4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

FCC/ISED Test Report

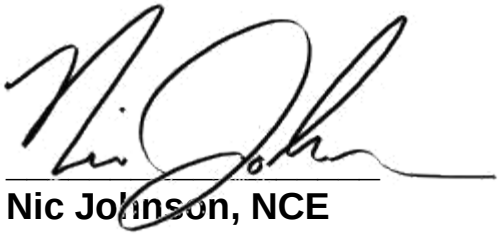
Client: **Ainstein AI Inc.**

EUT: **2029 Becker Drive**
Bioscience & Technology Business Center,
Lawrence, KS 66047 USA

Product: **UAC Radar Altimeter US-D1**

Test Report No.: **R20190604-21-E2A**

Approved By:



Nic Johnson, NCE

EMC Test Engineer,
iNARTE Certified EMC Engineer #EMC-041453-E

Date: **22 January 2021**

Total Pages: **28**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

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Revision Page

Rev. No.	Date	Description
Original	1/8/2021	Approved by – NJohnson Prepared by KVepuri
A	1/22/2021	Updated field strength data table at the top of Page 10. Moved test equipment list to Annex C -NJ

Table of Contents

1 Summary of Test Results

1.1 Emissions Test Results

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15.249

Testing was performance in accordance with the methods published in ANSI C63.10-2013

Table 1 - Emissions Test Results

Emissions Tests	Test Method and Limits	Result
Fundamental, Harmonic, Spurious Emissions, and Band Edges	FCC Part 15.249	Complies

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 - Equipment under Test (EUT)

EUT	UAC Radar Altimeter US-D1
EUT Received	11/19/2020
EUT Tested	11/20/2020 - 1/7/2021
Serial No.	LAG2020080601 (Low channel) LAG2020080624 (Mid channel) LAG2020080619 (High channel) LAG2020080618 (Rx mode/sweep mode)
Operating Band	24 GHz - 24.25 GHz
Device Type	Low-power transmitter

2.2 Laboratory Description

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number: 1953.01
FCC Accredited Test Site Designation No: US1060
Industry Canada Test Site Registration No: 4294A-1
NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 32 ± 4%
Temperature of 22 ± 3° Celsius

2.3 EUT Setup

The EUT was powered by 12 VDC (Marine Battery) unless specified and set to transmit continuously on the default frequency channels.

Channel	Frequency
	GHz
Low	24.028
Mid	24.125
High	24.220

3 Test Results

3.1 Radiated Emissions, Fundamental & Harmonics

Test: FCC Part 15.249

Test Result: Complies

3.1.1 Test Description

The analyzer was set to a resolution bandwidth of 8 MHz and a video bandwidth of 50 MHz for fundamental power measurements. The resolution bandwidth was set to 1 MHz and video bandwidth set to 3 MHz for harmonic measurements. The results were compared against the limits published in FCC Part 15.249.

3.1.2 Test Results

No radiated emissions measurements were found in excess of the limits. Test result data can be seen below.

3.1.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 33 ± 5%
Temperature of 22 ±2^{o} C

3.1.4 Test Setup

For measurements from 24 – 100 GHz, RF absorber was not used. The antennas used was a directional antenna and all measurements were performed line-of-sight. Reflections from the floor or any other surface were not a significant factor in the measurements. Note that a ferrite was wrapped on power leads with one loop to decrease the reflections from the battery. In this case battery is considered an auxiliary equipment. See Section 2.3 for further details.

3.1.5 Test Pictures and/or Figures

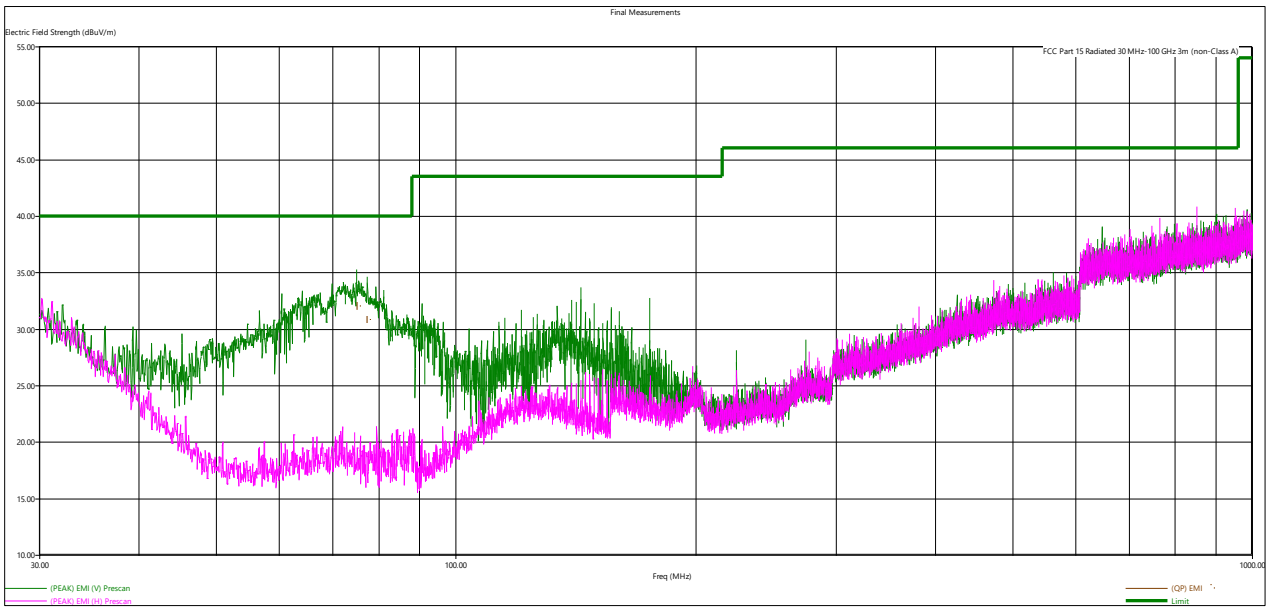

Figure 1 - Radiated Emissions Data Plot, 30M-1GHz, Receive mode

Table 3 - Radiated Emissions Quasi-Peak Data, 30MHz – 24 GHz, Receive mode

Frequency	Level	Limit	Margin	Height	Angle	Polarity
MHz	dBµV/m	dBµV/m	dB	cm	deg	
74.995200	31.99	40.00	8.01	117.00	231.00	V
77.340960	30.77	40.00	9.23	120.00	339.00	V

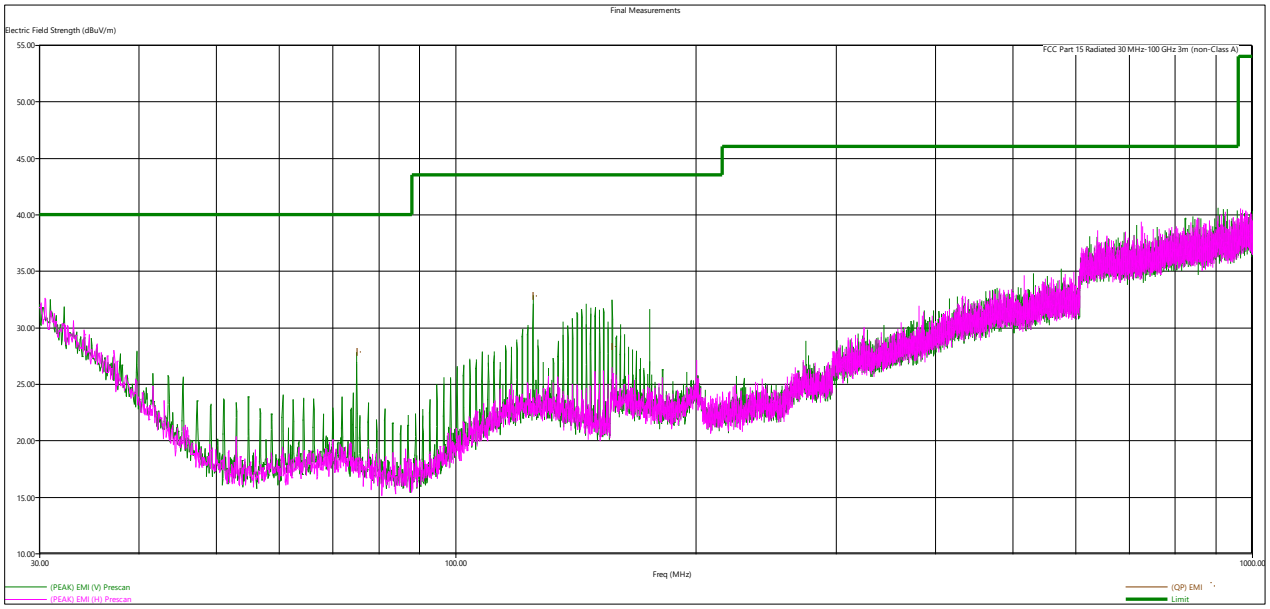

Figure 2 - Radiated Emissions Data Plot, 30M-1GHz, Low Channel

Table 4 - Radiated Emissions Quasi-Peak Data, 30MHz – 24 GHz, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Polarity
MHz	dBµV/m	dBµV/m	dB	cm	deg	
74.990640	27.73	40.00	12.27	121.00	52.00	V
124.958880	32.72	43.52	10.80	105.00	70.00	V
157.089360	28.29	43.52	15.23	105.00	279.00	V

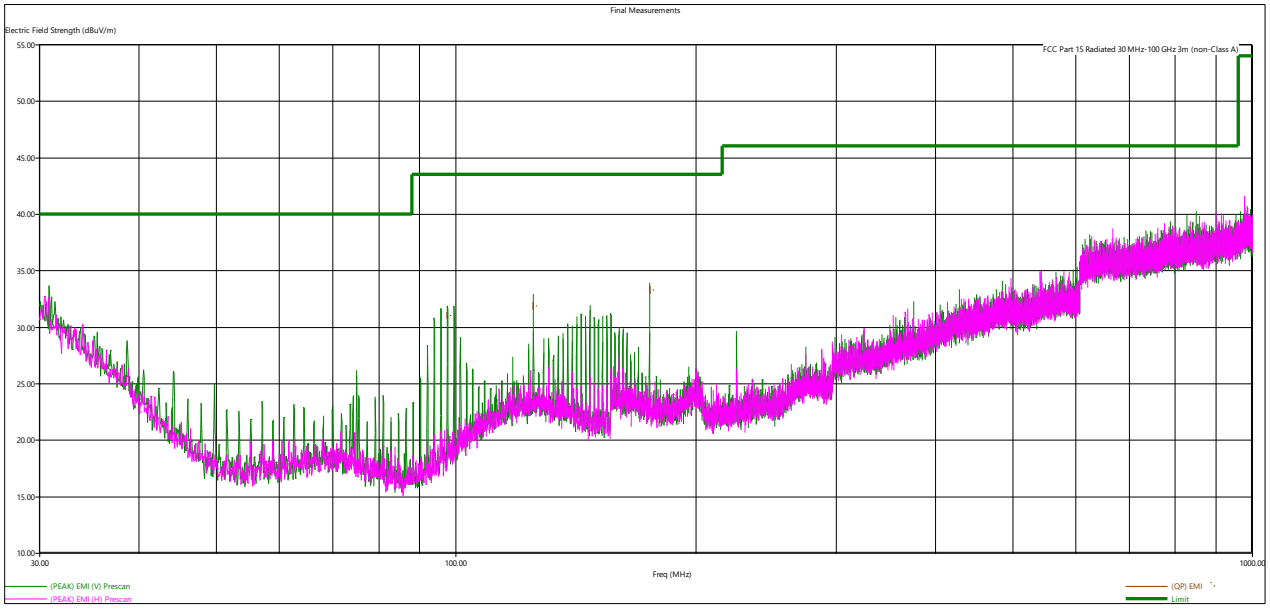

Figure 3 - Radiated Emissions Data Plot, 30M-1GHz, Mid Channel

Table 5 - Radiated Emissions Quasi-Peak Data, 30MHz – 24 GHz, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Polarity
MHz	dBµV/m	dBµV/m	dB	cm	deg	
97.578720	30.96	43.52	12.56	115.00	69.00	V
124.999200	31.84	43.52	11.68	108.00	121.00	V
175.015920	33.29	43.52	10.23	106.00	134.00	V

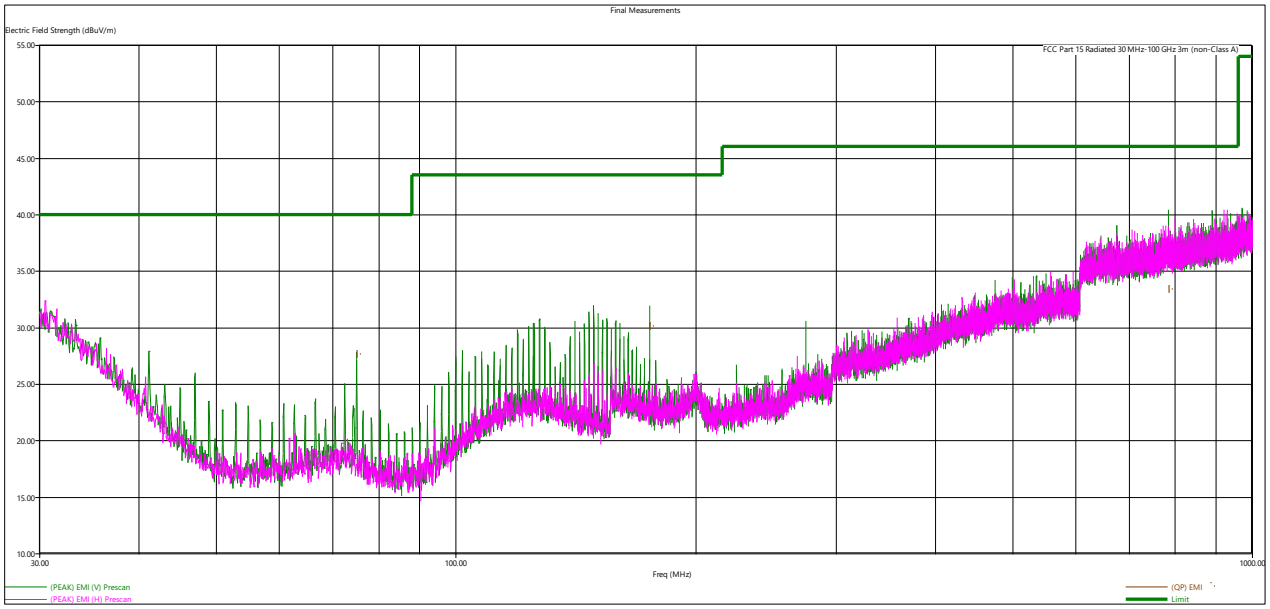

Figure 4 - Radiated Emissions Data Plot, 30M-1GHz, High Channel

Table 6 - Radiated Emissions Quasi-Peak Data, 30MHz – 24 GHz, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Polarity
MHz	dBµV/m	dBµV/m	dB	cm	deg	
75.012960	27.61	40.00	12.39	134.00	360.00	V
174.980880	30.08	43.52	13.44	119.00	315.00	V
784.543680	33.39	46.02	12.63	247.00	313.00	V

Table 7 - Fundamental and Harmonic Emissions Data

Fundamental										
Channel	**Frequency**	**SA reading**	**Test Distance**	**Cable Loss**	**Antenna Factor**	**Average Field Strength level at test distance**	**Corrected level @ 3m**	**Duty cycle correction**	**Average Limit Part 15.249**	**Margin**
	GHz	**dBmV**	**m**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dB**	**dBmv/m**	**dB**
Low	24.028	21.922	1	1.31	45.564	46.096	36.554	22.7	47.96	11.41
Mid	24.124	20.357	1	1.31	45.502	44.469	34.927	22.7	47.96	13.03
High	24.22	21.873	1	1.31	45.502	45.985	36.443	22.7	47.96	11.51

Corrected Level at 3m= SA reading+ Cable Loss + Antenna Factor+20log (Test Distance/3)-Duty cycle correction

Fundamental										
Channel	**Frequency**	**SA reading**	**Test Distance**	**Cable Loss**	**Antenna Factor**	**Peak Field Strength level at test distance**	**Corrected level @ 3m**	**Duty cycle correction**	**Peak Limit Part 15.249**	**Margin**
	GHz	**dBmV**	**m**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dB**	**dBmv/m**	**dB**
Low	24.028	21.922	1	1.31	45.564	68.796	59.254	22.7	67.96	8.71
Mid	24.124	20.357	1	1.31	45.502	67.169	57.169	22.7	67.96	10.79
High	24.22	21.873	1	1.31	45.502	68.685	59.143	22.7	67.96	8.82

Corrected Level at 3m= SA reading+ Cable Loss + Antenna Factor+20log (Test Distance/3)-Duty cycle correction

Harmonics- Peak											
Channel	**Harmonic**	**Frequency**	**SA reading**	**Test Distance**	**Mixer Factor***	**Cable Loss***	**Antenna Factor**	**Field Strength Level**	**Field Strength @ 3m**	**Limit at 3m FCC Part 15.249**	**Margin**
		GHz	**dBmV/m**	**m**	**dB**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dBmV/m**	
Low	2nd	48.158000	-48.818	0.5	21.9	4.2	40.92	18.20	2.63	27.96	25.32
Mid	2nd	48.250000	-49.187	0.5	21.9	4.2	40.93	17.84	2.28	27.96	25.68
High	2nd	48.344000	-49.242	0.5	22.1	4.2	40.95	18.01	2.44	27.96	25.51
Low	3rd	72.237000	-21.517	0.5	0	0	43.44	21.92	6.36	27.96	21.60
Mid	3rd	72.375000	-25.824	0.5	0	0	43.44	17.61	2.05	27.96	25.91
High	3rd	72.516000	-21.369	0.5	0	0	43.47	22.10	6.54	27.96	21.42

Harmonics- Average											
Channel	**Harmonic**	**Frequency**	**SA Reading**	**Test Distance**	**Mixer Factor***	**Cable Loss***	**Antenna Factor**	**Field Strength Level**	**Field Strength @ 3m**	**Limit at 3m FCC Part 15.249**	**Margin**
		GHz	**dBmV/m**	**m**	**dB**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dBmV/m**	
Low	2nd	48.158000	-71.518	0.5	21.9	4.2	40.92	-4.50	-20.07	7.96	28.02
Mid	2nd	48.250000	-71.887	0.5	21.9	4.2	40.93	-4.86	-20.42	7.96	28.38
High	2nd	48.344000	-71.942	0.5	22.1	4.2	40.95	-4.69	-20.26	7.96	28.21
Low	3rd	72.237000	-44.217	0.5	0	0	43.44	-0.78	-16.34	7.96	24.30
Mid	3rd	72.375000	-48.524	0.5	0	0	43.44	-5.09	-20.65	7.96	28.61
High	3rd	72.516000	-44.069	0.5	0	0	43.47	-0.60	-16.16	7.96	24.12

All measurements were made with peak detector with max hold trace unless noted otherwise. Raw average value is obtained by applying the duty cycle correction to the peak values. See following page for limit, duty cycle correction and correction factors.

*This value is 0 if raw value includes these factors or losses.

Duty cycle corrections:

The transmitter 600 µs ON time and 8.2 ms period (see operation description, Section 3)
duty cycle correction = -22.7 dB

Limit calculations:

Fundamental limit: 250 mV/m at 3 meters = 47.96 dBmV/m

Harmonic limit: 2.5 mV/m at 3 meters = 7.96 dBmV/m

Correction Field strength calculations

Corrected PK Measurement = Un-corrected PK field strength (dBmV/m) + correction factors total (dB)

Corrected AVG Measurement = Un-corrected PK field strength (dBmV/m) + correction factors total (dB) – Duty cycle correction (dB)

Plots:

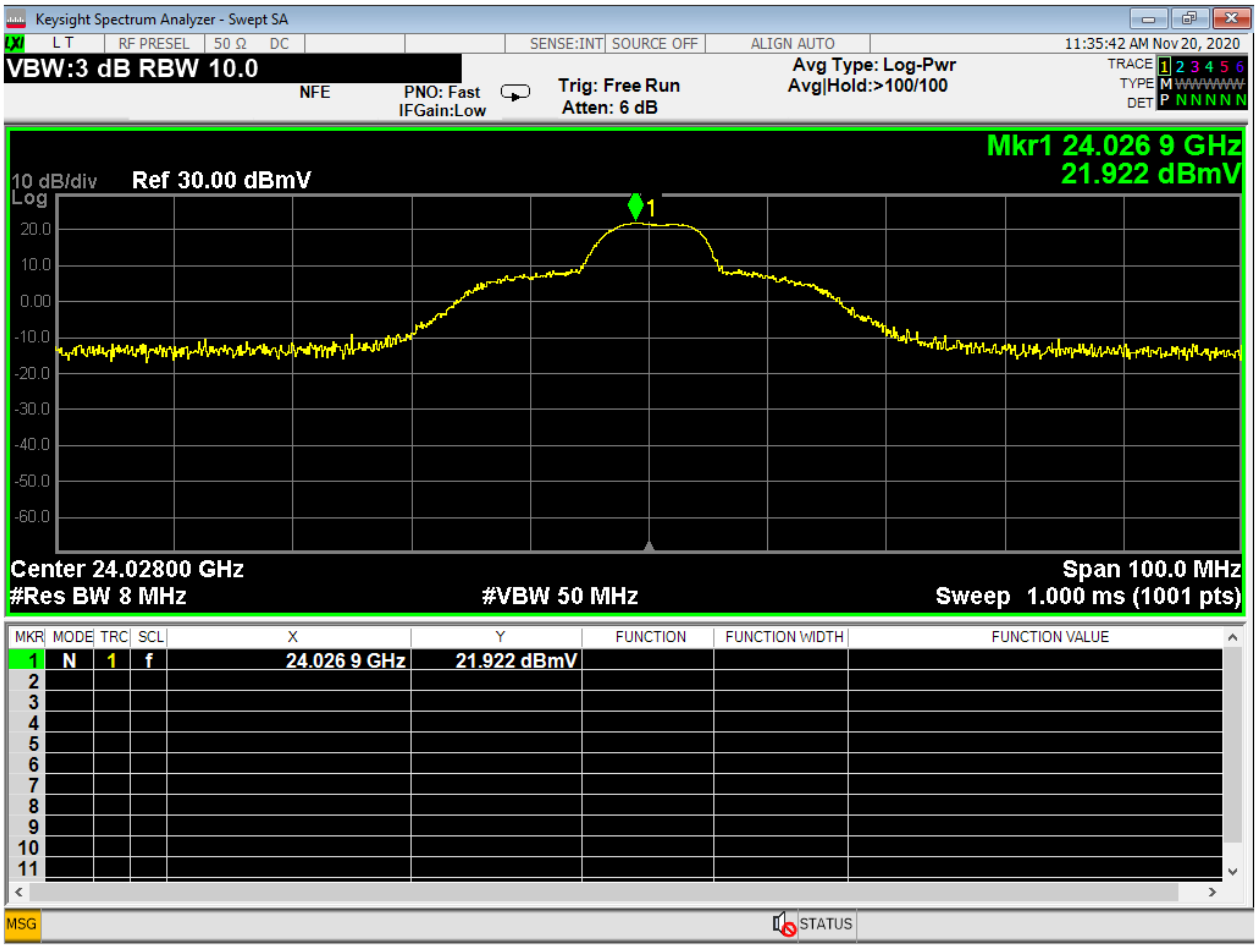

Figure 5 - Analyzer Measurement – Fundamental, Channel Low

Uncorrected measurement as recorded on spectrum analyzer

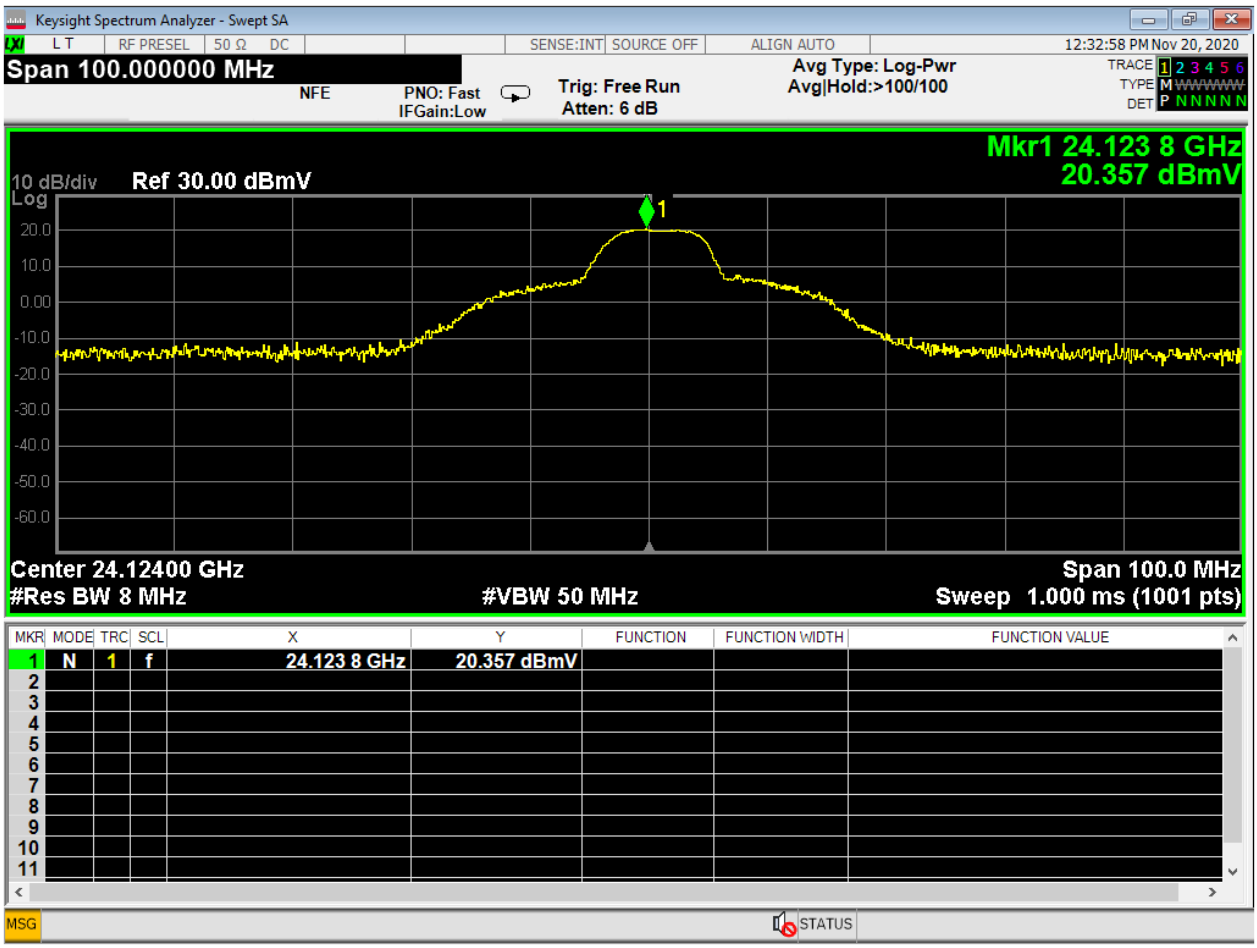

Figure 6 - Analyzer Measurement – Fundamental, Channel Mid

Uncorrected measurement as recorded on spectrum analyzer

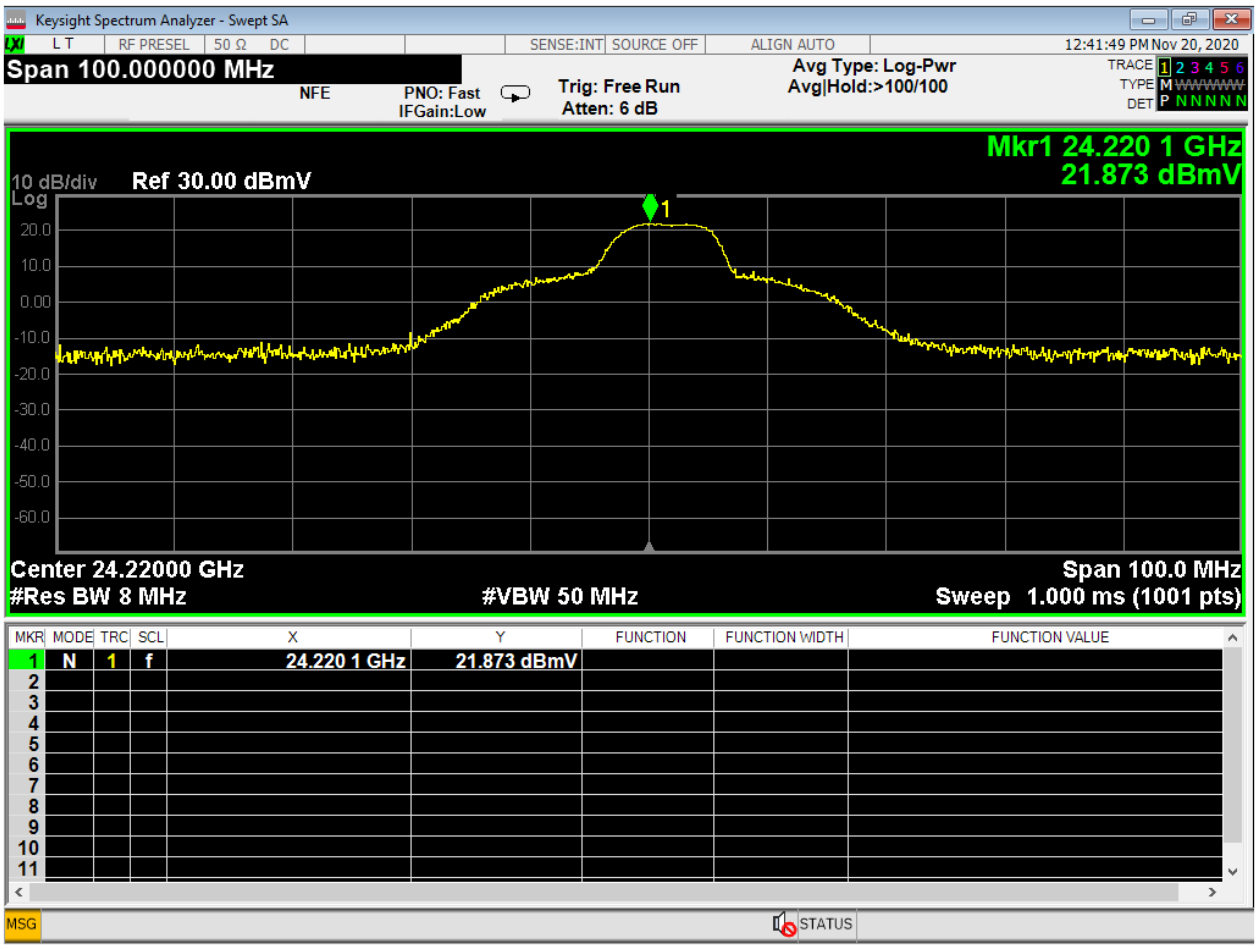

Figure 7 - Analyzer Measurement – Fundamental, Channel High

Uncorrected measurement as recorded on spectrum analyzer

3.2 Band-Edges and Occupied Bandwidth

Test Method: ANSI C63.10-2013, Section(s) 6.10.5, 6.10.6, 6.9.2

3.2.1 Limits of band-Edge measurements:

For emissions outside of the allowed band of operation, the emission level needs to be 50dB under the maximum fundamental field strength or general 15.209 limits. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

The limit from FCC Part 15.209 for all frequencies above 960 MHz is 500 µV/m at 3m.

500 µV/m = 20log (500) = 54 dBµV/m at 3m average

Peak limit = average limit + 20 dB=74 dBµV/m at 3m peak

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

3.2.2 Test procedures:

The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 1 MHz (unrestricted), 1 MHz (restricted). The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

Measurements were performed as radiated measurements in the same manner as Section 3.1 of this report.

The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW. The occupied bandwidth was measured using the spectrum analyzers 99% occupied bandwidth setting.

3.2.3 Deviations from test standard:

No deviation.

3.2.4 Test setup:

Unrestricted band-edge measurements were done at 1m test distance.
Restricted band-edge measurements were done at 2m test distance.

3.2.5 EUT operating conditions:

The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.

Test results:

Unrestricted Band Edges												
Band Edge	**Frequency**	**Fundamental SA Reading**	**Band Edge SA reading**	**Test Distance**	**Duty cycle Correction***	**Cable Loss**	**Antenna Factor**	**Corrected Band Edge FS level**	**Band Edge FS level @ 3m**	**Band Edge FS level @ 3m**	**Limit Part 15.209**	**Margin to 15.209 Limits**
	GHz	**dBmV/m**	**dBmV**	**m**	**dB**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dBµv/m**	**dBµv/m**	**dB**
Peak LBE	24	20.998	-25.774	1	0	1.31	45.564	21.1	11.558	71.558	74	2.442
Average LBE	24	20.573	-36.289	1	22.7	1.31	45.564	-12.115	-21.66	38.343	54	15.657
Peak HBE	24.25	21.222	-23.869	1	0	1.31	45.502	22.943	13.401	73.401	74	0.599
Average HBE	24.25	20.713	-42.161	1	22.7	1.31	45.502	-18.049	-27.59	32.409	54	21.591

Band Edge FS Level @ 3m= SA reading+ Cable Loss + Antenna Factor+20log (Test Distance/3)-Duty cycle correction
* Duty cycle is 0 if it's not applicable

Restricted Band Edges											
Band Edge	**Frequency Range**	**Duty cycle correction***	**SA reading**	**Test Distance**	**Cable Loss**	**Antenna Factor**	**FS level @ test distance**	**FS level @ 3m**	**FS level @ 3m**	**Limit Part 15.209**	**Margin**
	GHz	**dB**	**dBmV**	**m**	**dB**	**dB**	**dBmV/m**	**dBmV/m**	**dBµv/m**	**dBµv/m**	
Peak LBE	23.6-24	0	-34.042	2	1.31	45.564	12.832	9.310	69.310	74	4.690
Average LBE	23.6-24	22.7	-39.271	2	1.31	45.564	7.603	-18.619	41.381	54	12.619
Peak HBE	31.2-31.8	0	-40.119	2	3.035	47.368	10.284	6.762	66.762	74	7.238
Average HBE	31.2-31.8	22.7	-55.482	2	3.035	47.368	-5.079	-31.301	28.699	54	25.301

Band Edge FS Level @ 3m= SA reading+ Cable Loss + Antenna Factor+20log (Test Distance/3)-Duty cycle correction
* Duty cycle is 0 if it's not applicable

Band Edges

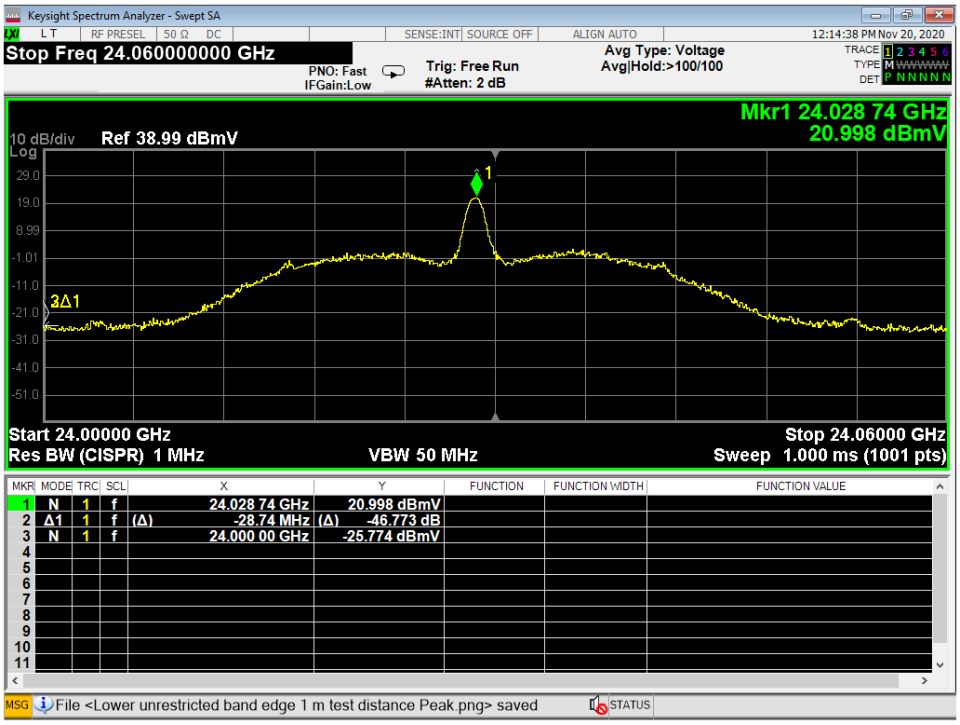

Figure 8 – Lower Band Edge, 24.00 GHz, Peak, Unrestricted
Uncorrected measurement as recorded on spectrum analyzer, 1 m test distance

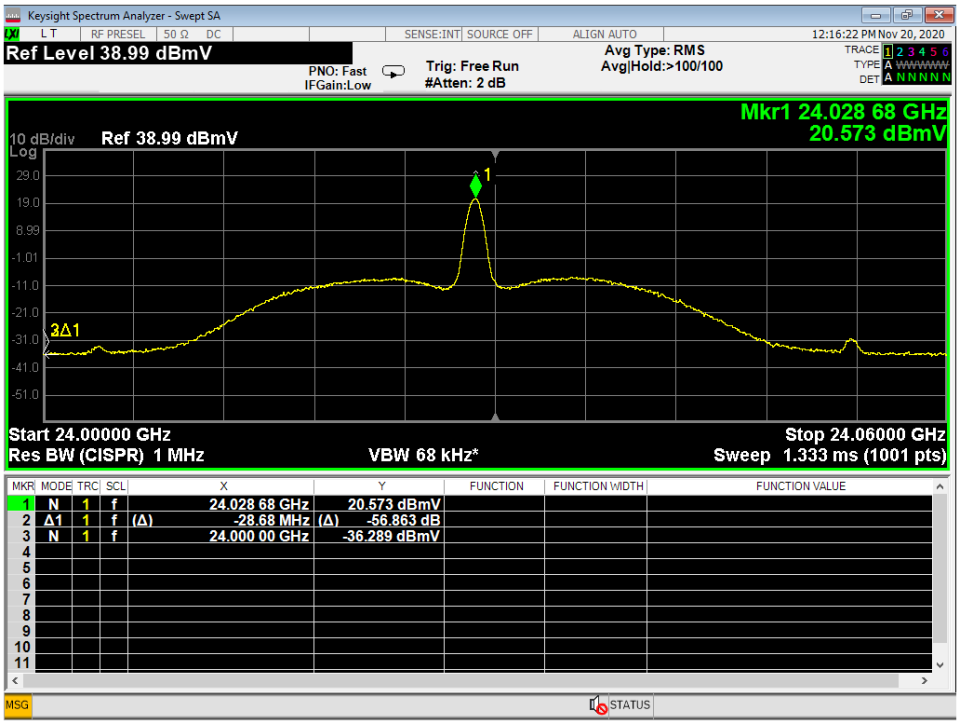

Figure 9 – Lower Band Edge, 24.00 GHz, Average, Unrestricted
Uncorrected measurement as recorded on spectrum analyzer, 1 m test distance

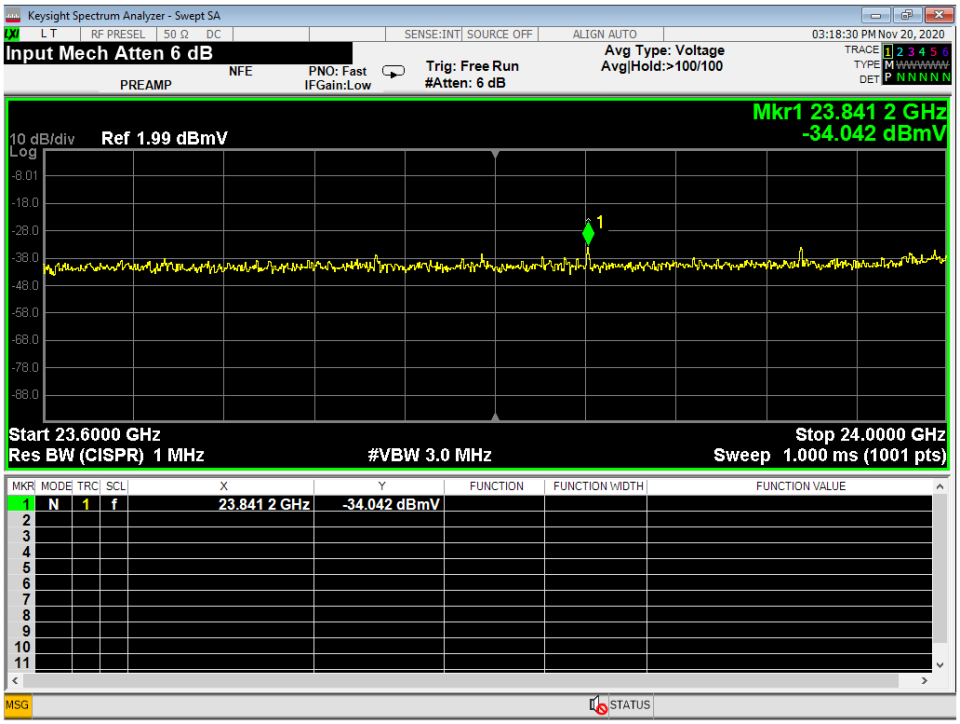

Figure 10 – Lower Band Edge, 24.00 GHz, Peak, Restricted
Uncorrected measurement as recorded on spectrum analyzer, 2 m test distance

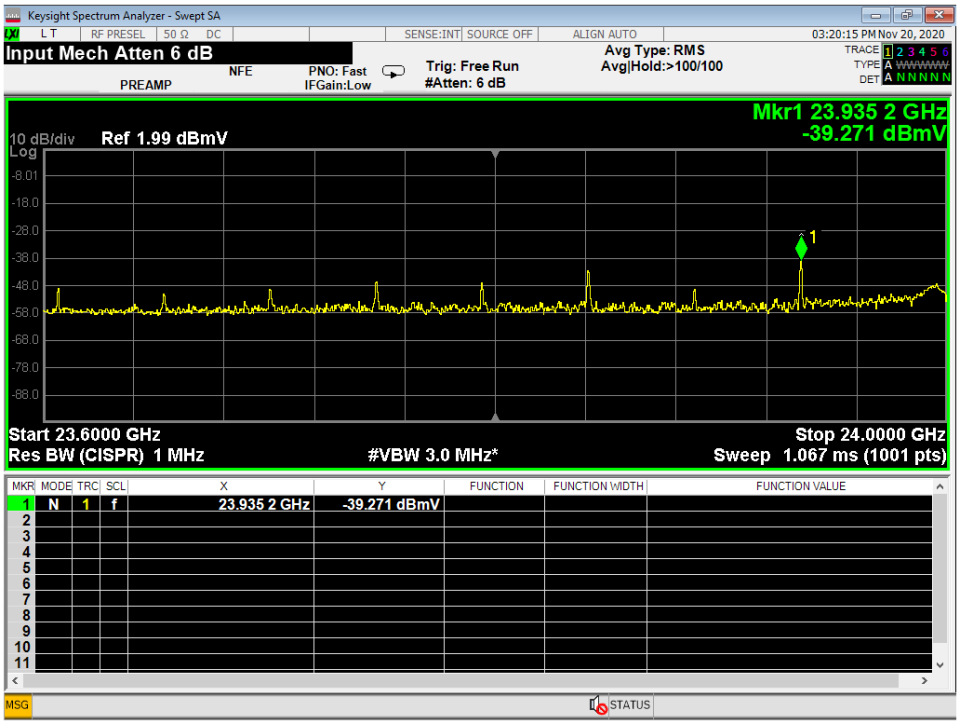

Figure 11 – Lower Band Edge, 24.00 GHz, Average, Restricted
Uncorrected measurement as recorded on spectrum analyzer, 2 m test distance

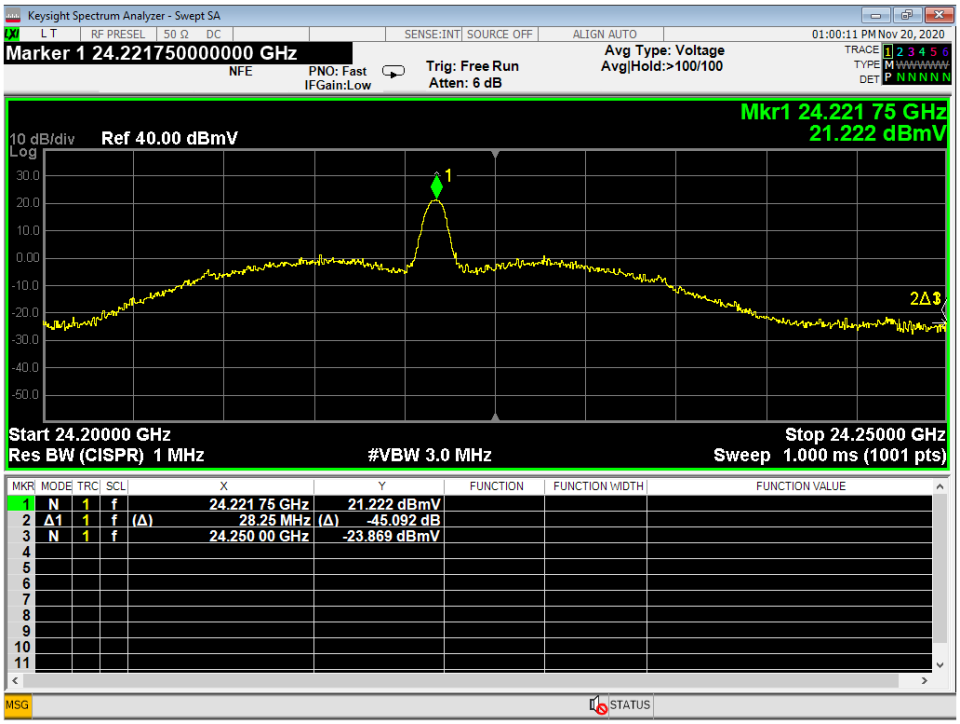

Figure 12 – Higher Band Edge, 24.25 GHz, Peak, Unrestricted
Uncorrected measurement as recorded on spectrum analyzer, 1 m test distance

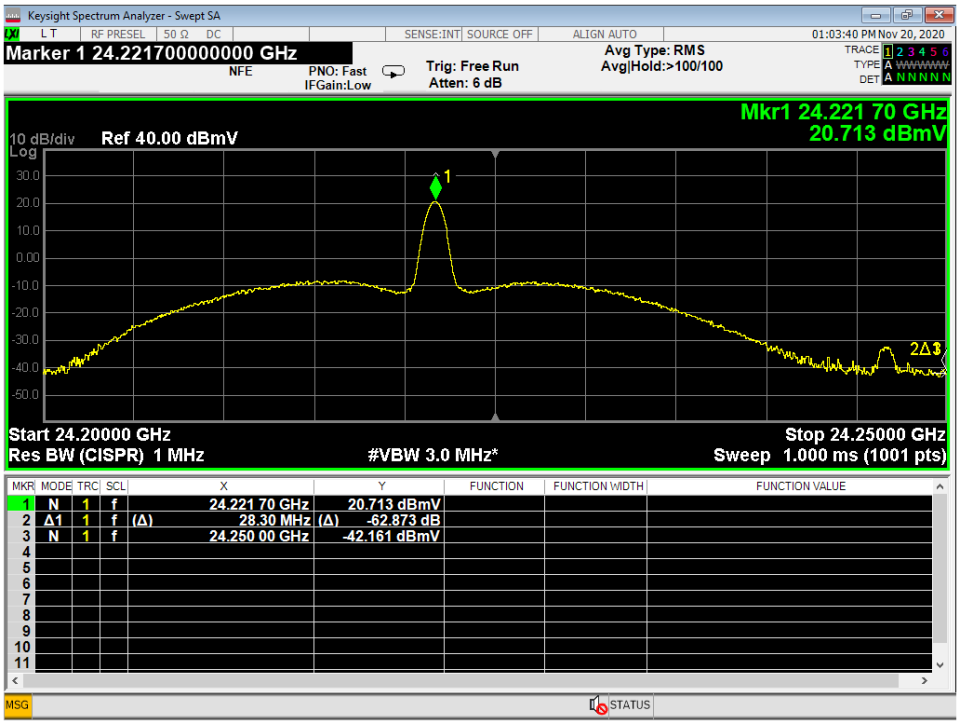

Figure 13 – Higher Band Edge, 24.25 GHz, Average, Unrestricted
Uncorrected measurement as recorded on spectrum analyzer, 1 m test distance

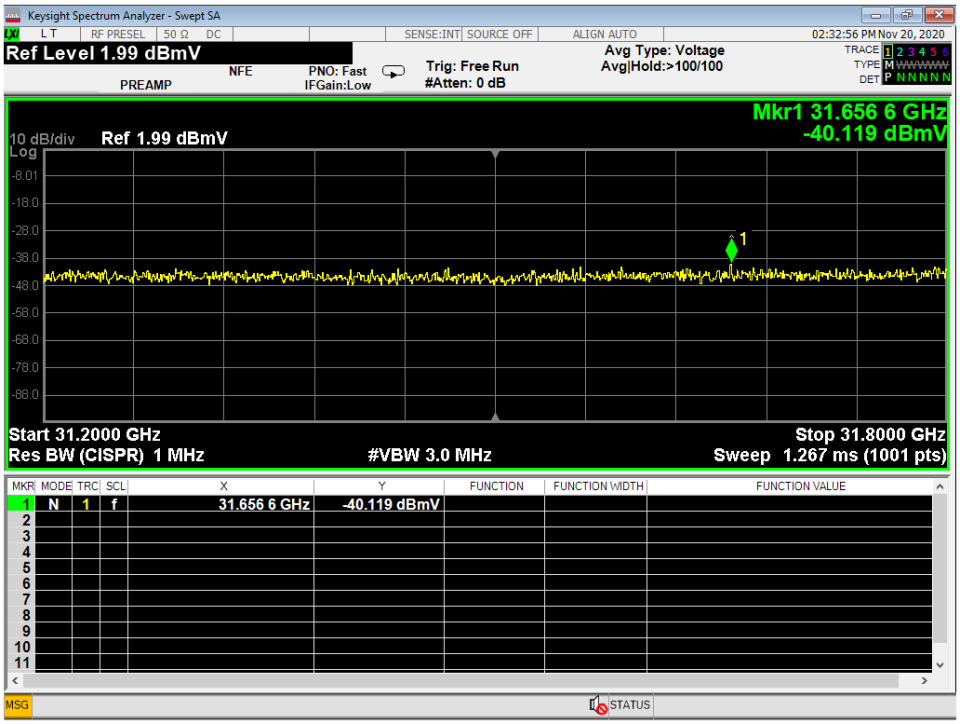

Figure 14 – Higher Band Edge, 24.25 GHz, Peak, Restricted
Uncorrected measurement as recorded on spectrum analyzer, 2 m test distance

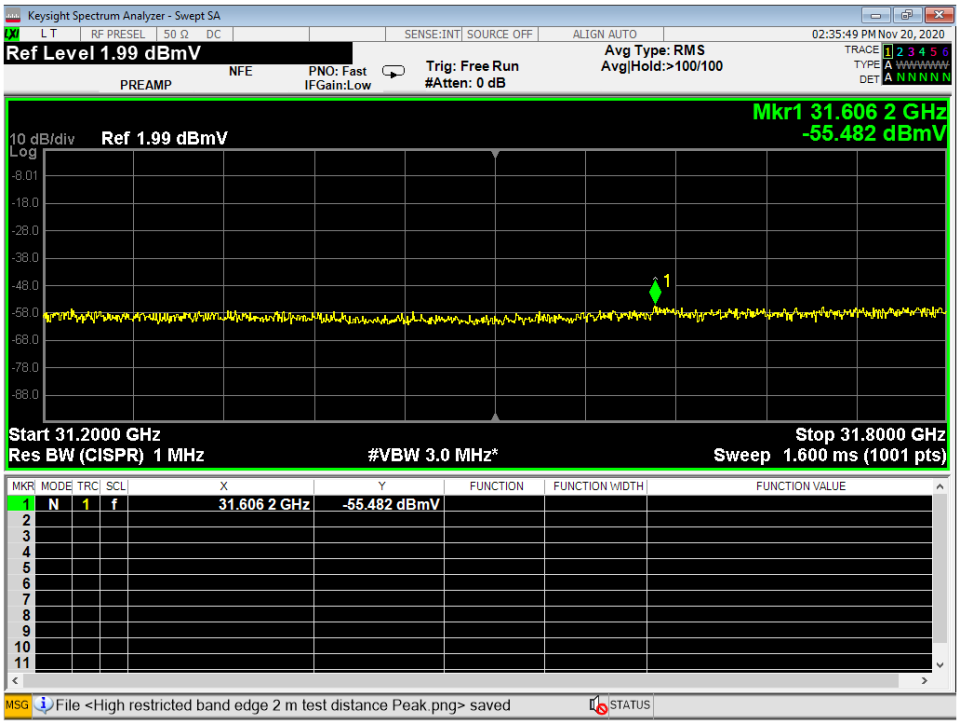

Figure 15 – Higher Band Edge, 24.25 GHz, Average, Restricted
Uncorrected measurement as recorded on spectrum analyzer, 2 m test distance

Occupied Bandwidth

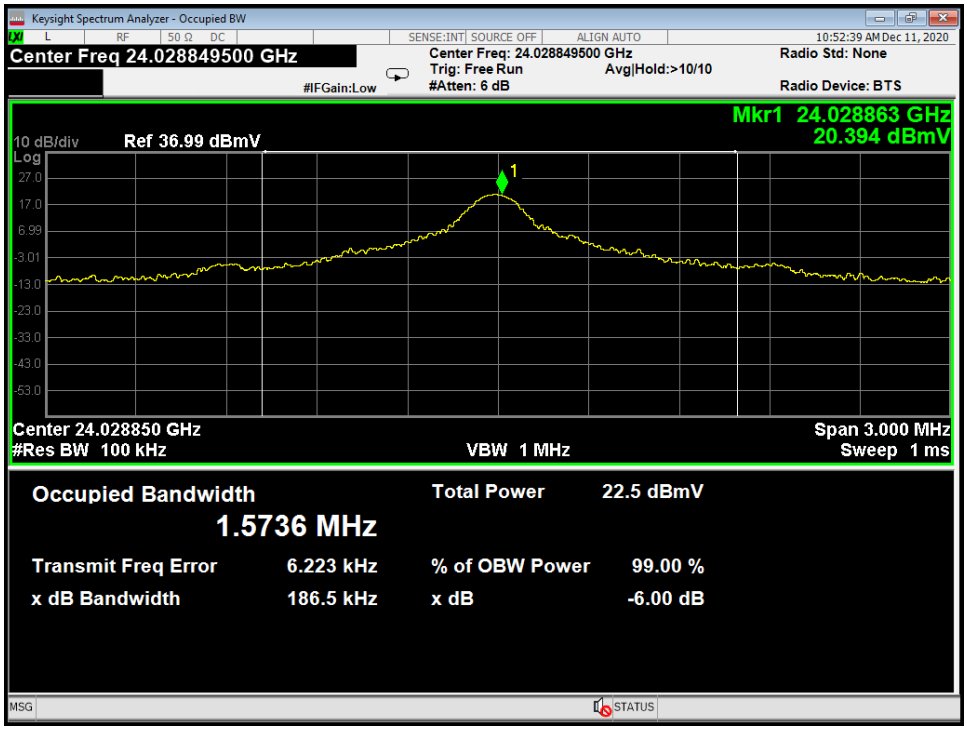

Figure 16 – Occupied Bandwidth, Low channel

The occupied bandwidth of the Low channel was found to be the largest.

Annex A - Sample Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

Power (watts) = 10^[Power (dBm)/10] x 1000

Field Strength (dBµV/m) = Field Strength (dBm) = 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = (FS x d^2)/30 = FS [(d^2)/30] = FS [0.3}

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = -95.23

10log(10^) is the conversion from micro to milli

Annex B – Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	150kHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

CISPR 16-4-2:2011 was used to calculate the above values.

Annex C – Test Equipment

3.2.1 Test equipment

Serial No.	Manufacturer	Model	Description	Last Cal.	Calibration due
A091418	SunAR RF Motion	JB1	Bicon Antenna	6 Mar 2020	6 Mar 2022
6415	EMCO-ETS	3115	DRG Horn	16 Mar 2020	16 Mar 2022
2576	ETS	3116	Horn Antenna	9 Mar 2020	9 Mar 2022
MY59050109	Keysight	N9038A	MXE Signal Analyzer	23 April 2019	23 April 2021
MY56400083	Keysight	N9038A	MXE Signal Analyzer	5 May 2020	5 May 2022
MY51391050	Keysight	M1970V-002	Mixer	13 Apr 2019	13 Apr 2021
32/2016	Pasternack	PE9881-24	Horn Antenna	CNR***	CNR***
3903A03916	Agilent	11970Q	Mixer	CNR**	CNR**
Ncee1	Pasternack	SH122-23	Horn Antenna	CNR***	CNR***
181004-2	OML	DPL313B	Diplexer	CNR**	CNR**

**Calibration Not Required, internal verification ***Calibration not required, standard gain horn antenna.

All mixers and pre-amplifiers were calibrated with associated cables.

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Trilithic High Pass Filter*	6HC330	23042	April 14, 2020	April 14, 2022
MiniCircuits High Pass Filter*	VHF-1320+	15542	April 14, 2020	April 14, 2022
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 14, 2020	April 14, 2022
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	April 14, 2020	April 14, 2022
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3874	April 14, 2020	April 14, 2022
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	April 14, 2020	April 14, 2022
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	April 14, 2020	April 14, 2022
N connector bulkhead (control room)*	PE9128	NCEEBH2	April 14, 2020	April 14, 2022

*Internal Characterization ** Extended Cal

REPORT END