TEST REPORT

Report Number : 15175342-E16V3

Applicant	:	APPLE INC. 1 APPLE PARK WAY CUPERTINO, CA 95104, U.S.A.
Model	:	A3212 (Parent Model) A3408, A3409 (Variant Models)
Brand	:	APPLE
FCC ID	:	BCG-E8725A (Parent Model) BCG-E8726A, BCG-E8727A (Variant Models)
IC	:	579C-E8725A (Parent Model) 579C-E8726A, 579C-E8727A (Variant Models)
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 2, PART 25 ISED RSS-GEN ISSUE 5, RSS-170 ISSUE 4

Date Of Issue:
2024-12-28

Prepared by:
UL Verification Services Inc.
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CERT #0751.05

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	2024-10-21	Initial Review	Chris Xiong
V2	2024-11-21	Addressed TCB Questions	Chris Xiong
V3	2024-12-28	Updated Conducted Power & Plots from Pages 36 to 44	Mengistu Mekuria

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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.
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FCC ID	BCG-E8725A (Parent Model) BCG-E8726A, BCG-E8727A (Variant Models)
IC	579C-E8725A (Parent Model) 579C-E8726A, 579-E8727A (Variant Models)
EUT Description	SMARTPHONE
Serial Number	Radiated: L52G6VJWHY Conducted: C07H80000070000J57
Sample Receipt Date	2024-08-07
Date Tested	2024-08-07 to 2024-12-28
Applicable Standards	FCC 47 CFR PART 2, PART 25 ISED RSS-GEN ISSUE 5, 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.

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 correctly integrating customer-provided data with measurements performed by UL Verification Services Inc.

Below is a list of the data provided by the customer:

1. Antenna gain, type and cable loss (see Section 6.4)

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

3. TEST METHODOLOGY

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

- ANSI C63.26:2015
- FCC 47 CFR Part 2, Part 25
- FCC KDB 971168 D01 : Power Meas License Digital Systems
- FCC KDB 971168 D02 : Misc Rev Approv License Devices
- FCC KDB 412172 D01. Determining ERP and EIRP
- ISED RSS-GEN ISSUE 5, RSS-170 ISSUE 4

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			

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}
Conducted Antenna Port Emission Measurement	1.940 dB
Power Spectral Density	2.466 dB
Time Domain Measurements Using SA	3.39 %
RF Power Measurement Direct Method Using Power Meter	1.300 dB Peak 0.450 dB Average
Radio Frequency (Spectrum Analyzer)	141.16 Hz
Occupied Bandwidth	1.22%
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

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

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The Apple iPhone is a smartphone with GSM, GPRS, EGPRS, WCDMA, LTE, 5GNR1, IEEE 802.11a/b/g/n/ac/ax, Bluetooth (BT), Global Positioning System (GPS), Near-Field Communication (NFC) and Mobile Satellite Service (MSS) technologies. The rechargeable battery is not user accessible. This device is not user-serviceable and requires special tools to disassemble.

6.2. MAXIMUM OUTPUT POWER

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: Transmitter output power for MESs (Mobile Earth Stations)
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.

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:

Frequency (MHz)	Conducted Average Power (dBm)	Antenna Gain (dBi)	Limit (W)	EIRP		99% BW (kHz)	Emission Designator
				(dBm)	(W)		
1610.17	28.67	-0.8	10000	27.87	0.612	206.35	206KG1D
1618.40	28.64		10000	27.84	0.608	204.06	204KG1D
1626.03	28.69		10000	27.89	0.614	206.49	206KG1D

6.3. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 1.0.23.

6.4. DESCRIPTION OF AVAILABLE ANTENNAS

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

Frequency Range (MHz)	ANT 1 Gain (dBi)	ANT 4 Gain (dBi)
1610.0 - 1626.5	-1.6	-0.8

Cable loss used for RF antenna port tests are as follow and had been offset to the test equipment during testing.

ANT 1 = 1.95 dB
ANT 4 = 1.77 dB

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations: X (Flatbed), Y (Landscape), and Z (Portrait) on both ANT 1 and ANT 4. It was determined that X (Flatbed) orientation was the worst-case orientation with AC/DC adapter for ANT 1 and Y (Landscape) for 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 were investigated from 9kHz to 30MHz and 30MHz-1GHz. There were no emissions found with less than 20dB of margin from 9kHz to 30MHz.

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.

NOTE: ANT 1 is disabled and data is for information only.

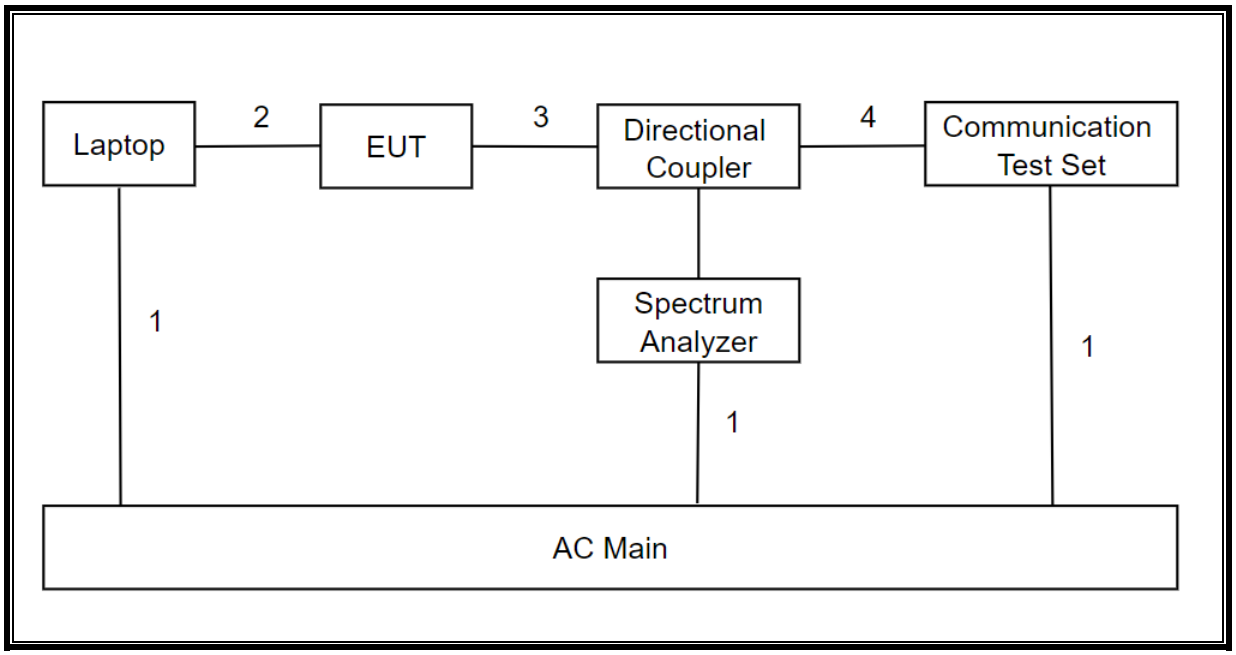
6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID/ DoC**
Laptop	Apple	MacBook Air	FVFHV01MQ6LD	DoC
Laptop AC/DC Adapter	Apple	A2166	C4H13903FJPM0WA9	DoC
EUT AC/DC Adapter	Apple	A1720	C3D8417A7R93KVPA8	DoC

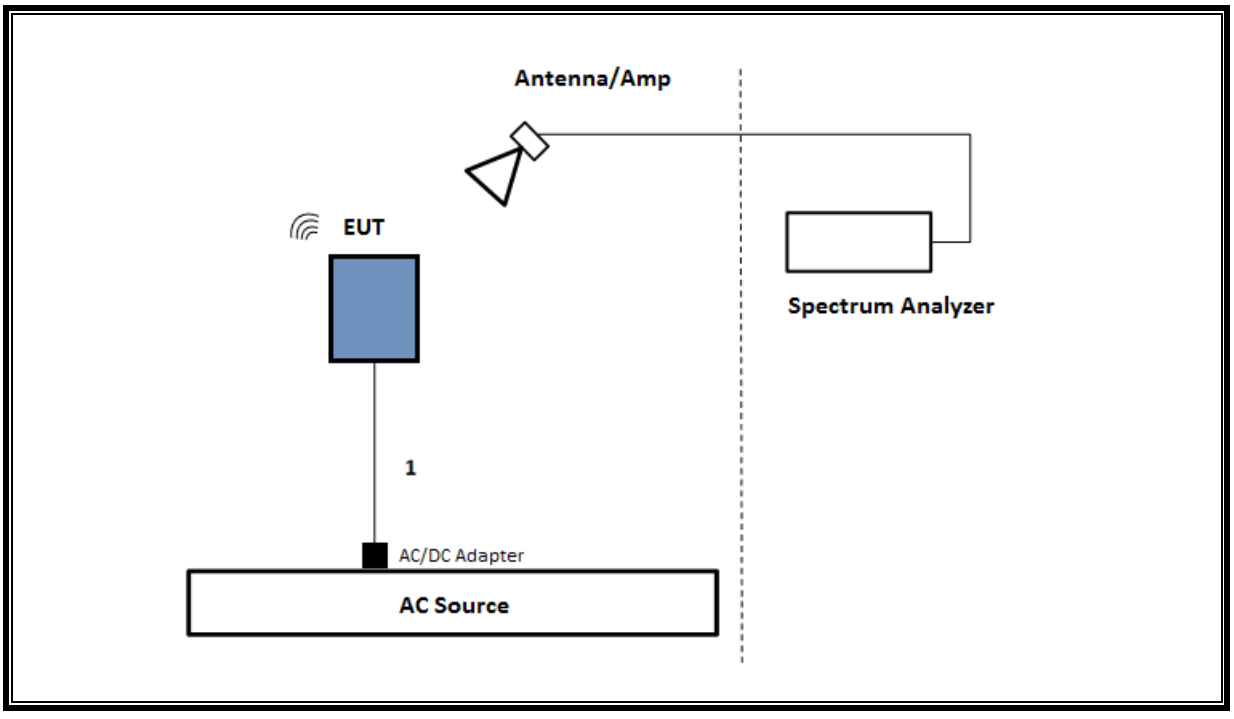
I/O CABLES (RF CONDUCTED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	3	US 115V	Un-shielded	2.0	N/A
2	USB	1	Type-C	Shielded	2.0	N/A
3	RF In/Out	1	SMA	Shielded	1.0	N/A
4	RF In/Out	1	SMA	Shielded	0.5	N/A
5	RF In/Out	1	SMA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

CONDUCTED SETUP



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**
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	201501	2024/11/30
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	81886	2025/03/31
RF Filter Box, 1-18GHz	UL-FR1	N/A	168534	2025/02/28
Antenna, Broadband Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	232076	2025/03/30
Amplifier, 100KHz to 1GHz, 32dB	Keysight Technologies Inc	8447D	80670	2025/08/30
Antenna, Passive Loop 30Hz – 1MHz	Electro-Metrics	EM-6871	170013	2025/07/31
Antenna, Passive Loop 100kHz – 30MHz	Electro-Metrics	EM-6872	170015	2025/07/31
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc.	N9030A	125178	2025/01/31
DC Power Supply	TDK-LAMBDA	GENH 60-25	PRE0074756	N/A
Directional Coupler	KRYTAR	152610	231740	2025/04/30
Wideband Radio Communication Tester	Rohde & Schwarz	CMW500	10533535	2025/07/12
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	82174	2025/01/31
Power Sensor, P-series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	81319	2025/01/31
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	191428	2025/02/28
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	206807	2025/02/28
RF Filter Box, 1-18GHz, 12 Port.	UL-FR1	Frankenstein	230878	2025/05/31
UL AUTOMATION SOFTWARE				
Radiated test software	UL	UL RF	Ver 9.5, May 1, 2023	

NOTES:

1. * Testing is completed before equipment expiration date.
2. 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 $\theta \leq 0°$
+ 40 + 3θ dBW in any 4 kHz band for $0° < \theta \leq 5°$

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: Transmitter output power for MESs (Mobile Earth Stations)
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) / 13.05 dB (ANT 4) (including 10.70 dB coupler and 2.53 dB cable (ANT 1) / 10.70 dB coupler and 2.35 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:	2024-09-12

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	27.19	28.67	-1.6	-0.8	25.59	27.87
1618.40	27.18	28.64			25.58	27.84
1626.03	27.20	**28.69**			25.60	**27.89**

9. CONDUCTED TEST RESULTS

9.1. OCCUPIED BANDWIDTH

RULE PART(S)

FCC: §2.1049
ISED: RSS-GEN

LIMITS

For reporting purposes only.

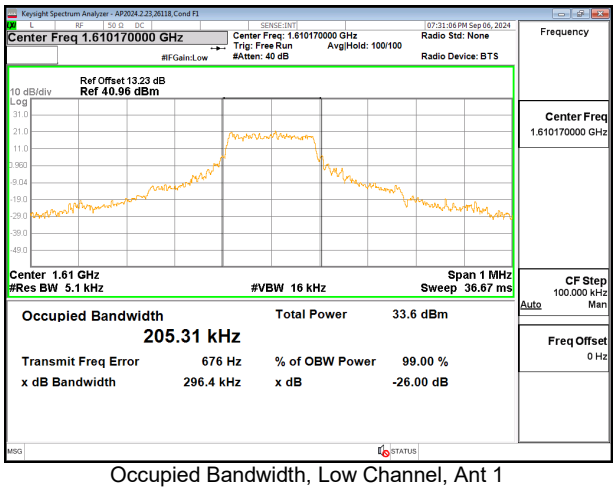
TEST PROCEDURE

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.

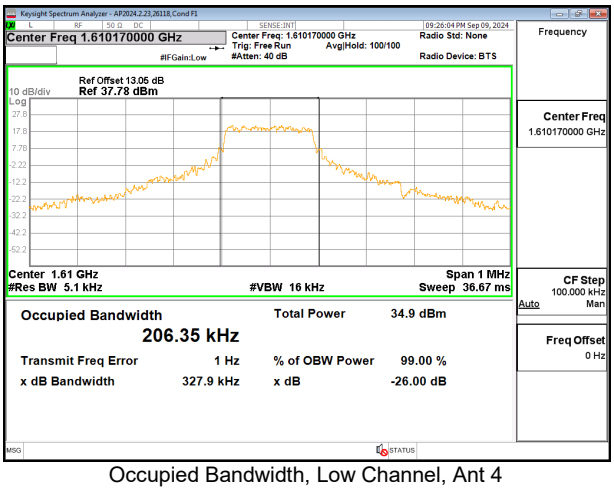
RESULTS

Test Engineer ID:	26118	Test Date:	2024-09-06

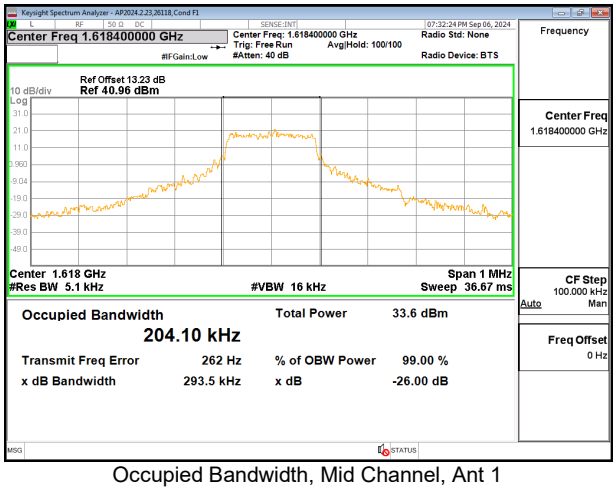
Test Frequency (MHz)	99% Bandwidth (kHz) ANT 1	99% Bandwidth (kHz) ANT 4
1610.17	205.31	206.35
1618.40	204.10	204.06
1626.03	201.83	206.49



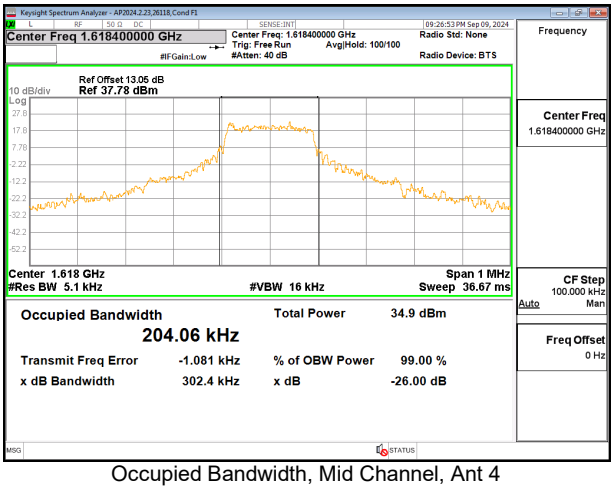
Occupied Bandwidth, Low Channel, Ant 1



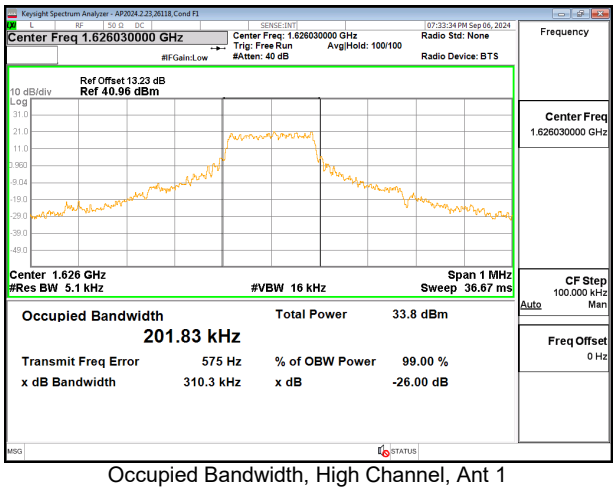
Occupied Bandwidth, Low Channel, Ant 4



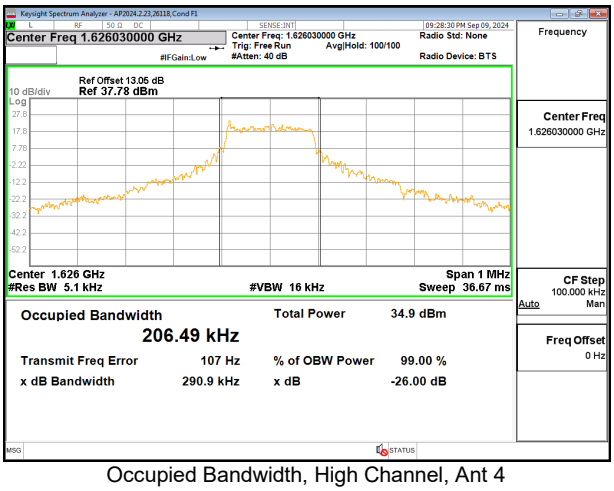
Occupied Bandwidth, Mid Channel, Ant 1



Occupied Bandwidth, Mid Channel, Ant 4



Occupied Bandwidth, High Channel, Ant 1



Occupied Bandwidth, High Channel, Ant 4

9.2. EMISSIONS MASK WITHIN 250% OF AUTHORIZED BANDWIDTH

LIMITS

FCC §25.202
(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;

ISED RSS-170§ 5.8: Unwanted emission limits for MESs in all frequency bands
The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:

a. 25 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater
b. 35 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

TEST PROCEDURE

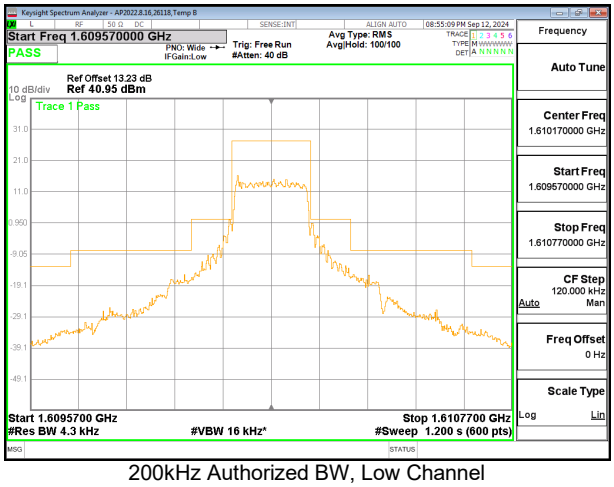
The transmitter output was connected to a calibrated coaxial cable and coupler, the other end of which was connected to a spectrum analyzer. The channel edge emissions were measured on the low, mid and high channels. The limits within 250% of the authorized bandwidth are relative to the total in-band (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

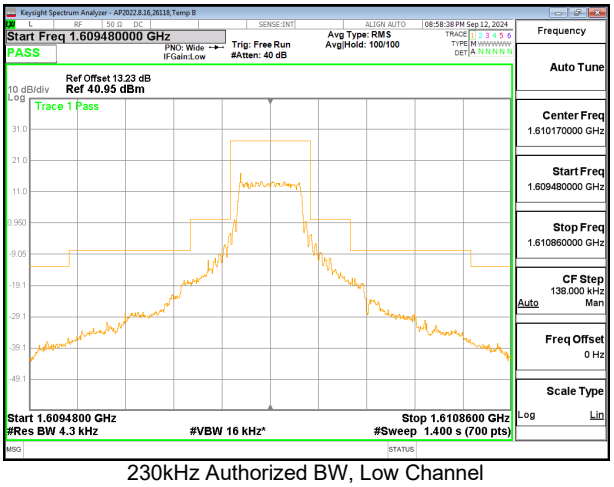
The tests were performed based on declared authorized bandwidths of 200kHz, 230kHz and 280kHz.

Test Engineer ID:	26118	Test Date:	2024-09-12

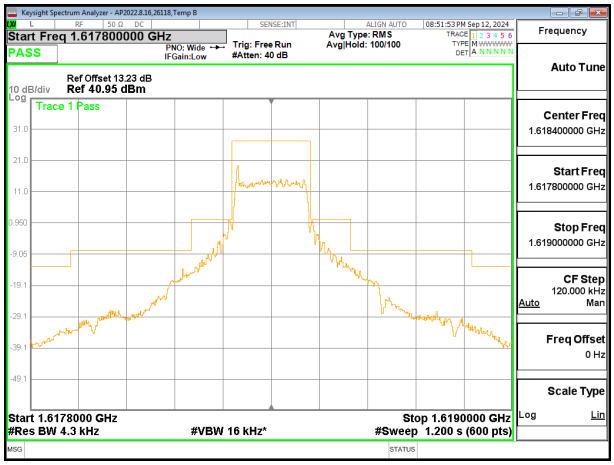
9.2.1. ANT 1



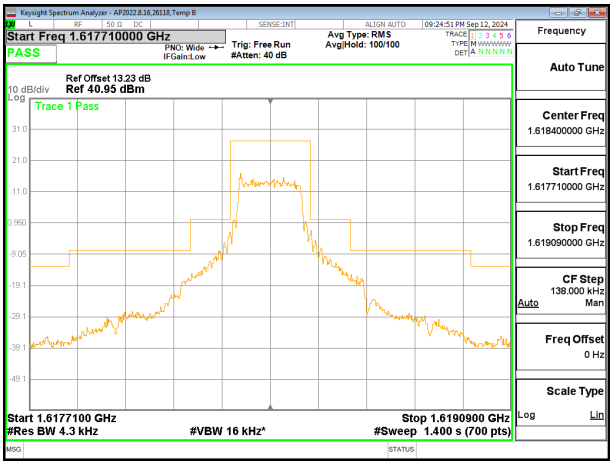
200kHz Authorized BW, Low Channel



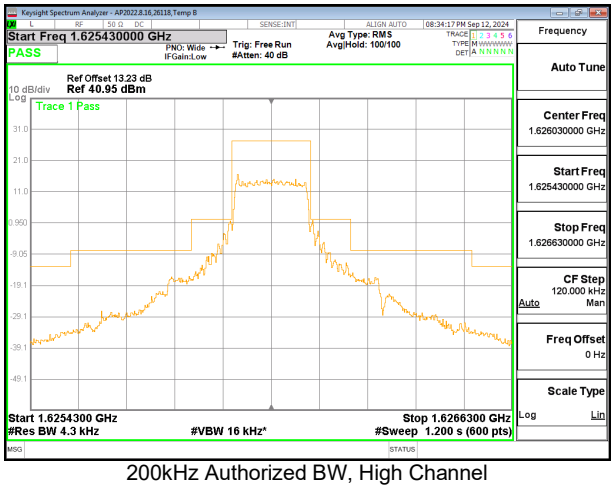
230kHz Authorized BW, Low Channel



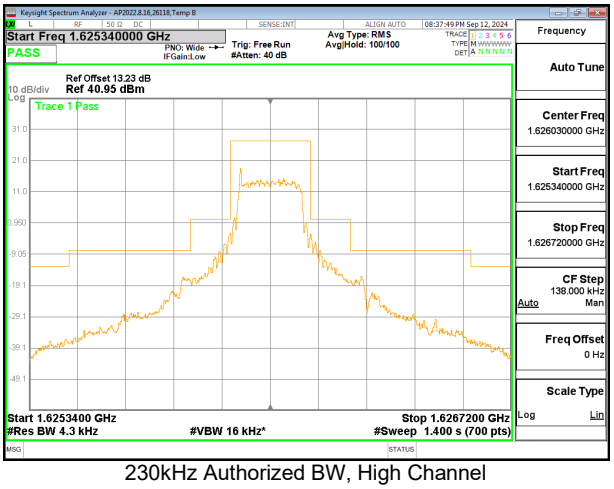
200kHz Authorized BW, Mid Channel



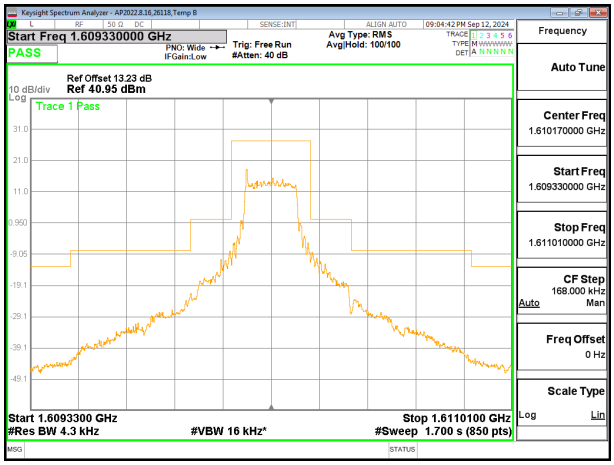
230kHz Authorized BW, Mid Channel



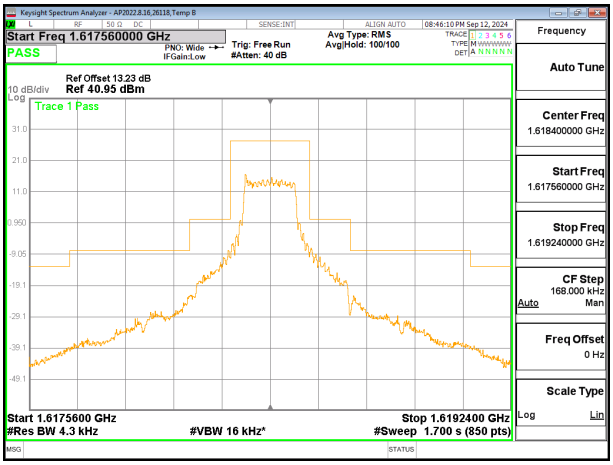
200kHz Authorized BW, High Channel



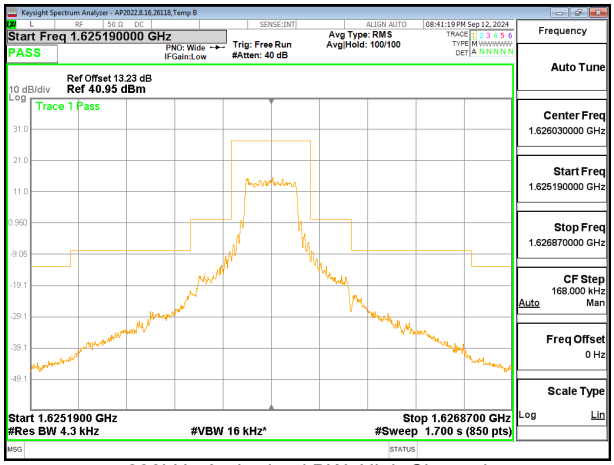
230kHz Authorized BW, High Channel



280kHz Authorized BW, Low Channel



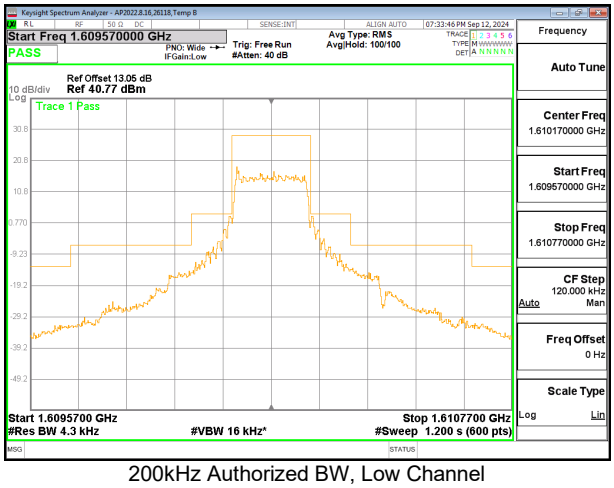
280kHz Authorized BW, Mid Channel



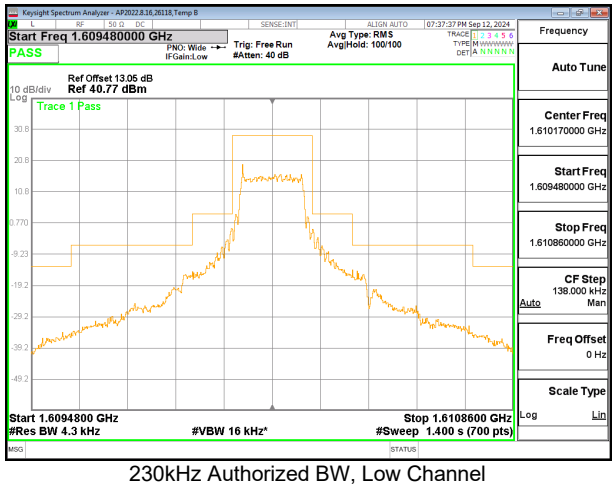
280kHz Authorized BW, High Channel

Intentionally Blank

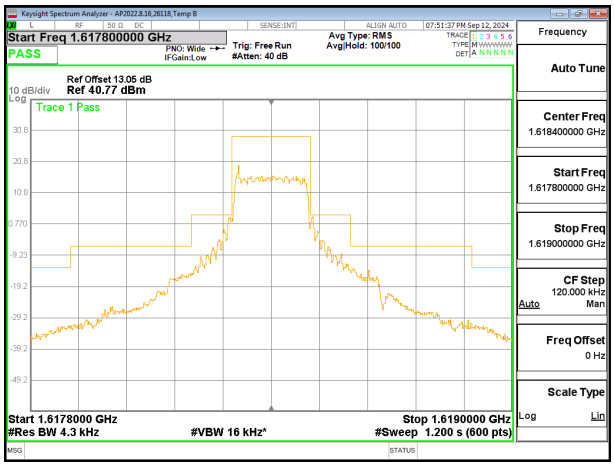
9.2.2. ANT 4



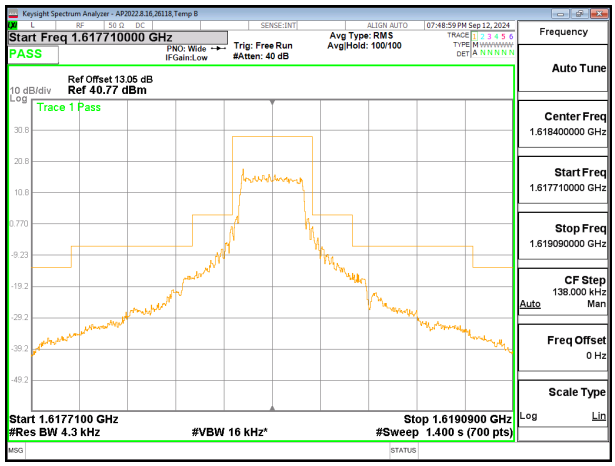
200kHz Authorized BW, Low Channel



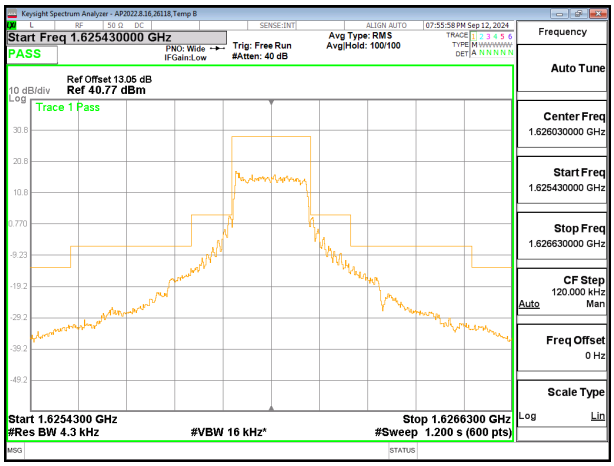
230kHz Authorized BW, Low Channel



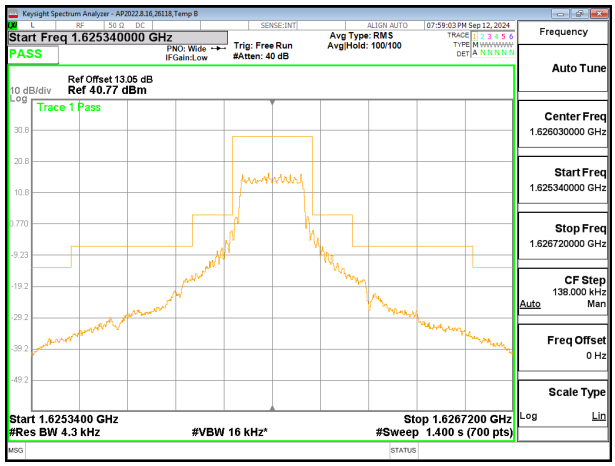
200kHz Authorized BW, Mid Channel



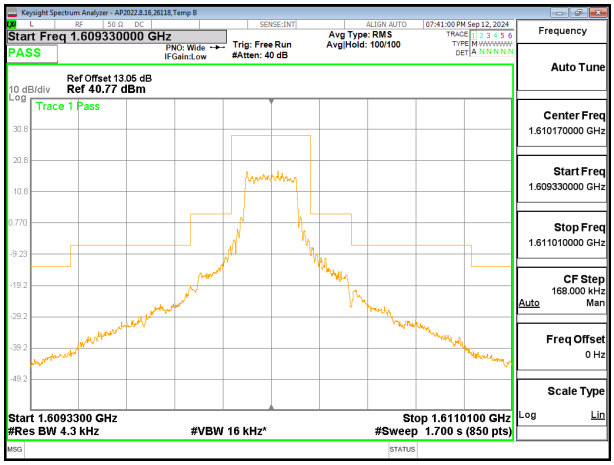
230kHz Authorized BW, Mid Channel



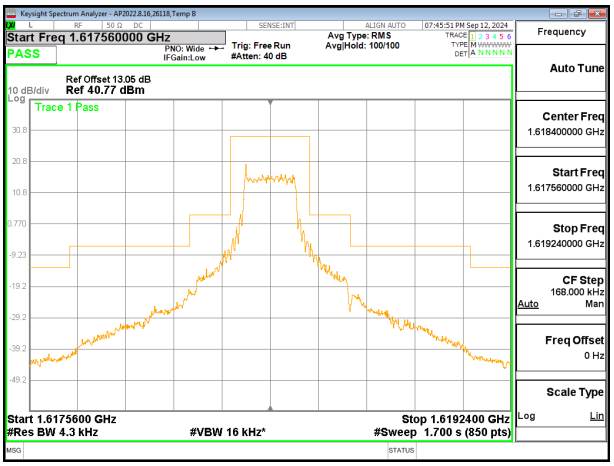
200kHz Authorized BW, High Channel



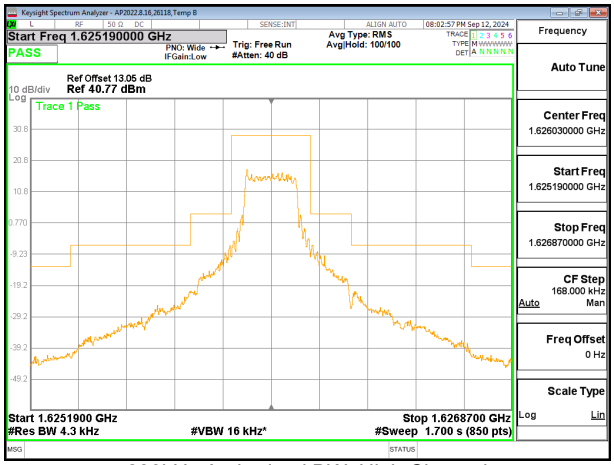
230kHz Authorized BW, High Channel



280kHz Authorized BW, Low Channel



280kHz Authorized BW, Mid Channel



280kHz Authorized BW, High Channel

Intentionally Blank

9.3. OUT OF BAND EMISSIONS

LIMITS

FCC §25.202 and
(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.

ISED RSS-170§5.8: Unwanted emission limits for MESs in all frequency bands

c. 43 + 10 log p (watts) in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

TEST PROCEDURE

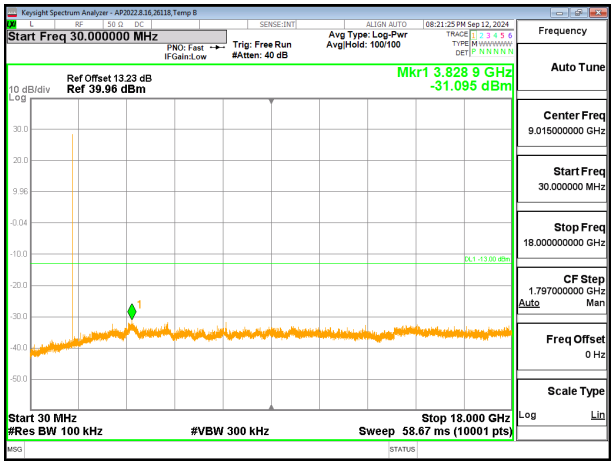
KDB 971168 D01/D02

For each out of band emissions measurement:

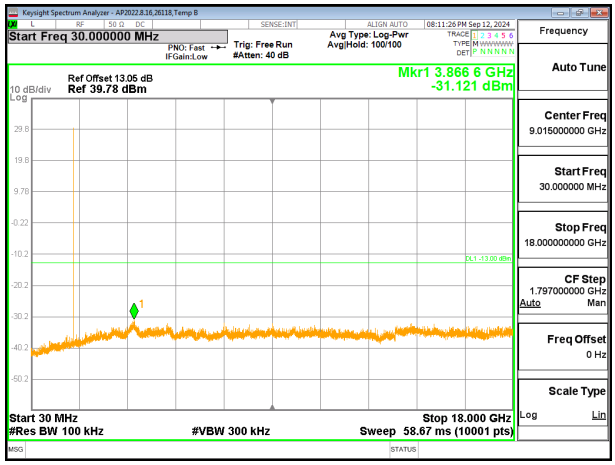
- Set display line at -13 dBm (the limit of 43 + 10Log(P))
- Set RBW >= 4kHz and VBW >= 3 x RBW with peak detector for all measurements. The limit is an average limit so any emissions that exceed the limit using the peak detector are measured using rms detection with an averaging time of 2ms.

RESULTS

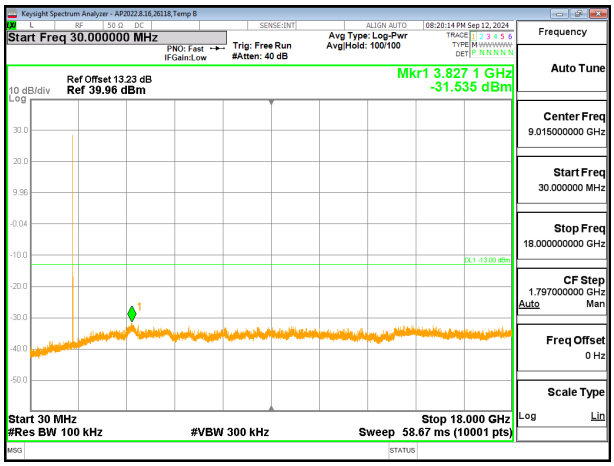
Test Engineer ID:	26118	Test Date:	2024-09-12



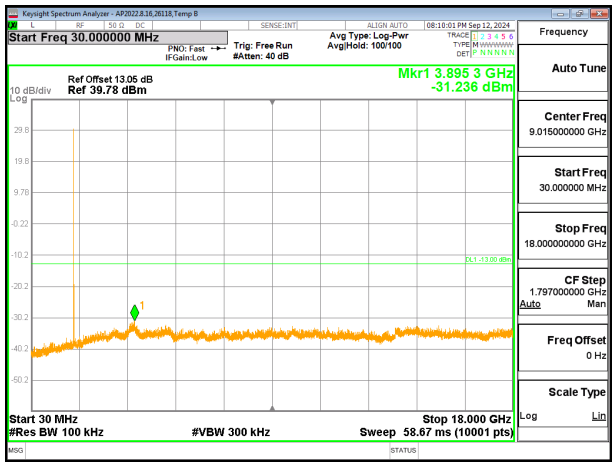
Low Channel 30MHz to 18GHz Ant1



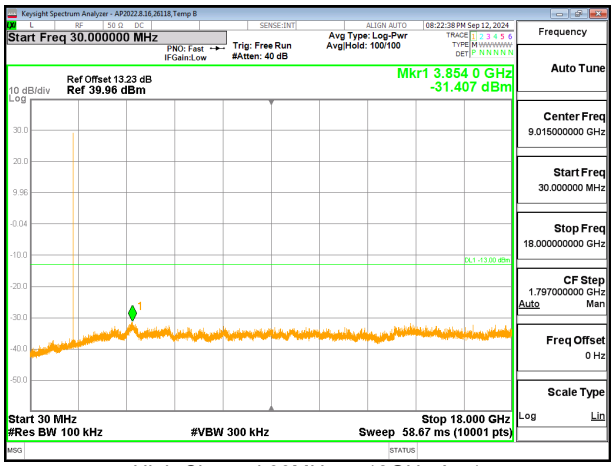
Low Channel 30MHz to 18GHz Ant4



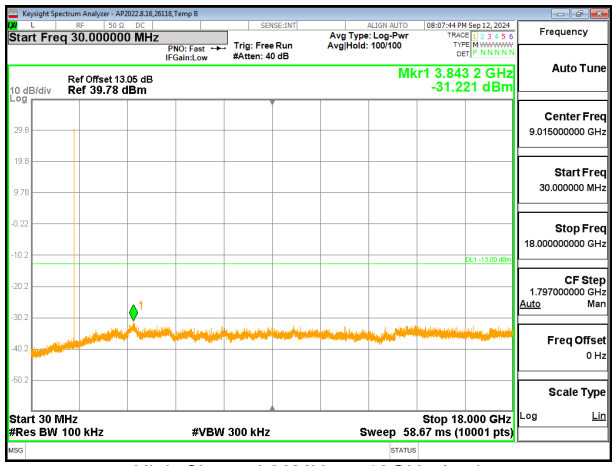
Mid Channel 30MHz to 18GHz Ant1



Mid Channel 30MHz to 18GHz Ant4



High Channel 30MHz to 18GHz Ant1



High Channel 30MHz to 18GHz Ant4

9.4. 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 MES equipment, the carrier frequency shall not drift 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, 3.80VDC and High voltage, 4.37VDC.
  End Voltage, 3.08VDC.

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:	2024-09-11 2024-10-02

ANT 1

Frequency Reference (MHz)		1610.17031		Frequency Reading (MHz)	Delta (Hz)	Frequency Stability (ppm)
Condition		F low @ -10dB BW (MHz)	F high @ -10dB BW (MHz)			
Temperature	Voltage					
Normal (20 C)		1610.078875	1610.261750	1610.17031		
Extreme (50C)		1610.077937	1610.261063	1610.16950	-812.8	-0.50
Extreme (40C)		1610.079125	1610.261375	1610.17025	-62.5	-0.04
Extreme (30C)		1610.078553	1610.260188	1610.16937	-942.5	-0.59
Extreme (10C)	Normal	1610.078500	1610.261875	1610.17019	-125.0	-0.08
Extreme (0C)		1610.078313	1610.261500	1610.16991	-406.2	-0.25
Extreme (-10C)		1610.076875	1610.262000	1610.16944	-875.0	-0.54
Extreme (-20C)		1610.077750	1610.261313	1610.16953	-781.2	-0.49
Extreme (-30C)		1610.077750	1610.261313	1610.16953	-781.2	-0.49
20C	15%	1610.078563	1610.260875	1610.169719	-593.8	-0.37
	-15%	1610.078313	1610.261000	1610.169656	-656.2	-0.41
	End Point	1610.079375	1610.259938	1610.169656	-656.2	-0.41

ANT 4

Frequency Reference (MHz)		1610.17010		Frequency Reading (MHz)	Delta (Hz)	Frequency Stability (ppm)
Condition		F low @ -10dB BW (MHz)	F high @ -10dB BW (MHz)			
Temperature	Voltage					
Normal (20 C)		1610.079274	1610.260922	1610.17010		
Extreme (50C)		1610.078963	1610.261670	1610.17032	218.8	0.14
Extreme (40C)		1610.078336	1610.261586	1610.16996	-136.8	-0.08
Extreme (30C)		1610.078500	1610.262295	1610.17040	299.6	0.19
Extreme (10C)	Normal	1610.078205	1610.262461	1610.17033	234.9	0.15
Extreme (0C)		1610.078125	1610.260616	1610.16937	-727.4	-0.45
Extreme (-10C)		1610.079688	1610.261032	1610.17036	261.9	0.16
Extreme (-20C)		1610.078485	1610.261101	1610.16979	-305.0	-0.19
Extreme (-30C)		1610.078780	1610.260315	1610.16955	-550.6	-0.34
20C	15%	1610.079616	1610.261976	1610.170796	698.3	0.43
	-15%	1610.078735	1610.261063	1610.169899	-199.4	-0.12
	End Point	1610.078461	1610.260836	1610.169649	-449.4	-0.28

10. RADIATED TEST RESULTS

Radiated measurement using the Field Strength Method

Using the test configuration shown in Figure 6 below, the radiated emissions is measured directly from the EUT and convert the measured field strength or received power to ERP or 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.

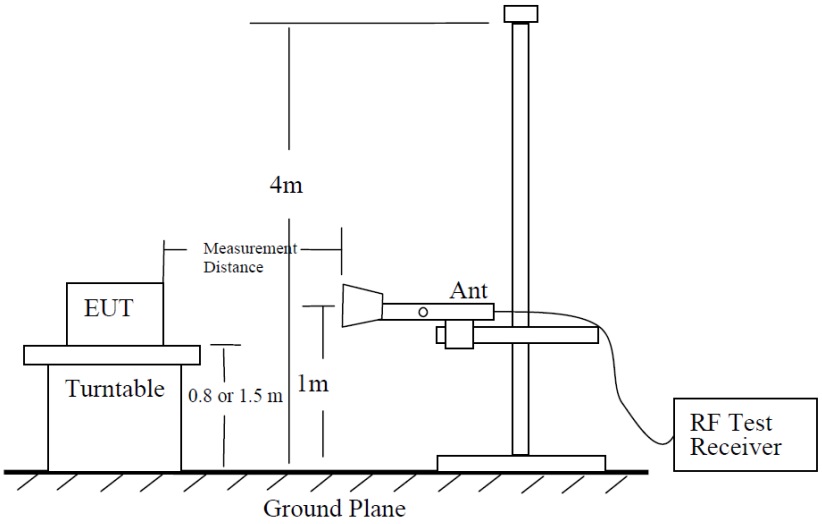


Figure 6—Test site-up for radiated ERP and/or EIRP measurements

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

10.1. FIELD STRENGTH OF SPURIOUS RADIATION

LIMITS

FCC §25.202
(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;

ISED RSS-170§5.8: Unwanted emission limits for MESs in all frequency bands

c. 43 + 10 log p (watts) in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

TEST PROCEDURE

KDB 971168 D01/D02

For each out of band emissions measurement:

- Set display line at -13 dBm (the limit of 43 + 10Log(P))
- Set RBW >= 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.

10.1.1. ANT 1 (Above 1GHz)

Date:	2024/09/13
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	02-RDE-E

LOW CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	4.830507	54.13	Pk	33.9	-95.2	-46.95	-54.12	-13	-41.12	68	107	H
5	5.410847	45.61	Pk	34.5	-95.2	-46.93	-62.02	-13	-49.02	0-360	150	H
4	4.830526	55.88	Pk	33.9	-95.2	-46.95	-52.37	-13	-39.37	314	107	V
6	5.421228	46.01	Pk	34.5	-95.2	-46.99	-61.68	-13	-48.68	0-360	150	V
1	3.220366	54.56	Pk	33	-95.2	-45.95	-53.59	-13	-40.59	197	169	H
2	3.220373	51.75	Pk	33	-95.2	-45.95	-56.4	-13	-43.4	23	102	V

Pk - Peak detector

MID CHANNEL DATA

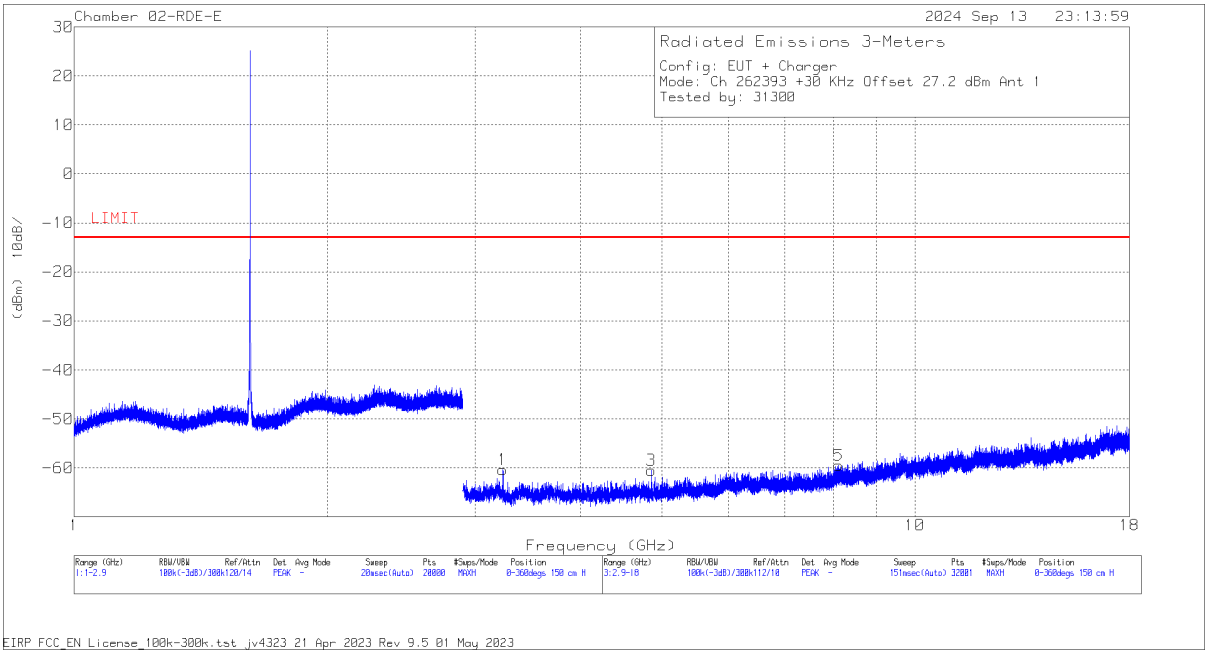
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	4.855316	50.77	Pk	33.9	-95.2	-46.82	-57.35	-13	-44.35	115	109	H
5	8.109028	43.83	Pk	35.9	-95.2	-44.03	-59.5	-13	-46.5	0-360	150	H
4	4.855325	52.3	Pk	33.9	-95.2	-46.82	-55.82	-13	-42.82	9	164	V
6	8.117994	44.73	Pk	35.9	-95.2	-43.95	-58.52	-13	-45.52	0-360	150	V
1	3.236847	51.53	Pk	33	-95.2	-46.04	-56.71	-13	-43.71	219	155	H
2	3.236939	50.58	Pk	33	-95.2	-46.04	-57.66	-13	-44.66	198	212	V

Pk - Peak detector

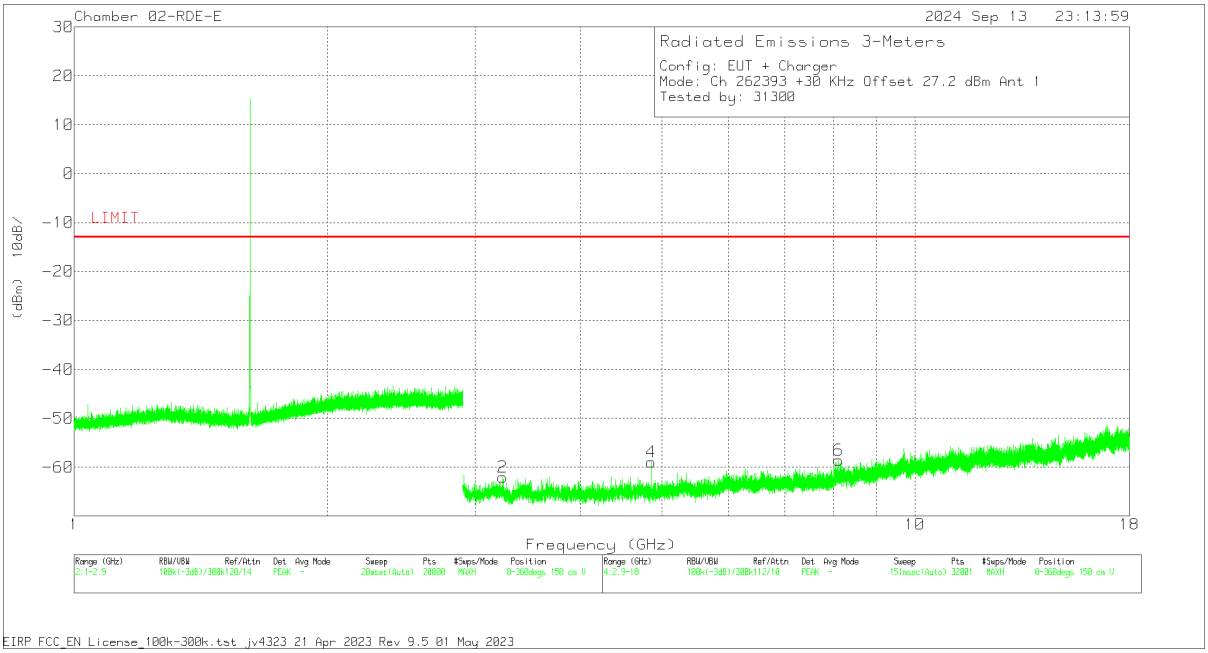
HIGH CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	3.797034	44.05	Pk	33.4	-95.2	-45.59	-63.34	-13	-50.34	0-360	150	H
5	4.878100	47.18	Pk	33.9	-95.2	-47.04	-61.16	-13	-48.16	0-360	150	H
4	3.808831	45.87	Pk	33.4	-95.2	-45.76	-61.69	-13	-48.69	0-360	150	V
6	4.878098	51.02	Pk	33.9	-95.2	-47.04	-57.32	-13	-44.32	7	118	V
2	3.246356	44.35	Pk	33	-95.2	-46.07	-63.92	-13	-50.92	0-360	150	V
1	3.252069	51.06	Pk	32.9	-95.2	-46.1	-57.34	-13	-44.34	193	113	H

Pk - Peak detector



MID CHANNEL HORIZONTAL



MID CHANNEL VERTICAL

10.1.2. ANT 4 (Above 1GHz)

Date:	2024/09/14
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	02-RDE-E

LOW CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	5.031459	46.45	Pk	34	-95.2	-47.41	-62.16	-13	-49.16	0-360	150	H
5	7.516353	44.05	Pk	35.7	-95.2	-45.2	-60.65	-13	-47.65	0-360	150	H
4	5.042313	45.5	Pk	34	-95.2	-47.42	-63.12	-13	-50.12	0-360	150	V
6	7.506916	43.5	Pk	35.7	-95.2	-45.3	-61.3	-13	-48.3	0-360	150	V
1	3.405850	47.47	Pk	32.8	-95.2	-45.74	-60.67	-13	-47.67	0-360	150	H
2	3.414816	45.51	Pk	32.8	-95.2	-45.7	-62.59	-13	-49.59	0-360	150	V

Pk - Peak detector

MID CHANNEL DATA

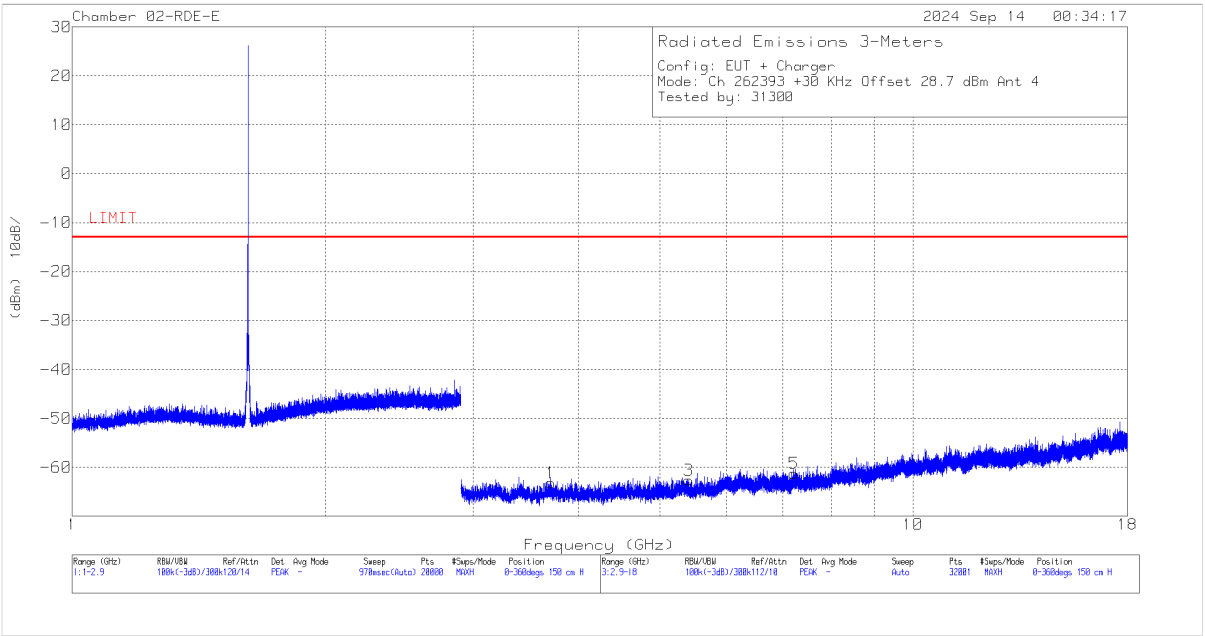
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.710209	44.69	Pk	33.3	-95.2	-45.9	-63.11	-13	-50.11	0-360	150	H
3	5.414150	45.11	Pk	34.5	-95.2	-47	-62.59	-13	-49.59	0-360	150	H
2	3.716344	45.83	Pk	33.3	-95.2	-45.79	-61.86	-13	-48.86	0-360	150	V
4	5.424531	47.5	Pk	34.5	-95.2	-47.02	-60.22	-13	-47.22	0-360	150	V
6	7.212466	44.64	Pk	35.6	-95.2	-44.5	-59.46	-13	-46.46	0-360	150	V
5	7.221431	42.76	Pk	35.6	-95.2	-44.41	-61.25	-13	-48.25	0-360	150	H

Pk - Peak detector

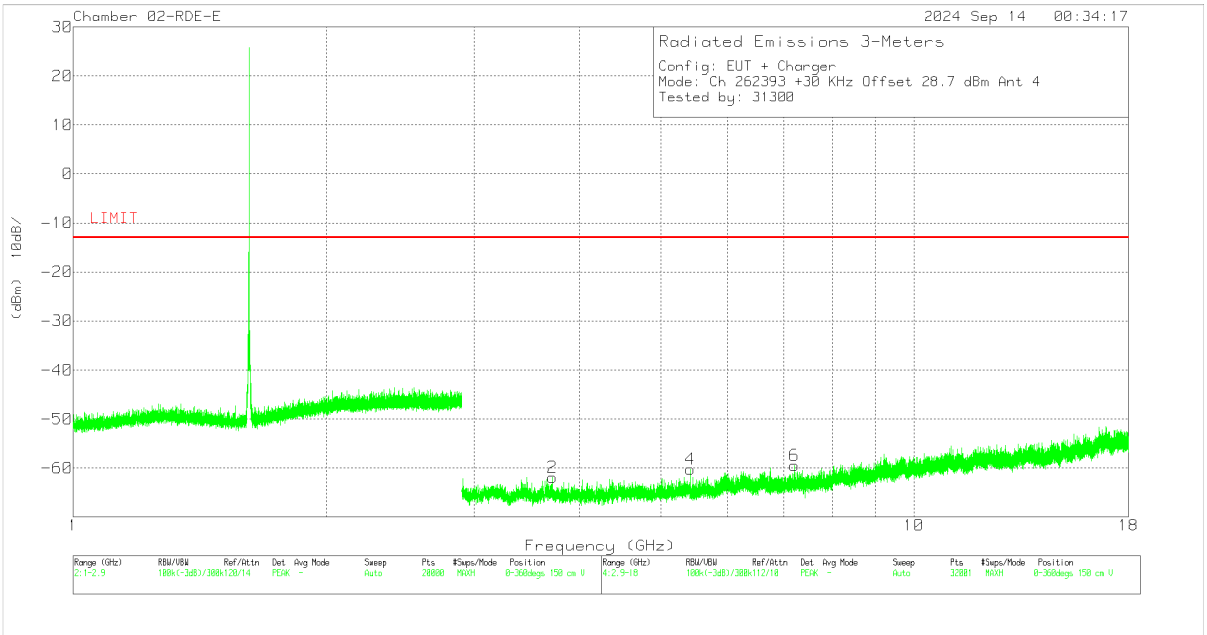
HIGH CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206807 ACF (dB/m)	EIRP CF (dB)	Gain/Loss (dB)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	4.135369	46.19	Pk	33.4	-95.2	-45.98	-61.59	-13	-48.59	0-360	150	H
5	8.226997	43.71	Pk	35.9	-95.2	-44.07	-59.66	-13	-46.66	0-360	150	H
2	4.151884	45.54	Pk	33.4	-95.2	-45.93	-62.19	-13	-49.19	0-360	150	V
6	8.223222	44.29	Pk	35.9	-95.2	-44.06	-59.07	-13	-46.07	0-360	150	V
4	6.597613	44.09	Pk	35.5	-95.2	-43.63	-59.24	-13	-46.24	0-360	150	V
3	6.616488	42.14	Pk	35.5	-95.2	-43.43	-60.99	-13	-47.99	0-360	150	H

Pk - Peak detector



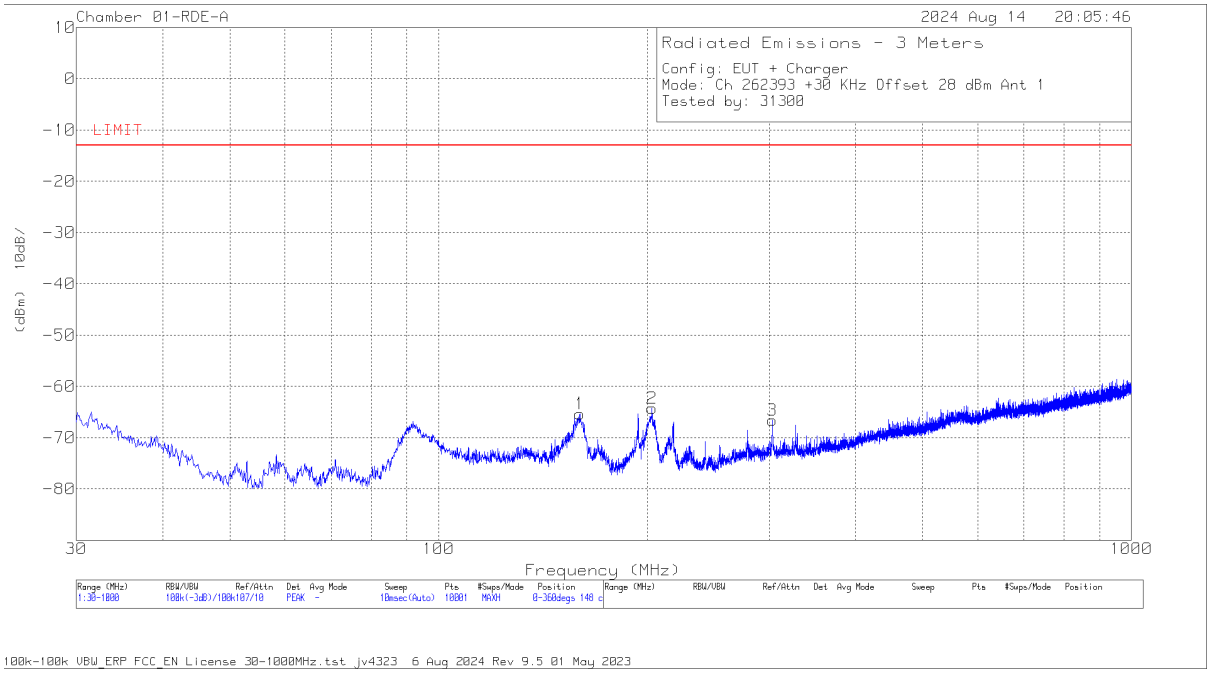
MID CHANNEL HORIZONTAL



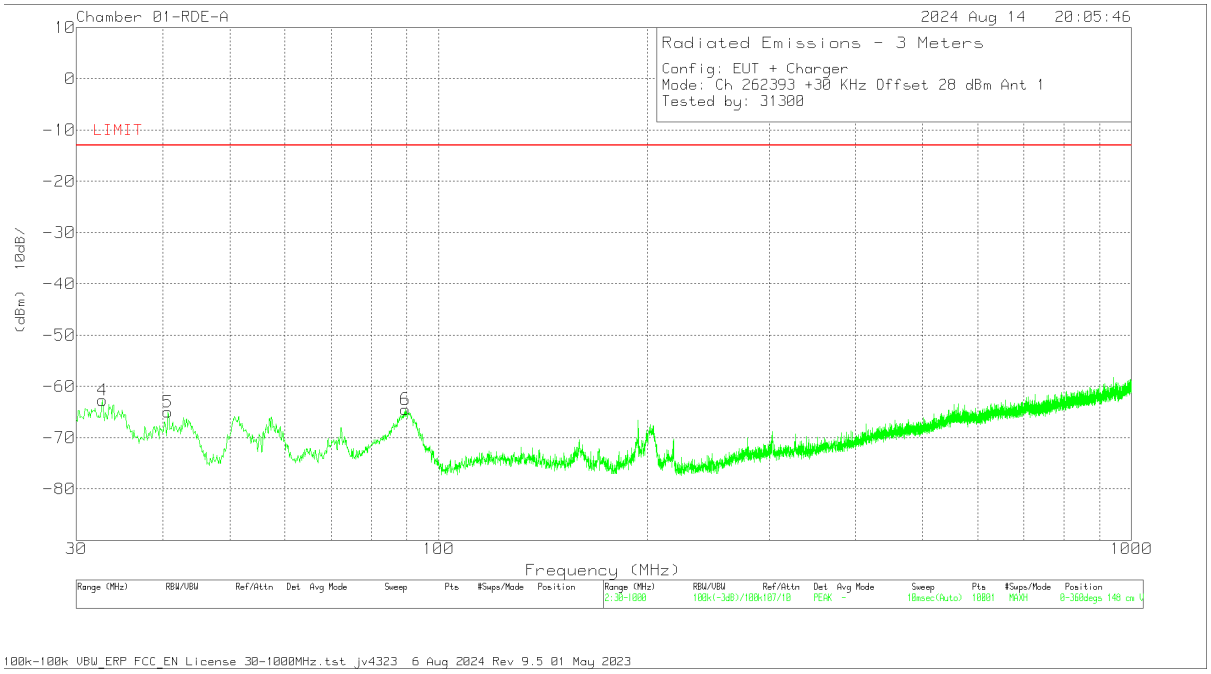
MID CHANNEL VERTICAL

10.1.3. ANT 1 (Below 1GHz)

Date:	2024/08/14
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	01-RDE-A



MID CHANNEL HORIZONTAL



MID CHANNEL VERTICAL

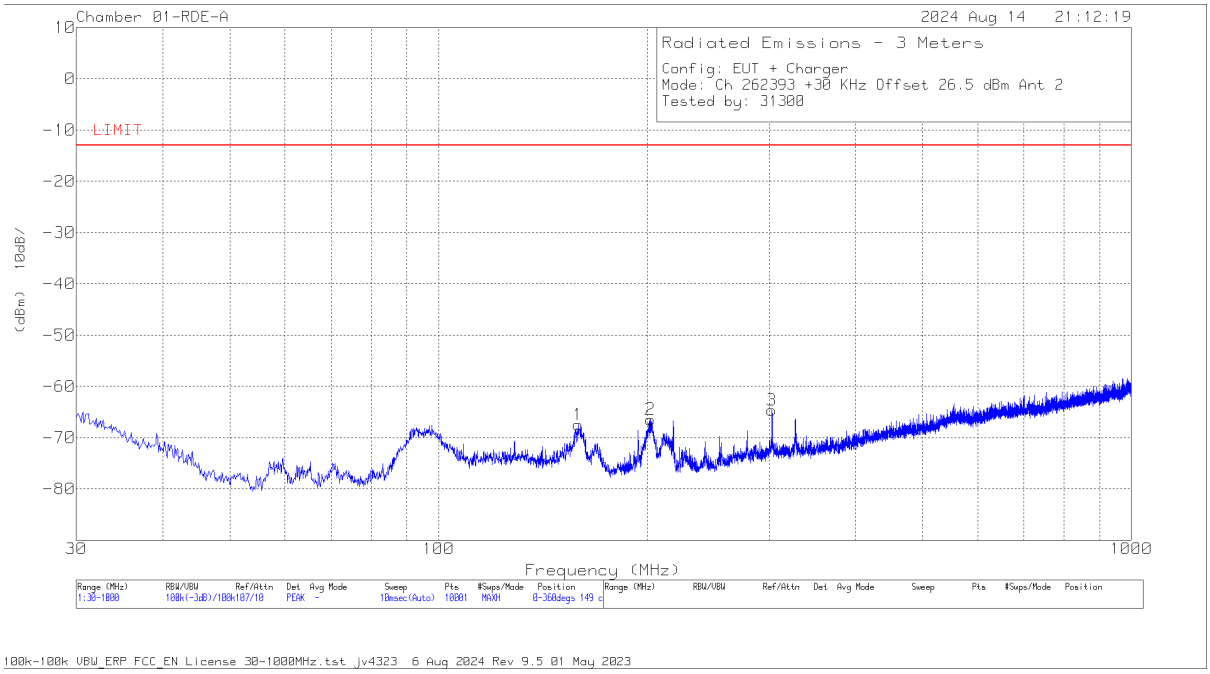
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	232075 ACF (dB/m)	Cbl (dB)	EIRP CF (dBm)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	32.716	34.5	Pk	25.1	-27.1	-95.2	-62.7	-13	-49.7	0-360	148	V
5	40.67	38.09	Pk	19.1	-27	-95.2	-65.01	-13	-52.01	0-360	148	V
6	89.558	43.3	Pk	13.8	-26.4	-95.2	-64.5	-13	-51.5	0-360	148	V
1	159.98	37.04	Pk	18.2	-25.4	-95.2	-65.36	-13	-52.36	0-360	148	H
2	203.339	38.63	Pk	17.4	-25.1	-95.2	-64.27	-13	-51.27	0-360	148	H
3	303.249	33.51	Pk	19.4	-24.3	-95.2	-66.59	-13	-53.59	0-360	148	H

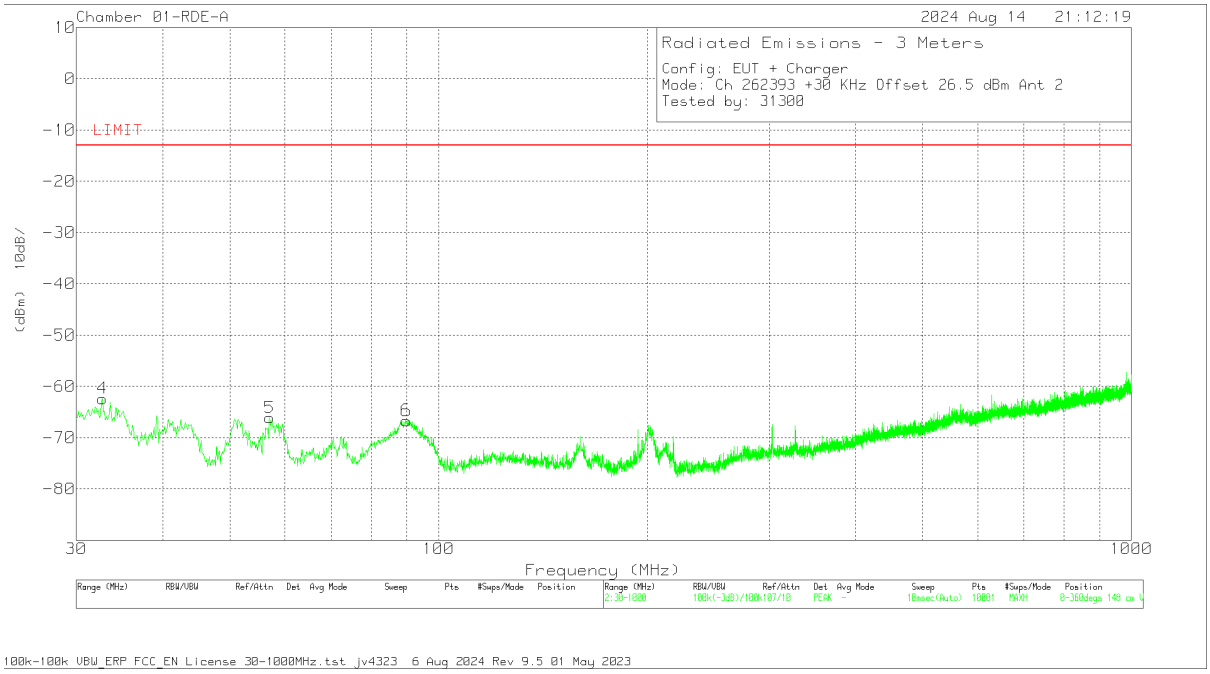
Pk - Peak detector

10.1.4. ANT 4 (Below 1GHz)

Date:	2024/08/14
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	01-RDE-A



MID CHANNEL HORIZONTAL



MID CHANNEL VERTICAL

DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	232075 ACF (dB/m)	Cbl (dB)	EIRP CF (dBm)	Corrected Reading (dBm)	LIMIT (dBm)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	32.716	34.84	Pk	25.1	-27.1	-95.2	-62.36	-13	-49.36	0-360	148	V
5	57.063	42.7	Pk	13.2	-26.8	-95.2	-66.1	-13	-53.1	0-360	148	V
6	89.849	41.02	Pk	13.9	-26.4	-95.2	-66.68	-13	-53.68	0-360	148	V
1	159.107	35.02	Pk	18.2	-25.5	-95.2	-67.48	-13	-54.48	0-360	149	H
2	202.369	36.25	Pk	17.6	-25.1	-95.2	-66.45	-13	-53.45	0-360	149	H
3	302.958	35.45	Pk	19.4	-24.3	-95.2	-64.65	-13	-51.65	0-360	149	H

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

(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.

ISED RSS-170§ 5.9.1: Band 1610-1626.5 MHz

For MESs with transmitting frequencies between 1610 MHz and 1626.5 MHz, the e.i.r.p. density of unwanted emissions shall not exceed the limits shown below, which are the same as those for the band 1605-1610 MHz, averaged over any 2 ms active transmission interval:

a. -70 dBW/MHz at 1605 MHz, linearly interpolated to -10 dBW/MHz at 1610 MHz, for broadband emissions
b. -80 dBW/kHz at 1605 MHz, linearly interpolated to -20 dBW/kHz at 1610 MHz, for discrete emissions

TEST PROCEDURE

KDB 971168 D01/D02

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

Measure narrowband emissions using:
RBW = 10kHz, VBW = 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

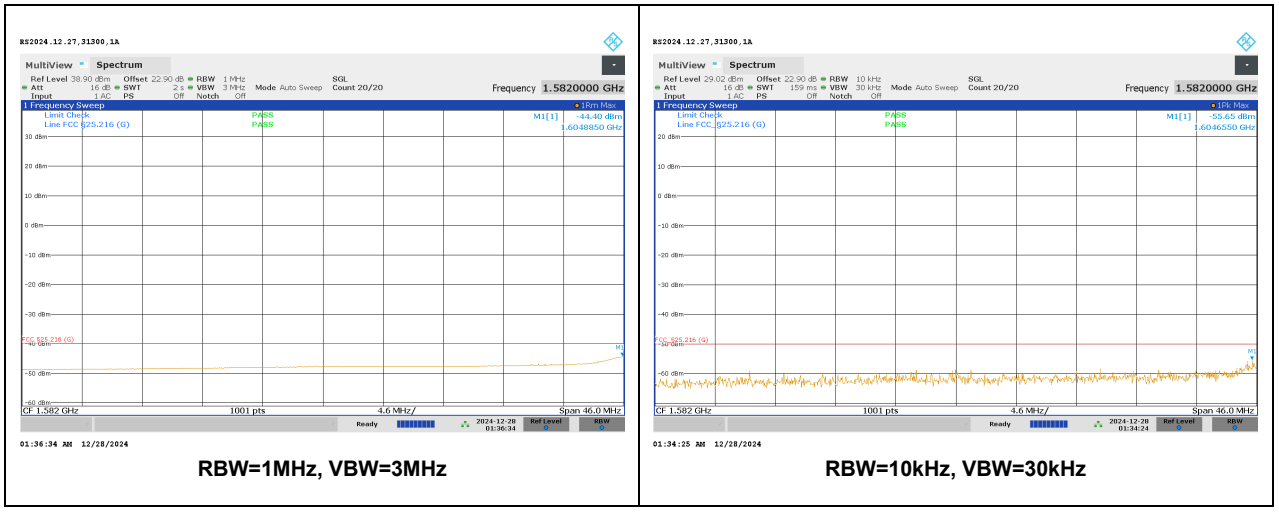
Both horizontal / vertical polarizations and low/ mid/ high channels were investigated on ANT 1 and ANT 4. Low channel was found to be worst case for both antennas.

Date:	2024/09/12
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	TX
Chamber #:	01-RDE-A

Offset Calculation= Antenna Factor + Amp/Cbl/Fltr/Pad + EIRP CF

Antenna Factor (dB/m)	Amp/Cbl/Fltr/Pad (dB)	EIRP CF	Offset (dB)
28.5	-17.4	11.8	22.9

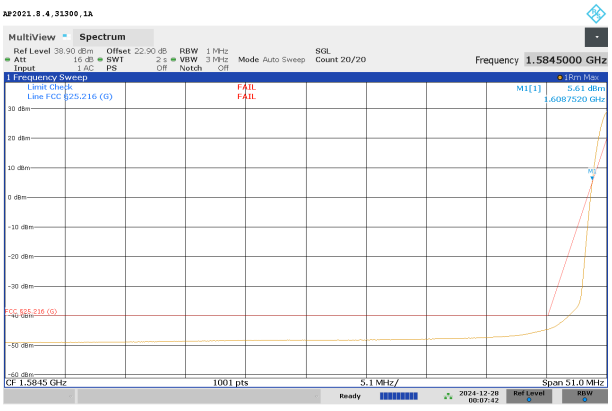
Plots for Determining Wide Band or Narrow Band Emissions



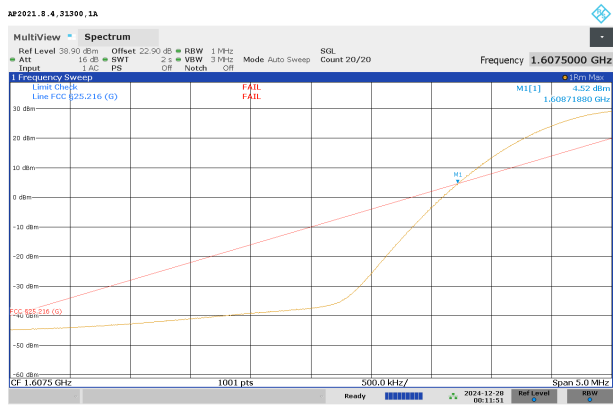
Note: It was found that the marker 1 @ 1604.885MHz frequency which belonged to wideband emission.

10.2.1. ANT 1 (HORIZONTAL)

Wideband Low Channel 1610.17MHz

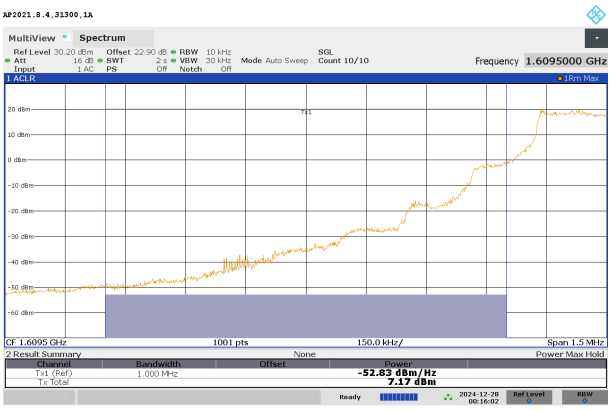


1559MHz -1610MHz

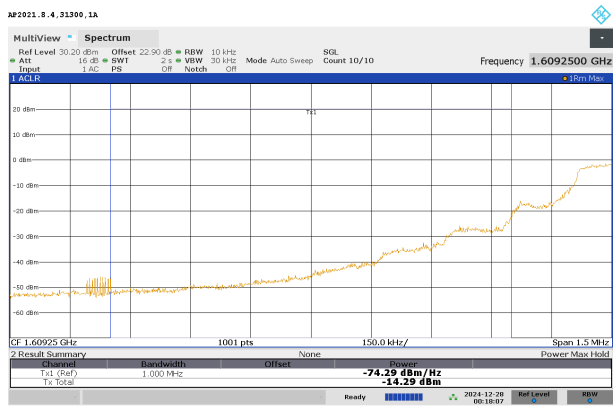


1605MHz -1610MHz (Zoom-in)

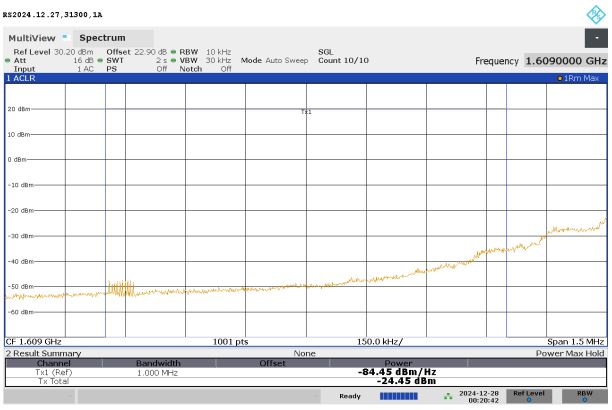
Plots below show passing result using integration method:



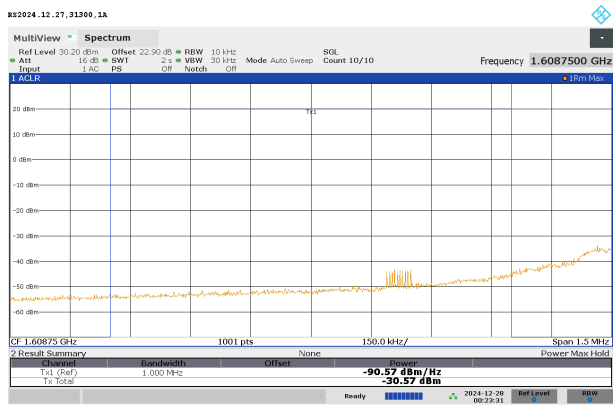
1609.5MHz, 1MHz Integration



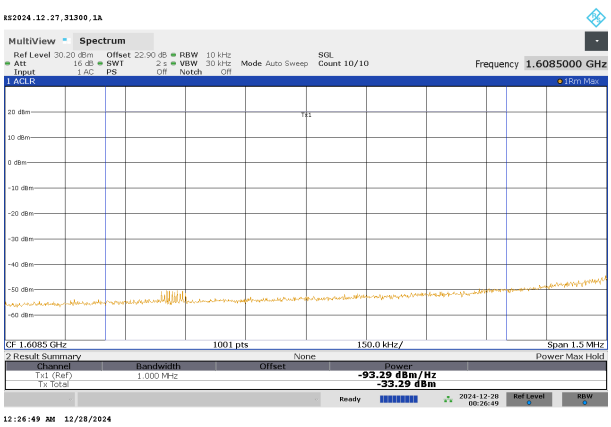
1609.25MHz, 1MHz Integration



1609.0MHz, 1MHz Integration

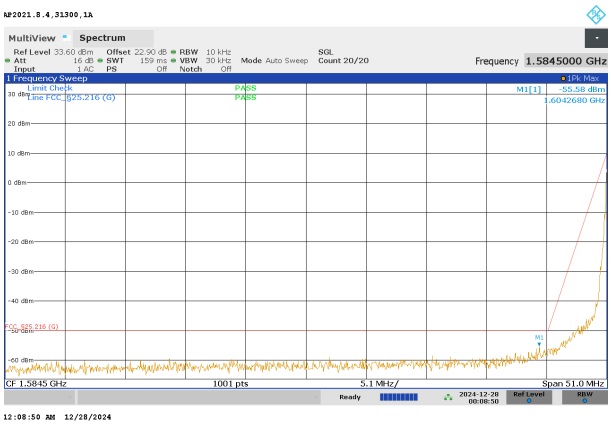


1608.75MHz, 1MHz Integration



1608.50MHz, 1MHz Integration

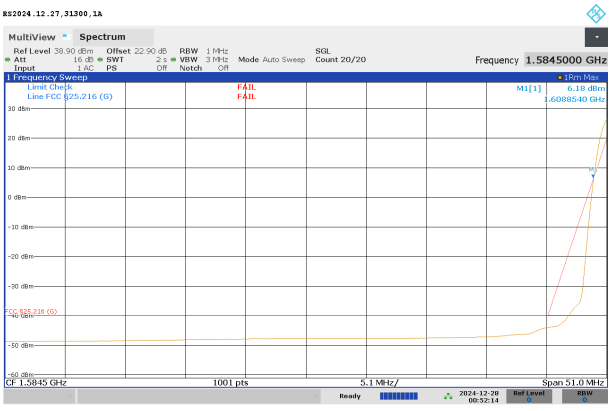
Narrowband Low Channel 1610.17MHz



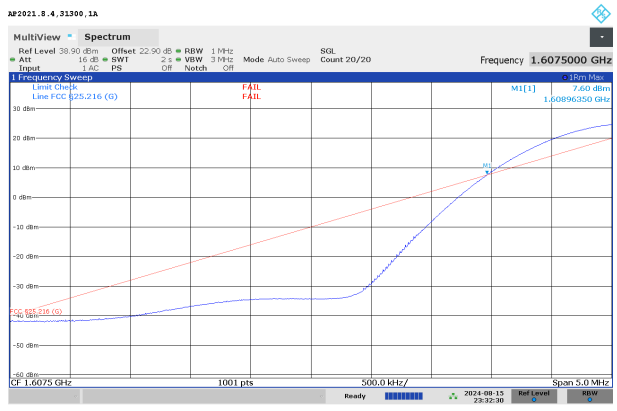
1559MHz – 1610MHz

10.2.2. ANT 1 (VERTICAL)

Wideband Low Channel 1610.17MHz

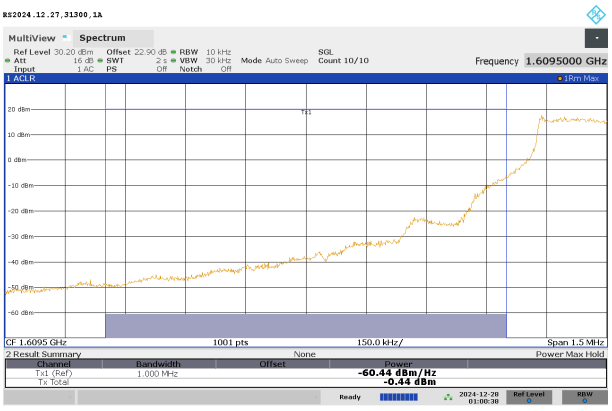


1559MHz -1610MHz



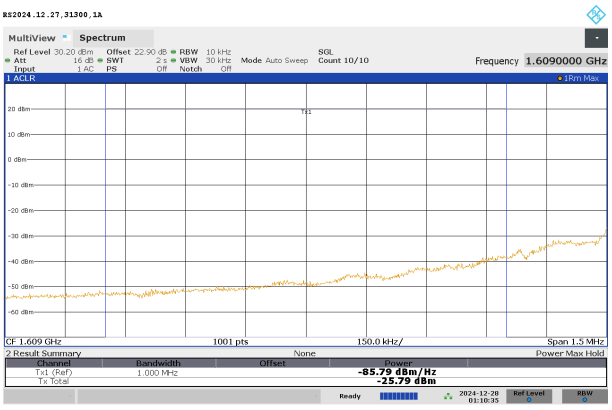
1605MHz -1610MHz (Zoom-in)

Plots below show passing result using integration method:

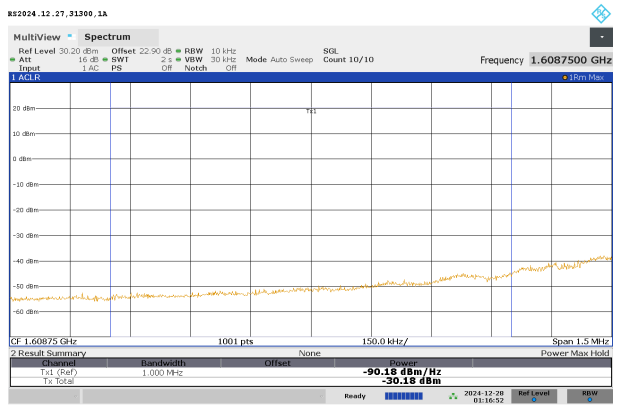


1609.5MHz, 1MHz Integration

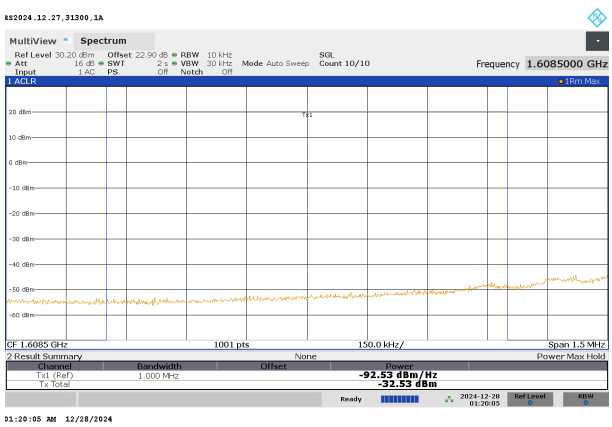
1609.25MHz, 1MHz Integration



1609.0MHz, 1MHz Integration

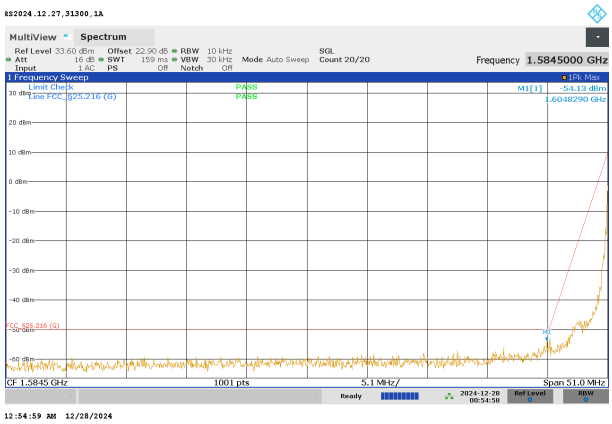


1608.75MHz, 1MHz Integration



1608.50MHz, 1MHz Integration

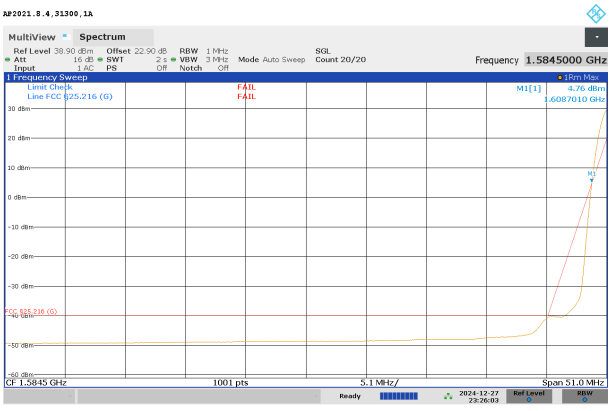
Narrowband Low Channel 1610.17MHz



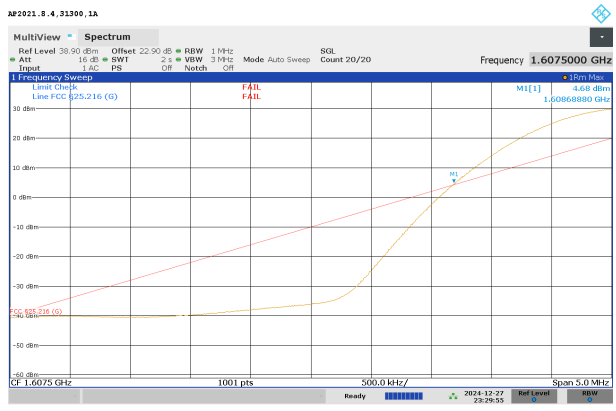
1559MHz – 1610MHz

10.2.3. ANT 4 (HORIZONTAL)

Wideband Low Channel 1610.17MHz

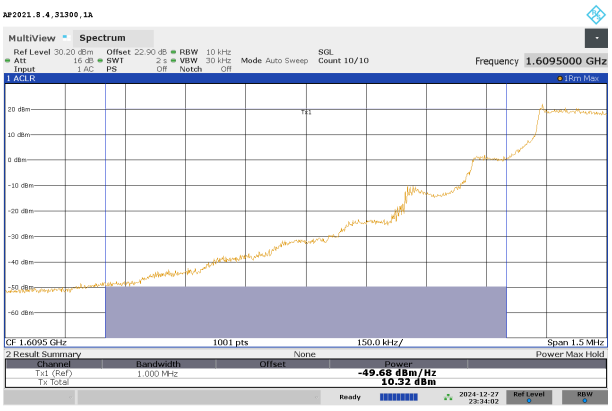


1559MHz -1610MHz



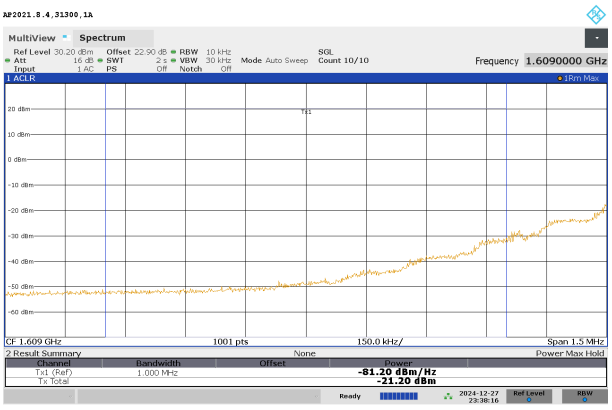
1605MHz -1610MHz (Zoom-in)

Plots below show passing result using integration method:

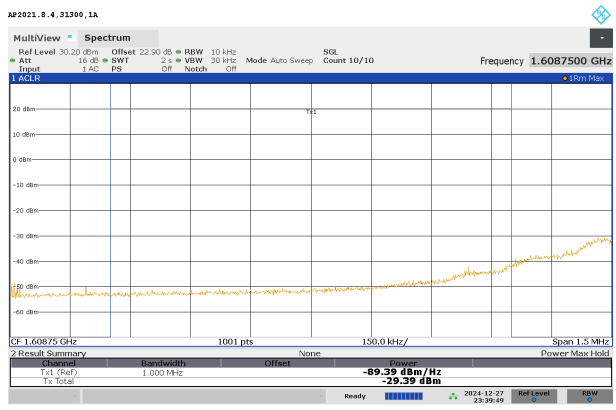


1609.5MHz, 1MHz Integration

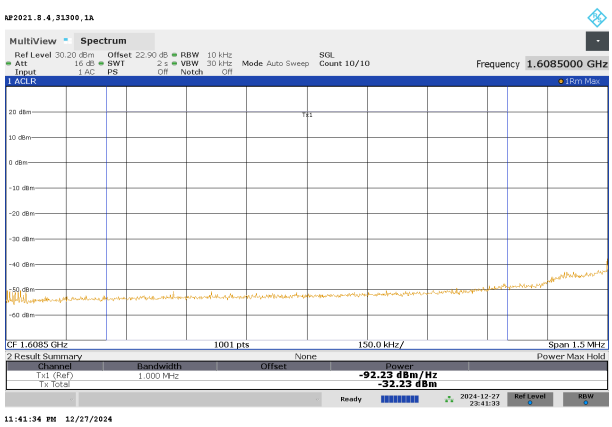
1609.25MHz, 1MHz Integration



1609.0MHz, 1MHz Integration

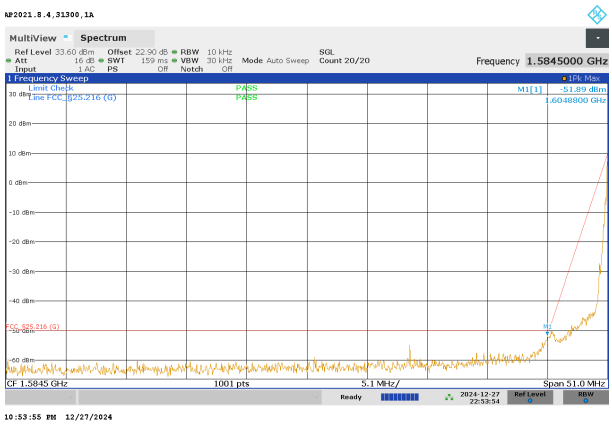


1608.75MHz, 1MHz Integration



1608.50MHz, 1MHz Integration

Narrowband Low Channel 1610.17MHz Vertical:

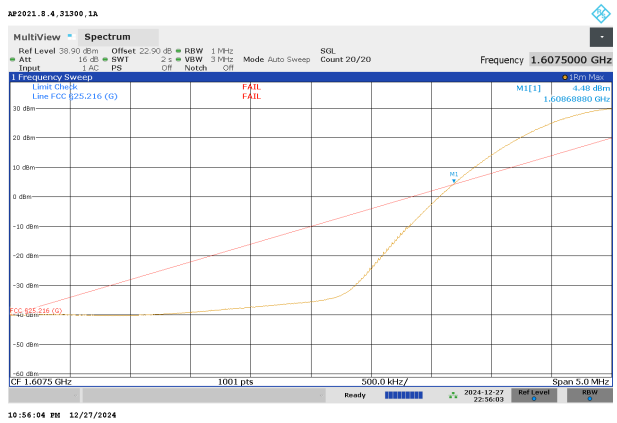


1559MHz – 1610MHz

10.2.4. ANT 4 (VERTICAL)

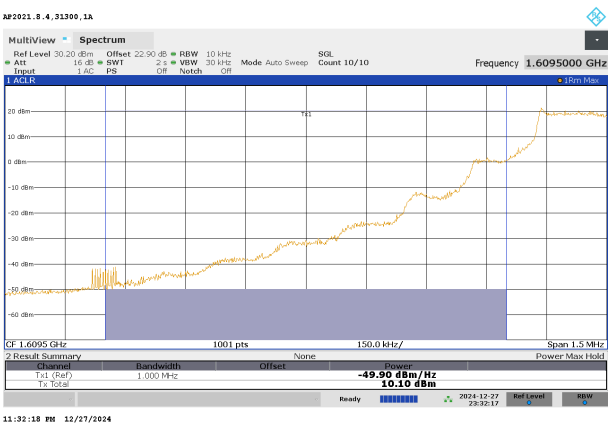
Wideband Low Channel 1610.17MHz

1559MHz -1610MHz

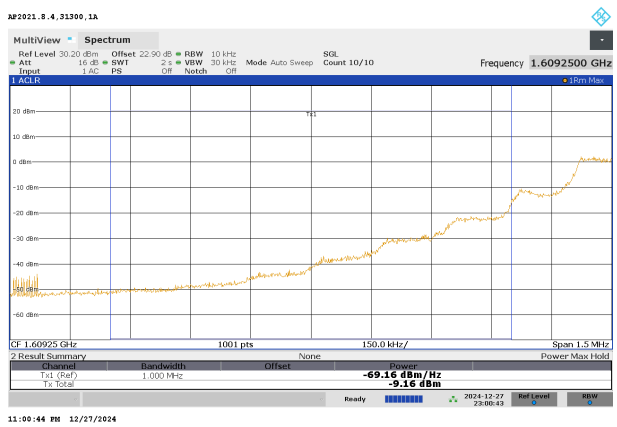


1605MHz -1610MHz (Zoom-in)

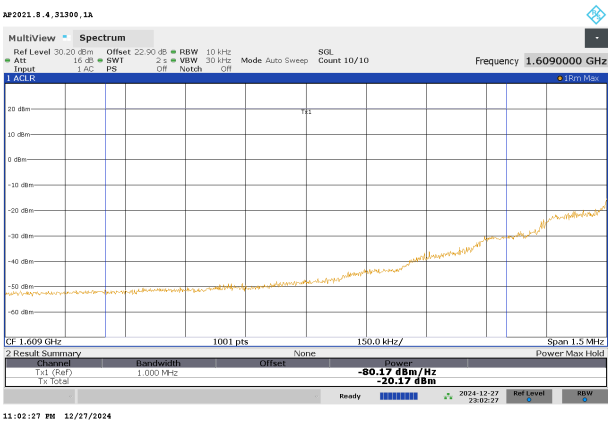
Plots below show passing result using integration method:



1609.5MHz, 1MHz Integration

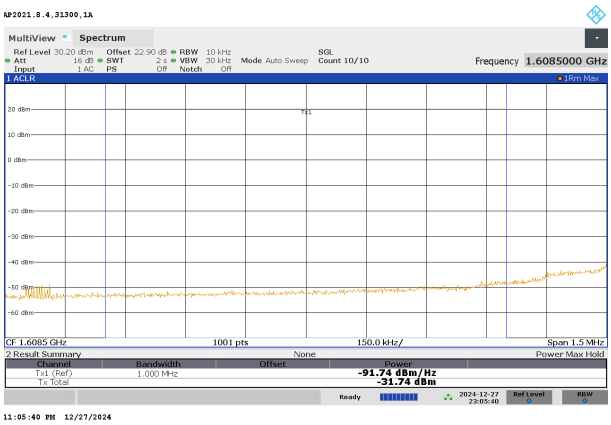


1609.25MHz, 1MHz Integration



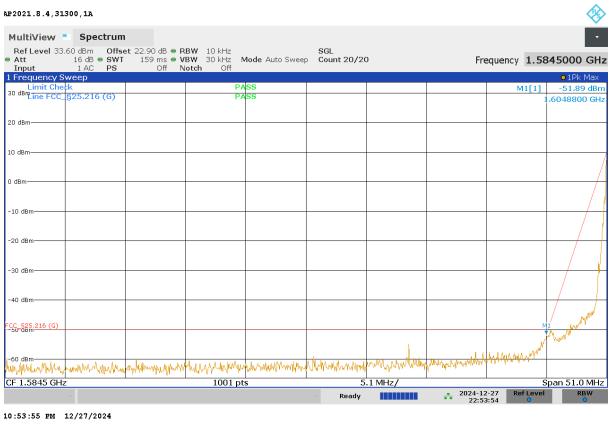
1609.0MHz, 1MHz Integration

1608.75MHz, 1MHz Integration



1608.50MHz, 1MHz Integration

Narrowband Low Channel 1610.17MHz



1559MHz – 1610MHz

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

LIMITS

FCC §25.216

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

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

TEST PROCEDURE

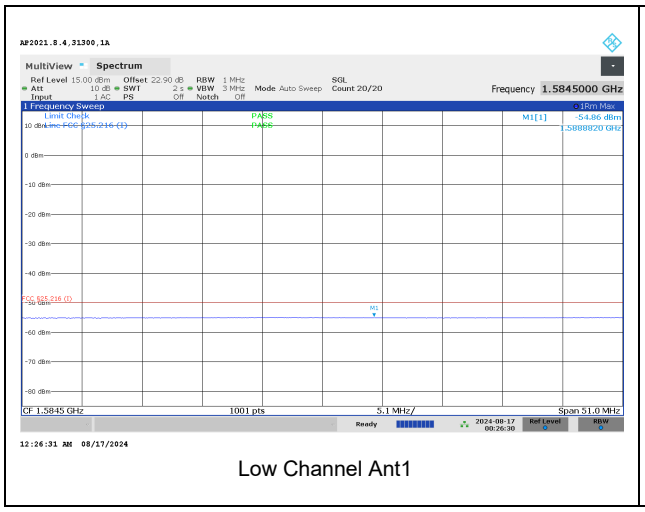
KDB 971168 D01/D02

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

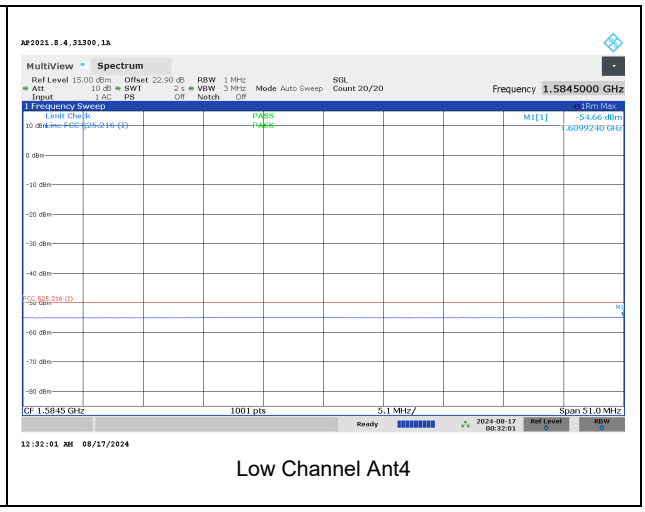
RESULTS

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

Date:	2024-08-17
Test Engineer:	31300
Configuration:	EUT + Charger
Mode:	RX
Chamber #:	01-RDE-A



Low Channel Ant1



Low Channel Ant4

11. SETUP PHOTOS

Please refer to 15175342-EP1V1 for setup photos

END OF REPORT

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