

FCC/ISED DXX Part 15.225 Test Report

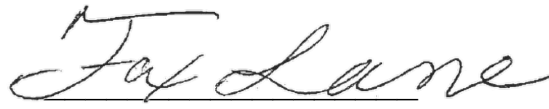
Prepared for: Garmin International Inc.

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

Product: A04543

Test Report No: R20230109-20-E9A

Approved By:


Fox Lane
EMC Test Engineer

DATE: 13 April 2023

Total Pages: 21



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	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

Revision Page

Rev. No.	Date	Description
0	31 March 2023	Issued by FLane Reviewed by FLane Prepared by GLarsen
A	13 April 2023	Corrected FCC/IC ID - FL

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

TABLE OF CONTENTS

1	Summary of Test Results	4
1.1	Emissions Test Results	4
2	EUT Description.....	5
2.1	Equipment under Test (EUT)	5
2.2	Laboratory Description	5
2.3	EUT Setup	5
3	Test Results	6
3.1	Radiated Emissions, Band Width, Field Strength and Band edge.....	6
3.2	Frequency Error	13
3.3	Conducted AC Mains Emissions.....	15
	APPENDIX A: SAMPLE CALCULATION.....	18
	APPENDIX B – MEASUREMENT UNCERTAINTY	20
	REPORT END	21

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

1 Summary of Test Results

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section(s):

1.1 Emissions Test Results

The EUT was tested for compliance to:

US CFR Title 47 FCC Part 15.225
RSS-210 Issue 10

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

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

EUT	A04543
FCC ID	IPH-04543
IC ID	1792A-04543
EUT Received	13 February 2023
EUT Tested	15 February 2023- 10 March 2023
Serial No.	3436743098 (Radiated Measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	☐ GMSK ☐ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☐ 802.11x ☒ NFC
Power Supply / Voltage	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (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 $28 \pm 4\%$
 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.

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

3 Test Results

3.1 Radiated Emissions, Band Width, Field Strength and Band edge

Test:	FCC Part 15.225 (a), (b), (c), (d)
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
150kHz – 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 $30 \pm 5\%$
Temperature of $23 \pm 2^\circ \text{C}$

3.1.4 Test Setup

See Section 2.3 for further details.

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

3.1.5 Test Equipment Used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
Com-Power Active Loop Antenna	AI-130R	10160084	April 12, 2022	April 12, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber- VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

*Internal Characterization

**Two Year Calibration Cycle

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

3.1.6 Test Pictures and/or Figures

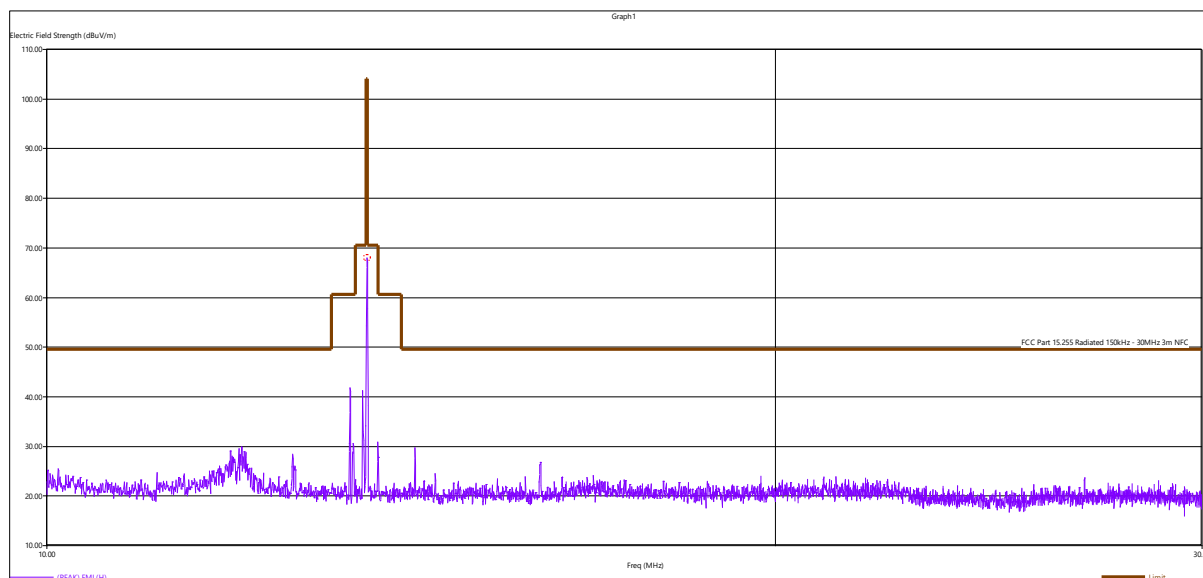


Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz

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

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

Peak Measurements, 10MHz – 30MHz			
Freq (MHz)	(PEAK) EMI (H) (dBuV/m)	Limit (dBuV/m)	(PEAK) Margin (H) (dB)
13.560000	67.93	104.00	36.07

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other emissions were found to be at least 6dB below the limit line.

NFC Field Strength			
Field Strength (dBμV/m)	Limit (dBμV/m)*	Margin	Result
67.93	104.00	36.07	PASS

*Limit extrapolated to 3m test distance.

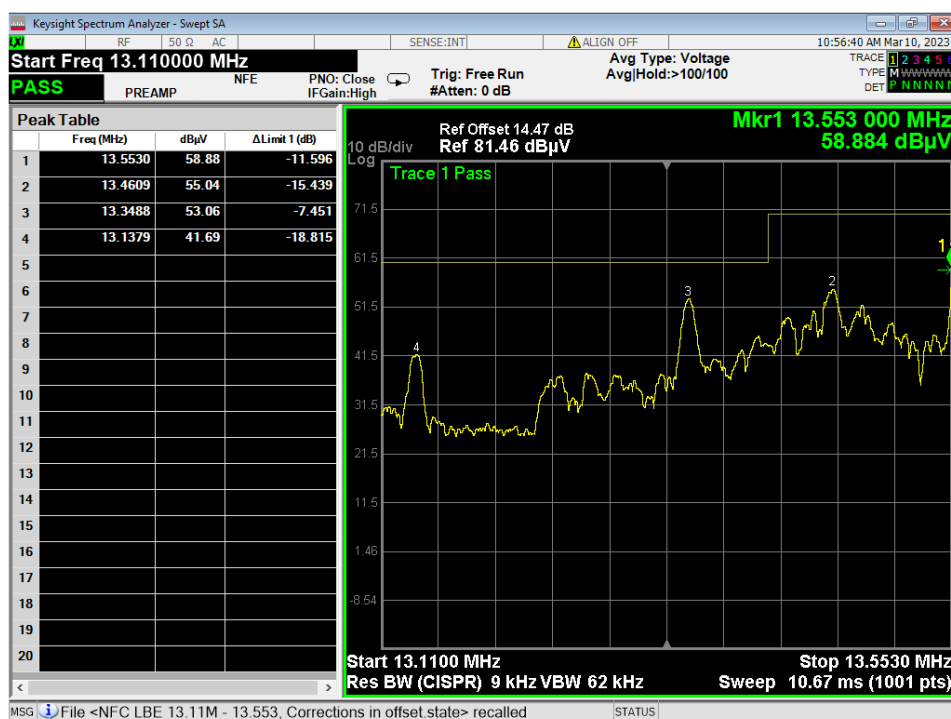


Figure 2 – Lower Band Edge

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		



Figure 3 – Upper Bandedge

Band Edge Measurements				
Band edge /Measurement Frequency (MHz)	Corrected band level dBμV/m @ 3m	Limit* dBμV	Margin	Result
13.3488	53.06	60.51	7.45	PASS
13.7726	53.35	60.51	7.16	PASS

*Limit extrapolated to 3m test distance

The EUT was maximized in all 3 orthogonal axes. The worst case is shown in the plot above. All other emissions were found to be at least 6dB below the limit line.

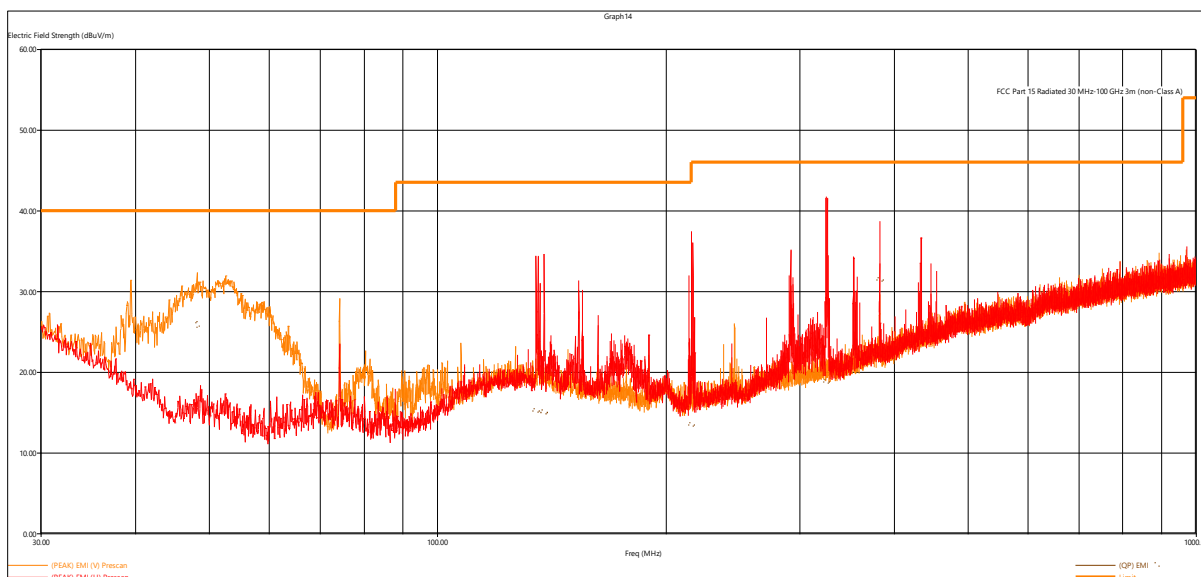


Figure 4 – NFC Radiated Emissions Plot, 30MHz – 1GHz

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

Quasi-Peak Measurements, 30MHz – 1GHz						
Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
134.832480	15.17	43.52	28.35	213.00	350.00	H
138.210000	14.98	43.52	28.54	147.00	348.00	H
216.000240	13.44	46.02	32.58	174.00	179.00	H
325.443120	18.74	46.02	27.28	132.00	20.00	H
382.498080	31.44	46.02	14.58	105.00	270.00	H
48.173760	25.86	40.00	14.14	106.00	275.00	V

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other emissions were found to be at least 6dB below the limit line. System Noise floor was at least 6 dB below the limit line throughout the test range.

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

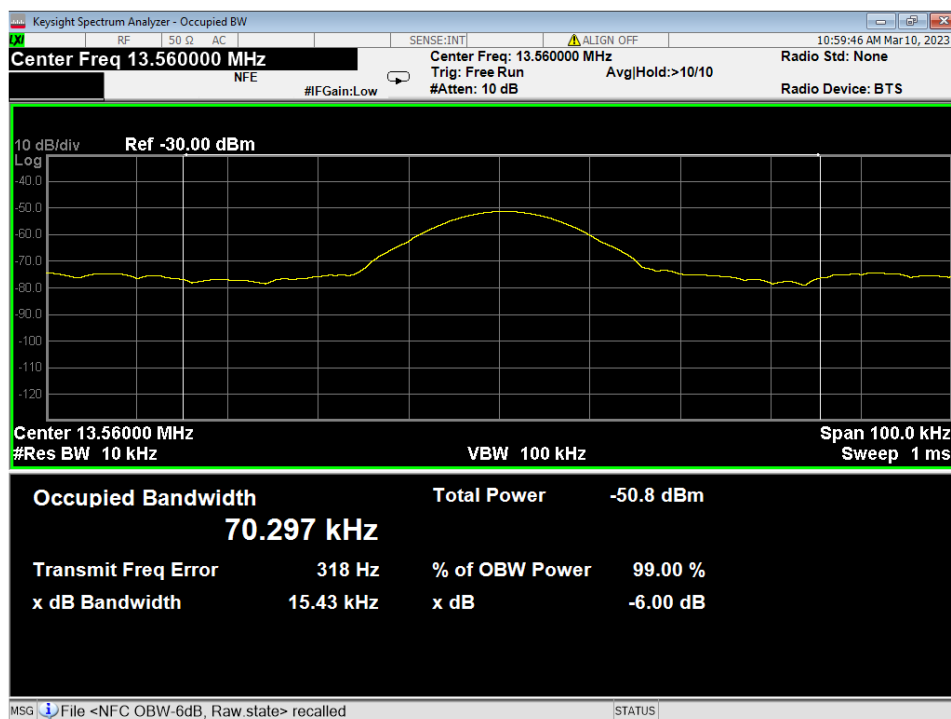


Figure 5 – NFC Occupied Bandwidth

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

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 $30 \pm 5\%$
Temperature of $23 \pm 2^\circ \text{C}$

3.2.4 Test Setup

Device was tested at 100% battery and 1% battery for worst case voltage for frequency error.
See Section 2.3 for further details.

3.2.5 Test Equipment Used

See section 2.4 for the equipment list.

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

3.2.6 Test results

A04543	
Temperature (°C)	Channel (Hz)
	13.56000 Nom.
-20°C	947
-10°C	916
0°C	854
10°C	813
20°C	840
30°C	764
40°C	1003
55°C	950

A04543		Nominal Battery Voltage: 3.87V
Voltage (V)	Temperature	Frequency Error (Hz)
3.54*	20°C	912
3.82	20°C	813
4.12	20°C	816
4.43*	20°C	829

*Tested voltage was the lowest/highest we could get battery powered EUT to achieve

Limit: 100 PPM = 0.01% = 0.01 x 13.56 kHz = 1356 Hz
 Values shown in Hz.
 Uncertainty = ±200 Hz

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

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 (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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	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

Test Results:

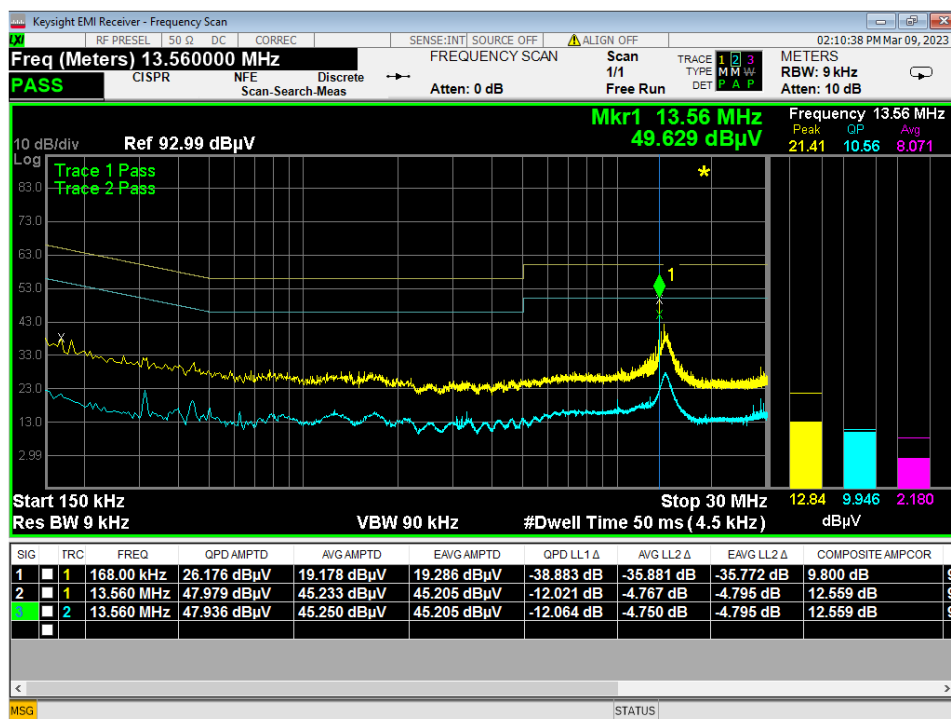


Figure 6 – Conducted Emissions Plot, Line, NFC

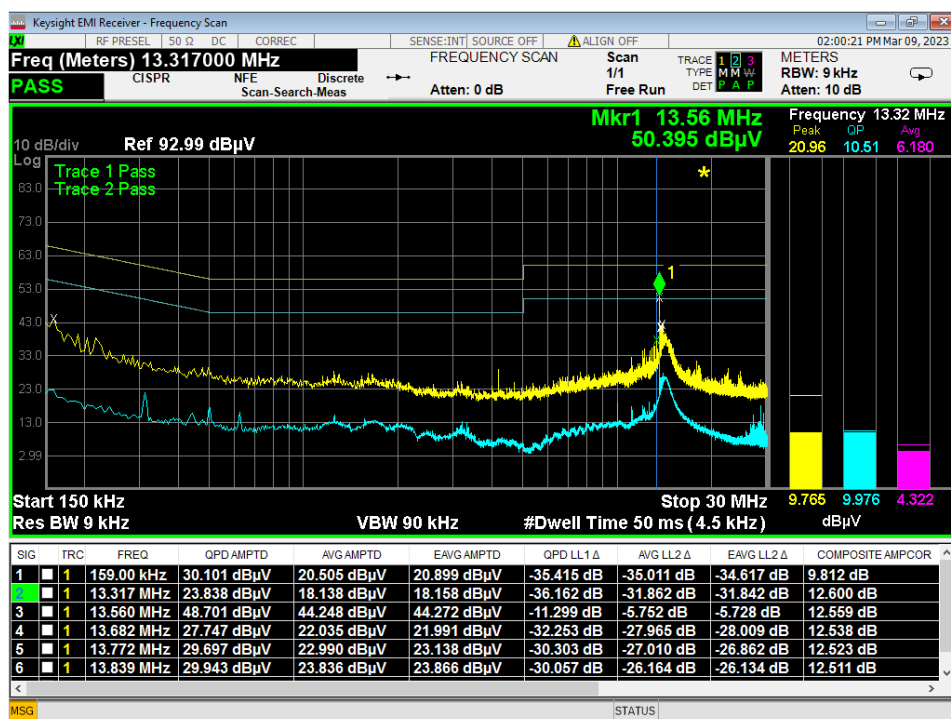


Figure 7 – Conducted Emissions Plot, Neutral, NFC

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

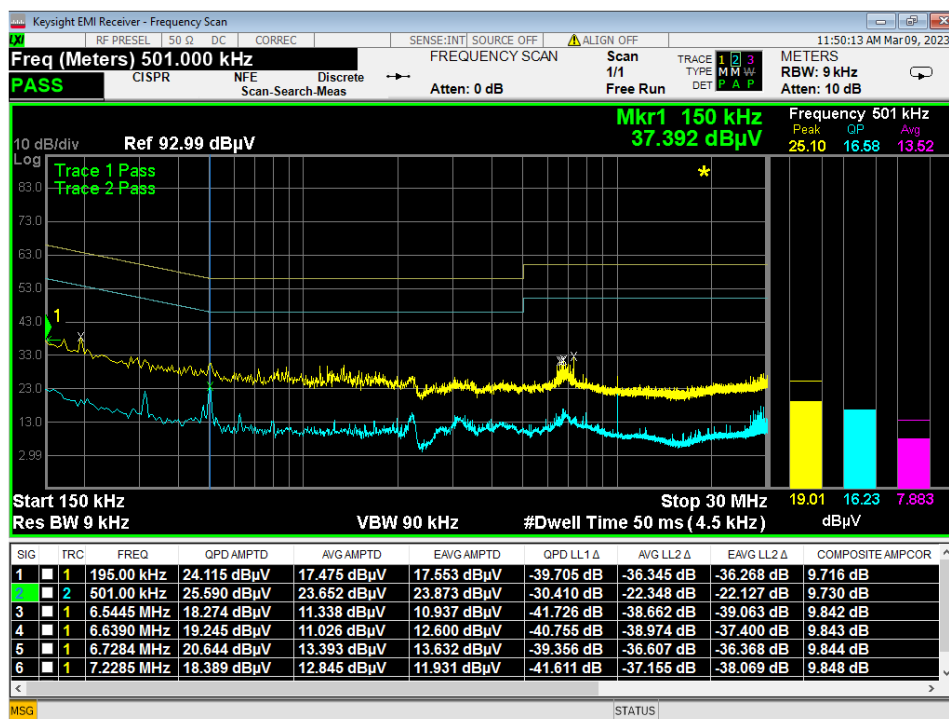


Figure 8 – Conducted Emissions Plot, Line, Idle

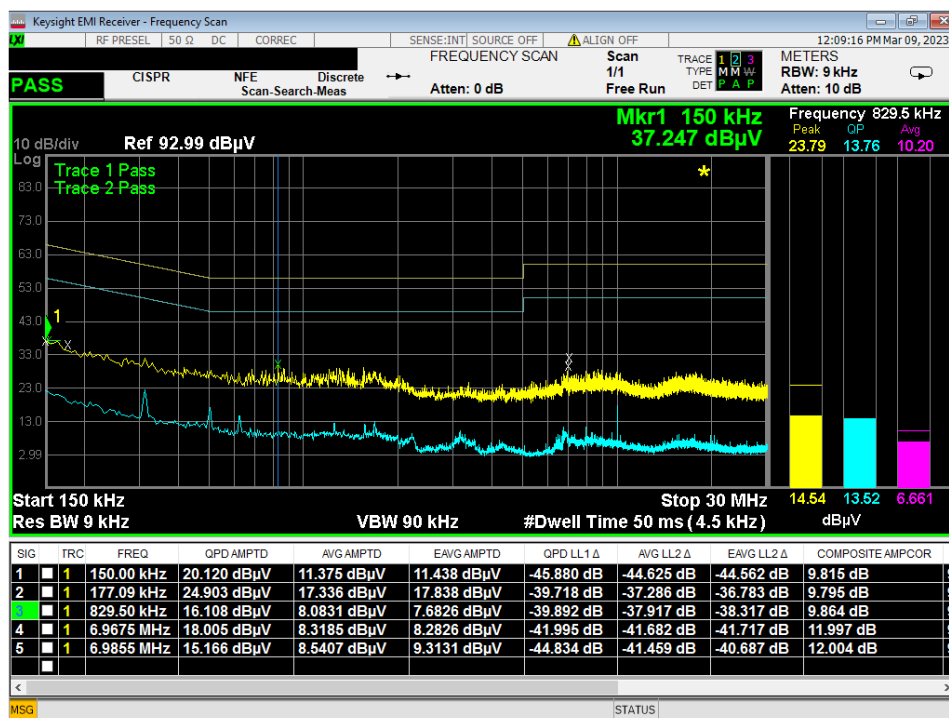


Figure 9 – Conducted Emissions Plot, Neutral, Idle

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

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.

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

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;

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

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

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

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

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

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

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

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

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

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

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	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

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

	Report Number:	R20230109-20-E9A	Rev	A
	Prepared for:	Garmin International, Inc.		

REPORT END