CERTIFICATION TEST REPORT

Report Number. : 12150954-E2V4

Applicant	:	ENERGOUS CORPORATION 3590 NORTH FIRST STREET SAN JOSE, CA 95134 U.S.A.
Model	:	NF-230
FCC ID	:	2ADNG-NF230
EUT Description	:	WIRELESS CHARGER
Test Standard(s)	:	FCC 47 CFR PART 18 SUBPART C

Date Of Issue:
March 30, 2018

Prepared by:
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	3/6/2018	Initial Issue	--
V2	3/13/2018	Updated Section 5.2 & 5.4 to address TCB's question	Tina Chu
V3	3/14/2018	Updated Page 8, Section 5.2 statement	Sol Kuwatani
V4	3/30/2018	Added statement on Section 7.1.2	Tina Chu

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: ENERGOUS CORPORATION
3590 NORTH FIRST STREET
SAN JOSE, CA 95134 U.S.A.

EUT DESCRIPTION: WIRELESS CHARGER

MODEL NUMBER: NF-230

SERIAL NUMBER: DD0172114010

DATE TESTED: FEBRUARY 22, 2018 – MARCH 05, 2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC 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 U.S. government.

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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. 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
Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Radiated Disturbance,1000 to 18000 MHz	4.32 dB
Radiated Disturbance,18000 to 26000 MHz	4.45 dB
Radiated Disturbance,26000 to 40000 MHz	5.24 dB
Occupied Channel Bandwidth	±0.39 %

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

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a single client RF near-field, contact charger that operates when a receiving device is placed on the charger pad's surface. The charger pad uses BLE to pair with the receiving device, and transmits a continuous carrier wave signal at 918 MHz frequency.

5.2. OPERATING FREQUENCY AND POWER

The EUT operates at 918 MHz.

The highest maximum measured conducted power is 28.8dBm for Antenna 1.

Band (MHz)	Mode	Freq. (MHz)	Antenna	Max. Meas. Avg Pwr (dBm)
				918 MHz
918	CW	918	1	28.8
			2	28.7

5.3. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was 3.0.1.64.
The software installed in the EUT during testing was WattUp app Version 3.1.13.

5.4. CONFIGURATION AND INVESTIGATED

The EUT supports two WPT antennas. The antennas are identical but placed at right angles to each other. Only one of the antennas is active at a time depending upon the position of the client device on the DUT. Investigation was performed on both antennas, it was determined that antenna 1 was worst-case; thus, fall final testing was performed on antenna 1.

Configuration	Description
Charging mode	EUT is powered by AC/DC adapter via USB cable and a receiving device is placed on the surface of the EUT and receives 918 MHz RF energy from EUT

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
Receiver	Energous	N/A	Key71	N/A
AC/DC Adapter	CUI INC	SMI10-S	3517HB	N/A

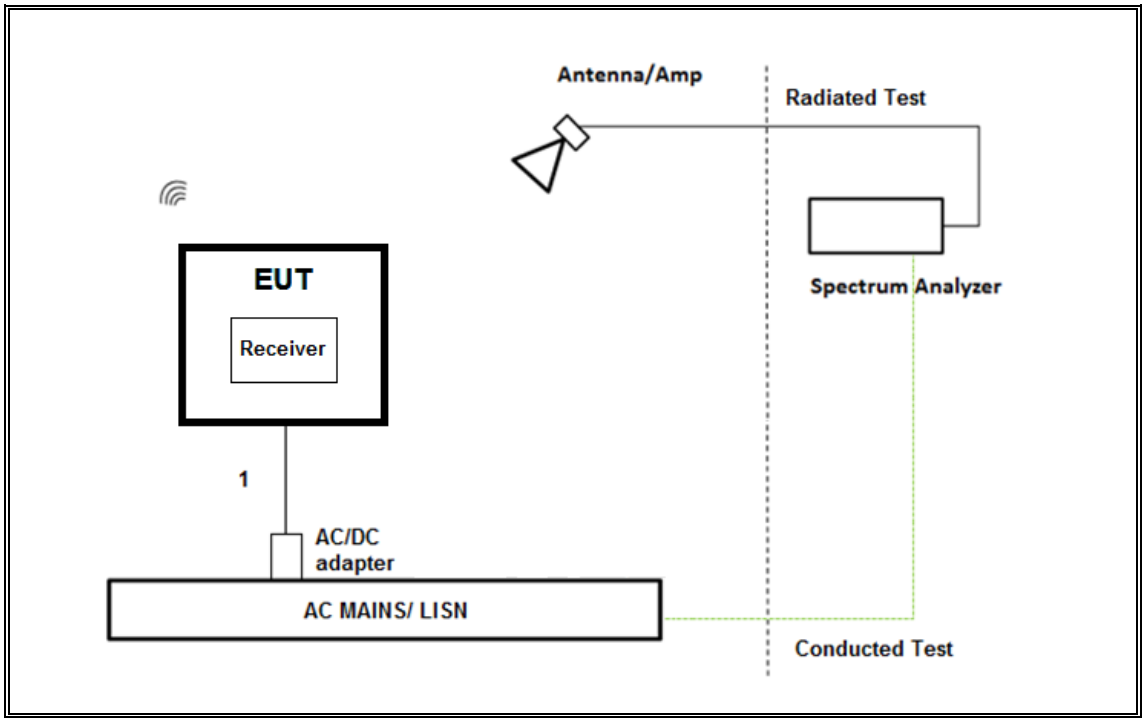
CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	USB	1	micro USB	Unshielded	1	EUT to AC/DC adapter

TEST SETUP-CONDUCTED TEST AND RADIATED TEST

The EUT is powered by AC/DC adapter via USB cable, a receiving device is placed on the EUT surface for wireless charging purpose.

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, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T757	09/14/2018
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310N	T300	12/11/2018
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1466	04/11/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T863	06/09/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T493	12/16/2018
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	8447D	T10	02/14/2019
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB3	T899	06/15/2018
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1454	01/08/2019
Filter, BRF 902 to 928MHz	MICRO-TRONICS	BRC50722	T1847	07/15/2018
AC Line Conducted				
EMI Test Receiver 10Hz-26.5GHz	Rohde & Schwarz	ESCI7	PRE0176493	02/21/2019
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/15/2018
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2018
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Ver 9.5, Dec 01, 2016	
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015	

NOTES:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

7. APPLICABLE LIMITS AND TEST RESULTS

7.1. RADIATED EMISSIONS

LIMIT

§18.301 Operating frequencies

The EUT operates at 918 MHz, within the tolerance of the ISM Frequency of 915 +/- 13MHz.

§18.305 Field Strength Limits
(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 (μV/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.

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.

KDB 414788 OATS and Chamber Correlation Justification

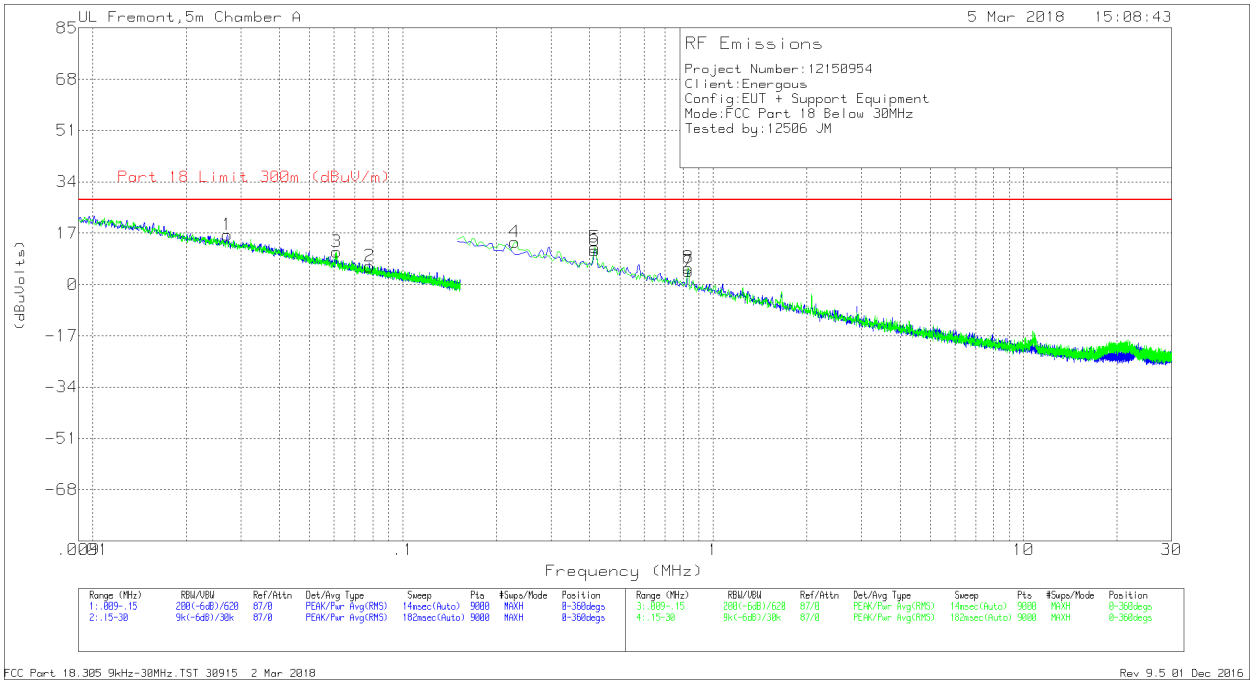
Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

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

RESULTS

7.1.1. SPURIOUS EMISSIONS 9 kHz TO 30 MHz

ANTENNA LOOP FACE ON AND FACE OFF



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.02715	43.16	Pk	13.2	.1	-40	16.46	28	-11.54	0-360
3	.06116	39.63	Pk	11.1	.1	-40	10.83	28	-17.17	0-360
2	.07823	34.98	Pk	10.9	.1	-40	5.98	28	-22.02	0-360
4	.22961	43.24	Pk	10.8	.1	-40	14.14	28	-13.86	0-360
6	.41536	40.48	Pk	10.7	.1	-40	11.28	28	-16.72	0-360
5	.41536	41.6	Pk	10.7	.1	-40	12.4	28	-15.6	0-360
7	.82999	33.6	Pk	10.6	.1	-40	4.3	28	-23.7	0-360
8	.82999	34.84	Pk	10.6	.1	-40	5.54	28	-22.46	0-360

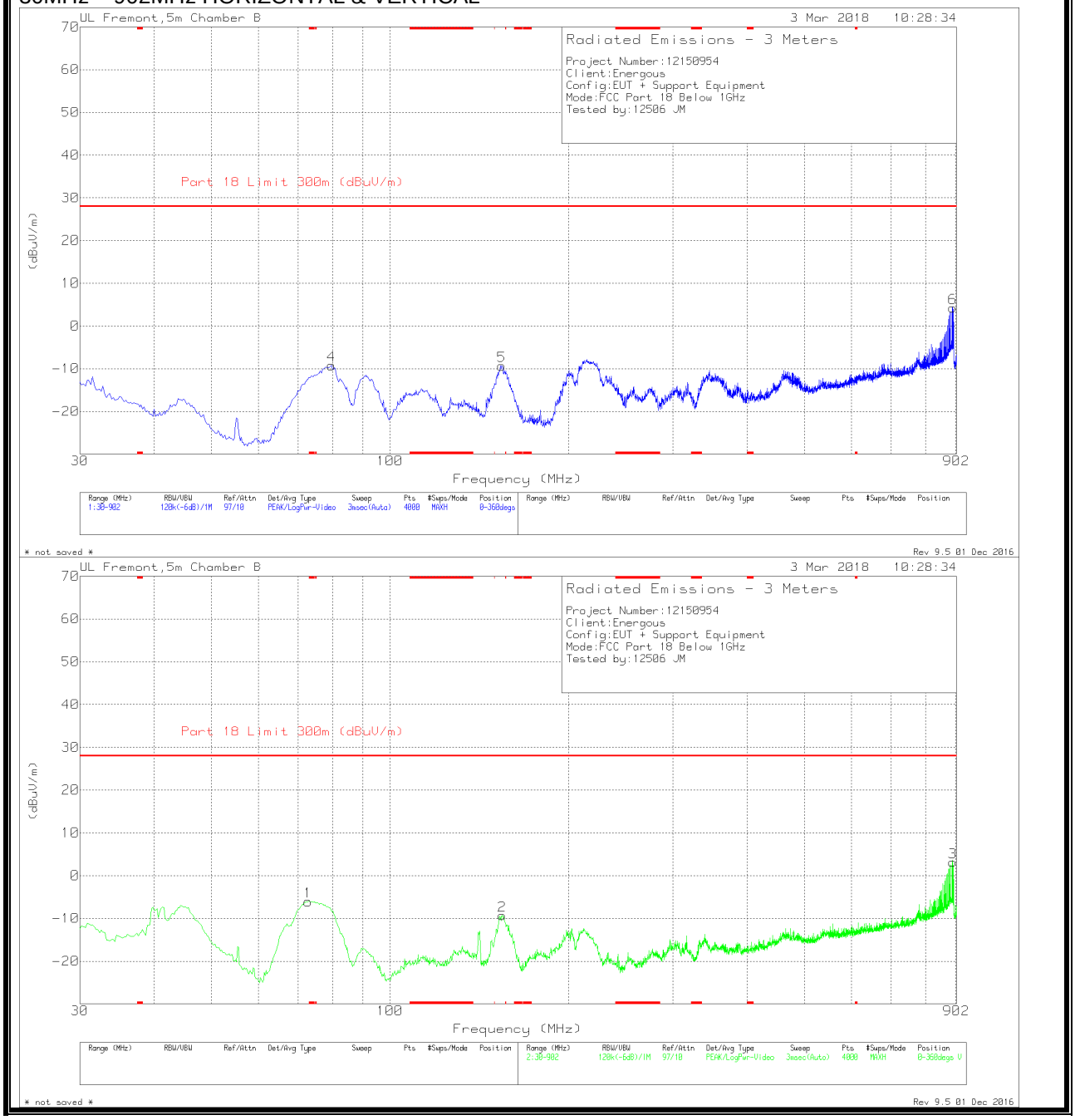
Pk - Peak detector

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

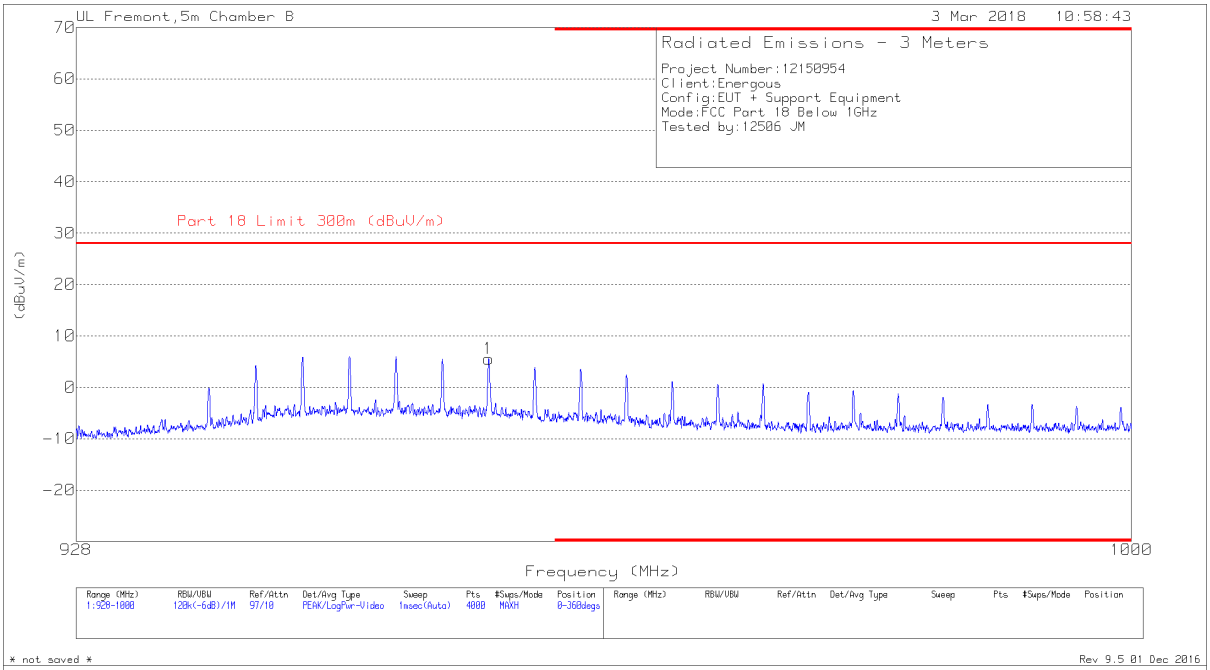
7.1.2. SPURIOUS EMISSIONS 30 MHz TO 1000 MHz

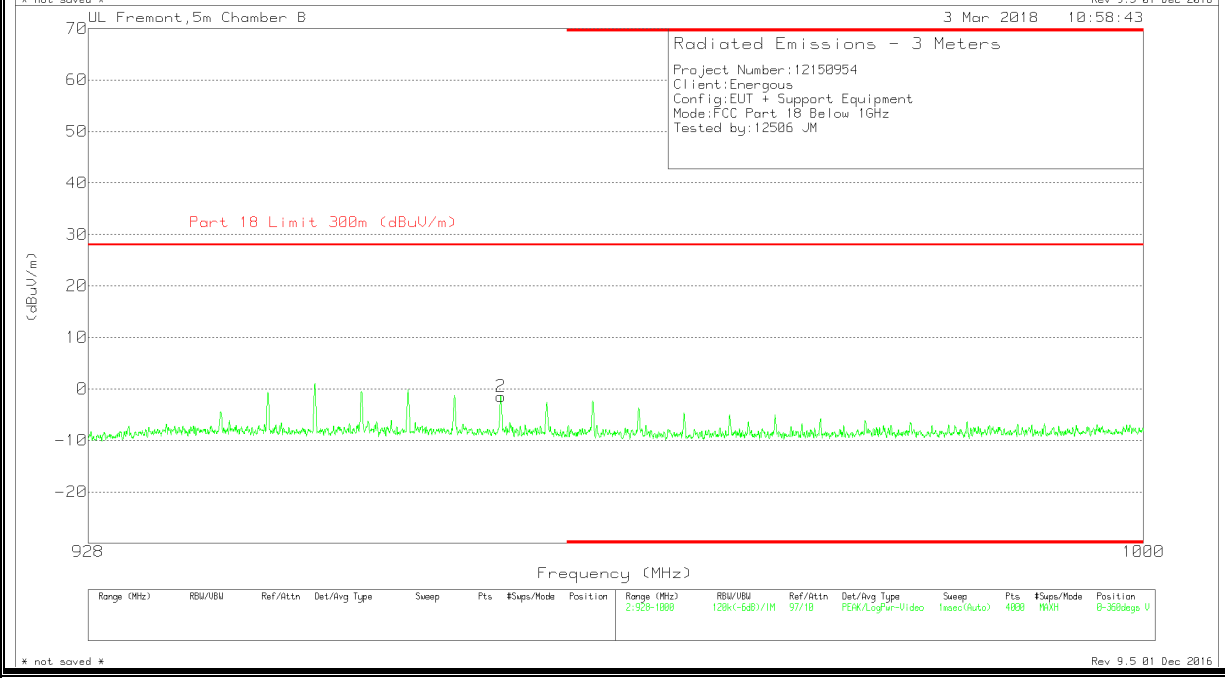
Spurious Emissions 30 – 1000 MHz with a Notch Filter

30MHz – 902MHz HORIZONTAL & VERTICAL



928MHz – 1000MHz HORIZONTAL & VERTICAL





DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T899 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	T1847 BRF (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	72.7388	49.83	Pk	11.9	-28.3	-40	.5	-6.07	28	-34.07	0-360	100	V
4	79.7165	47.26	Pk	11.2	-28.2	-40	.5	-9.24	28	-37.24	0-360	200	H
5	154.2914	41.24	Pk	16.2	-27.3	-40	.5	-9.36	28	-37.36	0-360	200	H
2	154.7275	41.37	Pk	16.1	-27.3	-40	.5	-9.33	28	-37.33	0-360	200	V
6	889.7909	41.35	Pk	25.9	-23.5	-40	.5	4.25	28	-23.75	0-360	200	H
3	889.7909	40.23	Pk	25.9	-23.5	-40	.5	3.13	28	-24.87	0-360	100	V

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T899 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	T1847 BRF (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	955.5116	41.34	Pk	26.8	-23.1	-40	.5	5.54	28	-22.46	0-360	200	H
2	955.5296	34.35	Pk	26.8	-23.1	-40	.5	-1.45	28	-29.45	0-360	200	V

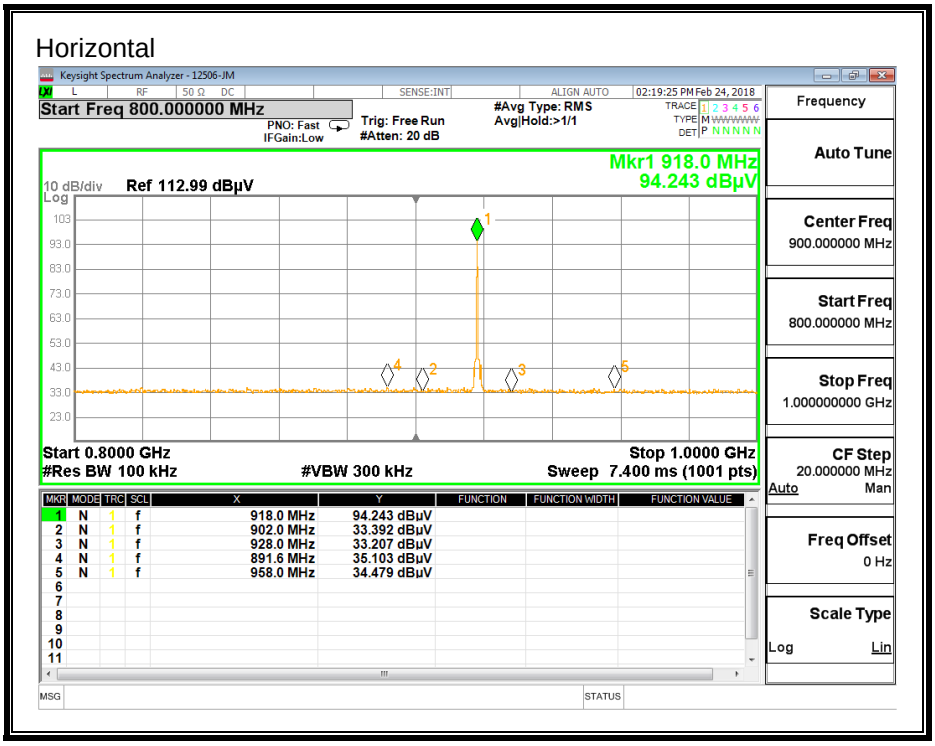
Pk - Peak detector

Note:

- Distance factor from 3m to 300m = 20log (3/300) = -40dB
- **Notch filter was used to prevent system overloading.**

Spurious Emissions 800 – 1000 MHz without a Notch Filter

Horizontal



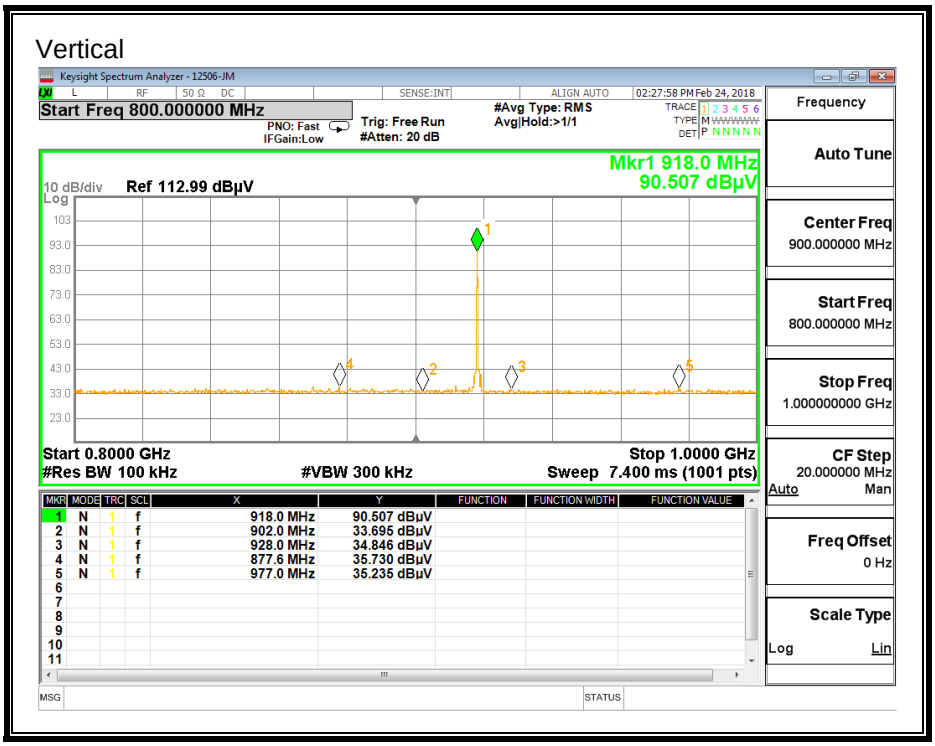
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T899 (dB/m)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	891.6	35.103	Pk	27.17	-40	22.27	28	-5.73	200	128	H
5	958	34.479	Pk	27.77	-40	22.25	28	-5.75	189	157	H

Pk - Peak detector

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

Vertical



DATA

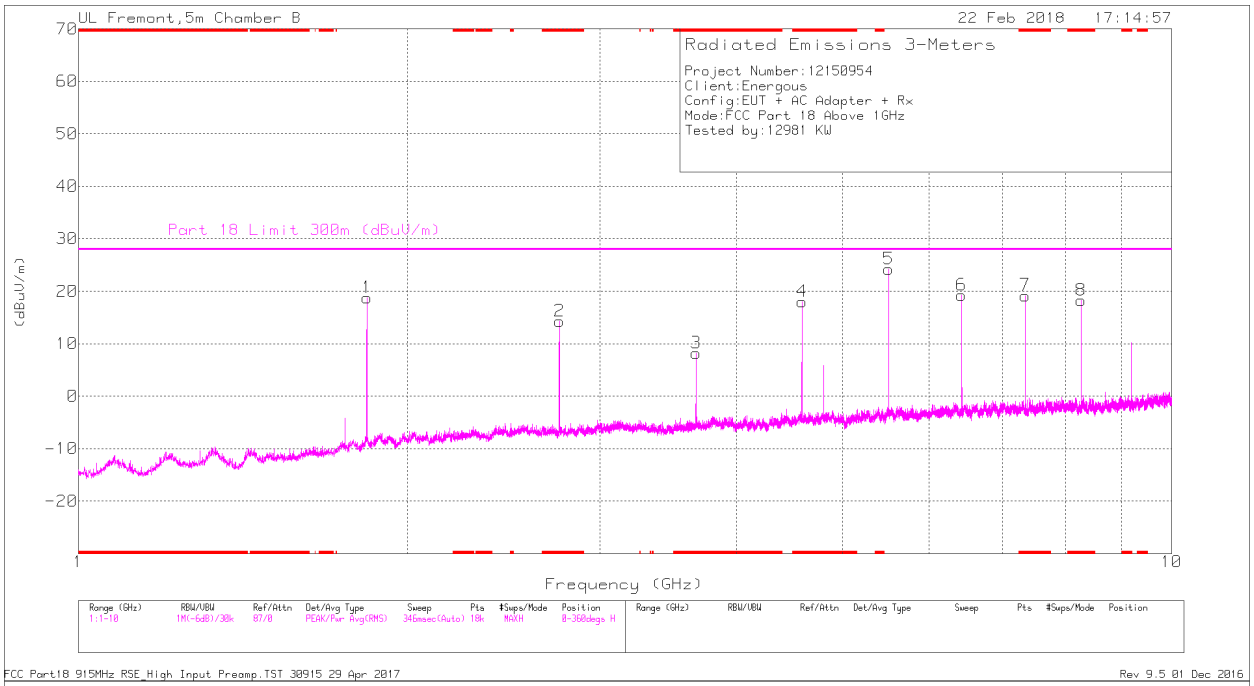
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T899 (dB/m)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	877.6	35.730	Pk	26.97	-40	22.70	28	-5.30	202	118	V
5	977	35.235	Pk	27.88	-40	23.12	28	-4.88	157	129	V

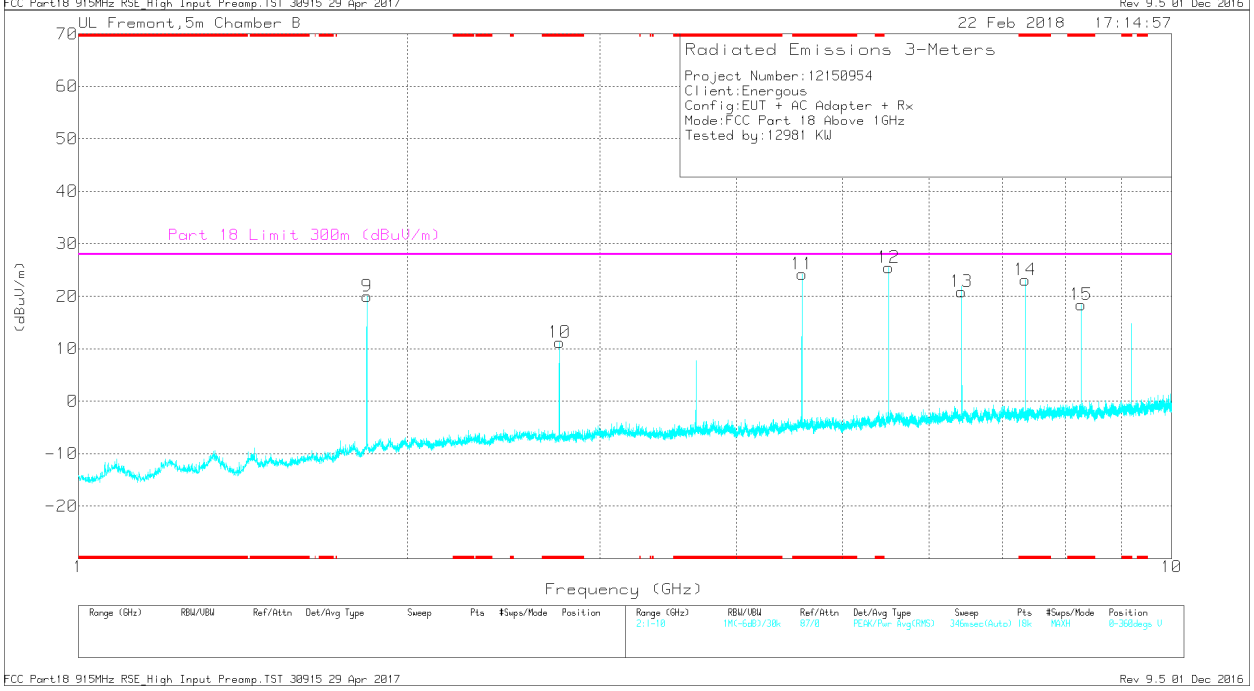
Pk - Peak detector

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

7.1.3. SPURIOUS EMISSIONS 1 GHz TO 10 GHz

HORIZONTAL & VERTICAL





DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (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	* 2.754	53.17	ADR	32.3	-32.7	.5	-40	13.27	28	-14.73	168	240	H
3	* 3.672	44.73	ADR	33.2	-31.7	.5	-40	6.73	28	-21.27	254	106	H
4	* 4.59	57.83	ADR	34.3	-30.9	.5	-40	21.73	28	-6.27	91	108	H
7	* 7.344	46.02	ADR	35.9	-29.1	.5	-40	13.32	28	-14.68	166	226	H
8	* 8.262	40.6	ADR	36.1	-27.9	.5	-40	9.3	28	-18.7	41	107	H
11	* 4.59	58.23	ADR	34.3	-30.9	.5	-40	22.13	28	-5.87	295	108	V
14	* 7.344	54.08	ADR	35.9	-29.1	.5	-40	21.38	28	-6.62	167	115	V
15	* 8.262	49.5	ADR	36.1	-27.9	.5	-40	18.2	28	-9.8	3	105	V
10	* 2.754	49.95	ADR	32.3	-32.7	.5	-40	10.05	28	-17.95	194	107	V
1	1.836	64.88	ADR	30.6	-33.6	.5	-40	22.38	28	-5.62	175	230	H
9	1.836	61.4	ADR	30.6	-33.6	.5	-40	18.9	28	-9.1	104	307	V
5	5.508	57.72	ADR	35.4	-31	.5	-40	22.62	28	-5.38	301	106	H
12	5.508	60.64	ADR	35.4	-31	.5	-40	25.54	28	-2.46	5	204	V
6	6.426	51.01	ADR	35.7	-30.1	.5	-40	17.11	28	-10.89	291	210	H
13	6.426	55.2	ADR	35.7	-30.1	.5	-40	21.3	28	-6.7	145	102	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
ADR - AD primary method, RMS average

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

7.2. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

§ 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).

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

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

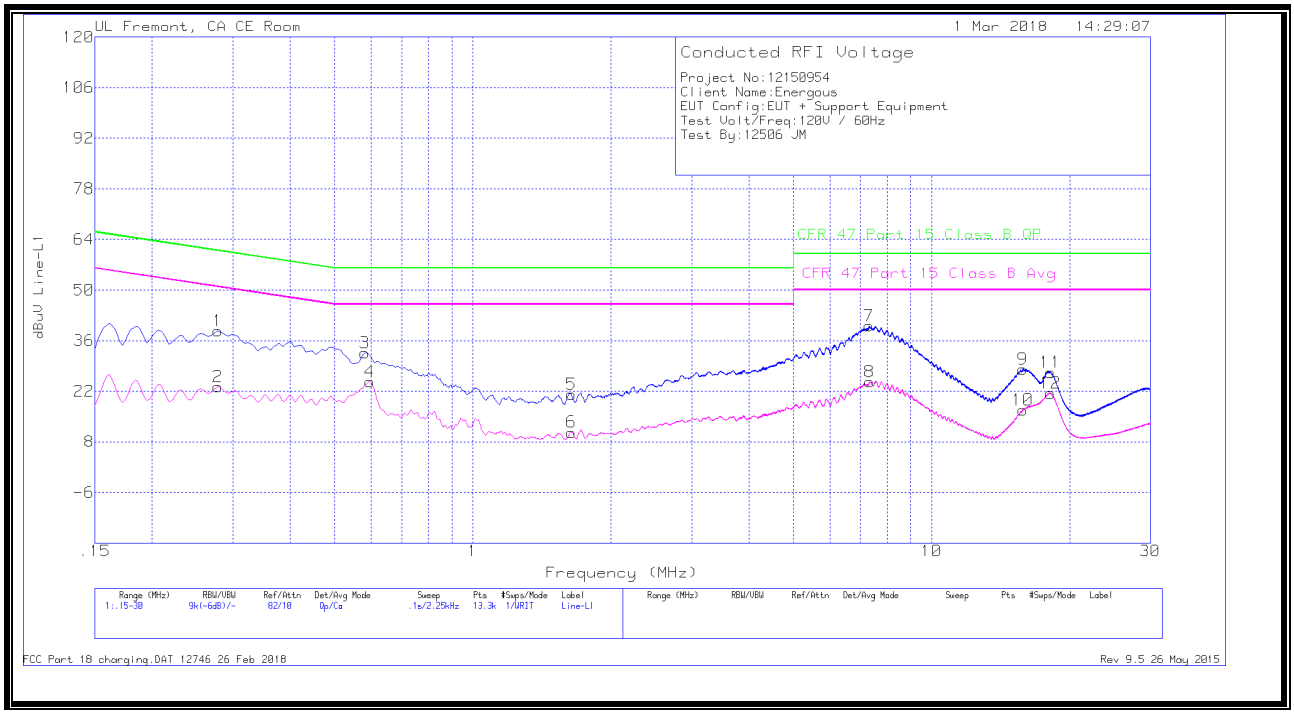
*Decreases with the logarithm of the frequency.

TEST PROCEDURE

FCC / OST MP-5

RESULTS

LINE 1 RESULTS

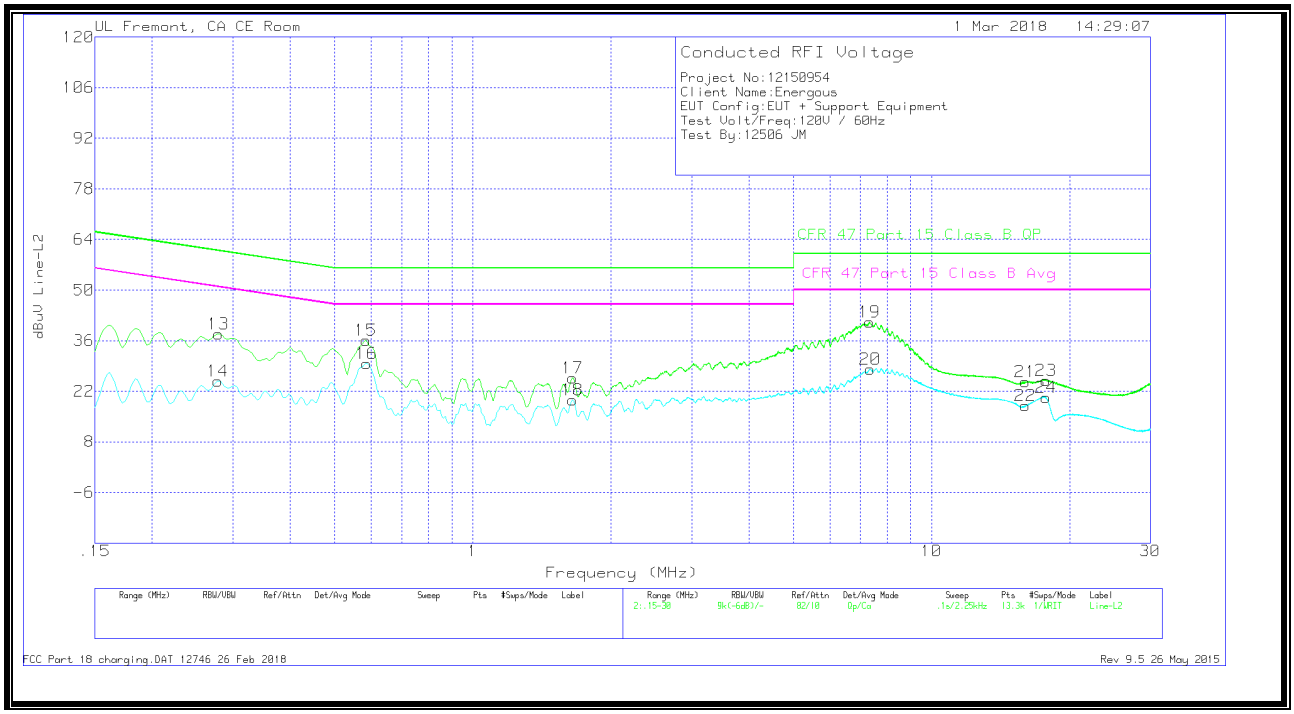


WORST EMISSIONS

Range 1: Line-L1 .15 - 30MHz										
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	Margin (dB)	CFR 47 Part 15 Class B Avg	Margin (dB)
1	.27825	38.72	Qp	0	0	38.72	60.87	-22.15	-	-
2	.27825	23.3	Ca	0	0	23.3	-	-	50.87	-27.57
3	.582	32.65	Qp	0	0	32.65	56	-23.35	-	-
4	.5955	24.6	Ca	0	0	24.6	-	-	46	-21.4
5	1.6395	21.1	Qp	0	.1	21.2	56	-34.8	-	-
6	1.6395	10.53	Ca	0	.1	10.63	-	-	46	-35.37
7	7.31175	39.82	Qp	0	.2	40.02	60	-19.98	-	-
8	7.32975	24.48	Ca	0	.2	24.68	-	-	50	-25.32
9	15.80325	27.75	Qp	0	.3	28.05	60	-31.95	-	-
10	15.80213	16.5	Ca	0	.3	16.8	-	-	50	-33.2
11	18.14775	26.94	Qp	0	.3	27.24	60	-32.76	-	-
12	18.15225	21.11	Ca	0	.3	21.41	-	-	50	-28.59

Qp - Quasi-Peak detector
Ca - CISPR average detection

LINE 2 RESULTS



WORST EMISSIONS

Range 2: Line-L2 .15 - 30MHz										
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	Margin (dB)	CFR 47 Part 15 Class B Avg	Margin (dB)
13	.27938	37.83	Qp	0	0	37.83	60.83	-23	-	-
14	.27825	24.83	Ca	0	0	24.83	-	-	50.87	-26.04
15	.58425	36.05	Qp	0	0	36.05	56	-19.95	-	-
16	.5865	29.69	Ca	0	0	29.69	-	-	46	-16.31
17	1.6485	25.61	Qp	0	.1	25.71	56	-30.29	-	-
18	1.64963	19.55	Ca	0	.1	19.65	-	-	46	-26.35
19	7.3365	40.9	Qp	0	.2	41.1	60	-18.9	-	-
20	7.3455	27.84	Ca	0	.2	28.04	-	-	50	-21.96
21	16.00125	24.33	Qp	0	.3	24.63	60	-35.37	-	-
22	16.00575	17.71	Ca	0	.3	18.01	-	-	50	-31.99
23	17.7585	24.73	Qp	0	.3	25.03	60	-34.97	-	-
24	17.75063	19.92	Ca	0	.3	20.22	-	-	50	-29.78

Qp - Quasi-Peak detector
Ca - CISPR average detection