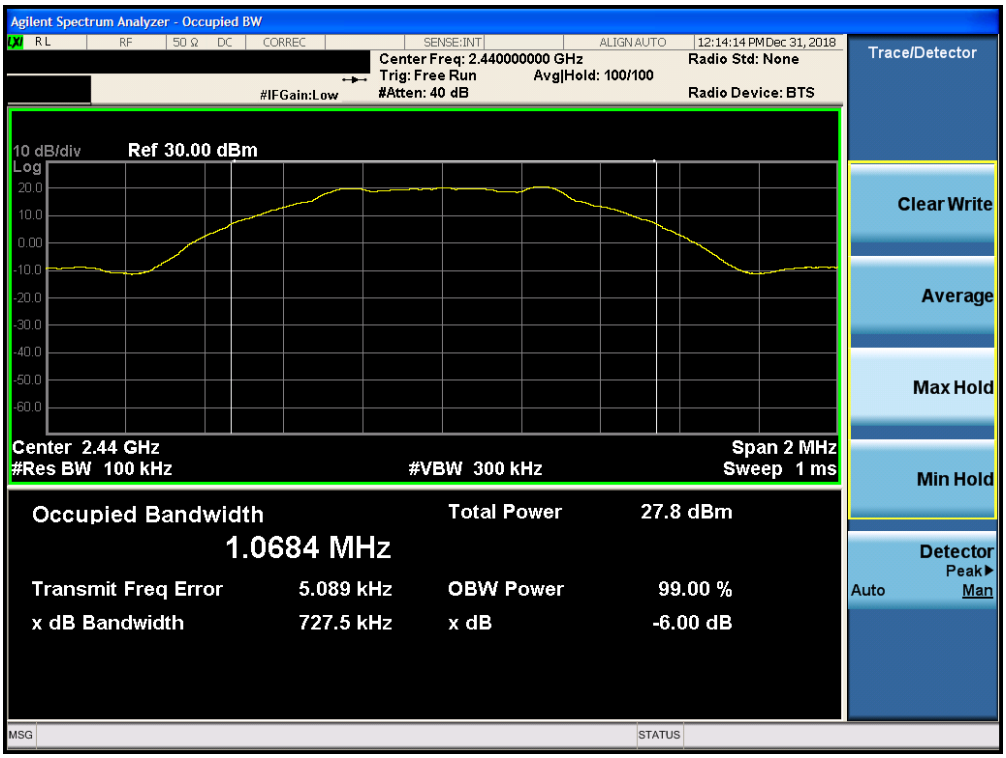
Antenna 0

Frequency [MHz]	Data Rate	Power Scheme	Channel No.	Bluetooth Mode	Measured Bandwidth [kHz]	Minimum Bandwidth [kHz]	Pass / Fail
2402	1 Mbps	ePA	0	LE	721.0	500	Pass
2440	1 Mbps	ePA	19	LE	727.5	500	Pass
2480	1 Mbps	ePA	39	LE	725.5	500	Pass
2402	2 Mbps	ePA	0	LE	1195.0	500	Pass
2440	2 Mbps	ePA	19	LE	1195.0	500	Pass
2480	2 Mbps	ePA	39	LE	1196.0	500	Pass

Table 7-2. Conducted Bandwidth Measurements ANT 0

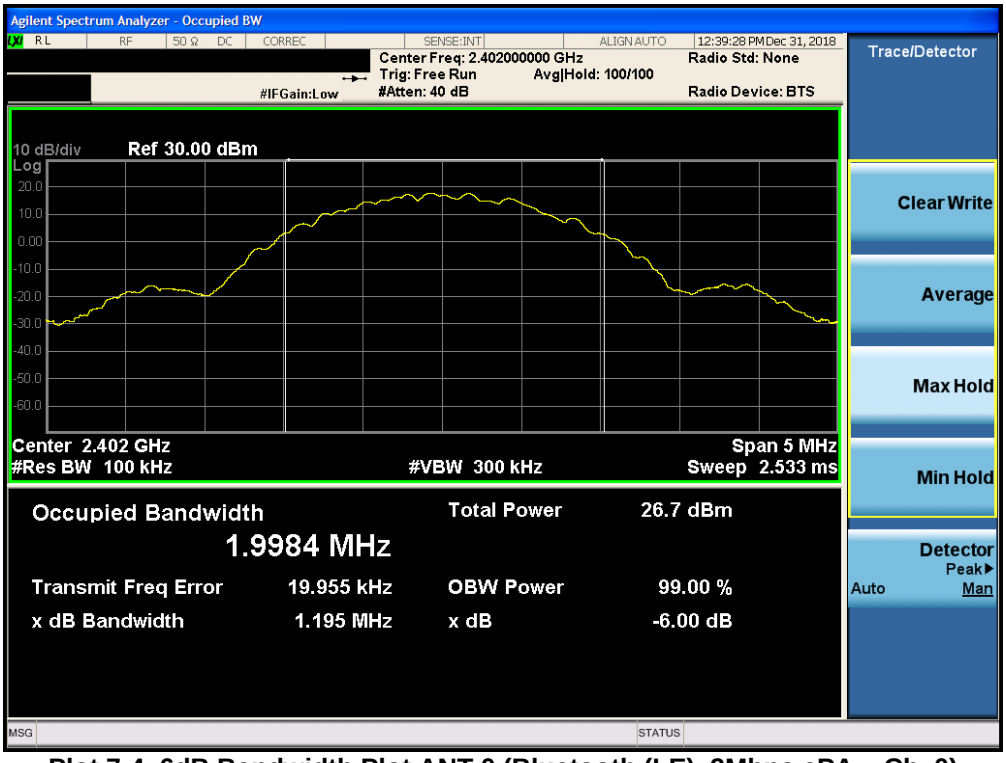


Plot 7-1. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



Plot 7-2. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 19)

Plot 7-3. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



Plot 7-4. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 0)

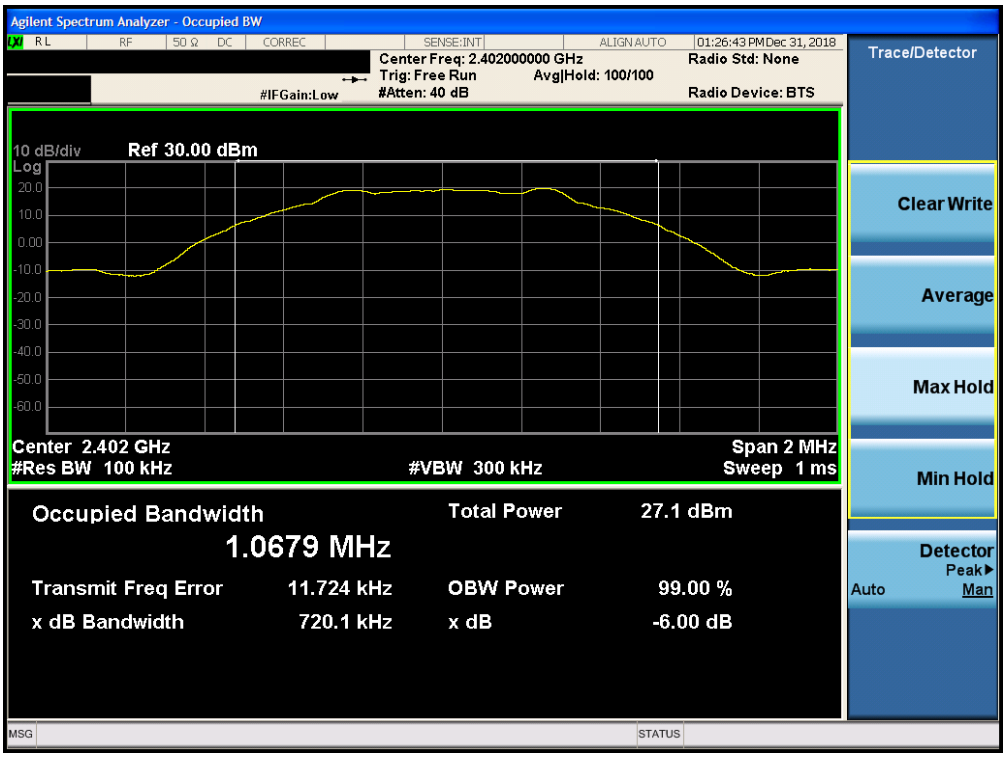
Plot 7-5. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 19)

Plot 7-6. 6dB Bandwidth Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 39)

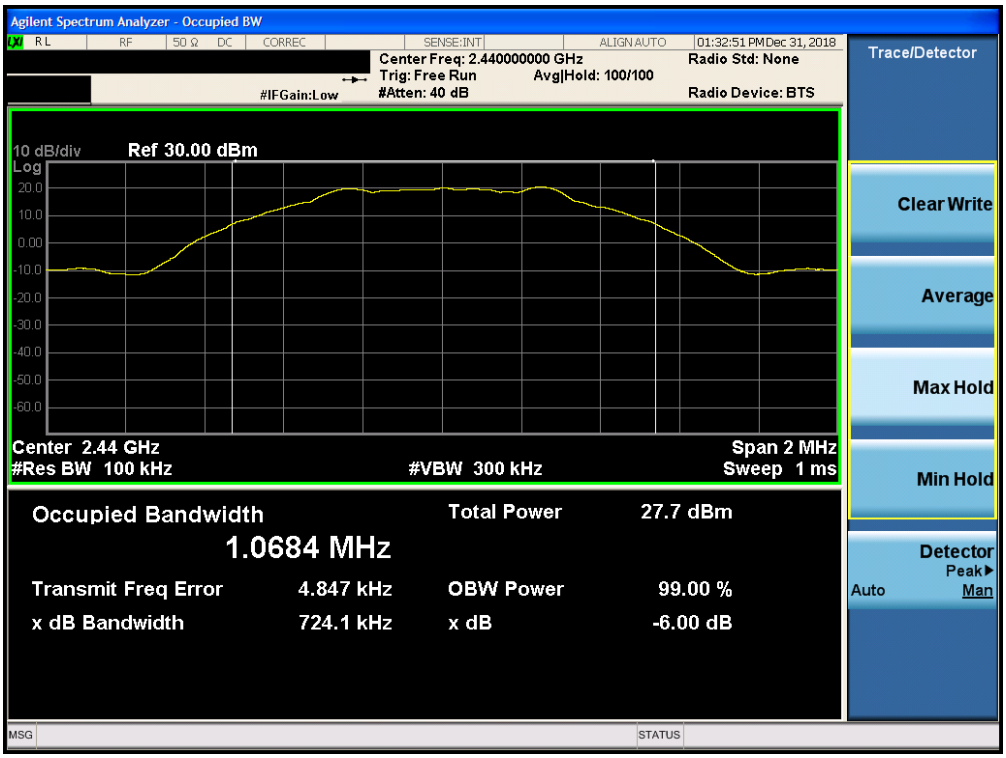
Antenna 1

Frequency [MHz]	Data Rate	Power Scheme	Channel No.	Bluetooth Mode	Measured Bandwidth [kHz]	Minimum Bandwidth [kHz]	Pass / Fail
2402	1 Mbps	ePA	0	LE	720.1	500	Pass
2440	1 Mbps	ePA	19	LE	724.1	500	Pass
2480	1 Mbps	ePA	39	LE	726.3	500	Pass
2402	2 Mbps	ePA	0	LE	1195.0	500	Pass
2440	2 Mbps	ePA	19	LE	1196.0	500	Pass
2480	2 Mbps	ePA	39	LE	1196.0	500	Pass

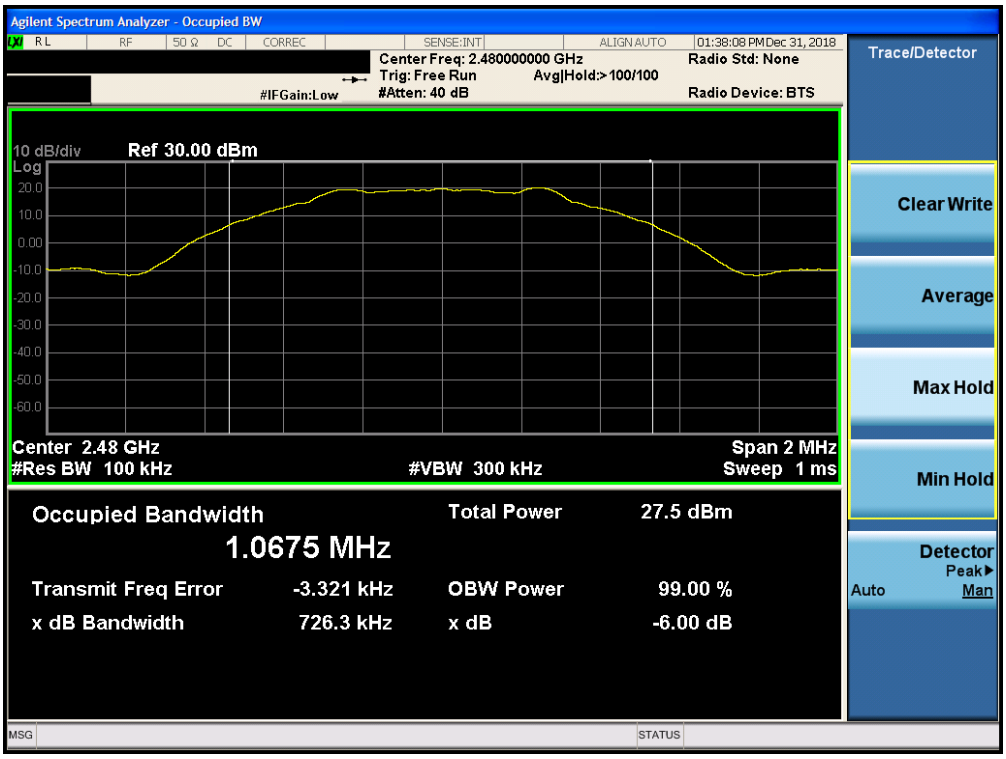
Table 7-3. Conducted Bandwidth Measurements ANT 1



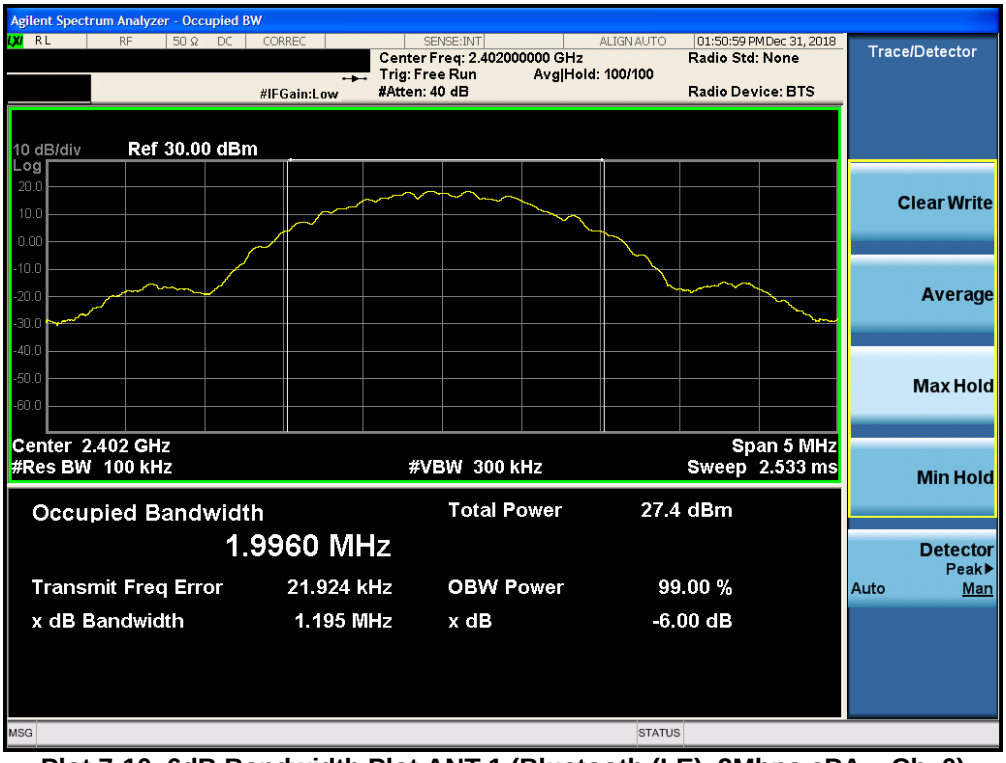
Plot 7-7. 6dB Bandwidth Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



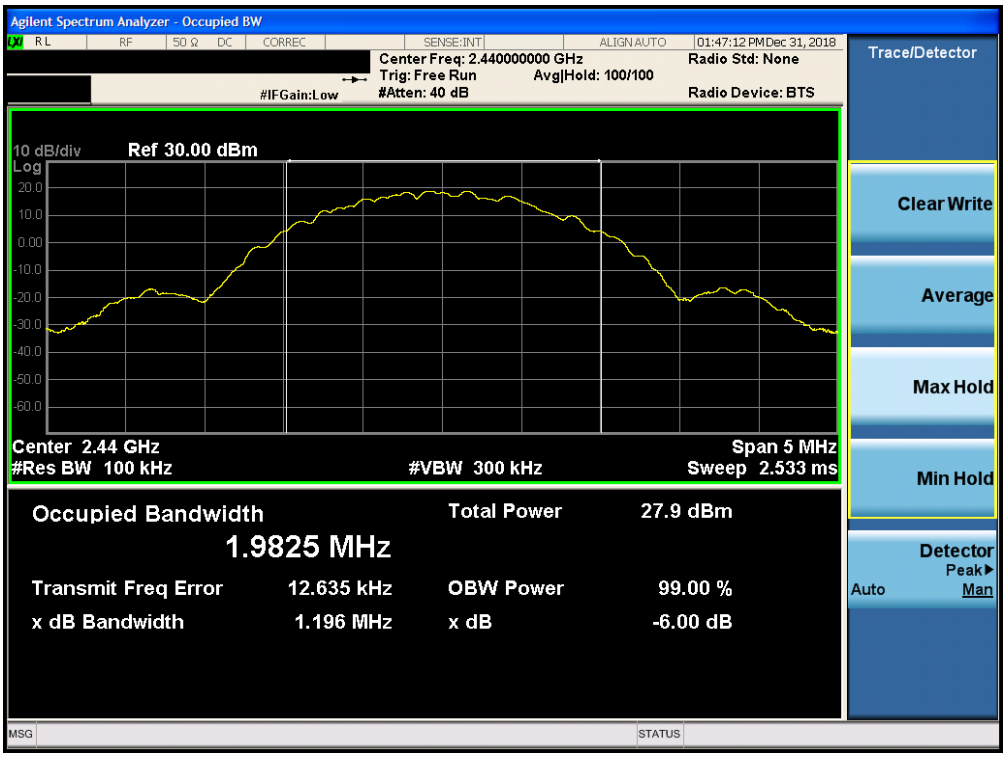
Plot 7-8. 6dB Bandwidth Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



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



Plot 7-10. 6dB Bandwidth Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 0)



Plot 7-11. 6dB Bandwidth Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 19)

Plot 7-12. 6dB Bandwidth Plot ANT 1 (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

KDB 558074 D01 v05r01 – Section 8.3.1.3, 8.3.2.3

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.	Bluetooth Mode	Peak Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
					[dBm]	[mW]				
2402	1 Mbps	ePA	0	LE	20.13	103.039	1.00	21.13	36.02	-14.89
2440	1 Mbps	ePA	19	LE	20.22	105.196	1.00	21.22	36.02	-14.80
2480	1 Mbps	ePA	39	LE	19.63	91.833	1.00	20.63	36.02	-15.39
2402	1 Mbps	iPA	0	LE	11.49	14.093	1.00	12.49	36.02	-23.53
2440	1 Mbps	iPA	19	LE	11.60	14.454	1.00	12.60	36.02	-23.42
2480	1 Mbps	iPA	39	LE	11.65	14.622	1.00	12.65	36.02	-23.37
2402	2 Mbps	ePA	0	LE	20.18	104.232	1.00	21.18	36.02	-14.84
2440	2 Mbps	ePA	19	LE	20.37	108.893	1.00	21.37	36.02	-14.65
2480	2 Mbps	ePA	39	LE	19.62	91.622	1.00	20.62	36.02	-15.40
2402	2 Mbps	iPA	0	LE	11.52	14.191	1.00	12.52	36.02	-23.50
2440	2 Mbps	iPA	19	LE	11.63	14.555	1.00	12.63	36.02	-23.39
2480	2 Mbps	iPA	39	LE	11.77	15.031	1.00	12.77	36.02	-23.25

Table 7-4. ANT 0 Peak Conducted Output Power Measurements (Bluetooth (LE))

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Bluetooth Mode	Peak Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
					[dBm]	[mW]				
2402	1 Mbps	ePA	0	LE	20.00	100.000	-0.01	19.99	36.02	-16.03
2440	1 Mbps	ePA	19	LE	20.15	103.514	-0.01	20.14	36.02	-15.88
2480	1 Mbps	ePA	39	LE	20.01	100.231	-0.01	20.00	36.02	-16.02
2402	1 Mbps	iPA	0	LE	11.51	14.158	-0.01	11.50	36.02	-24.52
2440	1 Mbps	iPA	19	LE	11.53	14.223	-0.01	11.52	36.02	-24.50
2480	1 Mbps	iPA	39	LE	11.51	14.158	-0.01	11.50	36.02	-24.52
2402	2 Mbps	ePA	0	LE	20.05	101.158	-0.01	20.04	36.02	-15.98
2440	2 Mbps	ePA	19	LE	20.31	107.399	-0.01	20.30	36.02	-15.72
2480	2 Mbps	ePA	39	LE	20.01	100.231	-0.01	20.00	36.02	-16.02
2402	2 Mbps	iPA	0	LE	11.56	14.322	-0.01	11.55	36.02	-24.47
2440	2 Mbps	iPA	19	LE	11.61	14.488	-0.01	11.60	36.02	-24.42
2480	2 Mbps	iPA	39	LE	11.57	14.355	-0.01	11.56	36.02	-24.46

Table 7-5. ANT 1 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.	Bluetooth Mode	Average Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
					[dBm]	[mW]				
2402	1 Mbps	ePA	0	LE	20.00	100.000	1.00	21.00	36.02	-15.02
2440	1 Mbps	ePA	19	LE	20.00	100.000	1.00	21.00	36.02	-15.02
2480	1 Mbps	ePA	39	LE	19.60	91.201	1.00	20.60	36.02	-15.42
2402	1 Mbps	iPA	0	LE	11.38	13.740	1.00	12.38	36.02	-23.64
2440	1 Mbps	iPA	19	LE	11.44	13.932	1.00	12.44	36.02	-23.58
2480	1 Mbps	iPA	39	LE	11.50	14.125	1.00	12.50	36.02	-23.52
2402	2 Mbps	ePA	0	LE	20.00	100.000	1.00	21.00	36.02	-15.02
2440	2 Mbps	ePA	19	LE	20.00	100.000	1.00	21.00	36.02	-15.02
2480	2 Mbps	ePA	39	LE	19.60	91.201	1.00	20.60	36.02	-15.42
2402	2 Mbps	iPA	0	LE	11.31	13.521	1.00	12.31	36.02	-23.71
2440	2 Mbps	iPA	19	LE	11.26	13.366	1.00	12.26	36.02	-23.76
2480	2 Mbps	iPA	39	LE	11.50	14.125	1.00	12.50	36.02	-23.52

Table 7-6. ANT 0 Average Conducted Output Power Measurements (Bluetooth (LE))

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Bluetooth Mode	Average Conducted Power		Ant. Gain [dBi]	EIRP [dBm]	Limit [dBm]	Margin [dB]
					[dBm]	[mW]				
2402	1 Mbps	ePA	0	LE	19.92	98.175	-0.01	19.91	36.02	-16.11
2440	1 Mbps	ePA	19	LE	19.98	99.541	-0.01	19.97	36.02	-16.05
2480	1 Mbps	ePA	39	LE	19.95	98.855	-0.01	19.94	36.02	-16.08
2402	1 Mbps	iPA	0	LE	11.38	13.740	-0.01	11.37	36.02	-24.65
2440	1 Mbps	iPA	19	LE	11.35	13.646	-0.01	11.34	36.02	-24.68
2480	1 Mbps	iPA	39	LE	11.36	13.677	-0.01	11.35	36.02	-24.67
2402	2 Mbps	ePA	0	LE	19.84	96.383	-0.01	19.83	36.02	-16.19
2440	2 Mbps	ePA	19	LE	19.90	97.724	-0.01	19.89	36.02	-16.13
2480	2 Mbps	ePA	39	LE	19.90	97.724	-0.01	19.89	36.02	-16.13
2402	2 Mbps	iPA	0	LE	11.30	13.490	-0.01	11.29	36.02	-24.73
2440	2 Mbps	iPA	19	LE	11.20	13.183	-0.01	11.19	36.02	-24.83
2480	2 Mbps	iPA	39	LE	11.25	13.335	-0.01	11.24	36.02	-24.78

Table 7-7. ANT 1 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 v05r01 – Section 8.4 DTS Maximum Power Spectral Density level in the fundamental emission

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

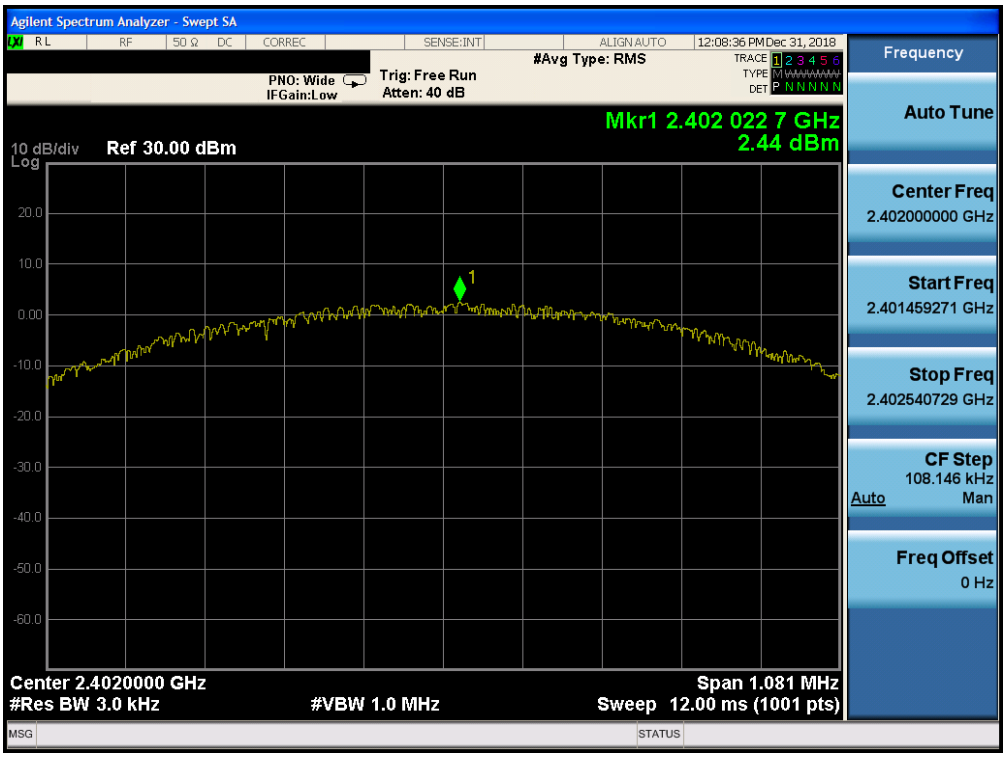
Test Notes

None

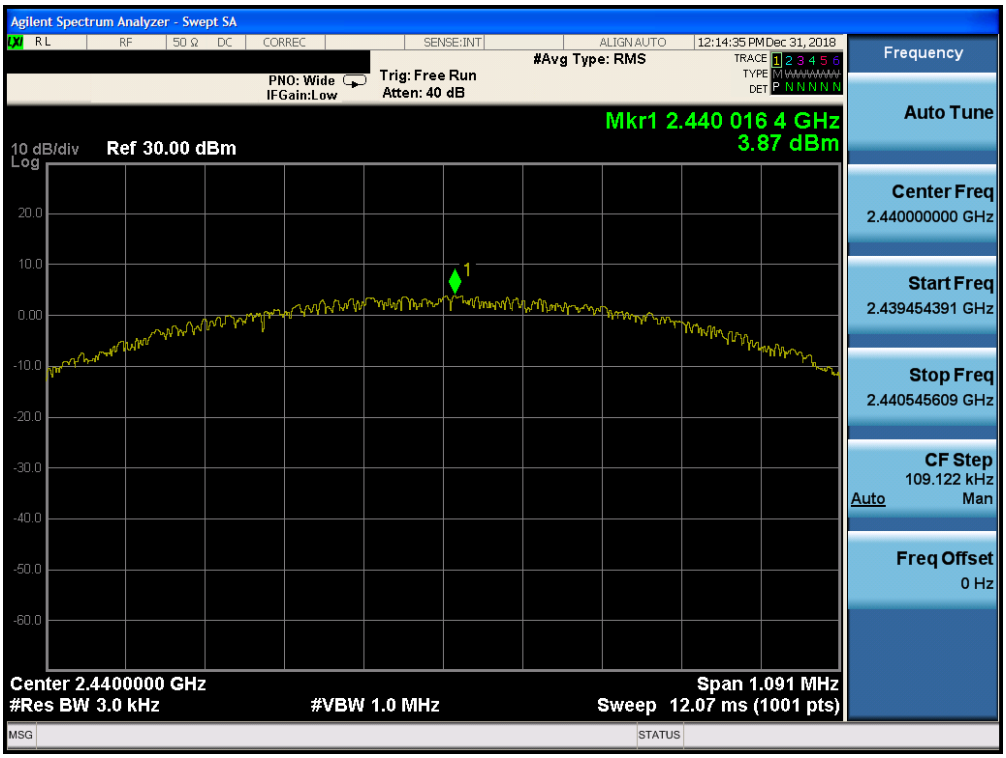
Antenna 0

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Bluetooth Mode	Measured Power Spectral Density [dBm / 3kHz]	Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]
2402	1 Mbps	ePA	0	LE	2.44	8.0	-5.56
2440	1 Mbps	ePA	19	LE	3.87	8.0	-4.13
2480	1 Mbps	ePA	39	LE	2.53	8.0	-5.47
2402	1 Mbps	iPA	0	LE	-6.22	8.0	-14.22
2440	1 Mbps	iPA	19	LE	-6.21	8.0	-14.21
2480	1 Mbps	iPA	39	LE	-6.07	8.0	-14.07
2402	2 Mbps	ePA	0	LE	1.80	8.0	-6.20
2440	2 Mbps	ePA	19	LE	3.32	8.0	-4.68
2480	2 Mbps	ePA	39	LE	1.95	8.0	-6.05
2402	2 Mbps	iPA	0	LE	-6.93	8.0	-14.93
2440	2 Mbps	iPA	19	LE	-7.02	8.0	-15.02
2480	2 Mbps	iPA	39	LE	-6.72	8.0	-14.72

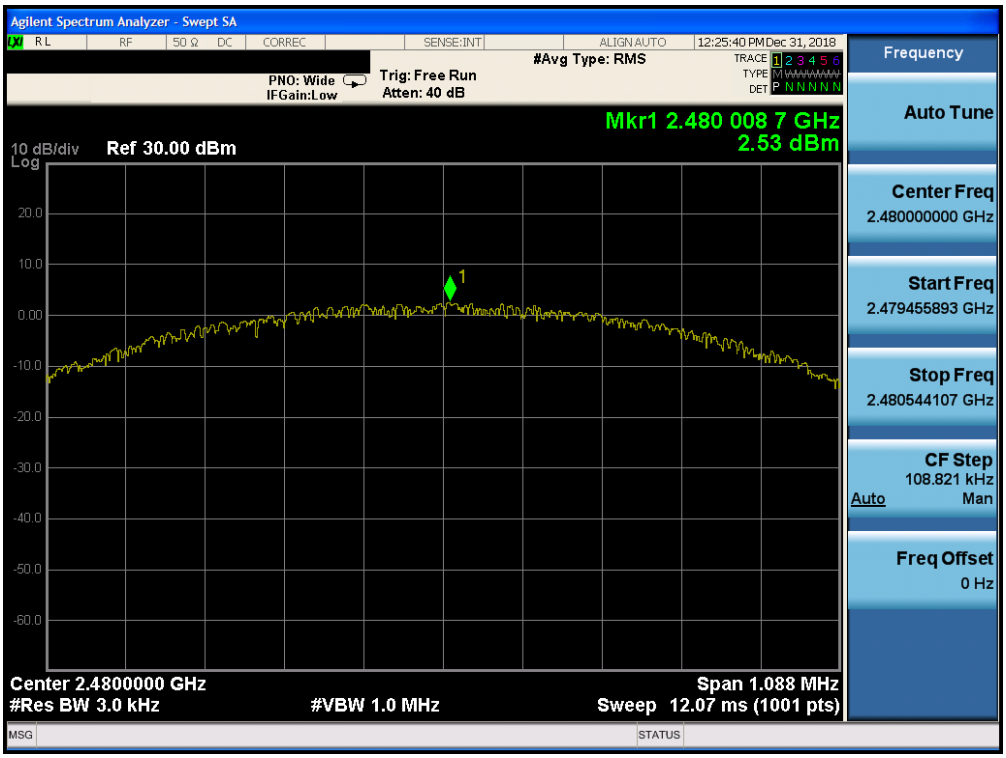
Table 7-8. ANT 0 Conducted Power Density Measurements



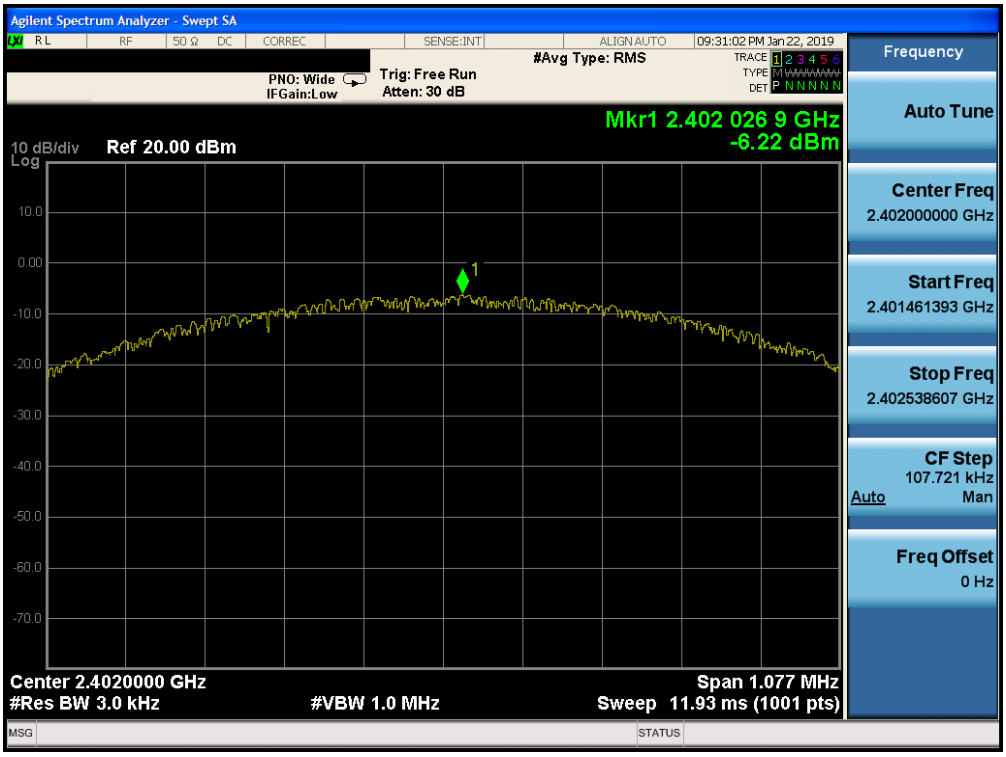
Plot 7-13. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



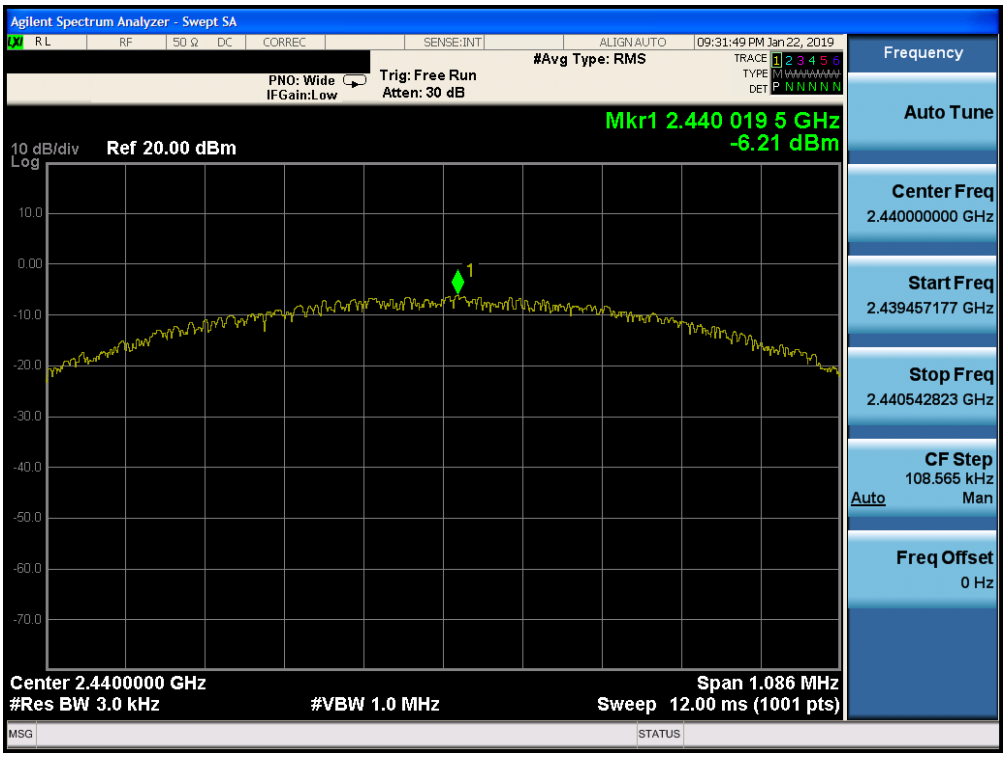
Plot 7-14. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



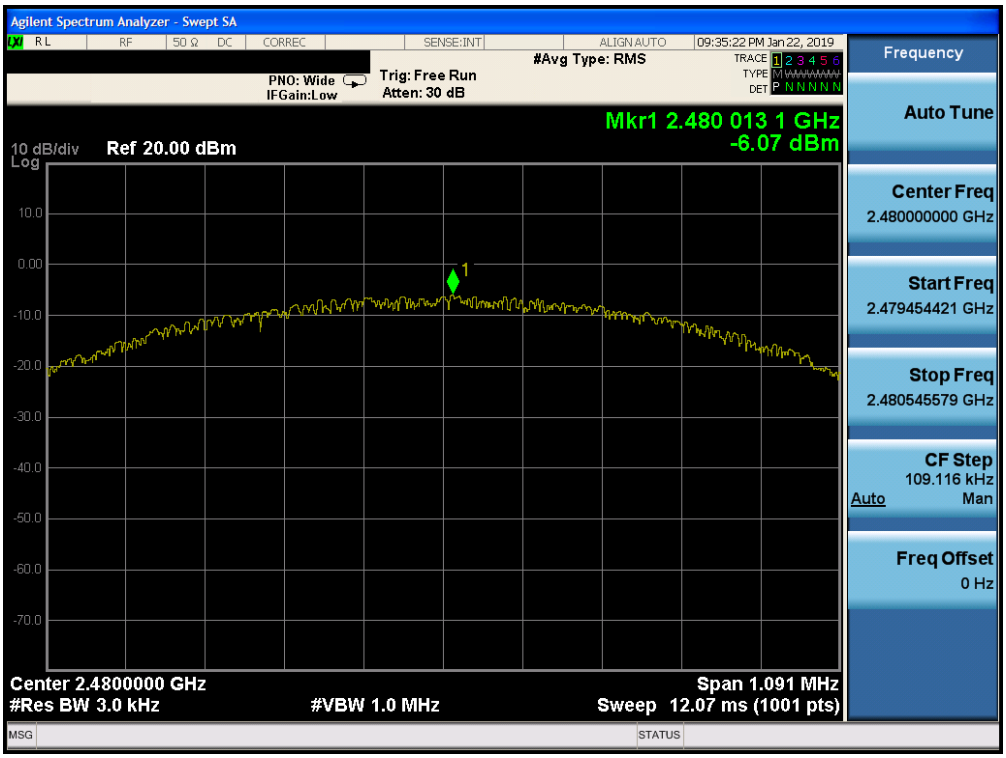
Plot 7-15. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



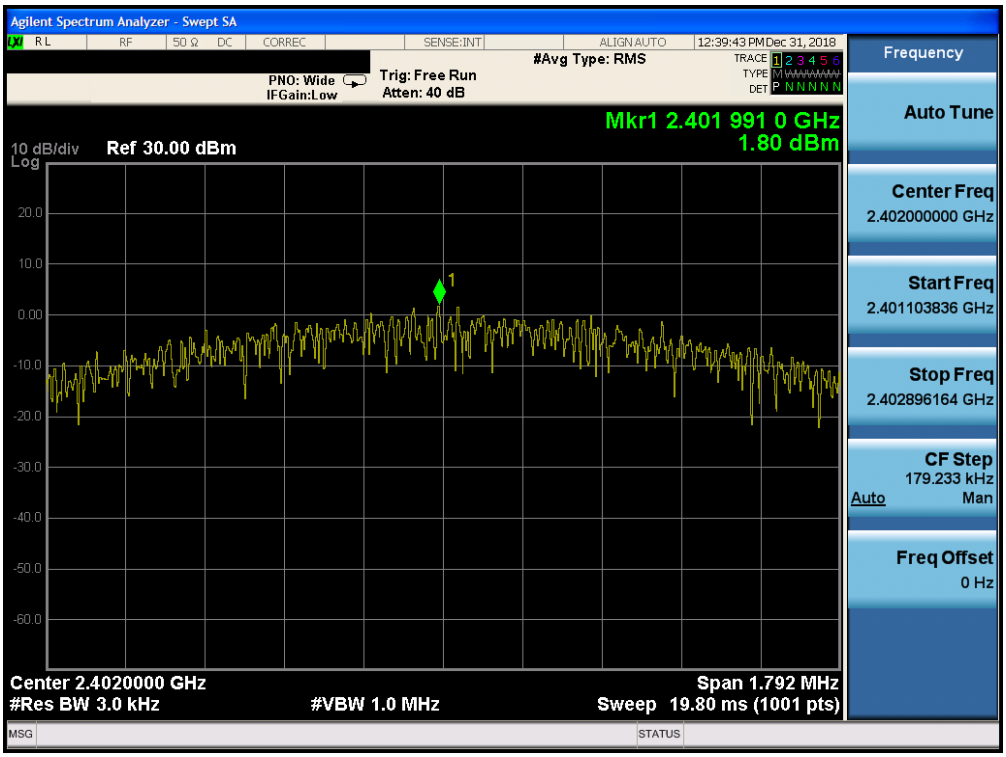
Plot 7-16. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps iPA – Ch. 0)



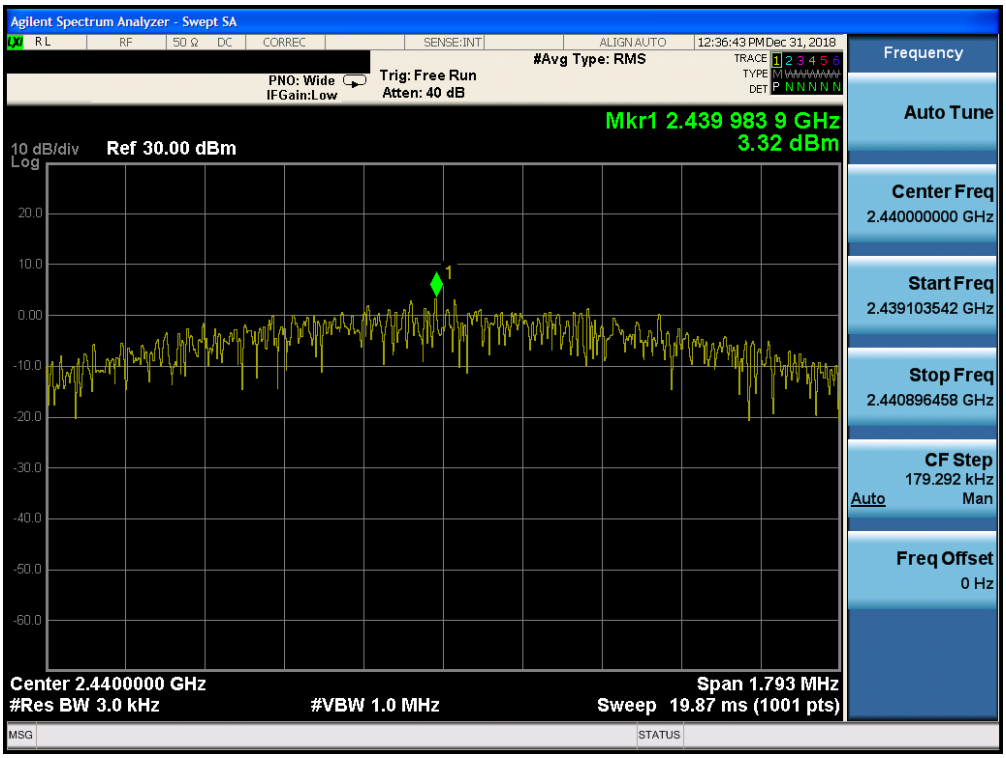
Plot 7-17. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps iPA – Ch. 19)



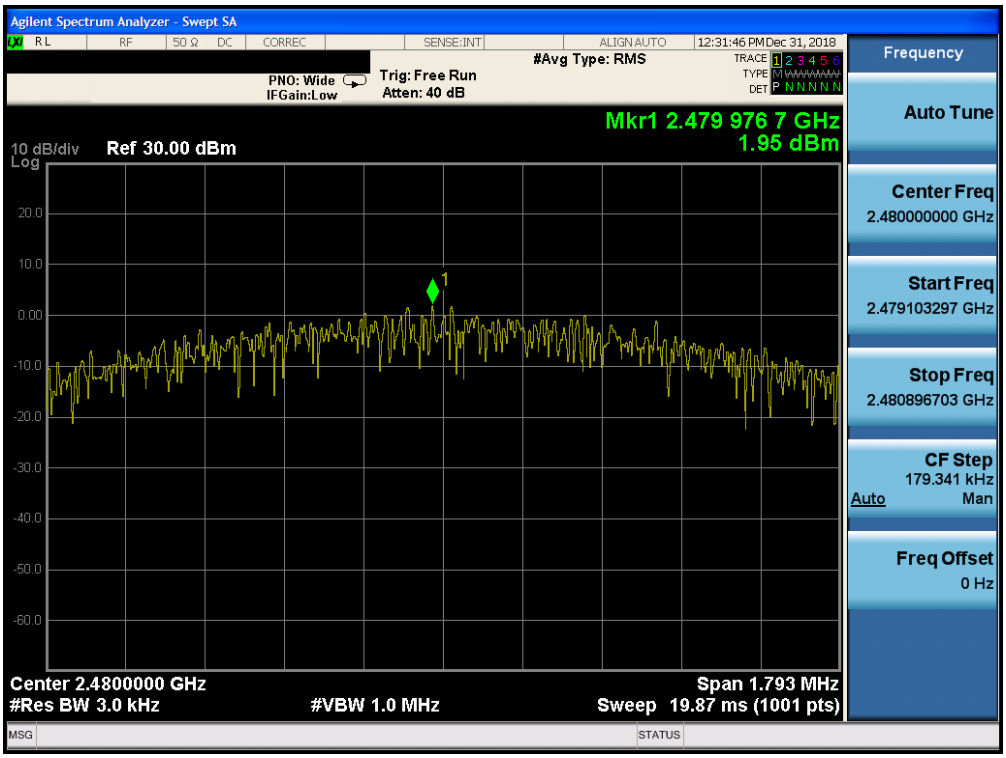
Plot 7-18. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 1Mbps iPA – Ch. 39)



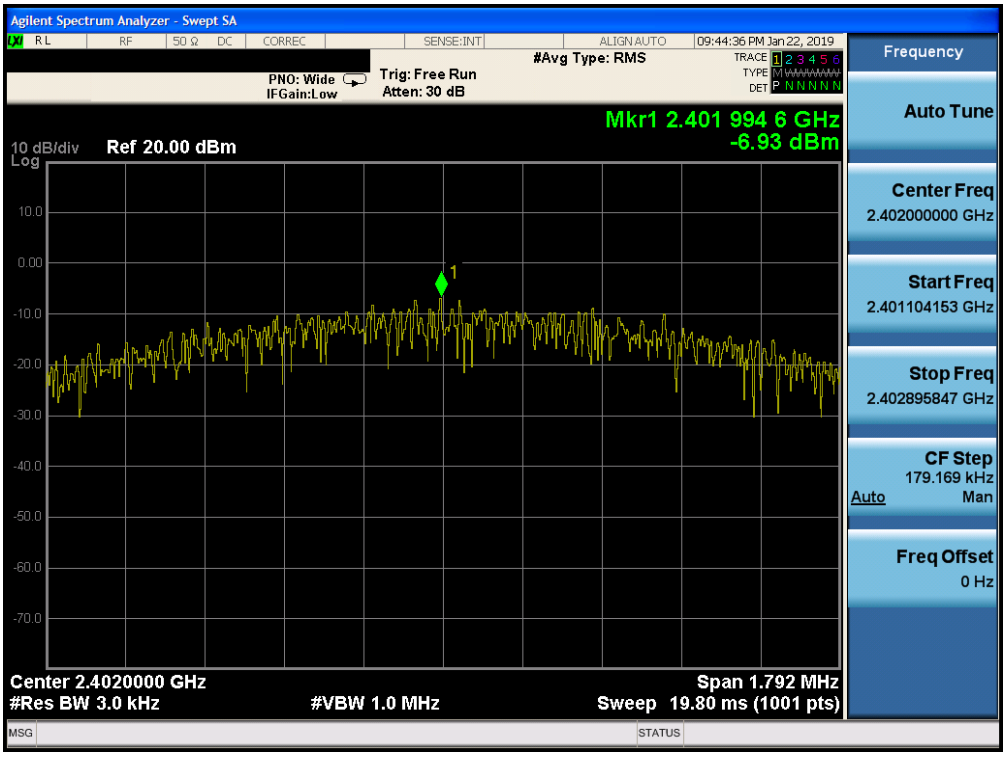
Plot 7-19. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 0)



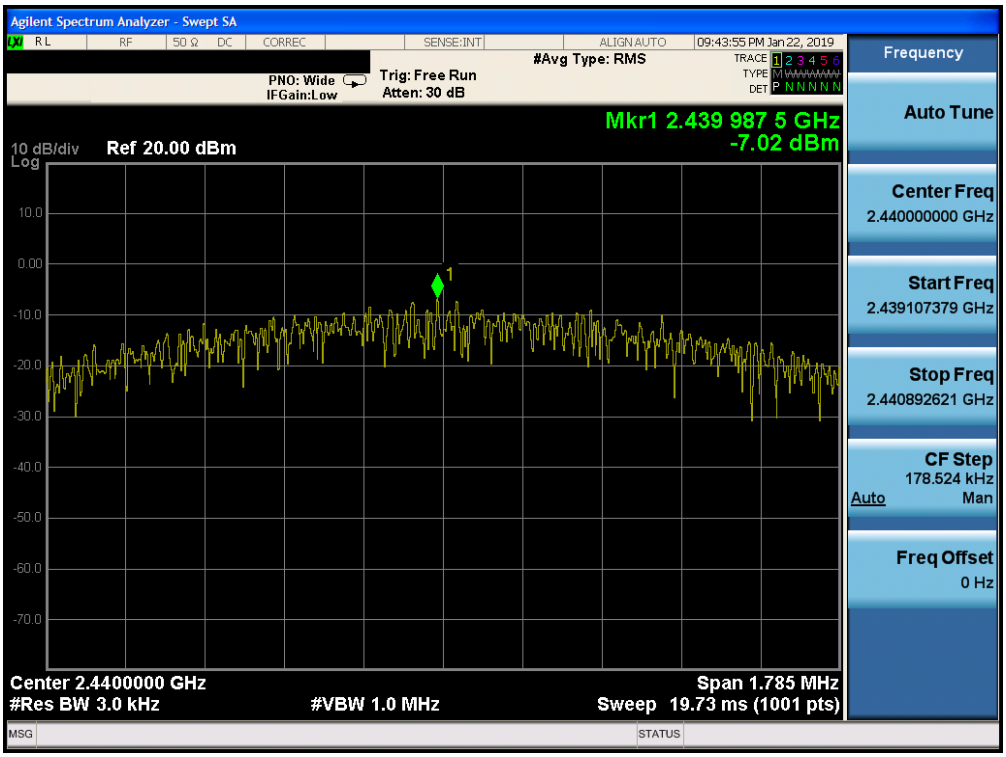
Plot 7-20. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 19)



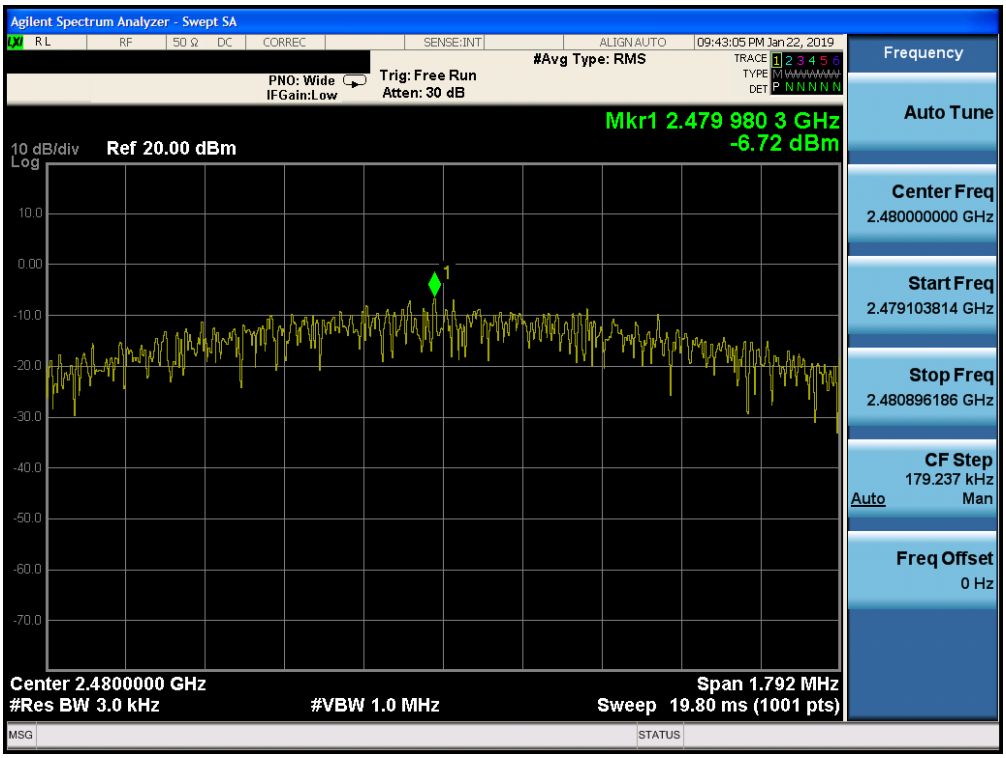
Plot 7-21. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 39)



Plot 7-22. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps iPA – Ch. 0)



Plot 7-23. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps iPA – Ch. 19)

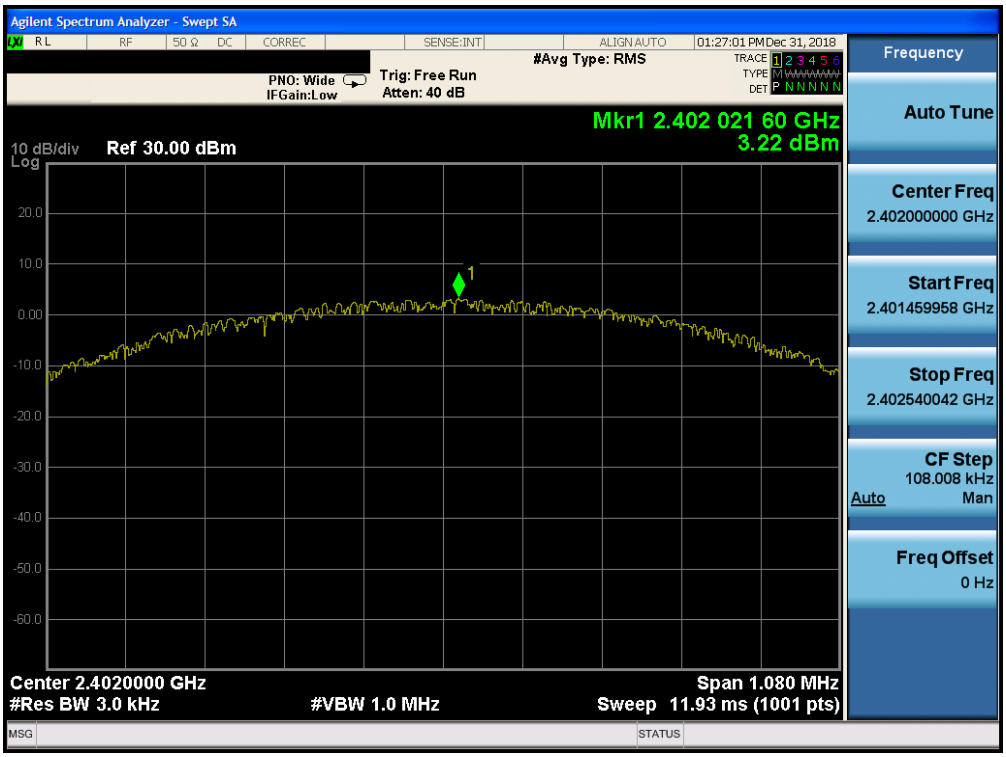


Plot 7-24. Power Spectral Density Plot ANT 0 (Bluetooth (LE), 2Mbps iPA – Ch. 39)

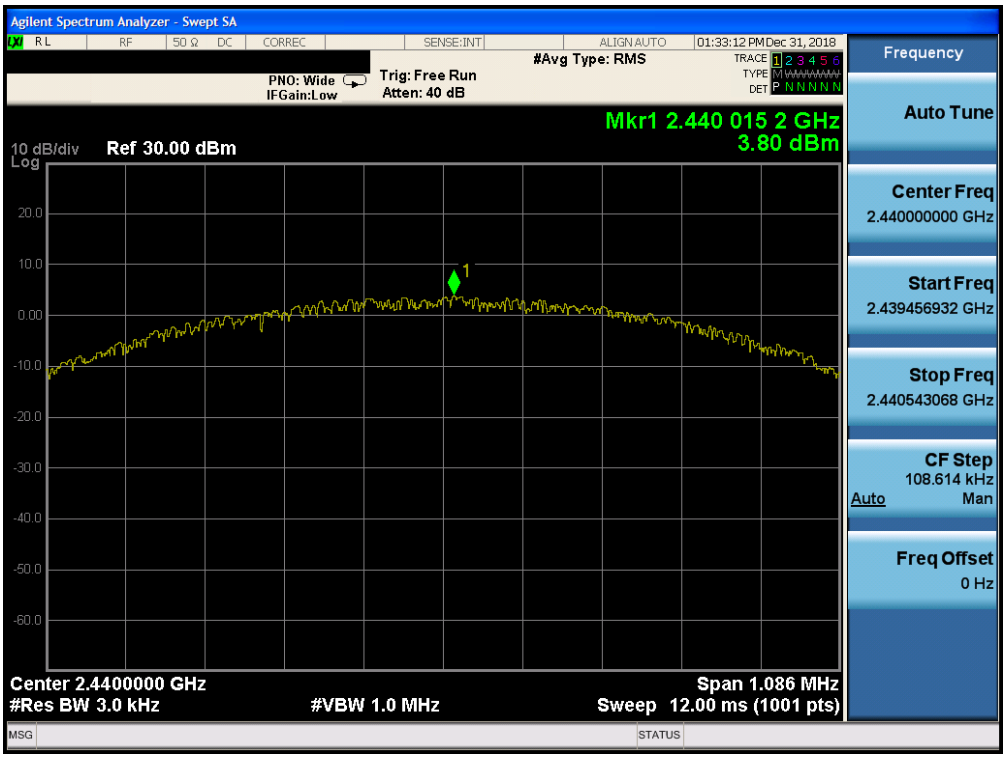
Antenna 1

Frequency [MHz]	Data Rate [Mbps]	Power Scheme	Channel No.	Bluetooth Mode	Measured Power Spectral Density [dBm / 3kHz]	Maximum Permissible Power Density [dBm / 3kHz]	Margin [dB]
2402	1 Mbps	ePA	0	LE	3.22	8.0	-4.78
2440	1 Mbps	ePA	19	LE	3.80	8.0	-4.20
2480	1 Mbps	ePA	39	LE	3.52	8.0	-4.48
2402	1 Mbps	iPA	0	LE	-6.22	8.0	-14.22
2440	1 Mbps	iPA	19	LE	-6.27	8.0	-14.27
2480	1 Mbps	iPA	39	LE	-6.43	8.0	-14.43
2402	2 Mbps	ePA	0	LE	2.61	8.0	-5.39
2440	2 Mbps	ePA	19	LE	3.10	8.0	-4.90
2480	2 Mbps	ePA	39	LE	2.90	8.0	-5.10
2402	2 Mbps	iPA	0	LE	-6.92	8.0	-14.92
2440	2 Mbps	iPA	19	LE	-7.08	8.0	-15.08
2480	2 Mbps	iPA	39	LE	-7.12	8.0	-15.12

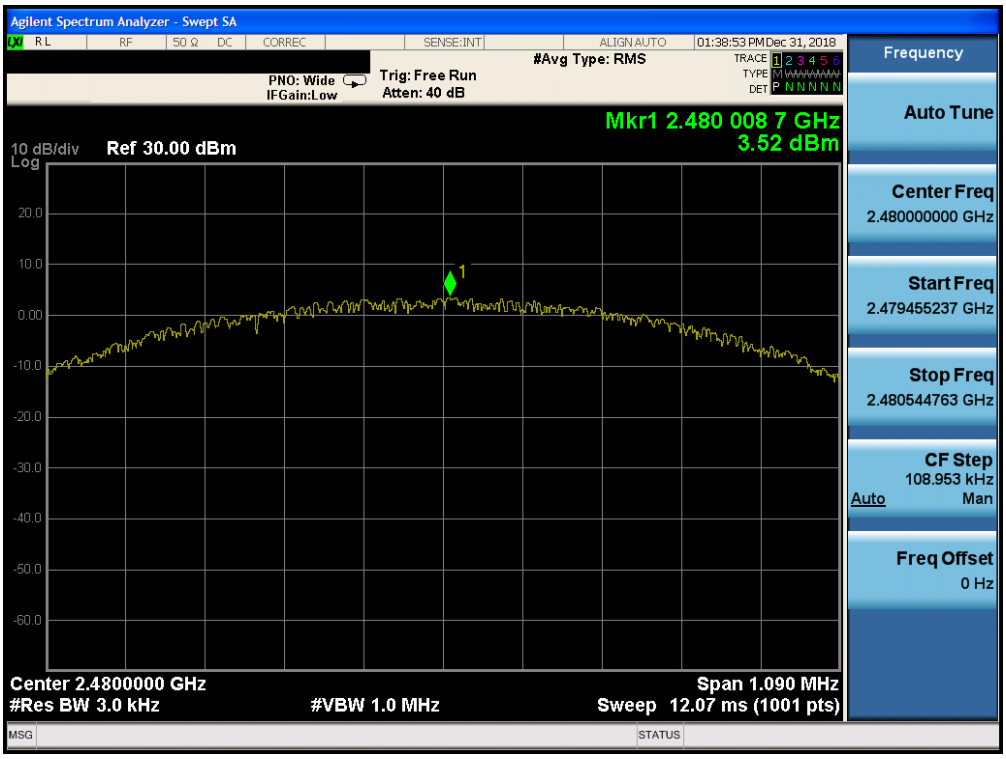
Table 7-9. ANT 1 Conducted Power Density Measurements



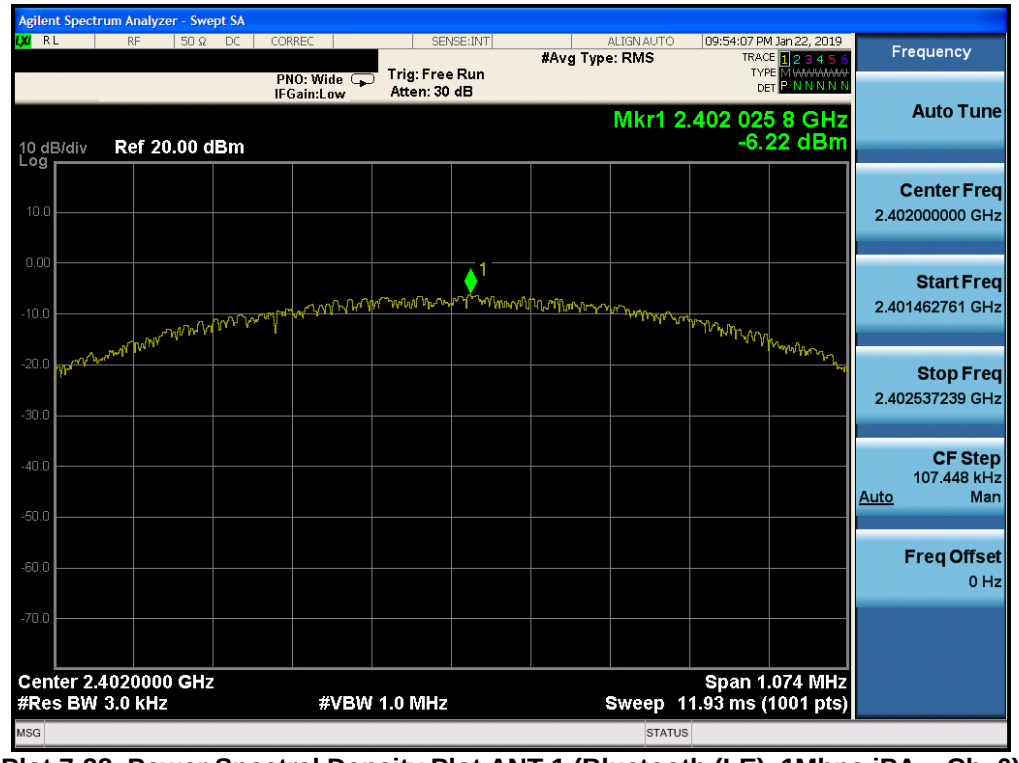
Plot 7-25. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



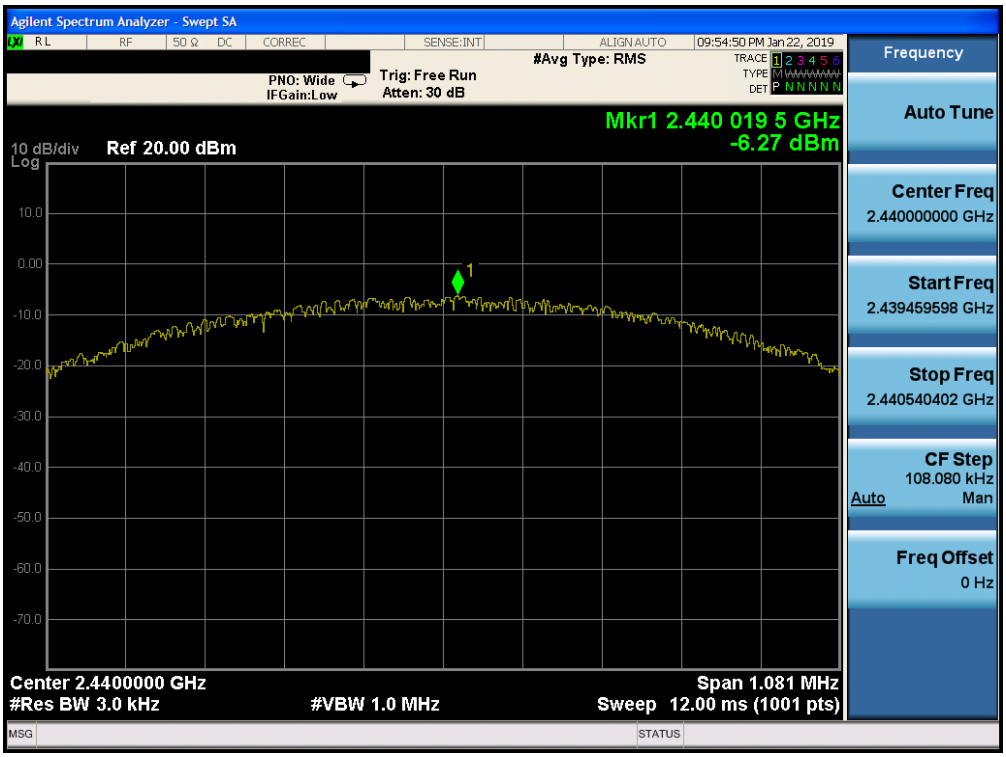
Plot 7-26. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



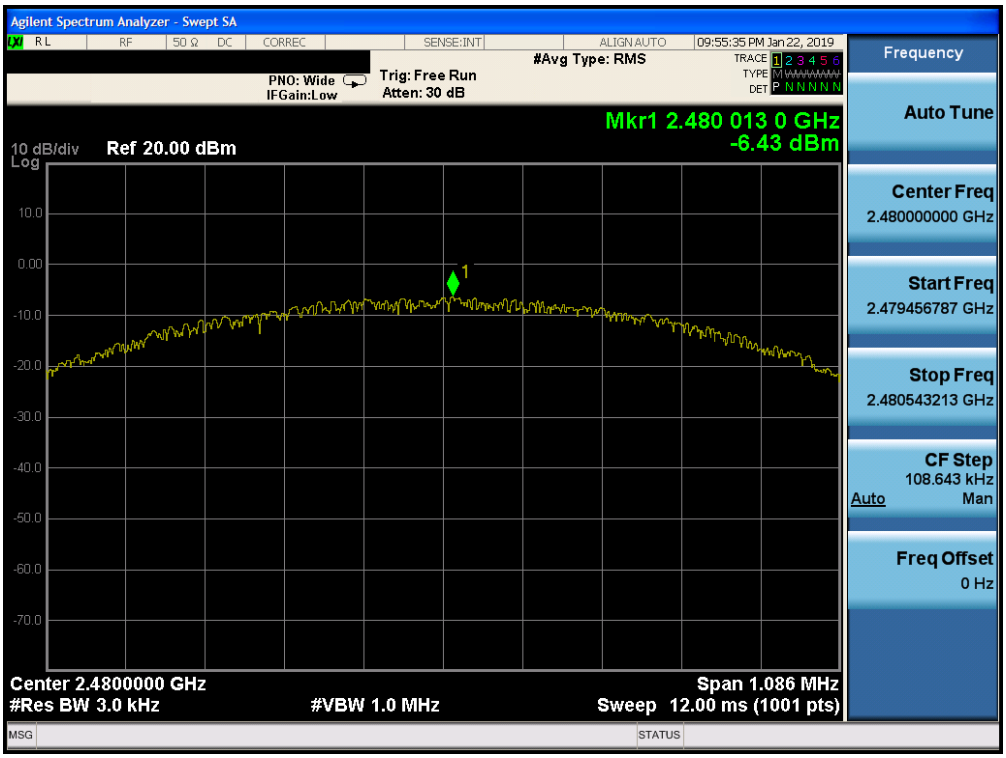
Plot 7-27. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



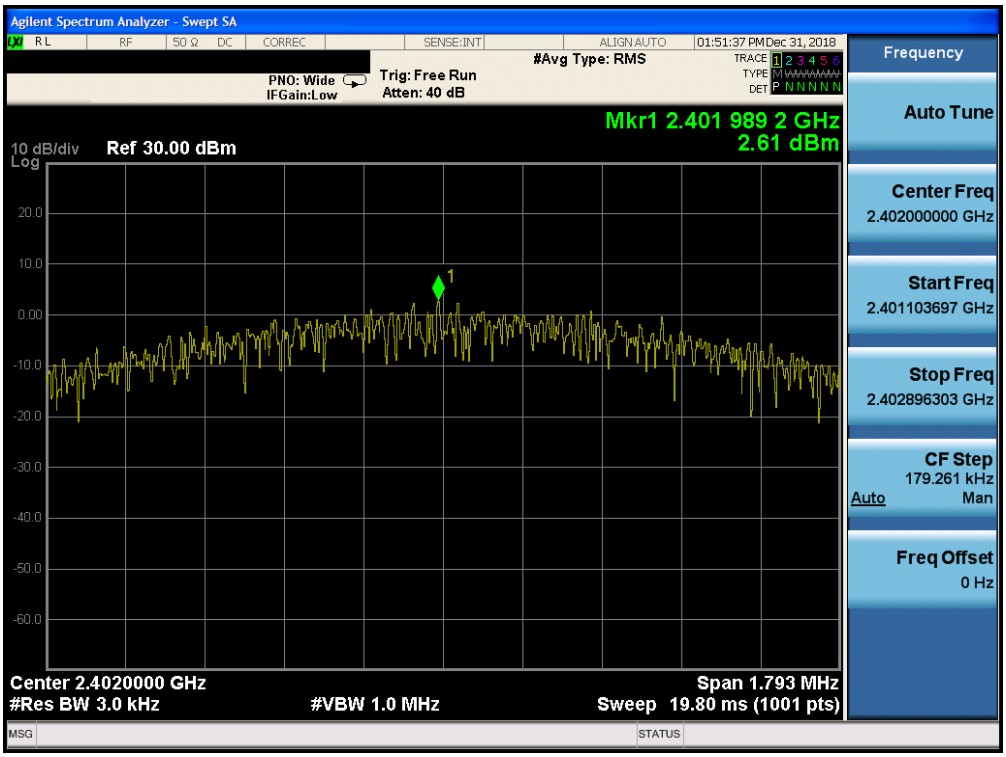
Plot 7-28. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps iPA – Ch. 0)



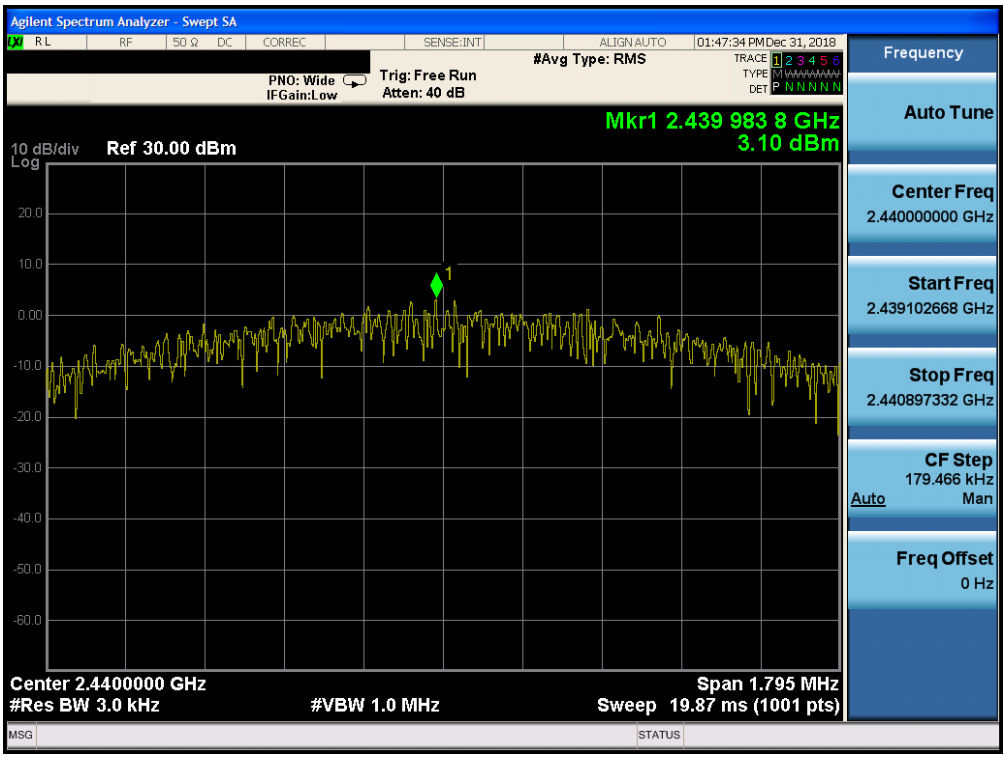
Plot 7-29. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps iPA – Ch. 19)



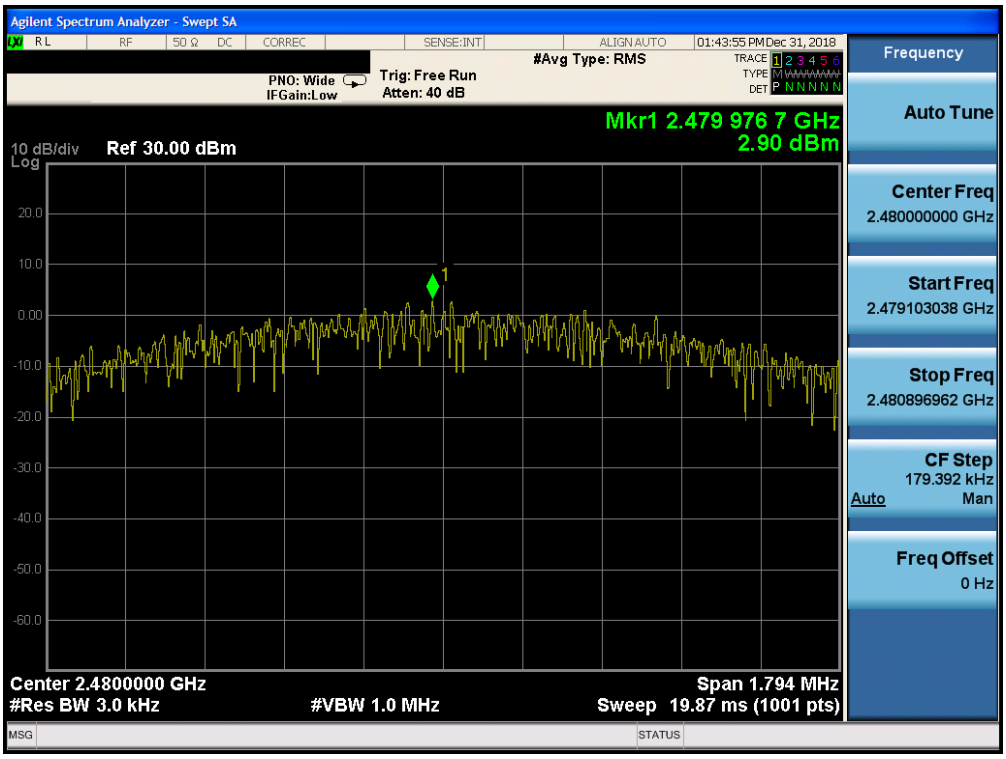
Plot 7-30. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 1Mbps iPA – Ch. 39)



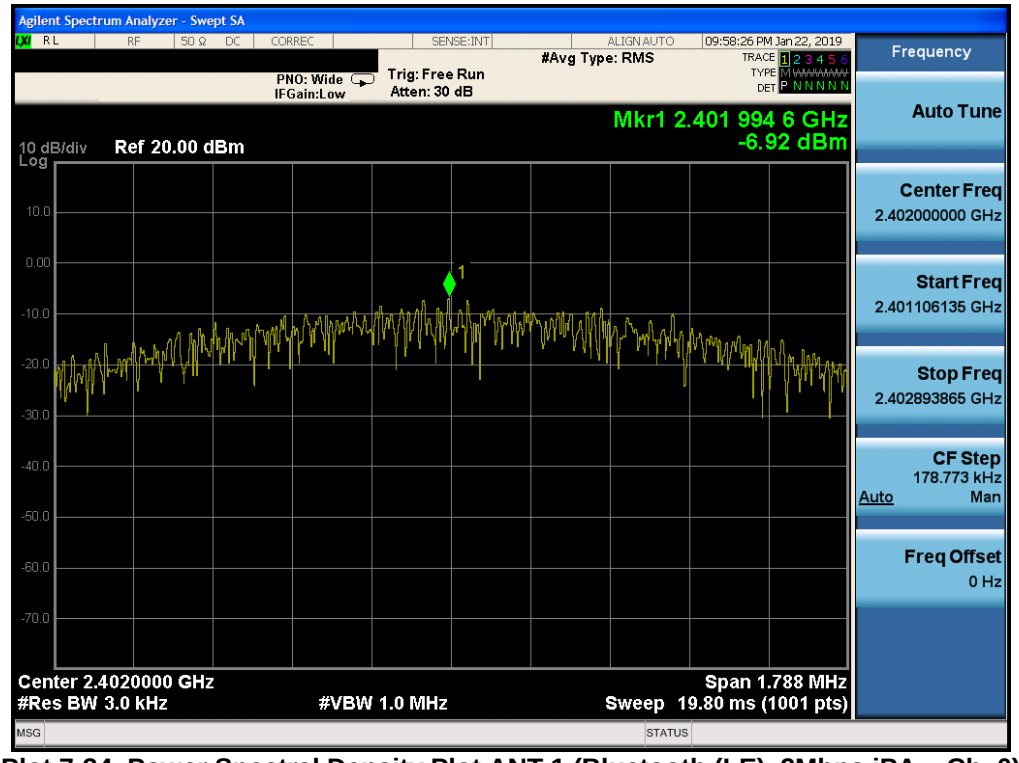
Plot 7-31. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 0)



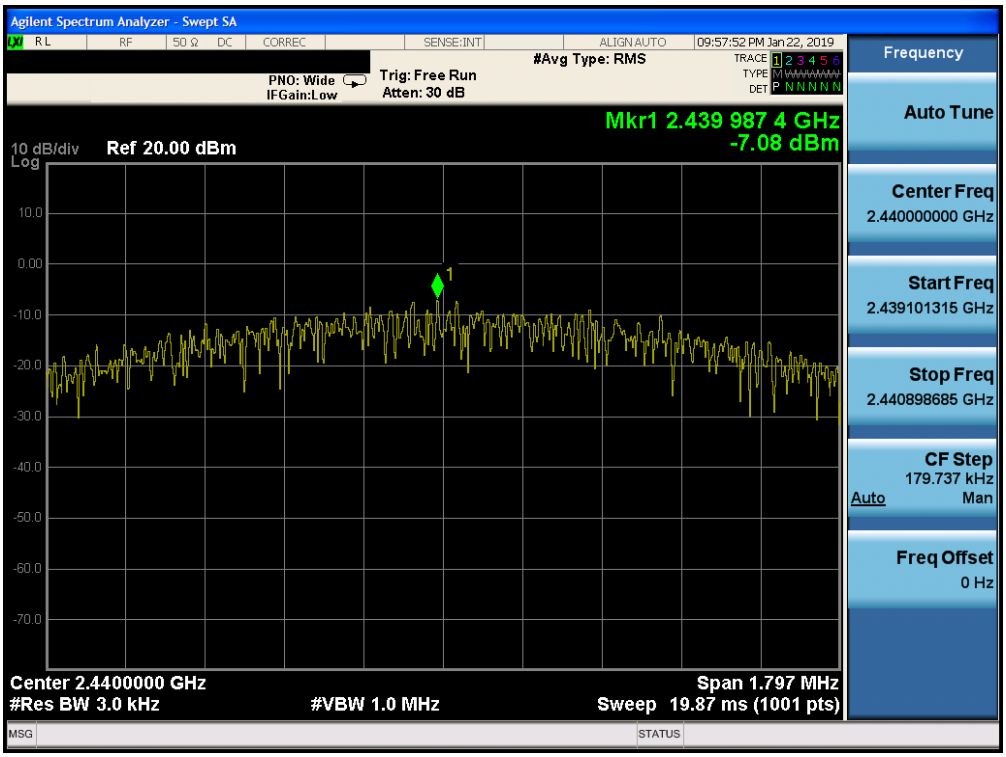
Plot 7-32. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 19)



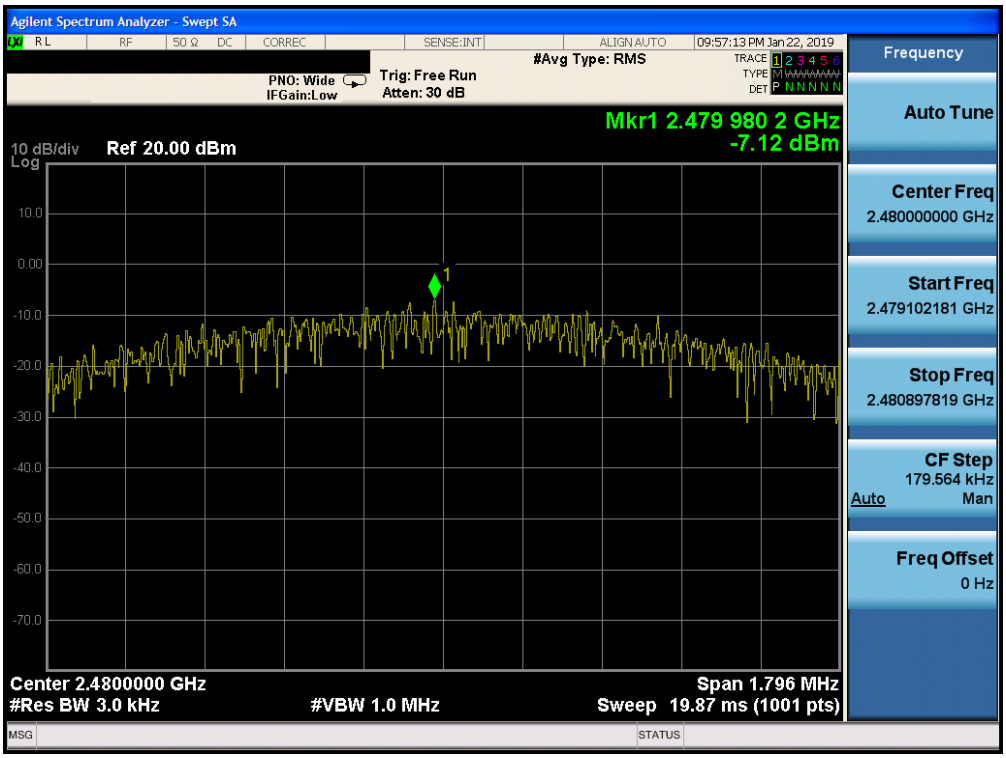
Plot 7-33. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 39)



Plot 7-34. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps iPA – Ch. 0)



Plot 7-35. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps iPA – Ch. 19)



Plot 7-36. Power Spectral Density Plot ANT 1 (Bluetooth (LE), 2Mbps iPA – Ch. 39)

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 v05r01 – 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

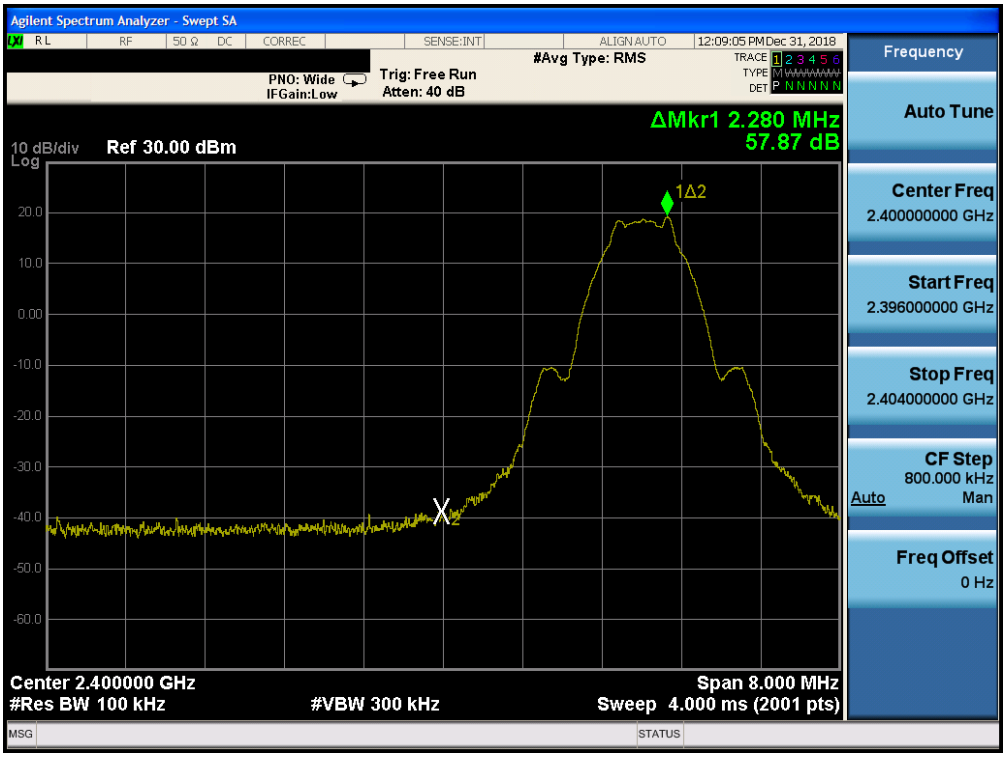
The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-4. Test Instrument & Measurement Setup

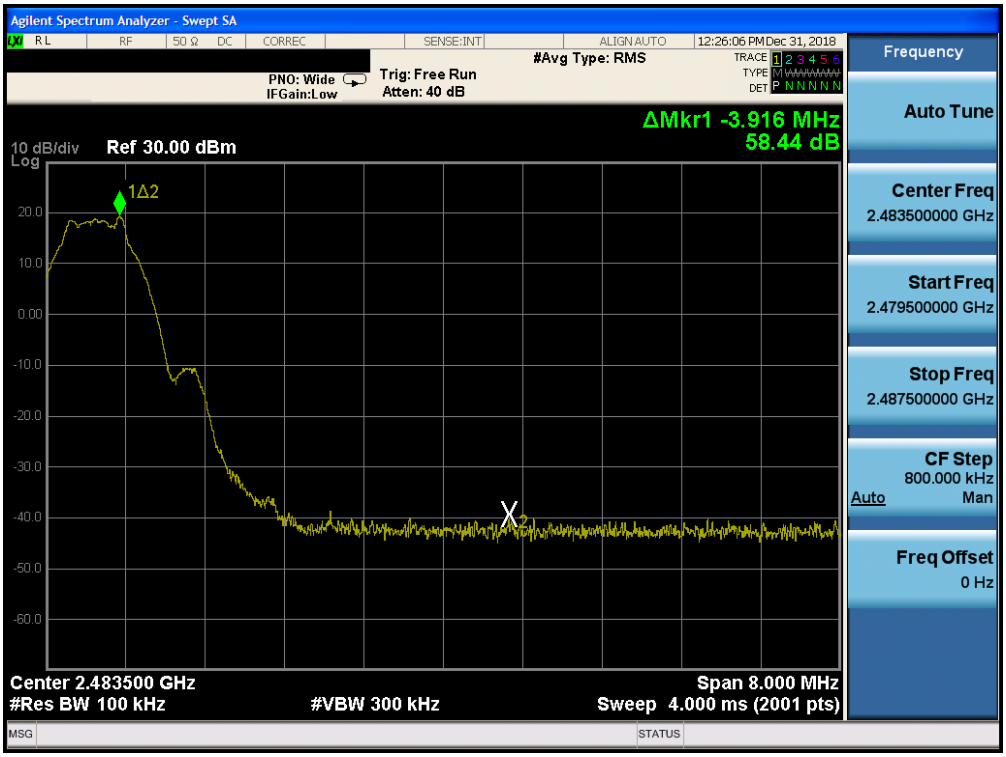
Test Notes

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

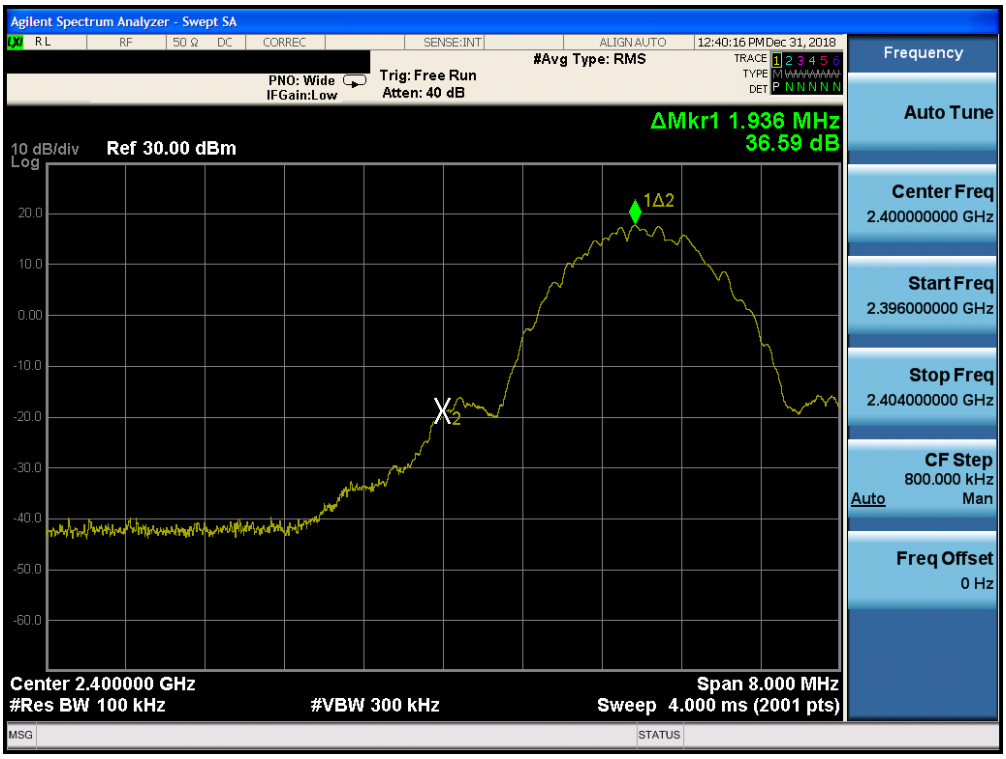
Antenna 0



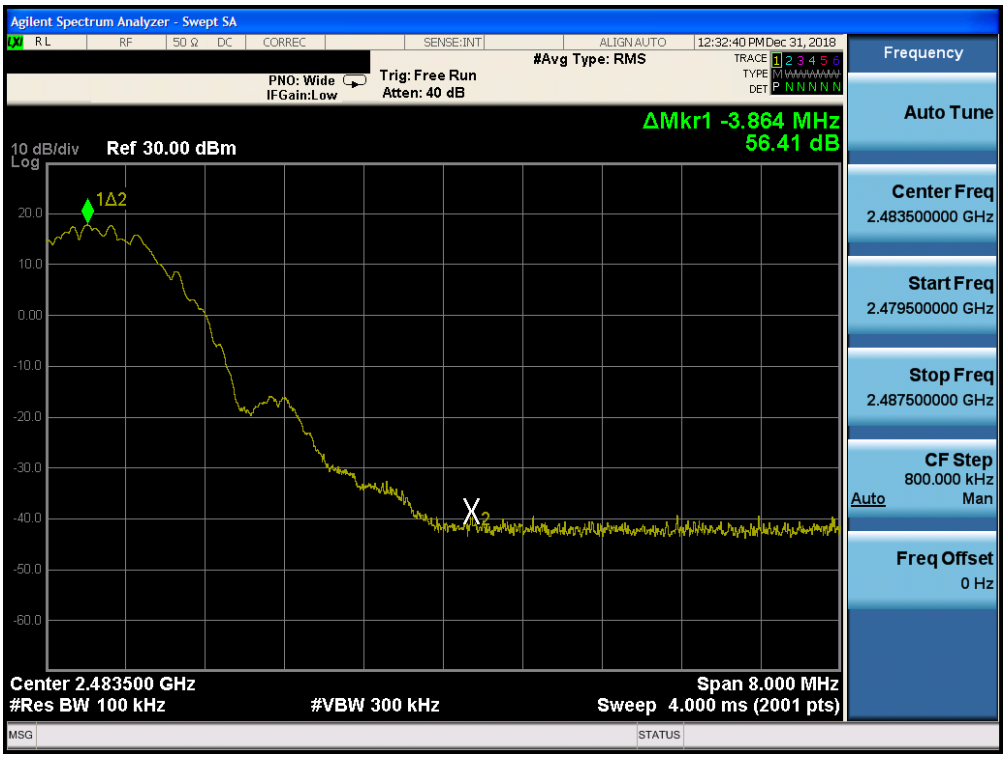
Plot 7-37. Band Edge Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



Plot 7-38. Band Edge Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 39)

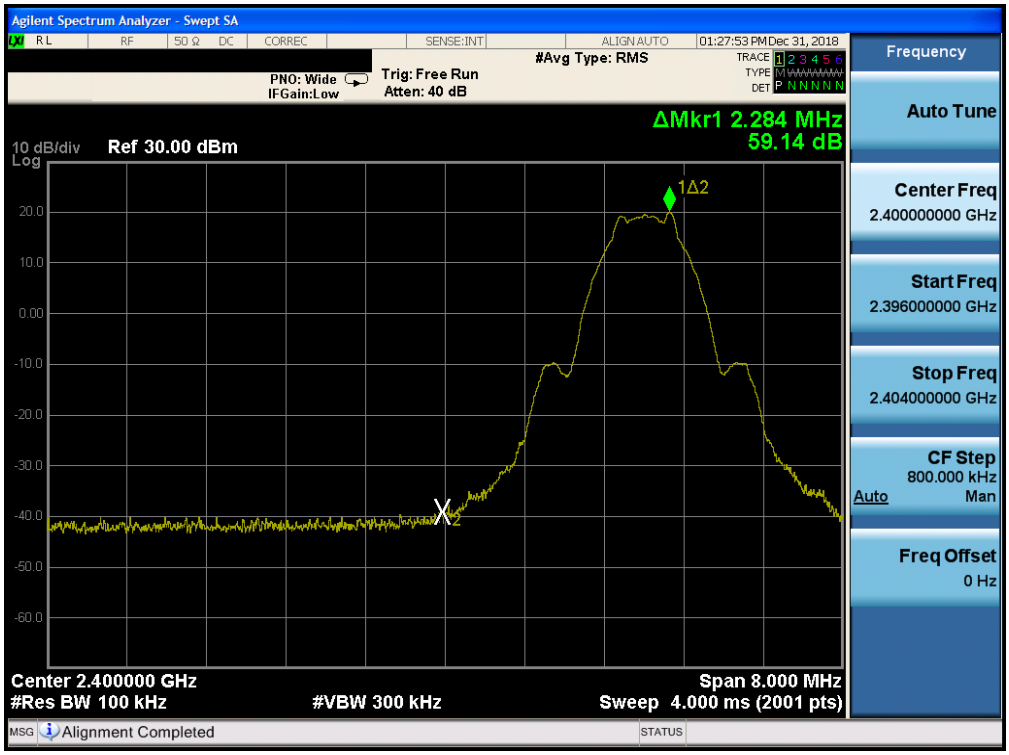


Plot 7-39. Band Edge Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 0)

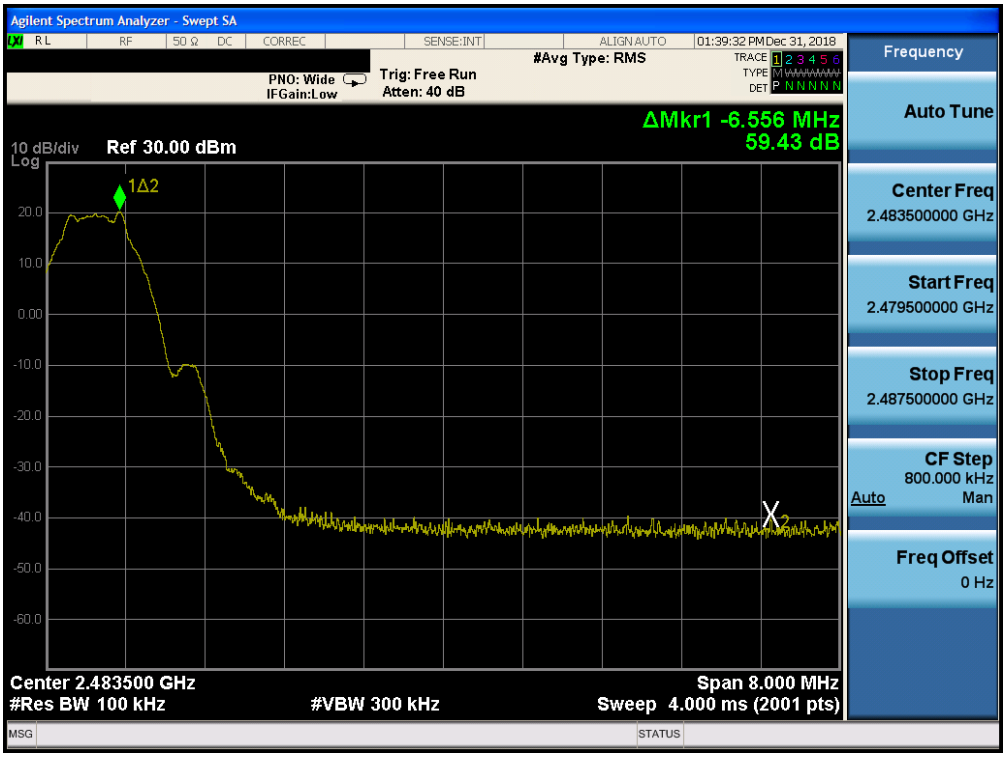


Plot 7-40. Band Edge Plot ANT 0 (Bluetooth (LE), 2Mbps ePA – Ch. 39)

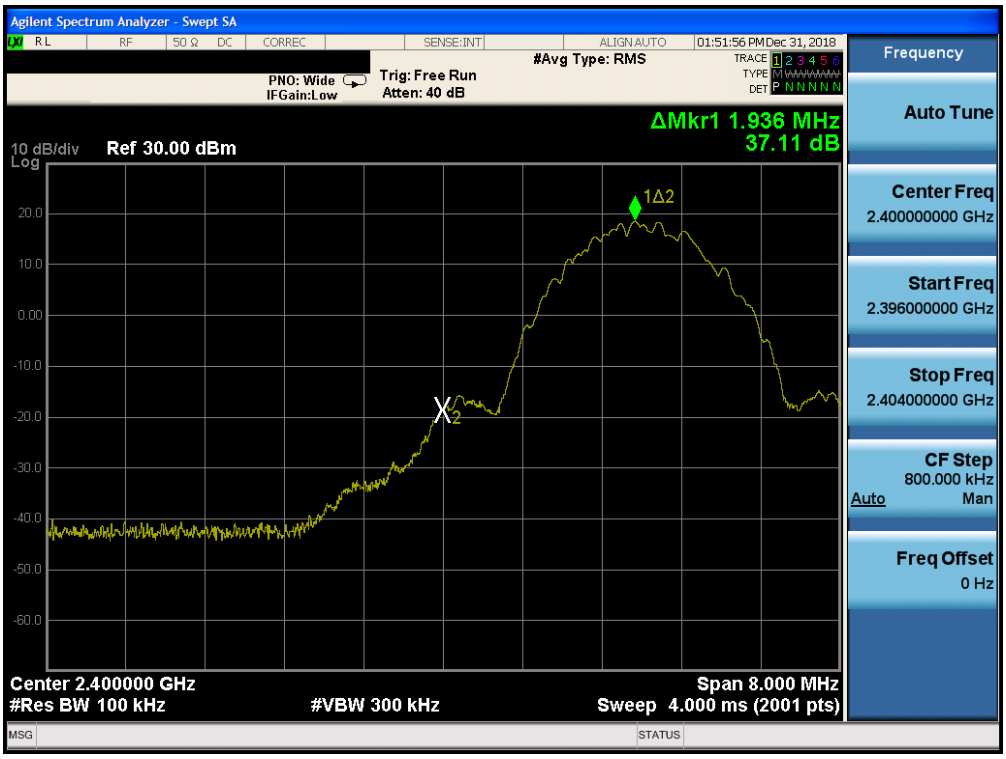
Antenna 1



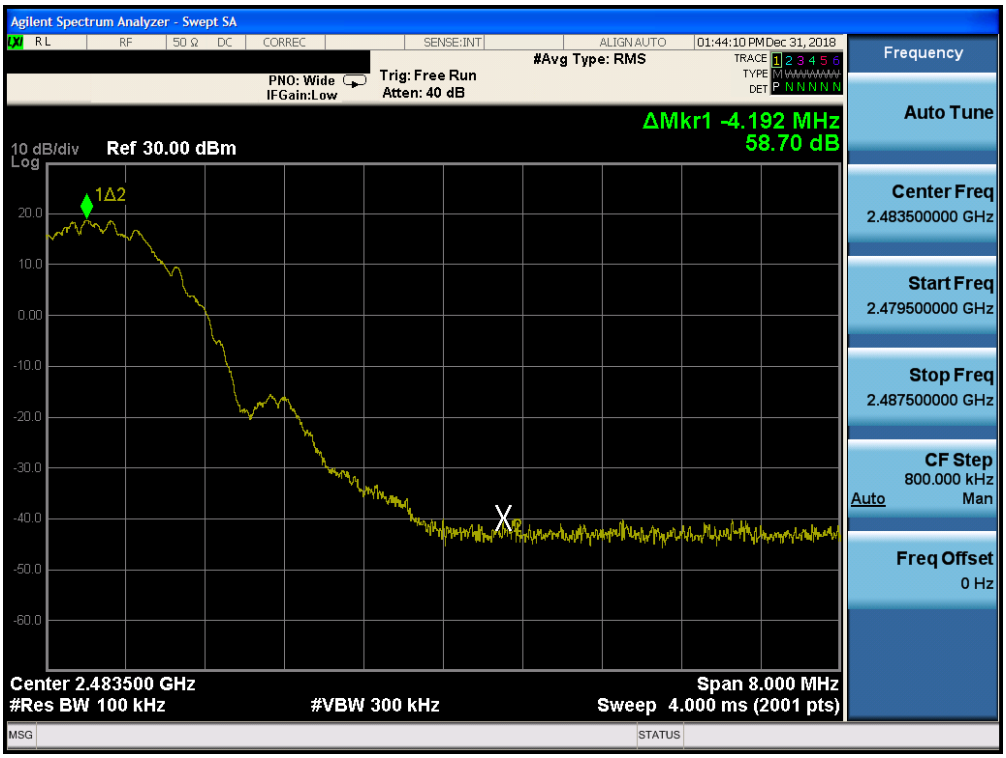
Plot 7-41. Band Edge Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



Plot 7-42. Band Edge Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



Plot 7-43. Band Edge Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 0)



Plot 7-44. Band Edge Plot ANT 1 (Bluetooth (LE), 2Mbps ePA – Ch. 39)

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 v05r01 and Section 11.11.3 of ANSI C63.10-2013.

Test Procedure Used

ANSI C63.10-2013 – Section 11.11.3
KDB 558074 D01 v05r01 – 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

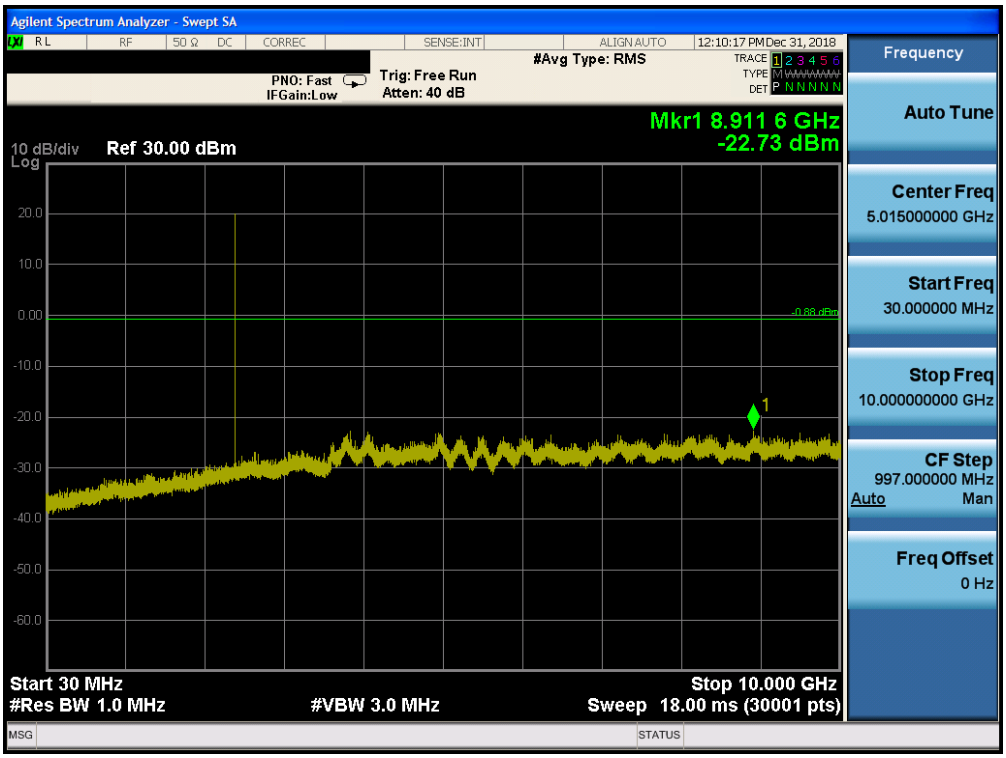
1. RBW was set to 1MHz rather than 100kHz in order to increase the measurement speed.

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.

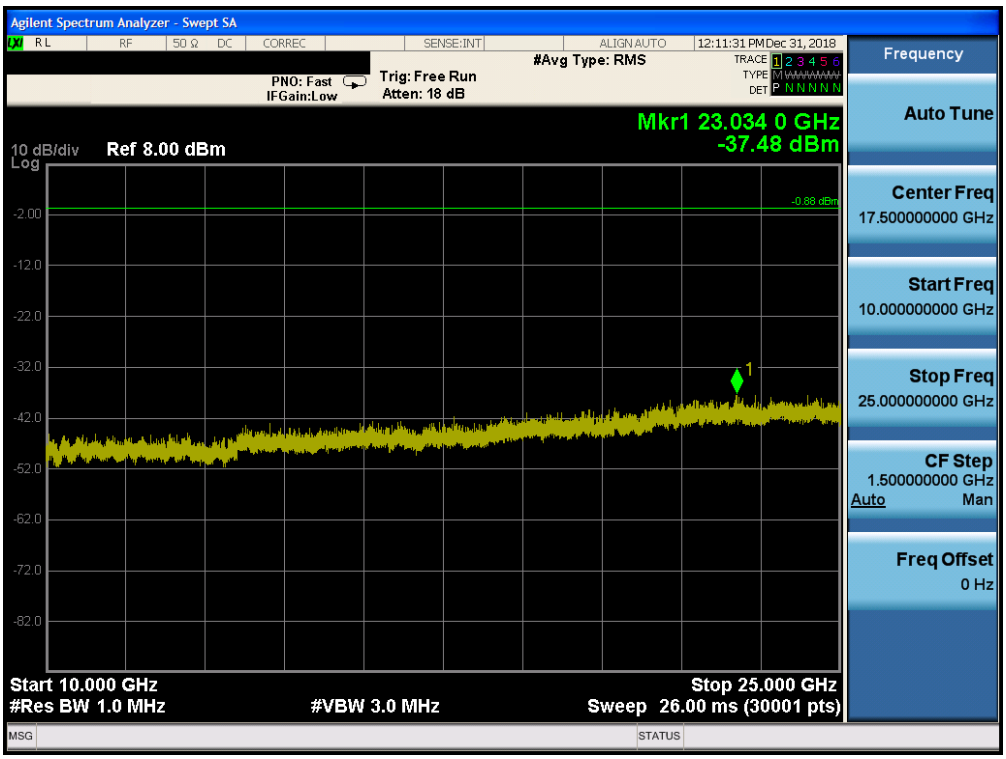
3. For plots showing conducted spurious emissions near the limit, the frequencies were investigated with a reduced RBW to ensure that no emissions were present.

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

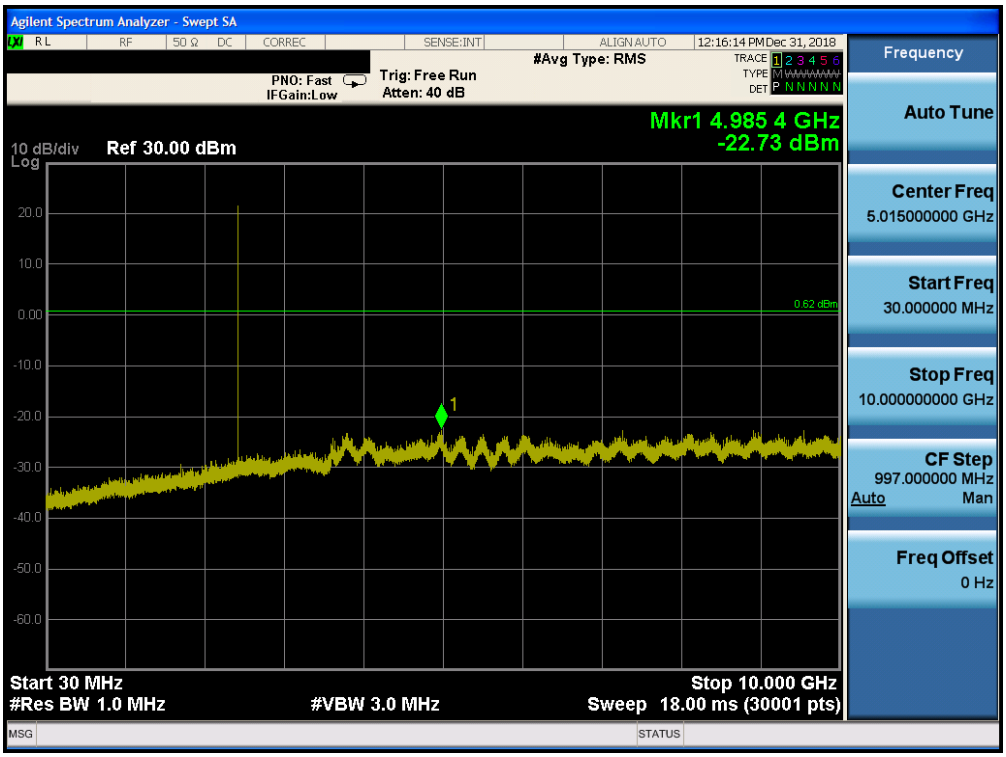
Antenna 0



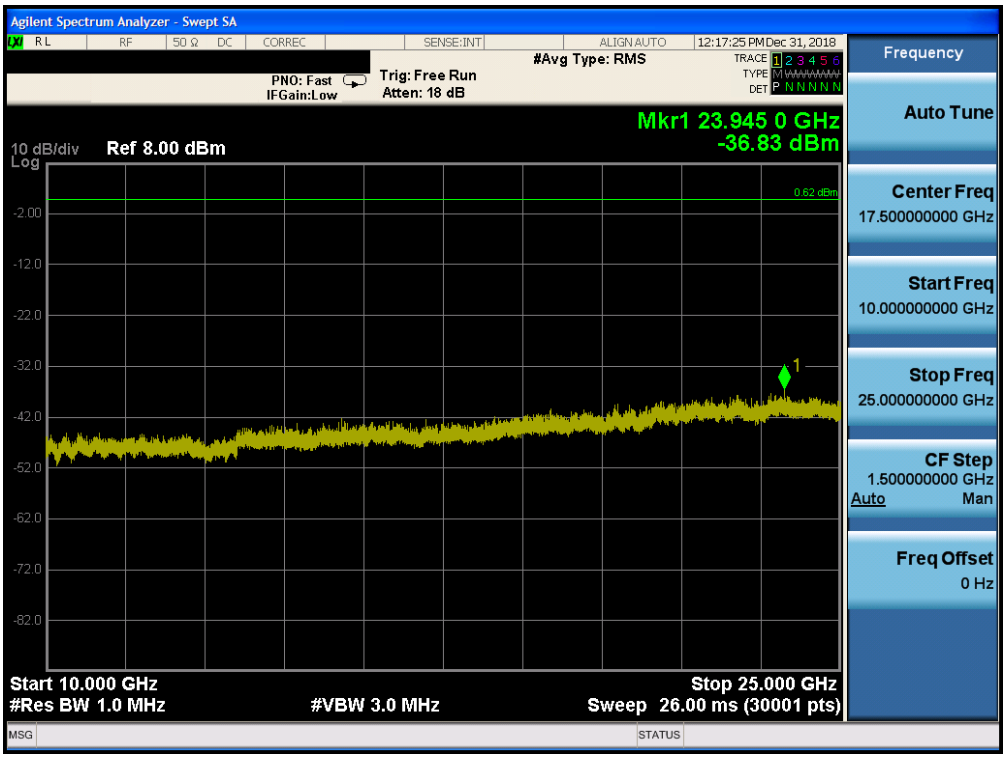
Plot 7-45. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



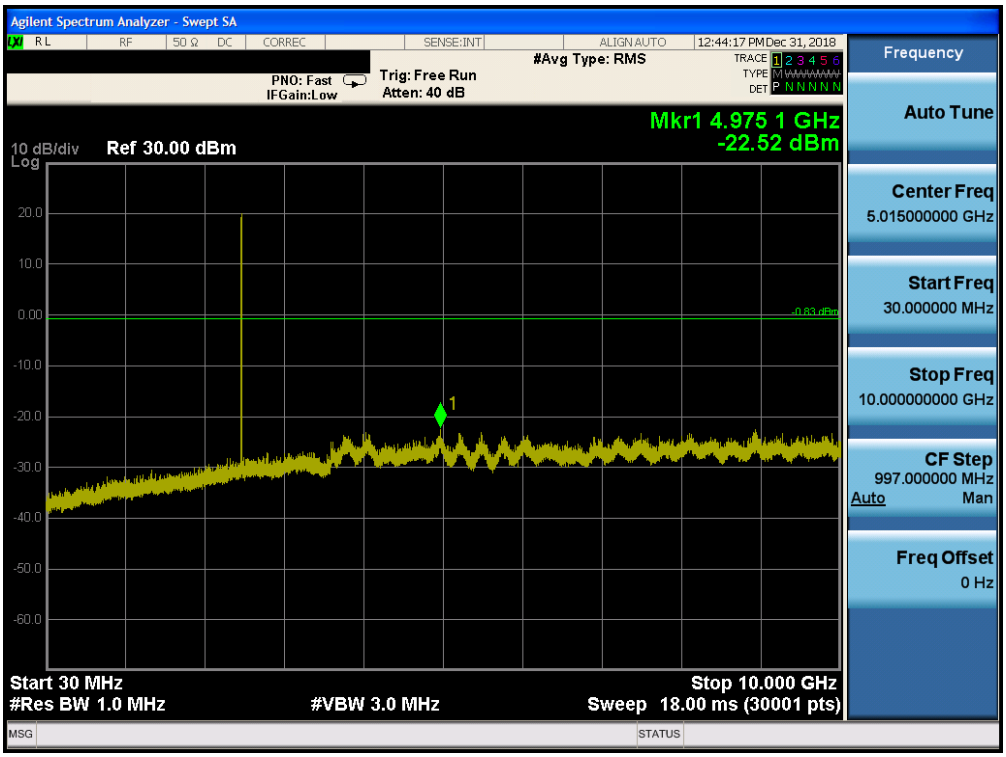
Plot 7-46. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



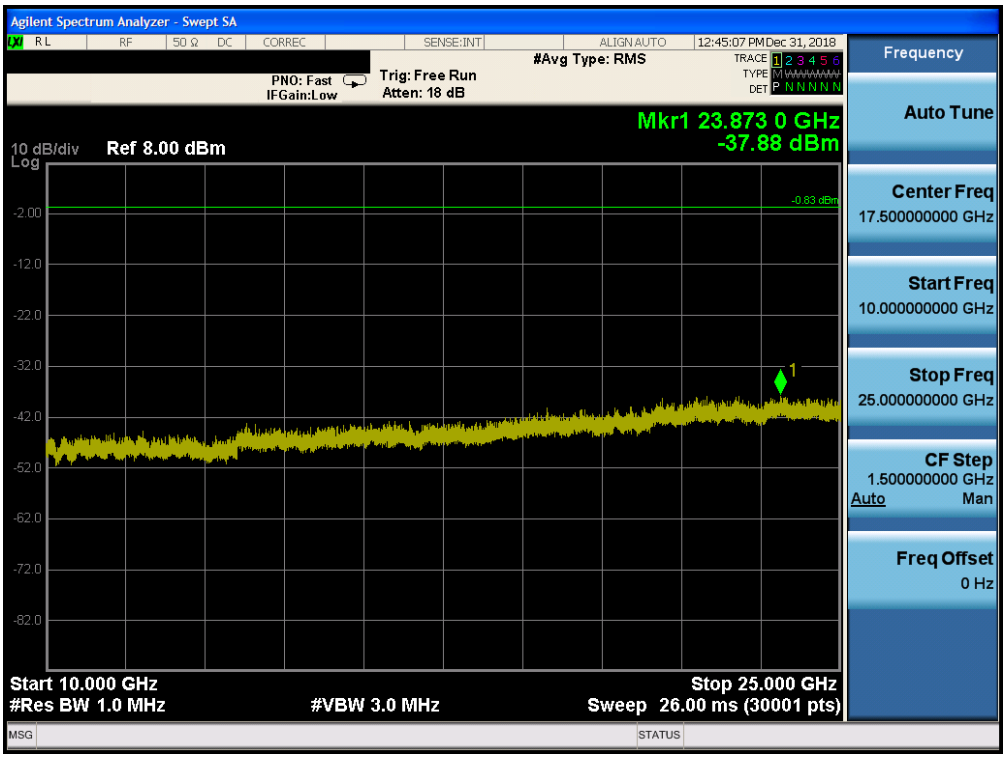
Plot 7-47. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



Plot 7-48. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 19)

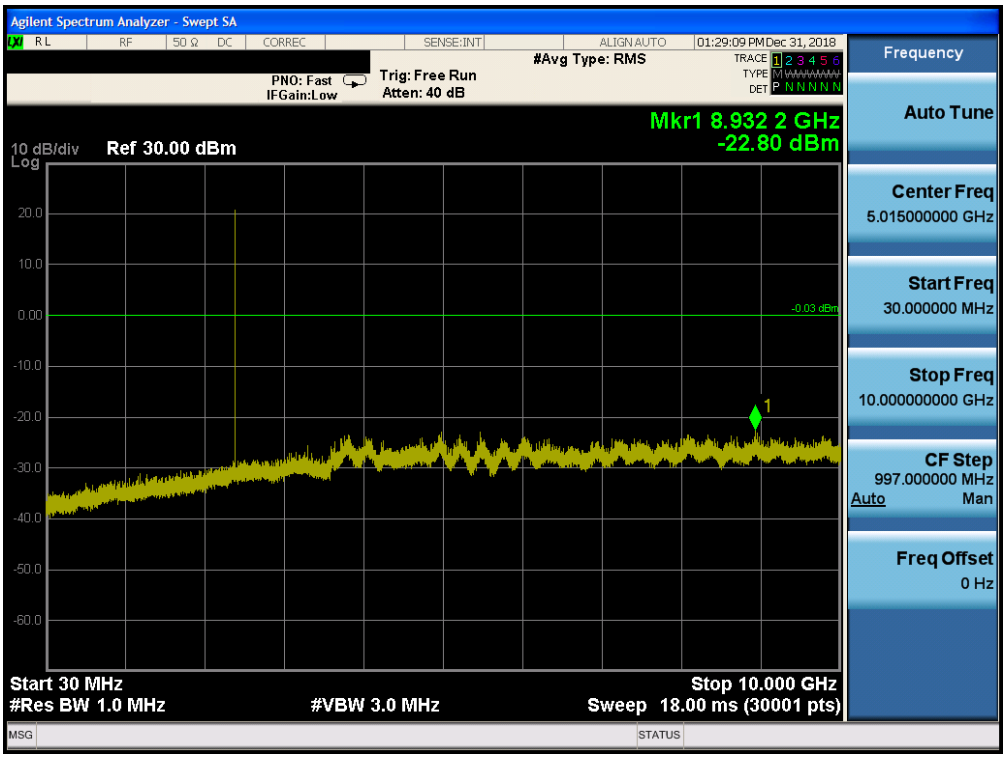


Plot 7-49. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 39)

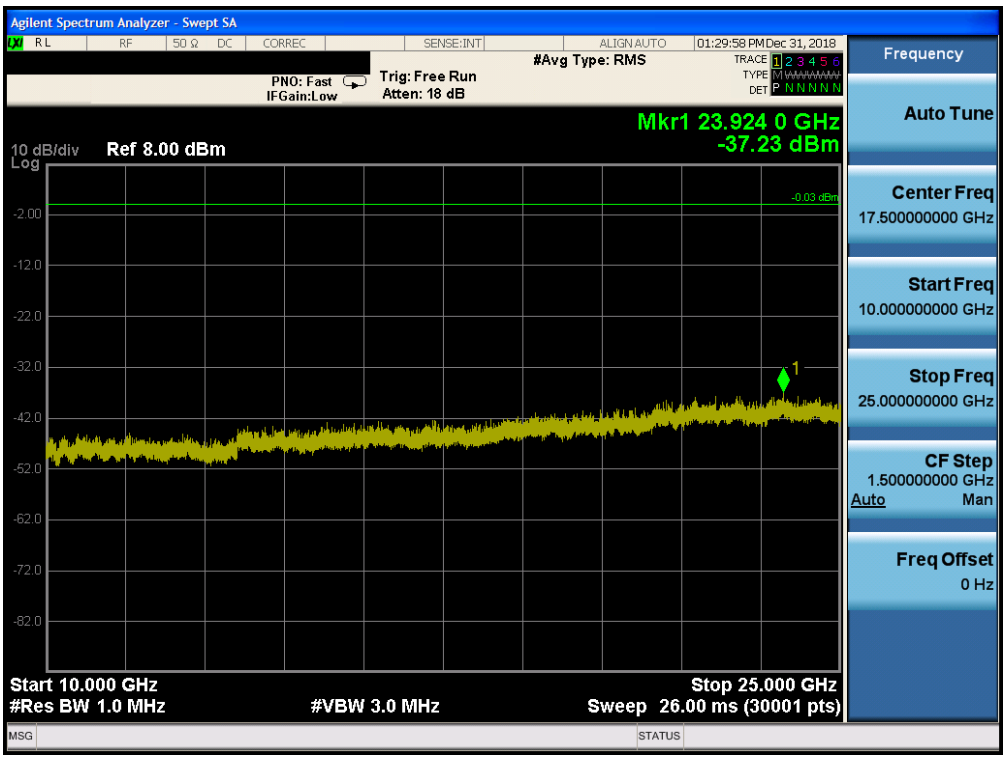


Plot 7-50. Conducted Spurious Plot ANT 0 (Bluetooth (LE), 1Mbps ePA – Ch. 39)

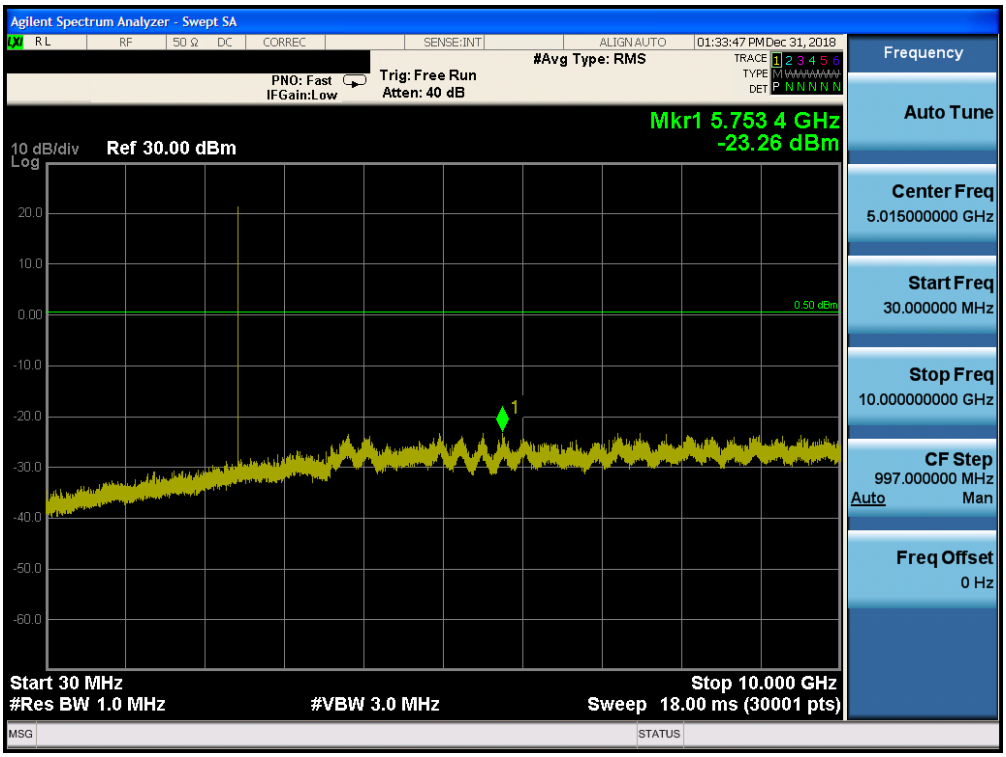
Antenna 1



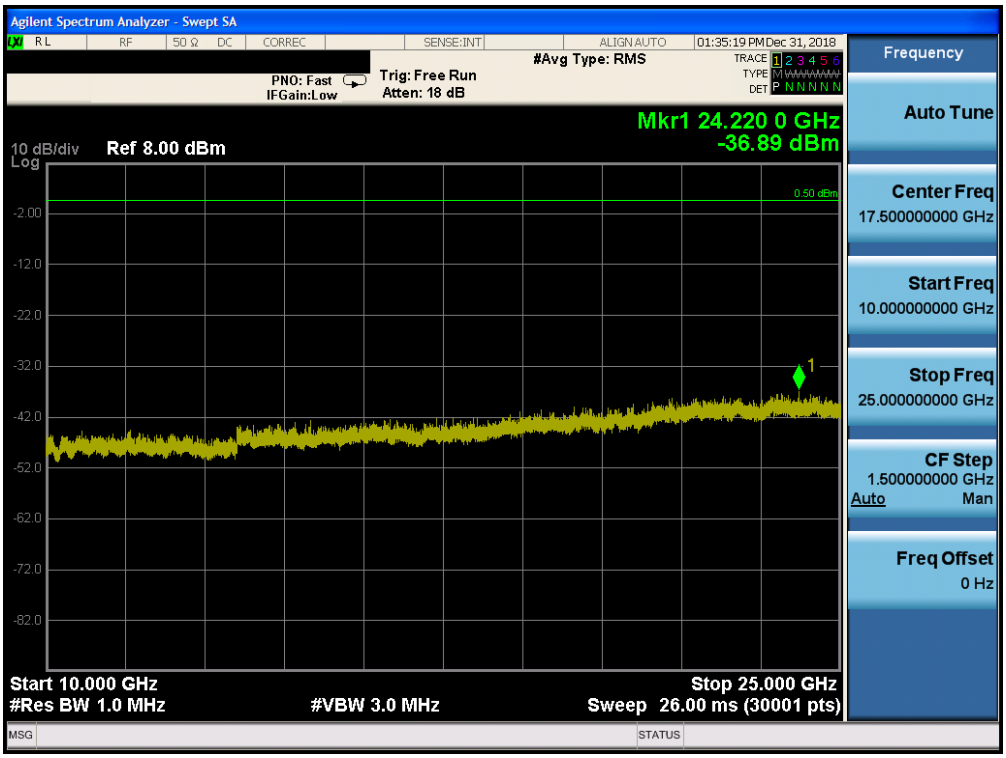
Plot 7-51. Conducted Spurious Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



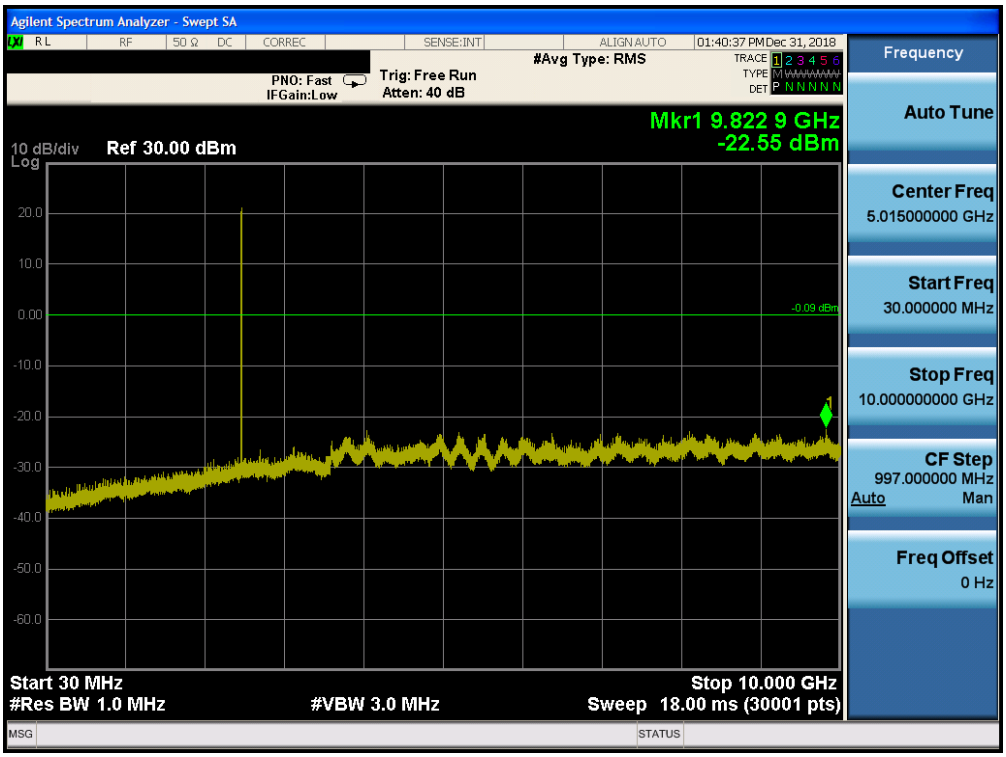
Plot 7-52. Conducted Spurious Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 0)



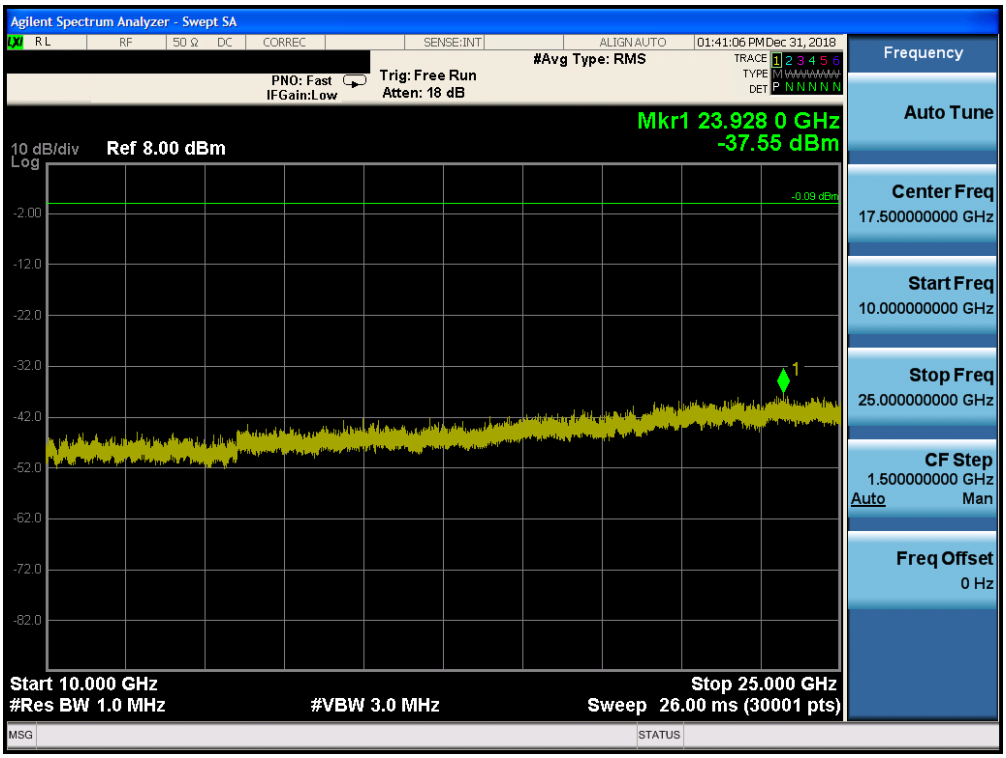
Plot 7-53. Conducted Spurious Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



Plot 7-54. Conducted Spurious Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 19)



Plot 7-55. Conducted Spurious Plot ANT 1 (Bluetooth (LE), 1Mbps ePA – Ch. 39)



Plot 7-56. Conducted Spurious Plot ANT 1 (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 6 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 7-10. Radiated Limits

Test Procedures Used

ANSI C63.10-2013 – Section 6.6.4.3

KDB 558074 D01 v05r01 – 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 = 3kHz > 1/T
4. Averaging type was set to RMS to ensure that video filtering was applied in the power domain
5. Detector = peak
6. Sweep time = auto
7. Trace mode = max hold
8. Trace was allowed to run for at least 50 times (1/duty cycle) traces

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW is set depending on measurement frequency, as specified in Table 7-11 below
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

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

Table 7-11. RBW as a Function of Frequency

Test Setup

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

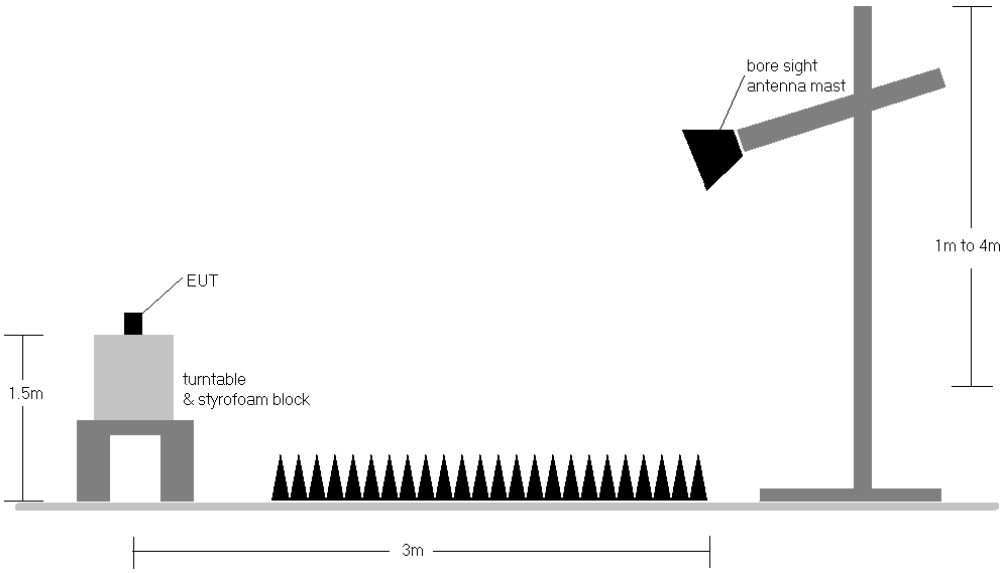


Figure 7-6. Radiated Test Setup >1GHz

Test Notes

1. The optional test procedures for antenna port conducted measurements of unwanted emissions per the guidance of KDB 558074 D01 v05r01 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 7-10.
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. Both power schemes were investigated, and only the worst case 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 $_{[dB\mu V/m]}$

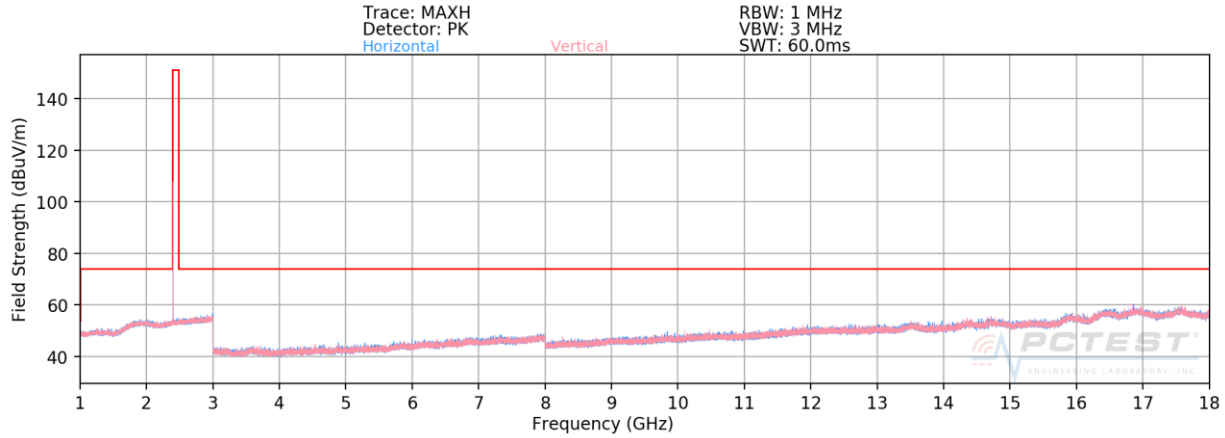
Radiated Band Edge Measurement Offset

- 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

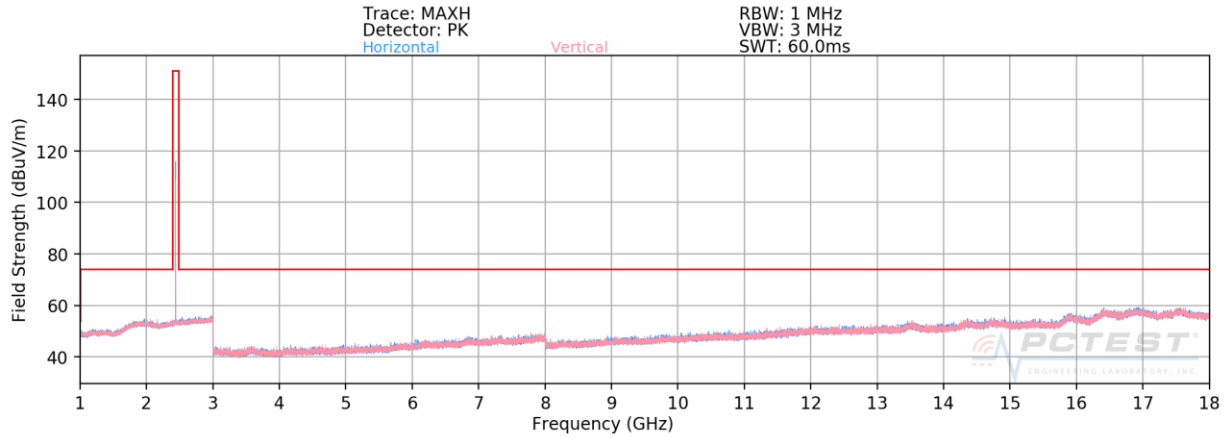
Radiated Spurious Emission Measurements

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

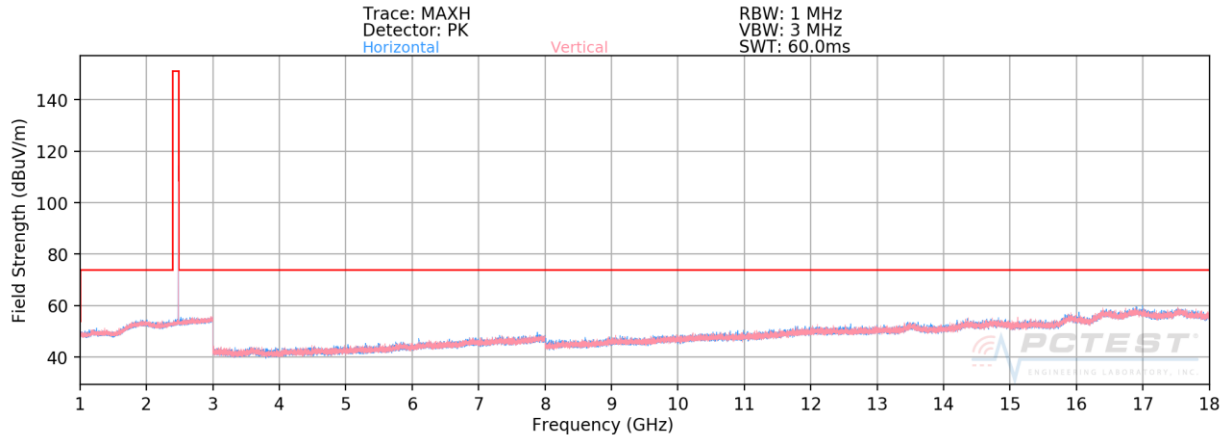
Antenna 0



Plot 7-57. Radiated Spurious Plot Above 1GHz ANT 0 (1Mbps, ePA – Ch. 0)

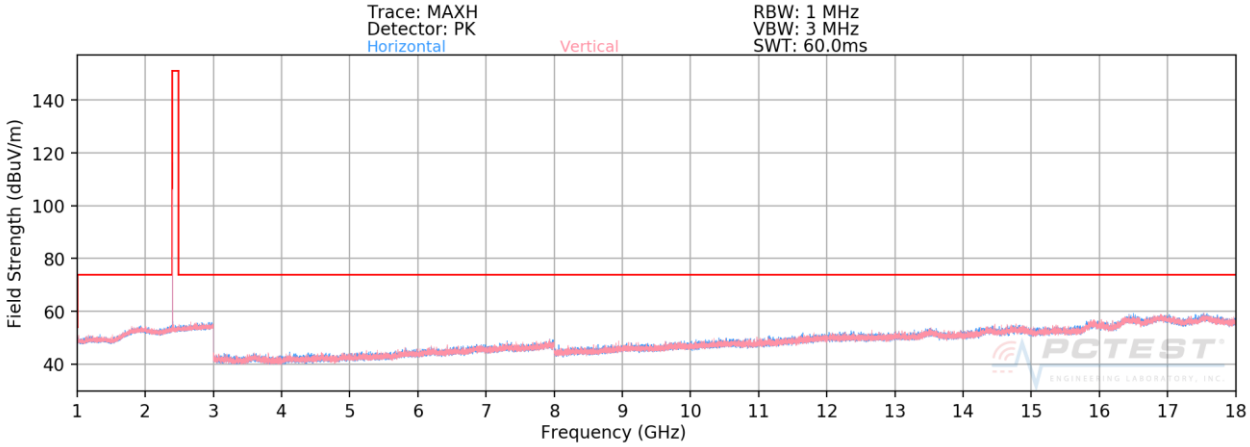


Plot 7-58. Radiated Spurious Plot Above 1GHz ANT 0 (1Mbps, ePA – Ch. 19)

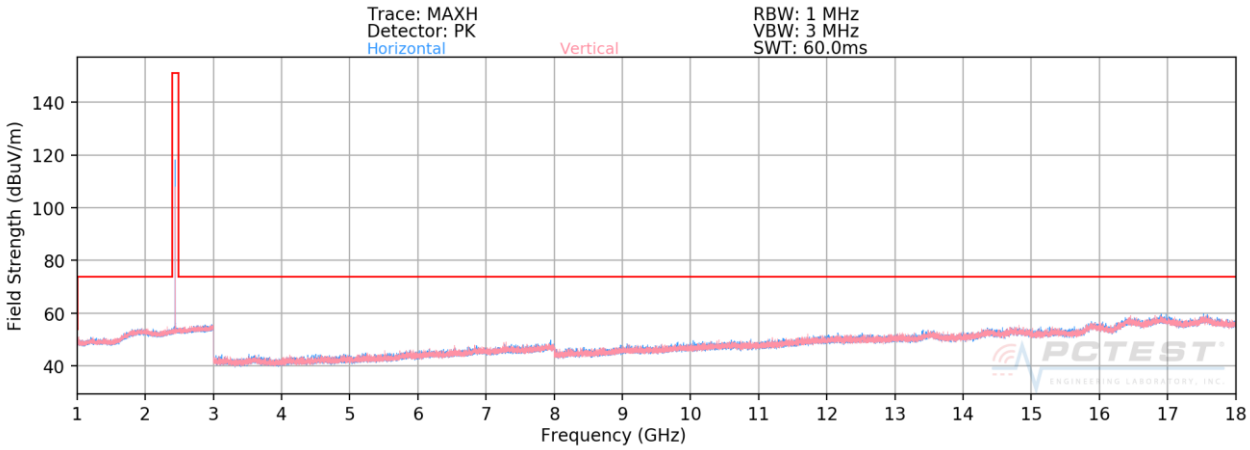


Plot 7-59. Radiated Spurious Plot Above 1GHz ANT 0 (1Mbps, ePA – Ch. 39)

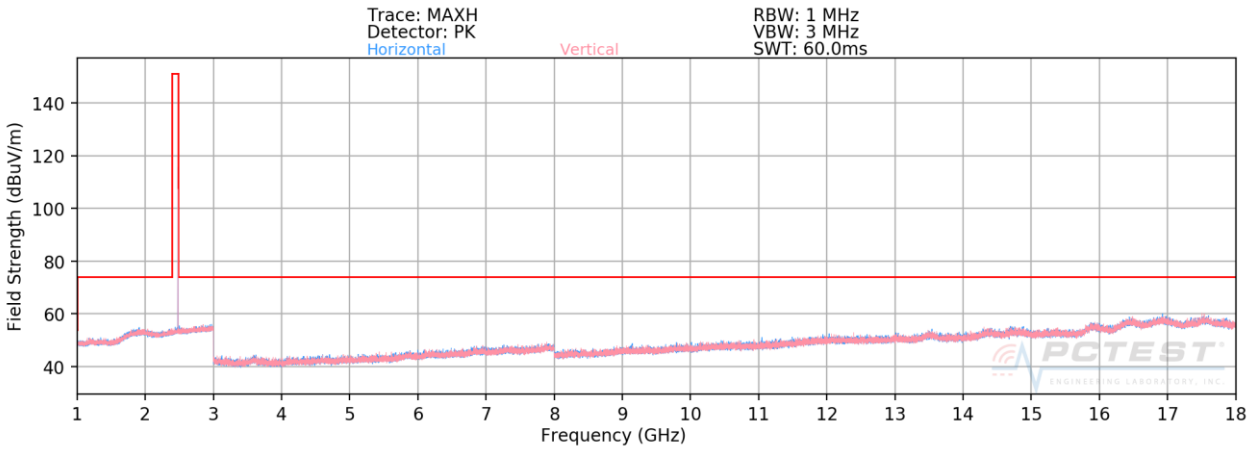
Antenna 1



Plot 7-60. Radiated Spurious Plot Above 1GHz ANT 1 (1Mbps, ePA – Ch. 0)



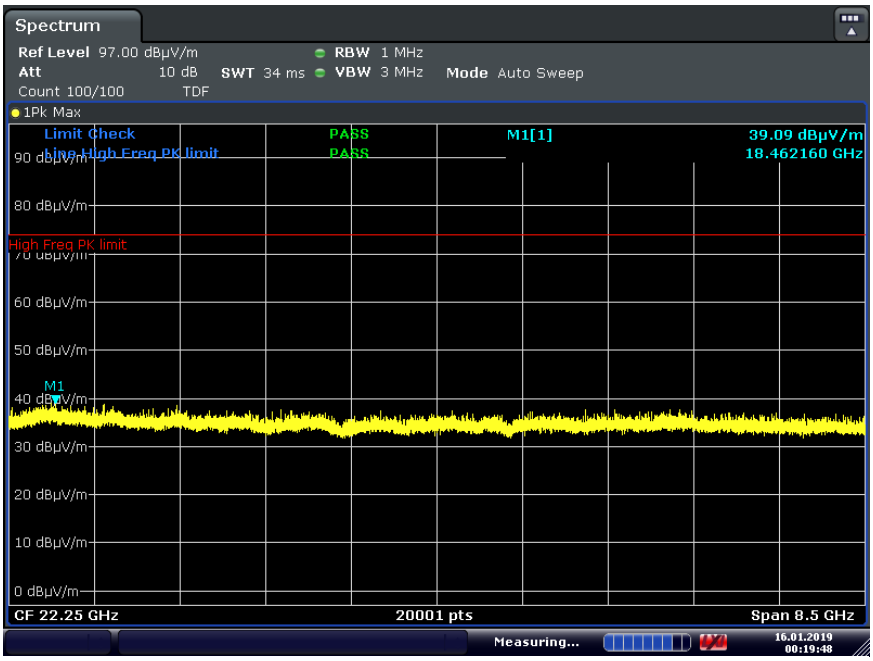
Plot 7-61. Radiated Spurious Plot Above 1GHz ANT 1 (1Mbps, ePA – Ch. 19)



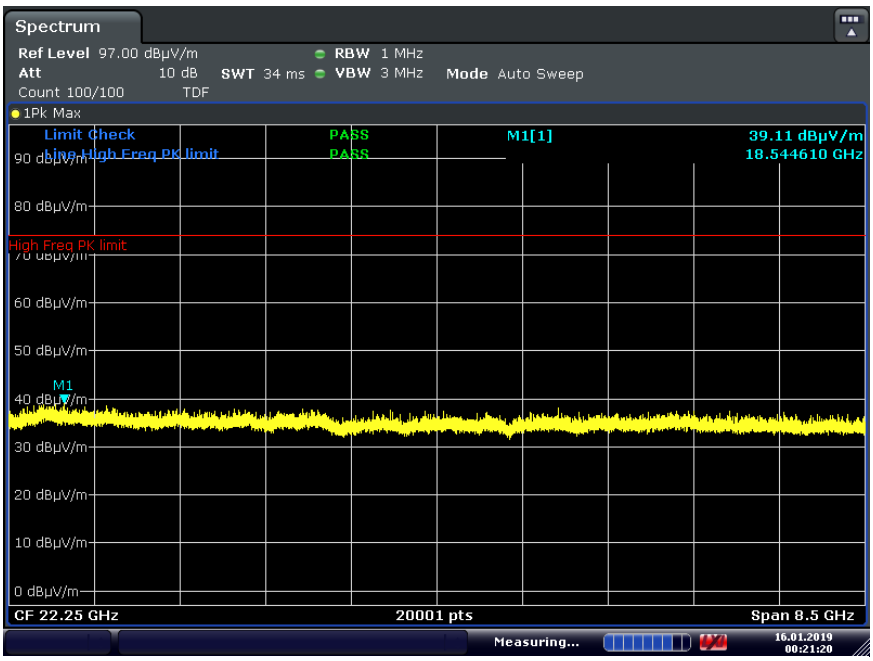
Plot 7-62. Radiated Spurious Plot Above 1GHz ANT 1 (1Mbps, ePA – Ch. 39)

Radiated Spurious Emission Measurements (Above 18GHz)

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



Plot 7-63. Radiated Spurious Plot Above 18GHz ANT 0 (1Mbps, ePA – Ch. 19, Ant. Pol. H)



Plot 7-64. Radiated Spurious Plot Above 18GHz ANT 0 (1Mbps, ePA – Ch. 19, Ant. Pol. V)

Radiated Spurious Emission Measurements

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

Antenna 0

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	-	-	-78.68	5.06	33.38	53.98	-20.60
4804.00	Peak	H	-	-	-66.44	5.06	45.62	73.98	-28.36
12010.00	Avg	H	-	-	-85.06	19.16	41.10	53.98	-12.88
12010.00	Peak	H	-	-	-73.84	19.16	52.32	73.98	-21.66

Table 7-12. Radiated Measurements @ 3 meters

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	-	-	-78.98	5.56	33.58	53.98	-20.40
4880.00	Peak	H	-	-	-66.88	5.56	45.68	73.98	-28.30
7320.00	Avg	H	348	108	-79.65	10.35	37.70	53.98	-16.28
7320.00	Peak	H	348	108	-68.09	10.35	49.26	73.98	-24.72
12200.00	Avg	H	-	-	-84.98	19.13	41.15	53.98	-12.83
12200.00	Peak	H	-	-	-73.27	19.13	52.86	73.98	-21.12

Table 7-13. Radiated Measurements @ 3 meters

Radiated Spurious Emission Measurements

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

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	-	-	-78.77	5.37	33.60	53.98	-20.38
4960.00	Peak	H	-	-	-67.22	5.37	45.15	73.98	-28.83
7440.00	Avg	H	-	-	-80.85	10.16	36.31	53.98	-17.66
7440.00	Peak	H	-	-	-69.14	10.16	48.02	73.98	-25.95
12400.00	Avg	H	-	-	-85.28	19.55	41.27	53.98	-12.71
12400.00	Peak	H	-	-	-73.79	19.55	52.76	73.98	-21.22

Table 7-14. Radiated Measurements @ 3 meters

Radiated Spurious Emission Measurements

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

Antenna 1

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	-	-	-78.87	5.06	33.19	53.98	-20.79
4804.00	Peak	H	-	-	-67.07	5.06	44.99	73.98	-28.99
12010.00	Avg	H	-	-	-84.90	19.16	41.26	53.98	-12.72
12010.00	Peak	H	-	-	-73.13	19.16	53.03	73.98	-20.95

Table 7-15. Radiated Measurements @ 3 meters

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	-	-	-78.96	5.56	33.60	53.98	-20.38
4880.00	Peak	H	-	-	-67.09	5.56	45.47	73.98	-28.51
7320.00	Avg	H	-	-	-80.83	10.35	36.52	53.98	-17.46
7320.00	Peak	H	-	-	-69.23	10.35	48.12	73.98	-25.86
12200.00	Avg	H	-	-	-84.96	19.13	41.17	53.98	-12.81
12200.00	Peak	H	-	-	-73.71	19.13	52.42	73.98	-21.56

Table 7-16. Radiated Measurements @ 3 meters

Radiated Spurious Emission Measurements

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

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	-	-	-78.66	5.37	33.71	53.98	-20.27
4960.00	Peak	H	-	-	-66.88	5.37	45.49	73.98	-28.49
7440.00	Avg	H	-	-	-80.76	10.16	36.40	53.98	-17.57
7440.00	Peak	H	-	-	-69.17	10.16	47.99	73.98	-25.98
12400.00	Avg	H	-	-	-85.40	19.55	41.15	53.98	-12.83
12400.00	Peak	H	-	-	-74.28	19.55	52.27	73.98	-21.71

Table 7-17. Radiated Measurements @ 3 meters

7.8 Radiated Restricted Band Edge Measurements

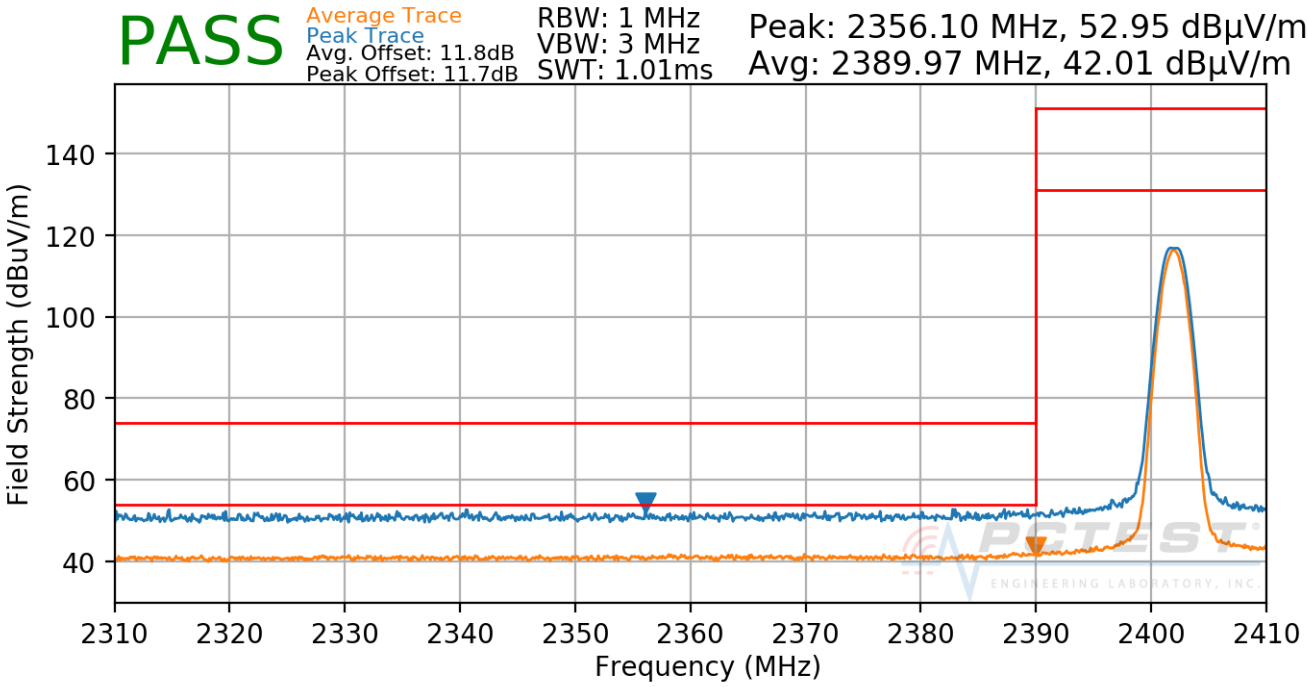
§15.205 §15.209; RSS-Gen [8.9]

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 7-65. Radiated Restricted Lower Band Edge Measurement ANT 0 (Average & Peak)

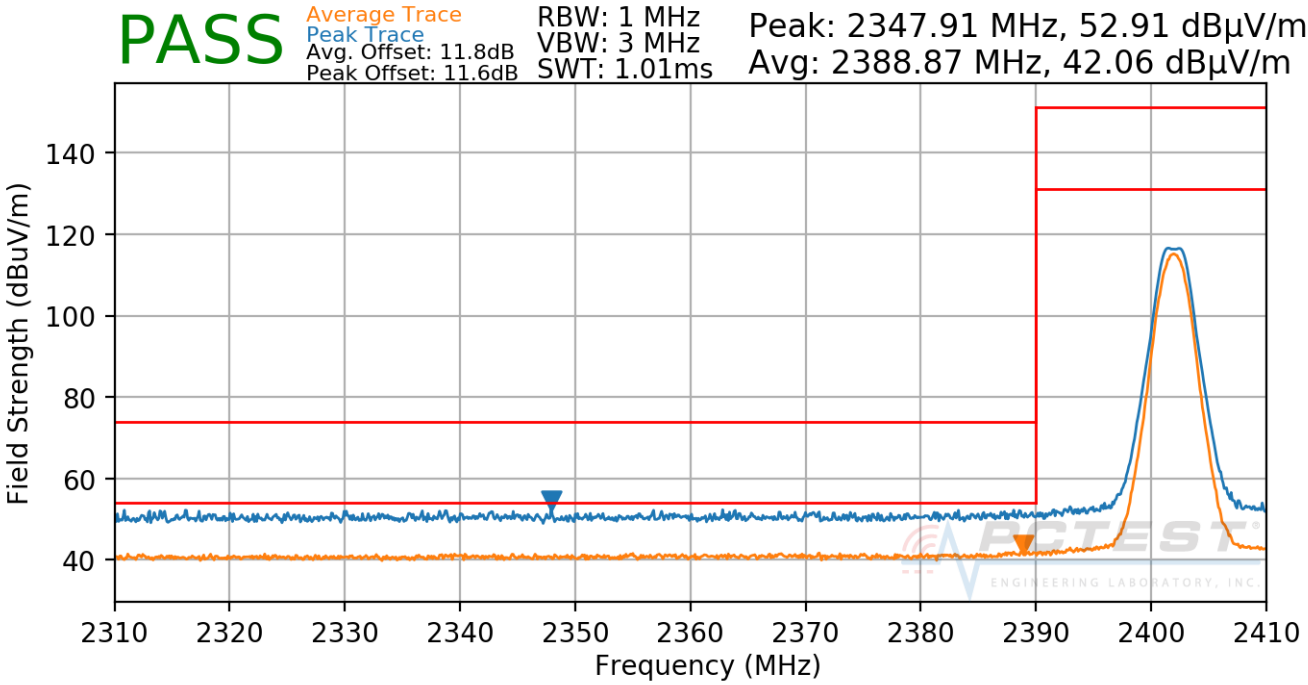
Radiated Restricted Band Edge Measurements

§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:	2402MHz
Channel:	0



Plot 7-66. Radiated Restricted Lower Band Edge Measurement ANT 0 (Average & Peak)

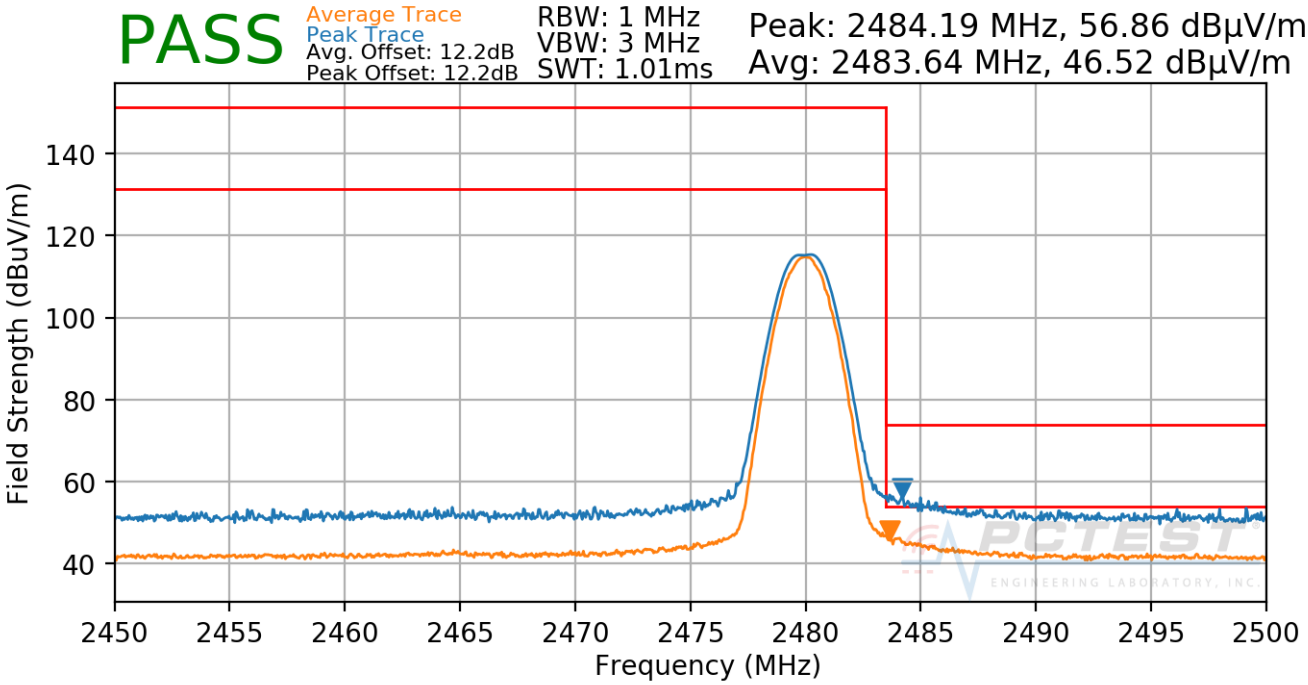
Radiated Restricted Band Edge Measurements

§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 7-67. Radiated Restricted Upper Band Edge Measurement ANT 0 (Average & Peak)

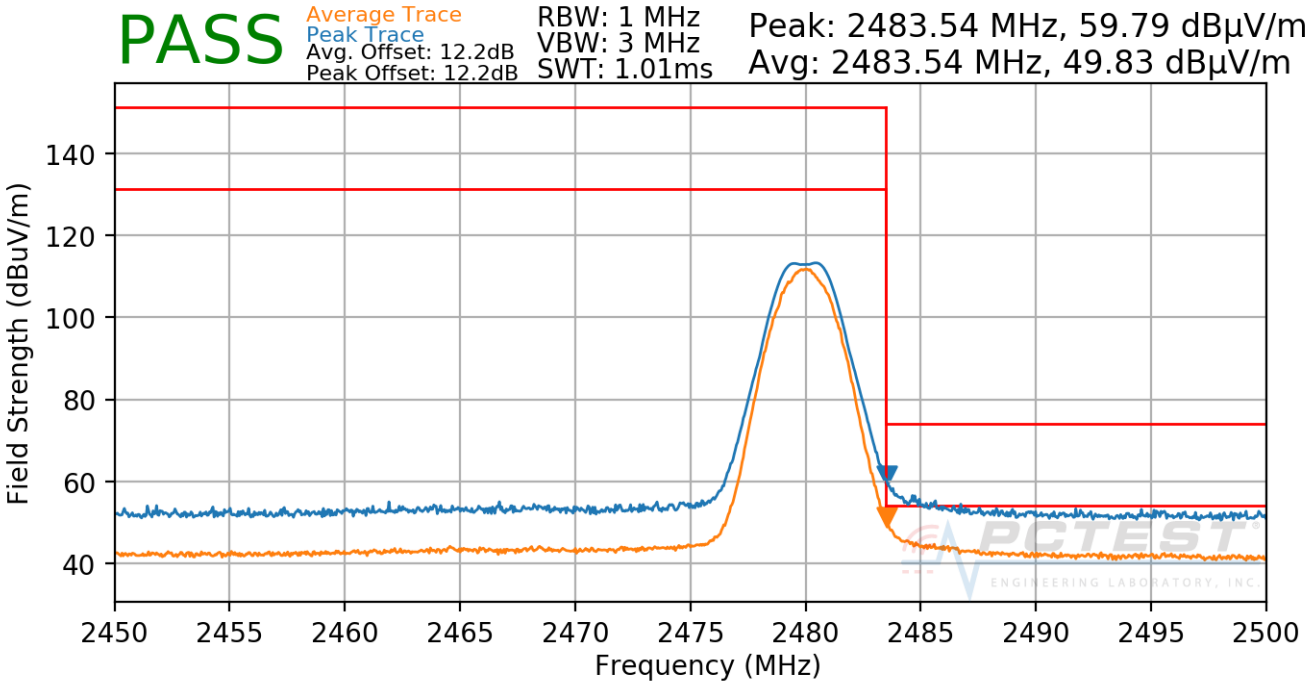
Radiated Restricted Band Edge Measurements

§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:	2480MHz
Channel:	39



Plot 7-68. Radiated Restricted Upper Band Edge Measurement ANT 0 (Average & Peak)

Radiated Restricted Band Edge Measurements

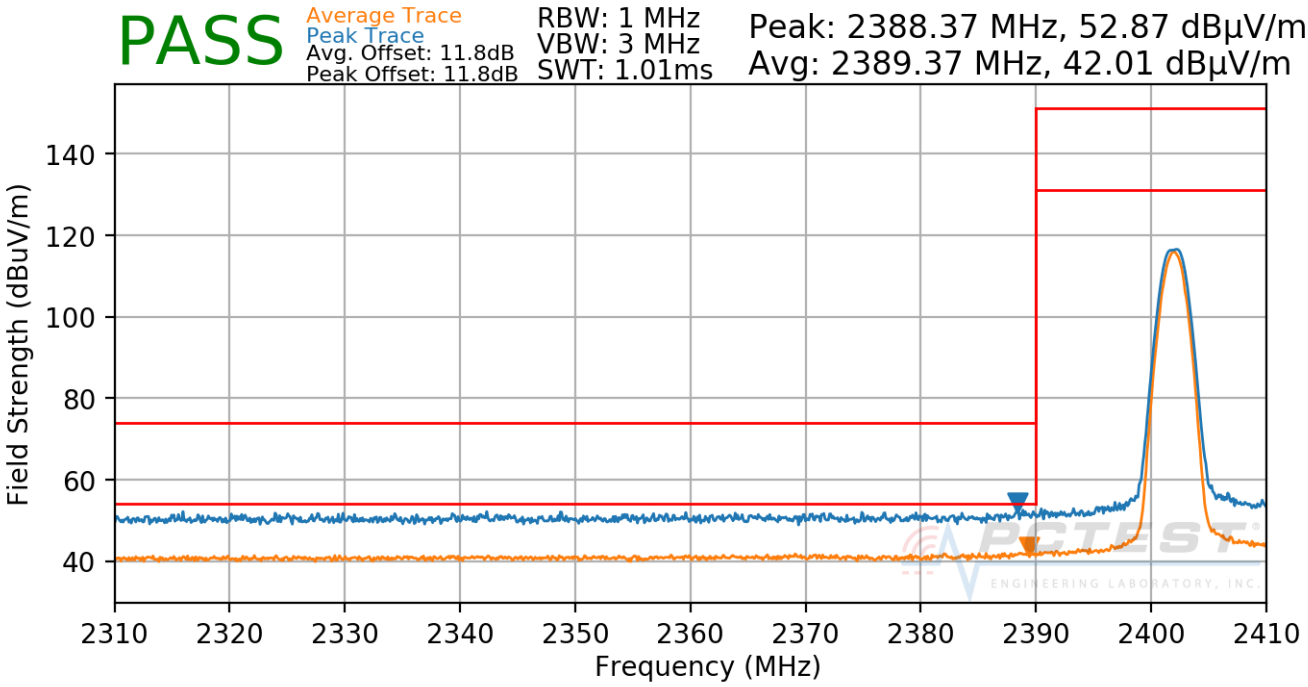
§15.205 §15.209; RSS-Gen [8.9]

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 7-69. Radiated Restricted Lower Band Edge Measurement ANT 1 (Average & Peak)

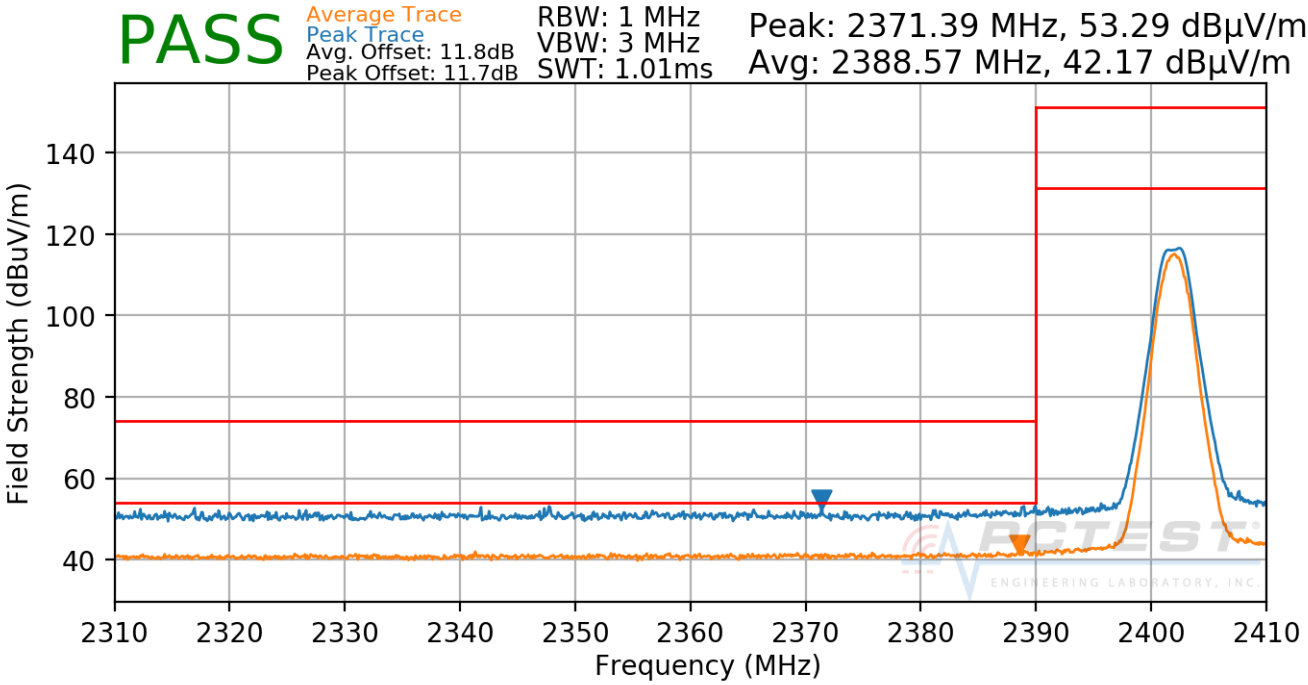
Radiated Restricted Band Edge Measurements

§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:	2402MHz
Channel:	0



Plot 7-70. Radiated Restricted Lower Band Edge Measurement ANT 1 (Average & Peak)

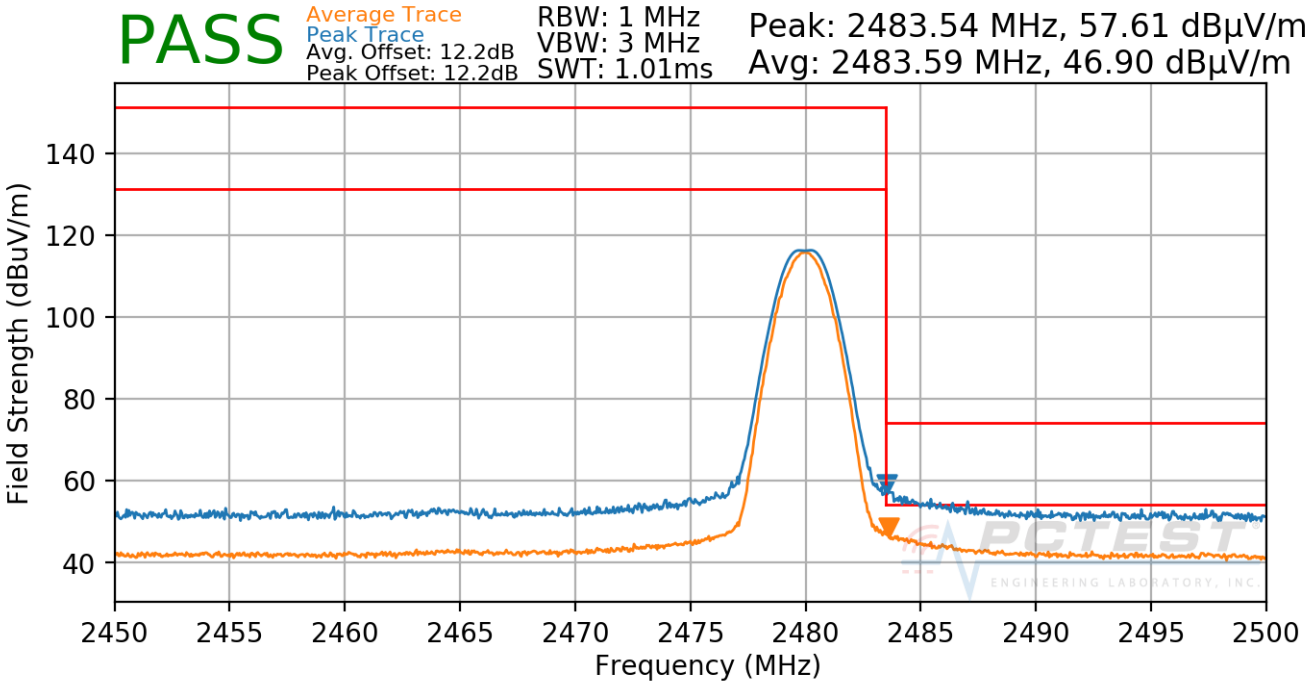
Radiated Restricted Band Edge Measurements

§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 7-71. Radiated Restricted Upper Band Edge Measurement ANT 1 (Average & Peak)

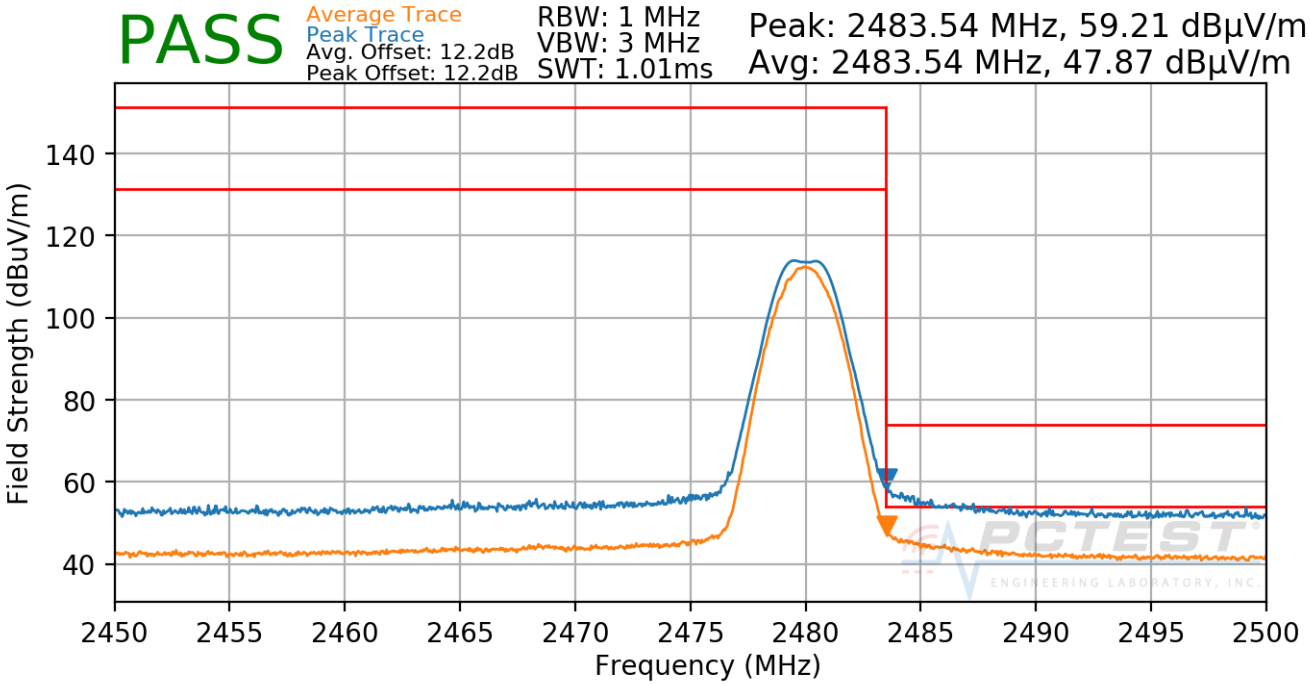
Radiated Restricted Band Edge Measurements

§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:	2480MHz
Channel:	39



Plot 7-72. Radiated Restricted Upper Band Edge Measurement ANT 1 (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 must not exceed the limits shown in Table 7-18 per Section 15.209.

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 7-18. 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

Test Setup

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

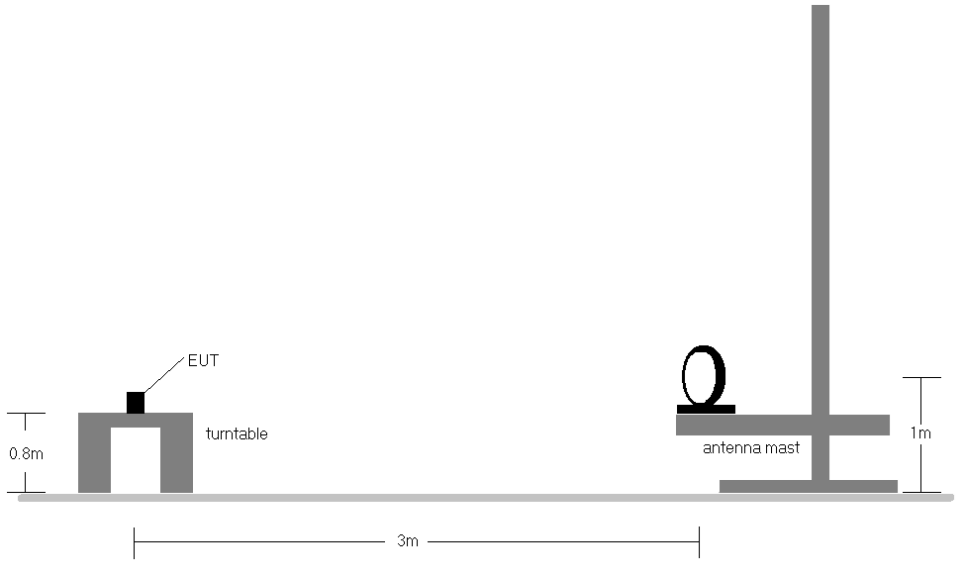


Figure 7-7. Radiated Test Setup < 30Mhz

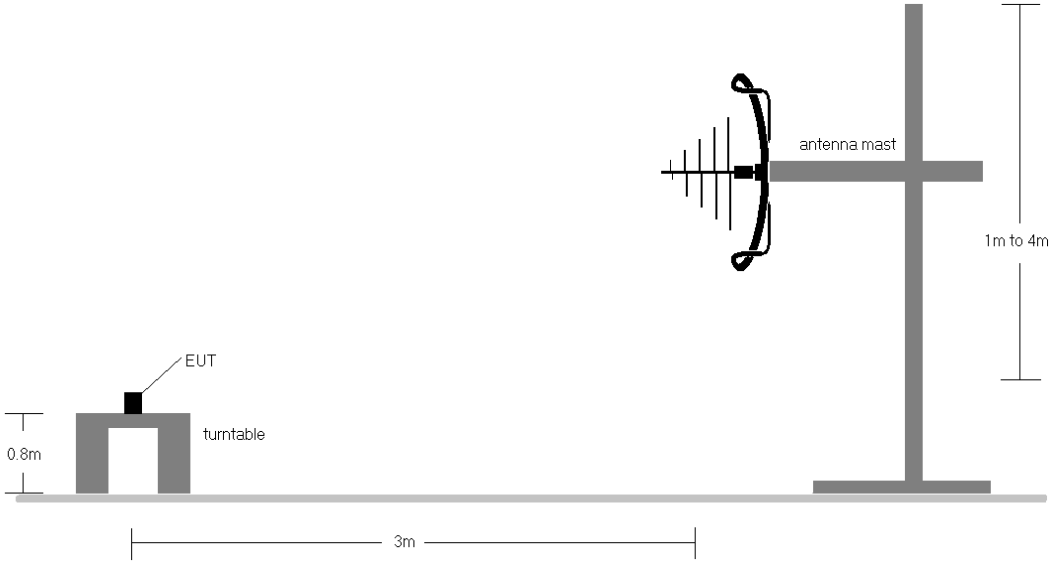
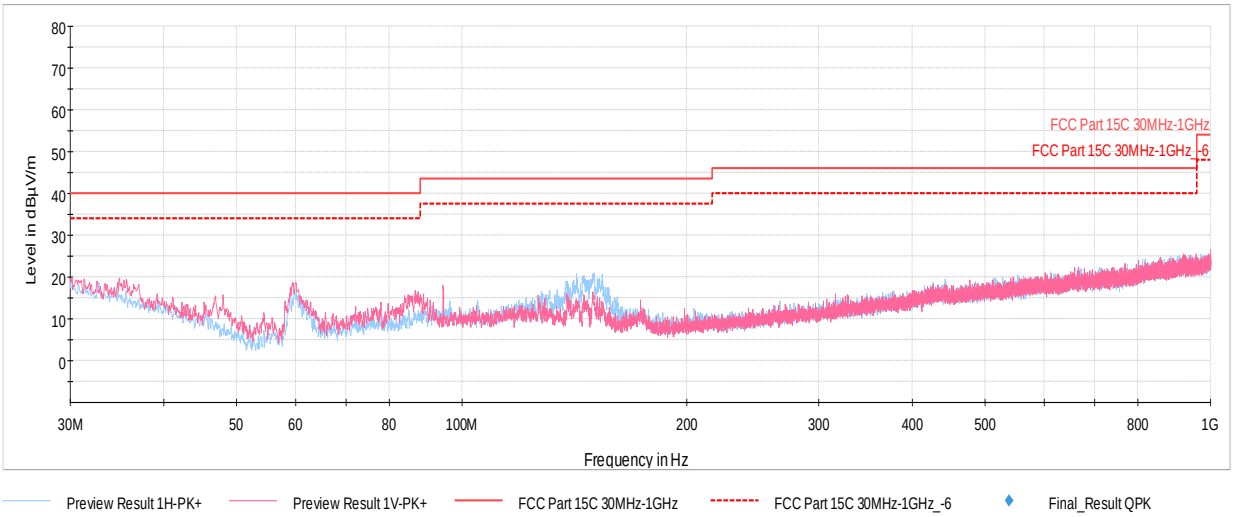


Figure 7-8. Radiated Test Setup < 1GHz

Test Notes

1. All emissions lying in restricted bands specified in §15.205 are below the limit shown in Table 7-18.
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. 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.



Plot 7-73. Radiated Spurious Plot below 1GHz (1Mbps, ePA – Ch.0, Pol. H & V, 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]
47.99	Peak	V	100	269	-75.66	-15.64	15.70	40.00	-24.30
59.92	Peak	V	250	138	-71.05	-17.77	18.18	40.00	-21.82
94.46	Peak	V	100	51	-75.68	-13.33	17.99	43.52	-25.53
173.37	Peak	V	100	18	-81.39	-11.05	14.56	43.52	-28.96
379.73	Peak	H	250	155	-83.85	-7.43	15.72	46.02	-30.30
593.67	Peak	V	100	305	-83.89	-3.16	19.95	46.02	-26.07

Table 7-19. Radiated Spurious Emissions Below 1GHz (1Mbps, ePA – Ch.0, 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 7-20. 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

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

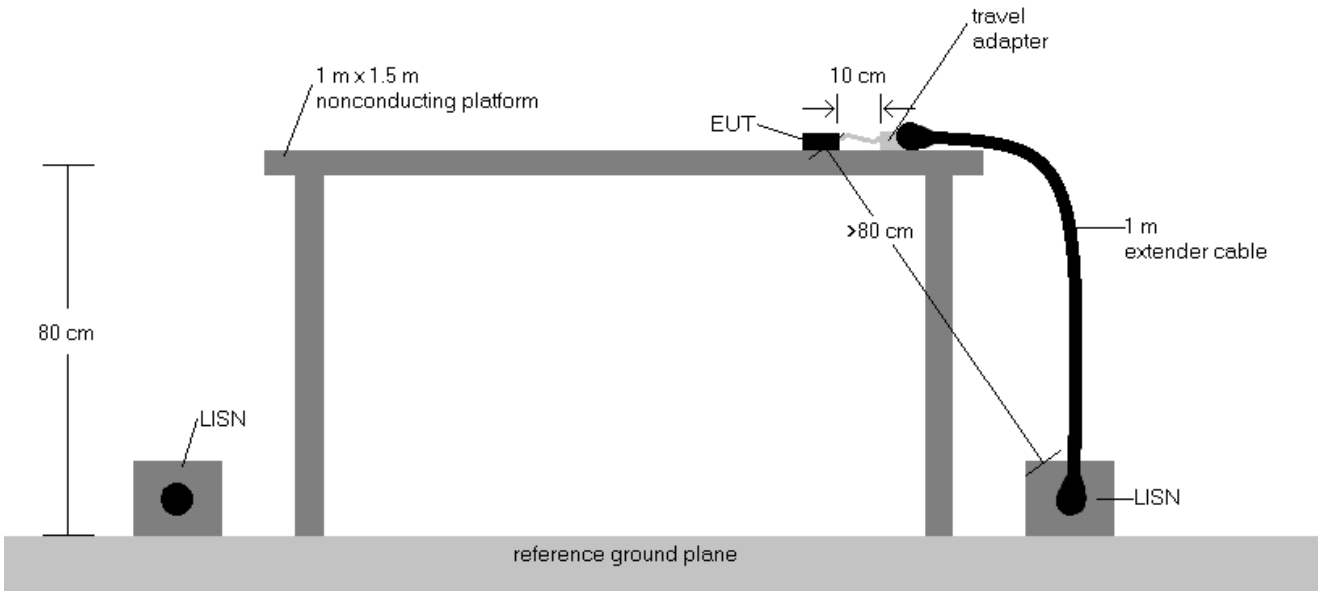
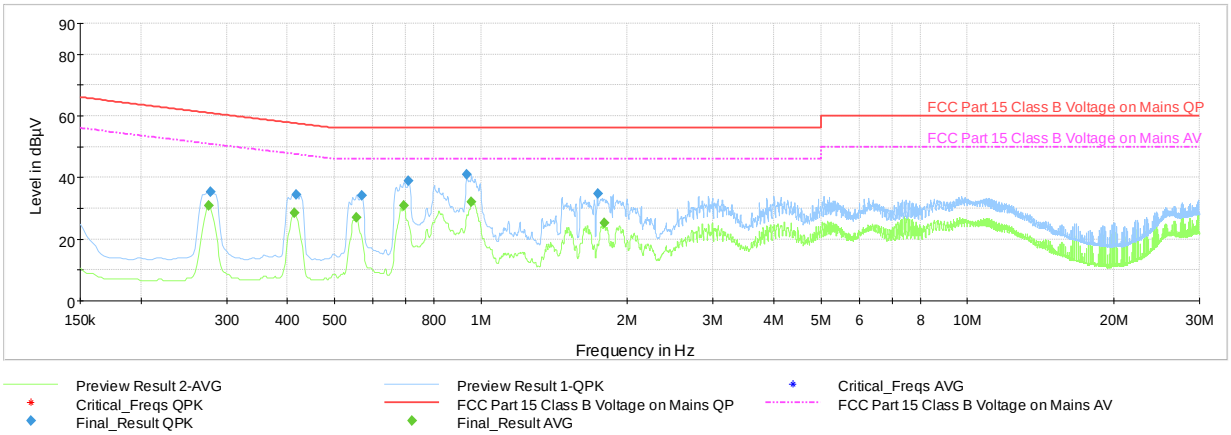


Figure 7-9. Test Instrument & Measurement Setup

Test Notes

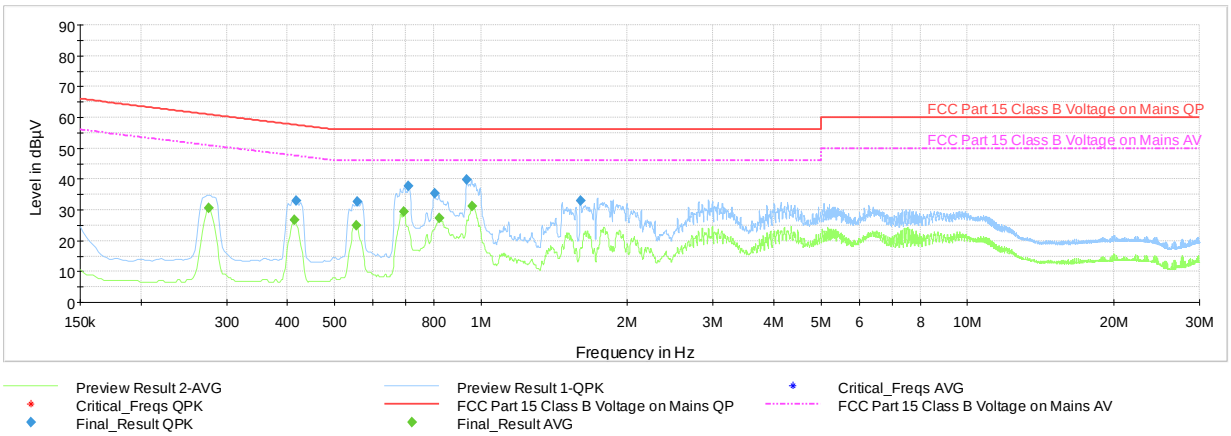
1. All modes of operation were investigated and the worst-case emissions are reported. The emissions found were not affected by the choice of channel used during testing.
2. The limit for an intentional radiator from 150kHz to 30MHz are specified in Part 15.207 and RSS-Gen (8.8).
3. Corr. (dB) = Cable 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 peak detector.
7. Deviations to the Specifications: None.



Plot 7-74. AC Line Conducted Plot with Bluetooth LE – 1Mbps ePA Ch.0 (L1, with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.276	FINAL	—	30.89	50.94	-20.04	L1	GND
0.278	FINAL	35.3	—	60.87	-25.53	L1	GND
0.413	FINAL	—	28.39	47.58	-19.19	L1	GND
0.418	FINAL	34.5	—	57.49	-22.98	L1	GND
0.555	FINAL	—	26.88	46.00	-19.12	L1	GND
0.569	FINAL	34.3	—	56.00	-21.74	L1	GND
0.695	FINAL	—	30.77	46.00	-15.23	L1	GND
0.710	FINAL	38.9	—	56.00	-17.15	L1	GND
0.935	FINAL	40.9	—	56.00	-15.12	L1	GND
0.956	FINAL	—	31.98	46.00	-14.02	L1	GND
1.736	FINAL	34.8	—	56.00	-21.22	L1	GND
1.790	FINAL	—	25.34	46.00	-20.66	L1	GND

Table 7-21. AC Line Conducted Measurements with Bluetooth LE – 1Mbps ePA Ch.0 (L1, with AC/DC Adapter)



Plot 7-75. AC Line Conducted Plot with Bluetooth LE – 1Mbps ePA Ch.0 (N, with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.276	FINAL	—	30.65	50.94	-20.28	N	GND
0.413	FINAL	—	26.62	47.58	-20.96	N	GND
0.418	FINAL	33.0	—	57.49	-24.54	N	GND
0.555	FINAL	—	25.06	46.00	-20.94	N	GND
0.557	FINAL	32.8	—	56.00	-23.19	N	GND
0.695	FINAL	—	29.34	46.00	-16.66	N	GND
0.710	FINAL	37.8	—	56.00	-18.24	N	GND
0.803	FINAL	35.4	—	56.00	-20.63	N	GND
0.821	FINAL	—	27.35	46.00	-18.65	N	GND
0.935	FINAL	39.9	—	56.00	-16.06	N	GND
0.958	FINAL	—	31.13	46.00	-14.87	N	GND
1.604	FINAL	32.9	—	56.00	-23.11	N	GND

Table 7-22. AC Line Conducted Measurements with Bluetooth LE – 1Mbps ePA Ch.0 (N, 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: BCGA2153** 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.