CERTIFICATION TEST REPORT

Report Number. : 11974648-E1V5

Applicant	:	ENERGOUS CORPORATION 3590 NORTH FIRST STREET SAN JOSE, CA 95134 USA
Model	:	MS-300
FCC ID	:	2ADNG-MS300
EUT Description	:	Wireless charger
Test Standard(s)	:	FCC 47 CFR PART 18 SUBPART C

Date Of Issue:
DECEMBER 19, 2017

Prepared by:
UL Verification Services Inc.
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NVLAP TESTING
NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	11/7/17	Initial Issue	Dan Coronia
V2	12/1/17	Updated Section 5.6 (added FCC ID of the client device) and 7.1 (added note)	Dan Coronia
V3	12/4/17	Updated Section 5.1 (added statement)	Dan Coronia
V4	12/12/17	Updated Section 5.2 and 5.6, Inserted new Section 7.1	Dan Coronia
V5	12/19/17	Updated Section 5.1 and 5.2	Dave Weaver

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: ENERGOUS CORPORATION
3590 NORTH FIRST STREET
SAN JOSE, CA 95134 USA

EUT DESCRIPTION: Wireless Charger

MODEL: MS-300

SERIAL NUMBER: MS3000-WN003

DATE TESTED: October 17– 20, 2017

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC 47 CFR PART 18 SUBPART C	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For
UL Verification Services Inc. By:

DAN CORONIA
OPERATIONS LEADER
UL VERIFICATION SERVICES INC.

Prepared By:

JASON QIAN
TEST ENGINEER
UL VERIFICATION SERVICES INC.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC / OST MP-5, "FCC Methods of Measurements of Radio Noise Emissions from Industrial, Scientific, and Medical Equipment."

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☐ Chamber A(IC: 2324B-1)	☐ Chamber D(IC: 22541-1)
☐ Chamber B(IC: 2324B-2)	☒ Chamber E(IC: 22541-2)
☐ Chamber C(IC: 2324B-3)	☐ Chamber F(IC: 22541-3)
	☐ Chamber G(IC: 22541-4)
	☐ Chamber H(IC: 22541-5)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313.
UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.
Chambers A through C is covered under Industry Canada company address code 2324B with site numbers 2324B -1 through 2324B-3, respectively. Chambers D through H are covered under Industry Canada company address code 22541 with site numbers 22541 -1 through 22541-5, respectively.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://ts.nist.gov/standards/scopes/2000650.htm.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

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

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	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.24 dB

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

5. EQUIPMENT UNDER TEST

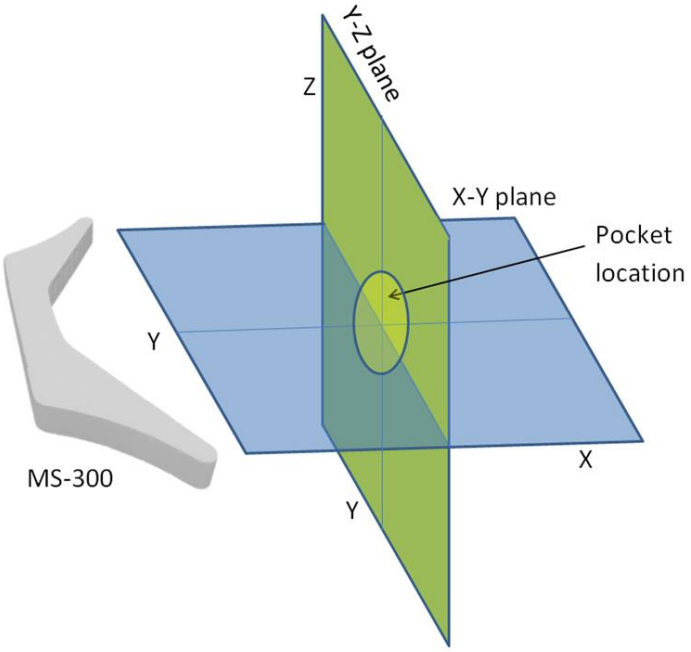
5.1. DESCRIPTION OF EUT

The MS-300 is a wireless power charging system that delivers RF energy to a Client Device seeking to be charged when positioned within the Charging Zone. The Charging Zone of the MS-300 is up to 90 cm for Client Devices placed in front of the MS-300, i.e. Client Devices within 90 cm of the front of the MS-300 may be charged; Client Devices further than 90 cm or outside an angle of ±35° from a centerline projecting from the front of the MS-300 will not be charged.

The MS-300 transfers RF energy at a frequency of 913 MHz. The MS-300 does not transmit information at this frequency. Data communication, for example for the authentication of client devices, is performed through standard 2.4 GHz BLE protocols. The MS-300 will only charge Client Devices that can authenticate.

The MS-300 falls under FCC Part 18.107(c) because it is designed to generate and use RF energy locally to charge domestic consumer electronic devices. The MS-300 transfers RF energy from the front of the transmitter and creates a pocket around the authenticated Client Device that will be charged. The Client Device uses this energy to power itself or charge internal batteries. The MS-300 is intended to be used by the general public in a residential or office environment.

The image below illustrates the RF pocket formed around a Client Device.



The MS-300 has an internal communication system to ensure it is working as designed. Once the MS-300 begins transferring RF energy to an authenticated Client Device, the communication system continues to monitor and track through proprietary fail-safes to ensure proper operation. If any single fail-safe is triggered, the RF transmission from the MS-300 is immediately shut down.

The MS-300 has five fail-safe features:

1) Self-check procedure to ensure proper operation of the motion detection sensors.
2) Self-check procedure to ensure no motion is detected in the Keep-Out Zone.
3) Self-check procedure to ensure proper operation of the BLE.
4) Self-check procedure to ensure proper operation of the MS-300 system.
5) Self-check procedure to determine if the Client Device is in the Charging Zone.

The Keep-Out Zone, is a zone within 50cm of the front of the transmitter where charging is suspended when motion is detected. This zone is established to provide an additional margin of RF safety. The MS-300 motion detection sensors are designed to detect all types of motion including breathing. The sensors are not designed to detect an inanimate object. Once motion is detected in the Keep-Out Zone, a timer in the MS-300 system will hold the transmitter in an off-state for 30 seconds. Any subsequent motion detected will hold the transmitter in an off-state and restart the timer.

The MS-300 will determine if the Client Device is located in the Charging Zone and oriented adequately to receive power. This determination is made by comparing the power received by the Client Device as reported via the BLE link between the Client Device and the MS-300. The reported power must be 30mW or more before the MS-300 will enable energy transfer to the Client Device. The optimum orientation for maximum power transfer is with the Client Device's antenna facing directly towards the MS-300. The receive power decreases as the Client Device orientates toward the edges or back. If the MS-300 determines that the Client Device is not oriented adequately, then power transfer will not occur. Edge and back orientations are below the 30mW threshold and the MS-300 will not enable energy transfer in these configurations. Therefore, these orientations are not applicable for compliance testing.

Ultimately, the Client Device can be charged at any point within the Charging Zone if three conditions are met; all self-checks passed, the device is determined to be positioned in the Charging Zone, and the device is receiving sufficient power to charge.

This report covers the ISM portion of the EUT.

5.2. OPERATING FREQUENCY AND OUTPUT POWER

The EUT operates at 913 MHz.

The maximum total rated conducted power is 40.2 dBm.

5.3. SOFTWARE AND FIRMWARE

The software installed in the EUT during testing was 3.0.17.57.

5.4. CONFIGURATIONS INVESTIGATED

Configuration	Description
Charging Mode	The EUT was configured to charge a client device.

5.5. MODIFICATIONS

No modifications were made during testing.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
AC/DC Adapter	Delta Elect. Inc.	MDS-090AAS15 B	861W321001P	N/A
Client Device	Energous	MS-RX300	DD0372062007	Proposed: 2ADNG-MS300a

NOTE: At the time of issue the client device was still undergoing certification.

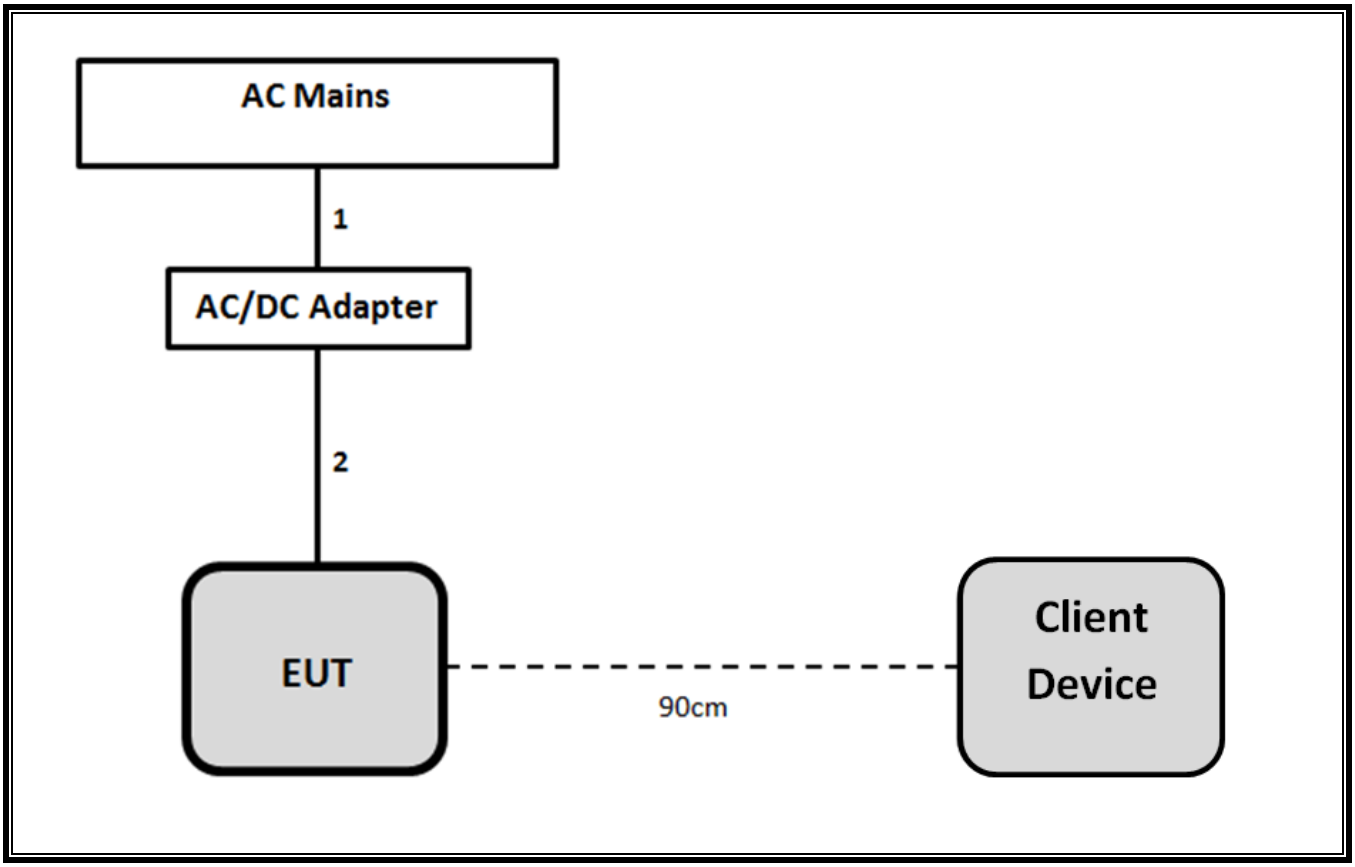
I/O CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC Power	1	3-Prong	Unshielded	1	N/A
2	DC	1	4 pin Din	Unshielded	1.2	N/A

TEST SETUP

The EUT is connected to AC Mains utility power. The client device is charged by the EUT. The distance between the EUT and the client device is 90cm. Test software exercised the EUT.

SETUP DIAGRAM



6. TEST AND MEASUREMENT EQUIPMENT

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

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Asset**	**Cal Due**
Antenna, Broadband Hybrid, 30MHz to 2000MHz	SUNOL SCIENCES	JB3	T900	05/31/2018
Antenna, Active Loop 9kHz-30MHz	ETS-LINDGREN	6502	T1683	02/17/2018
Antenna, Horn 1-18GHz	ETS-LINDGREN	3117	T346	03/28/2018
Amplifier, 1 to 18 GHz	MITEQ	AMF-4D-01000800-25-S-42	T741	11/29/2017
Amplifier, 30MHz – 1GHz, 32dB	SONOMA	310N	T285	06/24/2018
High Pass Filter, 1GHz	MICRO-TRONICS	HPM50114	T1852	07/16/2018
Band Reject Filter, 902 - 928MHz	MICRO-TRONICS	BRC50722	T1846	07/15/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent	N9030A	T906	02/14/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent	N9030A	T907	01/23/2018
LISN	FISCHER	FCC-LISN-50/250-25-2-01	T1310	06/15/2018
EMI Receiver	Rohde & Schwarz	ESR-EMI	T1436	01/06/2018

Test Software List			
Description	**Manufacturer**	**Model**	**Version**
Radiated Software	UL	UL EMC	Ver 9.5, Apr 26, 2016
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015

7. APPLICABLE LIMITS AND TEST RESULTS

7.1. WORST-CASE CLIENT LOCATION

Preliminary scans were performed with the client device located at combinations of the following positions within the charging zone of the EUT:

- Distance: up to 90 cm from the intersection of the central line normal to the EUT and the surface of the EUT (minimum distance 10 cm)
- Azimuth: 0° and 30° relative to the central line normal to the EUT
- Elevation: 0°, and ±45° relative to the central line normal to the EUT

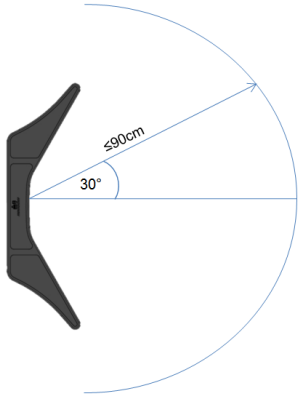


Illustration of Distance and Azimuth

The highest measured emissions were found with the client device located at Distance = 90 cm, Azimuth = 0º and Elevation = 0º. All final radiated emissions testing were performed using this worst-case location.

7.2. RADIATED EMISSIONS

LIMIT

§18.301 Operating frequencies

The EUT operates at 913 MHz.

§18.305 Field Strength Limits

§18.305 (b) The field strength levels of emissions which lie outside the bands specified in §18.301, unless otherwise indicated, shall not exceed the following:

Equipment	Operating frequency	RF Power generated by equipment (watts)	Field strength limit (uV/m)	Distance (meters)
Any type unless otherwise specified (miscellaneous)	Any ISM frequency	Below 500 500 or more	25 25×SQRT (power/500)	300 [1]300

[1]Field strength may not exceed 10μV/m at 1600 meters. Consumer equipment operating below 1000 MHz is not permitted the increase in field strength otherwise permitted here for power over 500 watts.

The RF Power generated by the equipment is below 500 W therefore the field strength limit is 25uV/m at 300 m.

TEST PROCEDURE

FCC / OST MP-5

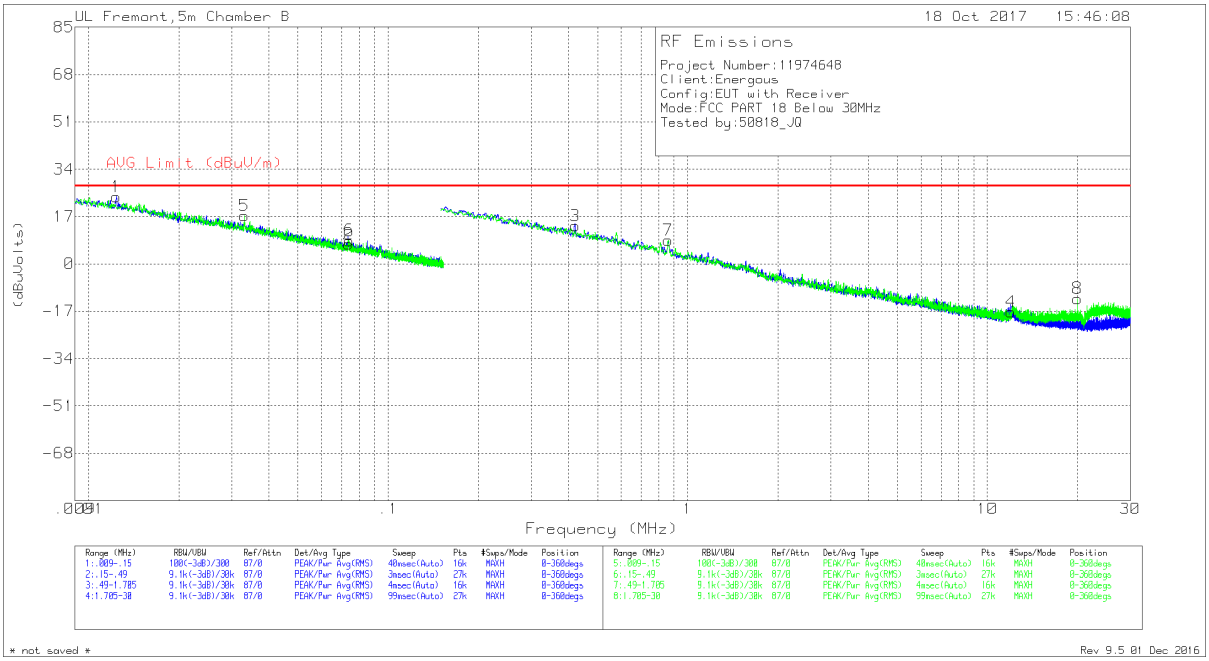
The frequency range was investigated from 9 kHz to 10 GHz.

RESULTS

No non-compliance noted:

7.2.1. SPURIOUS EMISSIONS 9 kHz - 30 MHz

HORIZONTAL & VERTICAL



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

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	AVG Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.01238	44.25	Pk	18.5	1.4	-40	24.15	28	-3.85	0-360
5	.03309	41.82	Pk	14	1.4	-40	17.22	28	-10.78	0-360
2	.07372	33.9	Pk	11.9	1.4	-40	7.2	28	-20.8	0-360
6	.07414	35.06	Pk	11.9	1.4	-40	8.36	28	-19.64	0-360
3	.42093	40.66	Pk	11.5	1.5	-40	13.66	28	-14.34	0-360
7	.8602	35.5	Pk	11.5	1.5	-40	8.5	28	-19.5	0-360
4	11.98902	10.62	Pk	10.6	1.6	-40	-17.18	28	-45.18	0-360
8	19.99889	16.28	Pk	9.7	1.6	-40	-12.42	28	-40.42	0-360

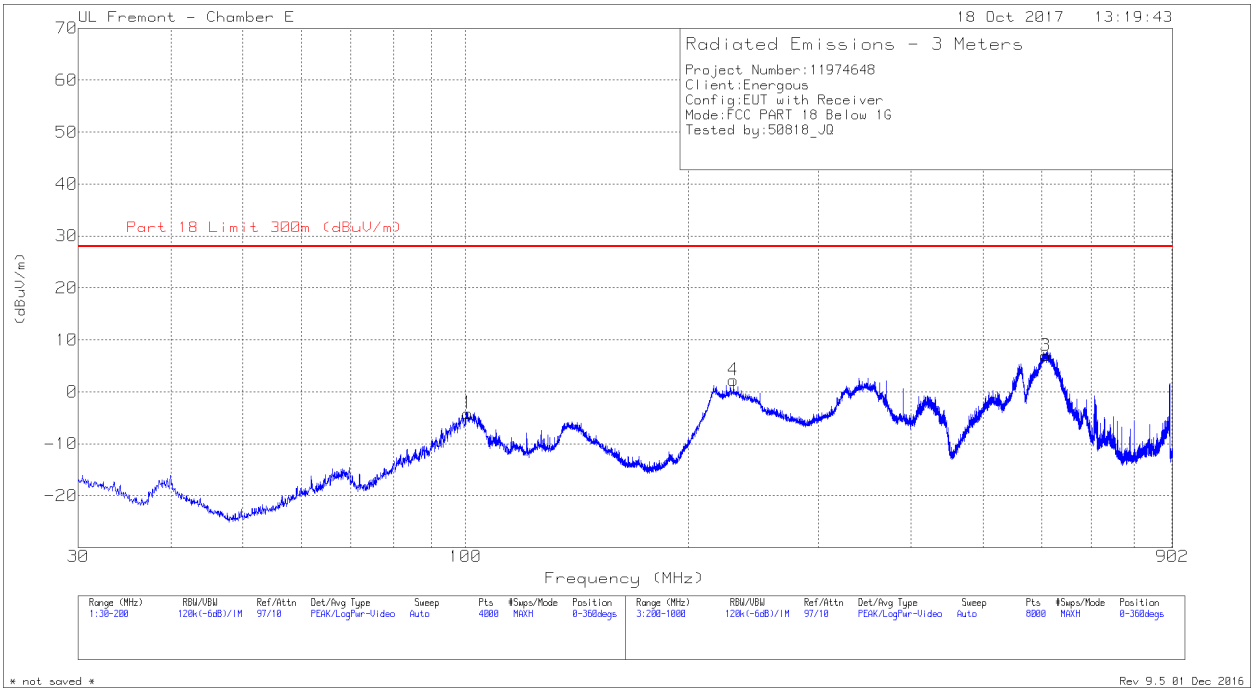
Pk - Peak detector

Note: Distance factor from 3m to 300m = 20log (3/300) = -40dB

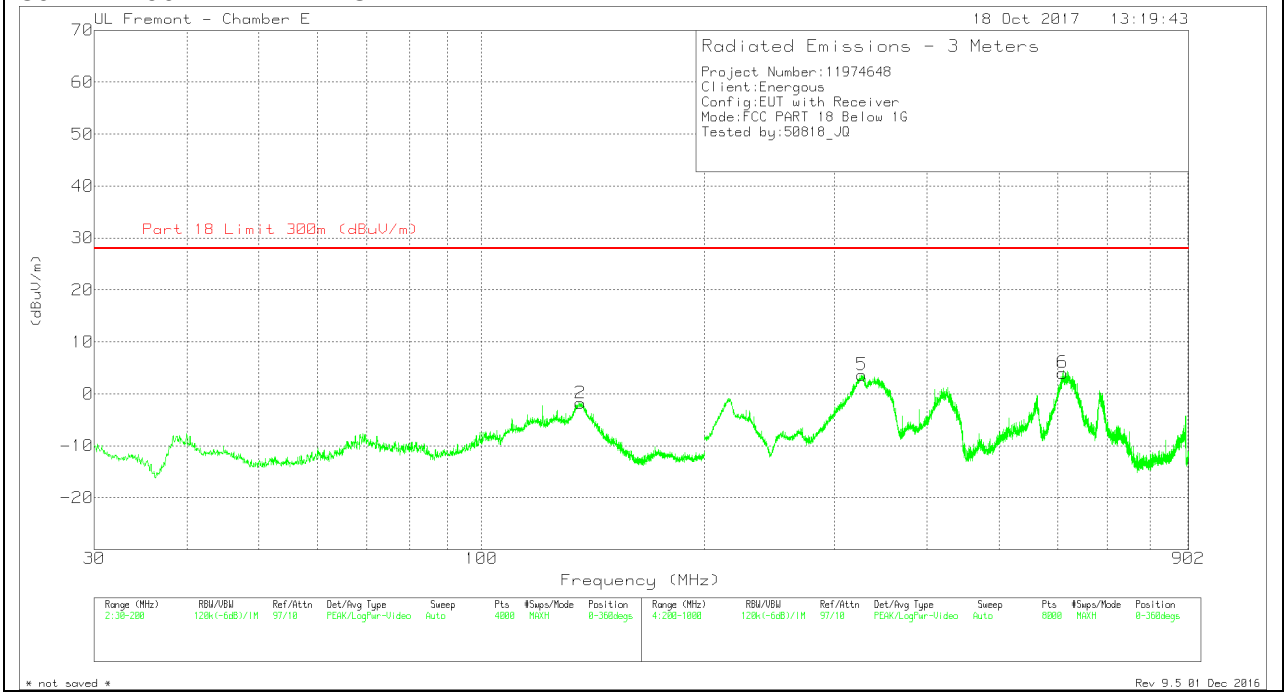
7.2.2. SPURIOUS EMISSIONS 30 - 1000 MHz

Spurious Emissions 30 – 1000 MHz With A Notch Filter

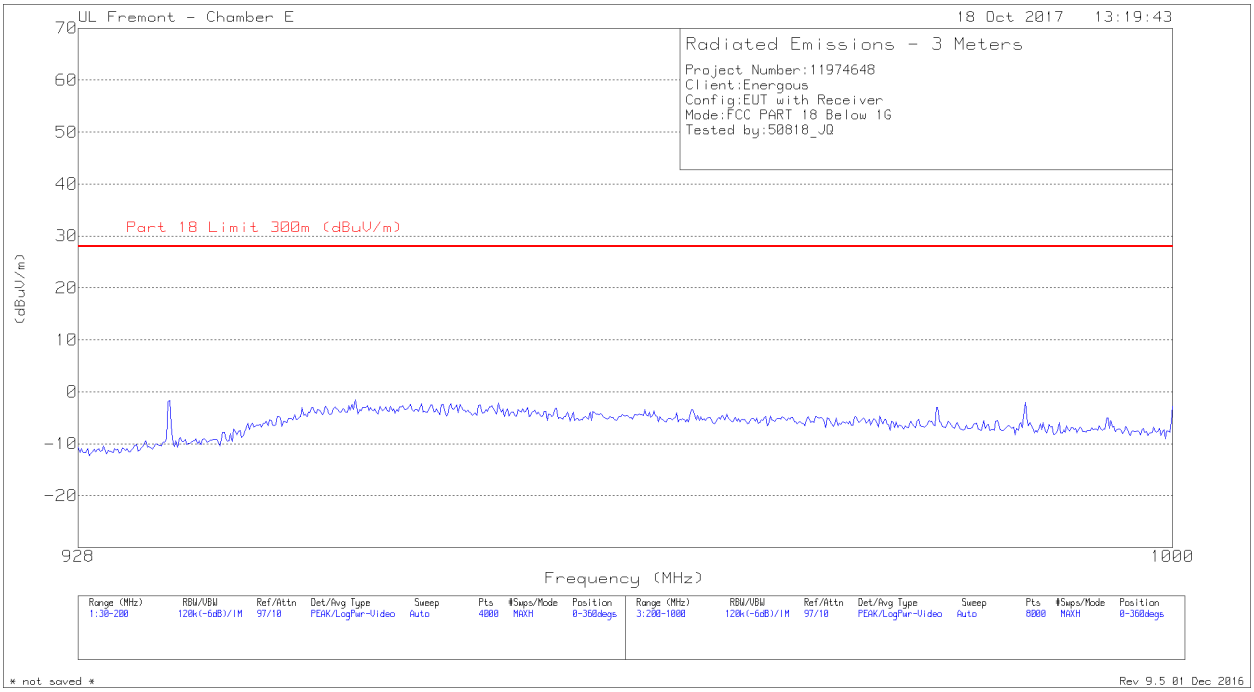
30MHz – 902MHz HORIZONTAL



30MHz – 902MHz VERTICAL



928MHz – 1000MHz HORIZONTAL



928MHz – 1000MHz VERTICAL

Trace Markers

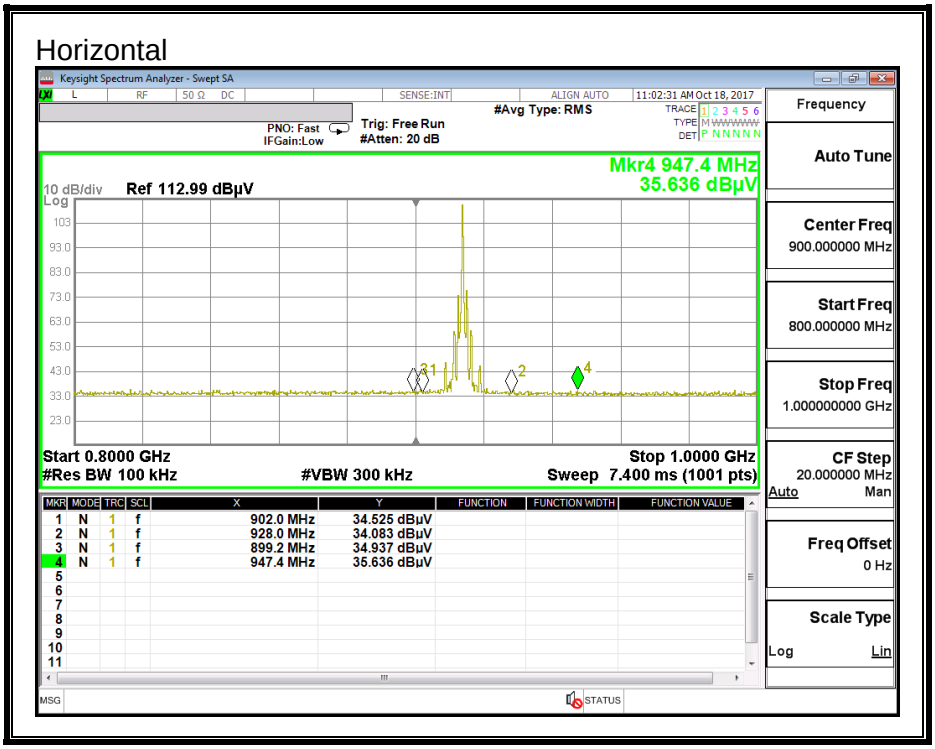
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T900 (dB/m)	Amp/Cbl (dB)	Filter Loss (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	100.8233	52.78	Pk	13.9	-30.8	0.15	-40	-3.97	28	-31.97	0-360	199	H
2	136.0649	51.5	Pk	17.2	-30.5	0.21	-40	-1.59	28	-29.59	0-360	100	V
4	230.0039	57.57	Pk	14.5	-29.8	0.16	-40	2.43	28	-25.57	0-360	100	H
5	326.6165	55.46	Pk	17.3	-29.1	0.19	-40	3.85	28	-24.15	0-360	100	V
3	608.2531	52.41	Pk	22.4	-27.8	0.31	-40	7.32	28	-20.68	0-360	100	H
6	609.6532	49.36	Pk	22.4	-27.7	0.31	-40	4.37	28	-23.63	0-360	100	V

Pk - Peak detector

Note: Distance factor from 3m to 300m = 20log (3/300) = -40dB

Spurious Emissions 800 – 1000 MHz Without A Notch Filter

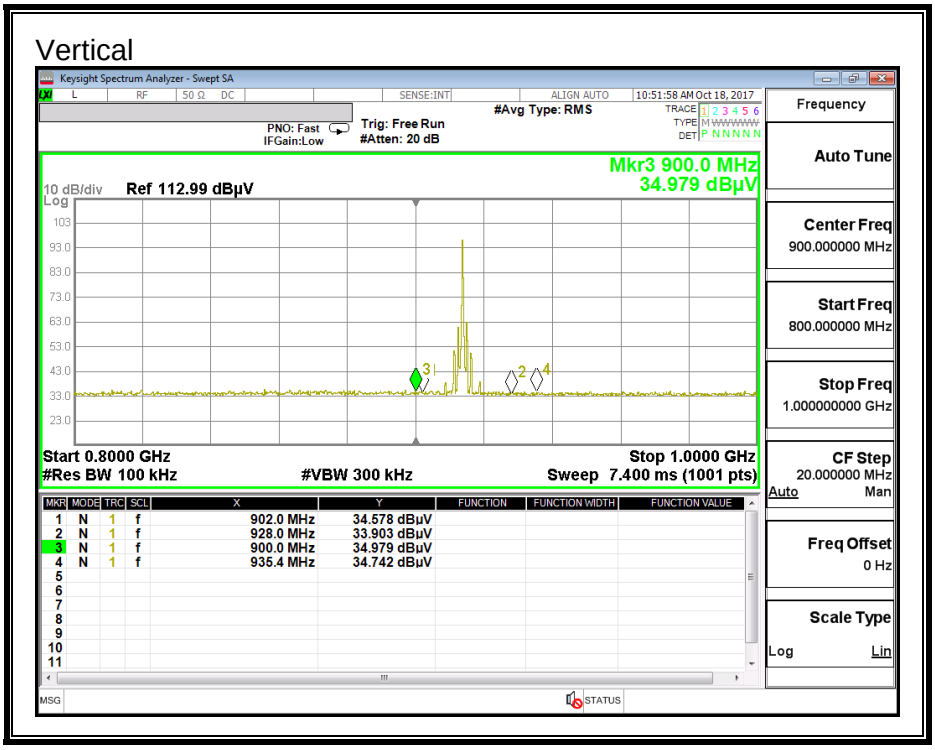
Horizontal



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T900 (dB/m)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	899.2	34.937	Pk	25.79	-40	20.727	28	-7.273	200	120	H
4	947.4	35.636	Pk	26.87	-40	22.506	28	-5.494	200	120	H

Note: Distance factor from 3m to 300m = 20log (3/300) = -40dB

Vertical

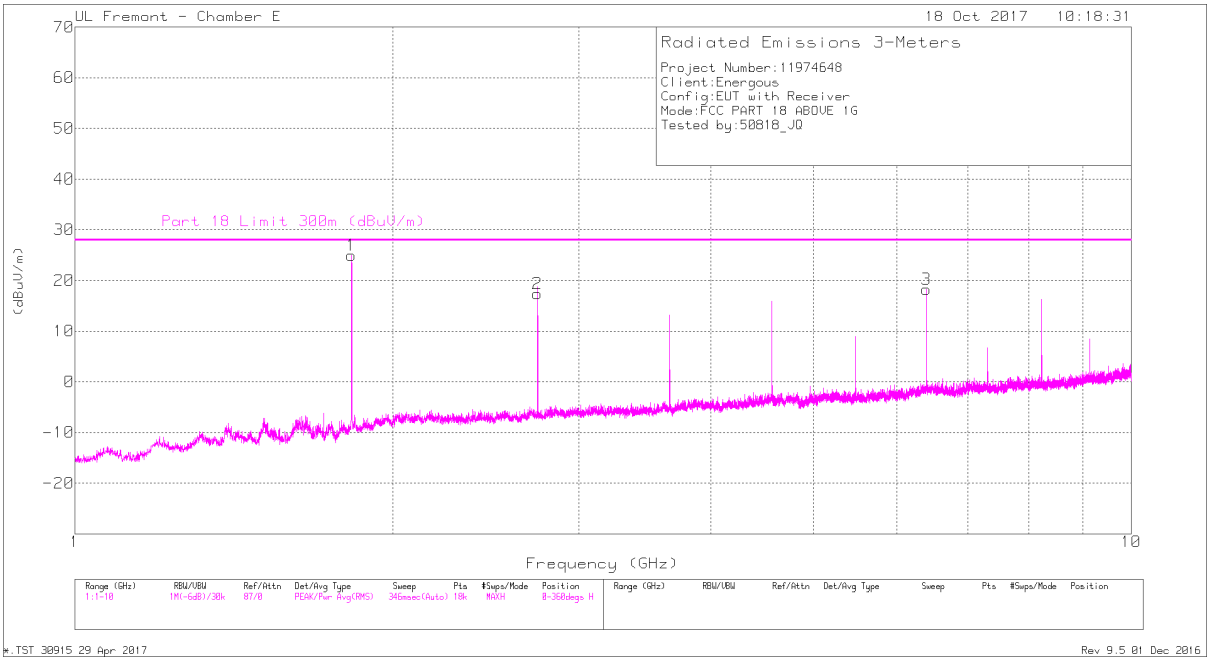


Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T900 (dB/m)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	900	34.979	Pk	25.79	-40	20.769	28	-7.231	215	135	V
4	935.4	34.742	Pk	26.51	-40	21.252	28	-6.748	215	135	V

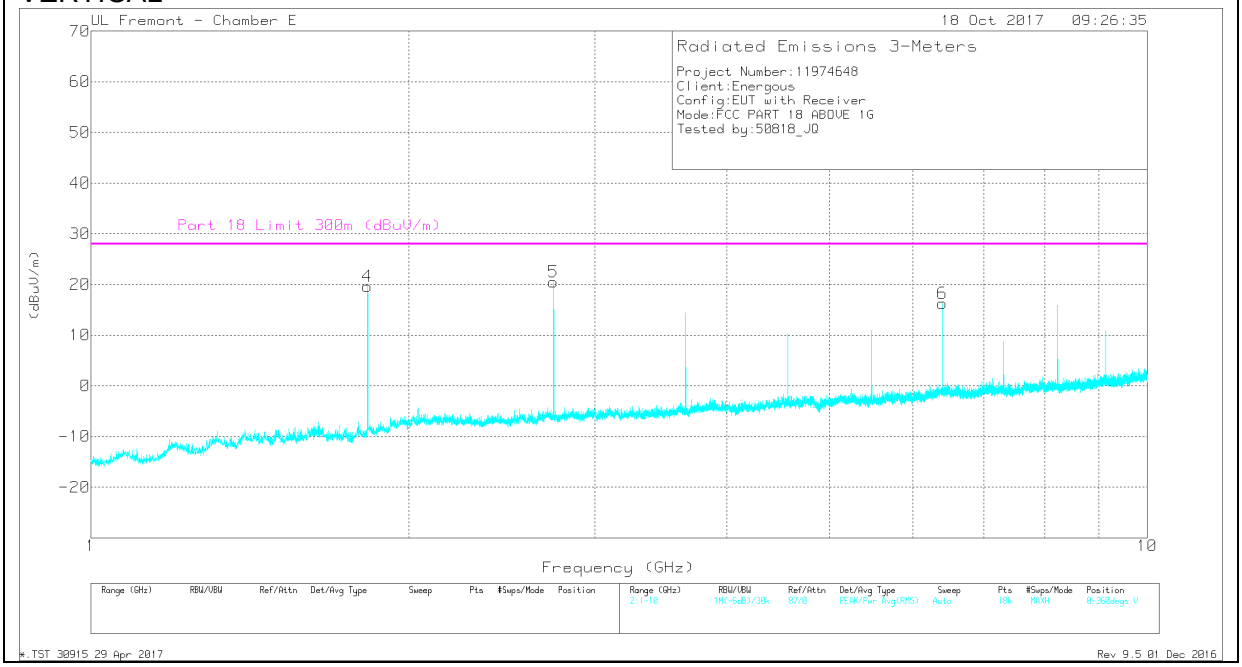
Note: Distance factor from 3m to 300m = 20log (3/300) = -40dB

7.2.3. SPURIOUS EMISSIONS 1 - 10 GHz

HORIZONTAL



VERTICAL



Trace Markers

Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Fltr (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2.741	59.93	MAv1	32.5	-32	0.38	-40	20.81	28	-7.19	86	240	H
2.741	53.81	MAv1	32.5	-32	0.38	-40	14.69	28	-13.31	299	170	V
1.828	65.22	MAv1	29.9	-33.7	0.48	-40	21.9	28	-6.1	158	117	H
1.828	66.16	MAv1	29.9	-33.7	0.48	-40	22.84	28	-5.16	214	149	V
6.396	50.08	MAv1	36.2	-28.9	0.4	-40	17.78	28	-10.22	344	115	H
6.396	46.71	MAv1	36.2	-28.9	0.4	-40	14.41	28	-13.59	312	104	V

MAv1 - KDB558074 Option 1 Maximum RMS Average

Note:
For pre-scans 1 – 10 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 average measurements where the values are represented in the Radiated Emissions table.

Distance factor from 3m to 300m = 20log (3/300) = -40dB

7.3. AC MAINS LINE CONDUCTED EMISSIONS

LIMIT

§ 18.307 For the following equipment, when designed to be connected to the public utility (AC) power line the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies shall not exceed the limits in the following table. Compliance with the provisions of this paragraph shall be based on the measurements of the radio frequency voltage between each power line and ground at the power terminal using a 50 µH/50 ohms line impedance stabilization network (LISN).

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§ 18.307 (b) All other Part 18 consumer devices:

Frequency range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50
* Decreases with the logarithm of the frequency.		

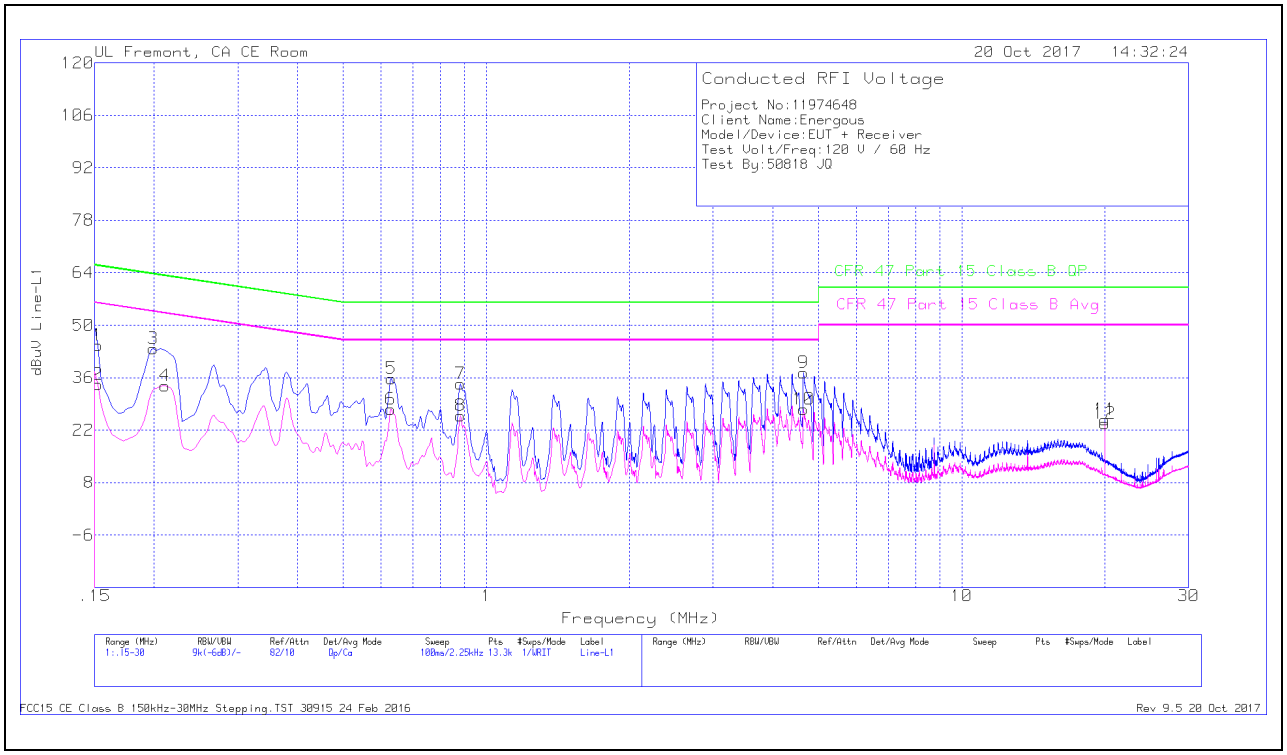
TEST PROCEDURE

FCC / OST MP-5

RESULTS

No non-compliance noted:

LINE 1 PLOT



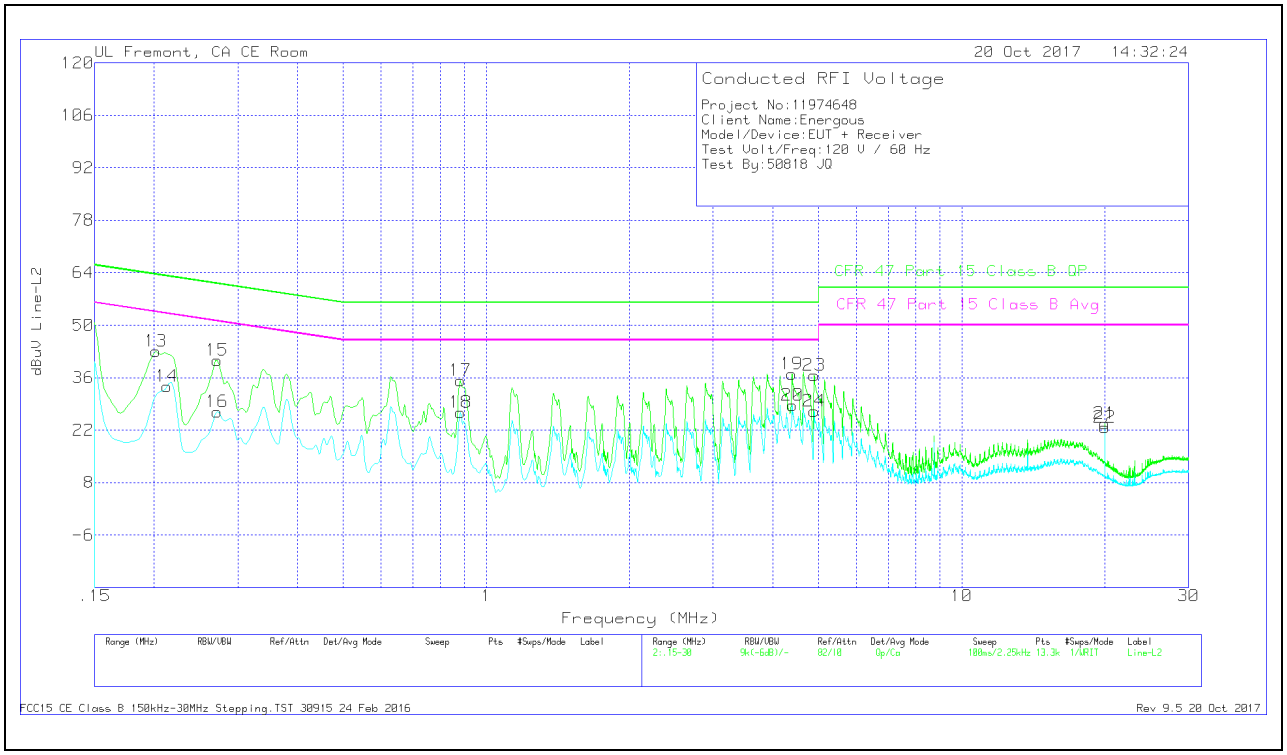
LINE 1 RESULTS

Trace Markers

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	.15225	34.38	Qp	.1	0	10.1	44.58	65.88	-21.3	-	-
2	.15225	23.98	Ca	.1	0	10.1	34.18	-	-	55.88	-21.7
3	.1995	33.72	Qp	0	0	10.1	43.82	63.63	-19.81	-	-
4	.21075	23.78	Ca	0	0	10.1	33.88	-	-	53.18	-19.3
5	.6315	25.63	Qp	0	0	10.1	35.73	56	-20.27	-	-
6	.62925	17.54	Ca	0	0	10.1	27.64	-	-	46	-18.36
7	.88125	24.26	Qp	0	0	10.1	34.36	56	-21.64	-	-
8	.8835	15.67	Ca	0	0	10.1	25.77	-	-	46	-20.23
9	4.64775	27.01	Qp	0	.1	10.2	37.31	56	-18.69	-	-
10	4.64775	17.26	Ca	0	.1	10.2	27.56	-	-	46	-18.44
11	19.9995	14.06	Qp	.1	.3	10.3	24.76	60	-35.24	-	-
12	19.9995	13.09	Ca	.1	.3	10.3	23.79	-	-	50	-26.21

Qp - Quasi-Peak detector
Ca - CISPR average detection

LINE 2 PLOT



LINE 2 RESULTS

Trace Markers

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	.20175	32.88	Qp	0	0	10.1	42.98	63.54	-20.56	-	-
14	.213	23.63	Ca	0	0	10.1	33.73	-	-	53.09	-19.36
15	.2715	30.54	Qp	0	0	10.1	40.64	61.07	-20.43	-	-
16	.2715	16.77	Ca	0	0	10.1	26.87	-	-	51.07	-24.2
17	.88125	25.15	Qp	0	0	10.1	35.25	56	-20.75	-	-
18	.8835	16.56	Ca	0	0	10.1	26.66	-	-	46	-19.34
19	4.39575	26.7	Qp	0	.1	10.2	37	56	-19	-	-
20	4.398	18.37	Ca	0	.1	10.2	28.67	-	-	46	-17.33
21	19.9995	13.13	Qp	0	.3	10.3	23.73	60	-36.27	-	-
22	19.9995	12.09	Ca	0	.3	10.3	22.69	-	-	50	-27.31
23	4.89525	26.3	Qp	0	.1	10.2	36.6	56	-19.4	-	-
24	4.89525	16.79	Ca	0	.1	10.2	27.09	-	-	46	-18.91

Qp - Quasi-Peak detector
Ca - CISPR average detection