ncee labs
Product Compliance Solutions
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.: **R20190604-21C**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

Date: **25 October 2019**

Total Pages: **23**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	9/16/2019	Approved by – Njohnson Prepared by KVepuri/CFarrington
A	10/9/2019	Corrected duty cycle calculation Added additional band edge measurements Includes NCEE Labs test report R20190604-21 and its amendment in full. -NJ
B	10/23/2019	Corrected duty cycle correction factor on pages 12 – 14. Added note to Section 3.2.1 to explain what limits were used and how they were converted to dBmV/m. Includes NCEE Labs test report R20190604-21A and its amendment in full. -NJ
C	10/25/2019	Removed all occupied bandwidth plots except for the one that was the largest. Includes NCEE Labs test report R20190604-21B and its amendment in full. -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

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, frequency tolerance 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	8/6/2019
EUT Tested	8/6/2019 - 8/21/2019
Serial No.	LAG2019070310 (Rx mode/sweep mode) LAG2019070333 & LAG2019070306 (Low channel) LAG2019070317 (Mid channel) LAG2019070343 (High channel)
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 5 VDC (Anker Power bank; Power core 5000 MN: A1109 SN: AACJQ90815118063 was used as source (This was provided by the manufacturer as a representative supply by connecting to a project board to simulate the drone battery)) unless specified and set to transmit continuously on the default frequency channel.

Channel	Frequency
	GHz
Low	24.017
Mid	24.125
High	24.247

3 Test Results

3.1 Radiated Emissions, Fundamental & Harmonics

Test: FCC Part 15.249

Test Result: Complies Date: 8/6/2019 - 9/11/2019

3.1.1 Test Description

Emissions measurements were made using a 26 GHz spectrum analyzer with an external mixer and horn antenna. Measurements were taken at a distance of 1 meter. The analyzer was set to a resolution bandwidth of 10 MHz and a video bandwidth of 10 MHz for the fundamental measurement. The resolution bandwidth was set to 1 MHz and video bandwidth set to 1 MHz for the harmonic measurement. The results were compared against the limits published in FCC Part 15.245.

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 we directional antennas and all measurements were performed line-of-sight. The measurements were performed at least 2 meters away from any other objects other than the non-conductive table and the test receiver. Reflections from the floor or any other surface were not a significant factor in the measurements. See Section 2.3 for further details.

3.1.5 Test Equipment Used

Serial No.	Manufacturer	Model	Description	Last Cal.	Calibration due
A082918-1	SunAR RF Motion	JB1	Bicon Antenna	15 Oct 2018	15 Oct 2020
6415	EMCO-ETS	3115	DRG Horn	26 Jan 2018	26 Jan 2020
2576	ETS	3116	Horn Antenna	31 Jan 2018	31 Jan 2020
100037	Rhode & Schwarz	ESI26*	EMI Test Receiver	30 Jan 2018	30 Jan 2020
MY59050109	Keysight	N9038A	MXE Signal Analyzer	23 Apr 2019	23 Apr 2021
8077	Pasternack	PE13U1002	Mixer	28 Jan 2017	28 Jan 2022
32/2016	Pasternack	PE9881-24	Horn Antenna	CNR***	CNR***
1823	Pasternack	SMW22AC001-24F	Mixer	13 Aug 2018	13 Aug 2020
Ncee1	Pasternack	SH122-23	Horn Antenna	CNR***	CNR***
1618	Pasternack	PE-W15CA001	WR-19 to WR-28 adapter	28 Jan 2017	28 Jan 2022

*Note: spectrum analyzer included a firmware upgrade and internal local oscillator output upgrade for measurements above 26.5 GHz. Rohde and Schwarz F/W version 4.32.**Calibration Not Required, internal verification***Calibration not required, standard gain horn antenna. All mixers and pre-amplimers were calibrated with associated cables.

3.1.6 Test Pictures and/or Figures

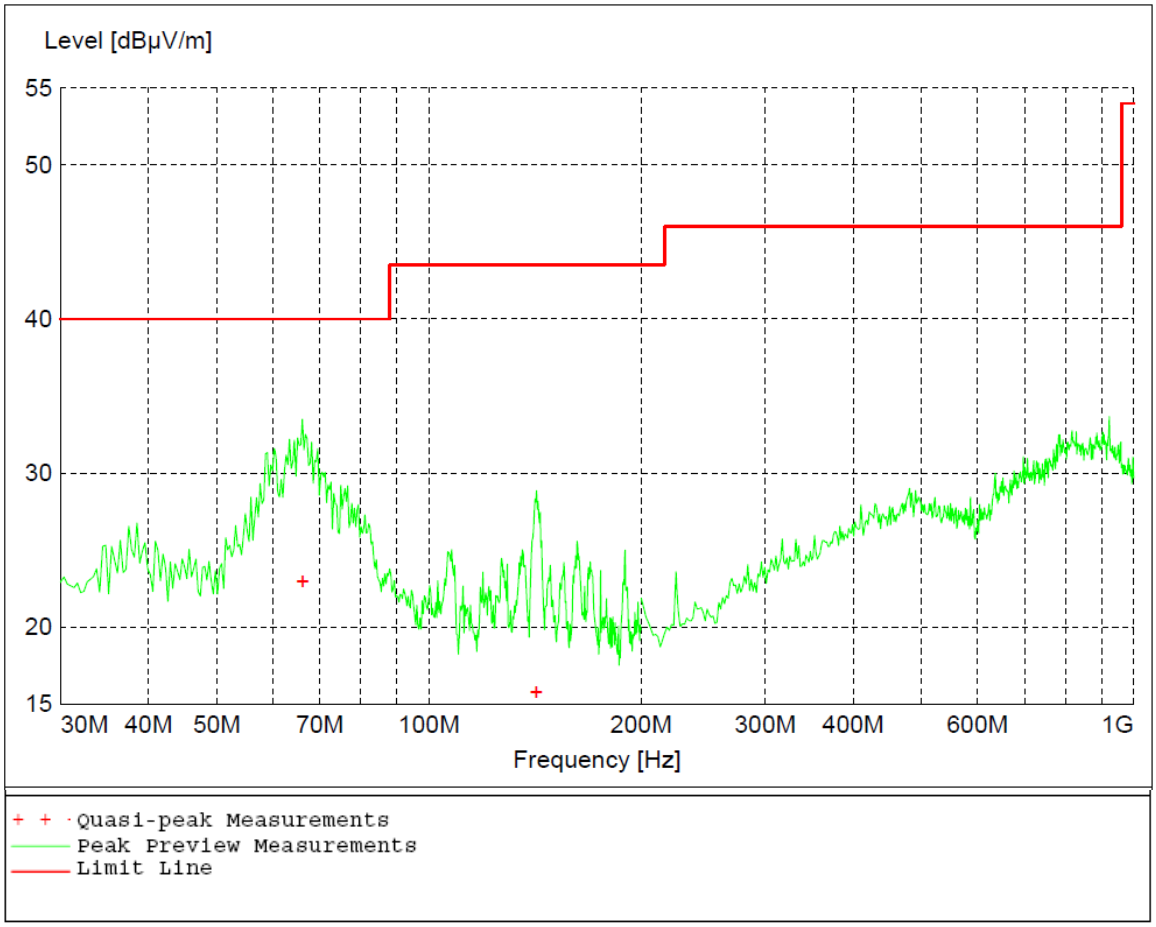

Figure 1 - Radiated Emissions Data Plot, 30M-1GHz, Receive mode

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	
66.240000	23.00	40.00	17.00	100	148	VERT
142.080000	15.77	43.50	27.70	396	35	VERT

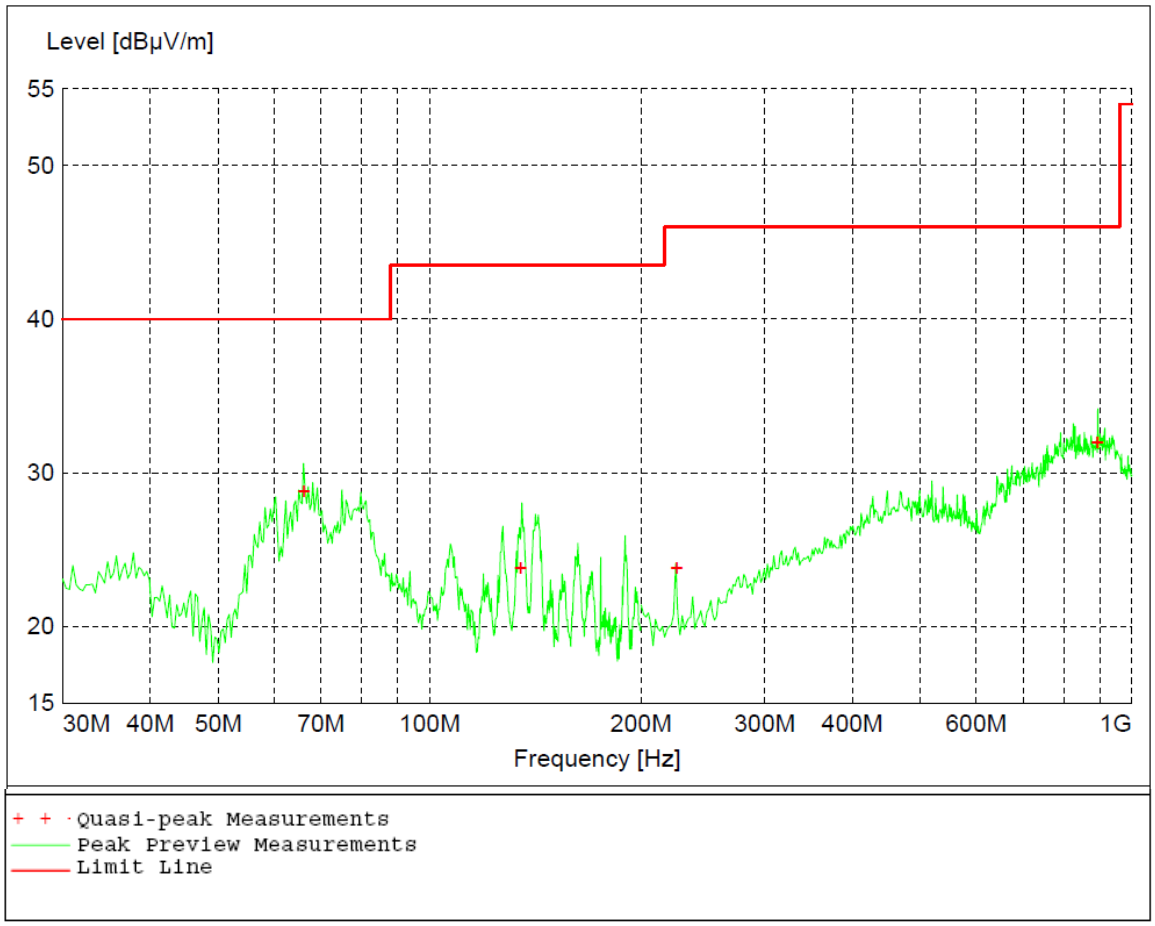

Figure 2 - Radiated Emissions Data Plot, 30M-1GHz, Low Channel

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	
66.240000	28.83	40.00	11.20	100	31	VERT
134.940000	23.80	43.50	19.70	115	256	VERT
225.000000	23.79	46.00	22.20	103	40	VERT
893.880000	32.01	46.00	14.00	318	328	HORI

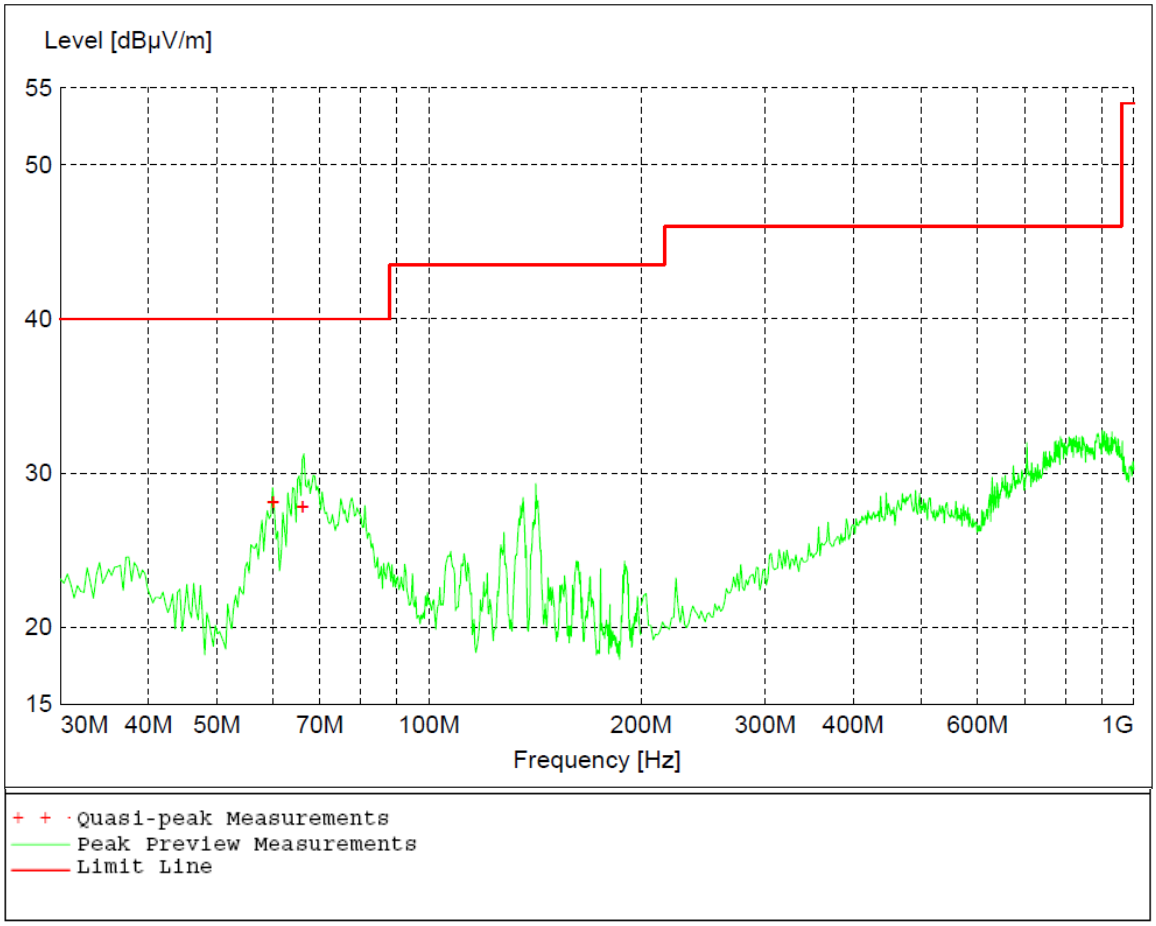

Figure 3 - Radiated Emissions Data Plot, 30M-1GHz, Mid Channel

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	
60.120000	28.14	40.00	11.90	100	173	VERT
66.180000	27.84	40.00	12.20	99	0	VERT

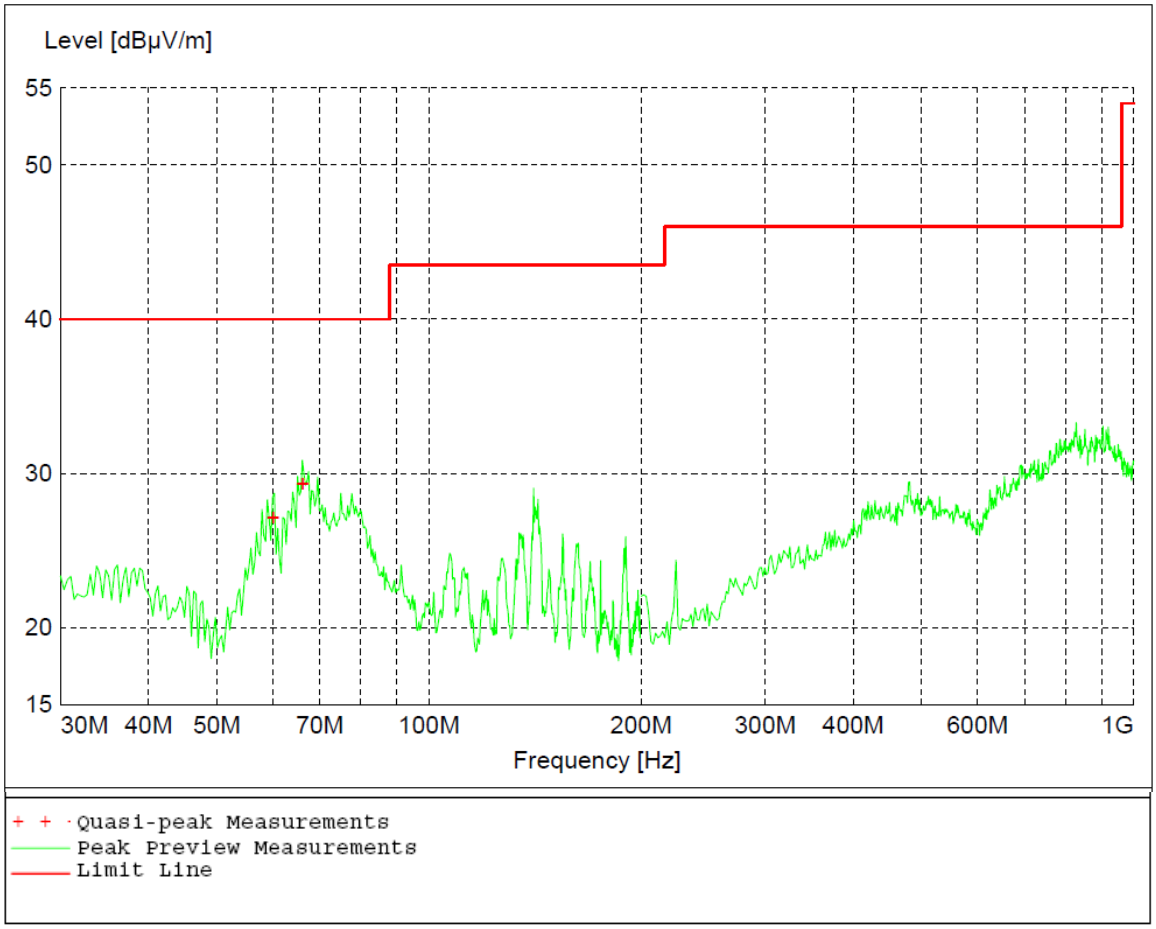

Figure 4 - Radiated Emissions Data Plot, 30M-1GHz, High Channel

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	
60.120000	27.14	40.00	12.90	98	182	VERT
66.240000	29.30	40.00	10.70	101	34	VERT

Table 7 - Fundamental and Harmonic Emissions Data

Measurements made at 1m. Limits extrapolated to 1 meter using 20dB/dec

Channel	Frequency (ƒ)	Un-corrected PK Field Strength Level	Corrected PK Field Strength Level	Corrected AVG Field Strength Level with DCCF	Fundamental Limit (AVG)	Harmonic Limit (AVG)	AVG Margin
	GHz	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dB
Low	24.017	19.711	65.72	43.02	57.50	-	13.83
Mid	24.125	20.683	66.69	43.99	57.50	-	12.86
High	24.247	17.192	63.20	40.5	57.50	-	16.35
Low	48.025	-19.97	21.29	-1.41	-	17.50	18.26
Mid	48.250	-19.88	21.38	-1.32	-	17.50	18.17
High	48.494	-20.84	20.42	-2.28	-	17.50	19.13
Low	72.042	-19.54	31.52	8.82	-	17.50	8.03
Mid	72.375	-18.87	32.19	9.49	-	17.50	7.36
High	72.741	-19.21	31.85	9.15	-	17.50	7.70

Channel	Frequency (ƒ)	Un-corrected PK Field Strength Level	Corrected PK Field Strength Level	Fundamental Limit (PK)	Harmonic Limit (PK)	PK Margin
	GHz	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dB
Low	24.017	19.711	65.72	77.50	-	11.78
Mid	24.125	20.683	66.69	77.50	-	10.81
High	24.247	17.192	63.20	77.50	-	14.30
Low	48.025	-19.97	21.29	-	37.50	16.21
Mid	48.250	-19.88	21.38	-	37.50	16.12
High	48.494	-20.84	20.42	-	37.50	17.08
Low	72.042	-19.54	31.52	-	37.50	5.98
Mid	72.375	-18.87	32.19	-	37.50	5.31
High	72.741	-19.21	31.85	-	37.50	5.65

All measurements were made with peak detector unless noted.

*Measurement was in the system noise floor

See following page for limit, duty cycle correction and correction factors

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 = 57.50 dBmV/m at 1 meter.

Harmonic limit: 2.5 mV/m at 3 meters = 7.95 dBmV/m = 17.50 dBmV/m at 1 meter.

Correction factors:

48 GHz: (41.26 dB total)	
Mixer	0.40 dB
Antenna factor	40.86 dB/m (standard gain horn, gain = 23 dBi)
72 GHz: (51.06 dB)	
Mixer	7.0 dB
WR-19 to WR-28 waveguide transition	0.55 dB
Antenna factor	43.51 dB/m (standard gain horn, gain = 24 dBi)

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)

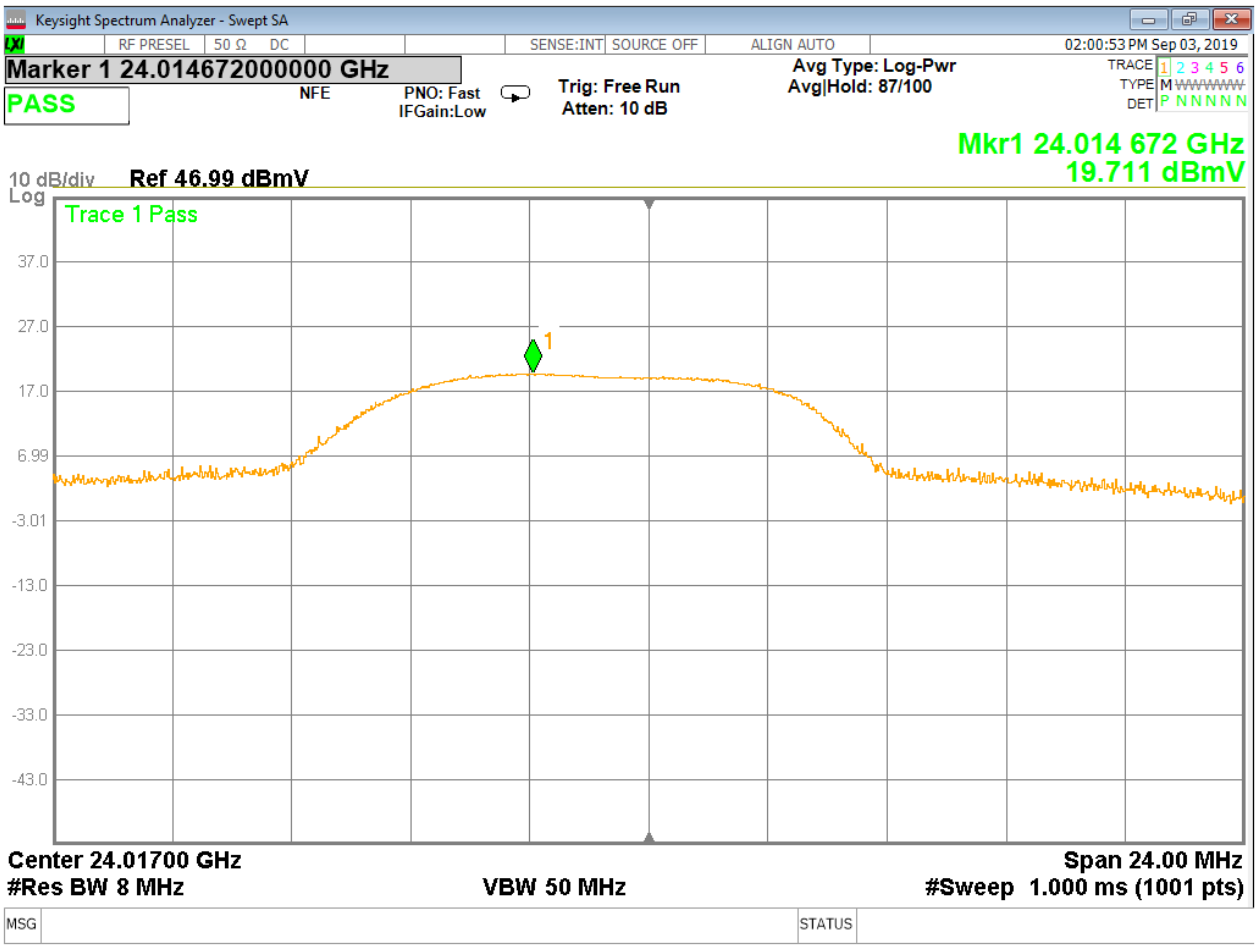

Figure 5 - Analyzer Measurement – Fundamental, Channel Low

Uncorrected measurement as recorded on spectrum analyzer

Level Measurement: 19.711 dBmV/m + 46.01 dB corrections – 22.7 dB duty cycle correction = 43.02 dBmV/m.

Cable	0.50 dB
Antenna	45.51 dB

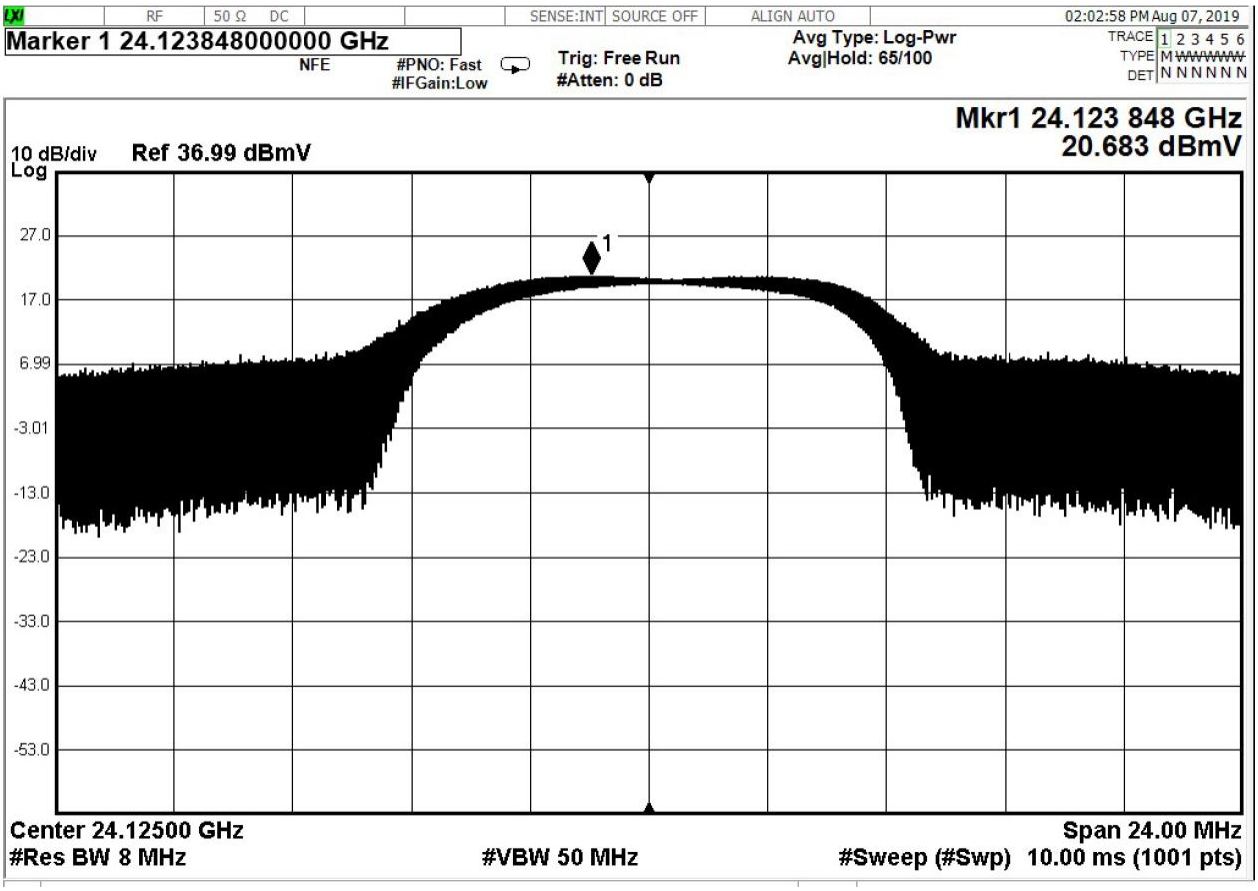

Figure 6 - Analyzer Measurement – Fundamental, Channel Mid

Uncorrected measurement as recorded on spectrum analyzer

Level Measurement: 20.683 dBmV/m + 46.01 dB corrections – 22.7 dB duty cycle correction = 43.99 dBmV/m.

Cable	0.50 dB
Antenna	45.51 dB

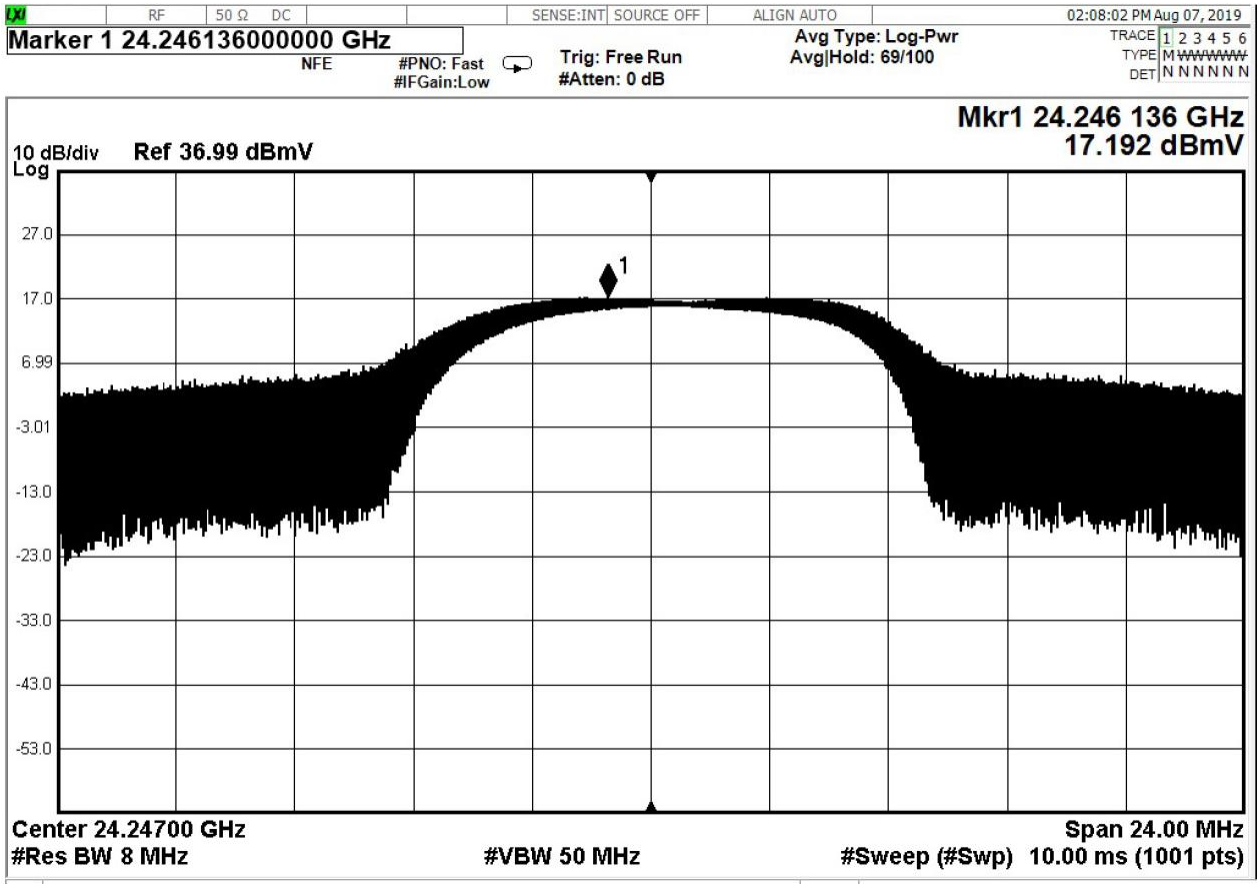

Figure 7 - Analyzer Measurement – Fundamental, Channel High

Uncorrected measurement as recorded on spectrum analyzer

Level Measurement: 17.192 dBmV/m + 46.01 dB corrections – 22.7 dB duty cycle correction = 40.502 dBmV/m.

Cable	0.50 dB
Antenna	45.51 dB

3.2 Bandedges 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 bandedge measurements:

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.

500 µV/m = 20log(500) = = 54 dBµV/m = 54 – 60 = -6 dBmV/m at 3m average

Peak limit = average limit + 20 dB = 14 dBmV/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 100kHz (unrestricted), 1MHz (restricted) and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge 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 300 kHz 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:

All the measurements were done at 1m test distance.

3.2.5 EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.

Test results:

Band Edges

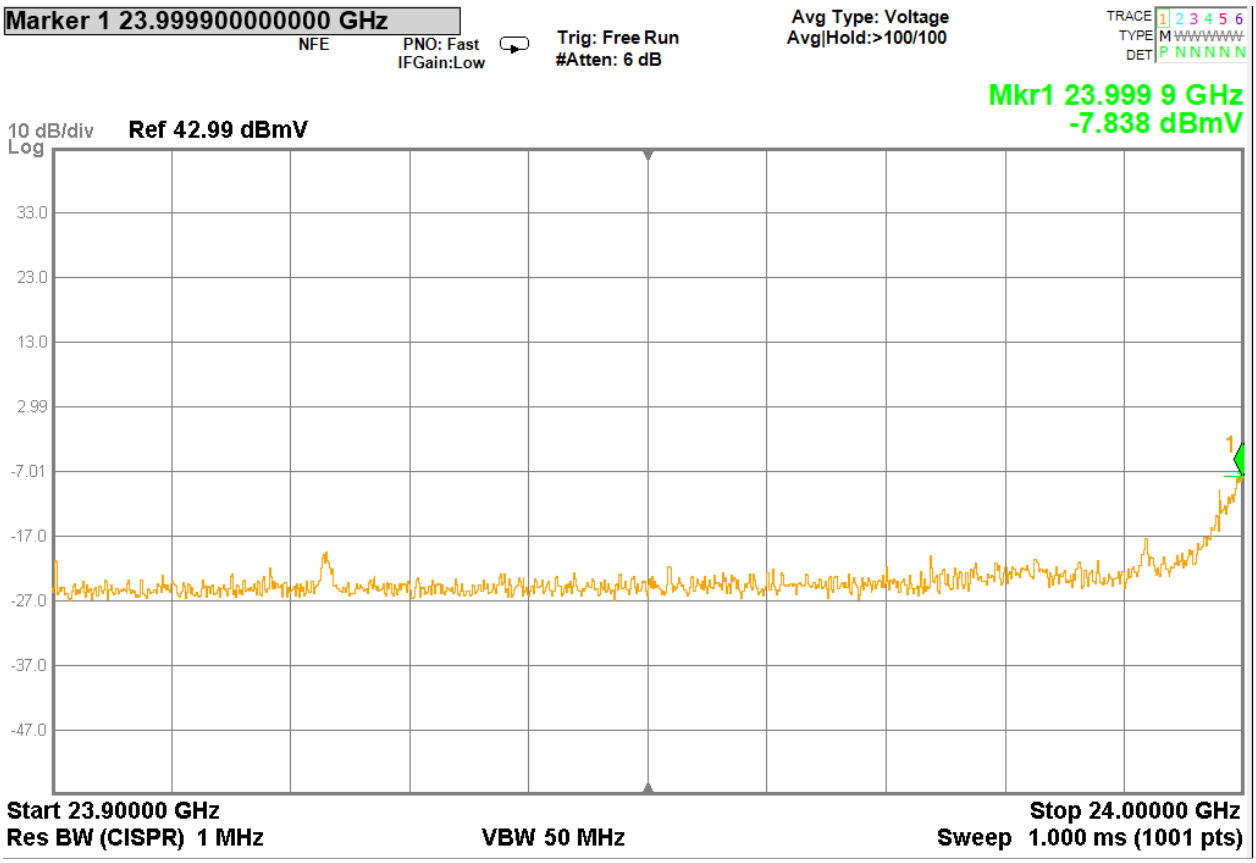

Figure 8 – Lower Band Edge, 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

Low Band Edge Measurement at 24.25 GHz

Peak level from Figure 8 = -7.84 dBmV
Corrected Restricted Band Peak Level = -7.84 dBmV/m + 46.01 dB (corrections)
= 38.17 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 22.7 (dccf) =
=15.47 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05)+(-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

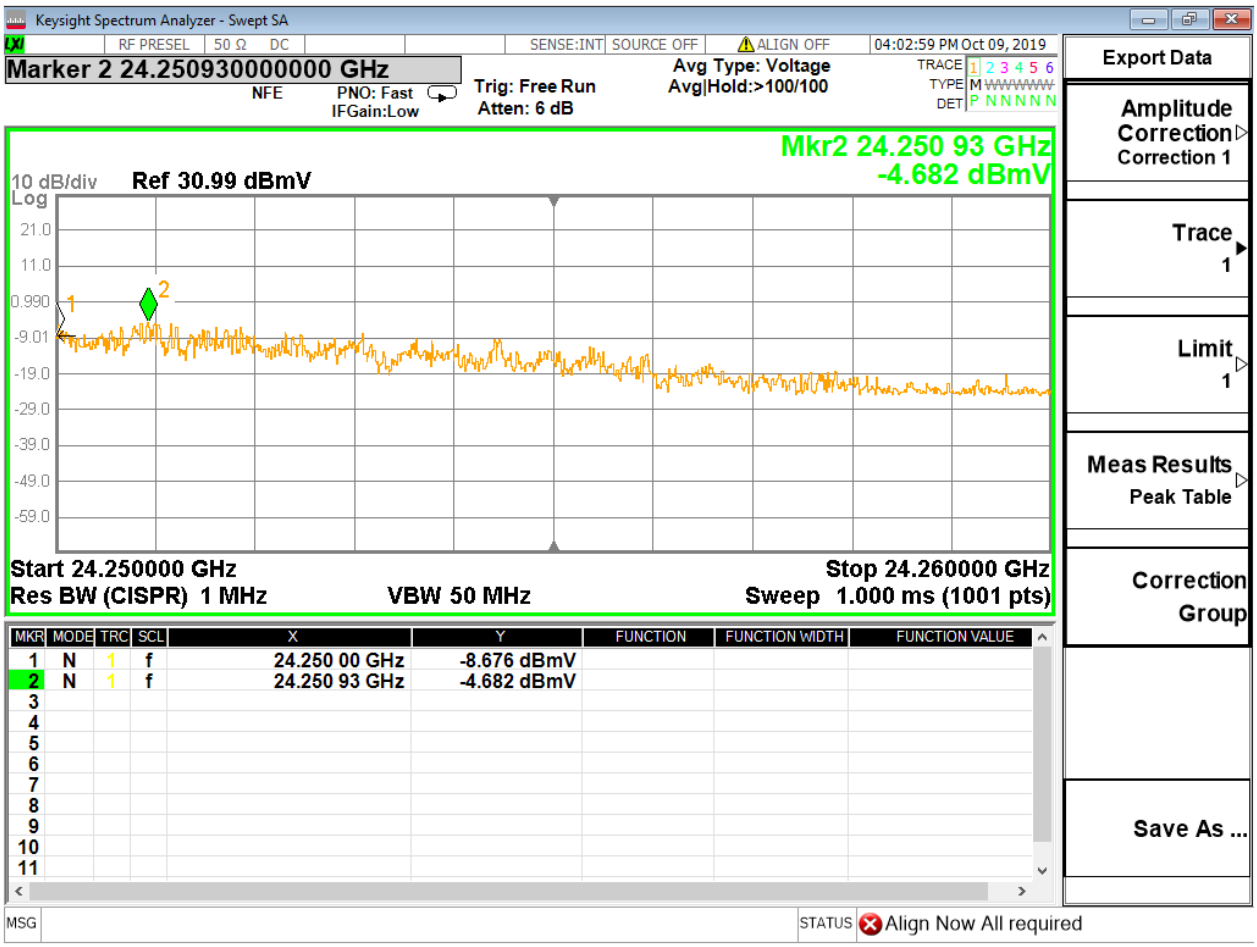

Figure 9 - Lower Band Edge, 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

High Band Edge Measurement at 24.25 GHz

Peak level from Figure 9 = -4.68 dBmV
Corrected Restricted Band Peak Level = -4.68 dBmV/m + 46.01 dB (corrections)
= 41.33 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 22.7 (dccf) =
= 18.63 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05) + (-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

Occupied Bandwidth

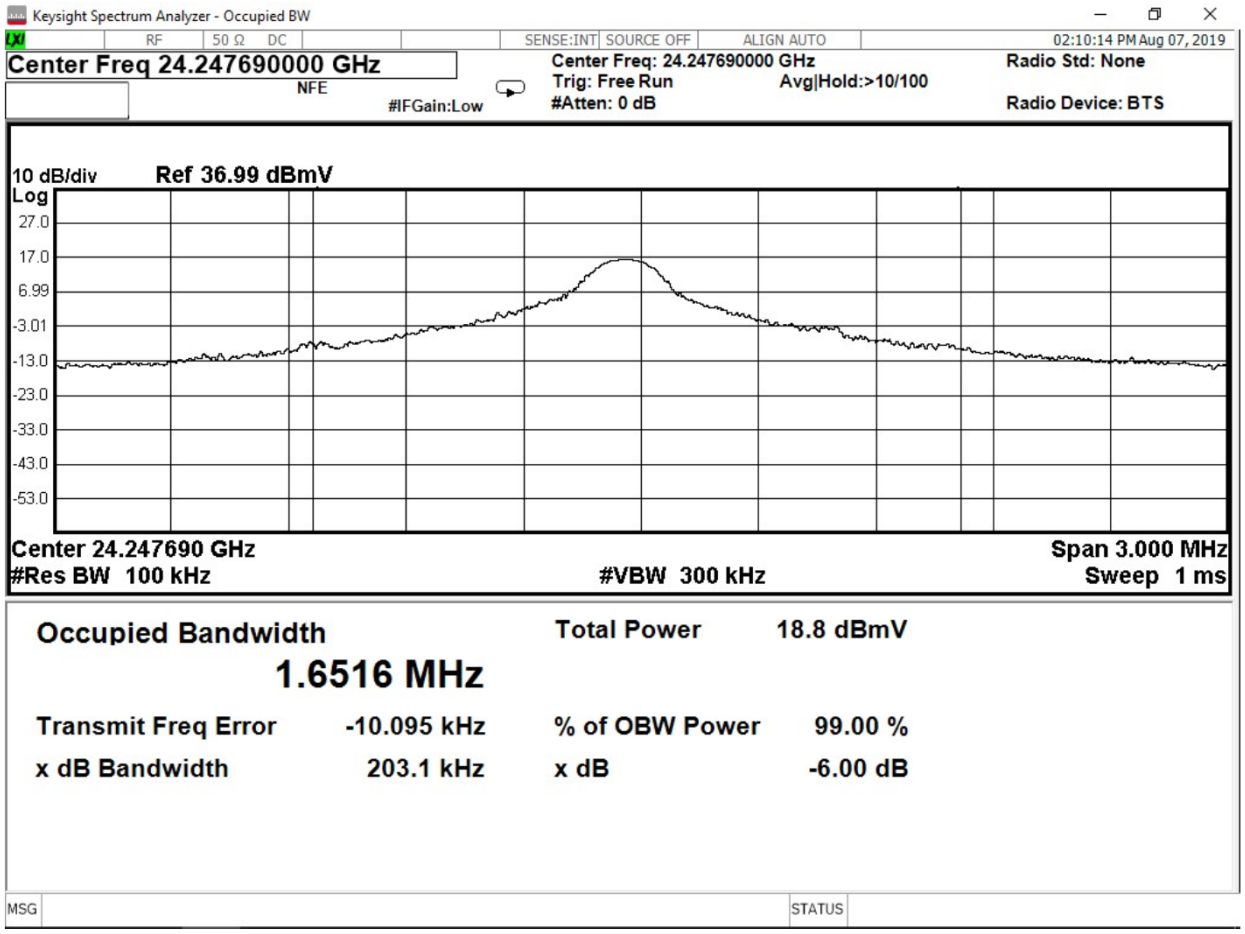

Figure 10 – Occupied Bandwidth, High channel
Uncorrected measurement as recorded on spectrum analyzer

The occupied bandwidth of the highest 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.

REPORT END