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

Applicant Name:

Apple Inc.
1 Infinite Loop
Cupertino, CA 95014
United States

Date of Testing:

10/31-2/14/2018

Test Site/Location:

PCTEST Lab., Morgan Hill, CA, USA

Test Report Serial No.:

1C1710060006-08.BCG

FCC ID:

BCGA1954

IC:

579C-A1954

APPLICANT:

Apple Inc.

Application Type:

Certification

Model/HVIN:

A1954

EUT Type:

Tablet Device

Max. RF Output Power:

48.42 mW (16.85 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 v04

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 v04. 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



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V 7.3 11/30/2017

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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 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 ISSED Standards (RSS).
- PCTEST facility is a registered (22831) test laboratory with the site description on file with ISSED.

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2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Tablet Device FCC ID: BCGA1954**. 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. The EUT operates in two power schemes per modulation. The power schemes are Internal Pre-Amplifier (iPA) and External Pre Amplifier (ePA).

Test Device Serial No.: F9FVT02RJM50, F9FVT00QJM4W

2.2 Device Capabilities

This device contains the following capabilities:

850/1900 CDMA/EvDO Rev0/A, 1x Advanced (BC0, BC1, BC10), 850/1900 GSM/GPRS/EDGE, 850/1700/1900 WCDMA/HSPA, Multi-band LTE, 802.11b/g/n WLAN, 802.11a/n/ac UNII, Bluetooth (1x, EDR, LE),

2.3 Antenna Description

Following antenna was used for the testing.

Frequency [GHz]	Antenna Gain (dBi)
2.4	1.91

Table 2-1. Antenna Peak Gain

2.4 Test Support Equipment

1	Apple MacBook	Model:	A1502	S/N:	C02P4004G1R8
	w/ AC/DC Adapter	Model:	A1435	S/N:	C04325505K1F288BG
2	Apple USB Cable	Model:	Kanzi	S/N:	3251F5
3	Apple Earphone	Model:	N/A	S/N:	N/A
4	USB Lightning Cable	Model:	N/A	S/N:	N/A
5	w/ 12 W AC Adapter	Model:	A1401	S/N:	N/A
6	DC Power Supply	Model:	EP20571-110V	S/N:	N/A

Table 2-2. Test Support Equipment Used

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2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013 and KDB 558074 D01 v04. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing. See Section 3.2 for radiated emissions test setups.

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

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. The worst orientation was found to be Y-orientation (landscape).

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

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

2.6 Software and Firmware

The test was conducted with firmware version 15E61570I installed on the EUT.

For conducted spurious emissions, automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance.

2.7 EMI Suppression Device(s)/Modifications

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

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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 v04 were used in the measurement of the EUT.

Deviation from measurement procedure.....None

3.2 Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. The test site inside the chamber is a 6m x 5.2m elliptical, obstruction-free area in accordance with Figure 5.7 of Clause 5 in ANSI C63.4-2014. A raised turntable is used for radiated measurement. It is a continuously rotatable, remote-controlled, metallic turntable and 2 meters (6.56 ft.) in diameter. 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(b)(1) depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up was placed on top of the 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, mode of operation, turntable azimuth, and receive antenna height was noted for each frequency found.

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

3.3 Environmental Conditions

The temperature is controlled within range of 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).

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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.

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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 ($\pm$ dB)
Conducted Bench Top Measurements	1.13
Line Conducted Disturbance	3.09
Radiated Disturbance (<1GHz)	4.98
Radiated Disturbance (>1GHz)	5.07
Radiated Disturbance (>18GHz)	5.09

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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
-	AM WN25	WLAN Cable Set	3/17/2017	Annual	3/17/2018	AM WN25
-	EMI 3117-ESW1	Radiated Cable Set	3/1/2017	Biennial	3/1/2018	N/A
-	EMI HL562E-ESW1	Radiated Cable Set	2/28/2017	Biennial	2/28/2018	N/A
Anritsu	MA2411B	Pulse Power Sensor	11/28/2017	Biennial	11/28/2018	1027293
Anritsu	ML2495A	Power Meter	11/28/2017	Biennial	11/28/2018	1039008
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna(18 -40GHz)	2/24/2017	Annual	2/24/2018	T058701-03
COM-POWER	LIN-120A	LISN	2/22/2017	Annual	2/22/2018	241296
Keysight Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	3/13/2017	Annual	3/13/2018	MY49430244
Rohde & Schwarz	ESW26	ESW26 EMI Test Receiver	7/15/2017	Annual	7/15/2018	101299
Rohde & Schwarz	FSW43	Signal & Spectrum Analyzer	4/24/2017	Annual	4/24/2018	104093
Rohde & Schwarz	ESW44	EMI Test Receiver	11/14/2017	Annual	11/14/2018	101570
Rohde & Schwarz	HL562E	Bi-Log Antenna (30MHz - 6GHz)	3/27/2017	Annual	3/27/2018	100810
Rohde & Schwarz	SFUNIT-RX	TS-SFUNIT SHIELDED FILTER UNIT	9/11/2017	Annual	9/11/2018	102132
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz - 18GHz)	2/3/2017	Annual	2/3/2018	101639
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz - 40GHz)	1/3/2017	Annual	1/3/2018	100052
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz - 8GHz)	2/3/2017	Annual	2/3/2018	102325
Rohde & Schwarz	TC-TA18	CROSS POL. VIVALDI ANT (400MHz - 18GHz)	11/13/2017	Annual	11/13/2018	101056-AE
Traceable	1208T91	Humidity/Temperature/Dew Point Meter	9/27/2017	Biennial	9/27/2018	160838829

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.

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7.0 TEST RESULTS

7.1 Summary

Company Name: Apple Inc.
 FCC ID: BCGA1954
 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(a)]	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(b)]	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

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 3.0.
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 1.1.5.

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7.2 6dB Bandwidth Measurement – Bluetooth (LE)

§15.247(a.2); RSS-247 [5.2(a)]

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 v04 – Section 8.2 Option 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 $\geq 3 \times$ RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. The trace was allowed to stabilize

Test Setup

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



Figure 7-1. Test Instrument & Measurement Setup

Test Notes

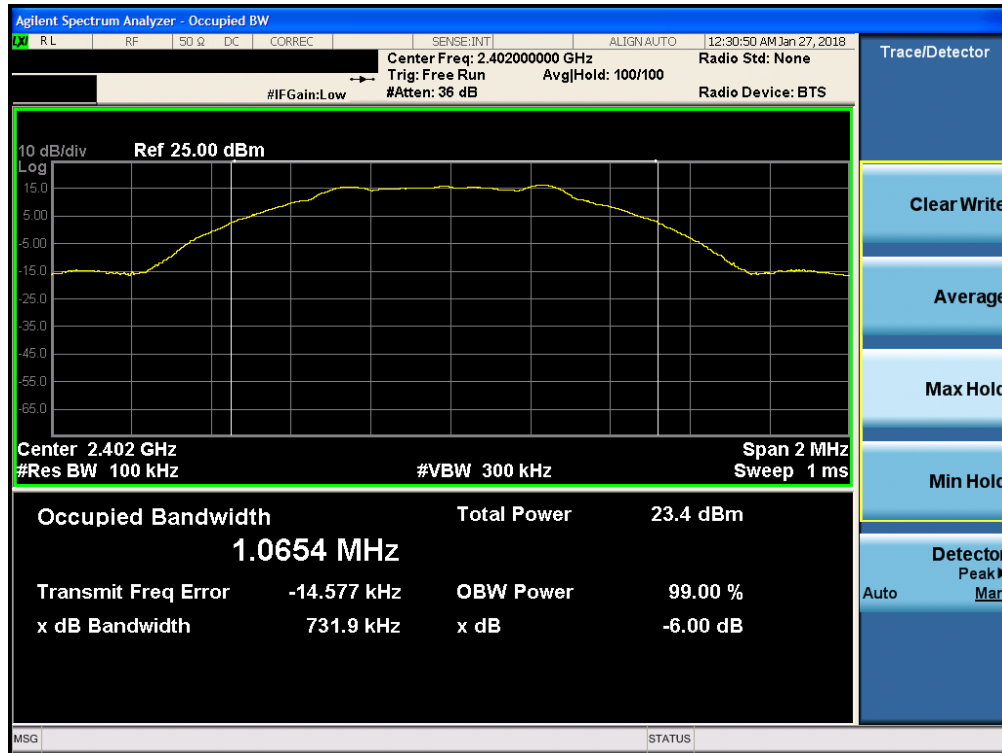
None

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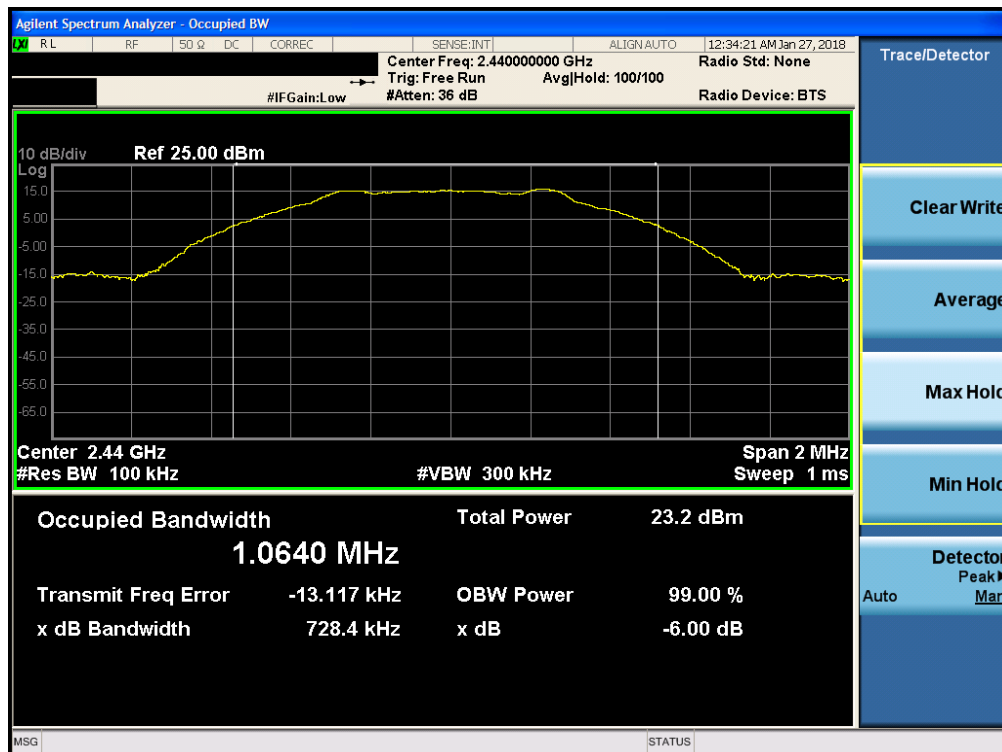
Frequency [MHz]	Modulation	Power Scheme	Bluetooth Mode	Measured Bandwidth [kHz]	Minimum Bandwidth [kHz]	Pass / Fail
2402	GFSK	ePA	LE	731.9	500	Pass
2440		ePA		728.4	500	Pass
2480		ePA		729.5	500	Pass
2402		iPA		729.0	500	Pass
2440		iPA		731.5	500	Pass
2480		iPA		731.1	500	Pass

Table 7-2. Conducted Bandwidth Measurements

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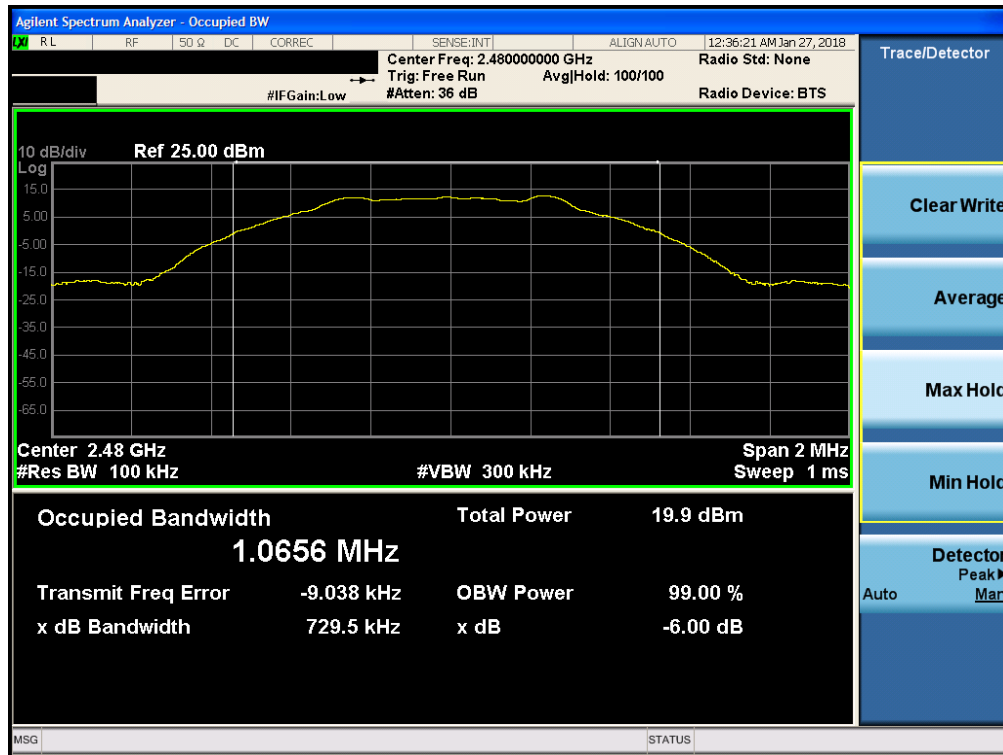


Plot 7-1. 6dB Bandwidth Plot (Bluetooth (LE), ePA – Ch. 0)

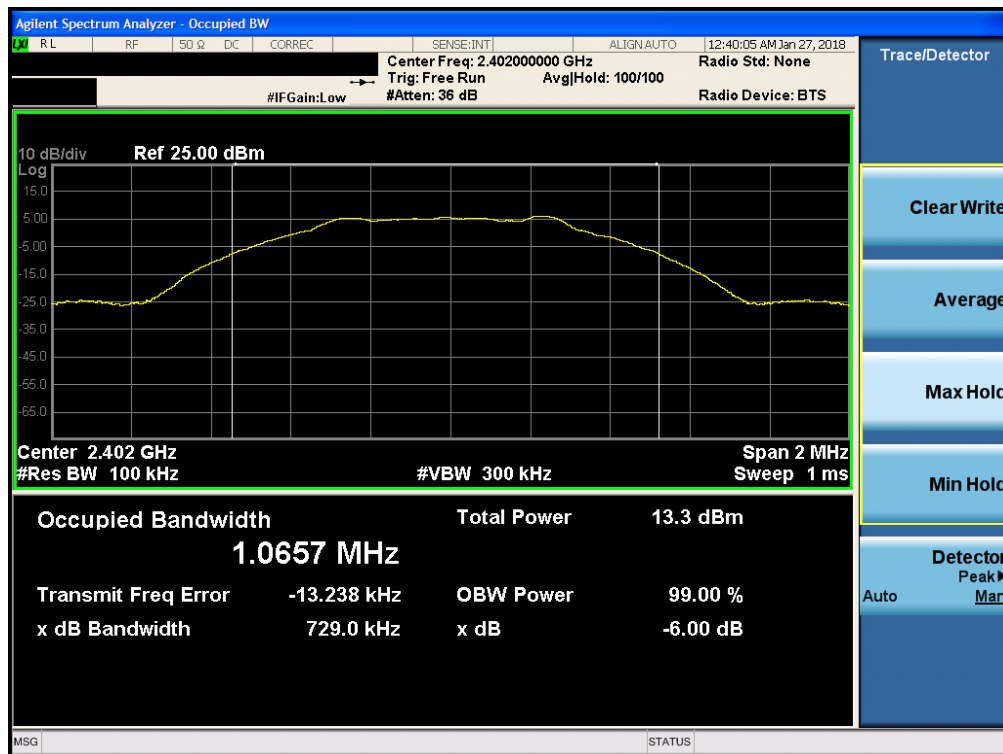


Plot 7-2. 6dB Bandwidth Plot (Bluetooth (LE), ePA – Ch. 19)

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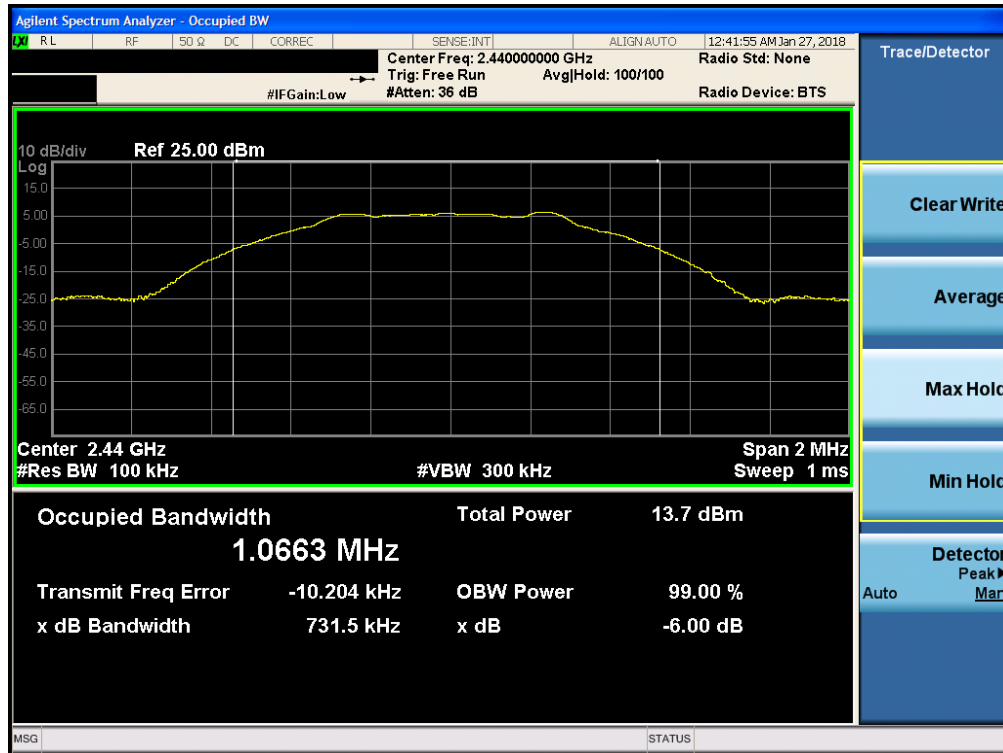


Plot 7-3. 6dB Bandwidth Plot (Bluetooth (LE), ePA – Ch. 39)

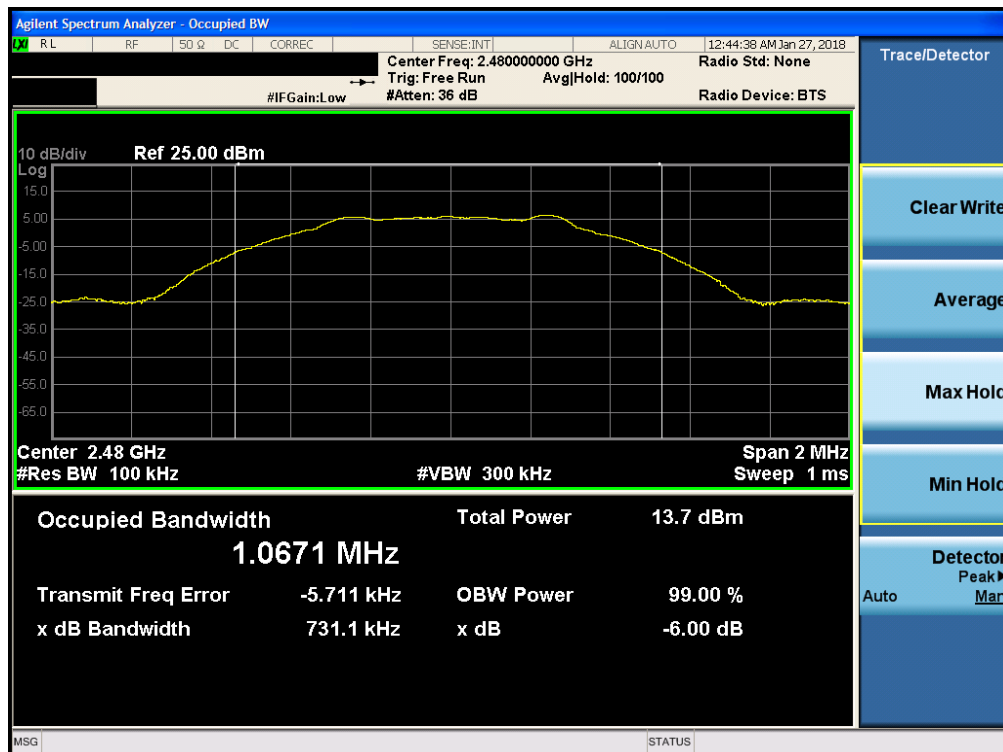


Plot 7-4. 6dB Bandwidth Plot (Bluetooth (LE), iPA – Ch. 0)

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Plot 7-5. 6dB Bandwidth Plot (Bluetooth (LE), iPA – Ch. 19)



Plot 7-6. 6dB Bandwidth Plot (Bluetooth (LE), iPA – Ch. 39)

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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 v04 – Section 9.2.3.2

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

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7.3.1 Peak Output Power Measurement - Bluetooth (LE)

§15.247(b.3), RSS-247 [5.4(d)]

Frequency [MHz]	Data Rate	Modulation	Channel No.	Peak Conducted Power	
				[dBm]	[mW]
2402	ePA	BLE	0	16.85	48.42
2441			19	16.82	48.08
2480			39	16.34	43.05
2402	iPA	BLE	0	6.84	4.83
2441			19	7.33	5.41
2480			39	7.23	5.28

Table 7-3. Peak Conducted Output Power Measurements (Bluetooth (LE))

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7.3.2 Average Output Power Measurement - Bluetooth (LE)

§15.247(b.3), RSS-247 [5.4(d)]

Frequency [MHz]	Data Rate	Modulation	Channel No.	Avg Conducted Power (Continuous)	
				[dBm]	[mW]
2402	ePA	BLE	0	16.53	44.98
2441			19	16.51	44.77
2480			39	16.17	41.40
2402	iPA	BLE	0	6.57	4.54
2441			19	7.07	5.09
2480			39	6.98	4.99

Table 7-4. Average Conducted Output Power Measurements (Bluetooth (LE))

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7.4 Power Spectral Density – Bluetooth (LE)

§15.247(e); RSS-247 [5.2(b)]

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 v04 – Section 10.2 Method PKPSD

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

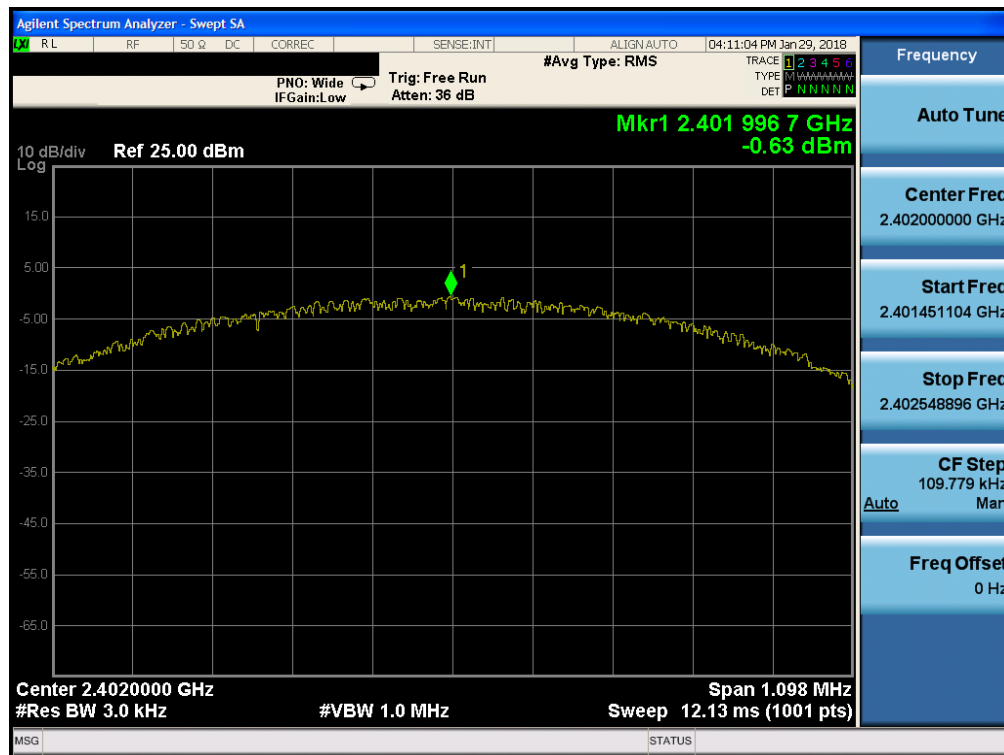
Test Notes

None

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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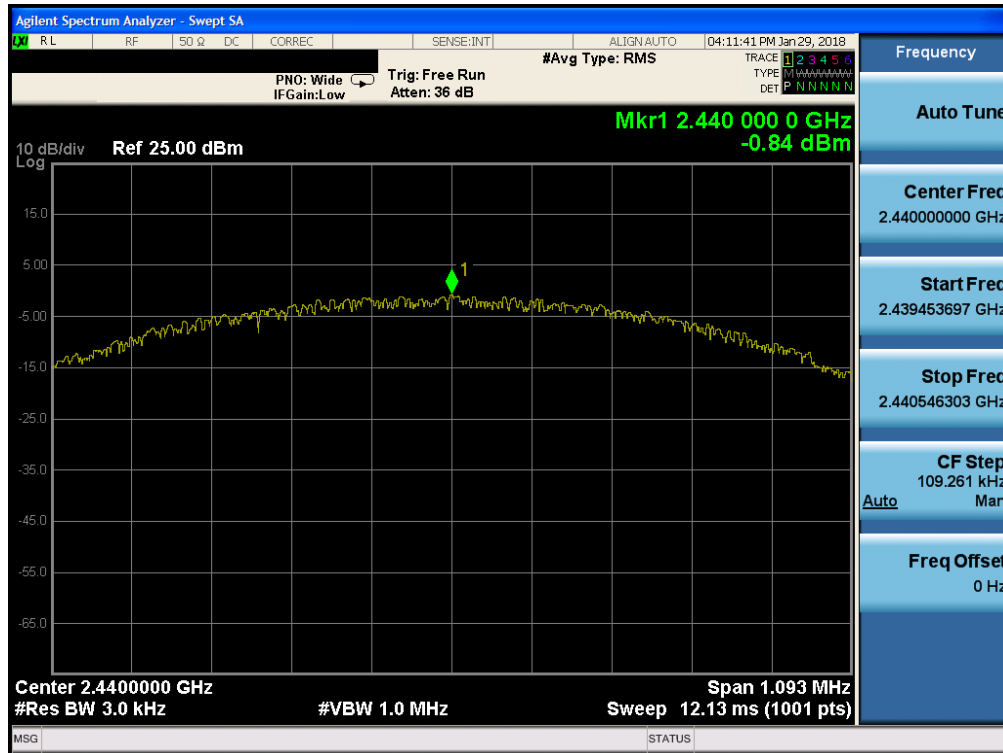
Frequency [MHz]	Modulation	Bluetooth Mode	Power Scheme	Channel No.	Measured Power Spectral Density [dBm]	Maximum Permissible Power Density [dBm/3kHz]	Margin [dB]	Pass / Fail
2402	GFSK	LE	ePA	0	-0.63	8.0	-8.63	Pass
2440			ePA	19	-0.84	8.0	-8.84	Pass
2480			ePA	39	-4.23	8.0	-12.23	Pass
2402			iPA	0	-10.89	8.0	-18.89	Pass
2440			iPA	19	-10.44	8.0	-18.44	Pass
2480			iPA	39	-10.60	8.0	-18.60	Pass

Table 7-5. Conducted Power Density Measurements

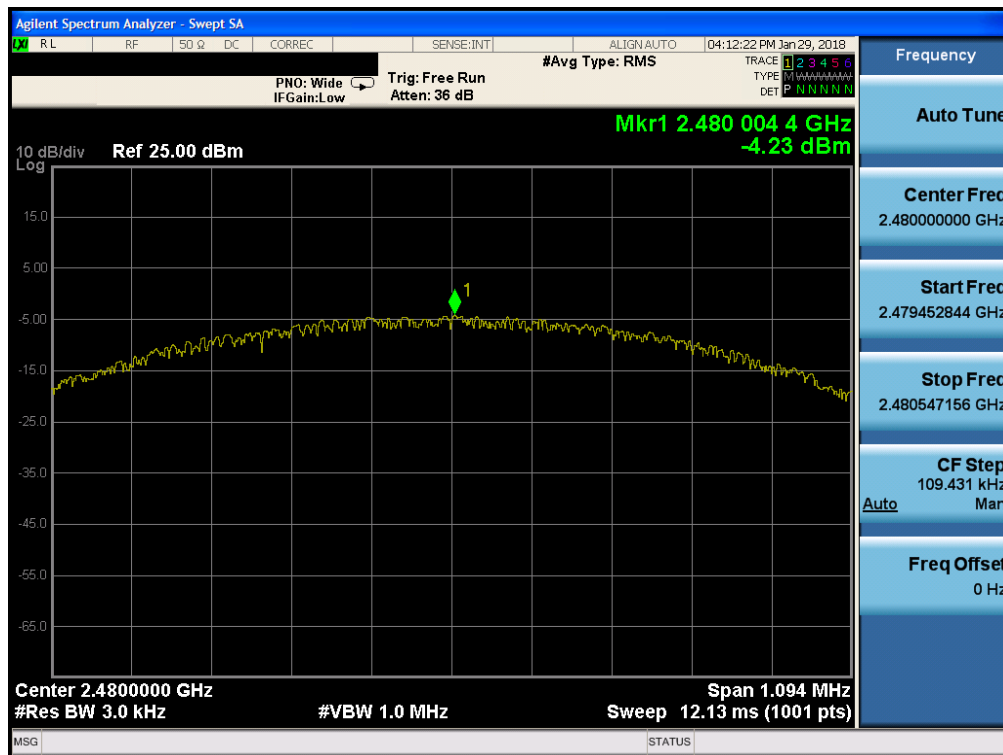


Plot 7-7. Power Spectral Density Plot (Bluetooth (LE), ePA – Ch. 0)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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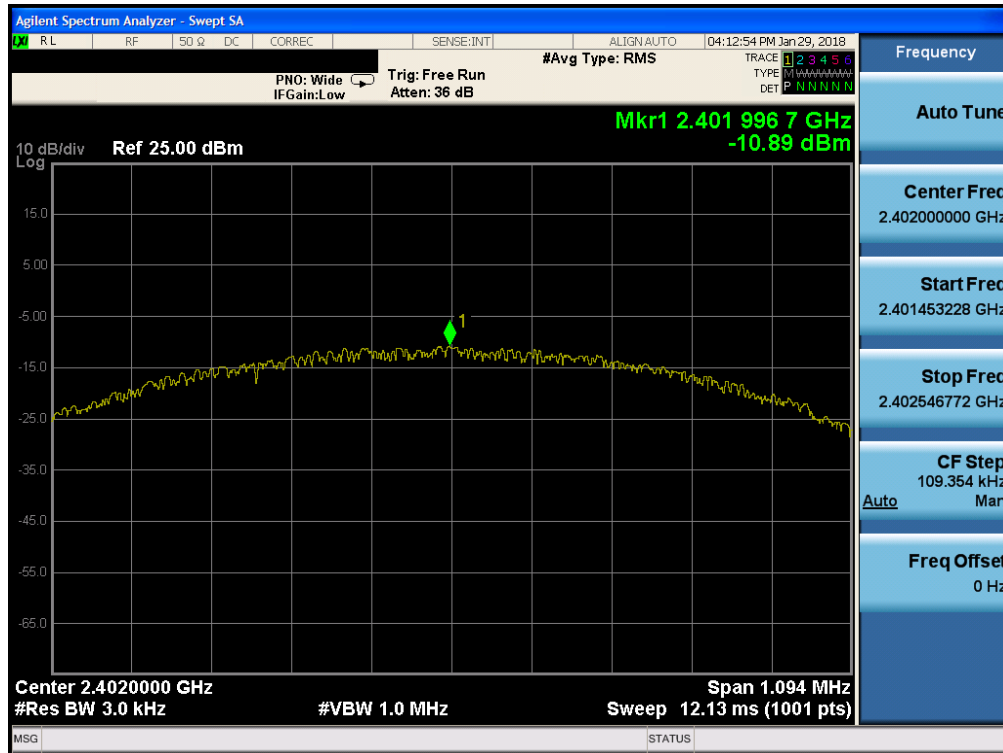


Plot 7-8. Power Spectral Density Plot (Bluetooth (LE), ePA – Ch. 39)

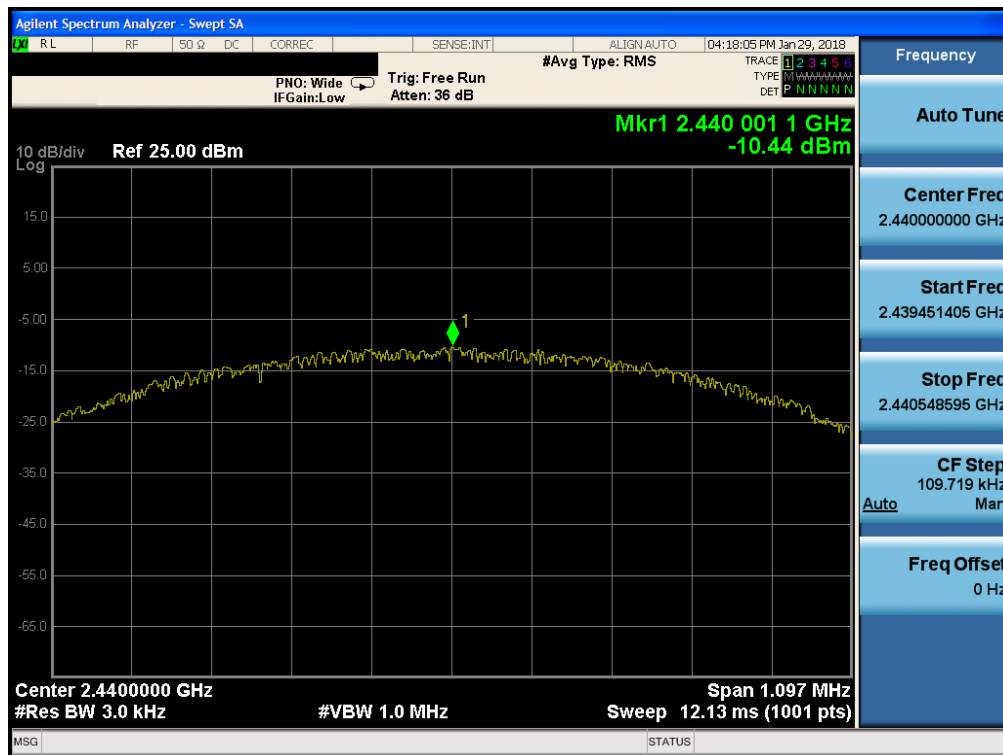


Plot 7-9. Power Spectral Density Plot (Bluetooth (LE), ePA – Ch. 78)

FCC ID: BCGA1954	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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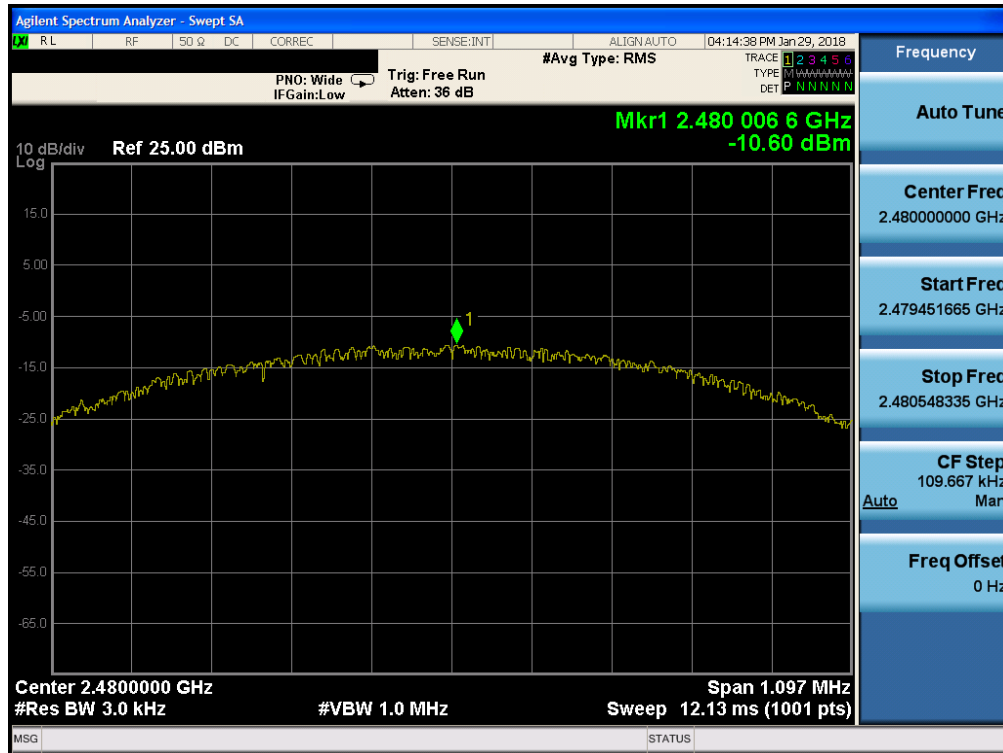


Plot 7-10. Power Spectral Density Plot (Bluetooth (LE), iPA – Ch. 0)



Plot 7-11. Power Spectral Density Plot (Bluetooth (LE), iPA – Ch. 19)

FCC ID: BCGA1954	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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Plot 7-12. Power Spectral Density Plot (Bluetooth (LE), iPA – Ch. 39)

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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 v04 – Section 11.3

Test Settings

1. Start and stop frequency were set such that the band edge would be placed in the center of the plot
2. Span was set large enough so as to capture all out of band emissions near the band edge
3. RBW = 100kHz
4. VBW = 300kHz
5. Detector = Peak
6. Number of sweep points $\geq 2 \times \text{Span/RBW}$
7. Trace mode = max hold
8. Sweep time = auto couple
9. The trace was allowed to stabilize

Test Setup

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

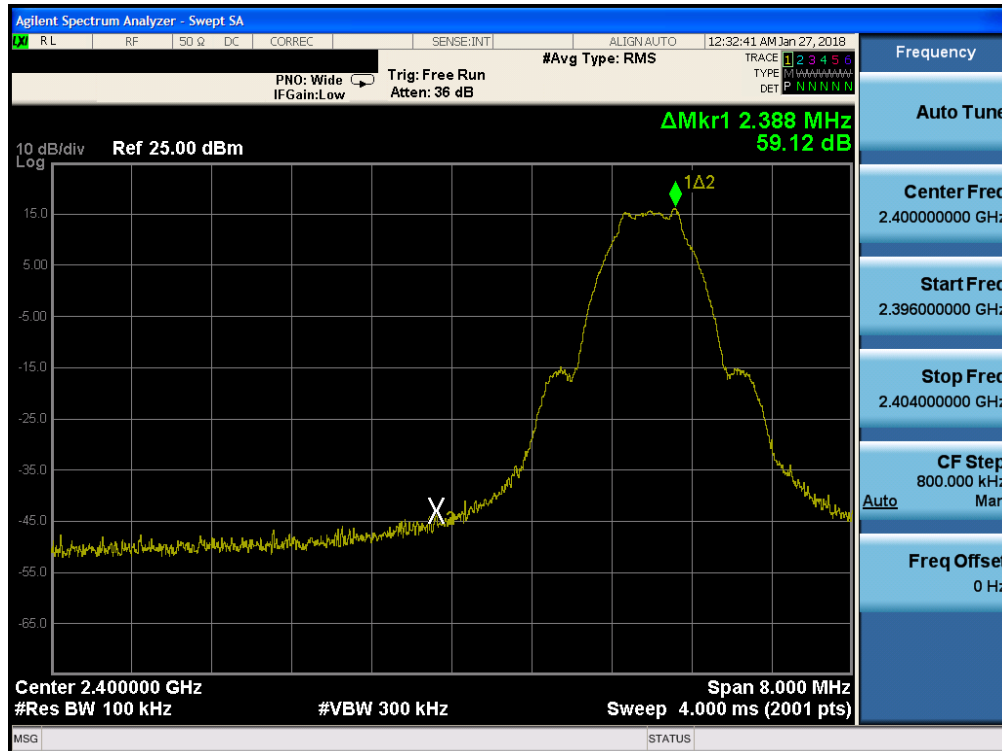


Figure 7-4. Test Instrument & Measurement Setup

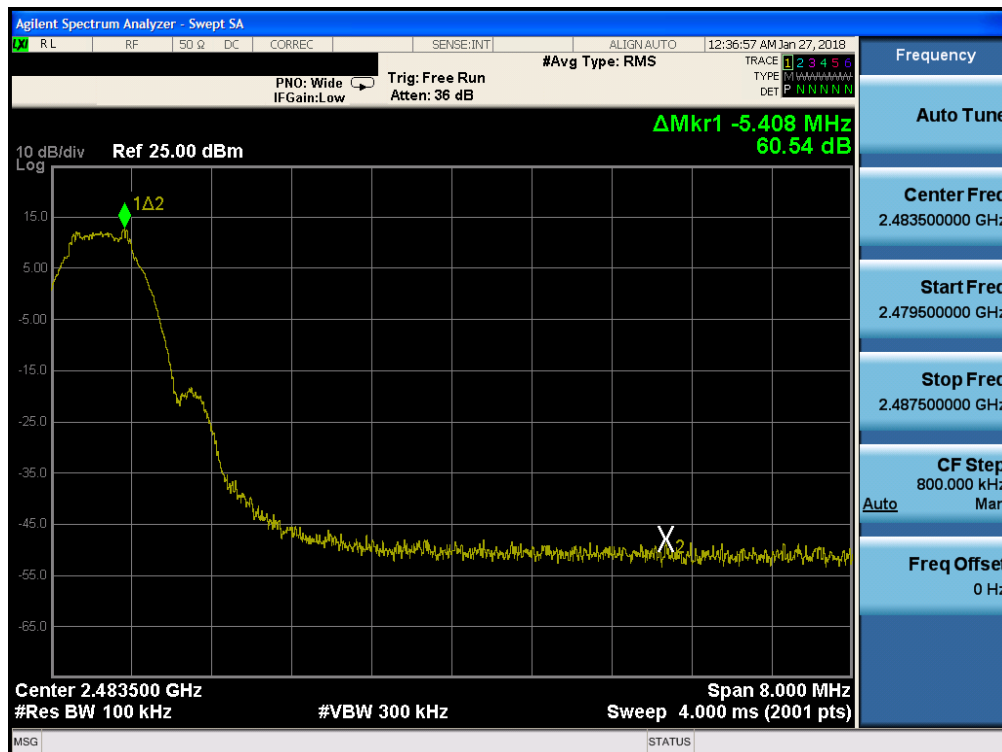
Test Notes

None

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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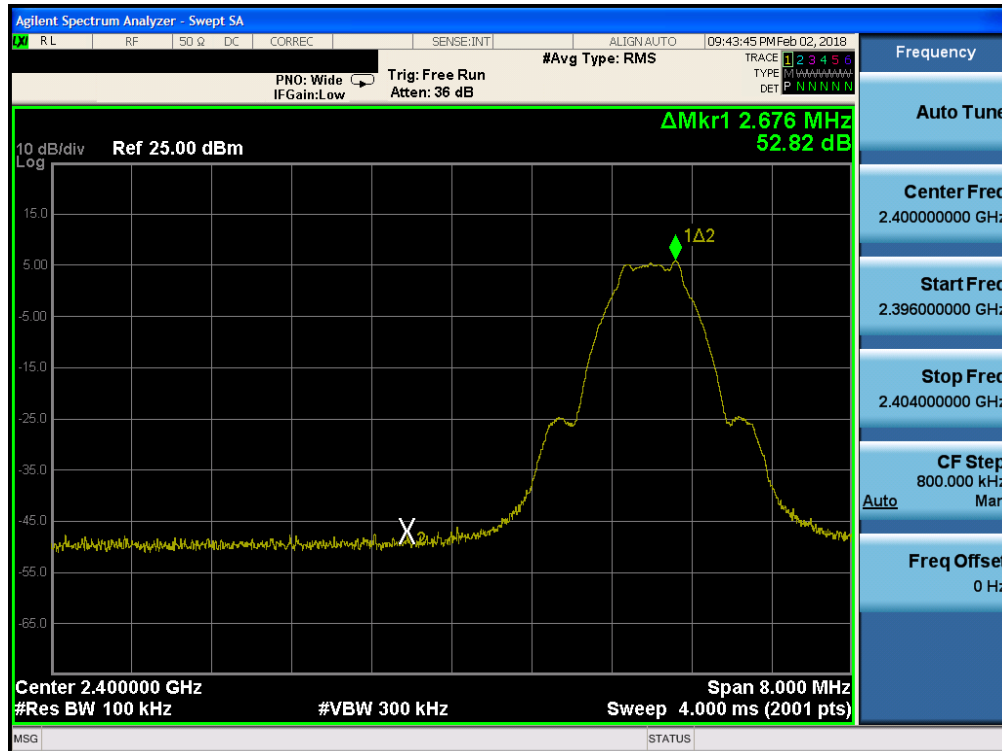


Plot 7-13. Band Edge Plot (Bluetooth (LE), ePA – Ch. 0)

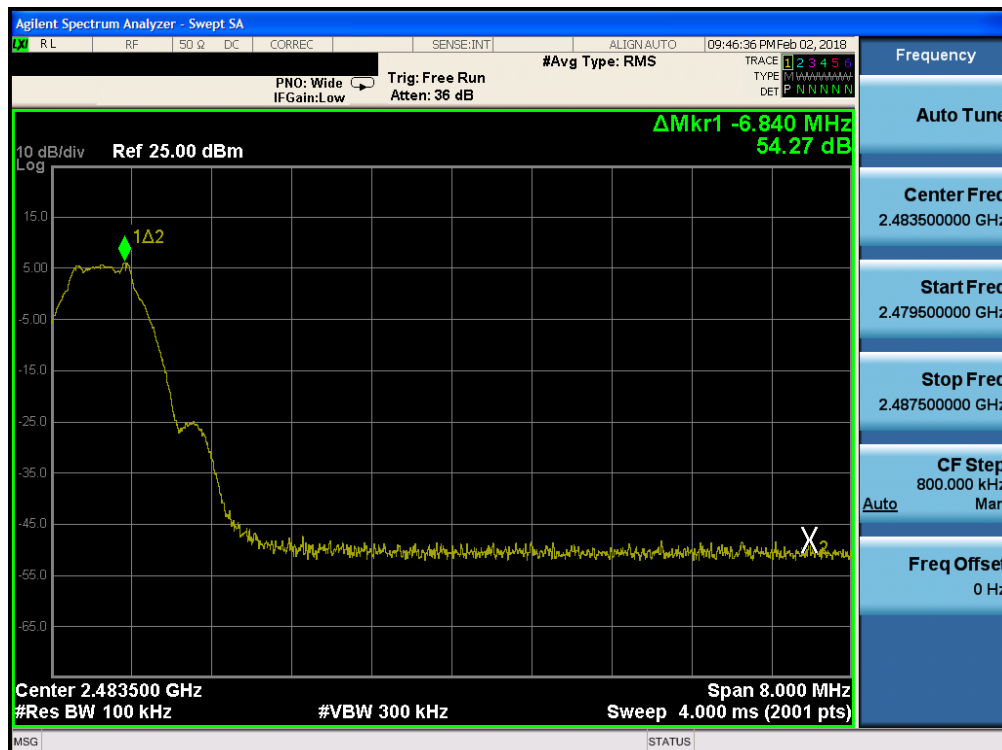


Plot 7-14. Band Edge Plot (Bluetooth (LE), ePA – Ch. 78)

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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Plot 7-15. Band Edge Plot (Bluetooth (LE), iPA - Ch. 0)



Plot 7-16. Band Edge Plot (Bluetooth (LE), iPa - Ch. 78)

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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 11.3 of KDB 558074 D01 v04 and Section 11.11.3 of ANSI C63.10-2013.

Test Procedure Used

ANSI C63.10-2013 – Section 11.11.3
KDB 558074 D01 v04 – Section 11.3

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.



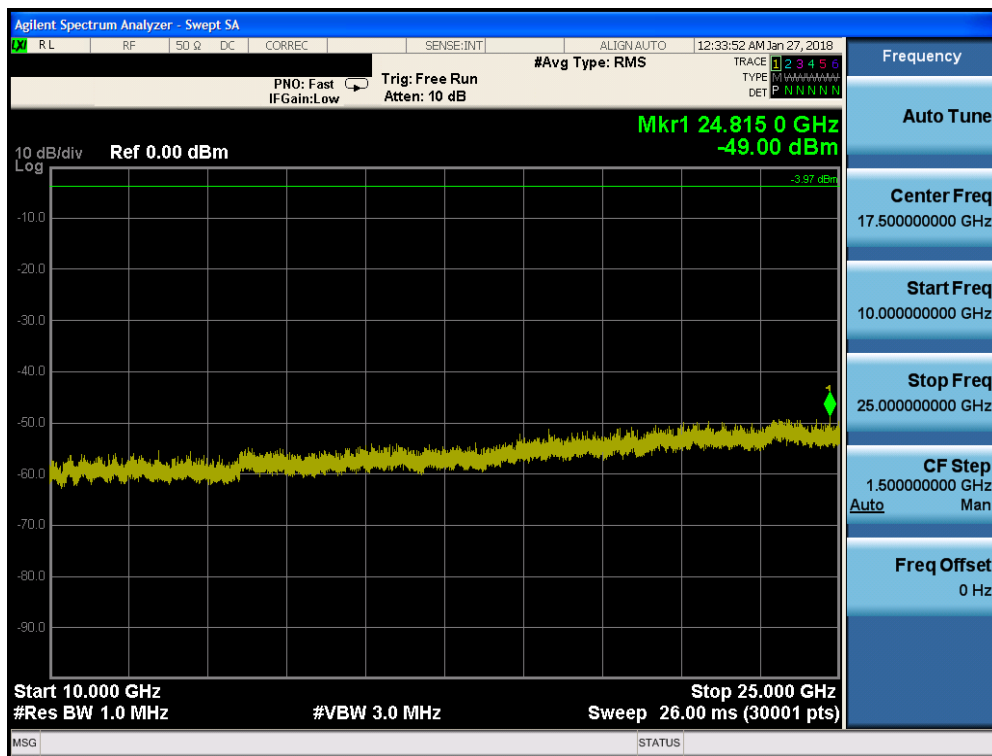
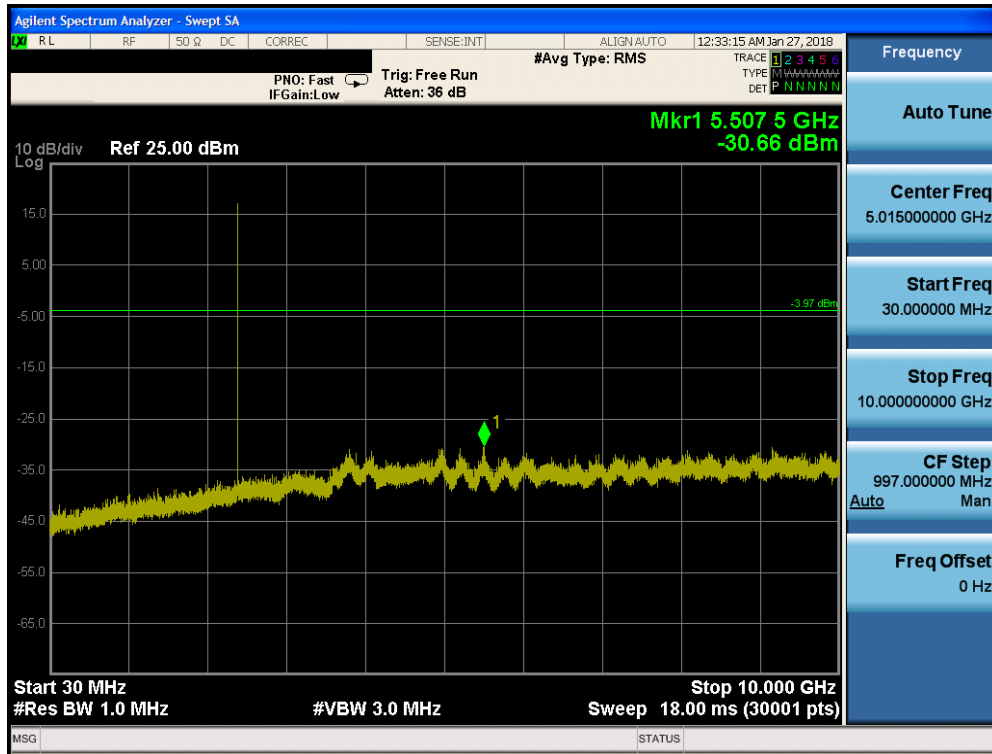
Figure 7-5. Test Instrument & Measurement Setup

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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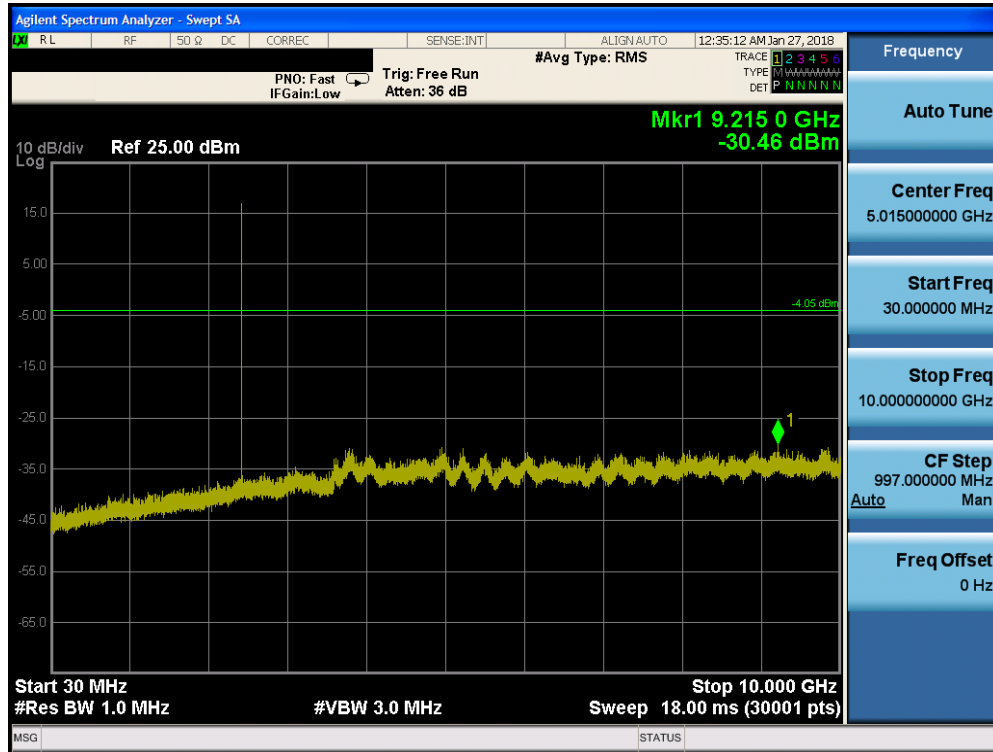
Test Notes

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.

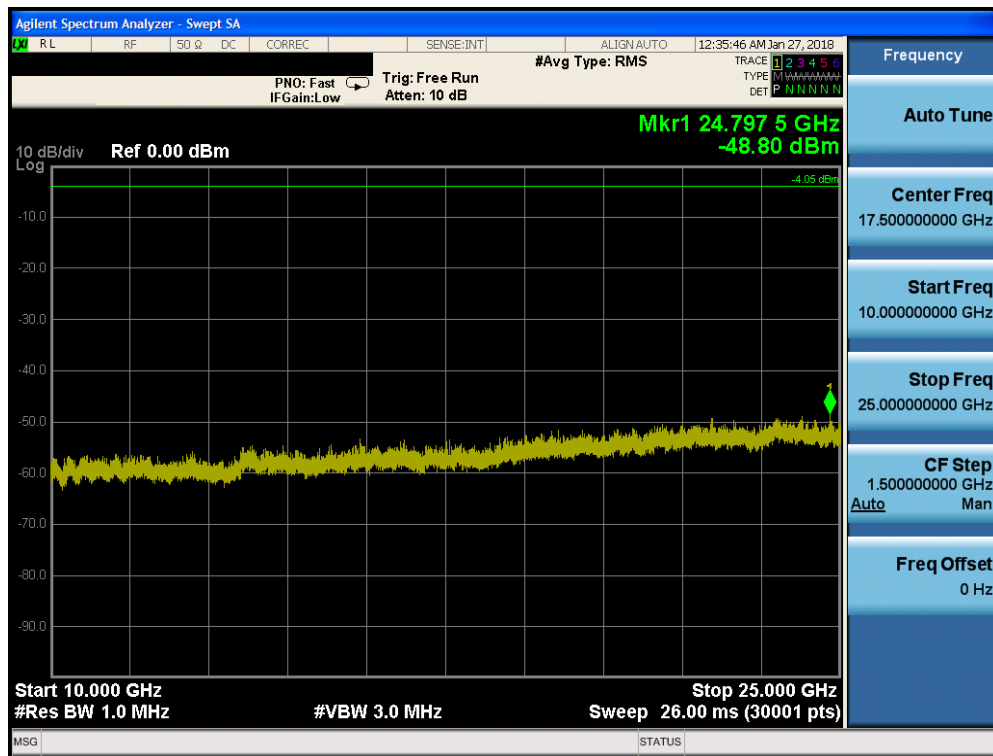
FCC ID: BCGA1954		MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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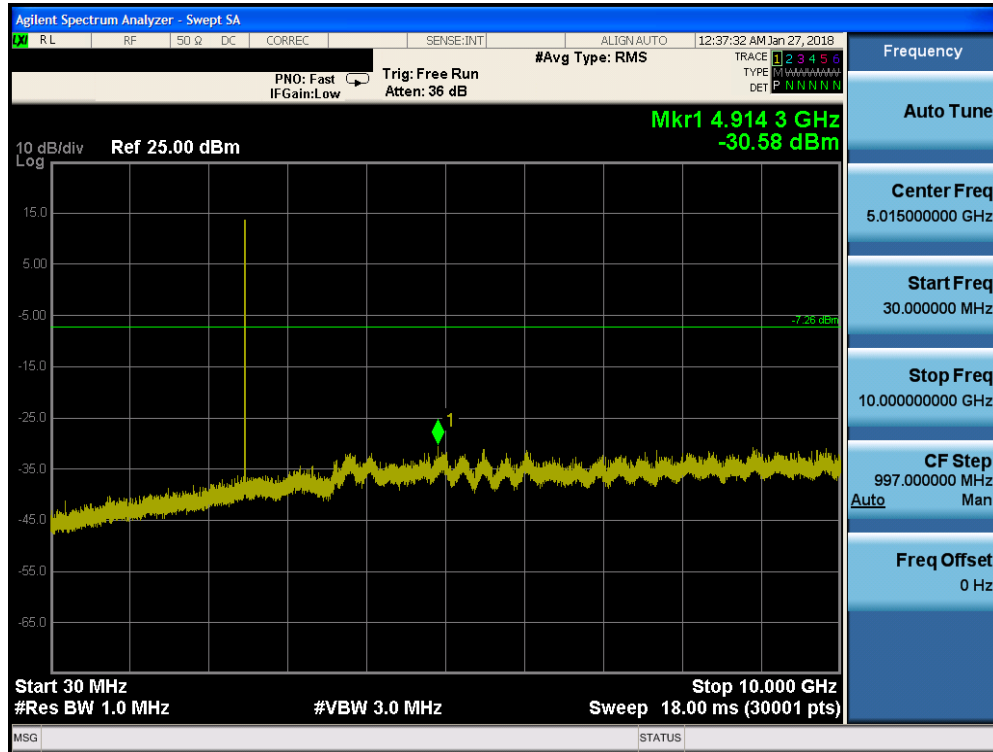


Plot 7-19. Conducted Spurious Plot (Bluetooth (LE), ePA – Ch. 39)

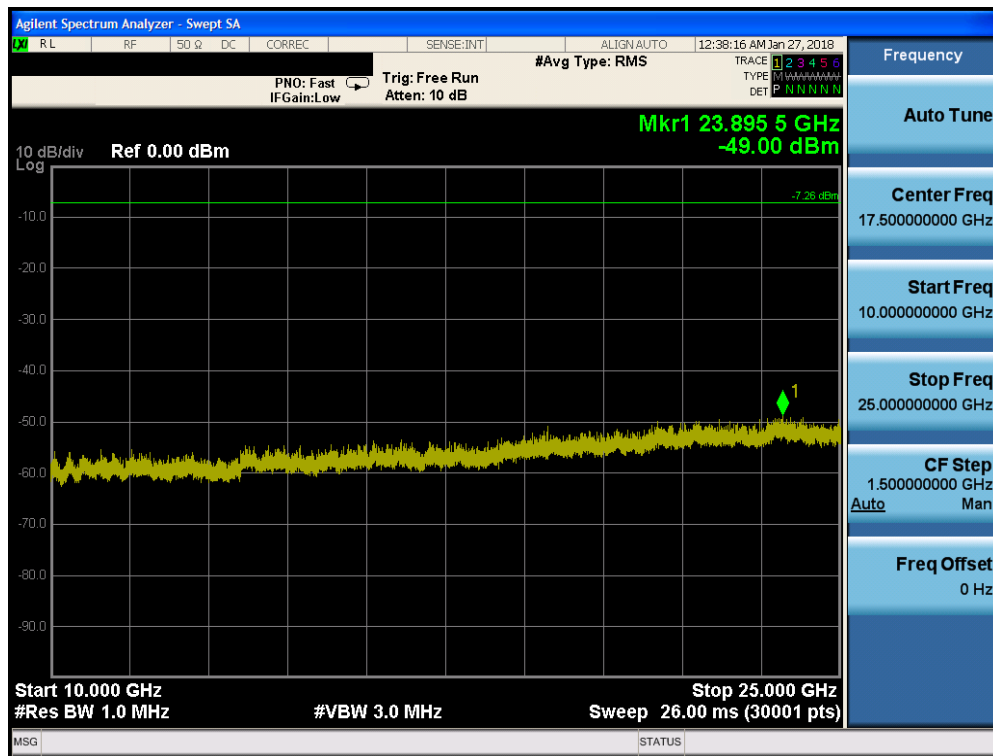


Plot 7-20. Conducted Spurious Plot (Bluetooth (LE), ePA – Ch. 39)

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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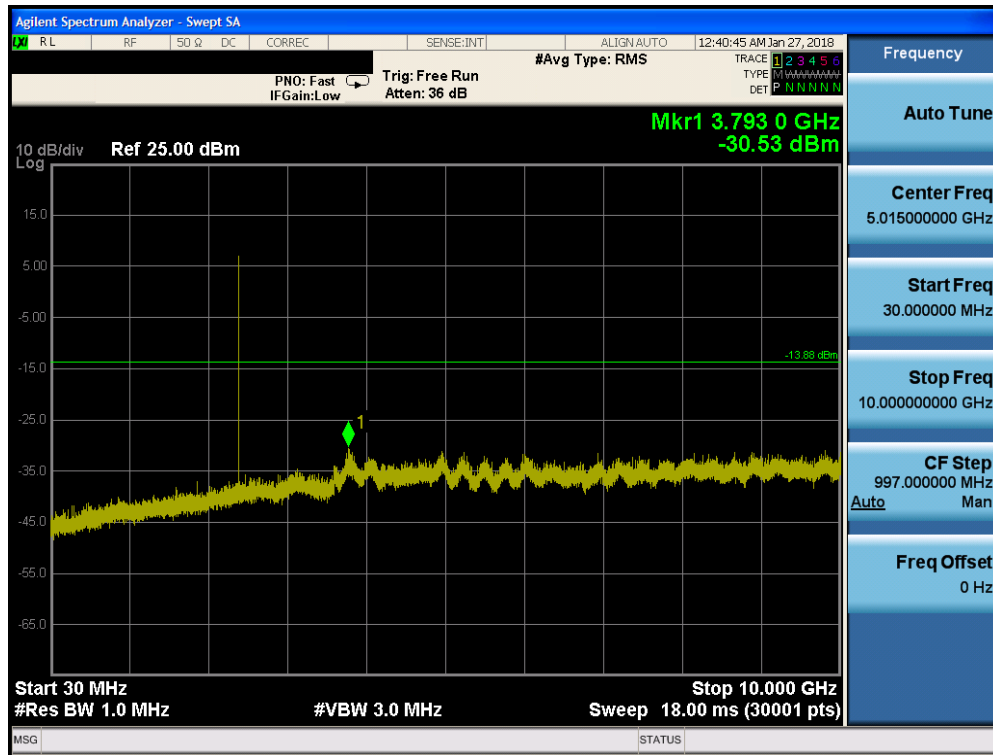


Plot 7-21. Conducted Spurious Plot (Bluetooth (LE), ePA – Ch. 78)

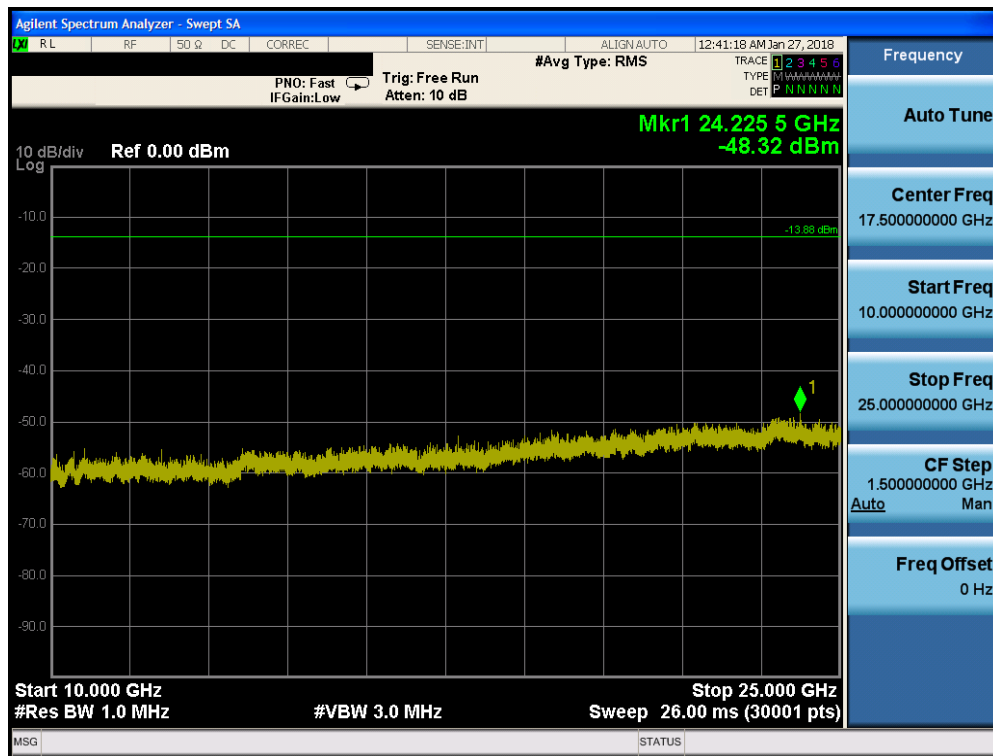


Plot 7-22. Conducted Spurious Plot (Bluetooth (LE), ePA – Ch. 78)

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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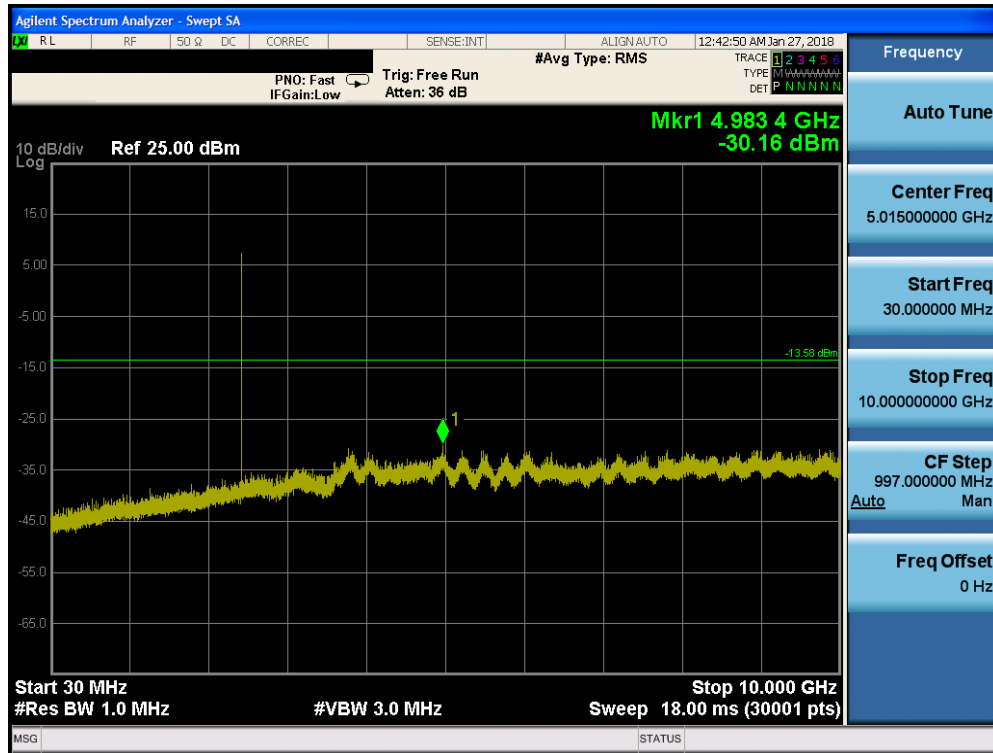


Plot 7-23. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 0)

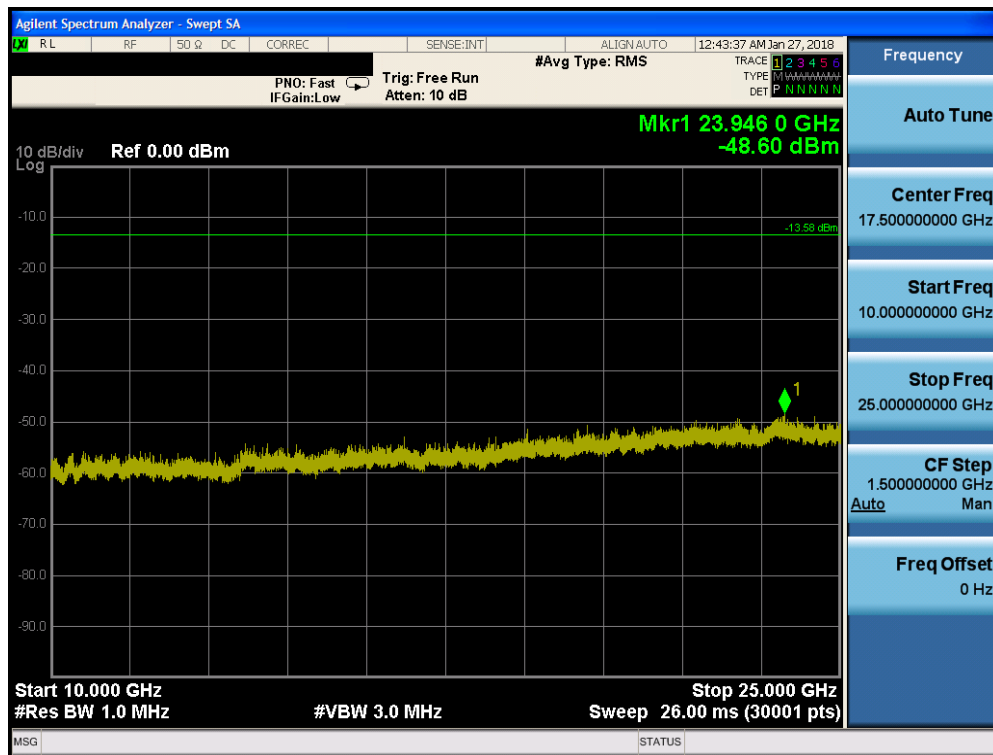


Plot 7-24. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 0)

FCC ID: BCGA1954	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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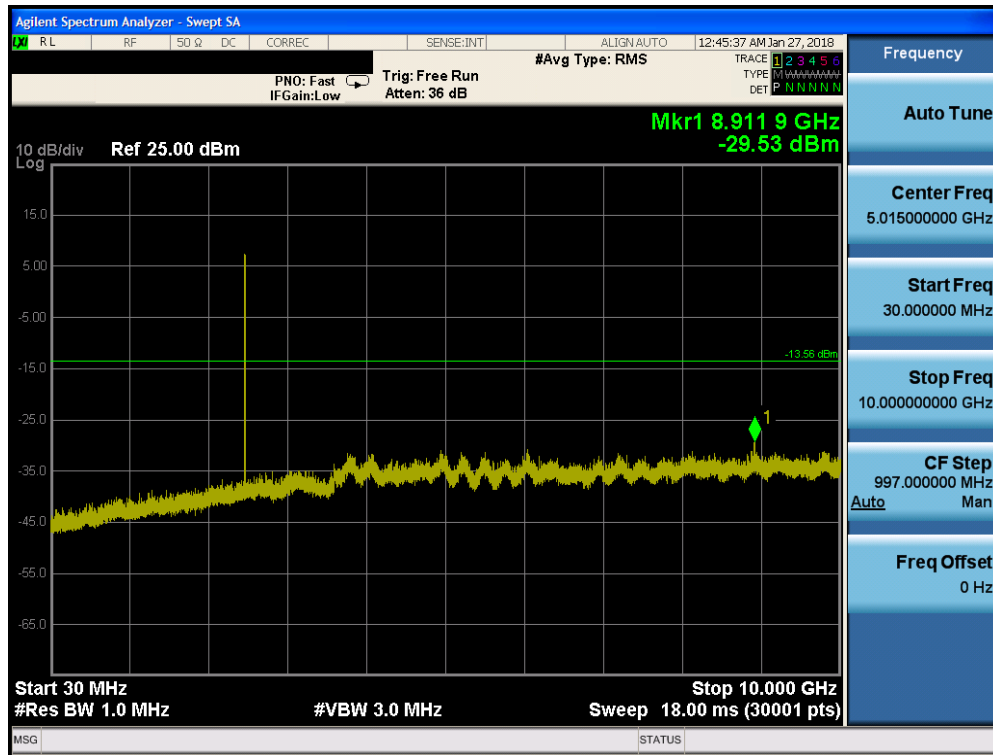


Plot 7-25. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 39)

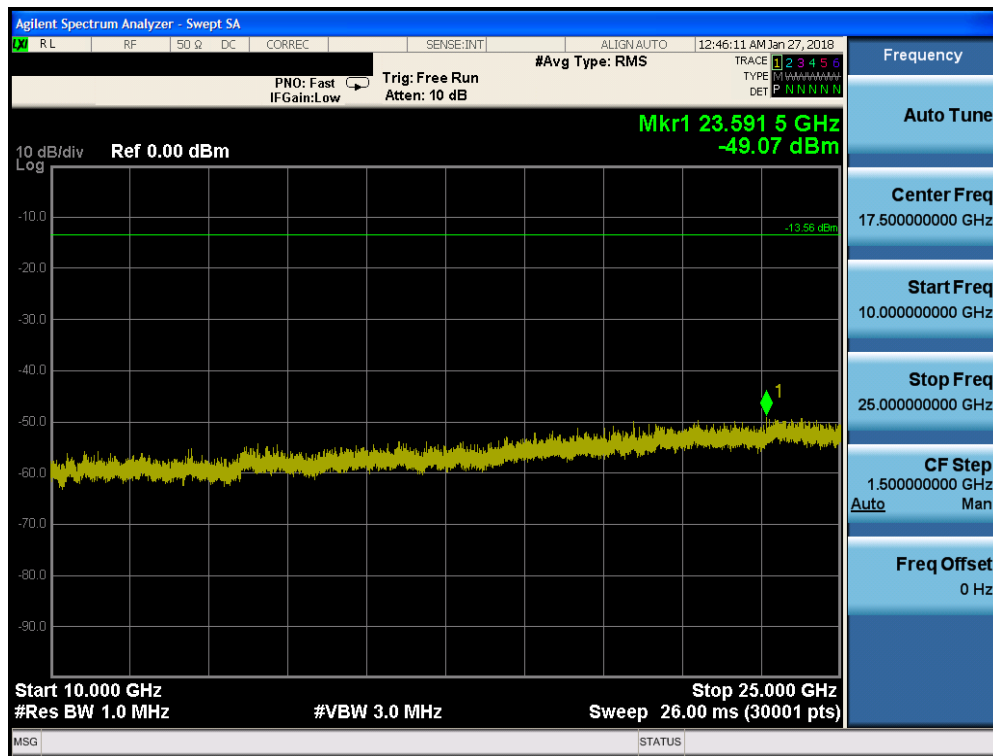


Plot 7-26. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 39)

FCC ID: BCGA1954	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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Plot 7-27. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 78)



Plot 7-28. Conducted Spurious Plot (Bluetooth (LE), iPA – Ch. 78)

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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 7-6 per Section 15.209 and RSS-Gen (8.9).

Frequency	Field Strength [$\mu\text{V/m}$]	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 7-6. Radiated Limits

Test Procedures Used

ANSI C63.10-2013 – Section 6.6.4.3

KDB 558074 D01 v04 – Section 12.1, 12.2.7

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 $\geq 2 \times \text{span/RBW}$)
6. Sweep time = auto
7. Trace (RMS) averaging was performed over at least 100 traces

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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 7-7 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 7-7. RBW as a Function of Frequency

Test Setup

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

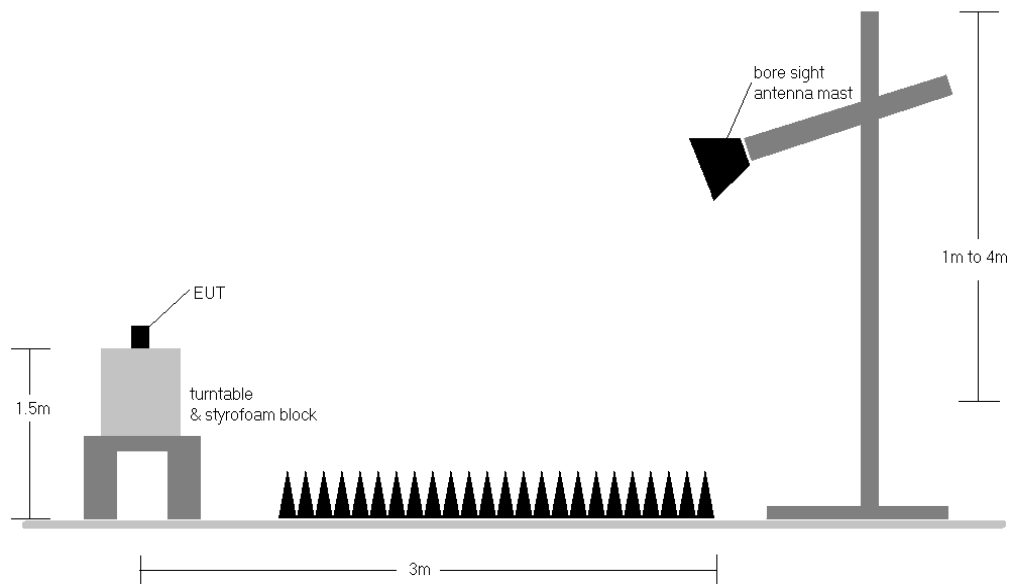


figure 7-6. Radiated Test Setup >1GHz

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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Test Notes

1. The optional test procedures for antenna port conducted measurements of unwanted emissions per the guidance of KDB 558074 D01 v04 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 7-6.
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.

Sample Calculations

Determining Spurious Emissions Levels

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

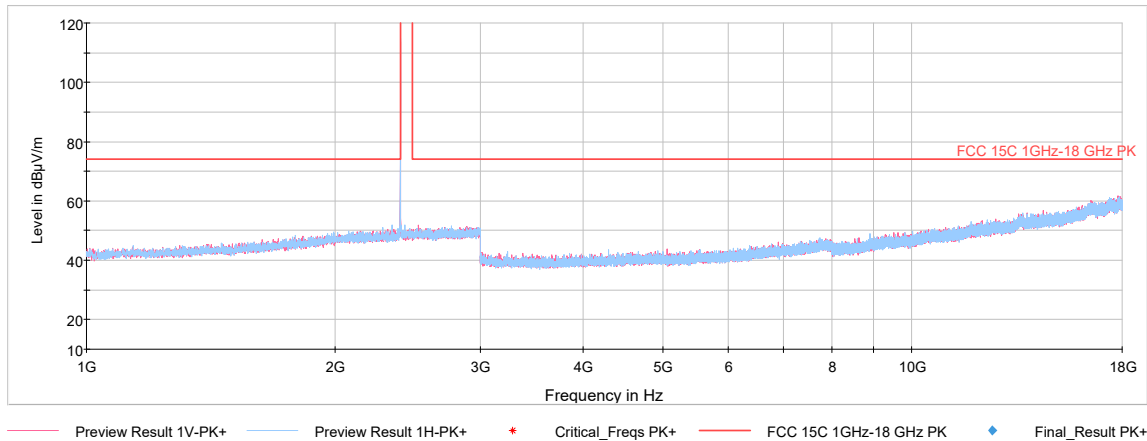
Radiated Band Edge Measurement Offset

- o 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

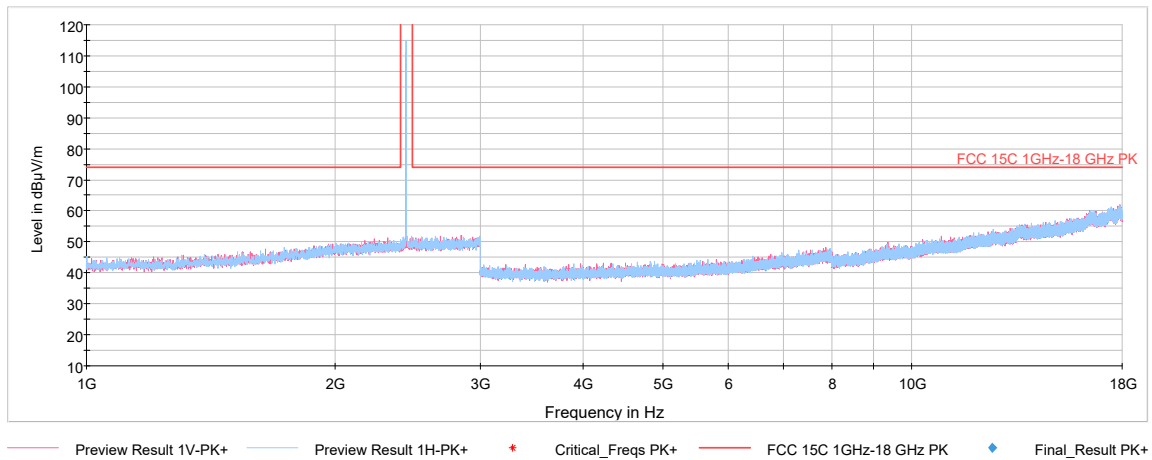
FCC ID: BCGA1954		MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 37 of 46

Radiated Spurious Emission Measurements

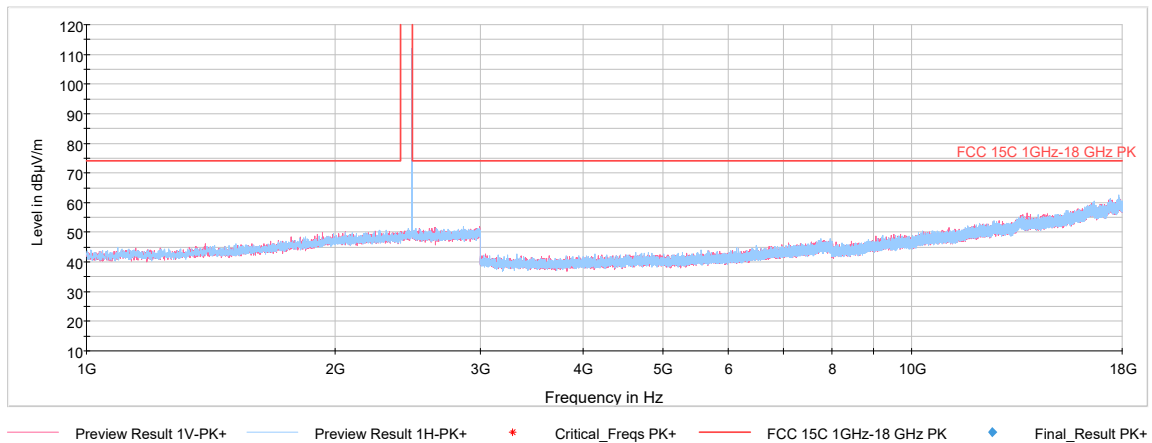
§15.205 §15.209 §15.247(d); RSS-Gen [8.9]



Plot 7-29. Radiated Spurious Plot above 1GHz (GFSK ePA – Ch. 0, Ant. Pol. H & V)



Plot 7-30. Radiated Spurious Plot above 1GHz (GFSK ePA – Ch. 19, Ant. Pol. H & V)

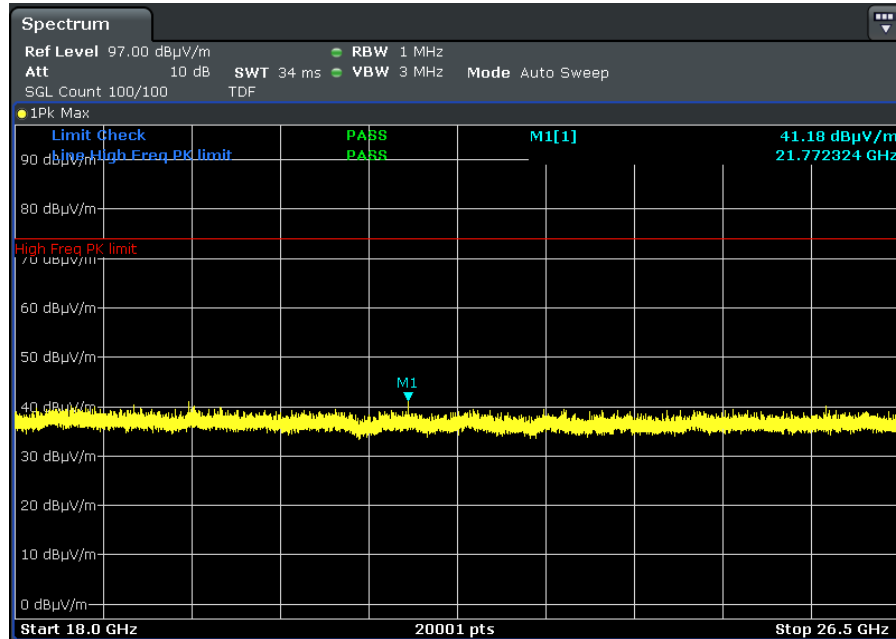


Plot 7-31. Radiated Spurious Plot above 1GHz (GFSK ePA – Ch. 39, Ant. Pol. H & V)

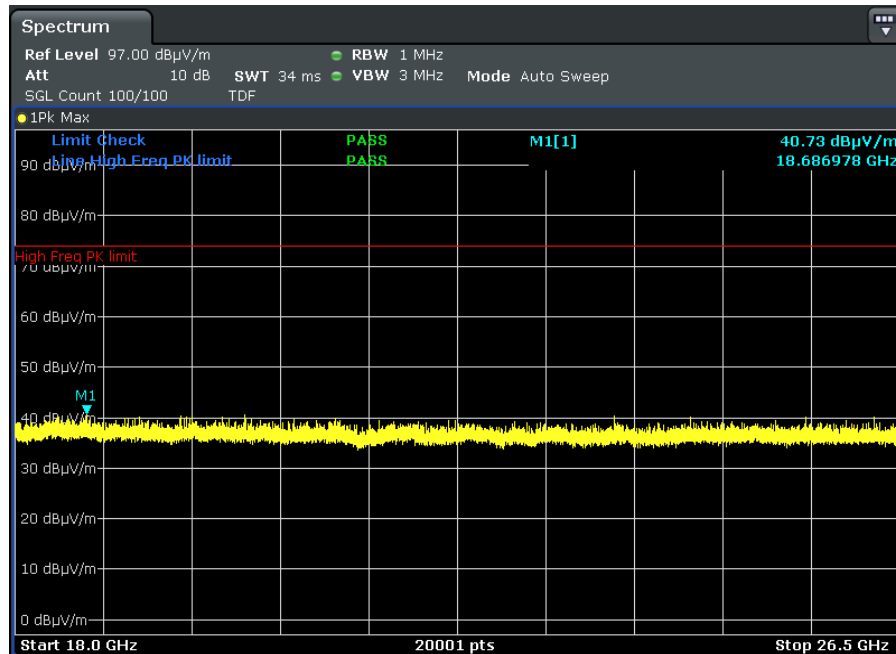
FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
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Radiated Spurious Emissions Measurements (Above 18GHz)

\$15.209



Plot 7-32. Radiated Spurious Plot above 18GHz (GFSK ePA, Pol. H)



Plot 7-33. Radiated Spurious Plot above 18GHz (GFSK ePA, Pol. V)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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Radiated Spurious Emission Measurements

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

Bluetooth Mode: LE
 Modulation: GFSK
 Power Scheme: ePA
 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	-	-	-83.93	9.47	32.54	53.98	-21.44
4804.00	Peak	H	-	-	-70.67	9.47	45.80	73.98	-28.18
12010.00	Avg	H	-	-	-89.10	25.29	43.19	53.98	-10.79
12010.00	Peak	H	-	-	-75.46	25.29	56.83	73.98	-17.15

Table 7-8. Radiated Measurements @ 3 meters

Bluetooth Mode: LE
 Modulation: GFSK
 Power Scheme: ePA
 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	-	-	-82.99	9.56	33.57	53.98	-20.41
4880.00	Peak	H	-	-	-70.36	9.56	46.20	73.98	-27.78
7320.00	Avg	H	-	-	-85.33	15.14	36.81	53.98	-17.17
7320.00	Peak	H	-	-	-72.44	15.14	49.70	73.98	-24.28
12200.00	Avg	H	-	-	-89.10	25.33	43.23	53.98	-10.74
12200.00	Peak	H	-	-	-76.61	25.33	55.72	73.98	-18.25

Table 7-9. Radiated Measurements @ 3 meters

FCC ID: BCGA1954		MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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Radiated Spurious Emission Measurements

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

Bluetooth Mode: LE
 Modulation: GFSK
 Power Scheme: ePA
 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	-	-	-82.89	9.29	33.40	53.98	-20.58
4960.00	Peak	H	-	-	-70.40	9.29	45.89	73.98	-28.09
7440.00	Avg	H	-	-	-85.75	15.67	36.92	53.98	-17.06
7440.00	Peak	H	-	-	-73.05	15.67	49.62	73.98	-24.36
12400.00	Avg	H	-	-	-89.72	25.78	43.06	53.98	-10.92
12400.00	Peak	H	-	-	-77.34	25.78	55.44	73.98	-18.54

Table 7-10. Radiated Measurements @ 3 meters

FCC ID: BCGA1954	 MEASUREMENT REPORT (CERTIFICATION)		Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 41 of 46

7.8 Radiated Restricted Band Edge Measurements

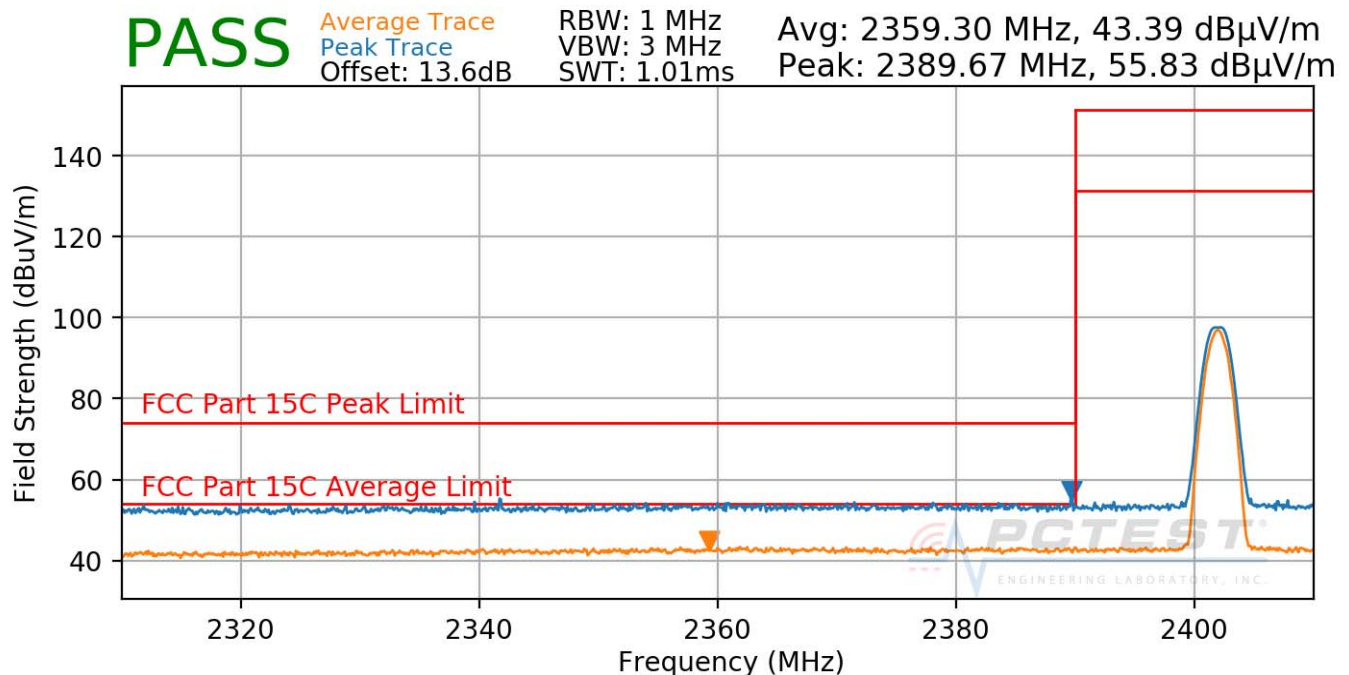
§15.205 §15.209; RSS-Gen [8.9]

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
Power Scheme:	ePA
Measurement Distance:	3 Meters
Operating Frequency:	2402MHz
Channel:	0



Plot 7-34. Radiated Restricted Lower Band Edge Measurement (Average & Peak)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
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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:

$$\text{Offset (dB)} = (\text{Antenna Factor} + \text{Cable Loss} + \text{Attenuator}) - \text{Preamplifier Gain}$$

Bluetooth Mode: LE

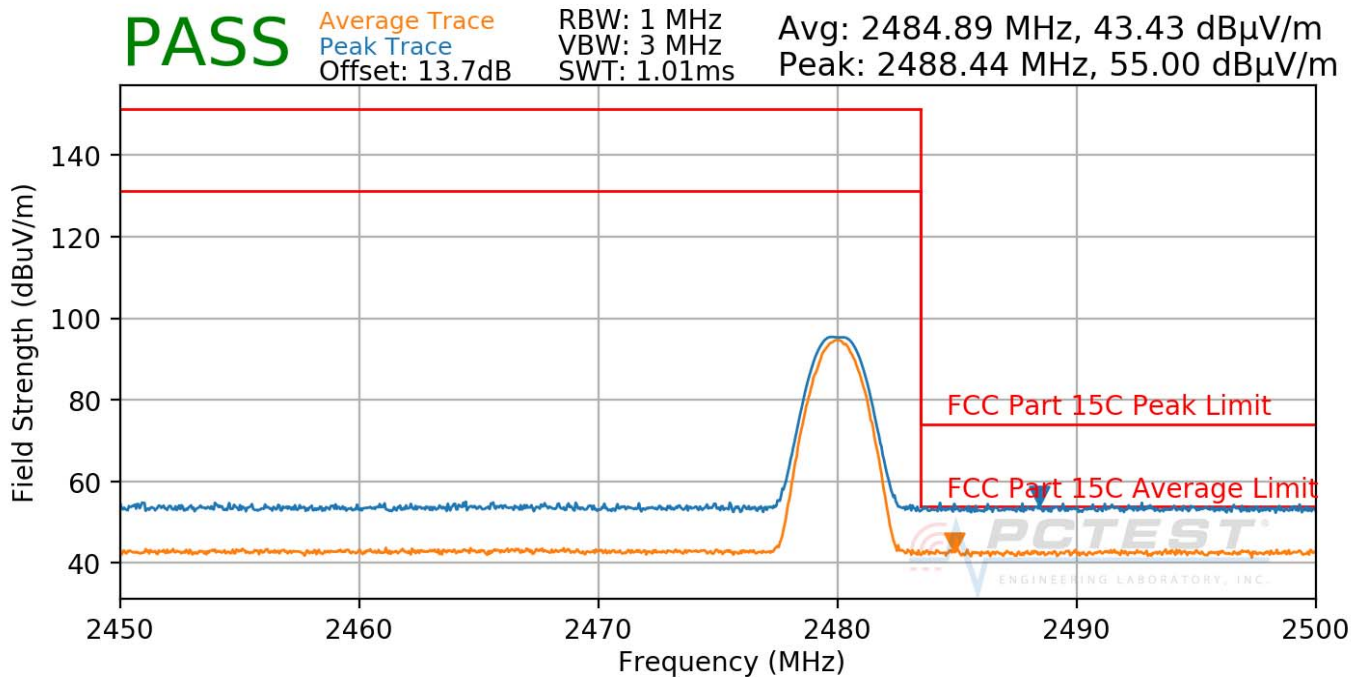
Modulation: GFSK

Power Scheme: ePA

Measurement Distance: 3 Meters

Operating Frequency: 2480MHz

Channel: 39



Plot 7-35. Radiated Restricted Upper Band Edge Measurement (Average & Peak)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 43 of 46

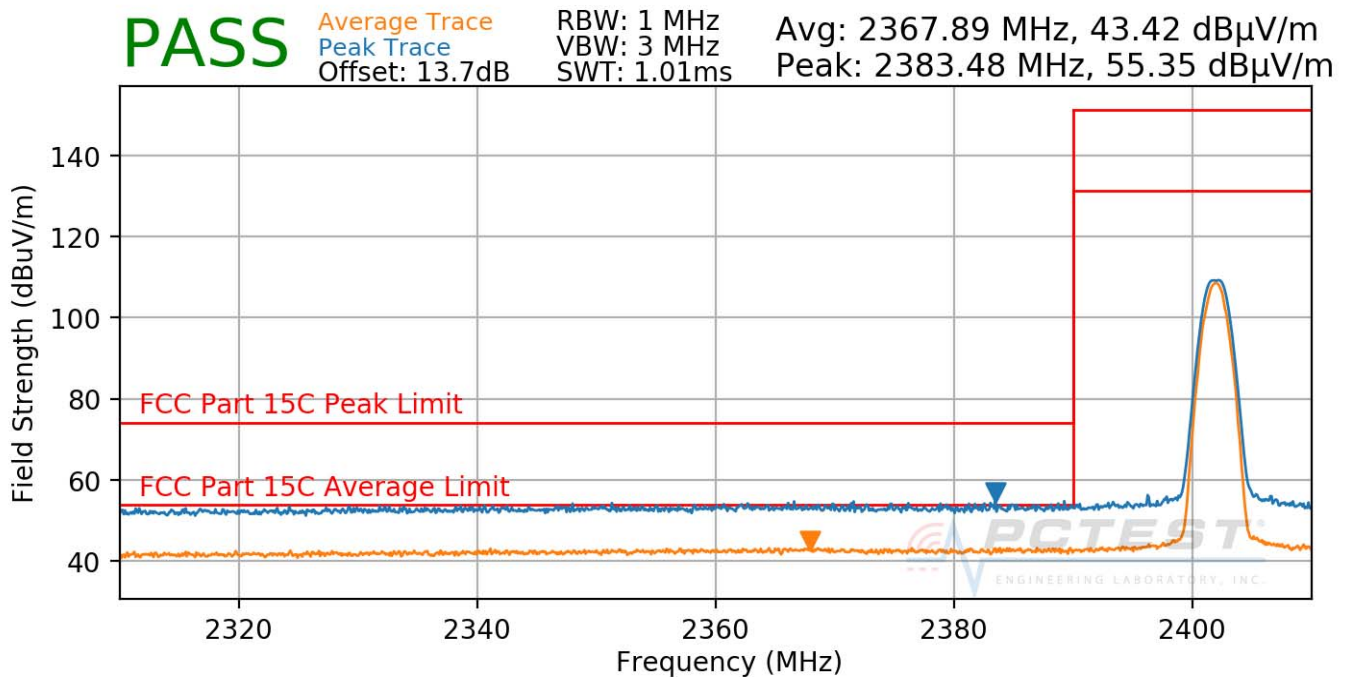
Radiated Restricted Band Edge Measurements

§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
Power Scheme: iPA
Measurement Distance: 3 Meters
Operating Frequency: 2402MHz
Channel: 0



Plot 7-36. Radiated Restricted Lower Band Edge Measurement (Average & Peak)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 44 of 46

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:

$$\text{Offset (dB)} = (\text{Antenna Factor} + \text{Cable Loss} + \text{Attenuator}) - \text{Preamplifier Gain}$$

Bluetooth Mode: LE

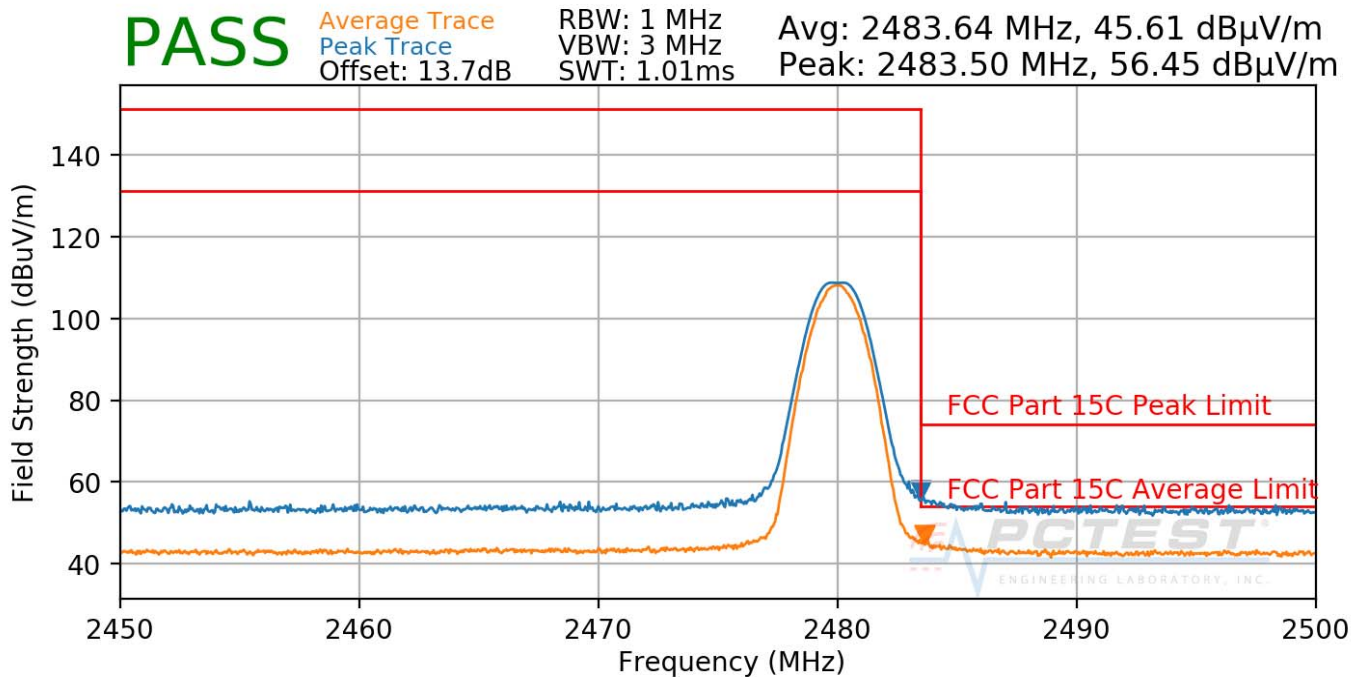
Modulation: GFSK

Power Scheme: iPA

Measurement Distance: 3 Meters

Operating Frequency: 2483MHz

Channel: 39



Plot 7-37. Radiated Restricted Upper Band Edge Measurement (Average & Peak)

FCC ID: BCGA1954	PCTEST ENGINEERING LABORATORY, INC.	MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 45 of 46

8.0 CONCLUSION

The data collected relate only the item(s) tested and show that the **Apple Tablet Device FCC ID: BCGA1954** 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.

FCC ID: BCGA1954		MEASUREMENT REPORT (CERTIFICATION)	Approved by: Quality Manager
Test Report S/N: 1C1710060006-08.BCG	Test Dates: 10/31-2/14/2018	EUT Type: Tablet Device	Page 46 of 46