CERTIFICATION TEST REPORT

Report Number. : R12933554-E1

Applicant	:	Cascoda Ltd Southampton Science Park 1 Venture Road Southampton SO16 1NP United Kingdom
Model	:	Chili2D/Chili2S
FCC ID	:	2ATTO-CHILI2
IC	:	21580-CHILI2
EUT Description	:	802.15.4 Radio Module
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
2019-08-02

Prepared by:
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NVLAP Lab code: 200246-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2019-08-02	Initial Issue	Niklas Haydon

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Cascoda Ltd
Southampton Science Park
1 Venture Road
Southampton
SO16 1NP
United Kingdom

EUT DESCRIPTION: 802.15.4 Radio Module

MODEL: Chili2D/Chili2S

SERIAL NUMBER: Radiated: 2401591, 2401595
Antenna port conducted Samples: 2401594, 2401589
Power line conducted: 2401595

DATE TESTED: 2019-07-12 to 2019-07-16

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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2. 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, KDB 558074 D01 15.247 Meas Guidance v05R02, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

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

12 Laboratory Dr.	2800 Suite Perimeter Park Dr.
ISED Site Code: 2180C	
☐ Chamber A	☒ Chamber North
☐ Chamber C	☒ Chamber South

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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

RADIATED EMISSIONS
Where relevant, the following sample calculation is provided:
Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS
Where relevant, the following sample calculation is provided:
Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

4.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	2.00%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
RF output power, radiated (SAC)	4.52 dB
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	2.50 dB
All emissions, radiated	4.88 dB
Temperature	2.26°C
Humidity	6.79%
DC Supply voltages	1.70%
Time	3.39%

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

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5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is a 802.15.4 radio module transceiver.

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 - 2480	802.15.4	9.12	8.17

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an on board chip antenna with a maximum gain of 1.75 dBi.

5.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was version cede62f4849918fef1da2ac9428f1e9c5a44305d.

5.5. WORST-CASE CONFIGURATION AND MODE

Worst-case explorations for antenna port conducted and radiated emissions were performed and determined that Chili2S was worst-case for all tests; therefore all testing was completed on the Chili2S.

Radiated emissions below 1GHz, above 18GHz, 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.

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 802.15.4 mode were made at 250 kbps.

For antenna port conducted testing all tests except for power were completed with low, middle, and high channels set to middle channel power.

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5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	T450s	PCOBHFNX	NA
USB to UART Edge Connect	Tag-Connect	EC-14	Non-serialized	NA

I/O CABLES

I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
None						

TEST SETUP

The EUT is connected to a test laptop during the tests. Test software exercised the radio.

SETUP DIAGRAMS

Please refer to R12933554-EP1 for setup diagrams

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6. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10 Section 11.6

6 dB BW: ANSI C63.10 Subclause 11.8.1

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Output Power: ANSI C63.10 Subclause 11.9.1.3 (PKPM1)

PSD: ANSI C63.10 Subclause 11.10.2 (Peak PSD)

Out-of-band emissions in non-restricted bands: ANSI C63.10-2013 Section 11.11 & 6.10.4

Out-of-band emissions in restricted bands: ANSI C63.10-2013 Section 11.12.1 & 6.10.5 and KDB 558074 D01 15.247 Section 11. FAQ 3c

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

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

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7. TEST AND MEASUREMENT EQUIPMENT

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

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

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL087	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3W06143-240	2019-05-29	2020-05-29
s/n 181562858	Environmental Meter	Fisher Scientific	14-650-118	2018-09-04	2020-09-04
LISN003	LISN, 50-ohm/50-uH, 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50-25-2-01-550V	2018-08-21	2019-08-21
75141 (PRE0101521)	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2018-08-22	2019-08-22
PS215	AC Power Source	Elgar	CW2501M (s/n 1523A02397)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
72822 (PRE0100902)	Spectrum Analyzer	Agilent Technologies	E4446A	2018-11-19	2019-11-19
PWM005	RF Power Meter	Keysight Technologies	N19112A	2019-07-08	2020-07-08
PWS008 (PRE0126444)	Peak and Avg Power Sensor, 50MHz to 6GHz	Keysight Technologies	E9288A	2019-05-06	2020-05-06
SN 181474341	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27
76023 (EC0225)	Temp/Humid Chamber	Cincinnati Sub-Zero	ZPH-8-3.5-SCT/AC	2019-06-14	2020-06-14

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

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	1-18 GHz				
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2019-04-22	2020-04-22
	Gain-Loss Chains				
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2019-03-13	2020-03-13
	Receiver & Software				
SA0025	Spectrum Analyzer	Agilent	N9030A	2019-02-28	2020-02-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
	Additional Equipment used				
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27

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

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	30-1000 MHz				
AT0073	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2018-08-06	2019-08-06
	Gain-Loss Chains				
N-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2019-05-02	2020-05-02
	Receiver & Software				
SA0026	Spectrum Analyzer	Agilent	N9030A	2019-03-19	2020-03-19
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
	Additional Equipment used				
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27

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8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

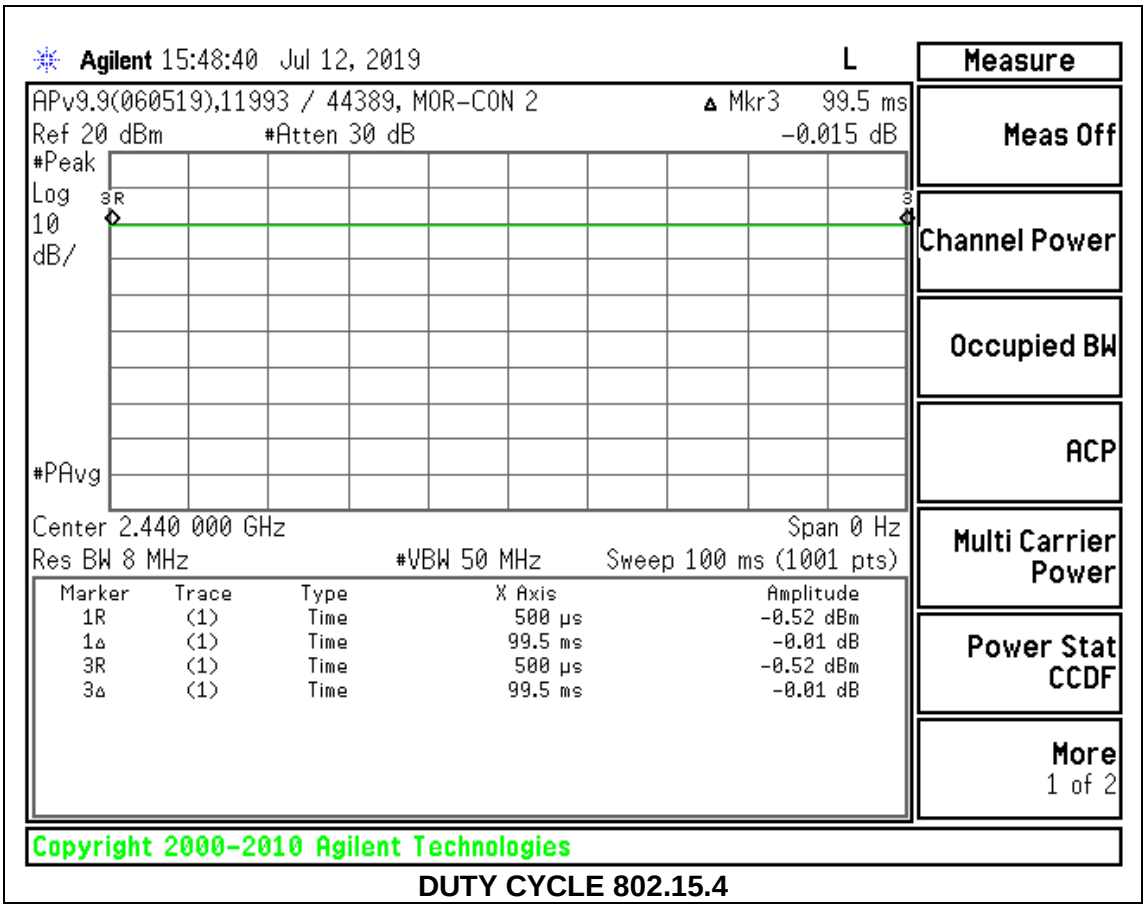
KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Note: Duty cycle below shows how sample operated during testing. Real life worst-case duty cycle is protocol limited to 55%.

	B (msec)	(msec)	x (linear)	Cycle (%)	Correction Factor (dB)	Minimum VBW (kHz)
2.4GHz Band						
802.15.4	99.500	99.500	1.000	100.00%	0.00	0.010

DUTY CYCLE PLOTS



DUTY CYCLE 802.15.4

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8.2. 99% BANDWIDTH

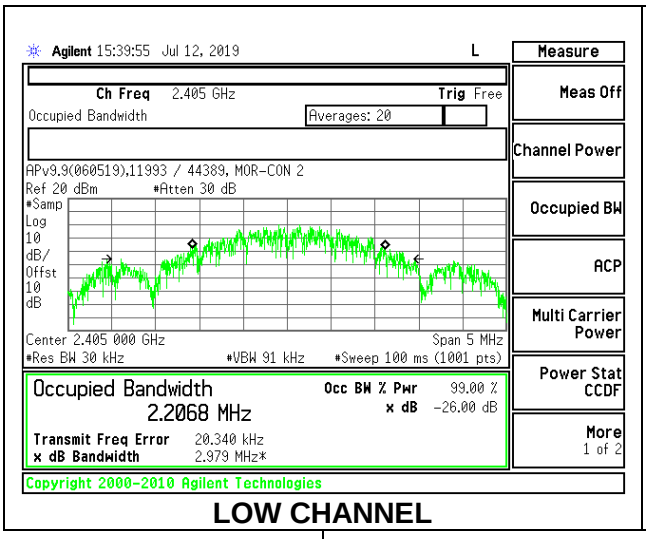
LIMITS

None; for reporting purposes only.

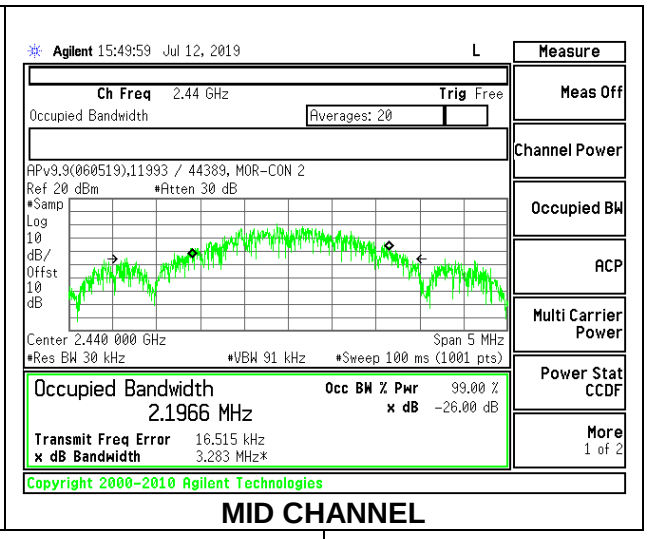
RESULTS

8.2.1. 802.15.4

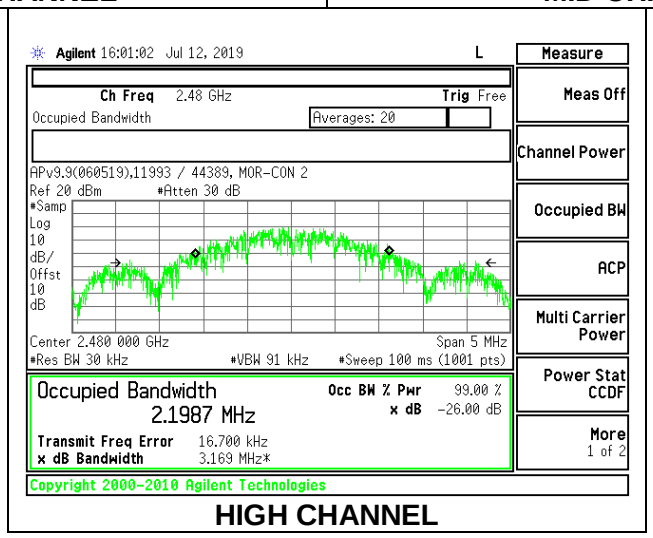
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2405	2.2068
Middle	2440	2.1966
High	2480	2.1987



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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8.3. 6 dB BANDWIDTH

LIMITS

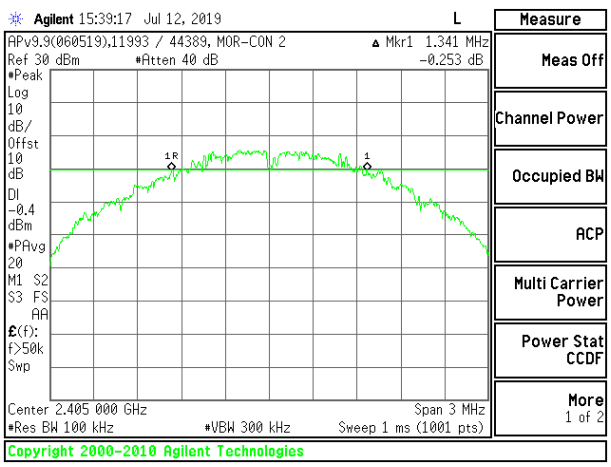
FCC §15.247 (a) (2)
RSS-247 5.2 (a)

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

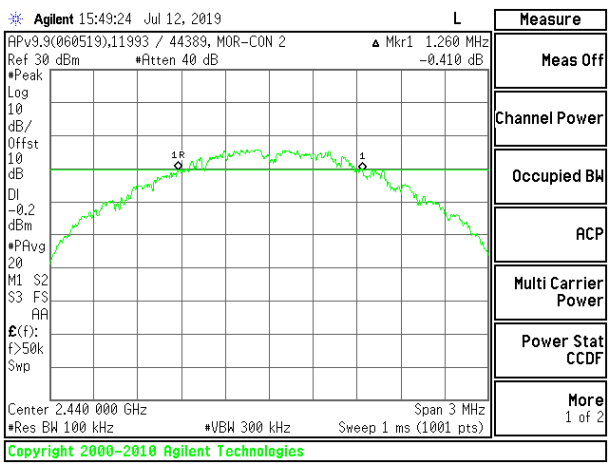
RESULTS

8.3.1. 802.15.4

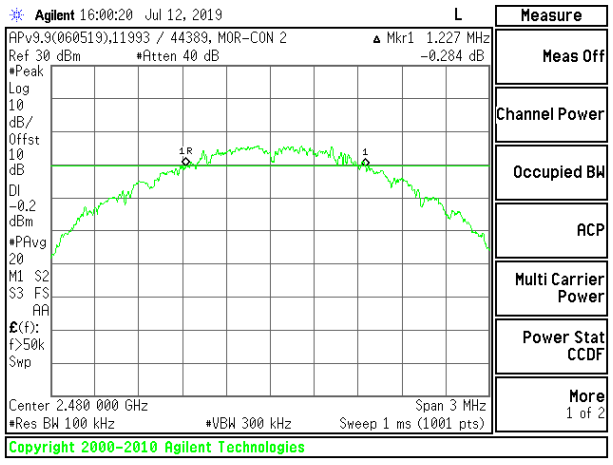
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.341	0.5
Middle	2440	1.260	0.5
High	2480	1.227	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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8.4. OUTPUT POWER

LIMITS

FCC §15.247 (b) (3)
RSS-247 5.4 (d)

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 dB was entered as an offset in the power meter to allow for a peak reading of power.

RESULTS

8.4.1. 802.15.4

Tested By:	11993/44389
Date:	7/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2405	8.67	30	-21.33
Middle	2440	8.95	30	-21.05
High	2475	9.12	30	-20.88
High	2480	4.38	30	-25.62

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8.5. AVERAGE POWER

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10 dB was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

8.5.1. 802.15.4

Tested By:	11993/44389
Date:	7/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2405	8.62
Middle	2440	8.91
High	2475	9.08
High	2480	4.29

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8.6. POWER SPECTRAL DENSITY

LIMITS

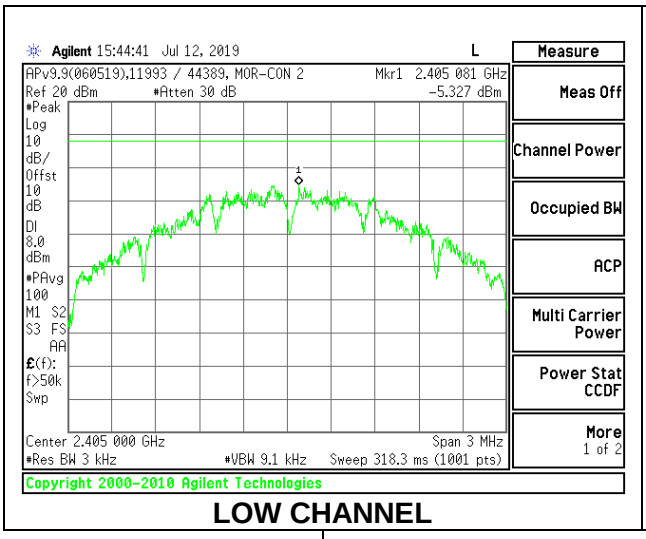
FCC §15.247 (e)
RSS-247 (5.2) (b)

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.

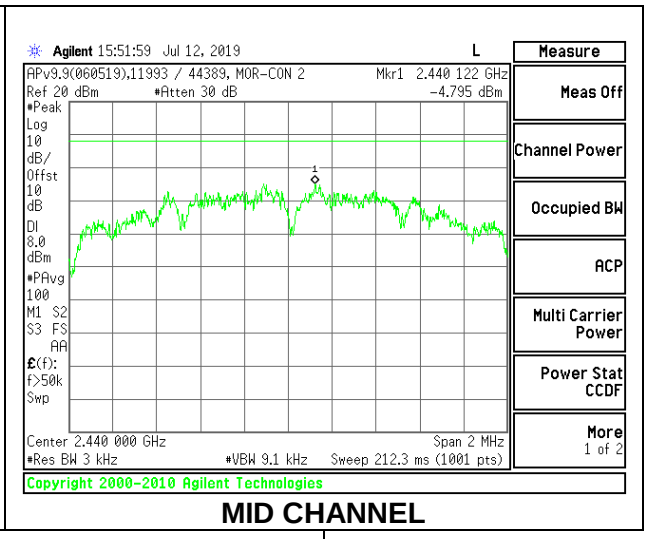
RESULTS

8.6.1. 802.15.4

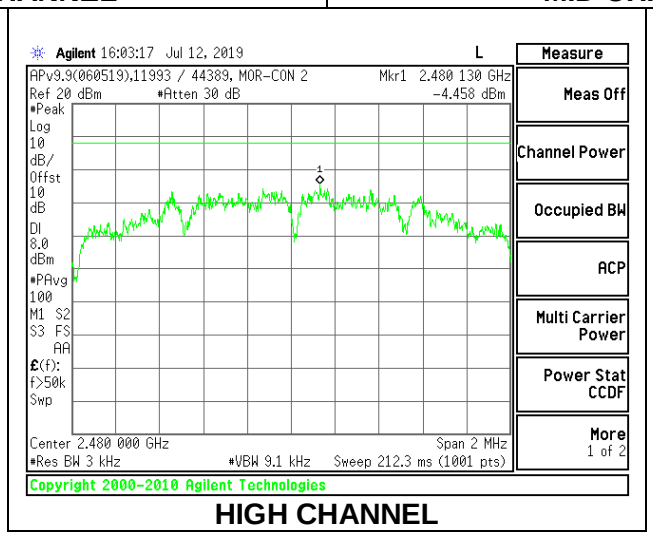
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2405	-5.327	8	-13.327
Middle	2440	-4.795	8	-12.795
High	2480	-4.458	8	-12.458



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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8.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

RSS-247 5.5

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

RESULTS

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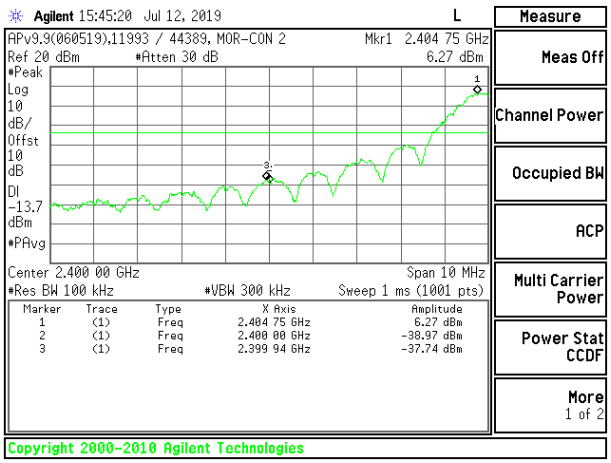
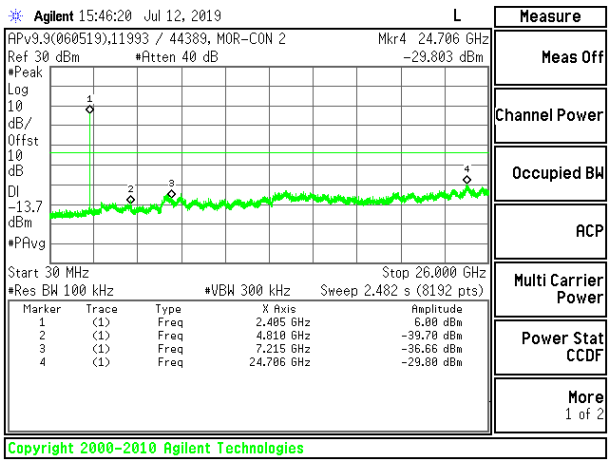
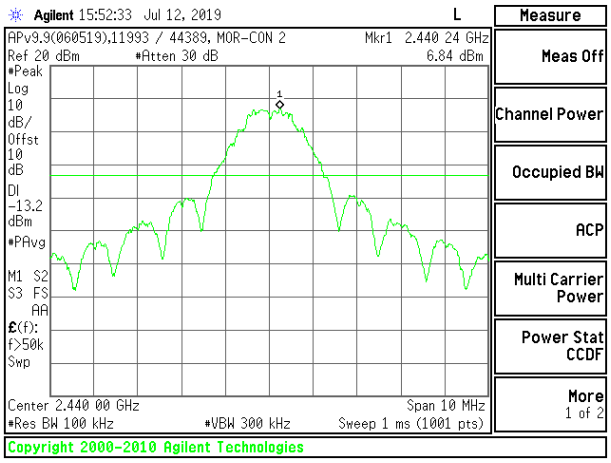
8.7.1. 802.15.4



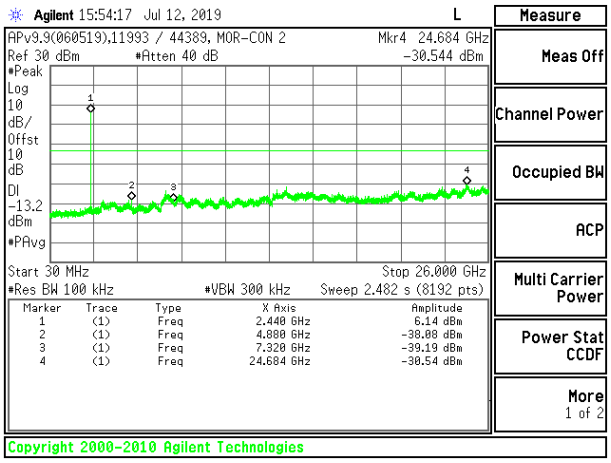
LOW CHANNEL BANDEDGE



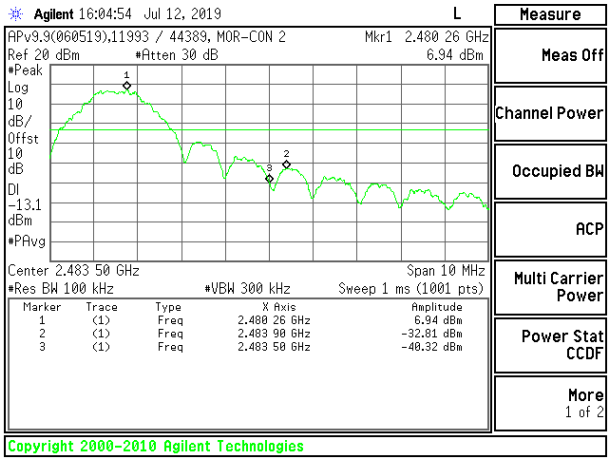
OUT-OF-BAND LOW CHANNEL



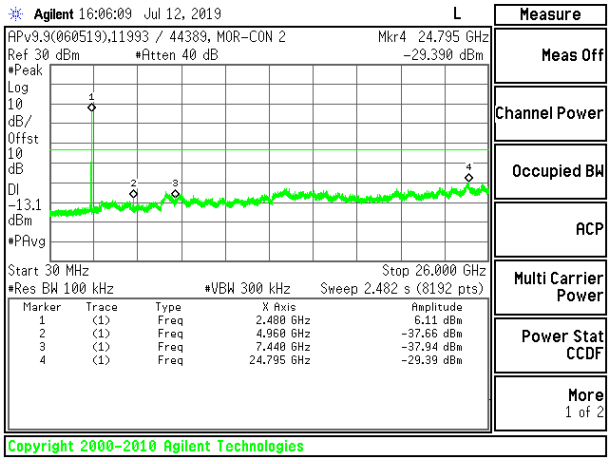
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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9. RADIATED TEST RESULTS

9.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209

RSS-GEN, Section 8.9 and 8.10.

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) @ 300 m	-
0.490-1.705	24000/F(kHz) @ 30 m	-
1.705 - 30	30 @ 30m	-
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 measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

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

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 30 kHz for peak measurements.

For final measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements. For average measurements above 1GHz, the resolution bandwidth and video bandwidth are set as described in ANSI C63.10:2013 for the applicable measurement. The particular averaging method used for this test program was voltage averaging.

The spectrum from 1 GHz to 18 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band. Below 1GHz and above 18GHz emissions, the channel with the highest output power was tested.

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

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3D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel).

KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

KDB 558074 D01 15.247 Meas Guidance V05r02

11. Frequently Asked Questions; Answer 3: c)

A voltage averaging measurement was taken in accordance to ANSI C63.10. The average measurement was corrected down based on the protocol-limited worst-case duty cycle of 55% provided by the manufacturer. The calculation of 20*log(1/0.55) leads to a 5.19 dB correction factor that is subtracted from the average measurement.

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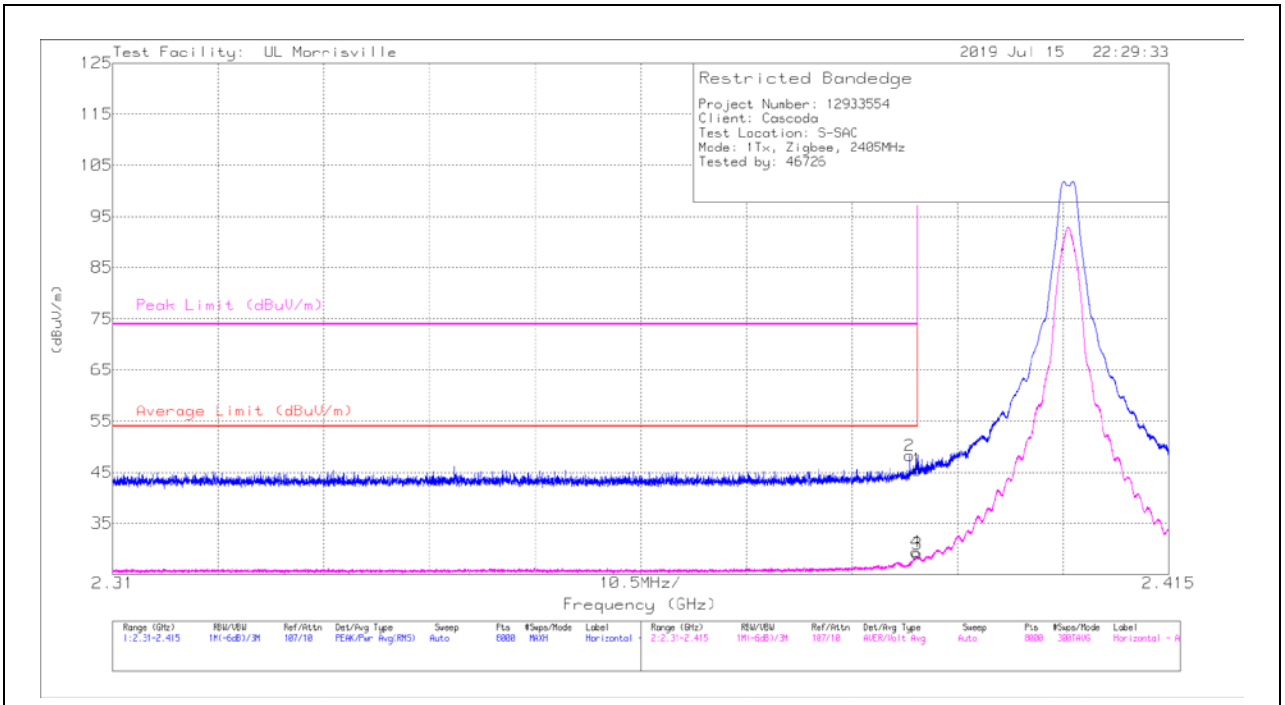
9.2. TRANSMITTER ABOVE 1 GHz

9.2.1. 802.15.4

Antenna 1

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	37.59	Pk	31.9	-24	0	45.49	-	-	74	-28.51	62	147	H
2	* ** 2.38924	40.33	Pk	31.9	-24	0	48.23	-	-	74	-25.77	62	147	H
3	* ** 2.39	26.37	Av	31.9	-24	-5.19	29.08	54	-24.92	-	-	62	147	H
4	* ** 2.38985	26.76	Av	31.9	-24	-5.19	29.47	54	-24.53	-	-	62	147	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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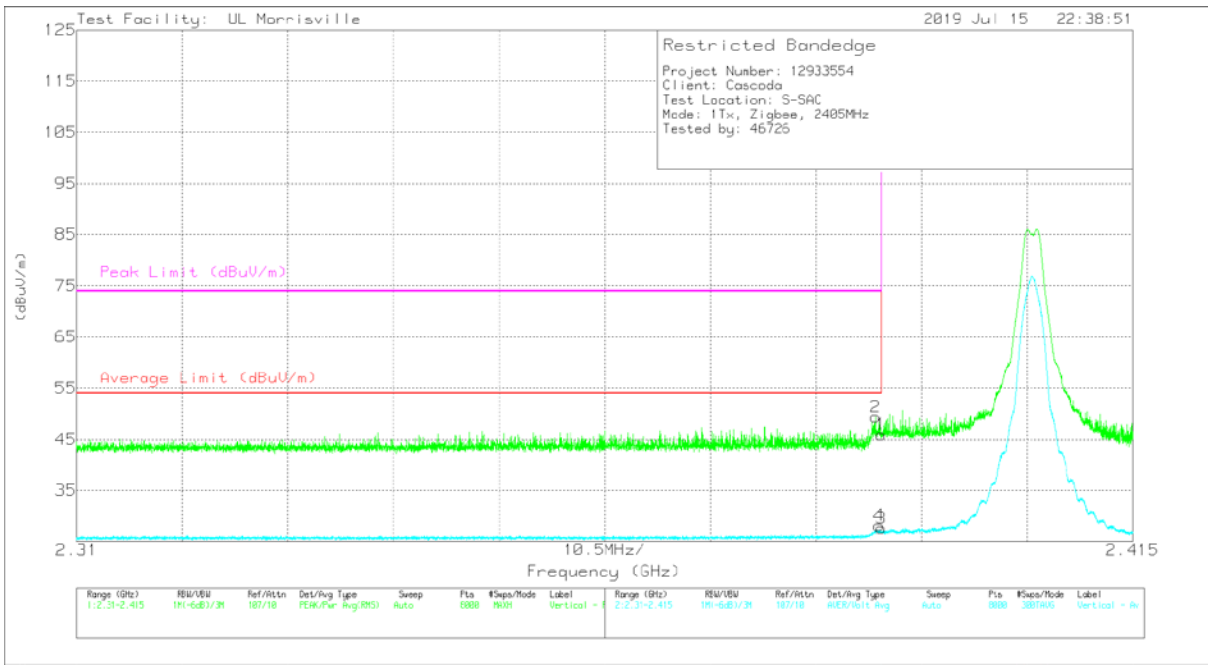
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	38.05	Pk	31.9	-24	0	45.95	-	-	74	-28.05	321	144	V
2	* ** 2.38941	41.49	Pk	31.9	-24	0	49.39	-	-	74	-24.61	321	144	V
3	* ** 2.39	24.9	Av	31.9	-24	-5.19	27.61	54	-26.39	-	-	321	144	V
4	* ** 2.38977	25.43	Av	31.9	-24	-5.19	28.14	54	-25.86	-	-	321	144	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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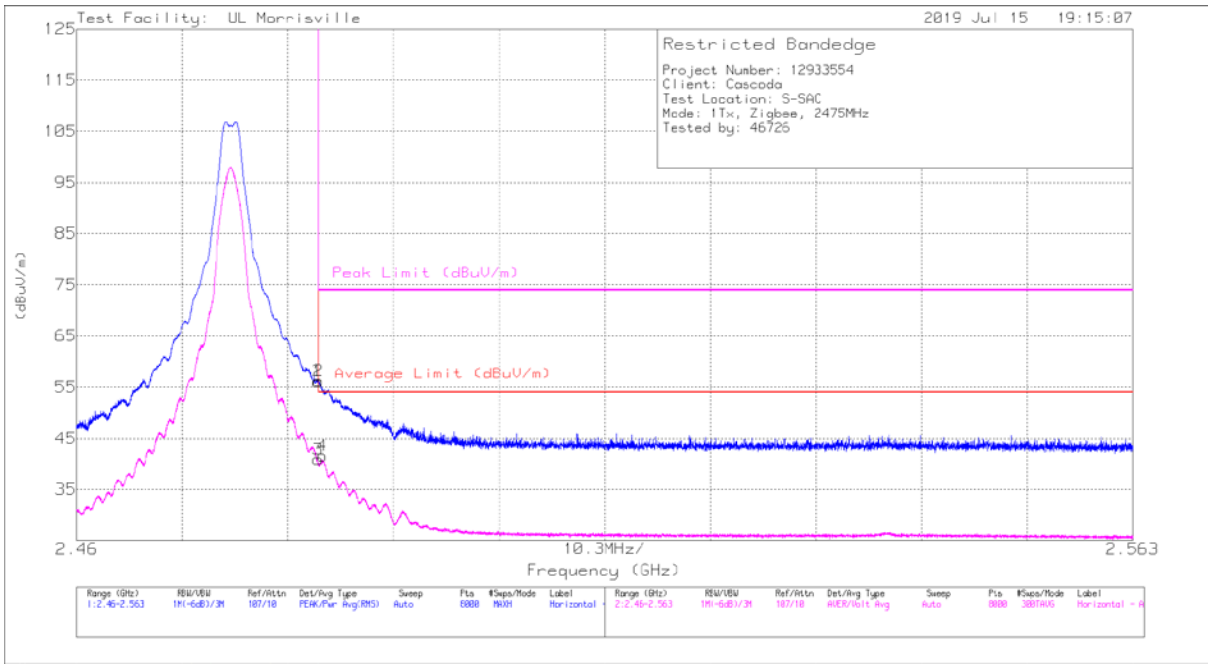
BANDEDGE (HIGH CHANNEL 2475 MHz)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 2.4835	48.26	Pk	32.3	-24.5	0	56.06	-	-	74	-17.94	170	262	H
2	* ** 2.48351	48.43	Pk	32.3	-24.5	0	56.23	-	-	74	-17.77	170	262	H
3	* ** 2.4835	38.24	Av	32.3	-24.5	-5.19	40.85	54	-13.15	-	-	170	262	H
4	* ** 2.48398	38.95	Av	32.3	-24.5	-5.19	41.56	54	-12.44	-	-	170	262	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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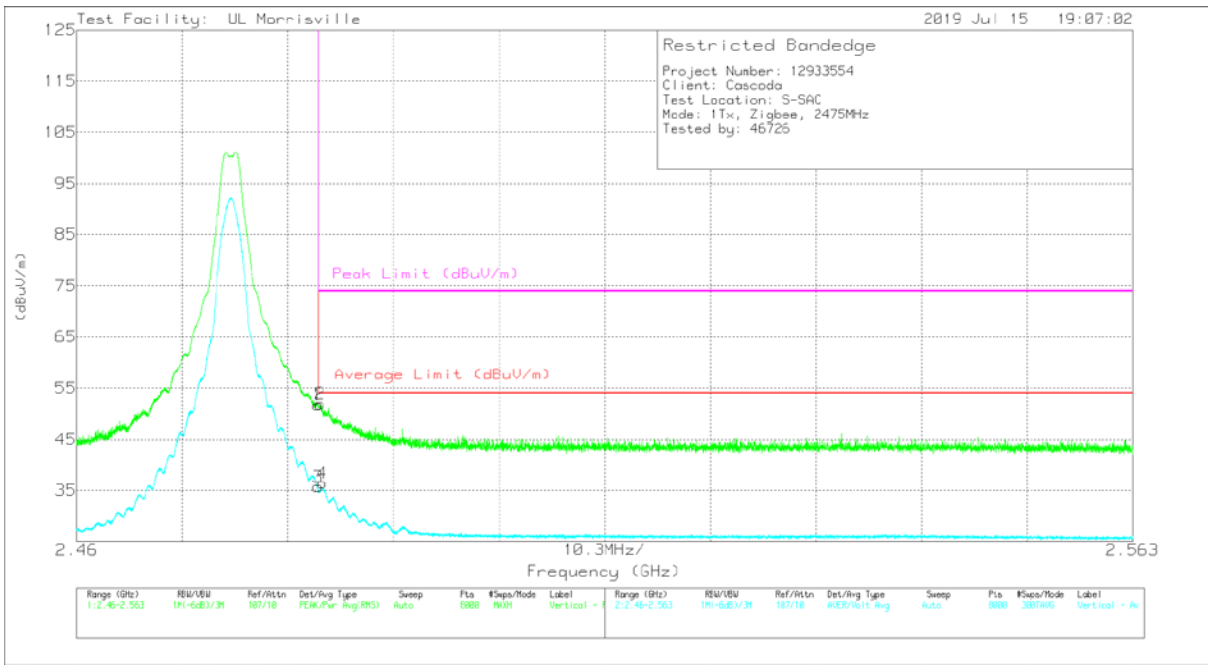
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 2.4835	43.86	Pk	32.3	-24.5	0	51.66	-	-	74	-22.34	225	378	V
2	* ** 2.48369	44.09	Pk	32.3	-24.5	0	51.89	-	-	74	-22.11	225	378	V
3	* ** 2.4835	33.09	Av	32.3	-24.5	-5.19	35.7	54	-18.3	-	-	225	378	V
4	* ** 2.48394	33.85	Av	32.3	-24.5	-5.19	36.46	54	-17.54	-	-	225	378	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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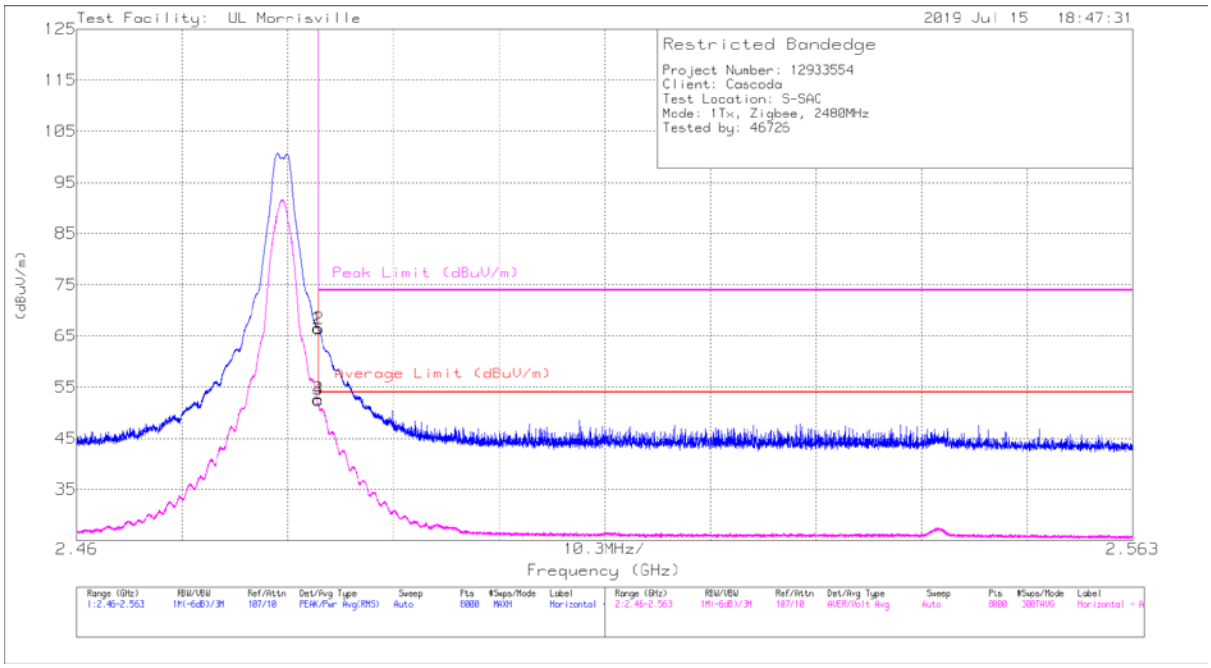
BANDEDGE (HIGH CHANNEL 2480 MHz)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 2.4835	58.78	Pk	32.3	-24.5	0	66.58	-	-	74	-7.42	157	213	H
2	* ** 2.48357	58.62	Pk	32.3	-24.5	0	66.42	-	-	74	-7.58	157	213	H
3	* ** 2.4835	50.1	Av	32.3	-24.5	-5.19	52.71	54	-1.29	-	-	157	213	H
4	* ** 2.48353	49.89	Av	32.3	-24.5	-5.19	52.5	54	-1.5	-	-	157	213	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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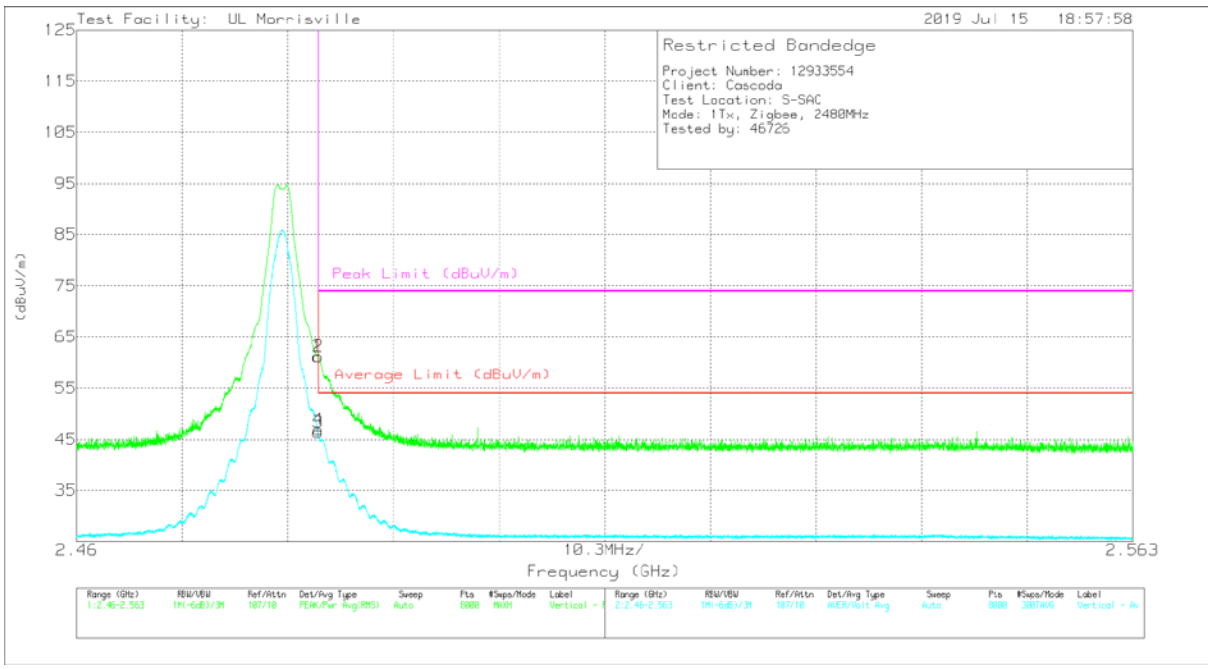
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 2.4835	53.33	Pk	32.3	-24.5	0	61.13	-	-	74	-12.87	221	380	V
2	* ** 2.48353	53.4	Pk	32.3	-24.5	0	61.2	-	-	74	-12.8	221	380	V
3	* ** 2.4835	43.82	Av	32.3	-24.5	-5.19	46.43	54	-7.57	-	-	221	380	V
4	* ** 2.48351	44.26	Av	32.3	-24.5	-5.19	46.87	54	-7.13	-	-	221	380	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
Av - Average detection

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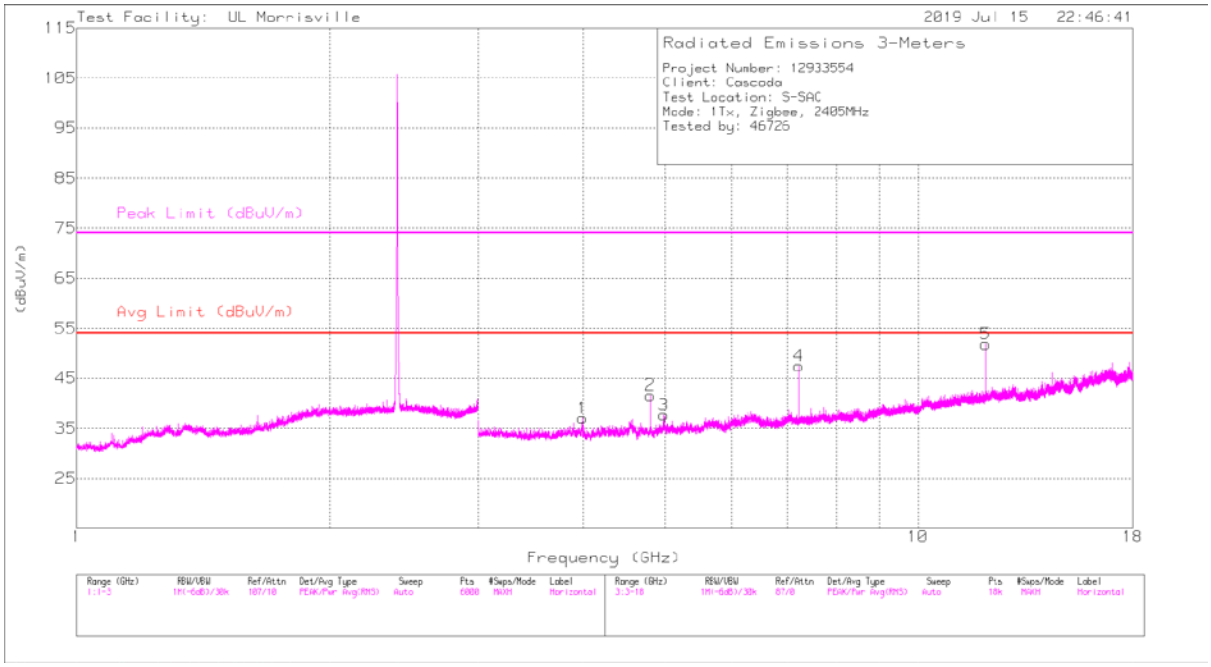
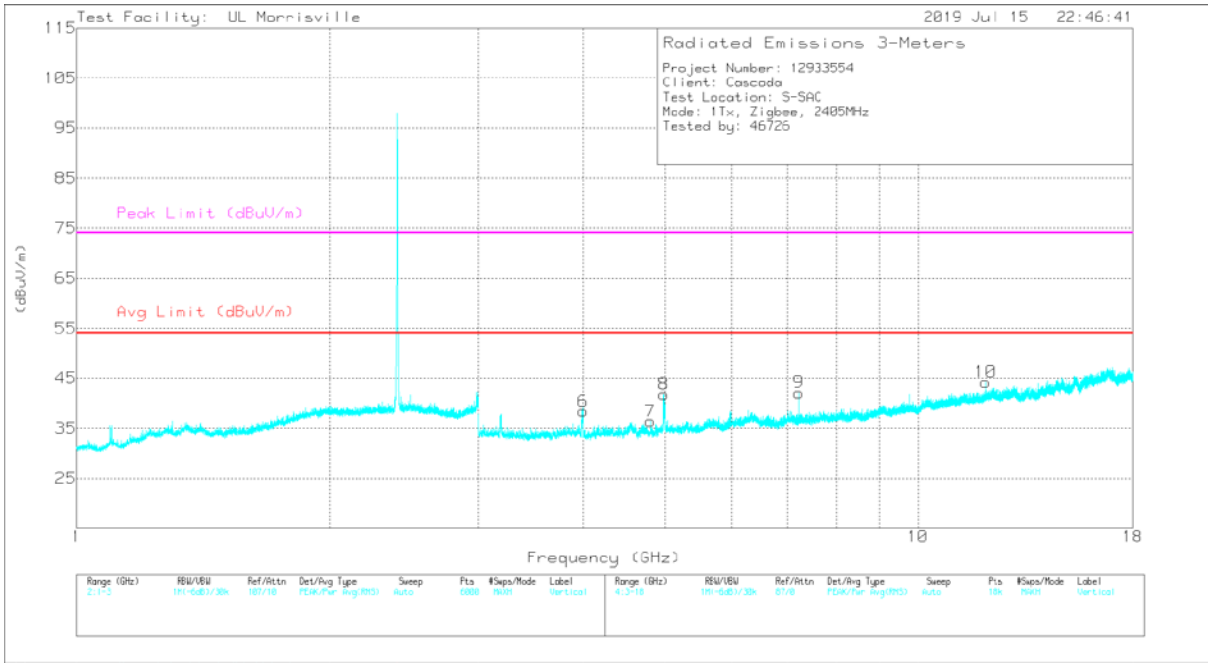
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 3.99676	46.82	PK-U	33.4	-31.8	0	48.42	-	-	74	-25.58	156	240	H
	* ** 3.99653	27.23	ADV	33.4	-31.8	-5.19	23.64	54	-30.36	-	-	156	240	H
2	* ** 4.80905	43.84	PK-U	34.2	-31	0	47.04	-	-	74	-26.96	28	114	H
	* ** 4.80907	33.64	ADV	34.2	-31	-5.19	31.65	54	-22.35	-	-	28	114	H
3	* ** 4.99508	44.44	PK-U	34.2	-31.1	0	47.54	-	-	74	-26.46	266	210	H
	* ** 4.9949	26.58	ADV	34.2	-31.1	-5.19	24.49	54	-29.51	-	-	266	210	H
5	* ** 12.02746	40.41	PK-U	38.7	-23.5	0	55.61	-	-	74	-18.39	116	102	H
	* ** 12.02731	30.81	ADV	38.7	-23.5	-5.19	40.82	54	-13.18	-	-	116	102	H
6	* ** 3.99478	48.98	PK-U	33.4	-31.8	0	50.58	-	-	74	-23.42	130	129	V
	* ** 3.99399	27.28	ADV	33.4	-31.8	-5.19	23.69	54	-30.31	-	-	130	129	V
7	* ** 4.81091	40.49	PK-U	34.2	-30.9	0	43.79	-	-	74	-30.21	144	204	V
	* ** 4.81089	28.41	ADV	34.2	-30.9	-5.19	26.52	54	-27.48	-	-	144	204	V
8	* ** 4.9784	48.22	PK-U	34.1	-31.1	0	51.22	-	-	74	-22.78	154	106	V
	* ** 4.97811	26.98	ADV	34.1	-31.1	-5.19	24.79	54	-29.21	-	-	154	106	V
10	* ** 12.02741	38.84	PK-U	38.7	-23.5	0	54.04	-	-	74	-19.96	84	362	V
	* ** 12.02735	27.72	ADV	38.7	-23.5	-5.19	37.73	54	-16.27	-	-	84	362	V
4	7.21607	39.65	Pk	35.7	-27.9	0	47.45	-	-	-	-	0-360	101	H
9	7.21607	34.33	Pk	35.7	-27.9	0	42.13	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
ADV - U-NII AD primary method, Linear Voltage Average
Pk - Peak detector

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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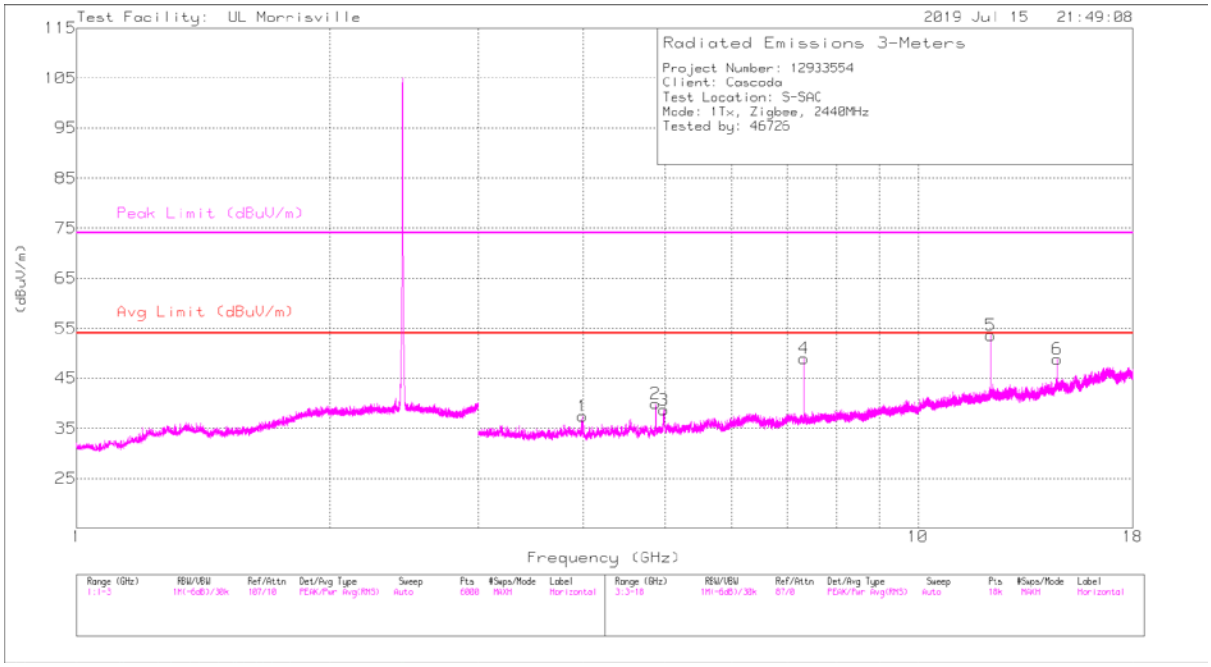
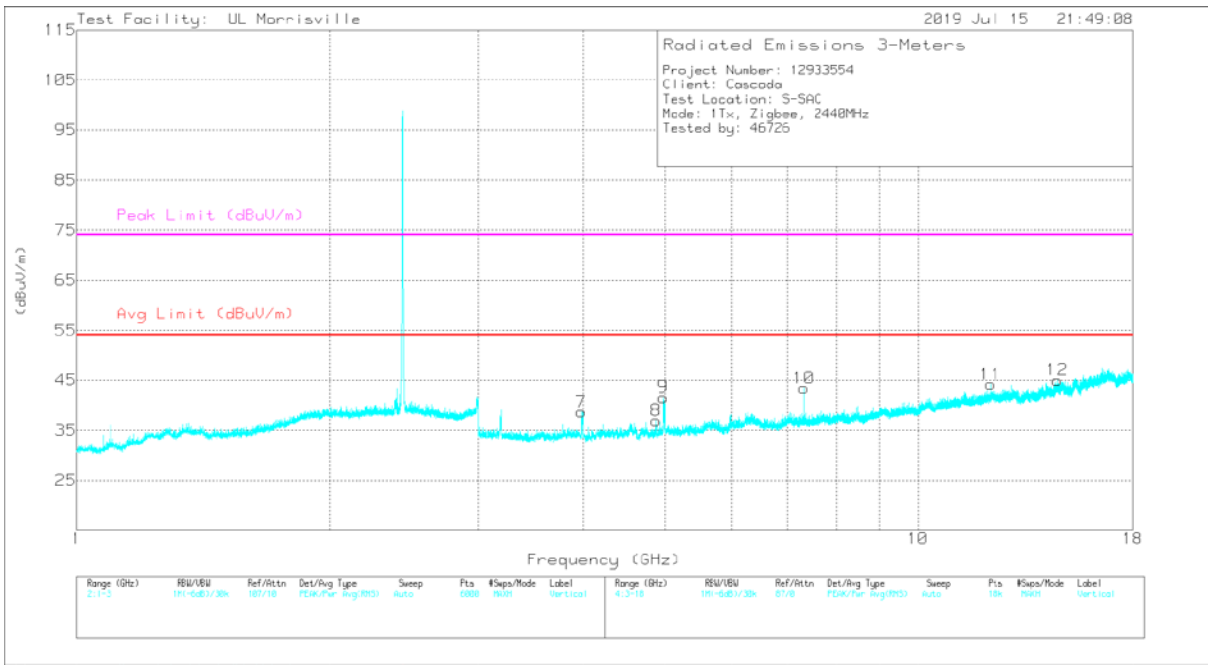
MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 3.99664	45.66	PK-U	33.4	-31.8	0	47.26	-	-	74	-26.74	296	167	H
	* ** 3.99656	27.07	ADV	33.4	-31.8	-5.19	23.48	54	-30.52	-	-	296	167	H
2	* ** 4.88112	43.33	PK-U	34	-30.6	0	46.73	-	-	74	-27.27	32	113	H
	* ** 4.88092	32.53	ADV	34	-30.6	-5.19	30.74	54	-23.26	-	-	32	113	H
3	* ** 4.97867	44.7	PK-U	34.1	-31.1	0	47.7	-	-	74	-26.3	180	215	H
	* ** 4.97896	26.61	ADV	34.1	-31.1	-5.19	24.42	54	-29.58	-	-	180	215	H
4	* ** 7.32139	45.82	PK-U	35.7	-27.5	0	54.02	-	-	74	-19.98	340	104	H
	* ** 7.32136	36.55	ADV	35.7	-27.5	-5.19	39.56	54	-14.44	-	-	340	104	H
5	* ** 12.2025	41.99	PK-U	38.9	-23.8	0	57.09	-	-	74	-16.91	114	125	H
	* ** 12.20231	32.84	ADV	38.9	-23.8	-5.19	42.75	54	-11.25	-	-	114	125	H
7	* ** 3.99664	48.99	PK-U	33.4	-31.8	0	50.59	-	-	74	-23.41	130	122	V
	* ** 3.99645	27.44	ADV	33.4	-31.8	-5.19	23.85	54	-30.15	-	-	130	122	V
8	* ** 4.88078	40.73	PK-U	34	-30.6	0	44.13	-	-	74	-29.87	103	344	V
	* ** 4.88088	28.11	ADV	34	-30.6	-5.19	26.32	54	-27.68	-	-	103	344	V
9	* ** 4.97752	49.56	PK-U	34.1	-31.1	0	52.56	-	-	74	-21.44	159	109	V
	* ** 4.9781	27.32	ADV	34.1	-31.1	-5.19	25.13	54	-28.87	-	-	159	109	V
10	* ** 7.32146	44.94	PK-U	35.7	-27.5	0	53.14	-	-	74	-20.86	292	337	V
	* ** 7.3213	36.25	ADV	35.7	-27.5	-5.19	39.26	54	-14.74	-	-	292	337	V
11	* ** 12.20238	38.97	PK-U	38.9	-23.8	0	54.07	-	-	74	-19.93	83	323	V
	* ** 12.20234	27.67	ADV	38.9	-23.8	-5.19	37.58	54	-16.42	-	-	83	323	V
12	14.63732	27.92	Pk	39.4	-22.3	0	45.02	-	-	-	-	0-360	101	V
6	14.64315	31.72	Pk	39.4	-22.3	0	48.82	-	-	-	-	0-360	101	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
ADV - U-NII AD primary method, Linear Voltage Average
Pk - Peak detector

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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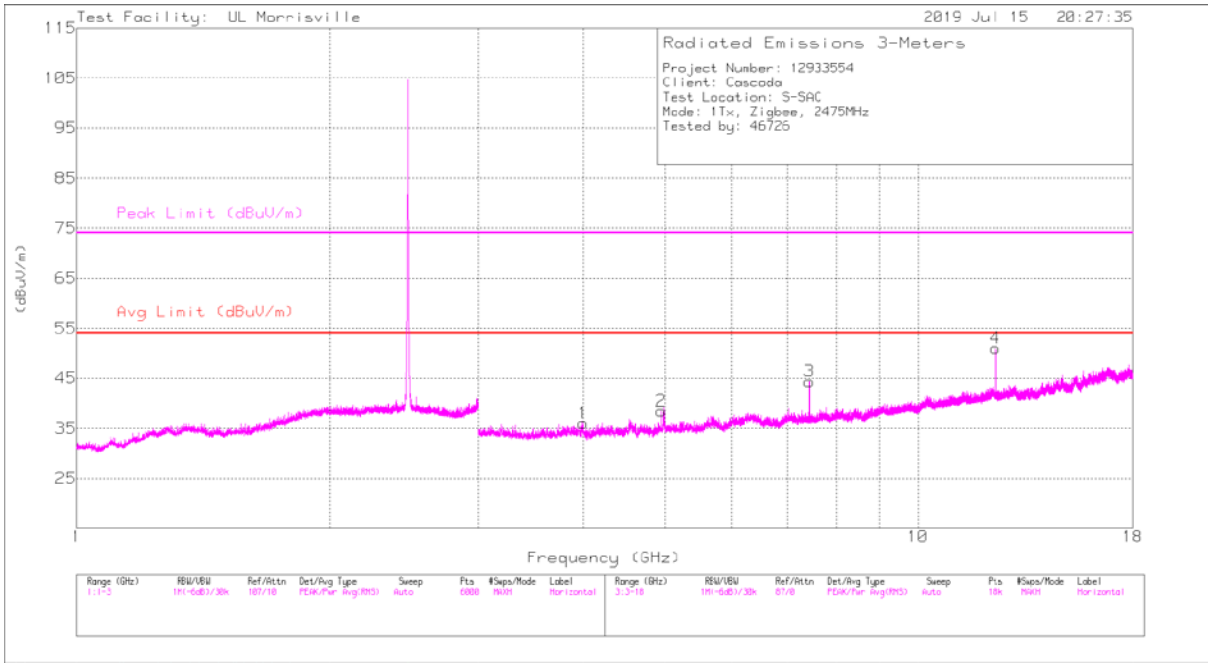
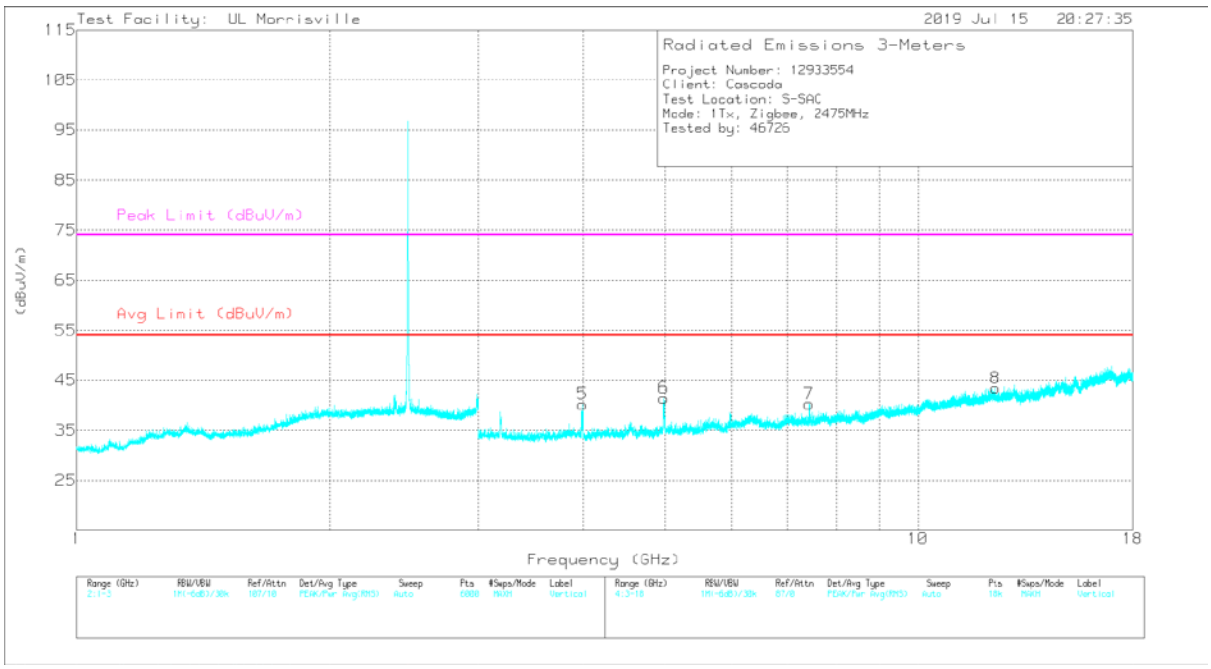
HIGH CHANNEL (2475 MHZ) RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 3.99941	45.81	PK-U	33.4	-31.9	0	47.31	-	-	74	-26.69	291	261	H
	* ** 3.99908	27.17	ADV	33.4	-31.9	-5.19	23.48	54	-30.52	-	-	291	261	H
2	* ** 4.95078	42.52	PK-U	34.1	-30.8	0	45.82	-	-	74	-28.18	22	109	H
	* ** 4.95094	30.6	ADV	34.1	-30.8	-5.19	28.71	54	-25.29	-	-	22	109	H
3	* ** 7.4236	42.21	PK-U	35.8	-27.7	0	50.31	-	-	74	-23.69	360	393	H
	* ** 7.42377	32.56	ADV	35.8	-27.7	-5.19	35.47	54	-18.53	-	-	360	393	H
4	* ** 12.37737	42.29	PK-U	38.8	-23.7	0	57.39	-	-	74	-16.61	122	110	H
	* ** 12.37733	33.32	ADV	38.8	-23.7	-5.19	43.23	54	-10.77	-	-	122	110	H
5	* ** 3.99684	49.86	PK-U	33.4	-31.8	0	51.46	-	-	74	-22.54	131	133	V
	* ** 3.99667	27.71	ADV	33.4	-31.8	-5.19	24.12	54	-29.88	-	-	131	133	V
6	* ** 4.97824	49.98	PK-U	34.1	-31.1	0	52.98	-	-	74	-21.02	167	114	V
	* ** 4.97812	27.44	ADV	34.1	-31.1	-5.19	25.25	54	-28.75	-	-	167	114	V
7	* ** 7.42373	42.02	PK-U	35.8	-27.7	0	50.12	-	-	74	-23.88	310	337	V
	* ** 7.42379	32.41	ADV	35.8	-27.7	-5.19	35.32	54	-18.68	-	-	310	337	V
8	* ** 12.37314	36.79	PK-U	38.8	-23.7	0	51.89	-	-	74	-22.11	99	389	V
	* ** 12.37289	25.29	ADV	38.8	-23.7	-5.19	35.2	54	-18.8	-	-	99	389	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
ADV - U-NII AD primary method, Linear Voltage Average

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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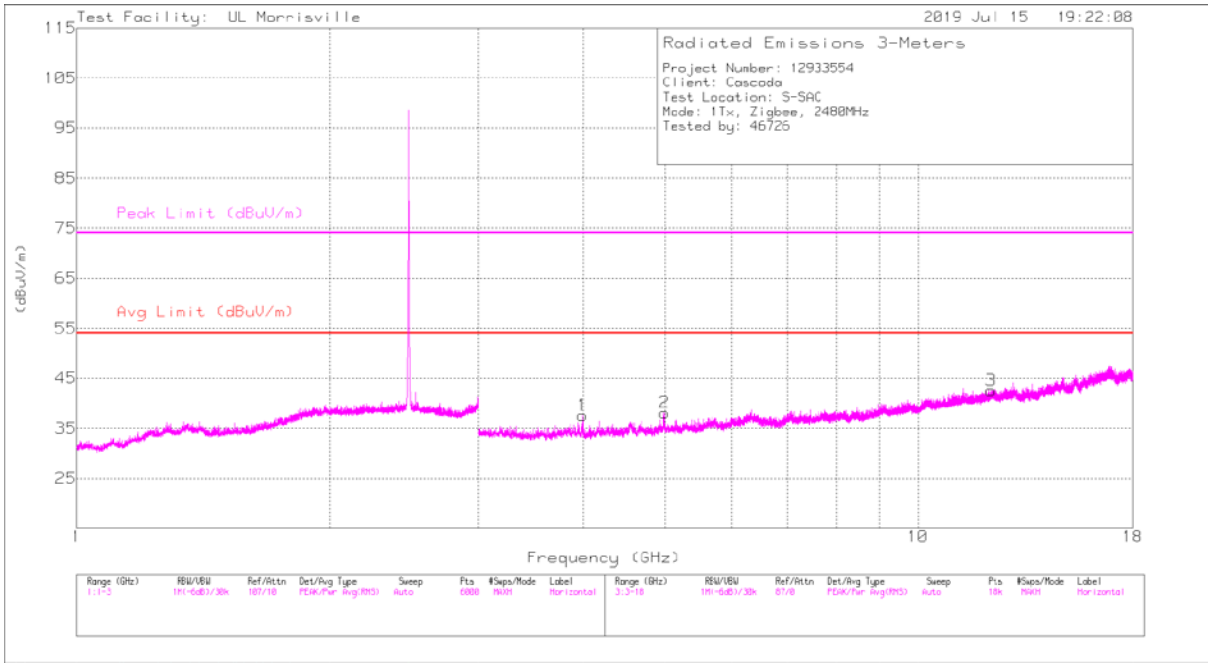
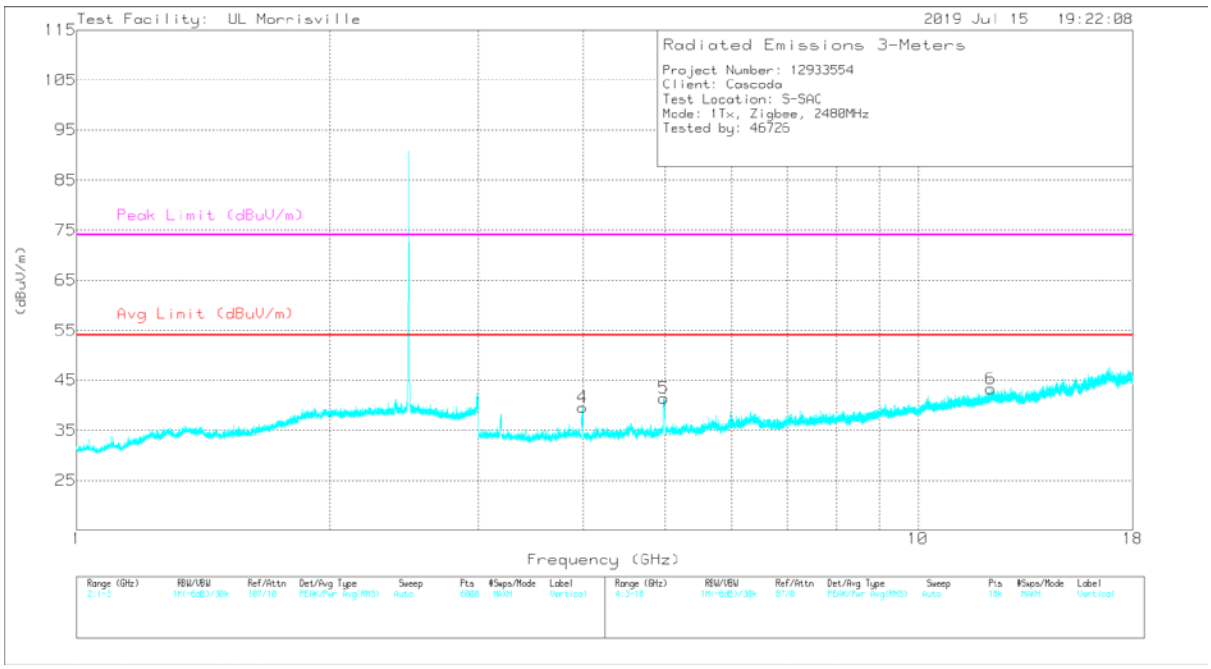
HIGH CHANNEL (2480 MHZ) RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (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	* ** 3.99639	45.85	PK-U	33.4	-31.8	0	47.45	-	-	74	-26.55	293	239	H
	* ** 3.99645	27.21	ADV	33.4	-31.8	-5.19	23.62	54	-30.38	-	-	293	239	H
2	* ** 4.98843	41.67	PK-U	34.1	-31.1	0	44.67	-	-	74	-29.33	258	168	H
	* ** 4.98779	26.72	ADV	34.1	-31.1	-5.19	24.53	54	-29.47	-	-	258	168	H
3	* ** 12.20866	34.25	PK-U	38.9	-23.8	0	49.35	-	-	74	-24.65	232	330	H
	* ** 12.20878	21.16	ADV	38.9	-23.8	-5.19	31.07	54	-22.93	-	-	232	330	H
4	* ** 3.9924	47.14	PK-U	33.4	-31.8	0	48.74	-	-	74	-25.26	100	231	V
	* ** 3.9924	27.18	ADV	33.4	-31.8	-5.19	23.59	54	-30.41	-	-	100	231	V
5	* ** 4.97744	50.48	PK-U	34.1	-31.1	0	53.48	-	-	74	-20.52	162	115	V
	* ** 4.97836	27.52	ADV	34.1	-31.1	-5.19	25.33	54	-28.67	-	-	162	115	V
6	* ** 12.2002	34.35	PK-U	38.9	-23.8	0	49.45	-	-	74	-24.55	202	145	V
	* ** 12.20037	21.15	ADV	38.9	-23.8	-5.19	31.06	54	-22.94	-	-	202	145	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
ADV - U-NII AD primary method, Linear Voltage Average

Note – The 802.15.4 radio duty cycle corrected down because it's considered a protocol limited device as described in FCC KDB 558074 D01 15.247 Meas Guidance v05r02, FAQ section.

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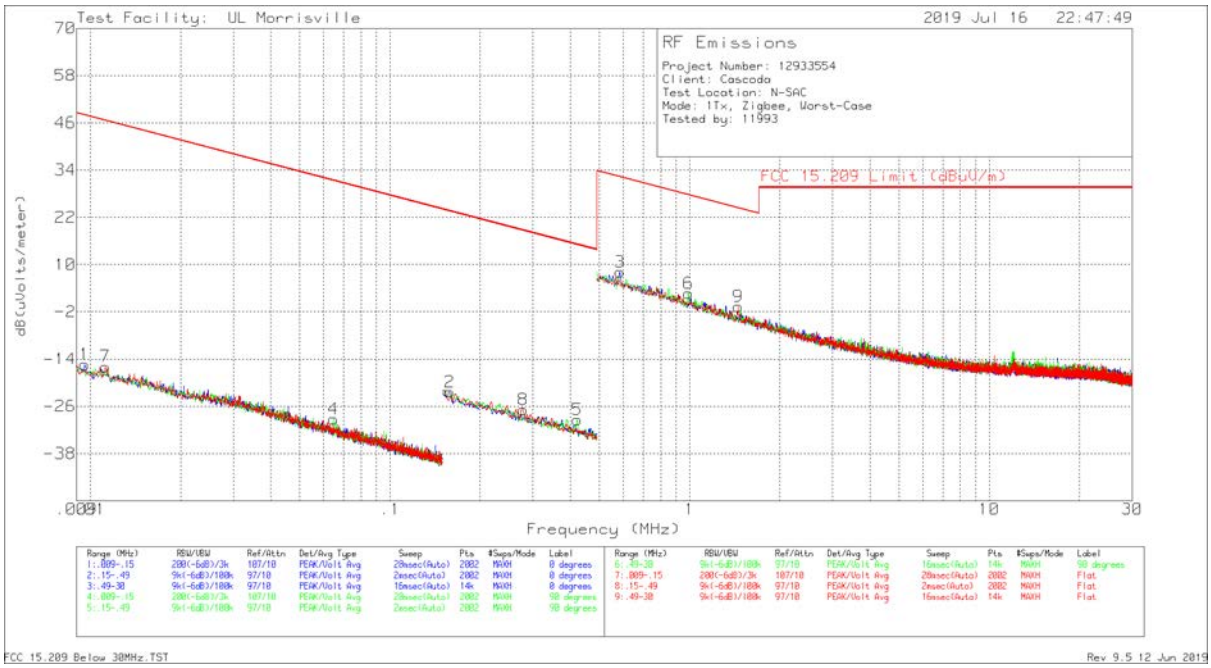
9.3. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) 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 (test distance / specification distance).



ANTENNA- THREE ORIENTATIONS

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0059 (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	FCC 15.209 Avg/QP Limit (dBuV/m)	FCC 15.209 Pk Limit (dBuV/m)	Worst-case Margin (dB)	Azimuth (Degs)	Antenna Face
1	.00956	44.68	Pk	19.8	.1	-80	-15.42	48	68	-63.42	0-360	On
7	.01124	45.28	Pk	18.7	.1	-80	-15.92	46.59	66.59	-62.51	0-360	Flat
4	.06479	39.56	Pk	11.1	.1	-80	-29.24	31.37	51.37	-60.61	0-360	Off
2	.15816	47.15	Pk	10.4	.1	-80	-22.35	23.62	43.62	-45.97	0-360	On
8	.27818	42.85	Pk	10.2	.1	-80	-26.85	18.72	38.72	-45.57	0-360	Flat
5	.42132	40.3	Pk	10.2	.1	-80	-29.4	15.11	35.11	-44.51	0-360	Off
3	.58486	37.59	Pk	10.4	.1	-40	8.09	32.26	-	-24.17	0-360	On
6	.9896	31.89	Pk	10.6	.2	-40	2.69	27.7	-	-25.01	0-360	Off
9	1.45125	28.49	Pk	10.6	.2	-40	-.71	24.37	-	-25.08	0-360	Flat

Pk - Peak detector

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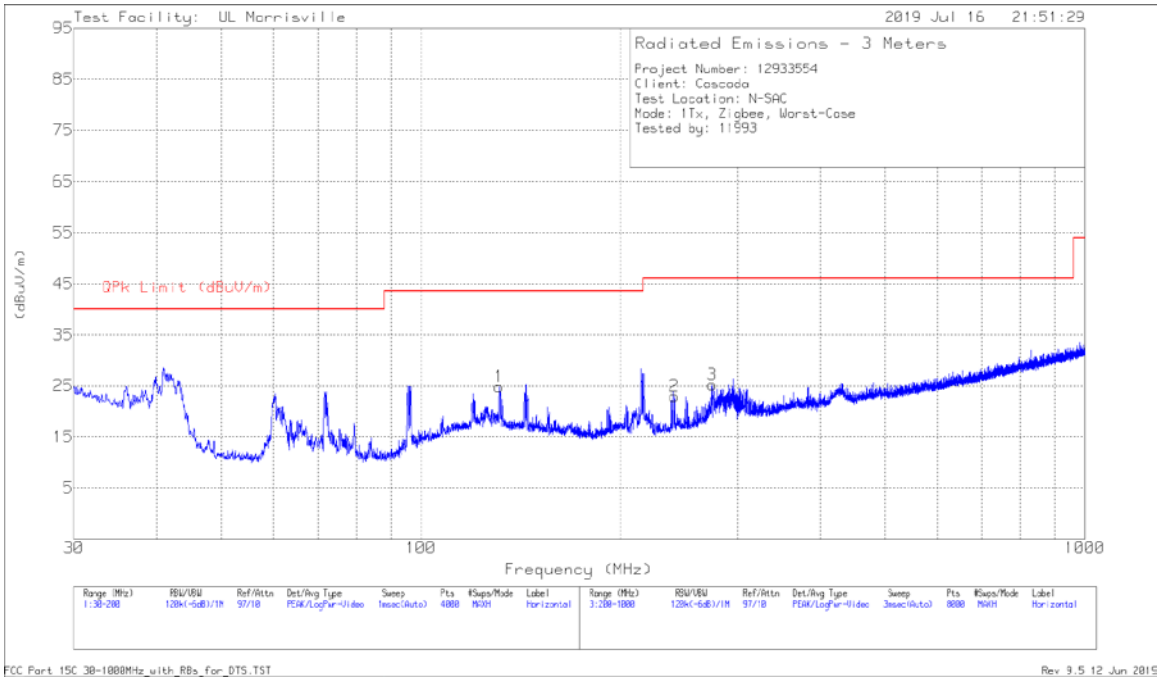
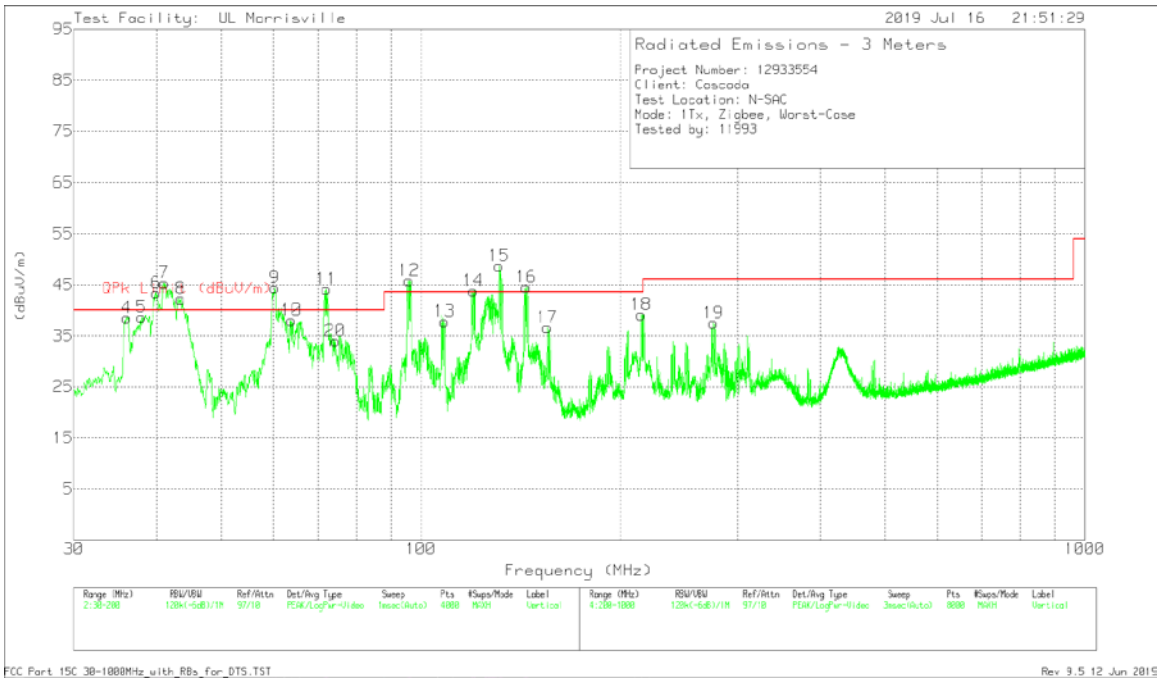
9.4. WORST CASE BELOW 1 GHZ

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



HORIZONTAL



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Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 ACF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 131.2612	35.46	Pk	20.1	-30.7	24.86	43.52	-18.66	0-360	399	H
5	* 38.1443	45.96	Qp	21.9	-31.6	36.26	40	-3.74	282	107	V
13	* 108.4221	47.91	Qp	18.7	-30.8	35.81	43.52	-7.71	256	102	V
14	* 119.7805	51.39	Qp	20	-30.8	40.59	43.52	-2.93	249	102	V
15	* 131.4144	52.15	Qp	20.1	-30.7	41.55	43.52	-1.97	263	118	V
20	* 74.2591	47.09	Qp	14.3	-31.1	30.29	40	-9.71	349	118	V
2	* 241.0053	34.62	Pk	18.2	-29.9	22.92	46.02	-23.1	0-360	199	H
3	* 274.4097	34.92	Pk	19.8	-29.5	25.22	46.02	-20.8	0-360	102	H
19	* 275.7098	47.34	Pk	19.8	-29.6	37.54	46.02	-8.48	0-360	199	V
4	36.0153	46.72	Pk	23.5	-31.7	38.52	-	-	0-360	102	V
6	39.9051	54.4	Pk	20.6	-31.6	43.4	-	-	0-360	102	V
7	41.0529	57.18	Pk	19.8	-31.6	45.38	-	-	0-360	102	V
8	43.476	55.85	Pk	18	-31.6	42.25	-	-	0-360	102	V
9	60.2253	61.86	Pk	13.9	-31.3	44.46	-	-	0-360	102	V
10	63.7962	55.26	Pk	14.1	-31.3	38.06	-	-	0-360	102	V
11	72.0009	61.08	Pk	14.3	-31.2	44.18	-	-	0-360	102	V
12	95.9771	61.59	Pk	15.2	-31	45.79	-	-	0-360	102	V
16	144.0145	55.86	Pk	19.3	-30.6	44.56	-	-	0-360	102	V
17	155.0249	48.22	Pk	18.8	-30.4	36.62	-	-	0-360	102	V
18	214.6019	51.71	Pk	17.4	-30	39.11	-	-	0-360	102	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
QP – Quasi-Peak Detector

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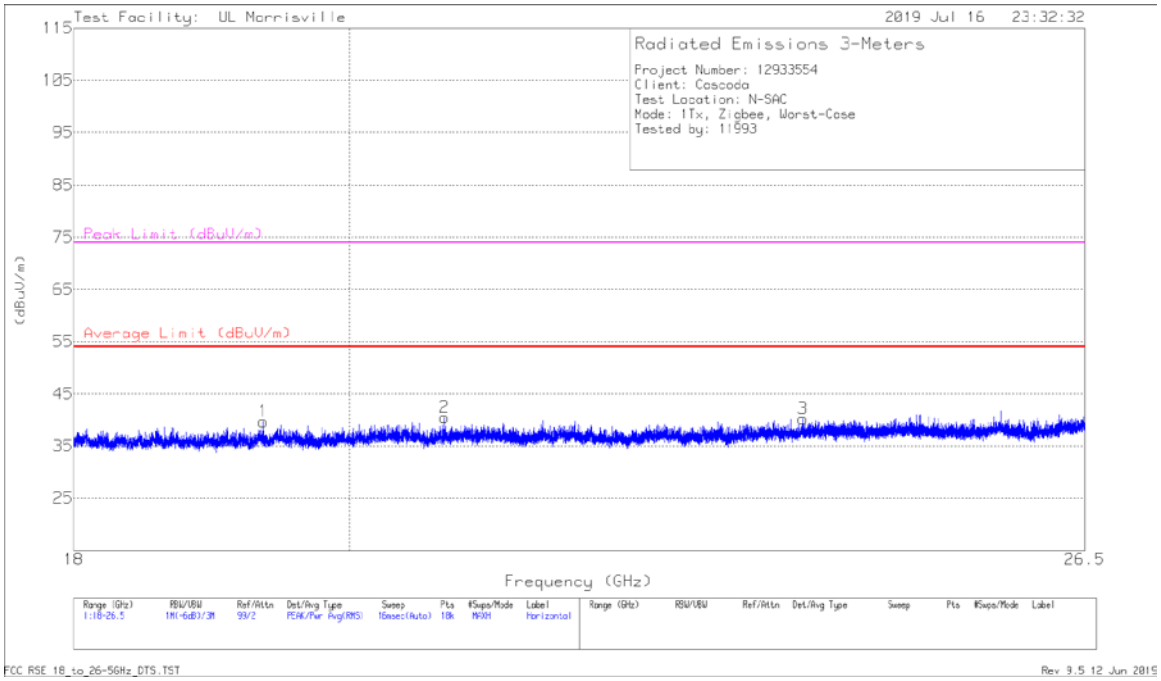
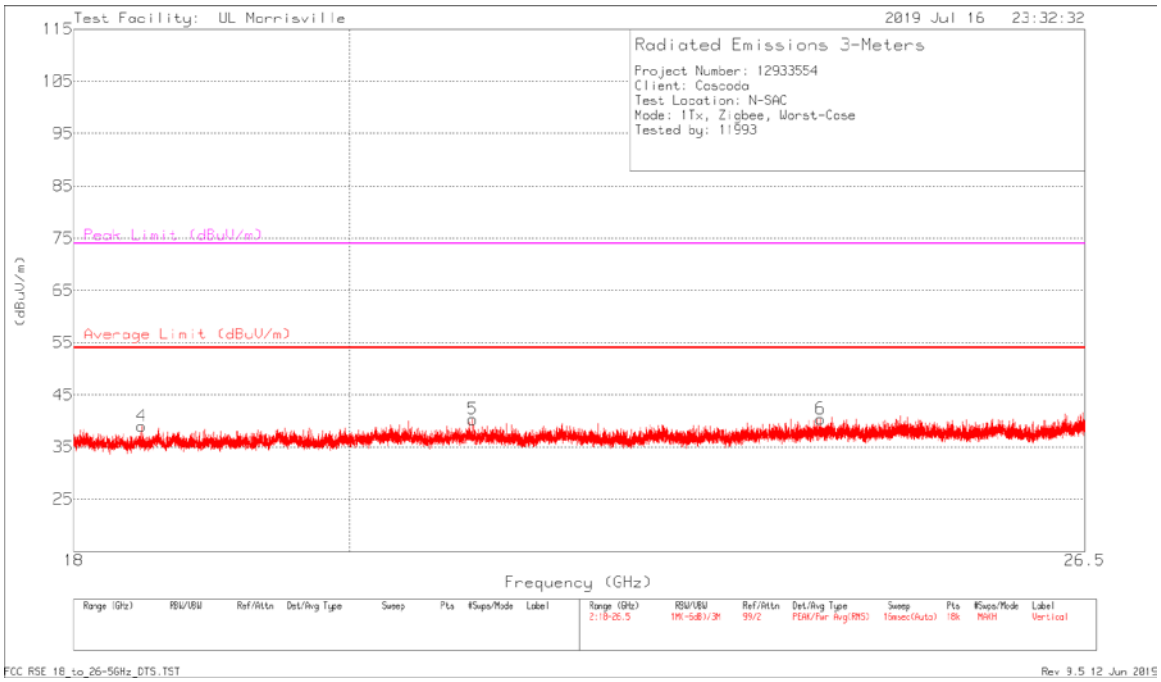
9.5. WORST CASE 18-26 GHZ

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



HORIZONTAL



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18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0076 AF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 19.35157	46.38	Pk	32.8	-39.5	39.68	54	-14.32	74	-34.32	0-360	299	H
2	* 20.74282	47.27	Pk	33	-39.8	40.47	54	-13.53	74	-33.53	0-360	149	H
3	* 23.78976	45.18	Pk	34	-39	40.18	54	-13.82	74	-33.82	0-360	299	H
4	* 18.47319	45.85	Pk	32.4	-39.3	38.95	54	-15.05	74	-35.05	0-360	299	V
5	* 20.96761	46.79	Pk	33.2	-39.7	40.29	54	-13.71	74	-33.71	0-360	299	V
6	* 23.95127	45.29	Pk	34	-38.9	40.39	54	-13.61	74	-33.61	0-360	152	V

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

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10. 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.

RESULTS

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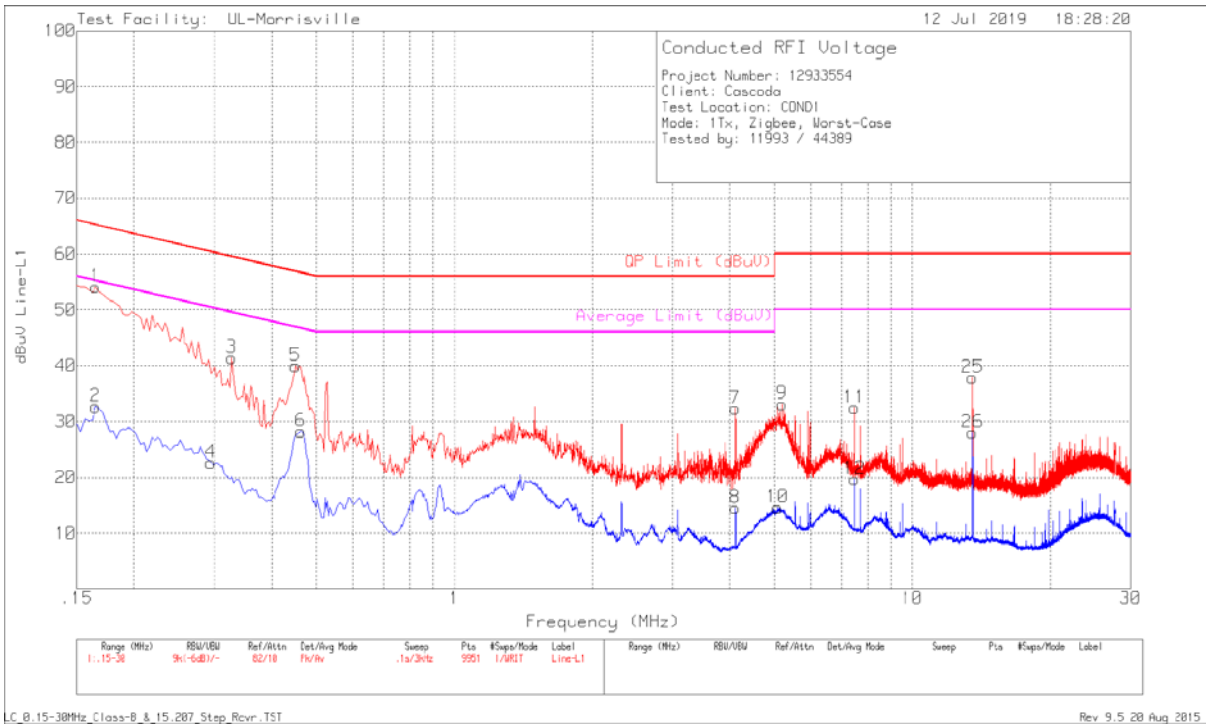
10.1.1. AC Power Line Host

LINE 1 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 (dBuV)	Margin (dB)	Average Limit (dBuV)	Margin (dB)
1	.165	43.95	Pk	.2	10	54.15	65.21	-11.06	-	-
2	.165	22.47	Av	.2	10	32.67	-	-	55.21	-22.54
3	.327	31.3	Pk	.1	10	41.4	59.53	-18.13	-	-
4	.294	12.55	Av	.1	10	22.65	-	-	50.41	-27.76
5	.45	29.83	Pk	.1	10	39.93	56.88	-16.95	-	-
6	.462	18.24	Av	0	10	28.24	-	-	46.66	-18.42
7	4.113	22.25	Pk	0	10.1	32.35	56	-23.65	-	-
8	4.116	4.46	Av	0	10.1	14.56	-	-	46	-31.44
9	5.19	22.95	Pk	0	10.2	33.15	60	-26.85	-	-
10	5.085	4.4	Av	0	10.2	14.6	-	-	50	-35.4
11	7.482	22.07	Pk	.1	10.3	32.47	60	-27.53	-	-
12	7.488	9.26	Av	.1	10.3	19.66	-	-	50	-30.34
25	13.56	27.37	Pk	.1	10.4	37.87	60	-22.13	-	-
26	13.56	17.53	Av	.1	10.4	28.03	-	-	50	-21.97

Pk - Peak detector
Av - Average detection

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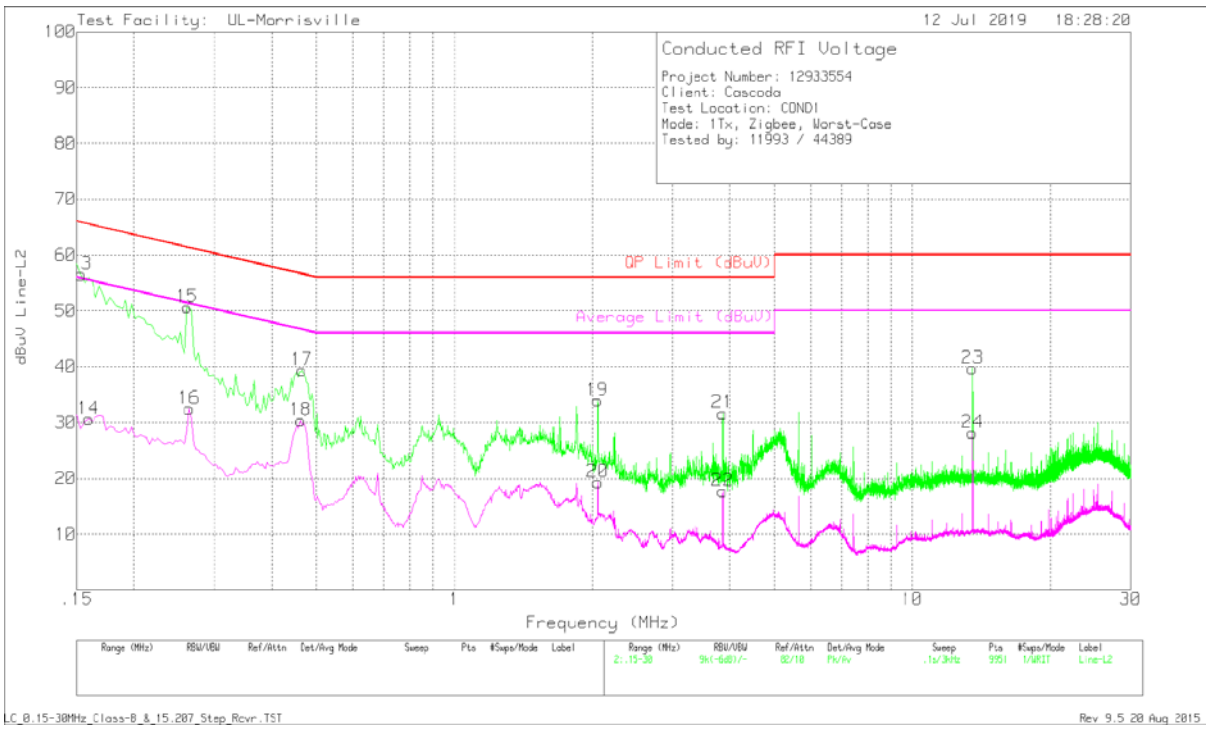
LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz										
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN VCF (dB)	Cbl/Limiter (dB)	Corrected Reading dBuV	QP Limit (dBuV)	Margin (dB)	Average Limit (dBuV)	Margin (dB)
13	.153	46.31	Pk	.2	10	56.51	65.84	-9.33	-	-
14	.159	20.4	Av	.2	10	30.6	-	-	55.52	-24.92
15	.261	40.57	Pk	.1	10	50.67	61.4	-10.73	-	-
16	.264	22.4	Av	.1	10	32.5	-	-	51.3	-18.8
17	.465	29.29	Pk	.1	10	39.39	56.6	-17.21	-	-
18	.462	20.31	Av	.1	10	30.41	-	-	46.66	-16.25
19	2.055	23.87	Pk	0	10.1	33.97	56	-22.03	-	-
20	2.058	9.22	Av	0	10.1	19.32	-	-	46	-26.68
21	3.855	21.57	Pk	0	10.1	31.67	56	-24.33	-	-
22	3.855	7.6	Av	0	10.1	17.7	-	-	46	-28.3
23	13.56	29.24	Pk	.1	10.4	39.74	60	-20.26	-	-
24	13.56	17.64	Av	.1	10.4	28.14	-	-	50	-21.86

Pk - Peak detector
Av - Average detection

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11. SETUP PHOTOS

Please refer to 12933554-EP1 for setup photos

END OF TEST REPORT

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