



**FCC 47 CFR PART 15 SUBPART E  
INDUSTRY CANADA RSS-210 ISSUE 8**

**CLASS II PERMISSIVE CHANGE  
BLUETOOTH LOW ENERGY**

**FOR**

**802.11a/b/g/n WLAN + BLUETOOTH PCI-E MINI CARD**

**MODEL NUMBER: BCM943228HMB**

**FCC ID: QDS-BRCM1058  
IC: 4324A-BRCM1058**

**REPORT NUMBER: 13U16745-4, Revision A**

**ISSUE DATE: FEBRUARY 25, 2014**

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**NVLAP LAB CODE 200065-0**

Revision History

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
--	01/29/14	Initial Issue	F. Ibrahim
A	02/25/14	Revised AG in section 5.3 by changing 0.85 dBi to 1.58 dBi	F. Ibrahim

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# 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** BROADCOM CORPORATION  
190 MATHILDA PLACE  
SUNNYVALE, CA 94086, U.S.A.

**EUT DESCRIPTION:** 802.11a/b/g/n WLAN + Bluetooth PCI-E Mini Card

**MODEL:** BCM943228HMB

**SERIAL NUMBER:** 1403512

**DATE TESTED:** JANUARY 23 - 27, 2014

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



Frank Ibrahim  
WiSE PROGRAM MANAGER  
UL Verification Services Inc.

Tested By:



Joey Gomez  
WiSE Lab Engineer  
UL Verification Services Inc.

## 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.

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
<input checked="" type="checkbox"/> Chamber A	<input type="checkbox"/> Chamber D
<input type="checkbox"/> Chamber B	<input type="checkbox"/> Chamber E
<input type="checkbox"/> Chamber C	<input type="checkbox"/> Chamber F

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://ts.nist.gov/standards/scopes/2000650.htm>.

## 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 an 802.11a/b/g/n WLAN + Bluetooth PCI-E Mini card manufactured by Broadcom.

The radio module is manufactured by Broadcom.

### 5.2. MAXIMUM OUTPUT POWER

Average Output power was verified to be within +/- 0.5 dB from original values covered by report number 11U13795-18A

### 5.3. DESCRIPTION OF CLASS II PERMISSIVE CHANGE

Purpose of C2PC is to add the following antenna:

Antenna Type: Dipole Antenna

Antenna Gain (dBi)		
Band	Chain 0 (TX1)	Chain 1 (TX2)
2.4	-0.45	<b>1.26</b>
5.2	-0.36	<b>1.58</b>
5.3	-0.36	<b>1.58</b>
5.6	-0.07	<b>1.01</b>
5.8	0.83	<b>1.09</b>

### 5.4. SOFTWARE AND FIRMWARE

The test utility software used during testing was Broadcom BlueTool ver 1.7.5.1

### 5.5. WORST-CASE CONFIGURATION AND MODE

The EUT was tested as an external module installed in a test jig board connected to a host Laptop PC.

Radiated Emissions test in the frequency range of 30-1000 MHz was performed with the EUT set to transmit in the channel and mode with highest output power as worst-case scenario.

All legacy modes were measured at Aux port, connector J2 (chain 1), antenna TX2, as worst-case scenario; this port is connected to the antenna with higher gain.

## 5.6. DESCRIPTION OF TEST SETUP

### SUPPORT EQUIPMENT

Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Lenovo	G560	CBU4473193	DoC
AC Adapter	Lenovo	PA-1650-56LC	11S36001651ZZ40006E2PR	DoC
Adapter Board	Broadcom	BRCM JUAN01	1788087	N/A

### I/O CABLES

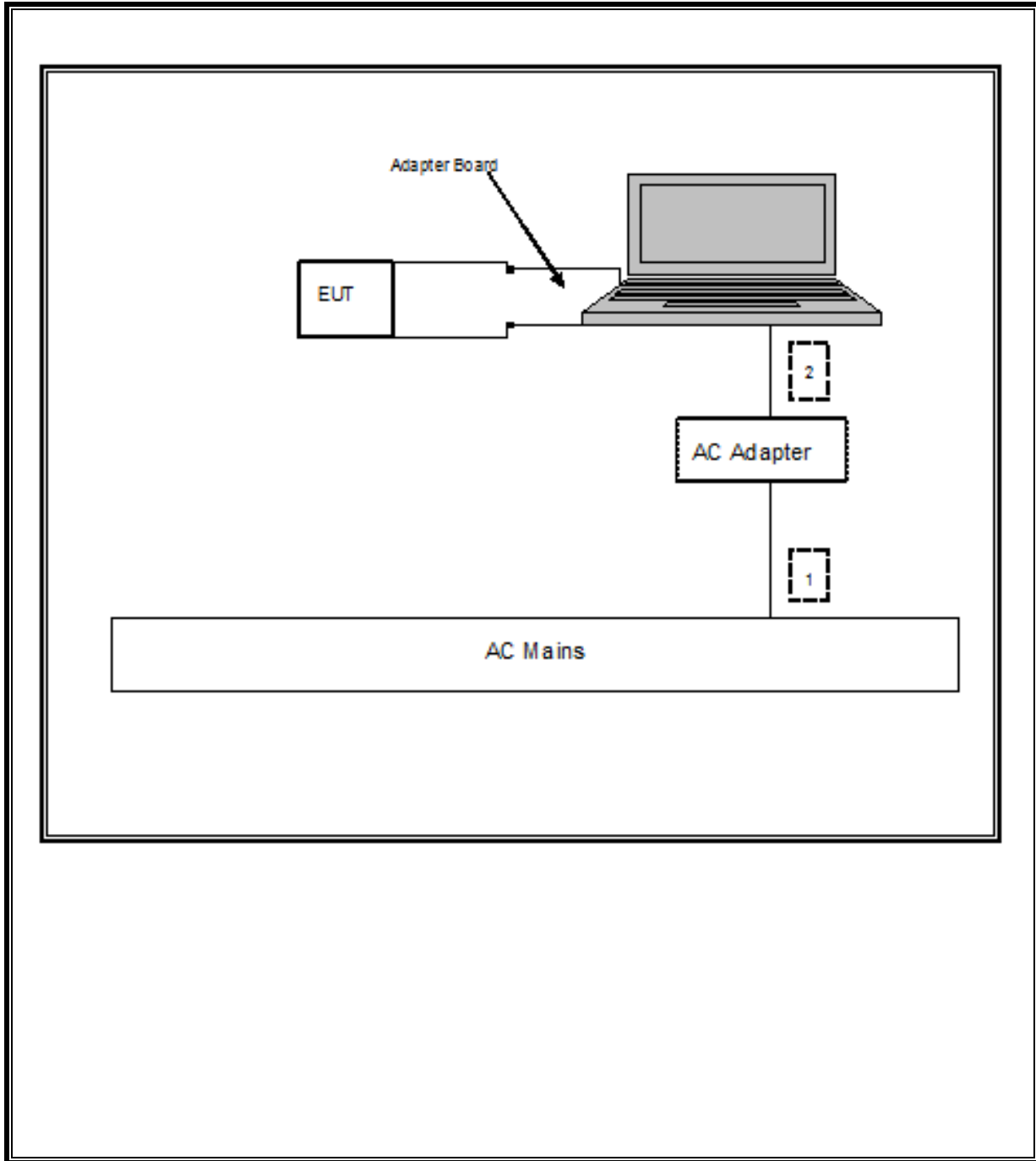
I/O CABLE LIST						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length	Remarks
1	AC	1	US 115V	Shielded	1.5m	NA
2	DC	1	DC	Un-shielded	1.5m	Ferrite at laptop's end

### TEST SETUP

The EUT was attached to a jig board which was installed in the PCMCIA slot of a host laptop computer during the tests. Test software exercised the radio card.



**SETUP DIAGRAM FOR 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 Date	Cal Due
Spectrum Analyzer, 26.5 GHz	Agilent / HP	E4440A	C01179	02/16/13	02/16/14
EMI Test Receiver, 9kHz-7GHz	R&S	ESCI 7	1000741	07/13/13	07/13/14
Horn Antenna, 1GHz-18GHz	ETS Lindgren	3117	T345	02/19/13	02/19/14
Antenna, Horn, 18 GHz	EMCO	3115	C01218/1000614	01/17/14	01/17/15
Antenna, Horn, 26.5 GHz	ARA	MWH-1826/B	C00980	11/14/13	11/14/14
Antenna, Bilog, 30MHz-1 GHz	Sunol Sciences	JB1	C01171	02/13/13	02/13/14
Preamplifier, 26.5 GHz	Agilent / HP	8449B	C00749	10/19/13	10/19/14
Preamplifier, 1300 MHz	Agilent / HP	8447D	C00885	06/26/14	06/26/15
Low Pass Filter	Micro-Tronics	LPS17541	F00219	06/26/13	06/26/14
High Pass Filter	Micro-Tronics	HPS17542	F00222	06/26/13	06/26/14
High Pass Filter	Micro-Tronics	HPM17543	F00224	06/26/13	06/26/14
PreAmplifier, 1-26.5GHz	Agilent	8449B	F00167	03/23/13	03/23/14
Antenna, Horn, 26.5 GHz	ARA	MWH-1826/B	C00980	11/26/13	11/26/14

## 7. ON TIME, DUTY CYCLE AND MEASUREMENT METHODS

### LIMITS

None; for reporting purposes only.

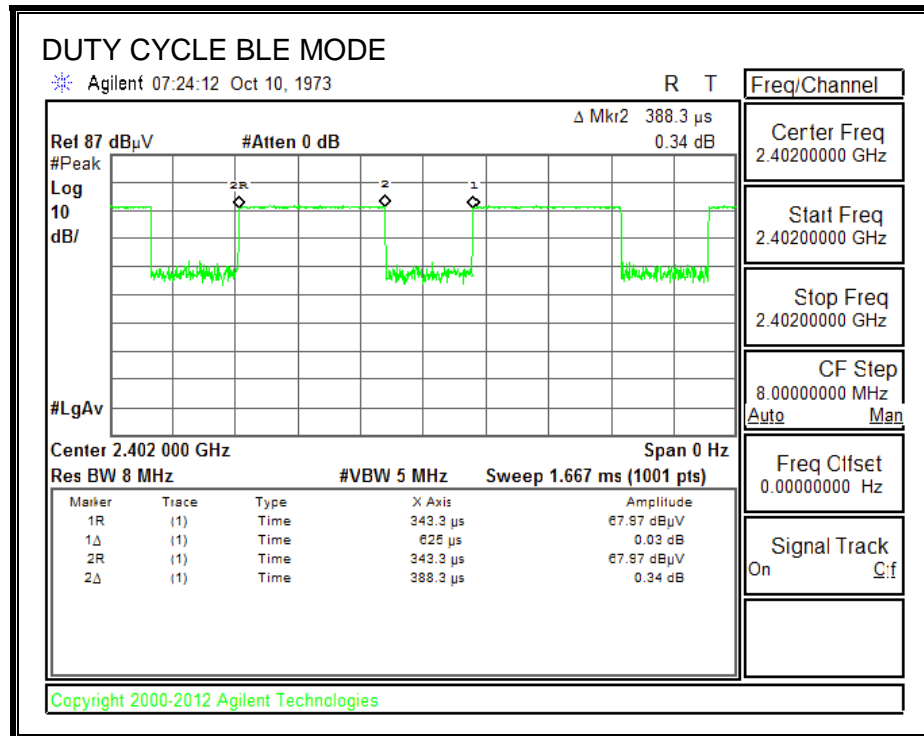
### PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

### 7.1. ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
BLE	0.3883	0.6250	0.621	62.13%	2.07	2.575

### 7.2. DUTY CYCLE PLOTS



## 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.

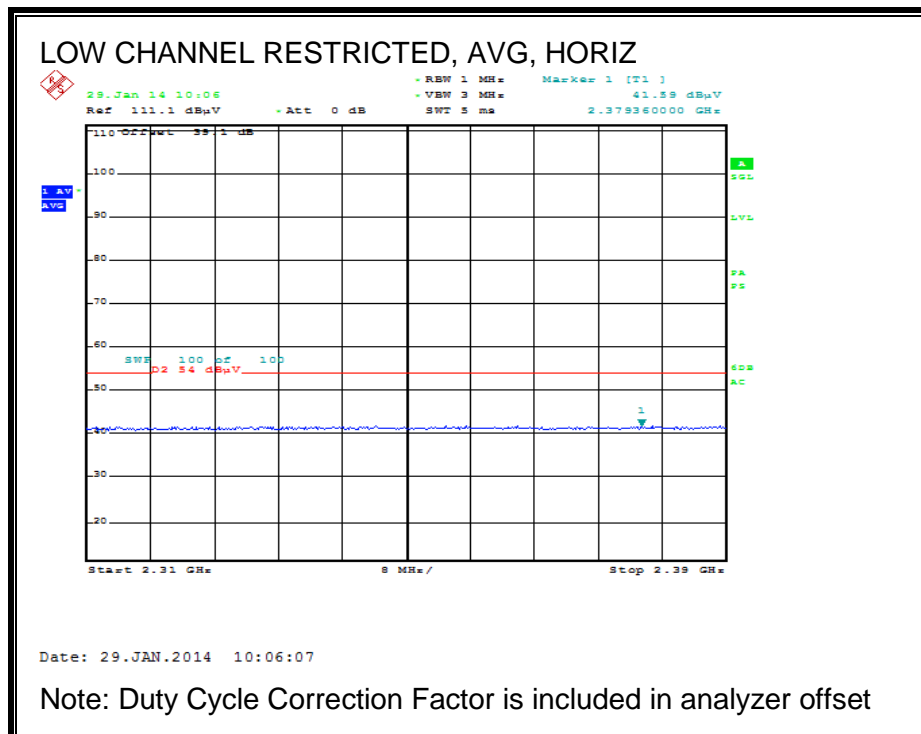
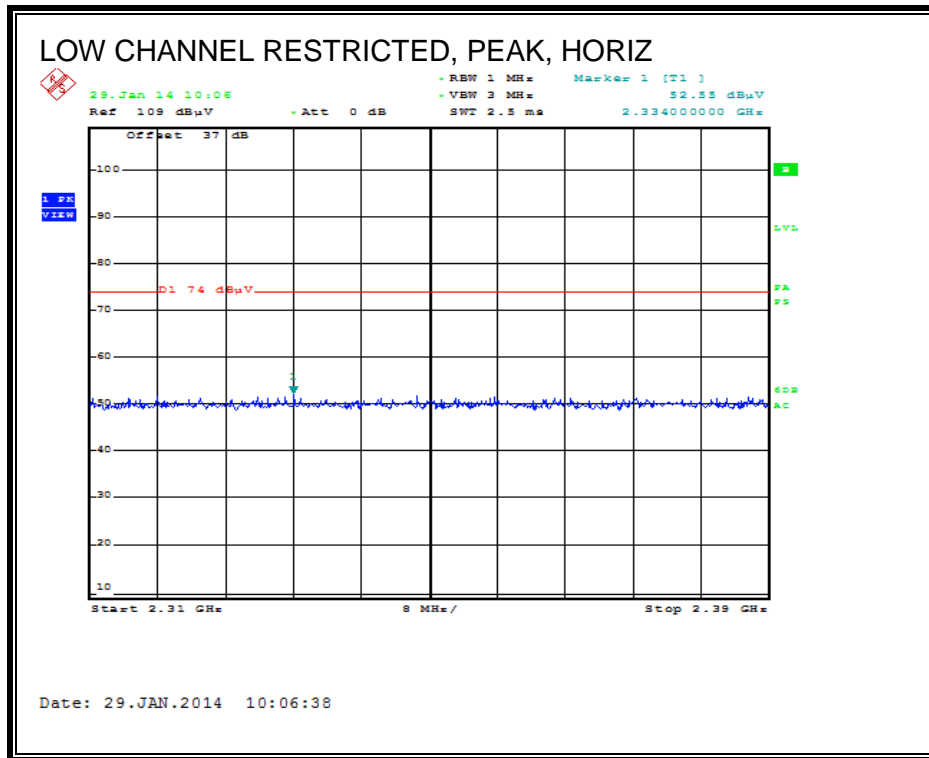
The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in the 2.4 GHz band.

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.

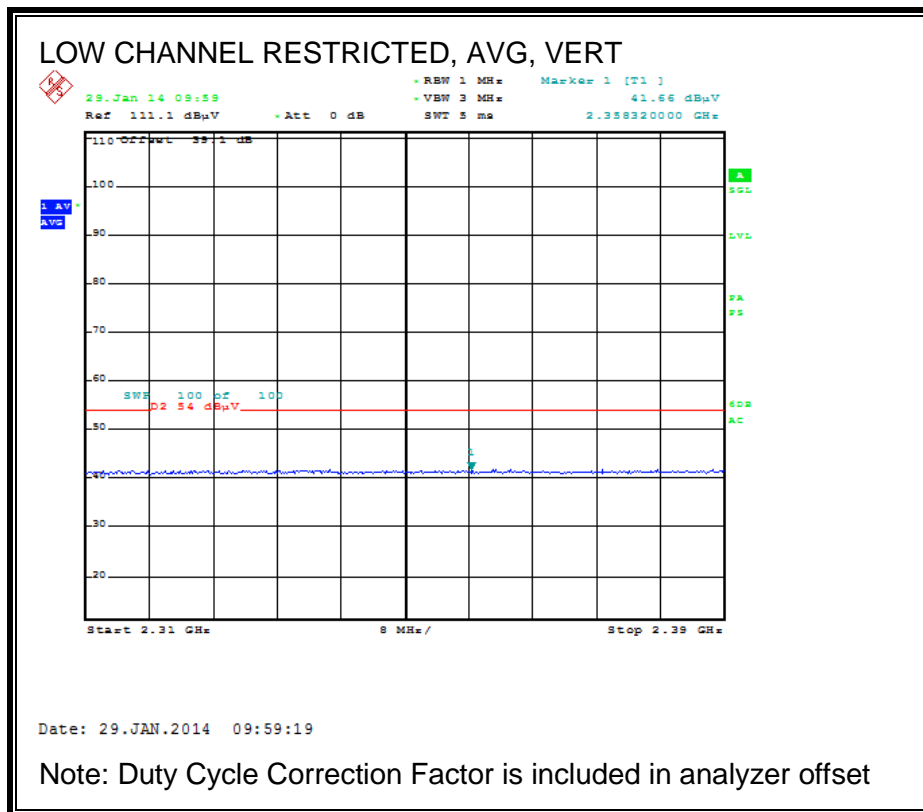
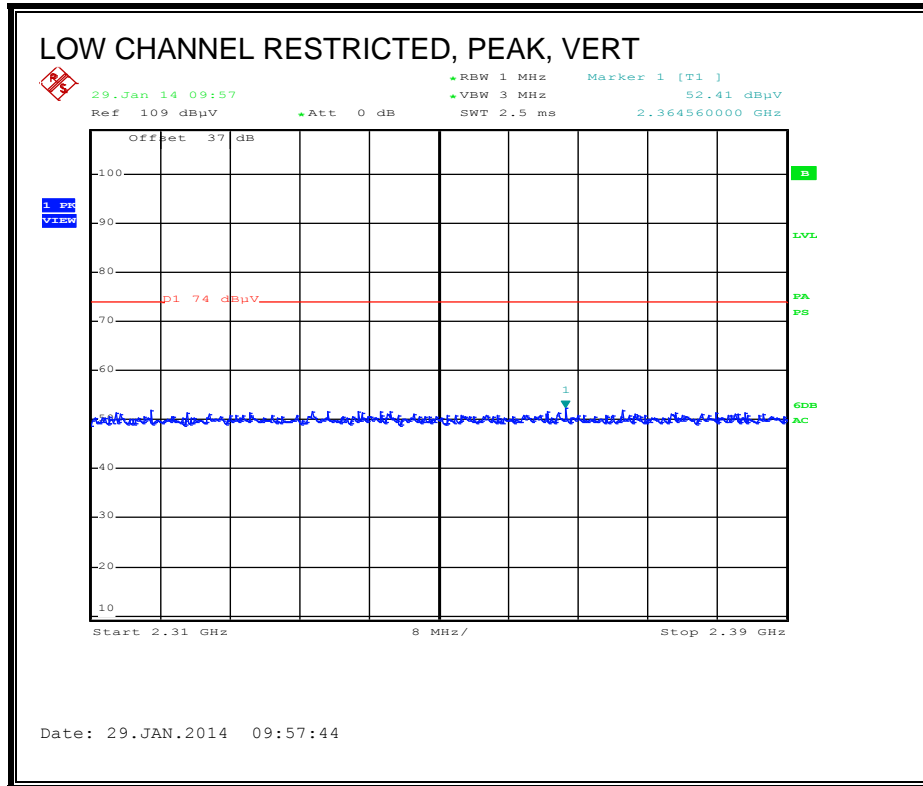
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized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

## 8.2. TX ABOVE 1 GHz FOR BLE MODE IN THE 2.4 GHz BAND

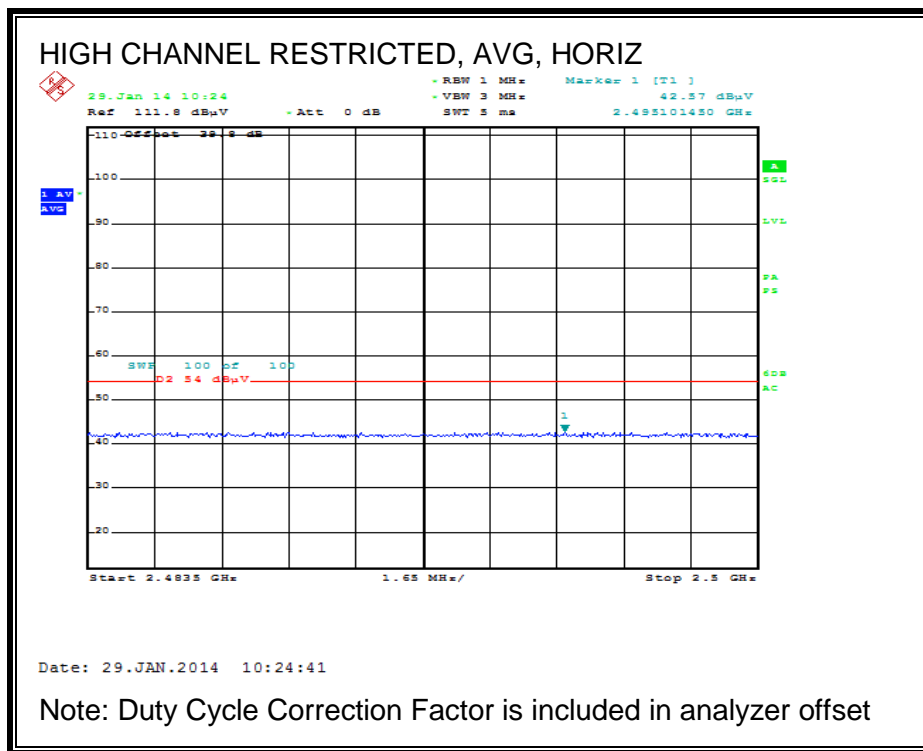
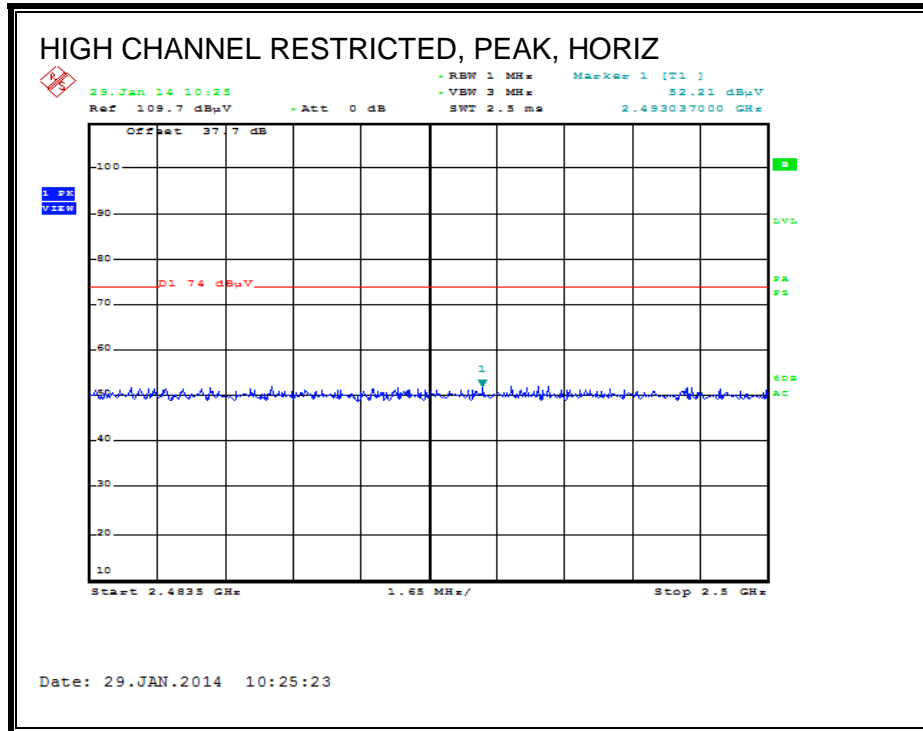
### RESTRICTED BANDEDGE (LOW CHANNEL, HORIZONTAL)



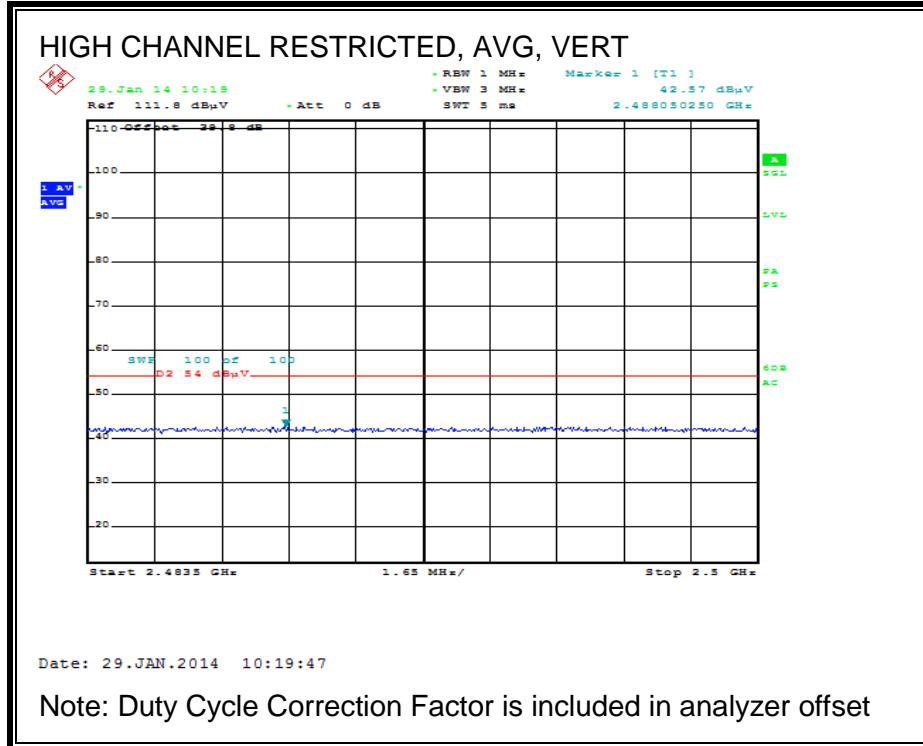
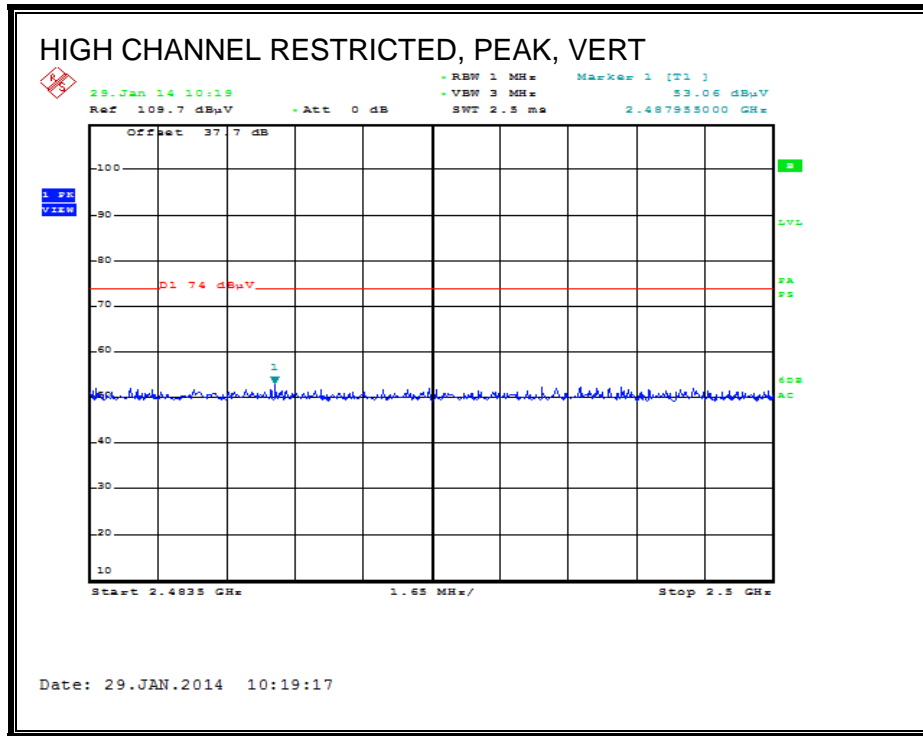
**RESTRICTED BANDEDGE (LOW CHANNEL, VERTICAL)**



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



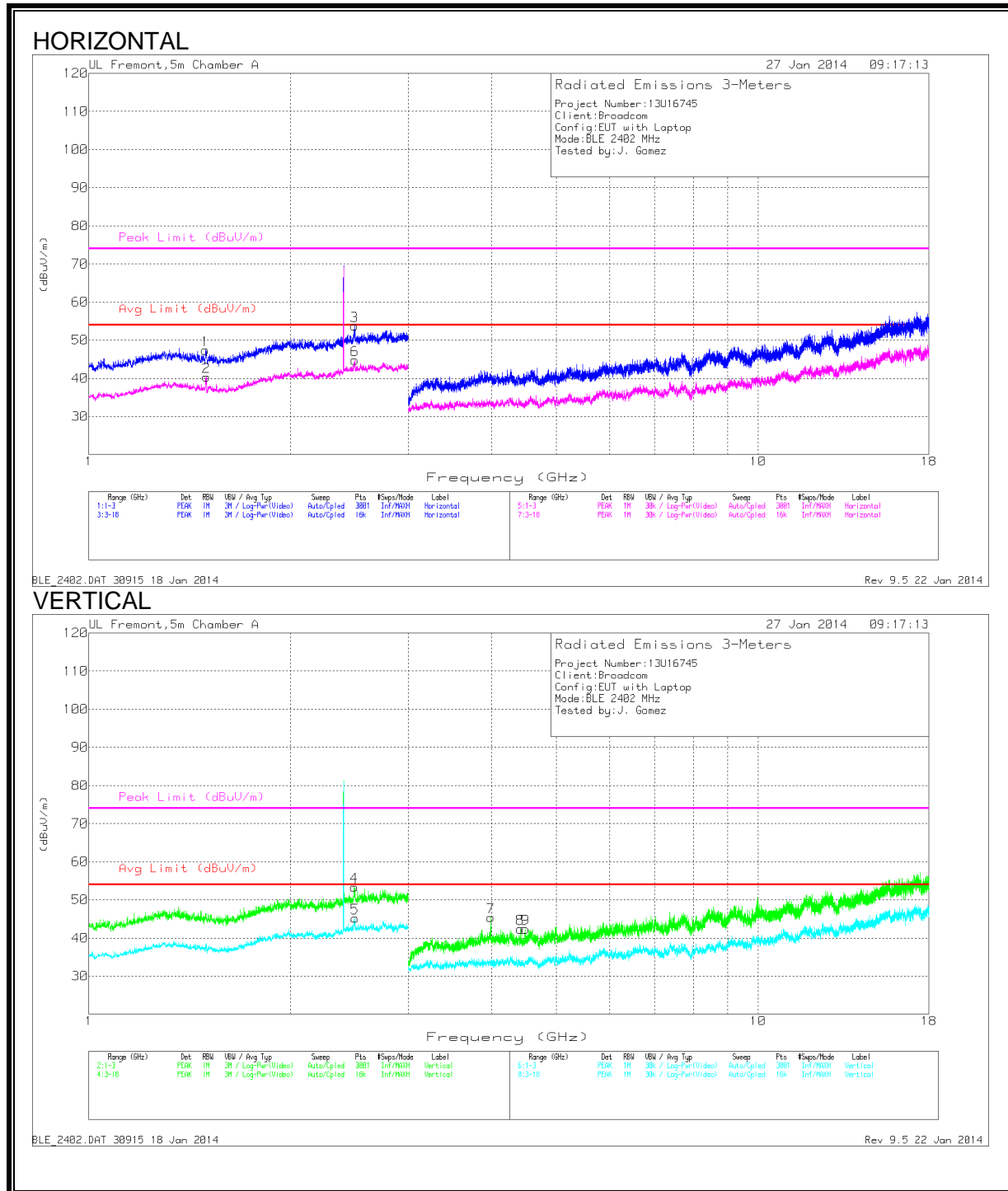
**RESTRICTED BANDEDGE (HIGH CHANNEL, VERTICAL)**





**HARMONICS AND SPURIOUS EMISSIONS**

**LOW CHANNEL**



Trace Markers

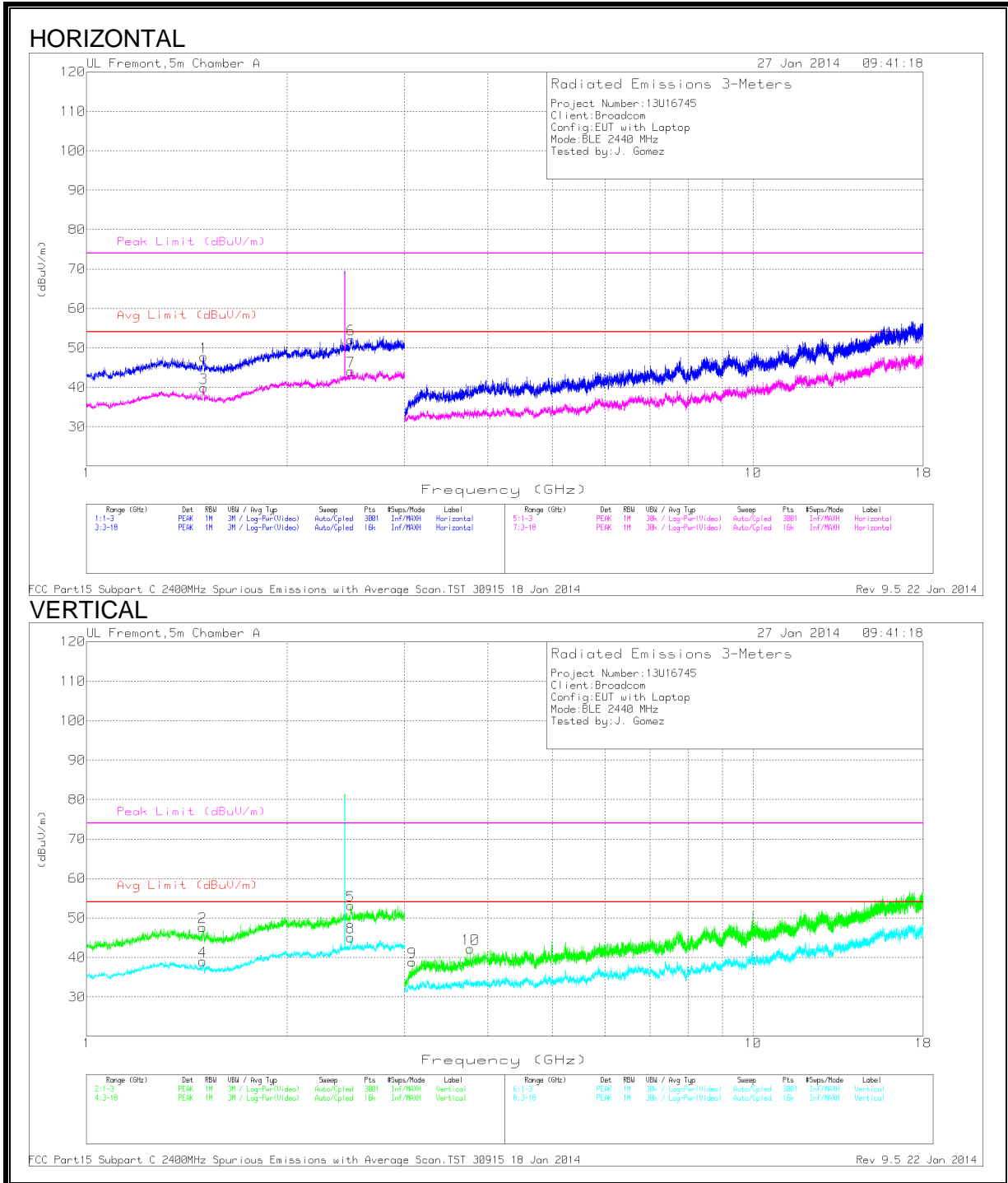
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T136 (dB/m)	Amp/Cb/Fitr /Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.493	45.22	PK	29	-26.8	0	47.42	-	-	74	-26.58	0-360	101	H
3	* 2.494	44.65	PK	32.6	-23.5	0	53.75	-	-	74	-20.25	0-360	200	H
4	* 2.491	44.26	PK	32.6	-23.5	0	53.36	-	-	74	-20.64	0-360	200	V
7	* 3.985	42.61	PK	33.8	-31	0	45.41	54	-8.59	74	-28.59	0-360	201	V
2	* 1.499	38.67	Avg	28.9	-27.2	0	40.37	54	-13.63	-	-	0-360	101	H
6	* 2.497	35.82	Avg	32.6	-23.6	0	44.82	54	-9.18	-	-	0-360	200	H
5	* 2.499	36.2	Avg	32.6	-23.6	0	45.2	54	-8.8	-	-	0-360	101	V
8	4.413	39.4	PK	33.6	-30.6	0	42.4	-	-	-	-	0-360	101	V
9	4.489	39.1	PK	33.8	-30.5	0	42.4	-	-	-	-	0-360	101	V

\* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

Avg - Video bandwidth < Resolution bandwidth

**MID CHANNEL**



Trace Markers

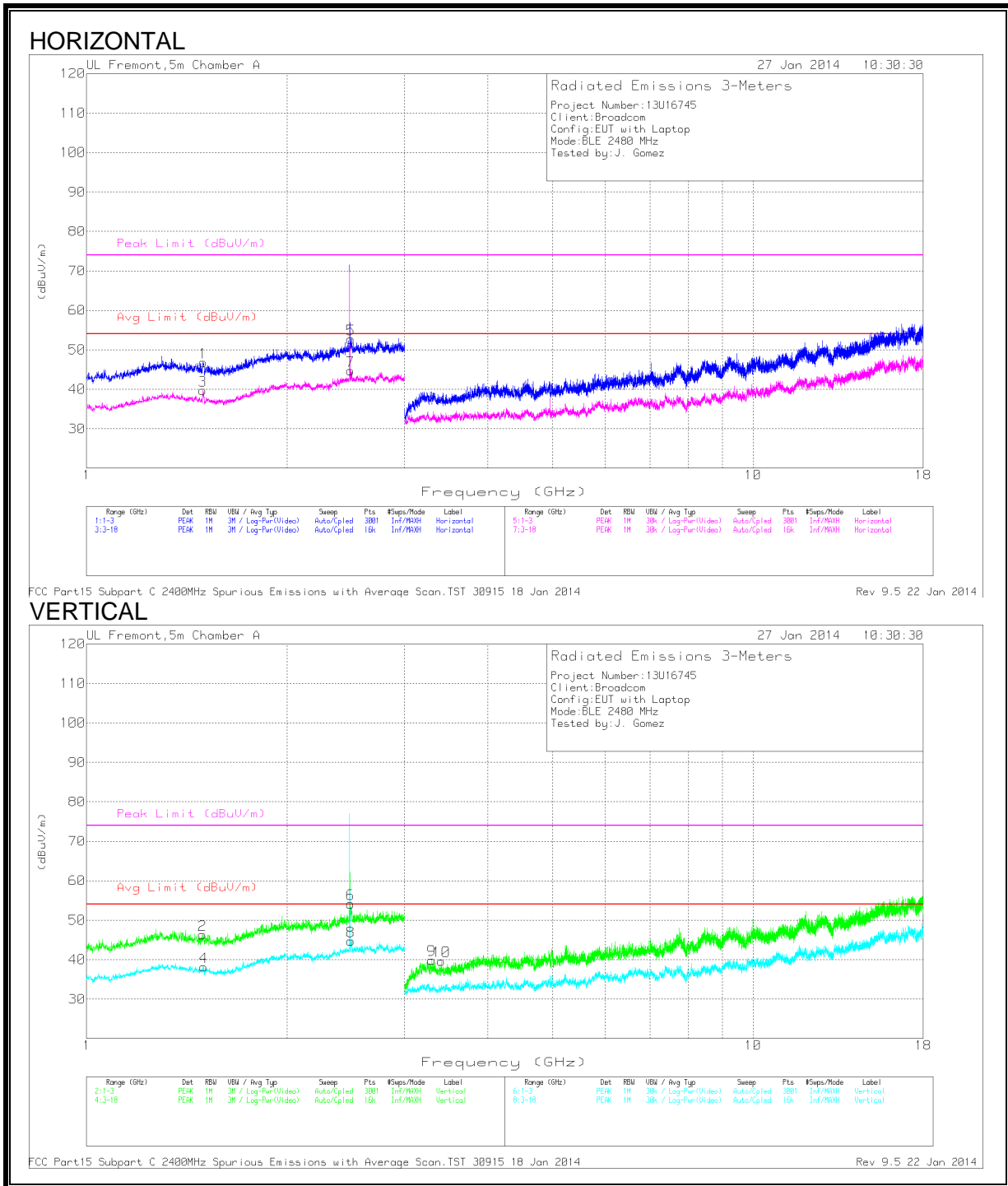
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T136 (dB/m)	Amp/Cb/Fitr /Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 1.493	45.48	PK	29	-26.8	0	47.68	-	-	74	-26.32	0-360	201	V
4	* 1.494	36.94	Avg	29	-26.9	0	39.04	54	-14.96	-	-	0-360	201	V
1	* 1.499	46.04	PK	28.9	-27.2	0	47.74	-	-	74	-26.26	0-360	100	H
3	* 1.499	38.27	Avg	28.9	-27.3	0	39.87	54	-14.13	-	-	0-360	101	H
5	* 2.489	44.06	PK	32.5	-23.4	0	53.16	-	-	74	-20.84	0-360	101	V
8	* 2.489	36	Avg	32.5	-23.4	0	45.1	54	-8.9	-	-	0-360	101	V
7	* 2.491	34.93	Avg	32.6	-23.5	0	44.03	54	-9.97	-	-	0-360	200	H
6	* 2.493	43.03	PK	32.6	-23.5	0	52.13	-	-	74	-21.87	0-360	200	H
10	* 3.765	38.92	PK	33.4	-30.1	0	42.22	54	-11.78	74	-31.78	0-360	101	V
9	3.081	36.64	PK	32.8	-30.6	0	38.84	-	-	-	-	0-360	101	V

\* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

Avg - Video bandwidth < Resolution bandwidth

**HIGH CHANNEL**



Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T136 (dB/m)	Amp/Cb/Fitr /Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 1.493	44.12	PK	29	-26.8	0	46.32	-	-	74	-27.68	0-360	201	V
3	* 1.493	37.55	Avg	29	-26.8	0	39.75	54	-14.25	-	-	0-360	101	H
1	* 1.497	45.04	PK	28.9	-27.1	0	46.84	-	-	74	-27.16	0-360	101	H
4	* 1.499	36.58	Avg	28.9	-27.3	0	38.18	54	-15.82	-	-	0-360	201	V
6	* 2.489	45.03	PK	32.5	-23.4	0	54.13	-	-	74	-19.87	0-360	201	V
7	* 2.489	35.63	Avg	32.5	-23.4	0	44.73	54	-9.27	-	-	0-360	200	H
8	* 2.49	35.53	Avg	32.6	-23.4	0	44.73	54	-9.27	-	-	0-360	201	V
5	* 2.492	43.59	PK	32.6	-23.5	0	52.69	-	-	74	-21.31	0-360	200	H
9	3.293	38.12	PK	32.9	-31.1	0	39.92	-	-	-	-	0-360	200	V
10	3.407	37.36	PK	33	-30.7	0	39.66	-	-	-	-	0-360	101	V

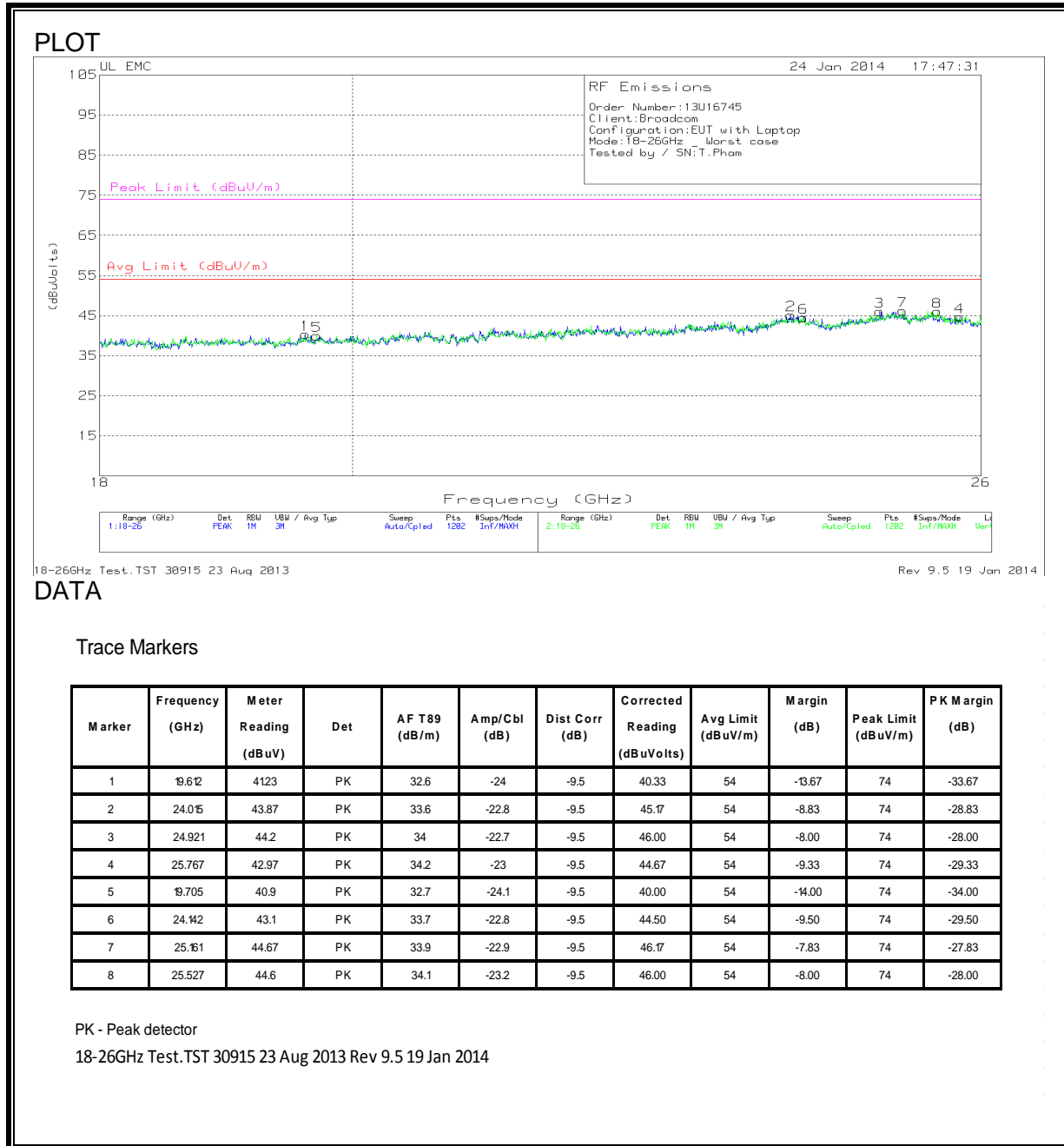
\* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

Avg - Video bandwidth < Resolution bandwidth

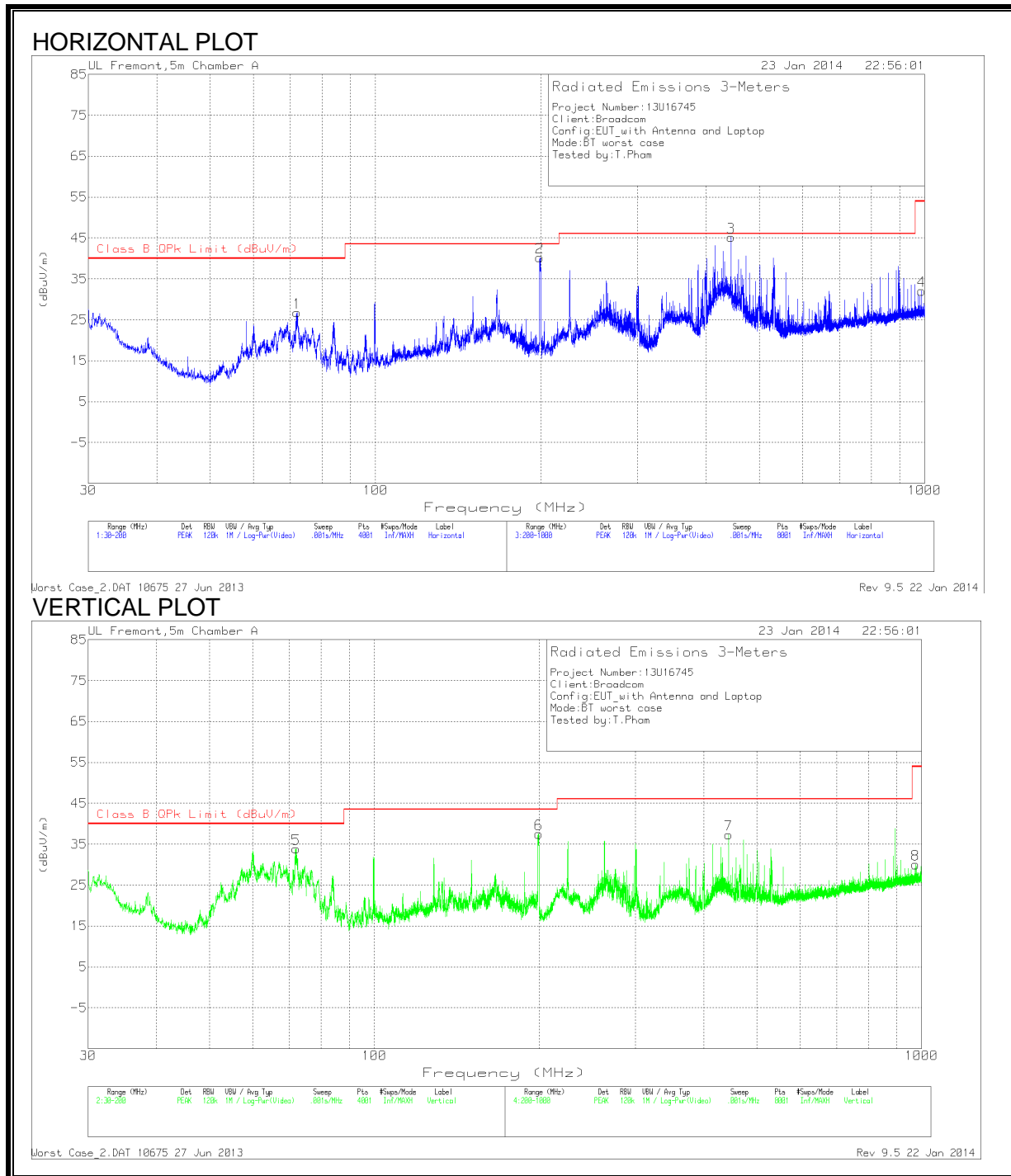
**WORST-CASE 18GHz -26GHz**

**SPURIOUS EMISSIONS 18GHz TO 26GHz (WORST-CASE CONFIGURATION)**



### 8.3. WORST-CASE BELOW 1 GHz

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





### Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T477 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	Class B QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	71.99	45.6	PK	8.3	-27.1	26.8	40	-13.2	0-360	301	H
5	71.99	52.67	PK	8.3	-27.1	33.87	40	-6.13	0-360	101	V
2	199.15	54.08	PK	12.3	-26.1	40.28	43.52	-3.24	0-360	201	H
6	199.7875	51.32	PK	12.3	-26.1	37.52	43.52	-6	0-360	101	V
3	443.9	53.08	PK	16.9	-24.8	45.18	46.02	-.84	0-360	101	H
7	443.9	45.24	PK	16.9	-24.8	37.34	46.02	-8.68	0-360	201	V
8	975.5	29.74	PK	22.8	-22.5	30.04	53.97	-23.93	0-360	201	V
4	987.9	31.87	PK	22.6	-22.4	32.07	53.97	-21.9	0-360	101	H

PK - Peak detector

### Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T477 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	Class B QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
199.1446	52.25	QP	12.3	-26.1	38.45	43.52	-5.07	280	172	H
199.1794	51.74	PK	12.3	-26.1	37.94	43.52	-5.58	167	169	H
443.8553	32.83	QP	16.9	-24.8	24.93	46.02	-21.09	280	172	H
443.8553	50.29	QP	16.9	-24.8	42.39	46.02	-3.63	9	103	H
443.8559	47.79	PK	16.9	-24.8	39.89	46.02	-6.13	114	104	H

PK - Peak detector

QP - Quasi-Peak detector

Worst Case\_2.DAT 10675 27 Jun 2013 Rev 9.5 22 Jan 2014