

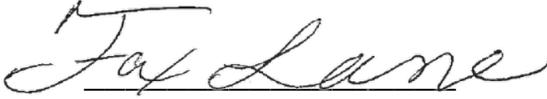
FCC/ISED DXX Part 15.225 Test Report

Prepared for: Garmin International Inc.

Address: 1200 E. 151st Street
Olathe, Kansas, 66062, USA

Product: AC4308

Test Report No: R20211005-21-E16B

Approved By: 
Fox Lane
EMC Test Engineer

DATE: 16 May 2022

Total Pages: 23



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Revision Page

Rev. No.	Date	Description
0	5 March 2022	Original – KVepuri / NJohnson Prepared by GLarsen, SProbst and FLane
A	12 May 2022	Added additional test points to Sec 3.2
B	16 May 2022	Removed references to data leveraging

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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

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2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

EUT	AC4308
Test Dates	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)

EUT was tested alongside a similar unit, worst case was reported.

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

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 $28 \pm 4\%$ Temperature of $22 \pm 3^\circ \text{C}$

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.

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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 50 μ H / 250 μ H - 50 Ω	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 Preampfier*	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

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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.

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3.1.6 Test Pictures and/or Figures

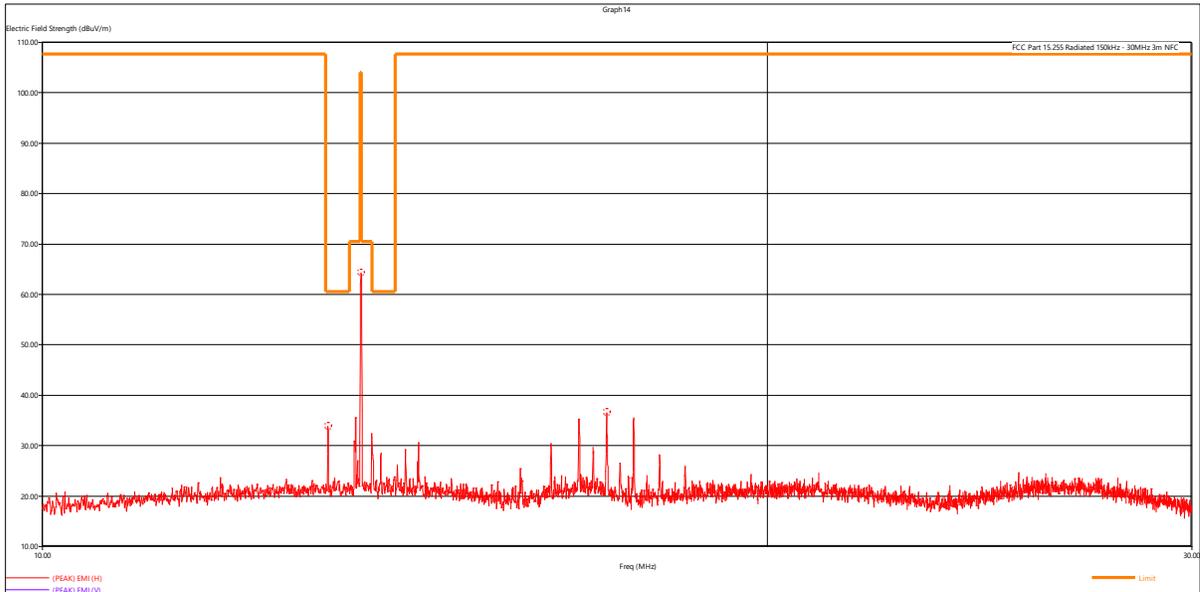


Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz
All emissions were found to be at least 6dB below limit line

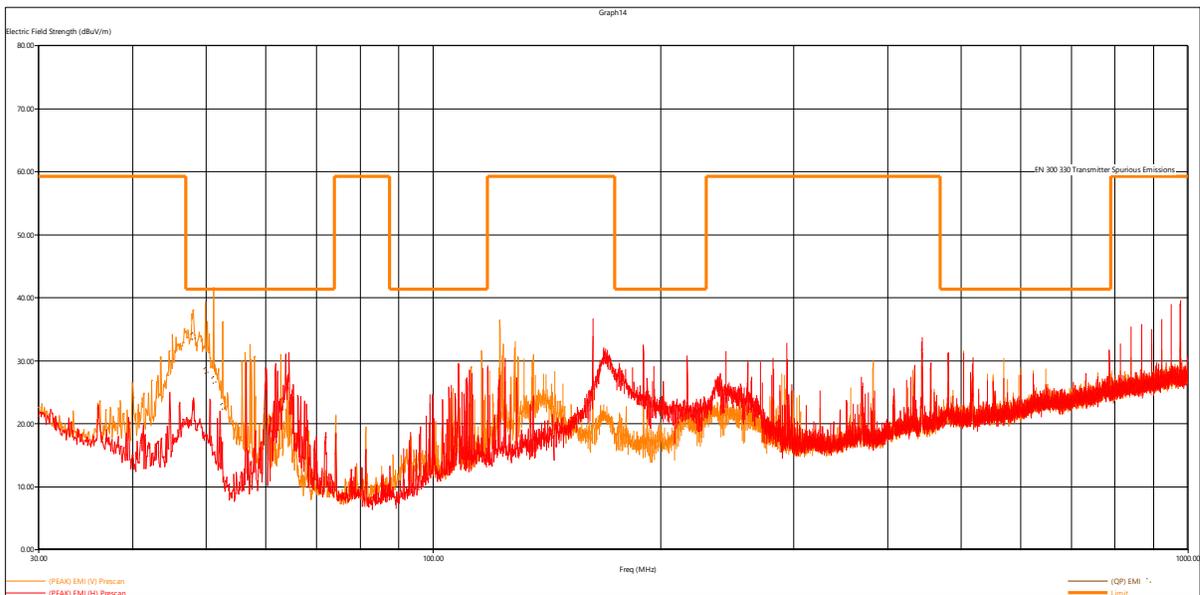


Figure 2 – NFC Radiated Emissions Plot, 30MHz – 1GHz

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Quasi-Peak Measurements						
Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/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

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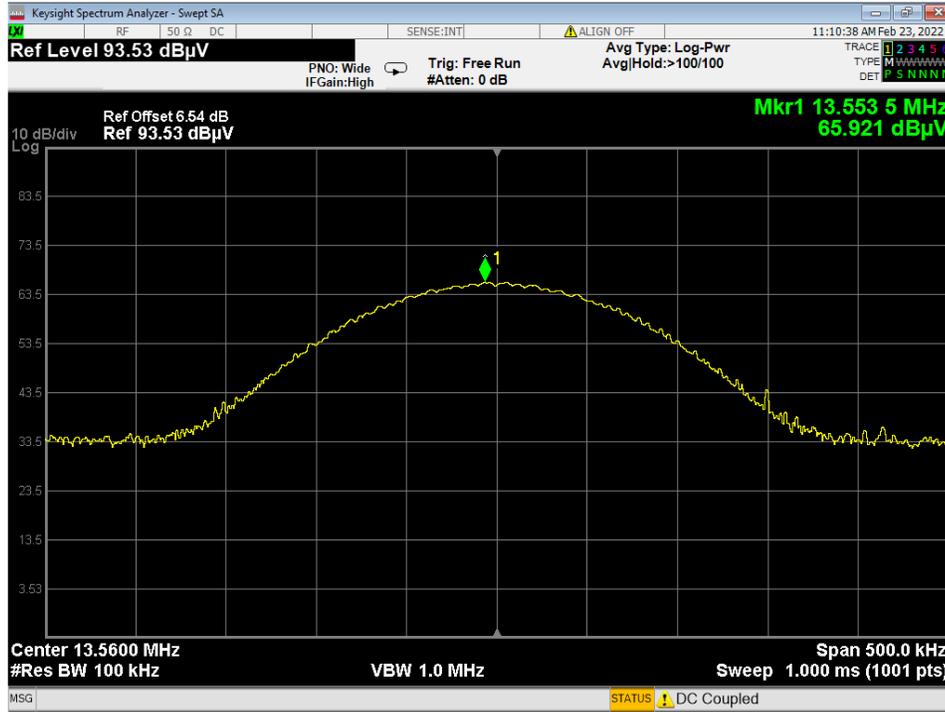


Figure 3 – NFC Field Strength Plot

Corrections included

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

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Band Edge Measurements:

Band edge /Measurement Frequency (MHz)	Corrected band level dB μ V/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.

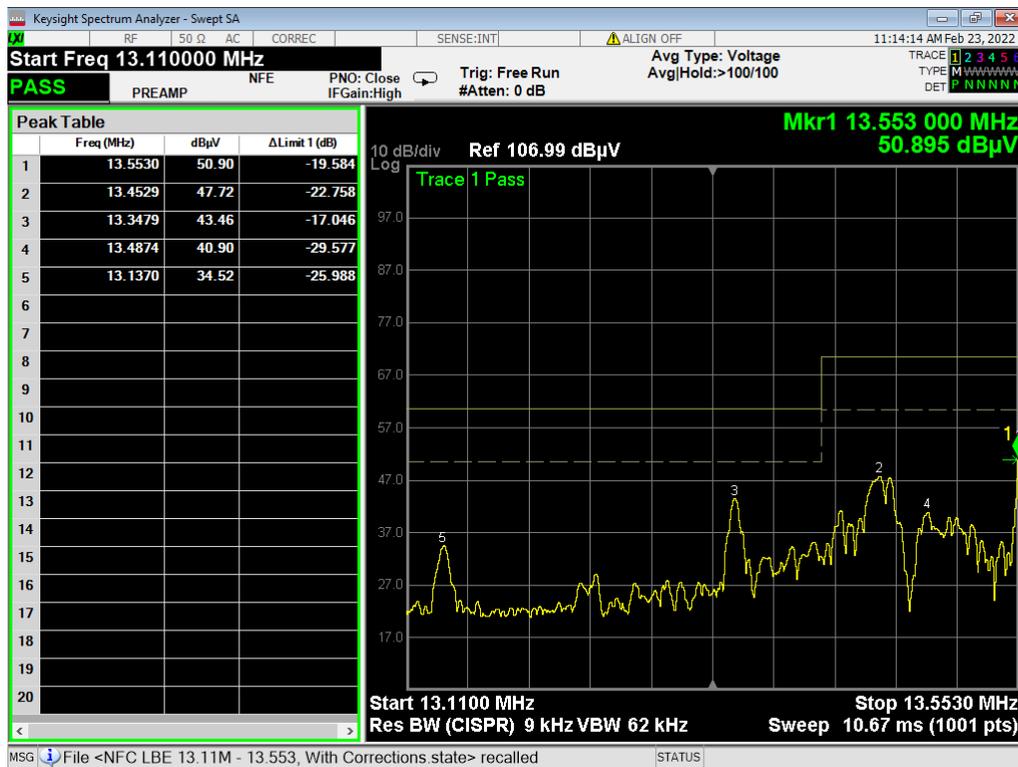


Figure 4 – NFC Lower Band-edge

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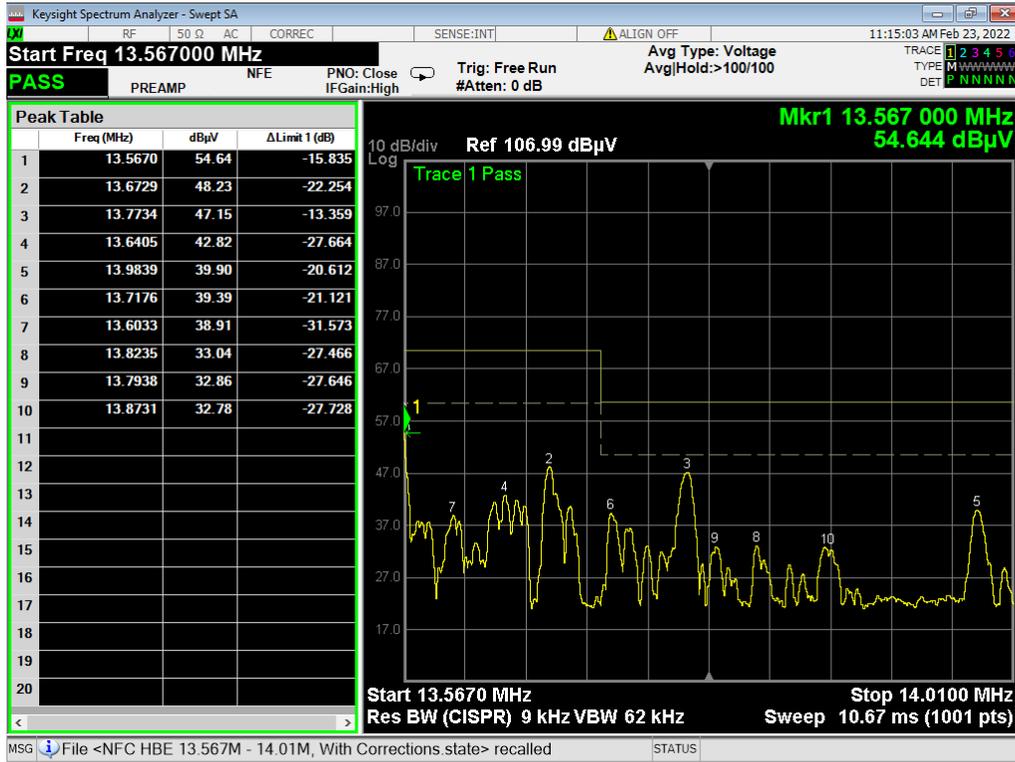


Figure 5 – NFC Higher Bandedge

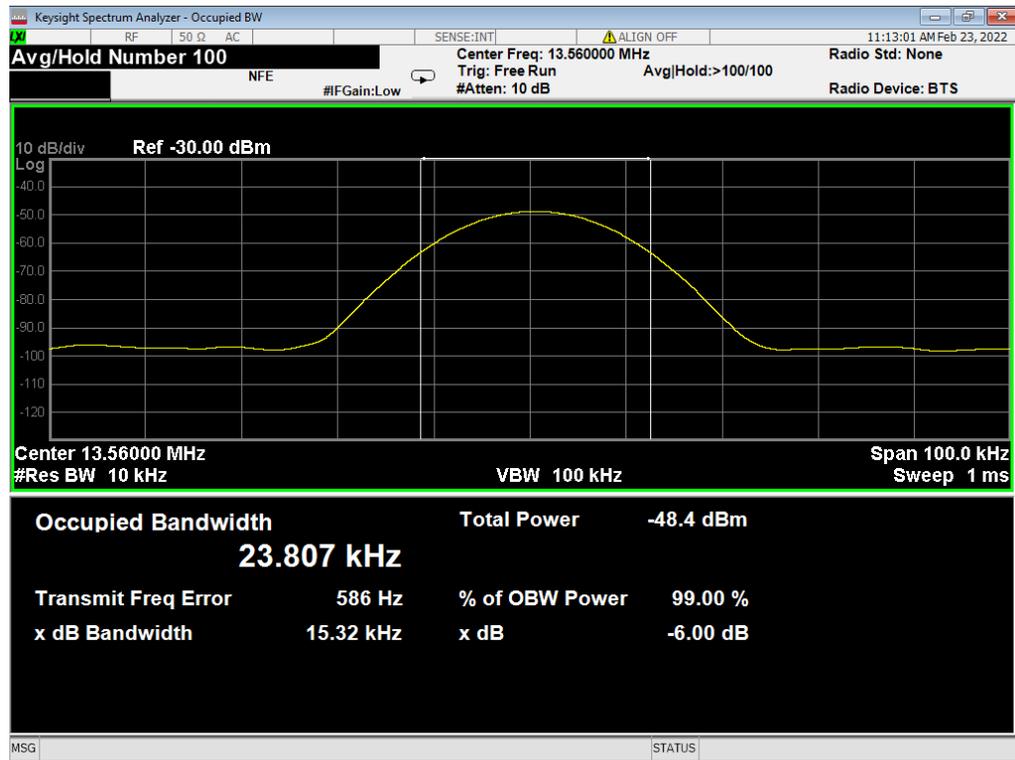


Figure 6 – NFC Occupied Bandwidth

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3.1 Frequency Error

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

3.1.1 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

3.1.2 Test Results

No results were found to be in excess of the limits. A table of the results 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 $30 \pm 5\%$
Temperature of $23 \pm 2^\circ \text{C}$

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.

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3.1.6 Test results

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

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

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3.2 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 (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	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.

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Test Results:

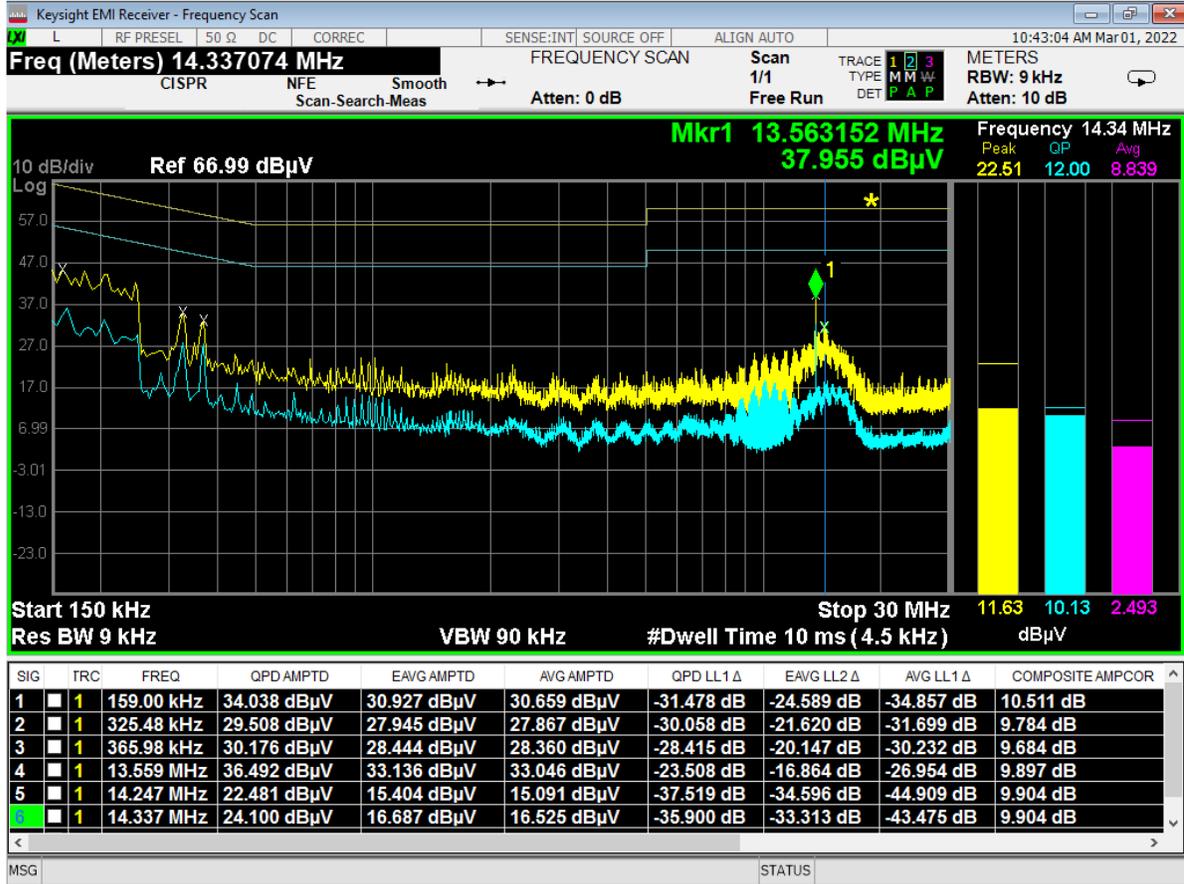


Figure 7 – Conducted Emissions Plot, Line, NFC

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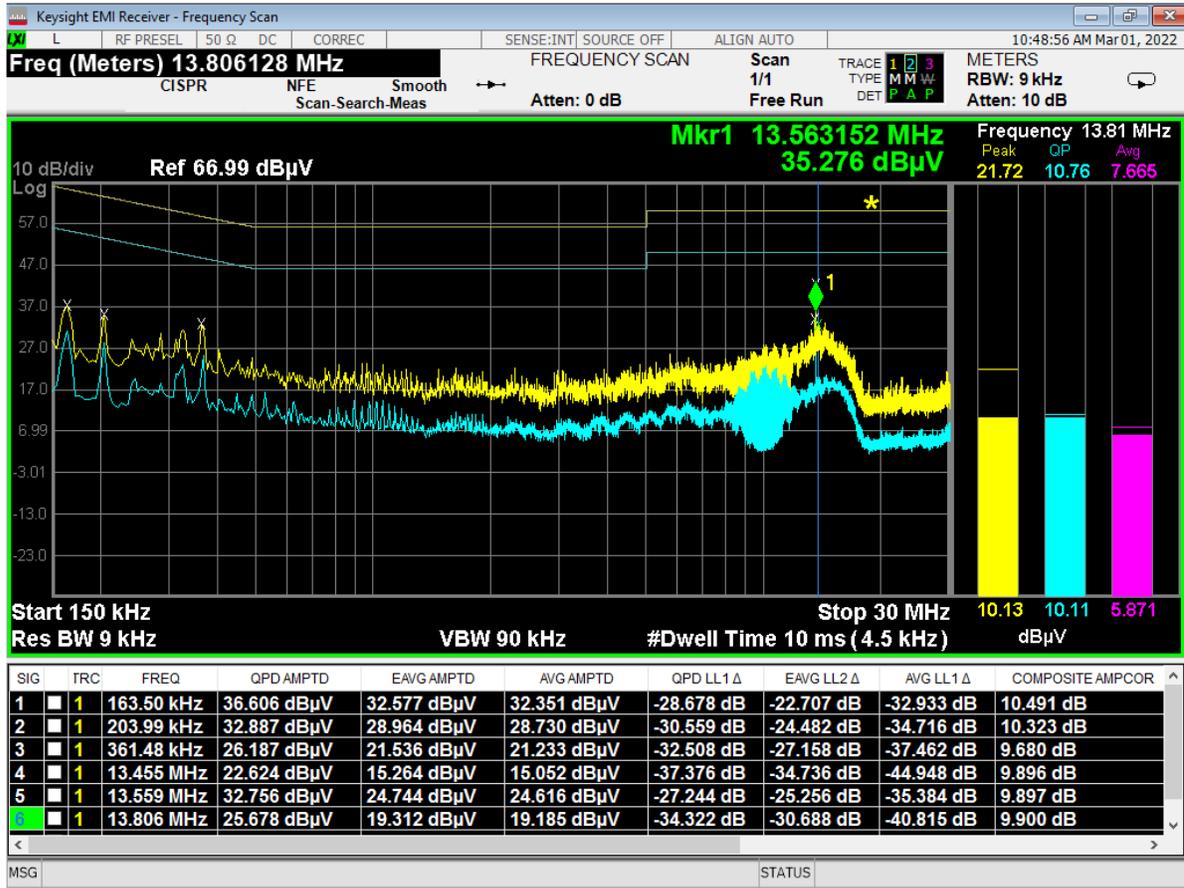


Figure 8 – Conducted Emissions Plot, Neutral, NFC

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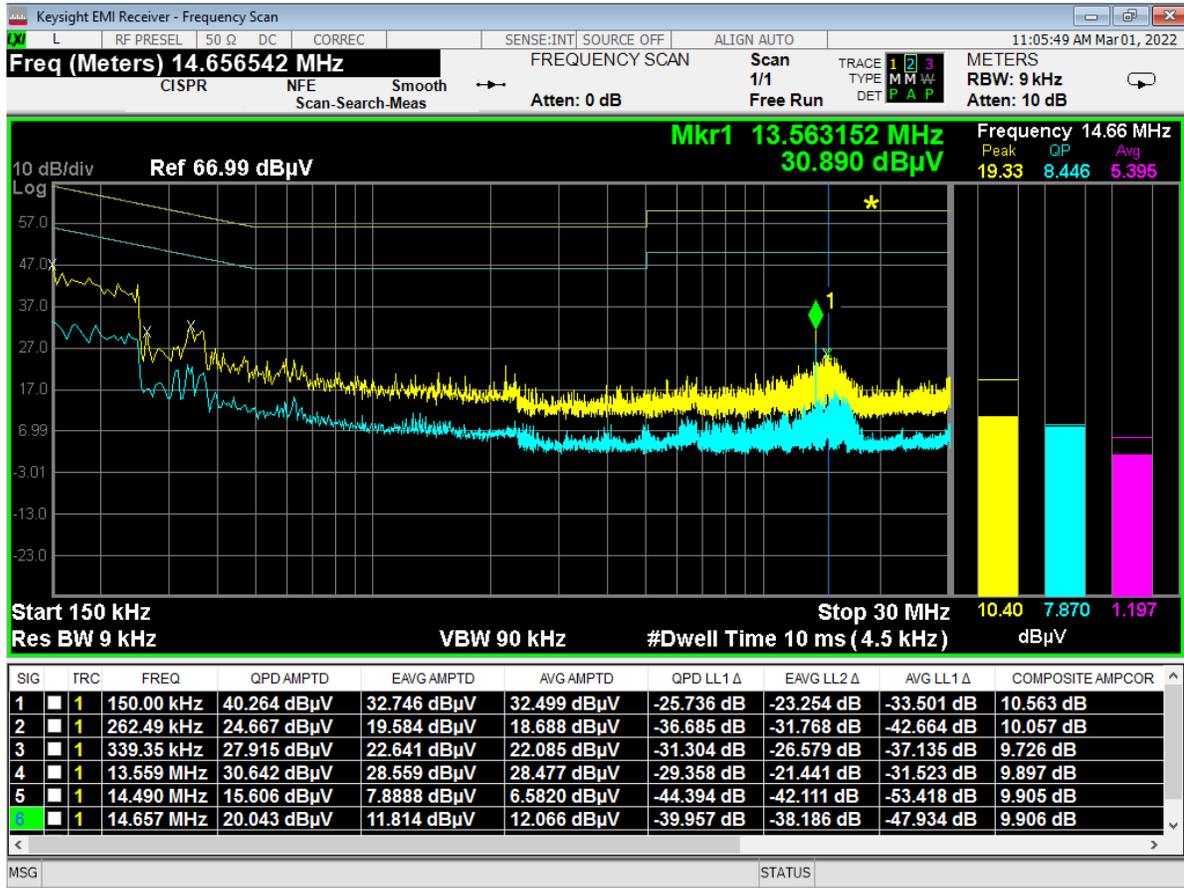


Figure 9 – Conducted Emissions Plot, Line, Idle

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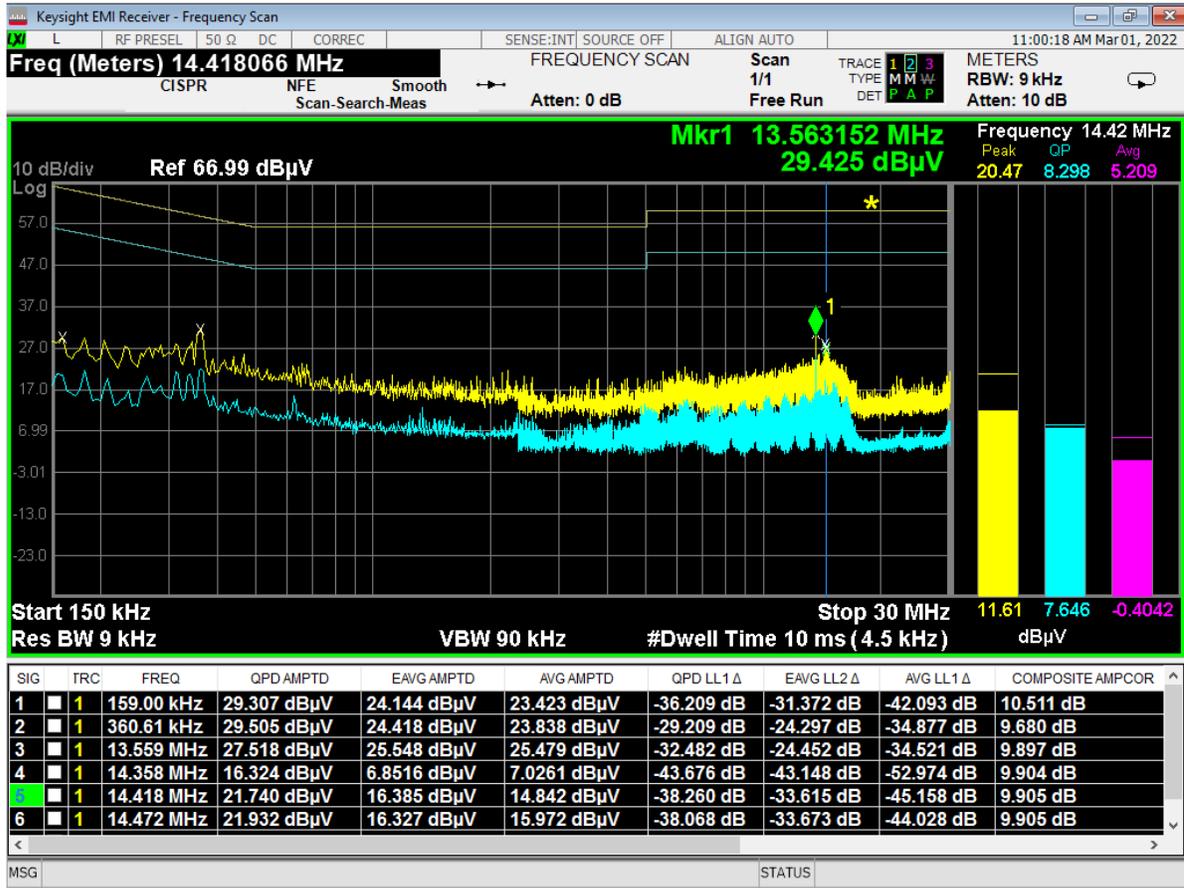


Figure 10 – Conducted Emissions Plot, Neutral, Idle

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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 dB μ V 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 dB μ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

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

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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;

$$EIRP \text{ (Watts)} = [Field \text{ Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[Power \text{ (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[Field \text{ Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

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

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(\text{dBm}) = FS(\text{dB}\mu\text{V/m}) - 10(\log 10^9) + 10\log[0.3] = FS(\text{dB}\mu\text{V/m}) - 95.23$$

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

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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%.

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