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

FDS Test Report

Client:	**Ainstein AI, Inc.**
Address:	**1421 Research Park Drive Suite 2A, Lawrence KS, United states, 66049**
Product:	**AGR-300**
Test Report No.:	**R20220517-22-E2A**

Approved By:

Fox Lane,
EMC Test Engineer

Date:	**6 March 2024**
Total Pages:	**36**

A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	5 February 2024	Issued by FLane Prepared by FLane
A	6 March 2024	Added HVIN Added sample calculation Updated test setup drawing – FL

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
(2) ISED RSS-210, Issue 10
(3) ISED RSS-Gen, Issue 5

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 and Harmonics	47 CFR 15.249(a) 47 CFR 15.249(e) RSS-210, Issue 10, Annex B10	Complies
Radiated Emissions	47 CFR 15.249(a) RSS-210, Issue 10, Annex B10 RSS-Gen, Issue 5	Complies
Band edges	47 CFR 15.249(d) RSS-210, Issue 10, Annex B10 RSS-Gen, Issue 5	Complies

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 - Equipment under Test (EUT)

EUT	AGR-300
IC	26683-AGR300V3
FCC ID	2ATMB-AGR300V3
HVIN	1.0.0.0
CNH Part #	92046111
EUT Received	18 December 2023
EUT Tested	18 December 2023 – 19 December 2023
Serial No.	0300ZG3234140011
Operating Band	24.0GHz – 24.25GHz
Device Type	Field Disturbance Sensor
Power Supply / Voltage	12VDC Marine Battery

2.2 Description of test modes

Radar Channels	
Channel	**Frequency**
Low	24.007 GHz
Mid	24.125 MHz
High	24.247 MHz

2.3 EUT Setup

The EUT was powered by a 12 VDC marine battery for entirety of testing.

3 Laboratory and General Test Description

3.1 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 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 Test personnel

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing and Report
2	Blake Winter	Test Engineer	Testing
3	Ethan Schmidt	Test Technician	Testing

Notes:
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 Test equipment

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 17, 2023	July 17, 2025
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	July 17, 2023	July 17, 2025
SunAR RF Motion	JB1	A091418	July 27, 2023	July 26, 2024
ETS-Lindgren Red Horn Antenna	3115	218576	July 31, 2023	July 30, 2024
EMCO Horn Antenna	3116	2576	July 31, 2023	July 30, 2024
Agilent Preamp*	87405A	3950M00669	June 5, 2023	June 5, 2025
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	June 5, 2023	June 5, 2025
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	June 5, 2023	June 5, 2025
Keysight, External Harmonic Mixer, 75-110G	M1971W	MY56390145	April 12, 2019	April 11, 2024
Sage Standard Gain Horn Antenna, 75-110G	SAZ-2410-10-S1	16434-01	CNR***	CNR***
Cable to M1971W, 75-110G	SLU18-SMNM-01.00M	121108	April 12, 2019	April 11, 2024
Cable to M1970V-002, 75-110G	SLU18-SMNM-01.00M	121099	April 13, 2019	April 12, 2024
Keysight, External Harmonic Mixer, 50-80G	M1970V-002	MY51391050	April 13, 2019	April 12, 2024
Pasternack Standard Gain Horn Antenna, 50-80G	PE9881-24	32/2016	CNR***	CNR***
Agilient External Harmonic Mixer, 33-50G	11970Q	3903A03916	CNR***	CNR***
Pasternack Standard Gain Horn Antenna, 33-50G	SH122-23	SH122-23	CNR***	CNR***
OML Diplexer	DPL313B	181004-2	CNR***	CNR***
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2024
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2025
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	June 5, 2023	June 5, 2025
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	June 5, 2023	June 5, 2025
RF Cable (control room bulkhead to test receiver)	FSCM 64639	01F1206	June 5, 2023	June 5, 2025
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	June 5, 2023	June 5, 2025
N connector bulkhead (control room)	PE9128	NCEEBH2	June 5, 2023	June 5, 2025
TDK Emissions Lab Software	V11.25	700307	NA	NA

*Internal Characterization

Notes:
All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

3.4 General Test Procedure and Setup for Radio Measuremnts

Measurement type presented in this report (Please see the checked box below):

Conducted ☐

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Figure 1 – Conducted Measurement Test Setup

Radiated ☒

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

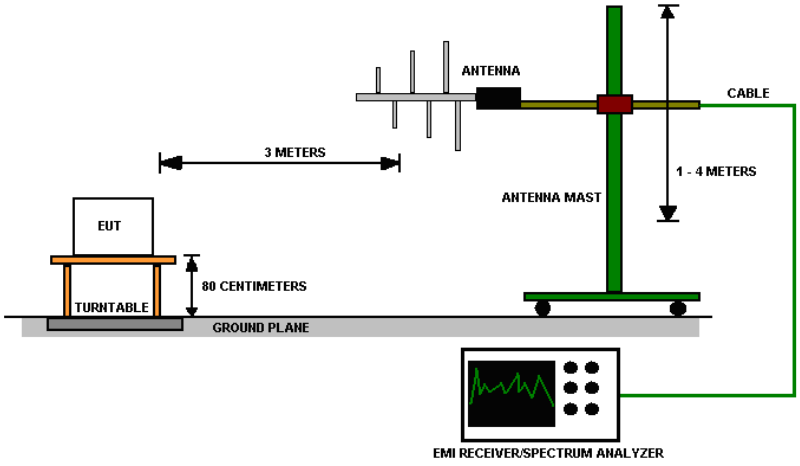


Figure 2 - Radiated Emissions Test Setup

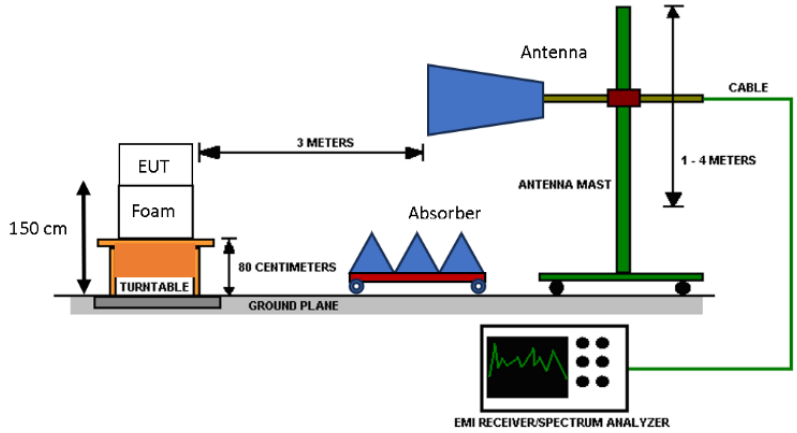


Figure 3 - Radiated Emissions Test Setup, 1GHz-18GHz

4 Test Results

4.1 Fundamental and Harmonic Emissions

Standard:	FCC Part 15.249, RSS-210, Issue 10
Test Result:	Complies

4.1.1 Test Description

Measurements distances can be seen in the below tables.

4.1.2 Test Results

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

4.1.3 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° C

4.1.4 Test Setup

See Section 2.3 for further details.

4.1.5 Test Pictures and/or Figures

Table 3 - Fundamental Data

Fundamental, FCC 15.249										
Ch	**Frequency**	**SA Reading (Peak) (SAR)**	**Antenna Factor (AF)**	**Cable loss (CL)**	**DCCF**	**FS Level (Peak) (FSL)**	**Test Distance (TD)**	**FS level @ 3m (FSL 3)**	**avg Limit (Part 15.249)**	**Margin**
	GHz	**dBmV**	**dB**	**dB**	**dB**	**dBmV/m**	**m**	**dBmV/m**	**dBmv/m**	**dB**
Low	24.007000	19.98	45.564	2.260	-27.4	**40.404**	0.5	**24.84097**	47.9588	23.118
Mid	24.125000	19.475	45.502	2.260	-27.4	**39.837**	0.5	**24.27397**	47.9588	23.685
High	24.247000	19.813	45.454	2.260	-27.4	**40.127**	0.5	**24.56397**	47.9588	23.395
FSL=SAR+AF+CL+DCCF; FSL 3=FSL+20*log(TD/3); Margin=Limit-FSL 3										

Table 4 - Harmonic Emissions Data, Peak

Harmonics - Peak Limit, FCC 15.249											
Ch	Harmonic	Frequency	SA reading (Peak Detector) (SAR)	Test Distance (TD)	Cable loss (CL)	Mixer Factor (MF)	Antenna Factor (AF)	Field Strength Level (FSL)	FS extrapolated to 3m (FSL 3)	Avg Limit (at 3m FCC Part 15.249)	Margin
		GHz	dBmV/m	m	dB	dB	dB	dBmV/m	dBmV/m	dBmV/m	
Low	2nd	48.014	-24.424	0.5	1.3	21.9	40.92	40.19	24.63	27.9588	3.33
Mid	2nd	48.250	-26.755	0.5	1.3	22	40.93	37.98	22.42	27.9588	5.54
High	2nd	48.494	-26.959	0.5	1.3	22.1	40.95	37.89	22.33	27.9588	5.63
Low	3rd	72.021	-11.513	0.5	0	0	43.42	32.41	16.84	27.9588	11.12
Mid	3rd	72.375	-11.215	0.5	0	0	43.46	32.75	17.18	27.9588	10.78
High	3rd	72.741	-13.484	0.5	0	0	43.49	30.50	14.94	27.9588	13.02
Low	4th	96.028	-15.821	0.25	0	0	45.94	30.37	8.78	27.9588	19.18
Mid	4th	96.500	-14.631	0.25	0	0	45.95	31.57	9.99	27.9588	17.97
High	4th	96.988	-14.339	0.25	0	0	45.97	31.88	10.30	27.9588	17.66
FSL=SAR+MF+AF+CL; FSL3=FSL+20*log(TD/3); Margin=Limit-FSL3; CL and MF=0 if it's accounted for in the plot.											

Table 5 - Harmonic Emissions Data, Average

Harmonics - Avg Limit FCC 15.249												
Ch	Harm.	Freq.	SA reading (Peak Detector) (SAR)	Test Distance (TD)	Cable loss (CL)	Mixer Factor (MF)	Antenna Factor (AF)	DCCF	Field Strength Level (FSL)	FS extrapolated to 3m (FSL 3)	Avg Limit (at 3m FCC Part 15.249)	Margin
		GHz	dBmV/m	m	dB	dB	dB	dB	dBmV/m	dBmV/m	dBmV/m	
Low	2nd	48.014	-24.424	0.5	1.3	21.9	40.89	-27.4	12.27	-3.30	7.9588	11.25
Mid	2nd	48.250	-26.755	0.5	1.3	22	40.93	-27.4	10.08	-5.48	7.9588	13.44
High	2nd	48.494	-26.959	0.5	1.3	22.1	40.98	-27.4	10.02	-5.54	7.9588	13.50
Low	3rd	72.021	-11.513	0.5	0	0	43.42	-27.4	4.51	-11.06	7.9588	19.02
Mid	3rd	72.375	-11.215	0.5	0	0	43.46	-27.4	4.85	-10.72	7.9588	18.68
High	3rd	72.741	-13.484	0.5	0	0	43.49	-27.4	2.60	-12.96	7.9588	20.92
Low	4th	96.028	-15.821	0.25	0	0	45.91	-27.4	2.69	-18.89	7.9588	26.85
Mid	4th	96.500	-14.631	0.25	0	0	45.95	-27.4	3.92	-17.66	7.9588	25.62
High	4th	96.988	-14.339	0.25	0	0	46.00	-27.4	4.26	-17.32	7.9588	25.28
FSL=SAR+MF+AF+CL+DCCF; FSL3=FSL+20*log(TD/3); Margin=Limit-FSL3; CL and MF=0 if it's accounted for in the plot.												

Remarks relating to non-standard measurement distances:
Per FCC Part 15.31 (f) the distance is defined as:
To the extent practicable, the device under test shall be measured at the distance specified in the appropriate rule section. The distance specified corresponds to the horizontal distance between the measurement antenna and the closest point of the equipment under test, support equipment or interconnecting cables as determined by the boundary defined by an imaginary straight-line periphery describing a simple geometric configuration enclosing the system containing the equipment under test. The equipment under test, support equipment and any interconnecting cables shall be included within this boundary.

Per FCC Part 15.31(f)(1)
(1) At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. Measurements shall not be performed at a distance greater than 30 meters unless it can be further demonstrated that measurements at 30 meters or less are impractical. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

The measurements presented for 2nd, 3rd, and 4th harmonics in this report meet both criteria for allowing near-field measurements.

1. it can be shown that near field measurements are appropriate due to the characteristics of the device - (better signal to noise ratio when measuring an extremely narrow beam width.)

2. it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment.

Since the 20 dB/decade extrapolation is explicitly specified in the CFR, this takes precedence over the addition of the linear distance attenuation factor specified in C63.10, Section 9.1.

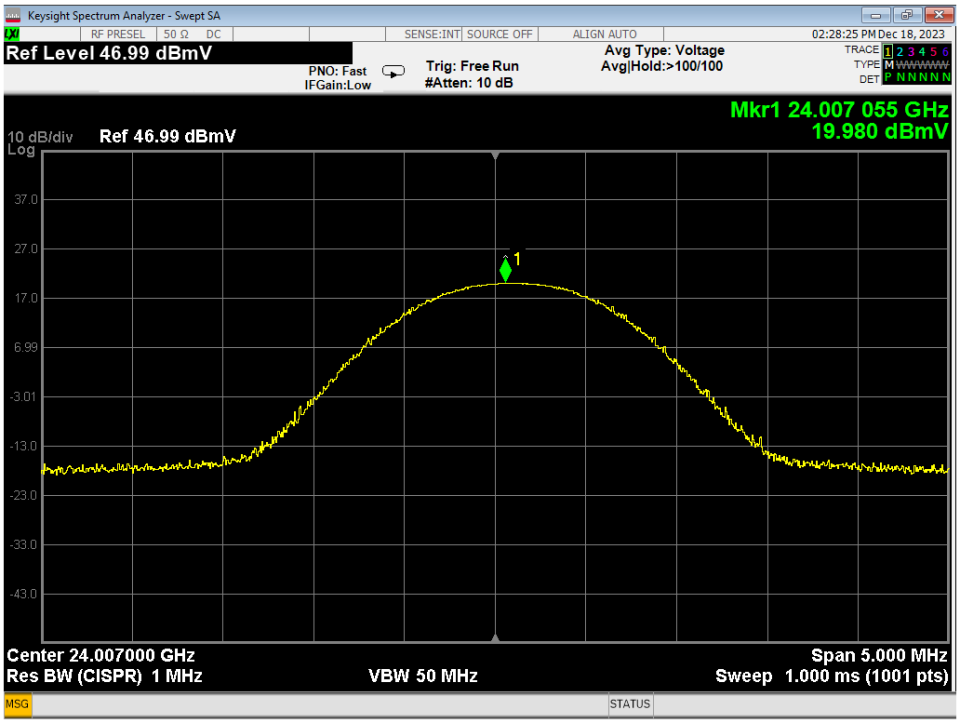


Figure 4 - Analyzer Measurement – Fundamental, Low Channel
Uncorrected measurement as recorded on spectrum analyzer.

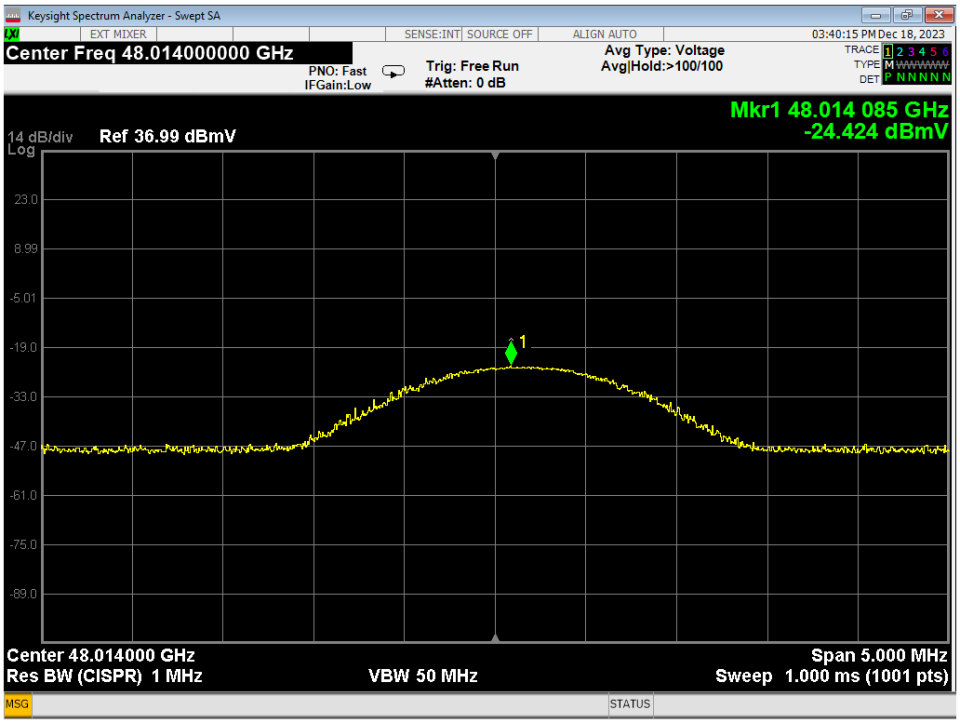


Figure 5 - Analyzer Measurement – 2nd Harmonic, Low Channel
Uncorrected measurement as recorded on spectrum analyzer.

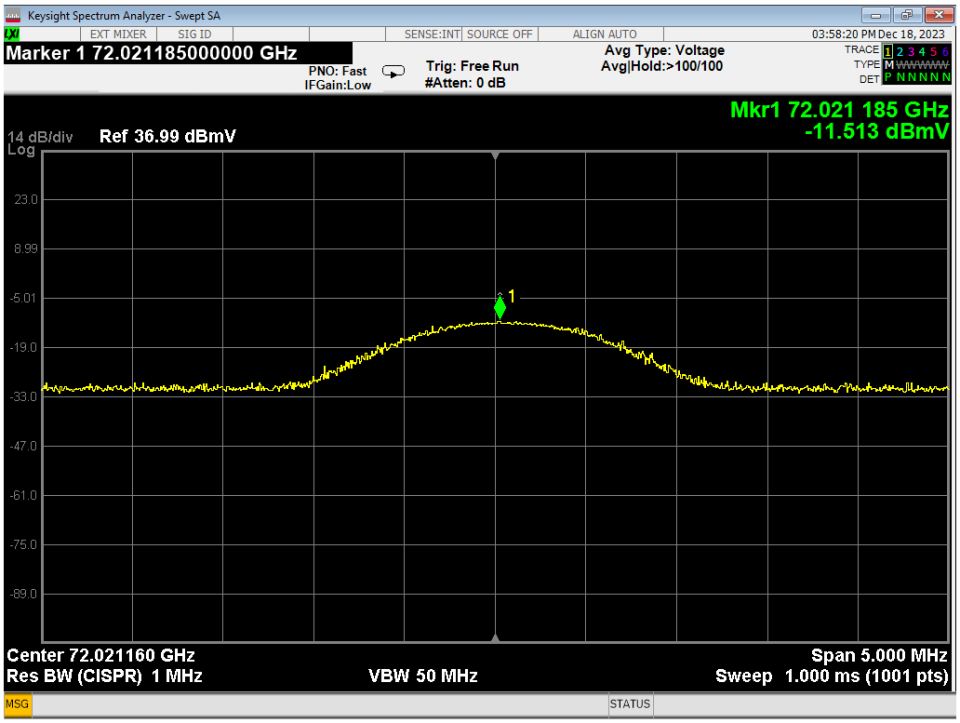


Figure 6 - Analyzer Measurement – 3rd Harmonic, Low Channel
Uncorrected measurement as recorded on spectrum analyzer.

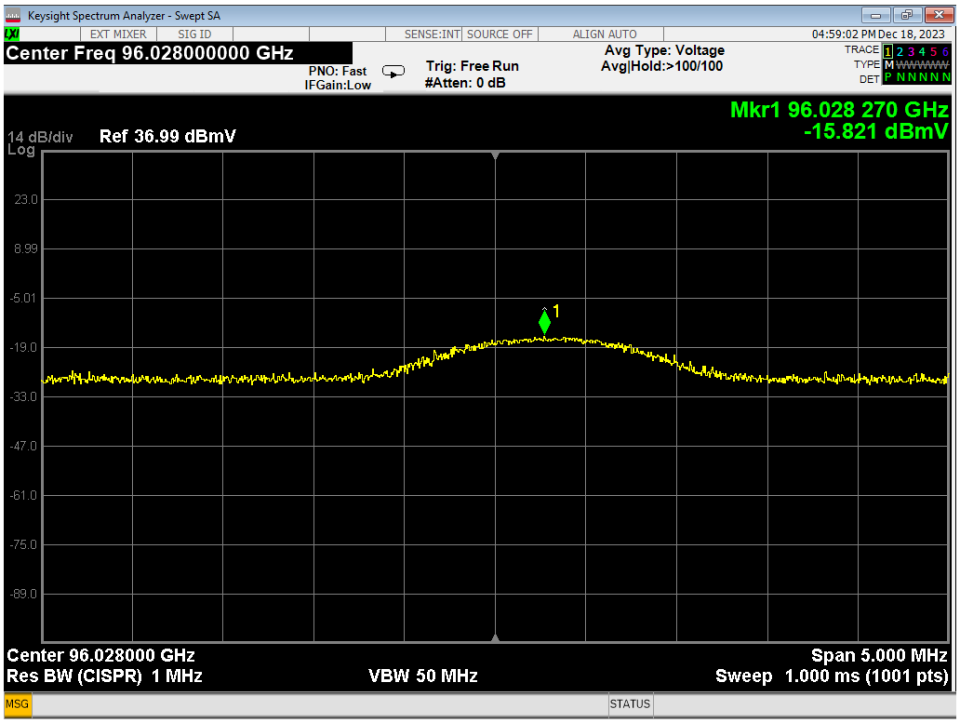


Figure 7 - Analyzer Measurement – 4th Harmonic, Low Channel
Uncorrected measurement as recorded on spectrum analyzer.

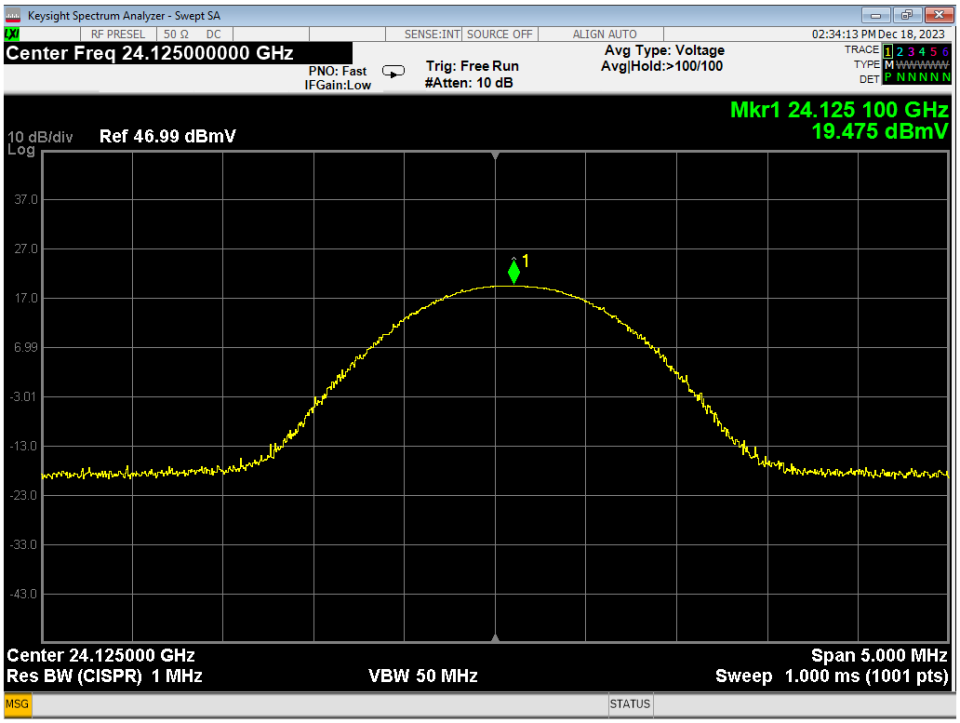


Figure 8 - Analyzer Measurement – Fundamental, Mid Channel
Uncorrected measurement as recorded on spectrum analyzer.

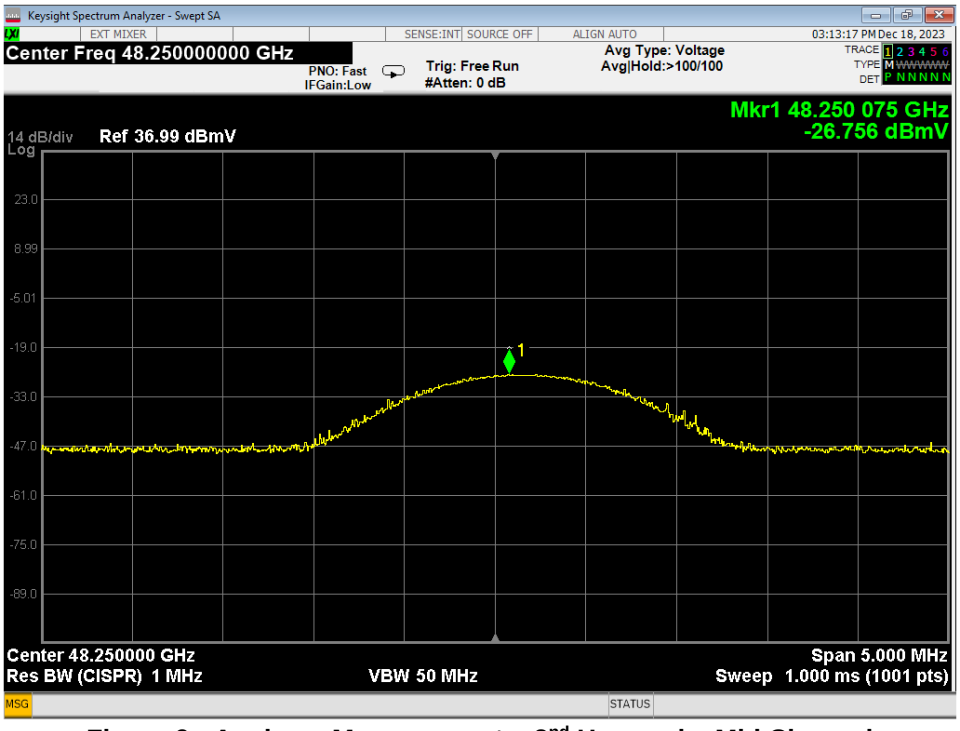


Figure 9 - Analyzer Measurement – 2nd Harmonic, Mid Channel
Uncorrected measurement as recorded on spectrum analyzer.

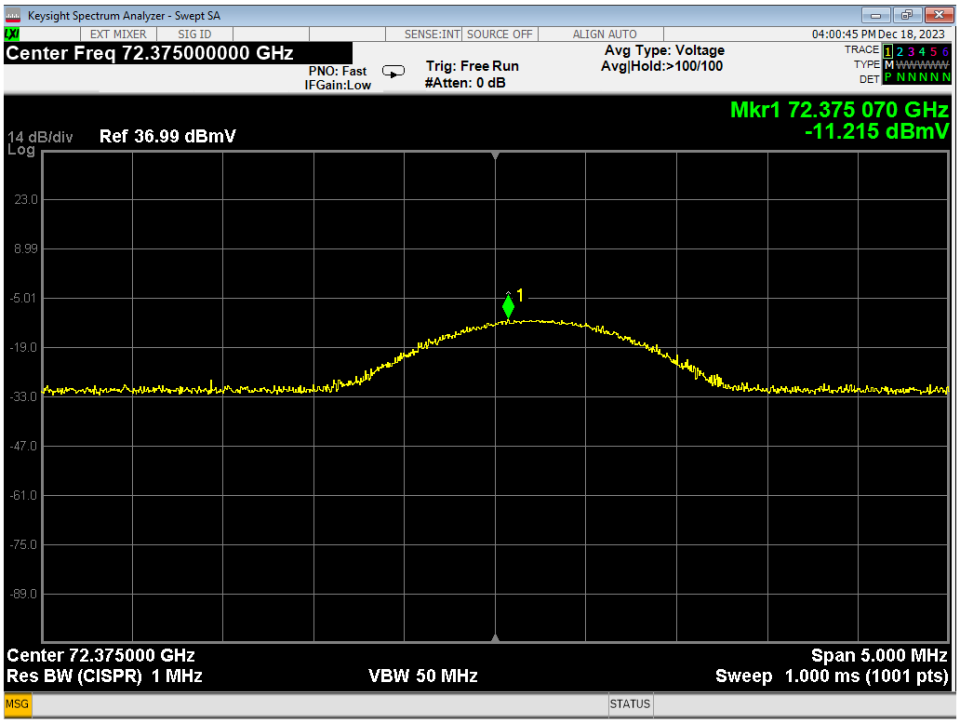


Figure 10 - Analyzer Measurement – 3rd Harmonic, Mid Channel
Uncorrected measurement as recorded on spectrum analyzer.

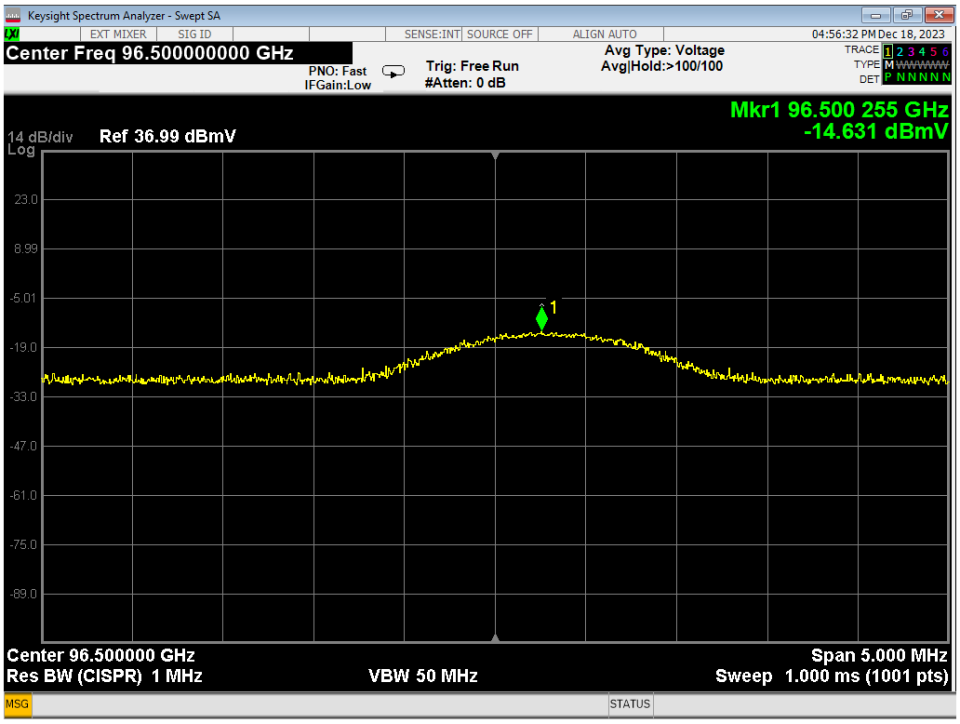


Figure 11 - Analyzer Measurement – 4th Harmonic, Mid Channel
Uncorrected measurement as recorded on spectrum analyzer.

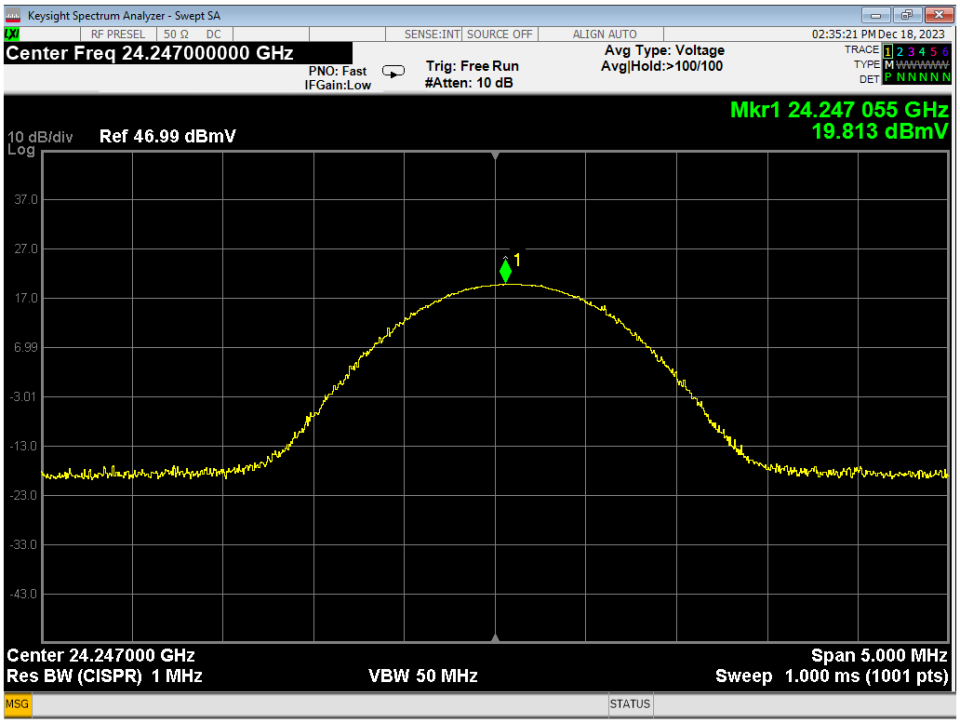


Figure 12 - Analyzer Measurement – Fundamental, High Channel
Uncorrected measurement as recorded on spectrum analyzer.

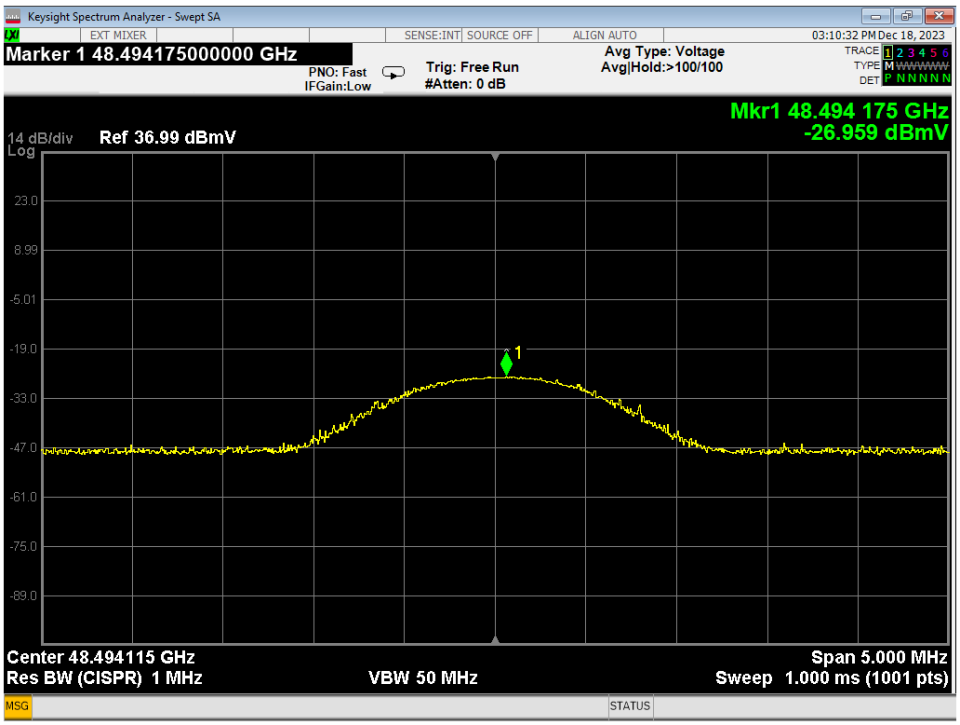


Figure 13 - Analyzer Measurement – 2nd Harmonic, High Channel
Uncorrected measurement as recorded on spectrum analyzer.

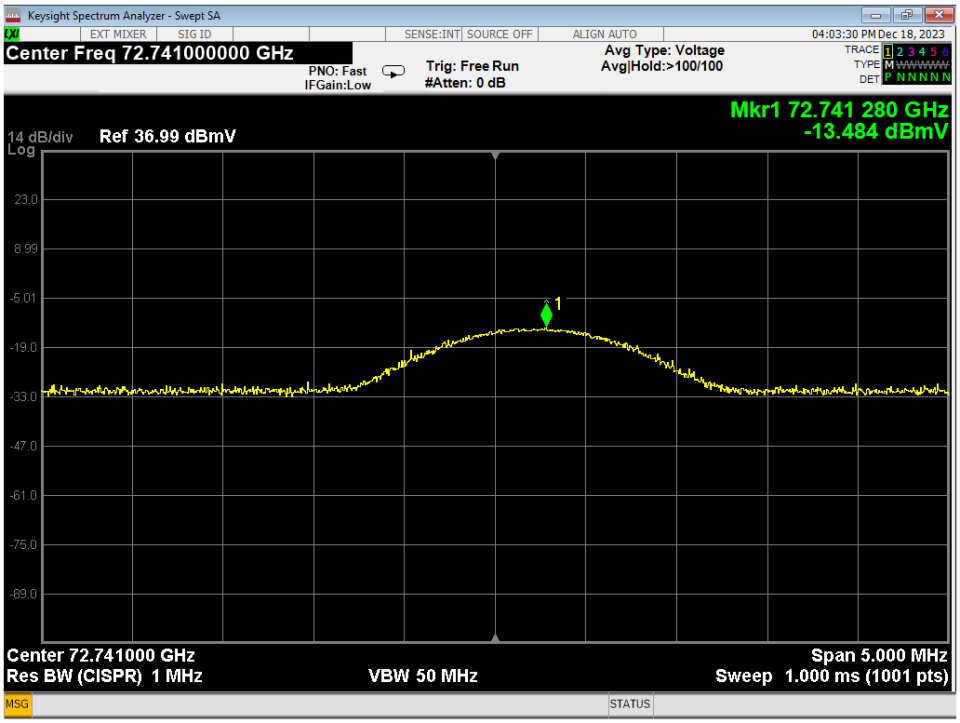


Figure 14 - Analyzer Measurement – 3rd Harmonic, High Channel
Uncorrected measurement as recorded on spectrum analyzer.

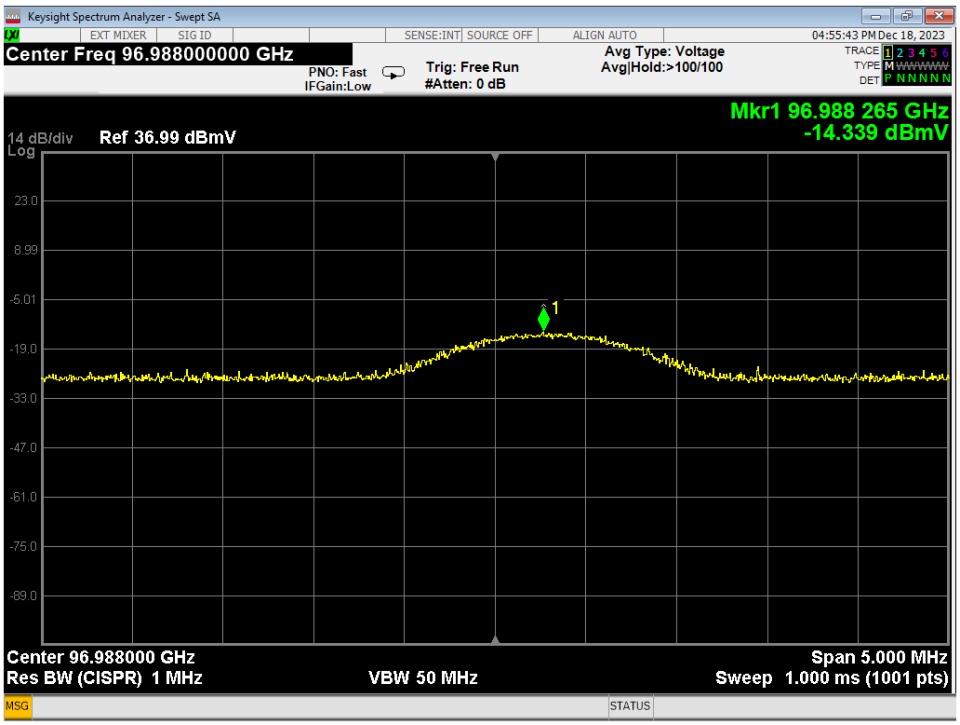


Figure 15 - Analyzer Measurement – 4th Harmonic, High Channel
Uncorrected measurement as recorded on spectrum analyzer.

4.2 Band edges

Test:	Band Edges
Test Method:	ANSI C63.10-2013, Section(s) 6.10.5, 6.10.6
Test Result:	Complies

4.2.1 Limits of bandedge measurements:

Test Description:
For emissions outside of the allowed band of operation, the emission level needs to be 50dB under the maximum fundamental field strength. 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.

Restricted Bands:

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			

4.2.2 Test procedures:

The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 1MHz. 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.

4.2.3 Deviations from test standard:

No deviation.

4.2.4 Test setup:

See Band edge tables for test distances.

4.2.5 EUT operating conditions:

The EUT was set to transmit continuously on the lowest, middle and the highest frequency channel.

4.2.6 Results

Table 6 – Peak Restricted Band Edge

Peak Restricted Band Edge												
Ch	**Band Edge**	**Band Frequency**	**Peak SA reading (SAR)**	**Antenna Factor (AF)**	**DCCF**	**Cable loss (CL)**	**Test Distance**	**FS level @ Test Distance**	**FS level @ 3m (FS 3 dBmV)**	**FS level @ 3m (FS 3 dBuV)**	**Peak Limit Part 15.209**	**Margin**
GHz		**GHz**	**dBmV**	**dB**	**dB**	**dB**	**m**	**dBmV/m**	**dBmV/m**	**dBµv/m**	**dBµv/m**	
Low	*LBE*	24.000	-27.90	45.56	0.00	2.26	1.00	**19.92**	**10.38**	**70.38**	74	3.62
High	*HBE*	31.200	-41.17	45.50	0.00	2.59	0.50	**6.92**	**-8.64**	**51.36**	74	22.64
FS = SAR 1+AF+CL; FS 3= FS TD +20*log(TD/3); SAR Detector type= Peak												

Table 7 – Average Restricted Band Edge

Average Restricted Band Edge, avg trace, average detector												
Ch	**Band Edge**	**Band Frequency**	**SA reading (SAR)**	**Antenna Factor (AF)**	**DCCF**	**Cable loss (CL)**	**Test Distance**	**FS level @ Test Distance**	**FS level @ 3m (FS 3 dBmV)**	**FS level @ 3m (FS 3 dBuV)**	**Avg Limit Part 15.209**	**Margin**
GHz		**GHz**	**dBmV**	**dB**	**dB**	**dB**	**m**	**dBmV/m**	**dBmV/m**	**dBµv/m**	**dBµv/m**	
Low	*LBE*	24.000	-27.90	45.56	-27.4	2.26	1.00	**-7.48**	**-17.02**	**42.98**	54	11.02
High	*HBE*	31.200	-41.17	45.50	-27.4	2.59	0.50	**-20.48**	**-36.04**	**23.96**	54	30.04
FS@TD = SAR+AF+CL+DCCF; FS3= FS@TD +20*log(TD/3); SAR Detector type= Peak												

Table 8 –Unrestricted Band Edge

Unrestricted Band-Edge							
Ch	**Mode**	**Band edge /Measurement Frequency (GHz)**	**Relative Highest out of band level**	**Relative Fund.**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	FMCW	24.00	-79.31	-28.15	51.17	50.00	PASS
Low	CW	24.00	-73.72	-23.07	50.65	50.00	PASS
High	FMCW	24.25	-34.782	21.511	56.292	50.00	PASS
High	CW	24.25	-34.708	22.852	57.56	50.00	PASS

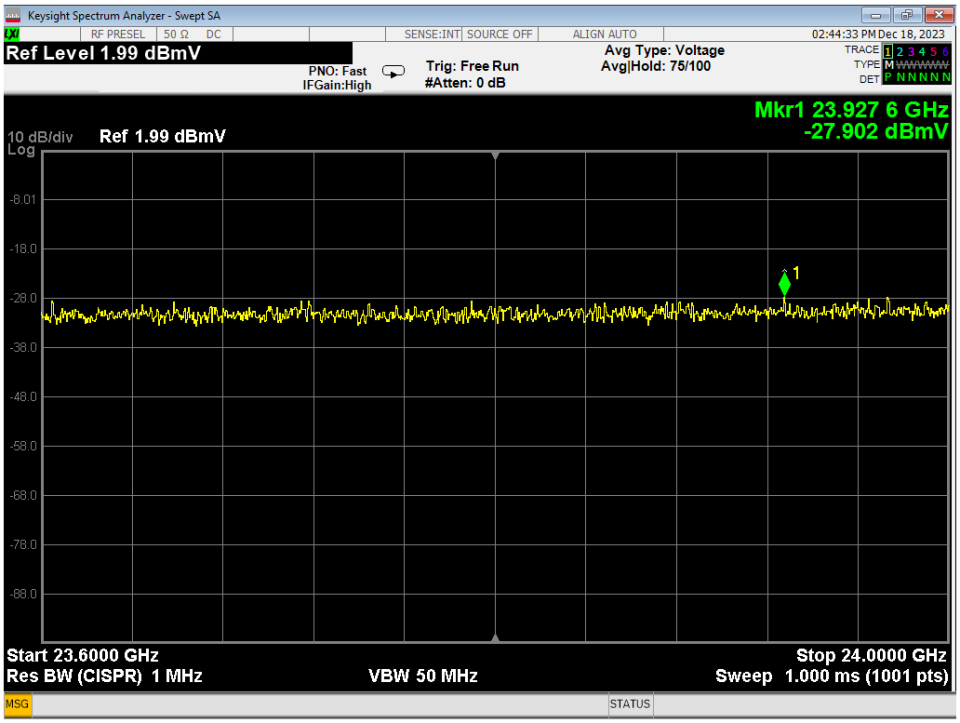


Figure 16 – Restricted Lower Band Edge
Uncorrected Analyzer Measurement, see Band edge table.

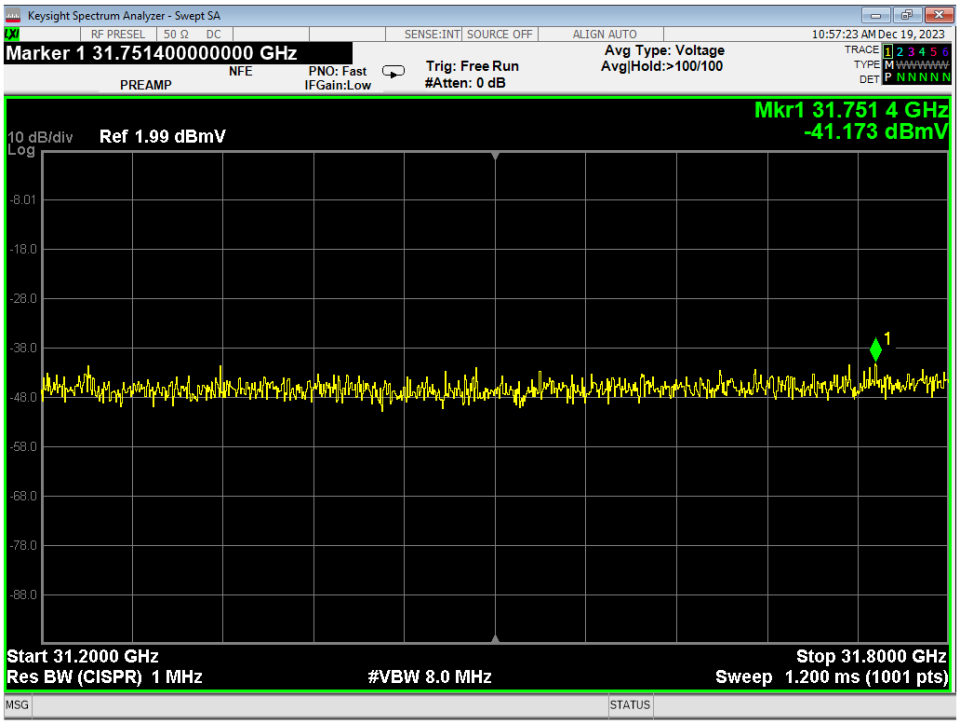


Figure 17 – Restricted Higher Band Edge
Uncorrected Analyzer Measurement, see Band edge table.

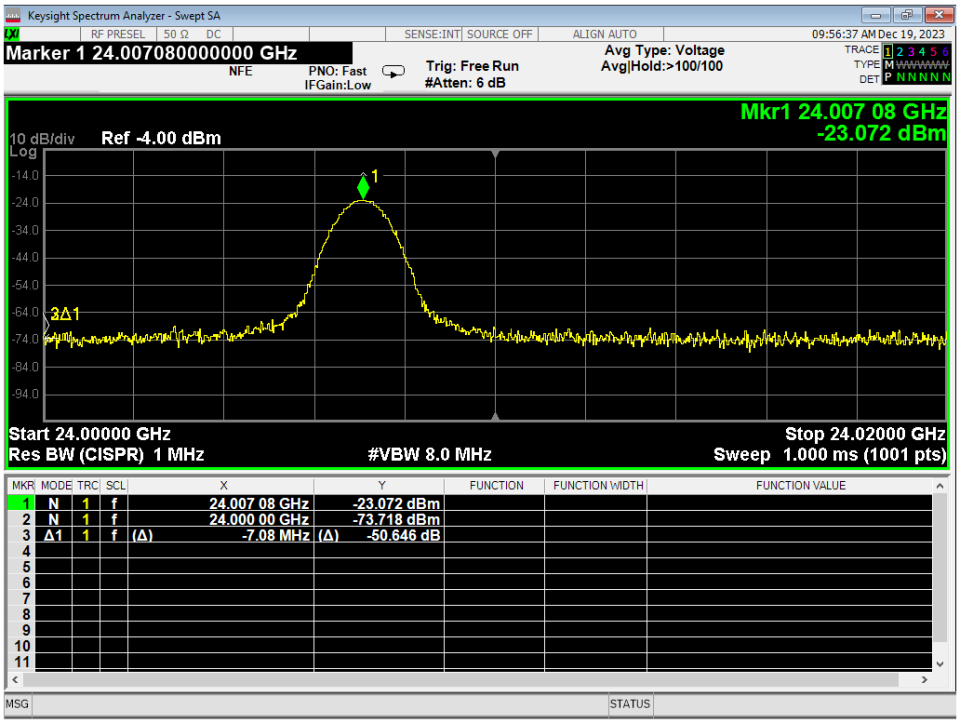


Figure 18 – Unrestricted Lower Band Edge, CW
Uncorrected Analyzer Measurement, see Band edge table.

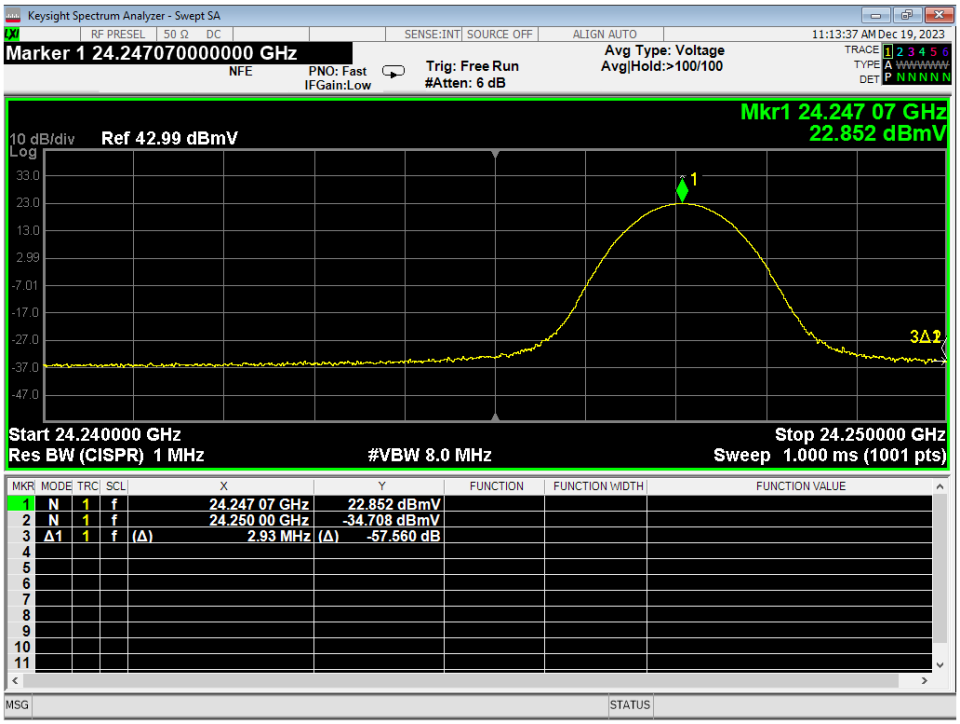


Figure 19 – Unrestricted Higher Band Edge, CW
Uncorrected Analyzer Measurement, see Band edge table.

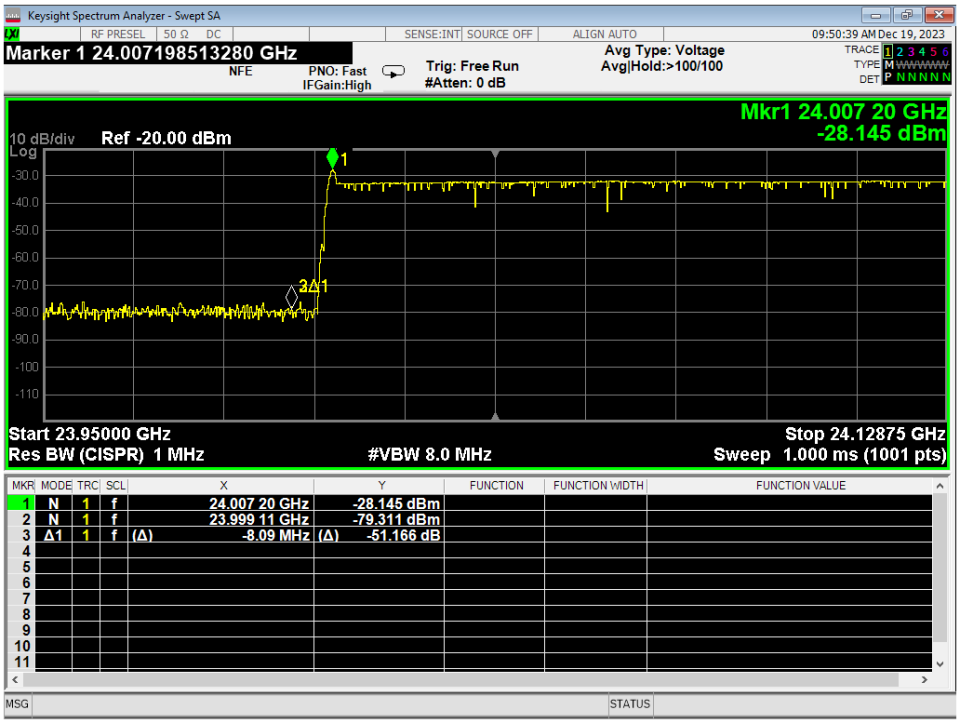


Figure 20 – Unrestricted Lower Band Edge, FMCW
Uncorrected Analyzer Measurement, see Band edge table.

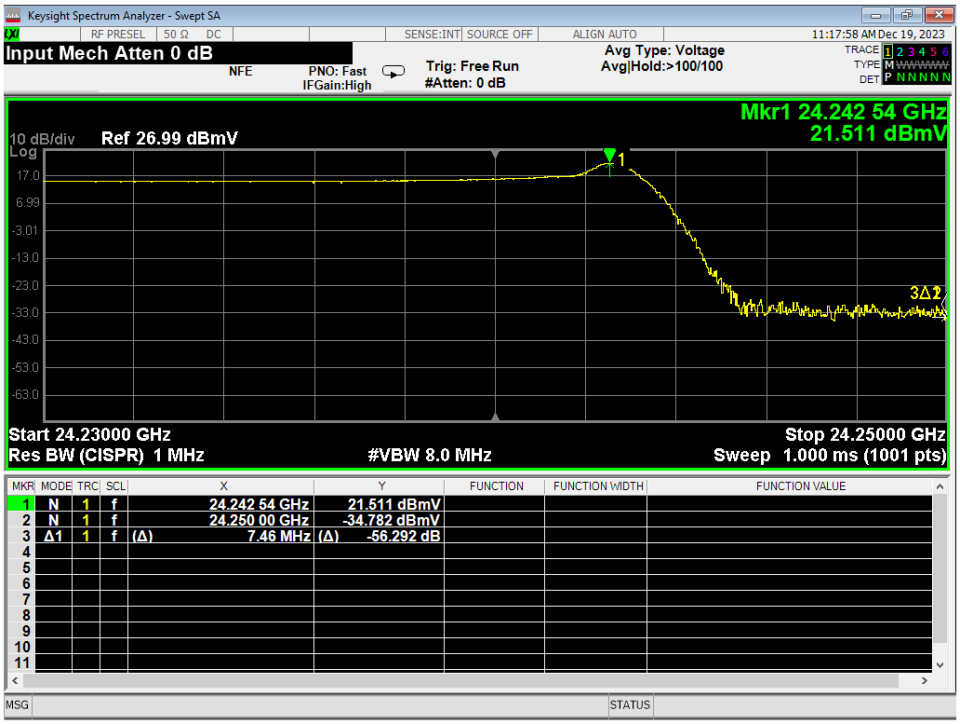


Figure 21 – Unrestricted Higher Band Edge, FMCW
Uncorrected Analyzer Measurement, see Band edge table.

4.3 Radiated Emissions

Test Method:
ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:
Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10-meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher. For emissions >18GHz device was:

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise, the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

Test setup:

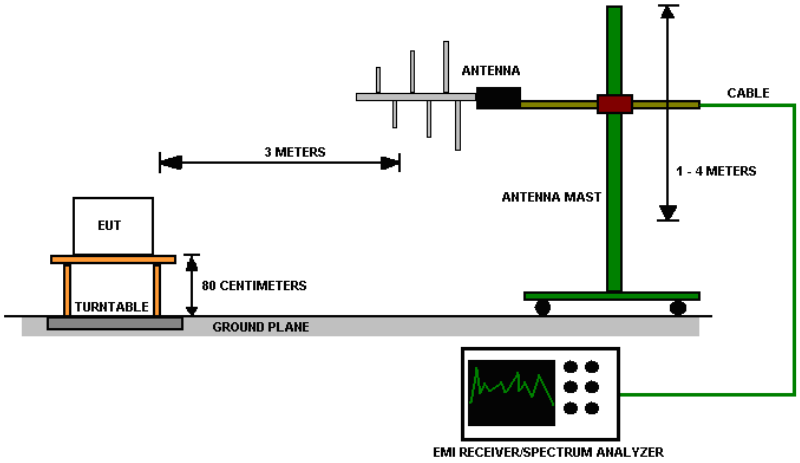


Figure 22 - Radiated Emissions Test Setup

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:
No deviation.

EUT operating conditions
Details can be found in section 2.1 of this report.

Test results:

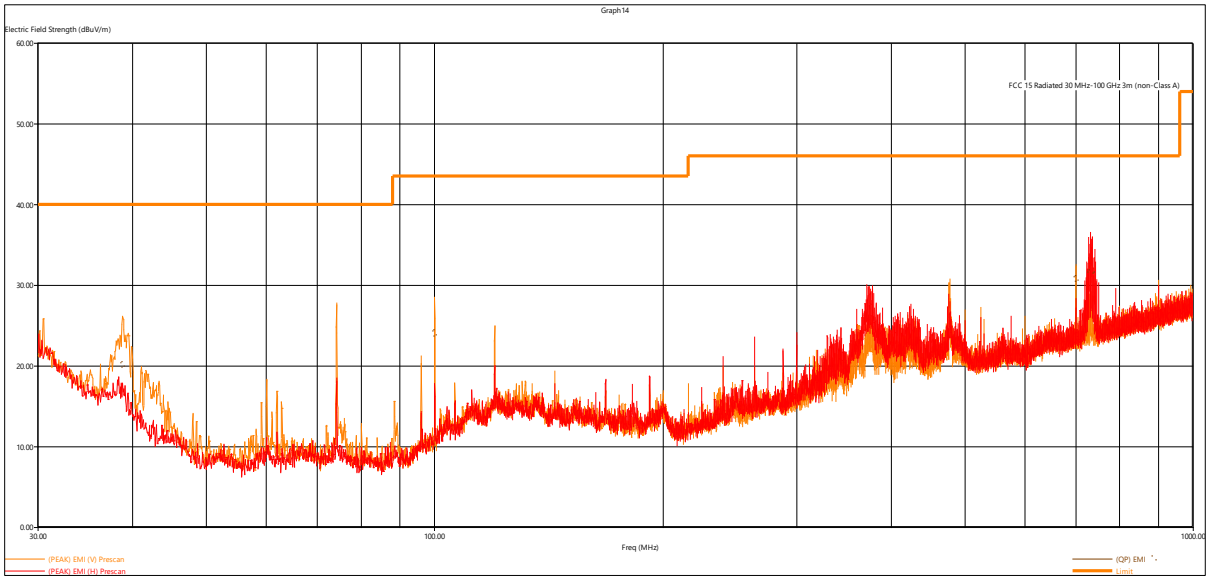


Figure 23 - Radiated Emissions Plot, Low Channel

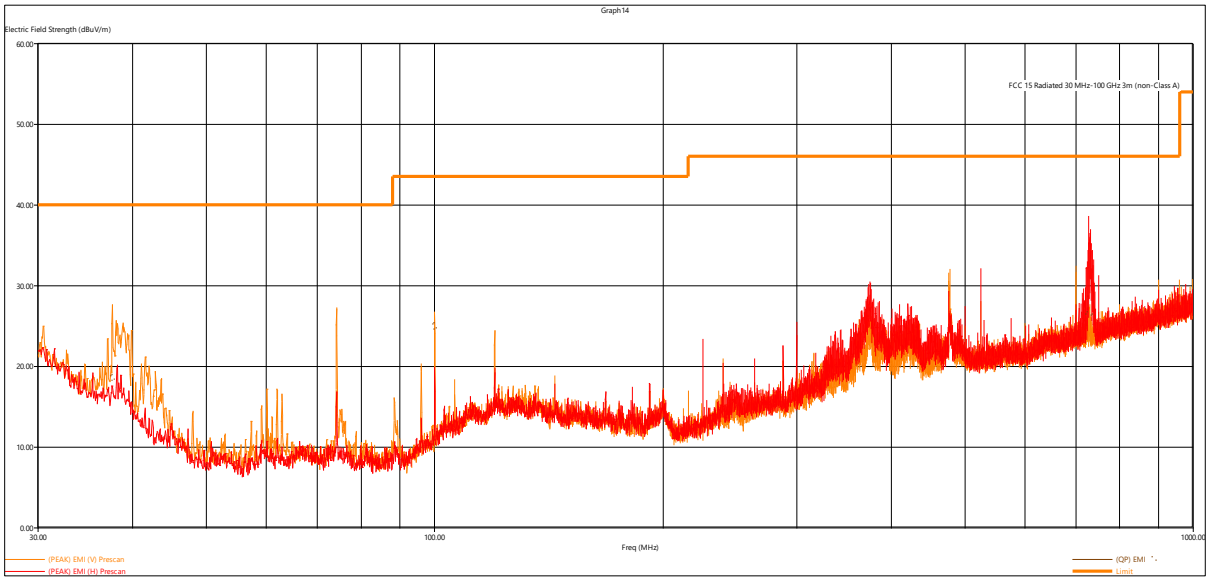


Figure 24 - Radiated Emissions Plot, Mid Channel

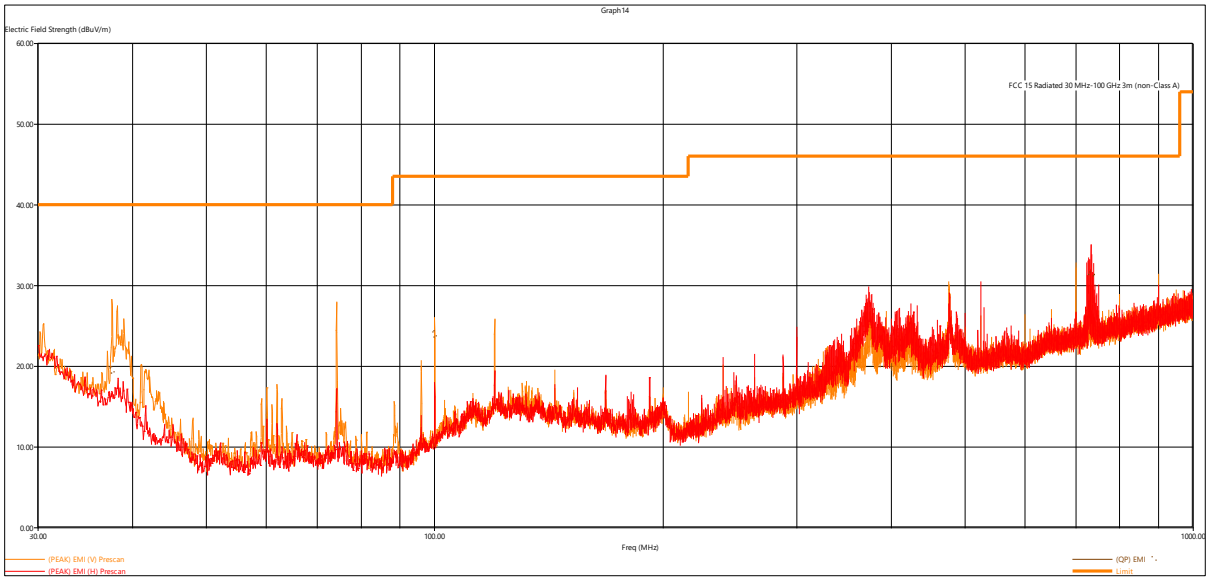


Figure 25 - Radiated Emissions Plot, High Channel

REMARKS:
1. Emission level (dBµV/m) = Raw Value (dBµV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value - Emission level

Quasi-Peak Measurements, 30MHz – 1GHz							
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol.**	**Channel**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm**	**deg**		
732.309840	31.64	46.02	14.38	119.61	359.75	H	Low
38.851200	20.04	40.00	19.96	120.02	335.00	V	Low
99.982080	23.97	43.52	19.55	112.32	288.00	V	Low
700.017600	30.76	46.02	15.26	177.52	16.25	V	Low
728.397360	26.47	46.02	19.55	143.61	303.25	H	Mid
37.738800	18.51	40.00	21.49	104.56	113.75	V	Mid
100.021440	24.89	43.52	18.63	110.35	296.00	V	Mid
733.012560	31.31	46.02	14.71	125.76	345.25	H	High
37.599360	19.48	40.00	20.52	110.59	288.00	V	High
99.997200	23.94	43.52	19.58	113.52	279.75	V	High
699.985000	31.86	46.02	14.16	100.00	10.00	V	High

The EUT was maximized in all 3 orthogonal axes. The worst-case axis and channel are shown in the plot and table above.

Peak Measurements, 1GHz – 18 GHz							
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol.**	**Channel**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm**	**deg**		
6001.780000	60.26	73.98	13.72	483.49	316.50	V	Low
12003.646000	61.05	73.98	12.93	440.86	10.50	V	Low
12062.362000	61.01	73.98	12.97	122.23	292.75	H	Mid
6031.358000	61.71	73.98	12.27	479.55	319.25	V	Mid
1762.586000	40.04	73.98	33.94	335.55	30.50	H	High
12148.530000	63.12	73.98	10.86	132.44	286.75	H	High
6074.304000	60.74	73.98	13.24	524.38	316.25	V	High

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.

Average Measurements, 1GHz – 18 GHz							
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol.**	**Channel**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm**	**deg**		
6001.780000	32.86	53.98	21.12	483.49	316.50	V	Low
12003.646000	33.65	53.98	20.33	440.86	10.50	V	Low
12062.362000	33.61	53.98	20.37	122.23	292.75	H	Mid
6031.358000	34.31	53.98	19.67	479.55	319.25	V	Mid
1762.586000	12.64	53.98	41.34	335.55	30.50	H	High
12148.530000	35.72	53.98	18.26	132.44	286.75	H	High
6074.304000	33.34	53.98	20.64	524.38	316.25	V	High

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.

Peak Spurious Measurements >18GHz

Ch	Detector	Frequency	SA reading (SAR)	Antenna Factor (AF)	Cable loss (CL)	Test Distance	FS level @ Test Distance	FS level @ 3m (FS 3 dBmV)	FS level @ 3m (FS 3 dBuV)	Limit Part 15.209	Margin to 15.209
		GHz	dBmV	dB	dB	m	dBmV/m	dBmV/m	dBµv/m	dBµV/m (15.209)	dB
Low	***Peak***	**18.0054**	**-25.29**	**45.06**	**2.26**	**1.00**	**22.03**	**12.49**	**72.49**	**74**	**1.51**
Mid	*Peak*	18.0938	-25.81	45.13	2.26	1.00	**21.59**	**12.05**	**72.05**	74	1.95
High	*Peak*	18.1854	-26.80	45.28	2.26	1.00	**20.75**	**11.20**	**71.20**	74	2.80
Low	*Peak*	36.0105	-28.45	46.97	2.59	0.50	**21.11**	**5.55**	**65.55**	74	8.45
Mid	*Peak*	36.1875	-28.41	46.65	2.59	0.50	**20.83**	**5.27**	**65.27**	74	8.73
High	*Peak*	36.3705	-29.06	45.97	2.59	0.50	**19.50**	**3.94**	**63.94**	74	10.06

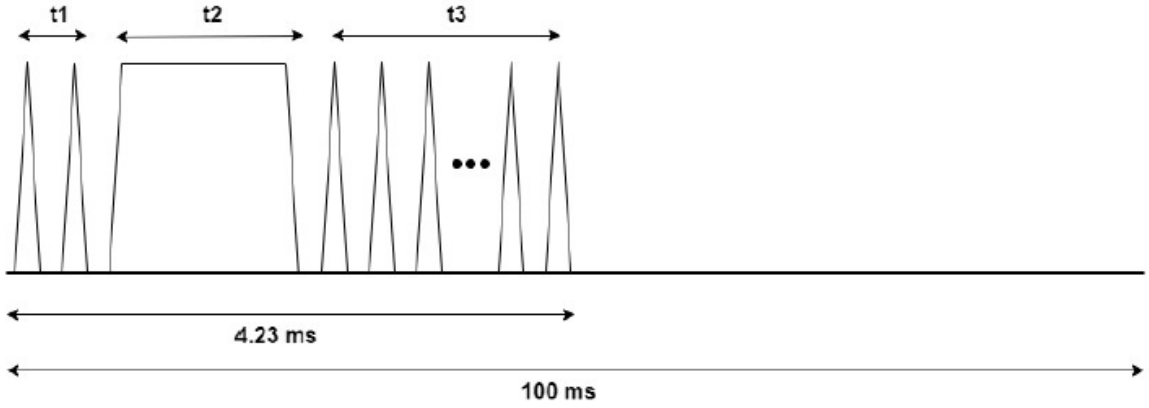
Average Spurious Measurements >18GHz

Ch	Detector / Trace	Frequency	SA reading (SAR)	Antenna Factor (AF)	DCCF	Cable loss (CL)	Test Distance	FS level @ Test Distance	FS level @ 3m (FS 3 dBmV)	FS level @ 3m (FS 3 dBuV)	Limit Part 15.209	Margin to 15.209
		GHz	dBmV	dB	dB	dB	m	dBmV/m	dBmV/m	dBµv/m	dBµV/m	dB
Low	*Peak*	18.0054	-25.29	45.06	-27.40	2.26	1.00	**-5.37**	**-14.91**	**45.09**	54	8.91
Mid	*Peak*	18.0938	-25.81	45.13	-27.40	2.26	1.00	**-5.81**	**-15.35**	**44.65**	54	9.35
High	*Peak*	18.1854	-26.80	45.28	-27.40	2.26	1.00	**-6.65**	**-16.20**	**43.80**	54	10.20
Low	*Peak*	36.0105	-28.45	46.97	-27.40	2.59	0.50	**-6.29**	**-21.85**	**38.15**	54	15.85
Mid	*Peak*	36.1875	-28.41	46.65	-27.40	2.59	0.50	**-6.57**	**-22.13**	**37.87**	54	16.13
High	*Peak*	36.3705	-29.06	45.97	-27.40	2.59	0.50	**-7.90**	**-23.46**	**36.54**	54	17.46

4.4 Duty Cycle

4.4.1 Test Results:

Figure 26 – Customer Provided Duty Cycle Calculation



$t1 = 0.009\ ms$
$t2 = 3.06\ ms$
$t3 = 1.161\ ms$
$Ton = t1 + t2 + t3 = 0.009\ ms + 3.06\ ms + 1.161\ ms = 4.23\ ms$

$$DCCF = 20Log_{10}(\frac{Ton}{100\ ms}) = 20Log_{10}(\frac{4.23\ ms}{100\ ms}) = -27.4\ dB$$

Customer Declares worst case duty cycle is 4.23%

Annex A - Sample Calculations

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 (if applicable)
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 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.

Distance extrapolation calculation

$E_{Limit} = E_{Meas} + 20*\log(D_{Meas}/D_{Limit})$

E_{Meas} = Measurement value at the specified distance
E_{Limit} = Measurement after the extrapolation to the Limit distance

Assume the measuring receiver is reading 50.5dBuV/m at 0.5m test distance but the limit is calculated at 3m.

E_{Limit} = 50.5dBuV/m + 20*log(0.5/3) = 34.9dBuV/m @ 3m

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	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	150kHz – 18GHz	±3.03

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

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

REPORT END