



TEST REPORT

Report Number: 14040863-E22V2

Applicant : APPLE INC.
1 APPLE PARK WAY
CUPERTINO, CA 95104, U.S.A.

Model : A2650 (Parent Model, Full Test)
A2889, A2890 (Variant Models)

Brand : APPLE

FCC ID : BCG-E8140A (Parent Model)
BCG-E8150A, BCG-E8151A (Variant Models)

IC : 579C-E8140A (Parent Model)
579C-E8150A, 579C-E8151A (Variant Models)

EUT Description : SMARTPHONE

Test Standard(s) : FCC CFR47 Part 25
ISED RSS-170 ISSUE 3 AMENDED

Date Of Issue:

JULY 14, 2022

Prepared by:

UL LLC

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Revision History


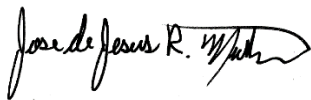

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
V1	6/21/2022	Initial Review	Thu Chan
V2	7/14/2022	Addressed TCB's Questions	Chris Xiong

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1. ATTESTATION OF TEST RESULTS

Applicant Name and Address	APPLE INC. 1 APPLE PARK WAY CUPERTINO, CA 95104, U.S.A.	
Model	A2650 (Parent Model, Full Test) A2889, A2890 (Variant Models)	
Brand	APPLE	
FCC ID	BCG-E8140A (Parent Model) BCG-E8150A, BCG-E8151A (Variant Models)	
IC	579C-E8140A (Parent Model) 579C-E8150A, 579C-E8151A (Variant Models)	
EUT Description	SMARTPHONE	
Serial Number	W7KCC4K19C (Conducted), XHQT24YDL9 (Radiated)	
Sample Receipt Date	APRIL 12, 2022 , APRIL 19, 2022	
Date Tested	APRIL 20, 2022 to MAY 17, 2022	
Applicable Standards	FCC CFR47 PART 25 ISED RSS-170 ISSUE 3 AMENDED	
Test Results	COMPLIES	
<p>UL LLC 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.</p> <p>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.</p> <p>This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC 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.</p>		
Approved & Released By:	Reviewed By:	Prepared By:
		
Thu Chan Staff Engineer UL LLC	Jose Martinez Senior Test Engineer UL LLC	Chris Xiong Senior Test Engineer UL LLC

2. SUMMARY OF TEST RESULTS

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

Requirement Description	Requirement Clause Number (FCC)	Requirement Clause Number (ISED)	Result*	Remarks
RF Output Power Verification	25.204 (a)	RSS-170 §5.3.2	Complies	
Occupied Bandwidth	2.1049	RSS-170 RSS-GEN	Reporting purposes only	
Emissions Mask - within 250% of Authorized Bandwidth	25.202 (f)(1)&(2)	RSS-170 §5.4.3.1 (1)&(2)	Complies	
Out of Band Emissions	25.202 (f)(3)	RSS-170 §5.4.3.1 (3)	Complies	
Additional Unwanted Emission (1559-1610MHz)	25.216 (c)&(g) FCC 03-283	RSS-170 §5.4.3.2.1 (g)	Complies	
Carrier-Off State Emissions (155901610MHz)	25.216 (i) FCC 03-283	RSS-170 §5.4.4	Complies	
Frequency Stability	25.202 (d)	RSS-170 §5.2	Complies	

3. TEST METHODOLOGY

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

- ANSI C63.26:2015
- ISED RSS-170 ISSUE 3 AMENDED
- FCC CFR 47 Part 2 and 25
- [FCC KDB 971168 D01 v03r01](#): Power Meas License Digital Systems
- [FCC KDB 971168 D02 v02r01](#): Misc Rev Approv License Devices
- [FCC KDB 412172 D01 v01r01](#). Determining ERP and EIRP

4. FACILITIES AND ACCREDITATION

UL LLC 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
<input checked="" type="checkbox"/>	Building 1: 47173 Benicia Street, Fremont, CA 94538, USA	US0104	2324A	550739
<input checked="" type="checkbox"/>	Building 2: 47266 Benicia Street, Fremont, CA 94538, USA	US0104	22541	550739
<input checked="" type="checkbox"/>	Building 4: 47658 Kato Rd, Fremont, CA 94538, USA	US0104	2324B	550739

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)

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

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The Apple iPhone is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and MSS. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM) in some models. The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible.

Testing was performed on the parent model and is used to support the application for the parent and variants identified in this report based on the test plan submitted and approved via KDB inquiry by the FCC and by ISED-Canada.

Parent Model: A2650, FCC ID: BCG-E8140A, IC: 579C-E8140A

Variant Models: A2889, FCC ID: BCG-E8150A, IC: 579C-E8150A
 A2890; FCC ID: BCG-E8151A, IC: 579C-E8151A

6.2. MAXIMUM OUTPUT POWER

EIRP/ERP TEST PROCEDURE

ANSI C63.26:2015
 KDB 971168 D01 Section 5.6

$$EIRP = P_{Meas} + GT - LC$$

where: EIRP = effective isotropic radiated power, respectively (expressed in the same units as P_{Meas}, typically dBW or dBm);

P_{Meas} = 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	27.88	-1.9	10000	25.98	0.396	197.96	198KG1D
1618.4	28.05		10000	26.15	0.412	197.46	197KG1D
1626.03	28.11		10000	26.21	0.418	196.47	196KG1D

6.3. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was FW Version: 0.15.02.

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	-1.9	-2.9

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.

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

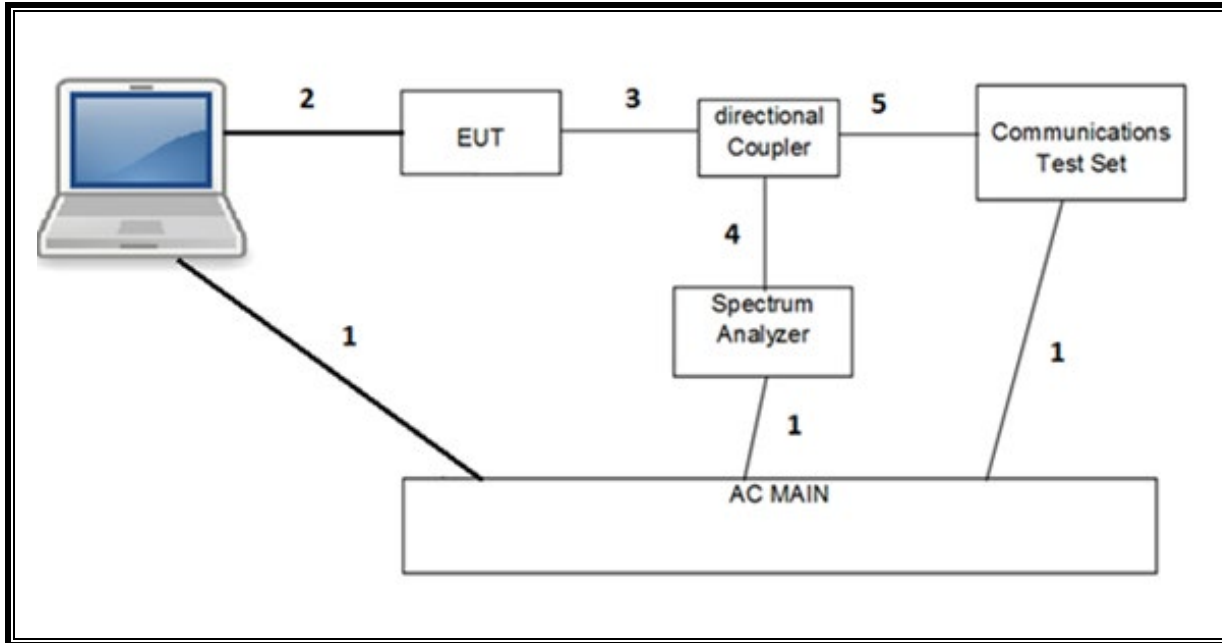
Radiated spurious emissions below 30MHz were investigated, there were no emissions found with less than 20dB of margin below the specified emissions limits.

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.

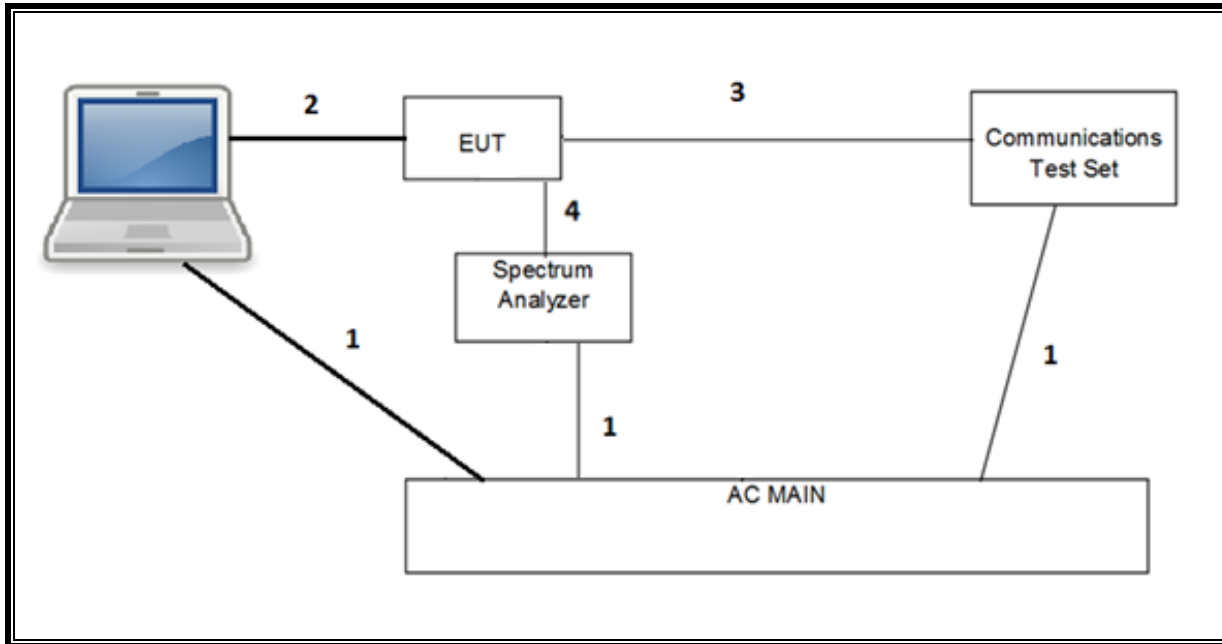
6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT						
Description	Manufacturer	Model	Serial Number	FCC ID/ DoC		
Laptop AC/DC adapter	Apple	61W A1555	C069083VXA1JFYFA8	DoC		
Laptop	Apple	MacBook Pro	CO2VT1RBHV29	DoC		
Laptop AC/DC adapter	Apple	87W A1719	C04719306NLGW85A9	DoC		
Laptop	Apple	MacBook Pro	C02TK02YJ10C	DoC		
AC/DC adapter	Apple	B820	C4H95160022PF4F4R	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	DC	Un-shielded	1.0	N/A
3	RF In/Out	1	EUT	Un-shielded	0.6	N/A
4	RF In/Out	1	Barrel	N/A	N/A	N/A
5	RF In/Out	1	SMA	Un-shielded	1.0	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	Lightning	Un-shielded	1.0	N/A

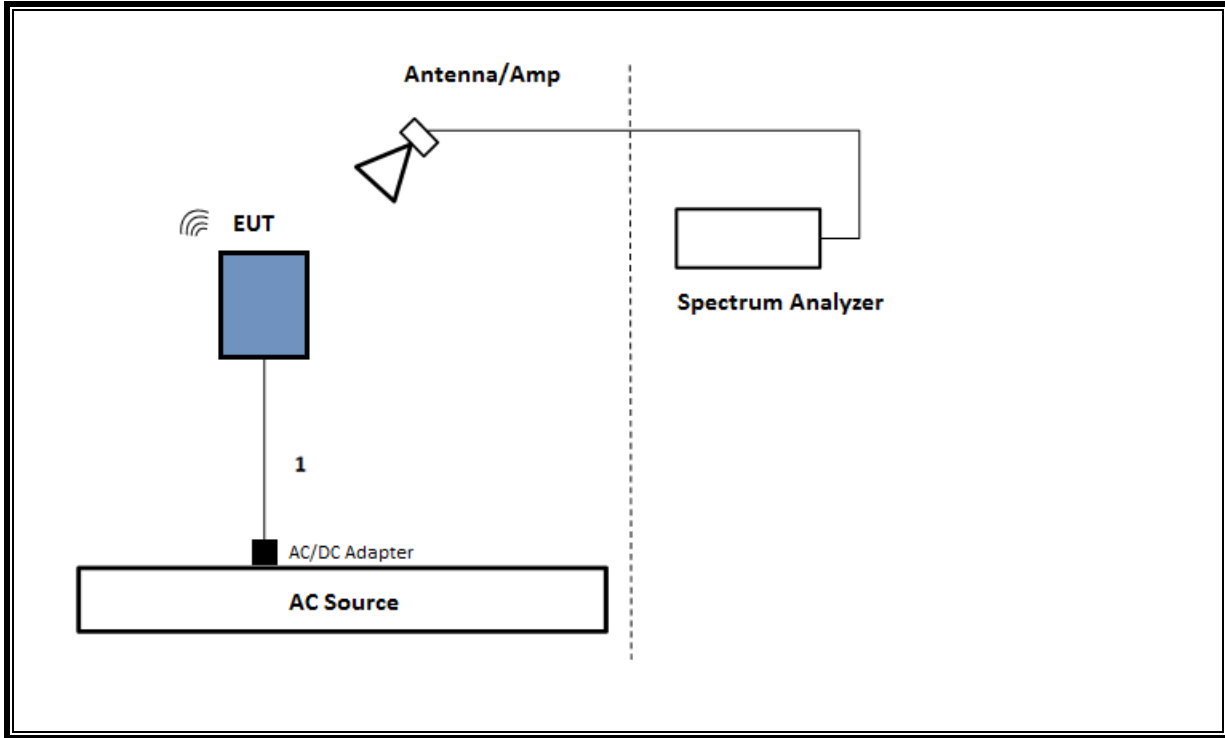
CONDUCTED SETUP ANT 1



CONDUCTED SETUP ANT 4



RADIATED SETUP



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, Horn 1- 18GHz	ETS-Lindgren	3117	T344	6/14/2022
RF Preamp, 1 – 18GHz	UL In-House	N/A	PRE0177819	6/12/2022
Spectrum Analyzer, PXA, 3Hz – 44GHz	Keysight Technologies Inc.	N9030A	85212	1/30/2023
Antenna, Horn 1- 18GHz	ETS-Lindgren	3117	206805	2/10/2023
RF Preamp, 1 – 18GHz	UL In-House	N/A	PRE0180997	6/22/2022
Antenna, Broadband Hybrid	Sunol Sciences Corp.	JB1	85150	10/15/2022
RF Preamp 9kHz – 1GHz	Sonoma Instrument Co.	310N	170648	2/10/2023
EMI Test Receiver	Rohde & Schwarz	ESW44	201497	2/18/2023
Chamber, Environmental	Cincinnati Sub-Zero Products Inc.	ZPHS-8-3.5-SCT/WC	T1154	12/05/2023
Spectrum Analyzer, PXA, 3Hz – 44GHz	Keysight Technologies Inc.	N9030A	85214	2/02/2023
Wideband Radio Communication Tester	Rohde & Schwarz	CMW500	10763796	8/20/2022
Directional Coupler, .5-26.5GHz	Krytar	152610	T1161	9/23/2022
Power Meter, P-Series Single Channel	Keysight Technologies Inc.	N1911A	90731	1/24/2023
Power Sensor, P - Series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc.	N1921A	81319	1/24/2023
DC Power Supply	TDK-LAMBDA	GENH 60-25	PRE0074664	Not Required
Antenna, Passive Loop 30Hz – 1MHz	Electro-Metrics	EM-6871	PRE0179465	7/29/2022
Antenna, Passive Loop 100kHz – 30MHz	Electro-Metrics	EM-6872	PRE0179467	7/29/2022
UL AUTOMATION SOFTWARE				
Radiated test software	UL	UL RF	Ver 9.5 February 2, 2021	

NOTES:

- * Testing is completed before equipment expiration date.
- Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

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 $\theta \leq 0^\circ$
- + 40 + 3 θ dBW in any 4 kHz band for $0^\circ < \theta \leq 5^\circ$

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:

5.3.2 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 13.06 dB (ANT 1) / 12.07 dB (ANT 4) (including 10.70 dB coupler and 2.36 dB cable (ANT 1) / 10 dB pad and 2.07 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:	20737	Test Date:	4/20/2022
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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	27.88	25.67	-1.9	-2.9	25.98	22.77
1618.4	28.05	25.75			26.15	22.85
1626.03	28.11	25.62			26.21	22.72

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

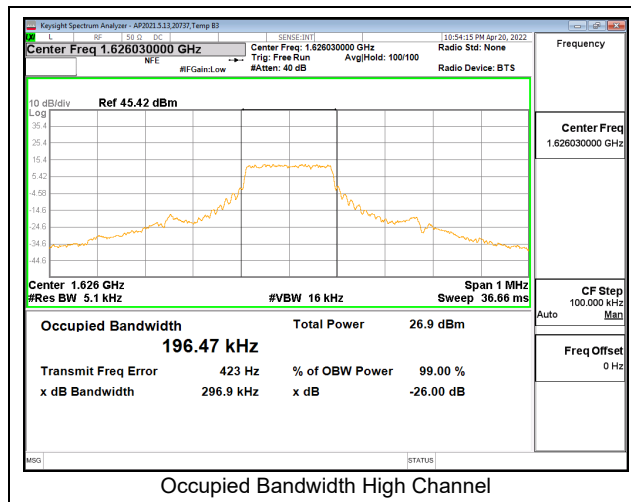
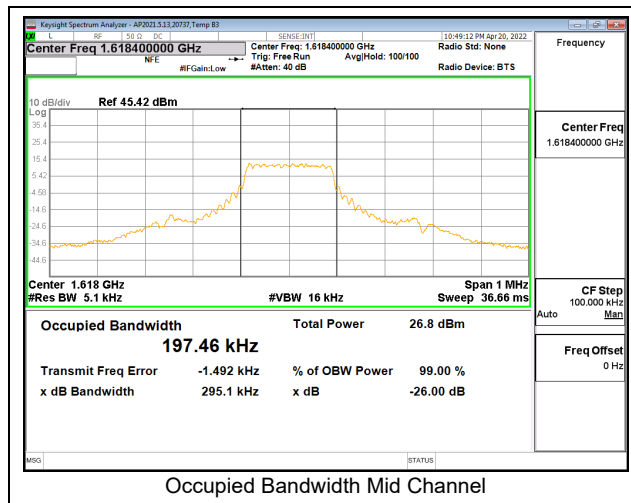
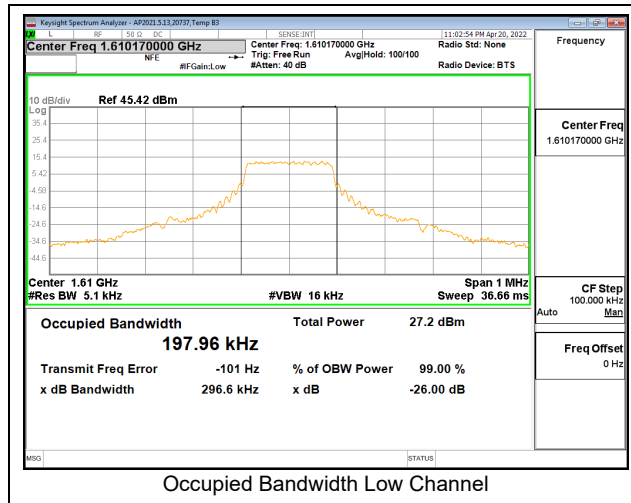
The transmitter output was connected to a calibrated coaxial cable and coupler, the other end of which was connected to a spectrum analyzer. The occupied bandwidth was measured with the spectrum analyzer at the middle channel in each band. The nominal RBW shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be set $\geq 3 \times$ 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:	20737	Test Date:	4/20/2022
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Test Frequency (MHz)	99% BW (kHz)
1610.17	197.96
1618.4	197.46
1626.03	196.47



9.2. EMISSIONS MASK WITHIN 250% OF AUTHORIZED BANDWIDTH

LIMITS

FCC §25.202 and ISED RSS-170: 5.4.3.1

(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 ≥ 4 kHz 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.

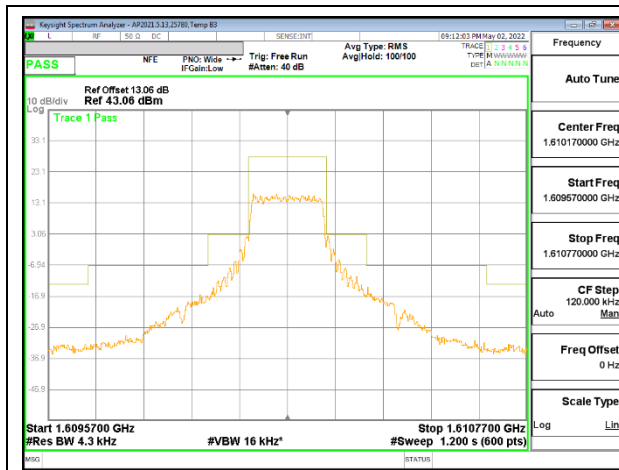
RESULTS

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

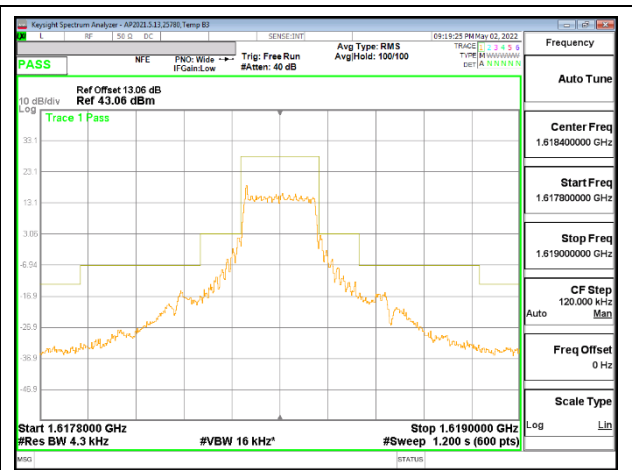
Test Engineer ID:	20737	Test Date:	5/2/2022
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9.2.1. ANT 1

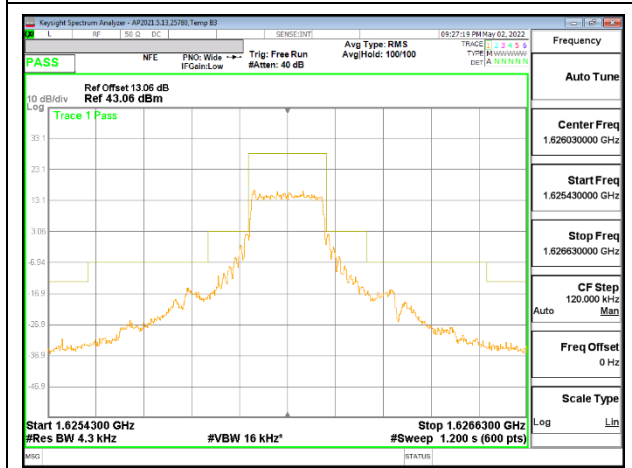
200kHz Authorized Bandwidth:



Low 1610.17MHz

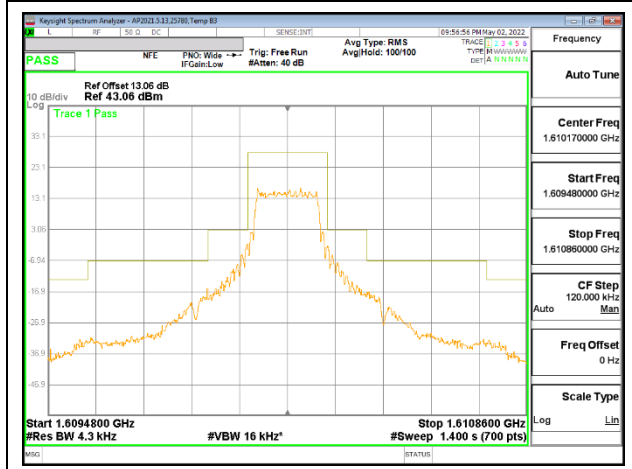


Mid 1618.40MHz

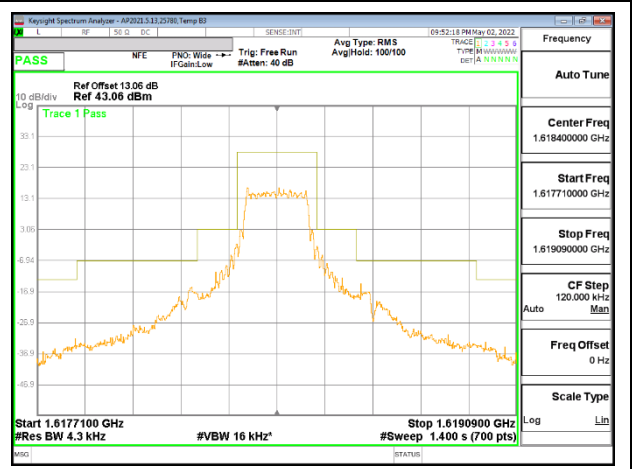


High 1626.03MHz

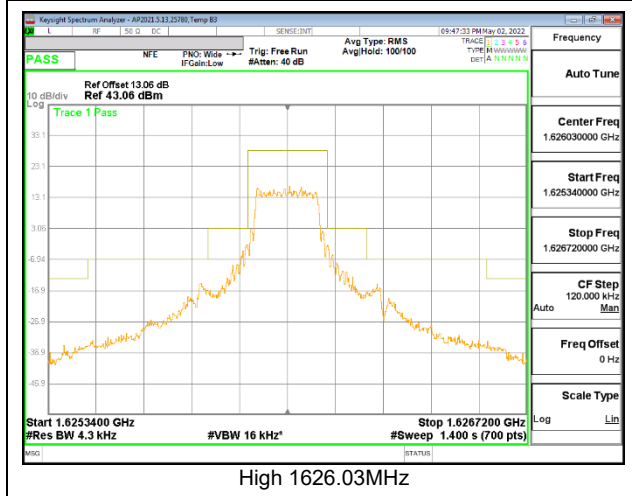
230kHz Authorized Bandwidth:



Low 1610.17MHz

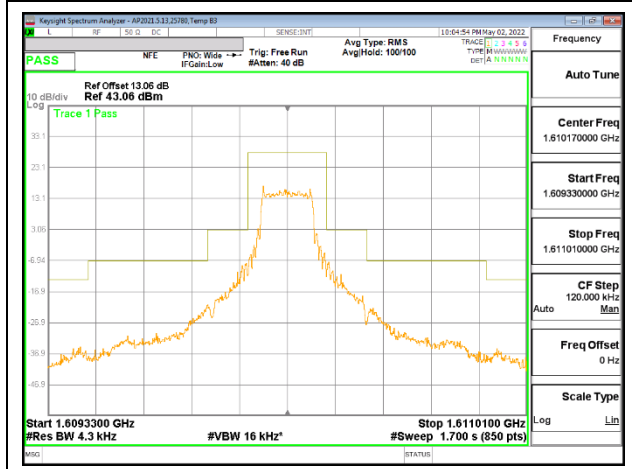


Mid 1618.40MHz

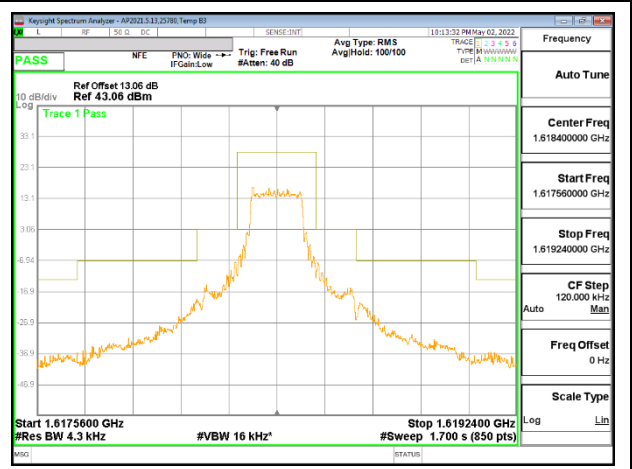


High 1626.03MHz

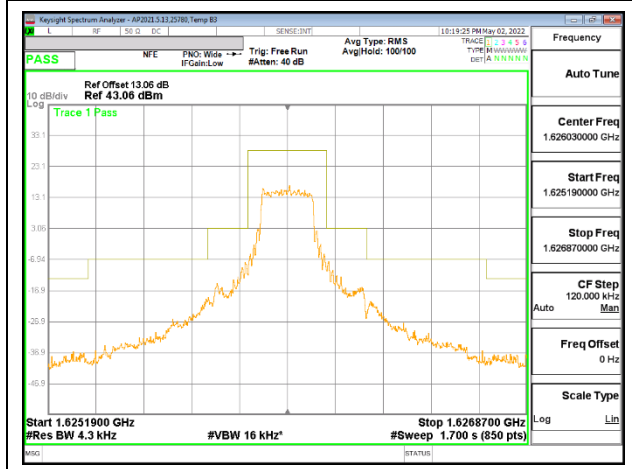
280kHz Authorized Bandwidth:



Low 1610.17MHz



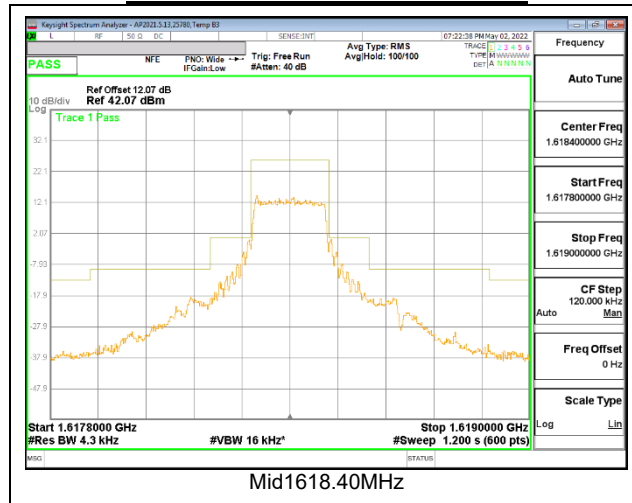
Mid 1618.40MHz



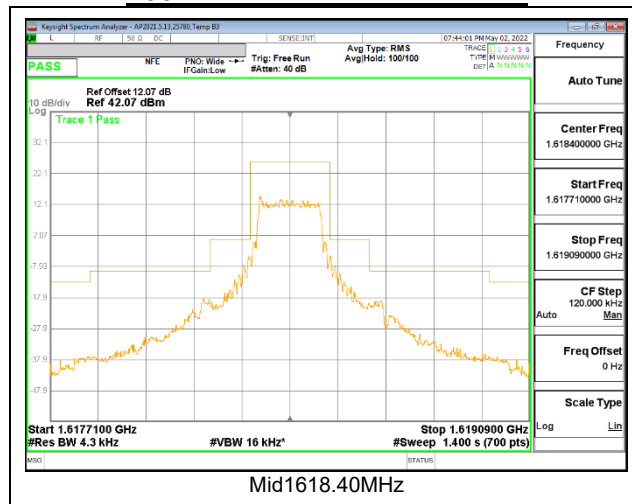
High 1626.03MHz

9.2.2. ANT 4

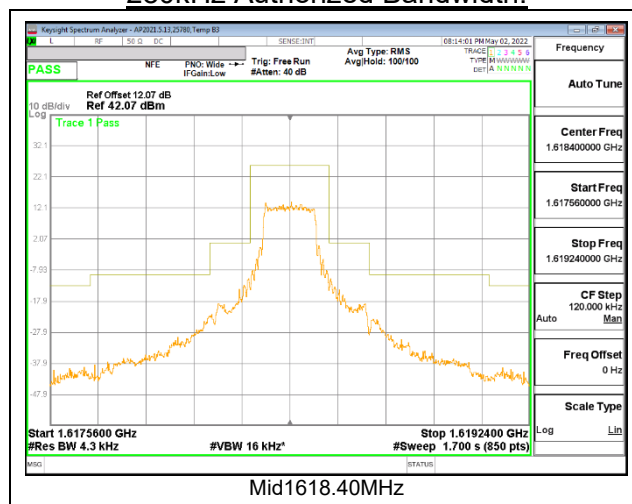
200kHz Authorized Bandwidth:



230kHz Authorized Bandwidth:



280kHz Authorized Bandwidth:



9.3. OUT OF BAND EMISSIONS

LIMITS

FCC §25.202 and ISED RSS-170: 5.4.3.1

(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 v02/r01

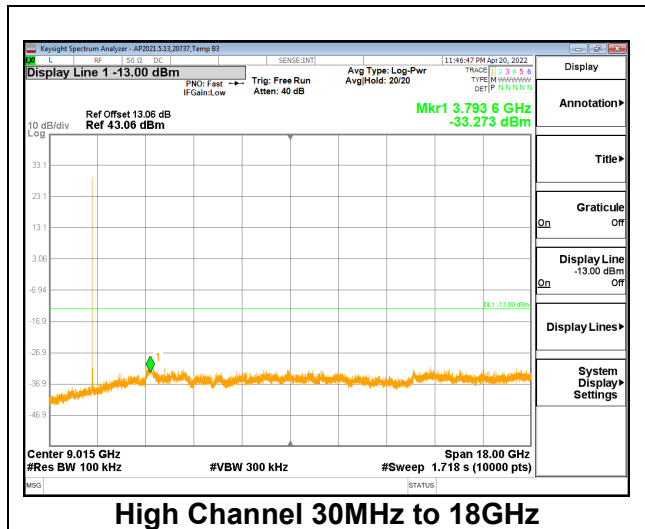
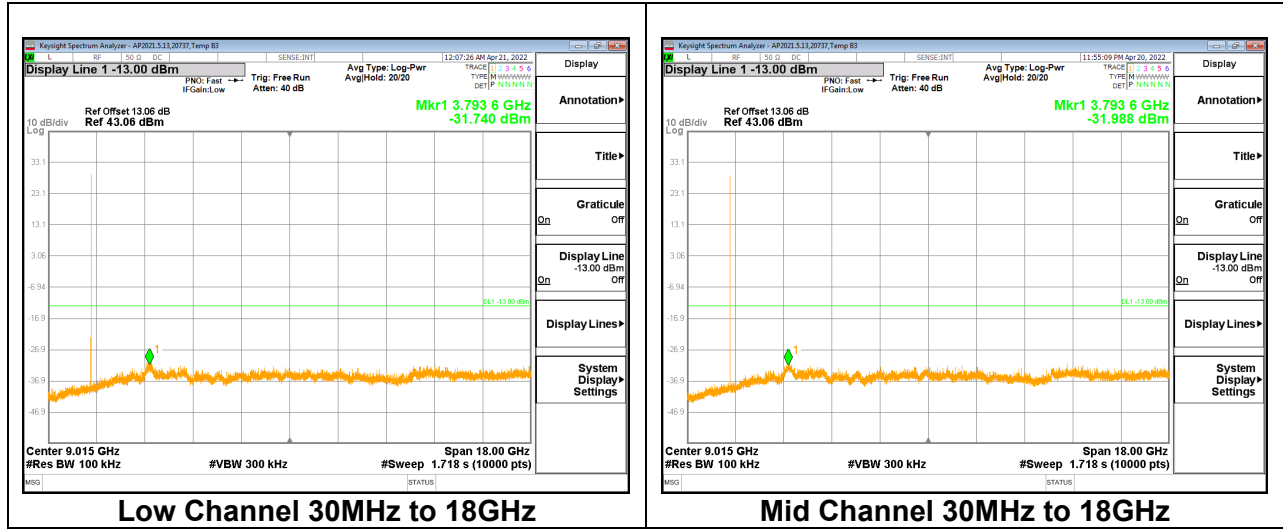
For each out of band emissions measurement:

- Set display line at -13 dBm (the limit of $43 + 10\text{Log}(P)$)
- Set RWB $\geq 4\text{kHz}$ and VBW $\geq 3 \times \text{RBW}$ 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.

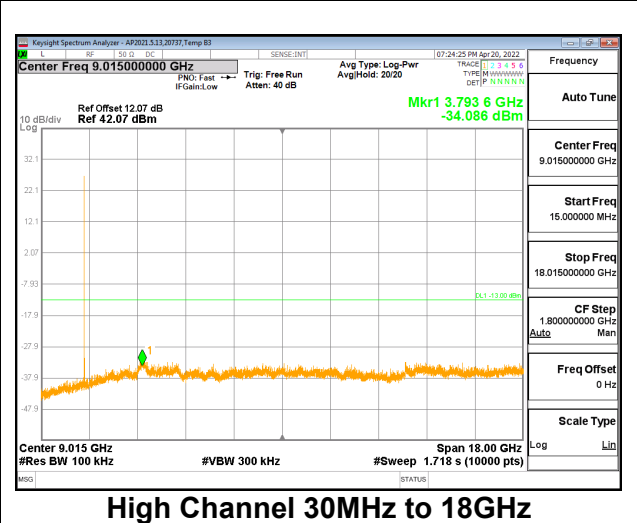
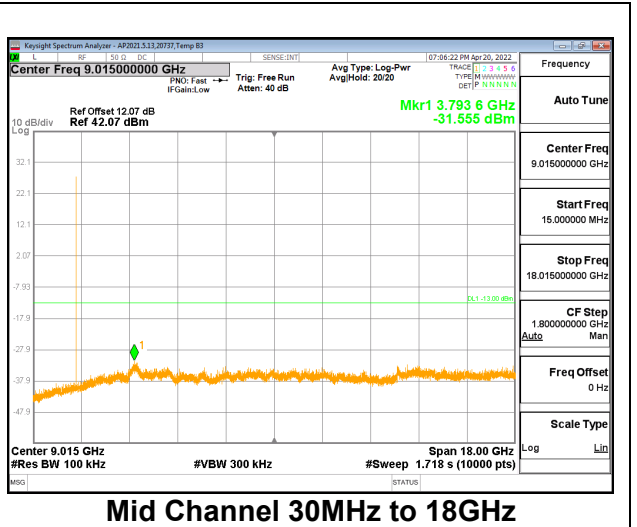
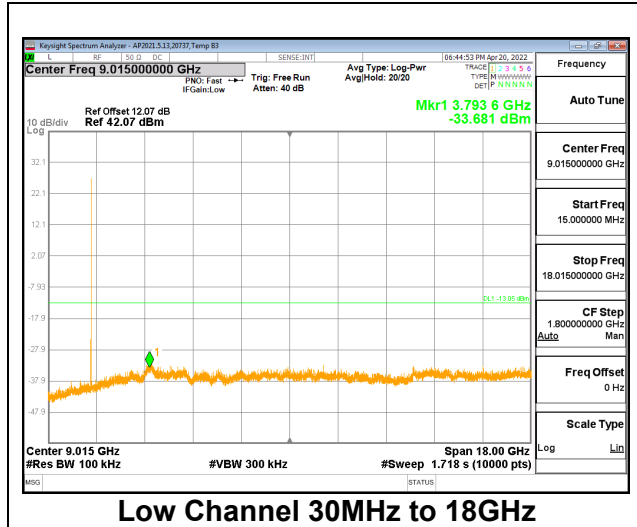
RESULTS

Test Engineer ID:	20737	Test Date:	4/20/2022 & 4/21/2022
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9.3.1. ANT 1



9.3.2. ANT 4



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.

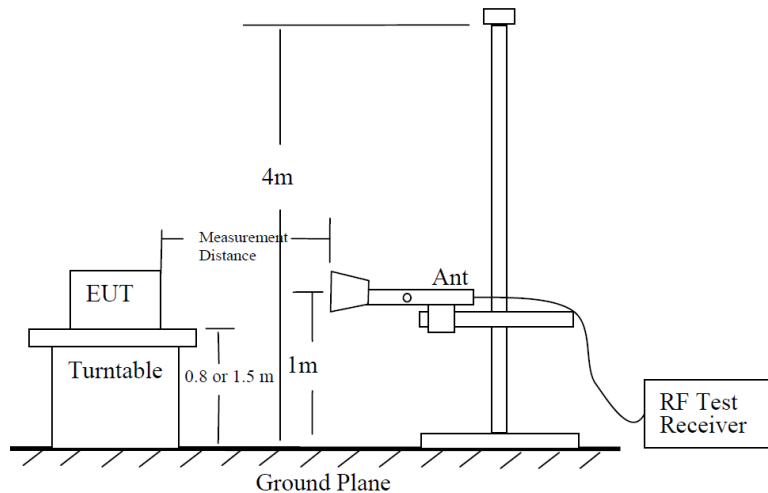


Figure 6—Test site-up for radiated ERP and/or EIRP measurements

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

- a) $E \text{ (dB}\mu\text{V/m)} = \text{Measured amplitude level (dB}\mu\text{V)} + \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$.
- b) $E \text{ (dB}\mu\text{V/m)} = \text{Measured amplitude level (dBm)} + 107 + \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$.
- c) $E \text{ (dB}\mu\text{V/m)} = \text{EIRP (dBm)} - 20\log(D) + 104.8$; where D is the measurement distance (in the far field region) in m.
- d) $\text{EIRP (dBm)} = E \text{ (dB}\mu\text{V/m)} + 20\log(D) - 104.8$; where D is the measurement distance (in the far field region) in m.

So, from d)

The measuring distance is usually at 3m, then $20 \cdot \log(3) = 9.5424$

Then, $\text{EIRP (dBm)} = E \text{ (dB}\mu\text{V/m)} + 9.5424 - 104.8 = E \text{ (dB}\mu\text{V/m)} - 95.2576$

10.1. FIELD STRENGTH OF SPURIOUS RADIATION

LIMITS

FCC §25.202 and ISED RSS-170: 5.4.3.1 (3)

(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 v02/r01

For each out of band emissions measurement:

- Set display line at -13 dBm (the limit of $43 + 10\text{Log}(P)$)
- Set RBW $\geq 4\text{kHz}$ and VBW $\geq 3 \times \text{RBW}$ 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 Mid Channel. Tabular data for all channels is presented.

10.1.1. ANT 1 (Above 1GHz)

Project #:	14040863
Date:	4/22/2022
Test Engineer:	25019
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	Chamber I

Low channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.220347	32.46	Pk	32.8	-27.3	-95.2	-57.24	-13	-44.24	71	172	H
3	4.830395	28.93	Pk	33.9	-25.6	-95.2	-57.97	-13	-44.97	43	178	H
5	6.829573	24.03	Pk	35.4	-23.1	-95.2	-58.87	-13	-45.87	96	301	H
2	3.21986	27.75	Pk	32.8	-27.3	-95.2	-61.95	-13	-48.95	262	289	V
4	4.83038	29.42	Pk	33.9	-25.6	-95.2	-57.48	-13	-44.48	28	121	V
6	6.793195	24.6	Pk	35.4	-23.6	-95.2	-58.8	-13	-45.8	151	362	V

Pk - Peak detector

Mid Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.236762	29.32	Pk	32.7	-27.7	-95.2	-60.88	-13	-47.88	21	109	H
3	4.855174	30.86	Pk	33.9	-25.9	-95.2	-56.34	-13	-43.34	17	129	H
5	6.353303	23.68	Pk	35.2	-24.4	-95.2	-60.72	-13	-47.72	42	130	H
2	3.236688	28.93	Pk	32.7	-27.7	-95.2	-61.27	-13	-48.27	16	293	V
4	4.855174	29.47	Pk	33.9	-25.9	-95.2	-57.73	-13	-44.73	22	119	V
6	6.35767	26.29	Pk	35.2	-24.5	-95.2	-58.21	-13	-45.21	243	294	V

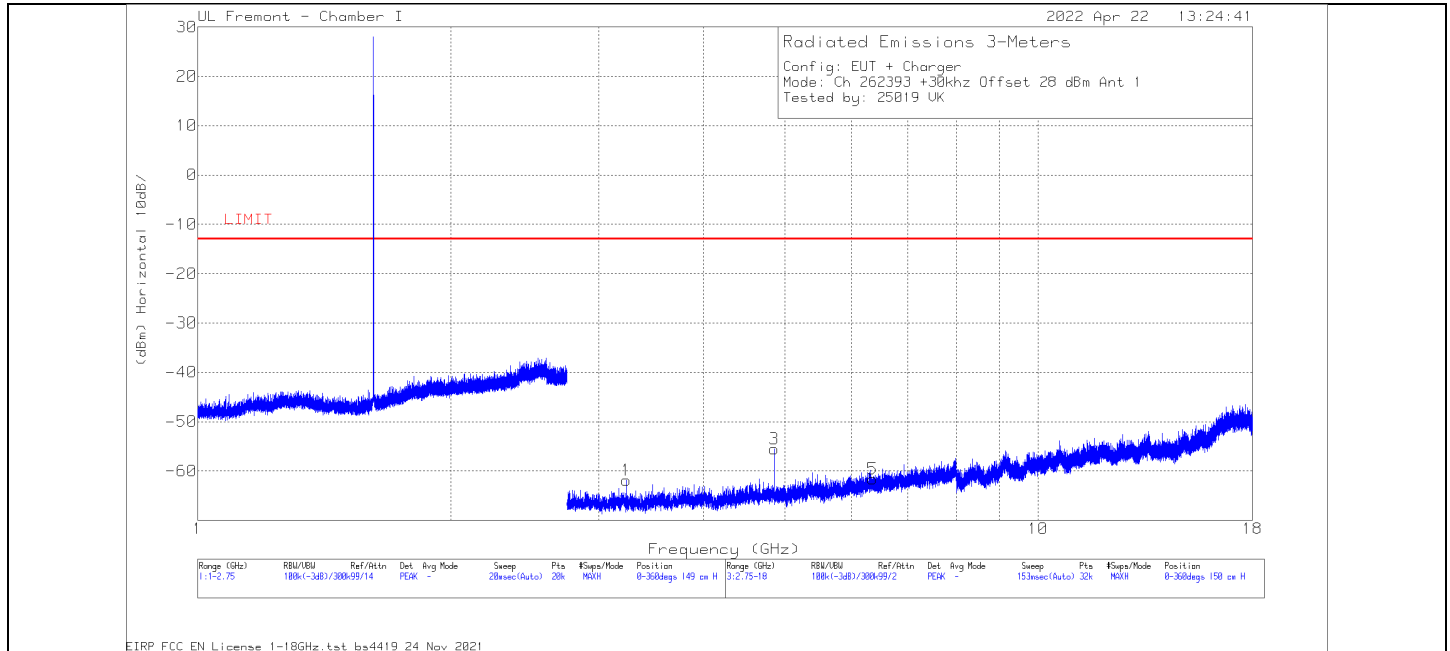
Pk - Peak detector

High Channel:

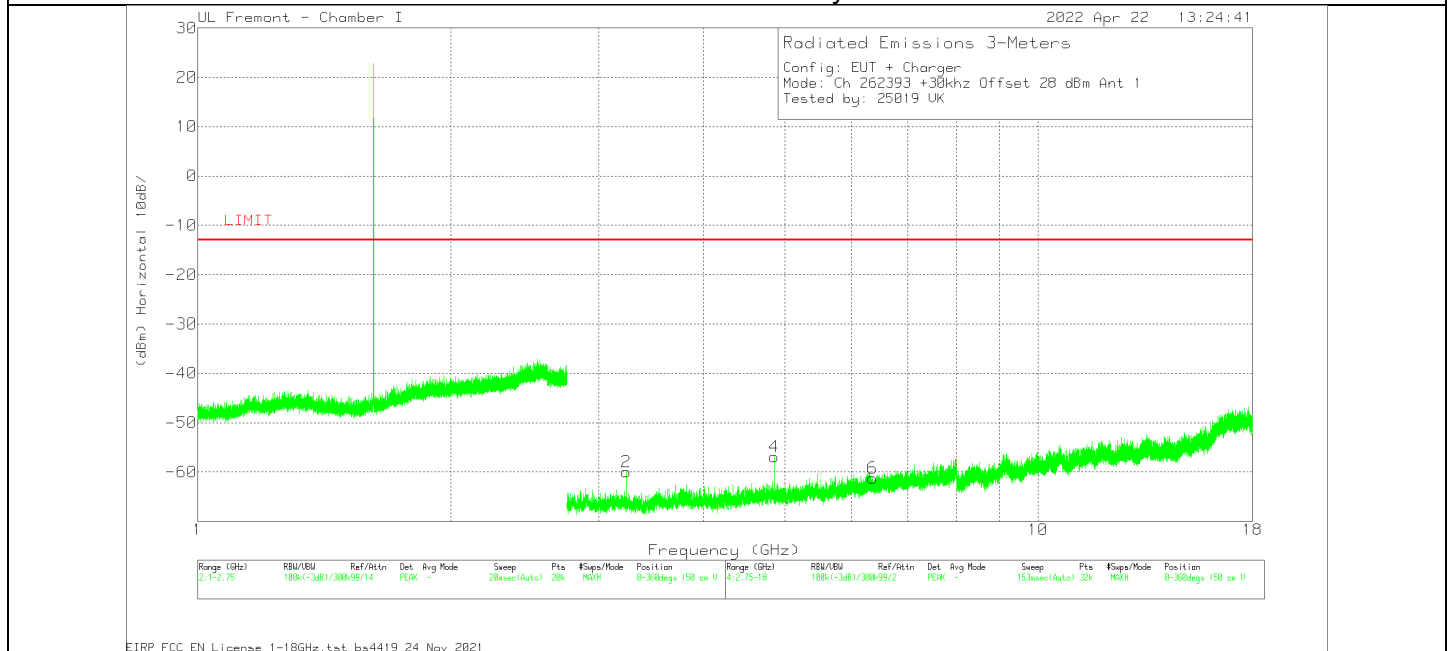
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.251932	27.4	Pk	32.7	-27.6	-95.2	-62.7	-13	-49.7	0	155	H
3	4.878044	36.06	Pk	33.9	-26	-95.2	-51.24	-13	-38.24	29	108	H
5	6.475342	26.19	Pk	35.3	-24.4	-95.2	-58.11	-13	-45.11	282	296	H
2	3.26037	26.15	Pk	32.7	-27.5	-95.2	-63.85	-13	-50.85	243	315	V
4	4.878016	25.26	Pk	33.9	-26	-95.2	-62.04	-13	-49.04	133	166	V
6	6.473828	23.25	Pk	35.3	-24.5	-95.2	-61.15	-13	-48.15	129	113	V

Pk - Peak detector

Mid Channel:



Horizontal Polarity



Vertical Polarity

10.1.2. ANT 4 (Above 1GHz)

Project #:	14040863
Date:	4/22/2022
Test Engineer:	24971 & 25019
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	Chamber I

Low channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.169707	28.08	Pk	32.7	-27.7	-95.2	-62.12	-13	-49.12	128	286	H
3	4.232958	27.41	Pk	33.2	-26.6	-95.2	-61.19	-13	-48.19	63	295	H
5	6.868539	24.77	Pk	35.4	-23.5	-95.2	-58.53	-13	-45.53	155	280	H
2	3.203846	28.12	Pk	32.8	-27.3	-95.2	-61.58	-13	-48.58	128	274	V
4	4.28873	27.92	Pk	33.3	-26.8	-95.2	-60.78	-13	-47.78	69	276	V
6	6.853182	25.09	Pk	35.4	-23	-95.2	-57.71	-13	-44.71	315	293	V

Pk - Peak detector

Mid Channel:

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.404912	25.18	Pk	32.6	-28.3	-95.2	-65.72	-13	-52.72	23	128	H
3	5.007034	25.47	Pk	33.9	-26.3	-95.2	-62.13	-13	-49.13	7	280	H
5	6.989523	24.64	Pk	35.4	-24.1	-95.2	-59.26	-13	-46.26	270	276	H
2	3.394743	28.07	Pk	32.6	-28.4	-95.2	-62.93	-13	-49.93	270	290	V
4	4.987062	26.39	Pk	33.9	-26.5	-95.2	-61.41	-13	-48.41	63	293	V
6	6.992516	25.07	Pk	35.4	-24.1	-95.2	-58.83	-13	-45.83	360	298	V

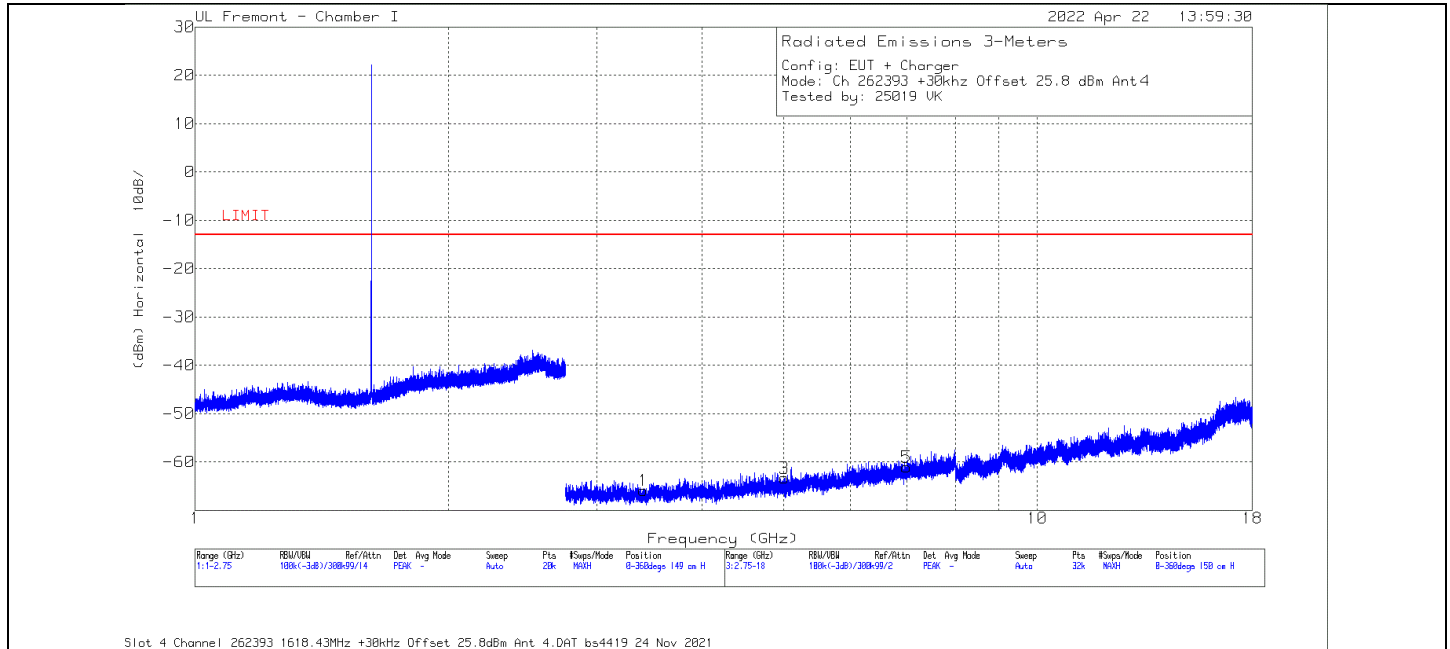
Pk - Peak detector

High Channel:

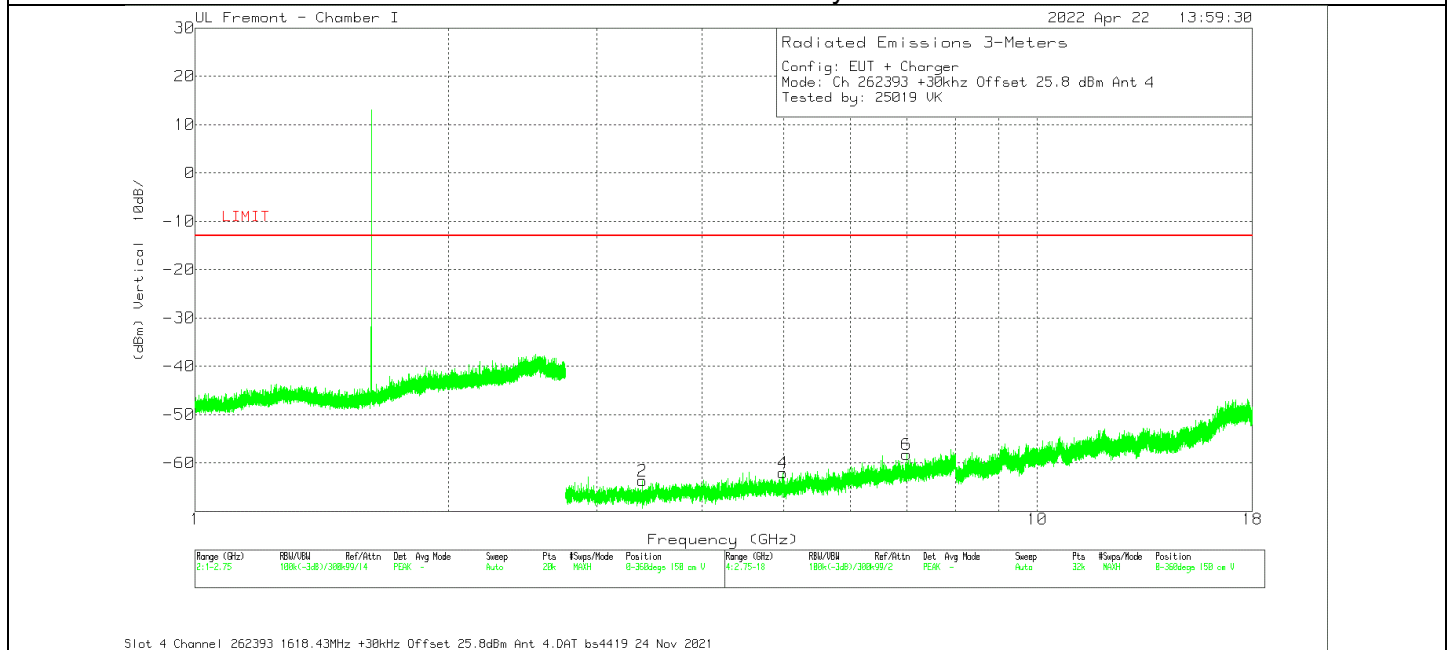
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF 206805 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	3.744499	27.52	Pk	33.2	-26.9	-95.2	-61.38	-13	-48.38	104	141	H
3	5.097003	25.52	Pk	34	-25.2	-95.2	-60.88	-13	-47.88	315	198	H
5	6.293081	23.43	Pk	35.2	-23.4	-95.2	-59.97	-13	-46.97	309	131	H
1	3.744415	25.48	Pk	33.2	-26.9	-95.2	-63.42	-13	-50.42	136	113	V
4	5.098876	25.01	Pk	34	-25.2	-95.2	-61.39	-13	-48.39	191	156	V
6	6.291693	24.25	Pk	35.2	-23.3	-95.2	-59.05	-13	-46.05	81	294	V

Pk - Peak detector

Mid Channel:



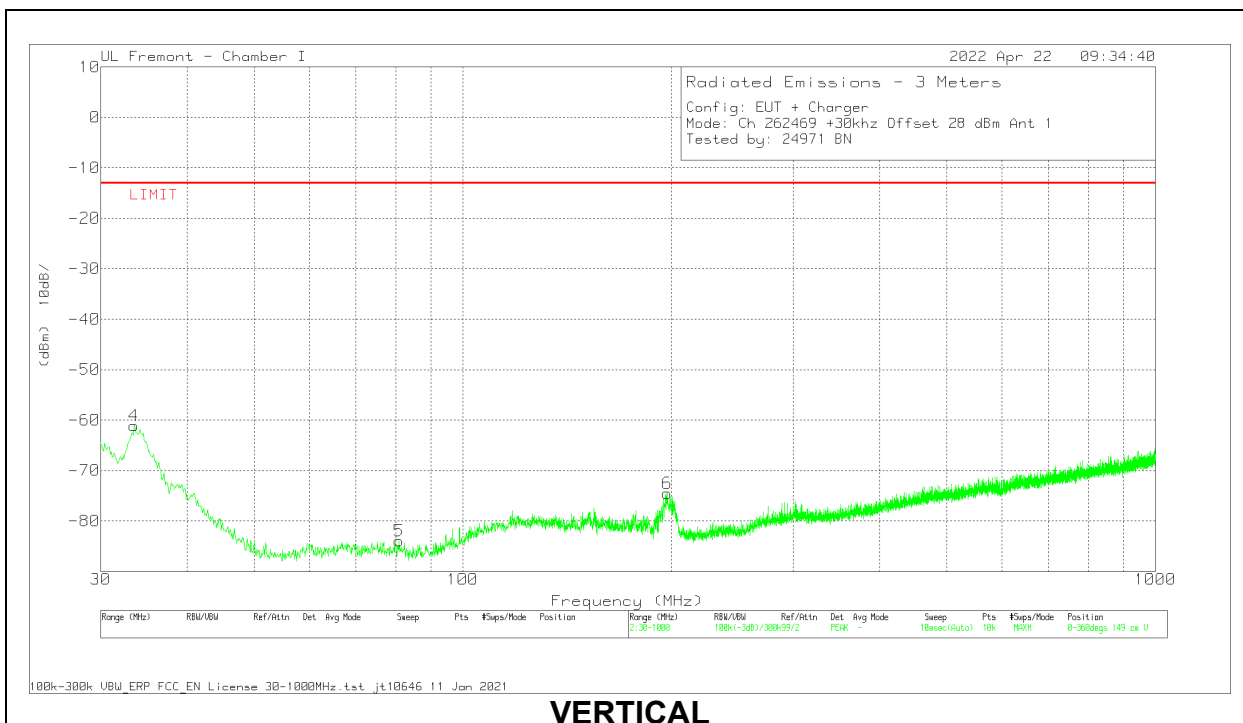
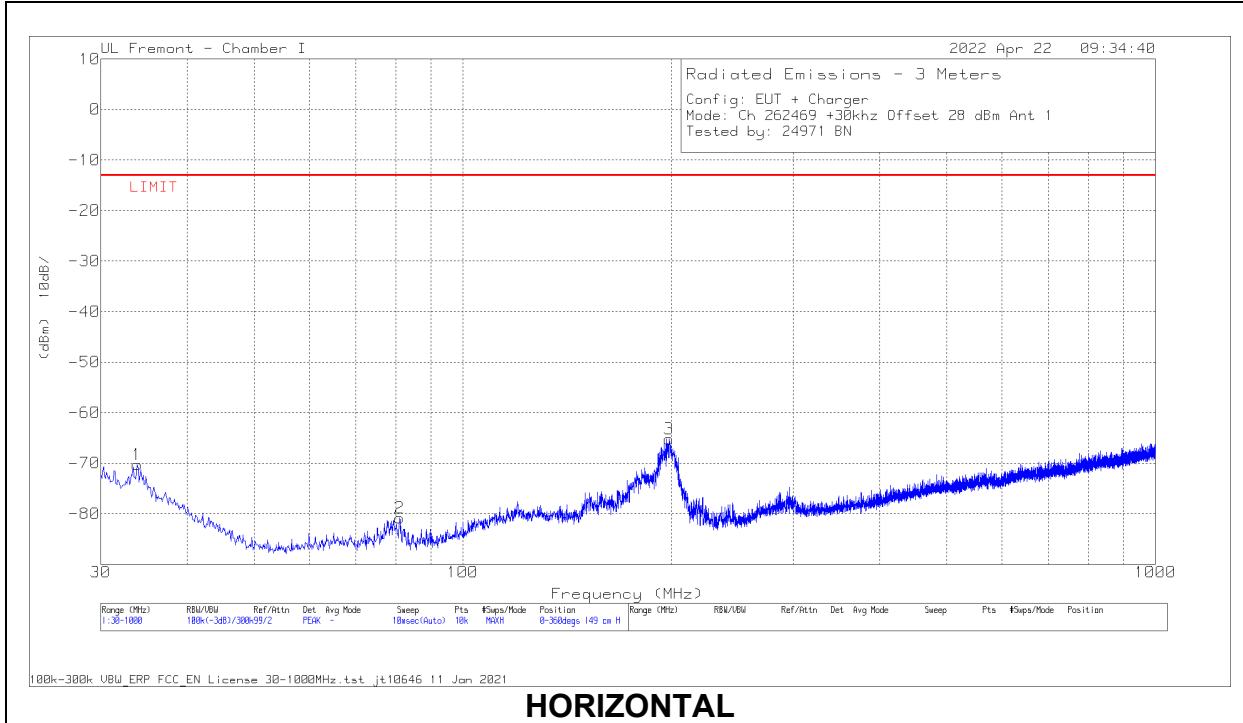
Horizontal Polarity



Vertical Polarity

10.1.3. ANT 1 (Below 1GHz)

Project #:	14040863
Date:	4/22/2022
Test Engineer:	24971 & 25019
Configuration:	EUT + Charger
Mode:	TX Worst Case Channel
Chamber #:	Chamber I

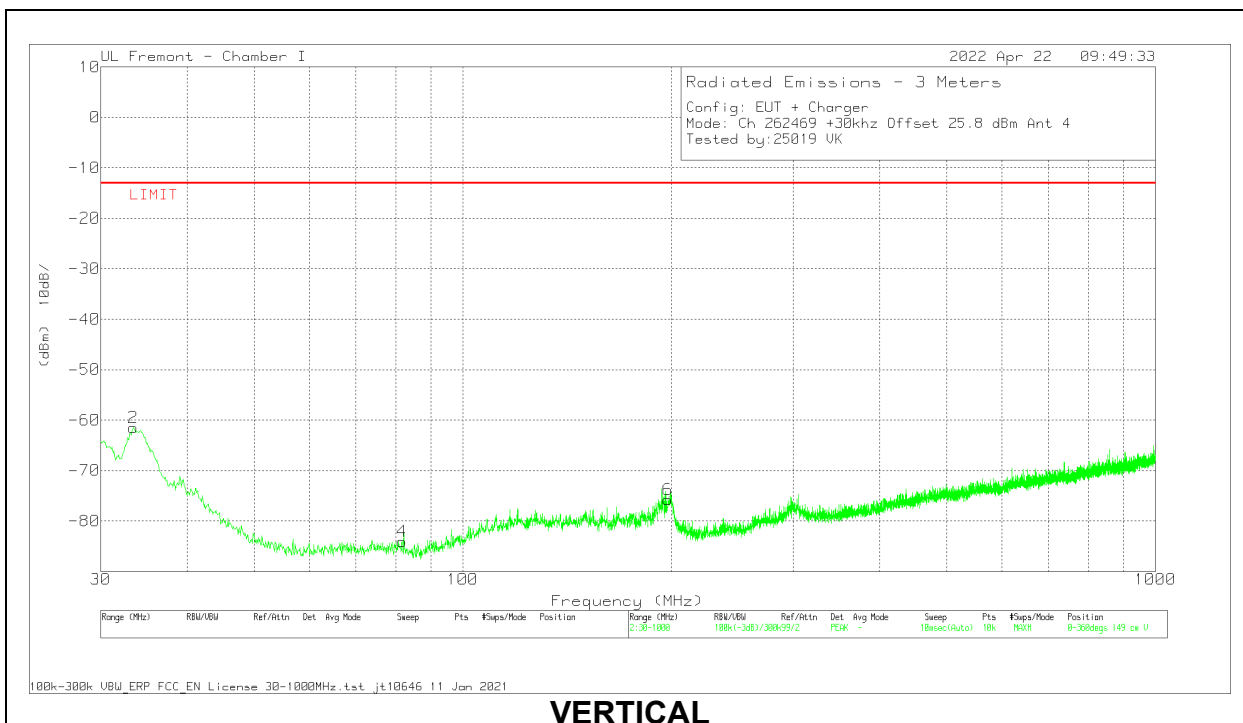
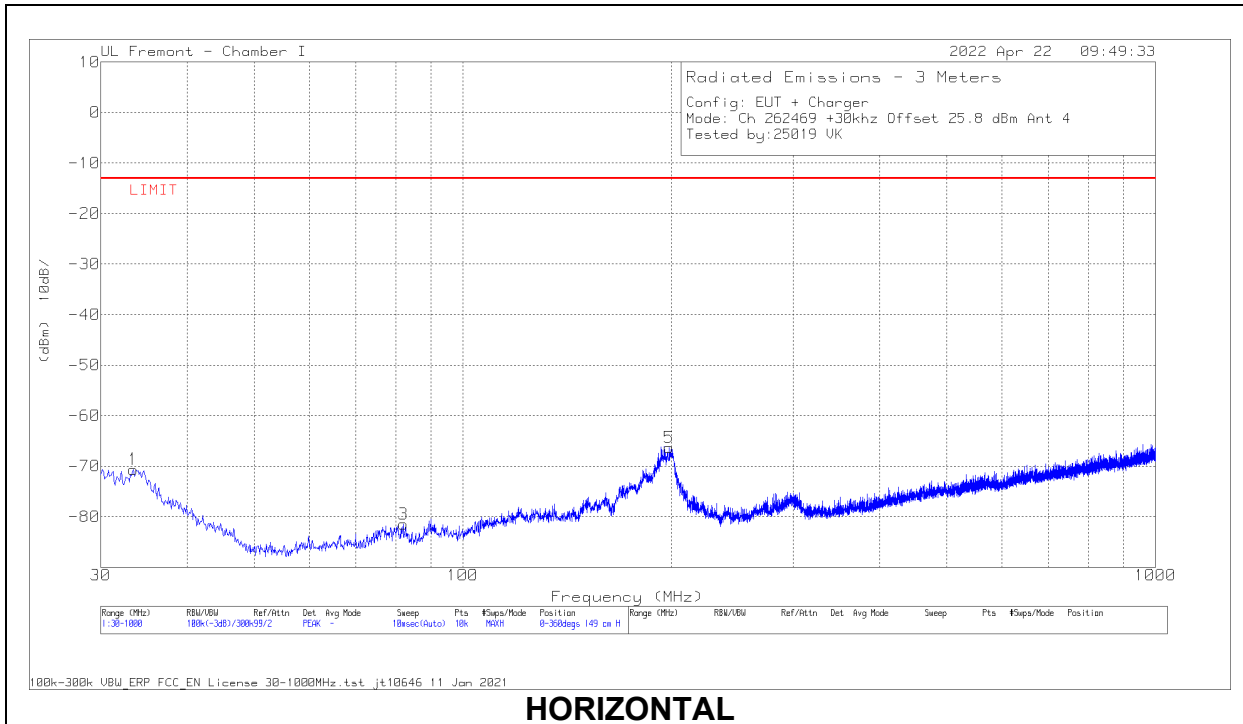


Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	85150 AF (dB/m)	Amp Cbl (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	33.88	31.49	Pk	24.8	-31.4	-95.2	-70.31	-13	-57.31	0-360	149	H
2	81.022	32.03	Pk	13.3	-31	-95.2	-80.87	-13	-67.87	0-360	149	H
3	198.683	41.84	Pk	18.5	-30.3	-95.2	-65.16	-13	-52.16	0-360	149	H
4	33.492	40.41	Pk	25.1	-31.4	-95.2	-61.09	-13	-48.09	0-360	149	V
	33.5867	42.44	Pk	25	-31.4	-95.2	-59.16	-13	-46.16	339	105	V
5	80.925	28.93	Pk	13.3	-31	-95.2	-83.97	-13	-70.97	0-360	149	V
6	197.131	32.72	Pk	18.3	-30.3	-95.2	-74.48	-13	-61.48	0-360	149	V

Pk - Peak detector

10.1.4. ANT 4 (Below 1GHz)

Project #:	14040863
Date:	4/22/2022
Test Engineer:	24971 & 25019
Configuration:	EUT + Charger
Mode:	TX Worst Case Channel
Chamber #:	Chamber I



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	85150 AF (dB/m)	Amp Cbl (dB)	EIRP CF	Corrected Reading (dBm)	LIMIT	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	33.395	30.79	Pk	25.2	-31.4	-95.2	-70.61	-13	-57.61	0-360	149	H
3	81.992	31.48	Pk	13.3	-31	-95.2	-81.42	-13	-68.42	0-360	149	H
5	198.586	40.69	Pk	18.5	-30.3	-95.2	-66.31	-13	-53.31	0-360	149	H
2	33.395	39.9	Pk	25.2	-31.4	-95.2	-61.5	-13	-48.5	0-360	149	V
	33.4645	42.34	Pk	25.1	-31.4	-95.2	-59.16	-13	-46.16	343	103	V
4	81.701	28.83	Pk	13.3	-31	-95.2	-84.07	-13	-71.07	0-360	149	V
6	197.713	31.38	Pk	18.4	-30.3	-95.2	-75.72	-13	-62.72	0-360	149	V

Pk - Peak detector

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: 5.4.3.2.1

(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 v02/r01

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

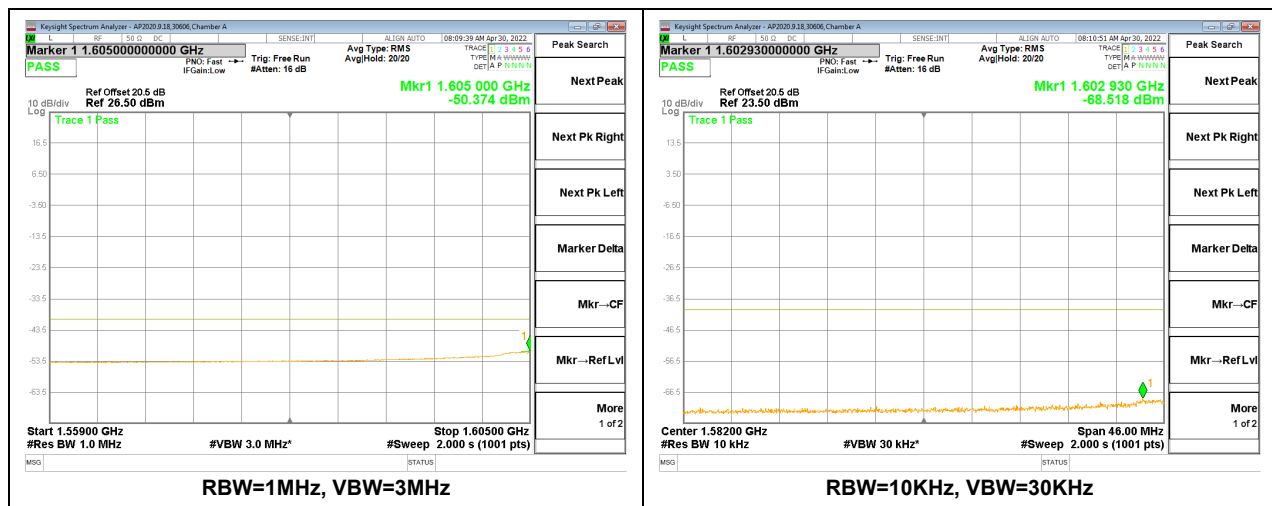
Both horizontal / vertical polarizations and low/ mid/ high channels were investigated on ANT 1 and ANT 4. It was found low channel to be worst case for both antennas.

Project #:	14040863
Date:	4/30/2022
Test Engineer:	30606
Configuration:	EUT + Charger
Mode:	TX Low Channel 1610.17MHz
Chamber #:	Chamber A

Offset Calculation Offset:

AF 80402 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	EIRP CF	Offset (dB)
28.1	-19.4	11.8	20.5

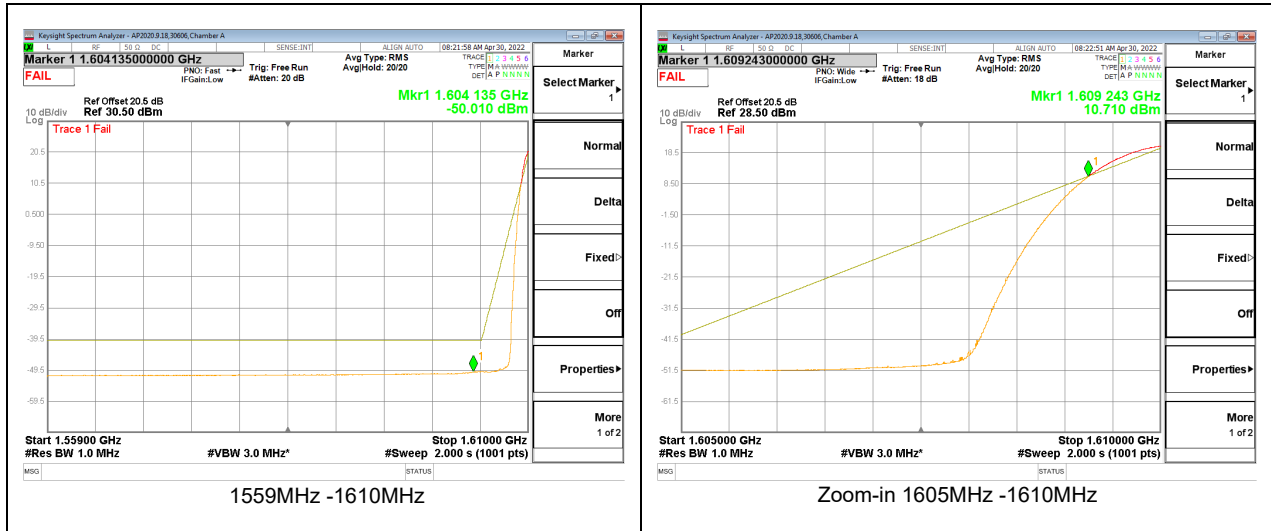
Plots for Determining Wide Band or Narrow Band Emissions



Note: It was found that the marker 1 @ 1605.00MHz frequency which belonged to wideband emission.

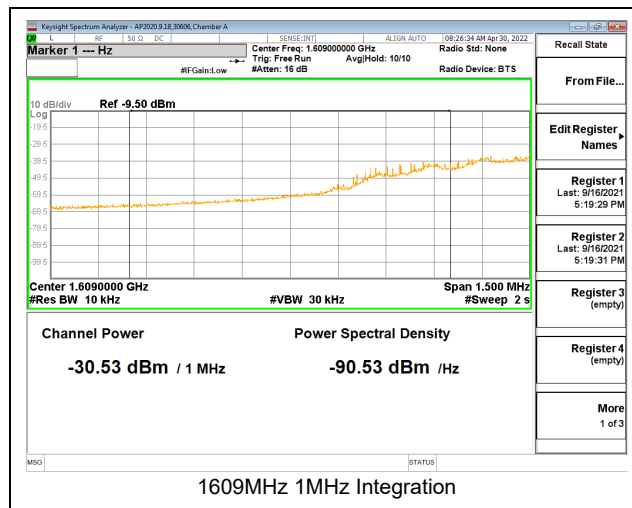
10.2.1. ANT 1

Wideband Low Channel 1610.17MHz Vertical:

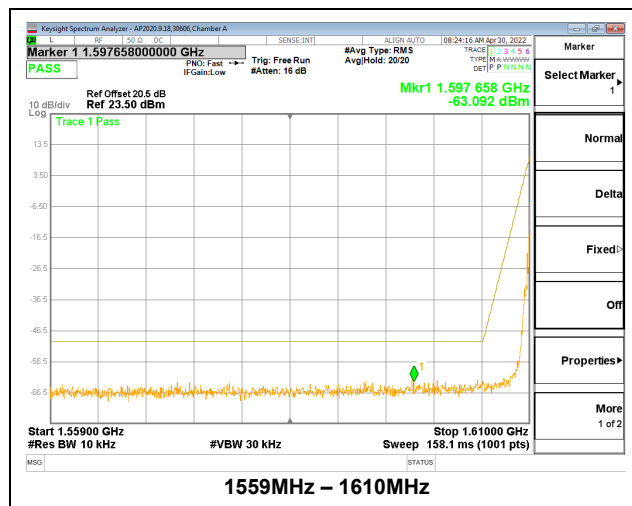


Plots below show passing result using integration method:

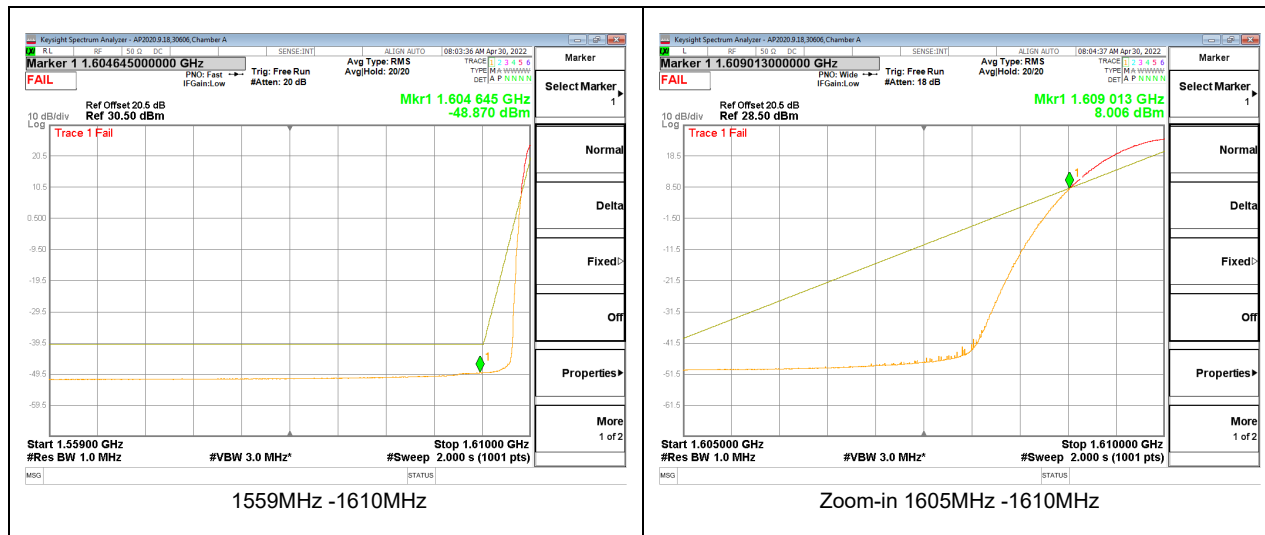




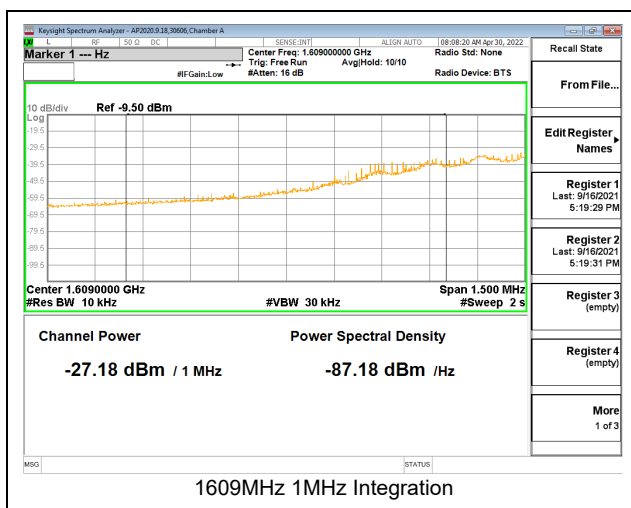
Narrowband Low Channel 1610.17MHz Vertical:



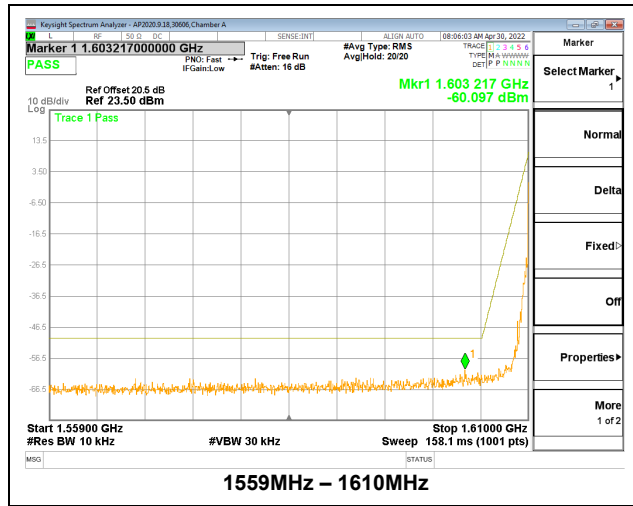
Wideband Low Channel 1610.17MHz Horizontal:



Plots below show passing result using integration method:

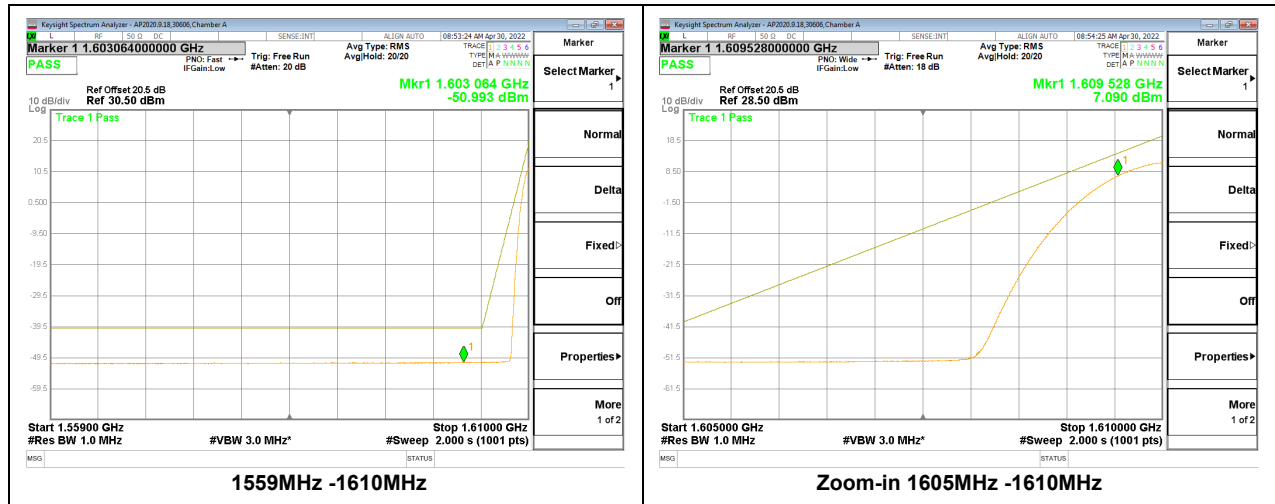


Narrowband Low Channel 1610.17MHz Horizontal:

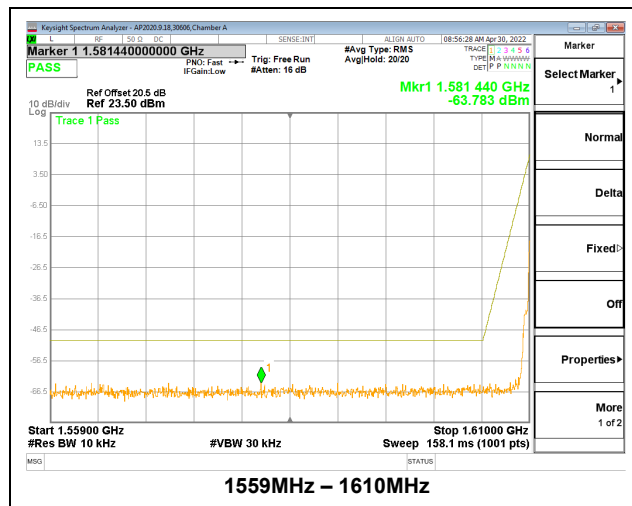


10.2.2. ANT 4

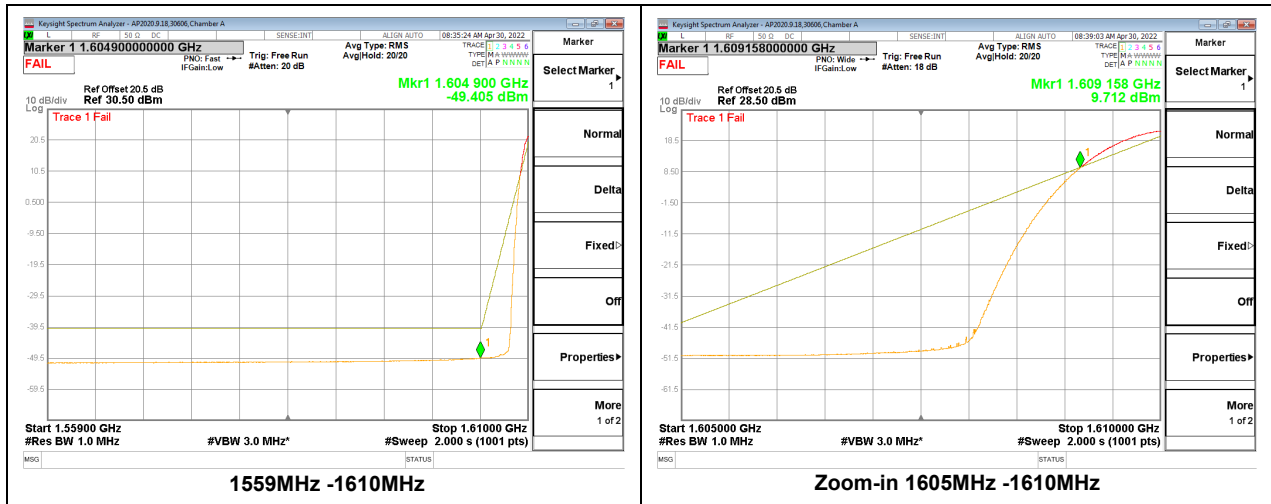
Wideband Low Channel 1610.17MHz Vertical:



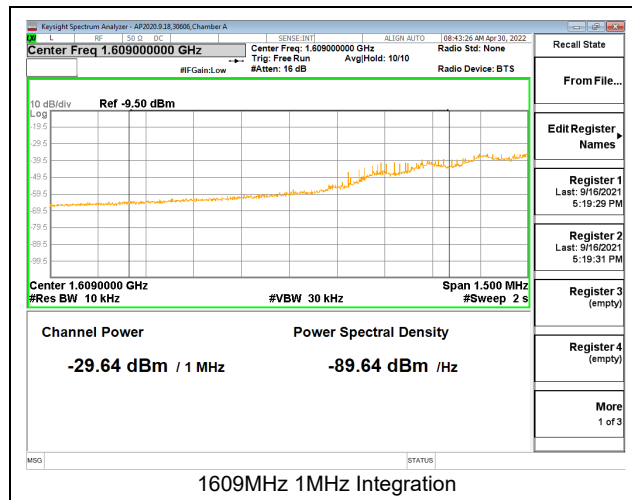
Narrowband Low Channel 1610.17MHz Vertical:



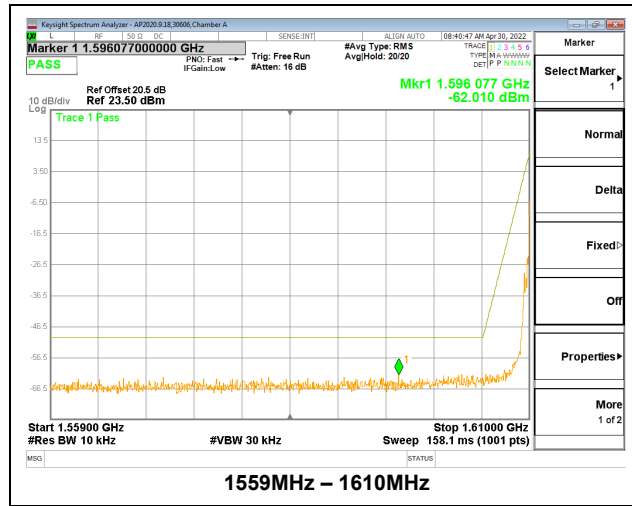
Wideband Low Channel 1610.17MHz Horizontal:



Plots below show passing result using integration method:



Narrowband Low Channel 1610.17MHz Horizontal:



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

LIMITS

FCC §25.216 and ISSED RSS-170: 5.4.4

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.

ISSED RSS-170: 5.4.4 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 v02/r01

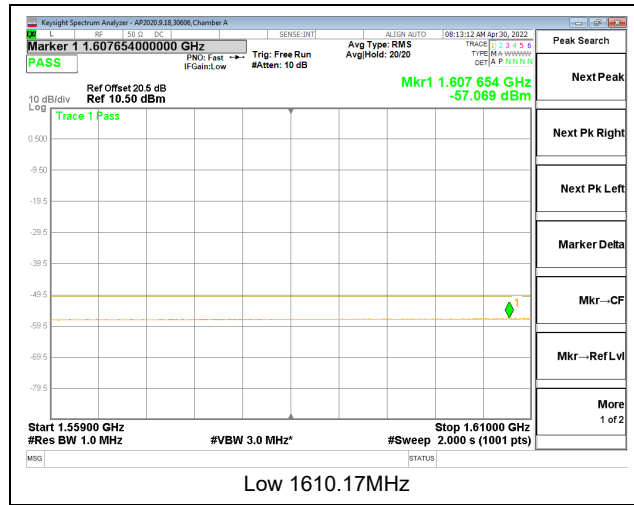
Set RBW = 1MHz, VB = 3MHz, detector = rms, sweep time ~ number of points x 2ms, and sweep multiple times with max hold enabled.

RESULTS

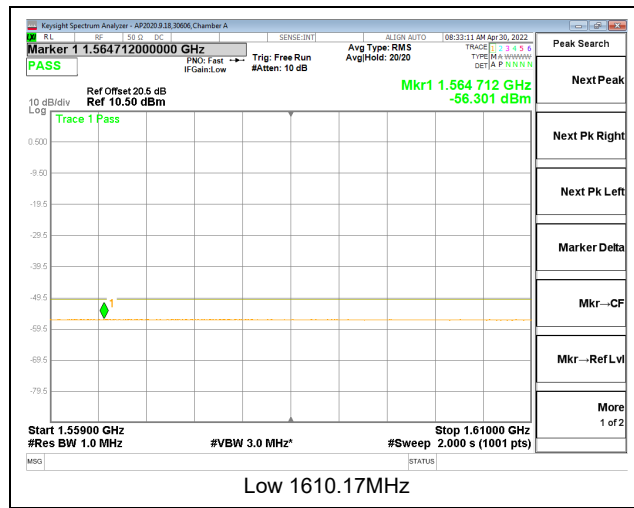
No emissions were found on both horizontal and vertical polarization for ANT 1 and ANT 4.

Project #:	14040863
Date:	4/30/2022
Test Engineer:	30606
Configuration:	EUT + Charger
Mode:	RX - TX off
Chamber #:	Chamber A

10.3.1. ANT 1



10.3.2. ANT 4



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: 5.2

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 $+50^{\circ}\text{C}$
- Voltage = (85% - 115%)

Low voltage, 3.23VDC, Normal, 3.8VDC and High voltage, 4.37VDC.
 End Voltage, 2.91VDC.

Frequency Stability vs Temperature:

The EUT is placed inside a temperature chamber. The temperature is set to 20°C 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 $+50^{\circ}\text{C}$ is reached.

Frequency Stability vs Voltage:

The peak frequency error is recorded (worst-case).

RESULTS

Test Engineer ID:	20737	Test Date:	5/17/2022
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Frequency Reference (MHz)		1610.17009		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	1610.07944	1610.26075	1610.17009		
Extreme (50C)		1610.07800	1610.26131	1610.16966	-437.5	-0.27
Extreme (40C)		1610.07869	1610.26138	1610.17003	-62.5	-0.04
Extreme (30C)		1610.07906	1610.26119	1610.17013	31.3	0.02
Extreme (10C)		1610.07825	1610.26106	1610.16966	-437.5	-0.27
Extreme (0C)		1610.07813	1610.26013	1610.16913	-968.8	-0.60
Extreme (-10C)		1610.07694	1610.26100	1610.16897	-1125.0	-0.70
Extreme (-20C)		1610.07881	1610.26069	1610.16975	-343.7	-0.21
Extreme (-30C)		1610.07944	1610.26056	1610.17000	-93.7	-0.06
20C		15%	1610.077313	1610.261875	1610.169594	-500.0
	-15%	1610.078438	1610.260063	1610.169250	-843.8	-0.52
	End Point Voltage	1610.079688	1610.261875	1610.170781	687.5	0.43

11. SETUP PHOTOS

Please refer to 14040863-EP1V1 for setup photos

END OF REPORT