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MEASUREMENT REPORT FCC Part 15C

Applicant Name:

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

Date of Testing:

9/13/2018-9/18/2018

Test Site/Location:

PCTEST Lab. Morgan Hill, CA, USA

Test Report Serial No.:

1C1806050011-11.BCG

FCC ID:

BCGA2014

APPLICANT:

Apple Inc.

Application Type:

Certification

Model/HVIN:

A2014

EUT Type:

Tablet Device

Operating Frequency:

127.77kHz

FCC Classification:

Part 15 Low Power Transmitter Below 1705 kHz (DCD)

FCC Rule Part(s):

FCC Part 15, Subpart C (15.207 & 15.209)

Test Procedure(s):

ANSI C63.10-2013, KDB 680106 D01 v02

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 v05. 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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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 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 **Tablet Device FCC ID: BCGA2014**. The test data contained in this report pertains only to the emissions due to the wireless power transfer function of the EUT.

Test Device Serial No.: DLXX600CKYD1

2.2 Device Capabilities

This device supports different charging rate

Charging Rate
10C
3C
2.5C
1C

Table 2-1. Charging Rate

2.3 Test Support Equipment

1	Apple MacBook	Model:	A1398	S/N:	C2QKP008F6F3
	w/AC/DC Adapter	Model:	A1435	S/N:	C04325505K1F288BG
2	Apple Pencil	Model:	A2051	S/N:	GQXXC1VFJKM9
3	Mithra Board	Model:	149	S/N:	X1079

Table 2-2. Test Support Equipment Used

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2.4 Test Configuration

The Tablet Device, FCC ID: BCGA2014, contains a proprietary wireless power transfer (WPT) module, which uses a magnetic inductive charging system. This feature allows for the Apple Pencil to be wirelessly charged using the tablet device.

All equipment is placed on the test table top and arranged in a typical configuration in accordance with ANSI C63.10-2013. For more information, please see Section 7.3 for test data and the test setup photos document for the test setup photographs.

Only the worst case charging rate was reported in this test report.

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, with the Apple Pencil wirelessly charging while attached to Tablet Device, following configuration were investigated and worst case was reported.

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

2.5 Software and Firmware

The test was conducted with firmware version 16B64 installed on the EUT.

2.6 EMI Suppression Device(s)/Modifications

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

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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 v05 were used in the measurement of the EUT.

Deviation from measurement procedure.....None

3.2 AC Line Conducted Emissions

The line-conducted facility is located inside a 7m x 3.66m x 2.7m shielded enclosure. The shielded enclosure is manufactured by AP Americas. The shielding effectiveness of the shielded room is in accordance with MIL-Std-285 or NSA 65-6. A 1m x 1.5m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50μH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. The external power line filter is EPCOS 2X60A Power Line Filter (100dB Attenuation, 14kHz-18GHz) and the two EPCOs 2X48A filters (100dB Minimum Insertion Loss, 14kHz - 10GHz). These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and this supply line(s) will be connected to the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference ground plane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

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

Line conducted emissions test results are shown in Section 7.4. 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.

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3.3 Radiated Emissions

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

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

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

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

3.4 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).

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4.0 SAMPLE CALCULATIONS

4.1 Radiated Emission Measurement Sample Calculation

@ 66.7 MHz

Class B limit	= 100 μ V/m = 40.0 dB μ V/m
Reading	= - 76.0 dBm (calibrated level)
Convert to dB μ V	= - 76.0 + 107 = 31.0 dB μ V
Antenna Factor + Cable Loss	= 5.8 dB/m
Total	= 36.8 dB μ V/m
Margin	= 36.8 - 40.0 = - 3.2 dB
	= 3.2 dB below limit

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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 data shown herein 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)
Line Conducted Disturbance	3.09
Radiated Disturbance (<1GHz)	4.98
Radiated Disturbance (>1GHz)	5.07

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6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST).

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
COM-POWER	LIN-120A	LISN	3/7/2018	Annual	3/7/2019	241296
Rohde & Schwarz	ESW44	EMI Test Receiver	12/20/2017	Annual	12/20/2018	101668
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)	11/29/2017	Annual	11/29/2018	101063
Rohde & Schwarz	HFH2-Z2	Loop Antenna	3/13/2018	Annual	3/13/2019	100519

Table 6-1. Annual Test Equipment Calibration Schedule

Note:

1. 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.
2. Equipment with a calibration date of "N/A" shown in this list was not used to make direct calibrated measurements.

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7.0 TEST DATA

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCGA2014

FCC Sections	Description	Result
2.1049	Occupied Bandwidth	N/A
15.207	Line Conducted Emissions	PASS
15.209	Radiated Emissions	PASS

Table 7-1. Summary of Test Results

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7.2 Occupied Bandwidth

§2.1049

Test Overview

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured. All modes of operation were investigated and the worst case configuration results are reported in this section.

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99% occupied bandwidth.
2. RBW = 100Hz
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.

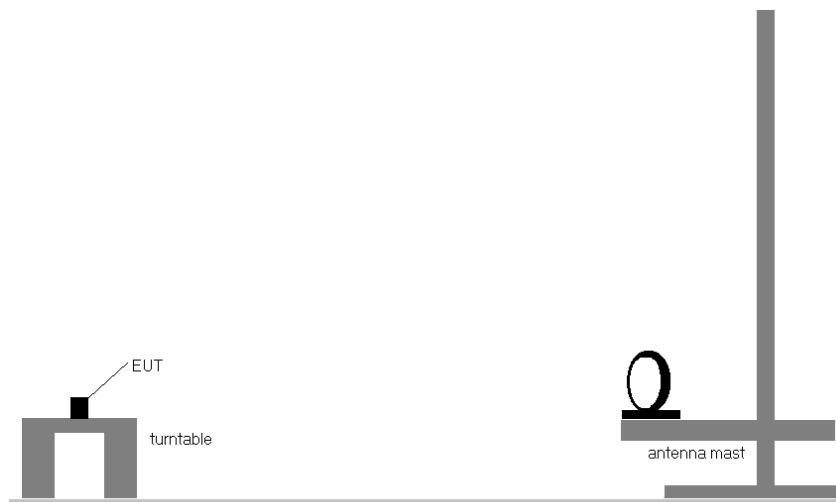
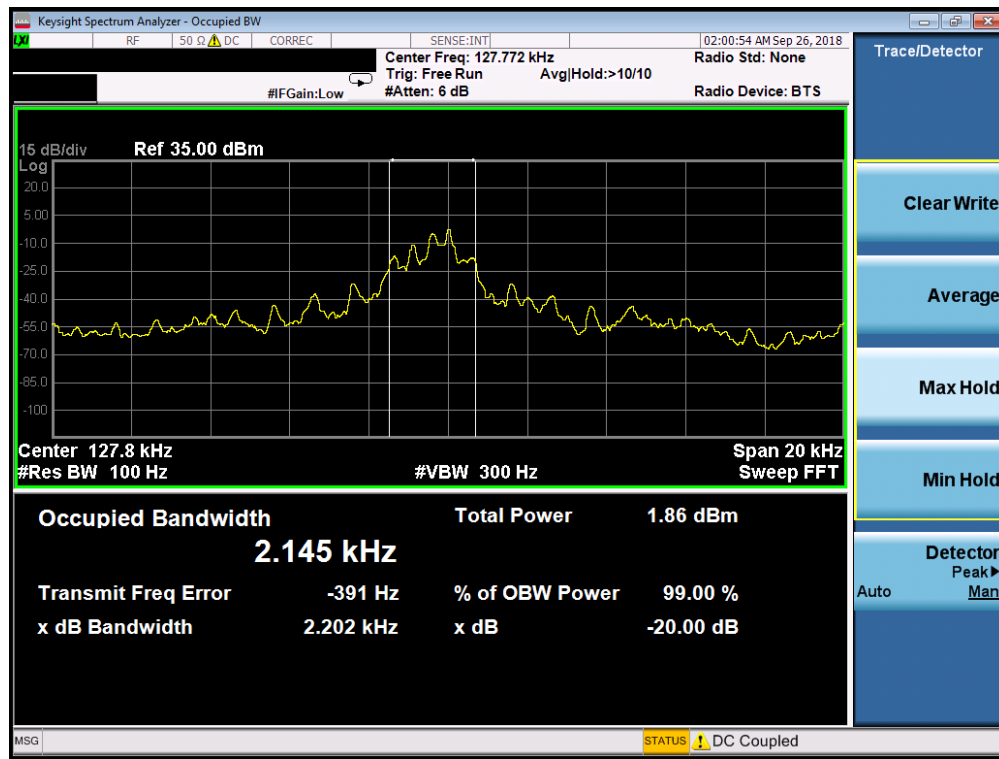


Figure 7-1. Test Setup

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Plot 7-1. Occupied Bandwidth Plot

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7.3 Radiated Measurement Data

§15.205 & 15.209

Limit

Frequency [MHz]	Field Strength Limit [$\mu\text{V/m}$]	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
> 960	500	3

Table 7-2. Radiated Limits (Section 15.209)

Test Procedure Used

ANSI C63.10-2013

Test Settings

Quasi-Peak Field Strength Measurements

1. Analyzer frequency set to the frequency of the radiated spurious emission of interest
2. Per the CISPR 16-1-1 standard, the RBW's are as follows:
9kHz – 150kHz (Band A): 200Hz
150kHz – 30MHz (Band B): 9kHz
30MHz – 1GHz (Band C): 120kHz
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 diagram below.

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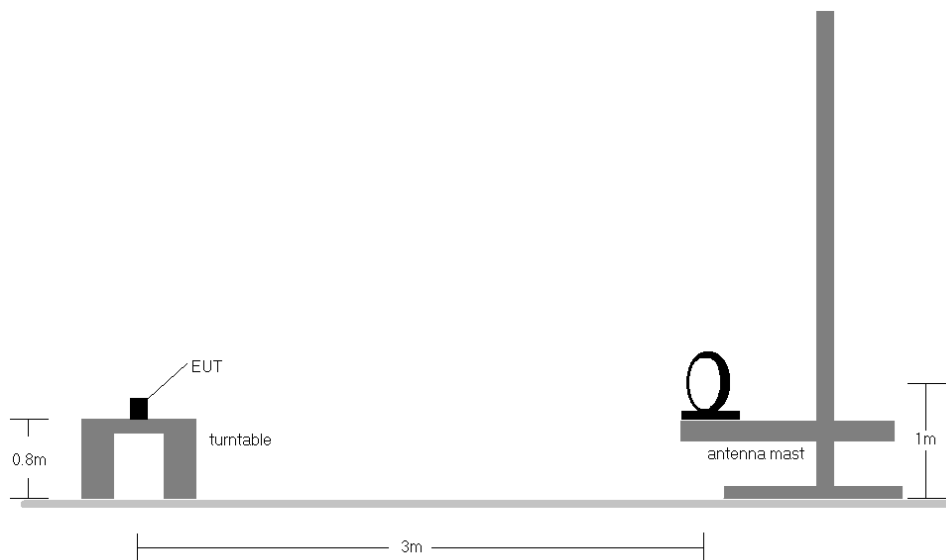


Figure 7-2. Radiated Test Setup < 30MHz

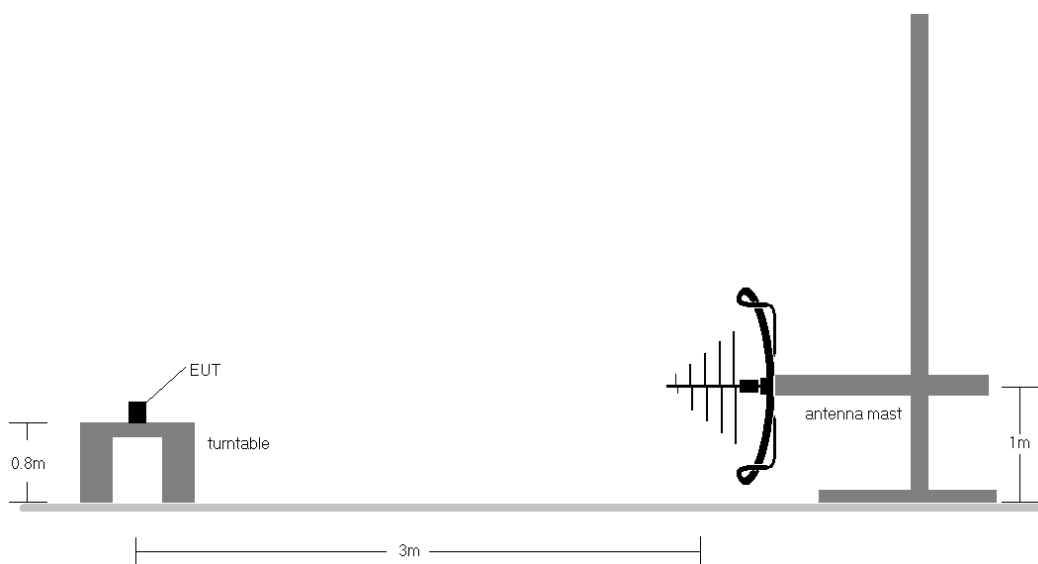


Figure 7-3. Radiated Test Setup < 1GHz

Sample Calculation:

- Field Strength Level [dB μ V/m] = Analyzer Level [dBm] + 107 + AFCL [dB]

Notes:

- AFCL = Antenna Factor [dB] + Cable Loss [dB]

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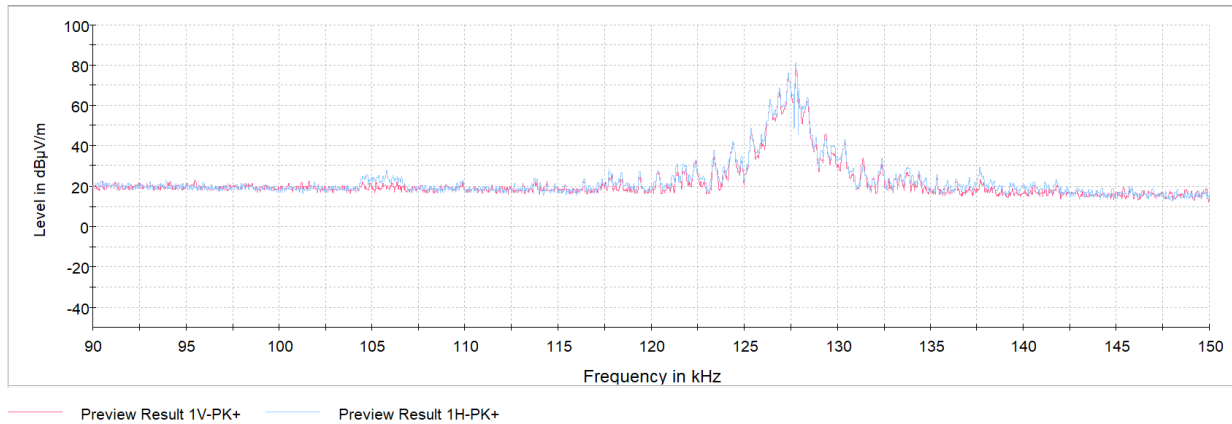
Notes:

1. The fundamental emission is denoted by a * next to the frequency.
2. All modes of operation were investigated, and the worst-case emissions are reported.
3. Radiated emissions were measured from 9kHz –1GHz.
4. The radiated limits for intentional radiators are shown in Table 7-2.
5. All readings are calibrated by a signal generator with accuracy traceable to the National Institute of Standards and Technology (NIST).
6. $AFCL\ (dB/m) = Antenna\ Factor\ (dB/m) + Cable\ Loss\ (dB)$
7. $Level\ (dB\mu V/m) = Analyzer\ Reading\ (dBm) + AFCL\ (dB/m) + 107$
8. $Margin\ (dB) = Field\ strength\ (dB\mu V/m) - Limit\ (dB\mu V/m)$
9. Radiated measurements below 30MHz were measured using a loop antenna. The antenna was positioned in three orthogonal planes (X front, Y side, Z top) and the position with the highest emission level is reported above.
10. For measurements made below 1GHz, the results recorded using the broadband antenna are known to correlate with the results obtained by using a tuned dipole with an acceptable degree of accuracy. The VSWR for the measurement antennas was found to be less than 2:1.
11. Calibrated low-loss microwaves cables are used.
12. The wide spectrum spurious emissions plots shown on the following pages are used only for the purpose of emission identification. These plots were taken without using any correction factors. Any emissions found to be within 20dB of the limit (after applying the correction factor) are fully investigated and the results are shown in Table 7-3 and Table 7-4.
13. The “-” shown in the tables below are used to denote noise floor measurements.
14. No significant emissions were found in the 90 – 110kHz restricted band.
15. All charging rates were investigated and only the worst case is reported

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Radiated Restricted Band Edge Measurements

§15.205 §15.209

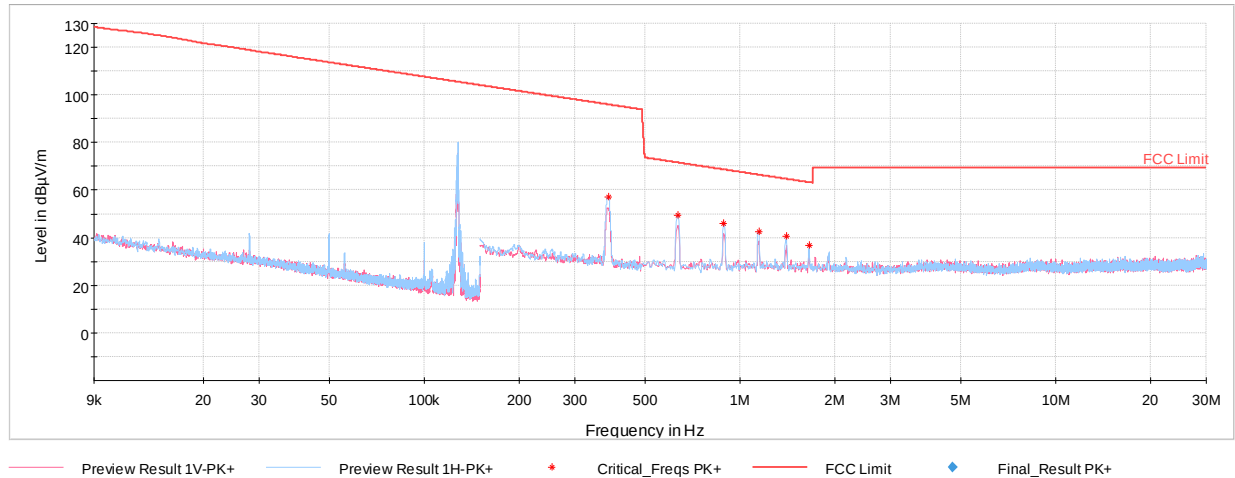


Plot 7-2. Radiated Restricted Lower Band Edge Measurement (Peak)

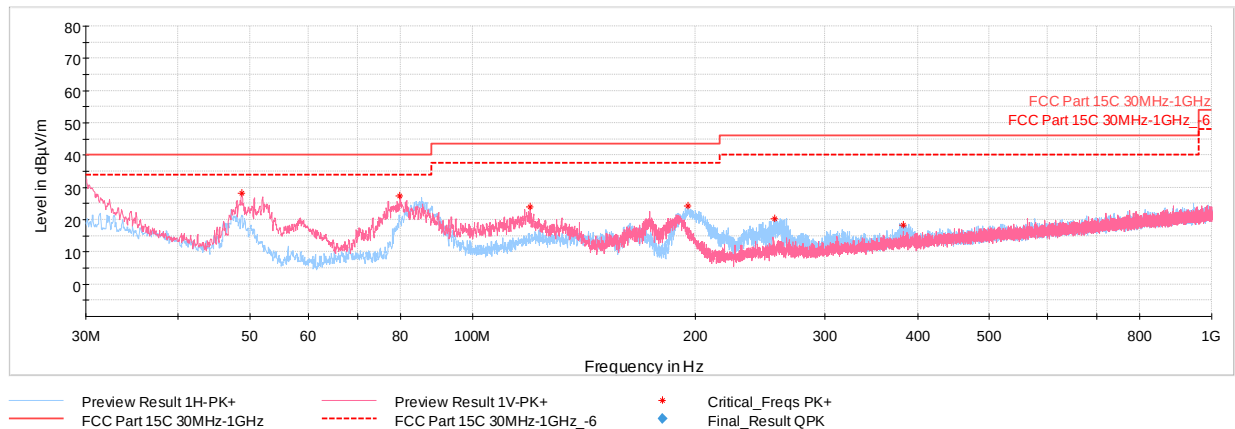
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Radiated Spurious Emissions Measurements

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Plot 7-3. Radiated Spurious Plot from 9kHz – 30MHz (Loop Antenna X & Y)



Plot 7-4. Radiated Spurious Plot above 30MHz (Pol. H & V)

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Radiated Spurious Emissions Measurements

§15.209

Frequency [MHz]	Detector	Ant. Pol. [X/Y]	Turntable Azimuth [degree]	AFCL [dB/m]	Field Strength [dBμV/m]	Limit [dBμV/m]	Margin [dB]
0.128 *	Peak	X	217	19.32	80.10	105.48	-25.38
0.3835	Peak	X	216	19.25	56.95	95.93	-38.98
0.6376	Peak	X	214	19.49	49.52	71.51	-21.99
0.8854	Peak	X	217	19.58	46.06	68.66	-22.60
1.1481	Peak	X	225	19.71	42.51	66.40	-23.89
1.4048	Peak	X	203	19.73	40.55	64.65	-24.10
1.6586	Peak	X	206	19.73	36.91	63.21	-26.30

Table 7-3. Radiated Measurements Below 30MHz at 3-meters

* WPT fundamental TX

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	AFCL [dB/m]	Field Strength [dBμV/m]	Limit [dBμV/m]	Margin [dB]
48.72	Peak	V	100.00	86.00	-21.31	28.25	40.00	-11.75
79.81	Peak	V	100.00	182.00	-19.42	27.48	40.00	-12.52
119.68	Peak	V	100.00	28.00	-17.48	23.94	43.52	-19.58
195.63	Peak	H	250.00	95.00	-19.65	24.27	43.52	-19.25
256.40	Peak	H	100.00	275.00	-17.30	20.40	46.02	-25.62
382.45	Peak	H	100.00	7.00	-13.69	18.41	46.02	-27.61

Table 7-4. Radiated Measurements Above 30MHz at 3-meters

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7.4 Line-Conducted Test Data

§15.207

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.

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 7-5. 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

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 = quasi-peak
4. Sweep time = auto couple
5. Trace mode = max hold
6. 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

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Test Setup

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

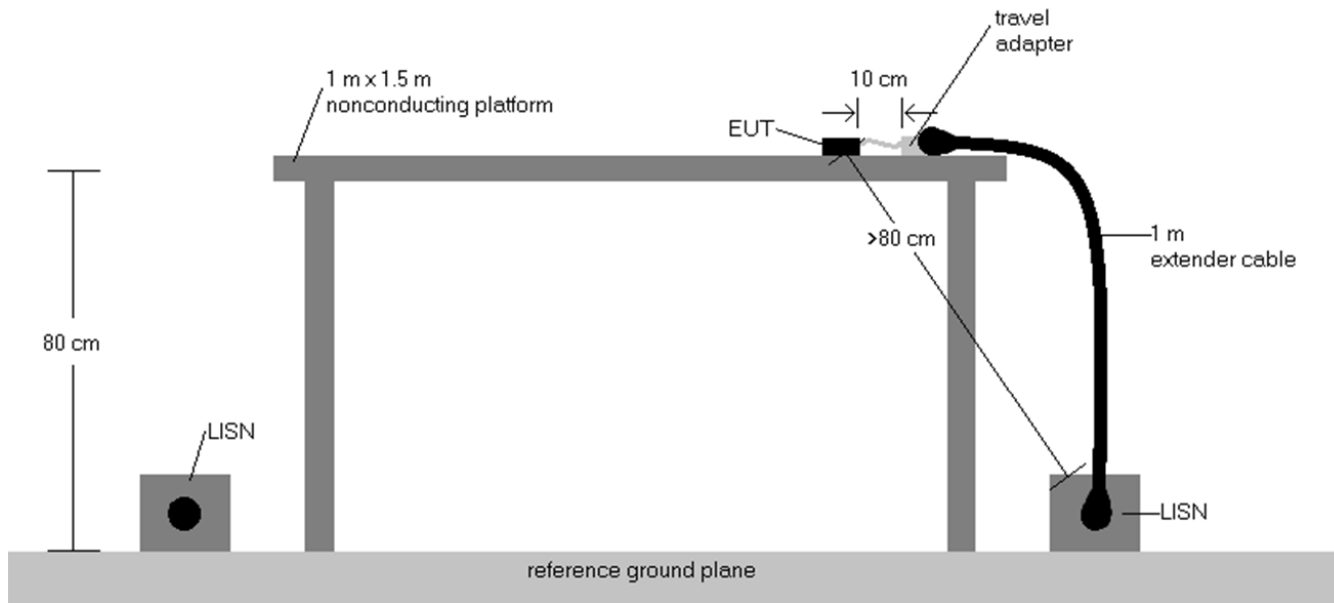
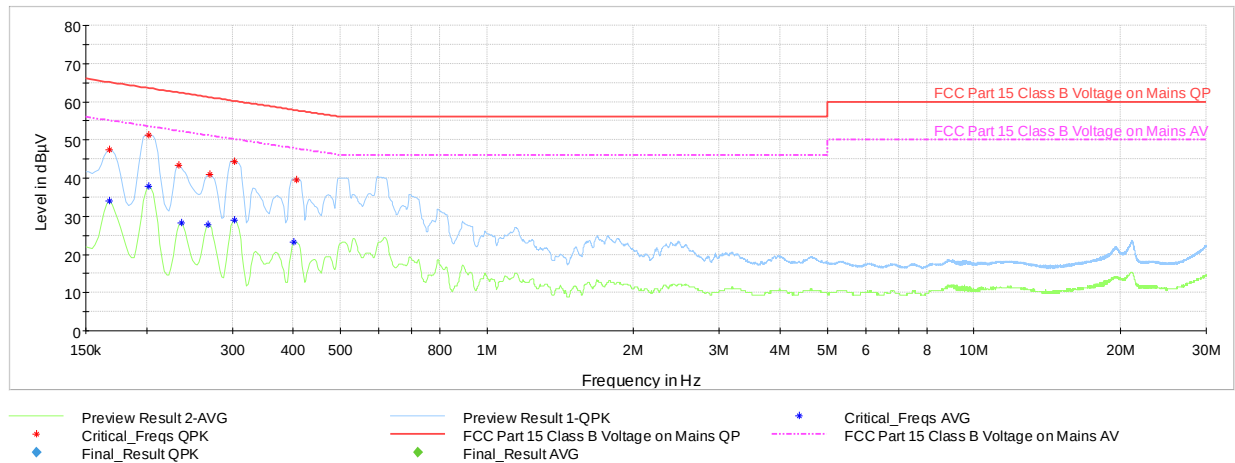


Figure 7-4. Test Instrument & Measurement Setup

Test Notes

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

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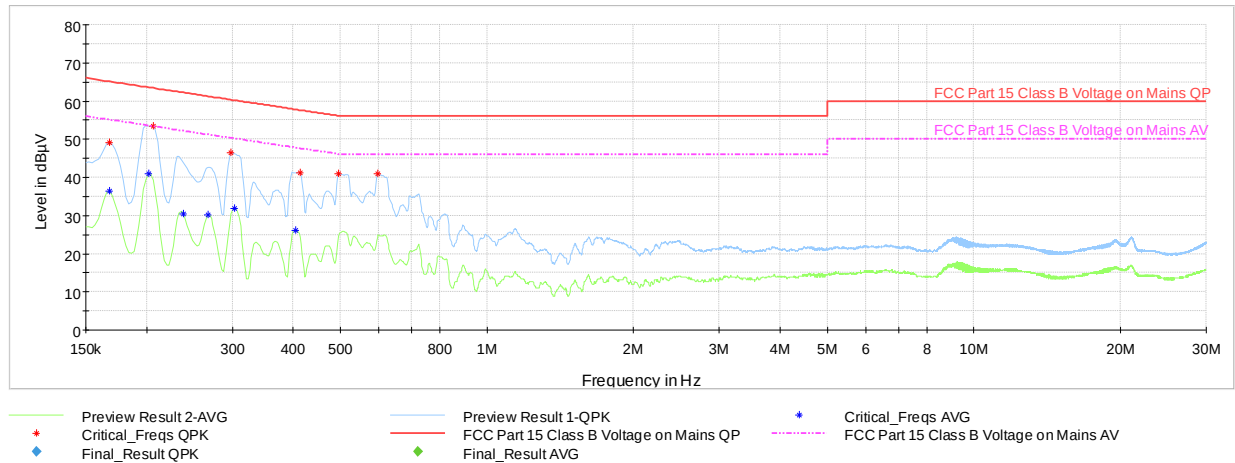


Plot 7-5. Line Conducted Plot (L1, with AC/DC Adapter)

Frequency MHz	Process State	QuasiPeak dBμV	Average dBμV	Limit dBμV	Margin dB	Line	PE
0.168000	FINAL	47.37	—	65.06	-17.69	L1	GND
0.168000	FINAL	—	33.97	55.06	-21.09	L1	GND
0.201750	FINAL	—	37.78	53.54	-15.76	L1	GND
0.201750	FINAL	51.27	—	63.54	-12.26	L1	GND
0.233250	FINAL	43.37	—	62.33	-18.97	L1	GND
0.235500	FINAL	—	28.17	52.25	-24.08	L1	GND
0.267000	FINAL	—	27.85	51.21	-23.36	L1	GND
0.269250	FINAL	40.85	—	61.14	-20.29	L1	GND
0.303000	FINAL	44.23	—	60.16	-15.93	L1	GND
0.303000	FINAL	—	28.86	50.16	-21.30	L1	GND
0.402000	FINAL	—	23.11	47.81	-24.70	L1	GND
0.406500	FINAL	39.59	—	57.72	-18.13	L1	GND

Table 7-6. Line Conducted Measurements (L1, with AC/DC Adapter)

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Plot 7-6. Line Conducted Plot (N, with AC/DC Adapter)

Frequency MHz	Process State	QuasiPeak dBμV	Average dBμV	Limit dBμV	Margin dB	Line	PE
0.168000	FINAL	—	36.40	55.06	-18.66	N	GND
0.168000	FINAL	49.03	—	65.06	-16.02	N	GND
0.201750	FINAL	—	40.97	53.54	-12.57	N	GND
0.206250	FINAL	53.34	—	63.36	-10.02	N	GND
0.237750	FINAL	—	30.52	52.17	-21.65	N	GND
0.267000	FINAL	—	30.13	51.21	-21.08	N	GND
0.298500	FINAL	46.46	—	60.28	-13.82	N	GND
0.303000	FINAL	—	31.93	50.16	-18.23	N	GND
0.404250	FINAL	—	26.04	47.77	-21.73	N	GND
0.413250	FINAL	41.10	—	57.58	-16.48	N	GND
0.496500	FINAL	40.87	—	56.06	-15.19	N	GND
0.595500	FINAL	40.91	—	56.00	-15.09	N	GND

Table 7-7. Line Conducted Measurements (N, with AC/DC Adapter)

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8.0 CONCLUSION

The data collected relate only the item(s) tested and show that the **Apple Tablet Device FCC ID: BCGA2014** is in compliance with Part 15 Subpart C (15.247) of the FCC Rules.

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