

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

**CERTIFICATION TEST REPORT** 

FOR

## QUAD-BAND RADIO WITH WLAN AND BT RADIO

MODEL NUMBER: A1456, A1532

FCC ID: BCG-E2644A IC ID: 579C-E2644A, 579C-E2644B

REPORT NUMBER: 13U14987-9

ISSUE DATE: JULY 22, 2013

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

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

NVLAP LAB CODE 200065-0

## **Revision History**

Rev.	Date	Revisions	Revised By
	07/22/13	Initial Issue	T. Chan

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# **1. ATTESTATION OF TEST RESULTS**

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

**EUT DESCRIPTION:** QUAD-BAND RADIO WITH WLAN AND BT RADIO

MODEL: A1456, A1532

SERIAL NUMBER: C39HV0HPF5P5 (Conducted), C39KP005FL57 (Radiated)

**DATE TESTED:** MAY 02-28, 2013

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 Verification Services Inc. 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 Verification Services 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 Verification Services and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services 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 Verification Services Inc. By:

Tested By:

Thu Chan WiSE Operations Manager UL Verification Services Inc.

Mona Hua WiSE Technician UL Verification Services Inc

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# 2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2009, 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 <u>http://www.ccsemc.com</u>.

# 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:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB) 36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

# 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%.

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# 5. EQUIPMENT UNDER TEST

# 5.1. DESCRIPTION OF EUT

Model A1456/A1532 is a mobile phone with multimedia functions (music, application support, and video), cellular GSM/GPRS/EGPRS/WCDMA/HSPA+/DC-HSDPA/CDMA/EVDO/LTE radio, IEEE 802.11a/b/g/n, Bluetooth and GPS radio. The rechargeable battery is not user accessible.

# 5.2. MAXIMUM OUTPUT POWER

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

Frequency Range	Mode	Output Power	Output Power
(MHz)		(dBm)	(mW)
2402 - 2480	BLE	11.48	14.06

# 5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a PiFA antenna, with a maximum gain of 0.21dBi.

## 5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was Broadcom Bluetool Version 1.4.8.7

## 5.5. WORST-CASE CONFIGURATION AND MODE

For Radiated Emissions below 1 GHz and Power line Conducted Emissions, the channel with the highest conducted output power was selected as worst-case scenario.

The worst-position was the EUT with highest emissions. To determine the worst-case, the EUT is a portable device that has three orientations; therefore X, Y and Z orientations have been investigated with and without AC adapter, and the worst case was found to be at Z position without AC Adapter.

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# 5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List					
Description	Manufacturer	Model	Serial Number		
AC adapter	Apple	A1385	NA		

### I/O CABLES (Conducted Setup)

	I/O Cable List					
Cable Port # of identical Connector Cable Type Cable Length Remarks		Remarks				
No		ports	Туре		(m)	
1	Antenna	1	SMA	Shielded	0.1m	To Spectrum Analyzer

### I/O CABLES (Radiated Setup)

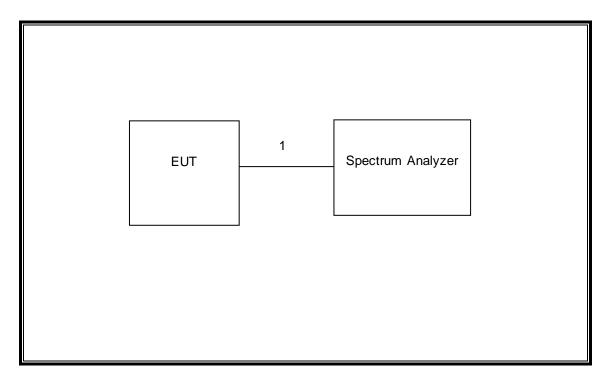
	I/O Cable List					
Cable	Port	# of identical	Connector	Cable Type	Cable Length	Remarks
No		ports	Туре		(m)	
1	Jack	1	Earphone	Unshielded	0.5m	N/A

### TEST SETUP

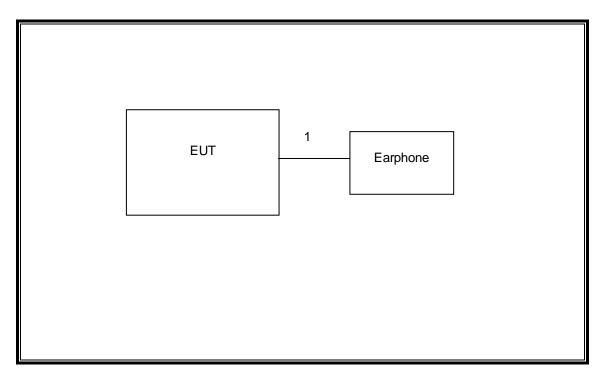
The EUT is a stand-alone device.

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### SETUP DIAGRAM FOR TESTS (CONDUCTED)



### SETUP DIAGRAM FOR TESTS (RADIATED)



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# 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	
Spectrum Analyzer, 44 GHz	Agilent / HP	N9030A	None	02/22/14	
Antenna, Horn, 18 GHz	EMCO	3117	None	02/19/14	
Antenna, Horn, 26.5 GHz	ARA	MWH-1826/B	C00589	04/28/14	
Antenna, Bilog, 2 GHz	Sunol Sciences	JB1	None	03/07/14	
Preamplifier, 1300 MHz	Sonoma	310	None	11/06/13	
Preamplifier, 26.5 GHz	Agilent / HP	8449B	None	03/18/14	
EMI Test Receiver, 9 kHz-7 GHz	R & S	ESCI 7	1000741	07/06/13	
LISN, 30 MHz	FCC	LISN-50/250-25-2	N02625	04/17/14	
Peak / Average Power Sensor	Agilent / HP	N1911A	None	04/05/14	
Peak Power Meter	Agilent / HP	E9323A	None	04/03/14	
Horn Antenna, 26.5 to 40GHz	ARA	MWH-2640/B	None	05/14/14	
Preamplifier, 40 GHz	Miteq	NSP4000-SP2	C00990	08/02/13	

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# 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

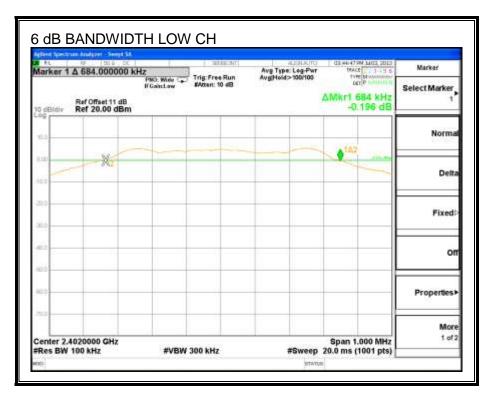
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

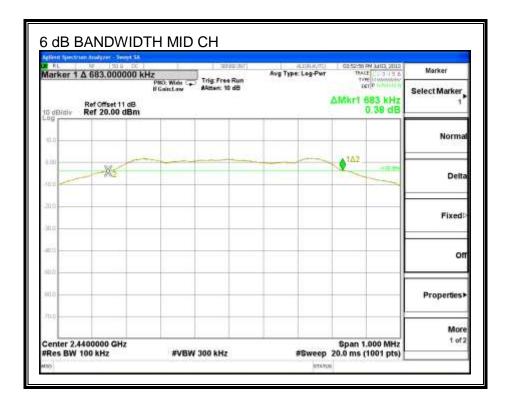
### **RESULTS**

Channel	nannel Frequency 6 dB Bandwidth		Minimum Limit
	(MHz)	(KHz)	(KHz)
Low	2402	684.000	500.0
Middle	2440	683.000	500.0
High	2480	695.000	500.0

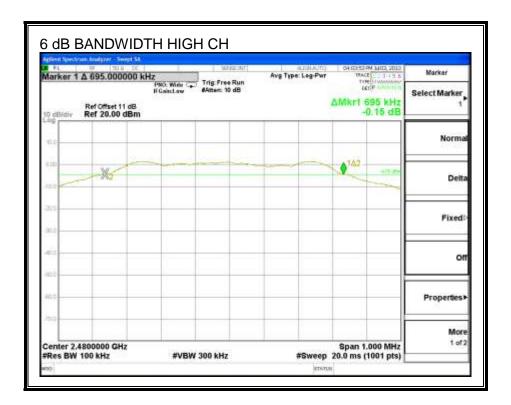
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### 6 dB BANDWIDTH





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# 7.1. 99% **BANDWIDTH**

### <u>LIMIT</u>

None; for reporting purposes only.

### TEST PROCEDURE

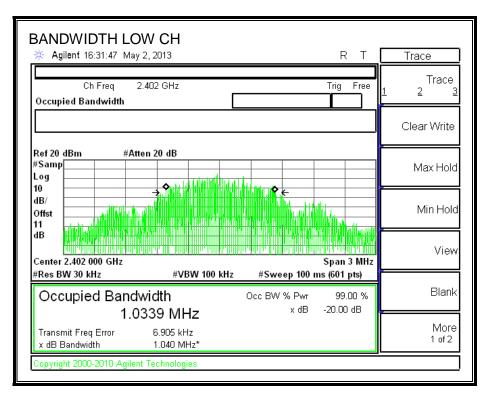
The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth and to 1% of the span. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

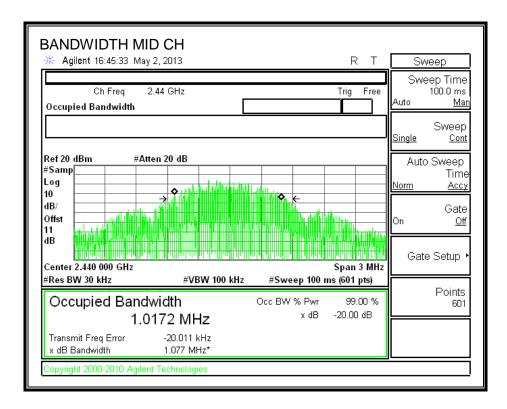
### **RESULTS**

Channel	Frequency	99% Bandwidth
	(MHz)	(MHz)
Low	2402	1.0339
Middle	2440	1.0172
High	2480	1.0560

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#### 99% BANDWIDTH





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🔆 Agilent 16:37:16 May 2, 20	)13		RT	Sw	еер
Ch Freq 2.48 ( Occupied Bandwidth	GHz		Trig Free		ep Tim 100.0 m <u>M</u>
			]	<u>Single</u>	Swee <u>Co</u>
Ref 20 dBm #Atten 20 #Samp Log 10 → dB/		king €		Auto <u>Norm</u>	Sweep Tin <u>Act</u>
Offst 11 dB				On Cata	Gat <u>C</u> Setup
Center 2.480 000 GHz #Res BW 30 kHz	#VBW 100 kHz	#Sweep 100 ı	Span 3 MHz ns (601 pts)		
Occupied Bandwid 1.0560		Occ BW % Pwr x dB	99.00 % -20.00 dB		Point 60
	9.240 kHz 104 MHz*				

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# 7.2. OUTPUT POWER

## <u>LIMIT</u>

§15.247 (b) (1)

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

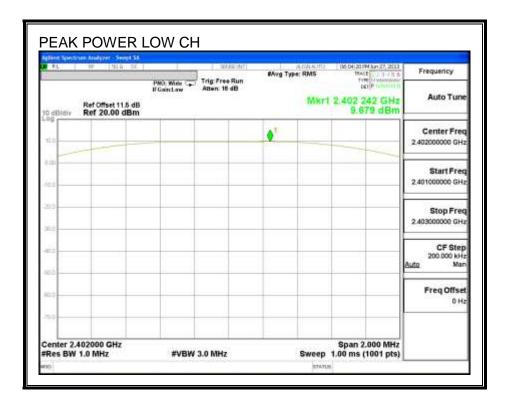
### TEST PROCEDURE

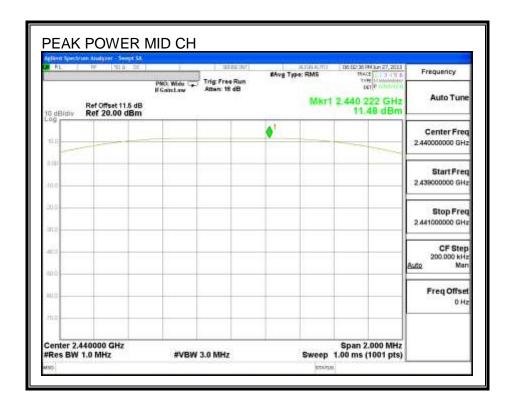
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

### **RESULTS**

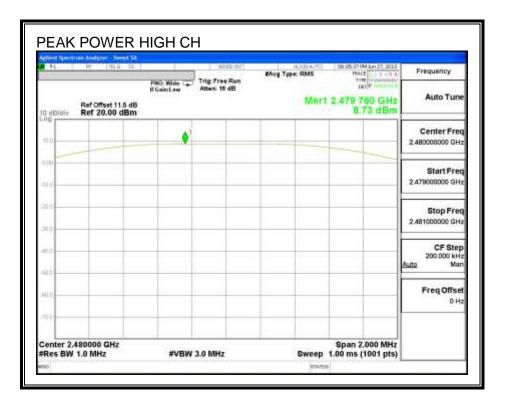
Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	9.679	30	-20.32
Middle	2440	11.480	30	-18.52
High	2480	8.730	30	-21.27

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# 7.1. AVERAGE POWER

### <u>LIMIT</u>

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	Average Power
	(MHz)	(dBm)
Low	2402	8.10
Middle	2440	8.82
High	2480	8.58

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# 7.2. POWER SPECTRAL DENSITY

### LIMITS

FCC §15.247 (e)

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

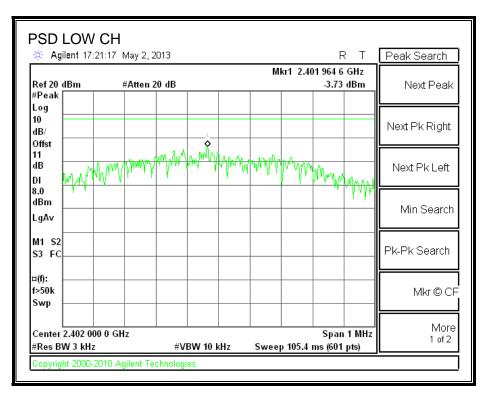
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

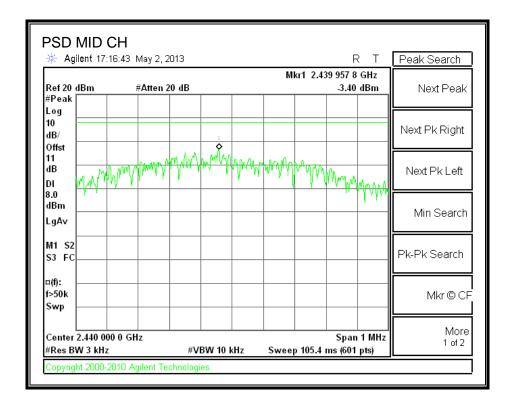
### **RESULTS**

Channel	Frequency	requency PPSD Limit			
	(MHz)	(dBm)	(dBm)	(dB)	
Low	2402	-3.73	8	-11.73	
Middle	2440	-3.40	8	-11.40	
High	2480	-3.75	8	-11.75	

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### POWER SPECTRAL DENSITY





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			May 2, 2				м	kr1 2.47	۲ د ۵۸۵ و		Freq/Cha	
Ref20 ∉ #Peak	dBm		#Atten 2	0 dB				NT 2.47		dBm	Center 2.4800000	
Log 10 dB/					11						Start 2.4795000	
Offst 11 dB	M	LM	hundr V.	MAA	migh	how when	MAN	MAN.	<b>M</b>		Stop 2.4805000	Freq
DI 8.0 dBm	may v	mγ γ		Y		Ϋ́.		¥	Mrya	Alathy		- Step
LgAv											<u>Auto</u>	<u>Ma</u>
M1 S2 S3 FC											Freq C 0.0000000	
¤(f): f>50k Swp											Signal <sup>-</sup> On	Track <u>Off</u>
Center #Res B\			lz		BW 10 I			o 105.4 i	•	1 MHz		

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# 7.3. 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.

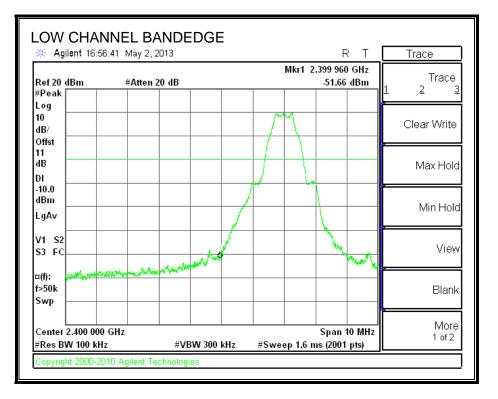
### TEST PROCEDURE

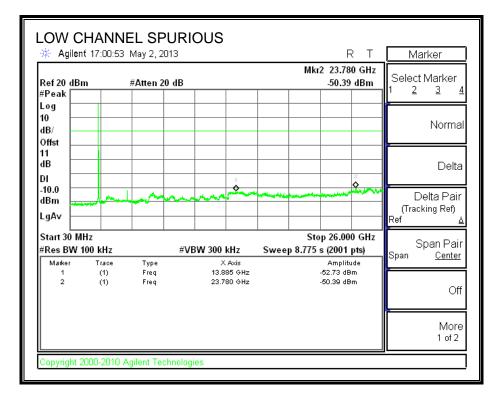
KDB 558074 D01 v01 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247".

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### **RESULTS**

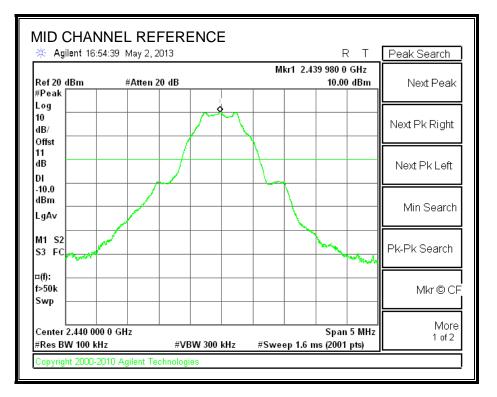
#### SPURIOUS EMISSIONS, LOW CHANNEL

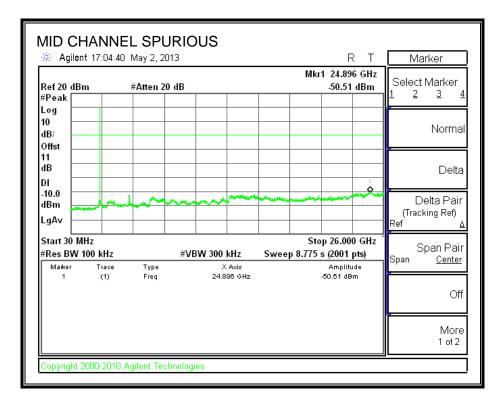




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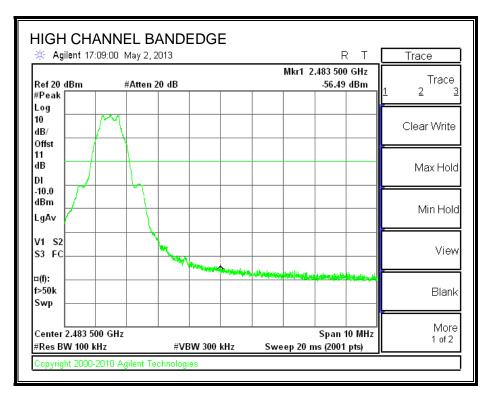
#### SPURIOUS EMISSIONS, MID CHANNEL

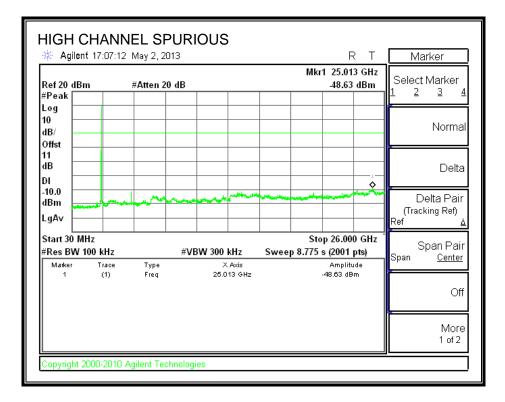




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#### SPURIOUS EMISSIONS, HIGH CHANNEL





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# 8. RADIATED TEST RESULTS

## 8.1. LIMITS AND PROCEDURE

## <u>LIMITS</u>

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.

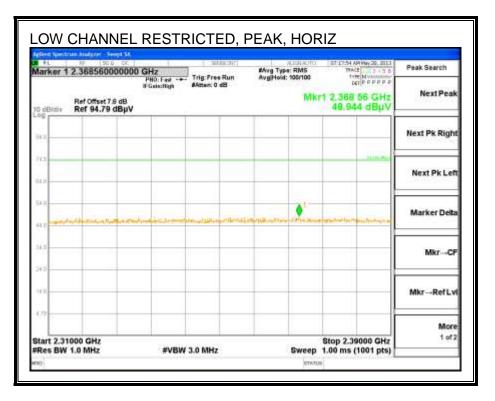
For 2.4 GHz band, the spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in the 2.4 GHz band.

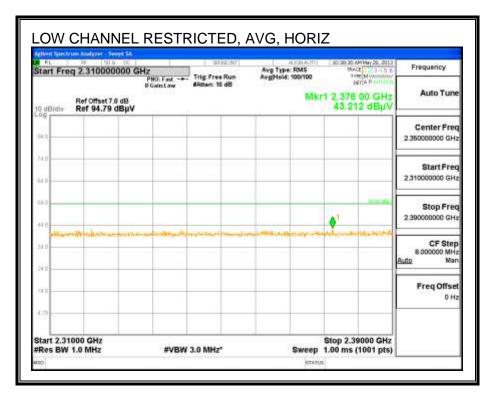
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized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

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# 8.2. TRANSMITTER ABOVE 1 GHz

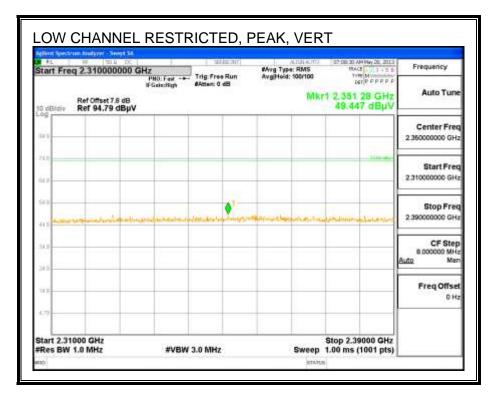
#### **RESTRICTED BANDEDGE (LOW CHANNEL, HORIZONTAL)**

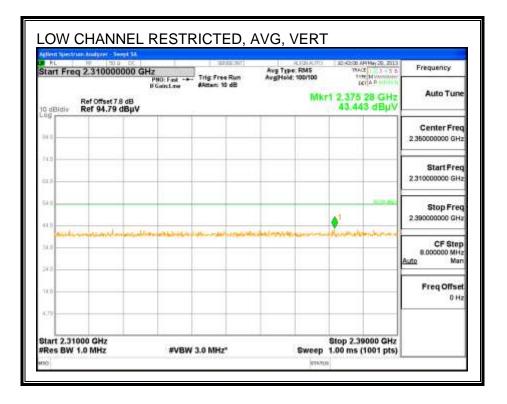




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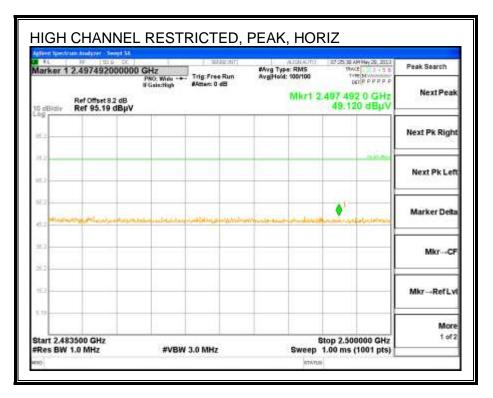
#### **RESTRICTED BANDEDGE (LOW CHANNEL, VERTICAL)**

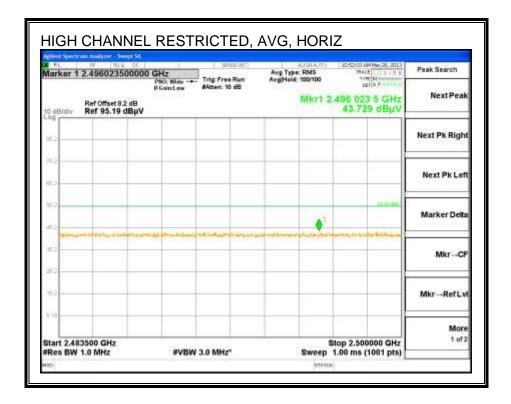




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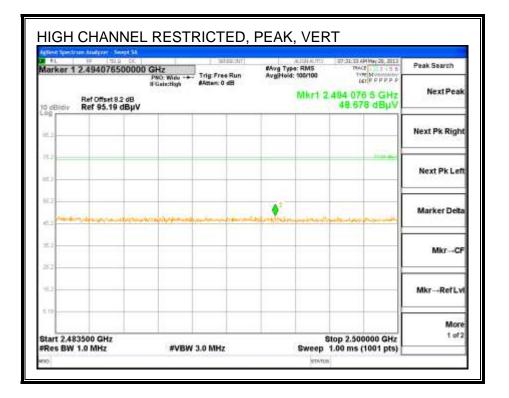
#### **RESTRICTED BANDEDGE (HIGH CHANNEL, HORIZONTAL)**

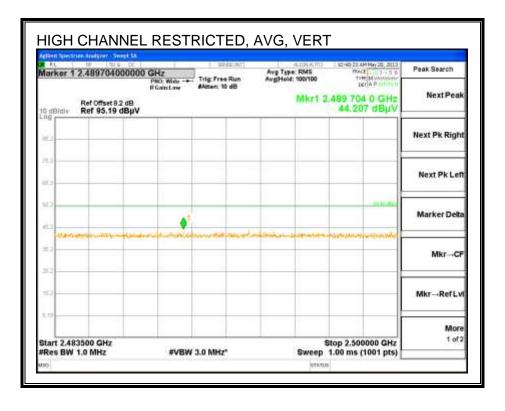




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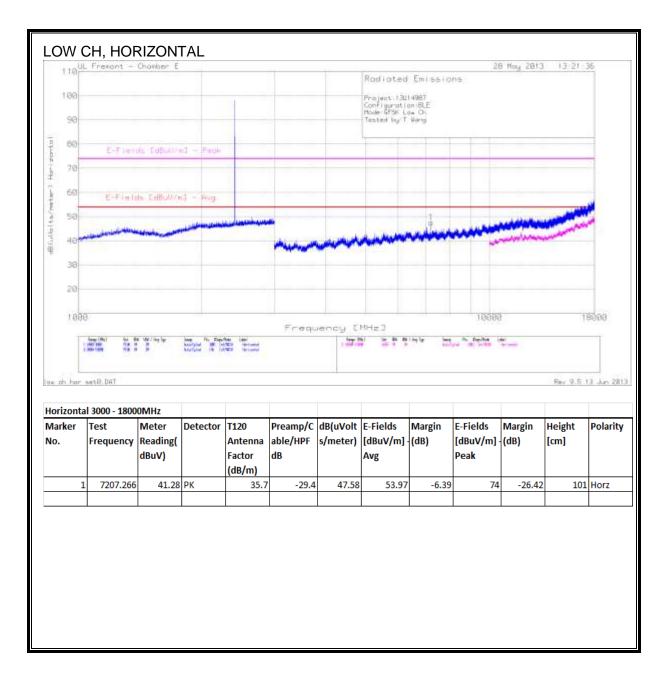
### **RESTRICTED BANDEDGE (HIGH CHANNEL, VERTICAL)**



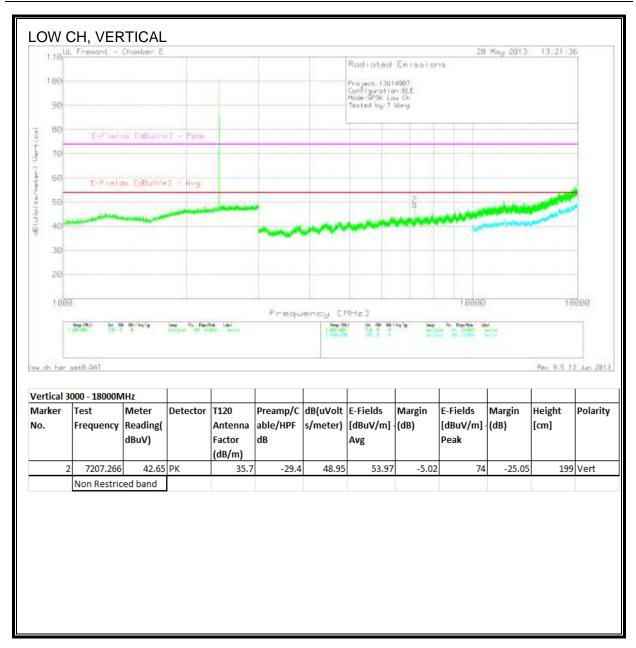


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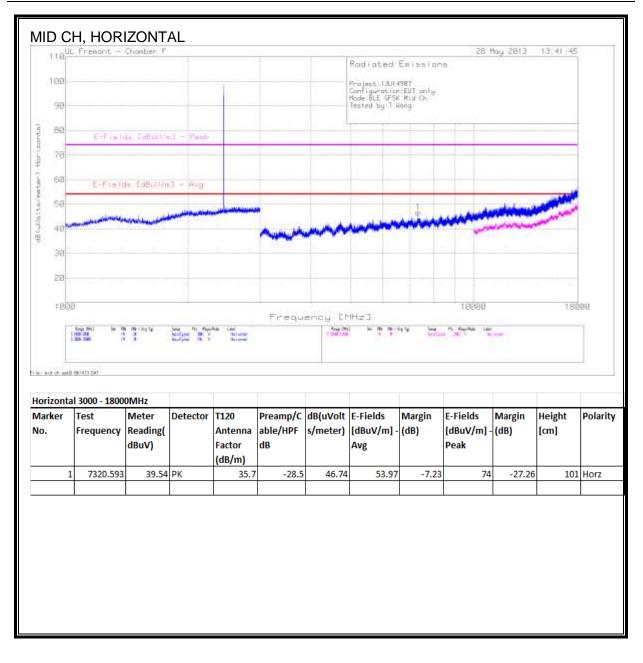
### HARMONICS AND SPURIOUS EMISSIONS



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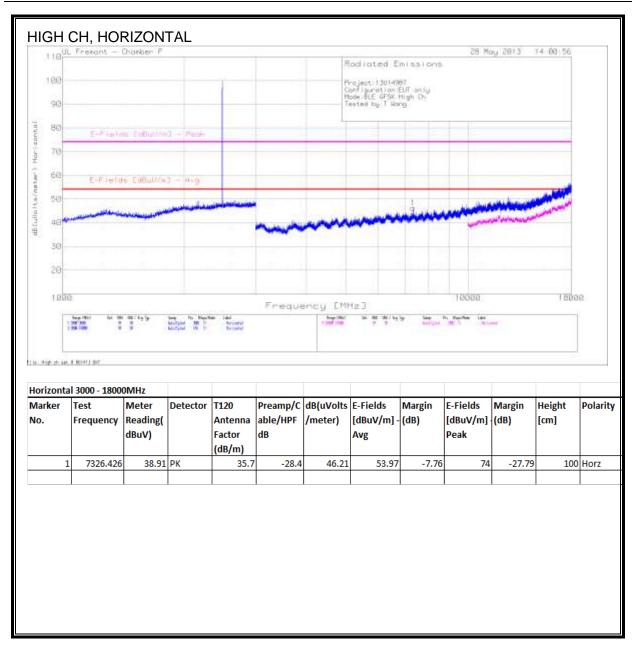
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1 DR	Ange Phil Inc. W		here to be	-No. (Au)	Frequ	lency El		49 3	Ps fights is		18	200
10 Letter /ertical	Ange 1991 An 19 49 (1913) 247 30000 - 1800001V	IHz							ft. fighte is			
1 DR	Ange Phil Inc. W	Hz Meter	Detector		Frequ Preamp/C able/HPF dB	dB(uVolt		Margin	Ps fights is	Margin	Height [cm]	Polarit

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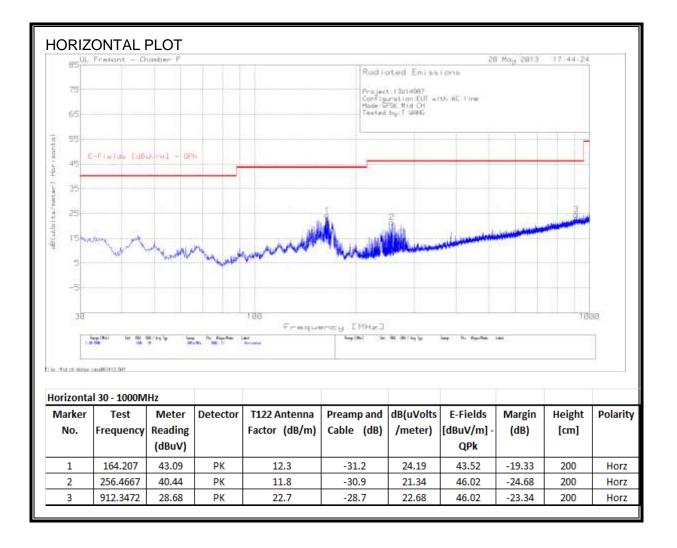
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	s CaBullin					Rodiated E Project 130149 anflguration 1 Made REE (FSK 1 Featail by T Wa			9¥ 5813		
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E-Fields	s Ca8u∪/w)	j - n-g									
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requency	Reading(	Detector	Antenna Factor				(dB)	[dBuV/m]	-	-	Polari
7439.753	37.99	РК	35.8	-29.2	44.59	53.97	-9.38	74	-29.41	199	Vert
•	o - 18000M est equency	D - 18000MHz est Meter requency Reading( dBuV)	2 - 18000MHz est Meter Detector requency Reading( dBuV)	D - 18000MHz Detector T120 est Meter Detector T120 Reading( Antenna dBuV) Factor (dB/m)	D - 18000MHz Detector T120 Preamp/C ast Meter Reading( dBuV) Factor (dB/m)	D - 18000MHz est Meter Detector T120 Preamp/C dB(uVolts requency Reading( dBuV) Factor (dB/m)	D - 18000MHz Detector T120 Preamp/C dB(uVolts E-Fields requency Reading( dBuV) Factor (dB/m)	D - 18000MHz est Meter Detector T120 Preamp/C dB(uVolts E-Fields Margin dBuV) Factor (dB/m) Avg (dB)	D - 18000MHz Detector T120 Reading( dBuV) Factor (dB/m) Preamp/C dB(uVolts E-Fields Margin E-Fields [dBuV/m] - (dB) [dBuV/m] - Peak	D- 18000MHz est Meter Detector T120 Preamp/C dB(uVolts E-Fields Margin E-Fields Margin (dB) dBuV/m] (dB) (dB) Peak (dB)	D- 18000MHz est Meter Detector T120 Preamp/C dB(uVolts E-Fields Margin E-Fields Margin (dB) [cm] Factor dB Antenna able/HPF /meter) Avg Peak (dB) [cm]

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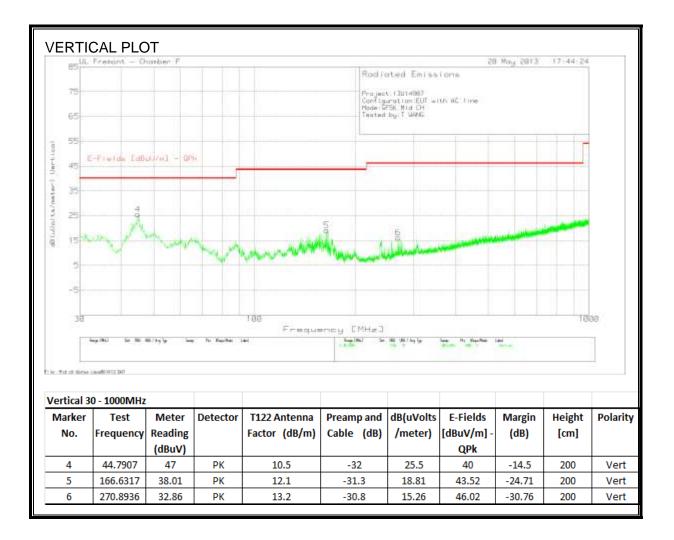
## 8.3. WORST-CASE BELOW 1 GHz

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



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



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# 9. AC POWER LINE CONDUCTED EMISSIONS

## LIMITS

FCC §15.207 (a)

RSS-Gen 7.2.2

Frequency of Emission (MHz)	Conducted I	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

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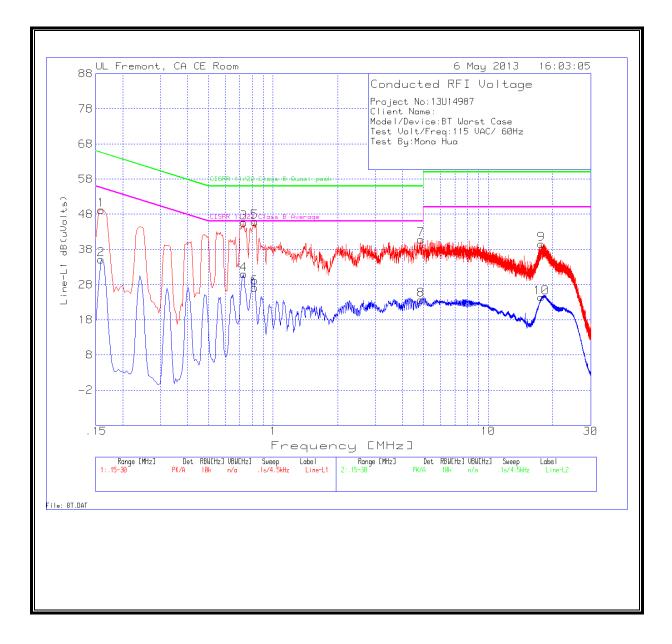
### **RESULTS**

#### **<u>6 WORST EMISSIONS</u>**

13U14987								
e:								
vice:WLAN	Worst Cas	е						
-								
- 30MHz								
					CISPR			
							CISPR	
		T24 IL	LC Cables		-		11/22	
Meter							-	
	Detector			dB(uVolts)	-	Margin		Margin
					-	-	-	-
					-	-	55.3	-57.66
					61.8	-24.5	-	-
					-	-	51.8	-54.94
					59.1	-24.93	-	-
					-	-	49.1	-50.64
					56	-21.38	-	-
					-	-	46	-40.14
					60	-35.89	-	-
			1		-	-	50	-50.58
- 30MHz								
					CISPR			
					11/22		CISPR	
		T24 IL	LC Cables		Class B		11/22	
Meter		L2.TXT	2&3.TXT				Class B	
Reading	Detector	(dB)	(dB)	dB(uVolts)	peak	Margin	Average	Margin
40.56	РК	0.1	0	40.66	64.8	-24.14	-	-
	Av	0.1	0		_	-	54.8	-57.64
37.6	РК	0.1	0	37.7	61.5	-23.8	-	-
-3.12	Av	0.1	0	-3.02	-	-	51.5	-54.52
33.88	РК	0.1	0	33.98	59.3	-25.32	-	-
-4.07	Av	0.1	0	-3.97	-	-	49.3	-53.27
34.2	РК	0.1	0	34.3	56	-21.7	-	-
4.8	Av	0.1	0	4.9	-	-	46	-41.1
21.76	РК	0.2	0.2	22.16	60	-37.84	-	-
-4.17	Av	0.2				-	50	-53.77
	ice:WLAN req:115V 6 rcisco Gua a 30MHz a 30MHz a 41.02 -2.46 37.2 -3.24 34.07 -1.64 34.52 5.76 23.71 -0.98 a 34.52 5.76 23.71 -0.98 a 40.56 -2.94 37.6 a 30MHz a b b b b b b b b b b b b b b b b b b	e:	e: disciple with a set of the set	e: Series VLAN Vorst Case Verse Case Verse Case Verse	e: Indexe Interval In	ei i i i i i i i i i i i i i i i i i i	e: View Vorst Case I and	e:Image: bit is a strature is a

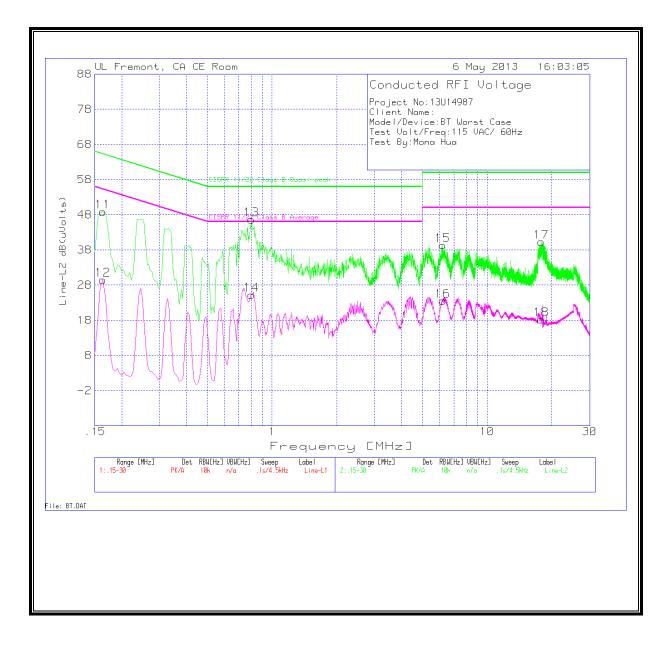
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### LINE 1 RESULTS



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### LINE 2 RESULTS



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