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FCC/ISED DXX Part 15.225
Test Report

Prepared for:	**Garmin International Inc.**
Address:	**1200 E. 151st Street** **Olathe, Kansas, 66062, USA**
Product:	**AB4308**
Test Report No:	**R20211005-21-E13A**
Approved By:	 **Fox Lane** **EMC Test Engineer,**
DATE:	**12 May 2022**
Total Pages:	**23**

ilac-MRA A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
0	5 March 2022	Original – KVepuri Prepared by GLarsen, SProbst and FLane
A	12 May 2022	Added additional test points to Sec 3.2

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1 Summary of Test Results

The EUT was tested for compliance to the following standards and/or regulations;

1.1 Emissions Test Results

The EUT was tested for compliance to:

US CFR Title 47 FCC Part 15.225
RSS-Gen Issue 5

Table 1 – Emissions Test Results

Emissions Tests	Test Method and Limits	Result
Radiated Emissions	FCC Part 15.225 (a), (b), (c), (d) RSS-Gen, Issue 5, 6.5, 6.13 RSS-210 Issue 10 B.6	Complies
Bandedge	FCC Part 15.225 (b) (c) RSS-210 Issue 10 B.6	Complies
Frequency Error	FCC Part 15.225 (e)	Complies
Conducted Emissions	FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Complies

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

Model	AB4308
EUT Tested	25 January 2022
Serial No.	3392435319 (Radiated Measurements)
Operating Band	13.56 MHz
Device Type	NFC
Antenna	Trace Antenna
Power Supply	Internal Battery/ 5VDC Charger: Garmin (Phi Hong) MN: PSAI10R-050Q (Representative Power Supply)

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 28 ± 4%
Temperature of 22 ± 3° C

2.3 EUT Setup

The EUT was powered by 120 VAC / 60Hz (5 VDC Output) for all tests. Emissions were compared between EUT charging and non-charging; worst case was reported.

EUT was paired with an NFC card reader (MN: ACR122U, SN: RR545-026162) for all testing.

For Conducted emissions an EUT Card Emulator (CE) mode was used.

2.4 Test Equipment Used for all Tests

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 21, 2021	July 21, 2023
Com-Power LISN 50µH / 250µH - 50Ω	LI-220C	20070017	September 22, 2020	September 22, 2022
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	May 5, 2020	May 5, 2022
SunAR RF Motion	JB1	A091418	July 27, 2021	July 27, 2022
EMCO Loop Antenna**	6512	00024936	February 11, 2019	February 11, 2022
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	February 1, 2021	February 1, 2023
Thermotron, Temp Chamber	SE1000-5-5	31373	NA	NA
Omega, Temp. Humidity Meter	iTHX-SD	ID # 2130155	April 23, 2021	April 23, 2023
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
TDK Emissions Lab Software	V11.25	700307	NA	NA

*Internal Characterization **Extended Cal

3 Test Results

3.1 Radiated Emissions, Band Width, Output Power and Band edge

Test:	FCC Part 15.225 (a), (b), (c), (d) RSS-Gen, Issue 5, 6.5, 6.13 RSS-210 Issue 10 B.6
Test Specifications:	Class A
Test Result:	Complies

3.1.1 Test Description

Radiated emissions measurements were made from 30MHz to 1GHz at a distance of 3m (Radiated Emissions) and 3m (Bandwidth, Field Strength and Band edges) inside a semi-anechoic chamber. The EUT was rotated 360°, the antenna height varied from 1-4 meters and both the vertical and horizontal antenna polarizations examined. For measurements below 30 MHz, the loop antenna was used to measure in all 3 axes. The results were compared against the limits. Measurements were made by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

30MHz – 1GHz: 120kHz IF bandwidth, 60kHz steps
10MHz – 30MHz: 9kHz RBW, 4.5 kHz steps

Intermodulation products were investigated by measuring spurious emissions with each of the two 2.4 GHz radios running in parallel with the NFC radio. No intermodulation products were found above the labs system sensitivity.

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 in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%
Temperature of 23 ±2° C

3.1.4 Test Setup

See Section 2.3 for further details.

3.1.5 Test Equipment Used

See section 2.4 for the equipment list.

3.1.6 Test Pictures and/or Figures

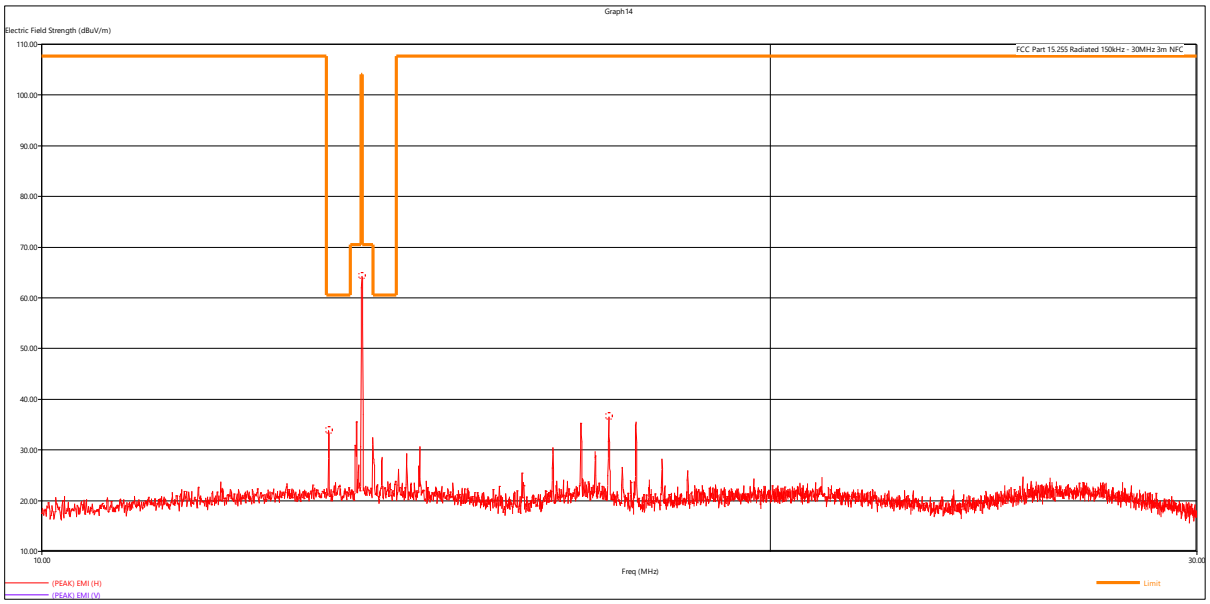


Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz

All emissions were found to be at least 6dB below limit line

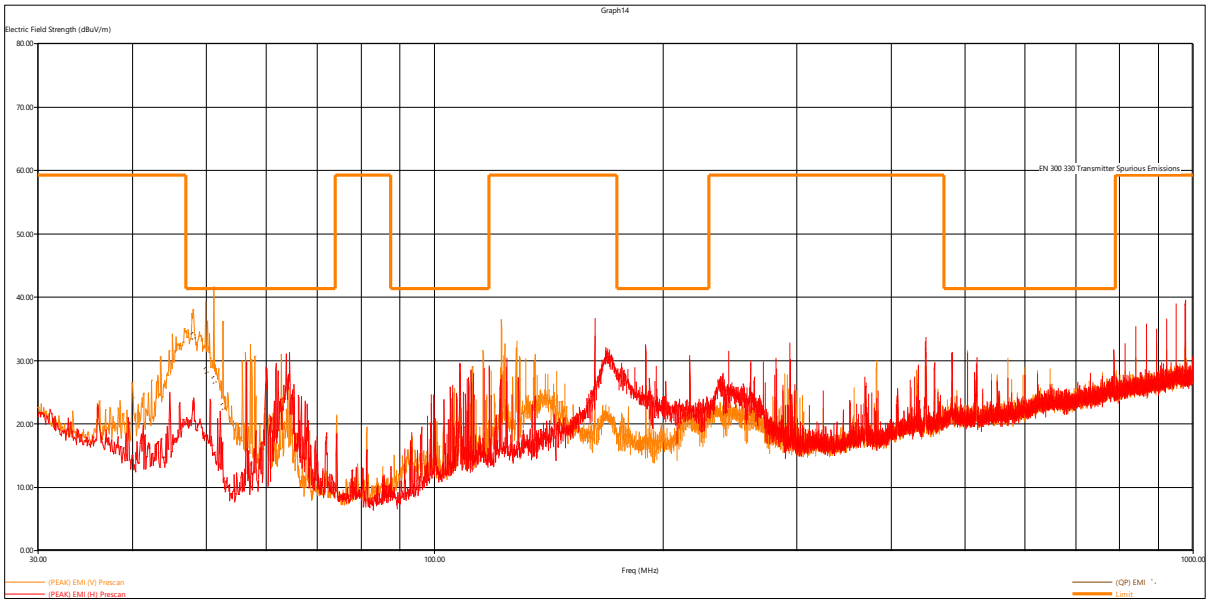


Figure 2 – NFC Radiated Emissions Plot, 30MHz – 1GHz

Quasi-Peak Measurements						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
48.015600	33.72	41.25	7.53	140.00	299.00	V
49.842960	28.30	41.25	12.95	114.00	0.00	V
51.012720	26.81	41.25	14.44	112.00	120.00	V
52.618560	22.54	41.25	18.71	108.00	146.00	V
57.211200	11.06	41.25	30.19	150.00	88.00	V

All other emissions were found to be at least 6dB below limit line

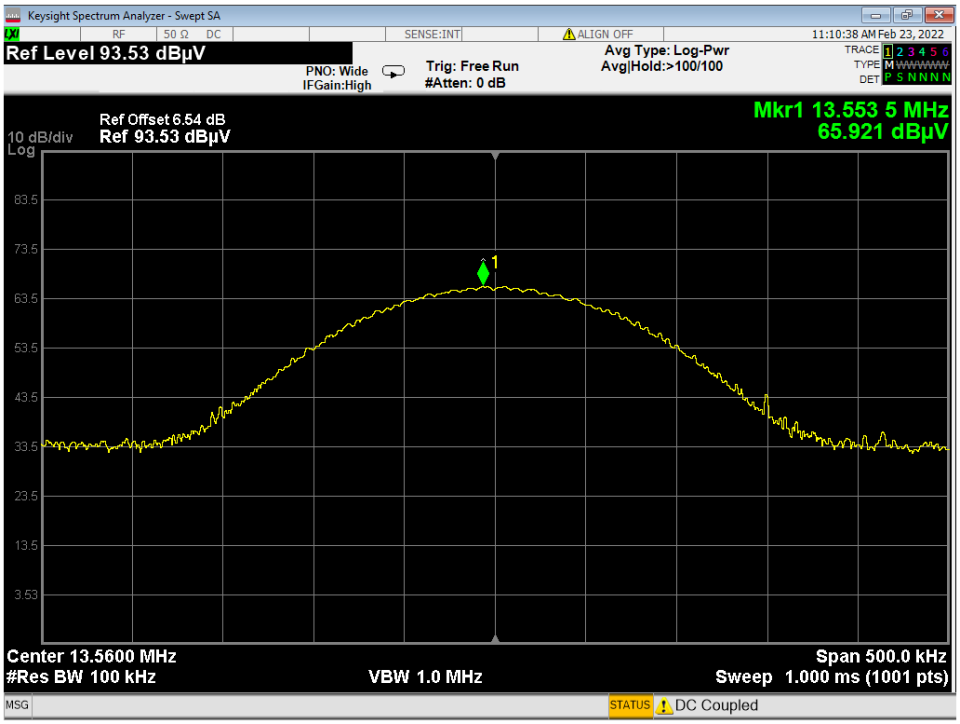


Figure 3 – NFC Field Strength Plot

Corrections included

NFC Field Strength			
Field Strength (dBµV/m)	**Limit (dBµV/m)**	**Margin (dB)**	**Result**
65.921	104.00	38.079	PASS

Band Edge Measurements:

Band edge /Measurement Frequency (MHz)	Corrected band level dBµV/m @ 3m	Limit* (dBuV)	Margin	Result
13.5530	50.895	70.47	19.575	PASS
13.5670	54.644	70.47	15.826	PASS
13.3479	43.46	60.51	17.05	PASS
13.7734	47.15	60.51	13.36	PASS

*Limit extrapolated to 3m test distance
all other emissions were found to be at least 20 dB below the applicable limit.

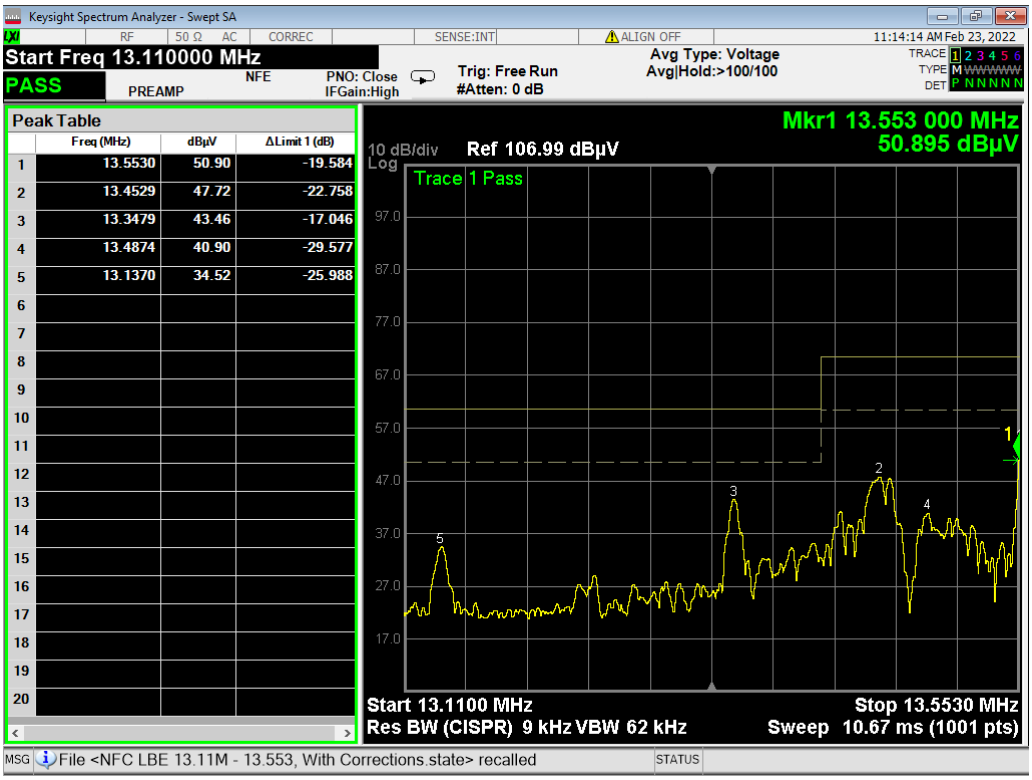


Figure 4 – NFC Lower Band-edge

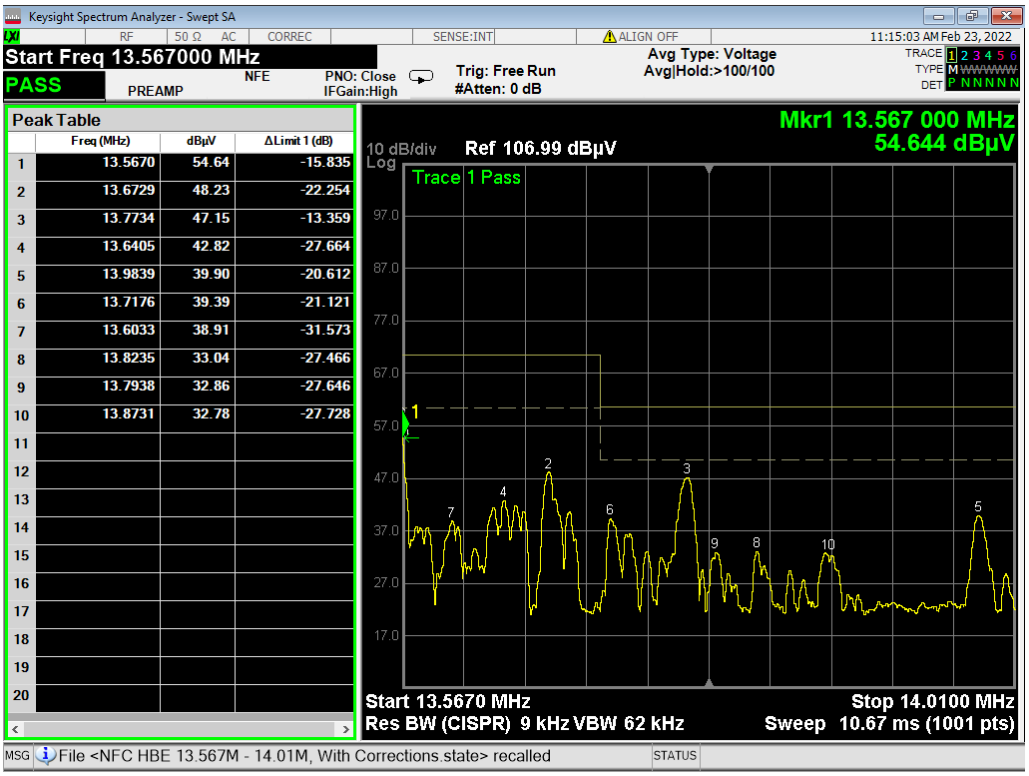


Figure 5 – NFC Higher Bandedge

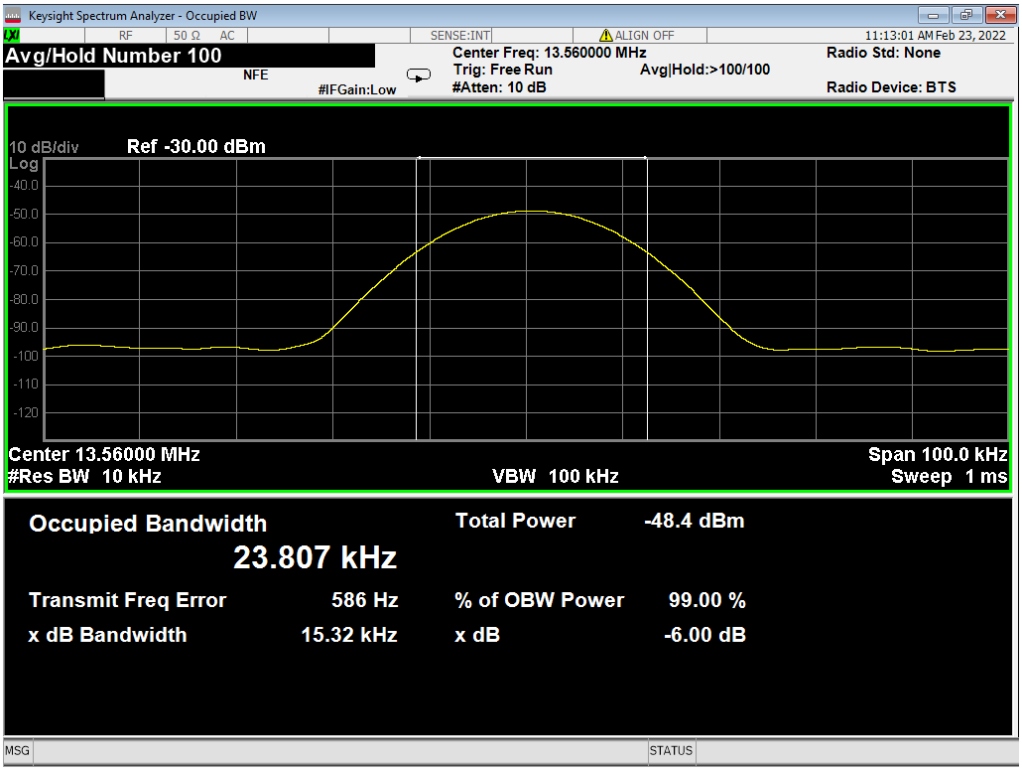


Figure 6 – NFC Occupied Bandwidth

3.2 Frequency Error

Test:	FCC Part 15.225 (e)
Test Result:	Complies

3.2.1 Test Description

Frequency error was determined using the built-in frequency error function of the spectrum analyzer. The analyzer finds the occupied bandwidth, calculates the center of the given band then returns the deviation with respect to the given transmit frequency. The temperature was varied from -20°C to 55°C. The voltage was not variable but the battery was let to drain, voltage of drained battery was reported.
Limit: 100 PPM

3.2.2 Test Results

No results were found to be in excess of the limits. A table of the results can be seen below.

3.2.3 Test Environment

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

Relative humidity of 30 ± 5%
Temperature of 23 ±2^{o} C

3.2.4 Test Setup

See Section 2.3 for further details.

3.2.5 Test Equipment Used

See section 2.4 for the equipment list.

Test results

AB4308	
Temperature (°C)	**Channel (Hz)**
	13.56000 Nom.
-20°C	711
-10°C	689
0°C	648
10°C	599
20°C	492
30°C	468
40°C	412
55°C	428

AB4308		Nom. Battery Voltage: 3.87V
Voltage (V)	**Temperature**	**Frequency Error (Hz)**
4.40	20°C	463
4.37	20°C	495
4.36	20°C	487
4.35	20°C	489
4.09	20°C	375
3.84	20°C	492
3.40*	20°C	482

*Lowest battery voltage lab could achieve at 1% battery life

Limit: 100 PPM = 0.01% = 0.01 x 13.56 kHz = 1356 Hz
Values shown in Hz.
Uncertainty = ±500 Hz

3.3 Conducted AC Mains Emissions

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5 0.5-5 5-30	66 to 56 56 60	56 to 46 46 50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

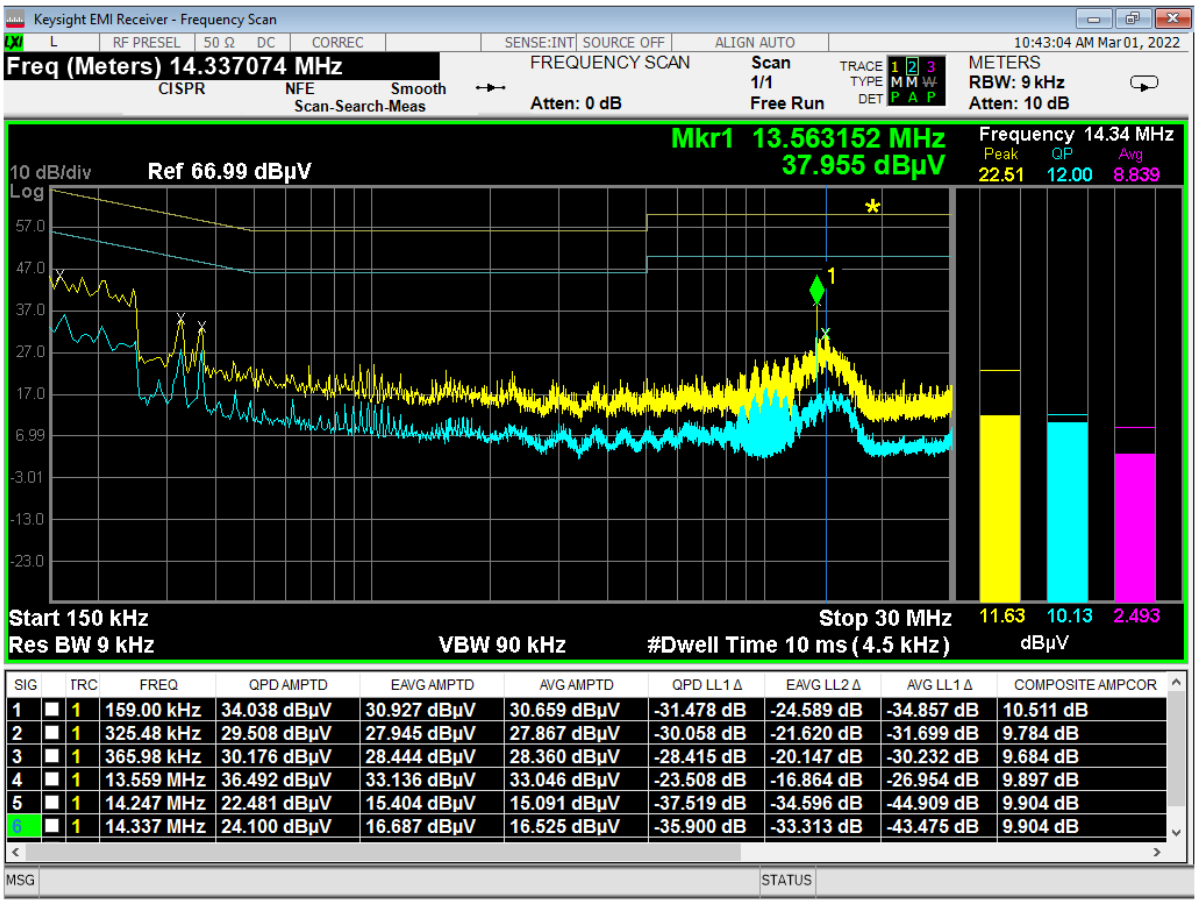
Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

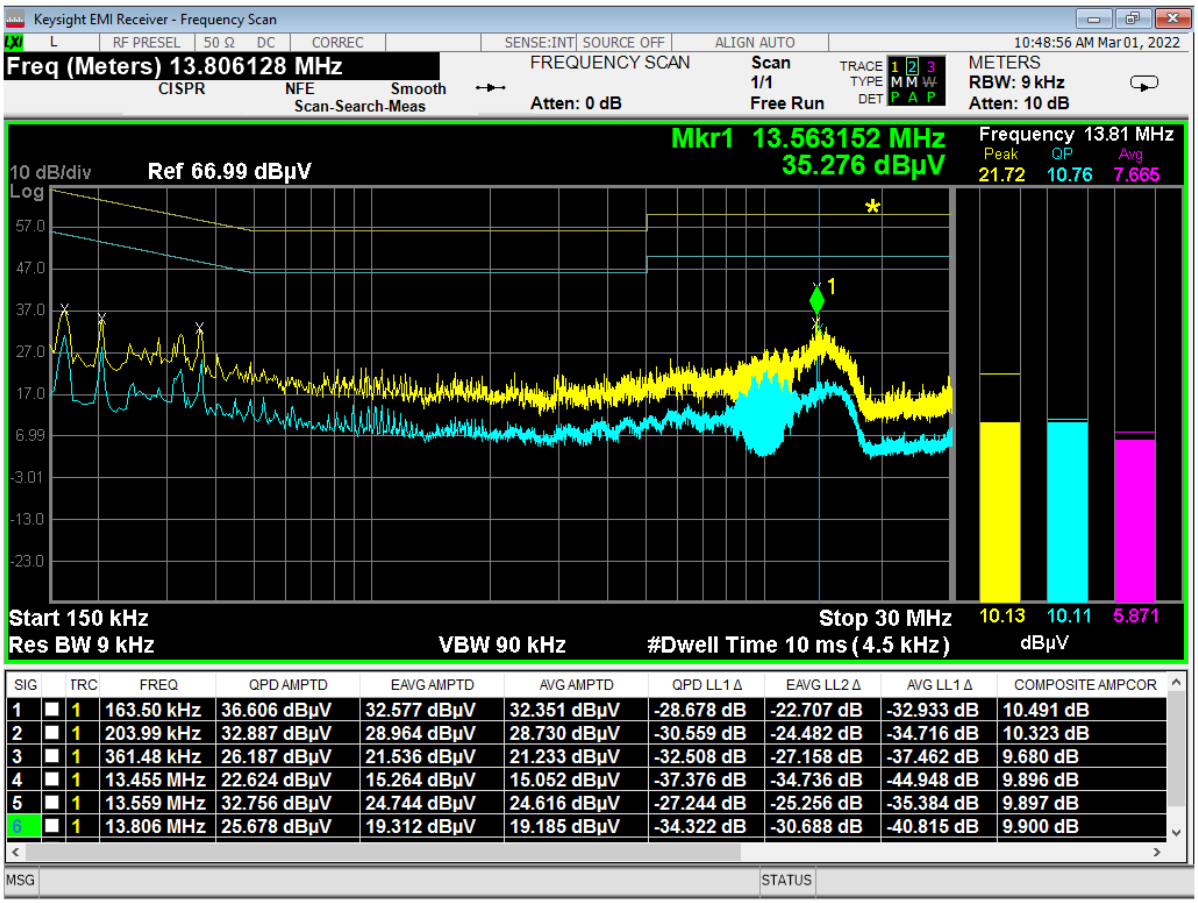
EUT operating conditions:
Details can be found in section 2.1 of this report.
.

Test Results:



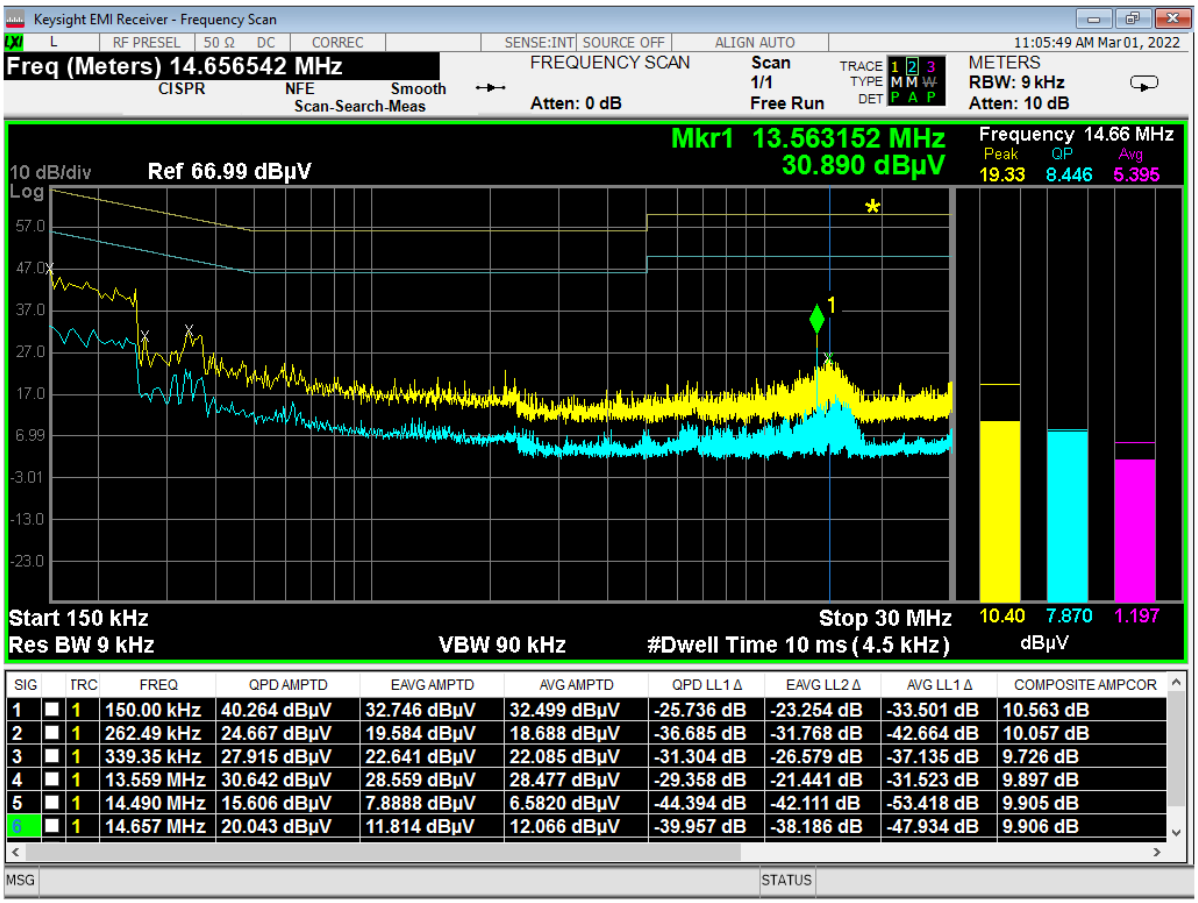
SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	159.00 kHz	34.038 dBµV	30.927 dBµV	30.659 dBµV	-31.478 dB	-24.589 dB	-34.857 dB	10.511 dB
2	1	325.48 kHz	29.508 dBµV	27.945 dBµV	27.867 dBµV	-30.058 dB	-21.620 dB	-31.699 dB	9.784 dB
3	1	365.98 kHz	30.176 dBµV	28.444 dBµV	28.360 dBµV	-28.415 dB	-20.147 dB	-30.232 dB	9.684 dB
4	1	13.559 MHz	36.492 dBµV	33.136 dBµV	33.046 dBµV	-23.508 dB	-16.864 dB	-26.954 dB	9.897 dB
5	1	14.247 MHz	22.481 dBµV	15.404 dBµV	15.091 dBµV	-37.519 dB	-34.596 dB	-44.909 dB	9.904 dB
6	1	14.337 MHz	24.100 dBµV	16.687 dBµV	16.525 dBµV	-35.900 dB	-33.313 dB	-43.475 dB	9.904 dB

Figure 7 – Conducted Emissions Plot, Line, NFC



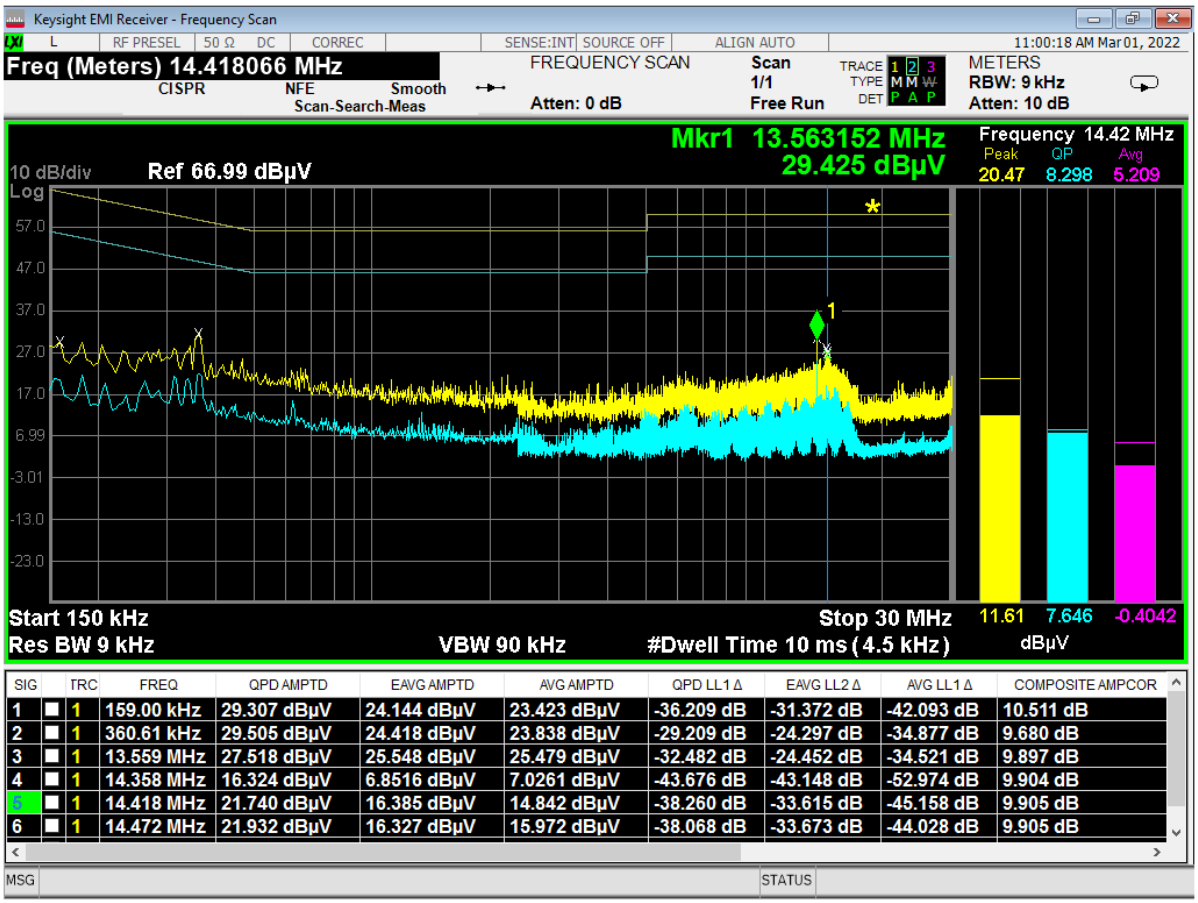
SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	163.50 kHz	36.606 dBµV	32.577 dBµV	32.351 dBµV	-28.678 dB	-22.707 dB	-32.933 dB	10.491 dB
2	1	203.99 kHz	32.887 dBµV	28.964 dBµV	28.730 dBµV	-30.559 dB	-24.482 dB	-34.716 dB	10.323 dB
3	1	361.48 kHz	26.187 dBµV	21.536 dBµV	21.233 dBµV	-32.508 dB	-27.158 dB	-37.462 dB	9.680 dB
4	1	13.455 MHz	22.624 dBµV	15.264 dBµV	15.052 dBµV	-37.376 dB	-34.736 dB	-44.948 dB	9.896 dB
5	1	13.559 MHz	32.756 dBµV	24.744 dBµV	24.616 dBµV	-27.244 dB	-25.256 dB	-35.384 dB	9.897 dB
6	1	13.806 MHz	25.678 dBµV	19.312 dBµV	19.185 dBµV	-34.322 dB	-30.688 dB	-40.815 dB	9.900 dB

Figure 8 – Conducted Emissions Plot, Neutral, NFC



SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	150.00 kHz	40.264 dBµV	32.746 dBµV	32.499 dBµV	-25.736 dB	-23.254 dB	-33.501 dB	10.563 dB
2	1	262.49 kHz	24.667 dBµV	19.584 dBµV	18.688 dBµV	-36.685 dB	-31.768 dB	-42.664 dB	10.057 dB
3	1	339.35 kHz	27.915 dBµV	22.641 dBµV	22.085 dBµV	-31.304 dB	-26.579 dB	-37.135 dB	9.726 dB
4	1	13.559 MHz	30.642 dBµV	28.559 dBµV	28.477 dBµV	-29.358 dB	-21.441 dB	-31.523 dB	9.897 dB
5	1	14.490 MHz	15.606 dBµV	7.8888 dBµV	6.5820 dBµV	-44.394 dB	-42.111 dB	-53.418 dB	9.905 dB
6	1	14.657 MHz	20.043 dBµV	11.814 dBµV	12.066 dBµV	-39.957 dB	-38.186 dB	-47.934 dB	9.906 dB

Figure 9 – Conducted Emissions Plot, Line, Idle



SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	159.00 kHz	29.307 dBµV	24.144 dBµV	23.423 dBµV	-36.209 dB	-31.372 dB	-42.093 dB	10.511 dB
2	1	360.61 kHz	29.505 dBµV	24.418 dBµV	23.838 dBµV	-29.209 dB	-24.297 dB	-34.877 dB	9.680 dB
3	1	13.559 MHz	27.518 dBµV	25.548 dBµV	25.479 dBµV	-32.482 dB	-24.452 dB	-34.521 dB	9.897 dB
4	1	14.358 MHz	16.324 dBµV	6.8516 dBµV	7.0261 dBµV	-43.676 dB	-43.148 dB	-52.974 dB	9.904 dB
5	1	14.418 MHz	21.740 dBµV	16.385 dBµV	14.842 dBµV	-38.260 dB	-33.615 dB	-45.158 dB	9.905 dB
6	1	14.472 MHz	21.932 dBµV	16.327 dBµV	15.972 dBµV	-38.068 dB	-33.673 dB	-44.028 dB	9.905 dB

Figure 10 – Conducted Emissions Plot, Neutral, Idle

APPENDIX 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
Power (watts) = 10^[Power (dBm)/10] / 1000
Voltage (dBµV) = Power (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(V/m) x d^2]/30 = FS [0.3] for d = 3

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

10log(10^9) is the conversion from micro to milli

APPENDIX 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	30MHz – 18GHz	±3.30 dB

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

REPORT END