



TEST REPORT

Report Number. : 13947251-E1V6

Applicant : ENERGOUS CORPORATION
3590 NORTH FIRST STREET,
SUITE 210,
SAN JOSE, CA 95134, U.S.A.

Model : VN15

Brand : ENERGOUS

FCC ID : 2ADNG-VN15

EUT Description : WIRELESS CHARGER

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C

Date Of Issue:

October 08, 2021

Prepared by:

UL VERIFICATION SERVICES

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REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/18/2021	Initial Issue	--
V2	8/23/2021	Updated page 6 with engineers' name added. Updated company address.	Tina Chu
V3	9/1/2021	Updated number of pulses plot on Section 9.5, Section 1 testing date and Section 7	Tina Chu
V4	9/2/2021	Updated number of pulses plot on Section 9.5	Tina Chu
V5	9/14/2021	Updated naming on Section 9.5 result table/plots	Tina Chu
V6	10/8/2021	Modified EUT description in Section 6.1	Tina Chu

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: ENERGOUS CORPORATION
3590 NORTH FIRST STREET,
SUITE 210,
SAN JOSE, CA 95134, U.S.A.

EUT DESCRIPTION: WIRELESS CHARGER

MODEL: VN15

BRAND: ENERGOUS

SERIAL NUMBER: 100D (CONDUCTED); 1012 & 100C (RADIATED)

SAMPLE RECEIPT DATE: AUGUST 02, 2021

DATE TESTED: AUGUST 02, 2021 – SEPTEMBER 01, 2021

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 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 A2LA, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released For
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2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for the validity of results after the integration of the data provided by the customer.

FCC Clause	Requirement	Result	Comment
See Comment	Duty Cycle	Reporting purposes only	Per ANSI C63.10, Section 11.6.
FCC §15.247 (a)(1)(i)	20dB BW/99% OBW	Complies	ANSI C63.10 Sections 6.9.2 and 6.9.3
15.247 (a)(1)	Hopping Frequency Separation	Complies	None.
15.247 (a)(1)(i)	Number of Hopping Channels	Complies	None.
15.247 (a)(1)(i)	Average Time of Occupancy	Complies	None.
15.247 (b)(2)	Output Power	Complies	None.
See Comment	Average Power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (d)	Conducted Spurious Emissions	Complies	None.
15.209, 15.205	Radiated Emissions	Complies	None.
15.207	AC Mains Conducted Emissions	Complies	None.

3. 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 v05r01, KDB 414788 D01 Radiated Test Site v01r01.

4. FACILITIES AND ACCREDITATION

UL Verification Services Inc. is accredited by A2LA, Certificate Number 0751.05, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
<input type="checkbox"/>	Building 1: 47173 Benicia Street, Fremont, California, USA	US0104	2324A	208313
<input type="checkbox"/>	Building 2: 47266 Benicia Street, Fremont, California, USA	US0104	22541	208313
<input checked="" type="checkbox"/>	Building 4: 47658 Kato Rd, Fremont, California, USA	US0104	2324B	208313

5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	U _{Lab}
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.78 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.40 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.84 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	6.01 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.73 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.51 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.29 dB

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

5.4. 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)

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

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.

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

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is a stand-alone wireless charger with BLE that is mounted on a ceiling or wall. The wireless charger transmits power via a frequency hopping signal between 916.5MHz to 918.1MHz and charges multiple receivers at a time.

6.2. MAXIMUM OUTPUT POWER

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

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
916.5 to 918.1	Normal	29.65	922.57

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

The radio utilizes an Patch antenna, with a maximum gain of 5 dBi.

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 5.0.255.255_2054

The test utility software used during testing was 5.0.255.255_2054

6.5. 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,Z, it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

BLE and WPT can transmit simultaneously, all radiated testing is with BLE in normal operating mode as the worst case.

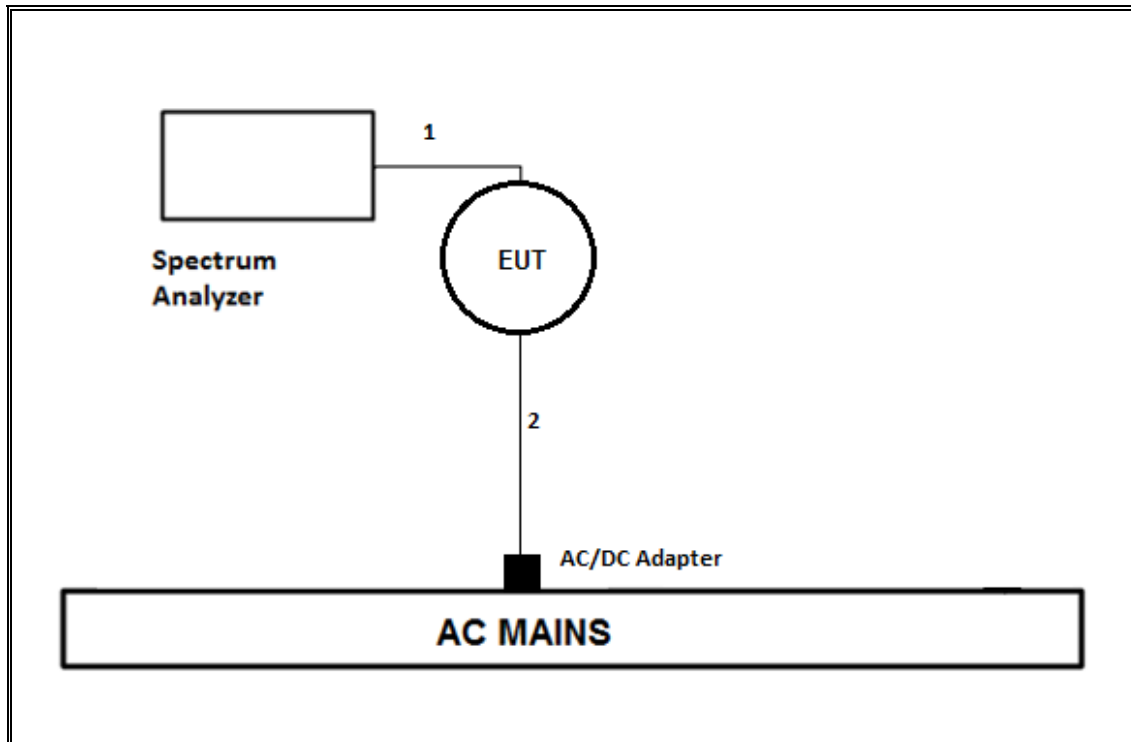
6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT						
Description	Manufacturer	Model	Serial Number	FCC ID/ DoC		
EUT AC/DC Adapter (30W)	Anker	A2013	AEYSCP0A50102610	DoC		
I/O CABLES (RF CONDUCTED TEST)						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	Antenna	1	SMA	Un-shielded	0.1	To spectrum analyzer
2	USB	1	USB Type C	Un-shielded	1	N/A
I/O CABLES (RF RADIATED/AC POWER LINE TEST)						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	USB	1	USB Type C	Un-shielded	1	N/A

TEST SETUP

The EUT is powered by AC/DC adapter via USB cable.

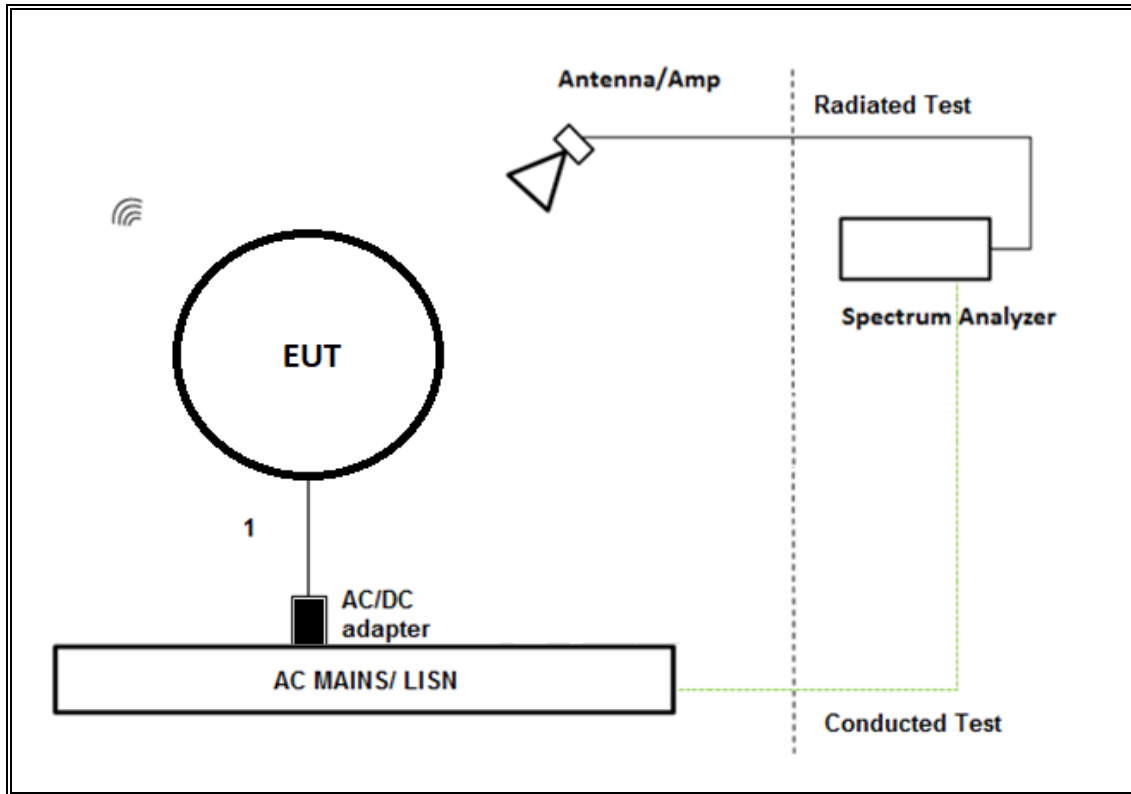
SETUP DIAGRAMS



TEST SETUP- RADIATED TEST/AC POWER LINE TEST

The EUT is powered by AC/DC adapter via USB cable.

SETUP DIAGRAM



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	Asset	Cal Due
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO METRICS	EM-6871	SC-8015	05/24/2022
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO METRICS	EM-6872	SC-8014	05/24/2022
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	08/31/2021
Amplifier, 100MHz-18GHz	AMPLICAL	AMP0.1G18-47-20	PRE0197319	04/08/2022
Antenna, Broadband Hybrid, 30MHz to 2GHz	Sunol Sciences Corp.	JB3	81560	09/24/2021
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	175953	01/21/2022
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	PRE0179367	02/21/2022
Filter, BRF 902 to 928MHz	MICRO-TRONICS	BRC50722	T1847	04/08/2022
Filter, Highpass 1.5GHz	MICRO-TRONICS	HPM50114	85494	07/30/2022
Spectrum Analyzer, PSA, 3Hz to 26.5GHz	Keysight Technologies Inc	E4440A	T198	05/13/2022
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	T1272	01/21/2022
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	T1223	06/17/2022
AC Line Conducted				
Description	Manufacturer	Model	ID Num	Cal Due
LISN	Fischer Custom Communications, Inc	FCC-LISN-50/250-25-2-01-480V	PRE0186446	01/20/2022
EMI TEST RECEIVER	Rohde & Schwarz	ESR	T1436	02/19/2022
Transient Limiter	COM-POWER	LIT-930A	PRE0213145	01/20/2022
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Rev 9.5, Jul 29, 2021, Aug 2, 2021	
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 07 Jul 2020	

8. MEASUREMENT METHODS

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

Occupied BW (20dB): ANSI C63.10-2013 Section 6.9.2

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

Carrier Frequency Separation: ANSI C63.10-2013 Section 7.8.2

Number of Hopping Frequencies: ANSI C63.10-2013 Section 7.8.3

Time of Occupancy (Dwell Time): ANSI C63.10-2013 Section 7.8.4

Peak Output Power: ANSI C63.10-2013 Section 7.8.5

Conducted Spurious Emissions: ANSI C63.10-2013 Section 7.8.8

Conducted Band-Edge: ANSI C63.10-2013 Section 6.10.4

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

Radiated Spurious Emissions 30-1000MHz: ANSI C63.10-2013 Section 6.3 and 6.5

Radiated Spurious Emissions above 1GHz: ANSI C63.10-2013 Section 6.3 and 6.6

Radiated Band-edge: ANSI C63.10-2013 Section 6.10.5

AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

ANSI C63.10, Section 11.6 : 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/T Minimum VBW (kHz)
WPT	1.00	1.00	1.000	100.00	0.00	0.010

Test Engineer: 19498 ER



9.2. 20 dB AND 99% BANDWIDTH

LIMITS

FCC §15.247 (a) (1)(i)

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

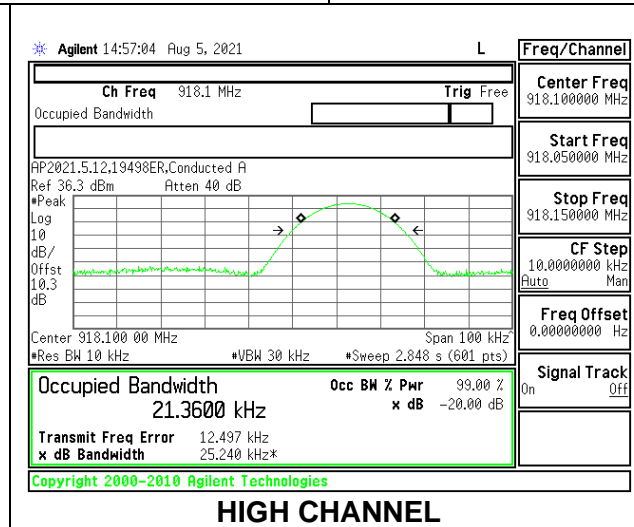
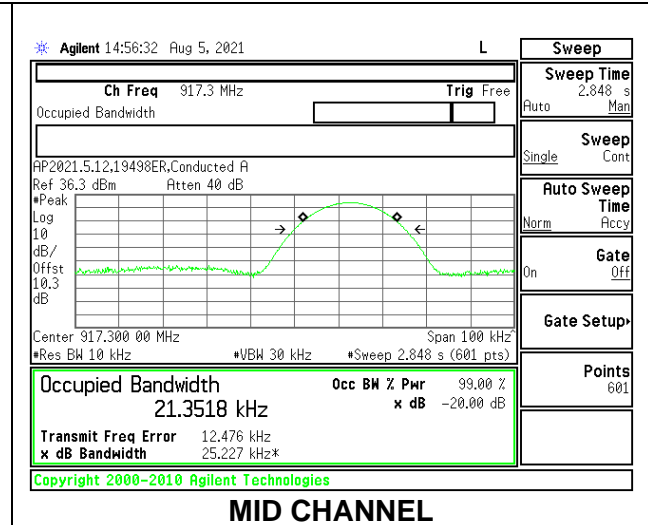
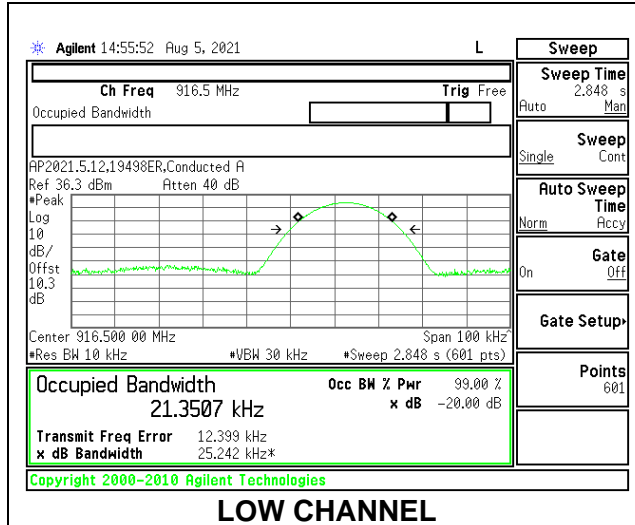
TEST PROCEDURE

The RBW is set to 10kHz. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

Note: Because the measured signal is CW or CW-like adjusting the RBW per C63.10 would not be practical since measured bandwidth will always follow the RBW and the result will be approximately twice the RBW.

RESULTS

Channel	Frequency (MHz)	20dB Bandwidth (kHz)	99% Bandwidth (kHz)
Low	916.5	25.242	21.3507
Mid	917.3	25.227	21.3518
High	918.1	25.240	21.3600



9.3. HOPPING FREQUENCY SEPARATION

LIMITS

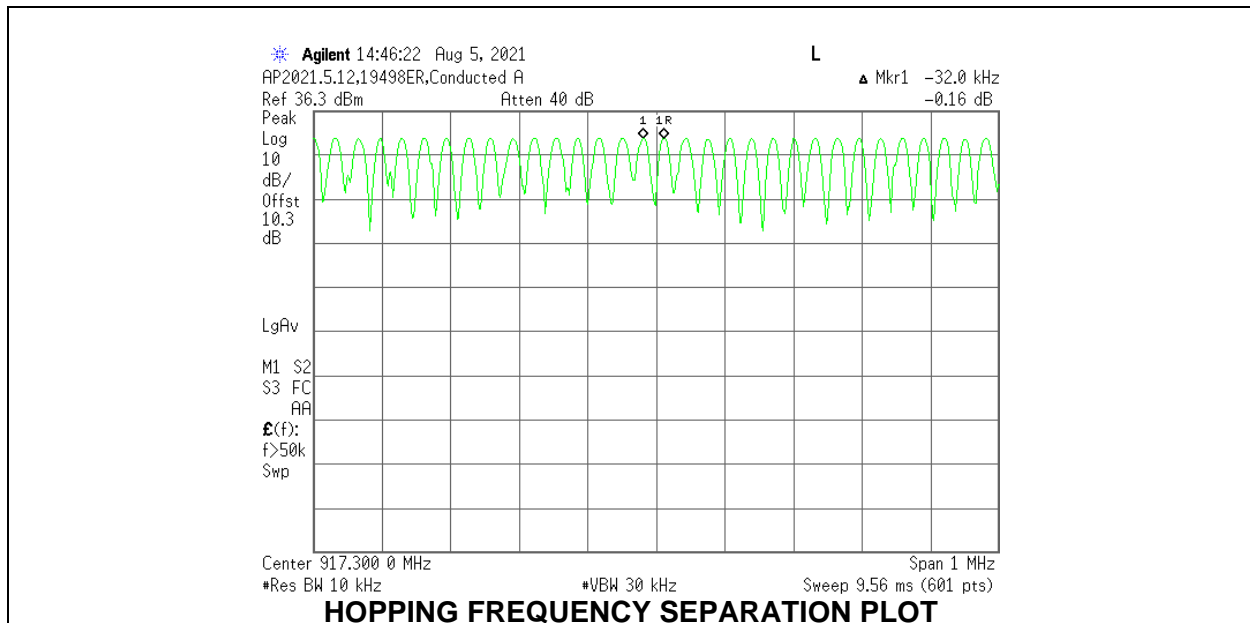
FCC §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 10 kHz and the VBW is set to 30 kHz. The sweep time is coupled.

RESULTS



9.4. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (i)

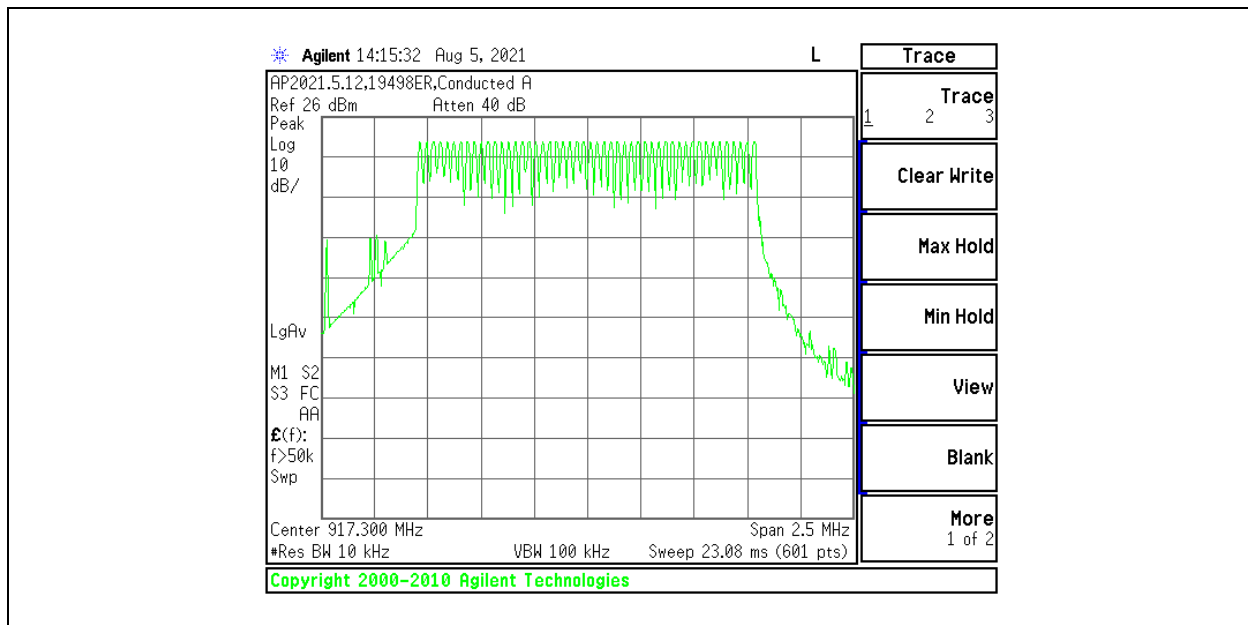
(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW (set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.) is set to 10 kHz and the VBW is set to > RBW. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 50 Channels Observed



9.5. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (i)

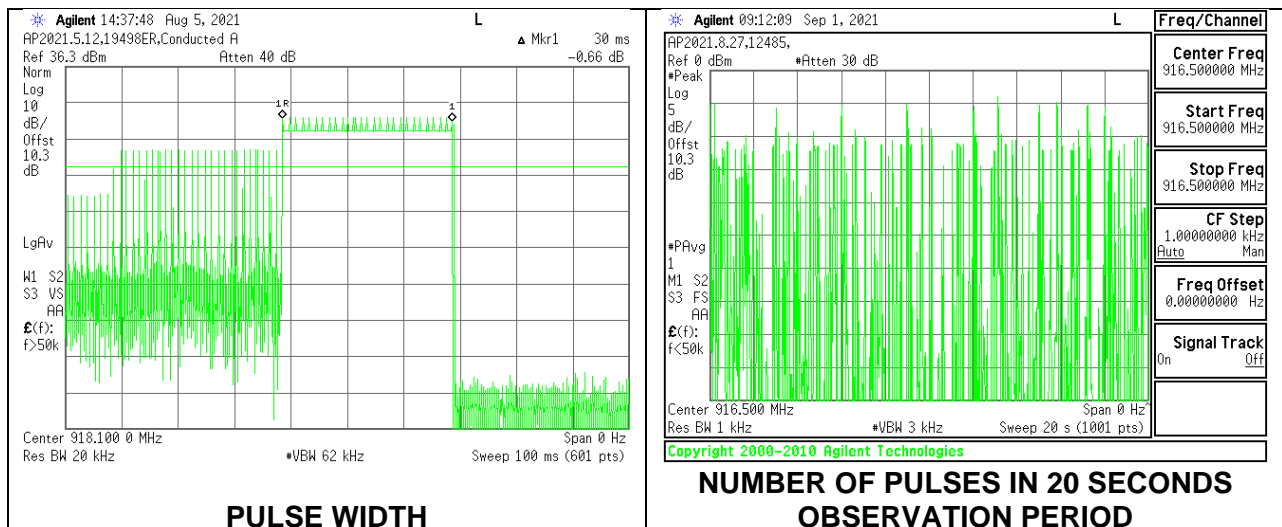
(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period;

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 5 second scan, to enable resolution of each occurrence.

RESULTS

Pulse Width (msec)	Number of Pulses in 20 seconds	Average Time of Occupancy in 20 seconds (sec)	Limit (sec)	Margin (sec)
30	11	0.3300	0.4	-0.0700



9.6. OUTPUT POWER

LIMITS

15.247 (b) (2)

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels as permitted under paragraph (a)(1)(i) of this section.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter via wideband peak power sensor. Peak output power was read directly from power meter.

RESULTS

Tested By:	19498 ER
Date:	8/2/2021

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	916.5	29.57	30	-0.43
Middle	917.3	29.58	30	-0.42
High	918.1	29.65	30	-0.35

9.7. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

The transmitter output is connected to a power meter.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter via wideband average power sensor. Gated average output power was read directly from power meter.

RESULTS

Tested By:	19498 ER
Date	8/2/2021

Channel	Frequency (MHz)	Average Power (dBm)
Low	916.5	29.52
Middle	917.3	29.53
High	918.1	29.59

9.8. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

Limit = -20 dBc

TEST PROCEDURE

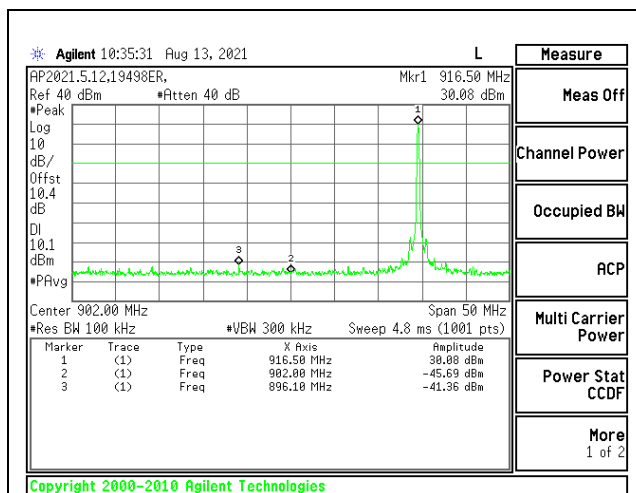
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

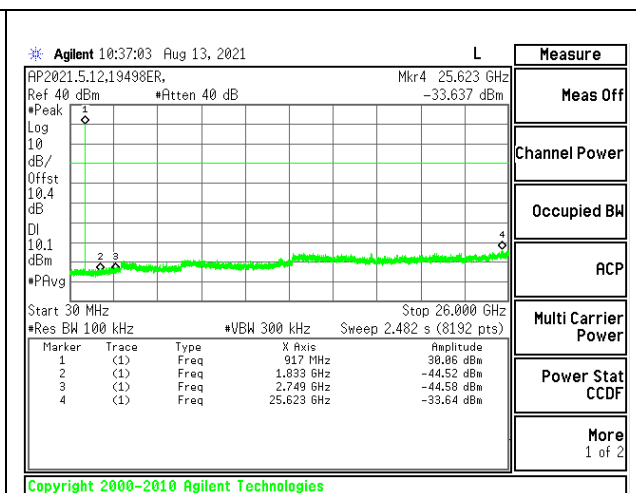
The bandedges at 902MHz and 928MHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

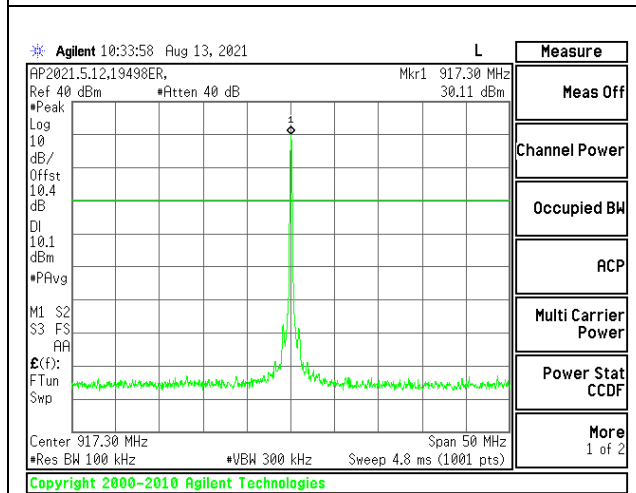
SPURIOUS EMISSIONS, NON-HOPPING



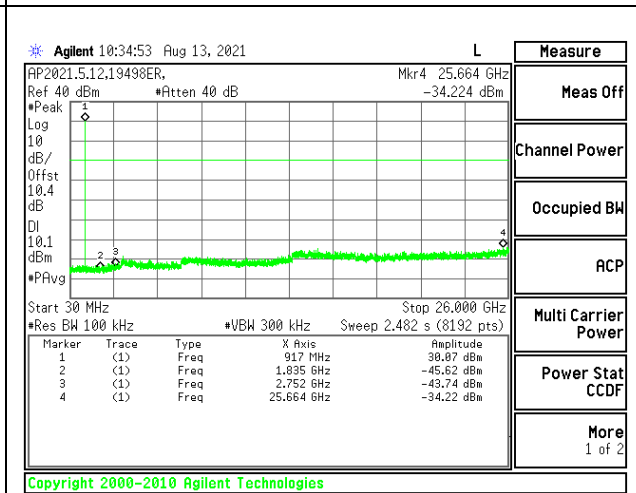
LOW CHANNEL BANDEDGE



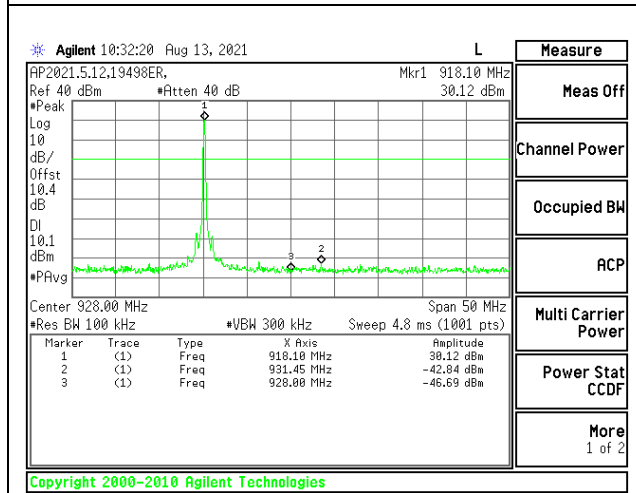
OUT-OF-BAND LOW CHANNEL



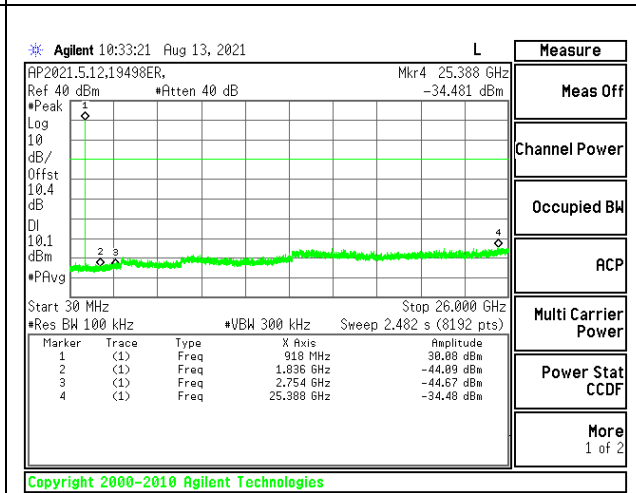
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

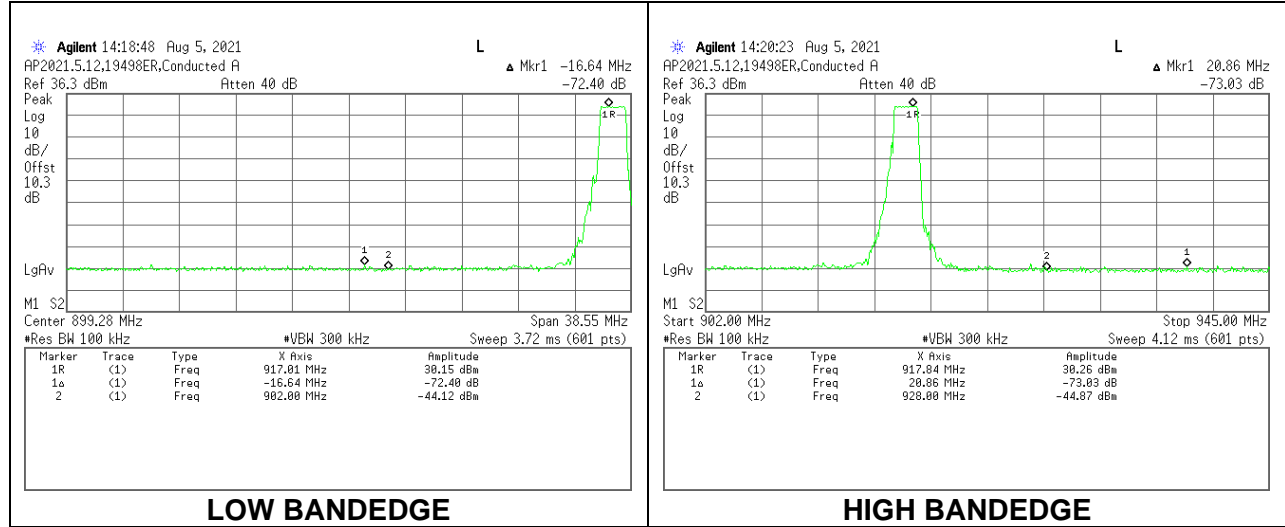


HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



10. RADIATED TEST RESULTS

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 in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9 to 150kHz range. Peak detection is used unless otherwise noted as quasi-peak or average (9-90kHz and 110-490kHz).

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 1 MHz resolution bandwidth with 1/T video bandwidth with peak detector 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.

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.

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.

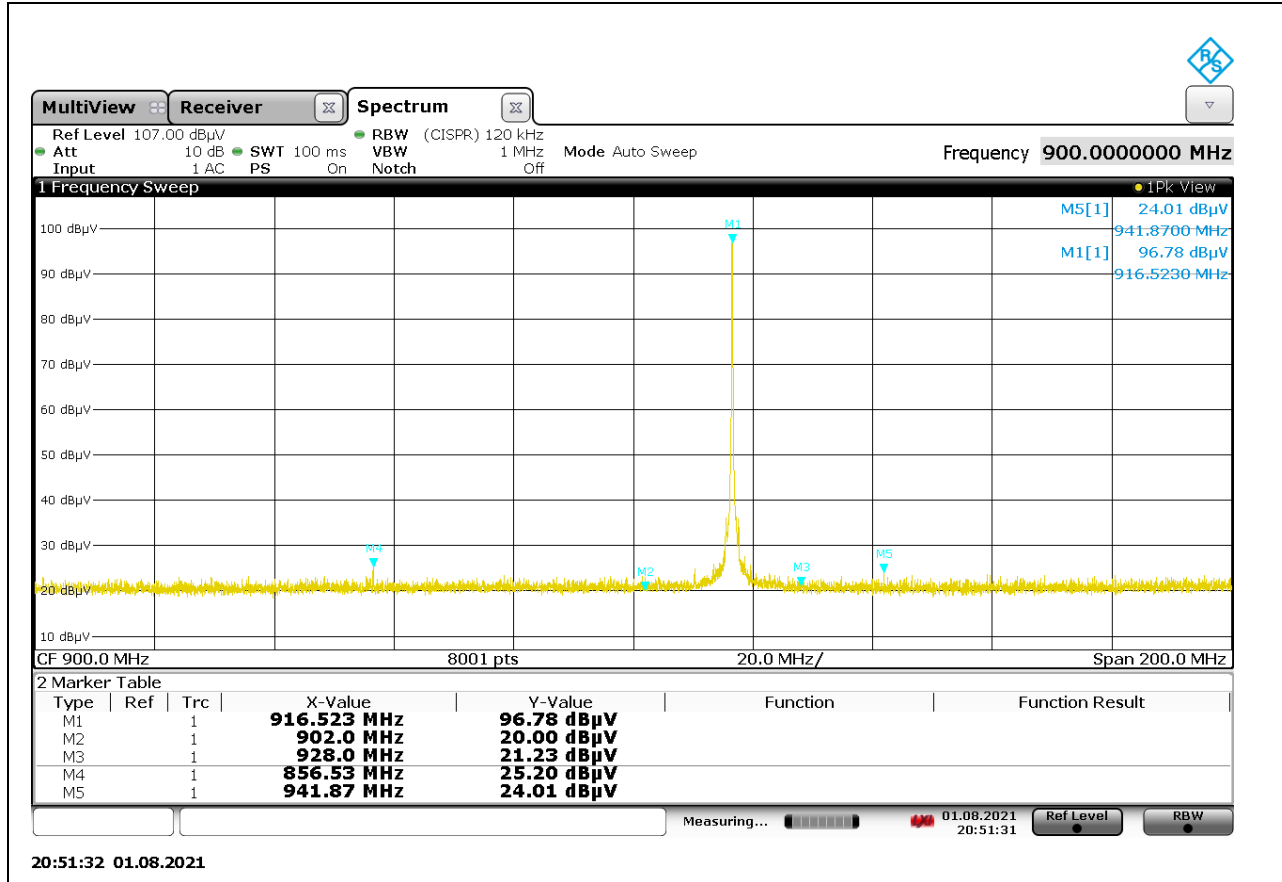
KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

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

10.1. TRANSMITTER BELOW 1 GHz

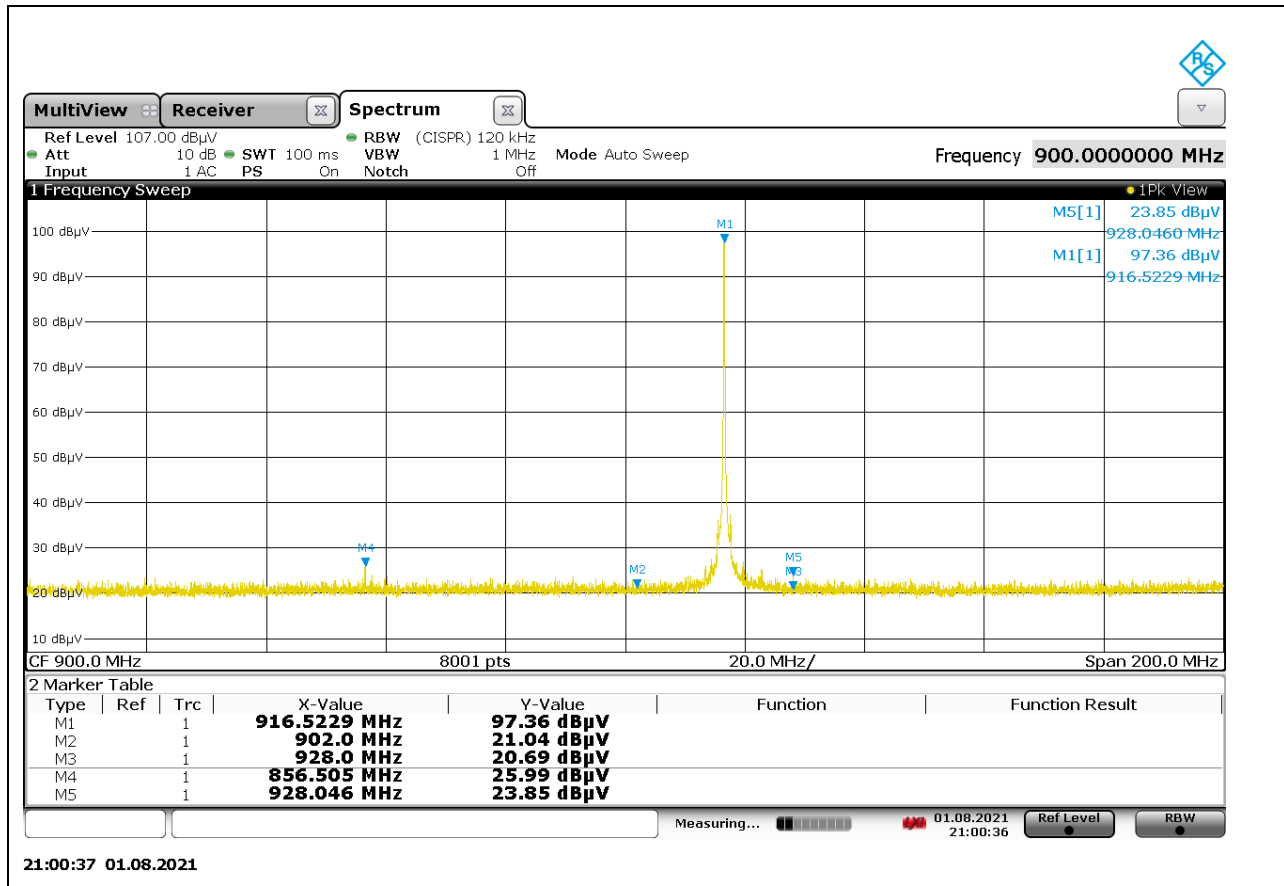
-20 dBc BANDEDGE WITHOUT NOTCH FILTER AND PRE-AMPLIFIER (LOW CHANNEL)

HORIZONTAL RESULT



M4 and M5 are not under restricted bands. With 20dBc from M1 96.78 dBuV= 76.78dBuV as limit, all of the M4 and M5 are passing.

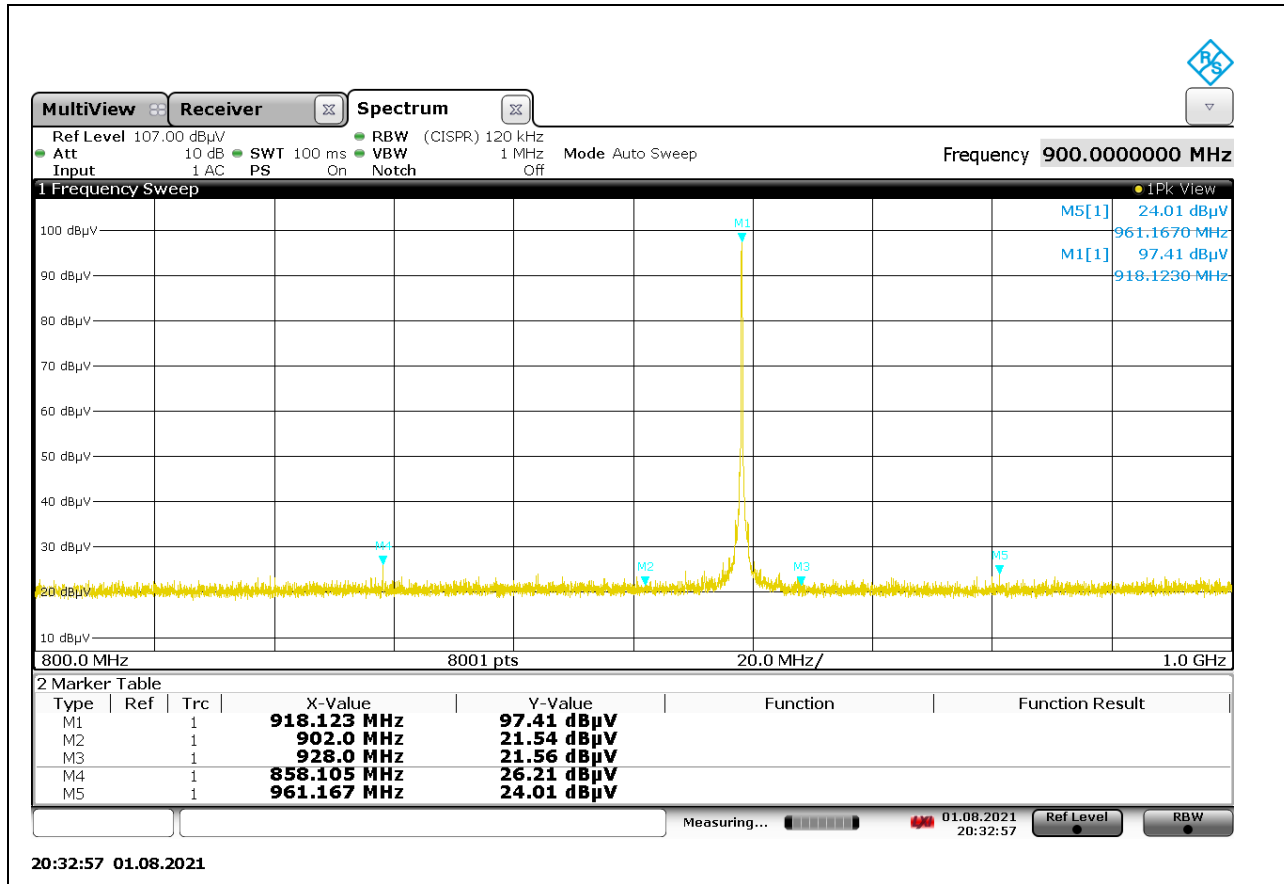
VERTICAL RESULT



M4 and M5 are not under restricted bands. With 20dBc from M1 97.36 dBuV= 77.36 dBuV as limit, all of the M4 and M5 are passing.

-20 dBc BANDEDGE WITHOUT NOTCH FILTER AND PRE-AMPLIFIER (HIGH CHANNEL)

HORIZONTAL RESULT



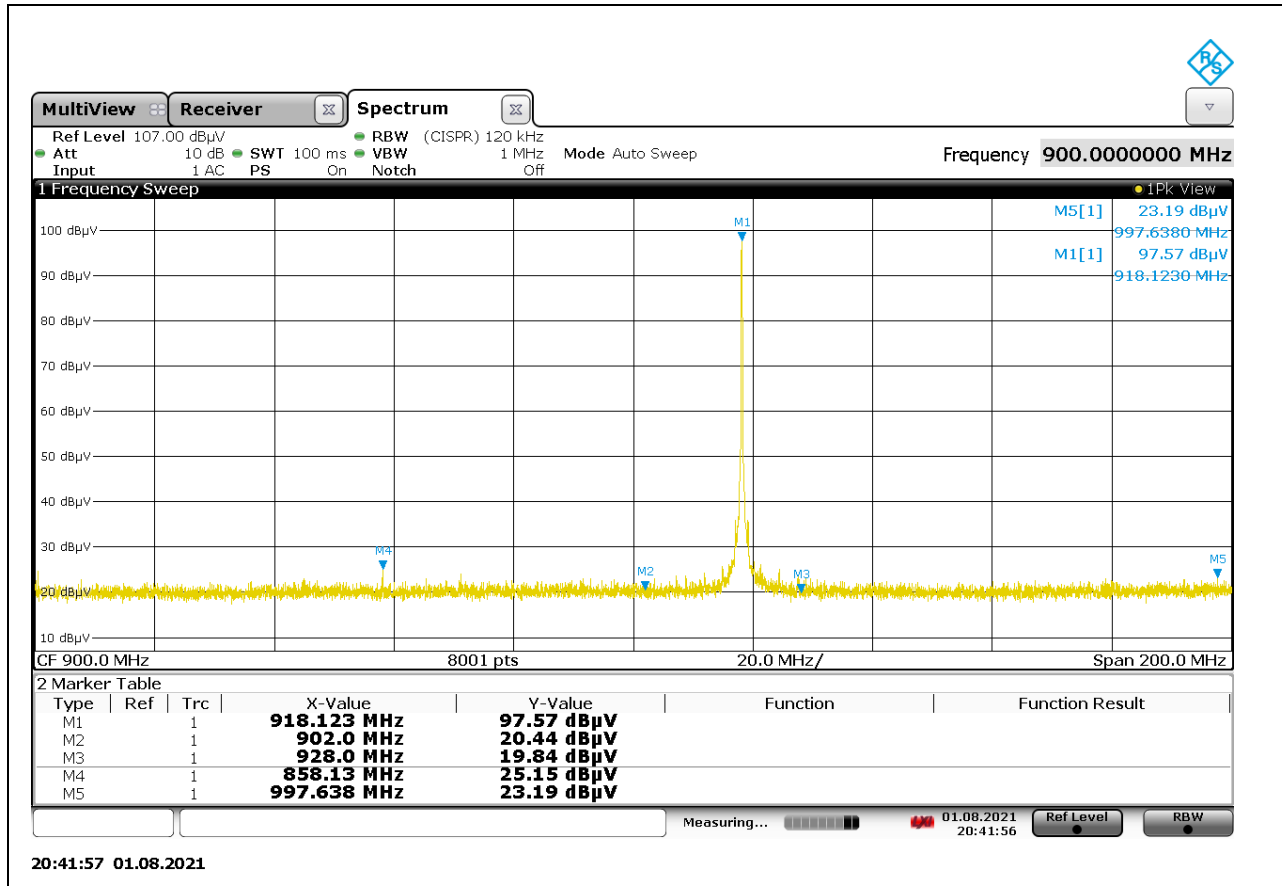
Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF 81560 (dB/m)	Bypass	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
961.167	24.01	Pk	29.3	4.1	57.41	46.02	11.39	0-360	100-400	H
* 965.665	1.02	Qp	29.4	4.1	34.52	46.02	-11.5	202	145	H

Pk – Peak detector
 Qp - Quasi-Peak detector

M4 is not under restricted bands. With 20dBc from M1 97.41 dBuV= 77.41 dBuV as limit, M4 is passing.

VERTICAL RESULT



Radiated Emissions

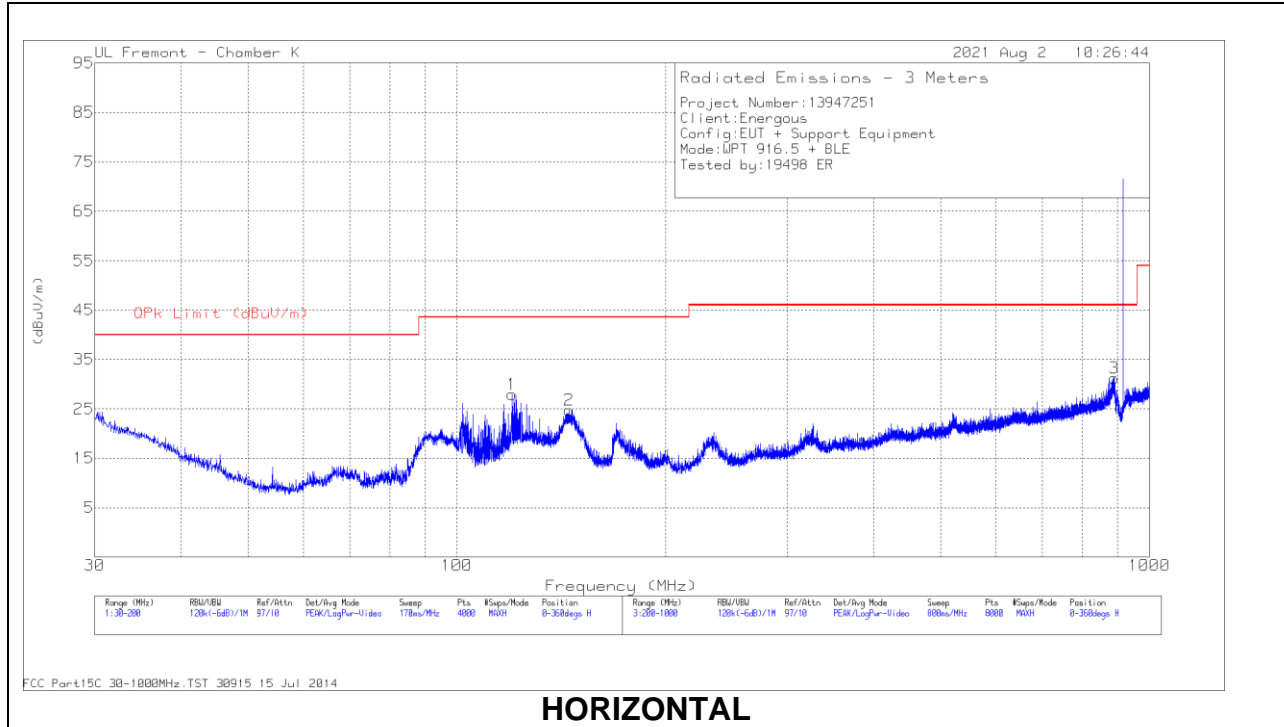
Frequency (MHz)	Meter Reading (dBuV)	Det	AF 81560 (dB/m)	Bypass	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
997.638	23.19	Pk	29.7	4.3	57.19	46.02	11.17	0-360	100-400	V
* 996.1808	1.65	Qp	29.7	4.3	35.65	46.02	-10.37	308	247	V

Pk – Peak detector
 Qp - Quasi-Peak detector

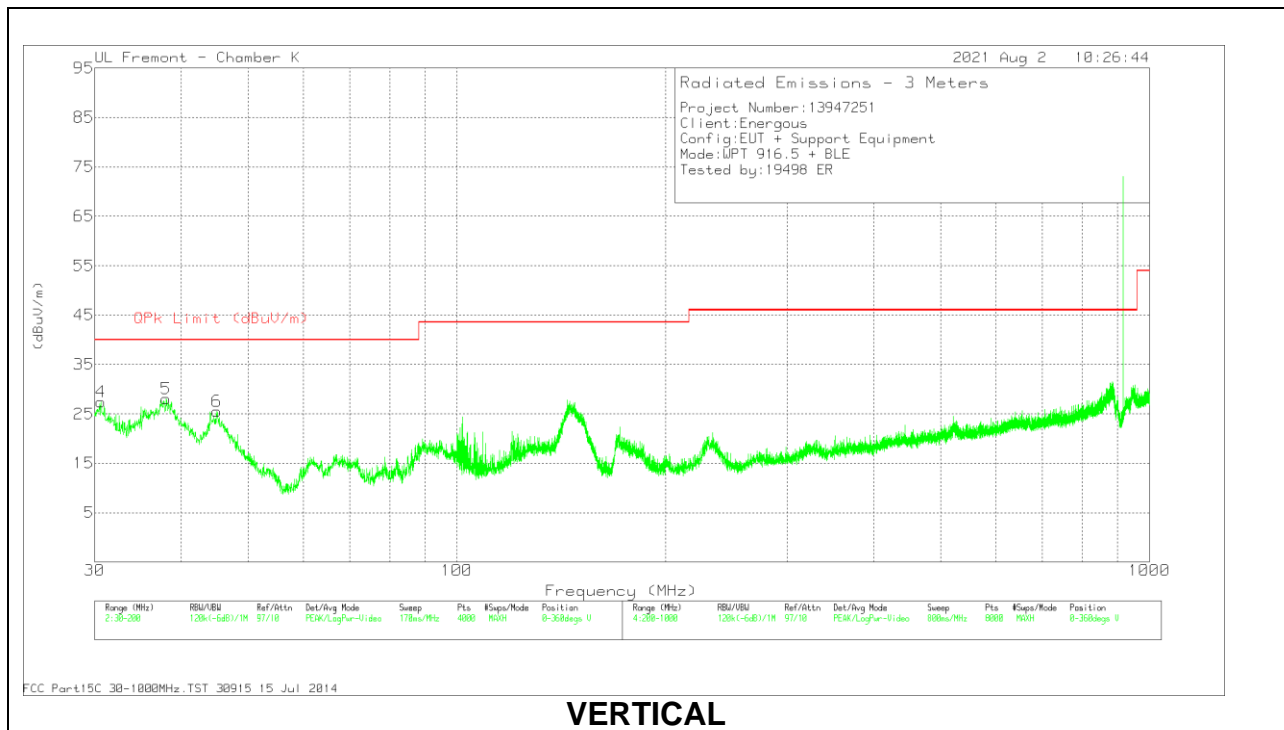
M4 is not under restricted bands. With 20dBc from M1 97.41 dBuV= 77.41 dBuV as limit, M4 is passing.

HARMONICS AND SPURIOUS EMISSIONS (WITH NOTCH FILTER)

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

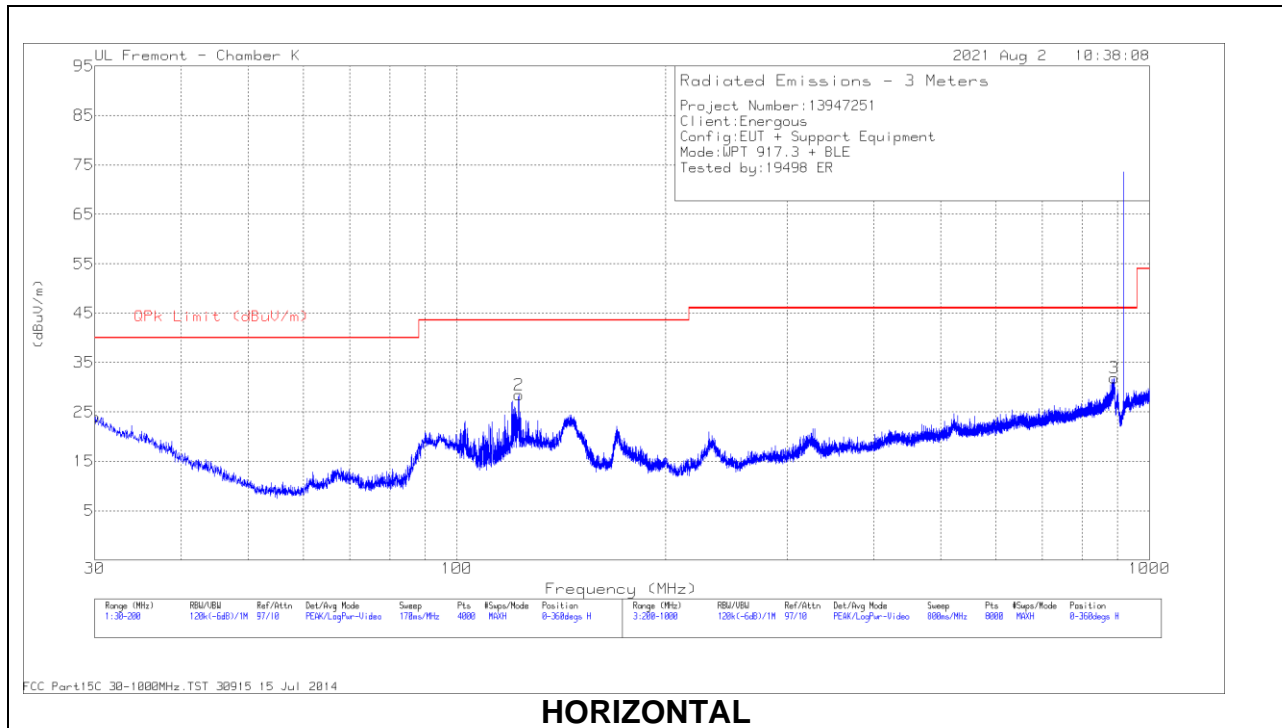
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF 81560 (dB/m)	Amp/Cbl (dB)	T847 BRF (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 120.2509	38.9	Pk	19.8	-30.8	0.13	28.03	43.52	-15.49	0-360	393	H
2	145.1198	36.44	Pk	18.9	-30.6	0.13	24.87	43.52	-18.65	0-360	197	H
3	890.5898	29.9	Pk	28.5	-27.2	2	33.2	46.02	-12.82	0-360	99	H
4	30.6377	31.49	Pk	27.5	-31.6	0.13	27.52	40	-12.48	0-360	97	V
5	* 38.0771	37.78	Pk	21.8	-31.5	0.13	28.21	40	-11.79	0-360	97	V
	* 37.7671	32.4	Qp	22.1	-31.5	0.13	23.13	40	-16.87	110	106	V
6	45.0064	40.04	Pk	16.9	-31.4	0.13	25.67	40	-14.33	0-360	97	V

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

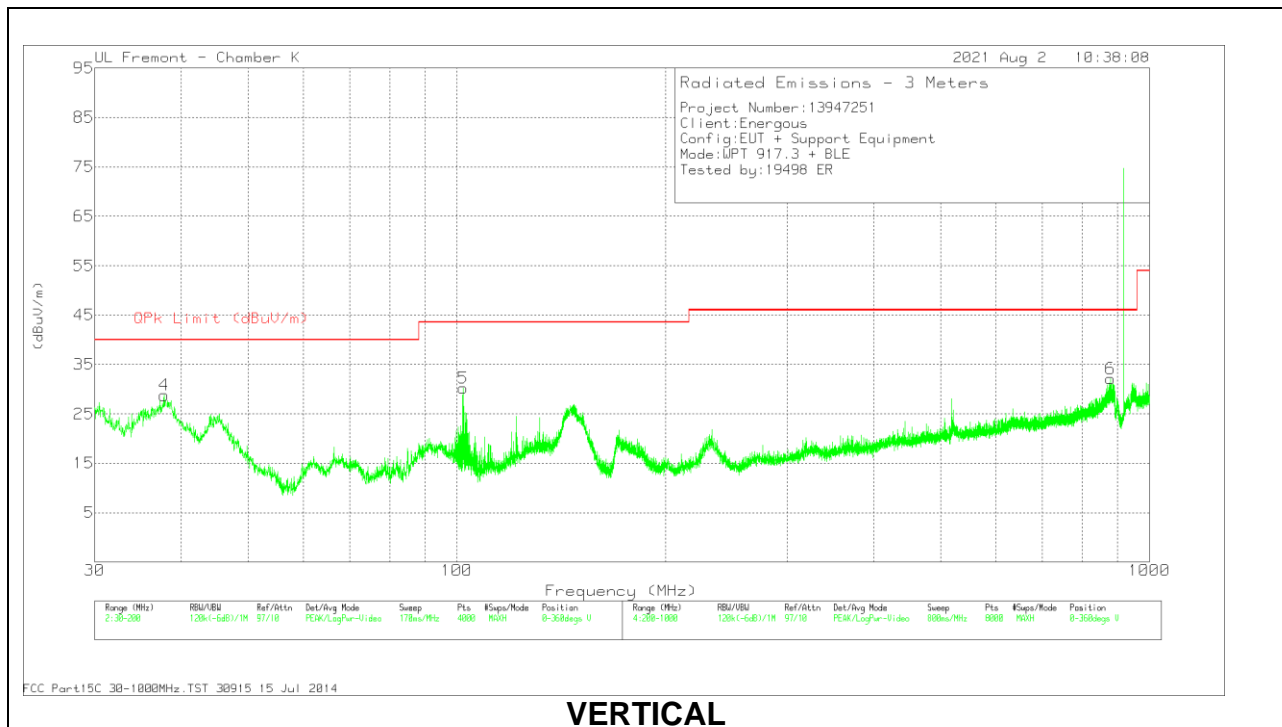
Pk - Peak detector

Qp - Quasi-Peak detector

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

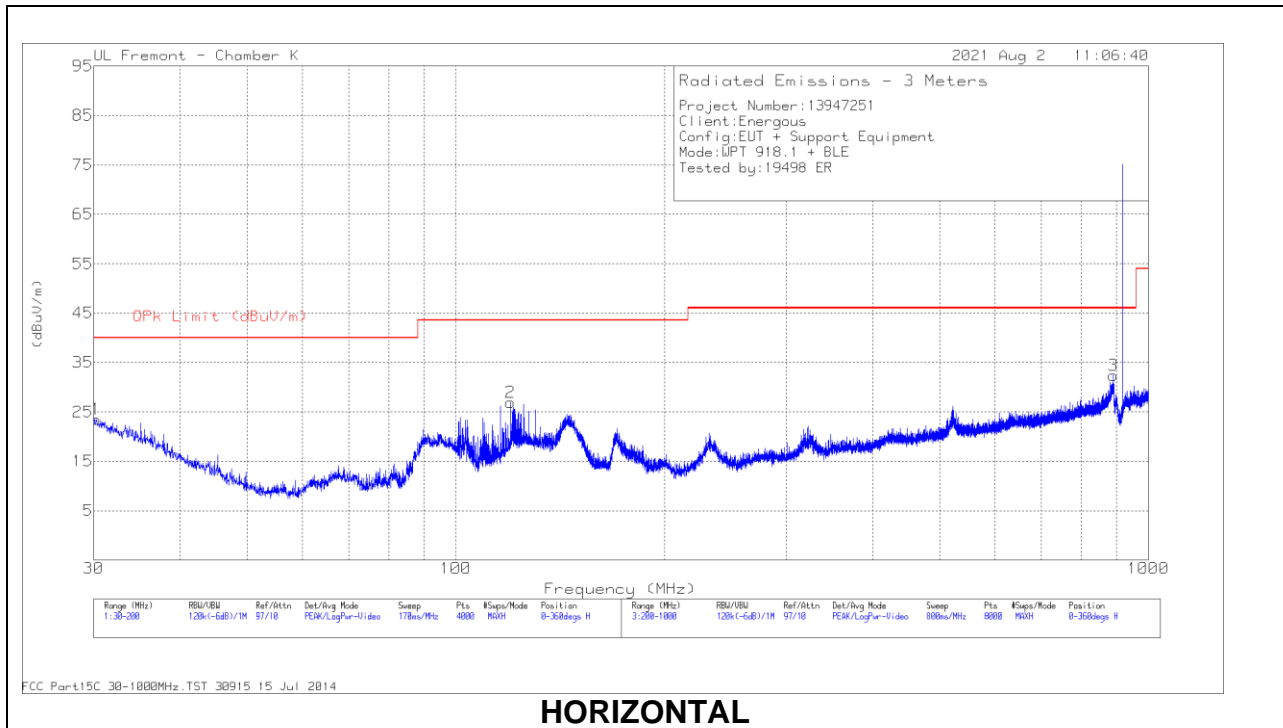
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF 81560 (dB/m)	Amp/Cbl (dB)	T847 BRF (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	30.0425	27.6	Pk	28	-31.6	0.13	24.13	40	-15.87	0-360	295	H
2	* 122.844	39.38	Pk	19.9	-30.8	0.13	28.61	43.52	-14.91	0-360	393	H
3	889.1896	30.54	Pk	28.5	-27.2	2	33.84	46.02	-12.18	0-360	99	H
4	* 37.7795	38.17	Pk	22.1	-31.5	0.13	28.9	40	-11.1	0-360	97	V
	38.3285	32.92	Qp	21.6	-31.5	0.13	23.15	40	-16.85	-16.98	88	97
5	102.1412	44.33	Pk	16.8	-30.9	0.13	30.36	43.52	-13.16	0-360	97	V
6	878.2882	31.11	Pk	28.3	-27.3	2	34.11	46.02	-11.91	0-360	199	V

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

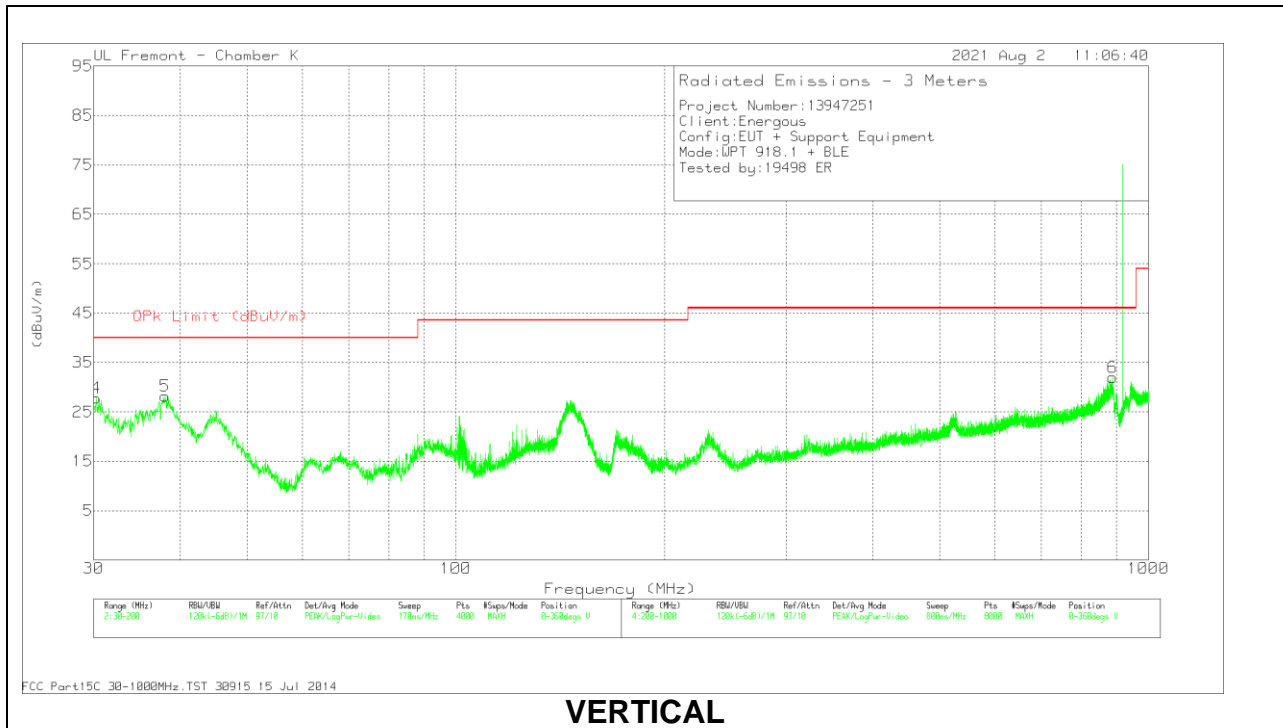
Pk - Peak detector

Qp - Quasi-Peak detector

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF 81560 (dB/m)	Amp/Cbl (dB)	T847 BRF (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	30.2551	27.35	Pk	27.8	-31.6	0.13	23.68	40	-16.32	0-360	295	H
2	* 119.9108	37.89	Pk	19.8	-30.8	0.13	27.02	43.52	-16.5	0-360	393	H
3	889.9897	31.14	Pk	28.5	-27.2	2	34.44	46.02	-11.58	0-360	97	H
4	30.2551	31.67	Pk	27.8	-31.6	0.13	28	40	-12	0-360	100	V
5	* 38.0346	37.77	Pk	21.9	-31.5	0.13	28.3	40	-11.7	0-360	100	V
	* 37.7546	31.6	Qp	22.1	-31.5	0.13	22.33	40	-17.67	283	114	V
6	888.2895	30.72	Pk	28.5	-27.2	2	34.02	46.02	-12	0-360	199	V

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

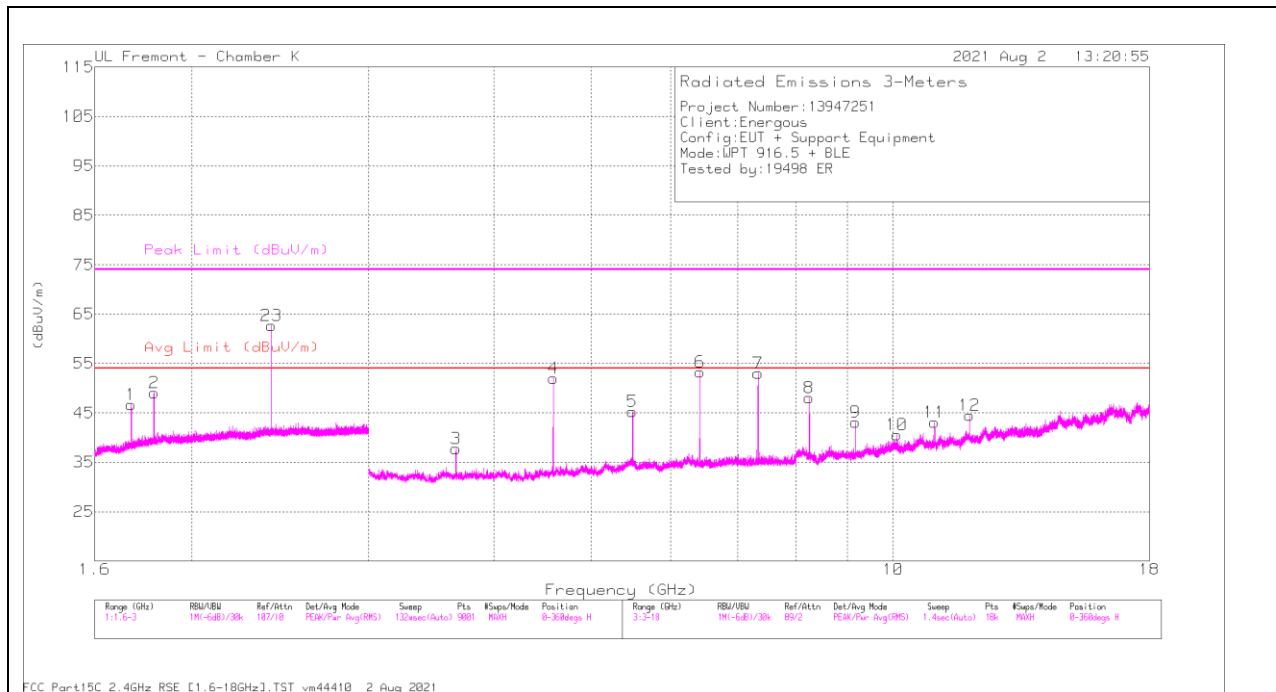
Pk - Peak detector

Qp - Quasi-Peak detector

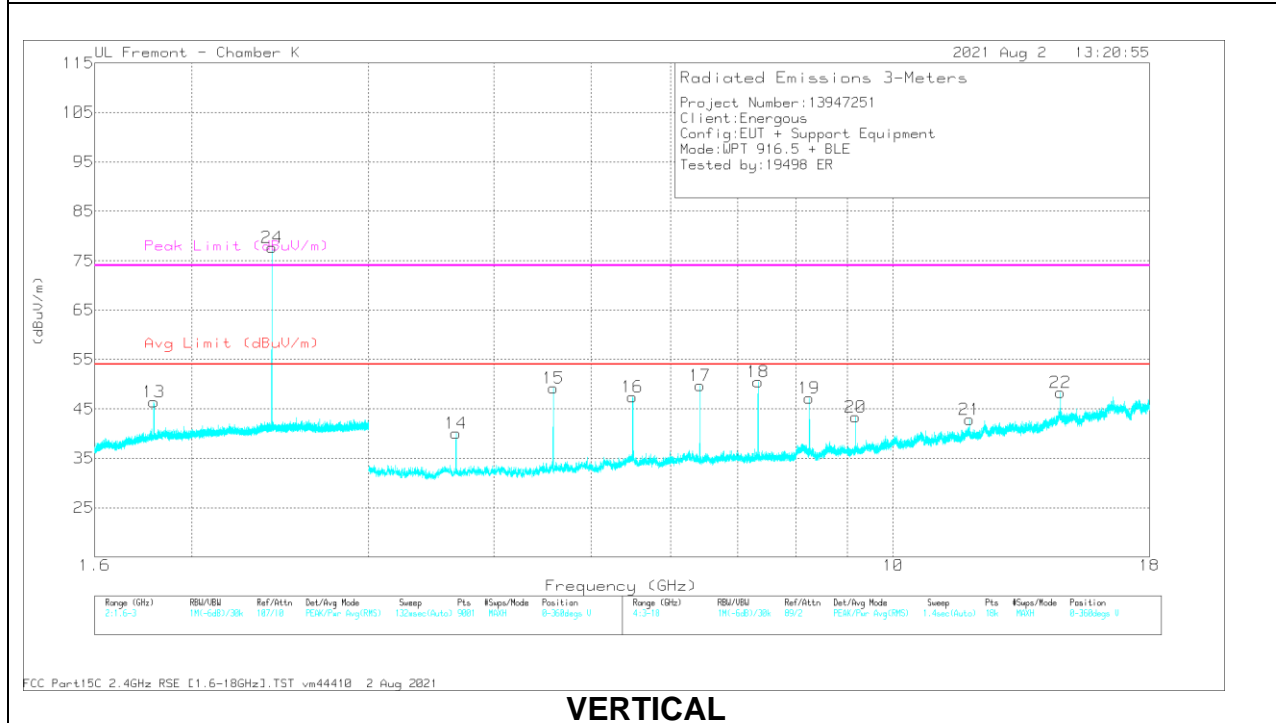
10.2. TRANSMITTER ABOVE 1 GHz

HARMONICS AND SPURIOUS EMISSIONS (WITH HPF 85494)

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	85494 HPF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
7	* 7.33212	55.29	PKFH	36	-37.3	0.72	54.71	-	-	74	-19.29	61	182	H
	* 7.33211	53.34	VA1T	36	-37.3	0.72	52.76	54	-1.24	-	-	61	182	H
4	* 4.58259	60.79	PKFH	34.3	-40.7	0.72	55.11	-	-	74	-18.89	348	143	H
	* 4.58256	58.01	VA1T	34.3	-40.7	0.72	52.33	54	-1.67	-	-	348	143	H
8	* 8.24862	51.31	PKFH	36.1	-36.6	0.72	51.53	-	-	74	-22.47	206	98	H
	* 8.24861	46.86	VA1T	36.1	-36.6	0.72	47.08	54	-6.92	-	-	206	98	H
18	* 7.33211	54.25	PKFH	36	-37.3	0.72	53.67	-	-	74	-20.33	199	98	V
	* 7.33211	51.15	VA1T	36	-37.3	0.72	50.57	54	-3.43	-	-	199	98	V
15	* 4.58244	55.79	PKFH	34.3	-40.7	0.72	50.11	-	-	74	-23.89	82	394	V
	* 4.58256	52.69	VA1T	34.3	-40.7	0.72	47.01	54	-6.99	-	-	82	394	V
19	* 8.24876	50.45	PKFH	36.1	-36.6	0.72	50.67	-	-	74	-23.33	97	98	V
	* 8.2486	44.28	VA1T	36.1	-36.6	0.72	44.5	54	-9.5	-	-	97	98	V

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

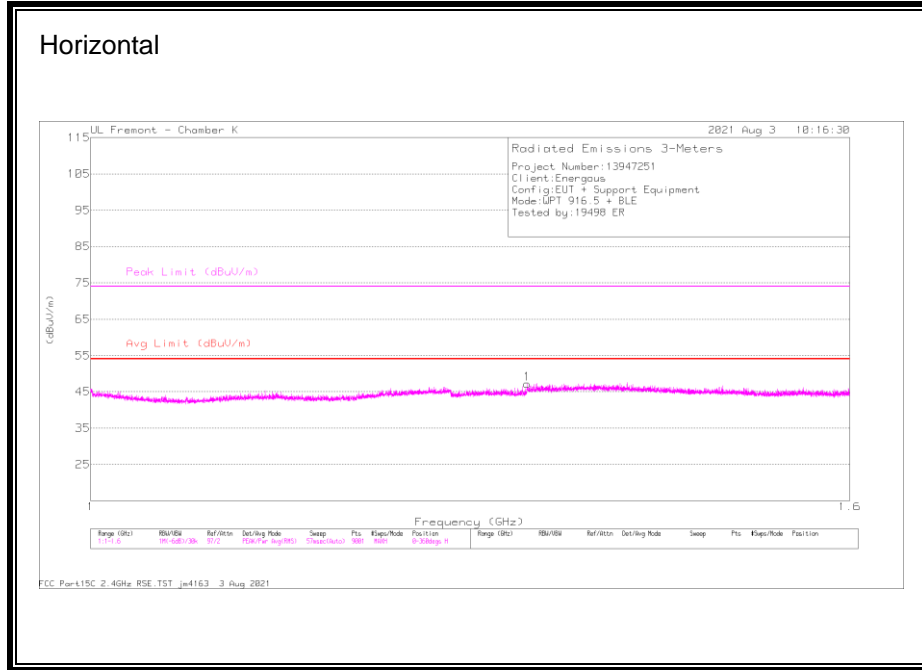
** - Markers 23 and 24 are BLE Signals

NOTE: Worst highest 6 markers frequencies in restricted bands are picked.

PKFH FHSS/BT RB=100k for Frequencies<1GHz / RB=1MHz for Frequencies>1GHz, VB=3 x RB, Peak VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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

Tested by:	19498 ER
Date:	8/3/21



DATA

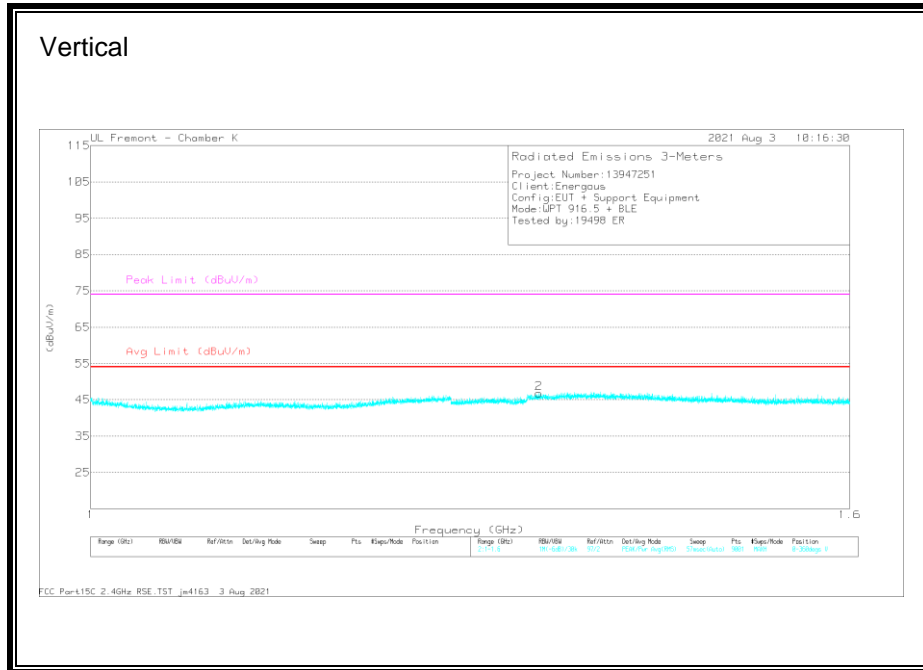
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.31033	12.54	Pk	29.3	5.3	47.14	-	-	74	-26.86	0-360	200	H

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

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.



DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 1.31987	12.31	Pk	29.2	5.3	46.81	-	-	74	-27.19	0-360	200	V

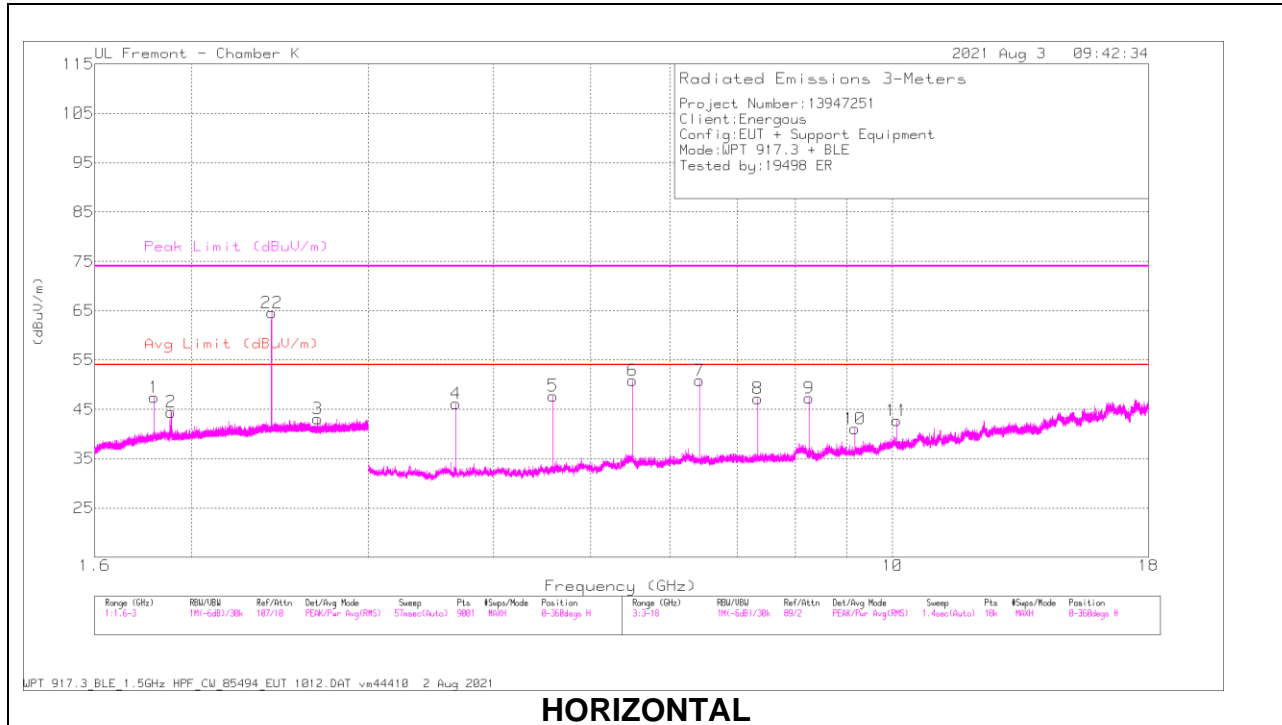
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

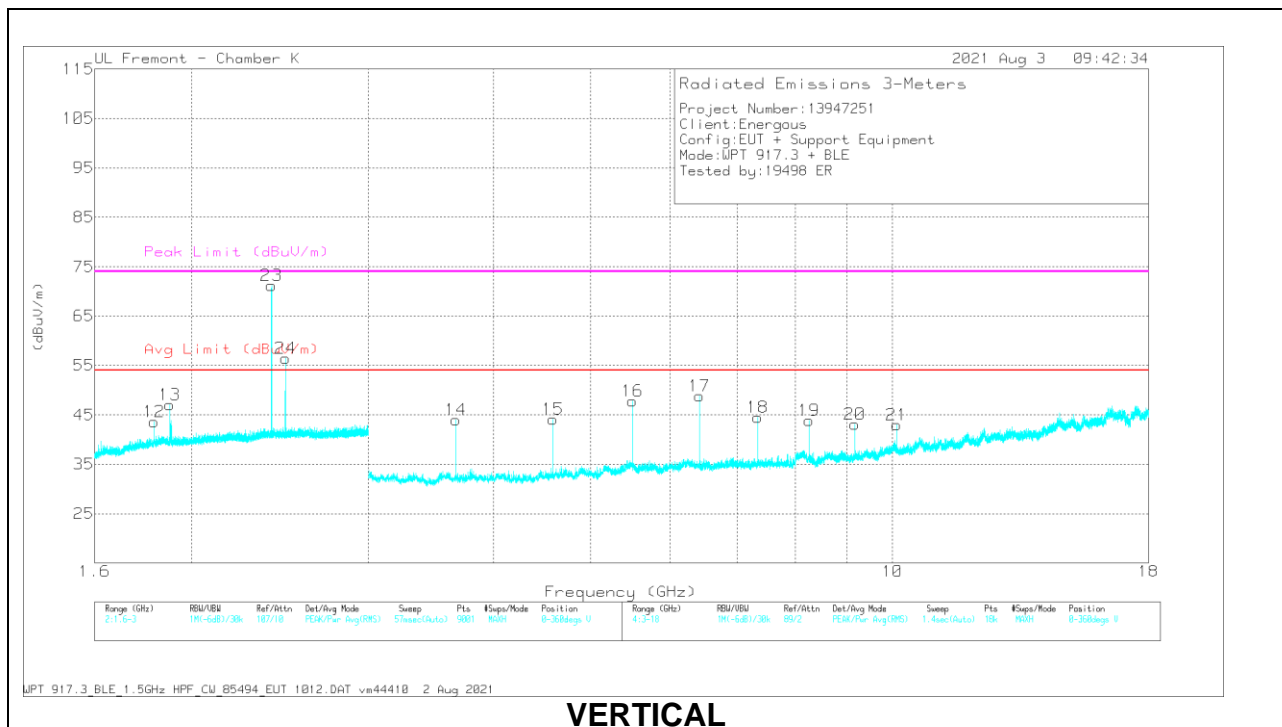
Note:

- Test was performed @ 3 meter distance.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	85494 HPF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
5	* 4.58652	57.2	PKFH	34.3	-40.8	0.72	51.42	-	-	74	-22.58	275	101	H
	* 4.58656	54.63	VA1T	34.3	-40.8	0.72	48.85	54	-5.15	-	-	275	101	H
4	* 3.66915	56.62	PKFH	33.4	-40.7	0.72	50.04	-	-	74	-23.96	202	98	H
	* 3.66925	53.26	VA1T	33.4	-40.7	0.72	46.68	54	-7.32	-	-	202	98	H
8	* 7.33844	51.9	PKFH	36	-37.2	0.72	51.42	-	-	74	-22.58	105	179	H
	* 7.33851	47.67	VA1T	36	-37.2	0.72	47.19	54	-6.81	-	-	105	179	H
9	* 8.25582	51.37	PKFH	36.1	-36.5	0.72	51.69	-	-	74	-22.31	20	216	H
	* 8.25581	47.78	VA1T	36.1	-36.5	0.72	48.1	54	-5.9	-	-	20	216	H
15	* 4.5865	54.52	PKFH	34.3	-40.8	0.72	48.74	-	-	74	-25.26	230	204	V
	* 4.58656	51.21	VA1T	34.3	-40.8	0.72	45.43	54	-8.57	-	-	230	204	V
18	* 7.33827	50.15	PKFH	36	-37.2	0.72	49.67	-	-	74	-24.33	69	209	V
	* 7.3385	45.57	VA1T	36	-37.2	0.72	45.09	54	-8.91	-	-	69	209	V

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

** - Markers 22, 23 and 24 are BLE Signals

NOTE: Worst highest 6 markers frequencies in restricted bands are picked.

PKFH FHSS/BT RB=100k for Frequencies<1GHz / RB=1MHz for Frequencies>1GHz, VB=3 x RB, Peak
 VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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

Tested by:	19498 ER
Date:	8/3/21



DATA

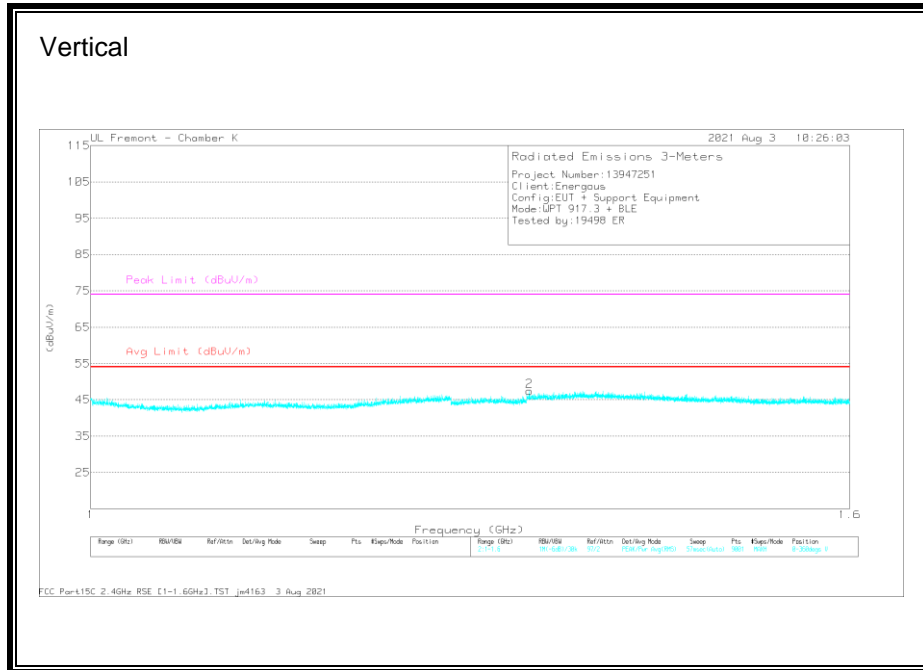
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.3394	12.75	Pk	29.3	5.3	47.35	-	-	74	-26.65	0-360	100	H

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

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.



DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 1.31207	12.82	Pk	29.3	5.3	47.42	-	-	74	-26.58	0-360	200	V

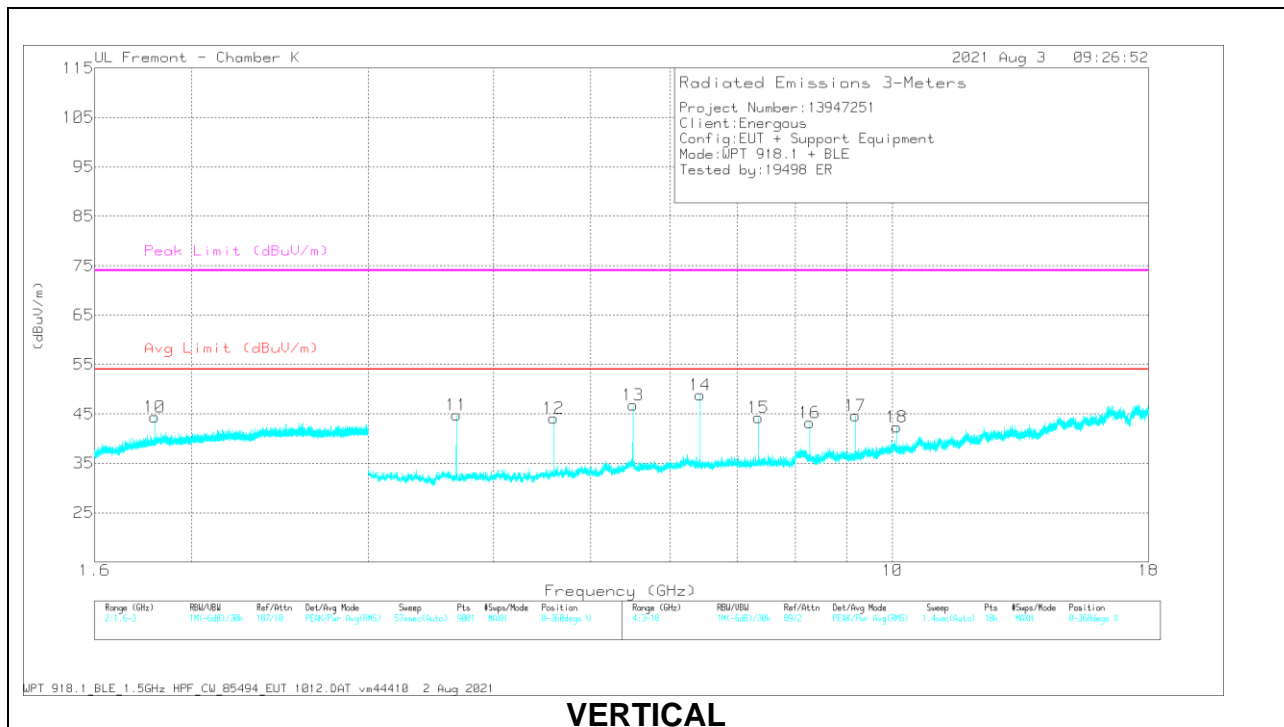
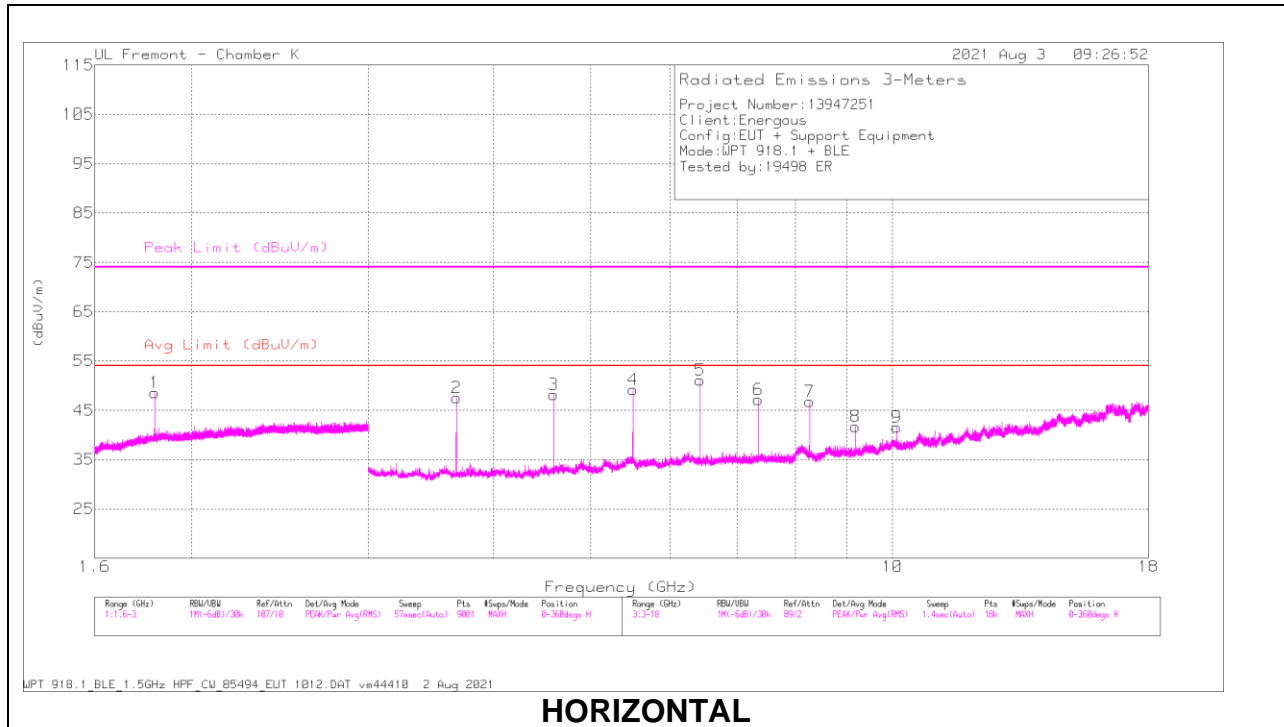
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.

HIGH CHANNEL RESULTS



RADIATED EMISSIONS

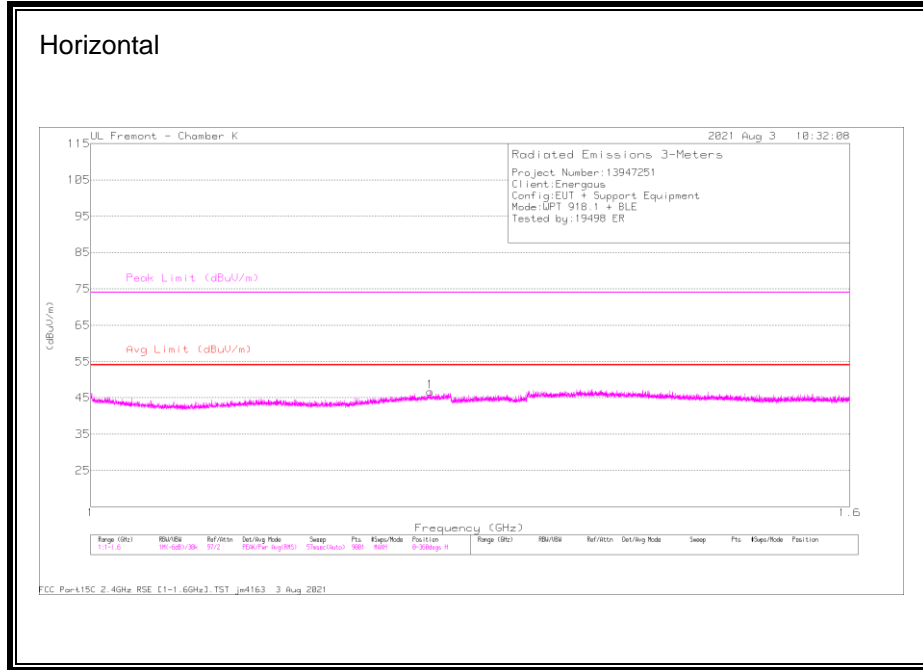
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Amp/Cbl/Fit r/Pad (dB)	85494 HPF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	* 4.59052	57.28	PKFH	34.2	-40.8	0.72	51.4	-	-	74	-22.6	276	99	H
	* 4.59056	54.63	VA1T	34.2	-40.8	0.72	48.75	54	-5.25	-	-	276	99	H
2	* 3.67248	57.04	PKFH	33.5	-40.7	0.72	50.56	-	-	74	-23.44	203	98	H
	* 3.67245	54.47	VA1T	33.5	-40.7	0.72	47.99	54	-6.01	-	-	203	98	H
6	* 7.34491	51.24	PKFH	36.1	-37.2	0.72	50.86	-	-	74	-23.14	64	198	H
	* 7.34492	47.08	VA1T	36.1	-37.2	0.72	46.7	54	-7.3	-	-	64	198	H
11	* 3.67237	57.93	PKFH	33.5	-40.7	0.72	51.45	-	-	74	-22.55	195	379	V
	* 3.67245	55.92	VA1T	33.5	-40.7	0.72	49.44	54	-4.56	-	-	195	379	V
15	* 7.34486	49.95	PKFH	36.1	-37.2	0.72	49.57	-	-	74	-24.43	69	208	V
	* 7.34489	45.3	VA1T	36.1	-37.2	0.72	44.92	54	-9.08	-	-	69	208	V
17	* 9.18104	49.64	PKFH	36.6	-35.8	0.72	51.16	-	-	74	-22.84	13	99	V
	* 9.18112	43.44	VA1T	36.6	-35.8	0.72	44.96	54	-9.04	-	-	13	99	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 NOTE: Worst highest 6 markers frequencies in restricted bands are picked.

PKFH FHSS/BT RB=100k for Frequencies<1GHz / RB=1MHz for Frequencies>1GHz, VB=3 x RB, Peak
 VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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

Tested by:	19498 ER
Date:	8/3/21



DATA

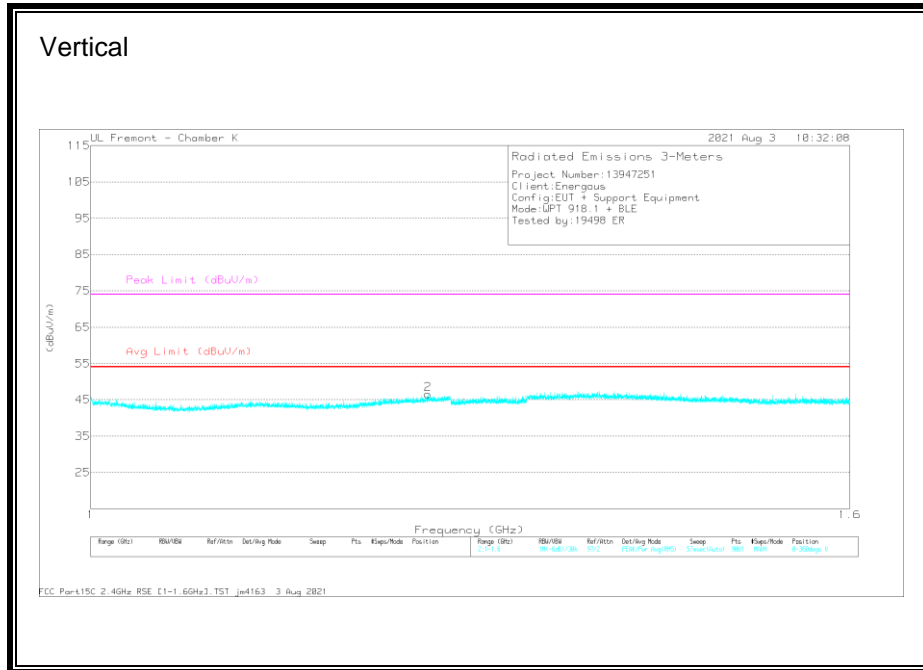
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 1.234	12.81	Pk	28.8	5.1	46.71	-	-	74	-27.29	0-360	100	H

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

Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.



DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T863 (dB/m)	Bypass (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 1.23213	12.68	Pk	28.8	5.1	46.58	-	-	74	-27.42	0-360	200	V

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

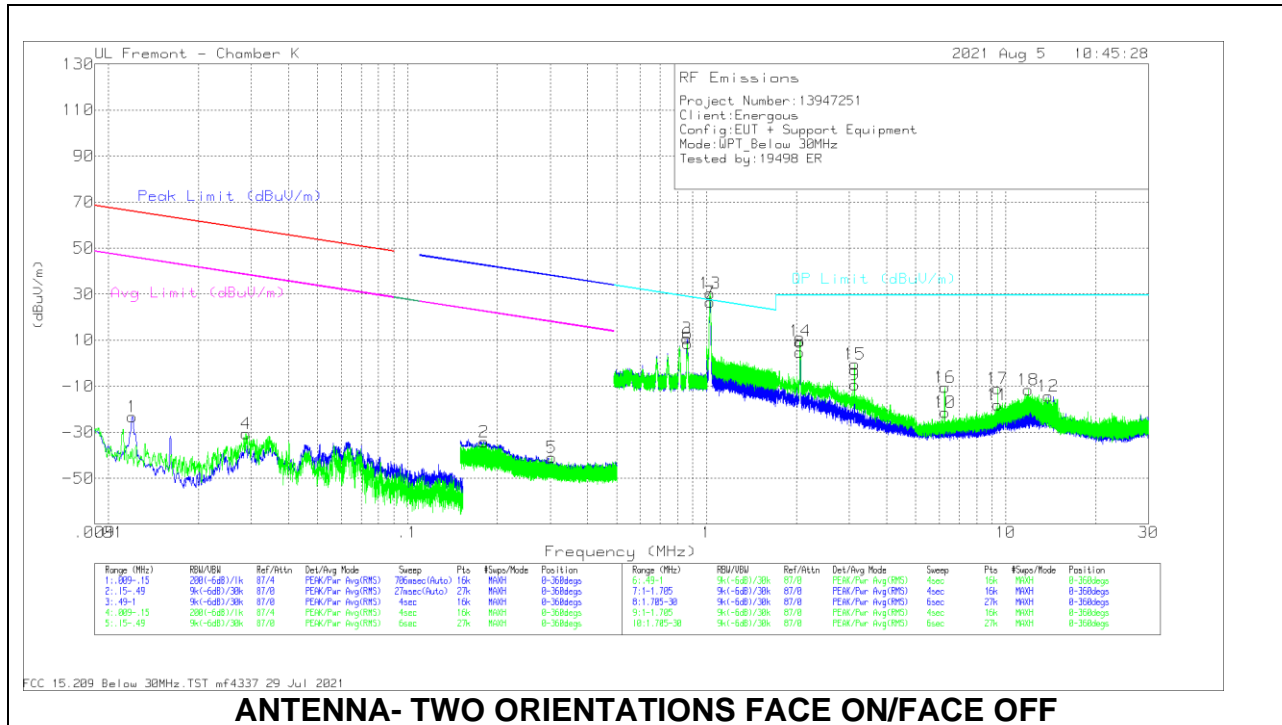
Pk - Peak detector

Note:

- Test was performed @ 3 meter distance.

10.3. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)



ANTENNA- TWO ORIENTATIONS FACE ON/FACE OFF

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (E ACF)	Amp/Cbl (dB)	Dist Corr 300m	Corrected Reading (dBuV/m)	Peak Limit (dBuV/m)	PK Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.01204	28.21	Pk	60.1	-31.5	-80	-23.19	65.97	-89.16	45.97	-69.16	0-360
2	.18026	21.9	Pk	56.1	-32.2	-80	-34.2	42.5	-76.7	22.5	-56.7	0-360
4	.02883	23.66	Pk	58	-32.2	-80	-30.54	58.39	-88.93	38.39	-68.93	0-360
5	.30393	14.95	Pk	56.2	-32.2	-80	-41.05	37.96	-79.01	17.96	-59.01	0-360

Pk - Peak detector

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (E ACF)	Amp/Cbl (dB)	Dist Corr 30m (dB) 40Log	Corrected Reading (dBuV/m)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
3	.86165	26.63	Pk	56.2	-32.2	-40	10.63	28.91	-18.28	0-360
6	.86264	24.56	Pk	56.2	-32.2	-40	8.56	28.9	-20.34	0-360
7	1.02658	51.95	Pk	46.6	-32.1	-40	26.45	27.39	-.94	0-360
	1.03627	36.67	Qp	46.5	-32.1	-40	11.07	27.31	-16.24	330
8	2.05189	35.37	Pk	41.4	-32.1	-40	4.67	29.5	-24.83	0-360
9	3.12504	24.05	Pk	38.5	-32	-40	-9.45	29.5	-38.95	0-360
10	6.25018	15.56	Pk	34.9	-31.9	-40	-21.44	29.5	-50.94	0-360
11	9.37322	19.5	Pk	34.3	-31.8	-40	-18	29.5	-47.5	0-360
12	13.85132	23.56	Pk	33.8	-31.8	-40	-14.44	29.5	-43.94	0-360
13	1.02702	55.93	Pk	46.6	-32.1	-40	30.43	27.39	3.04	0-360
	1.03468	47.61	Qp	46.5	-32.1	-40	22.01	27.33	-5.32	9
14	2.05608	40.5	Pk	41.3	-32.1	-40	9.7	29.5	-19.8	0-360
15	3.12504	33.11	Pk	38.5	-32	-40	-3.39	29.5	-29.89	0-360
16	6.25018	26.49	Pk	34.9	-31.9	-40	-10.51	29.5	-40.01	0-360
17	9.37426	26.47	Pk	34.3	-31.8	-40	-11.03	29.5	-40.53	0-360
18	11.88108	26.3	Pk	34	-31.8	-40	-11.5	29.5	-41	0-360

Pk - Peak detector

Qp - Quasi-Peak detector

11. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

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

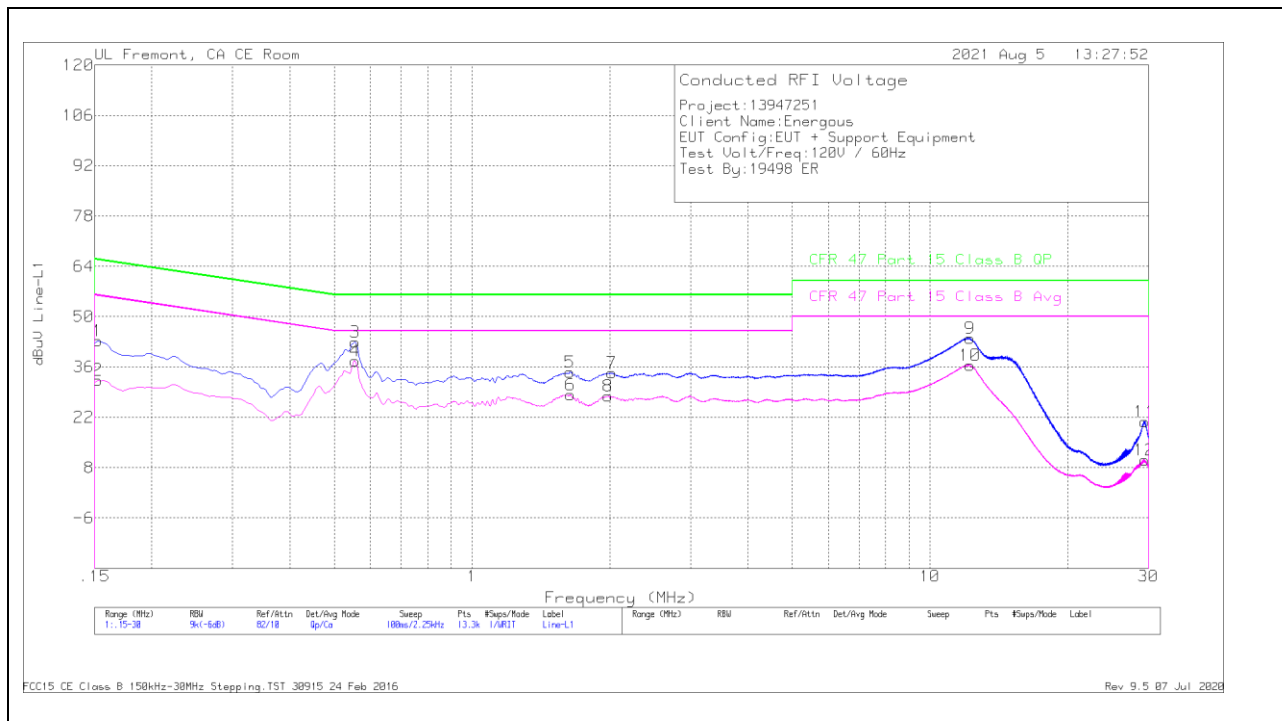
The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

Line conducted data is recorded for both NEUTRAL and HOT lines.

RESULTS

LINE 1 RESULTS

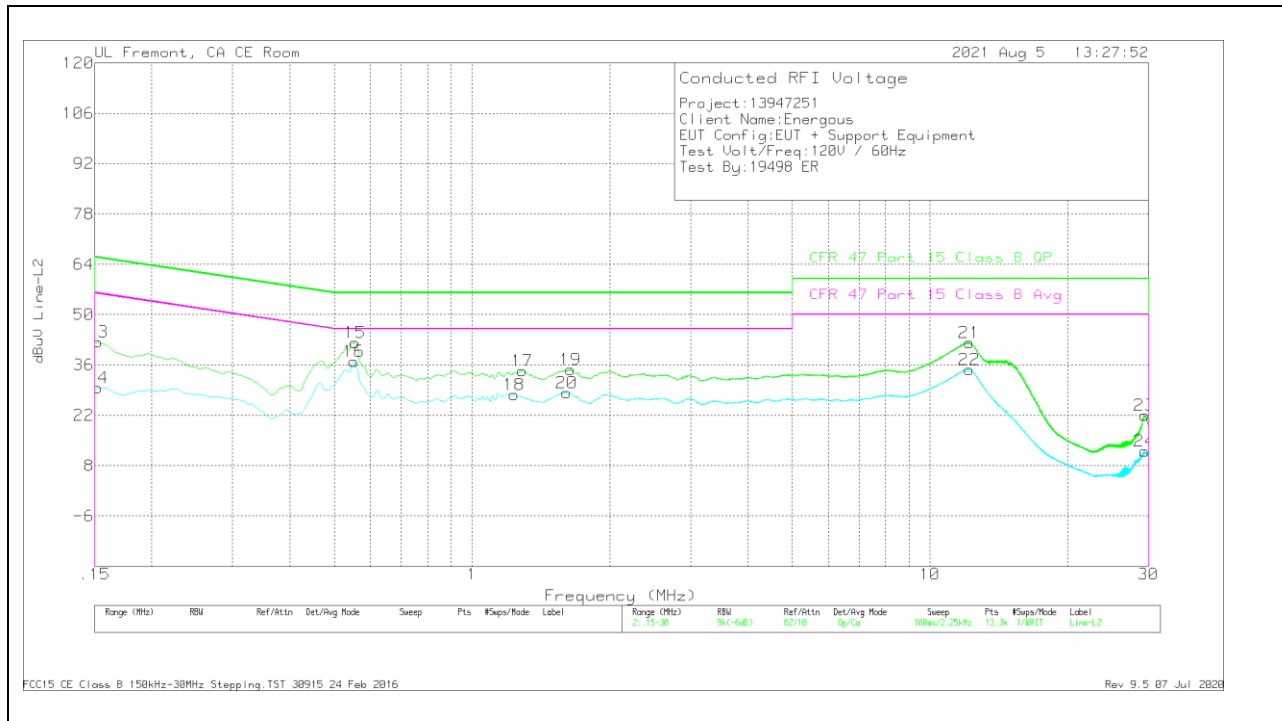


Trace Markers

Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	PRE018644 6 L1	LC Cables C1&C3 dB	TekBox Limiter TBFL1 Model 207	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
2	.15225	22.87	Ca	.1	0	9.4	32.37	-	-	55.88	-23.51
4	.555	28.41	Ca	0	0	9.3	37.71	-	-	46	-8.29
6	1.64175	18.85	Ca	0	.1	9.3	28.25	-	-	46	-17.75
8	1.98263	18.5	Ca	0	.1	9.3	27.9	-	-	46	-18.1
10	12.2325	26.89	Ca	.1	.2	9.3	36.49	-	-	50	-13.51
12	29.41688	.44	Ca	0	.3	9.4	10.14	-	-	50	-39.86
1	.15225	33.74	Qp	.1	0	9.4	43.24	65.88	-22.64	-	-
3	.555	33.6	Qp	0	0	9.3	42.9	56	-13.1	-	-
5	1.635	25.19	Qp	0	.1	9.3	34.59	56	-21.41	-	-
7	2.01975	24.92	Qp	0	.1	9.3	34.32	56	-21.68	-	-
9	12.23475	34.43	Qp	.1	.2	9.3	44.03	60	-15.97	-	-
11	29.40225	11.12	Qp	0	.3	9.4	20.82	60	-39.18	-	-

Qp - Quasi-Peak detector
 Ca - CISPR average detection

LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	PRE018644 6 L2	LC Cables C2&C3 dB	TekBox Limiter TBFL1 Model 207	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
14	.15225	20.3	Ca	0	0	9.4	29.7	-	-	55.88	-26.18
16	.55275	27.7	Ca	0	0	9.3	37	-	-	46	-9
18	1.2345	18.42	Ca	0	.1	9.3	27.82	-	-	46	-18.18
20	1.61138	18.86	Ca	0	.1	9.3	28.26	-	-	46	-17.74
22	12.2055	25.09	Ca	.1	.2	9.3	34.69	-	-	50	-15.31
24	29.41575	2.26	Ca	.1	.3	9.4	12.06	-	-	50	-37.94
13	.15225	33.07	Qp	0	0	9.4	42.47	65.88	-23.41	-	-
15	.555	32.89	Qp	0	0	9.3	42.19	56	-13.81	-	-
17	1.2885	24.94	Qp	0	.1	9.3	34.34	56	-21.66	-	-
19	1.64175	25.27	Qp	0	.1	9.3	34.67	56	-21.33	-	-
21	12.20775	32.6	Qp	.1	.2	9.3	42.2	60	-17.8	-	-
23	29.41575	12.26	Qp	.1	.3	9.4	22.06	60	-37.94	-	-

Qp - Quasi-Peak detector
 Ca - CISPR average detection