TEST REPORT

Report Number. : 12875574-E1V1

Applicant	:	SONOS, INC. 614 CHAPALA STREET SANTA BARBARA, CA 93101, U.S.A
Model	:	S24
FCC ID	:	SBVRM024
IC	:	5373A-RM024
EUT Description	:	802.11 a/b/g/n 4x4 (HT20) Client Device
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
January 30, 2020

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	1/30/2020	Initial Issue	

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TABLE OF CONTENTS

REPORT REVISION HISTORY 2

TABLE OF CONTENTS 3

1. ATTESTATION OF TEST RESULTS 5

2. TEST METHODOLOGY 7

3. FACILITIES AND ACCREDITATION 7

4. CALIBRATION AND UNCERTAINTY 8

4.1. MEASURING INSTRUMENT CALIBRATION 8

4.2. SAMPLE CALCULATION 8

4.3. MEASUREMENT UNCERTAINTY 8

5. EQUIPMENT UNDER TEST 9

5.1. EUT DESCRIPTION 9

5.2. MAXIMUM OUTPUT POWER 9

5.3. DESCRIPTION OF AVAILABLE ANTENNAS 9

5.4. SOFTWARE 9

5.5. WORST-CASE CONFIGURATION AND MODE 9

5.6. DESCRIPTION OF TEST SETUP 10

6. MEASUREMENT METHOD 12

7. TEST AND MEASUREMENT EQUIPMENT 13

8. ANTENNA PORT TEST RESULTS 14

8.1. ON TIME AND DUTY CYCLE 14

8.2. 99% BANDWIDTH 15

8.3. 6 dB BANDWIDTH 16

8.4. OUTPUT POWER 17

8.5. AVERAGE POWER 18

8.6. POWER SPECTRAL DENSITY 19

8.7. CONDUCTED SPURIOUS EMISSIONS 20

9. RADIATED TEST RESULTS 22

9.1. LIMITS AND PROCEDURE 22

9.2. TRANSMITTER ABOVE 1 GHz 24

9.3. WORST CASE BELOW 30MHZ 34

9.4. WORST CASE BELOW 1 GHZ 36

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.5. WORST CASE 18-26 GHZ 38

10. AC POWER LINE CONDUCTED EMISSIONS 40

11. SETUP PHOTOS 43

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS, INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A.

EUT DESCRIPTION: 802.11 a/b/g/n 4x4 (HT20) Client Device

MODEL: S24

SERIAL NUMBER: D100 1909CP 34-7E-5C-D0-02-60-7 (Conducted Sample)
D100 1909CP 34-7E-5C-D0-02-5C-3 (Radiated Sample)
D100 1909CP 34-7E-5C-D0-02-7E-3(Radiated Sample)

DATE TESTED: November 13 – November 22, 2019

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 Verification Services Inc. 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.

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 the U.S. government.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Approved & Released For
UL Verification Services Inc. By:

DAN CORONIA
Operations Leader
Consumer Technology Division
UL Verification Services Inc.

Prepared By:

JOSE MARTINEZ
Test Engineer
Consumer Technology Division
UL Verification Services Inc.

Reviewed By:

KIYA KEDIDA
Senior Project Engineer
Consumer Technology Division
UL Verification Services Inc.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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, KDB 414788 D01 Radiated Test Site v01r0, 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 47173 and 47266 Benicia Street, and 47658 Kato Road, 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	47658 Kato Rd.
☒ Chamber A	☐ Chamber D	☒ Chamber I
☐ Chamber B	☐ Chamber E	☐ Chamber J
☐ Chamber C	☐ Chamber F	☐ Chamber K
	☐ Chamber G	☐ Chamber L
	☐ Chamber H	

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.39 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.07 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is an 802.11 a/b/g/n 4x4 (HT20) Client Device.

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2402 - 2480	BLE	-0.11	0.97

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an antenna with a maximum gain of 2.95 dBi.

5.4. SOFTWARE

The test utility software used during testing was:
Sonos build 55.0-70090_mainline_integ_int_release

5.5. WORST-CASE CONFIGURATION AND MODE

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.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low, middle and high channels.

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	T440p	SON-00008522	N/A
AC Adapter	Lenovo	ADLX90NDC2A	11S36200285ZZ3004758D2	N/A

I/O CABLES

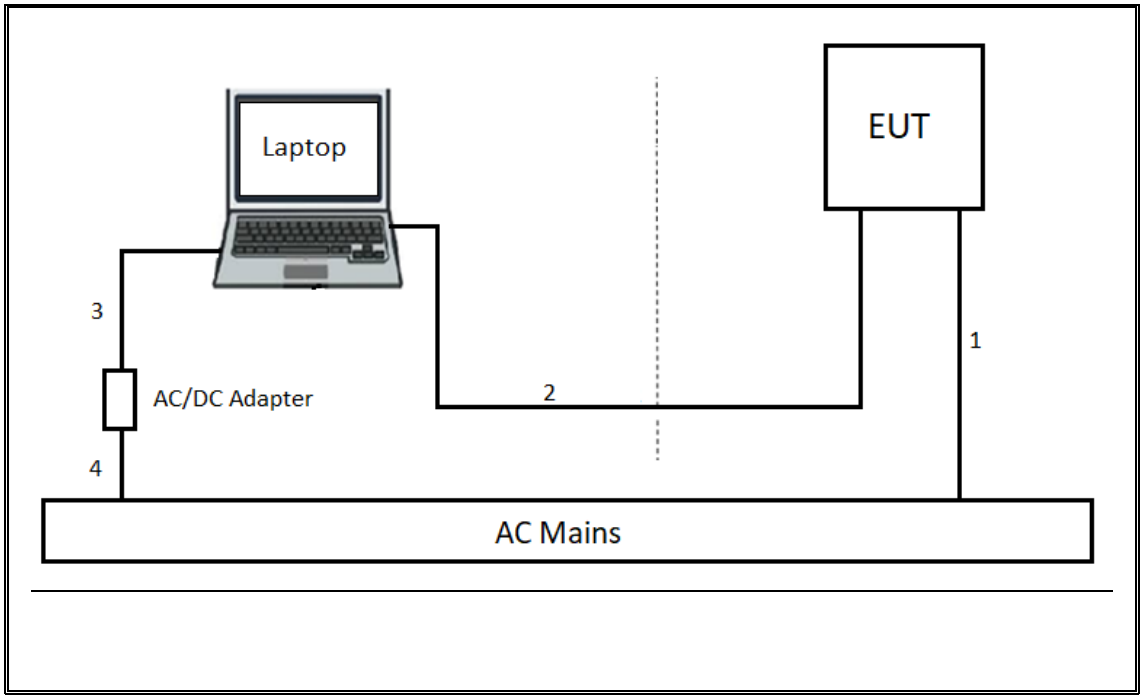
I/O Cable List						
Cable No	**Port**	**# of identical**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC Power	1	AC	Unshielded	2	AC Mains to EUT
2	Ethernet	1	RJ45	Unshielded	10	EUT to Laptop
3	DC Power	1	DC	Shielded	1.2	AC/DC Adapter to Laptop
4	AC Power	1	AC	Unshielded	1	AC Mains to AC/DC Adapter

TEST SETUP

The EUT connected to support laptop via the ethernet cable during testing.
The test utility software on support laptop exercised the radio card.
For radiated testing, the support laptop was set up outside the chamber.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

SETUP DIAGRAMS



UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10-2013 Section 11.6.

6 dB BW: ANSI C63.10 Section 11.8.1

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

Output Power: ANSI C63.10 Section 11.9.1.3 Method PKPM1 (Peak-reading power meter).

Output Power: ANSI C63.10 Section 11.9.2.3.2 Method AVGPM-G (Measurement using a gated RF average-reading power meter)

Power Spectral Density: ANSI C63.10 Section 11.10.2 Method PKPSD (peak PSD)

Band-edge: ANSI C63.10 Section 11.13.3.4 Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction factor

Radiated emissions non-restricted frequency bands: ANSI C63.10 Section 11.11

Radiated emissions restricted frequency bands: ANSI C63.10 Section 11.12.1

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4

Conducted emissions in restricted frequency bands: ANSI C63.10 Section 11.12.

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

7. 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**	**ID Num**	**Cal Due**	**Last Cal**
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies (Formerly Agilent)	N9030A	T908	01/23/2020	01/23/2019
RF Amplifier, 1-18GHz	MITEQ	AFS42-00101800-25-S-42	T1165	11/06/2020	11/06/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T346	05/14/2020	05/14/2019
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	PRE0179376	02/14/2020	02/14/2019
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	PRE0180175	05/29/2020	06/29/2019
Antenna,Broadband Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	PRE0184052	11/12/2020	11/12/2019
RF Amplifier, 1-18GHz	MITEQ	AFS42-00101800-25-S-42	171460	08/24/2020	08/24/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T862	06/05/2020	06/05/2019
Antenna, Active Loop 9KHz to 30MHz	COM-POWER	AL-130R	PRE0165308	04/11/2020	04/11/2019
Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	T447	08/13/2020	08/13/2019
Rf Amplifier, 18-26.5GHz, 60dB gain	AMPLICAL	Rf Amplifier, 18-26.5GHz, 60dB gain	PRE0181238	05/01/2020	05/01/2019
Power Meter, P-series single channel	Agilent (Keysight) Technologies	N1911A	T1265	01/29/2020	01/29/2019
Power Sensor, P-series, 50MHz to 18GHz, Wideband	Agilent (Keysight) Technologies	N1921A	T1227	02/05/2020	02/05/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies (Formerly Agilent)	N9030A	T917	01/24/2020	01/24/2019
Spectrum Analyzer, PSA, 3Hz to 26.5GHz	Keysight Technologies (Formerly Agilent)	E4440A	T200	01/28/2020	01/28/2019
AC Line Conducted					
EMI Receiver	Rohde & Schwarz	ESR	T1436	02/14/2020	02/14/2019
LISN for Conducted Emissions CISPR-16	FCC INC.	FCC LISN 50/250	T1310	01/24/2020	01/24/2019
Test Software List					
Radiated Software	UL	UL EMC		Ver 9.5, September 24, 2019	
Antenna Port Software	UL	UL RF		Ver 2019.10.18, October 18, 2019	
AC Line Conducted Software	UL	UL EMC		Ver 9.5, May 26, 2015	

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
BLE	0.382	0.624	0.612	61.18	2.13	2.619

DUTY CYCLE PLOTS

DUTY CYCLE BLE

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

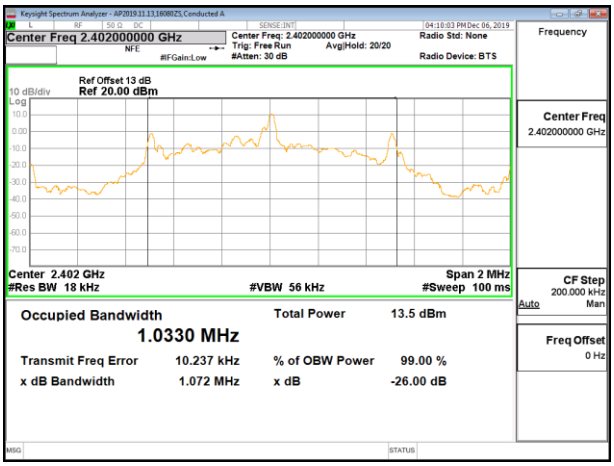
8.2. 99% BANDWIDTH

LIMITS

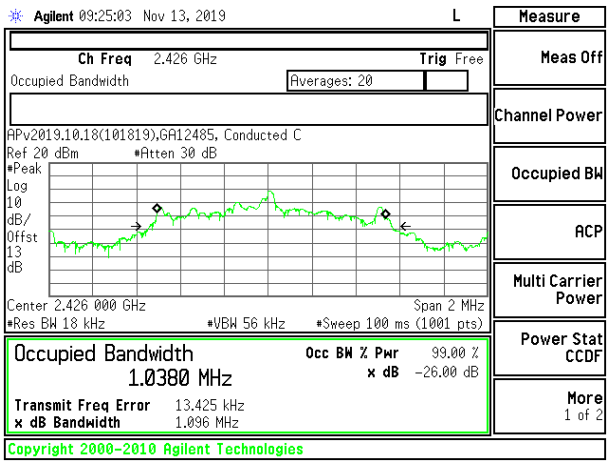
None; for reporting purposes only.

RESULTS

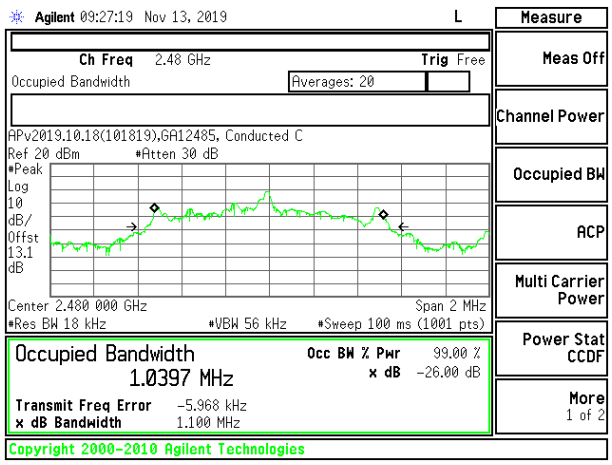
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.033
Middle	2426	1.038
High	2480	1.040



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3. 6 dB BANDWIDTH

LIMITS

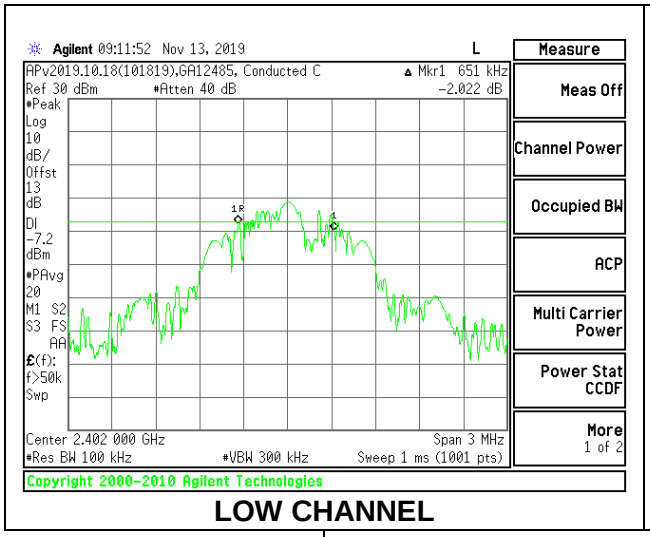
FCC §15.247 (a) (2)

RSS-247 5.2 (a)

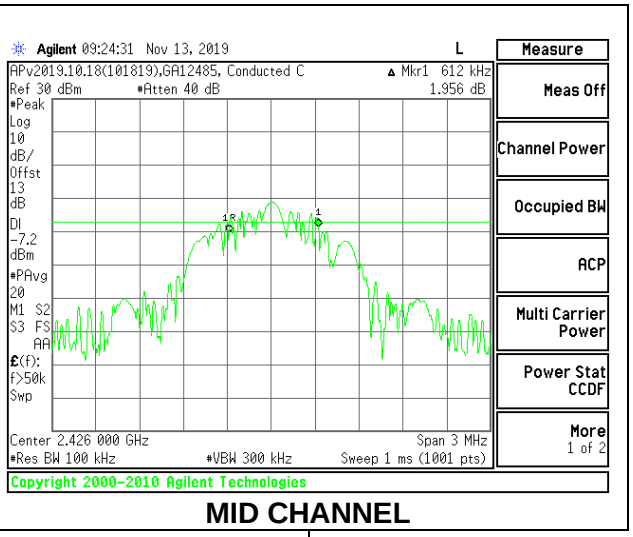
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

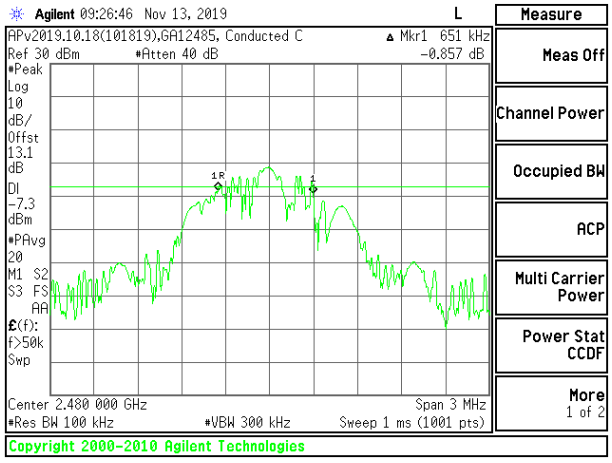
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.651	0.5
Middle	2426	0.612	0.5
High	2480	0.651	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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

RESULTS

Tested By:	12485 GA
Date:	11/13/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-0.28	30	-30.280
Middle	2440	-0.11	30	-30.110
High	2480	-0.13	30	-30.132

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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

RESULTS

Tested By:	12485 GA
Date:	11/13/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	-0.86
Middle	2426	-0.70
High	2480	-0.66

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6. POWER SPECTRAL DENSITY

LIMITS

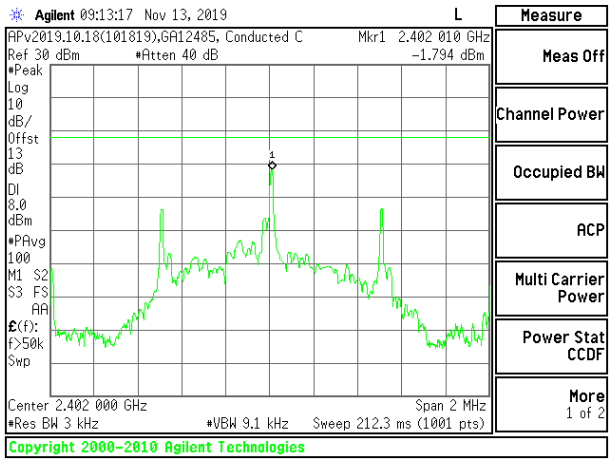
FCC §15.247 (e)

RSS-247 (5.2) (b)

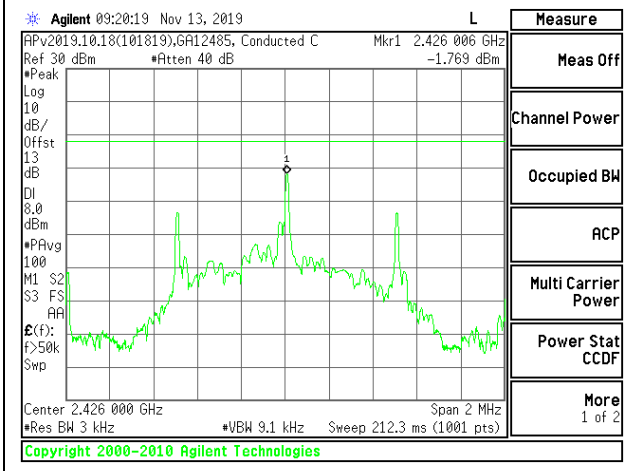
The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RESULTS

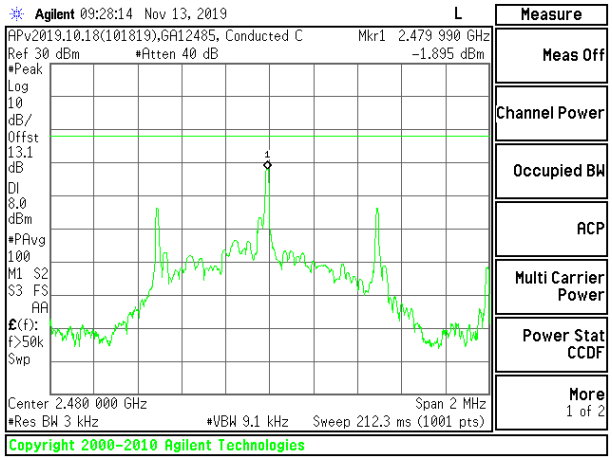
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-1.79	8	-9.79
Middle	2426	-1.77	8	-9.77
High	2480	-1.90	8	-9.90



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

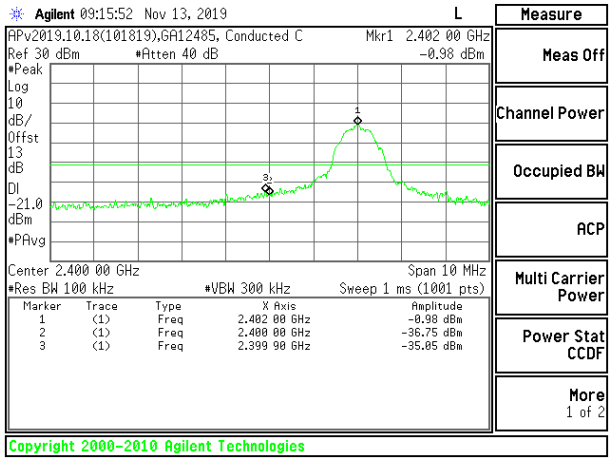
FCC §15.247 (d)

RSS-247 5.5

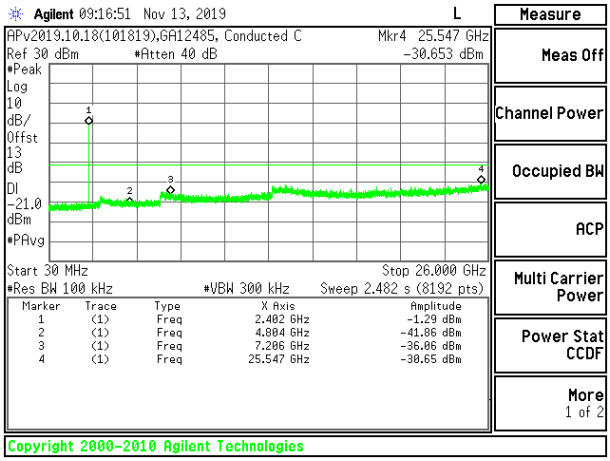
Output power was measured based on the use of a peak measurement, therefore the required attenuation is 20 dB.

RESULTS

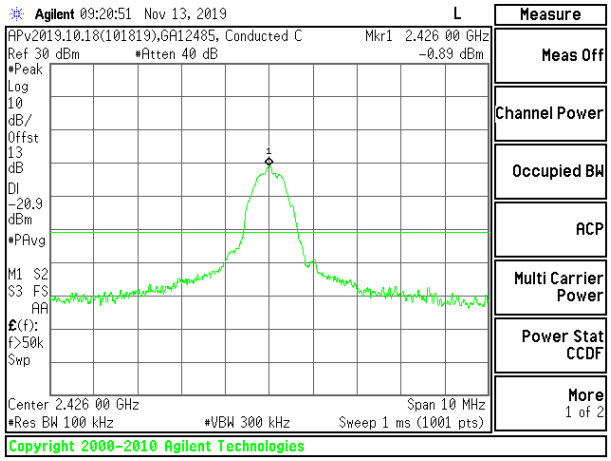
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



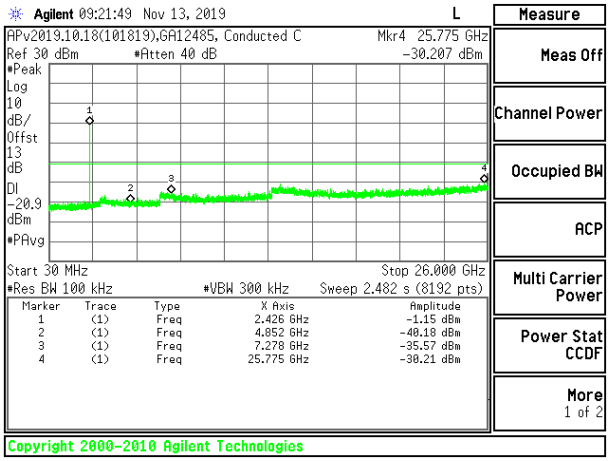
LOW CHANNEL BANDEDGE



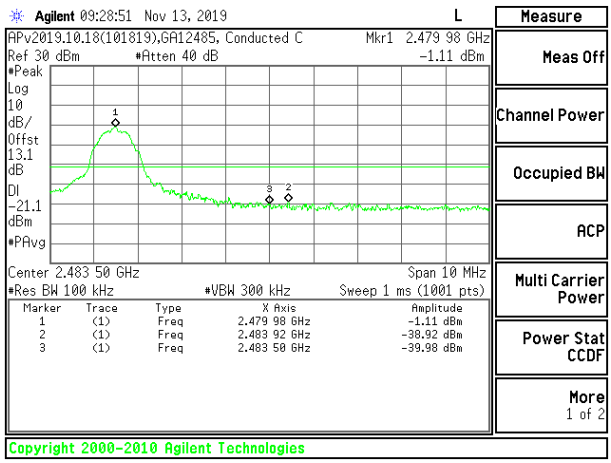
OUT-OF-BAND LOW CHANNEL



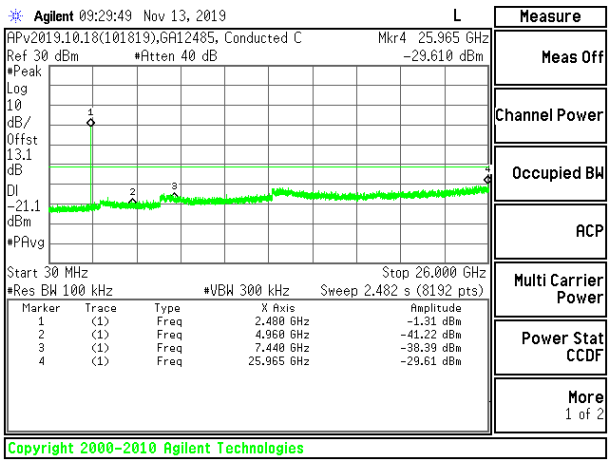
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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 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 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 and as applicable for average measurements.

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.

2D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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.

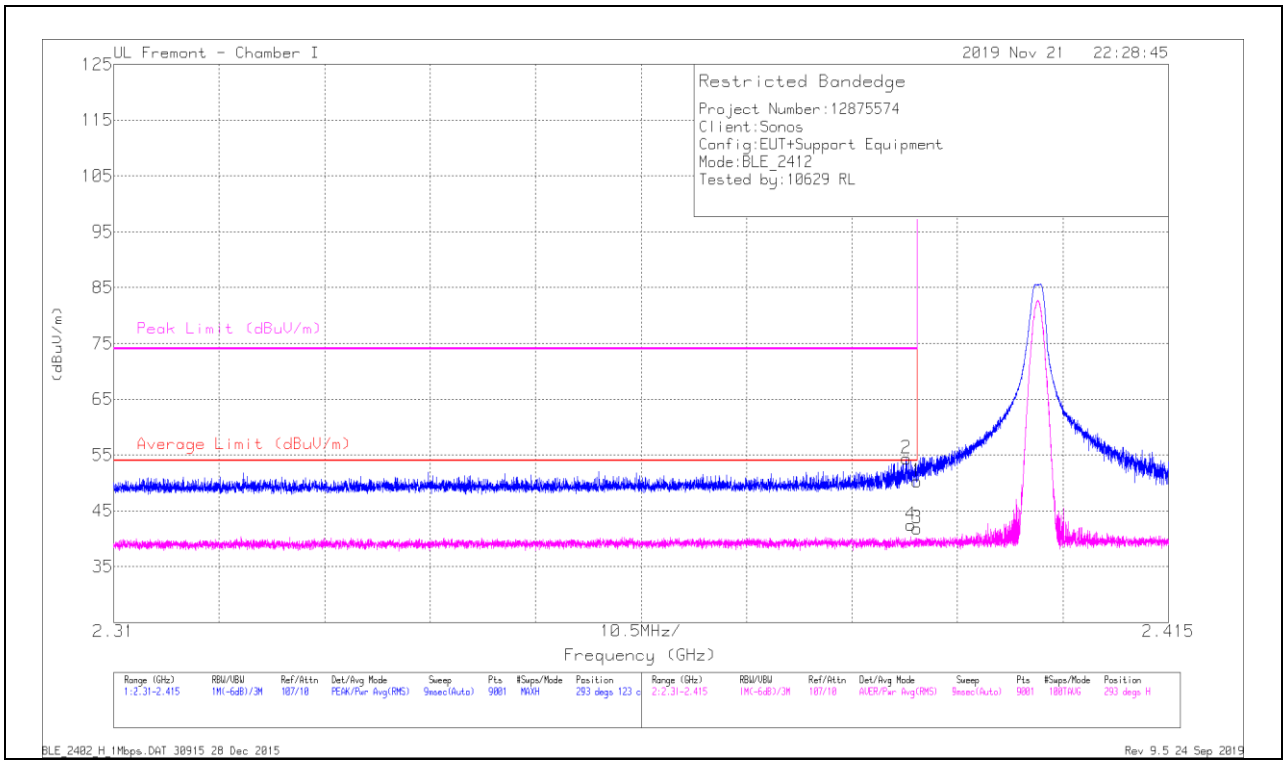
OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.2. TRANSMITTER ABOVE 1 GHz

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT

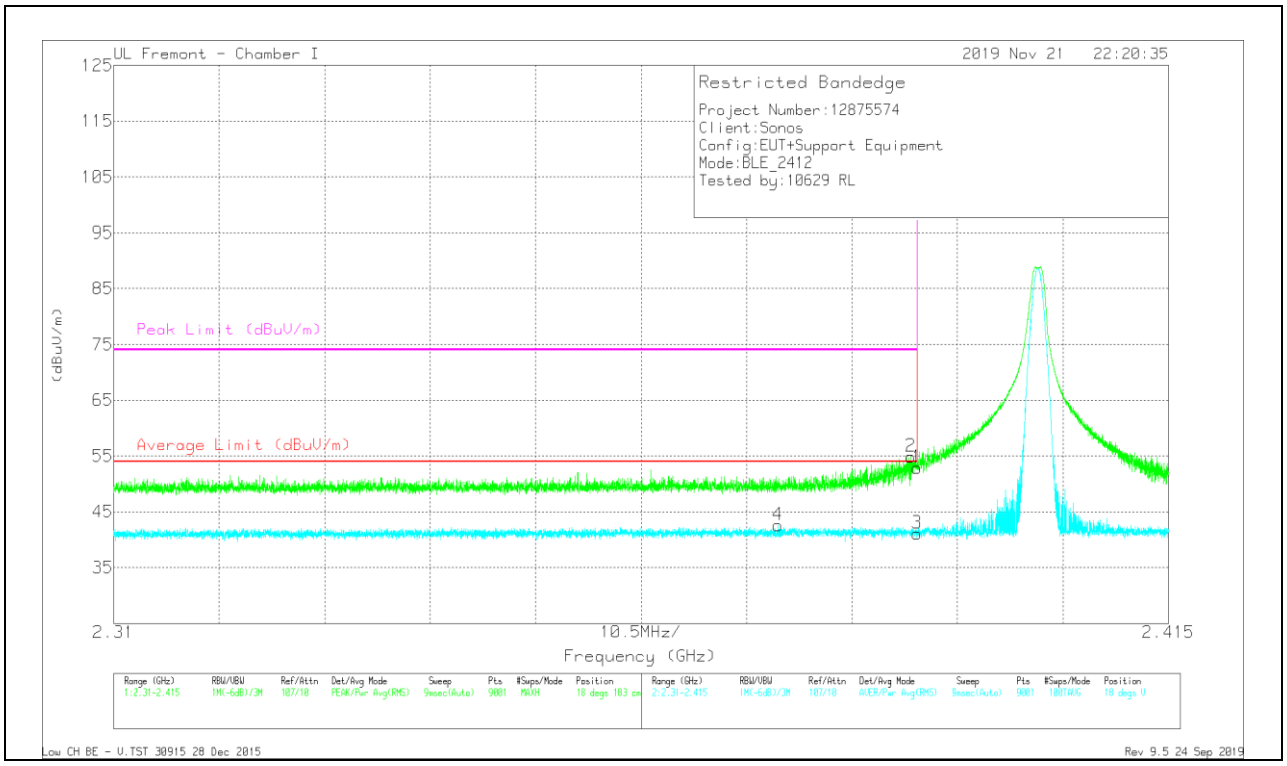


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.38999	38.14	Pk	31.9	-19.7	0	50.34	-	-	74	-23.66	293	123	H
2	* 2.3889	42.18	Pk	31.9	-19.7	0	54.38	-	-	74	-19.62	293	123	H
3	* 2.38999	27.52	RMS	31.9	-19.7	2.13	41.85	54	-12.15	-	-	293	123	H
4	* 2.38937	28.11	RMS	31.9	-19.7	2.13	42.44	54	-11.56	-	-	293	123	H

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

VERTICAL RESULT



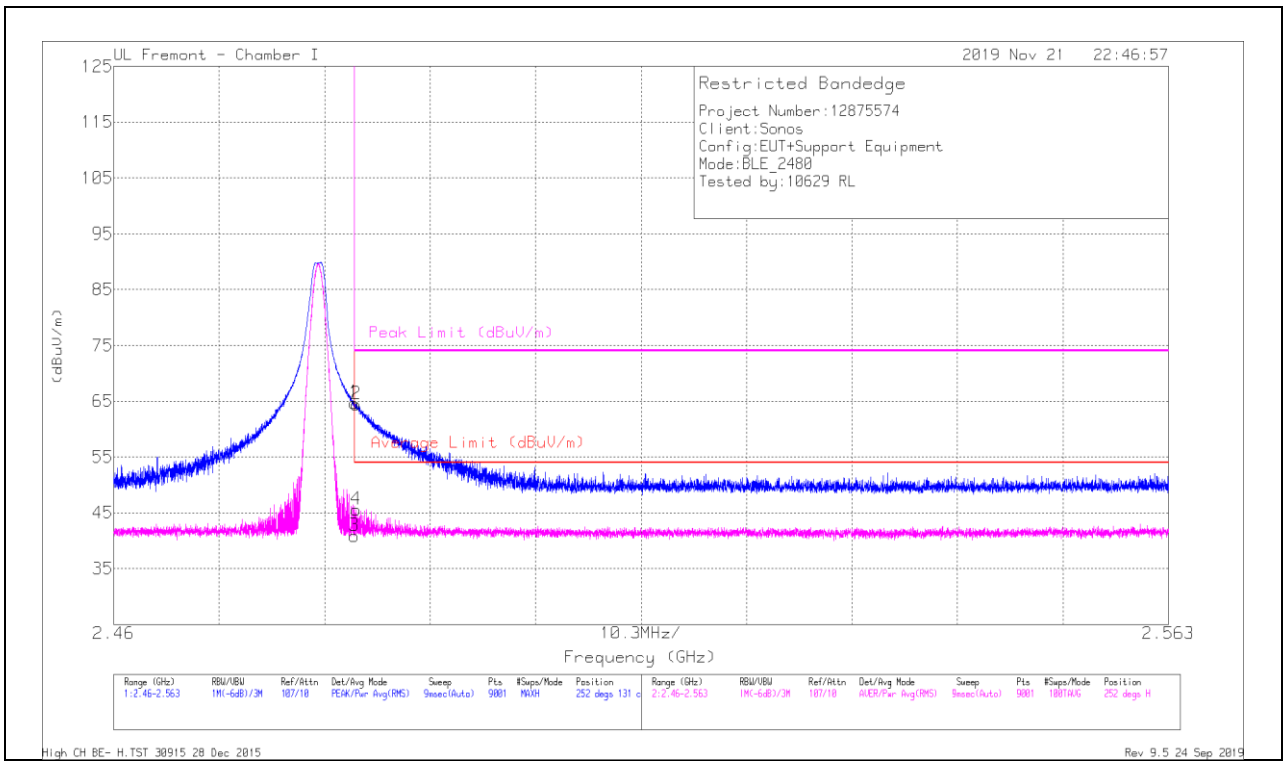
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.38999	40.74	Pk	31.9	-19.7	0	52.94	-	-	74	-21.06	18	183	V
2	* 2.38935	42.69	Pk	31.9	-19.7	0	54.89	-	-	74	-19.11	18	183	V
3	* 2.38999	26.83	RMS	31.9	-19.7	2.13	41.16	54	-12.84	-	-	18	183	V
4	* 2.37615	28.21	RMS	31.9	-19.7	2.13	42.54	54	-11.46	-	-	18	183	V

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT

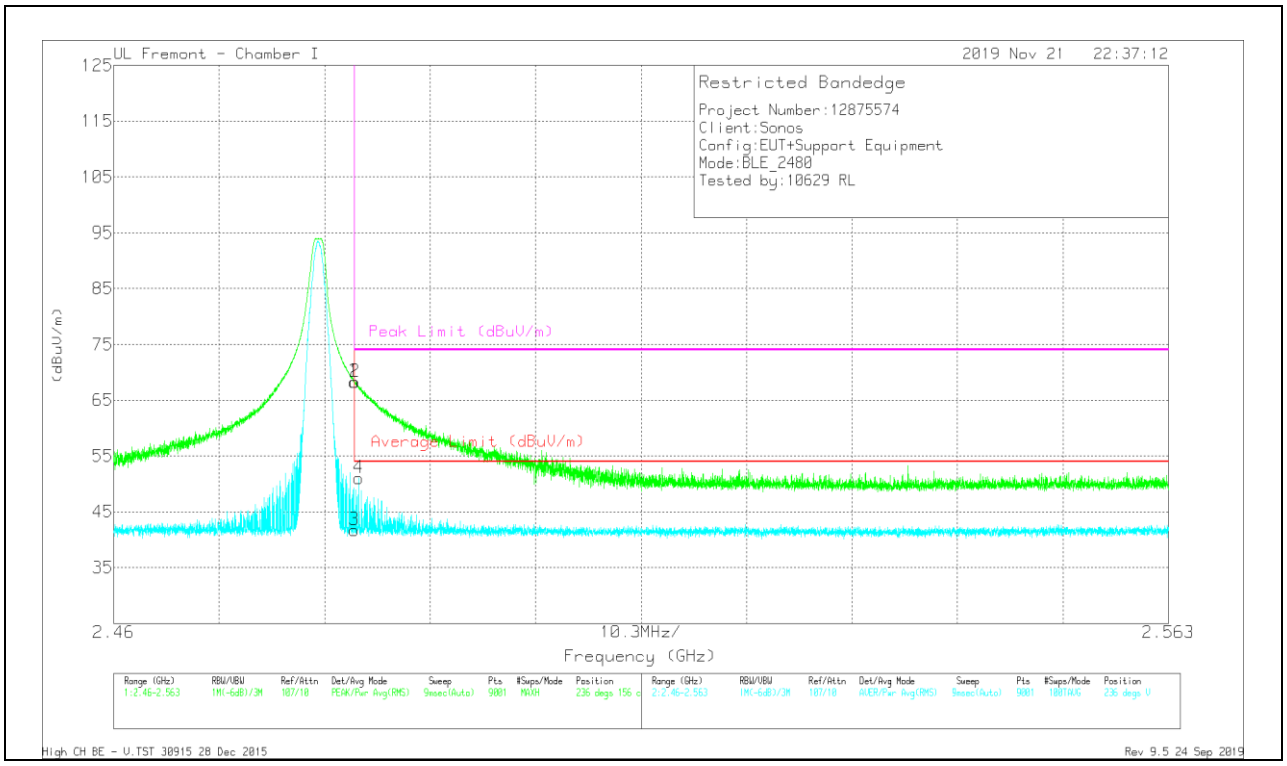


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dBim)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.48351	52.24	Pk	32.4	-20	0	64.64	-	-	74	-9.36	252	131	H
2	* 2.48365	52.09	Pk	32.4	-20	0	64.49	-	-	74	-9.51	252	131	H
3	* 2.48351	26.29	RMS	32.4	-20	2.13	40.82	54	-13.18	-	-	252	131	H
4	* 2.48365	31.1	RMS	32.4	-20	2.13	45.63	54	-8.37	-	-	252	131	H

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

VERTICAL RESULT



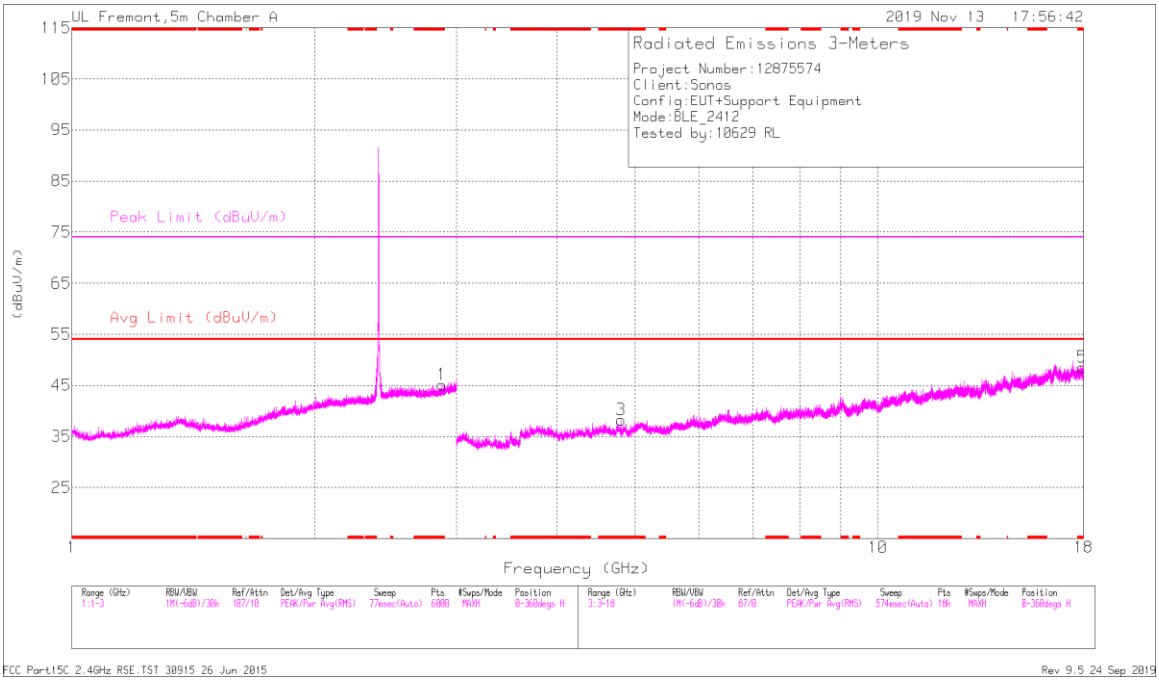
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.48351	55.93	Pk	32.4	-20	0	68.33	-	-	74	-5.67	236	156	V
2	* 2.48354	55.89	Pk	32.4	-20	0	68.29	-	-	74	-5.71	236	156	V
3	* 2.48351	27.24	RMS	32.4	-20	2.13	41.77	54	-12.23	-	-	236	156	V
4	* 2.48392	36.46	RMS	32.4	-20	2.13	50.99	54	-3.01	-	-	236	156	V

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

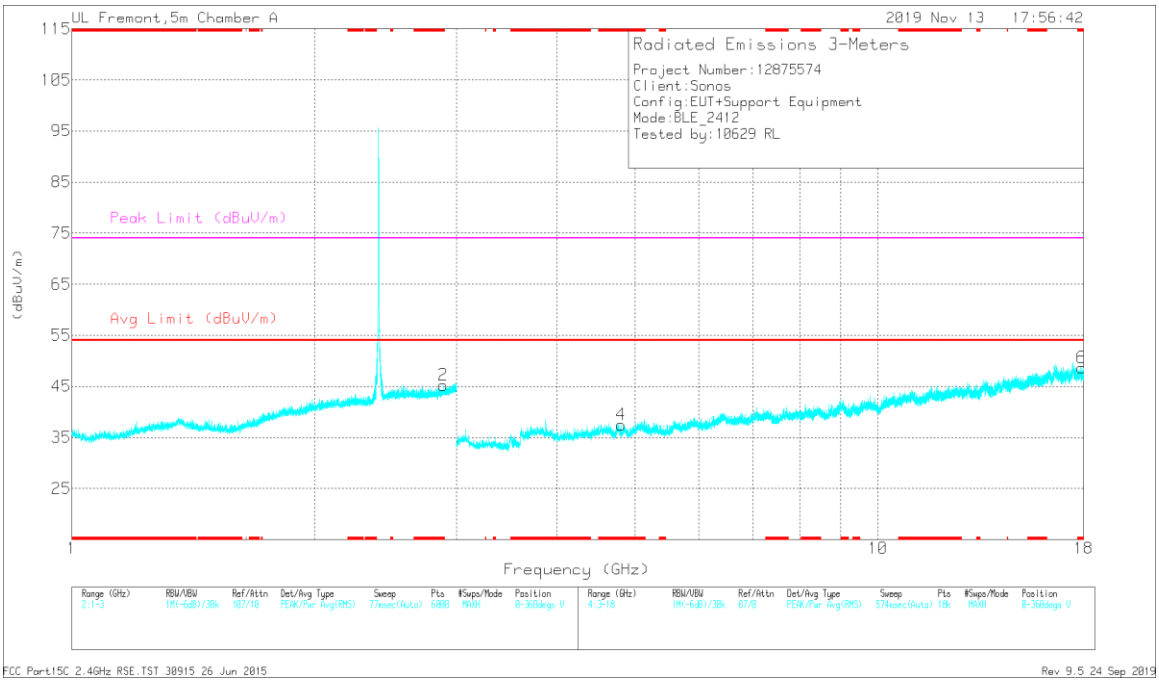
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

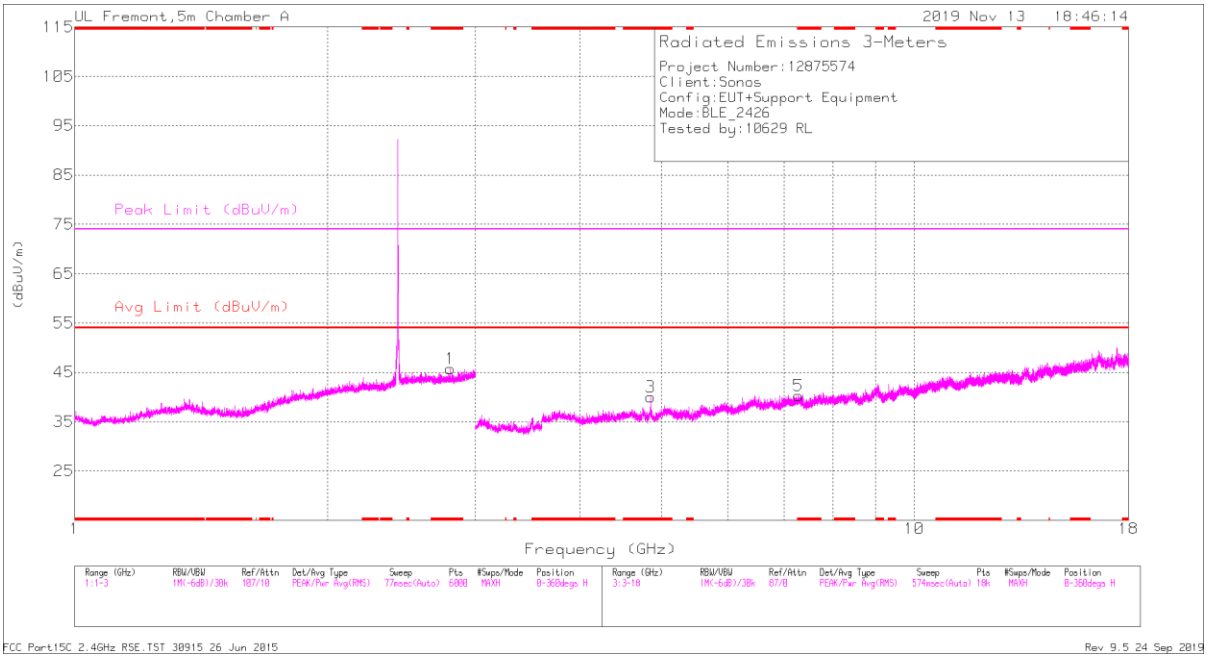
RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (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	* 2.87976	40.33	PK2	32.6	-22.3	0	50.63	-	-	74	-23.37	241	126	H
	* 2.87695	28.49	MAv1	32.6	-22.3	2.13	40.92	54	-13.08	-	-	241	126	H
2	* 2.89057	40.52	PK2	32.6	-22.3	0	50.82	-	-	74	-23.18	87	120	V
	* 2.88761	28.61	MAv1	32.6	-22.3	2.13	41.04	54	-12.96	-	-	87	120	V
3	* 4.8036	38.47	PK2	34.3	-27.5	0	45.27	-	-	74	-28.73	335	177	H
	* 4.80398	29.25	MAv1	34.4	-27.5	2.13	38.28	54	-15.72	-	-	335	177	H
5	* 17.93125	32.92	PK2	41	-19	0	54.92	-	-	74	-19.08	56	135	H
	* 17.92915	20.81	MAv1	41	-18.9	2.13	45.04	54	-8.96	-	-	56	135	H
4	* 4.8039	38.33	PK2	34.4	-27.5	0	45.23	-	-	74	-28.77	205	193	V
	* 4.8039	28.68	MAv1	34.4	-27.5	2.13	37.71	54	-16.29	-	-	205	193	V
6	* 17.90721	32.65	PK2	40.9	-18.6	0	54.95	-	-	74	-19.05	351	102	V
	* 17.90888	20.87	MAv1	41	-18.5	2.13	45.5	54	-8.5	-	-	351	102	V

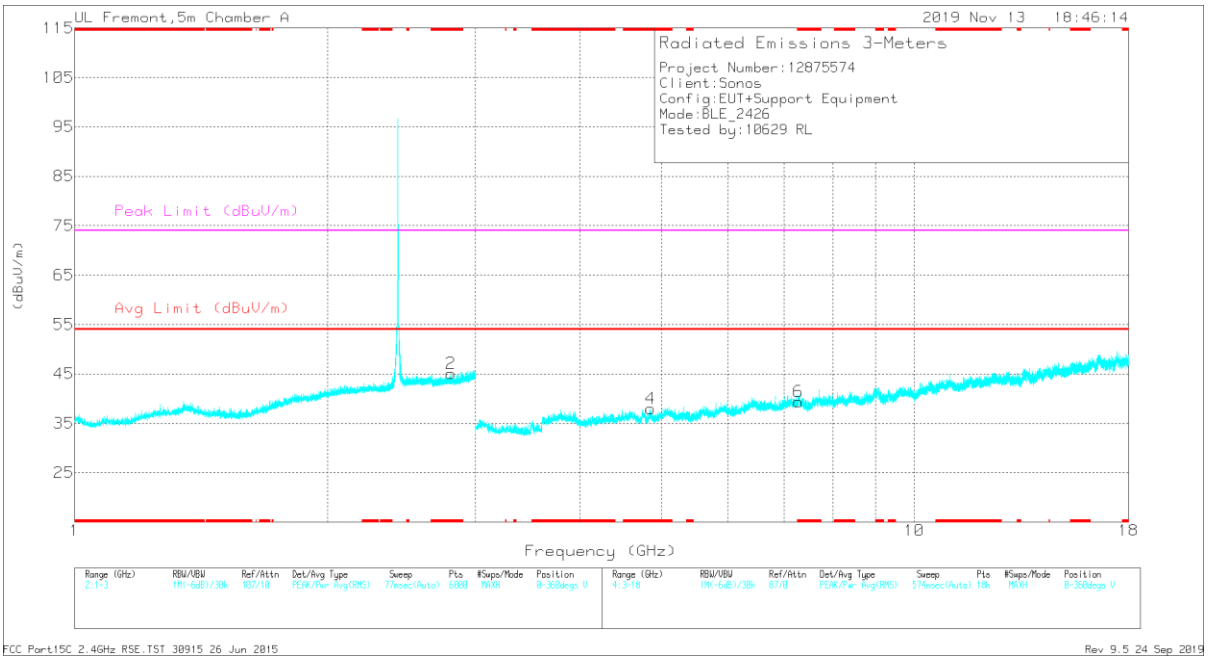
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK2 - KDB558074 Method: Maximum Peak
MAv1 - KDB558074 Option 1 Maximum RMS Average

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

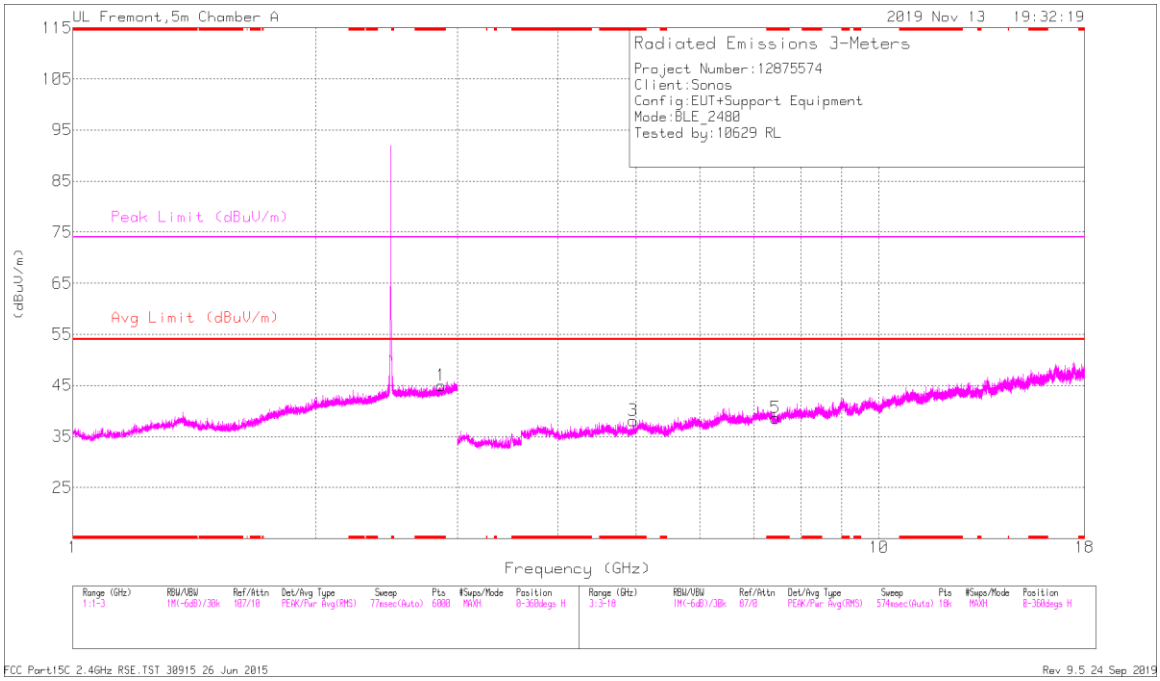
RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (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	* 2.80506	40.44	PK2	32.5	-22.7	0	50.24	-	-	74	-23.76	341	169	H
	* 2.80251	28.74	MAv1	32.6	-22.7	2.13	40.77	54	-13.23	-	-	341	169	H
2	* 2.80595	40.47	PK2	32.6	-22.7	0	50.37	-	-	74	-23.63	187	102	V
	* 2.80451	28.7	MAv1	32.5	-22.7	2.13	40.63	54	-13.37	-	-	187	102	V
3	* 4.85217	40.88	PK2	34.2	-28.2	0	46.88	-	-	74	-27.12	335	178	H
	* 4.85196	31.2	MAv1	34.2	-28.2	2.13	39.33	54	-14.67	-	-	335	178	H
5	* 7.27455	33.98	PK2	35.8	-23.4	0	46.38	-	-	74	-27.62	113	141	H
	* 7.27566	22.46	MAv1	35.8	-23.4	2.13	36.99	54	-17.01	-	-	113	141	H
4	* 4.85205	38.96	PK2	34.2	-28.2	0	44.96	-	-	74	-29.04	207	196	V
	* 4.85193	29.09	MAv1	34.2	-28.2	2.13	37.22	54	-16.78	-	-	207	196	V
6	* 7.27745	34.09	PK2	35.7	-23.4	0	46.39	-	-	74	-27.61	202	175	V
	* 7.27782	22.3	MAv1	35.7	-23.4	2.13	36.73	54	-17.27	-	-	202	175	V

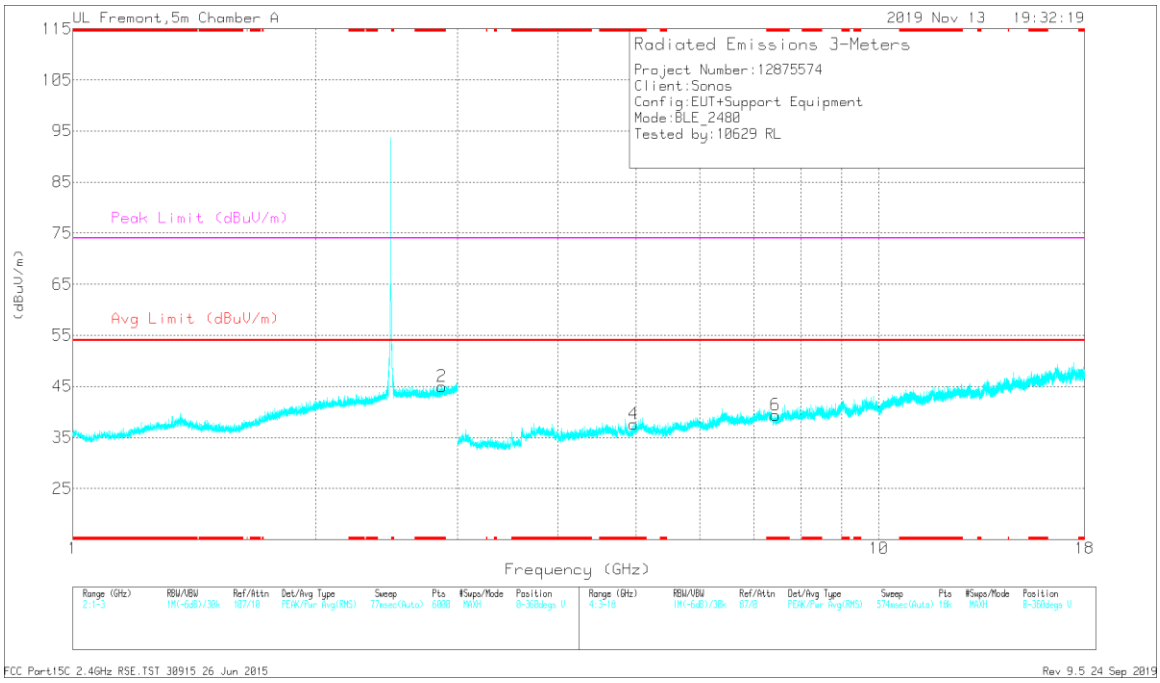
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK2 - KDB558074 Method: Maximum Peak
MAv1 - KDB558074 Option 1 Maximum RMS Average

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

RADIATED EMISSIONS

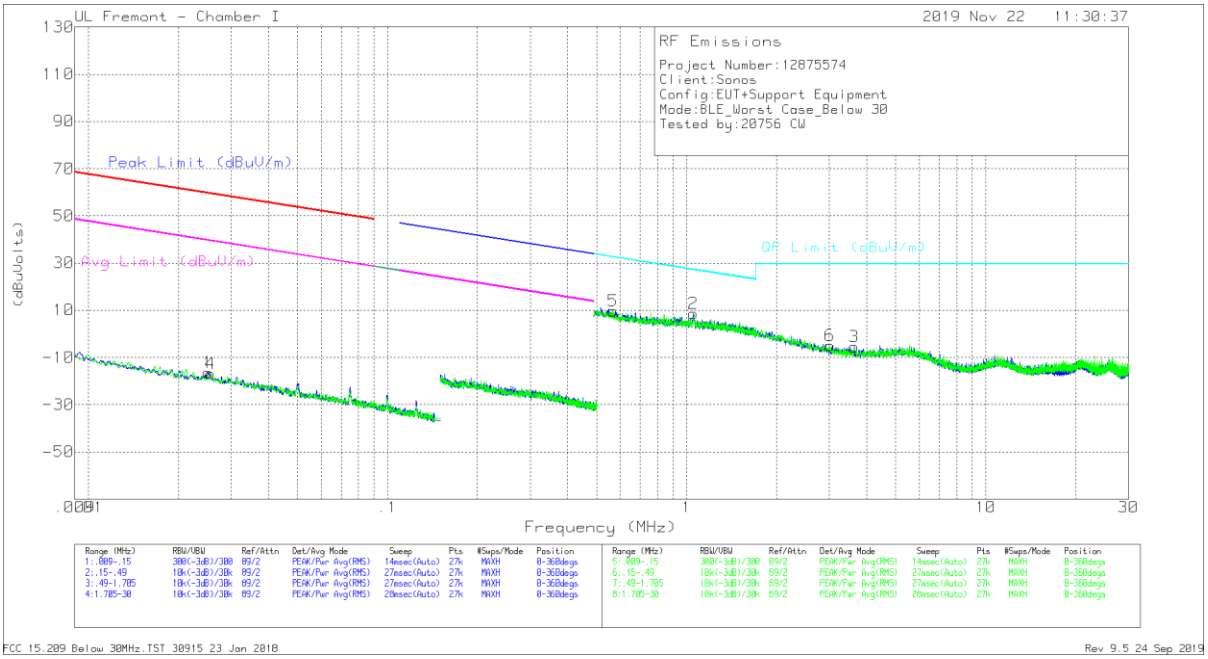
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.86835	40.7	PK2	32.5	-22.3	0	50.9	-	-	74	-23.1	243	205	H
	* 2.86871	28.59	MAv1	32.5	-22.3	2.13	40.92	54	-13.08	-	-	243	205	H
2	* 2.87219	40.4	PK2	32.5	-22.3	0	50.6	-	-	74	-23.4	290	198	V
	* 2.87169	28.57	MAv1	32.5	-22.3	2.13	40.9	54	-13.1	-	-	290	198	V
5	* 7.44723	34.26	PK2	35.7	-24.4	0	45.56	-	-	74	-28.44	65	124	H
	* 7.44567	22.32	MAv1	35.7	-24.4	2.13	35.75	54	-18.25	-	-	65	124	H
3	* 4.95919	39.4	PK2	34.2	-28.5	0	45.1	-	-	74	-28.9	334	180	H
	* 4.96003	29.56	MAv1	34.2	-28.5	2.13	37.39	54	-16.61	-	-	334	180	H
6	* 7.44521	34.02	PK2	35.7	-24.4	0	45.32	-	-	74	-28.68	43	108	V
	* 7.44763	22.31	MAv1	35.7	-24.4	2.13	35.74	54	-18.26	-	-	43	108	V
4	* 4.96077	38.81	PK2	34.2	-28.5	0	44.51	-	-	74	-29.49	206	197	V
	* 4.95981	29.39	MAv1	34.2	-28.5	2.13	37.22	54	-16.78	-	-	206	197	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK2 - KDB558074 Method: Maximum Peak
MAv1 - KDB558074 Option 1 Maximum RMS Average

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.3. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)



ANTENNA- TWO ORIENTATIONS FACE ON/FACE OFF

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cables (dB)	Dist Corr 300m	Corrected Reading (dBuVolts)	Peak Limit (dBuV/m)	Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.02516	48.46	Pk	15.1	0	-80	-16.44	59.57	-76.01	39.57	-56.01	0-360
4	.02559	47.92	Pk	15.1	0	-80	-16.98	59.43	-76.41	39.43	-56.41	0-360

Pk - Peak detector

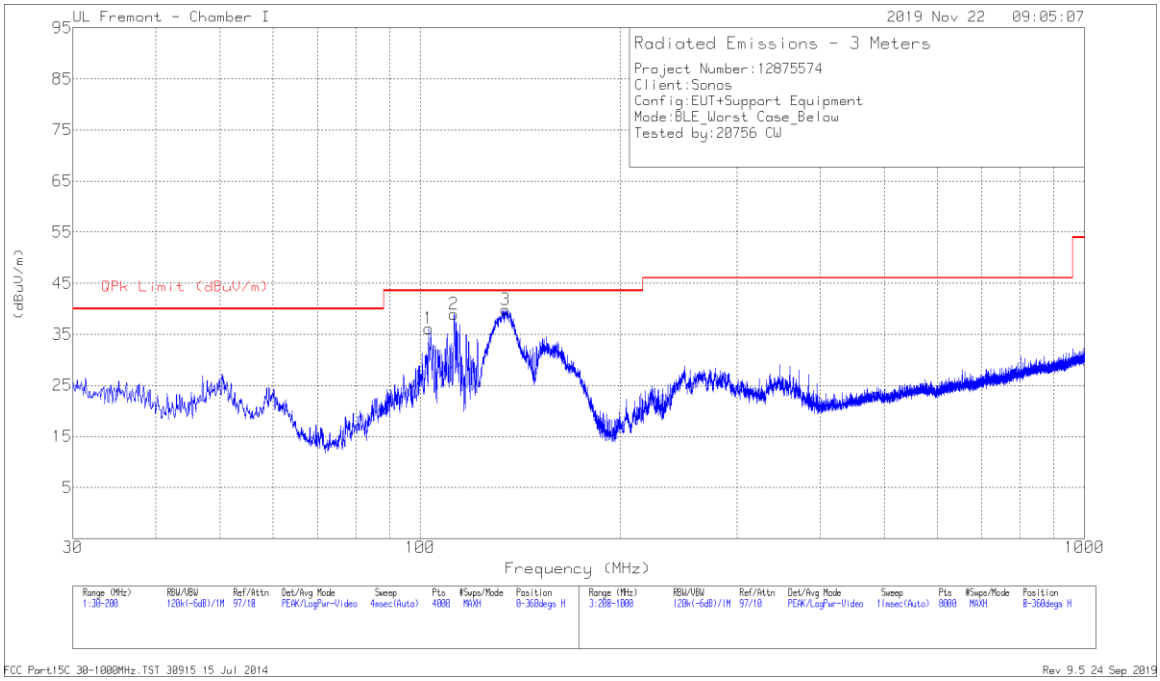
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cables (dB)	Dist Corr 30m (dB) 40Log	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
2	1.05315	34.09	Pk	14.4	.1	-40	8.59	27.17	-18.58	0-360
3	3.63856	19.41	Pk	14.8	.2	-40	-5.59	29.5	-35.09	0-360
5	.56837	35.56	Pk	14.1	.1	-40	9.76	32.51	-22.75	0-360
6	3.00347	20.06	Pk	14.7	.2	-40	-5.04	29.5	-34.54	0-360

Pk - Peak detector

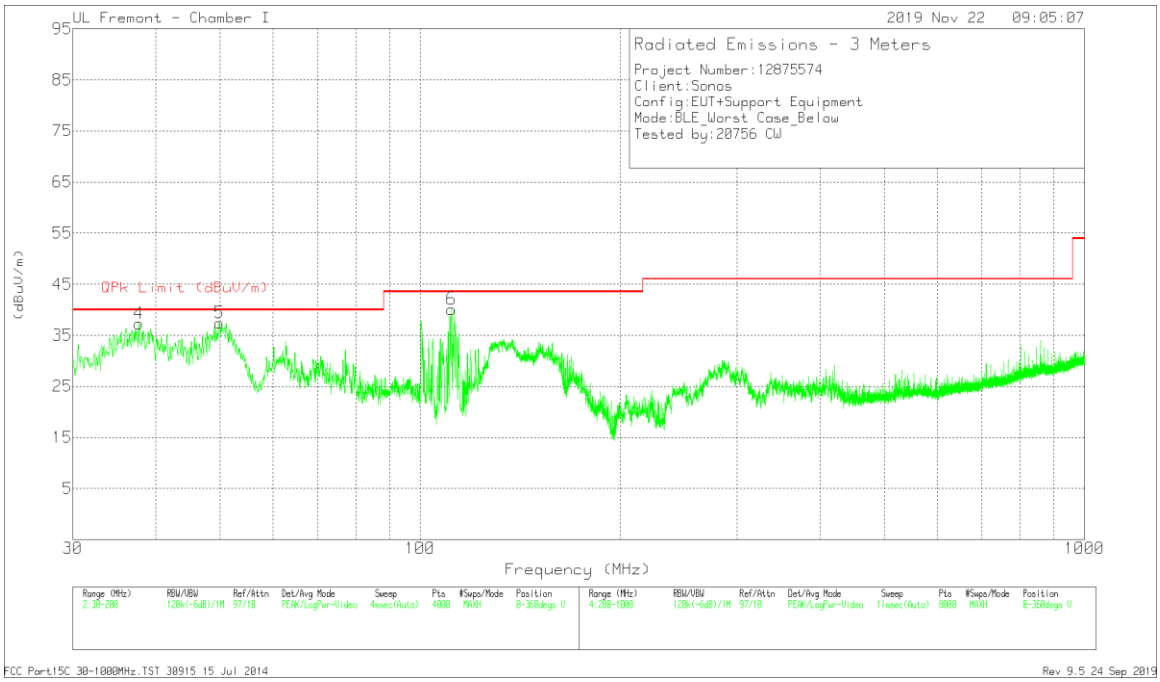
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.4. WORST CASE BELOW 1 GHZ

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



HORIZONTAL



VERTICAL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0184052 (dB/m)	Amp Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	102.9914	50.15	Pk	16.8	-30.8	36.15	43.52	-7.37	0-360	299	H
2	112.4713	50.89	Pk	18.7	-30.7	38.89	43.52	-4.63	0-360	299	H
3	134.3645	51.32	Pk	19.2	-30.7	39.82	43.52	-3.7	0-360	199	H
4	37.737	47.12	Pk	21.5	-31.3	37.32	40	-2.68	0-360	102	V
5	49.8526	54.97	Pk	13.7	-31.3	37.37	40	-2.63	0-360	102	V
6	111.4511	52.23	Pk	18.6	-30.7	40.13	43.52	-3.39	0-360	102	V

Pk - Peak detector

Radiated Emissions

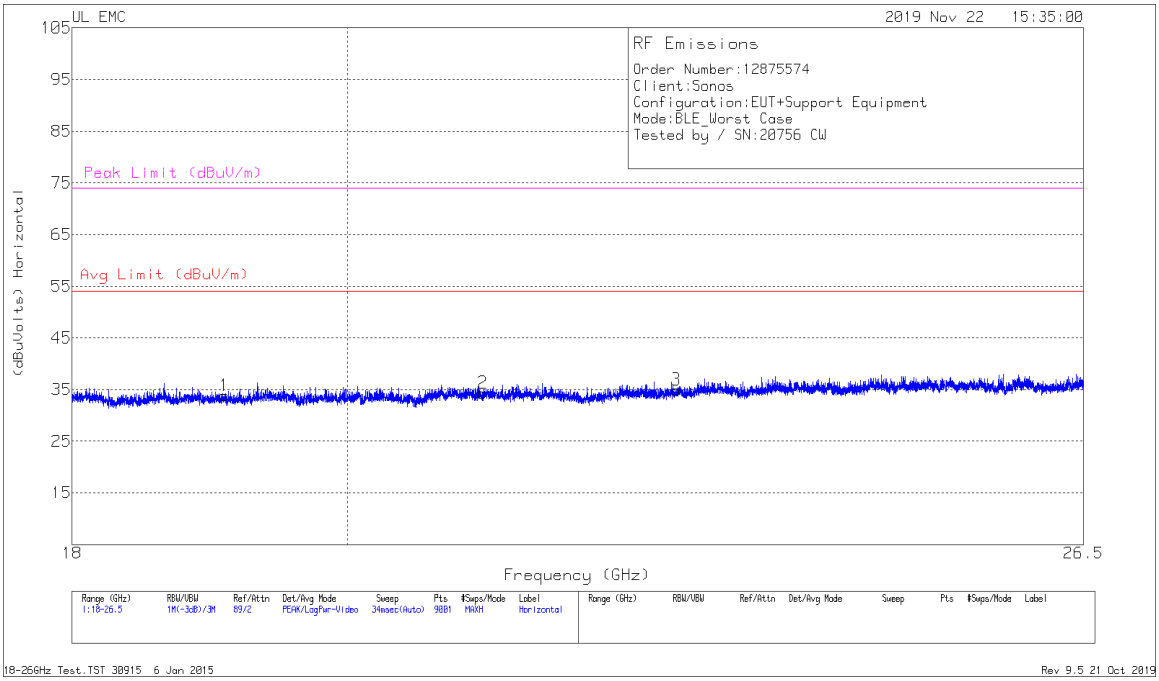
Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0184052 (dB/m)	Amp Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
110.817	38.55	Qp	18.5	-30.8	26.25	43.52	-17.27	358	317	H
132.7465	47.04	Qp	19.3	-30.7	35.64	43.52	-7.88	351	205	H
37.7889	45.57	Qp	21.4	-31.3	35.67	40	-4.33	23	105	V
50.432	52.92	Qp	13.6	-31.3	35.22	40	-4.78	77	103	V
111.6007	33.03	Qp	18.6	-30.7	20.93	43.52	-22.59	350	105	V

Qp - Quasi-Peak detector

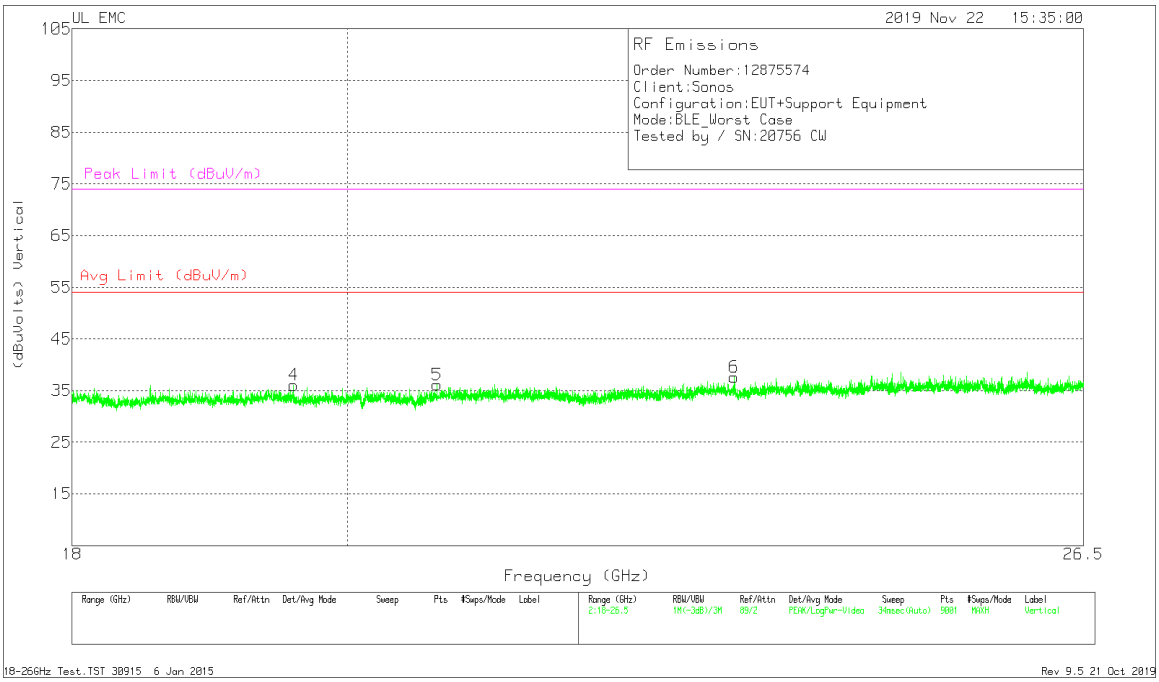
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.5. WORST CASE 18-26 GHZ

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



HORIZONTAL



VERTICAL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	T447 AF (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)
1	19.08044	68.46	Pk	32.6	-57.7	-9.5	33.86	54	-20.14	74	-40.14
2	21.05905	67.63	Pk	33.2	-57	-9.5	34.33	54	-19.67	74	-39.67
3	22.67689	68.54	Pk	33.6	-57.7	-9.5	34.94	54	-19.06	74	-39.06
4	19.59139	69.7	Pk	32.8	-57	-9.5	36	54	-18	74	-38
5	20.69544	69.71	Pk	33.1	-57.2	-9.5	36.11	54	-17.89	74	-37.89
6	23.18594	70.4	Pk	33.8	-57.1	-9.5	37.6	54	-16.4	74	-36.4

Pk - Peak detector

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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

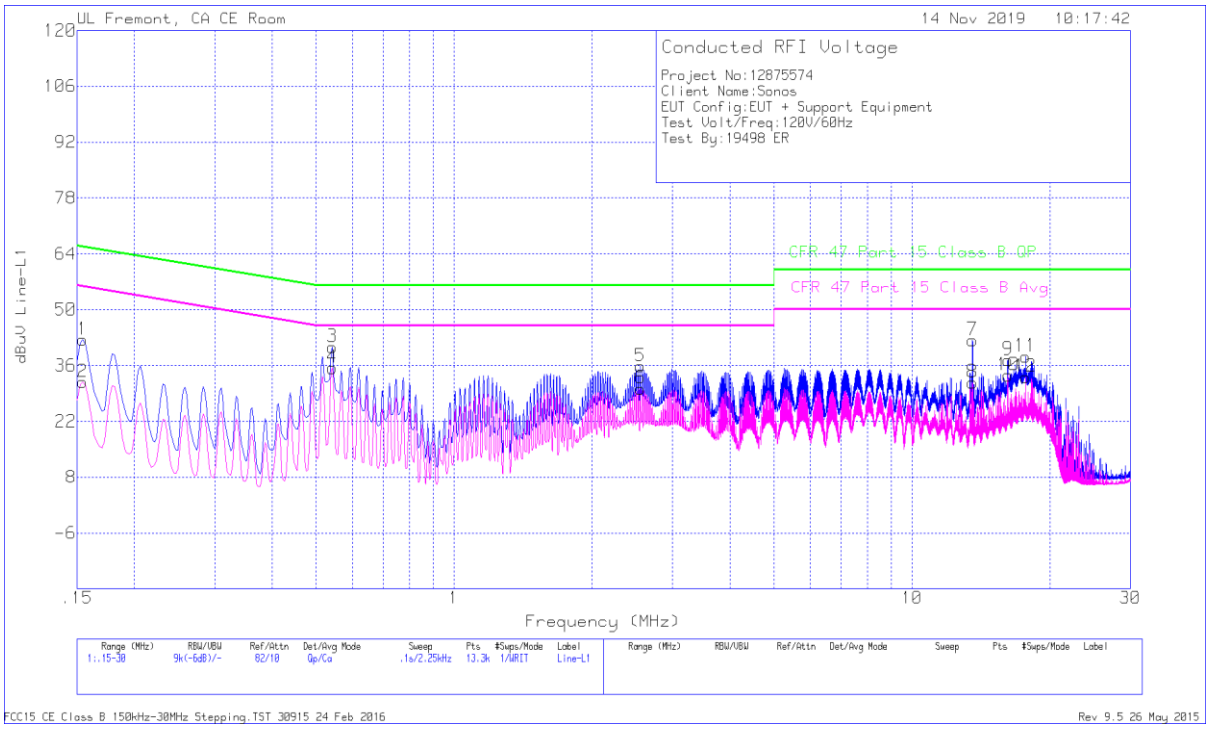
* Decreases with the logarithm of the frequency.

RESULTS

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

AC Power Line Norm

LINE 1 RESULTS



Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
1	.1545	32.24	Qp	.1	0	10.1	42.44	65.75	-23.31	-	-
2	.1545	21.67	Ca	.1	0	10.1	31.87	-	-	55.75	-23.88
3	.5415	30.56	Qp	0	0	10.1	40.66	56	-15.34	-	-
4	.5415	25.32	Ca	0	0	10.1	35.42	-	-	46	-10.58
5	2.55075	25.61	Qp	0	.1	10.1	35.81	56	-20.19	-	-
6	2.55075	20.04	Ca	0	.1	10.1	30.24	-	-	46	-15.76
7	13.56	31.83	Qp	.1	.2	10.2	42.33	60	-17.67	-	-
8	13.56	21.24	Ca	.1	.2	10.2	31.74	-	-	50	-18.26
9	16.2285	26.7	Qp	.1	.3	10.3	37.4	60	-22.6	-	-
10	16.2285	22.83	Ca	.1	.3	10.3	33.53	-	-	50	-16.47
11	17.6932	27.56	Qp	.1	.3	10.3	38.26	60	-21.74	-	-
12	17.6932	22.46	Ca	.1	.3	10.3	33.16	-	-	50	-16.84

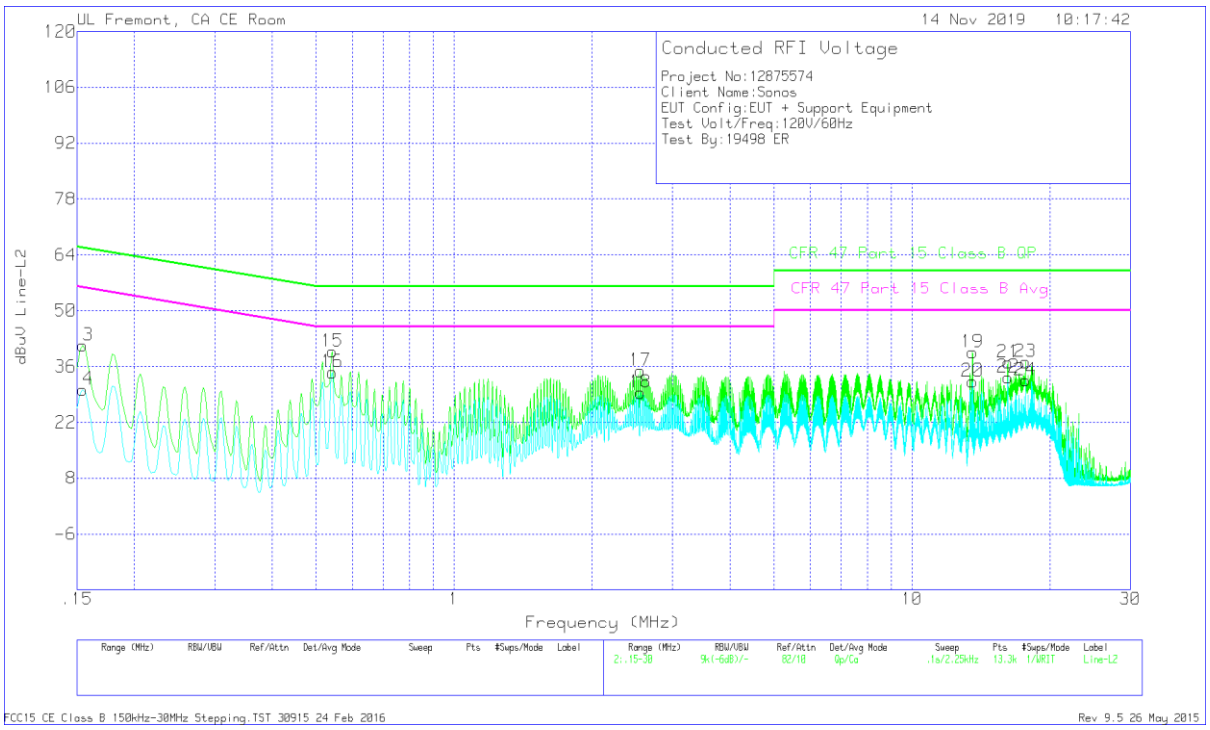
Qp - Quasi-Peak detector

Ca - CISPR average detection

NOTE: Markers 7 and 8, 13.56MHz is an external NFC signal unrelated to the EUT.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
13	.1545	31.08	Qp	.1	0	10.1	41.28	65.75	-24.47	-	-
14	.1545	20.03	Ca	.1	0	10.1	30.23	-	-	55.75	-25.52
15	.5415	29.64	Qp	0	0	10.1	39.74	56	-16.26	-	-
16	.5415	24.44	Ca	0	0	10.1	34.54	-	-	46	-11.46
17	2.55075	24.7	Qp	0	.1	10.1	34.9	56	-21.1	-	-
18	2.55075	19.23	Ca	0	.1	10.1	29.43	-	-	46	-16.57
19	13.56	29.03	Qp	.1	.2	10.2	39.53	60	-20.47	-	-
20	13.56	21.74	Ca	.1	.2	10.2	32.24	-	-	50	-17.76
21	16.2285	26.3	Qp	.1	.3	10.3	37	60	-23	-	-
22	16.2285	22.57	Ca	.1	.3	10.3	33.27	-	-	50	-16.73
23	17.6932	26.43	Qp	.1	.3	10.3	37.13	60	-22.87	-	-
24	17.6932	21.84	Ca	.1	.3	10.3	32.54	-	-	50	-17.46

Qp - Quasi-Peak detector

Ca - CISPR average detection

NOTE: Markers 19 and 20, 13.56MHz is an external NFC signal unrelated to the EUT.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.