



FCC CFR47 PART 15 SUBPART C
INDUSTRY CANADA RSS-210 ISSUE 8

BLUETOOTH LOW ENERGY
CERTIFICATION TEST REPORT

FOR

PORTABLE MEDIA PLAYER WITH BLUETOOTH RADIO

MODEL NUMBER: A1446

FCC ID: BCG-A1446A
IC: 579C-A1446A

REPORT NUMBER: 12U14520-2

ISSUE DATE: AUGUST 9, 2012

Prepared for
APPLE, INC.
1 INFINITE LOOP
CUPERTINO, CA 95014, U.S.A

Prepared by
UL CCS
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP®

NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	08/09/2012	Initial Issue	T. LEE

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS.....	4
2. TEST METHODOLOGY	5
3. FACILITIES AND ACCREDITATION.....	5
4. CALIBRATION AND UNCERTAINTY	5
4.1. <i>MEASURING INSTRUMENT CALIBRATION</i>	5
4.2. <i>SAMPLE CALCULATION.....</i>	5
4.3. <i>MEASUREMENT UNCERTAINTY.....</i>	5
5. EQUIPMENT UNDER TEST	6
5.1. <i>DESCRIPTION OF EUT</i>	6
5.2. <i>MAXIMUM OUTPUT POWER.....</i>	6
5.3. <i>DESCRIPTION OF AVAILABLE ANTENNAS</i>	6
5.1. <i>SOFTWARE AND FIRMWARE</i>	6
5.2. <i>WORST-CASE CONFIGURATION AND MODE.....</i>	7
5.3. <i>DESCRIPTION OF TEST SETUP.....</i>	8
6. TEST AND MEASUREMENT EQUIPMENT	10
7. ANTENNA PORT TEST RESULTS	11
7.1. <i>6 dB BANDWIDTH</i>	11
7.2. <i>99% BANDWIDTH.....</i>	15
7.3. <i>OUTPUT POWER</i>	19
7.4. <i>AVERAGE POWER.....</i>	23
7.5. <i>POWER SPECTRAL DENSITY</i>	24
7.6. <i>CONDUCTED SPURIOUS EMISSIONS</i>	28
8. RADIATED TEST RESULTS	35
8.1. <i>LIMITS AND PROCEDURE</i>	35
8.2. <i>TRANSMITTER ABOVE 1 GHz</i>	36
8.3. <i>TX ABOVE 1 GHz FOR BLUETOOTH LOW ENERGY MODE IN THE 2.4 GHz BAND</i>	36
8.4. <i>WORST-CASE BELOW 1 GHz</i>	45
9. AC POWER LINE CONDUCTED EMISSIONS	48
SETUP PHOTOS.....	52

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.
1 INFINITE LOOP
CUPERTINO, CA, 95014, U.S.A.

EUT DESCRIPTION: Portable media player with Bluetooth radio

MODEL: A1446

SERIAL NUMBER: Radiated: DVYJ1077F6VQ
Conducted: DCYHQ0A3F5GQ

DATE TESTED: JULY 25 - JULY 27, 2012

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Pass
INDUSTRY CANADA RSS-210 Issue 8 Annex 8	Pass
INDUSTRY CANADA RSS-GEN Issue 3	Pass

UL CCS tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL CCS based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL CCS will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For UL CCS By:



TIM LEE
STAFF ENGINEER
UL CCS

Tested By:



TOM CHEN
EMC ENGINEER
UL CCS

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2003, FCC CFR 47 Part 2, FCC CFR 47 Part 15, RSS-GEN Issue 3, and RSS-210 Issue 8.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Conducted Disturbance, 0.15 to 30 MHz	3.52 dB
Radiated Disturbance, 30 to 1000 MHz	4.94 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a Portable media player that incorporated flash memory, FM radio, pedometer, touchscreen display, and a Bluetooth radio. The unit is battery powered.

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2402 - 2480	Bluetooth LE	9.82	9.59

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a PIFA antenna, with a maximum gain of -2.8 dBi in the 2.4 GHz band.

5.1. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was 37A00374.

5.2. WORST-CASE CONFIGURATION AND MODE

Radiated emission and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

The fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that Y orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Y orientation.

Based on the manufacturer's attestation that the nominal output power is reduced as the data rate increases, the data rates tested represent the highest power and worst-case with respect to EMC performance.

5.3. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List			
Description	Manufacturer	Model	Serial Number
AC Adapter	Apple	A1344	NA
Laptop PC	Apple	MacBook Pro	NA
Directional Coupler	RF-Lambda	RFDC5M06G15	NA
Headset	Apple	NA	NA

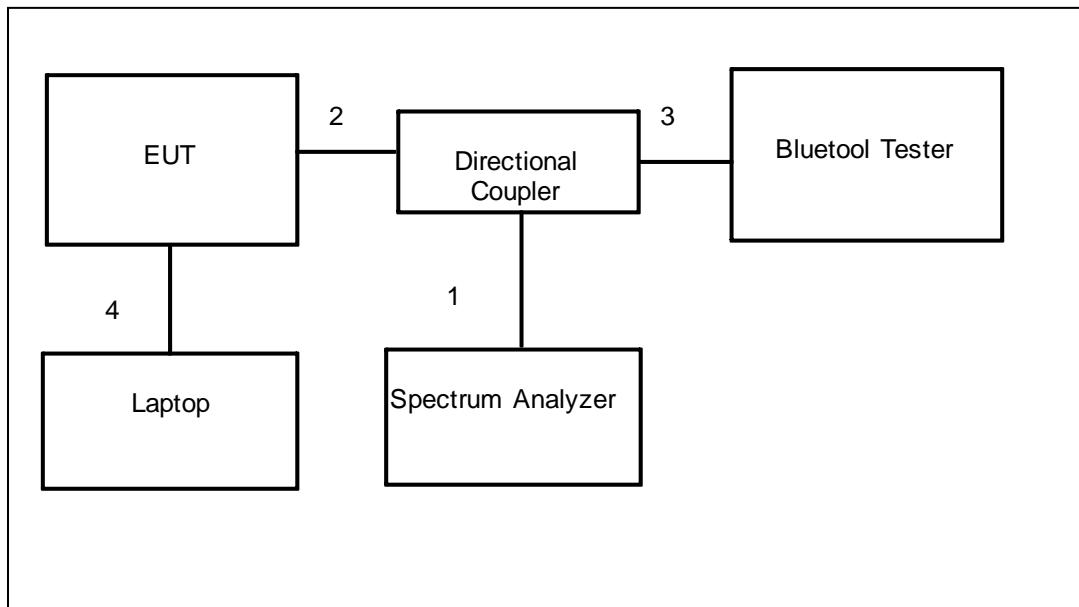
I/O CABLES (Conducted Setup)

Cable No.	Port	# of Identic Ports	Connector Type	Cable Type	Cable Length	Remarks
1	In/Out	1	SMA	Shielded	0.2m	NA
2	In/Out	1	SMA	Shielded	0.6m	NA
3	Antenna Port	1	SMA	Shielded	0.1m	NA
4	Laptop	1	USB	Un-shielded	1m	NA

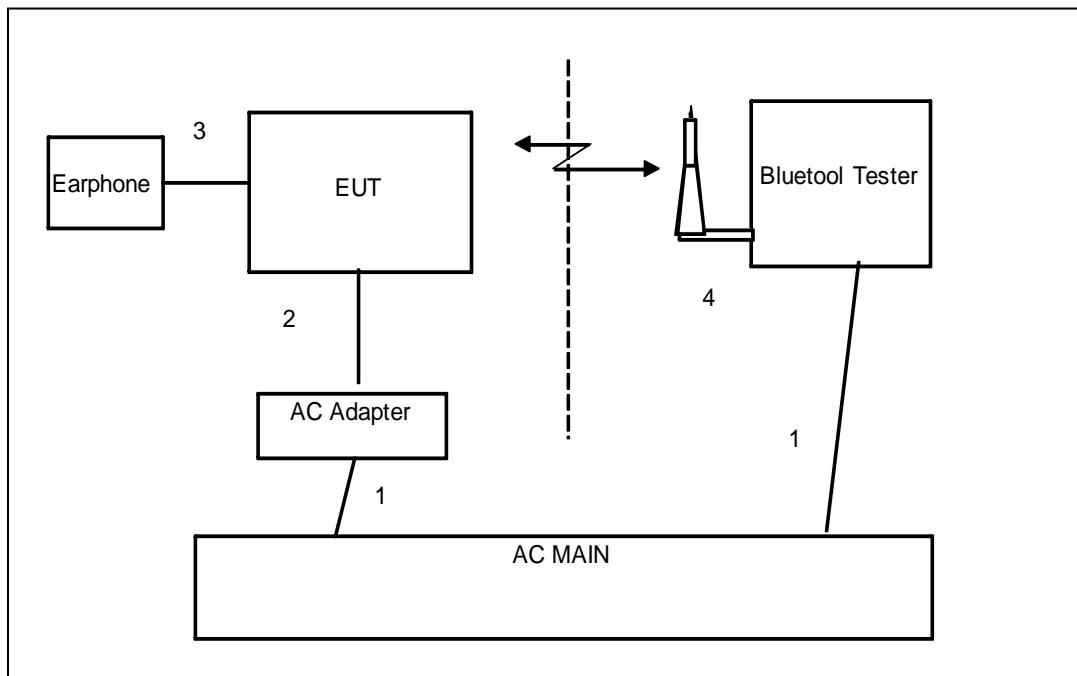
I/O CABLES (Radiated Setup)

I/O CABLE LIST						
Cable No.	Port	# of Identic Ports	Connector Type	Cable Type	Cable Length	Remarks
1	AC	1	US115VAC	Un-Shielded	2m	NA
2	DC	1	DC	Un-Shielded	1m	NA
3	Jack	1	Earphone	Shielded	0.5m	NA
4	Antenna Port	1	Horn	Un-shielded	2m	NA

SETUP DIAGRAM FOR RADIATED EMISSIONS TESTS



SETUP DIAGRAM FOR RADIATED TESTS



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	Manufacturer	Model	Asset	Cal Due
Preamplifier, 26.5 GHz	Agilent / HP	8449B	C01052	07/14/13
Antenna, Horn, 18 GHz	EMCO	3115	C00945	06/29/13
Preamplifier, 1300 MHz	Agilent / HP	8447D	C00580	11/11/12
Horn Antenna, 26.5 GHz	ARA	MWH-1826/B	C00589	07/28/13
Antenna, BiLog, 2 GHz	Sunol Sciences	JB1	C01016	07/12/13
Reject Filter, 2.0-2.9 GHz	Micro-Tronics	BRM50702	N02684	CNR
High Pass Filter, 7.6 GHz	Micro-Tronics	HPM13195	N02682	CNR
Spectrum Analyzer, 44 GHz	Agilent / HP	E4446A	C01159	04/09/13
Peak Power Meter	Agilent	N1911A	1260847C	09/04/12
Peak Power Sensor	Agilent	E9323A	1244073F	09/04/12
Reject Filter, 5.725-5.825 GHz	Micro-Tronics	BRC13192	N02676	CNR
Reject Filter, 2.4-2.5 GHz	Micro-Tronics	BRM50702	N02685	CNR
Highpass Filter, 7.6 GHz	Micro-Tronics	HPM13195	N02682	CNR

7. ANTENNA PORT TEST RESULTS

7.1. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

IC RSS-210 A8.2 (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

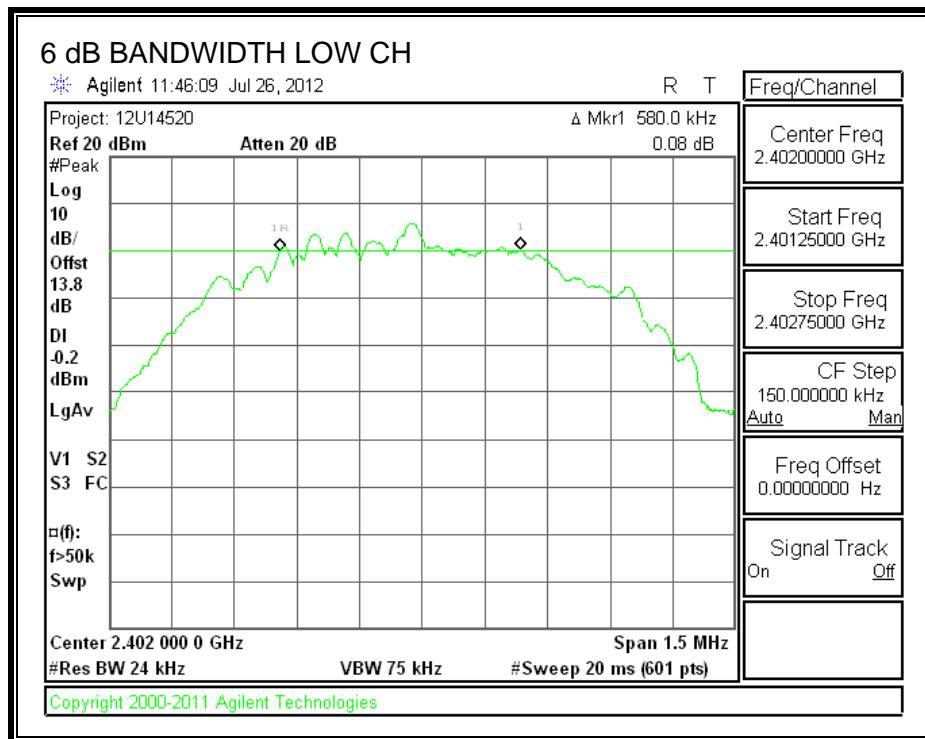
TEST PROCEDURE

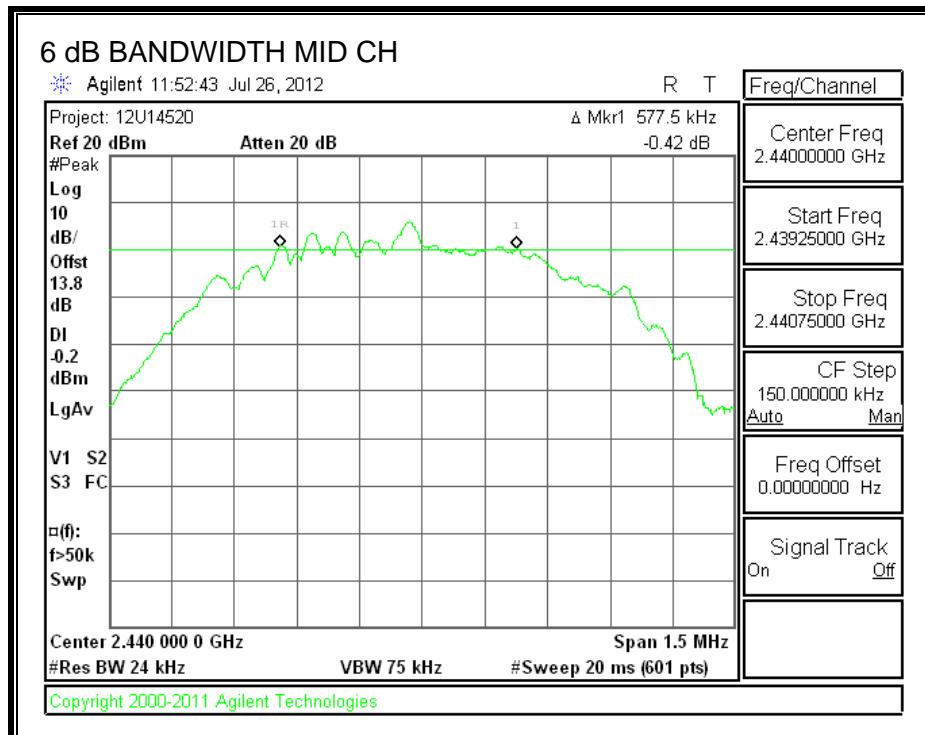
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

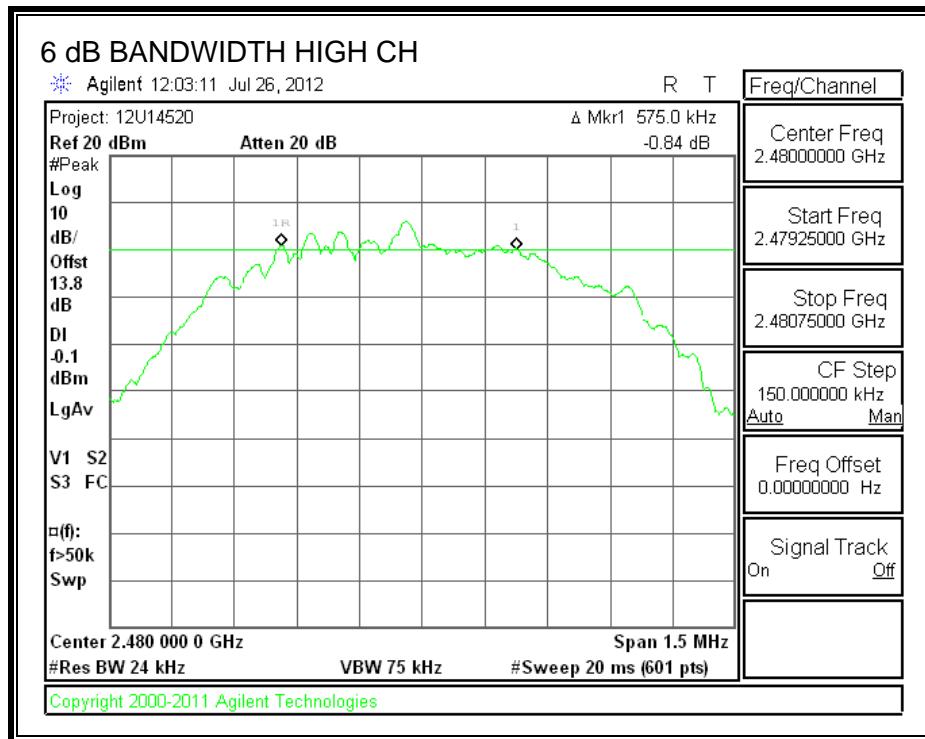
RESULTS

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.5800	0.5
Middle	2440	0.5775	0.5
High	2480	0.5750	0.5

6 dB BANDWIDTH







7.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

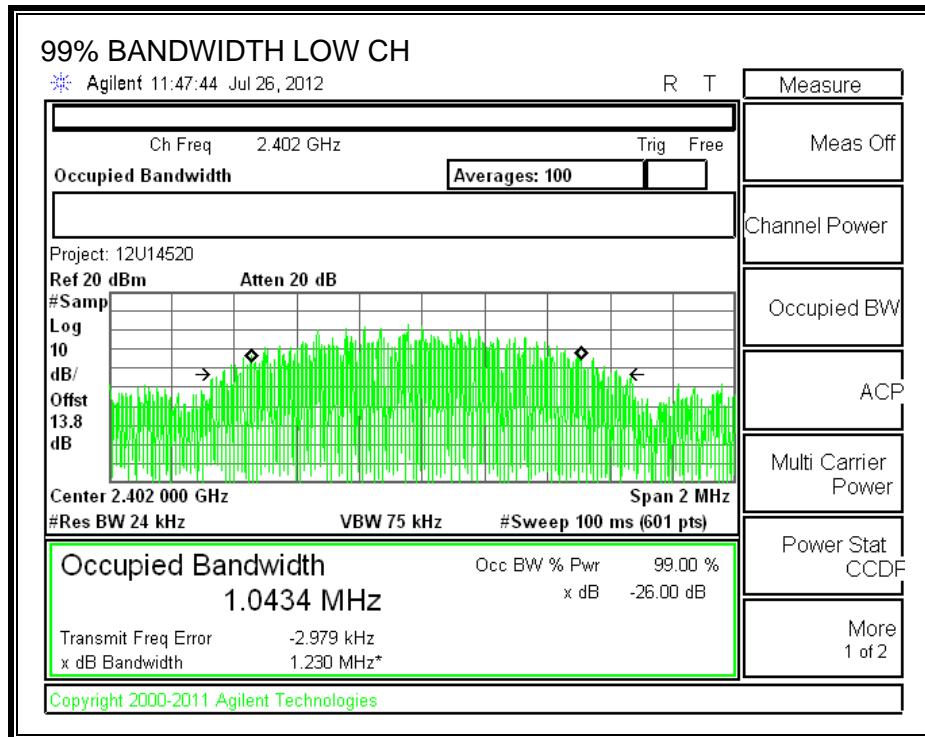
TEST PROCEDURE

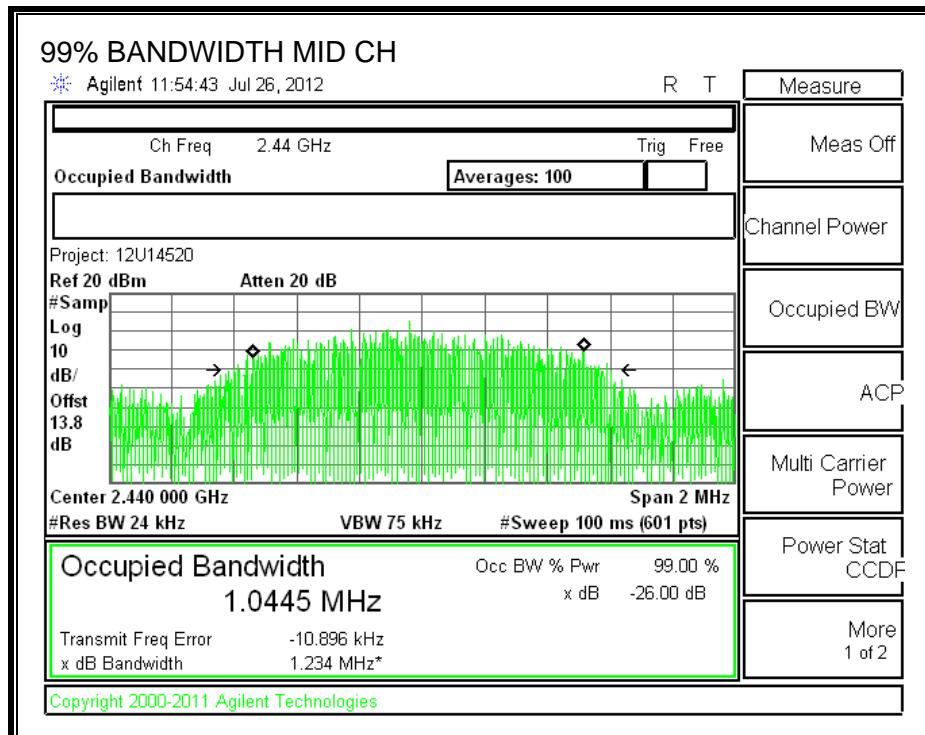
The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth and to 1% of the span. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

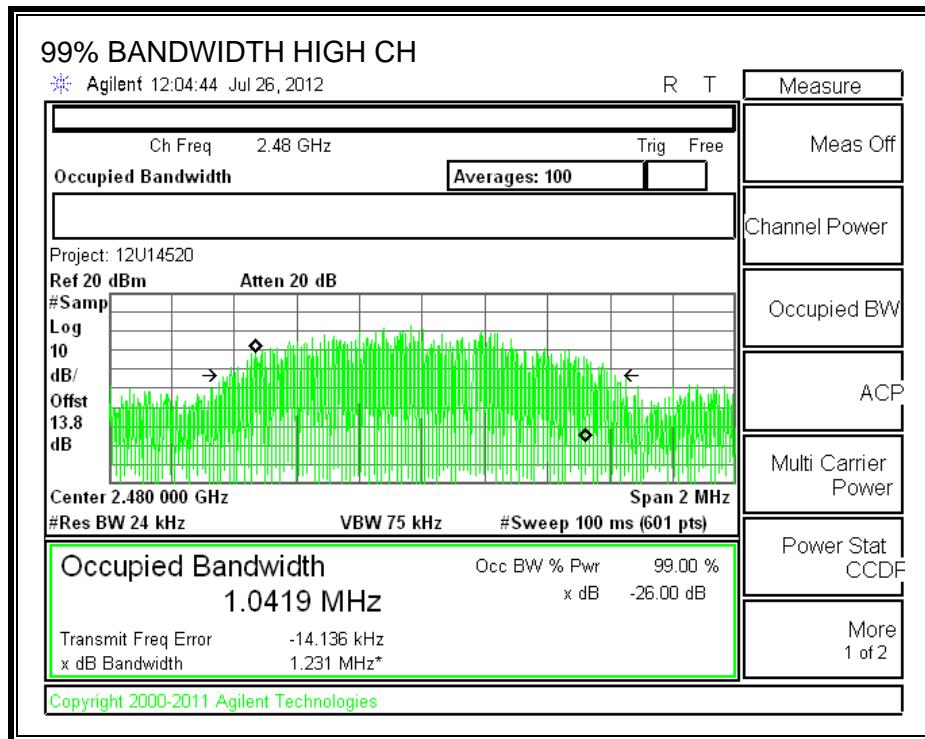
RESULTS

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0434
Middle	2440	1.0445
High	2480	1.0419

99% BANDWIDTH







7.3. OUTPUT POWER

LIMITS

FCC §15.247 (b)

IC RSS-210 A8.4

The maximum antenna gain is less than or equal to 6 dBi, therefore the limit is 30 dBm.

TEST PROCEDURE

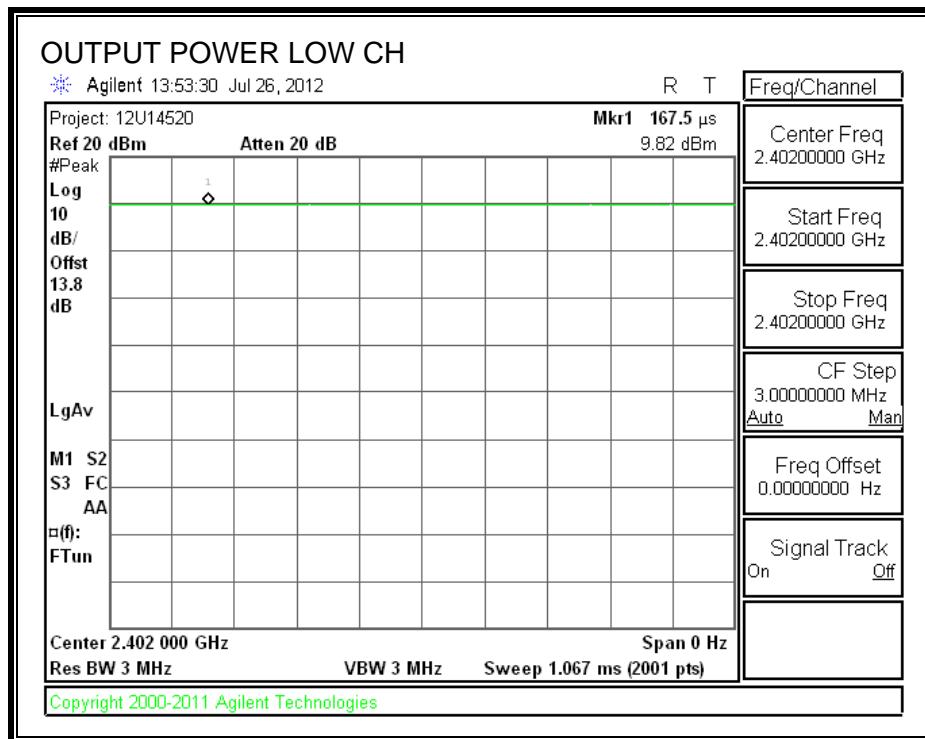
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

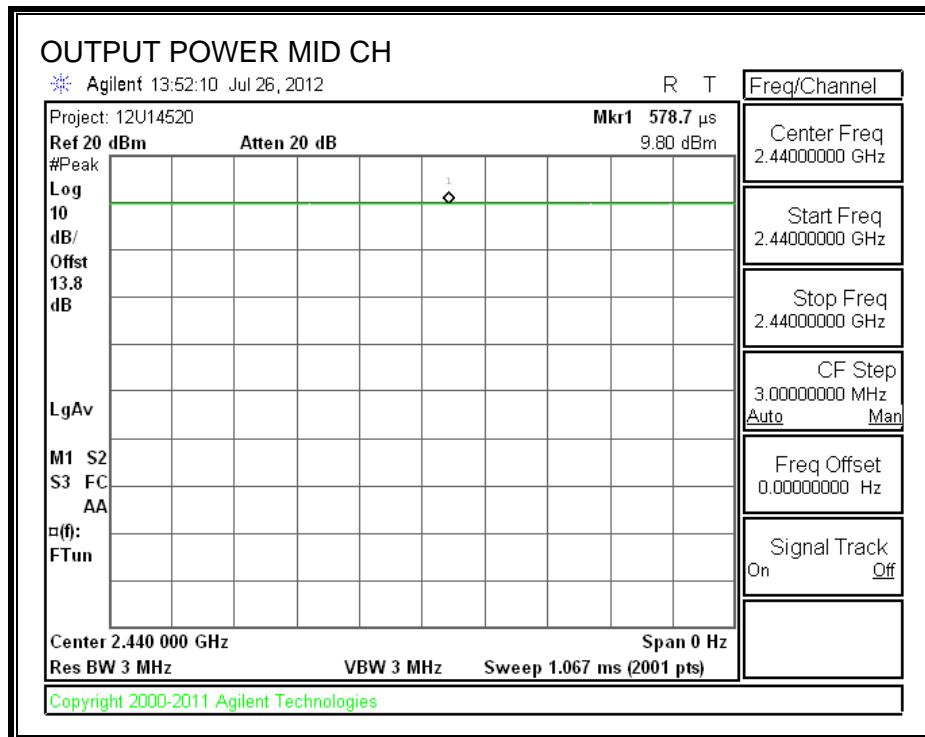
Peak power is measured using wide bandwidth Peak Power Meter.

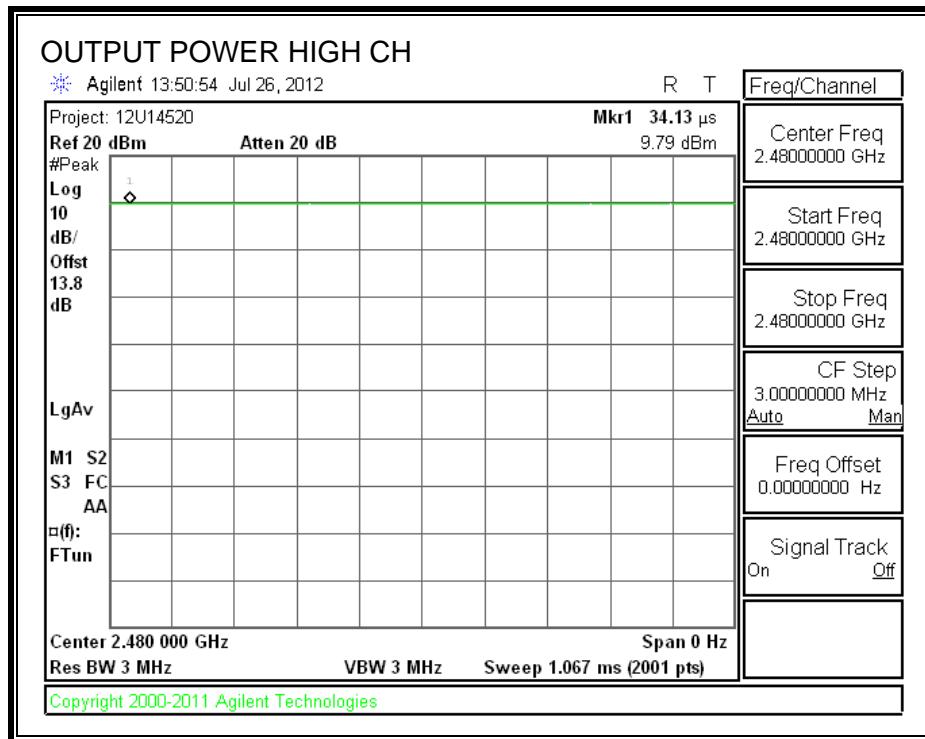
RESULTS

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	9.820	30	-20.180
Middle	2440	9.800	30	-20.200
High	2480	9.790	30	-20.210

OUTPUT POWER







7.4. AVERAGE POWER

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	9.40
Middle	2440	9.50
High	2480	9.55

7.5. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (e)

IC RSS-210 A8.2 (b)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

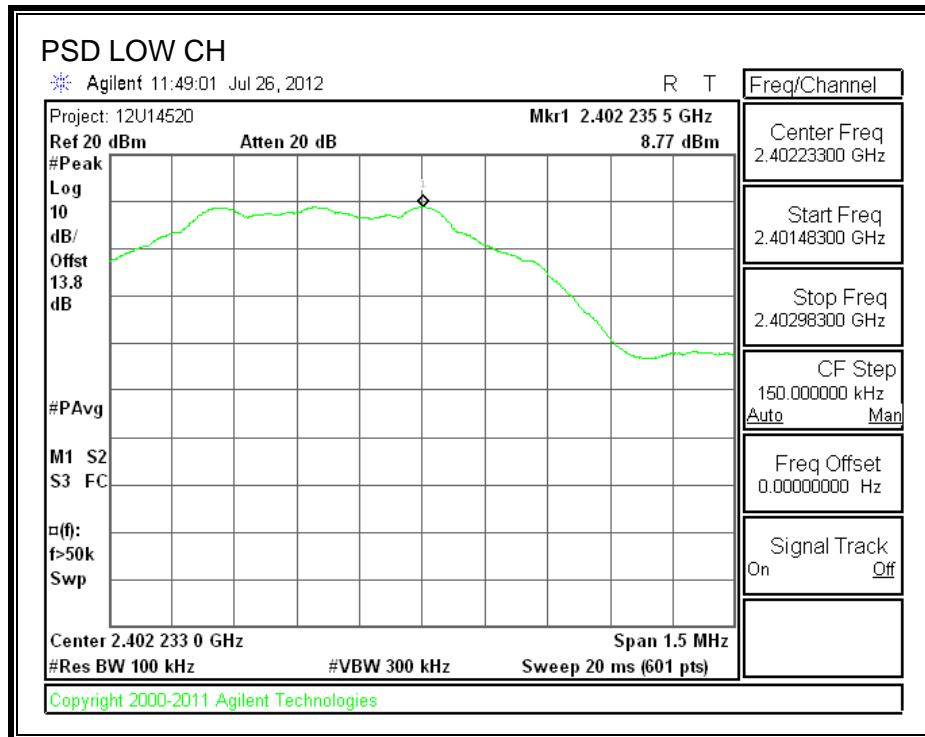
TEST PROCEDURE

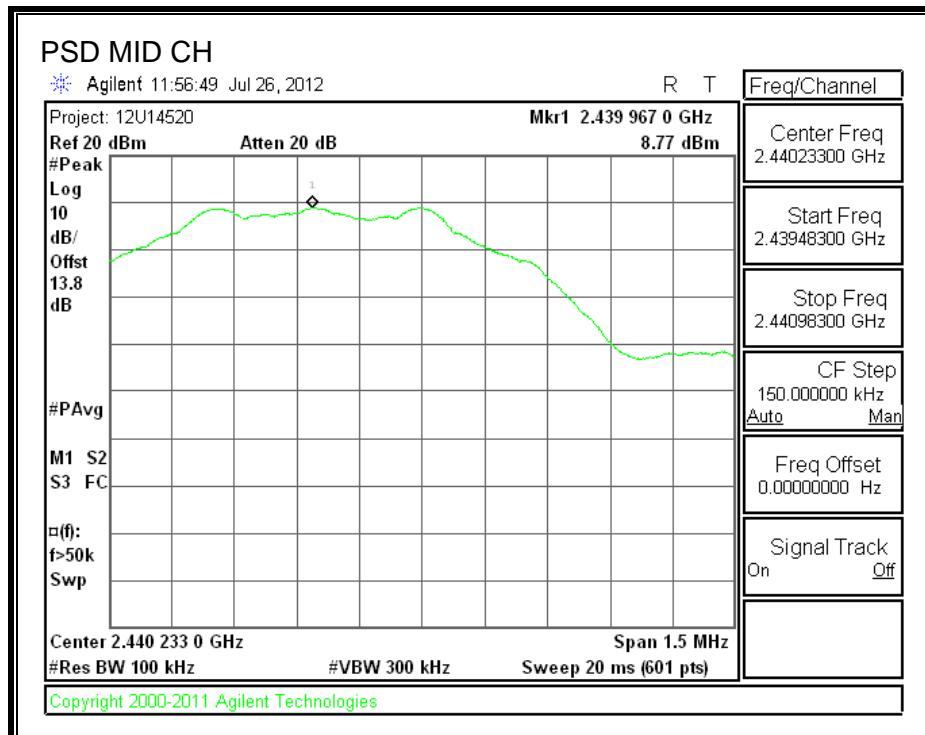
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

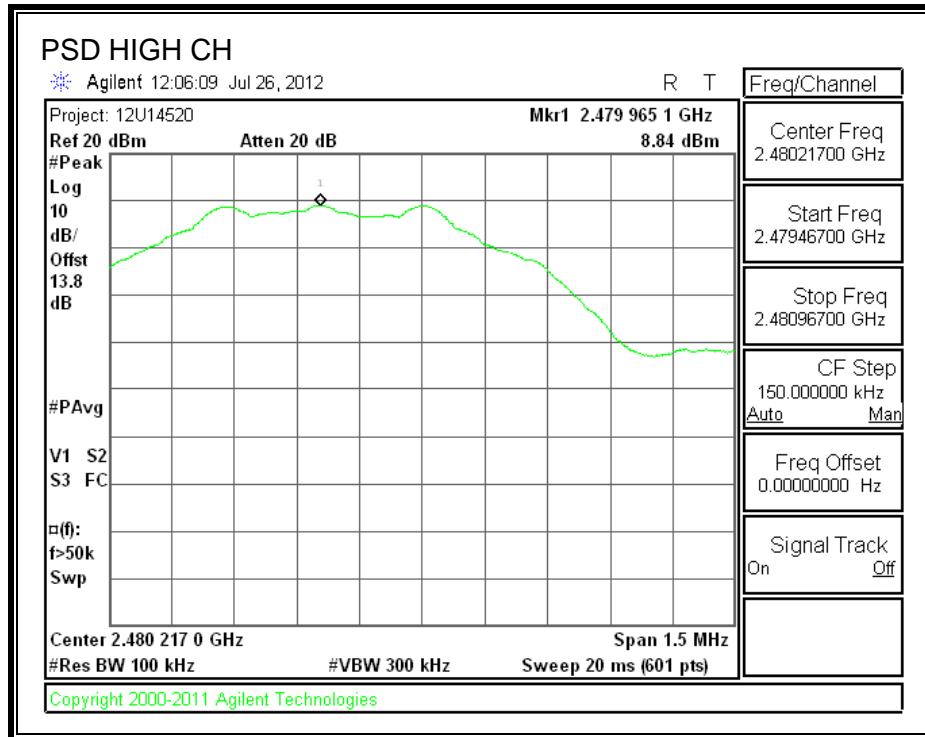
RESULTS

Channel	Frequency (MHz)	PSD (dBm)	$10\log(3\text{kHz}/100\text{kHz})$ (dBm)	Limit (dBm)	Margin (dB)
Low	2402	8.77	-15.2	8	-14.43
Middle	2440	8.77	-15.2	8	-14.43
High	2480	8.84	-15.2	8	-14.36

POWER SPECTRAL DENSITY







7.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-210 A8.5

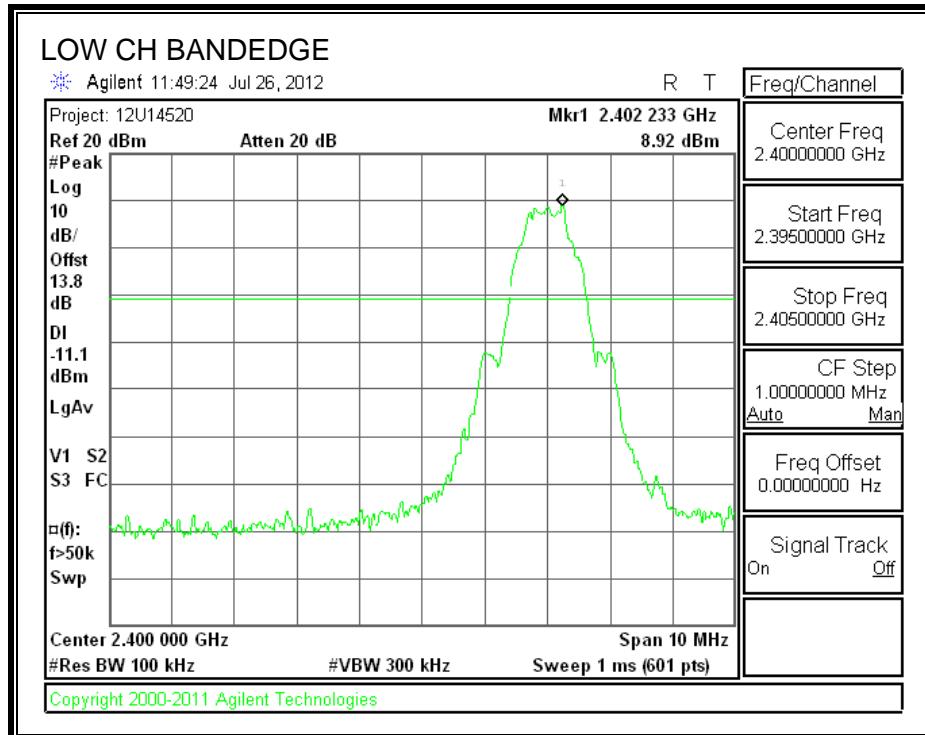
Output power was measured based on the use of a peak measurement, therefore the required attenuation is 20 dB.

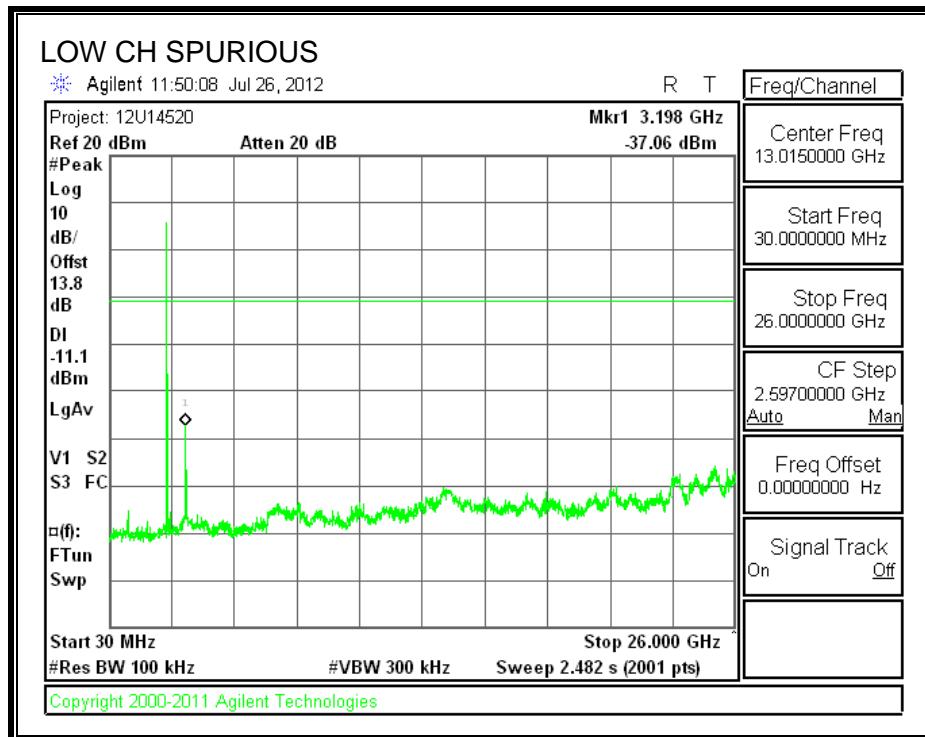
TEST PROCEDURE

KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

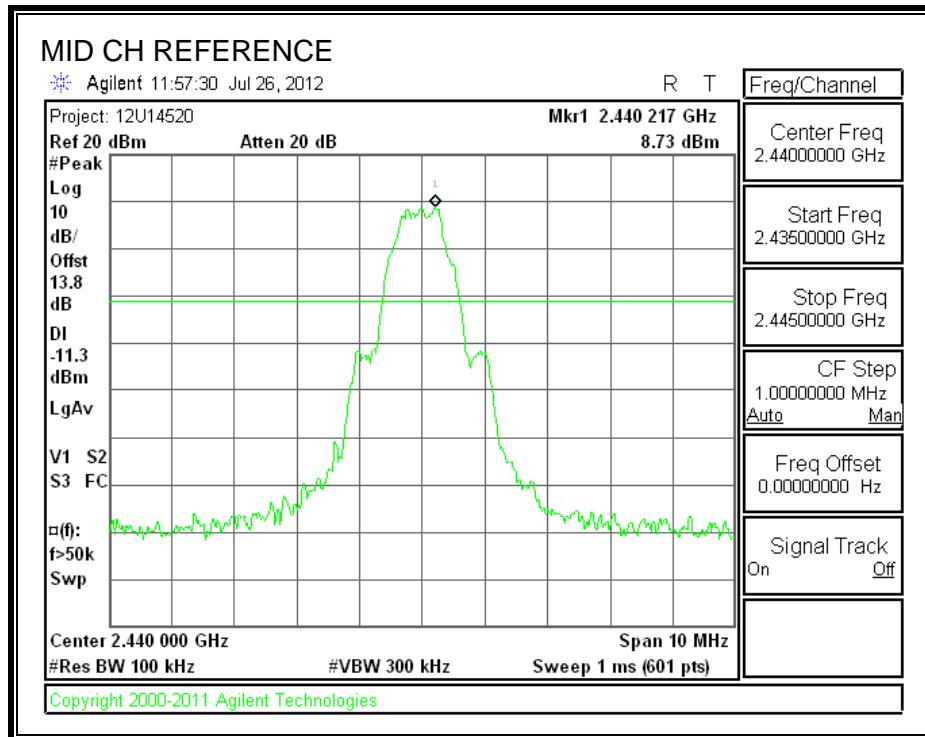
RESULTS

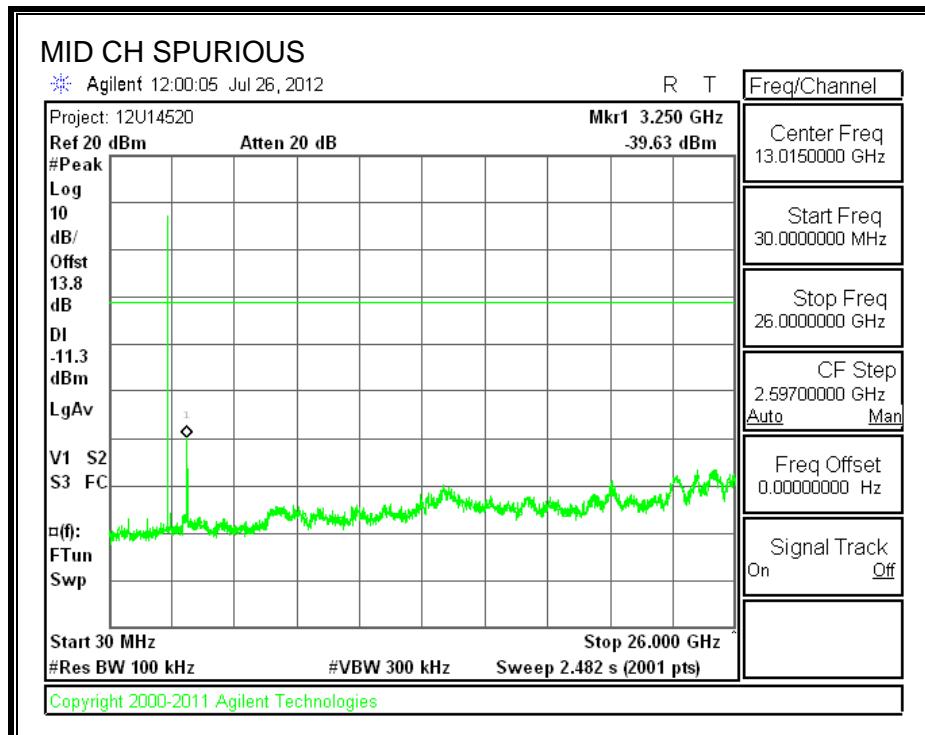
SPURIOUS EMISSIONS, LOW CHANNEL



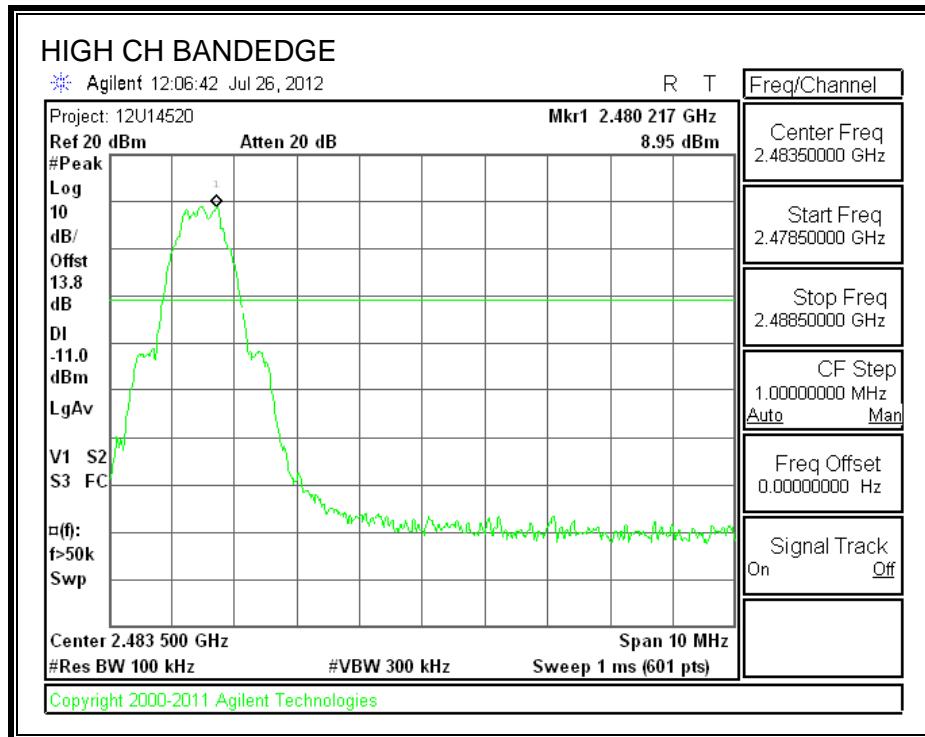


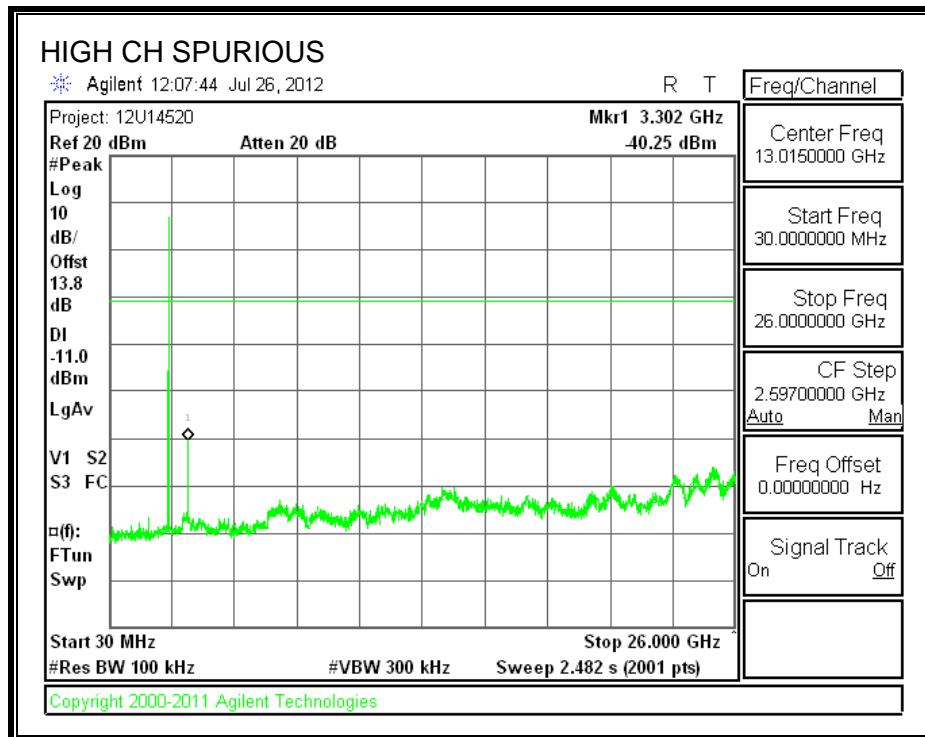
SPURIOUS EMISSIONS, MID CHANNEL





SPURIOUS EMISSIONS, HIGH CHANNEL





8. RADIATED TEST RESULTS

8.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209

IC RSS-210 Clause 2.6 (Transmitter)

IC RSS-GEN Clause 6 (Receiver)

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.4. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in the 2.4 GHz band.

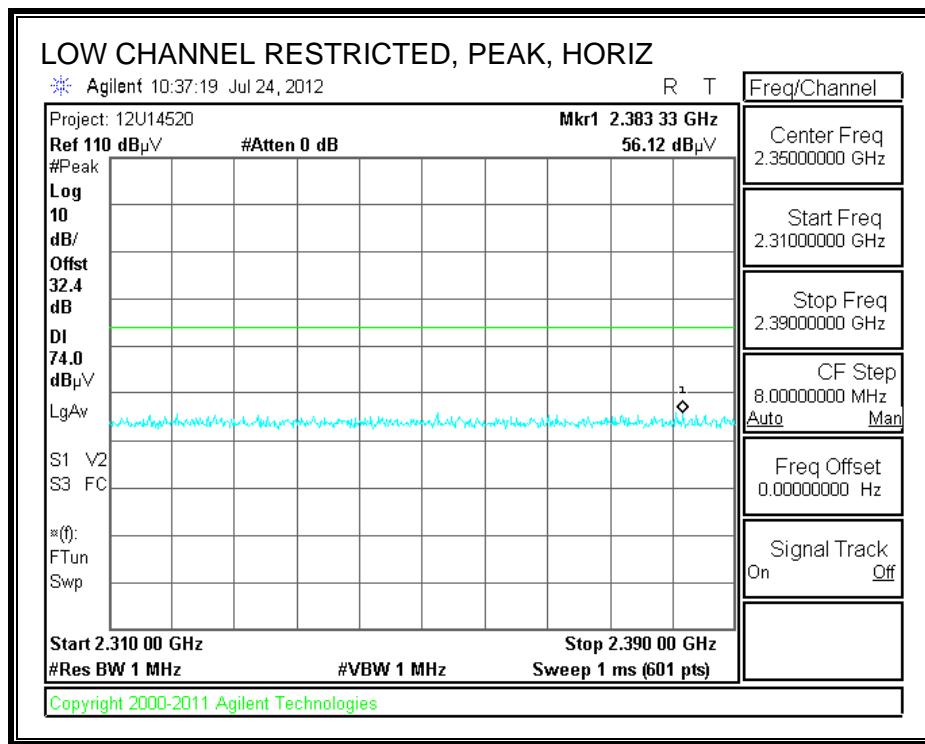
The spectrum from 30 MHz to 40 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band.

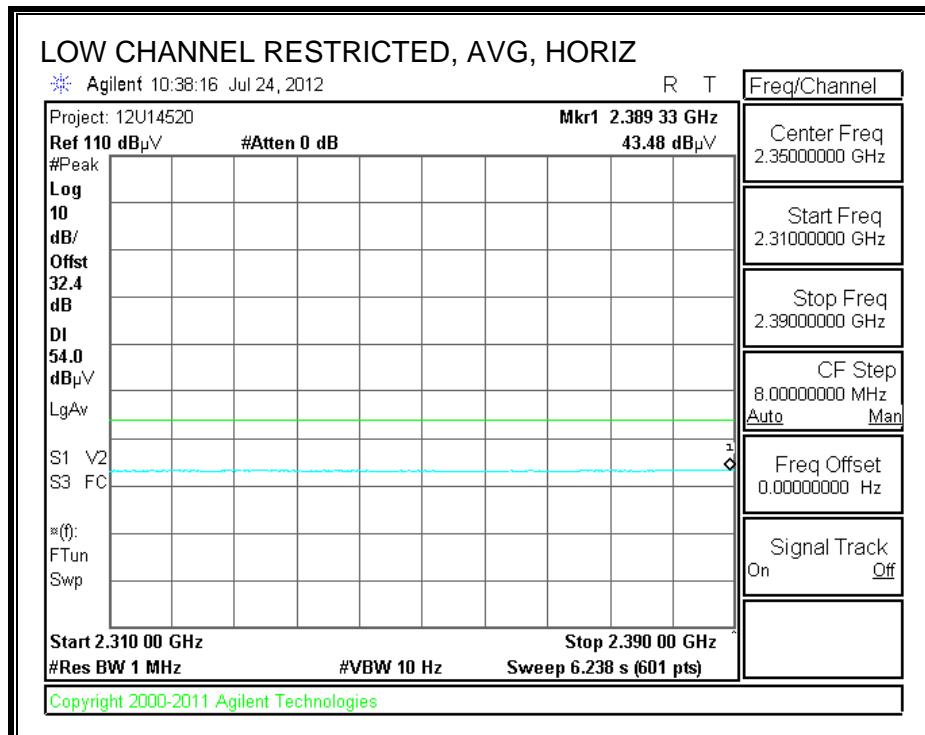
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

8.2. TRANSMITTER ABOVE 1 GHz

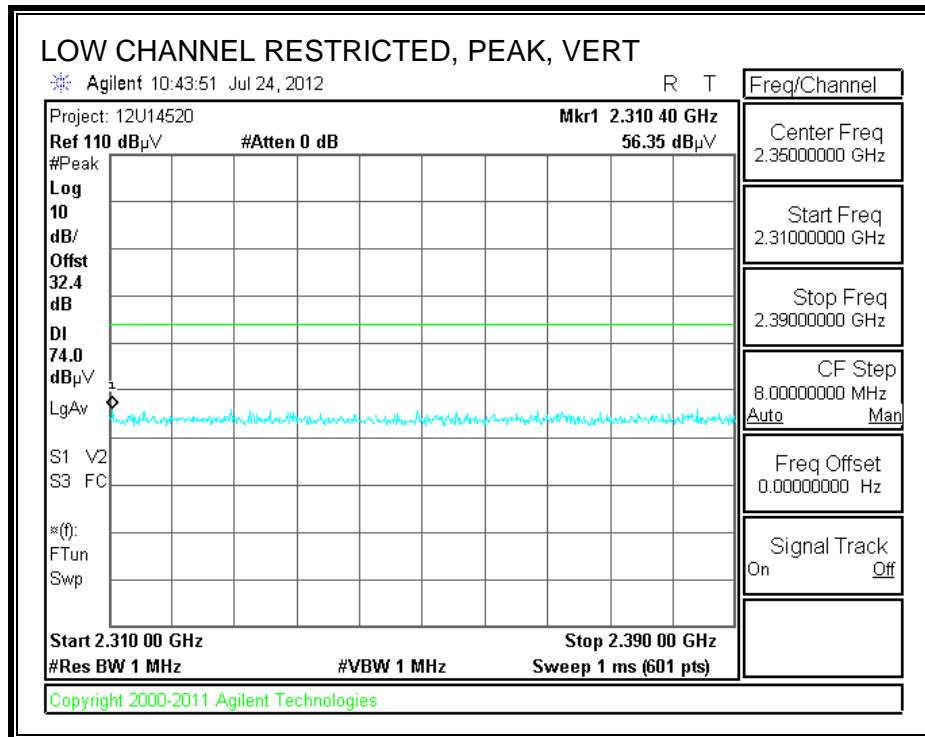
8.3. TX ABOVE 1 GHz FOR BLUETOOTH LOW ENERGY MODE IN THE 2.4 GHz BAND

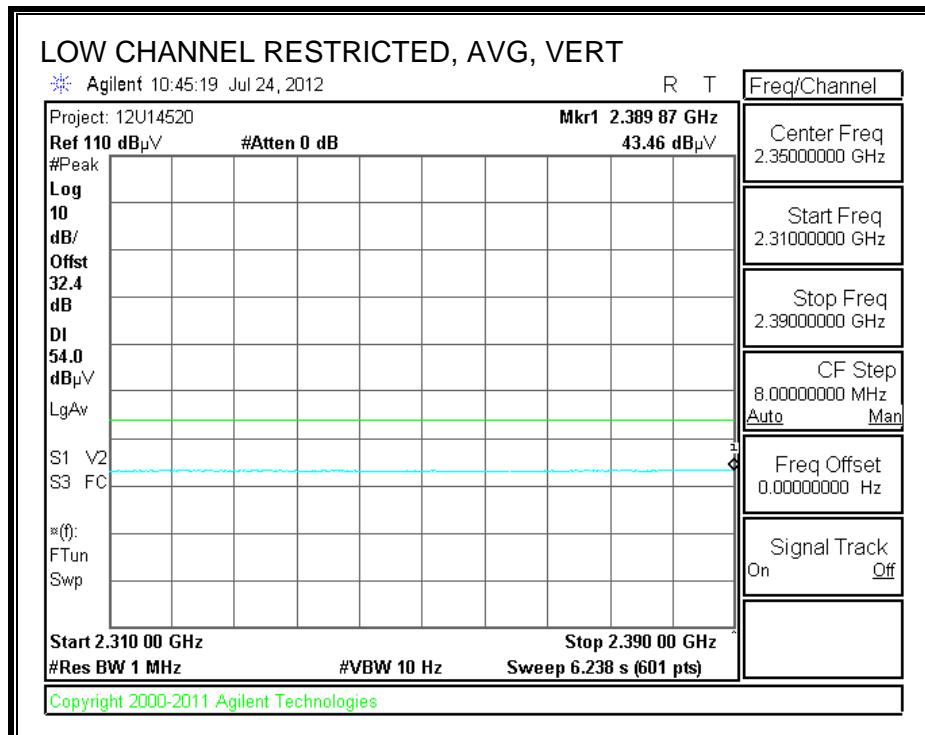
RESTRICTED BANDEDGE (LOW CHANNEL, HORIZONTAL)



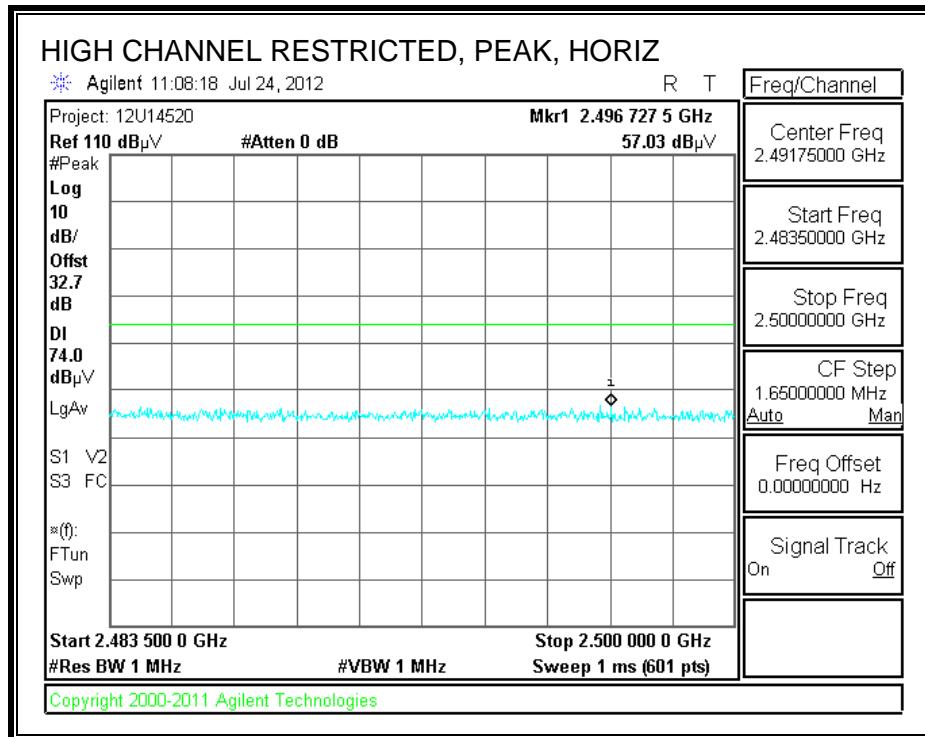


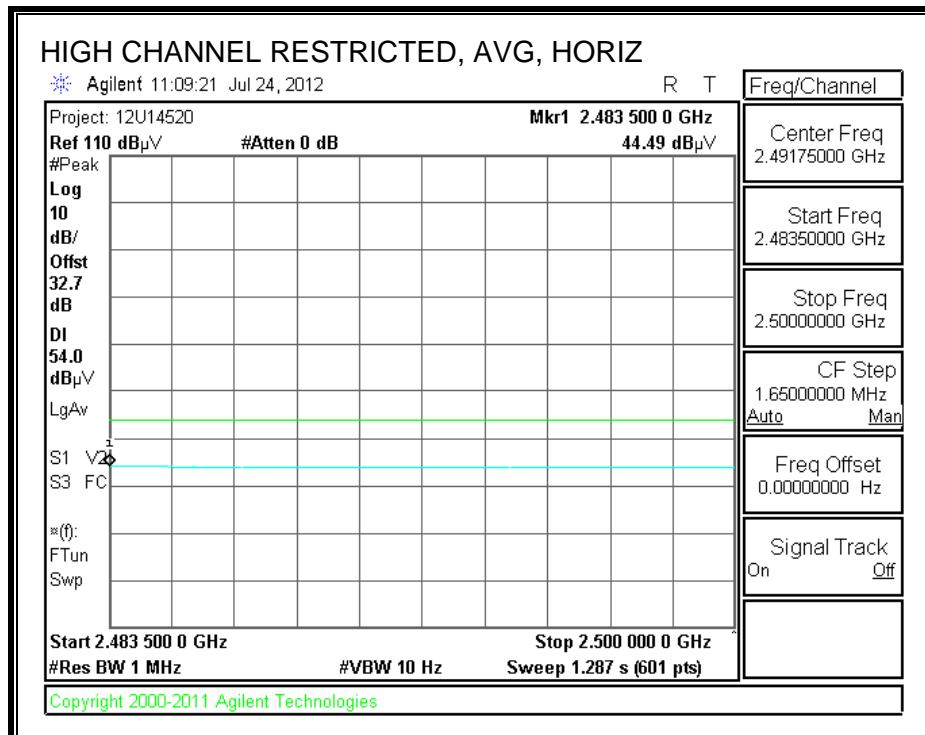
RESTRICTED BANDEDGE (LOW CHANNEL, VERTICAL)



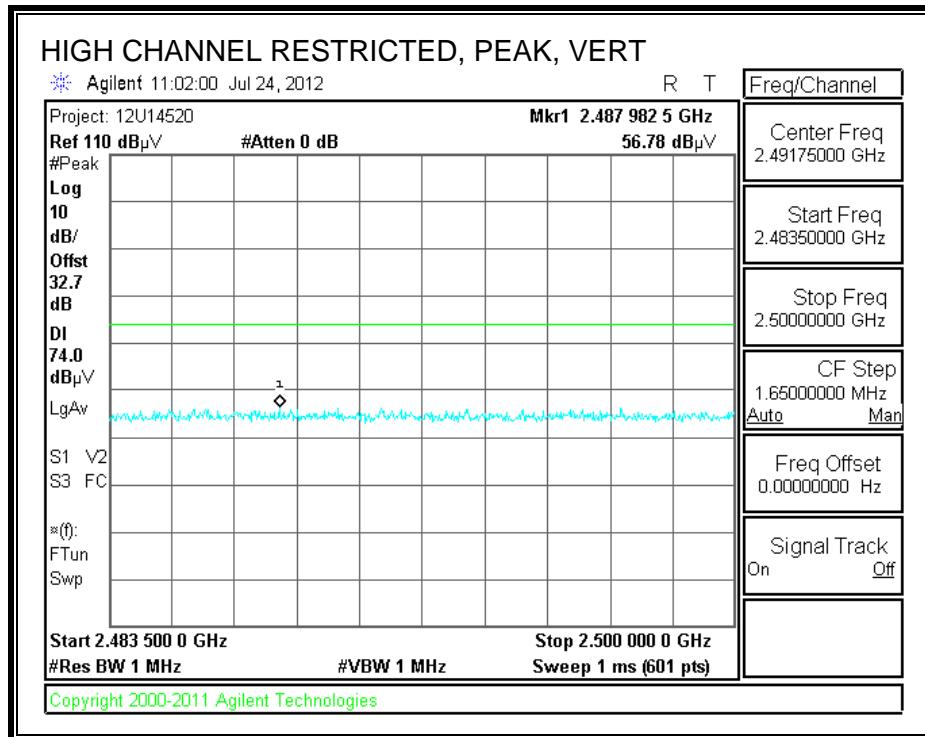


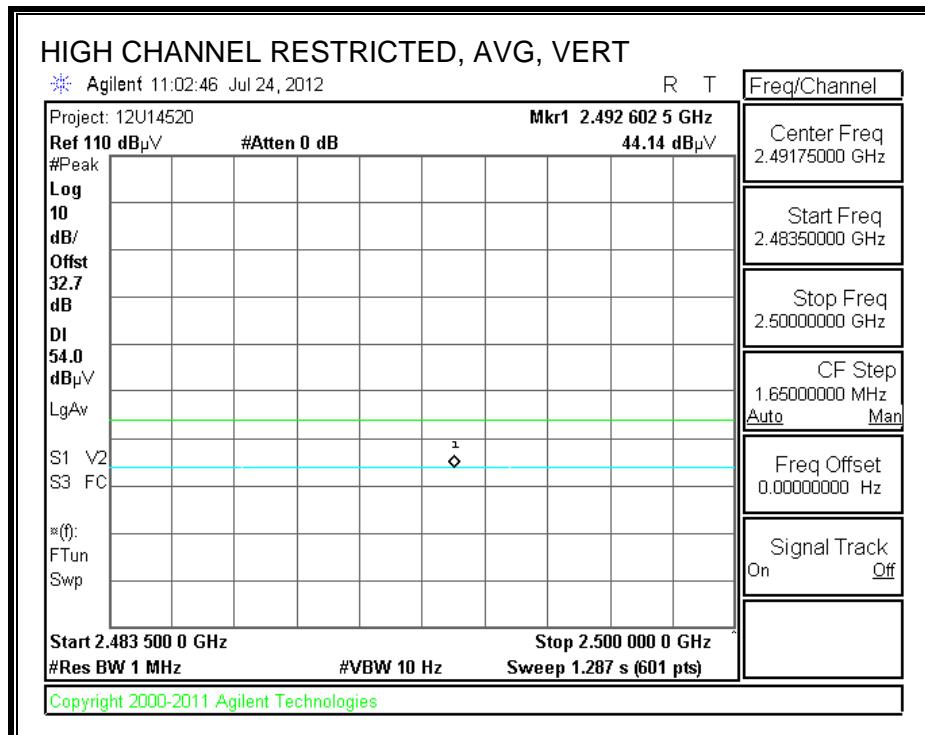
RESTRICTED BANDEDGE (HIGH CHANNEL, HORIZONTAL)





RESTRICTED BANDEDGE (HIGH CHANNEL, VERTICAL)





HARMONICS AND SPURIOUS EMISSIONS

High Frequency Measurement
Compliance Certification Services, Fremont 5m Chamber

Test Engr: Tom Chen
Date: 07/24/12
Project #: 12U14520
Company: Apple Inc.
Test Target: FCC Class B
Mode Oper: Bluetooth LE, TX mode

f	Measurement Frequency	Amp	Preamp Gain	Average Field Strength Limit
Dist	Distance to Antenna	D Corr	Distance Correct to 3 meters	Peak Field Strength Limit
Read	Analyzer Reading	Avg	Average Field Strength @ 3 m	Margin vs. Average Limit
AF	Antenna Factor	Peak	Calculated Peak Field Strength	Margin vs. Peak Limit
CL	Cable Loss	HPF	High Pass Filter	

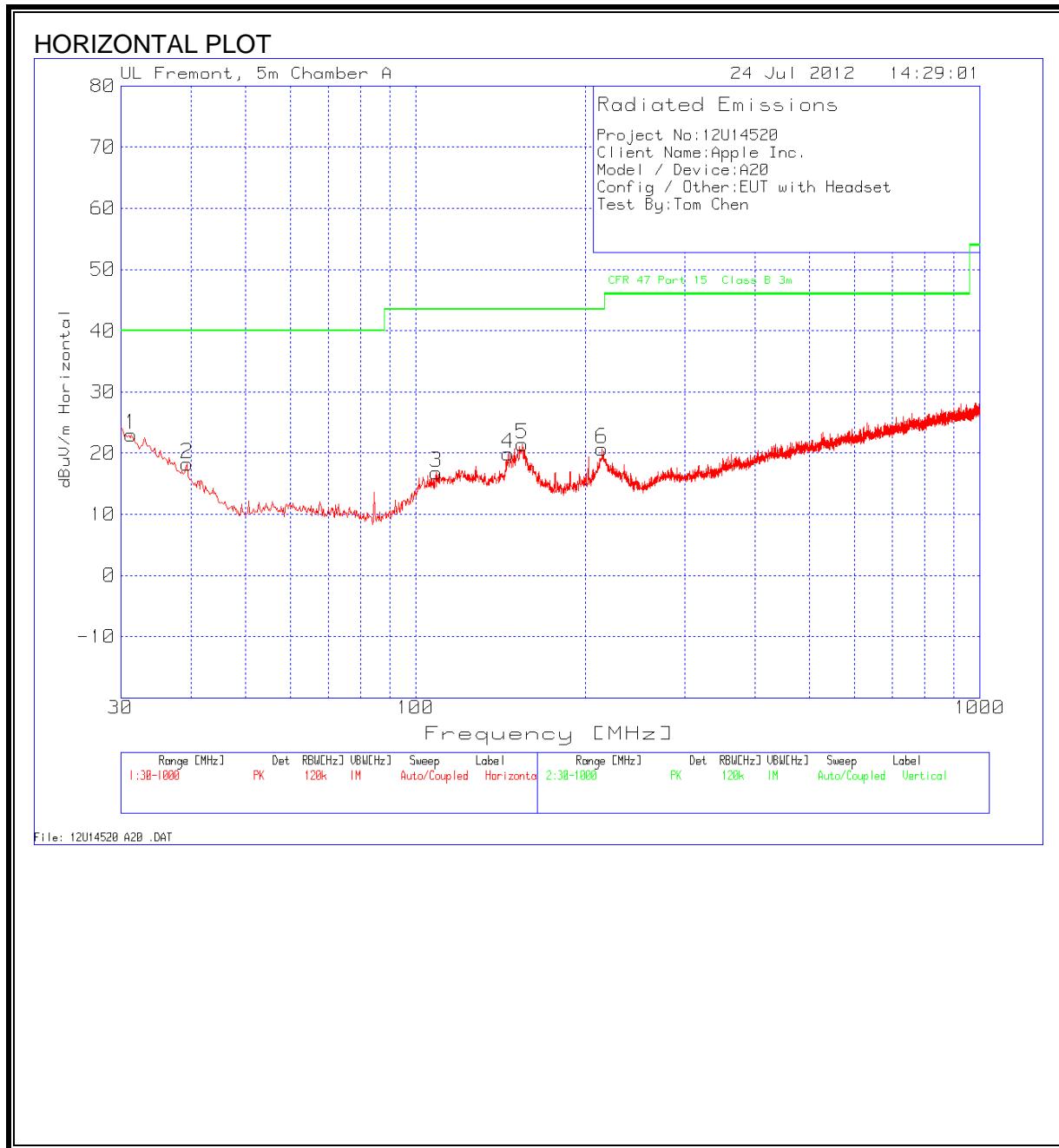
f GHz	Dist (m)	Read dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Fltr dB	Corr. dBuV/m	Limit dBuV/m	Margin dB	Ant. Pol. V/H	Det. P/A/QP	Notes
2402MHz BTLE													
4.804	3.0	41.5	33.4	6.3	-35.5	0.0	0.0	45.7	74.0	-28.3	V	P	
4.804	3.0	31.1	33.4	6.3	-35.5	0.0	0.0	35.2	54.0	-18.8	V	A	
4.804	3.0	42.7	33.4	6.3	-35.5	0.0	0.0	46.8	74.0	-27.2	H	P	
4.804	3.0	31.2	33.4	6.3	-35.5	0.0	0.0	35.3	54.0	-18.7	H	A	
2440MHz BTLE													
4.880	3.0	40.9	33.5	6.3	-35.5	0.0	0.0	45.2	74.0	-28.8	H	P	
4.880	3.0	30.0	33.5	6.3	-35.5	0.0	0.0	34.4	54.0	-19.6	H	A	
4.880	3.0	46.9	33.5	6.3	-35.5	0.0	0.0	51.2	74.0	-22.8	V	P	
4.880	3.0	35.9	33.5	6.3	-35.5	0.0	0.0	40.2	54.0	-13.8	V	A	
2480MHz BTLE													
4.960	3.0	43.5	33.6	6.4	-35.5	0.0	0.0	48.0	74.0	-26.0	H	P	
4.960	3.0	33.0	33.6	6.4	-35.5	0.0	0.0	37.5	54.0	-16.5	H	A	
4.960	3.0	43.0	33.6	6.4	-35.5	0.0	0.0	47.4	74.0	-26.6	V	P	
4.960	3.0	32.4	33.6	6.4	-35.5	0.0	0.0	36.9	54.0	-17.1	V	A	

Rev. 4.1.2.7

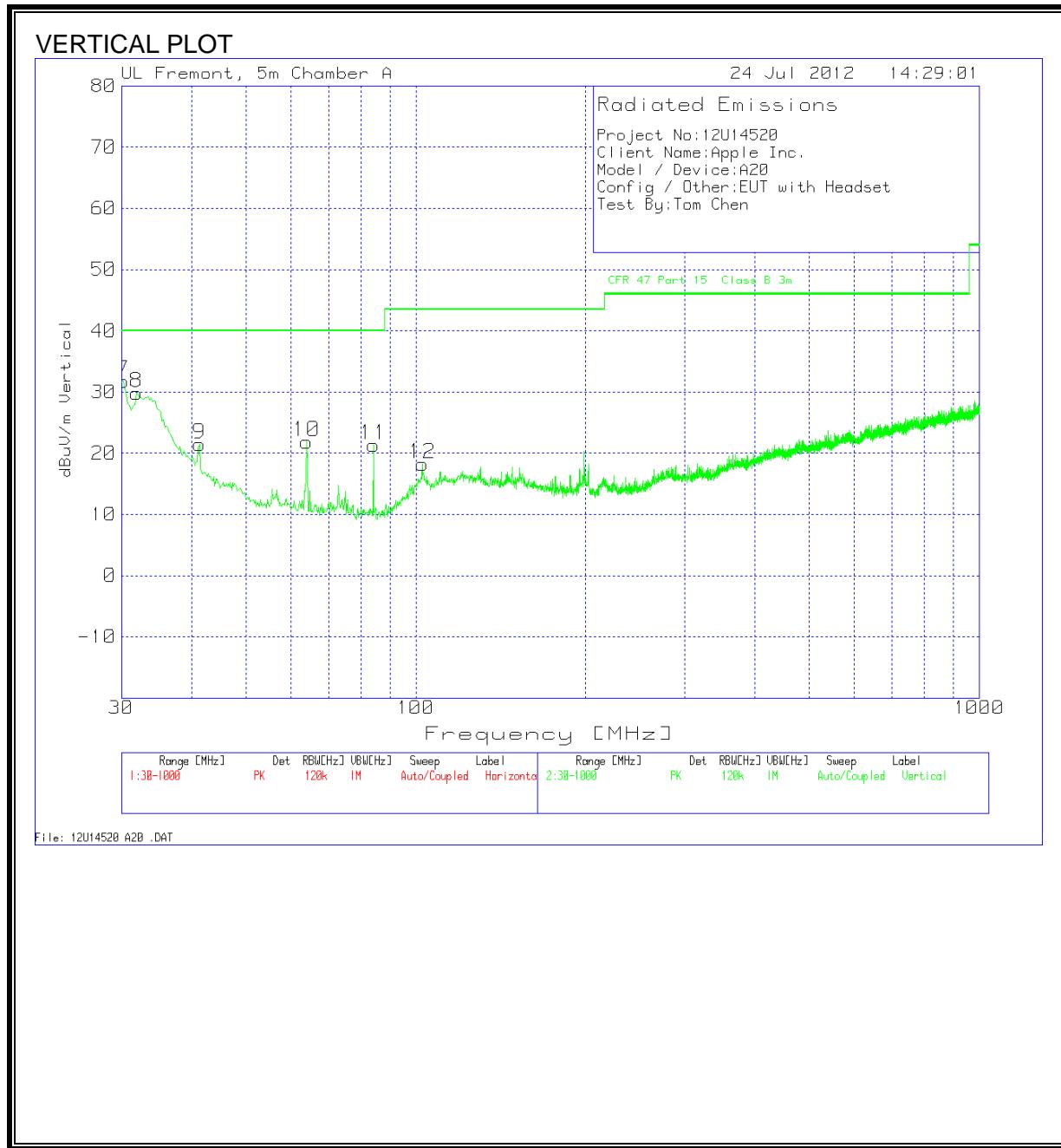
Note: No other emissions were detected above the system noise floor.

8.4. WORST-CASE BELOW 1 GHz

SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, HORIZONTAL)



SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, VERTICAL)



HORIZONTAL AND VERTICAL DATA

Project No:12U14520

Client Name:Apple Inc.

Model / Device: A1446

Config / Other:EUT with Headset

Test By:Tom Chen

Horizontal 30 - 1000MHz

Test Frequency	Meter Reading	Detector	25MHz-1GHz ChmbrA Amplified.TX (dB)	T243 Sunol Bilog.TXT (dB)	CFR 47 Part 15 Class B 3m	Margin	Polarity
31.3569	30.29	PK	-27.5	20.2	22.99	40	-17.01 Horz
39.3046	31.17	PK	-27.4	14.5	18.27	40	-21.73 Horz
108.701	31.22	PK	-26.8	12.4	16.82	43.5	-26.68 Horz
145.9193	34.08	PK	-26.6	12.4	19.88	43.5	-23.62 Horz
154.6423	35.96	PK	-26.5	12	21.46	43.5	-22.04 Horz
213.9588	36.34	PK	-26.1	10.5	20.74	43.5	-22.76 Horz

Vertical 30 - 1000MHz

Test Frequency	Meter Reading	Detector	25MHz-1GHz ChmbrA Amplified.TX (dB)	T243 Sunol Bilog.TXT (dB)	CFR 47 Part 15 Class B 3m	Margin	Polarity
30.1938	38.14	PK	-27.5	21.1	31.74	40	-8.26 Vert
31.9384	37.56	PK	-27.5	19.8	29.86	40	-10.14 Vert
41.243	35.71	PK	-27.4	13.1	21.41	40	-18.59 Vert
63.9229	41.45	PK	-27.2	7.6	21.85	40	-18.15 Vert
84.0827	41.03	PK	-27.1	7.4	21.33	40	-18.67 Vert
102.6918	34.2	PK	-26.9	10.9	18.2	43.5	-25.3 Vert

9. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

RSS-Gen 7.2.2

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 [*]	56 to 46 [*]
0.5-5	56	46
5-30	60	50

^{*} Decreases with the logarithm of the frequency.

TEST PROCEDURE

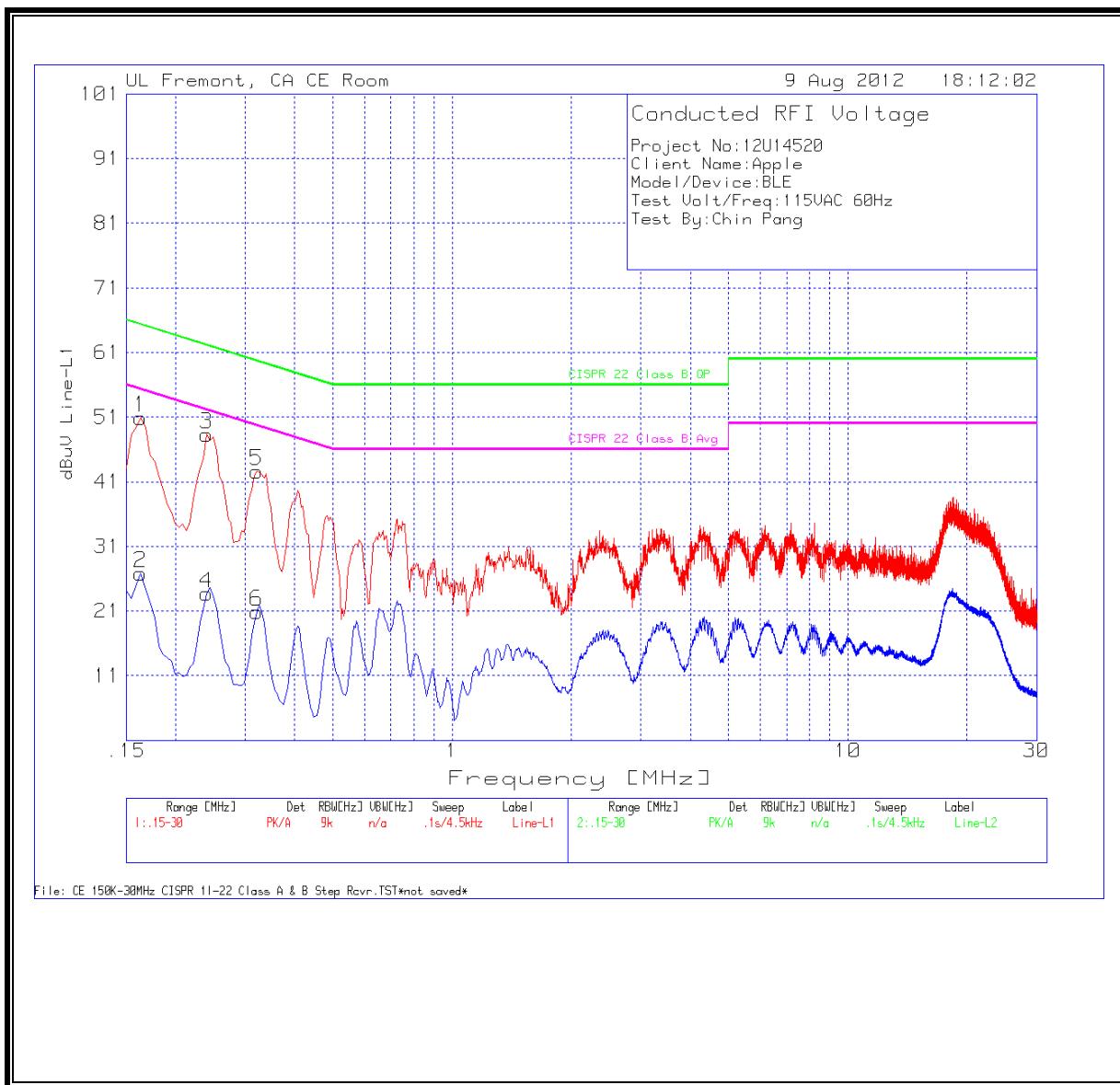
ANSI C63.4

RESULTS

6 WORST EMISSIONS

Project No:12U14520									
Client Name:Apple									
Model/Device:BLE									
Test Volt/Freq:115VAC 60Hz									
Test By:Chin Pang									
Line-L1 .15 - 30MHz									
Frequency	Reading	Detector	T24 IL L1.	LC Cables	dBuV	CISPR 22B QP	Margin	CISPR 22B Avg	Margin
0.1635	50.76	PK	0.1	0	50.86	65.3	-14.44	-	-
0.1635	26.73	Av	0.1	0	26.83	-	-	55.3	-28.47
0.24	48.24	PK	0.1	0	48.34	62.1	-13.76	-	-
0.24	23.57	Av	0.1	0	23.67	-	-	52.1	-28.43
0.321	42.47	PK	0.1	0	42.57	59.7	-17.13	-	-
0.321	20.8	Av	0.1	0	20.9	-	-	49.7	-28.8
Line-L2 .15 - 30MHz									
Frequency	Reading	Detector	T24 IL L1.	LC Cables	dBuV	CISPR 22B QP	Margin	CISPR 22B Avg	Margin
0.168	50.03	PK	0.1	0	50.13	65.1	-14.97	-	-
0.168	23.21	Av	0.1	0	23.31	-	-	55.1	-31.79
0.249	47.15	PK	0.1	0	47.25	61.8	-14.55	-	-
0.249	22.31	Av	0.1	0	22.41	-	-	51.8	-29.39
0.3255	42.25	PK	0.1	0	42.35	59.6	-17.25	-	-
0.3255	20.64	Av	0.1	0	20.74	-	-	49.6	-28.86
Project No:12U14520									
Client Name:Apple									
Model/Device:BLE									
Test Volt/Freq:115VAC 60Hz									
Test By:Chin Pang									

LINE 1 RESULTS



LINE 2 RESULTS

