



TEST REPORT

Report Number. : 13119172-E1V1

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

Model : MS-550

FCC ID : 2ADNG-MS550

EUT Description : OVER-THE-AIR, DISTANCE CHARGING TRANSMITTER

Test Standard(s) : FCC 47 CFR PART 18 SUBPART C

Date Of Issue:

December 18, 2019

Prepared by:

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NVLAP Lab code: 200065-0

Revision History

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
V1	12/18/2019	Initial Issue	--

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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: OVER-THE-AIR, DISTANCE CHARGING TRANSMITTER

MODEL NUMBER: MS-550

SERIAL NUMBER: 2032 & 2029

DATE TESTED: NOVEMBER 25, 2019 – DECEMBER 11, 2019

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. 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.

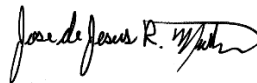
This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

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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, 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 Road
<input type="checkbox"/> Chamber A	<input type="checkbox"/> Chamber D	<input type="checkbox"/> Chamber I
<input type="checkbox"/> Chamber B	<input type="checkbox"/> Chamber E	<input type="checkbox"/> Chamber J
<input type="checkbox"/> Chamber C	<input type="checkbox"/> Chamber F	<input checked="" type="checkbox"/> Chamber K
	<input type="checkbox"/> Chamber G	<input type="checkbox"/> Chamber L
	<input type="checkbox"/> Chamber H	<input type="checkbox"/> Chamber M

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

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:

$$\text{Field Strength (dBuV/m)} = \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Preamp Gain (dB)}$$

$$36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$$

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

$$\text{Final Voltage (dBuV)} = \text{Measured Voltage (dBuV)} + \text{Cable Loss (dB)} + \text{Limiter Factor (dB)} + \text{LISN Insertion Loss.}$$

$$36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$$

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%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an over-the-air, distance charging transmitter. Wireless power transfer is only transmitting a continuous carrier wave signal at 917.5 MHz frequency single channel when client device is positioned within the charging zone. The charging zone of the EUT is up to 40cm for client device placed in front of the EUT. The EUT can only charge one client device at a time. The EUT uses BLE to pair with the client device.

This report documents test results of the Wireless Power Transfer ISM portion of the wireless charger.

The WPT portion of the EUT incorporates one loop antenna with a peak gain of 6.5 dBi.

5.2. OPERATING FREQUENCY AND POWER

The EUT operates at 917.5 MHz.

The highest maximum measured conducted average power as follow:

Mode	Frequency (MHz)	Antenna Meas Power (dBm)
CW	917.5	37.40

5.3. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was Version: 4.0.1.255.

The software installed in the EUT during testing was WattUp app Version 4.0.0.

5.4. CONFIGURATION

The EUT is a tabletop device and it has two ports, one is the USB type C port for power only, second port is for command line interface control, end user will not have access to it. Therefore, all final radiated testing was performed with the EUT in tabletop orientation powered by AC/DC adapter via USB cable.

The worst case orientation and position of the client device was investigated by the applicant. The applicant determined that the operating condition for worst-case emissions is when the charger is operating at the maximum rated level and the maximum possible power (as adjusted by internal power control circuitry) is coupled to the client device. This condition occurs at the following orientation and position: the client device is directly centered on the tabletop, 5.5 inches in front of the EUT, with the wristband clasped. All of the charging mode final testing is performed using this configuration of charger and client.

Configuration	Description
Standby mode	EUT is powered by AC/DC adapter via USB cable. Wireless Power Transfer ISM portion is in standby mode, BLE is in normal operating mode as the worst case.
Charging mode	EUT is powered by AC/DC adapter via USB cable and client device receives maximum 917.5 MHz RF energy from EUT. Wireless Power Transfer ISM portion and BLE can transmit simultaneously. BLE is in normal operating mode as the worst case.

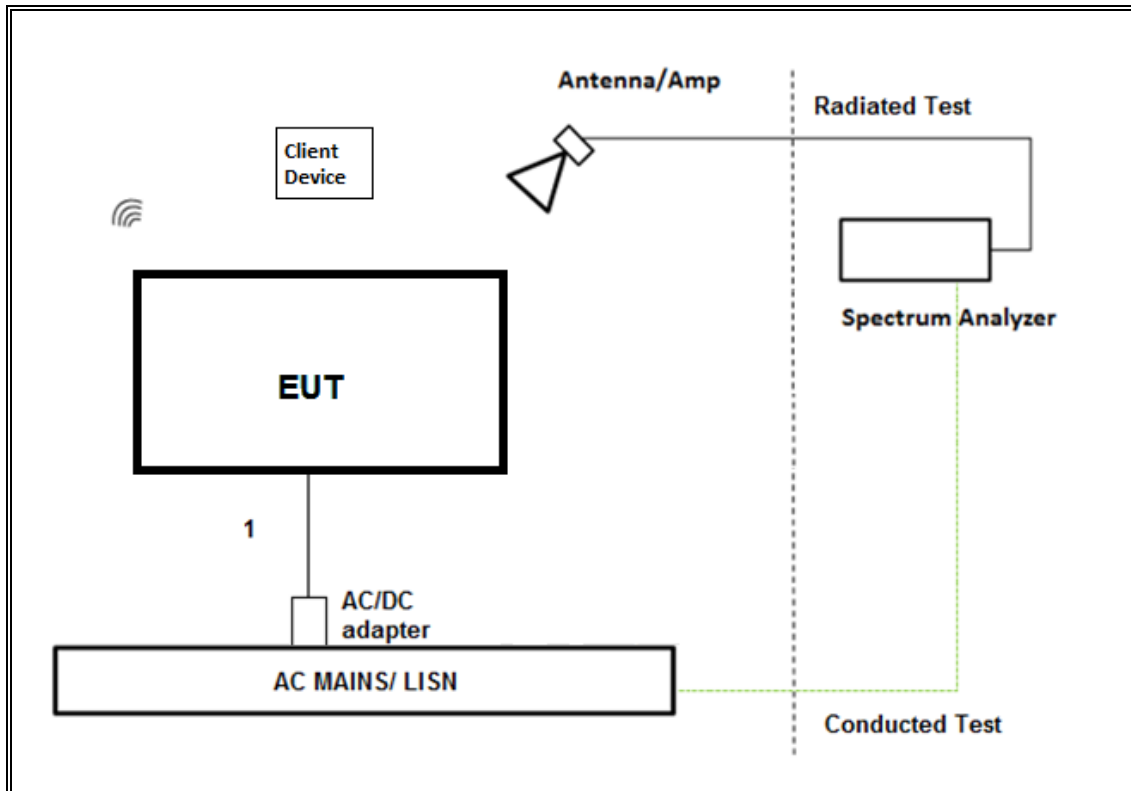
5.5. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT						
Description	Manufacturer	Model	Serial Number	FCC ID/ DoC		
1 Receiver (client device)	Energous	MS-550A	Nb44030	DoC		
EUT AC/DC Adapter	Anker	PD 30	AFZFD51915301545	DoC		
I/O CABLES (RF RADIATED TEST)						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	USB	1	USB Type C	Shielded	1	EUT to AC/DC adapter

TEST SETUP- RADIATED TEST

The EUT is powered by AC/DC adapter via USB cable, client device wristband clasped, directly centered on the tabletop in front of the EUT. All of the charging mode final testing is performed at this configuration.

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, Passive Loop 30Hz to 1MHz	ELETRO METRICS	EM-6871	PRE0179466	05/31/2020
Antenna, Passive Loop 100KHz to 30MHz	ELETRO METRICS	EM-6872	PRE0179468	05/31/2020
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	EMC4294	06/14/2020
Amplifier, 1 to 18GHz, 35dB	AMPLICAL	AMP1G18-35	T1569	05/04/2020
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	PRE0186650	12/13/2019
Antenna, BroadBand Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	PRE0181574	10/24/2020
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	PRE0179372	10/14/2020
Filter, BRF 902 to 928MHz	MICRO-TRONICS	BRC50722	T1847	07/29/2020
Filter, HPF 1.5 to 18GHz	MICRO-TRONICS	HPM50114	T1853	10/30/2020
AC Line Conducted				
EMI Receiver	Rohde & Schwarz	ESR	T1436	02/14/2020
LISN for Conducted Emissions CISPR-16	FCC INC.	FCC LISN 50/250	T1310	01/24/2020
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Rev 9.5, September 24, 2019	
AC Line Conducted Software	UL	UL EMC	Rev 9.5, May 26, 2015	

7. APPLICABLE LIMITS AND TEST RESULTS

7.1. RADIATED EMISSIONS

LIMIT

§18.301 Operating frequencies

The EUT operates at 917.5MHz, 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 ($\mu\text{V/m}$)	Distance (meters)
Any type unless otherwise specified (miscellaneous)	Any ISM frequency	Below 500 500 or more	25 $25 \times \text{SQRT}(\text{power}/500)$	300 1300

¹Field strength may not exceed $10\mu\text{V/m}$ 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 $25\mu\text{V/m}$ at 300 m, equivalent to 28 dBuV/m at 300 m.

TEST PROCEDURE

Tested in accordance with 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.

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

Radiated tests in the standby mode were performed with the EUT 80 cm above the ground plane.

Although the results will probably be only marginally different than with the 1 meter height specified in FCC/OST MP-5, the risk for discrepancies lies with the manufacturer.

Radiated tests in the charging mode were performed with the EUT 1 m above the ground plane.

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

For below 30MHz testing, based on KDB 414788, Clause 2, for Part 18 equipment, Section 2.1 of FCC Measurement Procedure MP-5 also permits the use of test sites other than an open-field test site only if it can be shown that the results obtained at such a location are correlated with those made at an open-field test site.

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

Distance Correction Factor

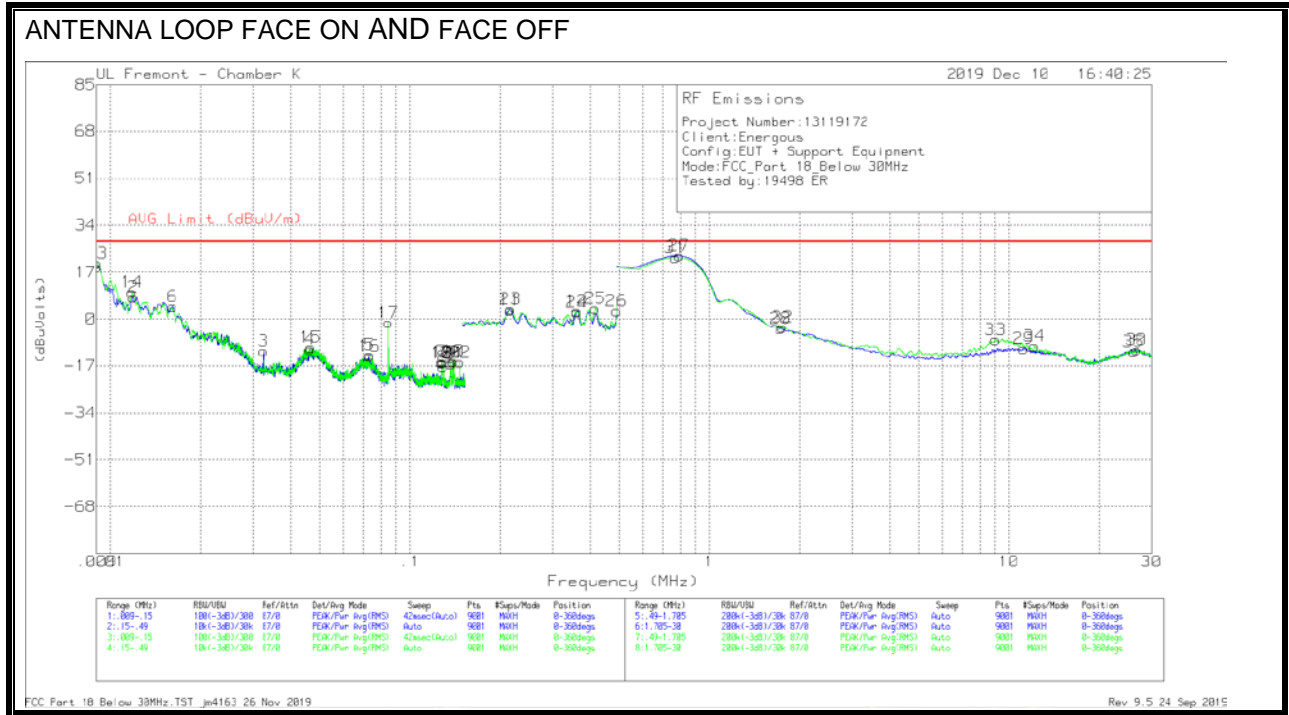
Based on FCC 18.305, note 2. Testing for compliance with these limits may be made at closer distances, provided a sufficient number of measurements are taken to plot the radiation pattern, to determine the major lobes of radiation, and to determine the expected field strength level at 30, 300, or 1600 meters. Alternatively, if measurements are made at only one closer fixed distance, then the permissible field strength limits shall be adjusted using $1/d$ as an attenuation factor.

- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

RESULTS

7.1.1. SPURIOUS EMISSIONS 9 kHz TO 30 MHz

STANDBY MODE



DATA

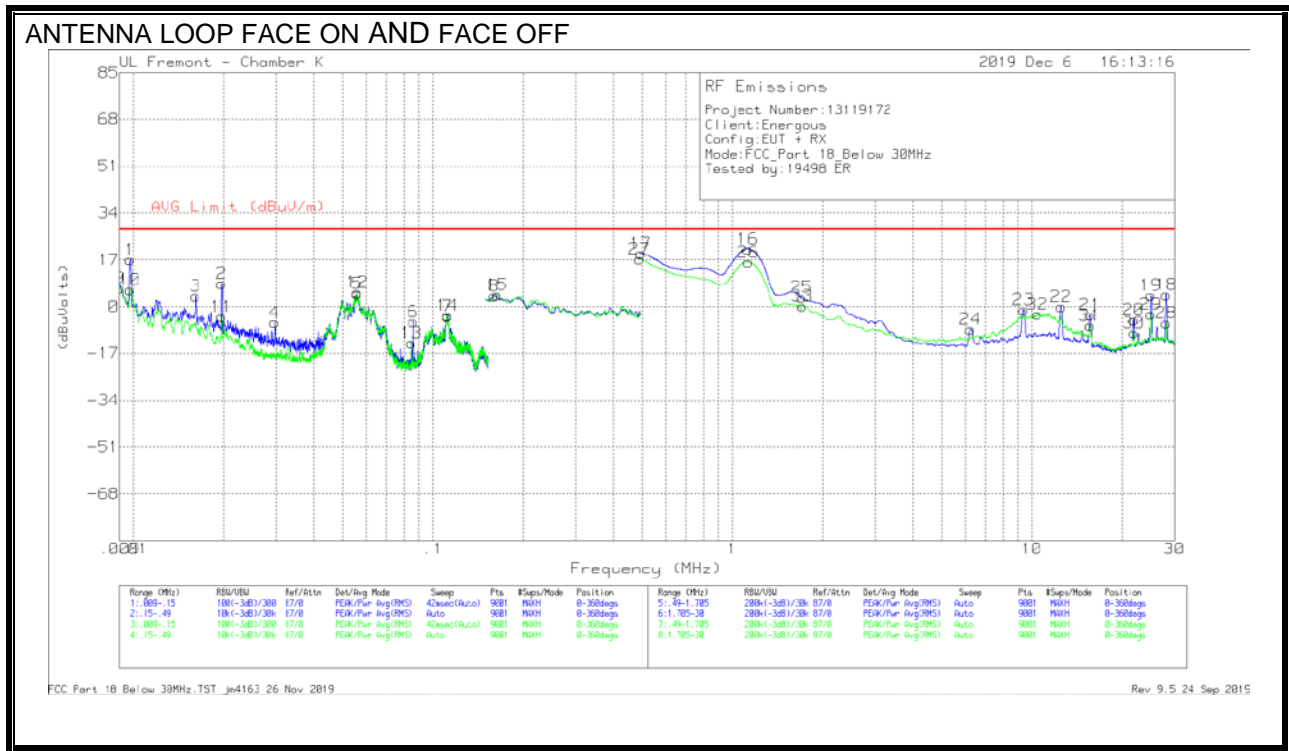
Marker	Frequency (MHz)	Meter Reading (dBUV)	Det	Loop Antenna (ACF)	Cables w/ PRE0186650	Dist Corr 300m	Corrected Reading (dBUVolts)	AVG Limit (dBUV/m)	Margin (dB)	Azimuth (Degs)
1	.00902	29.54	Pk	61.2	-31.8	-40	18.94	28	-9.06	0-360
2	.01191	19.84	Pk	59.9	-31.8	-40	7.94	28	-20.06	0-360
3	.03249	3.16	Pk	57.5	-32.2	-40	-11.54	28	-39.54	0-360
4	.04653	4.39	Pk	56.9	-32.2	-40	-10.91	28	-38.91	0-360
5	.07328	3.6	Pk	55.7	-32.2	-40	-12.9	28	-40.9	0-360
6	.01617	17.11	Pk	59.3	-31.9	-40	4.51	28	-23.49	0-360
7	.12743	1.1	Pk	55.6	-32.2	-40	-15.5	28	-43.5	0-360
8	.12916	-.6	Pk	55.6	-32.2	-40	-17.2	28	-45.2	0-360
9	.13726	.24	Pk	55.7	-32.2	-40	-16.26	28	-44.26	0-360
10	.14014	1.22	Pk	55.7	-32.2	-40	-15.28	28	-43.28	0-360
11	.2158	19.19	Pk	56.1	-32.1	-40	3.19	28	-24.81	0-360
12	.36236	18.98	Pk	56	-32.1	-40	2.88	28	-25.12	0-360
13	.00902	30.94	Pk	61.2	-31.8	-40	20.34	28	-7.66	0-360
14	.01183	21.63	Pk	59.9	-31.8	-40	9.73	28	-18.27	0-360
15	.04658	5.06	Pk	56.9	-32.2	-40	-10.24	28	-38.24	0-360
16	.07327	3.04	Pk	55.7	-32.2	-40	-13.46	28	-41.46	0-360
17	.0849	15.46	Pk	55.5	-32.2	-40	-1.24	28	-29.24	0-360
18	.12743	.73	Pk	55.6	-32.2	-40	-15.87	28	-43.87	0-360
19	.12916	.84	Pk	55.6	-32.2	-40	-15.76	28	-43.76	0-360
20	.13722	.73	Pk	55.7	-32.2	-40	-15.77	28	-43.77	0-360
21	.14012	.72	Pk	55.7	-32.2	-40	-15.78	28	-43.78	0-360
22	.14679	.8	Pk	55.7	-32.2	-40	-15.7	28	-43.7	0-360
23	.21682	19.69	Pk	56.1	-32.1	-40	3.69	28	-24.31	0-360
24	.361	18.67	Pk	56	-32.1	-40	2.57	28	-25.43	0-360
25	.41573	19.97	Pk	56	-32.1	-40	3.87	28	-24.13	0-360
26	.48968	19.04	Pk	56	-32.1	-40	2.94	28	-25.06	0-360
27	.7929	46.71	Pk	48.4	-32.1	-40	23.01	28	-4.99	0-360
28	1.7317	25.51	Pk	43	-32	-40	-3.49	28	-31.49	0-360
29	11.1983	26.64	Pk	34.4	-31.8	-40	-10.76	28	-38.76	0-360
30	26.6558	26.77	Pk	33.7	-31.6	-40	-11.13	28	-39.13	0-360
31	.7714	45.87	Pk	48.6	-32.1	-40	22.37	28	-5.63	0-360
32	1.76	26.18	Pk	42.8	-32	-40	-3.02	28	-31.02	0-360
33	9.0274	30.1	Pk	34.2	-31.8	-40	-7.5	28	-35.5	0-360
34	12.1918	27.83	Pk	34.3	-31.8	-40	-9.67	28	-37.67	0-360
35	26.0553	26.21	Pk	33.6	-31.6	-40	-11.79	28	-39.79	0-360

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

CHARGING MODE



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (ACF)	Cables w/ PRE0186650	Dist Corr 300m	Corrected Reading (dBuVolts)	AVG Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.00977	28.53	Pk	60.4	-31.8	-40	17.13	28	-10.87	0-360
2	.01972	21.73	Pk	58.8	-32	-40	8.53	28	-19.47	0-360
3	.01614	16.45	Pk	59.3	-31.9	-40	3.85	28	-24.15	0-360
4	.02967	8.8	Pk	57.7	-32.2	-40	-5.7	28	-33.7	0-360
5	.05601	20.51	Pk	56.4	-32.2	-40	4.71	28	-23.29	0-360
6	.08598	11.15	Pk	55.6	-32.2	-40	-5.45	28	-33.45	0-360
7	.11188	13.28	Pk	55.5	-32.2	-40	-3.42	28	-31.42	0-360
8	.16013	20.38	Pk	55.8	-32.2	-40	3.98	28	-24.02	0-360
9	.00902	17.39	Pk	61.2	-31.8	-40	6.79	28	-21.21	0-360
10	.00977	17.63	Pk	60.4	-31.8	-40	6.23	28	-21.77	0-360
11	.01972	9.59	Pk	58.8	-32	-40	-3.61	28	-31.61	0-360
12	.05599	21	Pk	56.4	-32.2	-40	5.2	28	-22.8	0-360
13	.0849	3.45	Pk	55.5	-32.2	-40	-13.25	28	-41.25	0-360
14	.11214	13.5	Pk	55.5	-32.2	-40	-3.2	28	-31.2	0-360
15	.16397	20.83	Pk	55.8	-32.2	-40	4.43	28	-23.57	0-360
16	1.1294	46.92	Pk	46.1	-32.1	-40	20.92	28	-7.08	0-360
17	.4936	39.22	Pk	52.3	-32.1	-40	19.42	28	-8.58	0-360
18	28.1319	42.93	Pk	33.1	-31.6	-40	4.43	28	-23.57	0-360
19	24.9895	41.75	Pk	33.9	-31.6	-40	4.05	28	-23.95	0-360
20	21.8785	33.03	Pk	33.8	-31.6	-40	-4.77	28	-32.77	0-360
21	15.6266	34.47	Pk	34.2	-31.7	-40	-3.03	28	-31.03	0-360
22	12.5109	37.61	Pk	34.2	-31.8	-40	.01	28	-27.99	0-360
23	9.3748	36.32	Pk	34.3	-31.8	-40	-1.18	28	-29.18	0-360
24	6.2465	28.77	Pk	35	-31.9	-40	-8.13	28	-36.13	0-360
25	1.7081	32.23	Pk	43.1	-32	-40	3.33	28	-24.67	0-360
26	1.1313	42.24	Pk	46.1	-32.1	-40	16.24	28	-11.76	0-360
27	.4906	36.99	Pk	52.4	-32.1	-40	17.29	28	-10.71	0-360
28	28.1335	32.54	Pk	33.1	-31.6	-40	-5.96	28	-33.96	0-360
29	25.0115	35.07	Pk	33.9	-31.6	-40	-2.63	28	-30.63	0-360
30	21.8958	28.38	Pk	33.8	-31.6	-40	-9.42	28	-37.42	0-360
31	15.6314	30.71	Pk	34.2	-31.7	-40	-6.79	28	-34.79	0-360
32	10.4202	34.62	Pk	34.4	-31.8	-40	-2.78	28	-30.78	0-360
33	1.7176	29.22	Pk	43.1	-32	-40	.32	28	-27.68	0-360

Pk - Peak detector

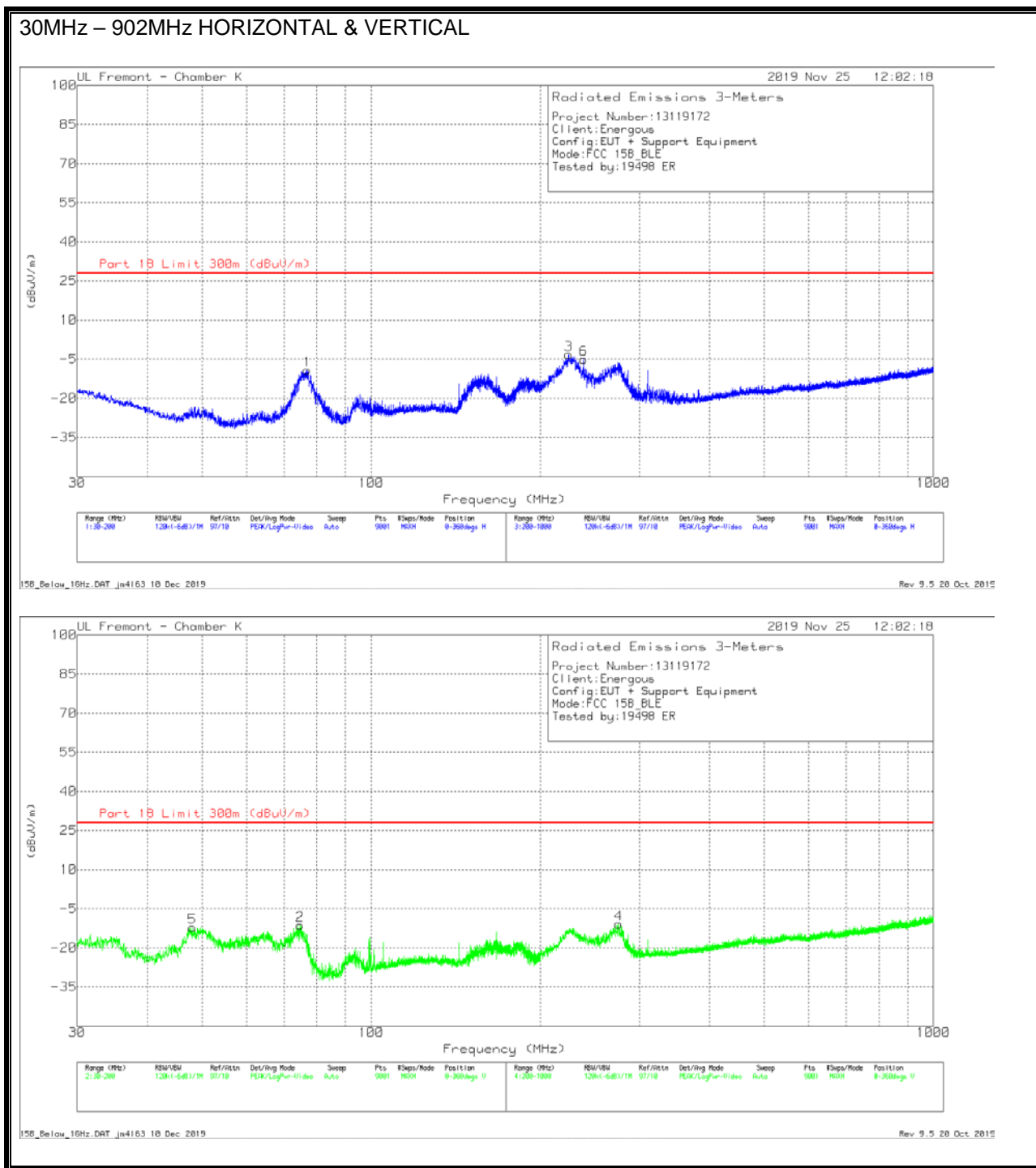
Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

7.1.2. SPURIOUS EMISSIONS 30 MHz TO 1000 MHz

STANDBY MODE

Spurious Emissions 30 – 1000 MHz Without Notch Filter



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181574 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	76.7669	50.31	Pk	13.8	-31.1	-40	-6.99	28	-34.99	257	231	H
	76.7549	43.83	Qp	13.8	-31.1	-40	-13.47	28	-41.47	257	231	H
2	74.748	45.85	Pk	13.9	-31.1	-40	-11.35	28	-39.35	0-360	95	V
5	48.1051	44.55	Pk	14.6	-31.4	-40	-12.25	28	-40.25	0-360	95	V
3	224.6223	50.14	Pk	16.8	-30.2	-40	-3.26	28	-31.26	0-360	99	H
6	238.6667	47.64	Pk	17.4	-30.1	-40	-5.06	28	-33.06	0-360	99	H
4	275.5557	39.9	PK	19.2	-30	-40	-10.9	28	-38.9	0-360	99	V

Pk - Peak detector
 Qp - Quasi-Peak detector

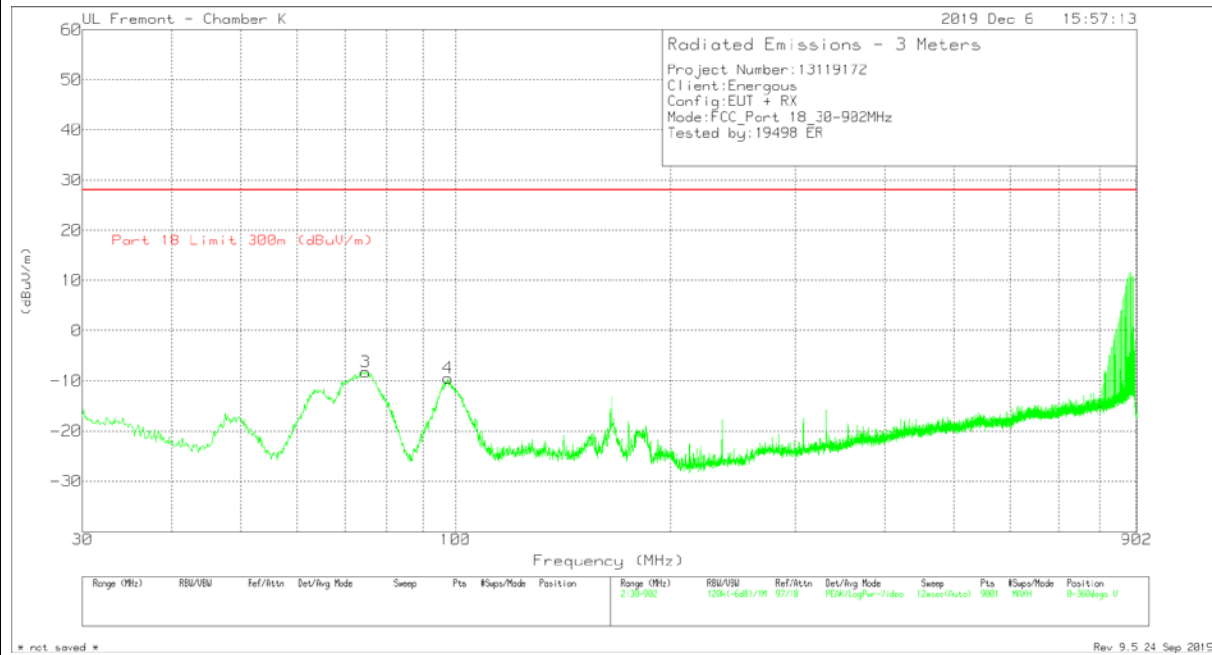
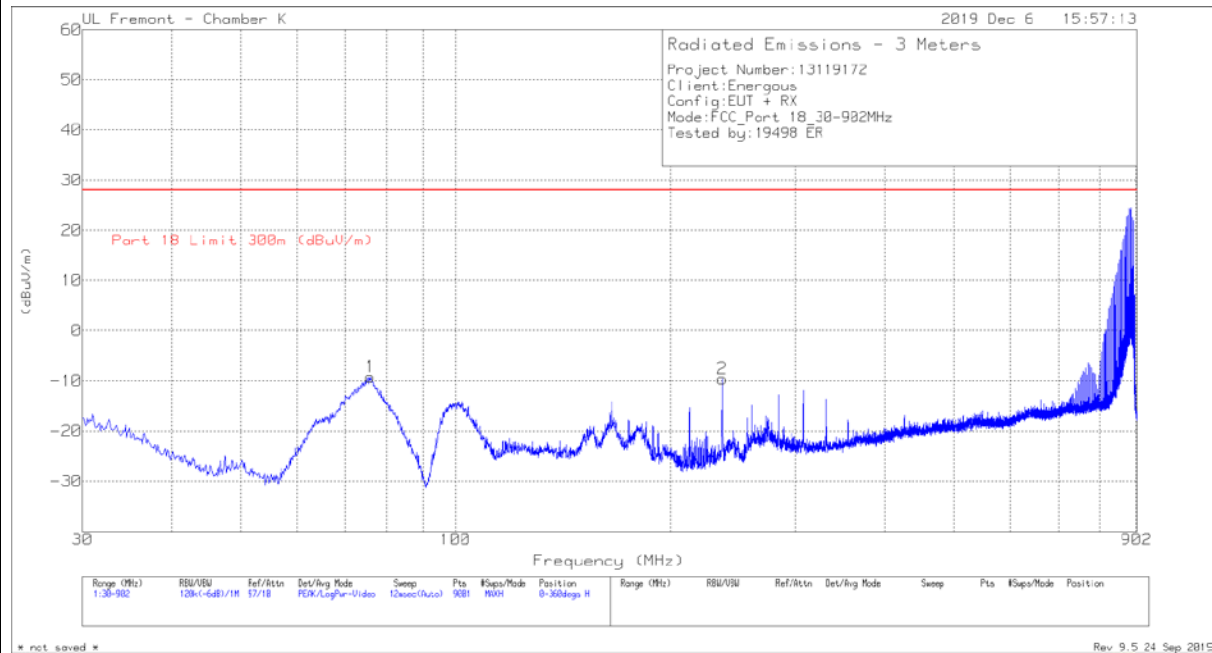
Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

CHARGING MODE

Spurious Emissions 30 – 1000 MHz with a Notch Filter

30MHz – 902MHz HORIZONTAL & VERTICAL



DATA

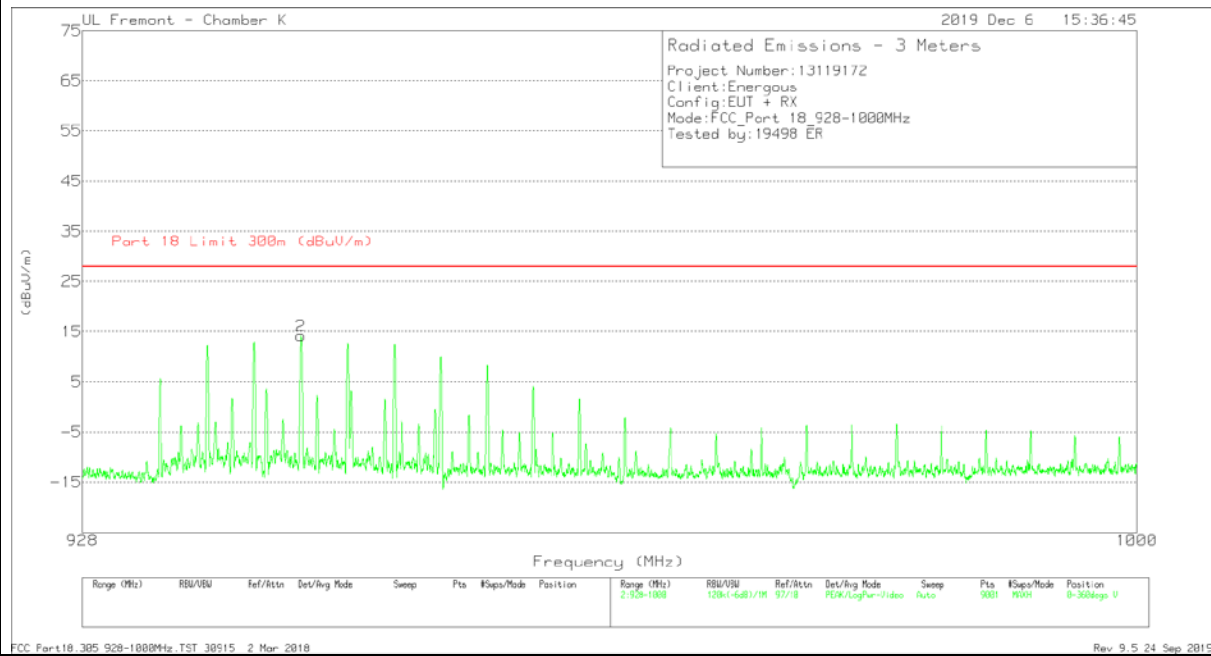
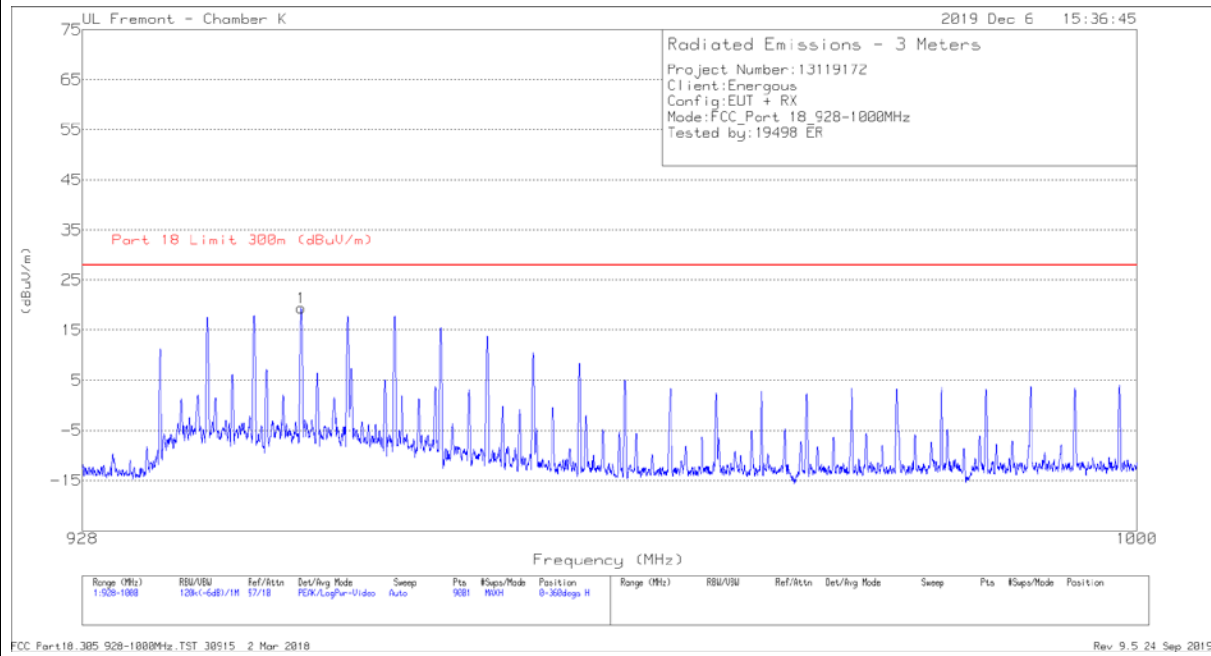
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181574 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	T1847 BRF (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	76.0223	47.5	Pk	13.9	-31.1	-40	.5	-9.2	28	-37.2	0-360	199	H
2	236.4705	42.89	Pk	17.3	-30.2	-40	.5	-9.51	28	-37.51	0-360	100	H
3	74.7627	48.5	Pk	13.9	-31.1	-40	.5	-8.2	28	-36.2	0-360	100	V
4	97.6285	45.6	Pk	15.5	-31	-40	.5	-9.4	28	-37.4	0-360	100	V

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$
- **Notch filter was used to prevent system overloading.**

928MHz – 1000MHz HORIZONTAL & VERTICAL



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181574 (dBm)	Amp/Cbl (dB)	Dist Corr (dB)	T1847 BRF (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Dege)	Height (cm)	Polarity
1	942.488	57.07	Pk	28.5	-26.7	-40	.5	19.37	28	-8.63	0-360	199	H
	942.489	61.83	Qp	28.5	-26.7	-40	.5	24.13	28	-3.67	99	117	H
2	942.48	51.82	Pk	28.5	-26.7	-40	.5	14.12	28	-13.88	0-360	100	V

Pk - Peak detector

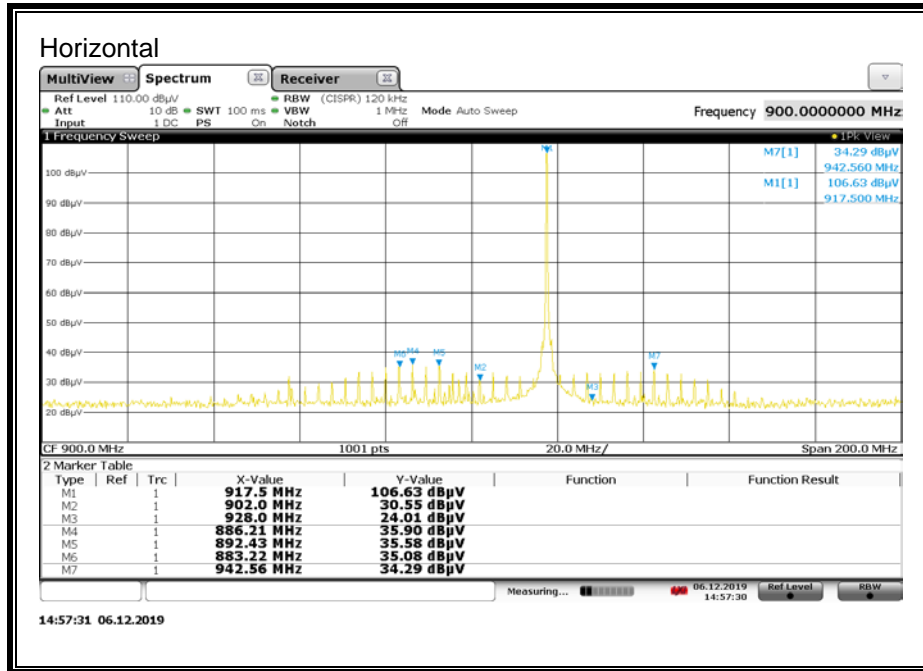
Qp - Quasi-Peak detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$
- **Notch filter was used to prevent system overloading.**

Spurious Emissions 800 – 1000 MHz without a Notch Filter and without amplifier

Tested By 19498 ER



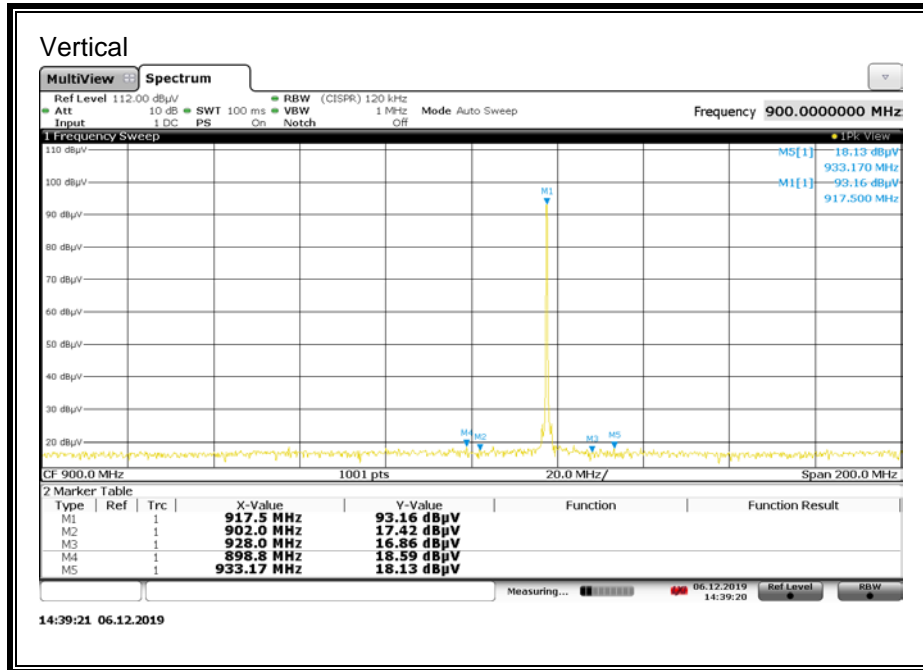
DATA

Marker	Frequency (MHz)	Meter Reading (dBµV)	Det	AF PRE0181574 (dB/m)	Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBµV/m)	FCC PART18 300m LIMIT (dBµV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
M4	886.21	35.90	Pk	27.8	4.0	-40	27.7	28	-0.3	-	-	H
	886.236	35.24	Qp	27.8	4.0	-40	27.04	28	-0.96	97	123	H
	886.236	34.93	Av	27.8	4.0	-40	26.73	28	-1.27	97	123	H
M7	942.56	34.29	Pk	28.5	4.1	-40	26.89	28	-1.11	-	-	H
	942.496	32.62	Qp	28.5	4.1	-40	25.22	28	-2.78	94	118	H
	942.496	31.51	Av	28.5	4.1	-40	24.11	28	-3.89	94	118	H

Pk - Peak detector
 Qp - Quasi-Peak detector
 Av - Average detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181574 (dB/m)	Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
M4	898.8	18.59	PK	27.8	3.9	-40	10.29	28	-17.71	-	-	V
	898.8	16.32	Qp	27.8	3.9	-40	8.02	28	-19.98	14	96	V
	898.8	15.24	Av	27.8	3.9	-40	6.94	28	-21.06	14	96	V
M5	933.17	18.13	PK	28.5	4.0	-40	10.63	28	-17.37	-	-	V
	933.119	22.57	Qp	28.5	4.0	-40	15.07	28	-12.93	8	95	V
	933.119	22.03	Av	28.5	4.0	-40	14.53	28	-13.47	8	95	V

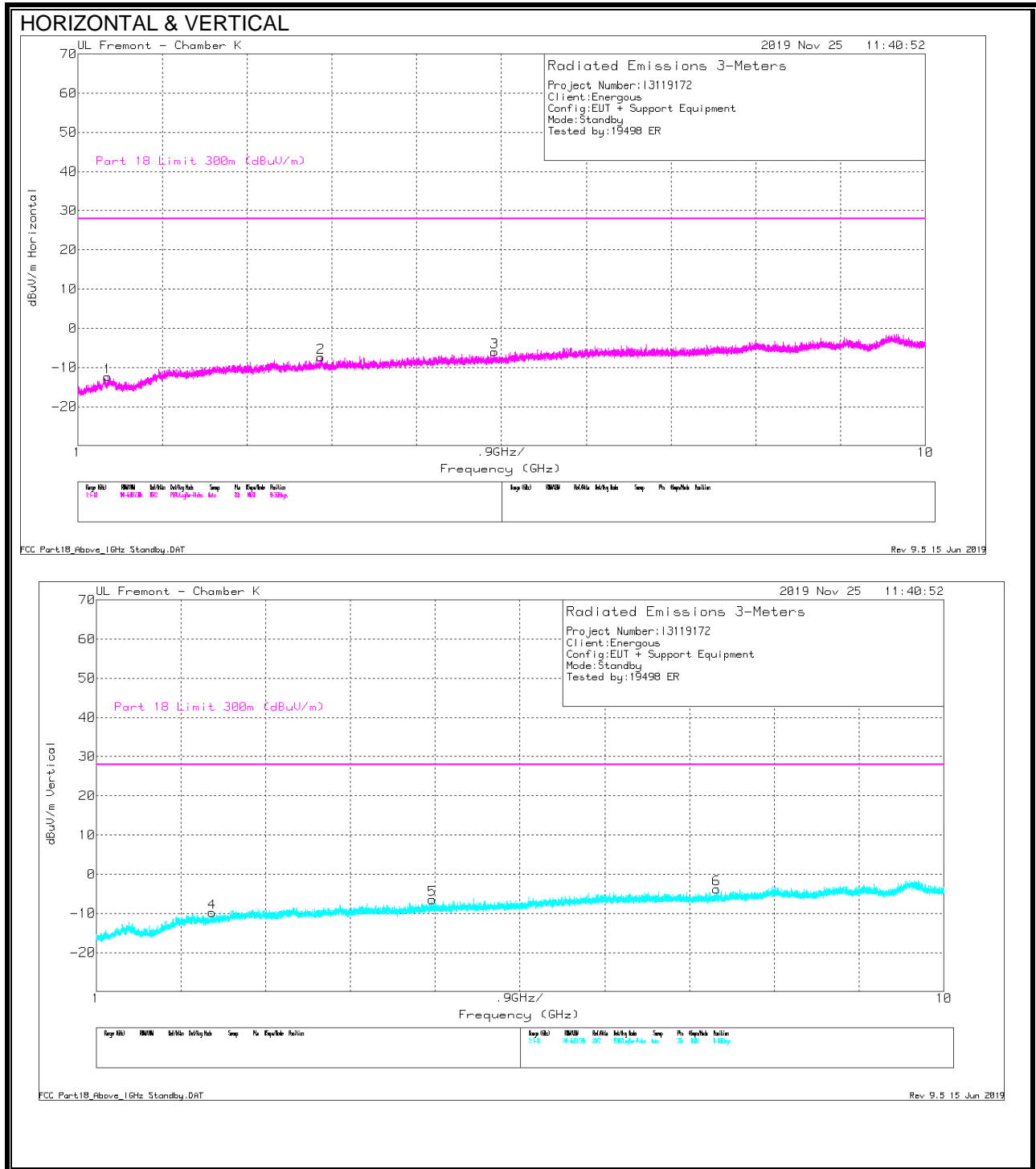
PK - Peak detector
 Qp - Quasi-Peak detector
 Av - Average detection

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

7.1.3. SPURIOUS EMISSIONS 1 GHz TO 10 GHz

STANDBY MODE



DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF EMC4294 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading dBuV/m	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.32324	29.14	ADR	29.2	-35.4	-40	-17.06	28	-45.06	225	135	H
2	3.58483	27.44	ADR	34	-33	-40	-11.56	28	-39.56	142	183	H
3	5.42447	24.96	ADR	34.5	-30.1	-40	-10.64	28	-38.64	115	292	H
4	2.23052	29.46	ADR	31.4	-35.4	-40	-14.54	28	-42.54	54	255	V
5	4.56969	25.93	ADR	33.9	-31.2	-40	-11.37	28	-39.37	165	174	V
6	7.58708	21.99	ADR	35.7	-26.7	-40	-9.01	28	-37.01	110	133	V

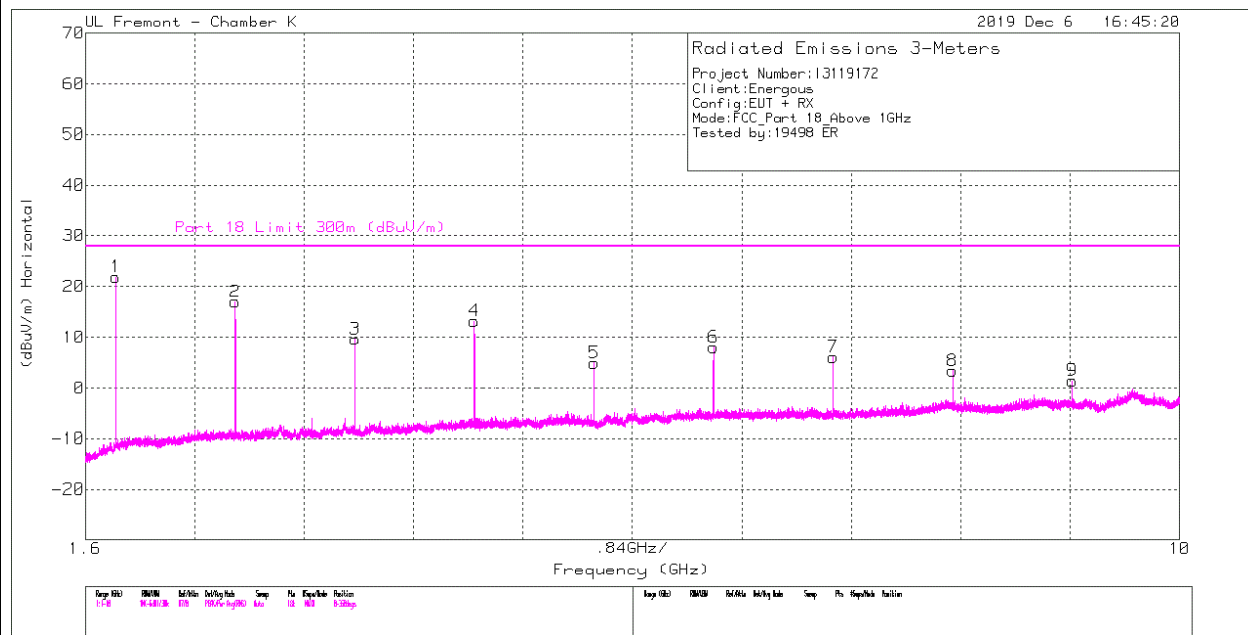
ADR - AD primary method, RMS average

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

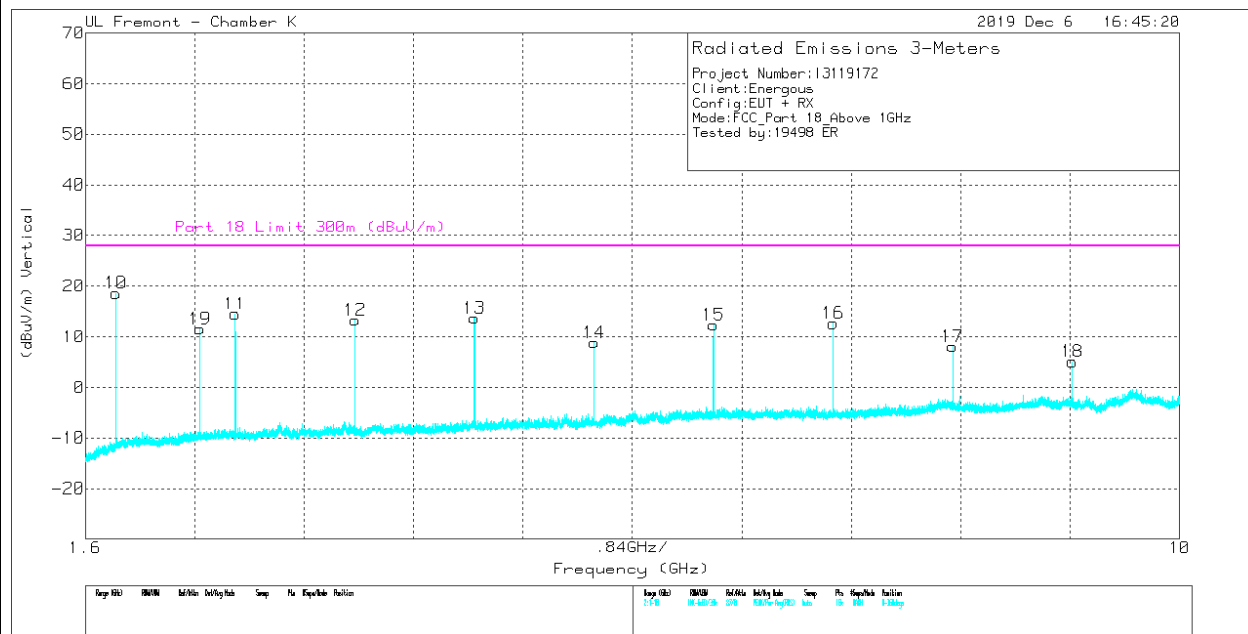
CHARGING MODE SPURIOUS EMISSION 1.6GHz to 10GHz with 1.5GHz HIGH PASS FILTER

HORIZONTAL & VERTICAL



FCC_Part18_Above_1GHz.DAT

Rev 9.5 15 Jun 2019



FCC_Part18_Above_1GHz.DAT

Rev 9.5 15 Jun 2019

DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF EMC4294 (dB/m)	Amp/Cbl (dB)	Fitr (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.83455	66.03	Pk	30.7	-35.4	1	-40	22.33	28	-5.67	0-360	199	H
2	2.7526	58.99	Pk	32.5	-35	1	-40	17.49	28	-10.51	0-360	199	H
3	3.67015	48.8	Pk	32.9	-32.6	1	-40	10.1	28	-17.9	0-360	98	H
4	4.5872	49.88	Pk	33.9	-31.1	1	-40	13.68	28	-14.32	0-360	98	H
5	5.50525	39.79	Pk	34.6	-30	1	-40	5.39	28	-22.61	0-360	199	H
6	6.4223	39.72	Pk	35.7	-27.9	1	-40	8.52	28	-19.48	0-360	199	H
7	7.33986	36.96	Pk	35.6	-27	1	-40	6.56	28	-21.44	0-360	199	H
8	8.25741	32.56	Pk	35.9	-25.6	1	-40	3.86	28	-24.14	0-360	98	H
9	9.17496	28.48	Pk	36.4	-24	1	-40	1.88	28	-26.12	0-360	199	H
10	1.83505	62.75	Pk	30.7	-35.4	1	-40	19.05	28	-8.95	0-360	101	V
11	2.7521	56.48	Pk	32.5	-35	1	-40	14.98	28	-13.02	0-360	101	V
12	3.66965	52.46	Pk	32.9	-32.6	1	-40	13.76	28	-14.24	0-360	199	V
13	4.58745	50.35	Pk	33.9	-31.1	1	-40	14.15	28	-13.85	0-360	101	V
14	5.50475	43.71	Pk	34.6	-30	1	-40	9.31	28	-18.69	0-360	199	V
15	6.4223	44.02	Pk	35.7	-27.9	1	-40	12.82	28	-15.18	0-360	199	V
16	7.33986	43.53	Pk	35.6	-27	1	-40	13.13	28	-14.87	0-360	199	V
17	8.25741	37.27	Pk	35.9	-25.6	1	-40	8.57	28	-19.43	0-360	199	V
18	9.17496	32.16	Pk	36.4	-24	1	-40	5.56	28	-22.44	0-360	199	V
19	2.47958	54.01	Pk	32.4	-35.4	1	-40	12.01	28	-15.99	0-360	101	V

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF EMC4294 (dB/m)	Amp/Cbl (dB)	Fitr (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	Part 18 Limit 300m (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
9	9.17494	29.18	ADR	36.4	-24	1	-40	2.58	28	-25.42	253	191	H
8	8.25745	32.11	ADR	35.9	-25.6	1	-40	3.41	28	-24.59	44	96	H
7	7.33994	37.56	ADR	35.6	-27	1	-40	7.16	28	-20.84	85	187	H
1	1.83499	67.84	ADR	30.7	-35.4	1	-40	24.14	28	-3.86	54	371	H
2	2.75248	58.35	ADR	32.5	-35	1	-40	16.85	28	-11.15	352	199	H
18	9.17493	31.28	ADR	36.4	-24	1	-40	4.68	28	-23.32	343	98	V
10	1.83499	62.55	ADR	30.7	-35.4	1	-40	18.85	28	-9.15	0	111	V
11	2.75248	56.45	ADR	32.5	-35	1	-40	14.95	28	-13.05	77	104	V
13	4.58747	50.91	ADR	33.9	-31.1	1	-40	14.71	28	-13.29	42	154	V
12	3.66997	53.5	ADR	32.9	-32.6	1	-40	14.8	28	-13.2	196	212	V

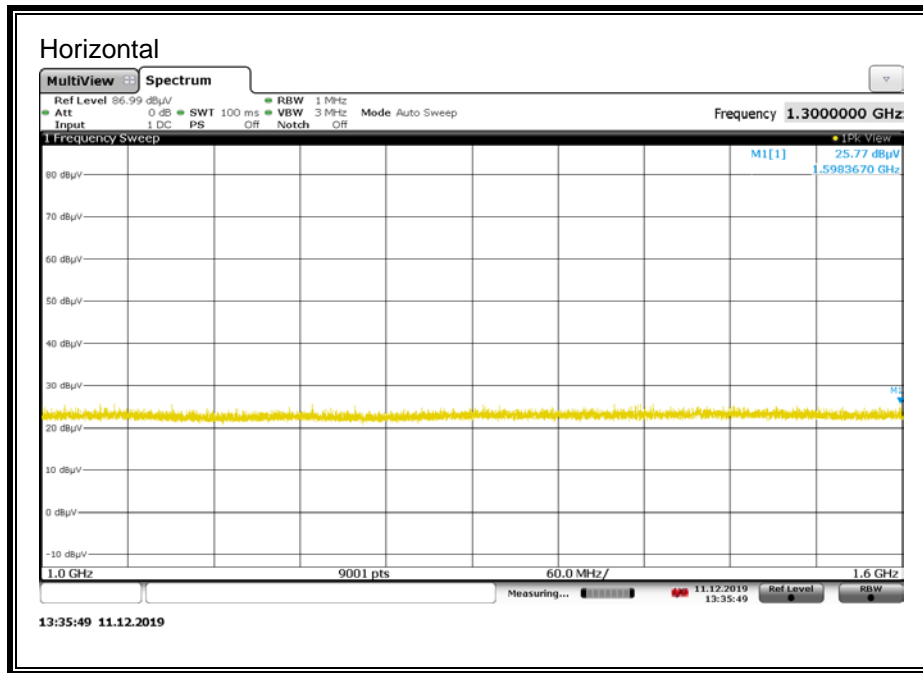
Pk - Peak detector
 ADR - AD primary method, RMS average

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$
- Marker 19 is BLE signal
- Frequency Range 1GHz – 1.6GHz was investigation using due to 1.5GHz high pass filter was used. See the following test result of frequency range 1G-1.6GHz.

Spurious Emissions 1GHz – 1.6GHz without a Notch Filter, without 1.5 GHz HPF, and without amplifier

Tested By 19498 ER



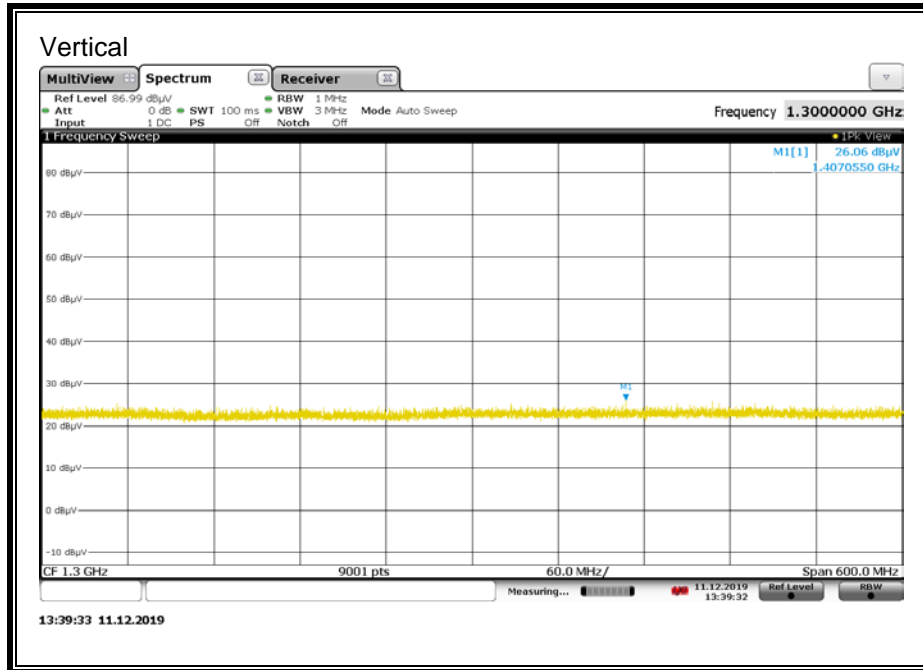
DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF EMC4294 (dB/m)	Cable (dB)	Dist Corr (dB)	Corrected Reading (dBuV/m)	FCC PART18 300m LIMIT (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.598	25.77	Pk	27.97	5.89	-40	19.63	28	-8.37	0-360	200	H

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$



DATA

Marker	Frequency (MHz)	Meter Reading (dBµV)	Det	AF EMC4294 (dB/m)	Cable (dB)	Dist Corr (dB)	Corrected Reading (dBµV/m)	FCC PART18 300m LIMIT (dBµV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.407	26.06	Pk	28.77	5.56	-40	20.39	28	-7.61	0-360	200	V

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.
- Distance factor from 3m to 300m = $20\log(3/300) = -40\text{dB}$

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 μ H/50 ohms line impedance stabilization network (LISN).

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

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	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.

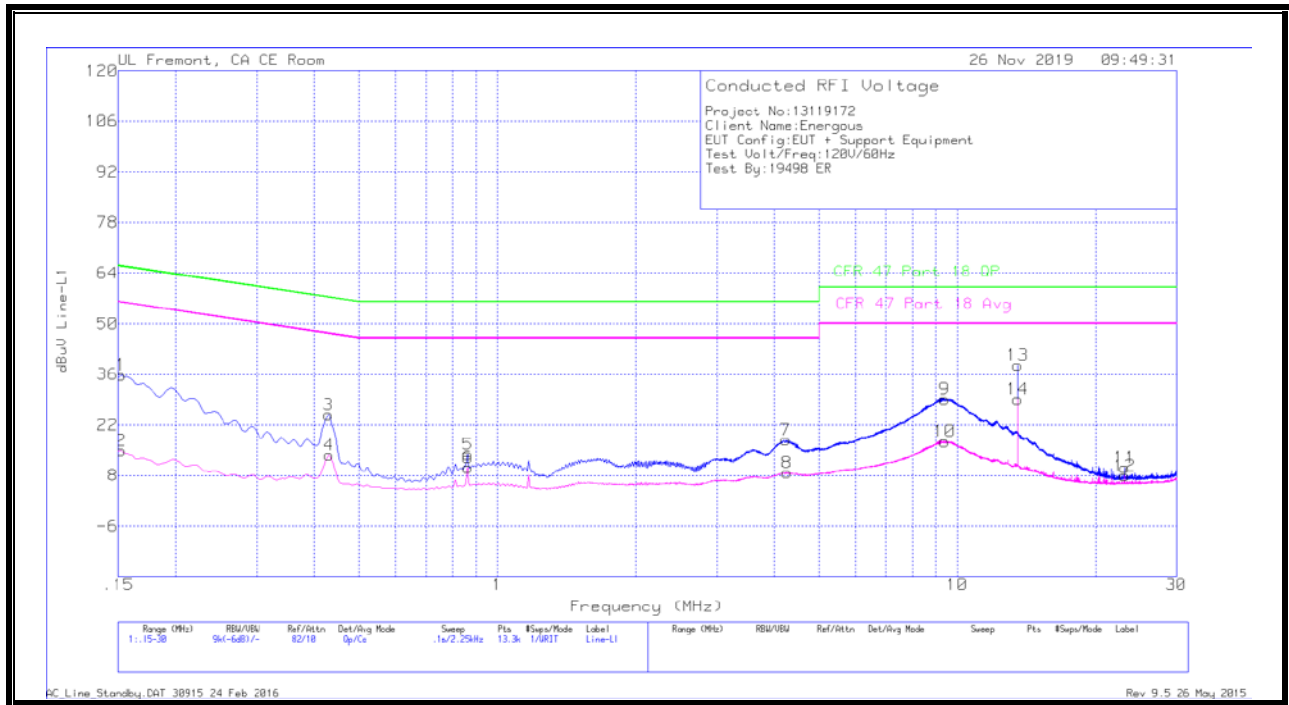
TEST PROCEDURE

Tested in accordance with FCC / OST MP-5

RESULTS

7.2.1. STANDBY MODE

LINE 1 RESULTS



WORST EMISSIONS

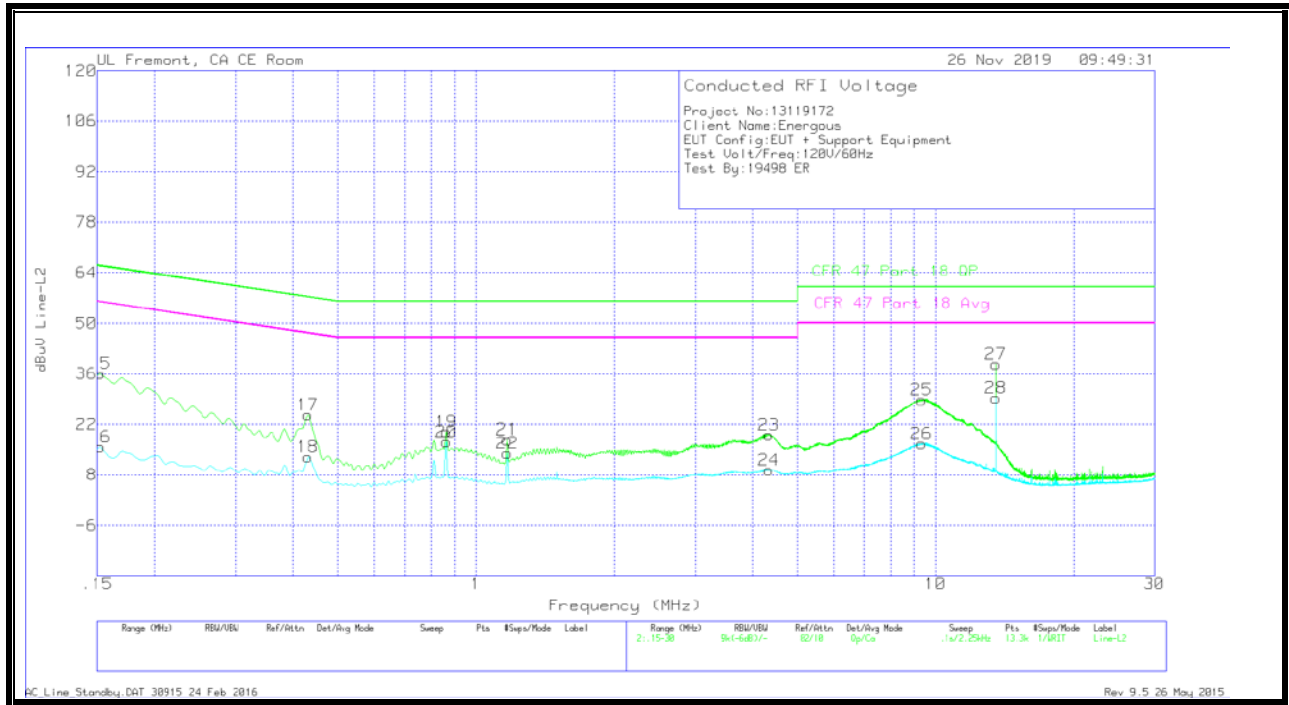
Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 18 QP	QP Margin (dB)	CFR 47 Part 18 Avg	Av(CISPR) Margin (dB)
1	.15225	25.63	Qp	.1	0	10.1	35.83	65.88	-30.05	-	-
2	.15225	4.76	Ca	.1	0	10.1	14.96	-	-	55.88	-40.92
3	.429	14.74	Qp	0	0	10.1	24.84	57.27	-32.43	-	-
4	.43125	3.63	Ca	0	0	10.1	13.73	-	-	47.23	-33.5
5	.861	3.74	Qp	0	0	10.1	13.84	56	-42.16	-	-
6	.861	.03	Ca	0	0	10.1	10.13	-	-	46	-35.87
7	4.23825	7.61	Qp	0	.1	10.1	17.81	56	-38.19	-	-
8	4.26075	-1.41	Ca	0	.1	10.1	8.79	-	-	46	-37.21
9	9.39975	18.78	Qp	0	.2	10.2	29.18	60	-30.82	-	-
10	9.402	7.01	Ca	0	.2	10.2	17.41	-	-	50	-32.59
11	23.1315	-.58	Qp	.1	.3	10.4	10.22	60	-49.78	-	-
12	23.1315	-2.86	Ca	.1	.3	10.4	7.94	-	-	50	-42.06
13	13.56	27.97	Qp	.1	.2	10.2	38.47	60	-21.53	-	-
14	13.56	18.61	Ca	.1	.2	10.2	29.11	-	-	50	-20.89

Qp - Quasi-Peak detector

Ca - CISPR average detection

NOTE: Markers 13 and 14, 13.56MHz is an ambient signal.

LINE 2 RESULTS



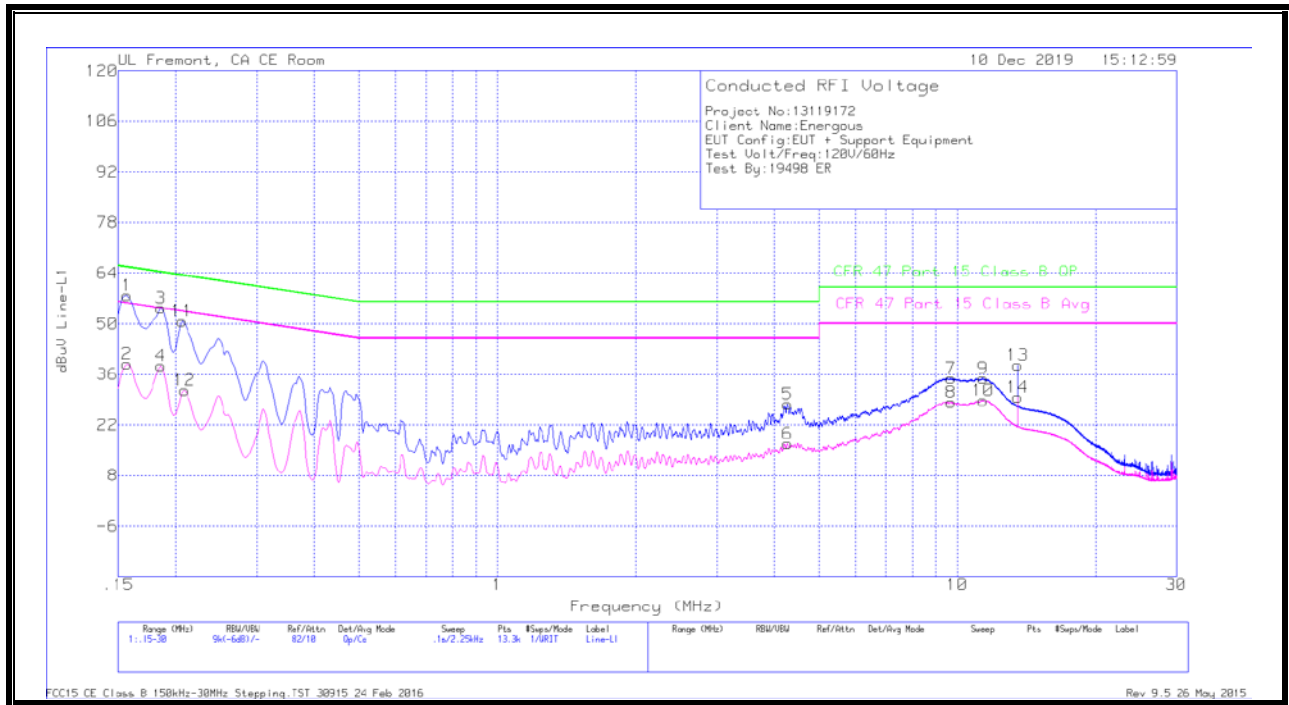
WORST EMISSIONS

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 18 QP	QP Margin (dB)	CFR 47 Part 18 Avg	Av(CISPR) Margin (dB)
15	.15225	25.9	Qp	.1	0	10.1	36.1	65.88	-29.78	-	-
16	.15225	5.49	Ca	.1	0	10.1	15.69	-	-	55.88	-40.19
17	.43125	14.6	Qp	0	0	10.1	24.7	57.23	-32.53	-	-
18	.43125	2.93	Ca	0	0	10.1	13.03	-	-	47.23	-34.2
19	.861	9.85	Qp	0	0	10.1	19.95	56	-36.05	-	-
20	.861	7.01	Ca	0	0	10.1	17.11	-	-	46	-28.89
21	1.16925	7.55	Qp	0	.1	10.1	17.75	56	-38.25	-	-
22	1.16925	3.78	Ca	0	.1	10.1	13.98	-	-	46	-32.02
23	4.3395	8.93	Qp	0	.1	10.1	19.13	56	-36.87	-	-
24	4.34175	-0.81	Ca	0	.1	10.1	9.39	-	-	46	-36.61
25	9.348	18.42	Qp	0	.2	10.2	28.82	60	-31.18	-	-
26	9.35025	6.19	Ca	0	.2	10.2	16.59	-	-	50	-33.41
27	13.56	28.13	Qp	.1	.2	10.2	38.63	60	-21.37	-	-
28	13.56	18.84	Ca	.1	.2	10.2	29.34	-	-	50	-20.66

Qp - Quasi-Peak detector
 Ca - CISPR average detection
 NOTE: Markers 27 and 28, 13.56MHz is an ambient signal.

7.2.2. CHARGING MODE

LINE 1 RESULTS



WORST EMISSIONS

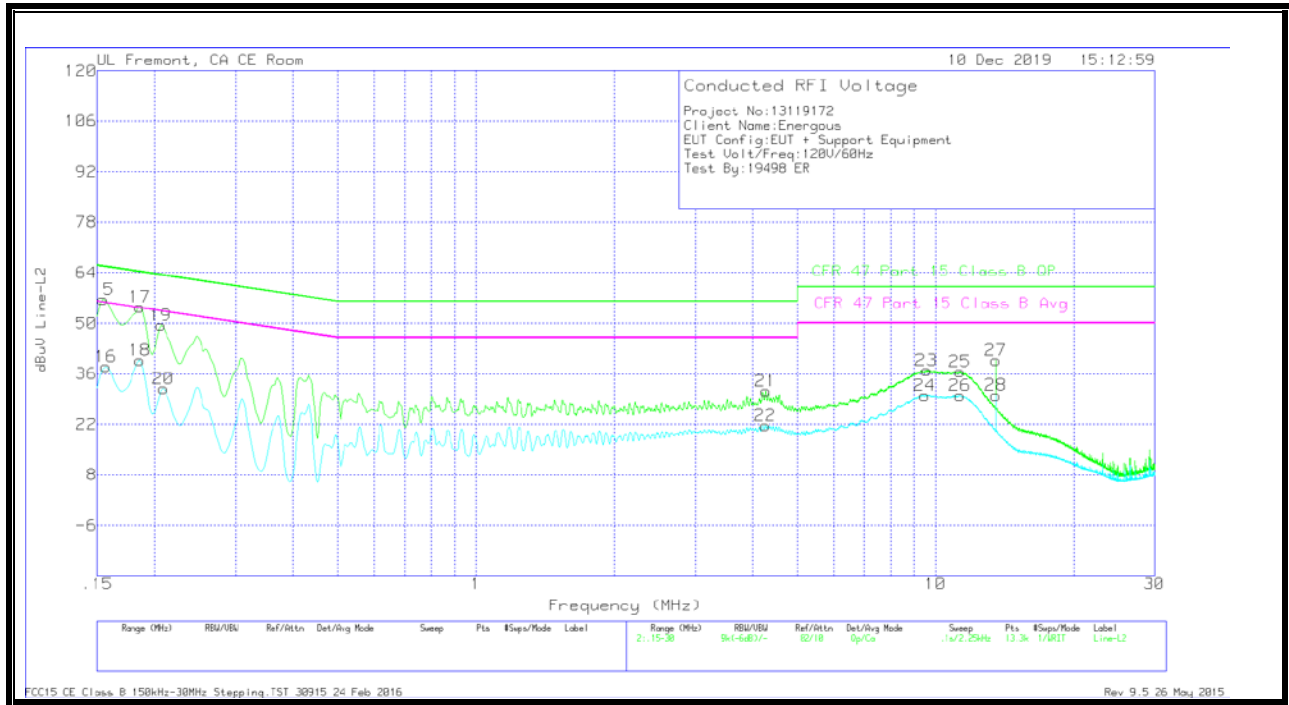
Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR) Margin (dB)
1	.15675	47.58	Qp	.1	0	10.1	57.78	65.63	-7.85	-	-
2	.15675	28.63	Ca	.1	0	10.1	38.83	-	-	55.63	-16.8
3	.186	44.25	Qp	0	0	10.1	54.35	64.21	-9.86	-	-
4	.186	28.24	Ca	0	0	10.1	38.34	-	-	54.21	-15.87
5	4.2765	17.55	Qp	0	.1	10.1	27.75	56	-28.25	-	-
6	4.272	6.57	Ca	0	.1	10.1	16.77	-	-	46	-29.23
7	9.6945	24.53	Qp	0	.2	10.2	34.93	60	-25.07	-	-
8	9.69	17.93	Ca	0	.2	10.2	28.33	-	-	50	-21.67
9	11.3955	24.4	Qp	.1	.2	10.2	34.9	60	-25.1	-	-
10	11.39775	18.35	Ca	.1	.2	10.2	28.85	-	-	50	-21.15
11	.20625	40.68	Qp	0	0	10.1	50.78	63.35	-12.57	-	-
12	.2085	21.43	Ca	0	0	10.1	31.53	-	-	53.26	-21.73
13	13.56	28	Qp	.1	.2	10.2	38.5	60	-21.5	-	-
14	13.56	19.17	Ca	.1	.2	10.2	29.67	-	-	50	-20.33

Qp - Quasi-Peak detector

Ca - CISPR average detection

NOTE: Markers 13 and 14, 13.56MHz is an ambient signal.

LINE 2 RESULTS



WORST EMISSIONS

Range 2: Line-L2 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Limiters (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)
15	.1545	46.41	Qp	.1	0	10.1	56.61	65.75	-9.14	-	-
16	.15675	27.78	Ca	.1	0	10.1	37.98	-	-	55.63	-17.65
17	.186	44.44	Qp	0	0	10.1	54.54	64.21	-9.67	-	-
18	.186	29.6	Ca	0	0	10.1	39.7	-	-	54.21	-14.51
19	.20625	39.41	Qp	0	0	10.1	49.51	63.35	-13.84	-	-
20	.2085	21.85	Ca	0	0	10.1	31.95	-	-	53.26	-21.31
21	4.272	21	Qp	0	.1	10.1	31.2	56	-24.8	-	-
22	4.263	11.53	Ca	0	.1	10.1	21.73	-	-	46	-24.27
23	9.56625	26.53	Qp	0	.2	10.2	36.93	60	-23.07	-	-
24	9.483	19.6	Ca	0	.2	10.2	30	-	-	50	-20
25	11.32575	26.15	Qp	.1	.2	10.2	36.65	60	-23.35	-	-
26	11.31	19.52	Ca	.1	.2	10.2	30.02	-	-	50	-19.98
27	13.56	29.24	Qp	.1	.2	10.2	39.74	60	-20.26	-	-
28	13.56	19.59	Ca	.1	.2	10.2	30.09	-	-	50	-19.91

Qp - Quasi-Peak detector

Ca - CISPR average detection

NOTE: Markers 27 and 28, 13.56MHz is an ambient signal.