



**FCC 47 CFR PART 15 SUBPART C
INDUSTRY CANADA RSS-210 ISSUE 8
BLUETOOTH LOW ENERGY
CERTIFICATION TEST REPORT**

FOR

2.4GHz LE MODULE

MODEL NUMBER: RN4020

**FCC ID: T9JRN4020
IC: 6514A-RN4020**

REPORT NUMBER: 14U17191-1

ISSUE DATE: MARCH 21, 2014

Prepared for
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NVLAP LAB CODE 200065-0

Revision History

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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. MEASURING INSTRUMENT CALIBRATION	5
4.2. SAMPLE CALCULATION	5
4.3. MEASUREMENT UNCERTAINTY.....	5
5. EQUIPMENT UNDER TEST	6
5.1. DESCRIPTION OF EUT	6
5.2. MAXIMUM OUTPUT POWER.....	6
5.3. DESCRIPTION OF AVAILABLE ANTENNAS	6
5.4. SOFTWARE AND FIRMWARE.....	6
5.5. WORST-CASE CONFIGURATION AND MODE.....	6
5.6. DESCRIPTION OF TEST SETUP.....	7
6. TEST AND MEASUREMENT EQUIPMENT	9
7. ANTENNA PORT TEST RESULTS	10
7.1. MEASUREMENT METHODS	10
7.2. 6 dB BANDWIDTH.....	11
7.3. 99% BANDWIDTH.....	14
7.4. OUTPUT POWER.....	17
7.5. AVERAGE POWER	20
7.6. POWER SPECTRAL DENSITY	21
7.7. CONDUCTED SPURIOUS EMISSIONS.....	24
8. RADIATED TEST RESULTS.....	28
8.1. LIMITS AND PROCEDURE	28
8.2. TX ABOVE 1 GHz FOR BLE MODE IN THE 2.4 GHz BAND.....	29
8.3. TRANSMITTER ABOVE 1 GHz	33
8.4. WORST-CASE BELOW 1 GHz.....	39
9. SETUP PHOTOS.....	41

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: MICROCHIP TECHNOLOGY INC.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199, U.S.A.

EUT DESCRIPTION: 2.4GHz LE MODULE

MODEL: RN4020

SERIAL NUMBER: RN4020-EVB

DATE TESTED: MARCH 10 – 11, 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:



Thu Chan
WiSE Operations Manager
UL Verification Services Inc.

Tested By:



Mona Hua
WiSE Lab Technician
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 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
☐ Chamber A	☒ Chamber D
☐ Chamber B	☐ Chamber E
☐ Chamber C	☐ 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 a 2.4GHz LE Module.

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	BLE	8.44	6.98

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a PCB antenna, with a maximum gain of -0.23 dBi.

5.4. SOFTWARE AND FIRMWARE

The EUT driver software installed during testing was ptest_CSR101x.xbv

The test utility software used during testing was uEnergy Tools 2.2.1

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated emission and 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, based on the baseline scan it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
USB to SPI Converter	CSR	CNS	282721	N/A
3.3V Batteries Power Supply	N/A	N/A	N/A	N/A
Laptop	HP	Compaq 6175b	CNU7311RQ7	N/A
Laptop AC Adapter	HP	ED494AA#ABA	N/A	N/A

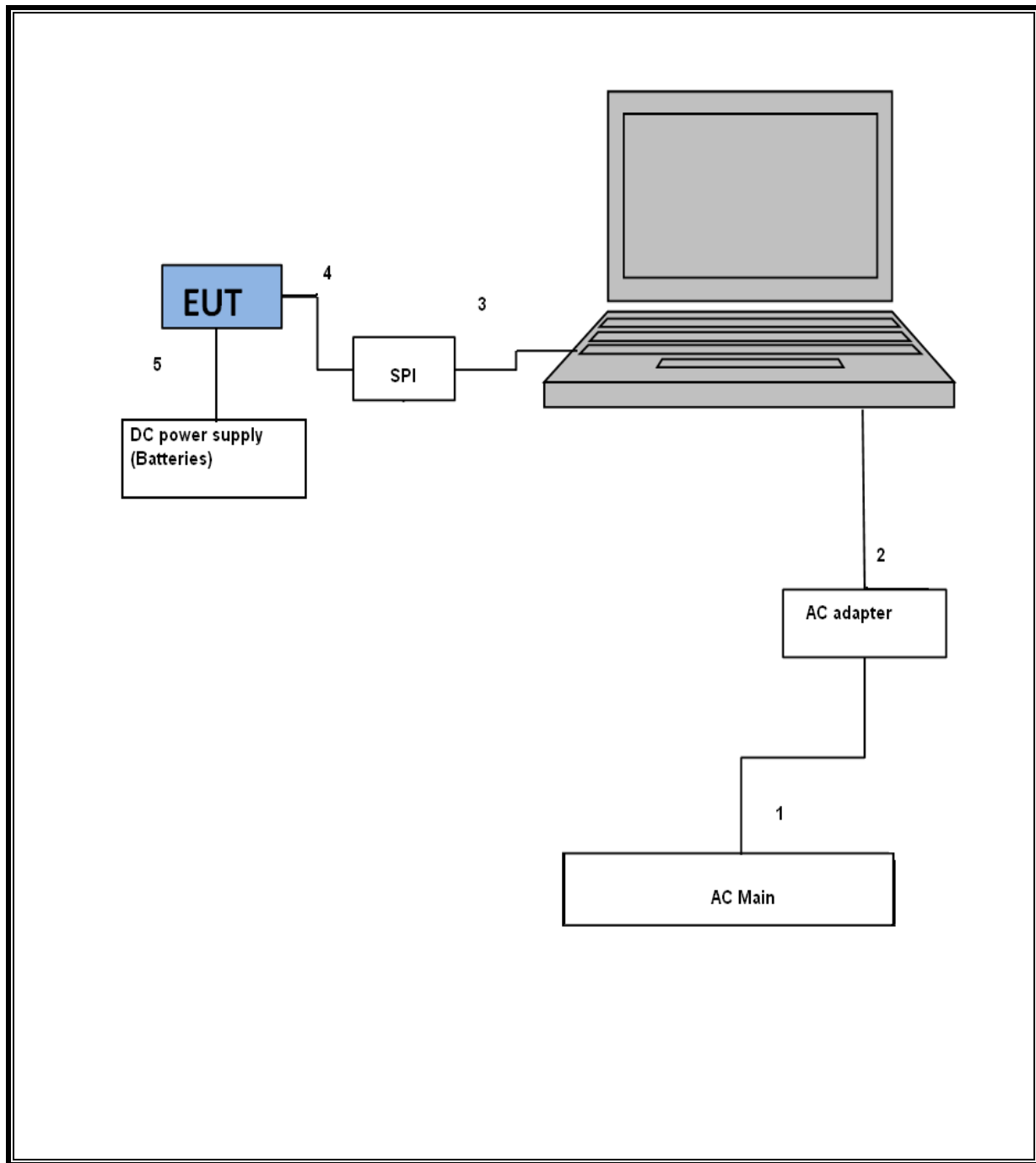
I/O CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	US 115V	Un-shielded	0.8m	N/A
2	DC	1	AC/DC Adapter	Un-shielded	0.6m	N/A
3	USB	1	SPI Card	Un-shielded	0.8m	N/A
4	USB	1	EUT	Un-shielded	0.2m	N/A
5	DC	1	3.3Vdc Battery	Un-shielded	0.3m	N/A

TEST SETUP

The EUT was tested as an external module, and 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 Due
Spectrum Analyzer, PXA, 3Hz to 50GHz	Agilent	N9030A	F00121	01/21/15
Antenna, Horn, 18 GHz	EMCO	3115	C00783	10/24/14
Antenna, Horn, 26.5 GHz	ARA	SWH-28	C01015	05/06/14
Antenna, Biconolog, 30MHz-1 GHz	Sunol Sciences	JB3	F00215	05/07/14
Preamplifier, 1000 MHz	Sonoma	310N	N02891	12/30/14
RF PreAmplifier, 1-18GHz	Miteq	AFS42-00101800 -25-S-42	F00353	08/24/14
Peak / Average Power Sensor	Agilent / HP	E9323A	F00163	04/03/14
P-Series single channel Power Meter	Agilent / HP	N1911A	F00164	04/03/14

7. ANTENNA PORT TEST RESULTS

7.1. MEASUREMENT METHODS

6 dB BW: KDB 558074 D01 v03r01, Section 8.1.

Output Power: KDB 558074 D01 v03r01, Section 9.1.1.

Power Spectral Density: KDB 558074 D01 v03r01, Section 10.2.

Out-of-band emissions in non-restricted bands: KDB 558074 D01 v03r01, Section 11.0.

Out-of-band emissions in restricted bands: KDB 558074 D01 v03r01, Section 12.1

Out-of-band emissions in restricted bands: KDB 558074 D01 v03r01, Section 12.2.

Band-edge: KDB 558074 D01 v03r01, Section 13.2.

7.2. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

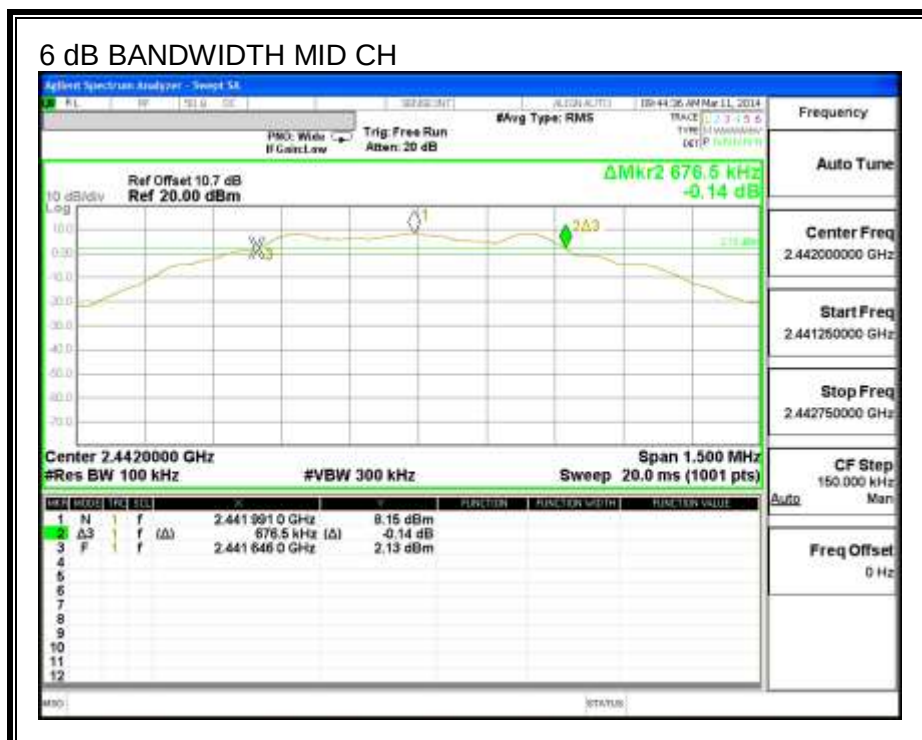
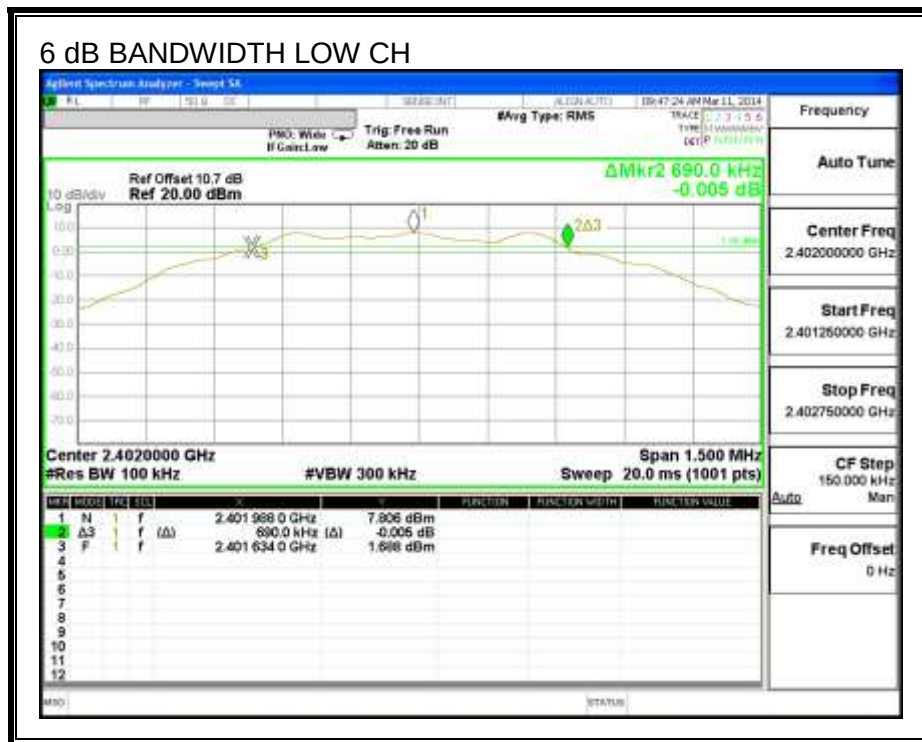
IC RSS-210 A8.2 (a)

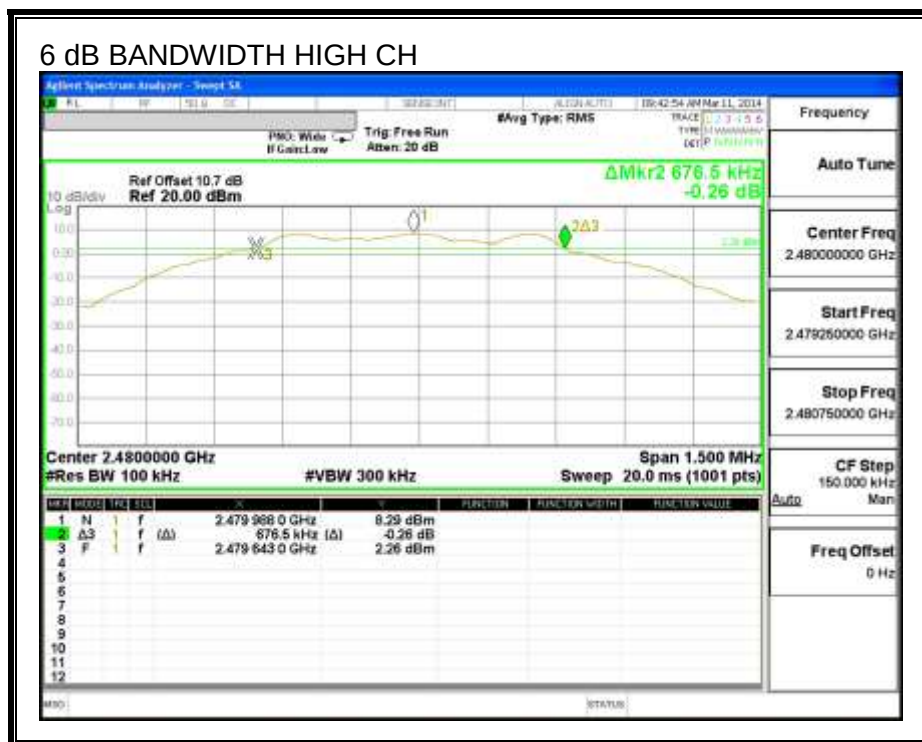
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6900	0.5
Middle	2442	0.6765	0.5
High	2480	0.6765	0.5

6 dB BANDWIDTH





7.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

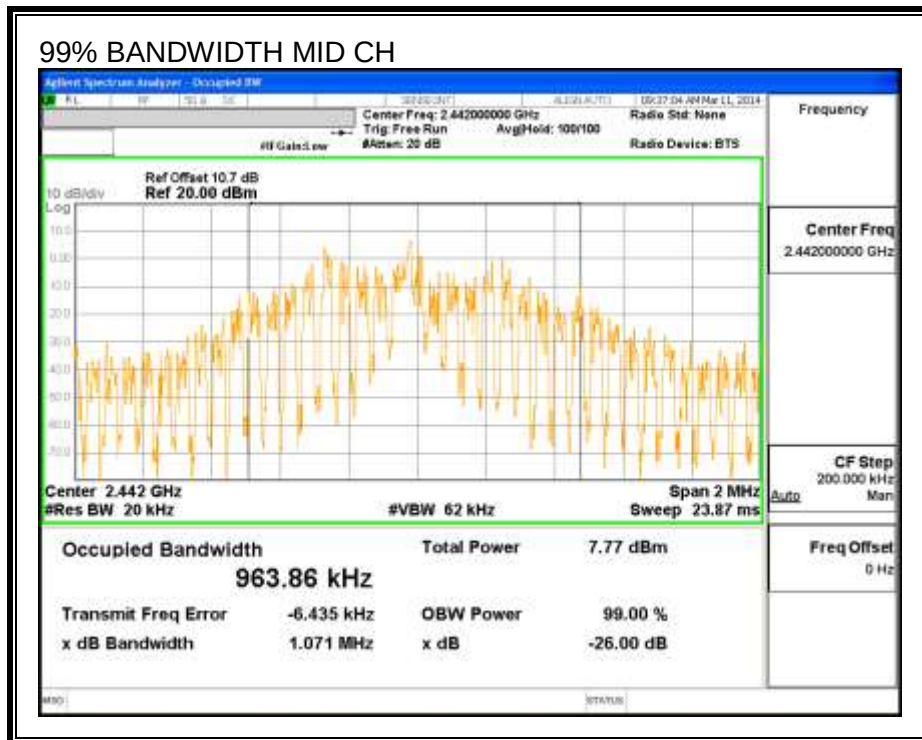
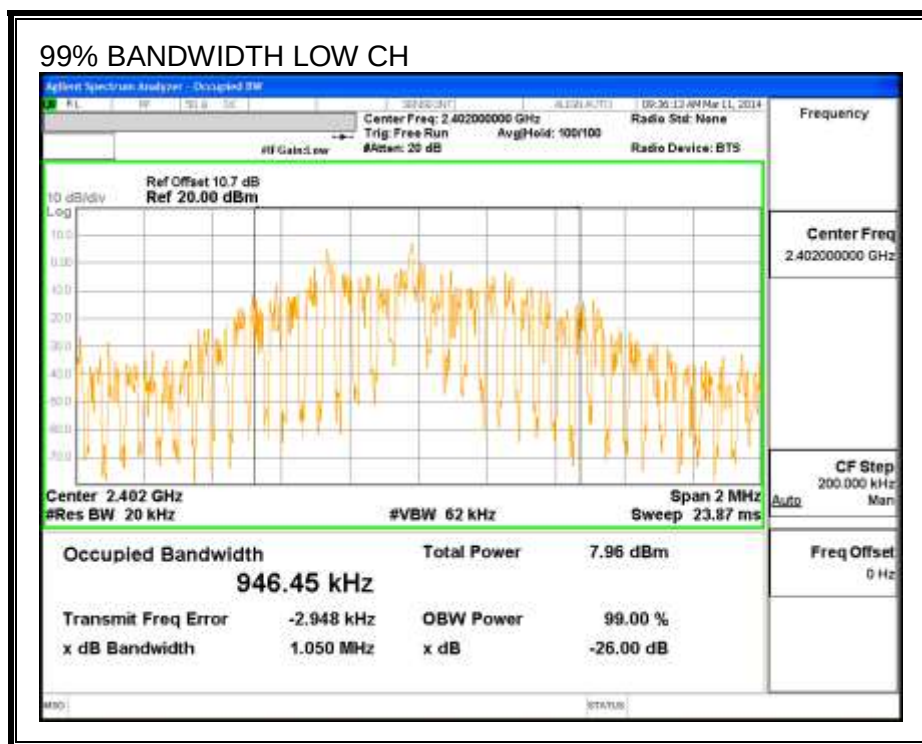
TEST PROCEDURE

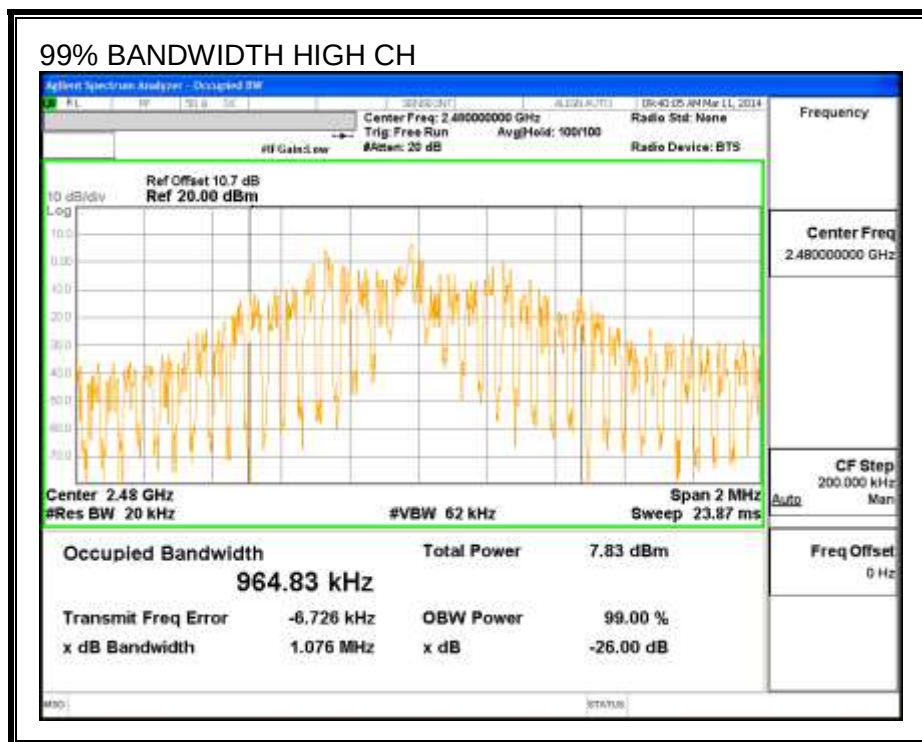
The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth and to 1% of the span. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	0.94645
Middle	2442	0.96386
High	2480	0.96483

99% BANDWIDTH





7.4. OUTPUT POWER

LIMITS

FCC §15.247 (b)

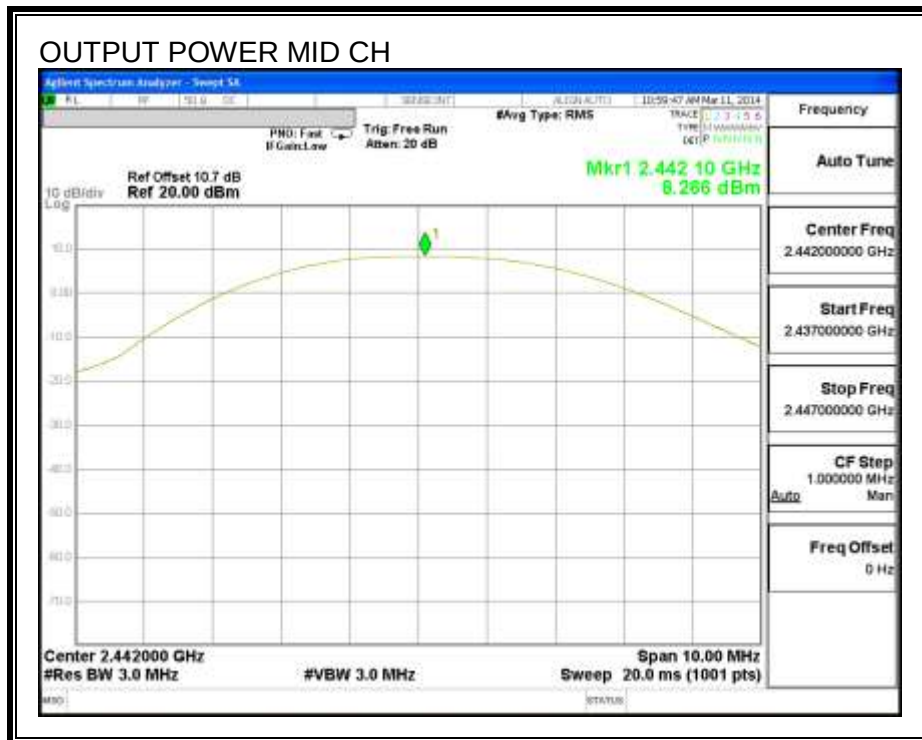
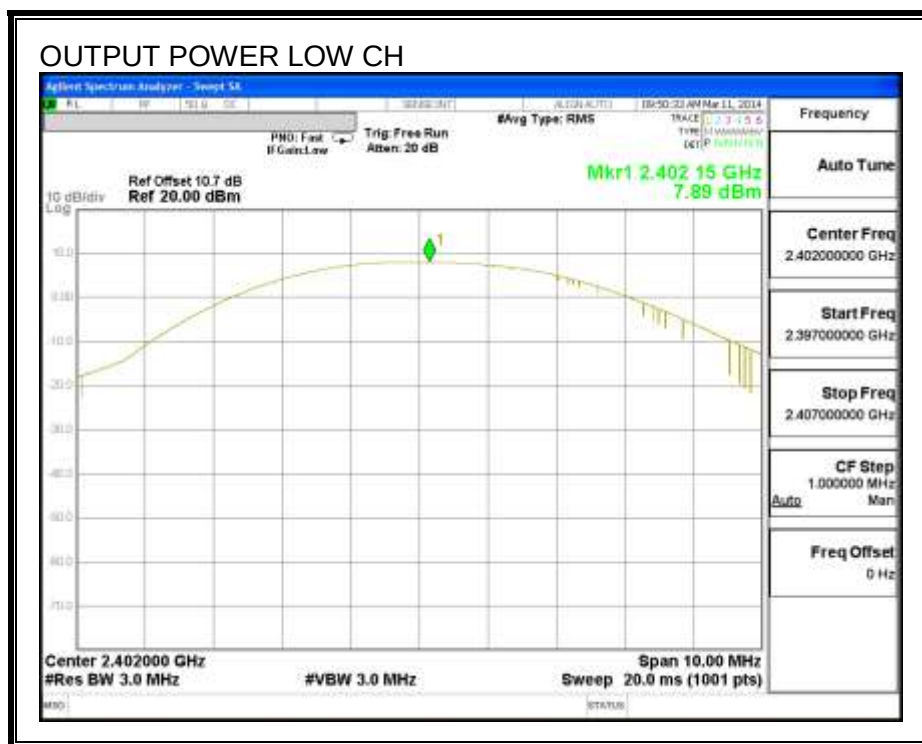
IC RSS-210 A8.4

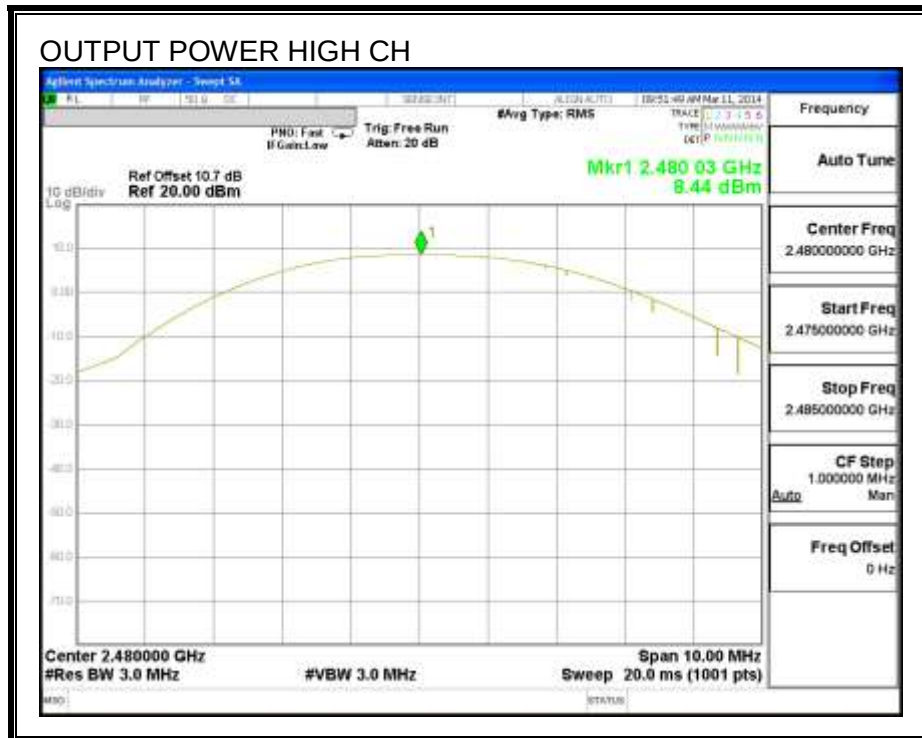
The maximum antenna gain is less than or equal to 6 dBi, therefore the limit is 30 dBm.

RESULTS

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	7.89	30	-22.110
Middle	2442	8.27	30	-21.730
High	2480	8.44	30	-21.560

OUTPUT POWER





7.5. AVERAGE POWER

LIMITS

None; for reporting purposes only.

RESULTS

The cable assembly insertion loss of 10.7 dB (including 10 dB pad and 0.7 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	7.71
Middle	2442	8.25
High	2480	8.34

7.6. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (e)

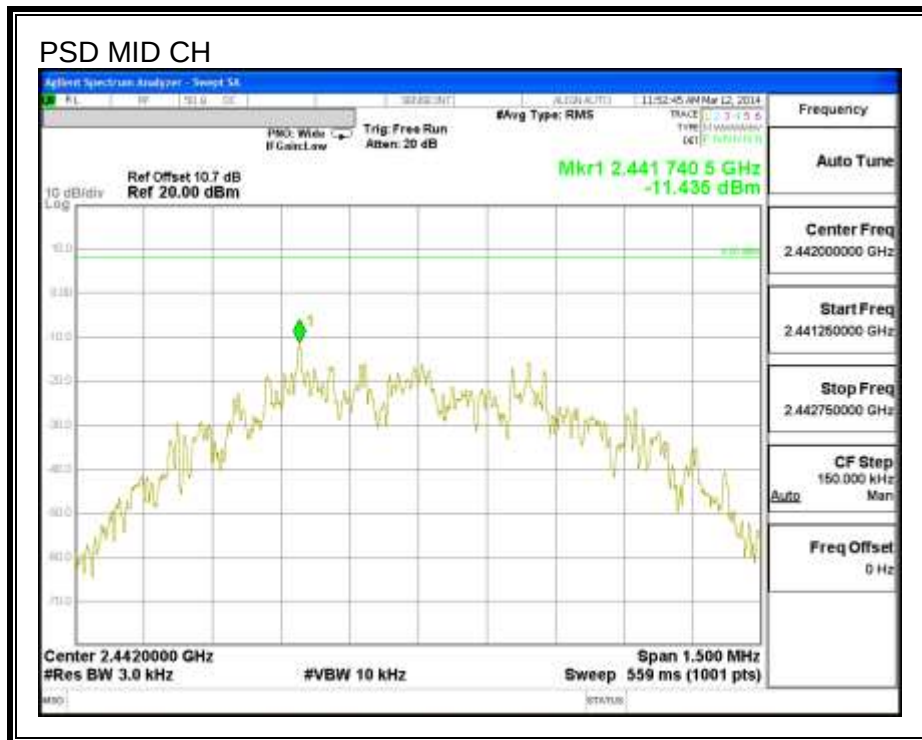
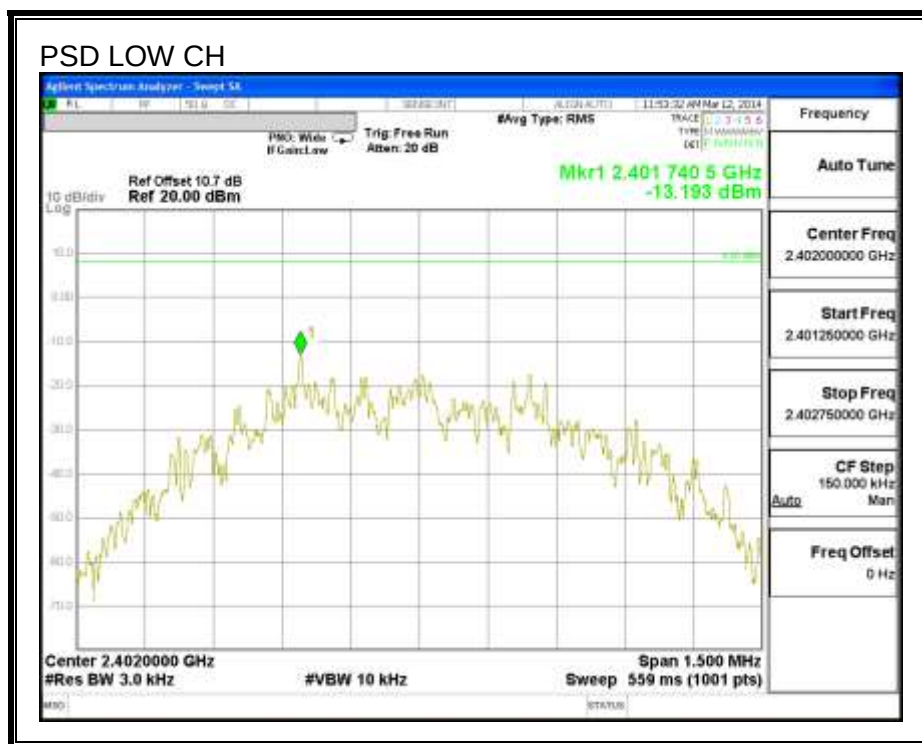
IC RSS-210 A8.2 (b)

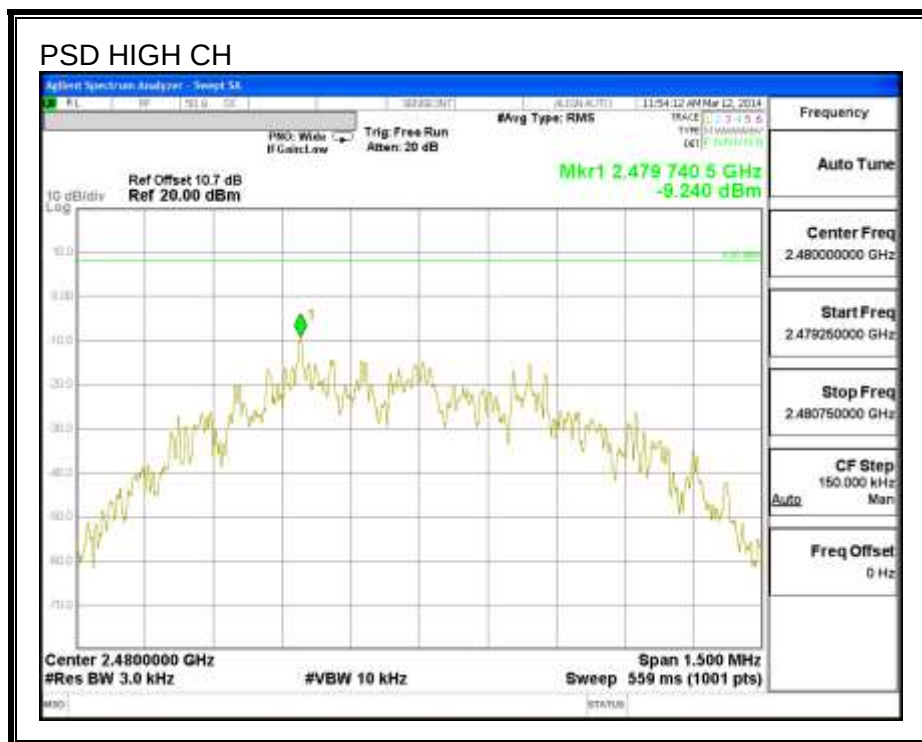
The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RESULTS

Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-13.19	8	-21.19
Middle	2442	-11.44	8	-19.44
High	2480	-9.24	8	-17.24

POWER SPECTRAL DENSITY





7.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

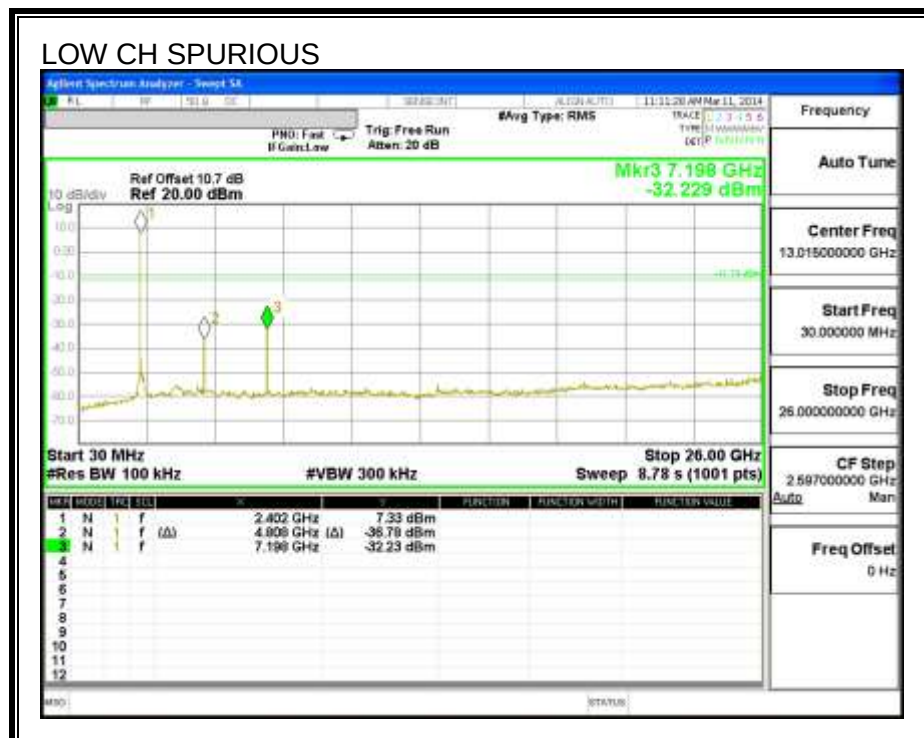
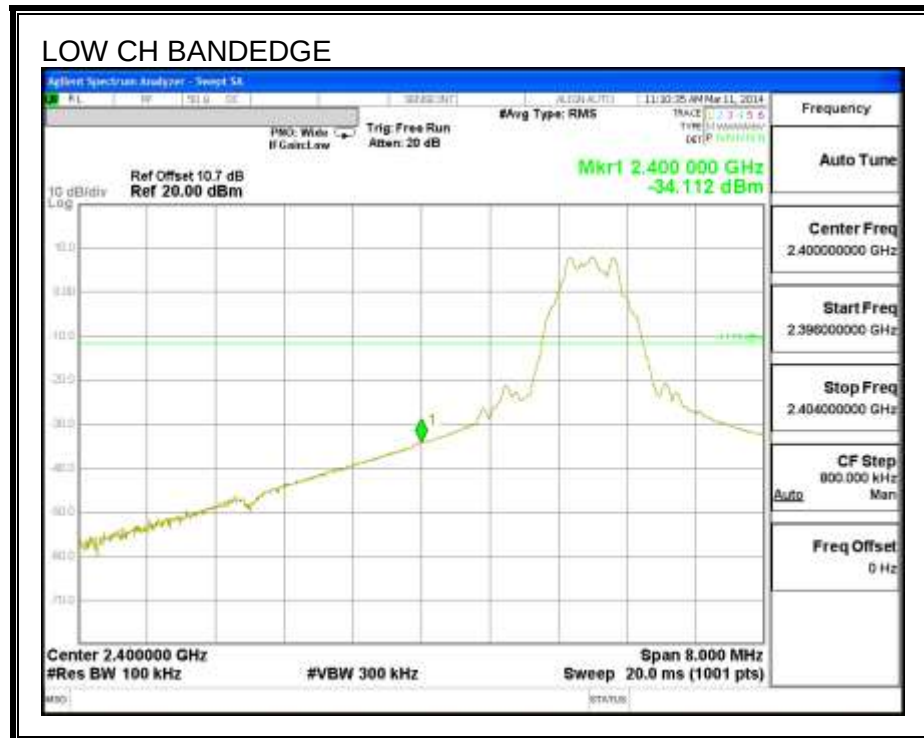
FCC §15.247 (d)

IC RSS-210 A8.5

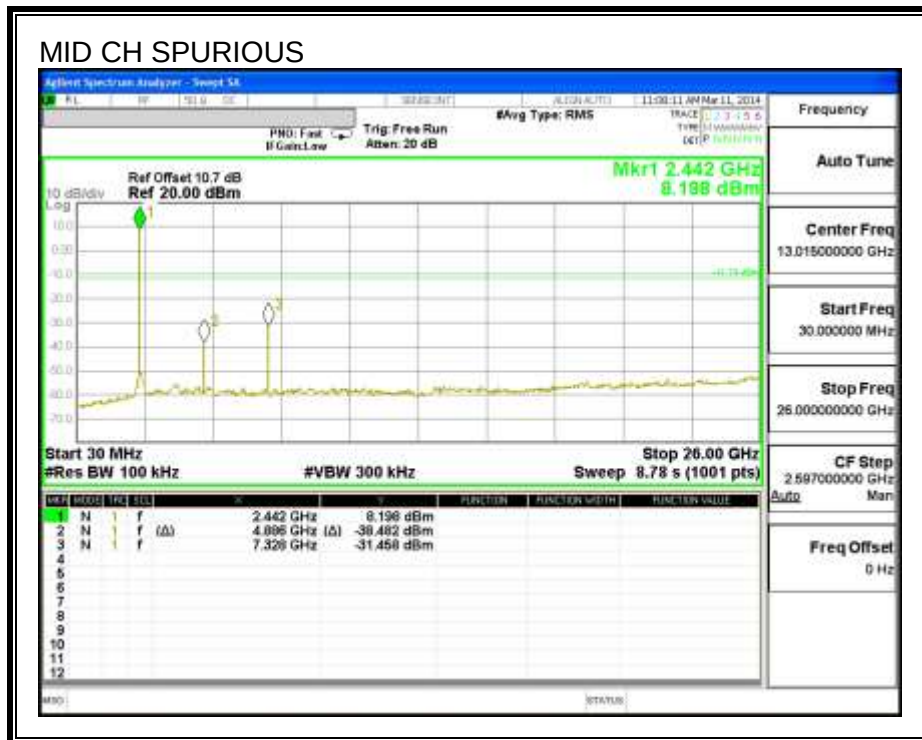
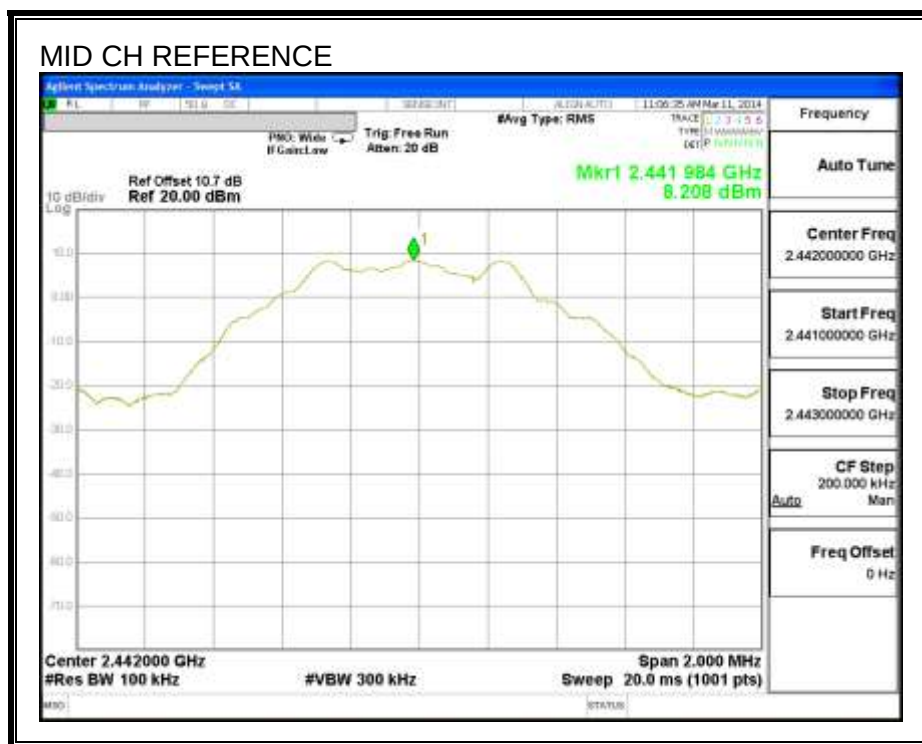
Output power was measured based on the use of a peak measurement, therefore the required attenuation is 20 dB.

RESULTS

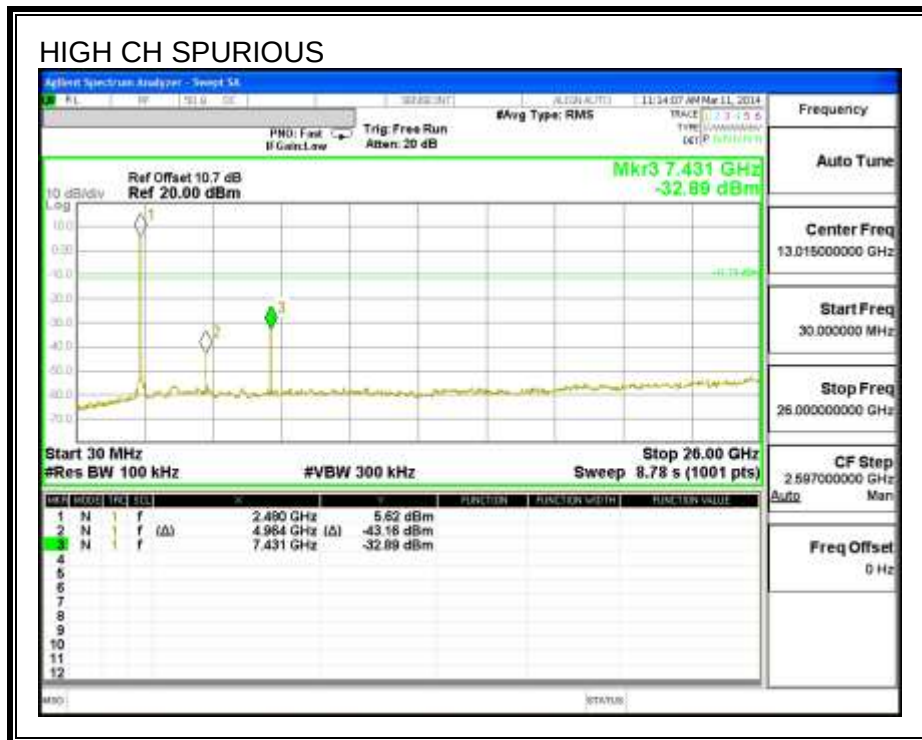
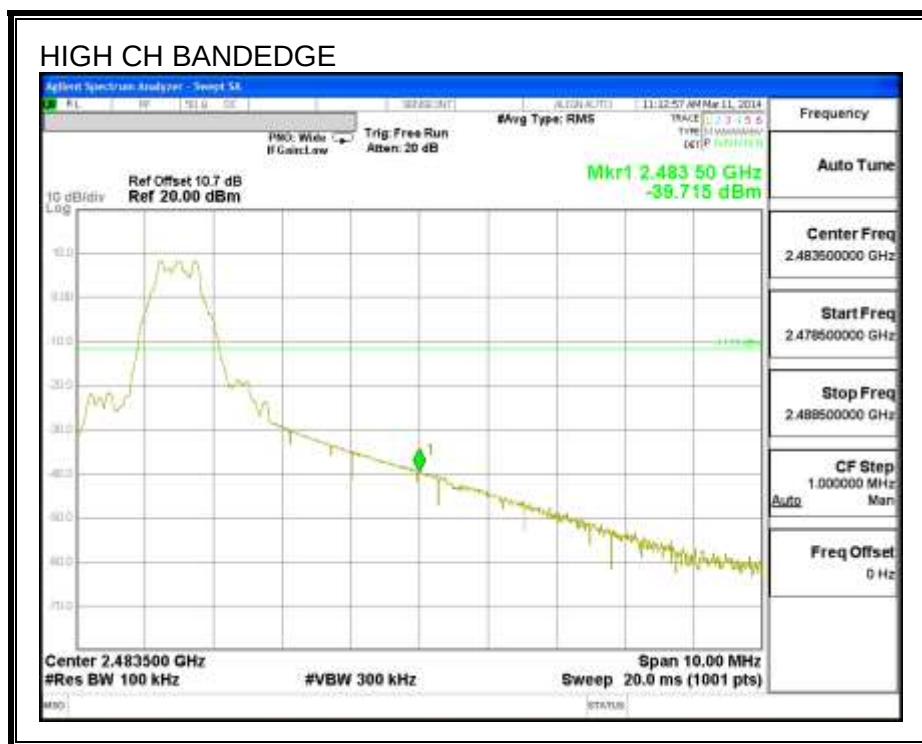
SPURIOUS EMISSIONS, LOW CHANNEL



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.

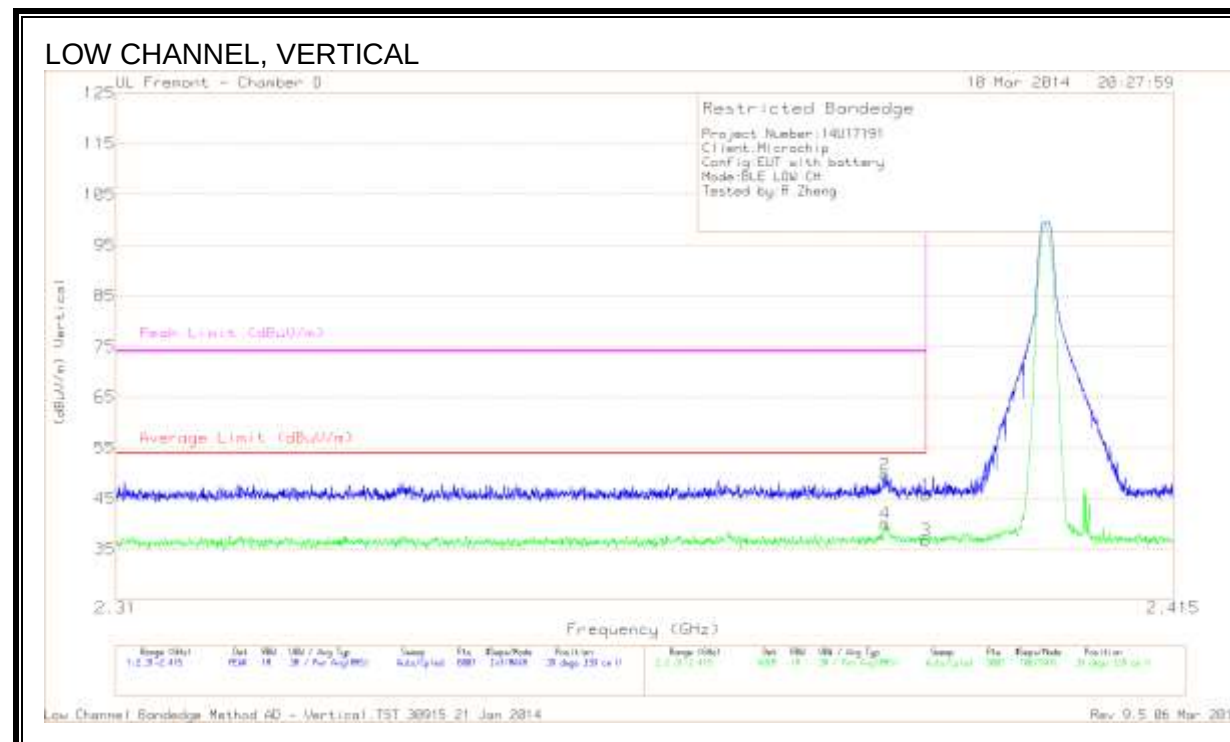
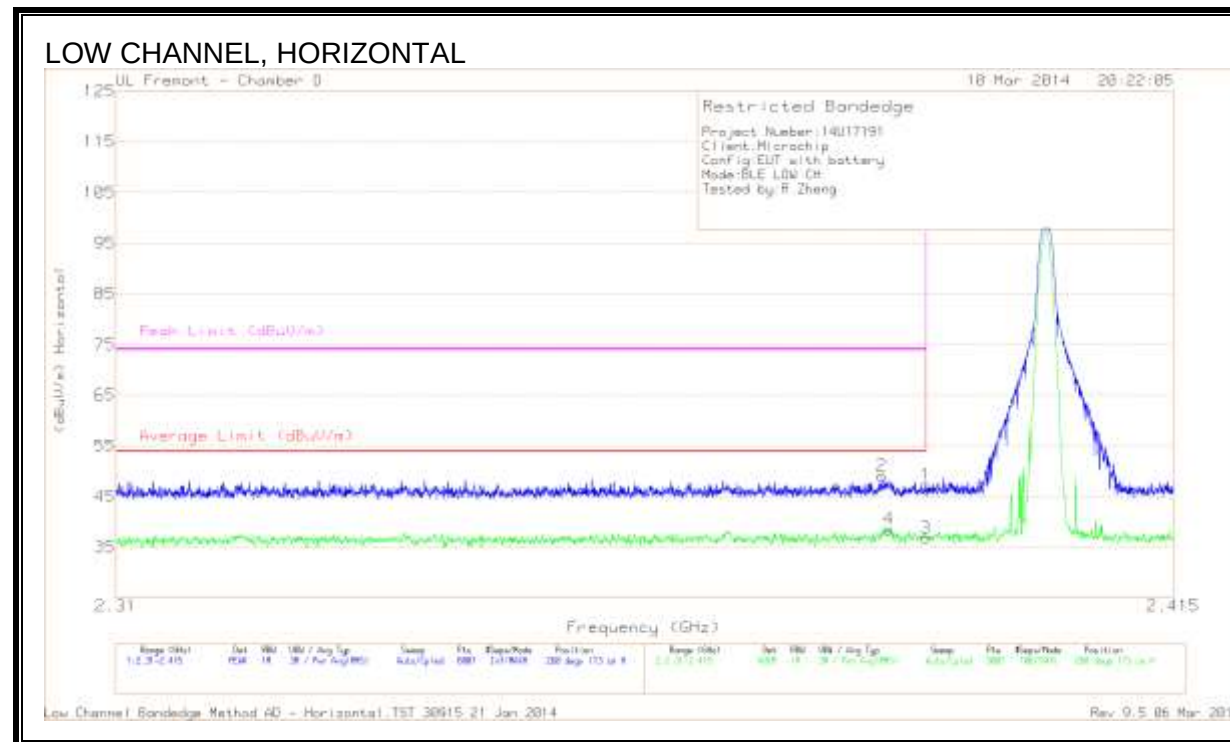
For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, and then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

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

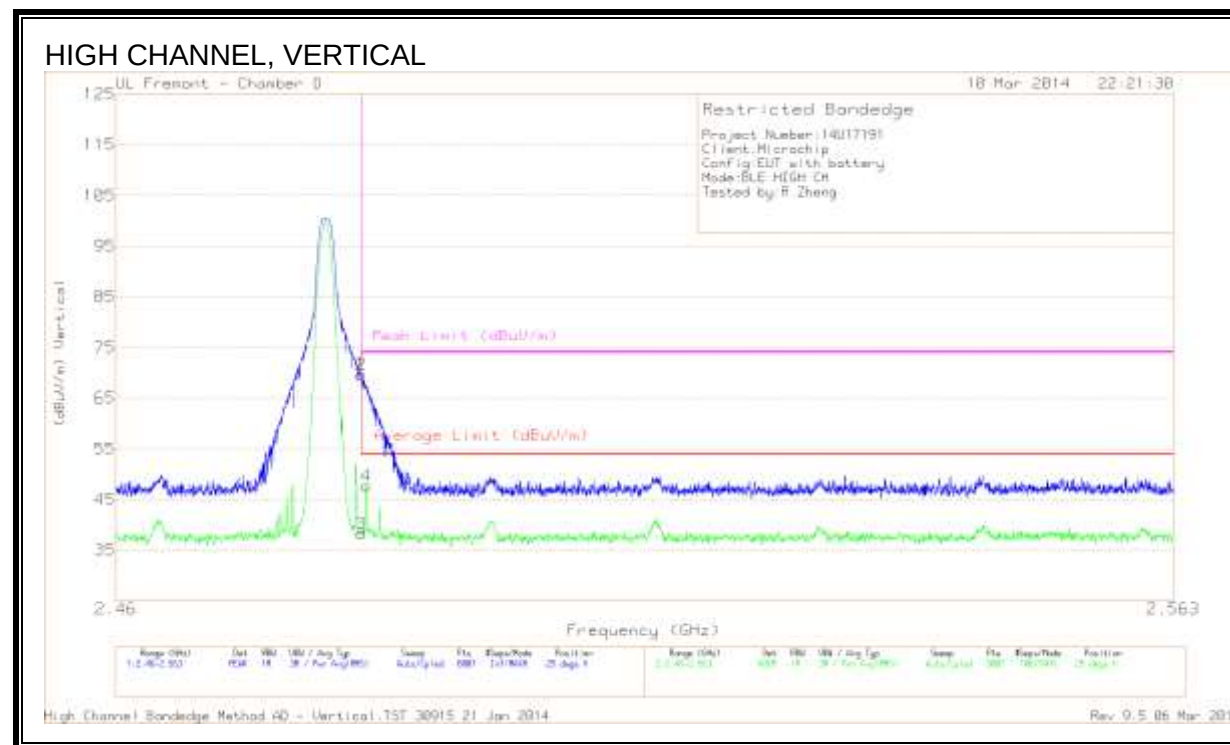
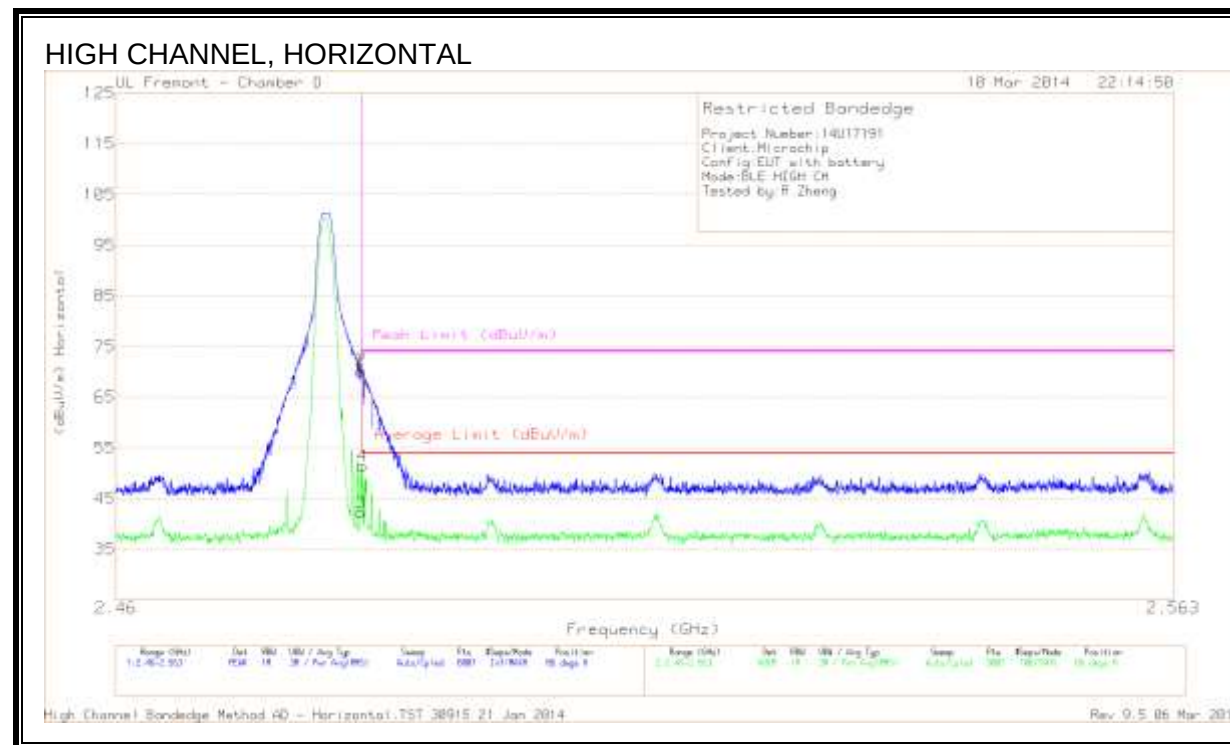


DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fitr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	2.390	36.36	PK	31.5	-20.6	47.26	-	-	74	-26.74	260	173	H
2	2.386	38.21	PK	31.5	-20.6	49.11	-	-	74	-24.89	260	173	H
3	2.390	25.95	RMS	31.5	-20.6	36.85	54	-17.15	-	-	260	173	H
4	2.386	27.66	RMS	31.5	-20.6	38.56	54	-15.44	-	-	260	173	H

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fitr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	2.390	34.79	PK	31.5	-20.6	45.69	-	-	74	-28.31	39	339	V
2	2.386	38.8	PK	31.5	-20.6	49.70	-	-	74	-24.30	39	339	V
3	2.390	25.9	RMS	31.5	-20.6	36.80	54	-17.20	-	-	39	339	V
4	2.386	29.23	RMS	31.5	-20.6	40.13	54	-13.87	-	-	39	339	V

PK - Peak detector
RMS - RMS detection



DATA

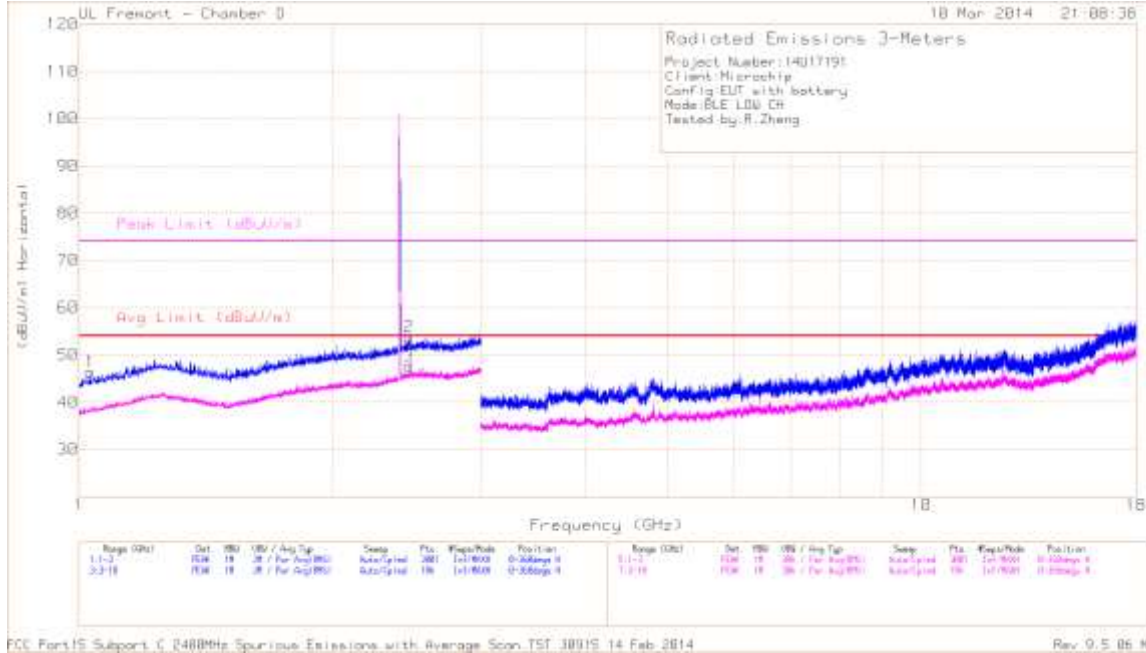
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	2.484	58.39	PK	32.1	-20.6	69.89	-	-	74	-4.11	86	212	H
2	2.484	58.84	PK	32.1	-20.6	70.34	-	-	74	-3.66	86	212	H
3	2.484	30.77	RMS	32.1	-20.6	42.27	54	-11.73	-	-	86	212	H
4	2.484	39.88	RMS	32.1	-20.6	51.38	54	-2.62	-	-	86	212	H

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	2.484	58.12	PK	32.1	-20.6	69.62	-	-	74	-4.38	25	320	V
2	2.484	58.12	PK	32.1	-20.6	69.62	-	-	74	-4.38	25	320	V
3	2.484	26.76	RMS	32.1	-20.6	38.26	54	-15.74	-	-	25	320	V
4	2.484	36.13	RMS	32.1	-20.6	47.63	54	-6.37	-	-	25	320	V

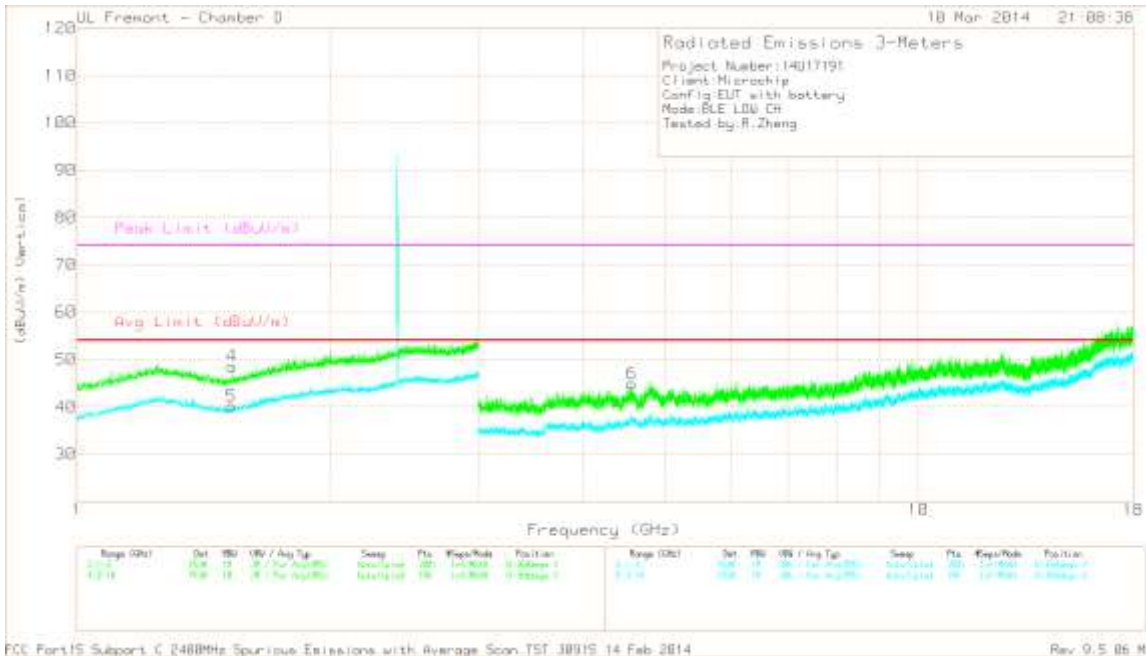
8.3. TRANSMITTER ABOVE 1 GHz

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL HORIZONTAL



LOW CHANNEL VERTICAL



DATA

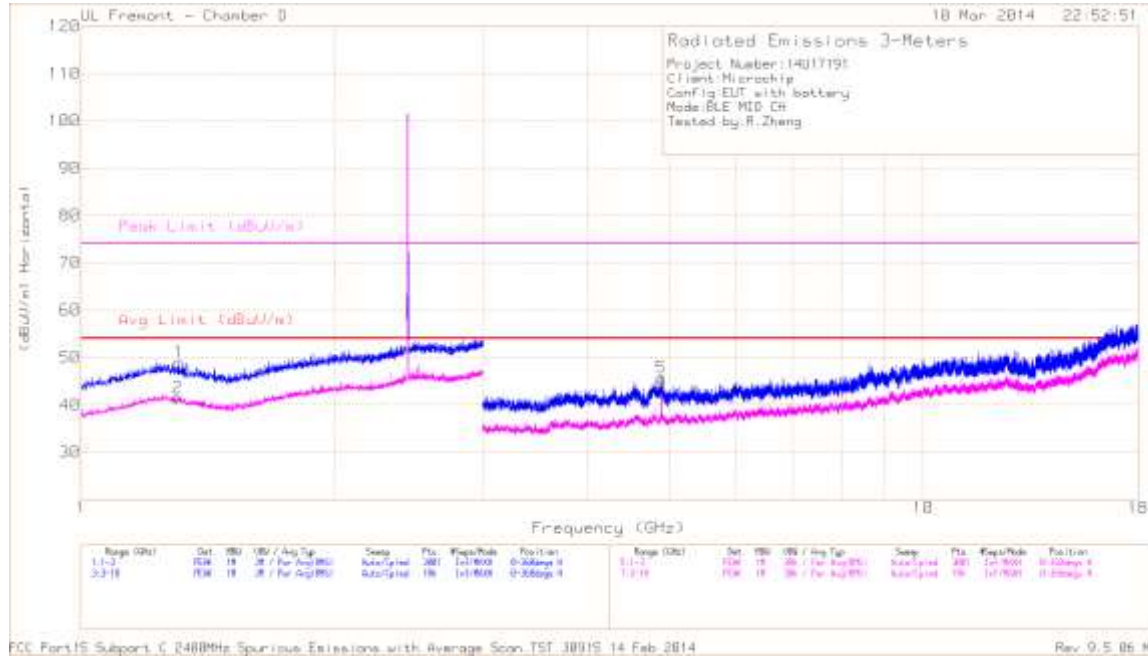
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1	* 1.032	42.28	PK	26.5	-22.4	46.38	54	-7.62	74	-27.62	0-360	100	H
2	2.464	42.40	PK	32.0	-20.6	53.80	-	-	-	-	0-360	100	H
3	2.466	36.32	VB	32.0	-20.6	47.72	54	-	-	-	0-360	201	H
4	* 1.529	43.01	PK	27.2	-21.6	48.61			74	-25.39	0-360	100	V
5	* 1.527	34.58	VB	27.2	-21.6	40.18	54	-13.82			0-360	201	V
6	* 4.564	37.85	PK	33.5	-26.4	44.95	54	-9.05	74	-29.05	0-360	201	V

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

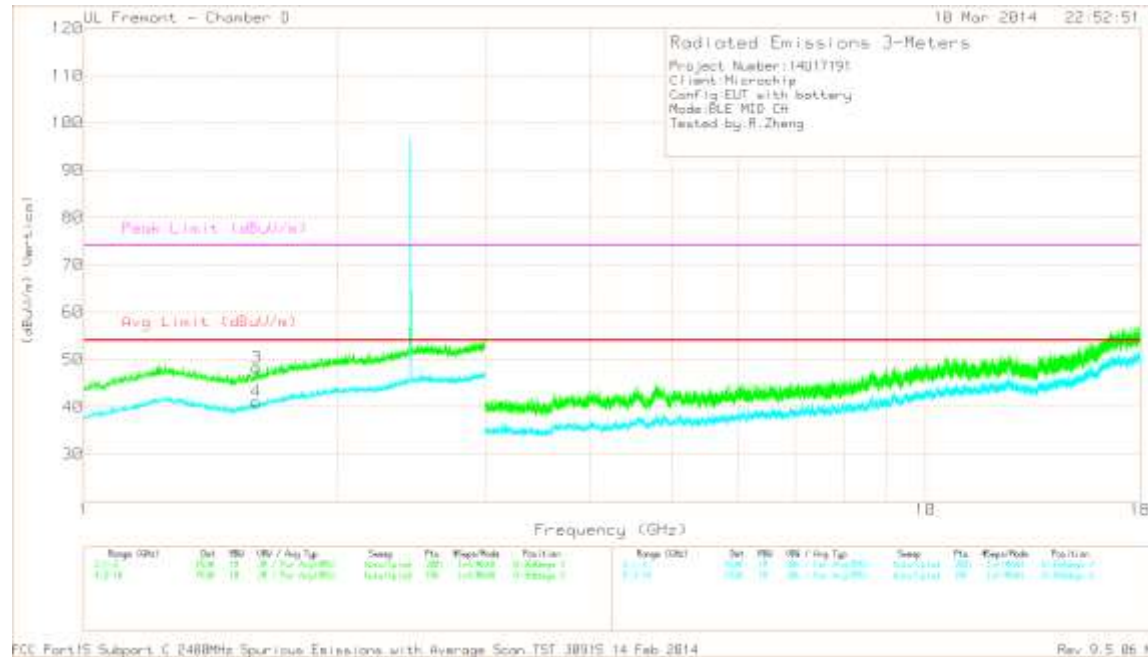
PK - Peak detector

VB – Reduced Video Bandwidth

MID CHANNEL HORIZONTAL



MID CHANNEL VERTICAL



DATA

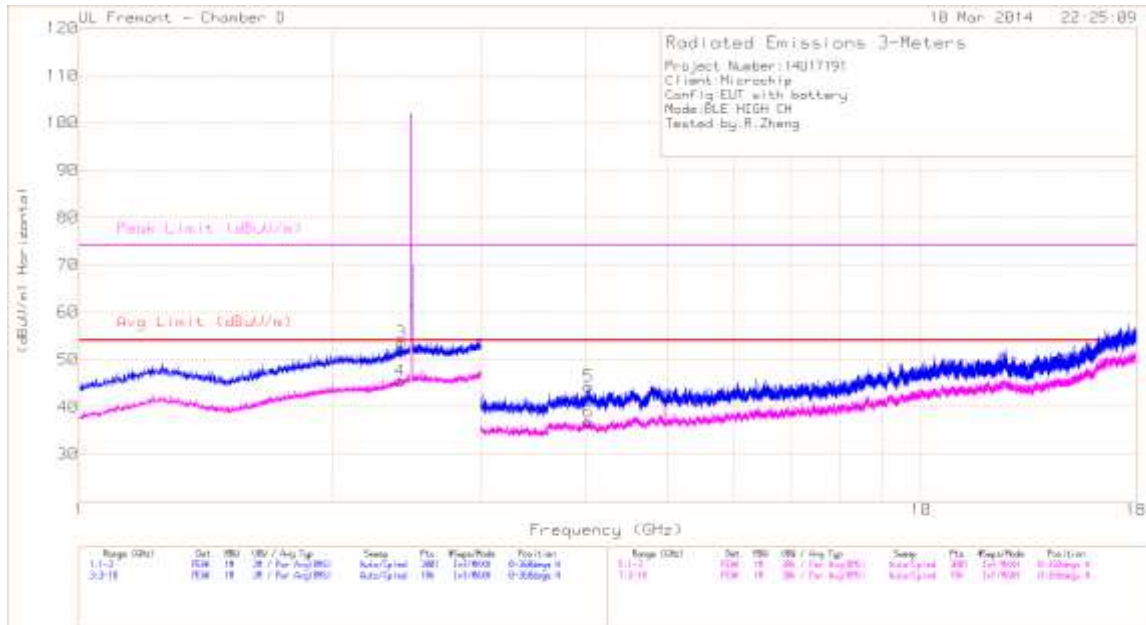
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fitr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.307	42.02	PK	29.0	-21.9	49.12			74	-24.88	0-360	100	H
2	* 1.302	34.42	VB	29.0	-21.9	41.52	54	-12.48			0-360	201	H
3	* 1.604	42.06	PK	27.9	-21.7	48.26			74	-25.74	0-360	201	V
4	* 1.602	34.86	VB	27.9	-21.7	41.06	54	-12.94			0-360	201	V
5	* 4.885	39.39	PK	33.5	-27.2	45.69			74	-28.31	0-360	201	H
6	* 4.884	36.28	VB	33.5	-27.1	42.68	54	-11.32			0-360	201	H

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

PK - Peak detector

VB – Reduced Video Bandwidth

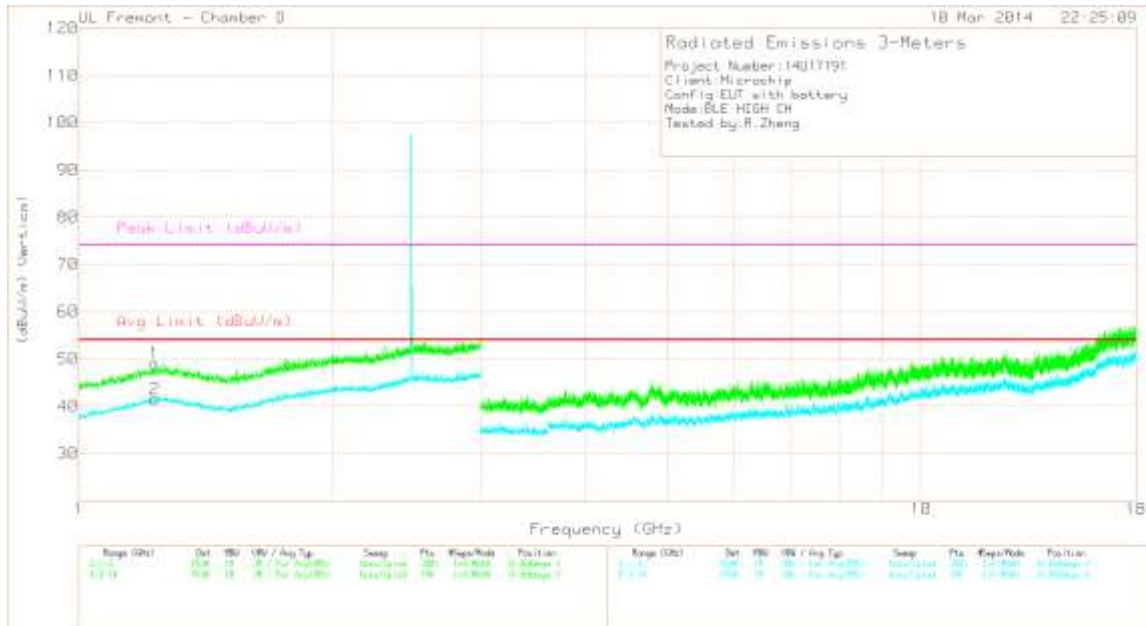
HIGH CHANNEL HORIZONTAL



FCC Part 15 Subpart C 2400MHz Spurious Emissions with Average Scan TST 38915 14 Feb 2014

Rev. 9.5 06 Mar 2014

HIGH CHANNEL VERTICAL



FCC Part 15 Subpart C 2400MHz Spurious Emissions with Average Scan TST 38915 14 Feb 2014

Rev. 9.5 06 Mar 2014

DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T712 (dB/m)	Amp/Cbl/ Fitr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.229	41.77	PK	29.3	-22.0	49.07	-	-	74	-24.93	0-360	201	V
2	* 1.230	34.23	VB	29.3	-22.0	41.53	54	-12.47	-	-	0-360	201	V
3	2.416	42.59	PK	31.7	-20.7	53.59	-	-	-	-	0-360	201	H
4	2.409	34.65	PK	31.6	-20.7	45.55	-	-	-	-	0-360	100	H
5	* 4.022	39.44	PK	32.9	-28.0	44.34	-	-	74	-29.66	0-360	201	H
6	* 4.027	32.07	VB	32.9	-28.1	36.87	54	-17.13	-	-	0-360	201	H

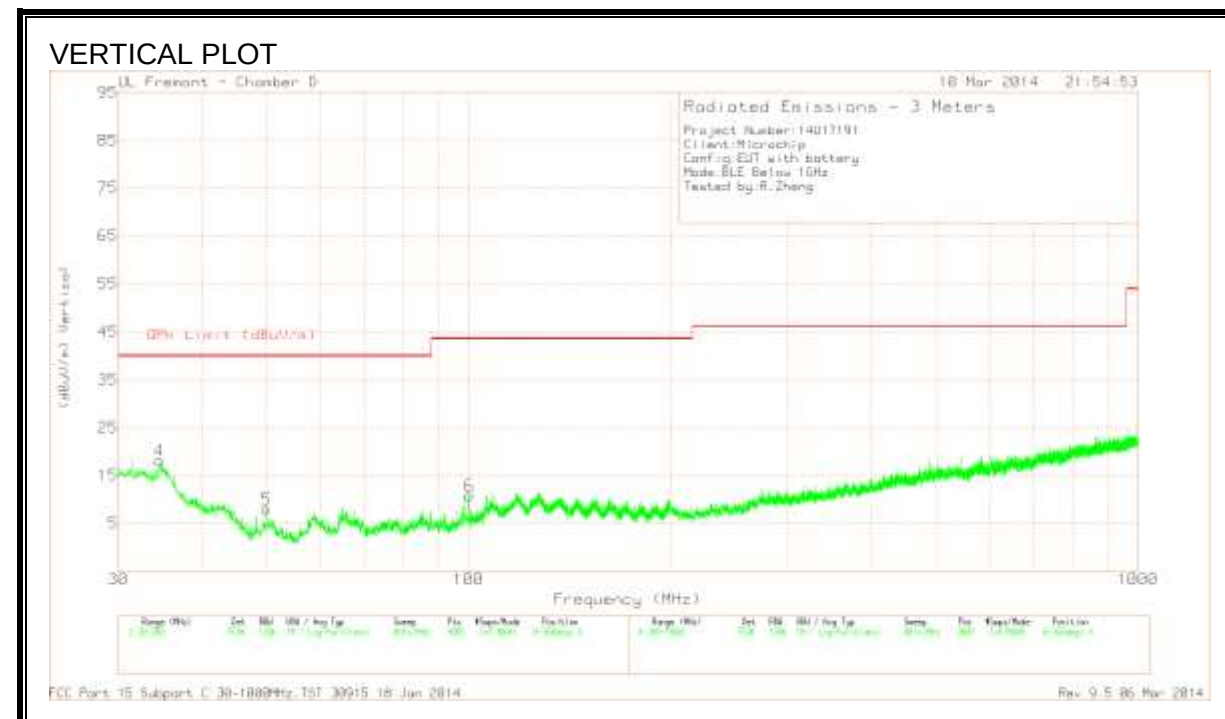
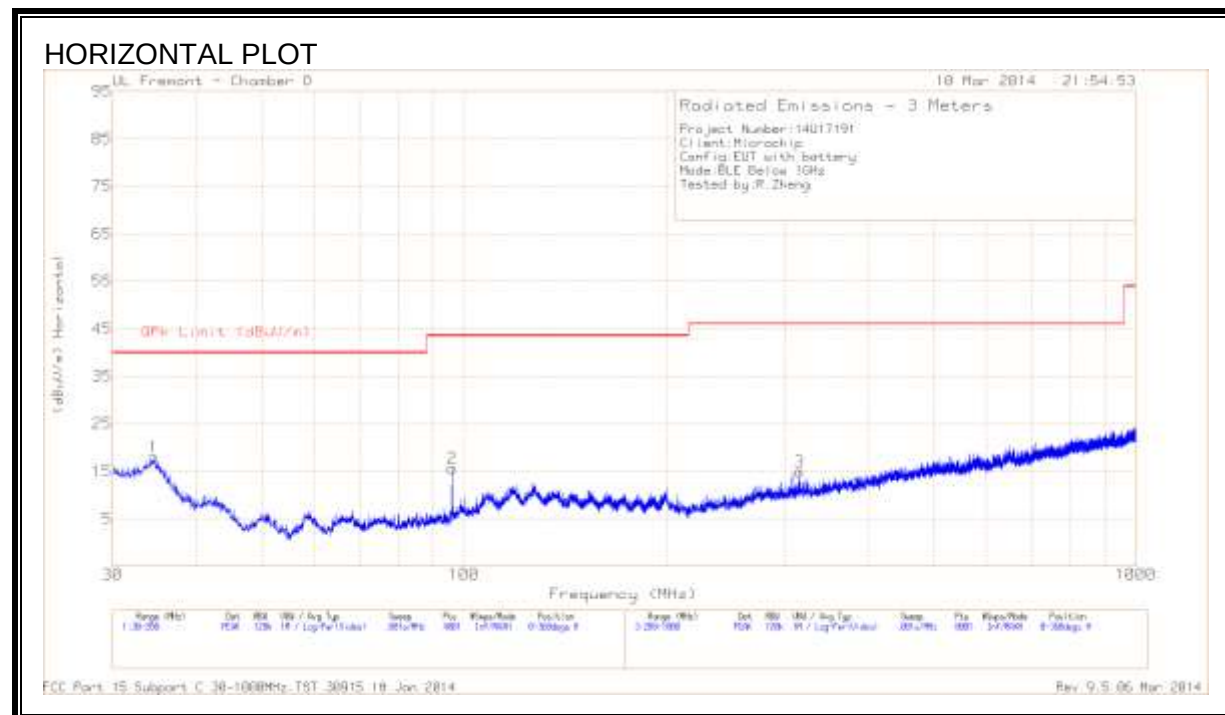
* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

VB – Reduced Video Bandwidth

8.4. WORST-CASE BELOW 1 GHz

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



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AFT407 dB/m	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	34.5900	31.93	PK	17.9	-31.9	17.93	40.00	-22.07	0-360	400	H
2	96.0025	37.86	PK	9.1	-31.3	15.66	43.52	-27.86	0-360	300	H
3	316.000	31.74	PK	13.7	-30.5	14.94	46.02	-31.08	0-360	100	H
4	34.5475	32.04	PK	18.0	-31.9	18.14	40.00	-21.86	0-360	100	V
5	49.8900	31.27	PK	8.0	-31.3	7.97	40.00	-32.03	0-360	100	V
6	100.295	32.38	PK	10.2	-31.7	10.88	43.52	-32.64	0-360	100	V

PK - Peak detector