



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

**ZIGBEE
CERTIFICATION TEST REPORT**

FOR

THERMOSTAT

MODEL NUMBER: C4-THERM

**FCC ID: R33C4THERM
IC: 7848A-C4THERM**

REPORT NUMBER: 14U19506-E2 REVISION E

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Prepared for
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	12/29/14	Initial Issue	P. Zhang
A	1/6/15	Updated page 5,6,7,10,11,21 regarding standard version and statement	P. Zhang
B	1/15/15	Updated equipment list	P. Zhang
C	1/21/15	Updated page 12 regarding standard version	P. Zhang
D	1/23/15	Updated equipment list; page 10; page 25; add appendix for DC factor calculation	P. Zhang
E	1/26/15	Updated page 23-24	P. Zhang

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ATTESTATION OF TEST RESULTS

COMPANY NAME: CONTROL 4 CORP.
EUT DESCRIPTION: THERMOSTAT
MODEL: C4-THERM
SERIAL NUMBER: 2010928
DATE TESTED: December 8 to 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 4	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:

Tested By:



PENG ZHANG
PROJECT LEAD
UL Verification Services Inc.



CHARLES VERGONIO
TEST ENGINEER
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2009, FCC CFR 47 Part 2, FCC CFR 47 Part 15, RSS-GEN Issue 4, 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
<input type="checkbox"/> Chamber A(IC: 2324B-1)	<input type="checkbox"/> Chamber D(IC: 2324B-4)
<input checked="" type="checkbox"/> Chamber B(IC: 2324B-2)	<input type="checkbox"/> Chamber E(IC: 2324B-5)
<input type="checkbox"/> Chamber C(IC: 2324B-3)	<input type="checkbox"/> Chamber F(IC: 2324B-6)
	<input type="checkbox"/> Chamber G(IC: 2324B-7)
	<input type="checkbox"/> Chamber H(IC: 2324B-8)

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 26000 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 residential-use wall-mount thermostat. The device has a 2.4 GHz Zigbee transceiver. The EUT is powered by 24 V, 50/60 Hz, and has battery backup

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)
2405-2475	ZIGBEE	2.06	1.61

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an FPCB antenna, with a maximum gain of 2.1 dBi.

5.4. WORST-CASE CONFIGURATION AND MODE

The worst-case data rate for each mode is determined to be as follows, based on input from the manufacturer of the radio.

All final tests in the ZIGBEE mode were made at power setting 2.

For radiated emissions below 1 GHz the worst-case configuration is determined to be the mode and channel with the highest output power.

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.

5.5. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST			
Description	Manufacturer	Model	Serial Number
Power supply/HVAC simulator	Control 4	No M/N	No S/N
Home Controller	Control 4	C4-HC250-BL	1408090006
Remote control	Control 4	C4-SR150RSK-B	C0LKA016131800033CHG

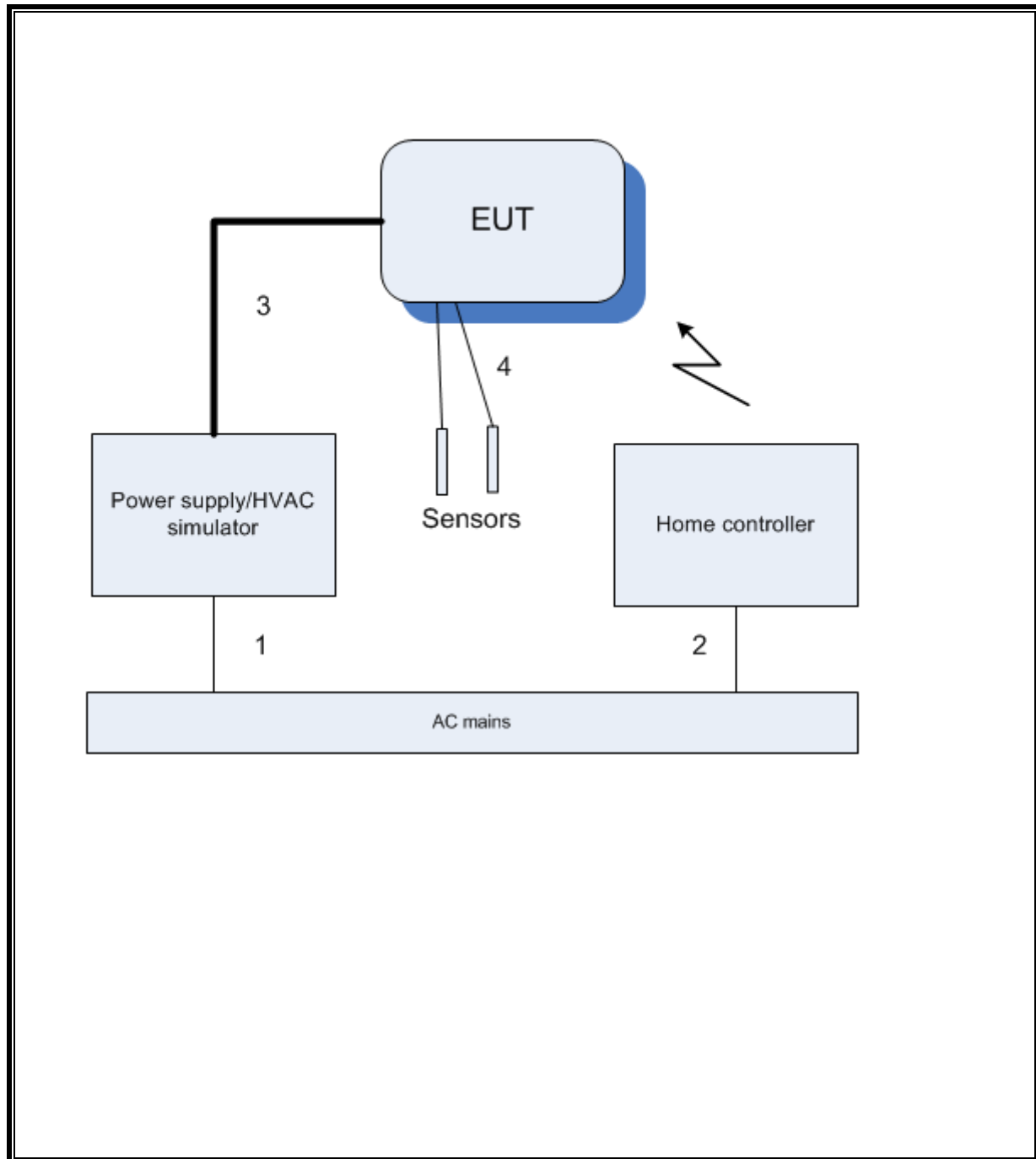
I/O CABLES

I/O CABLE LIST						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length m	Remarks
1	AC	1	2-prong	Unshielded	1.6	
2	AC	1	3-prong	Unshielded	1.8	
3	Power and control	1	Terminal blocks	Bundled	4.5	One 24 VAC cable and two control cables. Control cables were shielded but the shields were not terminated at either end.
4	Temp	2	Terminal block	Unshielded	1	

TEST SETUP

The EUT was operated according to instructions provided by the manufacturer and the display monitored for the radio link and display functionality.

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
Antenna, Biconolog, 30MHz-1 GHz	Sunol Sciences	JB1	C01171	02/13/15
Antenna, Horn, 18GHz	EMCO	3115	C00783	10/25/15
Antenna, Horn, 25.5 GHz	ARA	MWH-1826/B	C00980	11/14/15
Amplifier, 1 - 18GHz	Miteq	AFS42-00101800-25-S-42	1782153	6/23/2015
Preamplifier, 26.5 GHz	Agilent / HP	8449B	C01052	10/22/15
Spectrum Analyzer, 44 GHz	Agilent / HP	E4446A	C01069	12/20/15
Peak Power Meter	Agilent / HP	E4416A	C00963	12/13/15
Peak / Average Power Sensor	Agilent / HP	E9327A	C00964	12/13/15
LISN, 30 MHz	FCC	50/250-25-2	C00626	01/14/15
Reject Filter, 2.4GHz	Micro-Tronics	BRM50702	N02684	CNR

7. MEASUREMENT METHODS

KDB 558074 D01 DTS Meas Guidance v03r02: Measurement Procedure AVGPM-G is used for power and AVGPS-3 is used for power spectral density.

Unwanted emissions within Restricted Bands are measured using traditional radiated procedures.

Band edge emissions within Restricted Bands are measured using RMS with duty cycle factor offset method.

8. SUMMARY

FCC Part Section	RSS Section(s)	Test Description	Test Limit	Test Condition	Test Result	Worst Case
15.247 (a)(2)	RSS-210 A8.2(a)	Occupied Band width (6dB)	>500KHz	Conducted	Pass	1.54MHz
2.1051, 15.247 (d)	RSS-210 A8.5	Band Edge / Conducted Spurious Emission	-20dBc		Pass	-34.2dBm
15.247	RSS-210 A8.4	TX conducted output power	<30dBm		Pass	2.06dBm
15.247	RSS-210 A8.2	PSD	<8dBm		Pass	-7.45dBm
15.207 (a)	RSS-GEN 8.8	AC Power Line conducted emissions	Section 10	Radiated	Pass	35.13dBuV(PK)
15.205, 15.209	RSS-GEN 8.9	Radiated Spurious Emission	< 54dBuV/m		Pass	52.51dBuV/m

9. ANTENNA PORT TEST RESULTS

9.1. 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

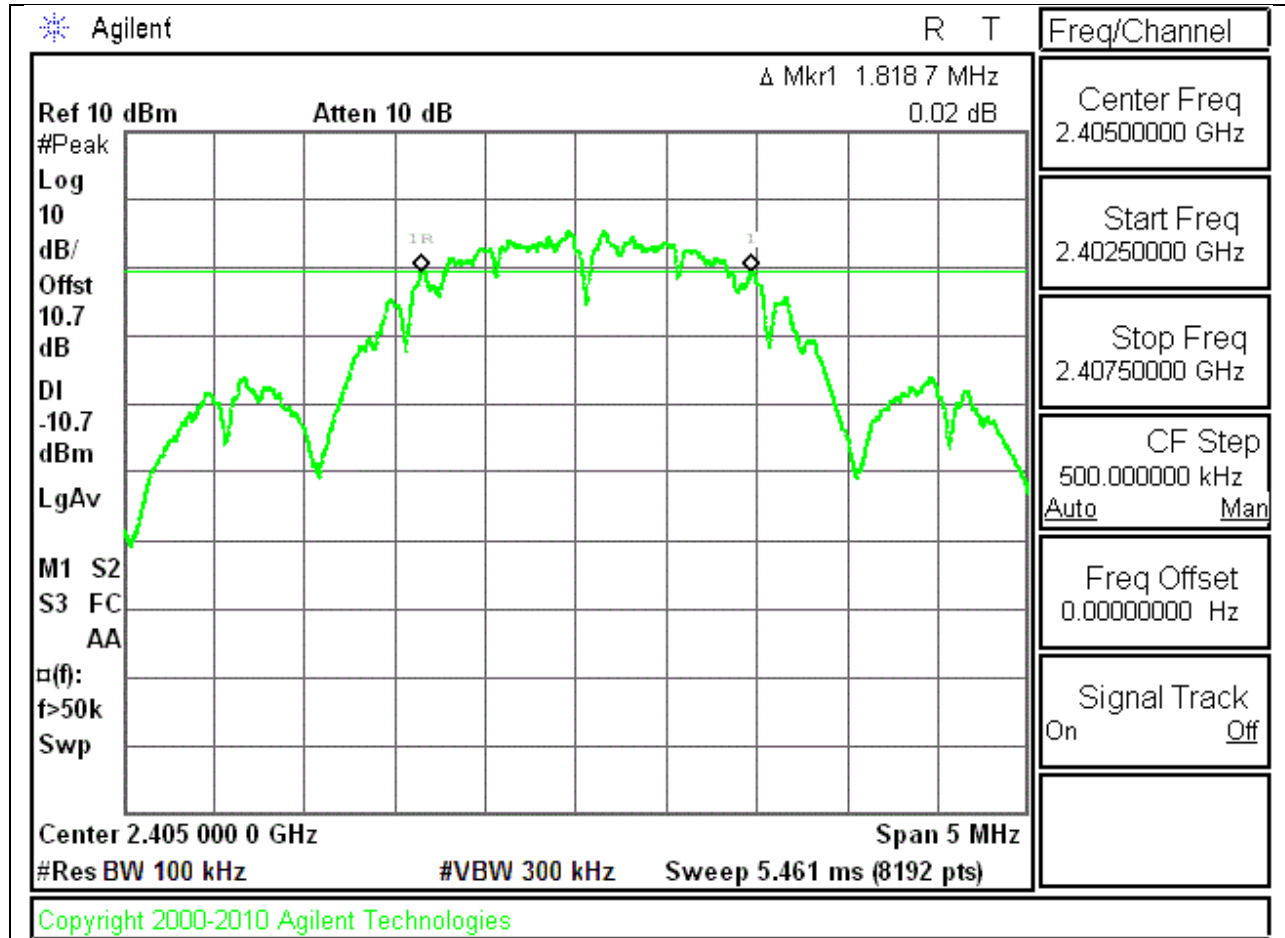
The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

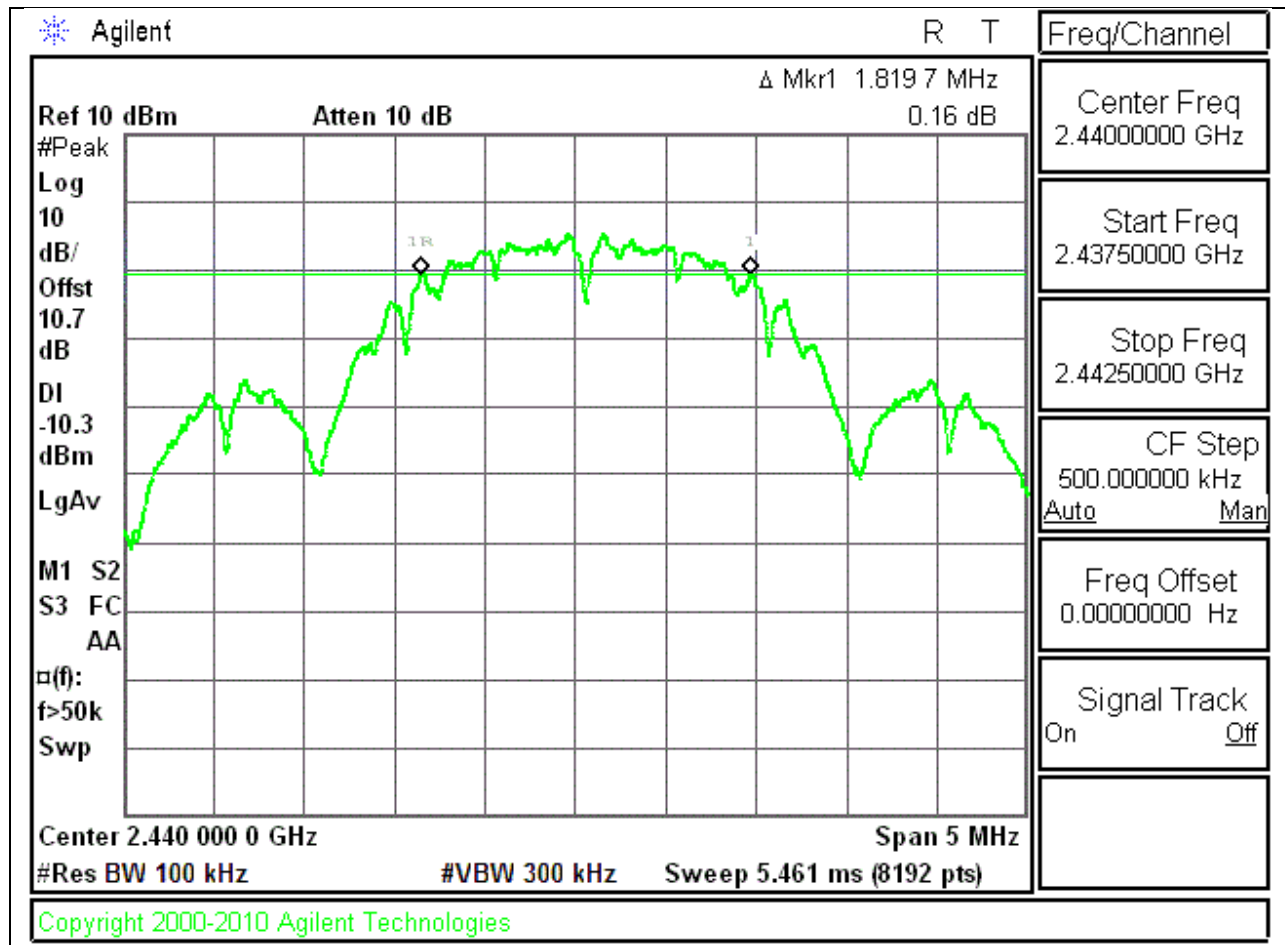
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2405	1.8187	0.5
Middle	2440	1.8197	0.5
High	2475	1.8205	0.5

6 dB BANDWIDTH PLOTS

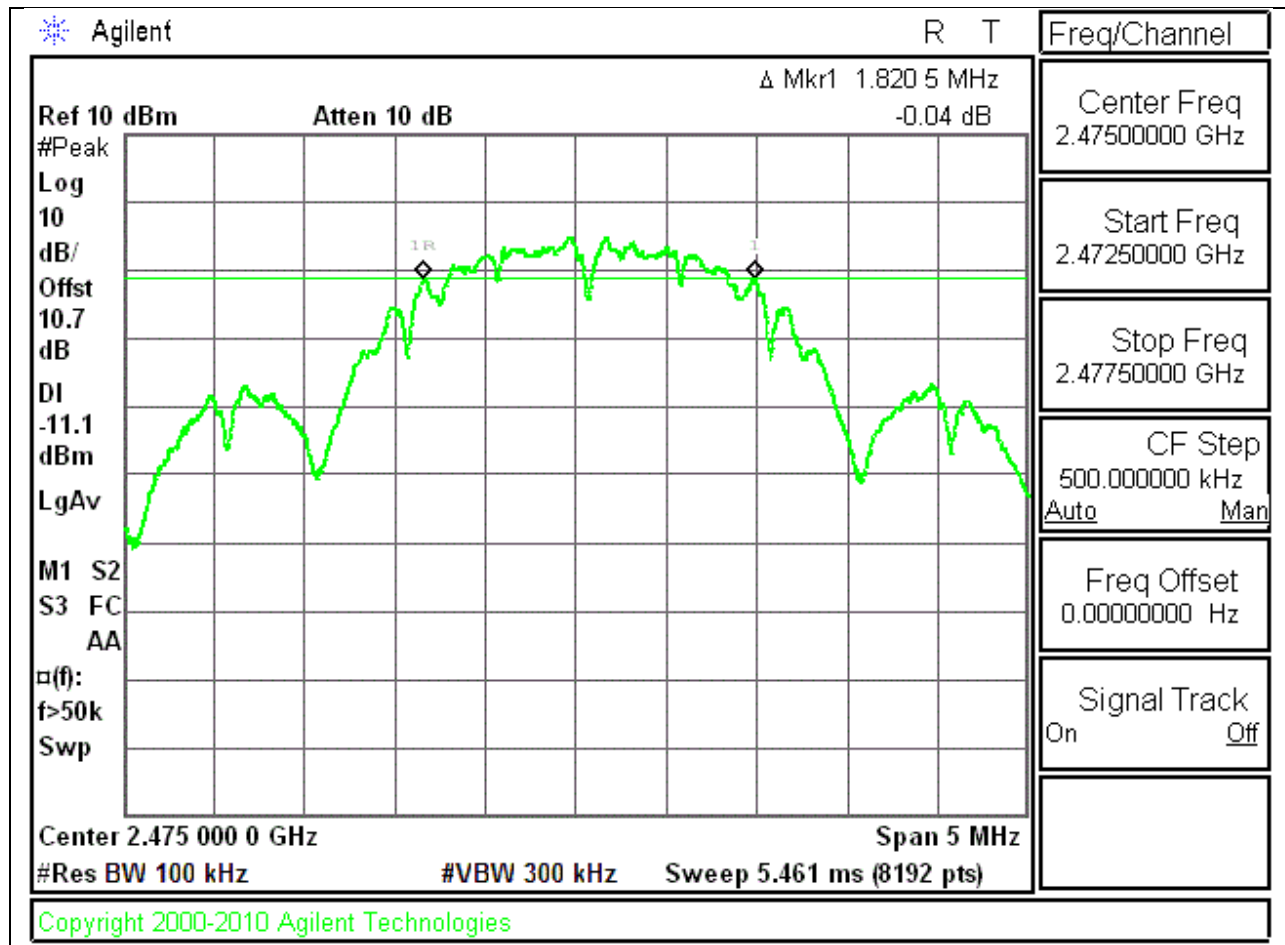
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL



9.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

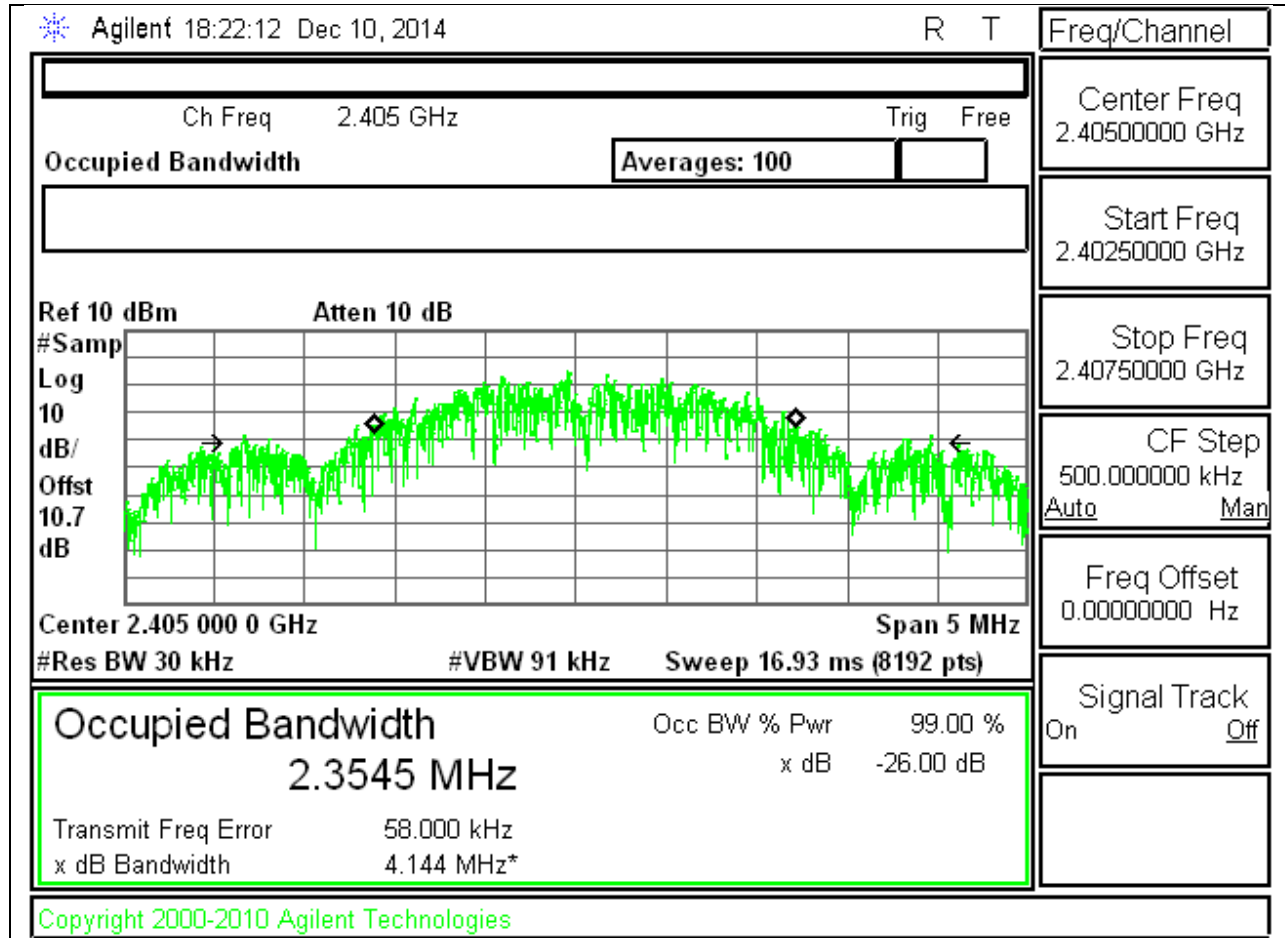
Reference to KDB558074 D01 DTS Meas Guidance v03r02: The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth and to 1% of the span. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

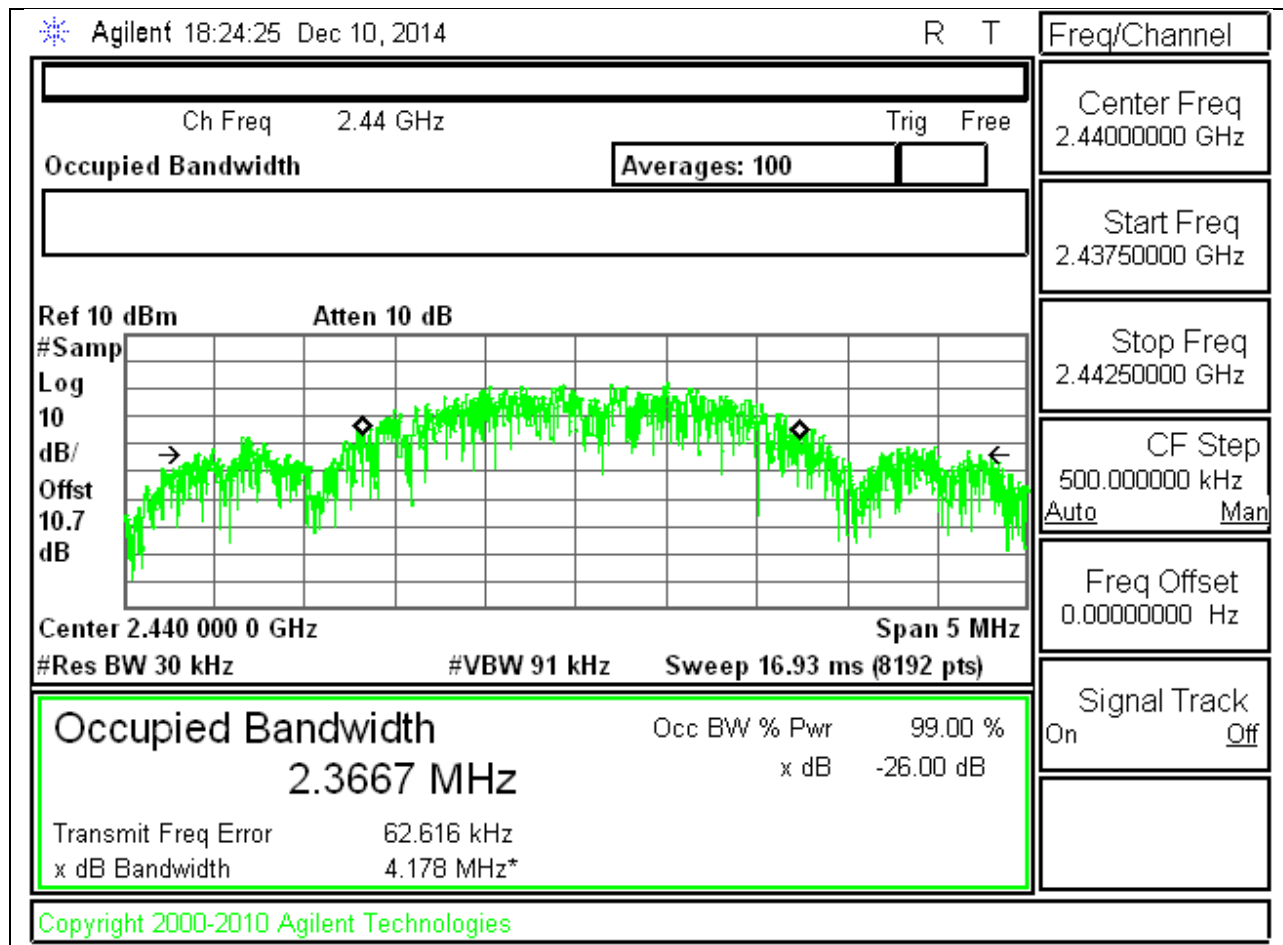
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.3545
Middle	2440	2.3667
High	2480	2.3591

99% BANDWIDTH PLOTS

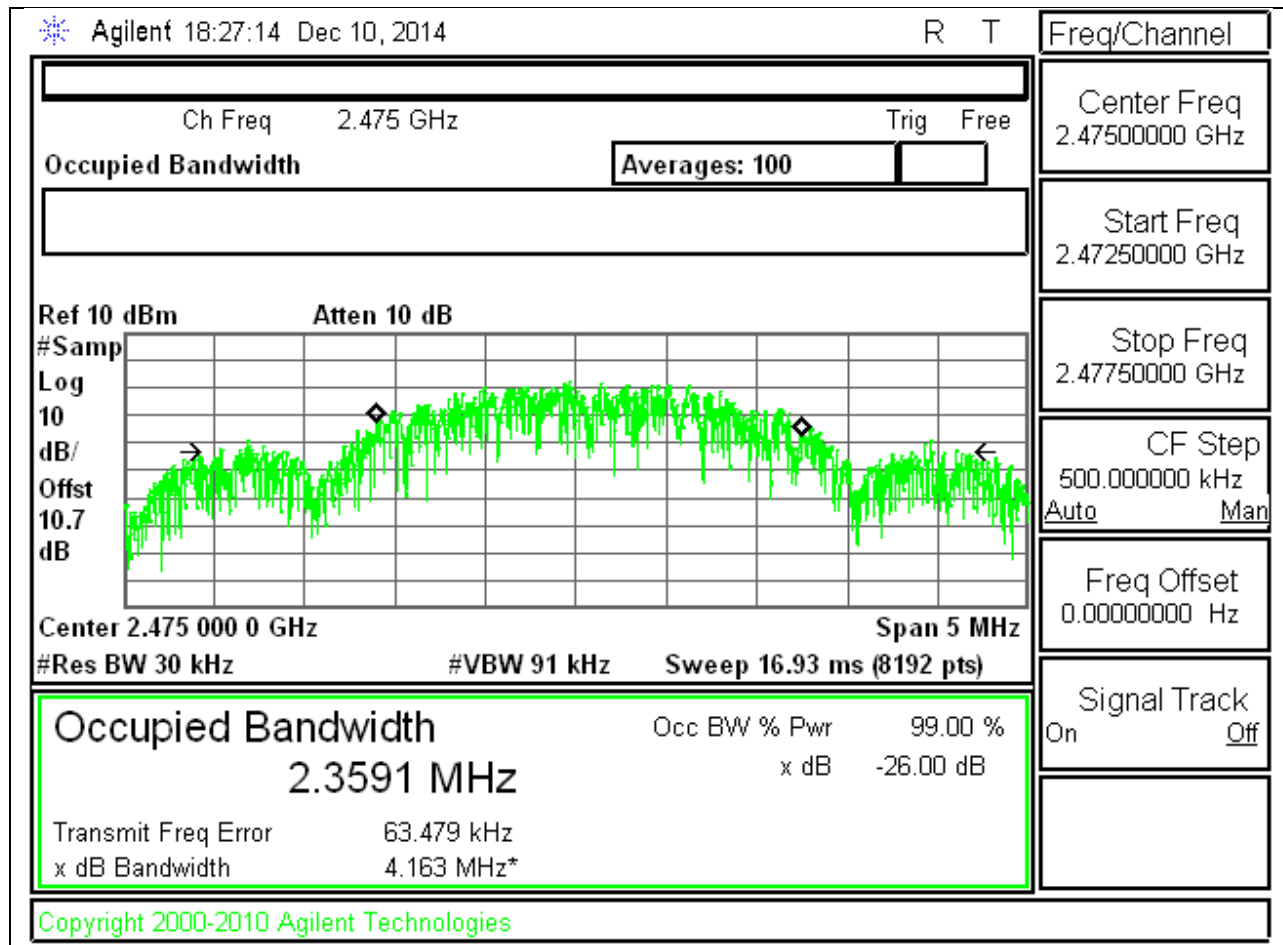
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL



9.3. 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

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10.2 dB (including 10 dB pad and 0.2 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

RESULTS

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	IC Power Limit (dBm)	IC EIRP Limit (dBm)	Max Power (dBm)
Low	2405	2.10	30.00	30	36	30.00
Mid	2440	2.10	30.00	30	36	30.00
High	2475	2.10	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Chain 0 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low	2405	2.06	2.06	30.00	-27.94
Mid	2440	1.99	1.99	30.00	-28.01
High	2475	1.96	1.96	30.00	-28.04
Worst			2.06		

9.4. 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

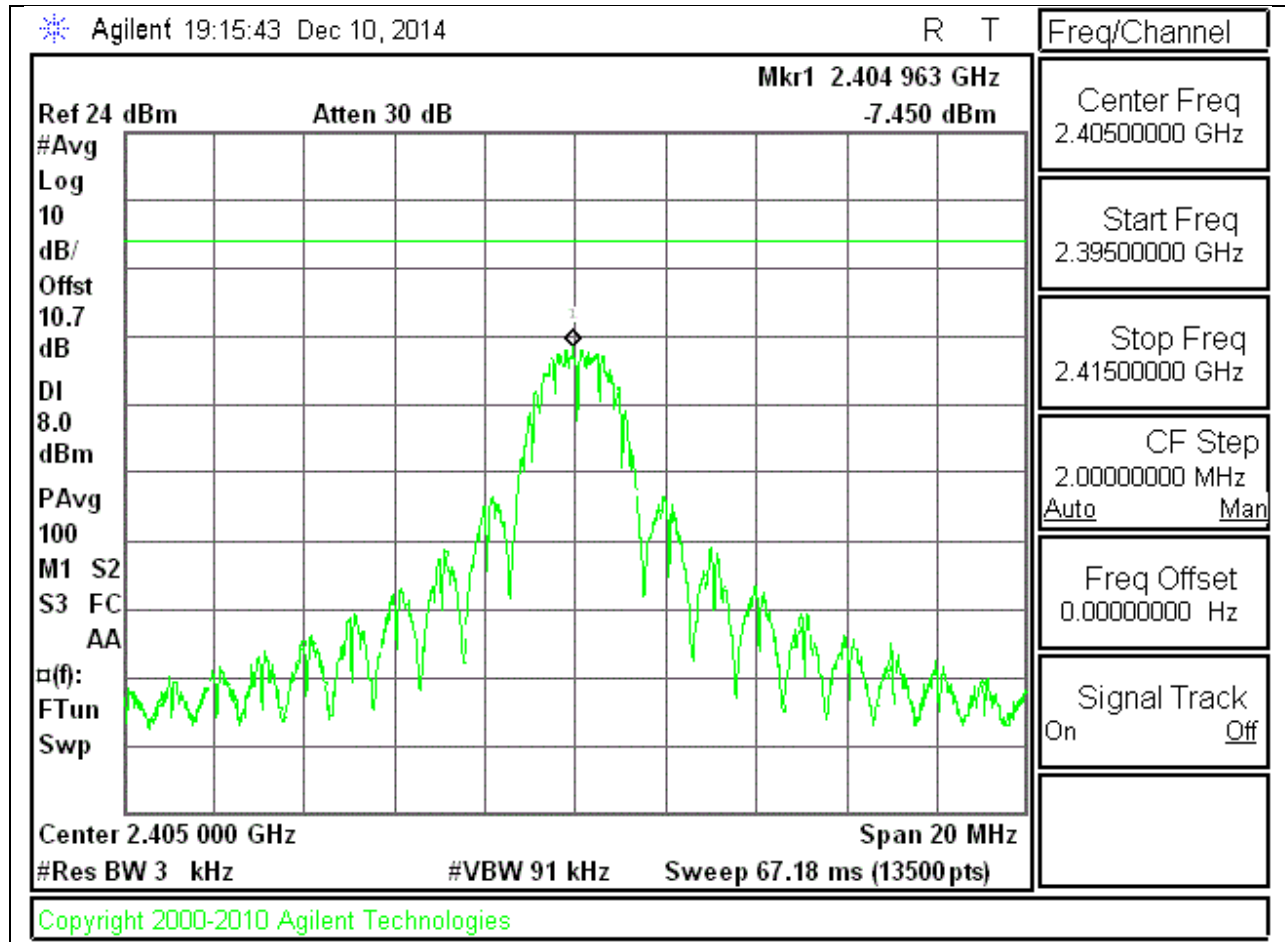
Power Spectral Density was performed utilizing the "Method AVGPS-3" under KDB558074 D01 DTS Meas Guidance v03r02

RESULTS

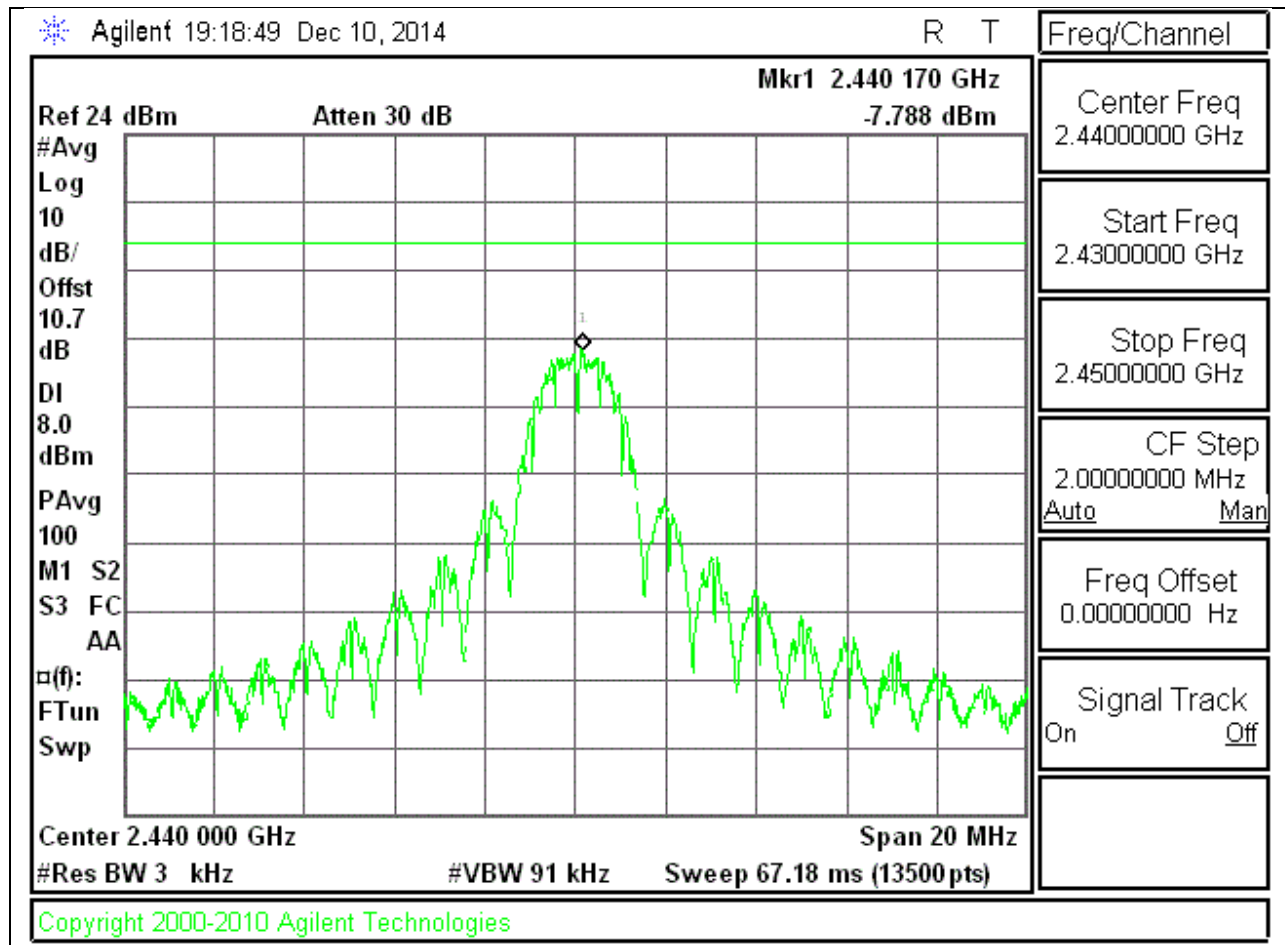
Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
Low	2405	-7.45	8	-15.45
Middle	2440	-7.79	8	-15.79
High	2475	-7.86	8	-15.86

POWER SPECTRAL DENSITY PLOTS

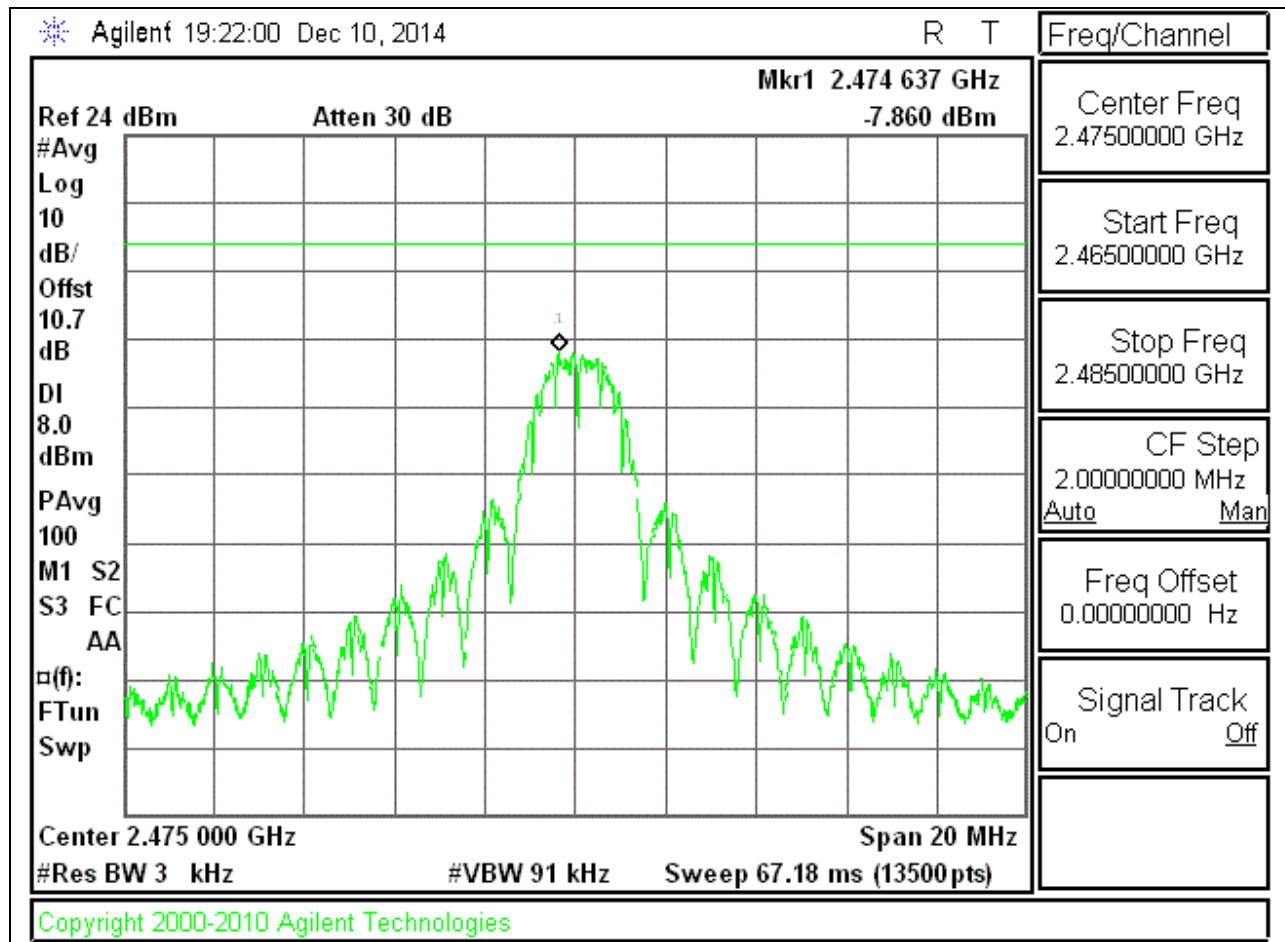
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL



9.5. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-210 A8.5

Output power was measured based on the use of a average measurement, therefore the required attenuation is 30 dB.

TEST PROCEDURE

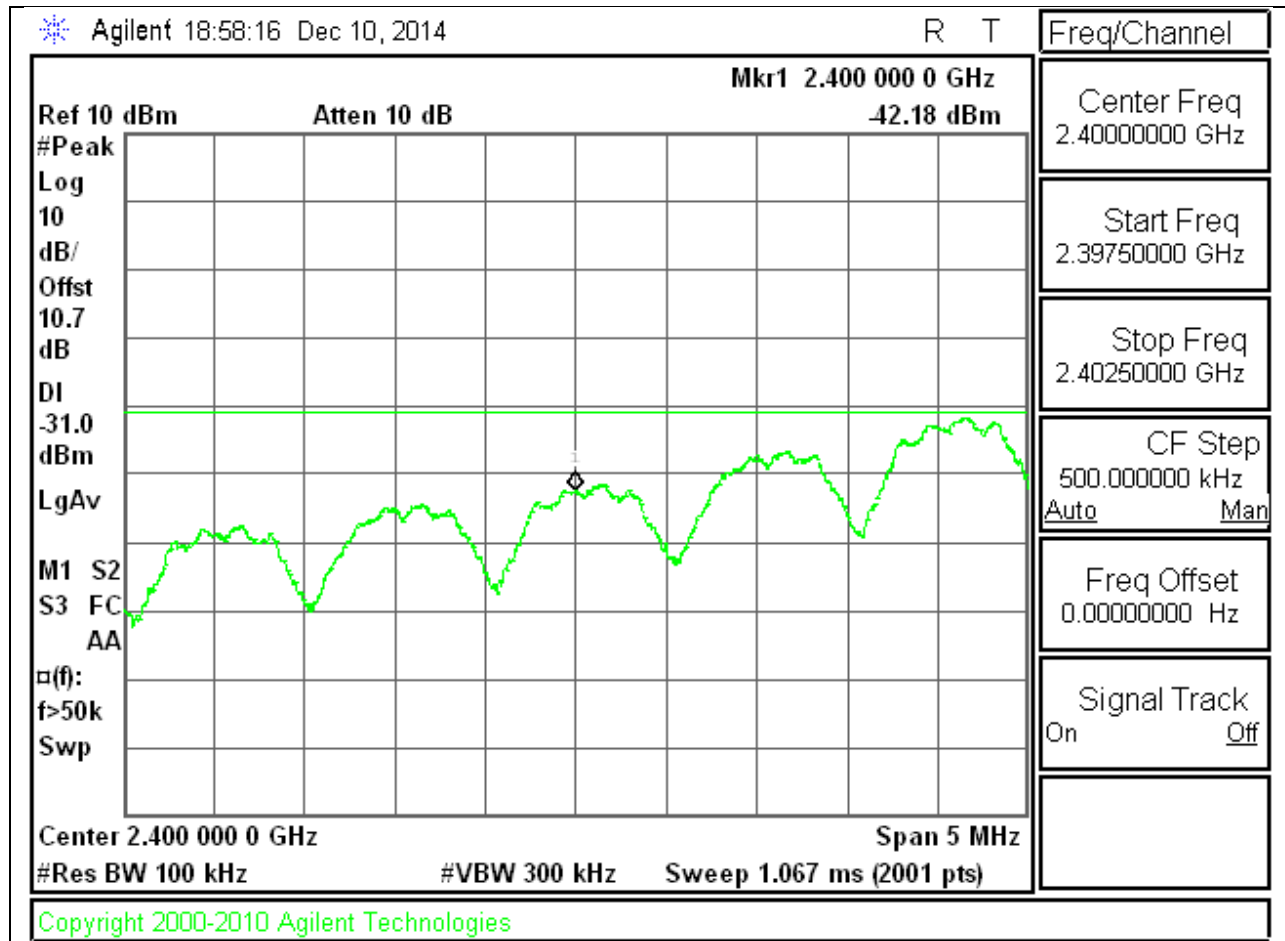
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

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

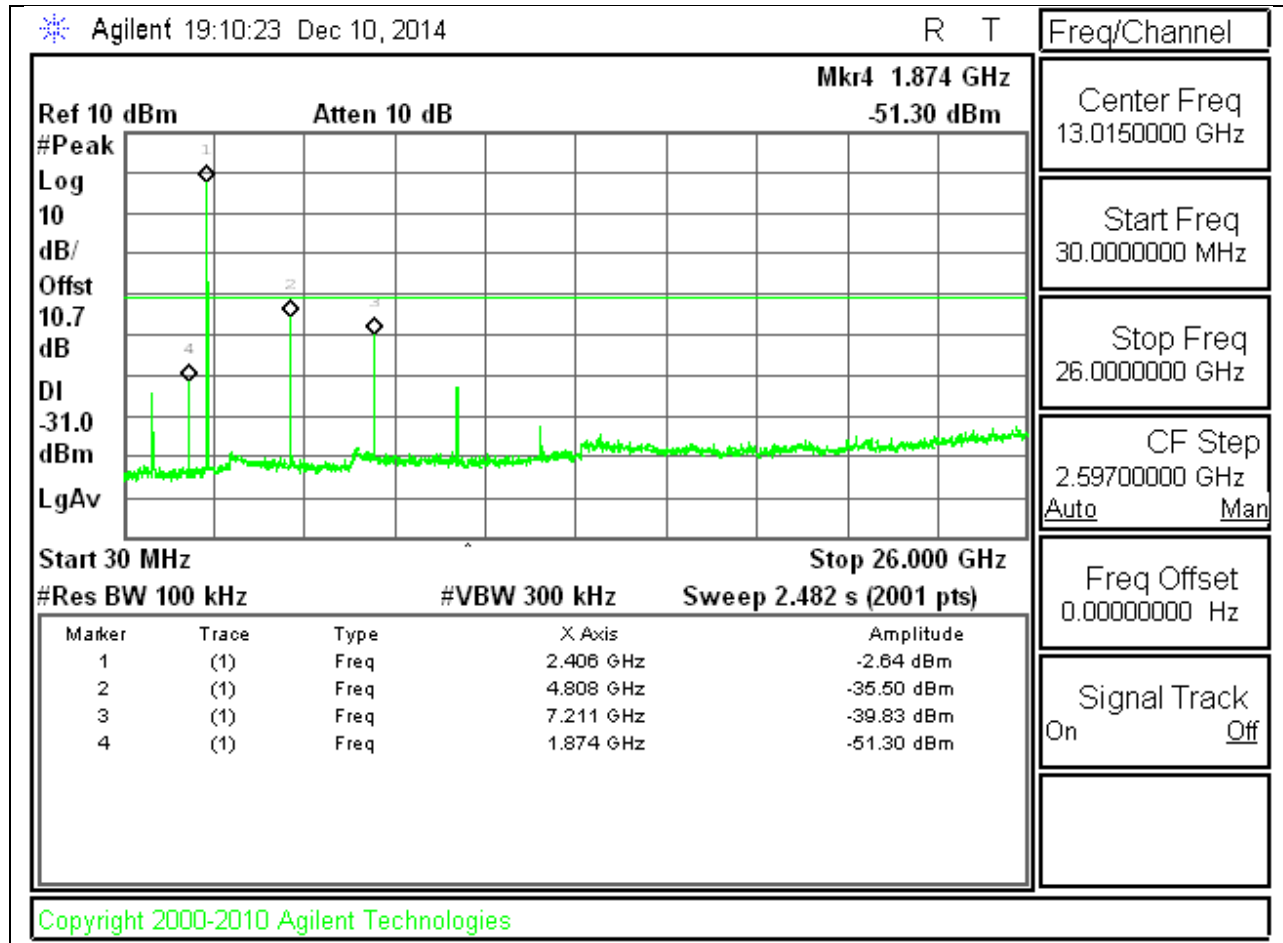
RESULTS

SPURIOUS EMISSIONS, LOW CHANNEL

LOW CHANNEL BANDEDGE

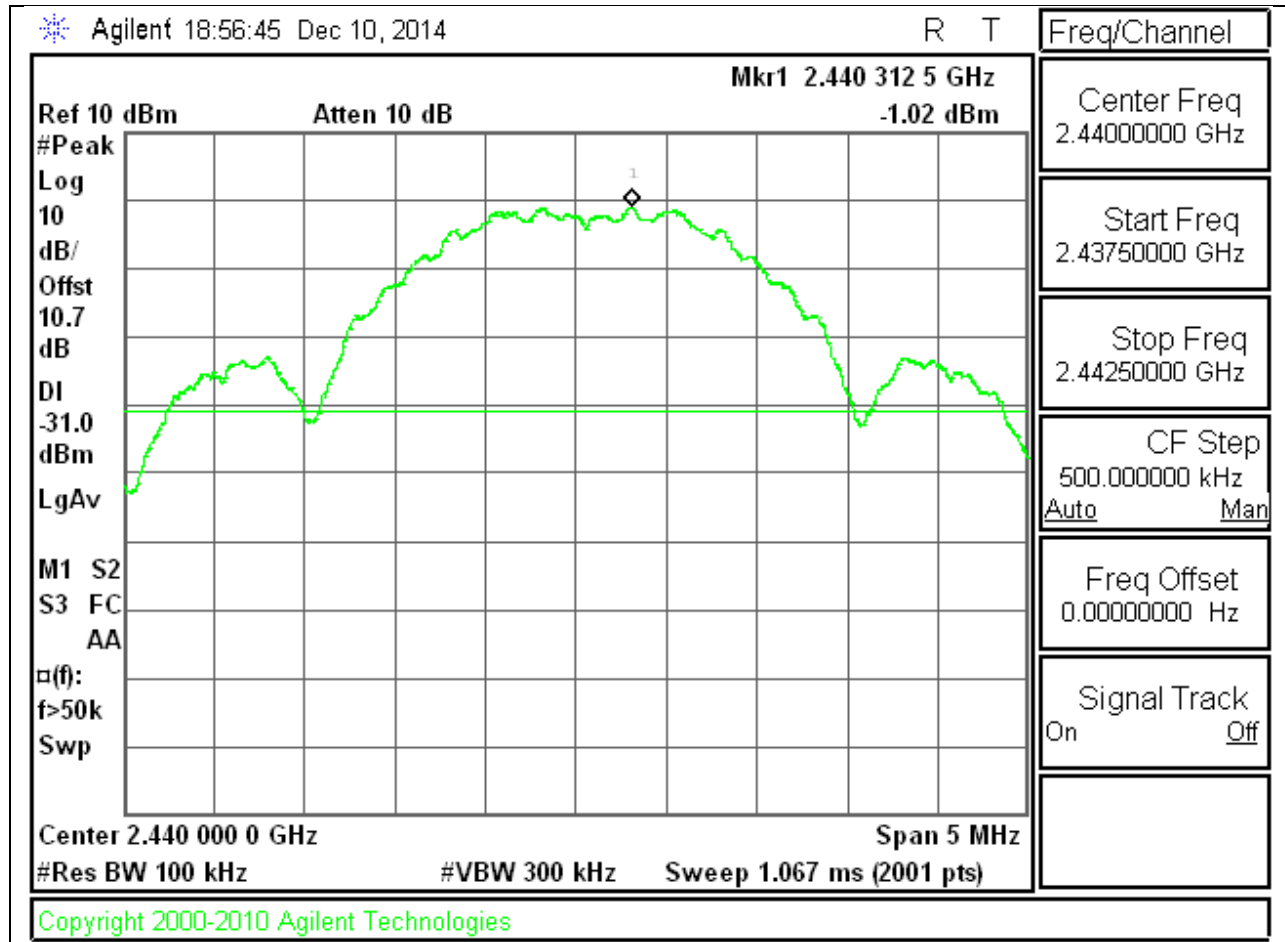


LOW CHANNEL SPURIOUS

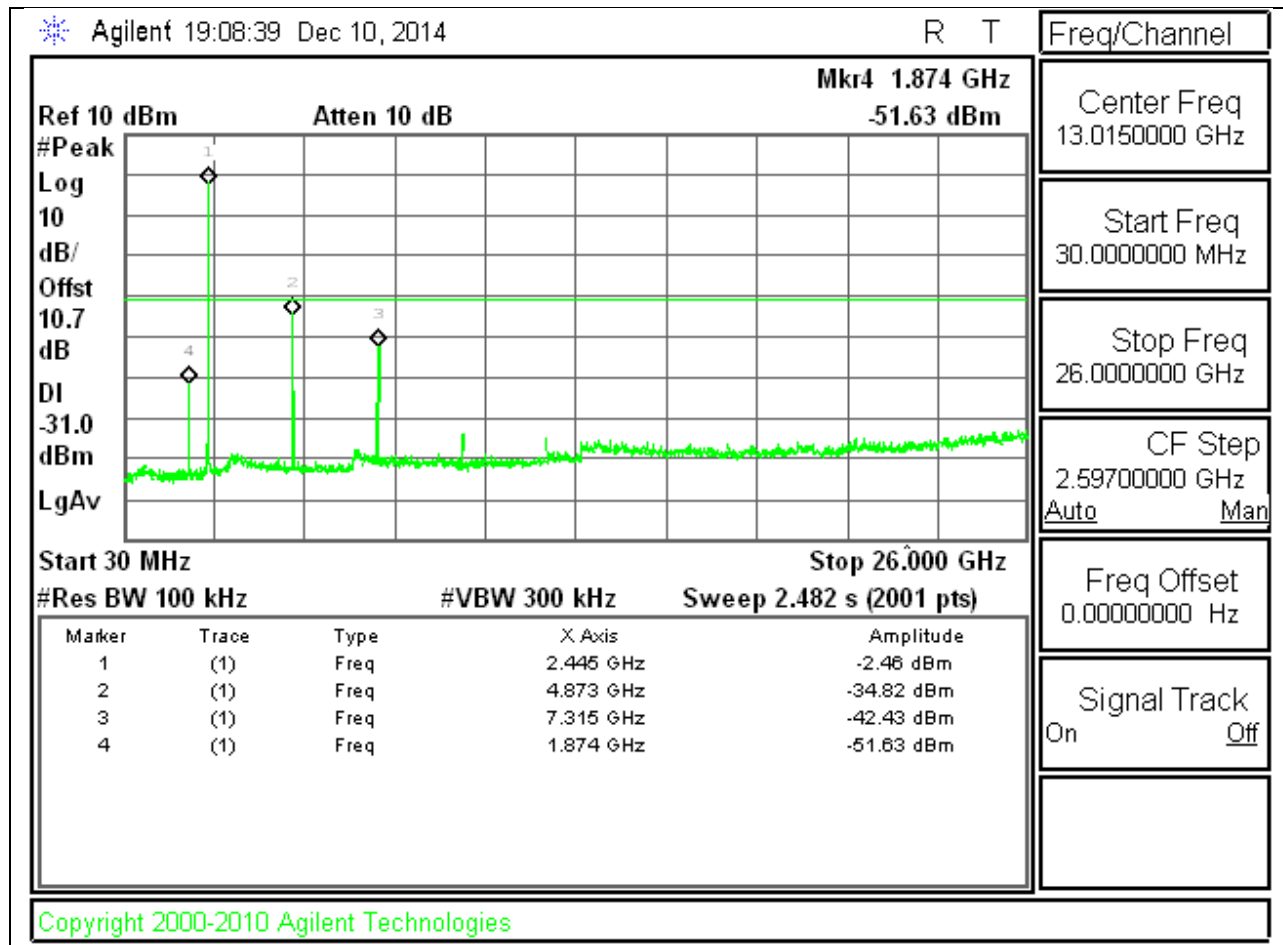


SPURIOUS EMISSIONS, MID CHANNEL

MID CHANNEL REFERENCE

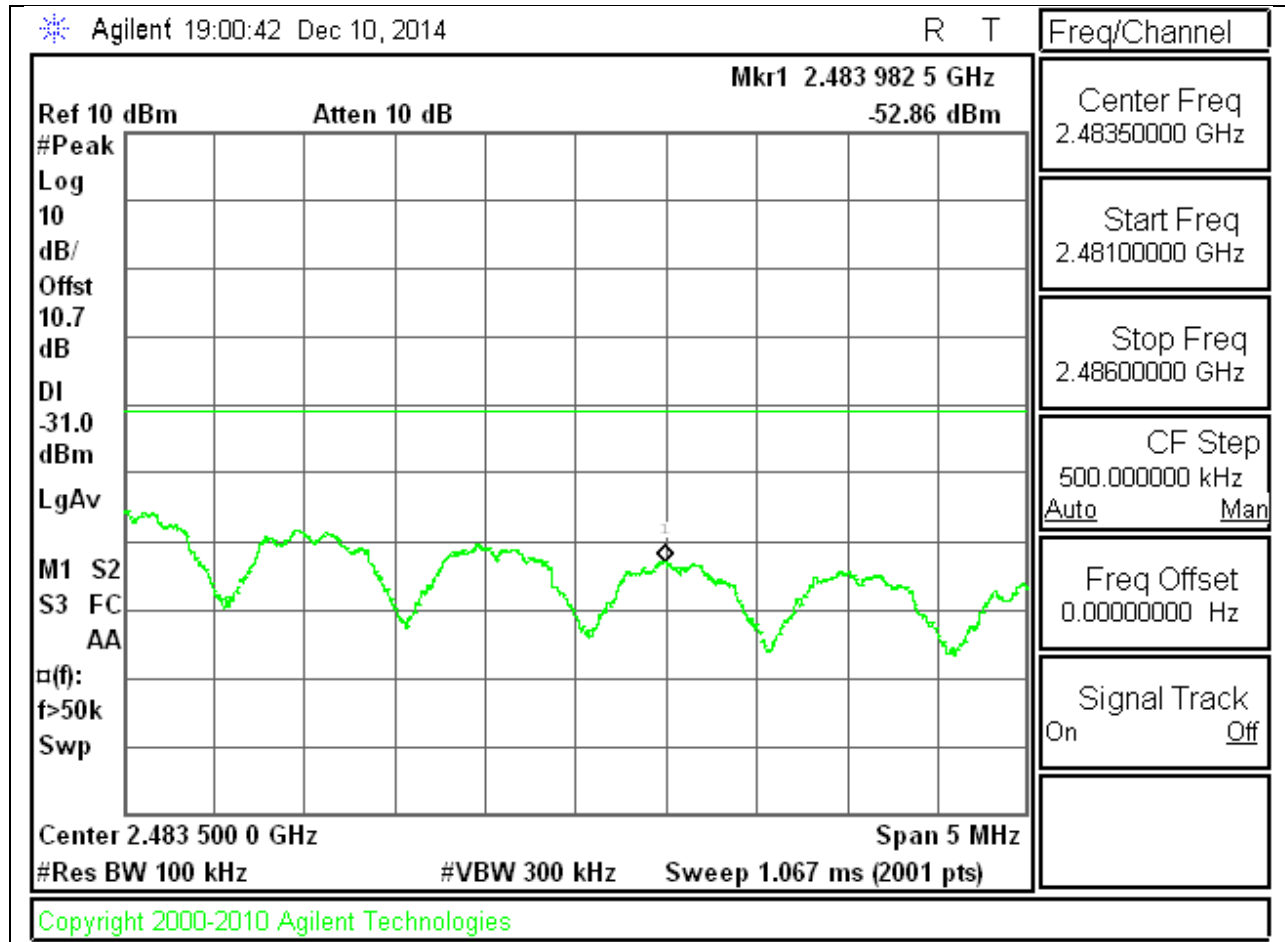


MID CHANNEL SPURIOUS

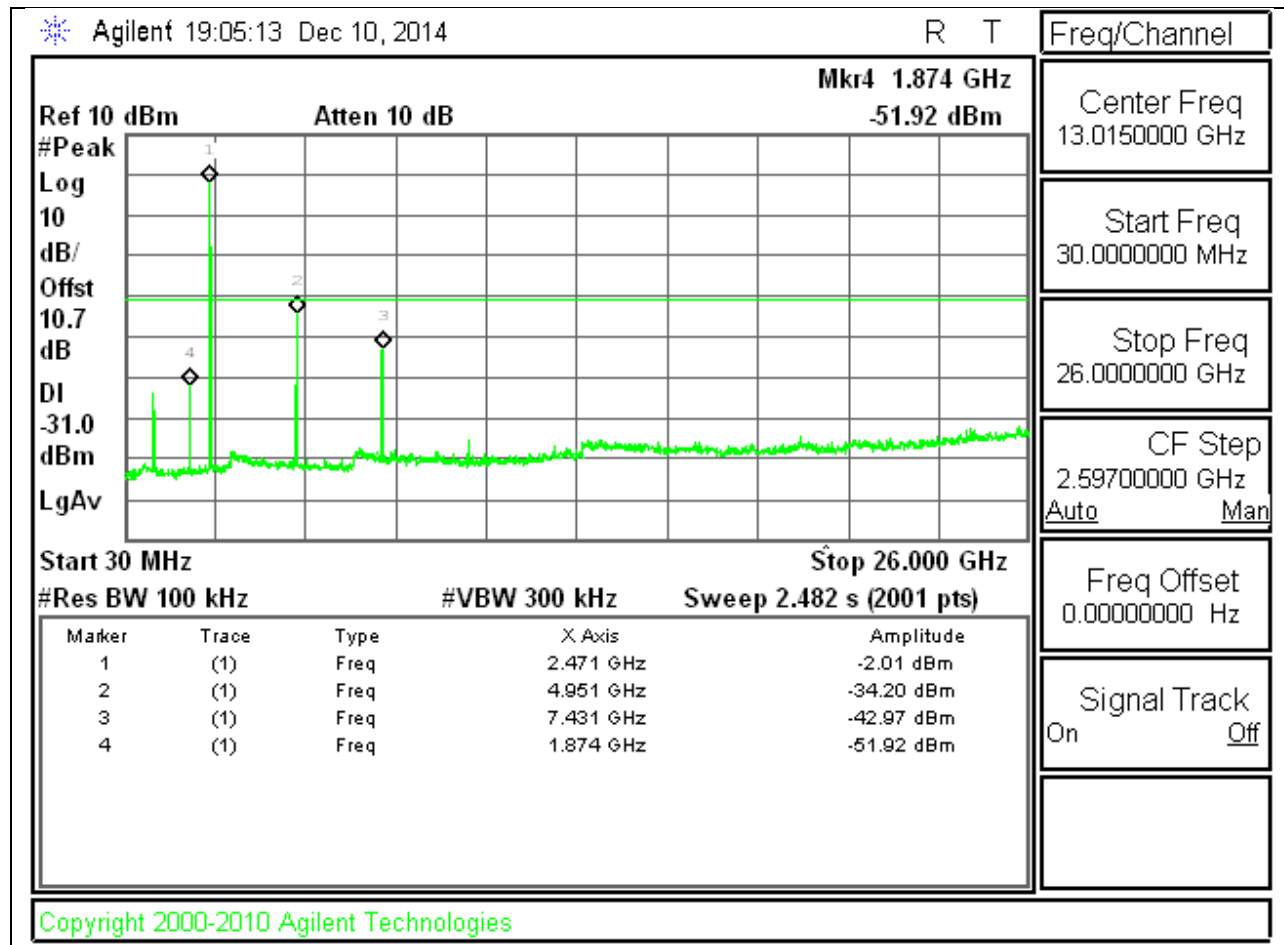


SPURIOUS EMISSIONS, HIGH CHANNEL

HIGH CHANNEL BANDEDGE



HIGH CHANNEL SPURIOUS



10. RADIATED TEST RESULTS

10.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209

IC RSS-GEN Clause 8.9 (Transmitter)

IC RSS-GEN Clause 7 (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 - 2009. 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 add duty cycle factor for average measurements. Duty cycle factor = $10 \log (1/x)$. For this sample: DCF = 0dB(>98%)

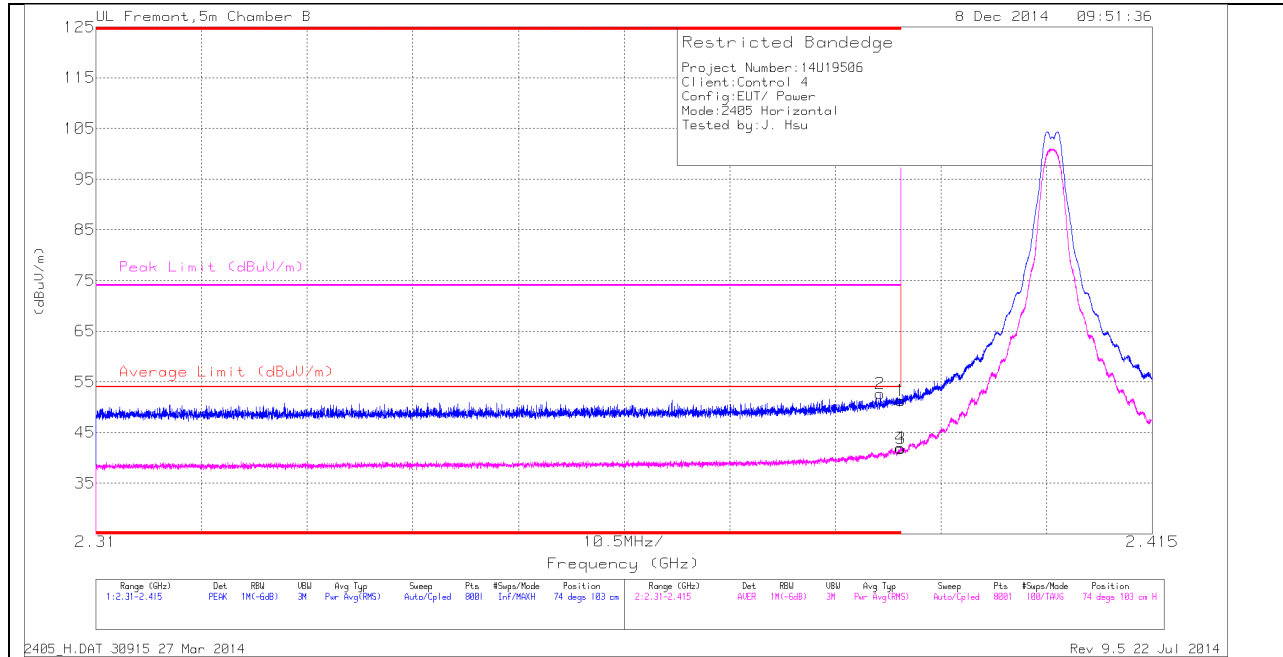
The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in the 2.4 GHz band.

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.

10.2. TRANSMITTER ABOVE 1 GHz RESTRICTED BANDEDGE (LOW CHANNEL)

HORIZONTAL PEAK AND AVERAGE PLOT

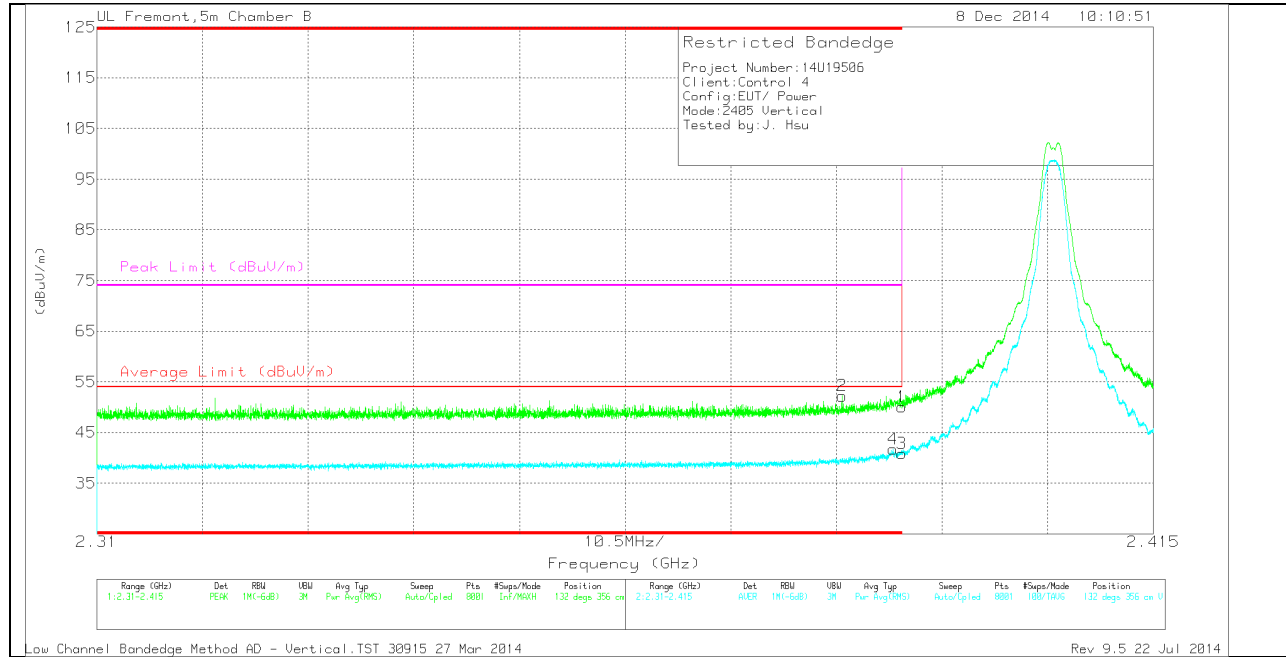


HORIZONTAL DATA

Marker	Frequen cy (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cb/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	41.93	PK	32.1	-22.7	51.33	-	-	74	-22.67	74	103	H
2	* 2.388	43.23	PK	32.1	-22.7	52.63	-	-	74	-21.37	74	103	H
3	* 2.39	32.4	RMS	32.1	-22.7	41.8	54	-12.2	-	-	74	103	H
4	* 2.39	32.62	RMS	32.1	-22.7	42.02	54	-11.98	-	-	74	103	H

* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band
PK - Peak detector
RMS - RMS detection

VERTICAL PEAK AND AVERAGE PLOT



VERTICAL DATA

Marker	Frequen cy (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	40.68	PK	32.1	-22.7	50.08	-	-	74	-23.92	132	356	V
2	* 2.384	42.82	PK	32.1	-22.7	52.22	-	-	74	-21.78	132	356	V
3	* 2.39	31.44	RMS	32.1	-22.7	40.84	54	-13.16	-	-	132	356	V
4	* 2.389	32.33	RMS	32.1	-22.7	41.73	54	-12.27	-	-	132	356	V

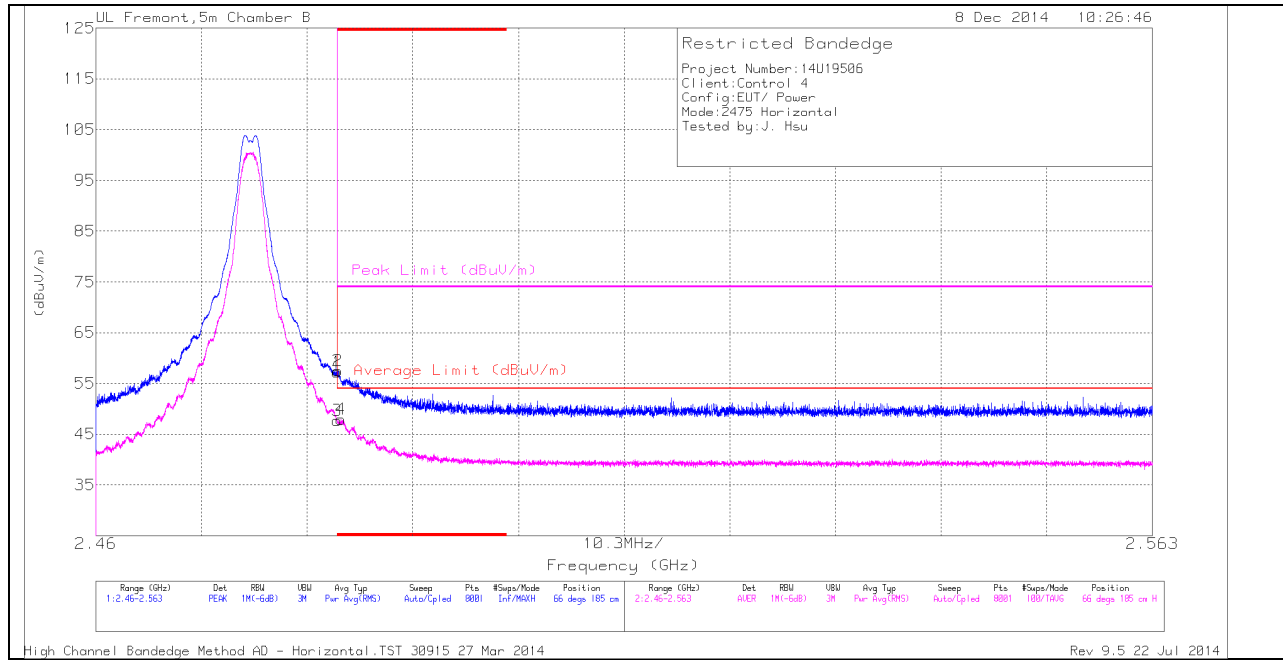
* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

RMS - RMS detection

AUTHORIZED BANDEDGE (HIGH CHANNEL)

HORIZONTAL PEAK AND AVERAGE PLOT



HORIZONTAL DATA

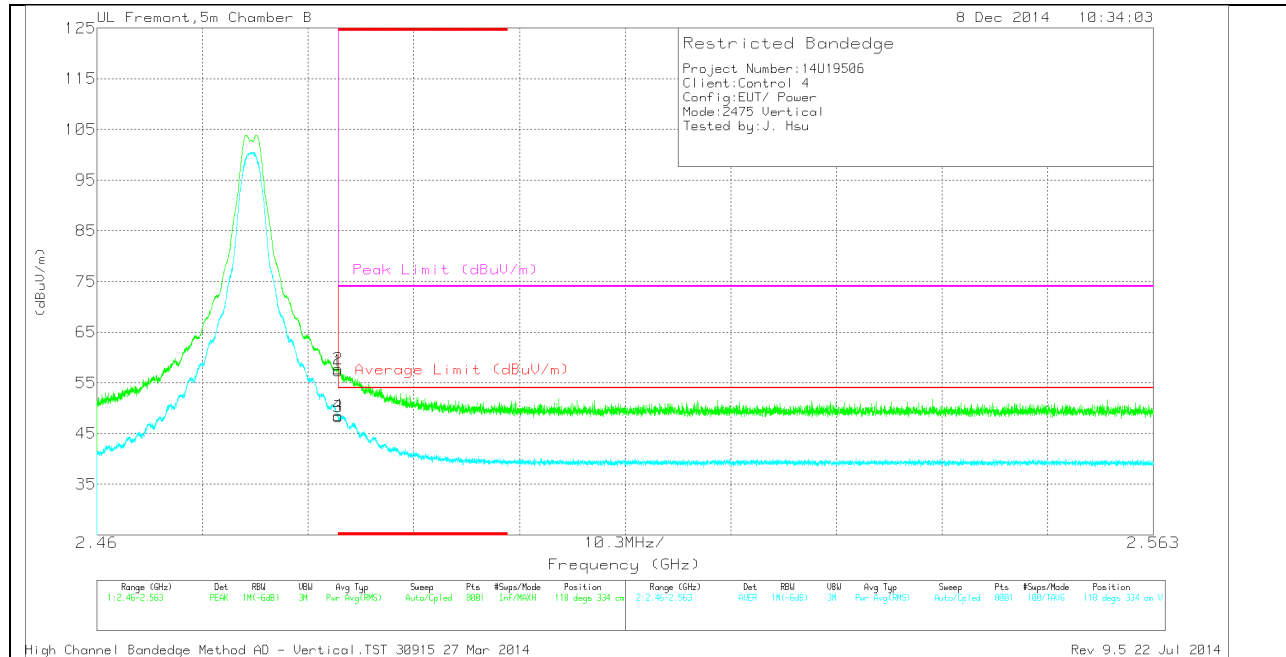
Marker	Frequen cy (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	47.48	PK	32.4	-22.6	57.28	-	-	74	-16.72	66	185	H
2	* 2.484	47.67	PK	32.4	-22.6	57.47	-	-	74	-16.53	66	185	H
3	* 2.484	37.83	RMS	32.4	-22.6	47.63	54	-6.37	-	-	66	185	H
4	* 2.484	38.08	RMS	32.4	-22.6	47.88	54	-6.12	-	-	66	185	H

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

PK - Peak detector

RMS - RMS detection

VERTICAL PEAK AND AVERAGE PLOT



VERTICAL DATA

Marker	Frequen cy (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	47.61	PK	32.4	-22.6	57.41	-	-	74	-16.59	118	334	V
2	* 2.484	47.98	PK	32.4	-22.6	57.78	-	-	74	-16.22	118	334	V
3	* 2.484	38.45	RMS	32.4	-22.6	48.25	54	-5.75	-	-	118	334	V
4	* 2.484	38.76	RMS	32.4	-22.6	48.56	54	-5.44	-	-	118	334	V

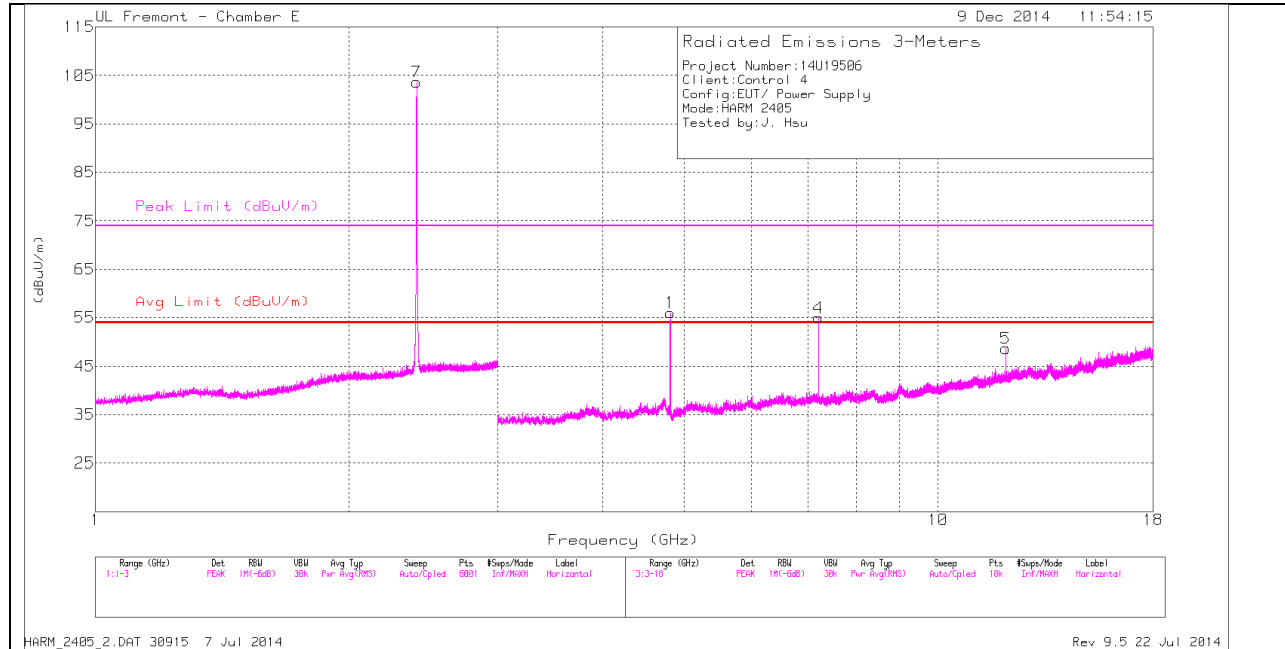
* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band

PK - Peak detector

RMS - RMS detection

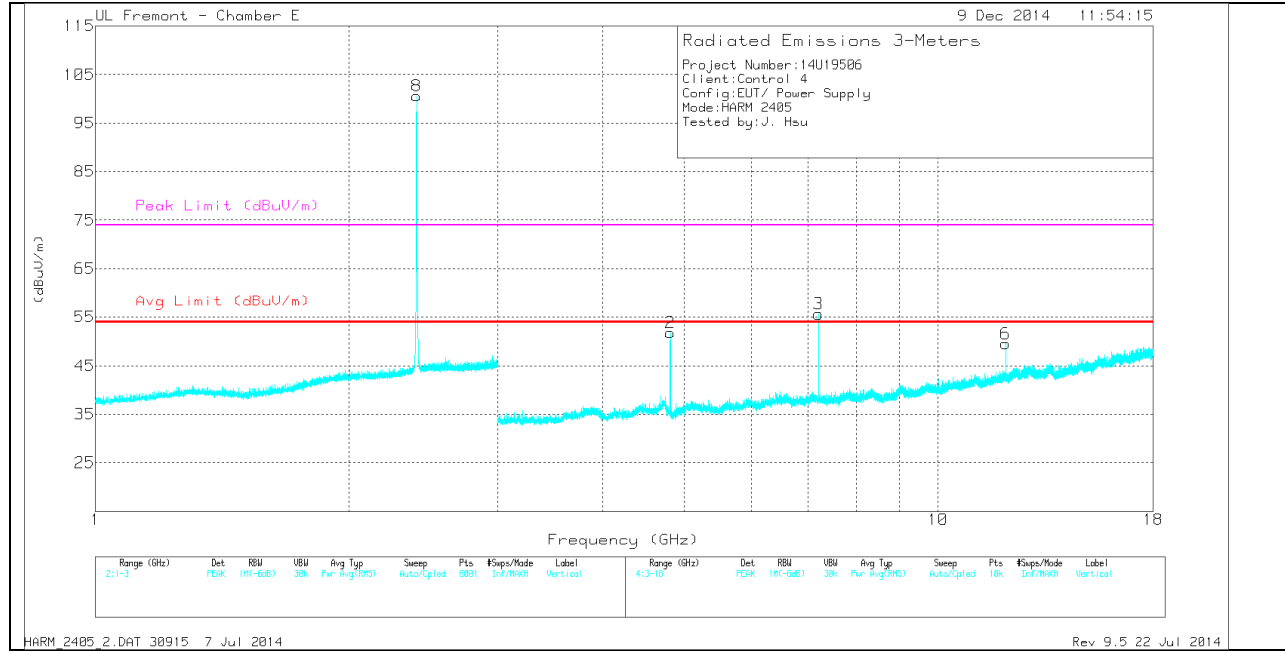
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL HORIZONTAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

LOW CHANNEL VERTICAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

LOW CHANNEL DATA

TRACE MARKERS

Marker	Frequenc y (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
7	2.405	94.15	PK	32.2	-22.7	103.65	-	-	-	-	0-360	200	H
8	2.406	91.09	PK	32.2	-22.7	100.59	-	-	-	-	0-360	200	V
1	4.809	51.51	PK	34.2	-29.7	56.01	-	-	74	-17.99	0-360	101	H
4	7.213	46.85	PK	35.5	-27.4	54.95	-	-	-	-	0-360	199	H
5	12.028	32.15	PK	38.7	-22.2	48.65	-	-	74	-25.35	0-360	199	H
2	4.809	47.3	PK	34.2	-29.7	51.8	-	-	74	-22.2	0-360	101	V
3	7.213	47.55	PK	35.5	-27.4	55.65	-	-	-	-	0-360	101	V
6	12.023	33.06	PK	38.7	-22.2	49.56	-	-	74	-24.44	0-360	199	V

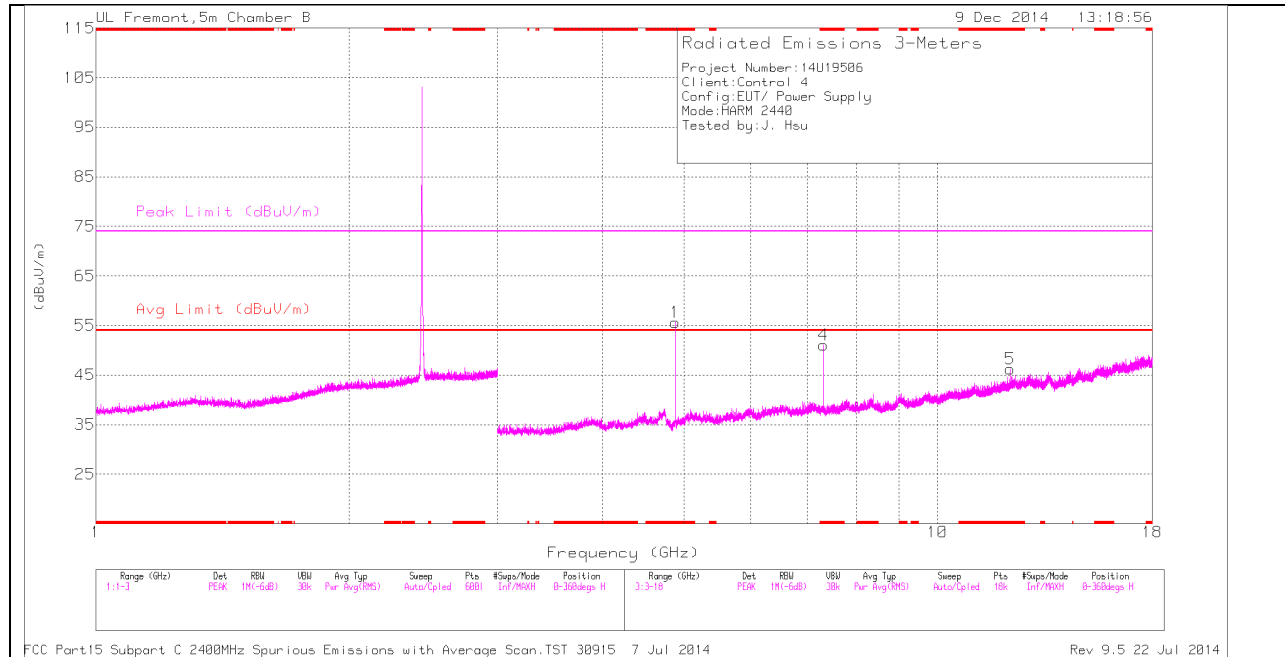
PK - Peak detector

Radiated Emissions

Frequenc y (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filtr/Pad (dB)	Correcte d Reading (dBuV/m)	protocol- based DC factor	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4.809	55.51	PK2	34.2	-29.7	60.01		-	-	74	-13.99	357	107	H
4.809	55.51	PK2	34.2	-29.7	52.51	-7.5	54	-1.49	-	-			
7.424	47.31	PK2	35.6	-27.2	55.71		-	-	74	-18.29	222	110	V
7.424	47.31	PK2	35.6	-27.2	48.21	-7.5	54	-5.79	-	-			

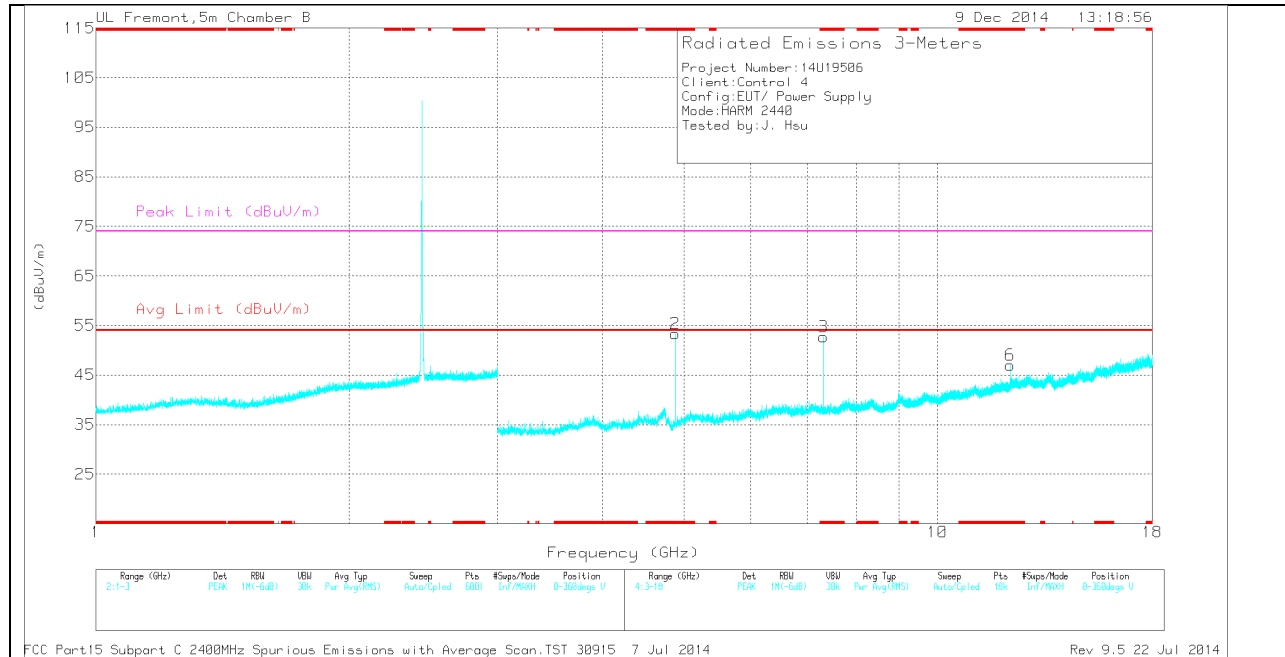
PK2 - KDB558074 Method: Maximum Peak

MID CHANNEL HORIZONTAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

MID CHANNEL VERTICAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

MID CHANNEL DATA

Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filt/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 4.881	52.12	PK	34.2	-30.7	55.62	-	-	74	-18.38	0-360	101	H
4	* 7.318	43.87	PK	35.6	-28.4	51.07	-	-	74	-22.93	0-360	101	H
5	* 12.198	29.7	PK	38.9	-22.4	46.2	-	-	74	-27.8	0-360	199	H
2	* 4.881	49.85	PK	34.2	-30.7	53.35	-	-	74	-20.65	0-360	101	V
3	* 7.321	45.48	PK	35.6	-28.4	52.68	-	-	74	-21.32	0-360	101	V
6	* 12.198	30.44	PK	38.9	-22.4	46.94	-	-	74	-27.06	0-360	101	V

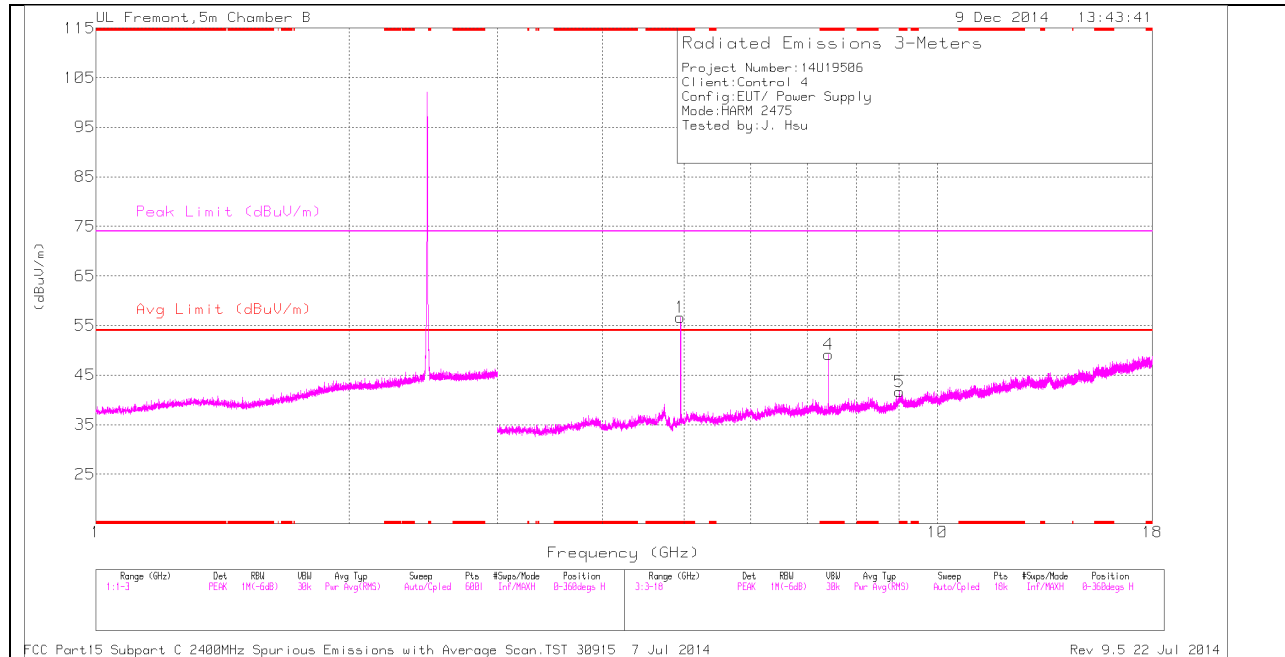
* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band
PK - Peak detector

Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filt/Pad (dB)	Corrected Reading (dBuV/m)	protocol-based DC factor	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 4.879	53.73	PK2	34.2	-30.8	57.13		-	-	74	-16.87	123	101	H
* 4.879	53.73	PK2	34.2	-30.8	49.63	-7.5	54	-4.37					
* 7.322	50.79	PK2	35.6	-28.4	57.99		-	-	74	-16.01	224	108	V
* 7.322	50.79	PK2	35.6	-28.4	50.49	-7.5	54	-3.51					

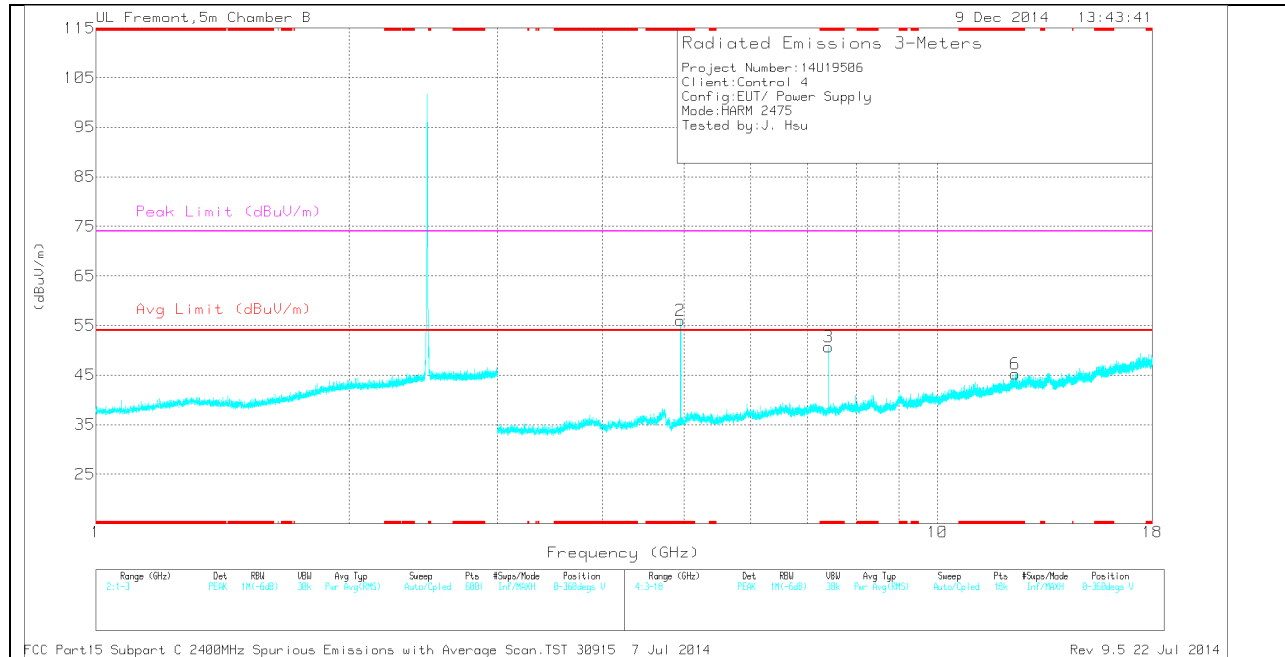
* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band
PK2 - KDB558074 Method: Maximum Peak

HIGH CHANNEL HORIZONTAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

HIGH CHANNEL VERTICAL



Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

HIGH CHANNEL DATA

Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filt/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 4.949	53.3	PK	34.2	-30.8	56.7	-	-	74	-17.3	0-360	101	H
4	* 7.426	40.65	PK	35.6	-27.1	49.15	-	-	74	-24.85	0-360	101	H
5	* 9.01	29.72	PK	36.2	-24.3	41.62	-	-	74	-32.38	0-360	200	H
2	* 4.949	52.58	PK	34.2	-30.8	55.98	-	-	74	-18.02	0-360	200	V
3	* 7.423	42.39	PK	35.6	-27.3	50.69	-	-	74	-23.31	0-360	101	V
6	* 12.373	28.22	PK	39	-22	45.22	-	-	74	-28.78	0-360	101	V

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

Radiated Emissions

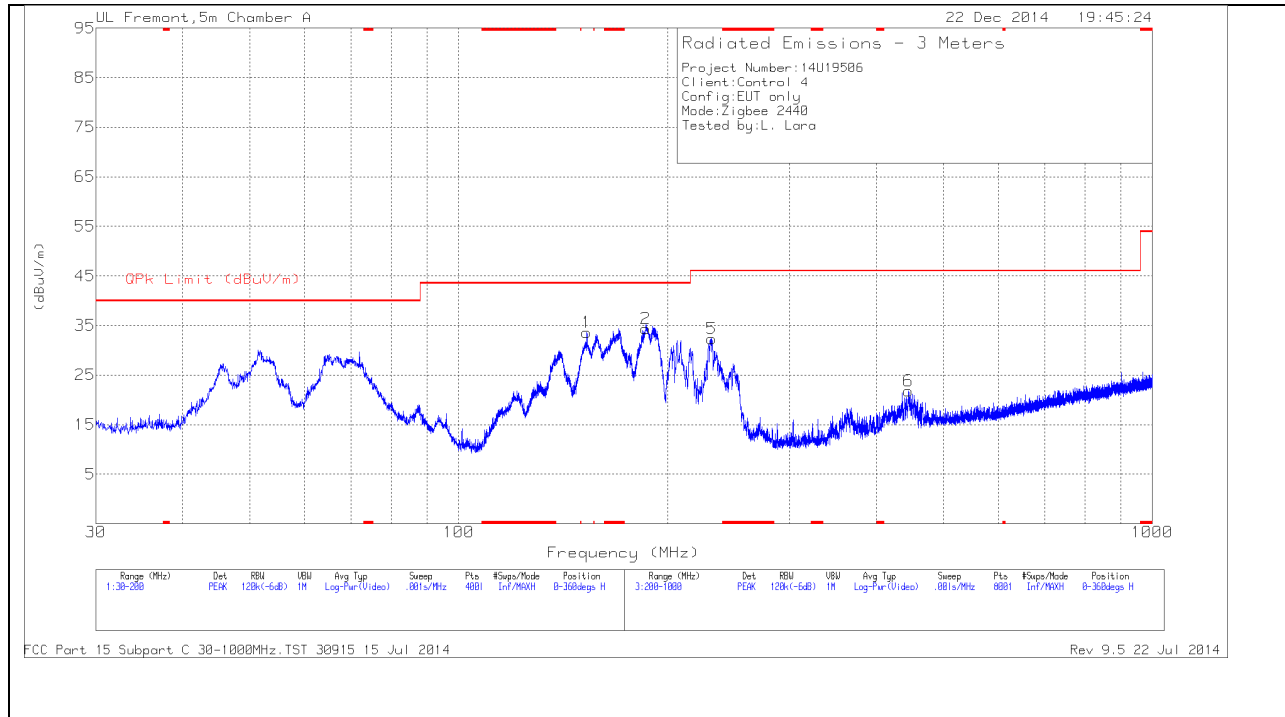
Frequency (GHz)	Meter Reading (dBuV)	Det	AF T345 (dB/m)	Amp/Cbl/ Filt/Pad (dB)	Corrected Reading (dBuV/m)	protocol-based DC factor	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 4.951	56.11	PK2	34.2	-30.7	59.61		-	-	74	-14.39	122	129	H
* 4.951	56.11	PK2	34.2	-30.7	52.11	-7.5	54	-1.89					
* 7.424	47.31	PK2	35.6	-27.2	55.71		-	-	74	-18.29	222	110	V
* 7.424	47.31	PK2	35.6	-27.2	48.21	-7.5	54	-5.79					

* - indicates frequency in CFR15.205/IC7.2.2 Restricted Band
PK2 - KDB558074 Method: Maximum Peak

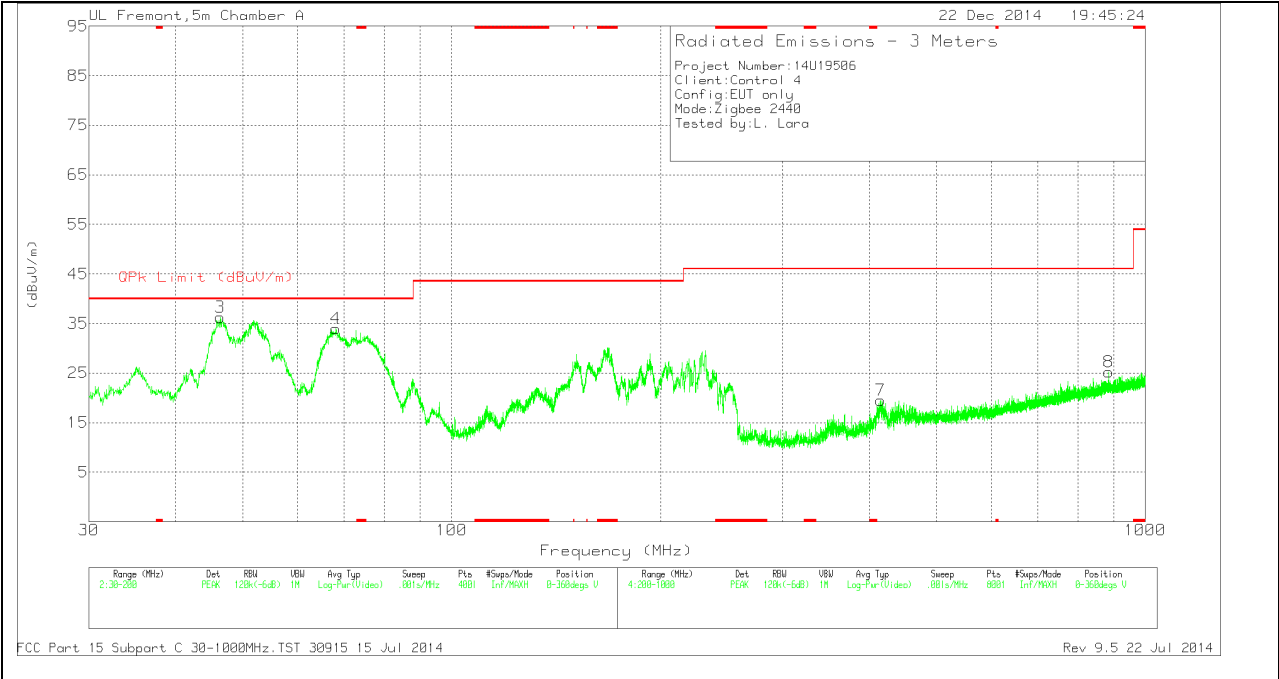
10.4. WORST-CASE BELOW 1 GHz

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

HORIZONTAL PLOT



VERTICAL PLOT



BELOW 1 GHz TABLE

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T130 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	46.405	57.51	PK	9.8	-31	36.31	40	-3.69	0-360	101	V
4	68.08	56.68	PK	8.1	-30.8	33.98	40	-6.02	0-360	101	V
1	153.0375	51.37	PK	12.4	-30.2	33.57	43.52	-9.95	0-360	200	H
2	185.89	52.91	PK	11.4	-30	34.31	43.52	-9.21	0-360	101	H
5	231.5	51.02	PK	11.1	-29.8	32.32	46.02	-13.7	0-360	101	H
7	415.2	32.75	PK	15.8	-29.1	19.45	46.02	-26.57	0-360	101	V
6	445.3	34.2	PK	16.5	-28.9	21.8	46.02	-24.22	0-360	101	H
8	885.7	30.41	PK	22.2	-27.4	25.21	46.02	-20.81	0-360	101	V

PK - Peak detector

11. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

RSS-Gen Issue 4 8.8

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.

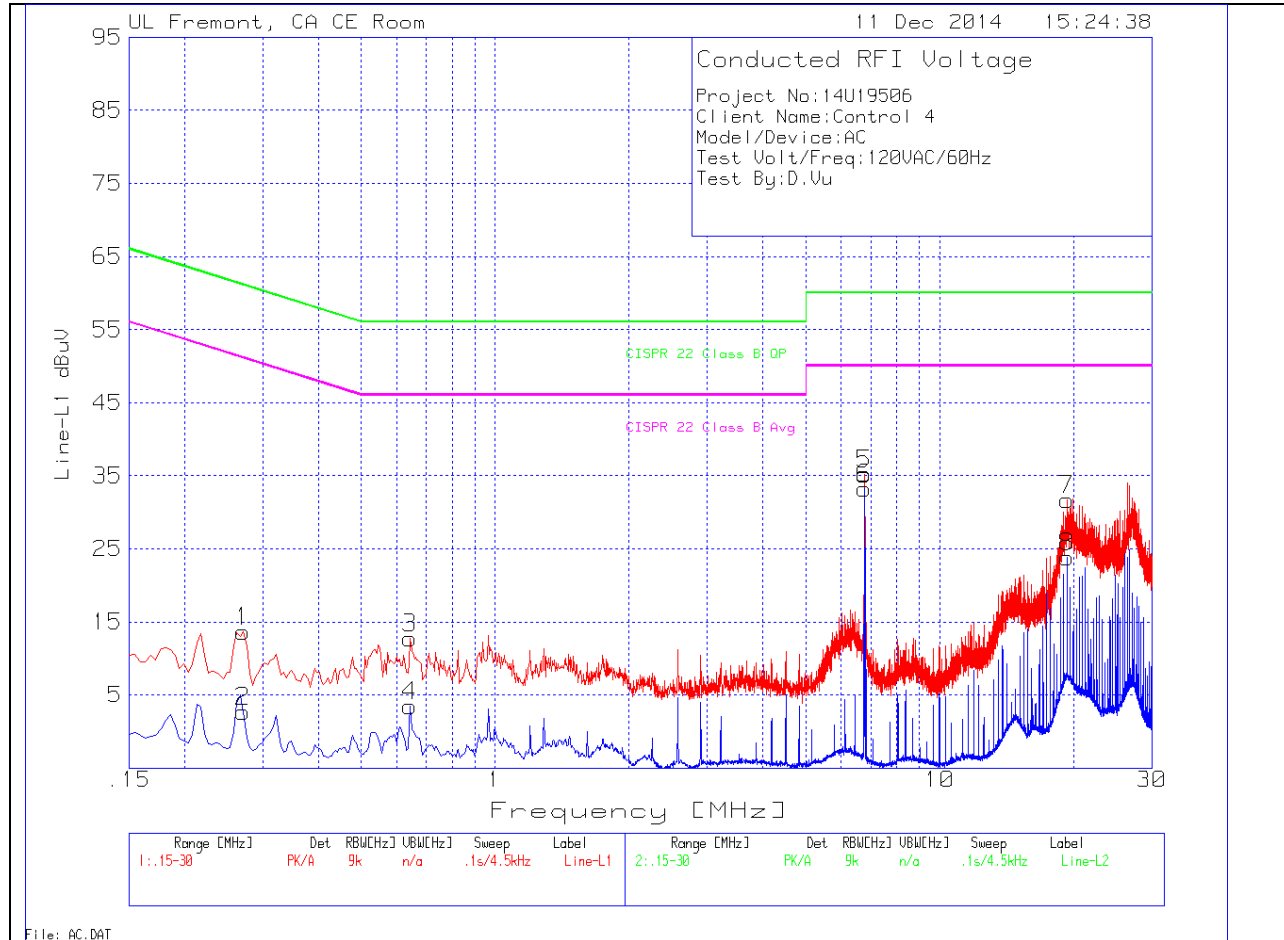
TEST PROCEDURE

ANSI C63.4 - 2009

RESULTS

6 WORST EMISSIONS

LINE 1 PLOT



LINE 1 RESULTS

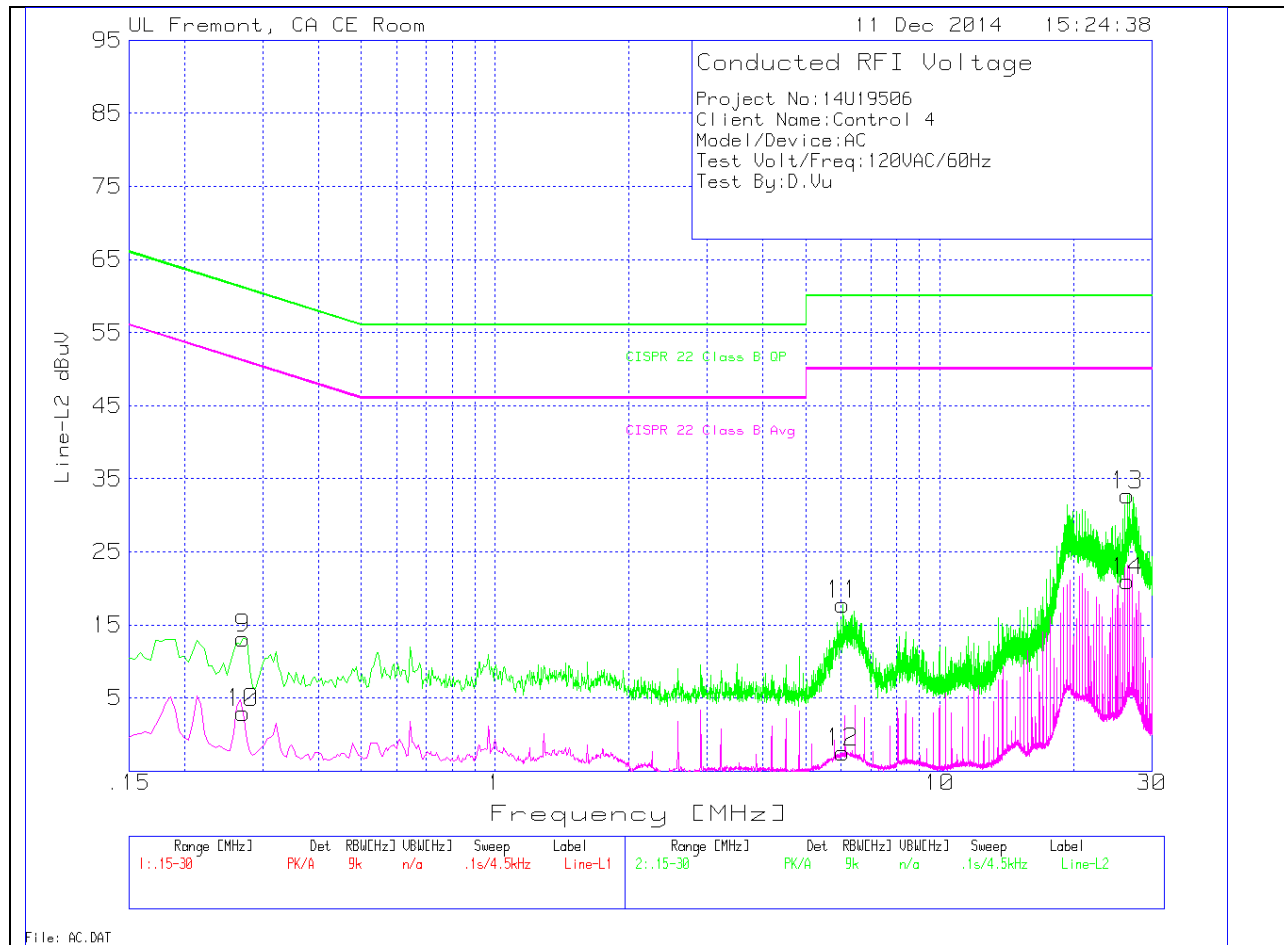
Line-L1 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	T24 IL L1 (dB)	LC Cables 1&3 (dB)	Corrected Reading dBuV	CISPR 22 Class B QP	Margin to Limit (dB)	CISPR 22 Class B Avg	Margin to Limit (dB)
1	.2715	13	PK	.6	0	13.6	61.1	-47.5	-	-
2	.2715	2.13	Av	.6	0	2.73	-	-	51.1	-48.37
3	.645	12.49	PK	.3	0	12.79	56	-43.21	-	-
4	.645	3.2	Av	.3	0	3.5	-	-	46	-42.5
5	6.7785	34.83	PK	.2	.1	35.13	60	-24.87	-	-
6	6.7785	32.9	Av	.2	.1	33.2	-	-	50	-16.8
7	19.32	31.22	PK	.3	.2	31.72	60	-28.28	-	-
8	19.32	23.38	Av	.3	.2	23.88	-	-	50	-26.12

PK - Peak detector

Av - average detection

LINE 2 PLOT



LINE 2 RESULTS

Line-L2 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	T24 IL L2 (dB)	LC Cables 2&3 (dB)	Corrected Reading dBuV	CISPR 22 Class B QP	Margin to Limit (dB)	CISPR 22 Class B Avg	Margin to Limit (dB)
9	.2715	12.49	PK	.7	0	13.19	61.1	-47.91	-	-
10	.2715	2.23	Av	.7	0	2.93	-	-	51.1	-48.17
11	6.0585	17.45	PK	.2	.1	17.75	60	-42.25	-	-
12	6.0585	-2.73	Av	.2	.1	-2.43	-	-	50	-52.43
13	26.3985	32.11	PK	.3	.3	32.71	60	-27.29	-	-
14	26.3985	20.34	Av	.3	.3	20.94	-	-	50	-29.06

PK - Peak detector

Av - average detection

12. APPENDIX TRANSMITTER DUTY CYCLE CALCULATIONS

IEEE 802.15.4-2003 2.4 GHz PHY Constants

Data Rate	250000	bits / sec	
	31250	bytes / sec	
Symbols/byte	2	sym / bytes	
Symbol Timing	62500	sym / sec	
	0.000016	sec / sym	
Byte Timing	0.000032	sec / byte	
PHY PSDU	6	bytes	4 Preamble, SPD, Length
Max Length	127	bytes	
Total Packet Length	133	bytes	
Maximum Time TX PKT	0.004256	sec	

Long Frame Scenario:

- 1) TX Frame Assume Frame is Data Frame
- 2) Wait for ACK
- 3) RX ACK
- 4) CPU Processing of ACK
- 5) Wait for Backoff
- 6) Repeat 1)

MAC-Level Calculation (LIFS)

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	40	sym	
Backoff Period	20	sym	
Maximum Backoff	31		Random between 0 and 31
Backoff Required	2		
Backoff Time	300	sym	Average at 15
Transmit Time			
TX Time (Packet)	0.004256		
Total TX Time (sec)	0.004256		
NOT Transmit time (RX or Idle)			
Wait for ACK (tack)	0.000192		
RX Time (ACK)	0.000352		
Backoff Time (tbo)	0.0048		
CPU Processing (tcpu)	0.0002		
CCA Assessment (tcca)	0.000128		
Turn Around Time (RX to TX)	0.000192		
Total Off Time (sec)	0.005864		
Total Time (ttotal)	0.01012	(0.004256 + 0.005864)	MAC TX Duty Cycle (On/Total) = 42.06