TEST REPORT

Report Number : 14523771-E23V1

Applicant	:	APPLE INC. 1 APPLE PARK WAY CUPERTINO, CA 95104, U.S.A.
Model	:	A2849
Brand	:	APPLE
FCC ID	:	BCG-E8439A
IC	:	579C-E8439A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR Part 25 ISED RSS-170 ISSUE 4

Date Of Issue:
AUGUST 01, 2023

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

CERT #0751.05

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	8/1/2023	Initial Review	--

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS 5

2. SUMMARY OF TEST RESULTS 6

3. TEST METHODOLOGY 6

4. FACILITIES AND ACCREDITATION 6

5. DECISION RULES AND MEASUREMENT UNCERTAINTY 7

5.1. METROLOGICAL TRACEABILITY 7

5.2. DECISION RULES 7

5.3. MEASUREMENT UNCERTAINTY 7

5.4. SAMPLE CALCULATION 7

6. EQUIPMENT UNDER TEST 8

6.1. DESCRIPTION OF EUT 8

6.2. MAXIMUM OUTPUT POWER 8

6.3. SOFTWARE AND FIRMWARE 9

6.4. MAXIMUM ANTENNA GAIN 9

6.5. WORST-CASE CONFIGURATION AND MODE 9

6.6. DESCRIPTION OF TEST SETUP 10

7. TEST AND MEASUREMENT EQUIPMENT 13

8. RF OUTPUT POWER VERIFICATION 14

9. CONDUCTED TEST RESULTS 15

9.1. OCCUPIED BANDWIDTH 15

9.2. EMISSIONS MASK WITHIN 250% OF AUTHORIZED BANDWIDTH 17

9.2.1. ANT 1 18

9.2.2. ANT 4 21

9.3. OUT OF BAND EMISSIONS 22

9.3.1. ANT 1 23

10. RADIATED TEST RESULTS 24

10.1. FIELD STRENGTH OF SPURIOUS RADIATION 25

10.1.1. ANT 1 (Above 1GHz) 26

10.1.2. ANT 4 (Above 1GHz) 28

10.1.3. ANT 1 (Below 1GHz) 30

10.1.4. ANT 4 (Below 1GHz) 32

10.2. ADDITIONAL UNWANTED EMISSION (1559MHz – 1610MHz) 34

10.2.1. ANT 1 36

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.2.2. ANT 4 40

10.3. CARRIER-OFF STATE EMISSIONS (1559MHz – 1610MHz) 44

10.3.1. ANT 1 45

10.3.2. ANT 4 45

10.4. FREQUENCY STABILITY 46

11. SETUP PHOTOS 47

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1. ATTESTATION OF TEST RESULTS

Applicant Name and Address	APPLE INC. 1 APPLE PARK WAY CUPERTINO, CA 95104, U.S.A.
Model	A2849
Brand	APPLE
FCC ID	BCG-E8439A
IC	579C-E8439A
EUT Description	SMARTPHONE
Serial Number	T5H7TDK9CW; M6M6JL97PD
Sample Receipt Date	MARCH 28, 2023
Date Tested	MARCH 30, 2023 to JULY 25, 2023
Applicable Standards	FCC CFR47 PART 25 ISED RSS-170 ISSUE 4
Test Results	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.

Approved & Released By:	Prepared & Reviewed By:
Thu Chan Staff Engineer UL Verification Services Inc.	Chris Xiong Senior Test Engineer UL Verification Services Inc.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

2. SUMMARY OF TEST RESULTS

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.

Below is a list of data provided by the customer:

1. Antenna gain and type (see Section 6.4)
2. Cable loss (see Section 8)

Requirement Description	Requirement Clause Number (FCC)	Requirement Clause Number (ISED)	Result	Remarks
RF Output Power Verification	25.204 (a)	RSS-170 §5.5	Complies	N/A
Occupied Bandwidth	2.1049	RSS-170 RSS-GEN	Reporting purposes only	N/A
Emissions Mask - within 250% of Authorized Bandwidth	25.202 (f)(1)&(2)	RSS-170 §5.8	Complies	N/A
Out of Band Emissions	25.202 (f)(3)	RSS-170 §5.8	Complies	N/A
Additional Unwanted Emission (1559-1610MHz)	25.216 (c)&(g) FCC 03-283	RSS-170 §5.9.1	Complies	N/A
Carrier-Off State Emissions (1559-1610MHz)	25.216 (i) FCC 03-283	RSS-170 §5.10	Complies	N/A
Frequency Stability	25.202 (d)	RSS-170 §5.3	Complies	N/A

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with the following:

- ANSI C63.26:2015
- ISED RSS-170 ISSUE 4
- FCC 47 CFR Part 2 and 25
- FCC KDB 971168 D01 v03r01: Power Meas License Digital Systems
- FCC KDB 971168 D02 v02r02: Misc Rev Approv License Devices
- FCC KDB 412172 D01 v01r01. Determining ERP and EIRP

4. FACILITIES AND ACCREDITATION

UL Verification Services Inc. is accredited by A2LA, certification #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
☒	Building 1: 47173 Benicia Street, Fremont, CA 94538 USA	US0104	2324A	550739
☒	Building 2: 47266 Benicia Street, Fremont, CA 94538 USA			
☒	Building 3: 843 Auburn Court, Fremont, CA 94538 USA			
☐	Building 4: 47658 Kato Rd, Fremont, CA 94538 USA			
☐	Building 5: 47670 Kato Rd, Fremont, CA 94538 USA			

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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	2.87 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
Occupied Channel Bandwidth	±1.22 %
Temperature	±0.57 °C
Supply voltages	±0.57 %
Time	±3.39 %

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 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The Apple iPhone is a smartphone with cellular GSM, GPRS, EGPRS, UMTS, LTE, 5GNR1, 5GNR2, IEEE 802.11a/b/g/n/ac/ax, Bluetooth (BT), Ultra-Wideband (UWB), GPS, NFC, NB UNII, 802.15.4, 802.15.4ab-NB and MSS technologies. The rechargeable battery is not user accessible.

6.2. MAXIMUM OUTPUT POWER

EIRP/ERP TEST PROCEDURE

ANSI C63.26:2015
KDB 971168 D01 Section 5.6

EIRP = PMeas + GT − LC
where: EIRP = effective isotropic radiated power, respectively (expressed in the same units as PMeas, typically dBW or dBm);
PMeas = measured transmitter output power or PSD, in dBm or dBW;
GT = gain of the transmitting antenna, in dBi (EIRP);
LC = signal attenuation in the connecting cable between the transmitter and antenna, in dB.

For devices utilizing multiple antennas, KDB 662911 provides guidance for determining the effective array transmit antenna gain term to be used in the above equation.

The transmitter has a maximum average conducted and EIRP output powers as follows:

FCC Part 25 & ISED RSS-170 (1610 - 1626.5MHz):

Frequency (MHz)	Conducted (Average) (dBm)	Antenna Gain (dBi)	Limit (W)	EIRP		99% BW (kHz)	Emission Designator
				(dBm)	(W)		
1610.17	27.98	-4.2	10000	23.78	0.239	203.71	204KG1D
1618.40	27.98		10000	23.78	0.239	202.51	203KG1D
1626.03	28.00		10000	23.80	0.240	199.04	199KG1D

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6.3. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was version 0.13.02.

6.4. MAXIMUM ANTENNA GAIN

The antenna(s) gain as provided by the manufacturer are as follow:

Frequency Range (MHz)	ANT 1 Antenna Gain (dBi)	ANT 4 Antenna Gain (dBi)
1610-1626.5	-4.2	-3.2

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X/Y/Z on both ANT 1 and ANT 4 antennas. It was determined that X (Flatbed) orientation was the worst-case orientation with AC/DC adapter for both ANT 1 and ANT 4.

The emissions mask tests were performed based on declared authorized bandwidths of 200kHz, 230kHz and 280kHz.

Conducted spurious emissions tests were performed on the worst-case antenna port because it has the highest conducted power.

Radiated spurious emissions below 1GHz were performed with the highest output power on both ANT 1 and ANT 4 as worst-case scenario.

Radiated spurious emissions below 30MHz were investigated and there were no emissions found with less than 20dB of margin below the specified emissions limits.

For simultaneous transmission of multiple channels in the 2.4GHz/5GHz WLAN, tests were conducted for various configurations having the highest power, least separation in frequencies and widest operation bandwidths. No noticeable new emission was found.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6.6. DESCRIPTION OF TEST SETUP

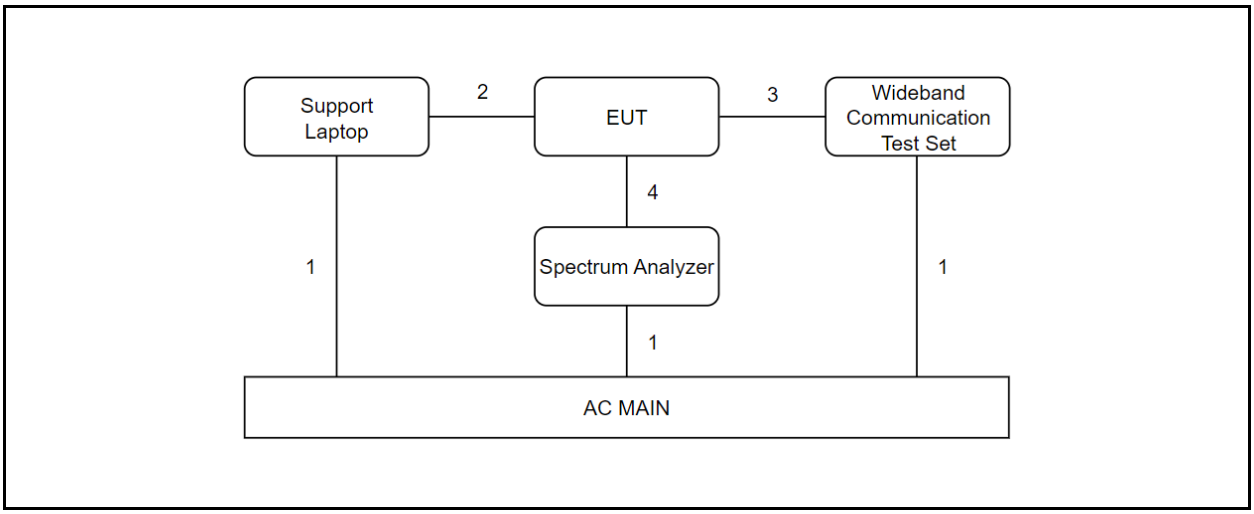
SUPPORT TEST EQUIPMENT				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID/ DoC**
Laptop	Apple	MacBook Pro	C02WG84CHV2L	DoC
Laptop AC/DC Adapter	Apple	61W Model A1947	C02VR00VJLM5	DoC
Laptop	Apple	MacBook Pro	C02VT1RBHV29	DoC
Laptop AC/DC Adapter	Apple	B920	N/A	DoC
EUT AC/DC Adapter	Apple	B820	C4H95130051PF4F4L	DoC

I/O CABLES (RF CONDUCTED TEST)						
Cable No.	**Port**	**# Of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	3	US 115V	Un-shielded	2.0	N/A
2	USB	1	Type-C	Shielded	2.0	N/A
3	RF In/Out	1	SMA	Shielded	1.0	N/A
4	RF In/Out	1	SMA	Shielded	0.5	N/A
5	RF In/Out	1	SMA Adapter	N/A	N/A	N/A

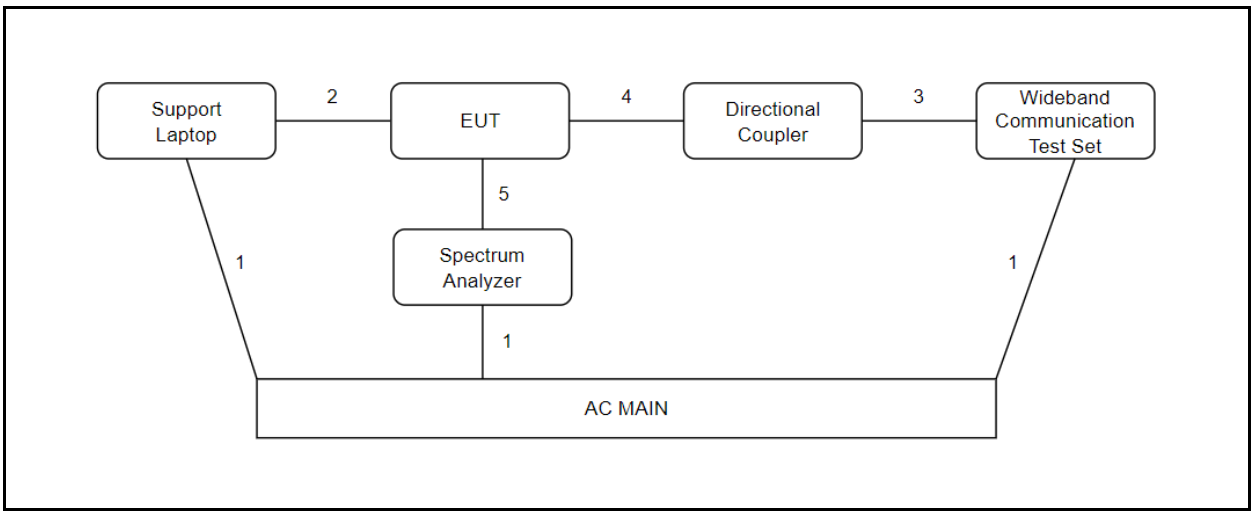
I/O CABLES (RF RADIATED TEST)						
Cable No.	**Port**	**# Of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	Type-C	Un-shielded	1.0	N/A

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

CONDUCTED SETUP - ANT 1

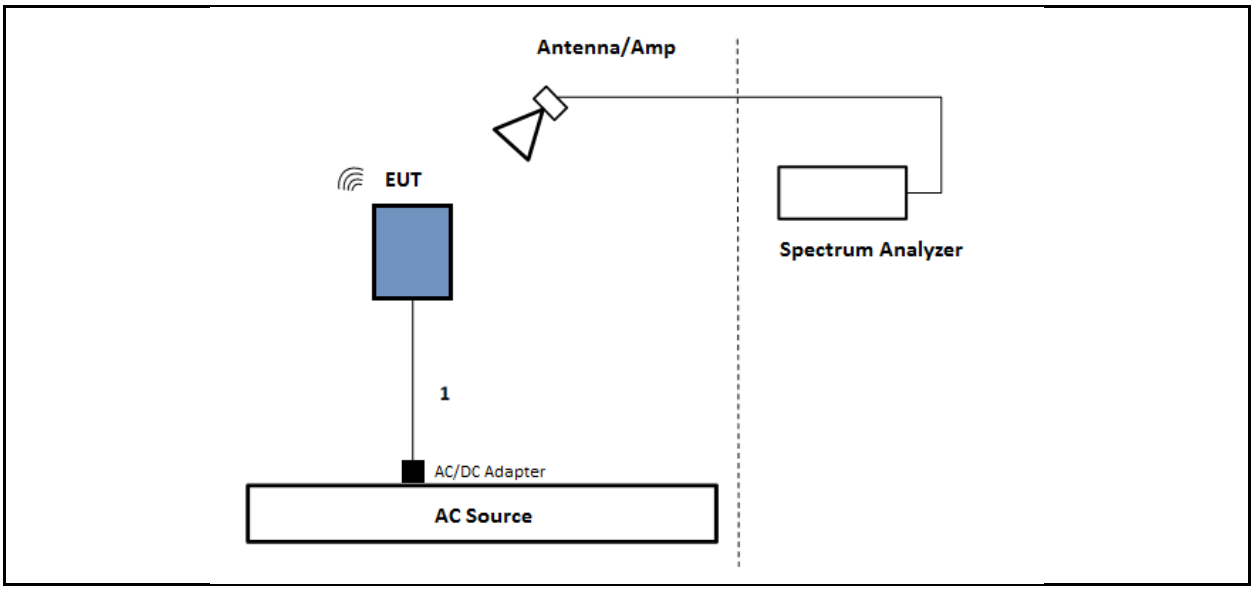


CONDUCTED SETUP - ANT 4



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

RADIATED SETUP



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

7. TEST AND MEASUREMENT EQUIPMENT

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

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Asset**	**Cal Due**
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	85212	02/29/2024
RF Filter Box, 1-18GHz	UL-FR1	NA	168534	01/05/2024
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	226672	01/09/2024
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	235670	04/30/2024
RF Filter Box, 1-18GHz, 17 Ports	UL-FR1	RATS 2	225079	10/31/2023
Antenna, Broad Band Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	232076	03/31/2024
Amplifier, 100KHz to 1GHz, 32dB	Keysight Technologies Inc	8447D	80670	08/10/2023
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO-METRICS	EM-6871	170014	07/19/2023
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO-METRICS	EM-6872	170016	07/19/2023
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	85201	02/29/2024
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	200786	03/31/2024
RF Filter Box, 1-18GHz	UL-FR1	NA	168535	02/01/2024
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	81188	01/31/2024
Directional Coupler	KRYTAR	152610	231740	02/29/2024
Wideband Communication Test Set, Call Box	Rohde & Schwarz	CMW500	10763796	08/04/2023
Environmental Chamber	Cincinnati Sub Zero	ZPHS-8-3.5-SCT/WC	89097	06/08/2024
UL AUTOMATION SOFTWARE				
Radiated test software	UL	UL RF	Ver 9.5 February 2, 2021	

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8. RF OUTPUT POWER VERIFICATION

LIMITS

FCC: §25.204
(a) In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits except as provided for in paragraph (c) of this section:

+ 40 dBW in any 4 kHz band for θ ≤0°
+ 40 + 3θ dBW in any 4 kHz band for 0° <θ ≤5°

where θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

ISED RSS-170:
5.5 Mobile Earth Stations (MESs)
The application for MES certification shall state the MES e.i.r.p. that is necessary for satisfactory communication. The maximum permissible e.i.r.p. will be the stated e.i.r.p. plus a 2 dB margin. If a detachable antenna is used, the certification application shall state the recommended antenna type and manufacturer, the antenna gain and the maximum transmitter output power at the antenna terminal.

TEST PROCEDURE

The transmitter output is connected to a wideband power meter/sensor which is greater than the occupied bandwidth as worst-case scenario, also the total power readings still comply with the required limit.

The cable assembly insertion loss of 13.23 dB (ANT 1) / 12.10 dB (ANT 4) (including 10.90 dB coupler and 2.33dB cable (ANT 1) / 10 dB pad and 2.10 dB cable (ANT 4)) was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

Test Engineer ID:	26118	**Test Date:**	4/3/23

Test Frequency (MHz)	Conducted Average Power (dBm)		Antenna Gain (dBi)		EIRP Average Power (dBm)	
	ANT 1	ANT 4	ANT 1	ANT 4	ANT 1	ANT 4
1610.17	27.98	25.79	-4.20	-3.20	23.78	22.59
1618.40	27.98	25.77			23.78	22.57
1626.03	**28.00**	25.80			**23.80**	22.60

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9. CONDUCTED TEST RESULTS

9.1. OCCUPIED BANDWIDTH

RULE PART(S)

FCC: §2.1049
ISED RSS-170 and RSS-GEN

LIMITS

For reporting purposes only.

TEST PROCEDURE

The transmitter output was connected to a calibrated coaxial cable and coupler, the other end of which was connected to a spectrum analyzer. The occupied bandwidth was measured with the spectrum analyzer at the middle channel in each band. The nominal RBW shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be set ≥ 3 × RBW. The 99% bandwidths were measured and recorded.

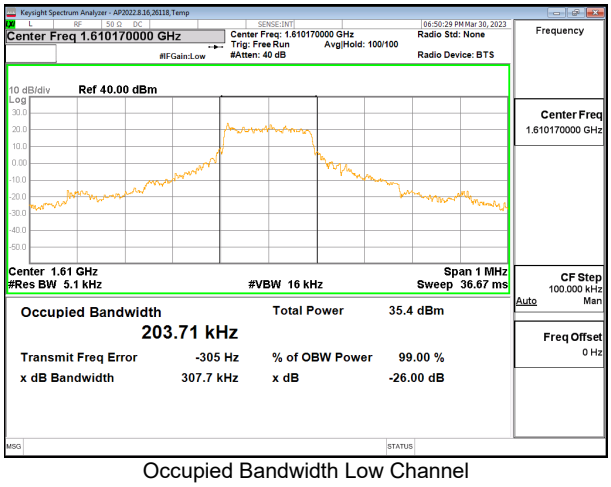
RESULTS

There is no limit required; therefore, only one port of higher power, ANT1, was tested.

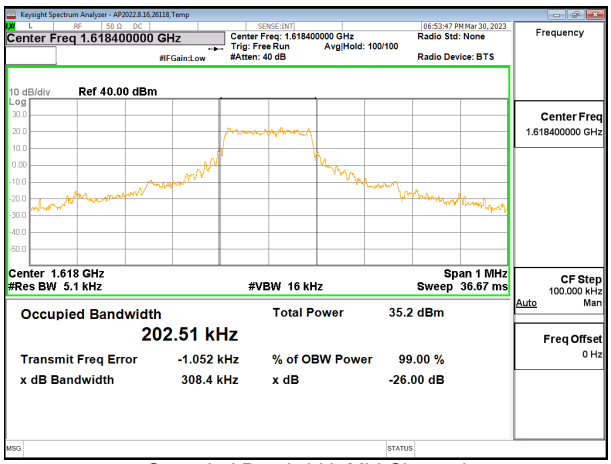
Test Engineer ID:	26118	**Test Date:**	3/30/23

Test Frequency (MHz)	99% BW (kHz)
1610.17	203.71
1618.40	202.51
1626.03	199.04

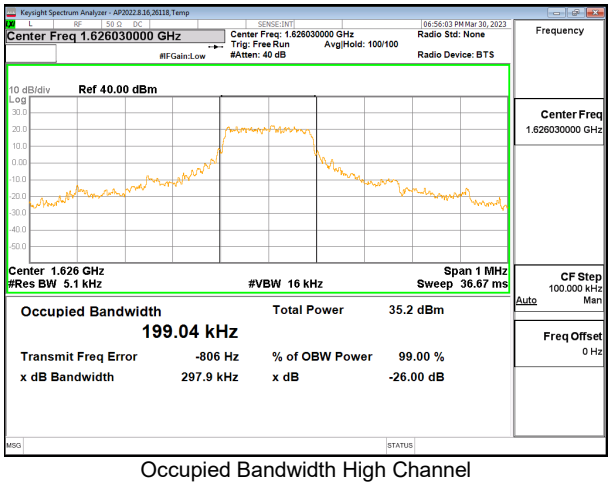
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



Occupied Bandwidth Low Channel



Occupied Bandwidth Mid Channel



Occupied Bandwidth High Channel

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.2. EMISSIONS MASK WITHIN 250% OF AUTHORIZED BANDWIDTH

LIMITS

FCC §25.202 and ISED RSS-170: 5.8
(f) Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

TEST PROCEDURE

The transmitter output was connected to a calibrated coaxial cable and coupler, the other end of which was connected to a spectrum analyzer. The channel edge emissions were measured on the low, mid and high channels. The limits within 250% of the authorized bandwidth are relative to the total in-band (channel) power. The measurement bandwidth (RBW) is set to >= 4kHz and VBW set to at least 3 times the RBW. To measure the average value of the emissions the detector is set to rms while observing the minimum required number of points as detailed in ANSI C63.26 for average rms measurements. The sweep time is set to 2ms multiplied by the number of points to obtain the average over 2ms. Multiple sweeps with max hold enabled are made to capture the maximum average value.

RESULTS

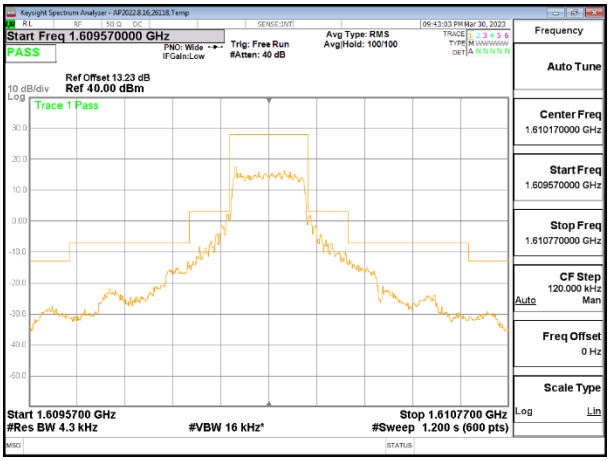
The tests were performed based on declared authorized bandwidths of 200kHz, 230kHz and 280kHz. The ANT 4 were performed only on center channel since it was the same signal to each antenna.

Test Engineer ID:	26118	**Test Date:**	3/30/23

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

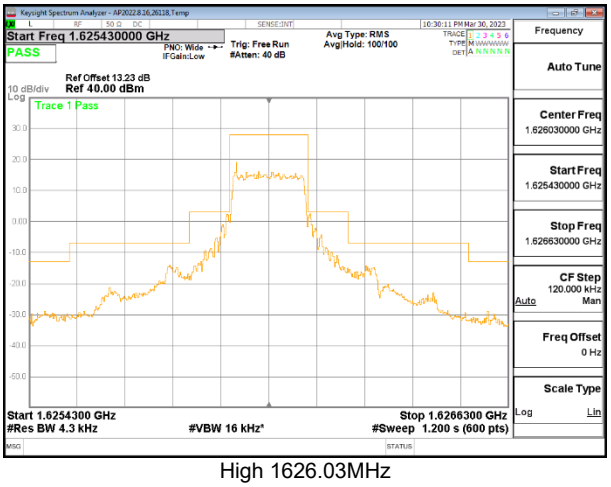
9.2.1. ANT 1

200kHz Authorized Bandwidth:



Low 1610.17MHz

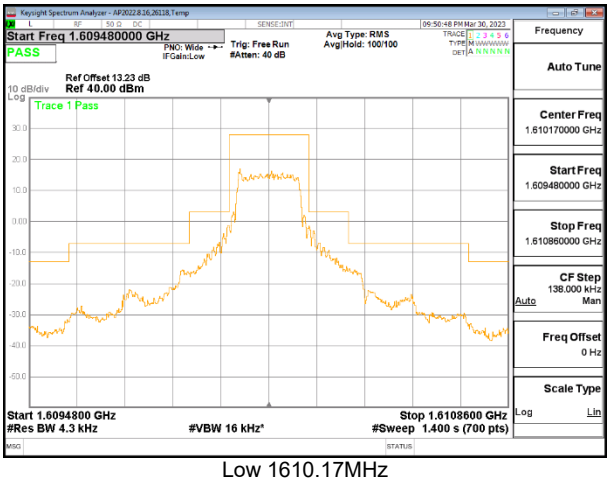
Mid 1618.40MHz



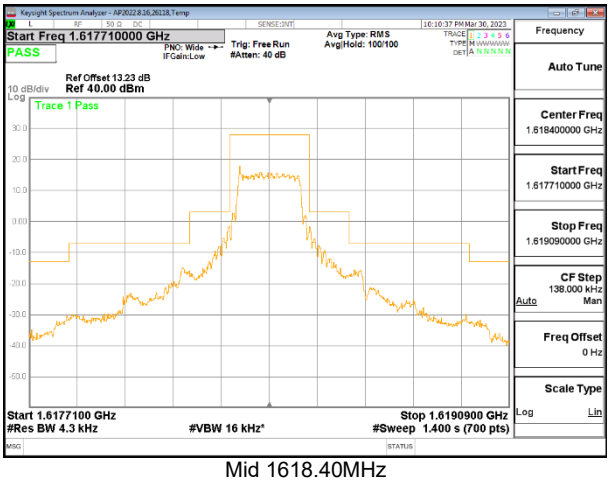
High 1626.03MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

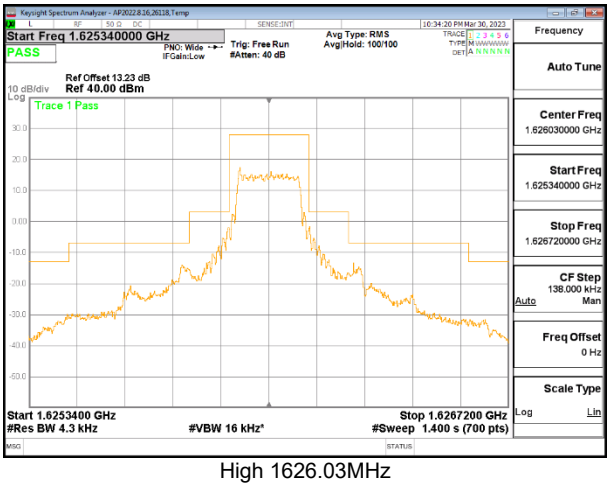
230kHz Authorized Bandwidth:



Low 1610.17MHz



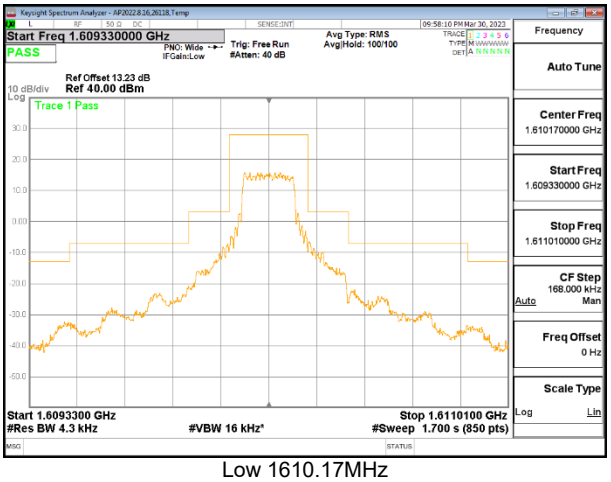
Mid 1618.40MHz



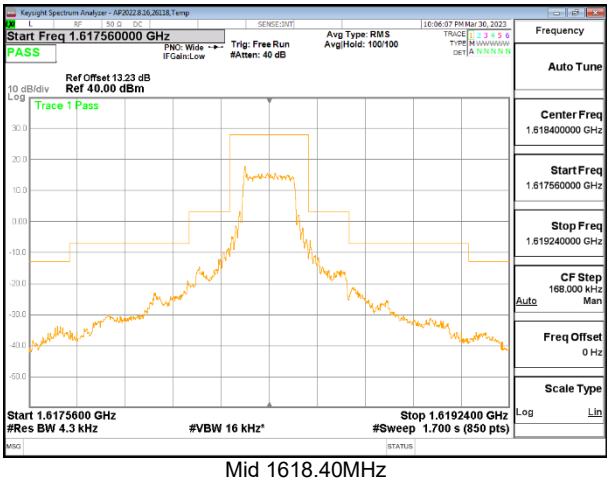
High 1626.03MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

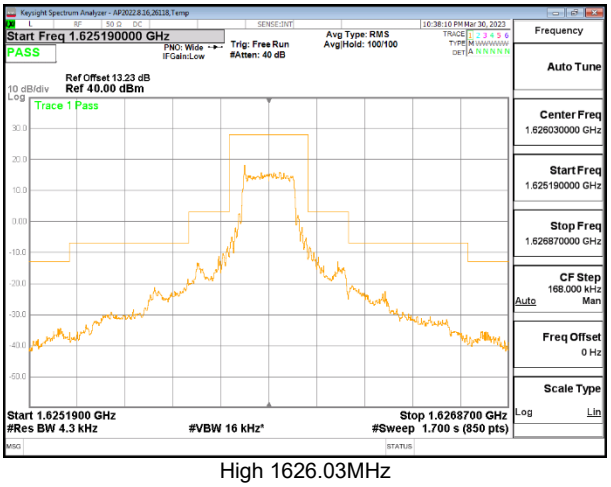
280kHz Authorized Bandwidth:



Low 1610.17MHz



Mid 1618.40MHz

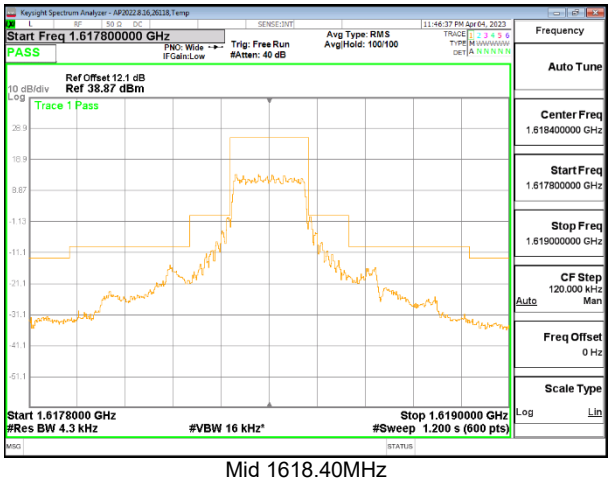


High 1626.03MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

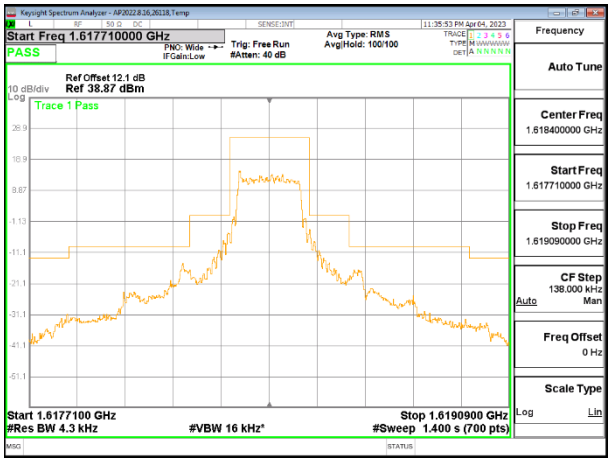
9.2.2. ANT 4

200kHz Authorized Bandwidth:



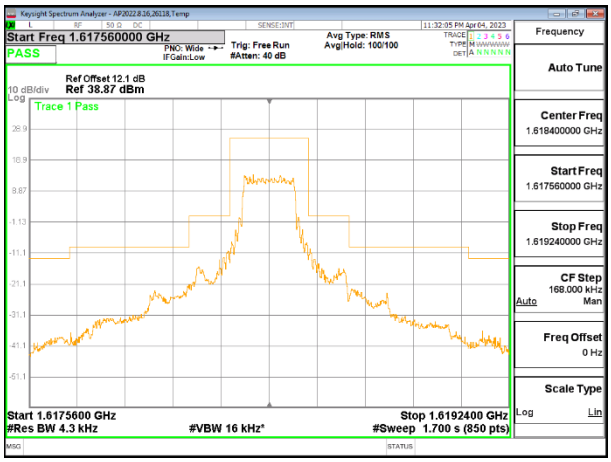
Mid 1618.40MHz

230kHz Authorized Bandwidth:



Mid 1618.40MHz

280kHz Authorized Bandwidth:



Mid 1618.40MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.3. OUT OF BAND EMISSIONS

LIMITS

FCC §25.202 and ISED RSS-170: 5.8
(f) Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts.

TEST PROCEDURE

KDB 971168 D01 v03r01/D02 v02r02

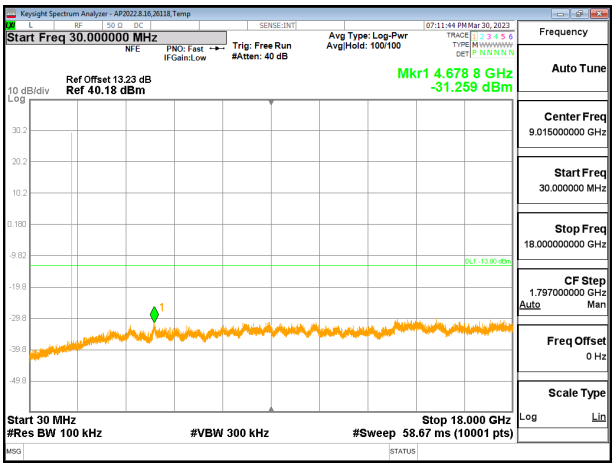
For each out of band emissions measurement:
- Set display line at -13 dBm (the limit of 43 + 10Log(P))
- Set RWB >= 4kHz and VBW >= 3 x RBW with peak detector for all measurements. The limit is an average limit so any emissions that exceed the limit using the peak detector are measured using rms detection with an averaging time of 2ms.

RESULTS

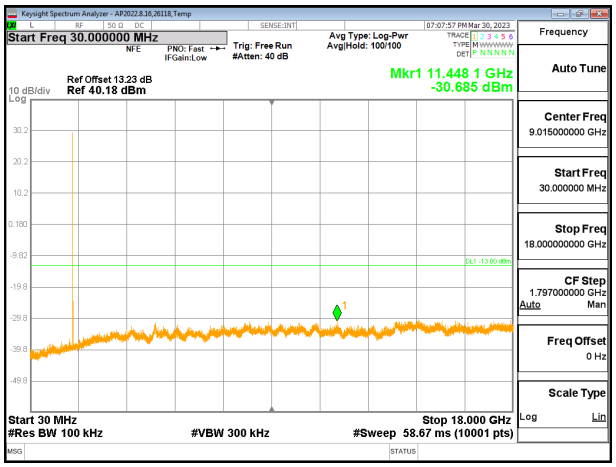
Test Engineer ID:	26118	**Test Date:**	3/30/23

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

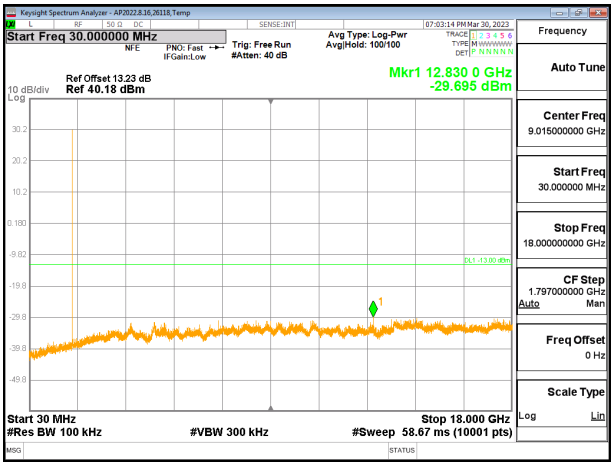
9.3.1. ANT 1



Low Channel 30MHz to 18GHz



Mid Channel 30MHz to 18GHz



High Channel 30MHz to 18GHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10. RADIATED TEST RESULTS

Radiated measurement using the Field Strength Method

Using the test configuration shown in Figure 6 below, we measure the radiated emissions directly from the EUT and convert the measured field strength or received power to EIRP, as required, for comparison to the applicable limits. As stated in 5.5.1 of ANSI C63.26-2015, the field strength measurement method using a test site validated to the requirements of ANSI C63.4 is an alternative to the substitution measurement method.

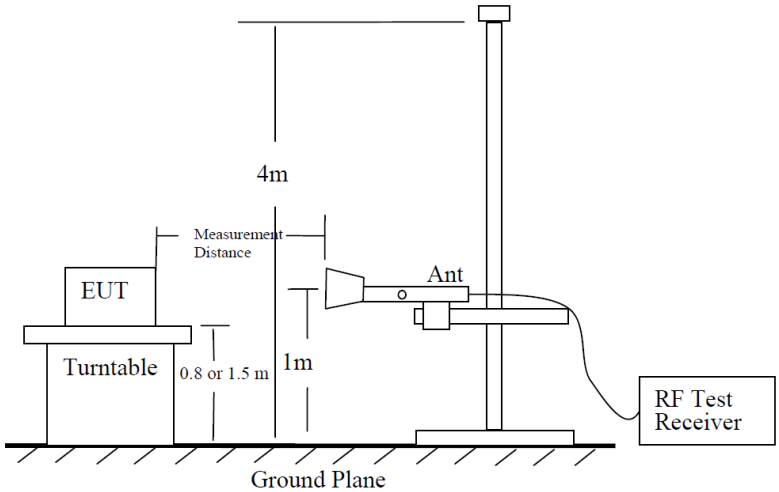


Figure 6 —Test site-up for radiated ERP and/or EIRP measurements

Radiated Power Measurement Calculation According to ANSI C63.26-2015

a) E (dBμV/m) = Measured amplitude level (dBμV) + Cable Loss (dB) + Antenna Factor (dB/m).
b) E (dBμV/m) = Measured amplitude level (dBm) + 107 + Cable Loss (dB) + Antenna Factor (dB/m).
c) E (dBμV/m) = EIRP (dBm) − 20log(D) + 104.8; where D is the measurement distance (in the far field region) in m.
d) EIRP (dBm) = E (dBμV/m) + 20log(D) − 104.8; where D is the measurement distance (in the far field region) in m.

So, from d)

The measuring distance is usually at 3m, then 20*Log (3) = 9.5424

Then, EIRP (dBm) = E (dBμV/m) + 9.5424 − 104.8 = E (dBμV/m) – 95.2576

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1. FIELD STRENGTH OF SPURIOUS RADIATION

LIMITS

FCC §25.202 and ISED RSS-170: 5.8
(f) Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;

TEST PROCEDURE

KDB 971168 D01 v03r01/D02 v02r02

For each out of band emissions measurement:
- Set display line at -13 dBm (the limit of 43 + 10Log(P))
- Set RWB >= 4kHz and VBW >= 3 x RBW with peak detector for all measurements. The limit is an average limit so any emissions that exceed the limit using the peak detector are measured using rms detection with an averaging time of 2ms.

RESULTS

Plots are provided for the center channel. Tabular data for all channels is presented.

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.1. ANT 1 (Above 1GHz)

Project #:	14523771
Date:	7/25/23
Test Engineer:	45258
Configuration:	EUT + Charger
Mode:	TX
Chamber:	A

Low channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	*3.220368	23.59	Pk	33	-95.2	-25.62	-64.23	-13	-51.23	0-360	151	H
1	*3.220368	24.22	Pk	33	-95.2	-25.62	-63.6	-13	-50.6	0-360	151	V
3	4.830198	32.66	Pk	34	-95.2	-21.82	-50.36	-13	-37.36	0-360	151	H
4	4.830198	40.03	Pk	34	-95.2	-21.82	-42.99	-13	-29.99	0-360	151	V
6	*6.440504	19.34	Pk	35.6	-95.2	-19.68	-59.94	-13	-46.94	0-360	151	H
5	*6.440504	19.93	Pk	35.6	-95.2	-19.68	-59.35	-13	-46.35	0-360	151	V

Pk - Peak detector
* - Noise Floor

Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	81886 ACF (dB) 3mH	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4.830483	42.88	Pk	34	-95.2	-21.83	-40.15	-13	-27.15	245	110	V
4.830504	37.68	Pk	34	-95.2	-21.84	-45.36	-13	-32.36	303	345	H

Pk - Peak detector

Mid Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	*3.236571	24.4	Pk	33.1	-95.2	-25.54	-63.24	-13	-50.24	0-360	150	H
1	*3.236571	24.96	Pk	33.1	-95.2	-25.54	-62.68	-13	-49.68	0-360	150	V
3	4.854979	30.77	Pk	34.1	-95.2	-22.16	-52.49	-13	-39.49	0-360	150	H
4	4.854979	34.2	Pk	34.1	-95.2	-22.16	-49.06	-13	-36.06	0-360	150	V
6	*6.473387	20	Pk	35.6	-95.2	-19.44	-59.04	-13	-46.04	0-360	150	H
5	*6.473387	18.86	Pk	35.6	-95.2	-19.44	-60.18	-13	-47.18	0-360	150	V

Pk - Peak detector
* - Noise Floor

Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	81886 ACF (dB) 3mH	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4.855273	31.37	Pk	34.1	-95.2	-22.16	-51.89	-13	-38.89	49	160	V
4.855311	30.31	Pk	34.1	-95.2	-22.16	-52.95	-13	-39.95	118	101	H

Pk - Peak detector

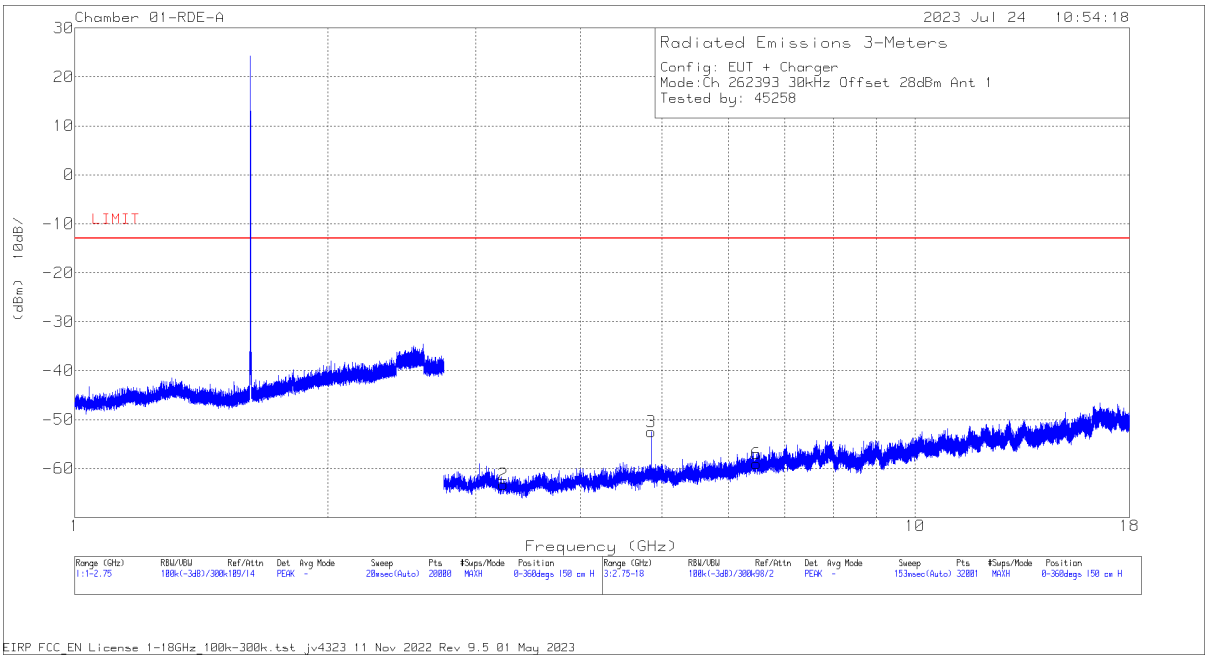
High Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	3.252774	23.61	Pk	33.1	-95.2	-25.28	-63.77	-13	-50.77	0-360	151	H
1	3.252774	24.49	Pk	33.1	-95.2	-25.28	-62.89	-13	-49.89	0-360	151	V
4	4.877854	23.86	Pk	34	-95.2	-22.64	-59.98	-13	-46.98	0-360	151	H
3	4.877854	22.13	Pk	34	-95.2	-22.64	-61.71	-13	-48.71	0-360	151	V
6	6.504363	19.51	Pk	35.6	-95.2	-19.66	-59.75	-13	-46.75	0-360	151	H
5	6.504363	20.47	Pk	35.6	-95.2	-19.66	-58.79	-13	-45.79	0-360	151	V

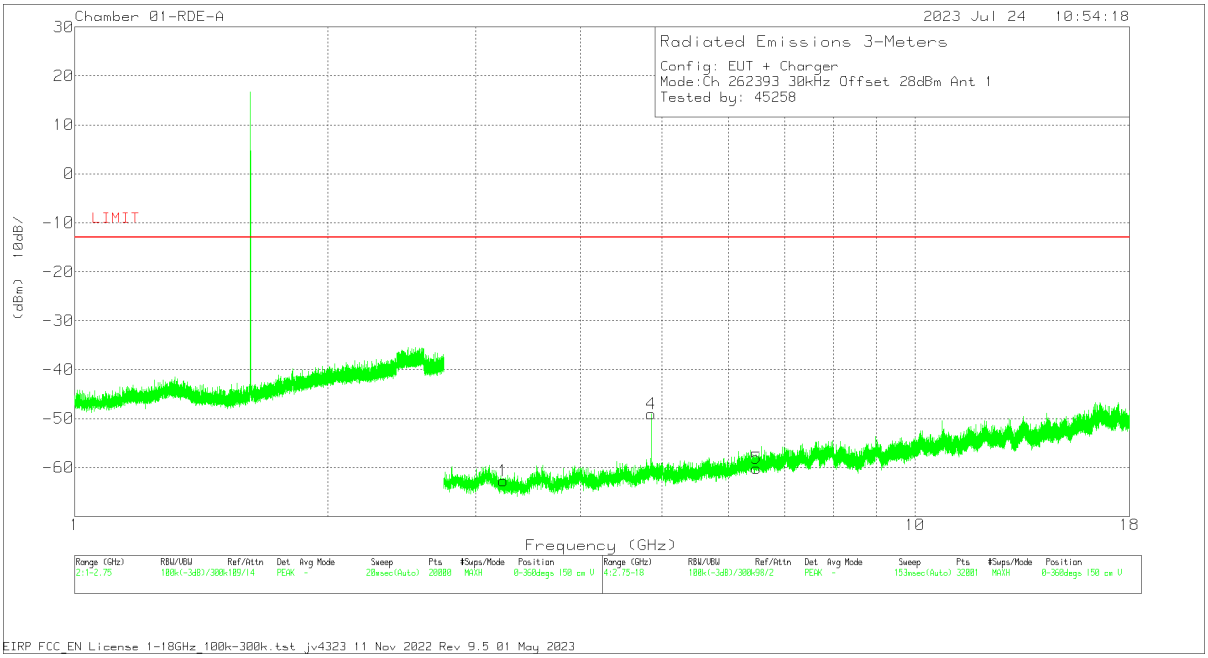
Pk - Peak detector
* - Noise Floor

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Mid Channel:



HORIZONTAL



VERTICAL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.2. ANT 4 (Above 1GHz)

Project #:	14523771
Date:	6/5/23
Test Engineer:	30606
Configuration:	EUT + Charger
Mode:	TX
Chamber:	A

Low channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB/m)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	*3.207977	25.87	Pk	32.8	-95.2	-25.69	-62.22	-13	-49.22	0-360	149	V
1	*3.217508	26.92	Pk	32.7	-95.2	-25.57	-61.15	-13	-48.15	0-360	149	H
2	*4.806369	24.25	Pk	34.1	-95.2	-21.62	-58.47	-13	-45.47	0-360	149	H
5	*4.818760	24.78	Pk	34.1	-95.2	-21.77	-58.09	-13	-45.09	0-360	149	V
6	*7.075286	22.29	Pk	35.5	-95.2	-18.8	-56.21	-13	-43.21	0-360	149	V
3	*7.081005	22.5	Pk	35.5	-95.2	-18.94	-56.14	-13	-43.14	0-360	149	H

Pk - Peak detector
* - Noise Floor

Mid Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB/m)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	3.255633	26.64	Pk	33.3	-95.2	-25.37	-60.63	-13	-47.63	0-360	149	V
1	3.258969	25.04	Pk	33.4	-95.2	-25.25	-62.01	-13	-49.01	0-360	149	H
2	5.027495	25.18	Pk	34.2	-95.2	-22.11	-57.93	-13	-44.93	0-360	149	H
5	5.034643	23.02	Pk	34.2	-95.2	-22.04	-60.02	-13	-47.02	0-360	149	V
6	7.647161	22.99	Pk	35.6	-95.2	-17.69	-54.3	-13	-41.3	0-360	149	V
3	7.672896	22.71	Pk	35.6	-95.2	-18.09	-54.98	-13	-41.98	0-360	149	H

Pk - Peak detector
* - Noise Floor

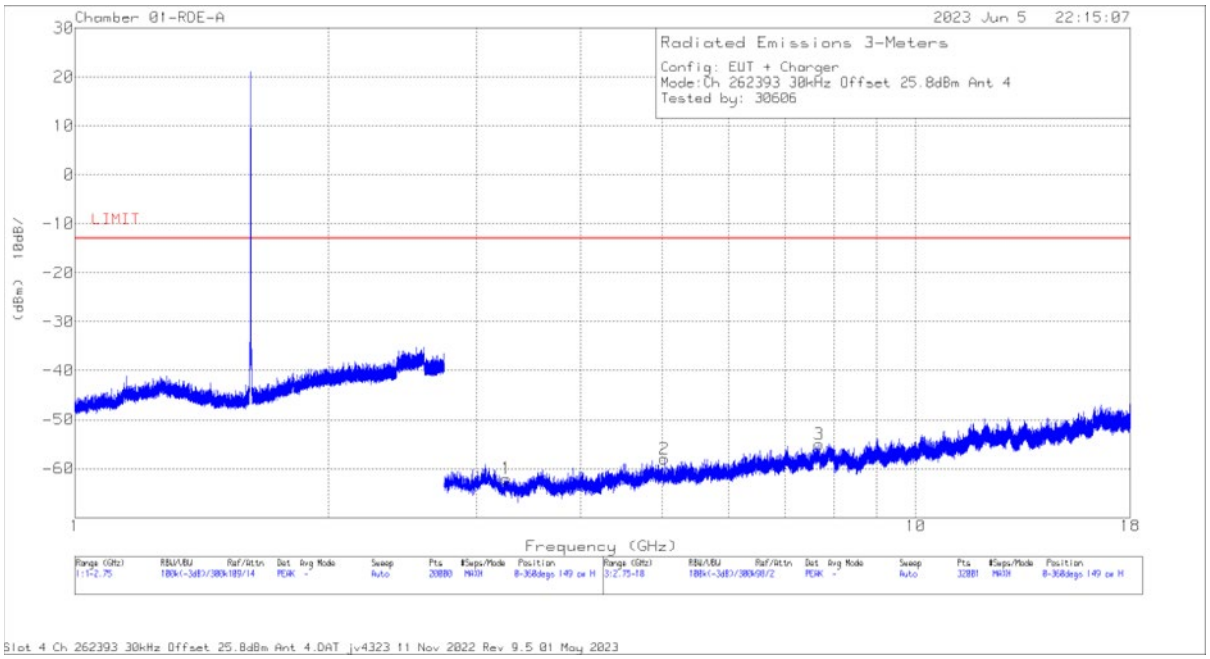
High Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	Horn Antenna ACF(dB/m)	EIRP CF	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*3.242290	26.77	Pk	32.8	-95.2	-25.52	-61.15	-13	-48.15	0-360	149	H
4	*3.247055	25.01	Pk	32.9	-95.2	-25.39	-62.68	-13	-49.68	0-360	149	V
5	*4.997948	24.56	Pk	34.2	-95.2	-22.53	-58.97	-13	-45.97	0-360	149	V
2	*5.009385	24.66	Pk	34.2	-95.2	-22.29	-58.63	-13	-45.63	0-360	149	H
6	*7.944060	23.19	Pk	35.6	-95.2	-17.98	-54.39	-13	-41.39	0-360	149	V
3	*7.944537	23.05	Pk	35.6	-95.2	-17.98	-54.53	-13	-41.53	0-360	149	H

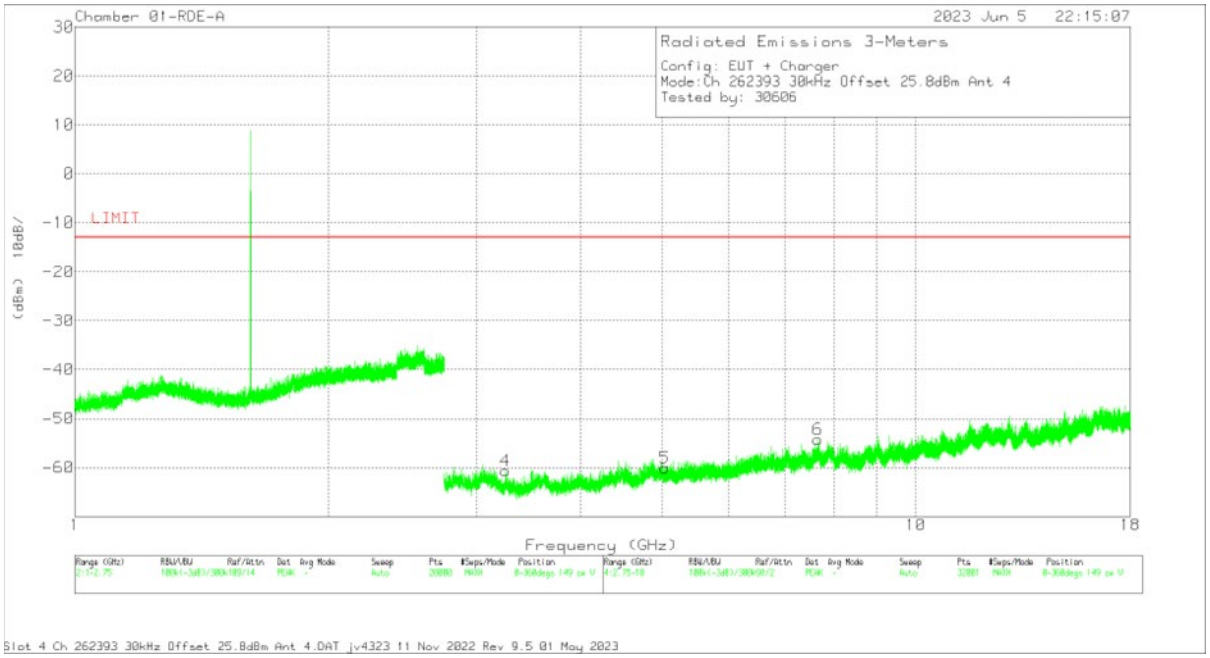
Pk - Peak detector
* - Noise Floor

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Mid Channel:



HORIZONTAL

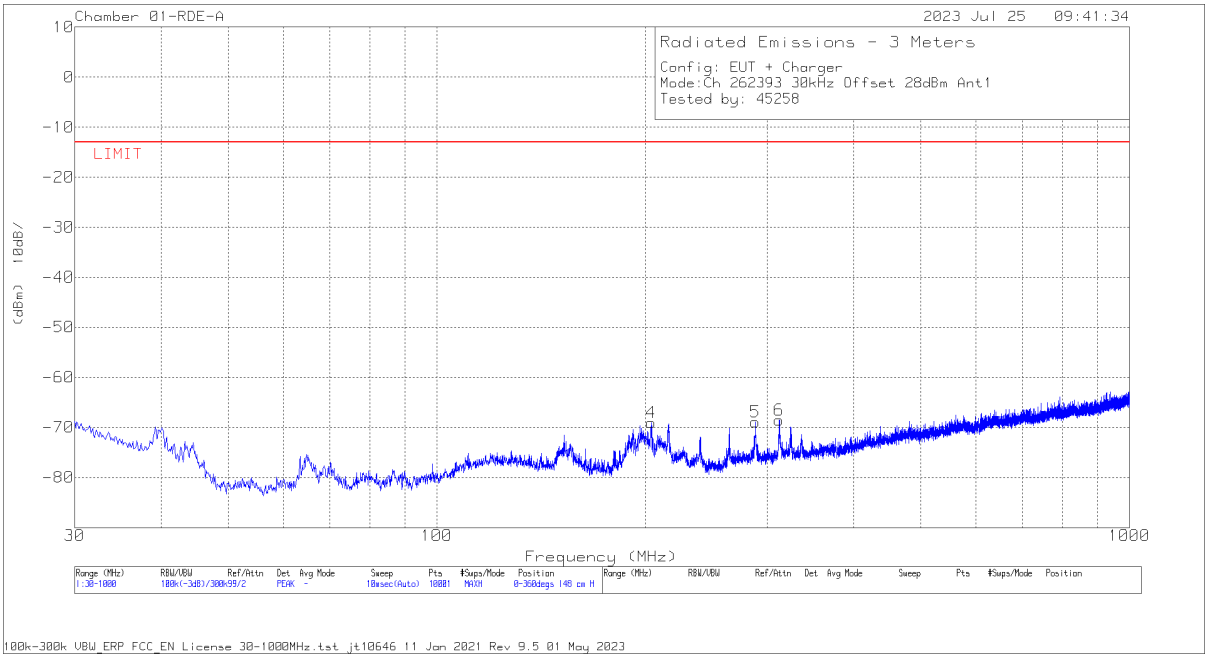


VERTICAL

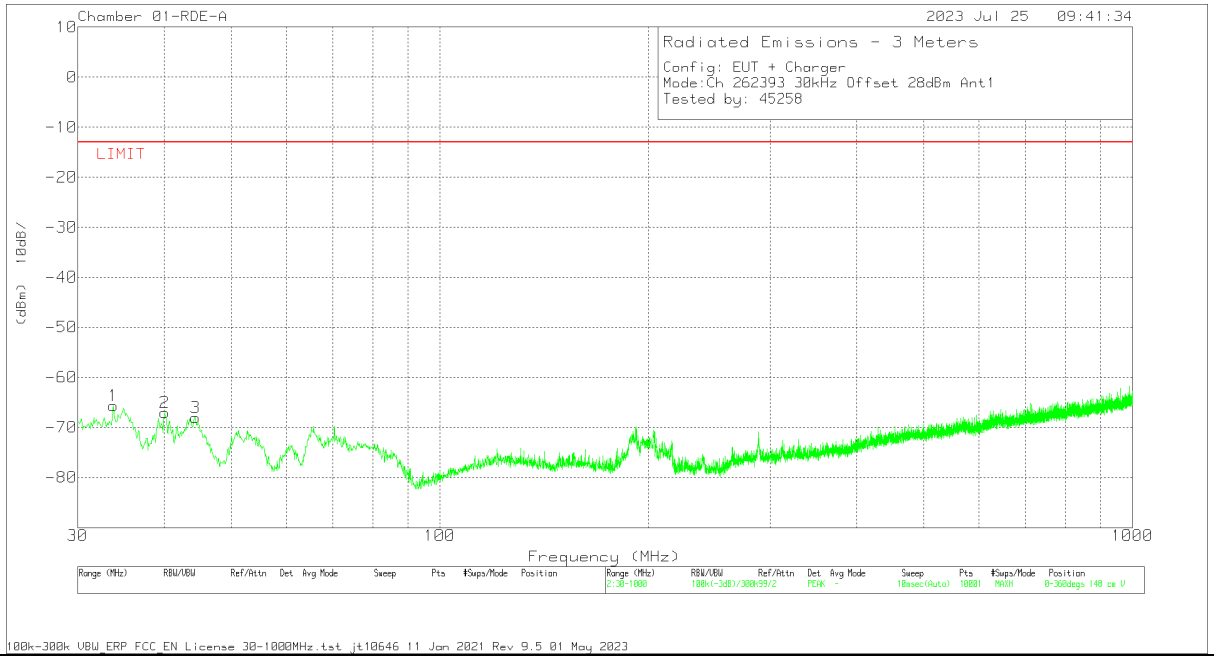
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.3. ANT 1 (Below 1GHz)

Project #:	14523771
Date:	7/25/2023
Test Engineer:	45258
Configuration:	EUT + Charger
Mode:	TX
Chamber:	A



HORIZONTAL



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

VERTICAL

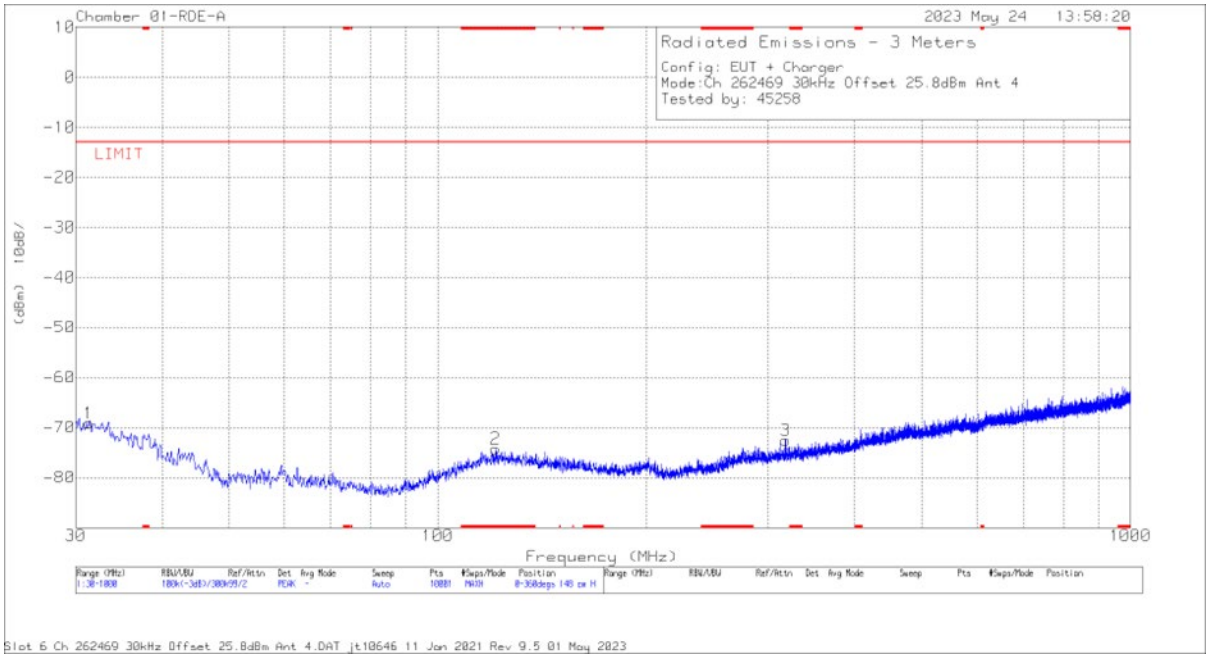
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	232075 ACF (dB/m)	Amp/Cbl (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	33.783	32.42	Pk	24.3	-27.2	-95.2	-65.68	-13	-52.68	0-360	148	V
2	40.088	35.77	Pk	19.5	-27.1	-95.2	-67.03	-13	-54.03	0-360	148	V
3	44.356	37.6	Pk	16.6	-27	-95.2	-68	-13	-55	0-360	148	V
4	204.115	33.91	Pk	17.3	-25.1	-95.2	-69.09	-13	-56.09	0-360	148	H
5	288.408	31.45	Pk	19.2	-24.4	-95.2	-68.95	-13	-55.95	0-360	148	H
6	312.27	31.31	Pk	19.7	-24.4	-95.2	-68.59	-13	-55.59	0-360	148	H

Pk - Peak detector

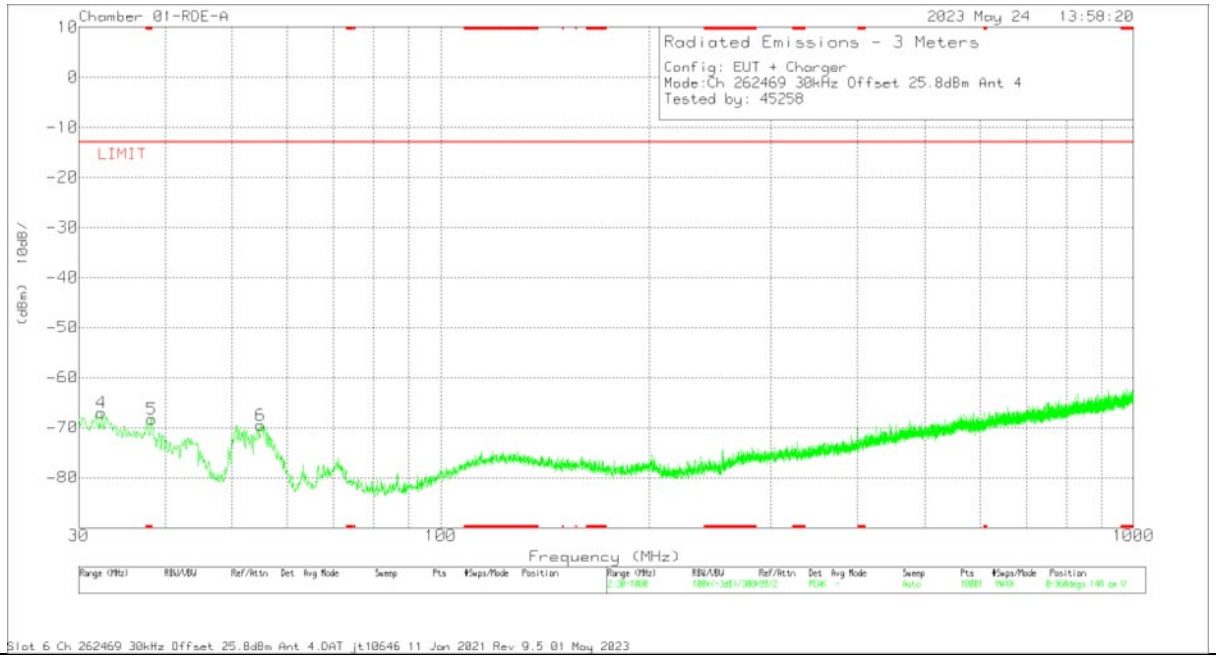
UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.4. ANT 4 (Below 1GHz)

Project #:	14523771
Date:	5/24/2023
Test Engineer:	45258
Configuration:	EUT + Charger
Mode:	TX
Chamber:	A



HORIZONTAL



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

VERTICAL

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	232075 ACF (dB/m)	Amp/Cbl (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	31.358	27.37	Pk	25.9	-27.2	-95.2	-69.13	-13	-56.13	0-360	148	H
4	32.328	30.07	Pk	25.3	-27.2	-95.2	-67.03	-13	-54.03	0-360	148	V
5	38.245	33.17	Pk	20.9	-27.1	-95.2	-68.23	-13	-55.23	0-360	148	V
6	54.929	39.38	Pk	13.2	-26.9	-95.2	-69.52	-13	-56.52	0-360	148	V
2	121.18	27.27	Pk	19.8	-26.1	-95.2	-74.23	-13	-61.23	0-360	148	H
3	317.605	27.4	Pk	19.7	-24.4	-95.2	-72.5	-13	-59.5	0-360	148	H

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.2. ADDITIONAL UNWANTED EMISSION (1559MHz – 1610MHz)

LIMITS

FCC §25.216

Limits on emissions from mobile earth stations for protection of aeronautical radionavigation-satellite service

(a) The e.i.r.p. density of emissions from mobile earth stations placed in service on or before July 21, 2002 …

(b) The e.i.r.p. density of emissions from mobile earth stations placed in service on or before July 21, 2002 …

(c) The e.i.r.p. density of emissions from mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1559-1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band.

FCC §25.216 and ISED RSS-170: 5.9.1

(g) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1610-1626.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

TEST PROCEDURE

KDB 971168 D01 v03r01/D02 v02r02

Measure wideband emissions using either:
RBW = 1MHz, VB = 3MHz
RBW < 1MHz, integrate over 1MHz if necessary

Measure narrowband emissions using:
RBW = 10kHz, VB = 30kHz as worst case setting

Set detector = rms, sweep time ~ number of points x 2ms, and sweep multiple times with max hold enabled. When the detector is set to rms the number of points is set to exceed the minimum number required by ANSI C63.26 for average measurements. A peak detector may be used (e.g. to avoid slow sweep times for the narrowband emissions measurements) in lieu of average rms detection as this will provide a more conservative (higher) measured value than the rms value.

RESULTS

Both horizontal / vertical polarizations and low/ mid/ high channels were investigated on ANT 1 and ANT 4. It was found low channel to be worst case for both antennas.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Project #:	14523771
Date:	06/14/23 & 07/25/23
Test Engineer:	30606
Configuration:	EUT + Charger
Mode:	TX
Chamber:	A

Offset Calculation Offset:

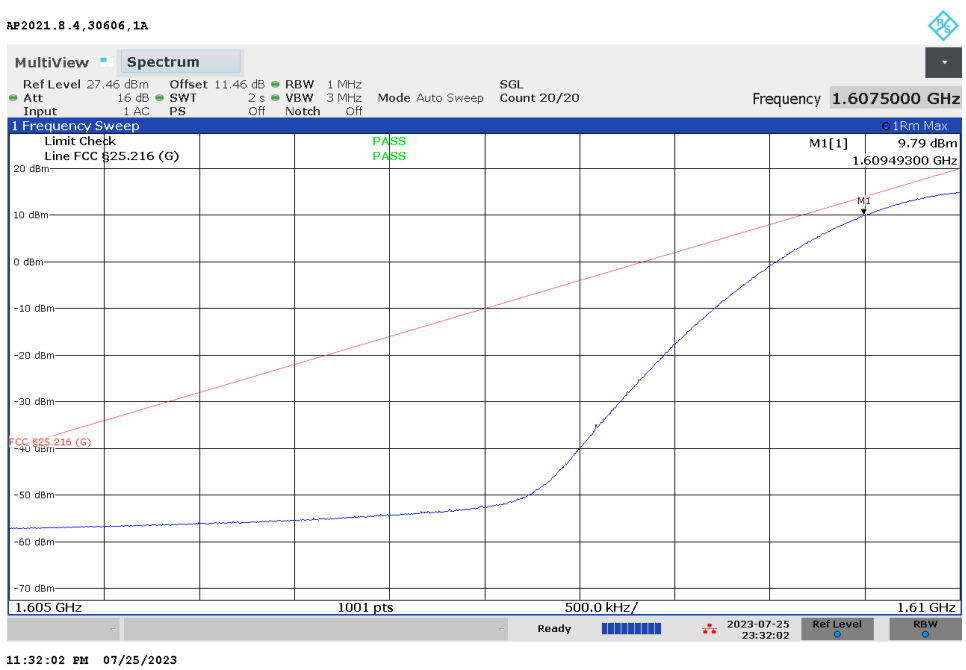
Antenna Factor (dB/m)	Amp/Cbl/Fltr/Pad (dB)	EIRP CF	Offset (dB)
28.50	-28.84	11.8	11.46

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.2.1. ANT 1

Wideband Low Channel 1610.17MHz Vertical:

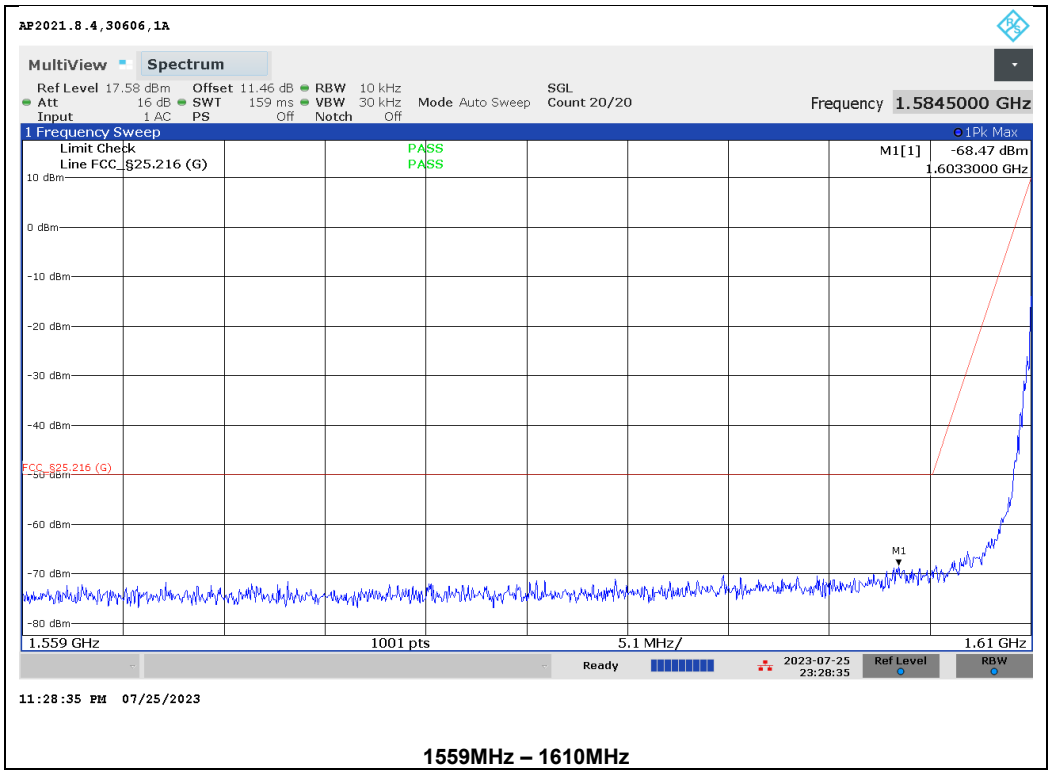
1559MHz -1610MHz



Zoom-in 1559MHz -1610MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Narrowband Low Channel 1610.17MHz Vertical:



1559MHz – 1610MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

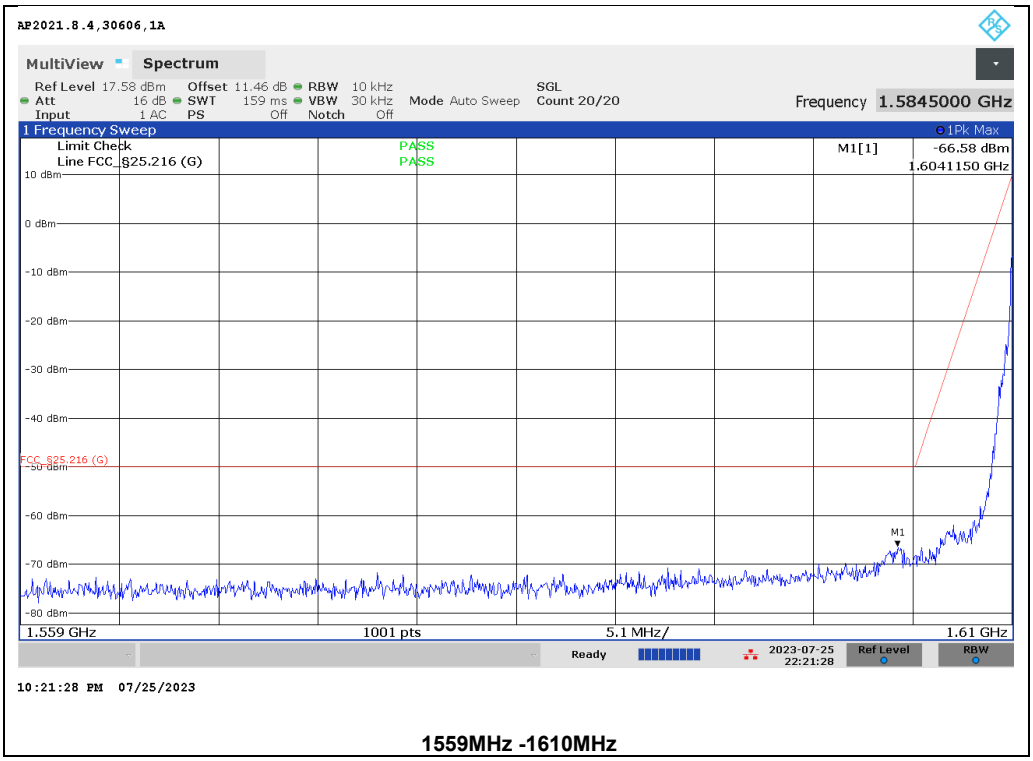
Wideband Low Channel 1610.17MHz Horizontal:

1559MHz -1610MHz

Zoom-in 1559MHz -1610MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Narrowband Low Channel 1610.17MHz Horizontal:



1559MHz -1610MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.2.2. ANT 4

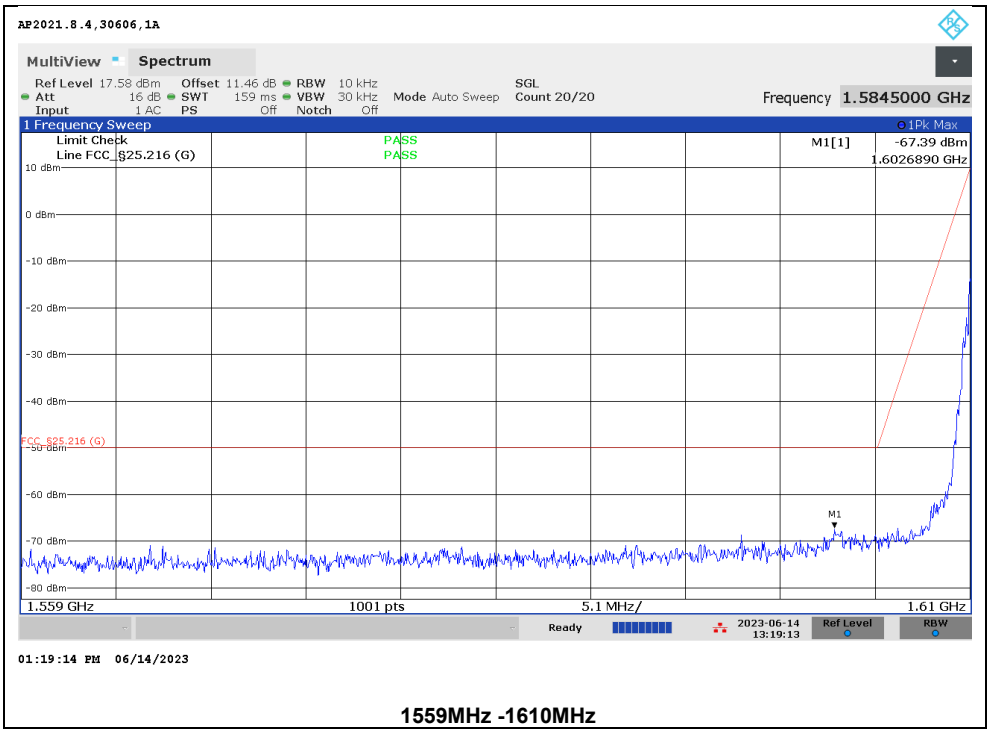
Wideband Low Channel 1610.17MHz Vertical:

1559MHz -1610MHz

Zoom-in 1559MHz -1610MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

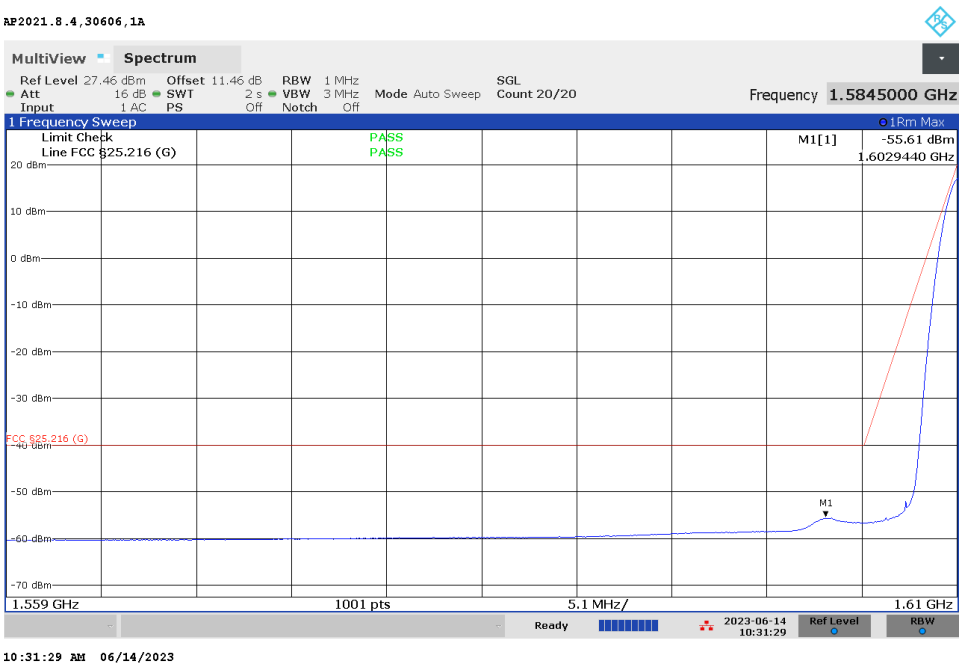
Narrowband Low Channel 1610.17MHz Vertical:



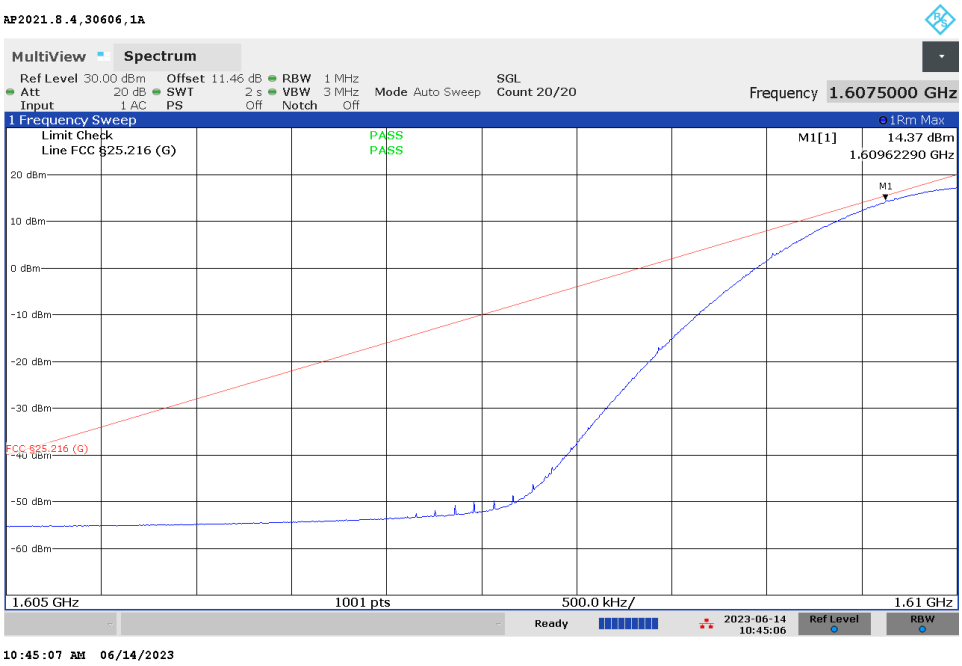
1559MHz -1610MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Wideband Low Channel 1610.17MHz Horizontal:



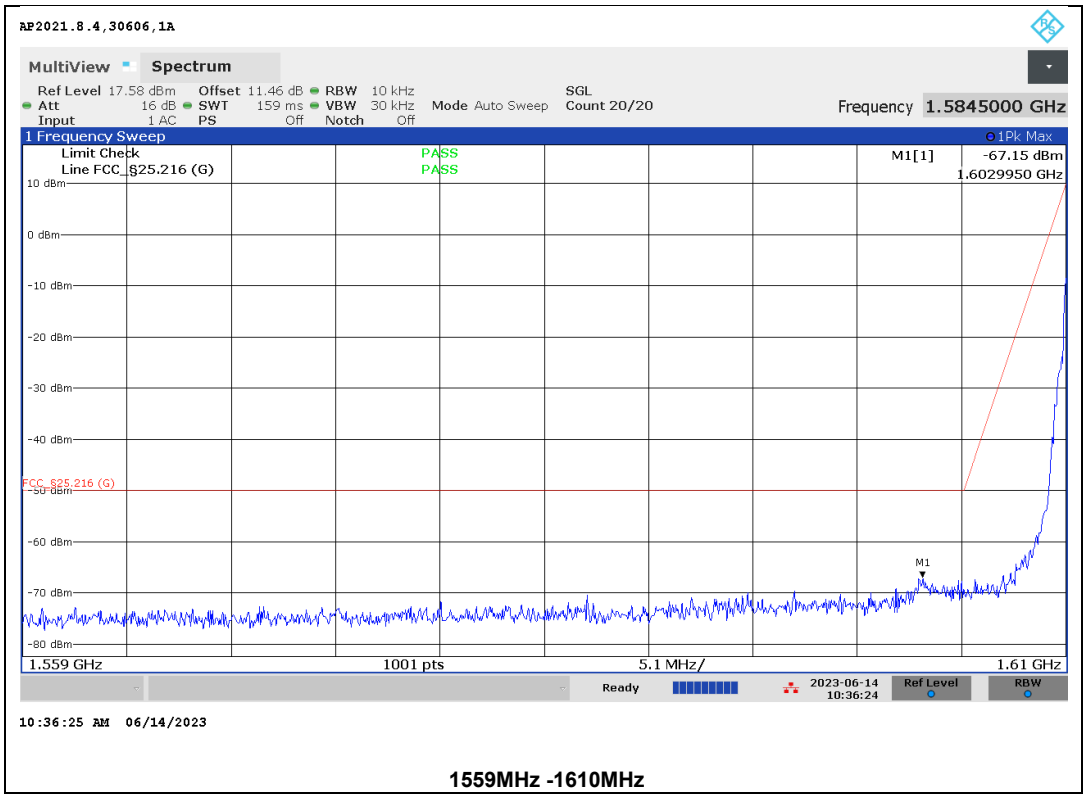
1559MHz -1610MHz



Zoom-in 1559MHz -1610MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

Narrowband Low Channel 1610.17MHz Horizontal:



1559MHz -1610MHz

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.3. CARRIER-OFF STATE EMISSIONS (1559MHz – 1610MHz)

LIMITS

FCC §25.216 and ISED RSS-170: 5.10

Limits on emissions from mobile earth stations for protection of aeronautical radionavigation-satellite service

(i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed −80 dBW/MHz in the 1559-1610 MHz band averaged over any two millisecond interval.

ISED RSS-170: 5.10 Carrier-off State Emissions

Mobile equipment with transmitting frequencies between 1 GHz and 3 GHz shall have the e.i.r.p. density of carrier-off state emissions in the band 1559-1610 MHz not exceed –80 dBW/MHz.

TEST PROCEDURE

KDB 971168 D01 v03r01/D02 v02r02

Set RBW = 1MHz, VB = 3MHz, Detector = RMS, Sweep Time = Number of Points x 2ms, and sweep multiple times with Max Hold enabled.

RESULTS

No emissions were found on both horizontal and vertical polarization for ANT 1 and ANT 4.

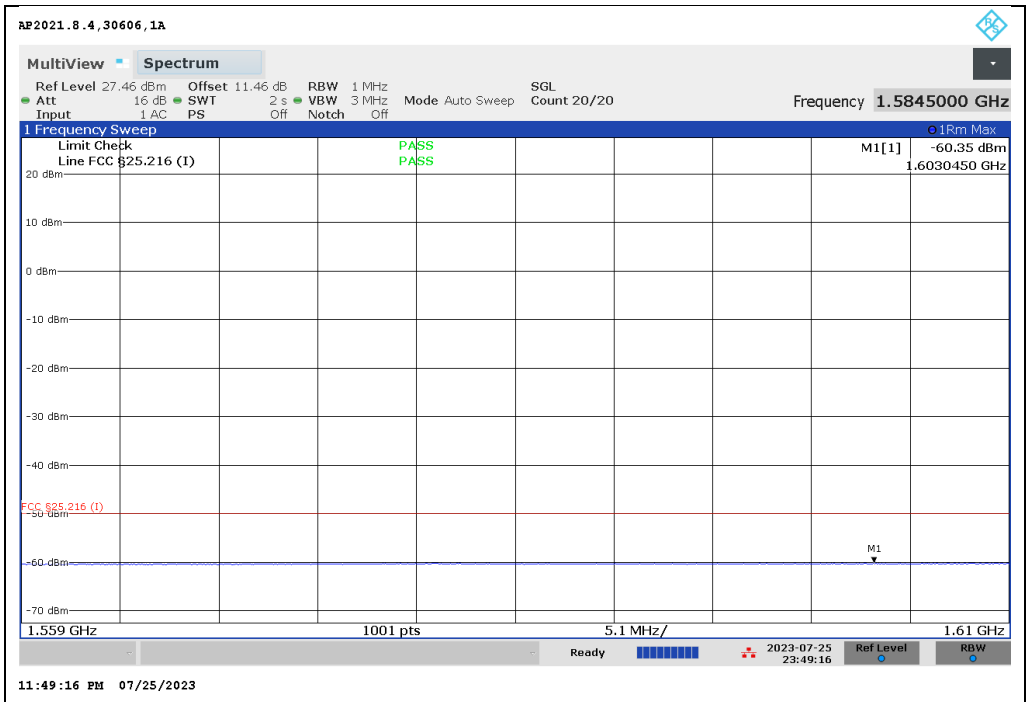
Project #:	14523771
Date:	06/14/23 & 07/25/23
Test Engineer:	30606
Configuration:	EUT + Charger
Mode:	RX
Chamber:	1-RDE-A

Offset Calculation Offset:

Antenna Factor (dB/m)	Amp/Cbl/Fltr/Pad (dB)	EIRP CF	Offset (dB)
28.50	-28.84	11.8	11.46

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.3.1. ANT 1



Low 1610.17MHz

10.3.2. ANT 4

Low 1610.17MHz

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701i
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.4. FREQUENCY STABILITY

LIMITS

FCC §25.202
(d) Frequency tolerance, Earth stations. The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent of the reference frequency.

ISED RSS-170: 5.3
For mobile earth station equipment, the carrier frequency shall not depart from the reference frequency by more than ±10 ppm.

TEST PROCEDURE

Use spectrum with Frequency Error measurement capability.

- Temp. = −30°C to +50°C
- Voltage = (85% - 115%)

  Low voltage, 3.23VDC, Normal, 3.8VDC and High voltage, 4.37VDC.
  End Voltage, 3.01VDC.

Frequency Stability vs Temperature:
The EUT is place inside a temperature chamber. The temperature is set to 20ºC and allowed to stabilize. After sufficient soak time, the transmitting frequency error is measured. The temperature is increased by 10 degrees, allowed to stabilize and soak, and then the measurement is repeated. This is repeated until +50ºC is reached.

Frequency Stability vs Voltage:
The peak frequency error is recorded (worst-case).

RESULTS

Test Engineer ID:	26118	Test Date:	4/06/23

Frequency Reference (MHz)		1610.17019		Frequency Reading (MHz)	Delta (Hz)	Frequency Stability (ppm)
Condition		F low @ -10dB BW (MHz)	F high @ -10dB BW (MHz)			
Temperature	Voltage					
Normal (20 C)	Normal	1610.078625	1610.26175	1610.170188		
Extreme (50C)		1610.078563	1610.261188	1610.169875	-312.5	-0.19
Extreme (40C)		1610.078875	1610.259438	1610.169156	-1031.2	-0.64
Extreme (30C)		1610.079438	1610.260375	1610.169906	-281.2	-0.17
Extreme (10C)		1610.078875	1610.260875	1610.169875	-312.5	-0.19
Extreme (0C)		1610.078313	1610.26075	1610.169531	-656.2	-0.41
Extreme (-10C)		1610.078125	1610.260938	1610.169531	-656.2	-0.41
Extreme (-20C)		1610.07775	1610.261063	1610.169406	-781.2	-0.49
Extreme (-30C)		1610.078625	1610.260313	1610.169469	-718.7	-0.45
20C	15%	1610.078313	1610.260875	1610.169594	-593.8	-0.37
	-15%	1610.079125	1610.261625	1610.170375	187.5	0.12
	End Point	1610.078188	1610.260688	1610.169438	-750.0	-0.47

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

11. SETUP PHOTOS

Please refer to 14523771-EP1V1 for setup photos

END OF REPORT

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.