



**FCC 47 CFR PART 15 SUBPART C
INDUSTRY (ISED) CANADA RSS-247 ISSUE 1**

**BLUETOOTH LOW ENERGY
CERTIFICATION TEST REPORT**

FOR

LED Light Bulb with BLE

MODEL NUMBER: TWST-LED-001

**FCC ID: 2AE49-TWSTLED1
IC: 20364-TWSTLED1**

REPORT NUMBER: R11039922-E5

ISSUE DATE: 2016-11-30

Prepared for
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NVLAP[®]
TESTING

NVLAP LAB CODE 200246-0

Revision History

Ver.	Issue Date	Revisions	Revised By
1	2016-11-18	Initial Issue	Richard Jankovics
2	2016-11-30	Added Data Reuse information, updated test setup diagrams, added prescan note to radiated spurious plots, updated AC Power Line conducted RSS-Gen reference, updated device antenna gain	Richard Jankovics

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1. DATA REUSE

1.1. INTRODUCTION

The 15.247 DTS antenna port conducted test results for TWST-LED-001 are represented by Astro device TWST-LED-001 test report R11039922-E2 (FCC ID: 2AE49-TWSTSPK1, IC: 20364-TWSTSPK1). This report for FCC ID: 2AE49-TWSTLED1, IC: 20364-TWSTLED1 contains AC power line conducted emissions measurements and full radiated emissions measurements.

Astro takes full responsibility that the data as referenced in report R11039922-E2 (FCC ID: 2AE49-TWSTSPK1, IC: 20364-TWSTSPK1) represents compliance for this FCC ID.

1.2. DIFFERENCES

The model TWST-LED-001 of this report is a LED bulb with BLE only variant of TWST-SPKR-001, having the 802.11b/g/n, audio amplifier and the speaker removed. The antenna port conducted data of this report was taken on the TWST-SPKR-001 unit of report R11039922-E2 and included in this report, as the BLE circuitry is identical. Radiated emissions and AC power line conducted emissions data was taken on a TWST-LED-001 configured unit.

1.3. TESTING PERFORMED

Testing performed under this Report (R11039922-E5) are AC power line conducted emissions and radiated emissions. All other data is referenced to R11039922-E2 (FCC ID: 2AE49-TWSTSPK1, IC: 20364-TWSTSPK1).

1.4. REFERENCE DETAIL SECTION

Equipment Class	Reference FCC ID	Type Grant	Grant Date	Reference Application	Report Title
DTS	FCC ID: 2AE49-TWSTSPK1, IC: 20364-TWSTSPK1	New	2016-11-29	AN16T0630/AN16I7046	R11039922-E2 Section 8 (Antenna Port Results)

2. ATTESTATION OF TEST RESULTS

COMPANY NAME: ASTRO INC.
450 W 33RD ST.
NEW YORK, NEW YORK, 10001, USA

EUT DESCRIPTION: LED Light Bulb with BLE

MODEL: TWST-LED-001

SERIAL NUMBER: FCC #1, FCC #2, FCC #3 (LED1 variant)

DATE TESTED: 2016-10-06 – 2016-11-17

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	PASS
INDUSTRY (ISED) CANADA RSS-247 Issue 1	PASS
INDUSTRY (ISED) CANADA RSS-GEN Issue 4	PASS

UL LLC 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 LLC 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 LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC 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, or any agency of the U.S. Government.

Approved & Released
For UL LLC By:


Jeff Moser
EMC Program Manager
UL – Consumer Technology Division

Prepared By:


Richard Jankovics
WiSE Engineer
UL – Consumer Technology Division

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, RSS-GEN Issue 4, RSS-247 Issue 1.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 12 Laboratory Dr., Research Triangle Park, NC 27709, USA and 2800 Suite B, Perimeter Park Drive, Morrisville, NC 27560.

12 Laboratory Dr., RTP, NC 27709
<input type="checkbox"/> Chamber A
<input type="checkbox"/> Chamber C
2800 Suite B Perimeter Park Dr., Morrisville, NC 27560
<input type="checkbox"/> Chamber NORTH
<input checked="" type="checkbox"/> Chamber SOUTH

The onsite chambers are covered under Industry (ISED) Canada company address code 2180C with site numbers 2180C -1 through 2180C-4, respectively.

UL LLC (RTP) is accredited by NVLAP, Laboratory Code 200246-0. The full scope of accreditation can be viewed at <http://www.nist.gov/nvlap/>

5. CALIBRATION AND UNCERTAINTY

5.1. 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.

5.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

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

5.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
Total RF power, conducted	± 0.45 dB
RF power density, conducted	± 1.5 dB
Spurious emissions, conducted	± 2.94 dB
All emissions, radiated up to 40 GHz	± 5.36 dB
Temperature	$\pm 0.07^\circ\text{C}$
Humidity	$\pm 2.26\%$ RH
DC and low frequency voltages	$\pm 1.27\%$
Conducted Emissions (0.150-30MHz)	± 3.65 dB

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

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is an LED Light Bulb with BLE. The model TWST-LED-001 of this report is a LED bulb with BLE only variant of TWST-SPKR-001, having the 802.11b/g/n, audio amplifier and the speaker removed. The RF conducted data of this report was taken on the TWST-SPKR-001 unit of report R11039922-E2 and included in this report, as the BLE circuitry is identical. Radiated emissions and AC power line conducted emissions data was taken on a TWST-LED-001 configured unit.

6.2. 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	1.69	1.48

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a trace antenna, with a maximum gain of -0.28 dBi.

6.1. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was FCC 1.0.

The test utility software used during testing was Ralink QA Test Program, version 1.0.1.0.

6.2. WORST-CASE CONFIGURATION AND MODE

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

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

Based on the baseline scan, the worst-case data rates were:

- BLE GFSK, Payload 37 bytes

6.3. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Lenovo	T440	NA	NA
Power Brick	Lenovo	ADLX65NLC2A	NA	NA
Serial to USB	NA	NA	NA	NA

Note: Laptop, Power Brick, and Serial to USB are only used to configure sample and removed. Not present during measurements.

I/O CABLES

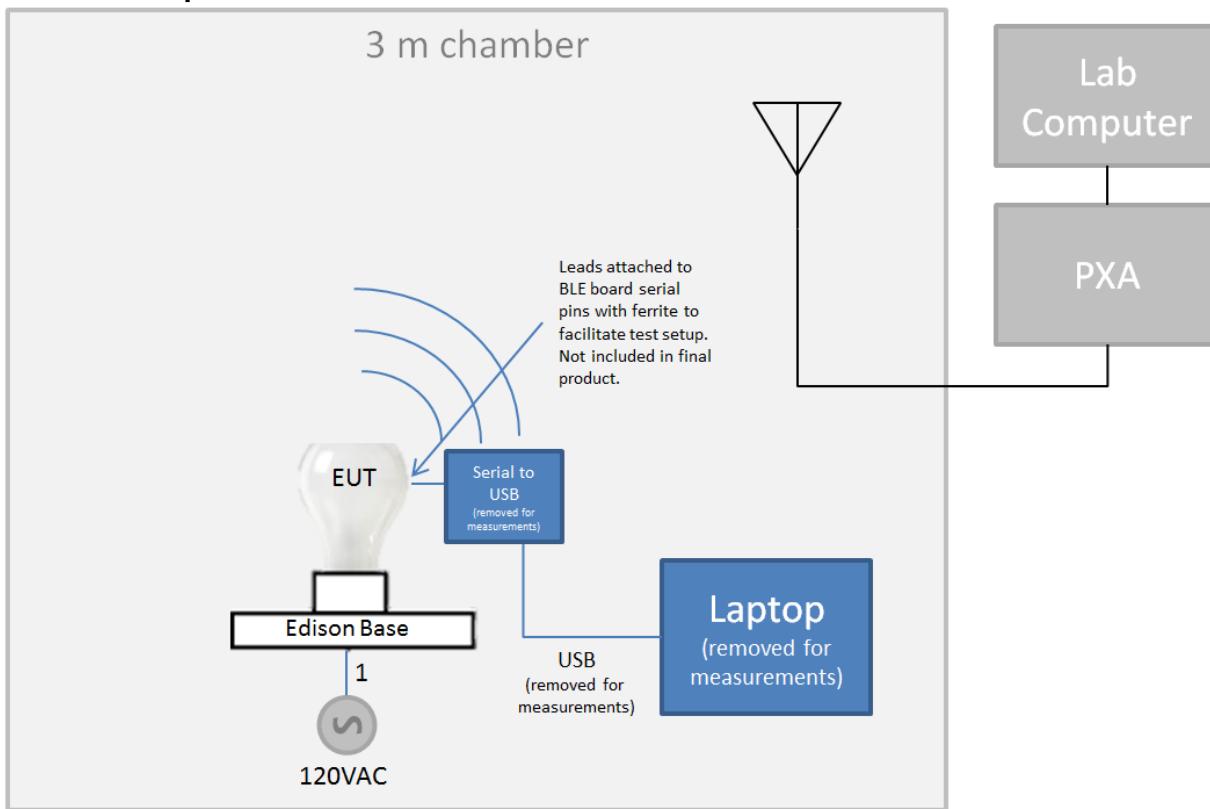
I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	Terminal	AC Inlet	2.95	18AWG line cord.
NA	Antenna	1	RF		0.3	
NA	NA	1	USB to Micro USB	USB cable	0.25	Configuration only. Not present during meas.

TEST SETUP

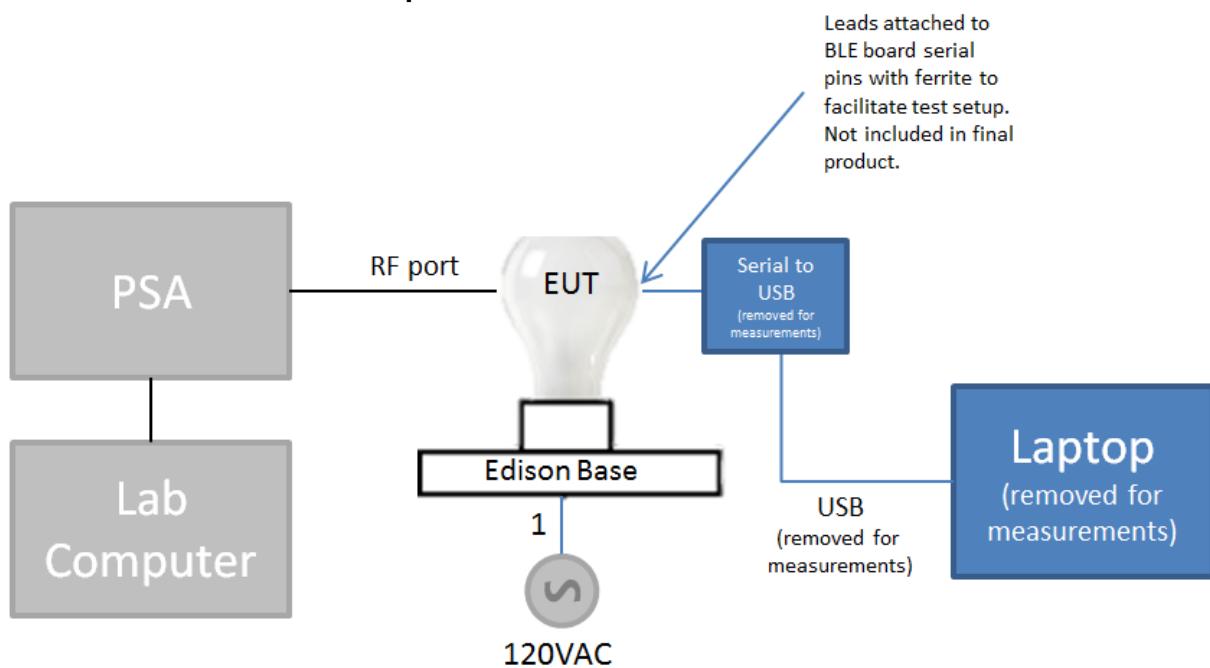
Different bulbs were provided. One unit was provided for radiated-emissions and line-conducted testing (an external serial port allowed for configuring the device) and one unit was provided for conducted-port testing. Units were modified with added serial port with serial to USB adapter to facilitate programming the RF output for testing. Once the device was running the test mode, the serial to USB adapter, USB cable and laptop were removed for measurements. Ports not present on finished product.

SETUP DIAGRAM FOR TESTS

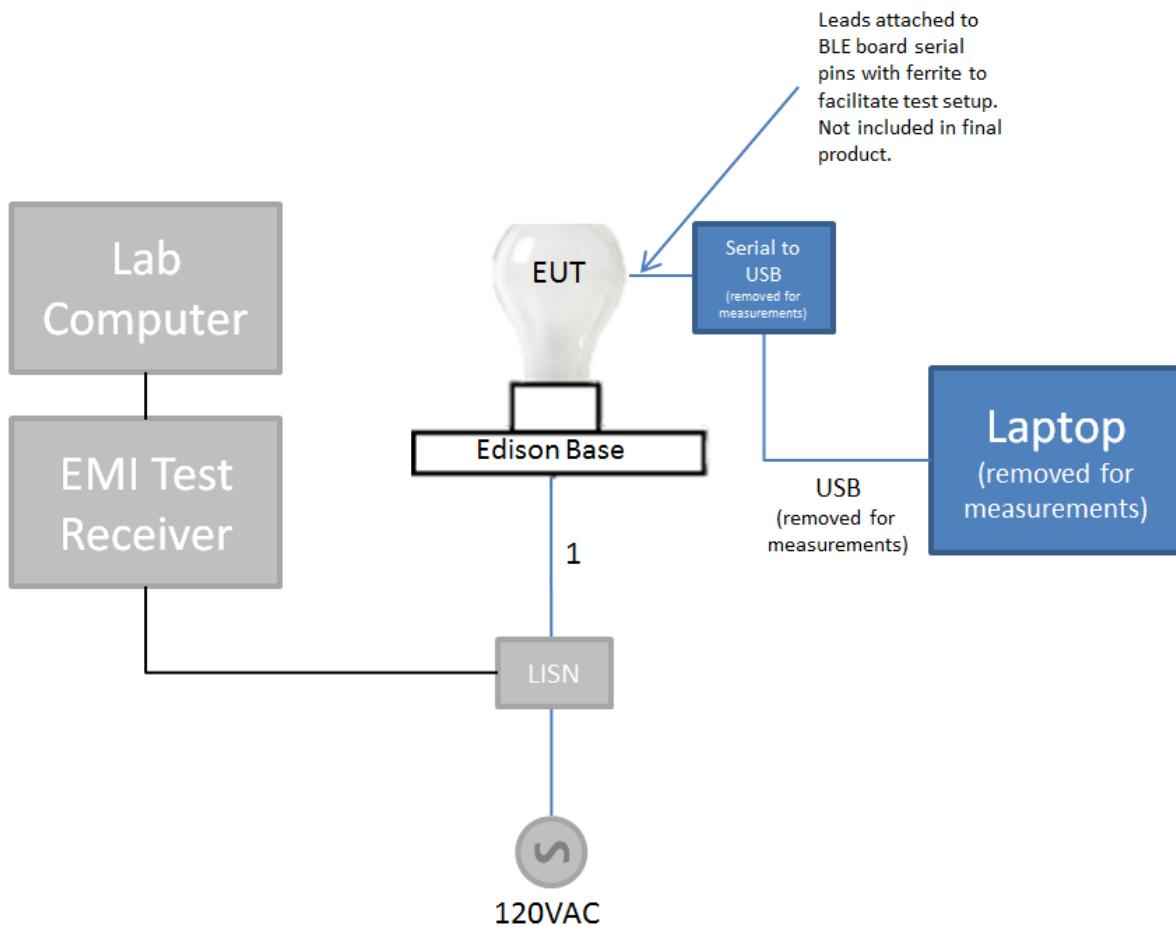
Radiated Setup



Antenna Port Conducted Setup



Line Conducted Setup



7. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - South Chamber)

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	0.009-30MHz	(Loop Ant.)			
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2015-12-08	2016-12-31
	30-1000 MHz				
AT0074	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2016-06-07	2017-06-30
	1-18 GHz				
AT0069	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2016-03-07	2017-03-31
	18-26 GHz				
AT0076	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2016-09-06	2017-09-30
	Gain-Loss Chains				
S-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2015-10-07, 2016-10-04	2016-10-31, 2017-10-04
S-SAC02	Gain-loss string: 30-1000MHz	Various	Various	2016-06-26	2017-06-30
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2016-08-28	2017-08-28
S-SAC04	Gain-loss string: 18-40GHz	Various	Various	2016-08-28	2017-08-28
	Receiver & Software				
SA0025	Spectrum Analyzer	Agilent	N9030A	2016-03-17	2017-03-31
SA0026 (18-40GHz RSE)	Spectrum Analyzer	Agilent	N9030A	2016-02-24	2017-02-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
	Additional Equipment used				
HI0078	Temp/Humid/Pressure Meter	Springfield Precision	PreciseTemp	2016-06-13	2017-06-13

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
Conducted Room 2					
SA0020	Spectrum Analyzer	Agilent Technologies	E4446A	2016-03-22	2017-03-31
PWM003	RF Power Meter	Keysight Technologies	N1911A	2016-06-21	2017-06-21
PWS001	Peak and Avg Power Sensor, 50MHz to 6GHz	Keysight Technologies	N1921A	2016-04-07	2017-04-31
UL139843	Temp/Humid/Pressure Meter	Fisher Scientific	14-650-118	2016-02-19	2017-02-19
MM0166	True RMS Multimeter	Agilent	U1232A	2016-03-15	2017-03-31

Test Equipment Used - Line-Conducted Emissions – Voltage (Morrisville – Conducted 1)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL077	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3476-240	2016-06-15	2017-06-30
139843	Temp/Humid/Pressure Meter	Control Co./Fisher	14-650-118	2016-02-19	2017-02-19
LISN003	LISN, 50-ohm/50-uH, 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50-25-2-01-550V	2016-08-24	2017-08-24
MM0170	Multi-meter	Fluke	83V	2016-03-15	2017-03-31
PRE0101521 (75141)	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2016-08-23	2017-08-23
TL001	Transient Limiter, 0.009-30MHz	Com-Power	LIT-930A	2016-06-09	2017-06-30
PS215	AC Power Source	Elgar	CW2501M (s/n 1523A02397)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA

8. MEASUREMENT METHODS

Duty Cycle: KDB 558074 D01 v03r05 Section 6.0

6 dB BW: KDB 558074 D01 v03r05, Section 8.1.

99% Occupied Bandwidth: ANSI C63.10-2013, Section 6.9.3

Output Power: KDB 558074 D01 v03r05, Section 9.1.2

Power Spectral Density: KDB 558074 D01 v03r05, Section 10.2.

Out-of-band emissions in non-restricted bands: KDB 558074 D01 v03r05, Section 11.0.

Out-of-band emissions in restricted bands: KDB 558074 D01 v03r05, Section 12.1.

General Radiated Emissions: ANSI C63.10:2013 Sections 6.3-6.6

Line Conducted Emissions: ANSI C63.10:2013 Sections 6.2

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME, DUTY CYCLE AND MEASUREMENT METHODS

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

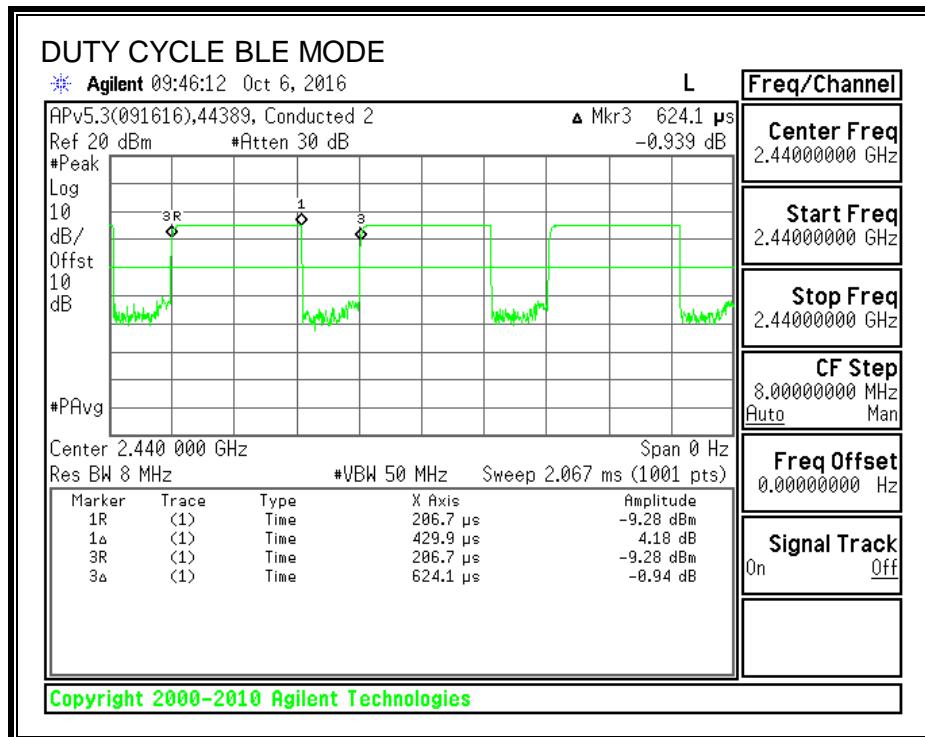
ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
BLE	0.430	0.624	0.689	68.88%	1.62	2.326

Test Performed: Niklas Haydon / Jeff Cabrera

Test Date: 2016-10-06

DUTY CYCLE PLOTS



9.2. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

IC RSS-247 5.2 (1)

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

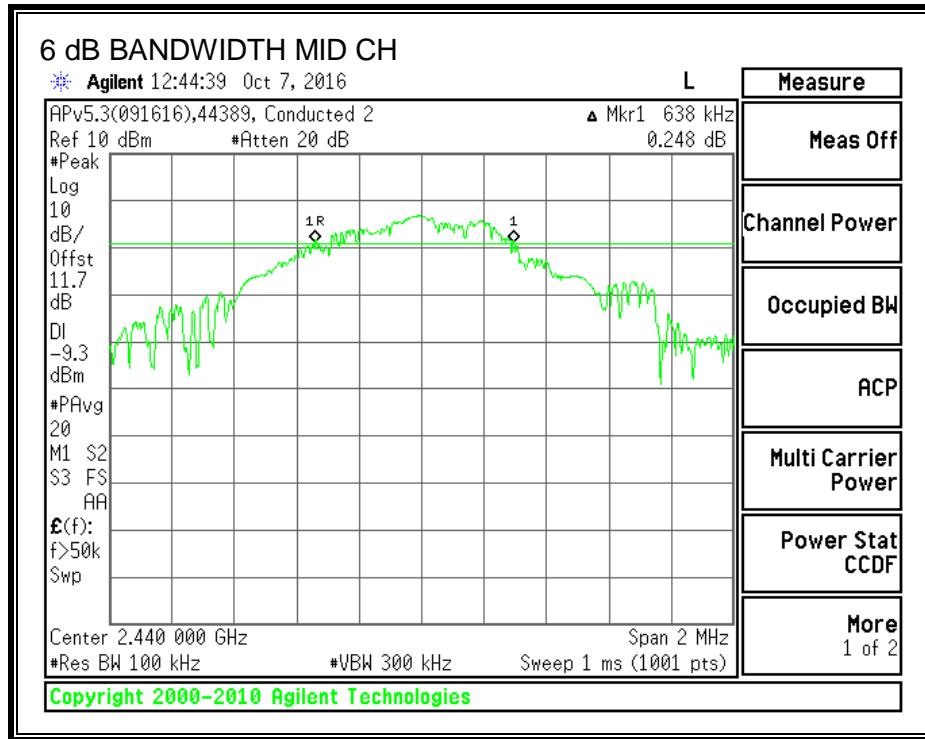
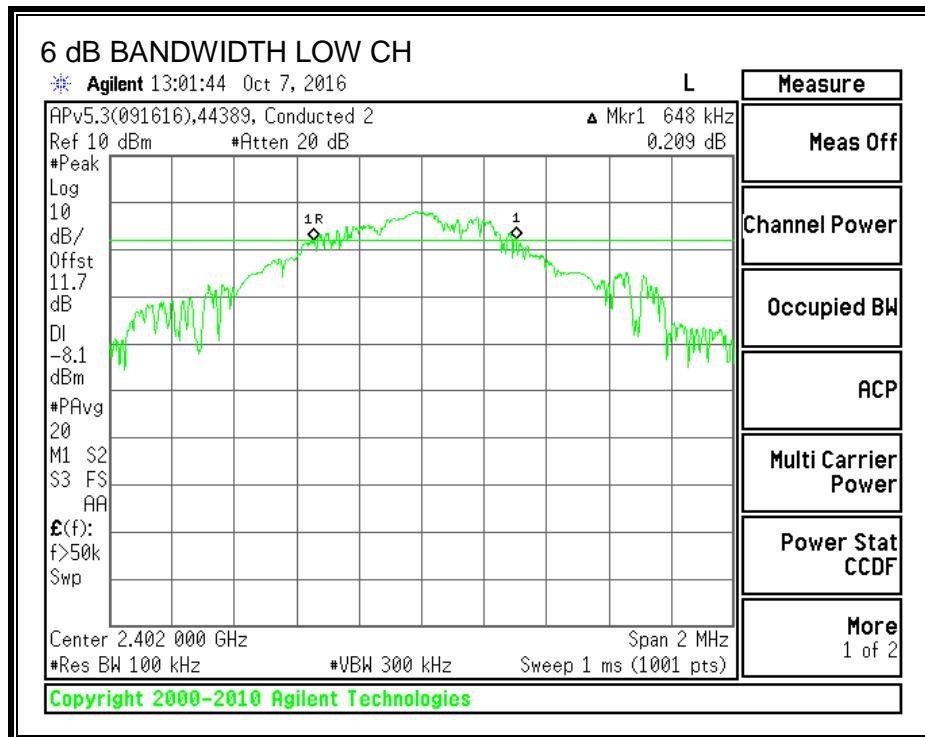
RESULTS

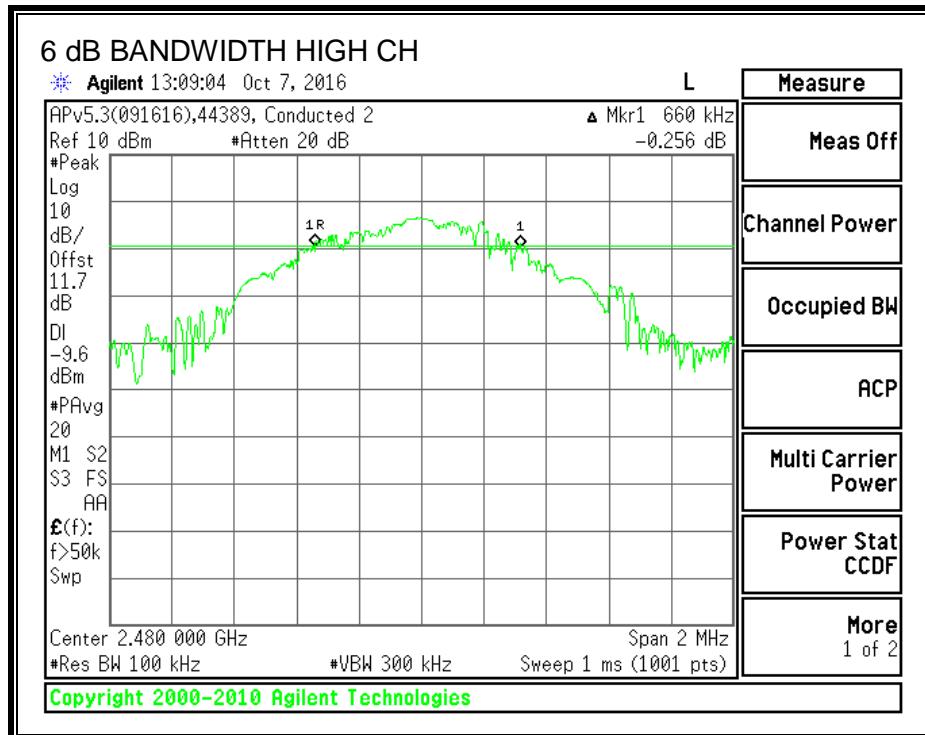
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6480	0.5
Middle	2440	0.6380	0.5
High	2480	0.6600	0.5

Test Performed: Niklas Haydon / Jeff Cabrera

Test Date: 2016-10-07

6 dB BANDWIDTH





9.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only. Testing per RSS-Gen Clause 6.6.

TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 5% of the 99 % bandwidth and to 1% of the span. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

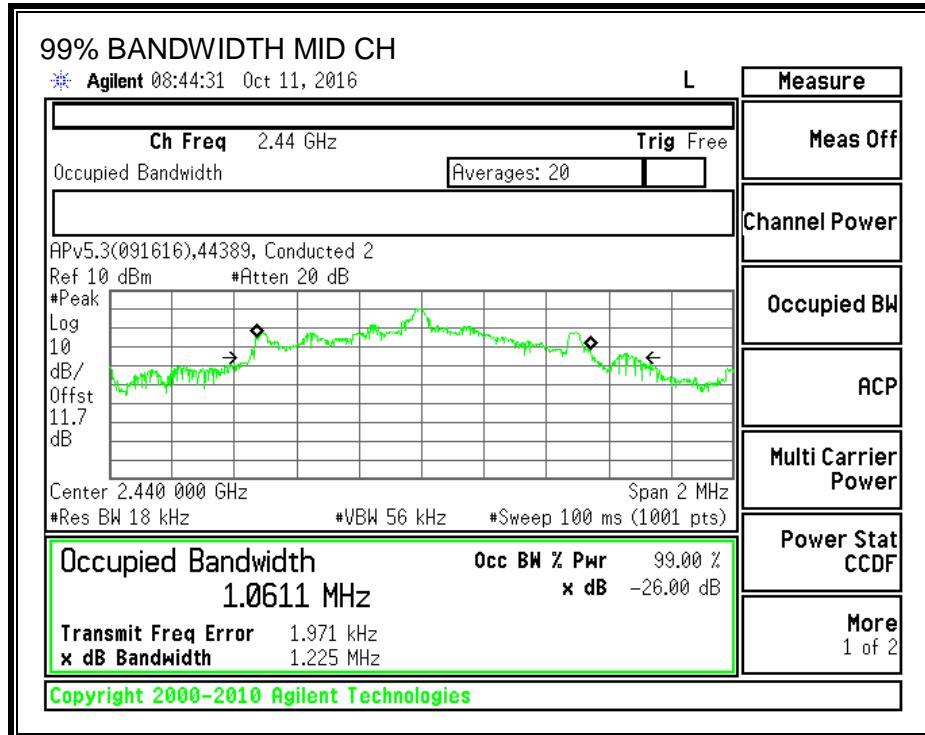
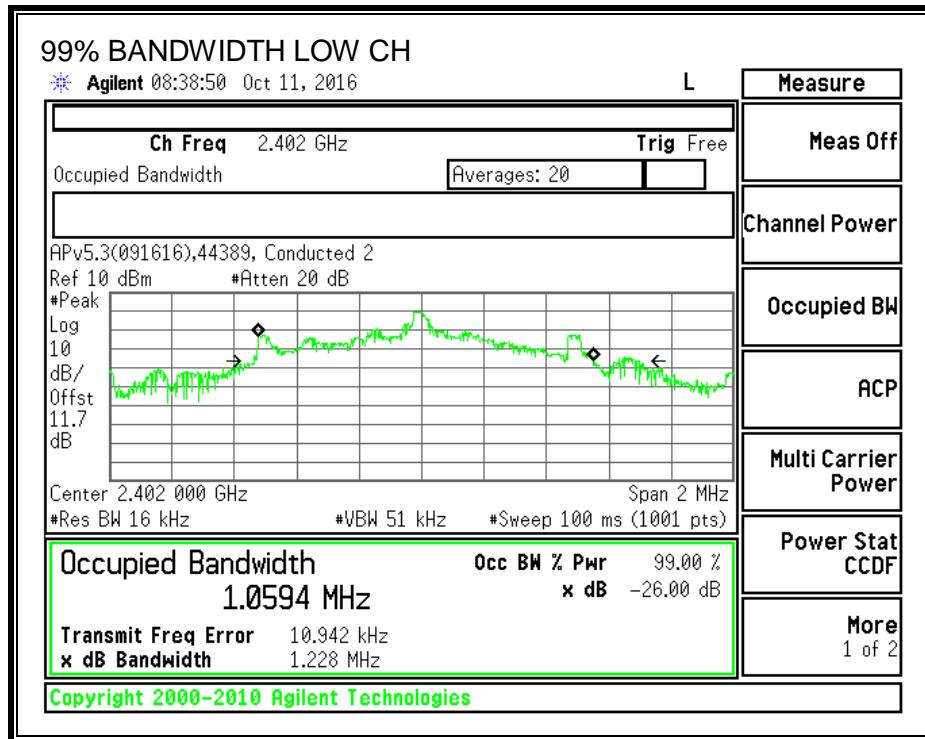
RESULTS

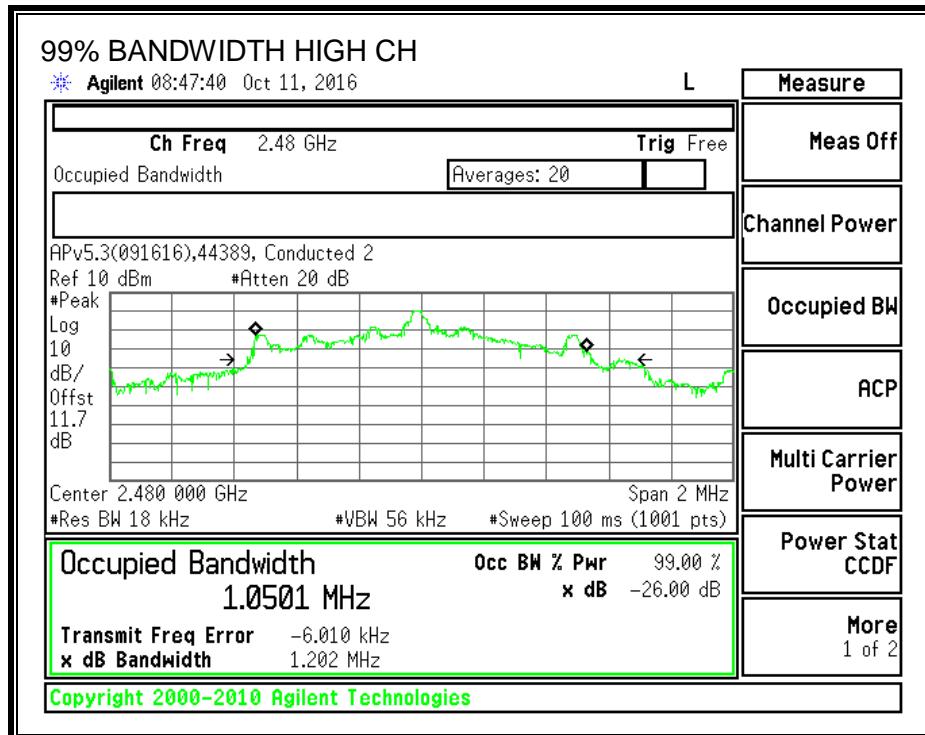
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0594
Middle	2440	1.0611
High	2480	1.0501

Test Performed: Niklas Haydon / Jeff Cabrera

Test Date: 2016-10-11

99% BANDWIDTH





9.4. OUTPUT POWER

LIMITS

FCC §15.247 (b) (3)

IC RSS-247 5.4 (4)

FCC - For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt, based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS - For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W.

RESULTS

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	1.240	30	-28.760
Middle	2440	1.690	30	-28.310
High	2480	1.630	30	-28.370

Test Performed: Niklas Haydon / Jeff Cabrera

Test Date: 2016-10-06

9.5. AVERAGE POWER

LIMITS

None; for reporting purposes only.

RESULTS

The cable assembly insertion loss of 11.7 dB (including 10 dB pad and 1.7 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	1.15
Middle	2440	1.61
High	2480	1.55

NOTE: Gated Measurements

9.6. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (e)

IC RSS-247 5.2 (2)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz to 100 kHz band during any time interval of continuous transmission.

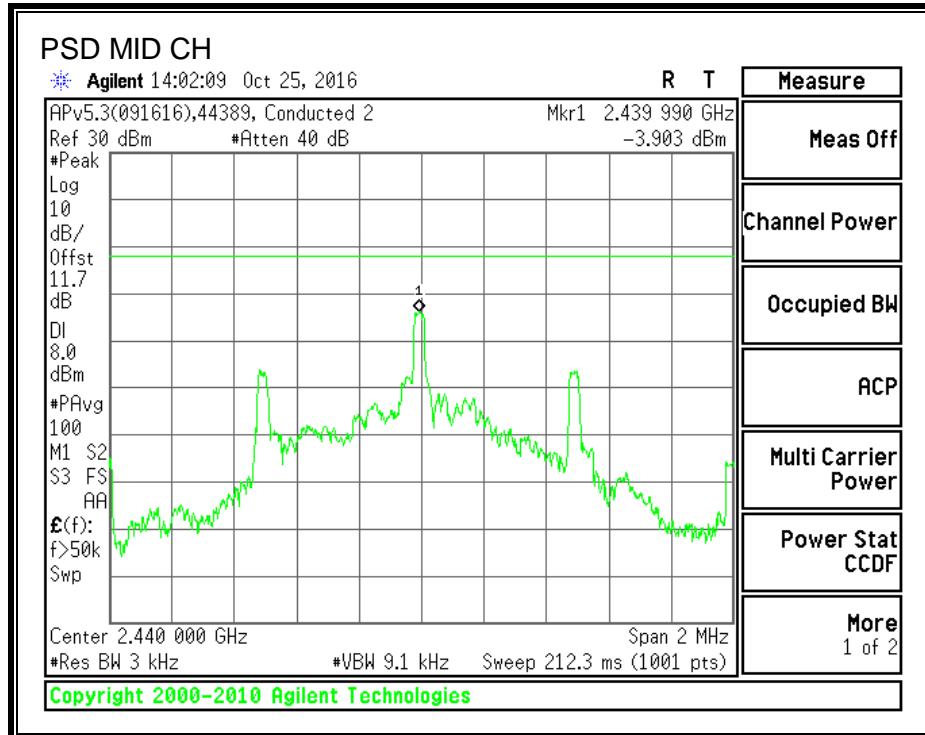
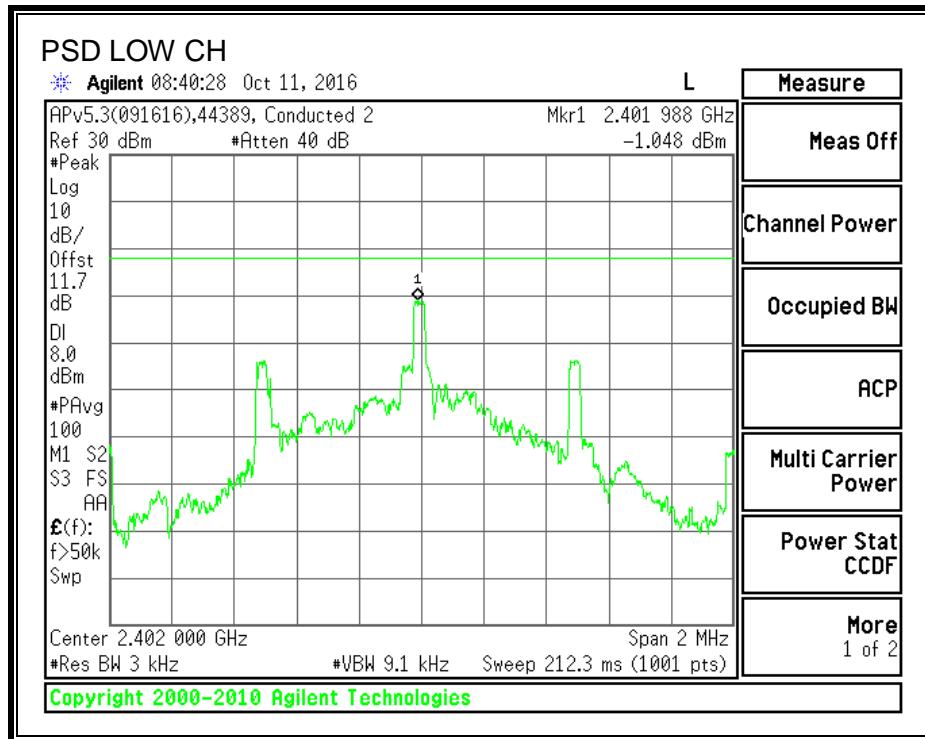
RESULTS

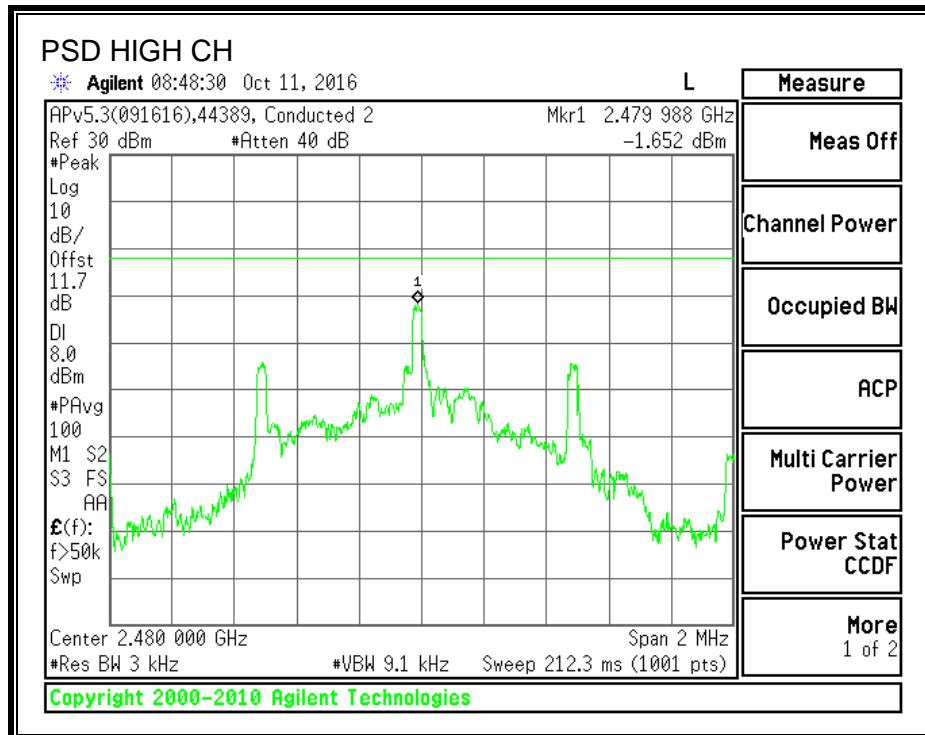
Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-1.05	8	-9.05
Middle	2440	-3.90	8	-11.90
High	2480	-1.65	8	-9.65

Test Performed: Niklas Haydon / Jeff Cabrera

Test Date: 2016-10-11, 2016-10-25

POWER SPECTRAL DENSITY





9.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-247 5.5

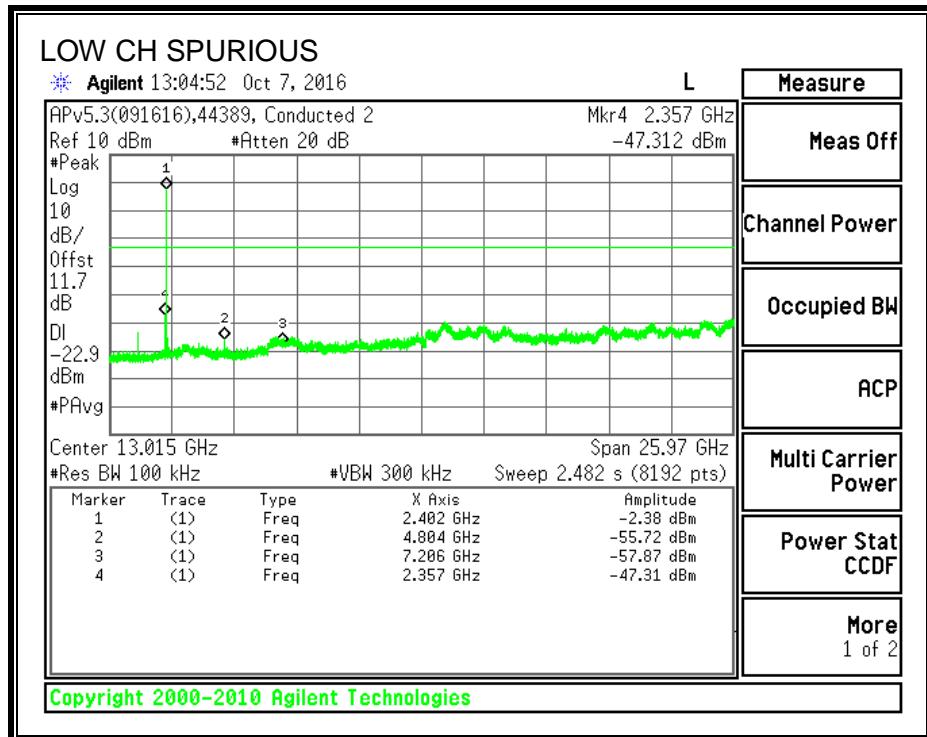
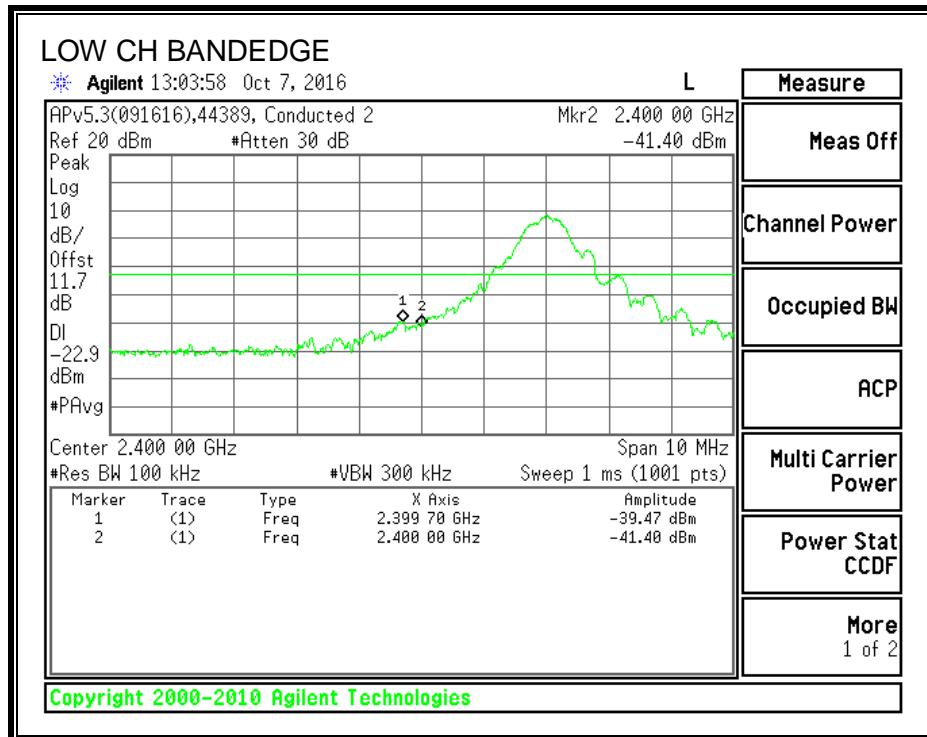
Output power was measured based on the use of a peak measurement, therefore the required attenuation is 20 dB.

Test Performed: Niklas Haydon / Jeff Cabrera

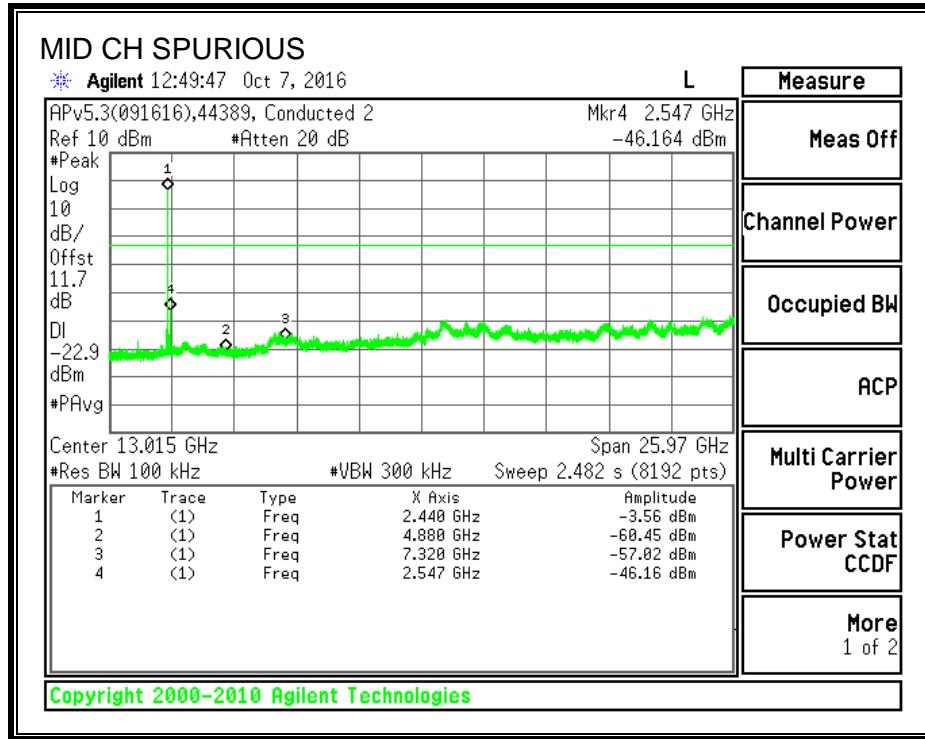
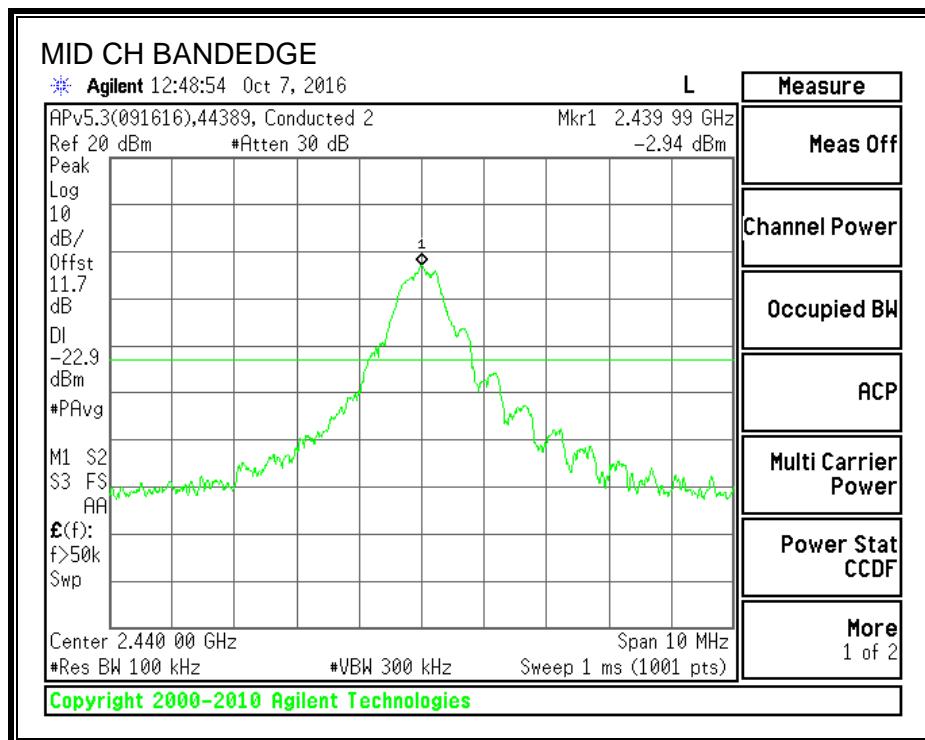
Test Date: 2016-10-07

RESULTS

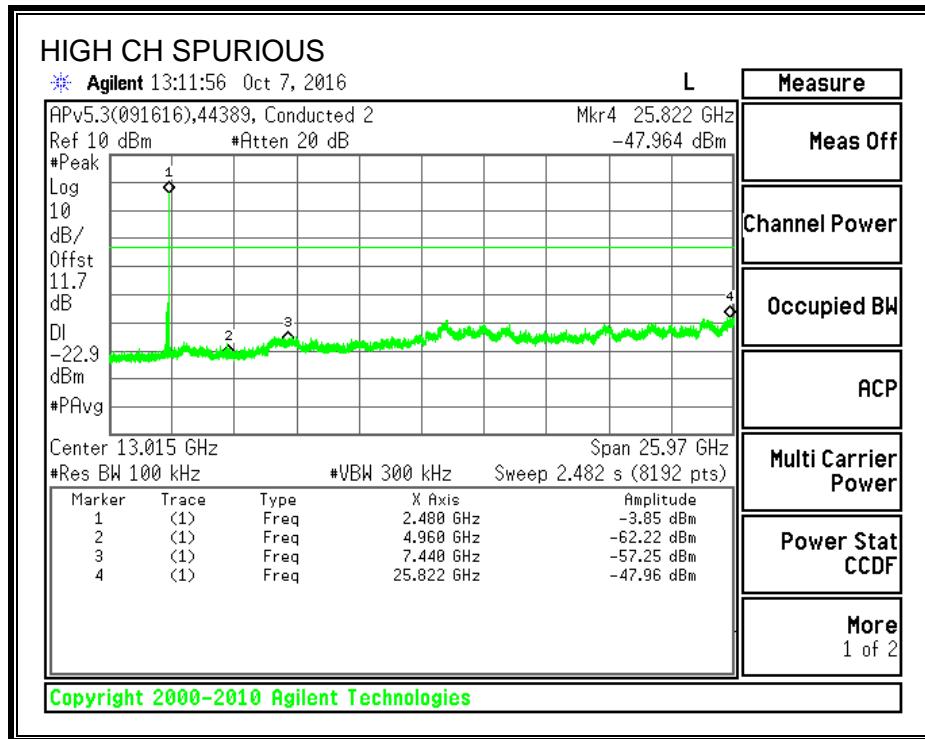
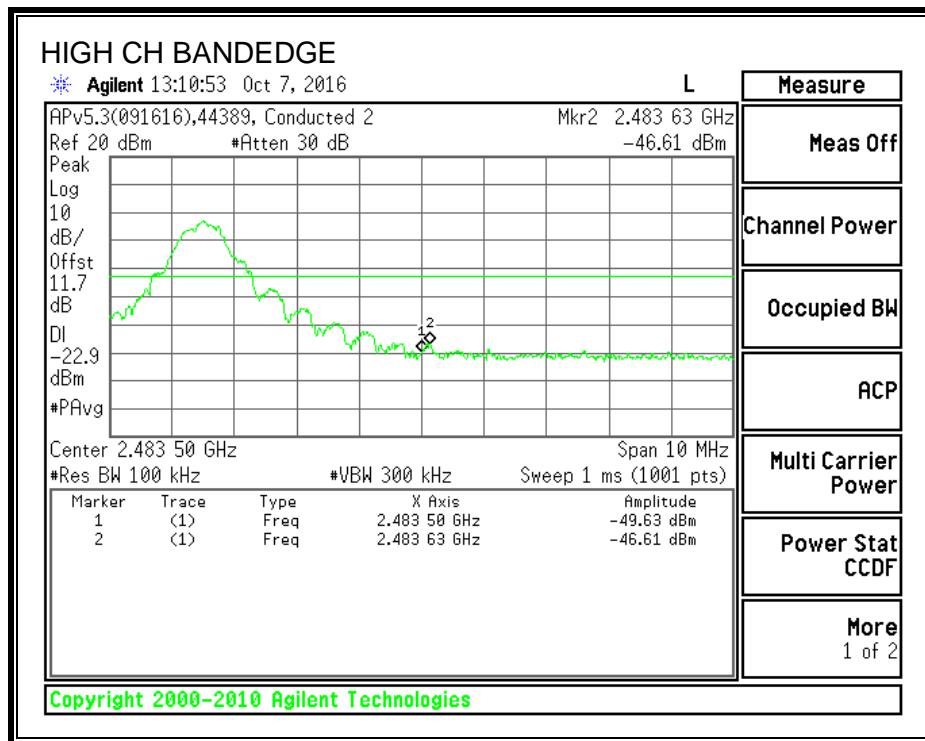
SPURIOUS EMISSIONS, LOW CHANNEL



SPURIOUS EMISSIONS, MID CHANNEL



SPURIOUS EMISSIONS, HIGH CHANNEL



10. RADIATED TEST RESULTS

10.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205, §15.209, §15.247 (d)

IC RSS-GEN Clause 8.9 (Transmitter)

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
0.009-0.490	2400/f(kHz) (at 300 m)	-
0.490-1.705	24000/f(kHz) (at 30 m)	-
1.705-30.0	30 (at 30 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 for below 1GHz measurements and 1.5 m above the ground plane for above 1GHz measurements. The antenna to EUT distance is 3 meters.

For measurements below 1 GHz the resolution bandwidth is set to 120 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements for the 30-1000 MHz range, 9 kHz for peak detection measurements or 9 kHz for quasi-peak detection measurements for the 0.15-30 MHz range and 200 Hz for peak detection measurements or 200 Hz for quasi-peak detection measurements for the 9 to 150 kHz range. Peak detection is used unless otherwise noted as quasi-peak.

For peak measurements above 1 GHz, the resolution bandwidth is set to 1 MHz and the video bandwidth is set to 3 MHz. For average measurements above 1GHz, the resolution bandwidth and video bandwidth are set as described in ANSI C63.10:2013 for the applicable measurement. For this evaluation, RMS Power Averaging was used and the resolution/video bandwidth settings were 1MHz/3MHz.

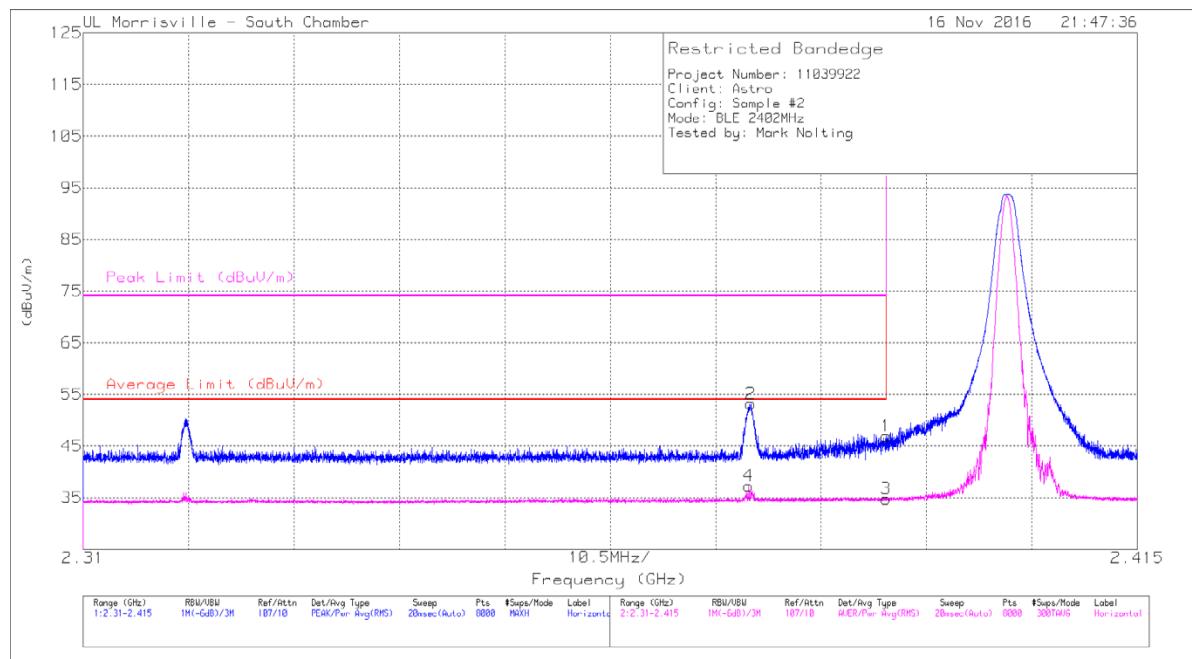
The spectrum from 9 kHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band.

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

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

RESTRICTED BANDEDGE (LOW CHANNEL, HORIZONTAL)



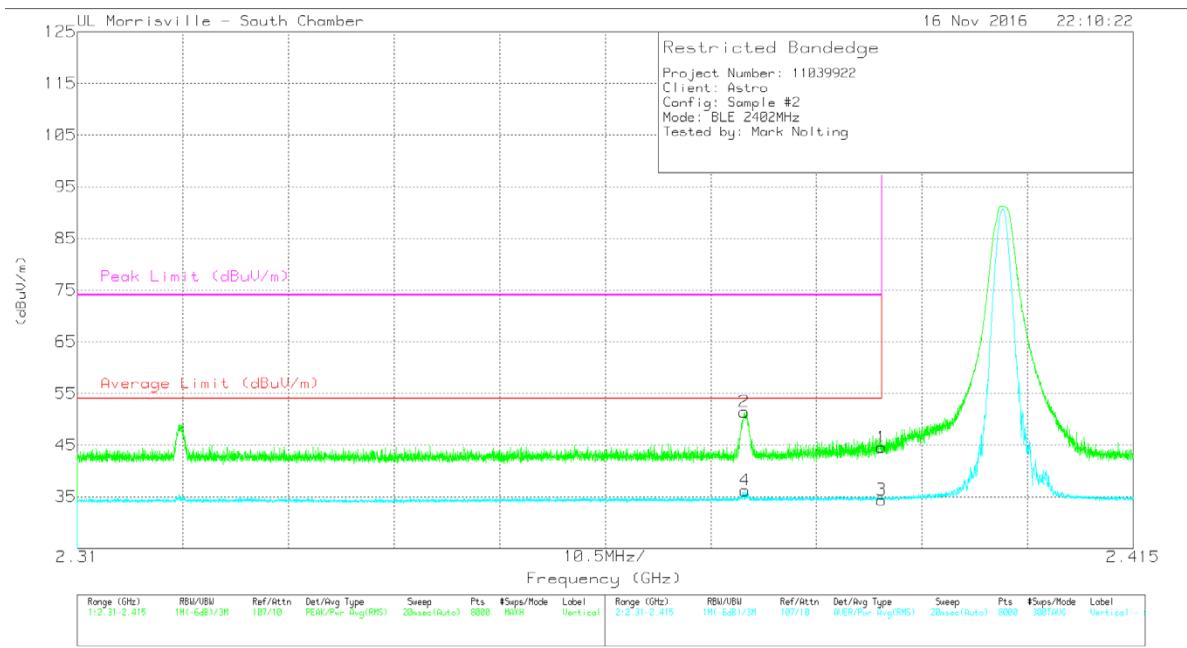
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	38.84	Pk	32.2	-24.1	0	46.94	-	-	74	-27.06	80	206	H
2	* 2.377	45.08	Pk	32.1	-24	0	53.18	-	-	74	-20.82	80	206	H
3	* 2.39	25.07	RMS	32.2	-24.1	1.62	34.79	54	-19.21	-	-	80	206	H
4	* 2.376	27.58	RMS	32.1	-24	1.62	37.3	54	-16.7	-	-	80	206	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

RMS - RMS detection

RESTRICTED BANDEDGE (LOW CHANNEL, VERTICAL)



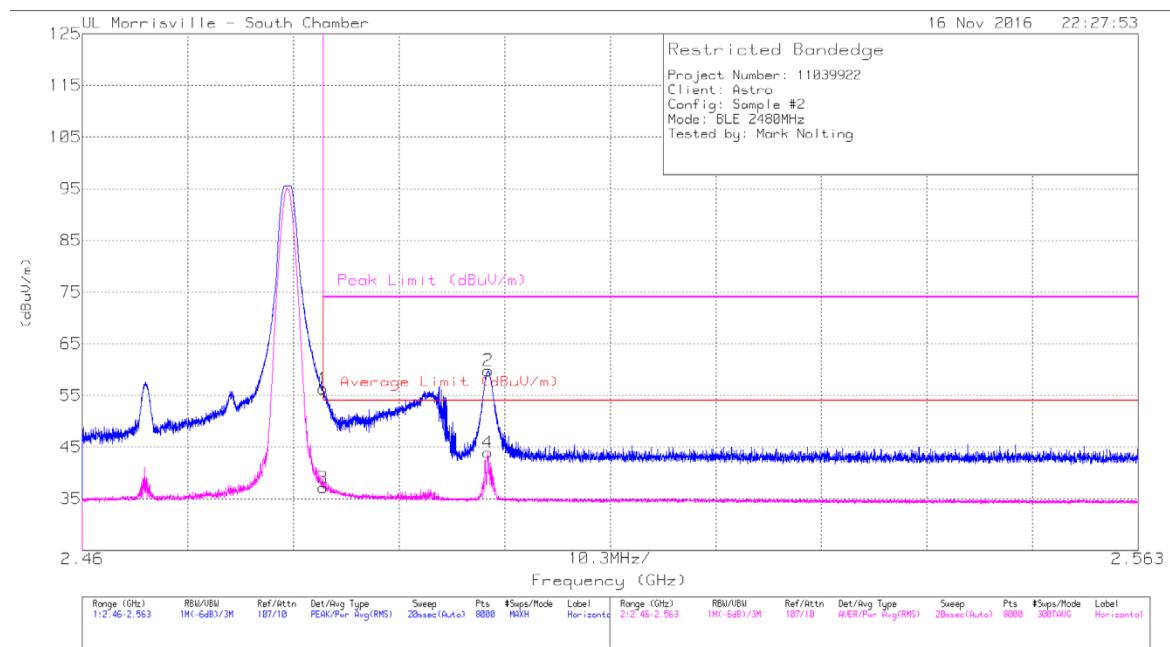
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 2.376	43.34	Pk	32.1	-24	0	51.44	-	-	74	-22.56	113	298	V
4	* 2.376	26.51	RMS	32.1	-24	1.62	36.23	54	-17.77	-	-	113	298	V
1	* 2.39	36.45	Pk	32.2	-24.1	0	44.55	-	-	74	-29.45	113	298	V
3	* 2.39	24.65	RMS	32.2	-24.1	1.62	34.37	54	-19.63	-	-	113	298	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

RMS - RMS detection

RESTRICTED BANDEDGE (HIGH CHANNEL, HORIZONTAL)



High CH Bandedge - H.TST

Rev 9.5 26 Oct 2016

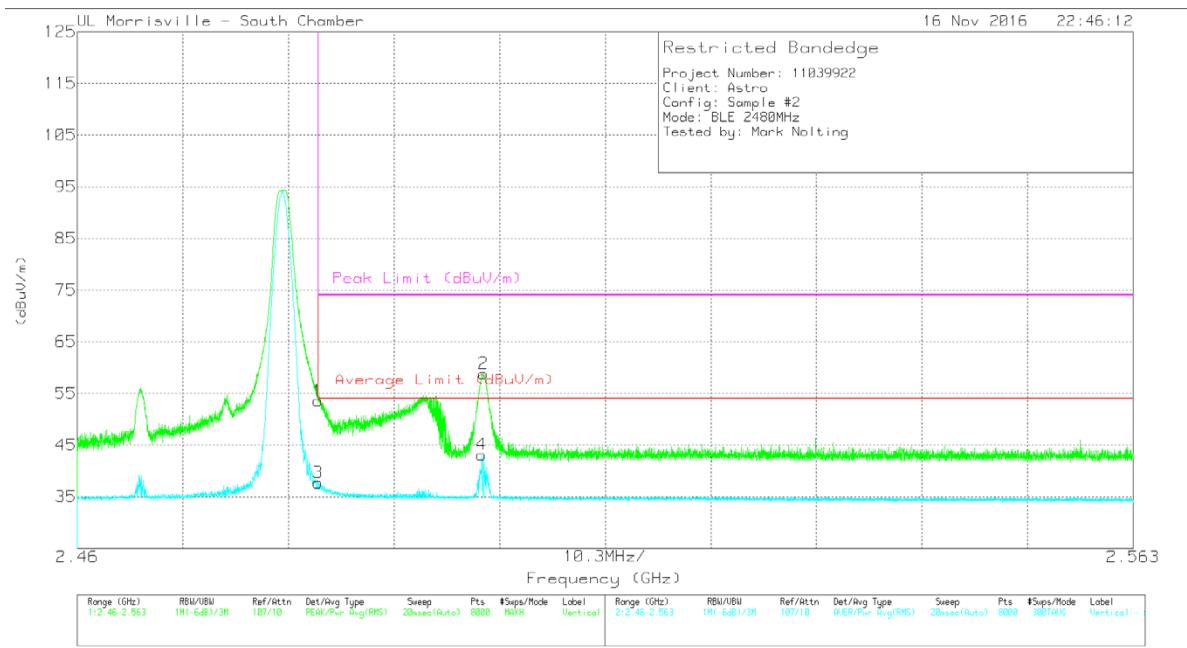
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	48.52	Pk	32.4	-24.6	0	56.32	-	-	74	-17.68	106	219	H
3	* 2.484	27.71	RMS	32.4	-24.6	1.62	37.13	54	-16.87	-	-	106	219	H
2	* 2.5	51.89	Pk	32.5	-24.6	0	59.79	-	-	74	-14.21	106	219	H
4	* 2.5	34.41	RMS	32.5	-24.6	1.62	43.93	54	-10.07	-	-	106	219	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

RMS - RMS detection

RESTRICTED BANDEDGE (HIGH CHANNEL, VERTICAL)



High CH Bandedge - U.TST

Rev 9.5 26 Oct 2016

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (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	45.74	Pk	32.4	-24.6	0	53.54	-	-	74	-20.46	118	235	V
3	* 2.484	28.29	RMS	32.4	-24.6	1.62	37.71	54	-16.29	-	-	118	235	V
4	* 2.499	33.63	RMS	32.5	-24.6	1.62	43.15	54	-10.85	-	-	118	235	V
2	* 2.5	50.92	Pk	32.5	-24.6	0	58.82	-	-	74	-15.18	118	235	V

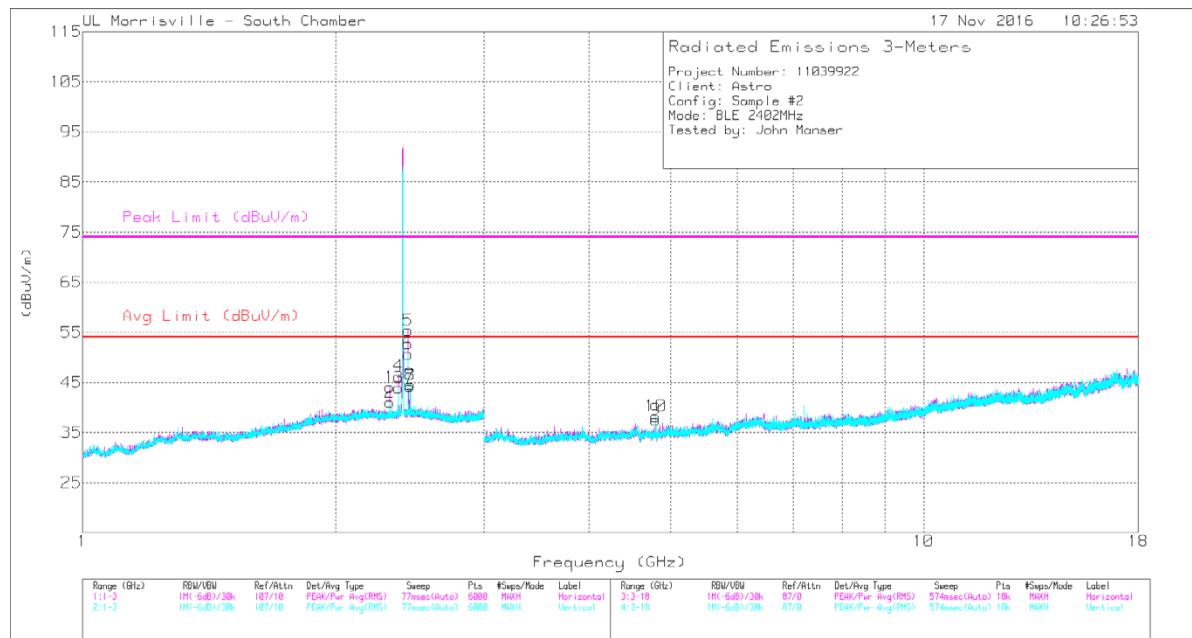
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

RMS - RMS detection

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL



FCC Part 15C 2.4GHz RSE, TST

Rev 9.5 26 Oct 2016

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/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	* 2.32	42.67	PK2	31.7	-23.7	0	50.67	-	-	74	-23.33	59	207	H
	* 2.32	26.58	MAv1	31.7	-23.7	1.62	36.2	54	-17.8	-	-	59	207	H
4	* 2.376	46.5	PK2	32.1	-24	0	54.6	-	-	74	-19.4	92	236	H
	* 2.376	27.9	MAv1	32.1	-24	1.62	37.62	54	-16.38	-	-	92	236	H
2	* 2.32	41.79	PK2	31.7	-23.7	0	49.79	-	-	74	-24.21	114	346	V
	* 2.32	27.36	MAv1	31.7	-23.7	1.62	36.98	54	-17.02	-	-	114	346	V
3	* 2.376	44.05	PK2	32.1	-24	0	52.15	-	-	74	-21.85	120	344	V
	* 2.376	26.98	MAv1	32.1	-24	1.62	36.7	54	-17.3	-	-	120	344	V
9	* 4.803	42.77	PK2	34	-31.1	0	45.67	-	-	74	-28.33	310	268	H
	* 4.804	30.13	MAv1	34	-31.1	1.62	34.65	54	-19.35	-	-	310	268	H
10	* 4.803	44.76	PK2	34	-31.1	0	47.66	-	-	74	-26.34	287	262	V
	* 4.804	32.55	MAv1	34	-31.1	1.62	37.07	54	-16.93	-	-	287	262	V
6	2.437	42.68	Pk	32.3	-24.3	0	50.68	-	-	-	-	0-360	199	V
5	2.438	47.39	Pk	32.3	-24.3	0	55.39	-	-	-	-	0-360	199	H
7	2.451	36.36	Pk	32.3	-24.4	0	44.26	-	-	-	-	0-360	199	H
8	2.452	36.7	Pk	32.3	-24.4	0	44.6	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

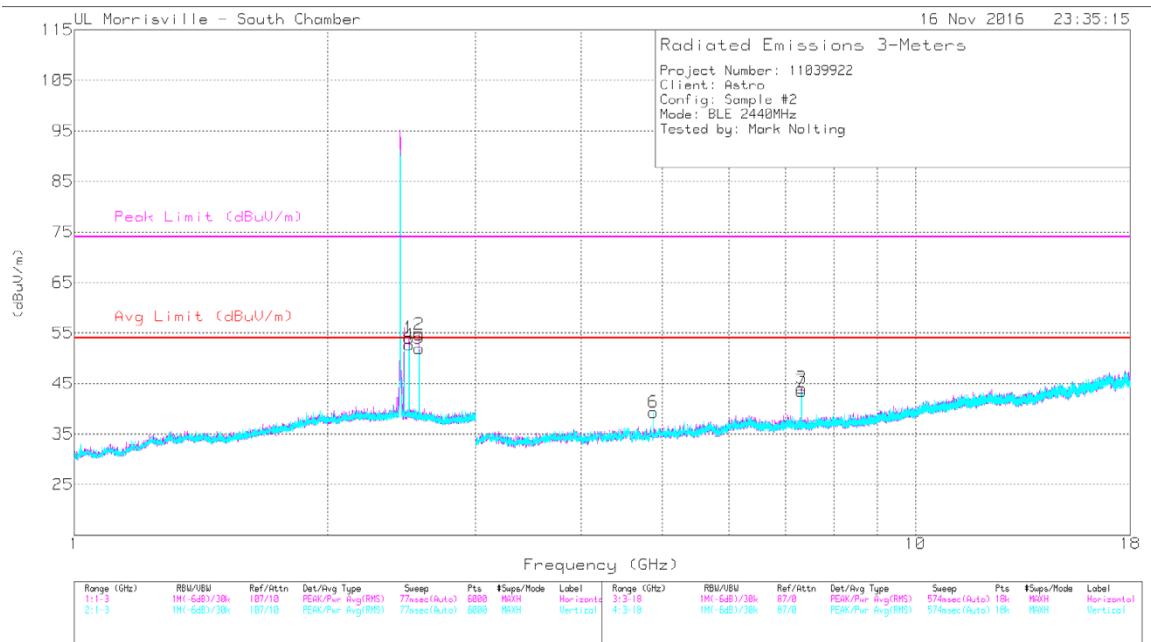
Pk - Peak detector

PK2 - Maximum Peak

MAv1 - Maximum RMS Average

Note: Plot above represents a prescan. All final measurements were made at RBW/VBW = 1MHz/3MHz.

MID CHANNEL



FCC Part15C 2.4GHz RSE.TST

Rev 9.5 26 Oct 2016

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/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	* 2.5	52.43	PK2	32.5	-24.6	0	60.33	-	-	74	-13.67	92	242	H
	* 2.5	31.66	MAv1	32.5	-24.6	1.62	41.18	54	-12.82	-	-	92	242	H
4	* 2.5	51.34	PK2	32.5	-24.6	0	59.24	-	-	74	-14.76	128	269	V
	* 2.5	30.1	MAv1	32.5	-24.6	1.62	39.62	54	-14.38	-	-	128	269	V
3	* 7.321	41.83	PK2	35.5	-27.9	0	49.43	-	-	74	-24.57	110	101	H
	* 7.32	33.36	MAv1	35.5	-27.9	1.62	42.58	54	-11.42	-	-	110	101	H
6	* 4.879	44.61	PK2	34.1	-31	0	47.71	-	-	74	-26.29	299	259	V
	* 4.879	28.22	MAv1	34.1	-31	1.62	32.94	54	-21.06	-	-	299	259	V
7	* 7.32	41.54	PK2	35.5	-27.9	0	49.14	-	-	74	-24.86	283	101	V
	* 7.32	32.86	MAv1	35.5	-27.9	1.62	42.08	54	-11.92	-	-	283	101	V
2	2.57	47.44	Pk	32.4	-25.1	0	54.74	-	-	-	-	0-360	199	H
5	2.57	44.63	Pk	32.4	-25.1	0	51.93	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

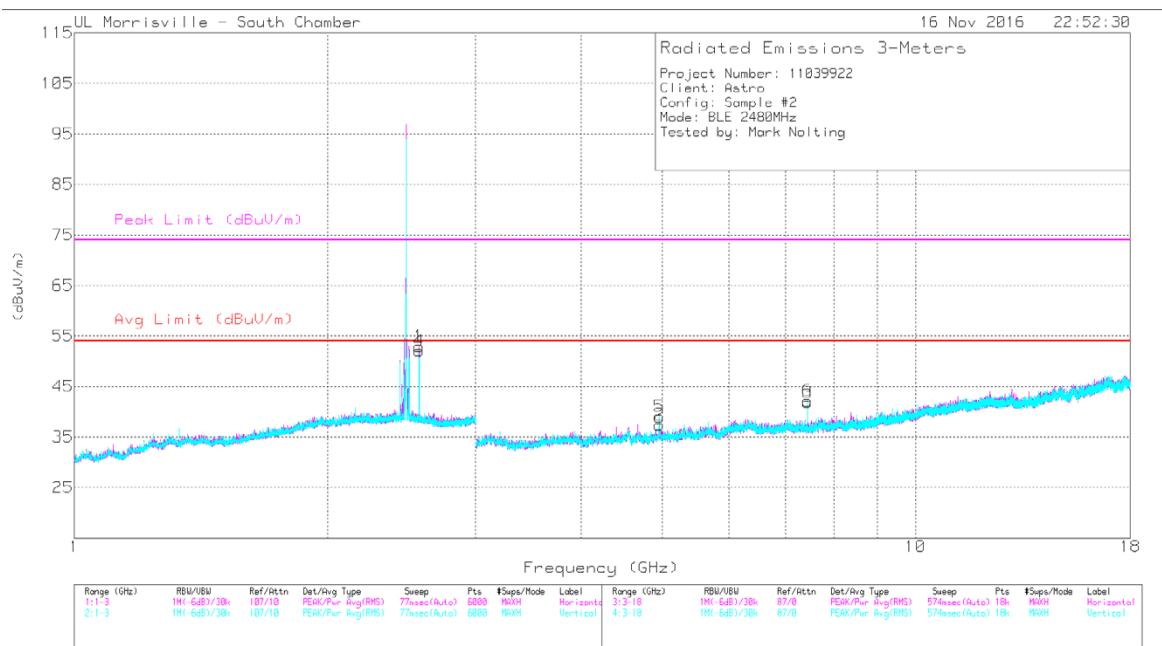
Pk - Peak detector

PK2 - Maximum Peak

MAv1 - Maximum RMS Average

Note: Plot above represents a prescan. All final measurements were made at RBW/VBW = 1MHz/3MHz.

HIGH CHANNEL



FCC Part15C 2.4GHz RSE, TST

Rev 9.5 26 Oct 2016

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0069 (dB/m)	Amp/Cbl/Fltr/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	* 4.96	43.6	PK2	34.1	-31.3	0	46.4	-	-	74	-27.6	117	142	H
	* 4.96	32.64	MAv1	34.1	-31.3	1.62	37.06	54	-16.94	-	-	117	142	H
3	* 7.44	41.21	PK2	35.5	-28.1	0	48.61	-	-	74	-25.39	92	103	H
	* 7.44	31.99	MAv1	35.5	-28.2	1.62	40.91	54	-13.09	-	-	92	103	H
5	* 4.96	44.58	PK2	34.1	-31.3	0	47.38	-	-	74	-26.62	273	190	V
	* 4.96	33.6	MAv1	34.1	-31.3	1.62	38.02	54	-15.98	-	-	273	190	V
6	* 7.44	41.57	PK2	35.5	-28.1	0	48.97	-	-	74	-25.03	281	101	V
	* 7.44	32.1	MAv1	35.5	-28.1	1.62	41.12	54	-12.88	-	-	281	101	V
1	2.57	45.67	Pk	32.4	-25.1	0	52.97	-	-	-	-	0-360	199	H
4	2.57	44.71	Pk	32.4	-25.1	0	52.01	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

PK2 - Maximum Peak

MAv1 - Maximum RMS Average

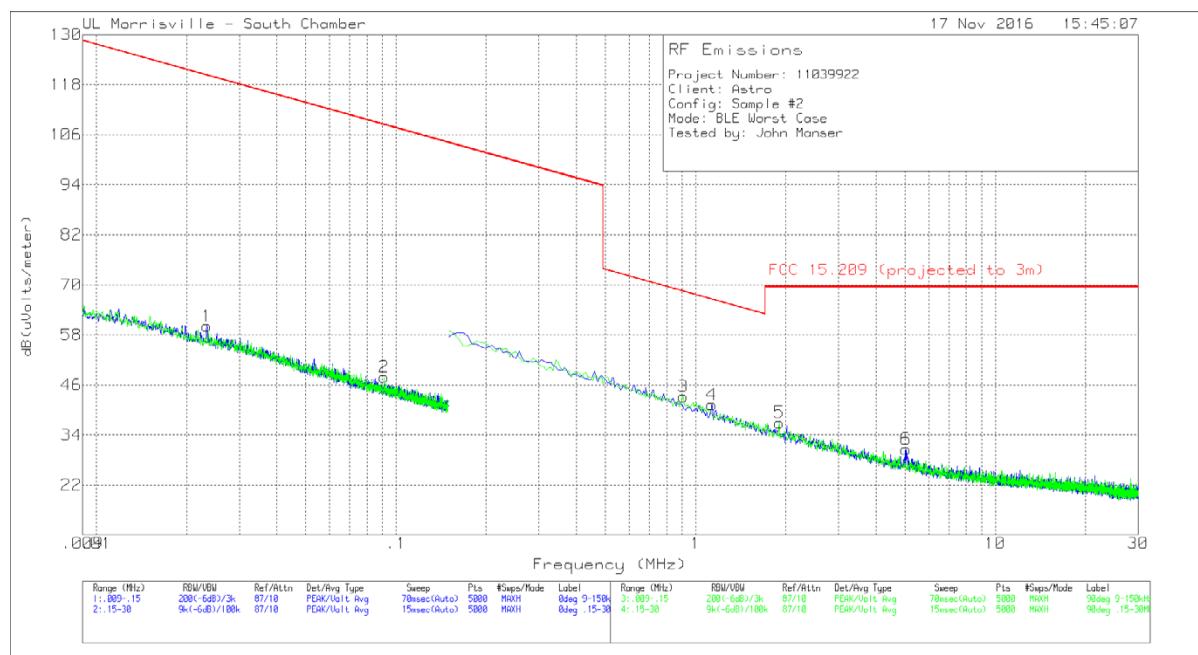
Note: Plot above represents a prescan. All final measurements were made at RBW/VBW = 1MHz/3MHz.

Note: Signal at 2500MHz was done during BE measurement of the high channel.

10.3. WORST-CASE BELOW 1 GHz

Note: All measurements were made at a test distance of 3 m. The limits in the plots and tabular data are the FCC/IC limits extrapolated from the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to the measurement distance to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (specification distance / test distance). Although these tests were performed at a test site other than an open area test site, adequate comparison measurements were confirmed against 30 m open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 937606.

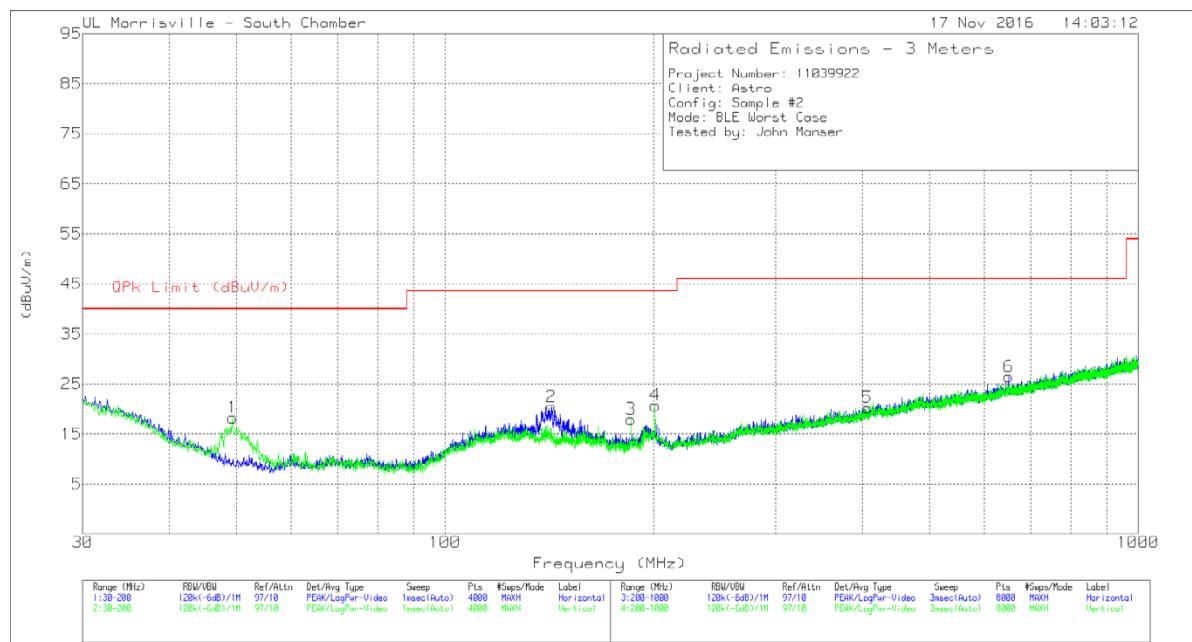
SPURIOUS EMISSIONS 9KHz TO 30 MHz (WORST-CASE CONFIGURATION)



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 AF (dB/m)	Cbl (dB)	Corrected Reading dB(uVolts/meter)	FCC 15.209 (projected to 3m)	Margin (dB)	Azimuth (Degs)
1	.02342	45.39	Pk	14.6	.1	60.09	120.21	-60.12	0-360
2	.09124	35.81	Pk	12	.1	47.91	108.4	-60.49	0-360
3	.90832	31.18	Pk	11.9	.1	43.18	68.44	-25.26	0-360
4	1.13223	29.14	Pk	11.9	.2	41.24	66.53	-25.29	0-360
5	1.8995	24.66	Pk	12.1	.2	36.96	69.54	-32.58	0-360
6	5.03428	18.92	Pk	11.3	.4	30.62	69.54	-38.92	0-360

Pk - Peak detector

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



FCC Part 15C 30-1000MHz, TST

Rev 9.5 26 Oct 2016

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 AF (dB/m)	Amp/Cbl (dB)	DC Corr (dB)	Corrected Reading (dBuV/m))	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
5	* 406.5528	23.15	Qp	20.5	-29.2	1.62	16.07	46.02	-29.95	240	172	V
1	49.385	36.95	Pk	12.8	-31.5	0	18.25	40	-21.75	0-360	101	V
2	142.3991	33.84	Pk	17.3	-30.7	0	20.44	43.52	-23.08	0-360	199	H
3	185.5052	32.56	Pk	15.7	-30.3	0	17.96	43.52	-25.56	0-360	101	V
4	201.0001	33.75	Pk	17.2	-30.2	0	20.75	43.52	-22.77	0-360	102	V
6	650.3585	30.58	Pk	24.4	-28.5	0	26.48	46.02	-19.54	0-360	102	H

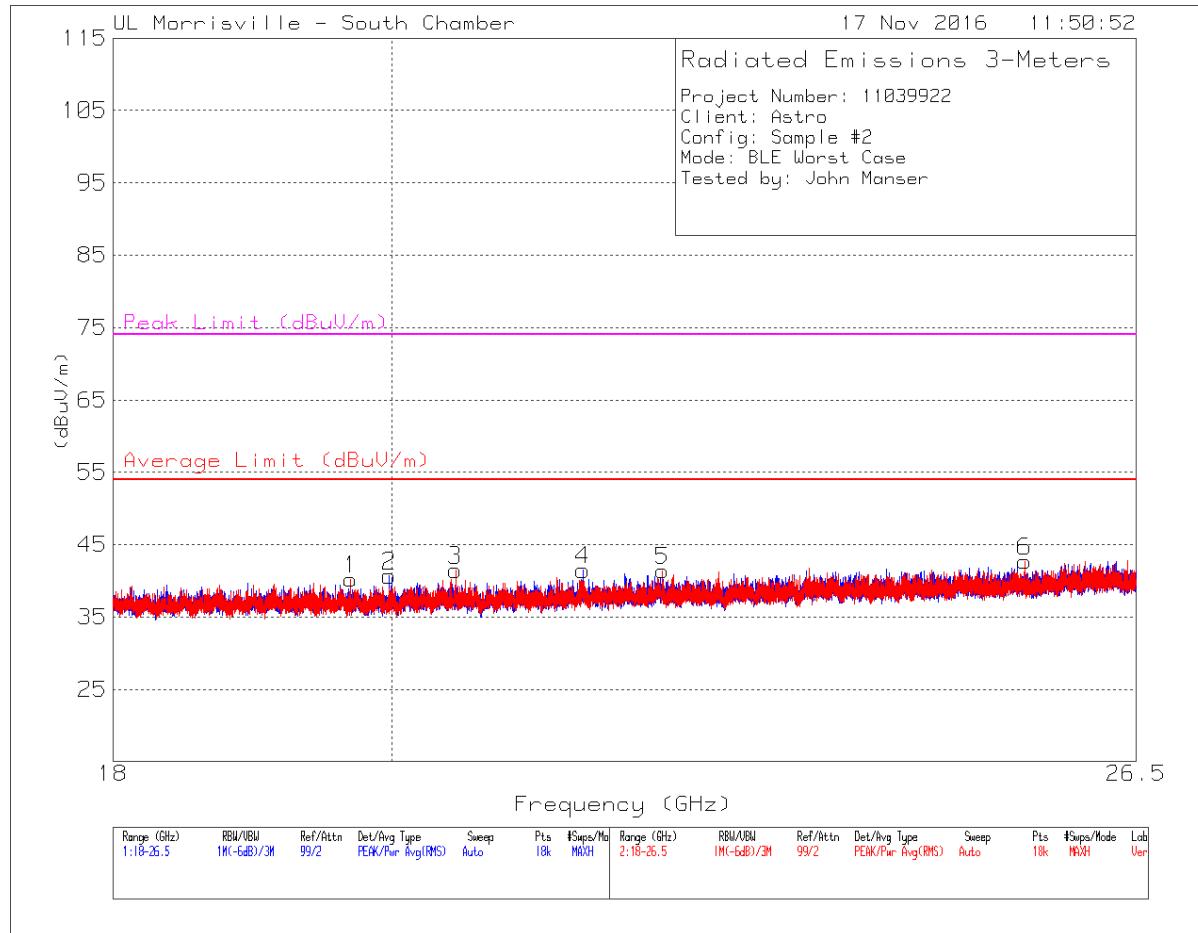
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

Qp - Quasi-Peak detector

10.4. WORST-CASE ABOVE 18 GHz

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



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0076	Amp/Cbl (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 19.983	47.98	PK2	32.8	-40.5	0	40.28	54	-13.72	74	-33.72	225	121	H
1	* 19.695	47.85	PK2	32.8	-40.6	0	40.05	54	-13.95	74	-33.95	225	251	V
3	* 20.489	47.07	PK2	33	-40	0	40.07	54	-13.93	74	-33.93	46	120	V
5	* 22.157	48.27	PK2	33.4	-39.8	0	41.87	54	-12.13	74	-32.13	320	229	V
4	21.499	48.29	Pk	33.2	-40	0	41.49	54	-12.51	74	-32.51	0-360	249	H
6	25.408	46.41	Pk	34.3	-38	0	42.71	54	-11.29	74	-31.29	0-360	300	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

PK2 - Maximum Peak

11. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

RSS-Gen 8.8

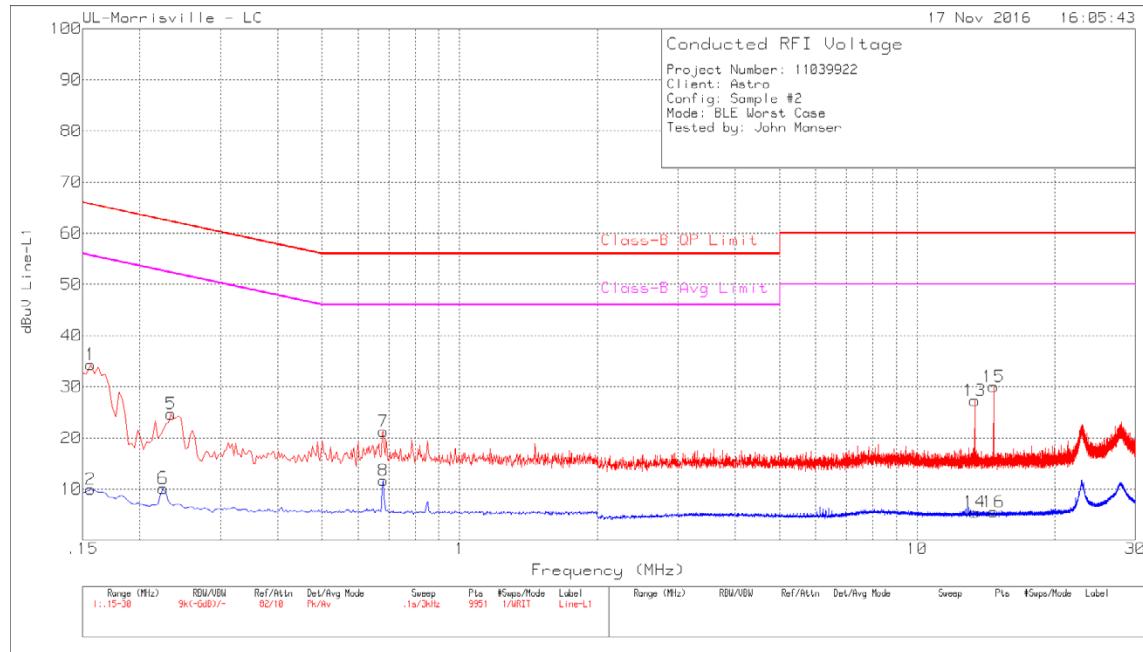
Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 [*]	56 to 46 [*]
0.5-5	56	46
5-30	60	50

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

TEST PROCEDURE

ANSI C63.10

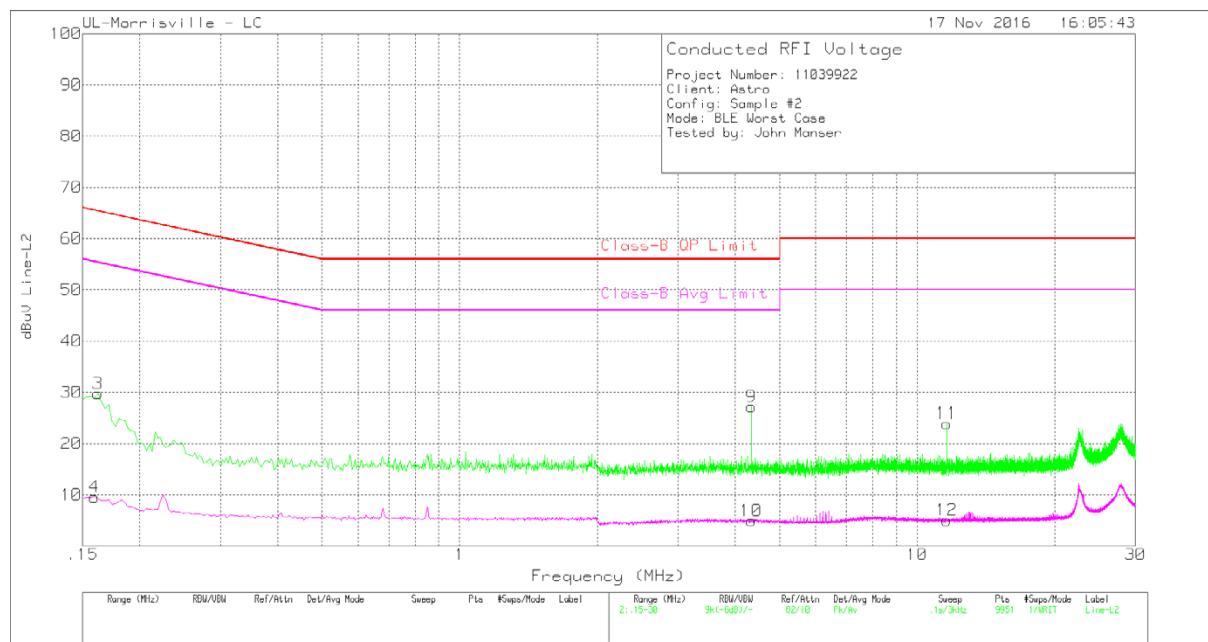
RESULTS



Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN VCF (dB)	Cbl/Limiter (dB)	Corrected Reading dBuV	QP Limit	Margin (dB)	Avg Limit	Margin (dB)	
1	.156	24.15	Pk	.2	10	34.35	65.67	-31.32	-	-	
2	.156	-.23	Av	.2	10	9.97	-	-	55.67	-45.7	
5	.234	14.58	Pk	.1	10	24.68	62.31	-37.63	-	-	
6	.225	.04	Av	.1	10	10.14	-	-	52.63	-42.49	
7	.681	11.3	Pk	0	10	21.3	56	-34.7	-	-	
8	.681	1.73	Av	0	10	11.73	-	-	46	-34.27	
13	13.362	16.77	Pk	.1	10.4	27.27	60	-32.73	-	-	
14	13.362	-5.01	Av	.1	10.4	5.49	-	-	50	-44.51	
15	14.691	19.52	Pk	.1	10.4	30.02	60	-29.98	-	-	
16	14.691	-4.93	Av	.1	10.4	5.57	-	-	50	-44.43	

Pk - Peak detector

Av - Average detection



Range 2: Line-L2 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN VCF (dB)	Cbl/Limiter (dB)	Corrected Reading dBuV	QP Limit	Margin (dB)	Avg Limit	Margin (dB)
3	.162	19.56	Pk	.2	10	29.76	65.36	-35.6	-	-
4	.159	-.64	Av	.2	10	9.56	-	-	55.52	-45.96
9	4.344	17.07	Pk	0	10.1	27.17	56	-28.83	-	-
10	4.338	-5.13	Av	0	10.1	4.97	-	-	46	-41.03
11	11.601	13.51	Pk	.1	10.3	23.91	60	-36.09	-	-
12	11.598	-5.38	Av	.1	10.3	5.02	-	-	50	-44.98

Pk - Peak detector

Av - Average detection