

FCC/ISED DXX Part 15.225 Test Report

Prepared for: Garmin International Inc.

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

Product: A04110

Test Report No: R20210128-20-E35A

Approved By:




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

DATE: 27 December 2021

Total Pages: 22



The Nebraska Center for Excellence in Electronics (NCEE) authorizes the above named company to reproduce this report provided it is reproduced in its entirety for use by the company's employees only. Any use that a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. NCEE accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report applies only to the items tested.

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

Revision Page

Rev. No.	Date	Description
0	27 December 2021	Original – Prepared by FLane Approved by NJohnson
A	4 January 2022	Added Conducted Emissions Section Updated test setup description - FL



	Report Number:	R20210128-20-E35A	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, Output Power and Band edge	6
3.2	Frequency Error	12
3.3	Conducted AC Mains Emissions.....	14
	APPENDIX A: SAMPLE CALCULATION.....	19
	APPENDIX B – MEASUREMENT UNCERTAINTY	21
	REPORT END	22

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

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-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-210, Sec 4.3	Complies
Bandedge	FCC Part 15.225 (b) (c)	Complies
Frequency Error	FCC Part 15.225 (e) RSS-210, Annex D	Complies
Conducted Emissions	FCC Part 15.207 RSS-Gen Issue 4, Section 7.2	Complies

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

Model	A04110
EUT Tested	21 December 2021
Serial No.	3364573626
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 $28 \pm 4\%$


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 except Conducted emissions.

For Conducted emissions an EUT test mode was used to keep NFC card reader emissions off of charging cord.

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

3 Test Results

3.1 Radiated Emissions, Band Width, Output Power 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 axis. 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 $30 \pm 5\%$
Temperature of $23 \pm 2^\circ \text{C}$

3.1.4 Test Setup

See Section 2.3 for further details.

	Report Number:	R20210128-20-E35A	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 (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, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA
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

**Two Year Calibration Cycle

***Three Year Calibration Cycle

3.1.6 Test Pictures and/or Figures

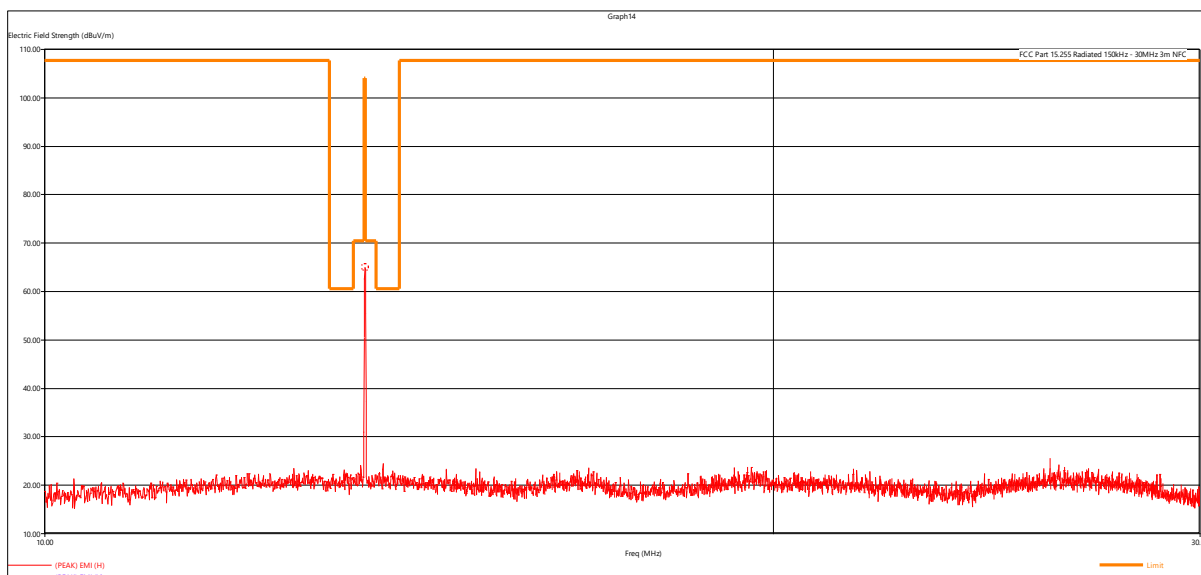


Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz

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

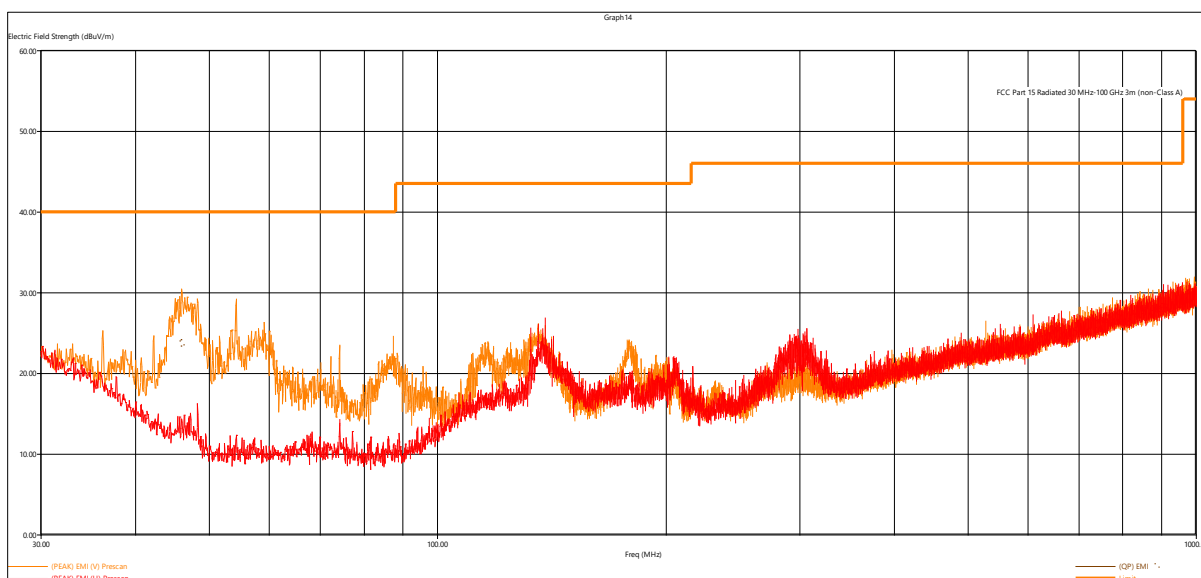



Figure 2 – NFC Radiated Emissions Plot, 30MHz – 1GHz

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

Quasi-Peak Measurements						
Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
45.985200	23.64	40.00	16.36	122.00	310.00	V

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

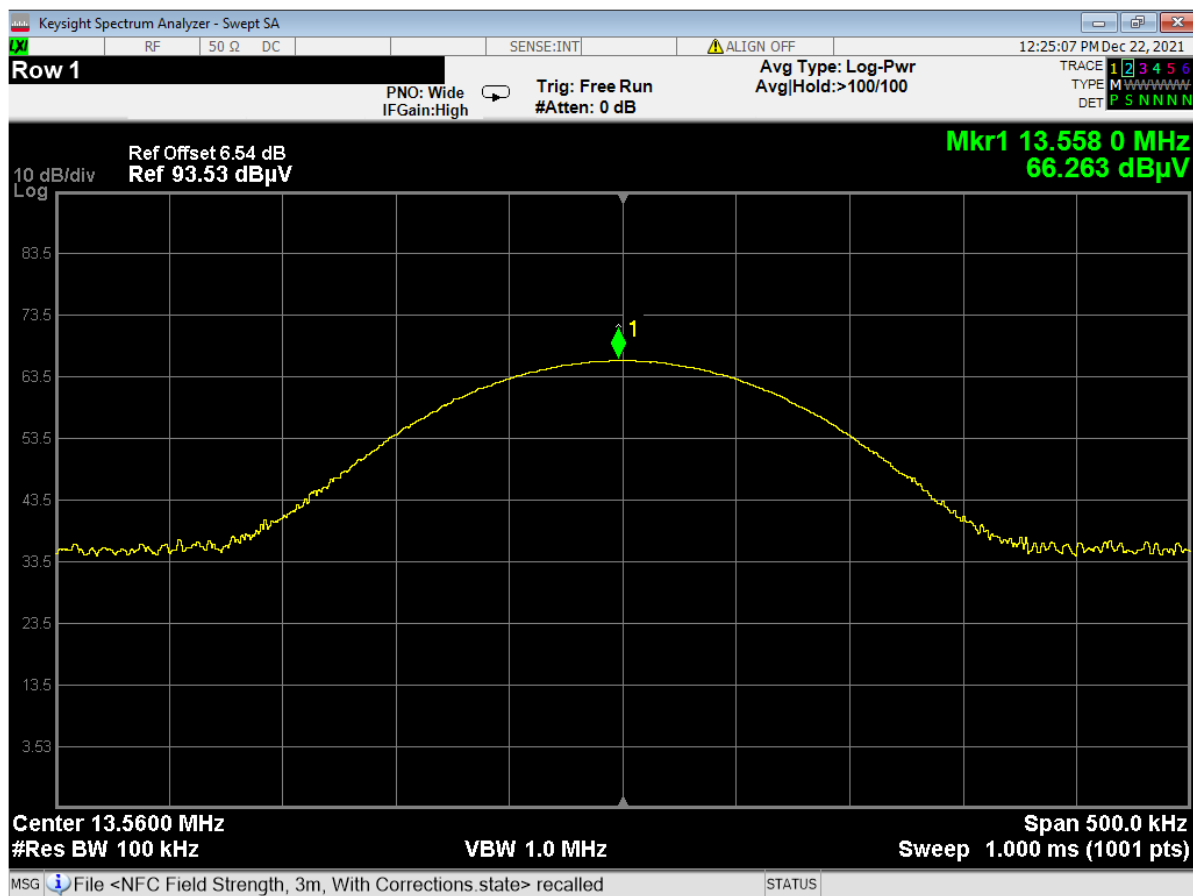



Figure 3 – NFC Field Strength Plot
Corrections included in reference offset

NFC Field Strength			
Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
66.263	104.00	37.737	PASS

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

Band Edge Measurements:

Band edge /Measurement Frequency (MHz)	Corrected band level dB μ V/m @ 3m	Limit* (dBuV)	Margin	Result
13.553	51.327	70.47	19.143	PASS
13.567	54.780	70.47	15.69	PASS

*Limit extrapolated to 3m test distance

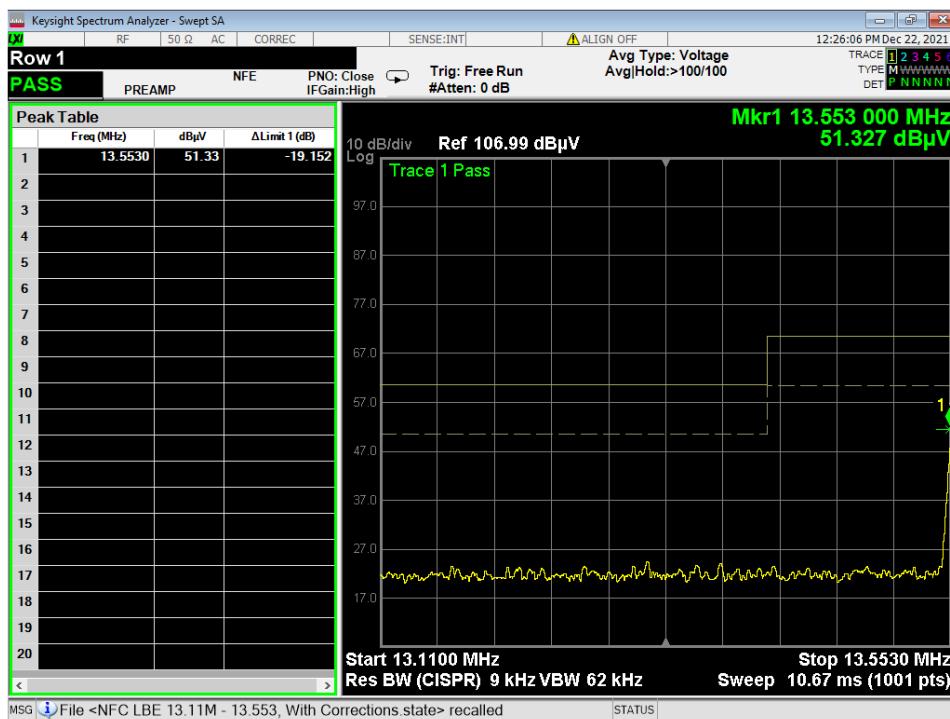



Figure 4 – NFC Lower Bandedge

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

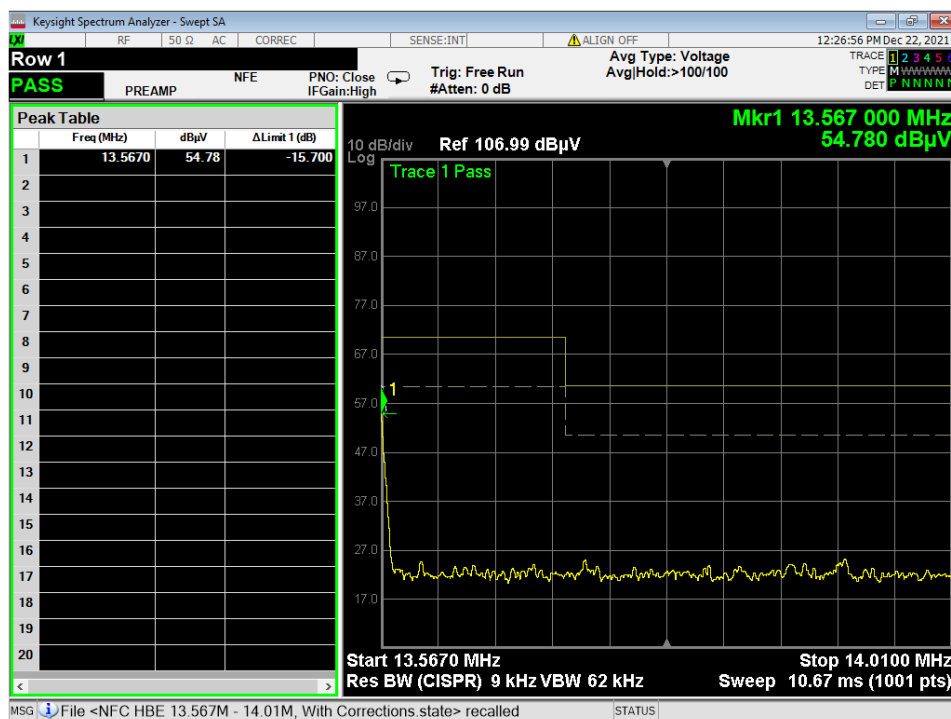


Figure 5 – NFC Higher Bandedge

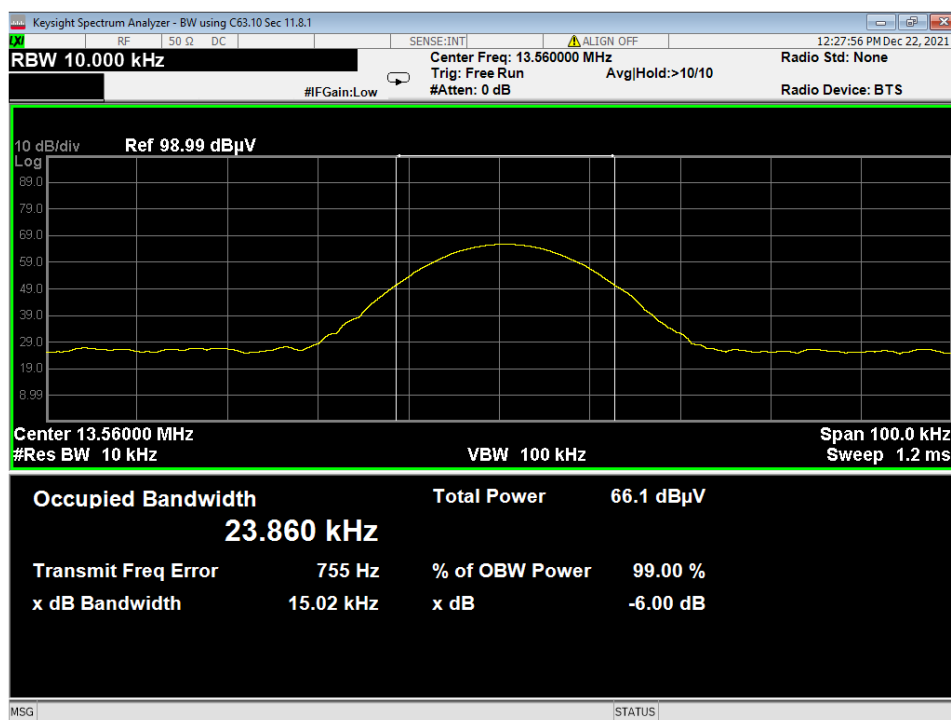



Figure 6 – NFC Occupied Bandwidth

	Report Number:	R20210128-20-E35A	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 50°C.

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


See Section 2.3 for further details.

3.2.5 Test Equipment Used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 21, 2021	July 21, 2023*
EMCO Loop Antenna	6512	00024936	February 11, 2019	February 11, 2022**
Thermotron, Temp Chamber	SE1000-5-5	31373	NA	NA
Omega, Temp. Humidity Meter	iTHX-SD	ID # 2130155	April 23, 2021	April 23, 2023*

*2 Year Calibration Cycle

**3 Year Calibration Cycle

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

3.2.6 Test results

A04110	
Temperature (°C)	Channel (MHz)
	13.56000 Nom.
-20°C	724
-10°C	705
0°C	656
10°C	602
20°C	546
30°C	494
40°C	459
50°C	43


A04110		
Temperature (°C)	Voltage (VDC)	Channel (MHz)
		13.56
20°C	3.2	649
20°C	3.9	575
20°C	4.75	546

Voltage ranges provided by the manufacturer

Limit: 100 PPM = 0.01% = 0.01 x 13.56 kHz = 1356 Hz

Values shown in Hz.

Uncertainty = ±500 Hz

	Report Number:	R20210128-20-E35A	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.

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

Test Results:

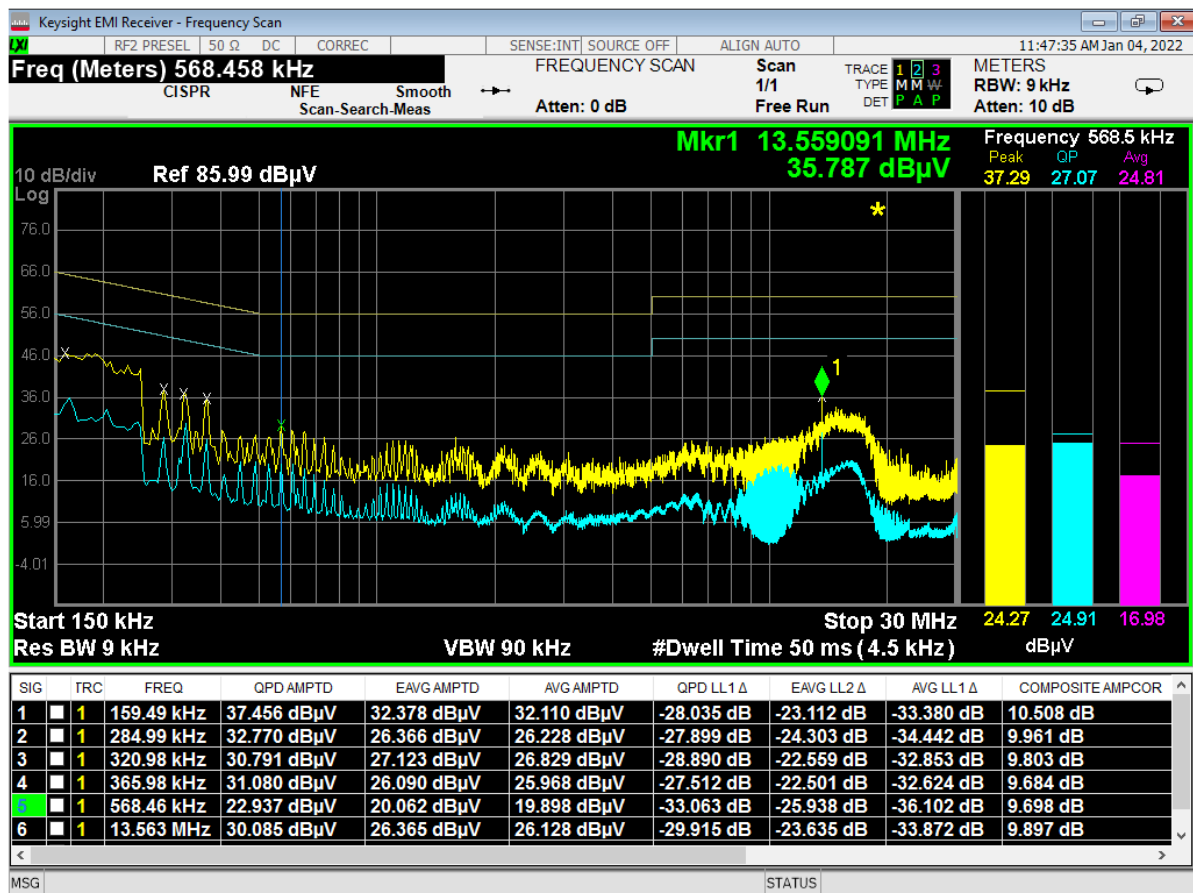



Figure 7 – Conducted Emissions Plot, Line, NFC

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

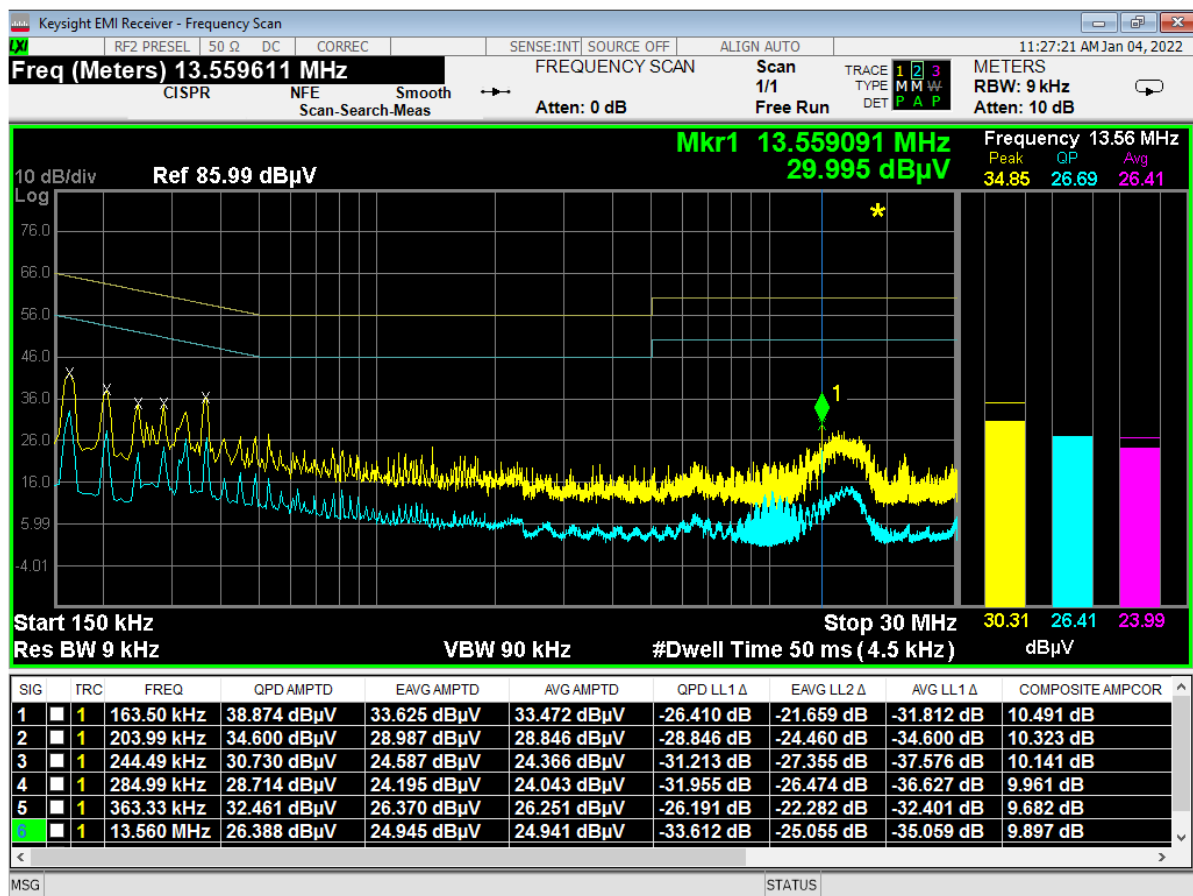



Figure 8 – Conducted Emissions Plot, Neutral, NFC

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

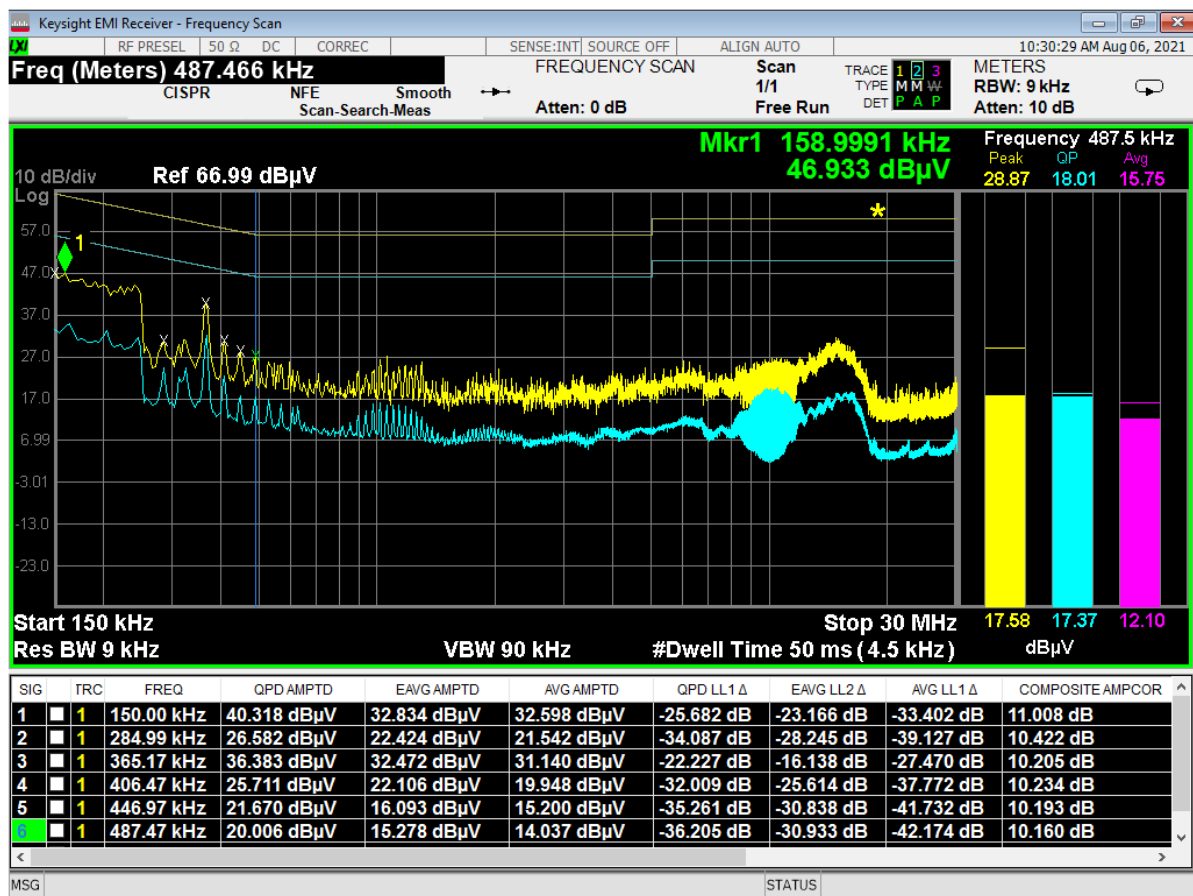



Figure 9 – Conducted Emissions Plot, Line, Idle

	Report Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

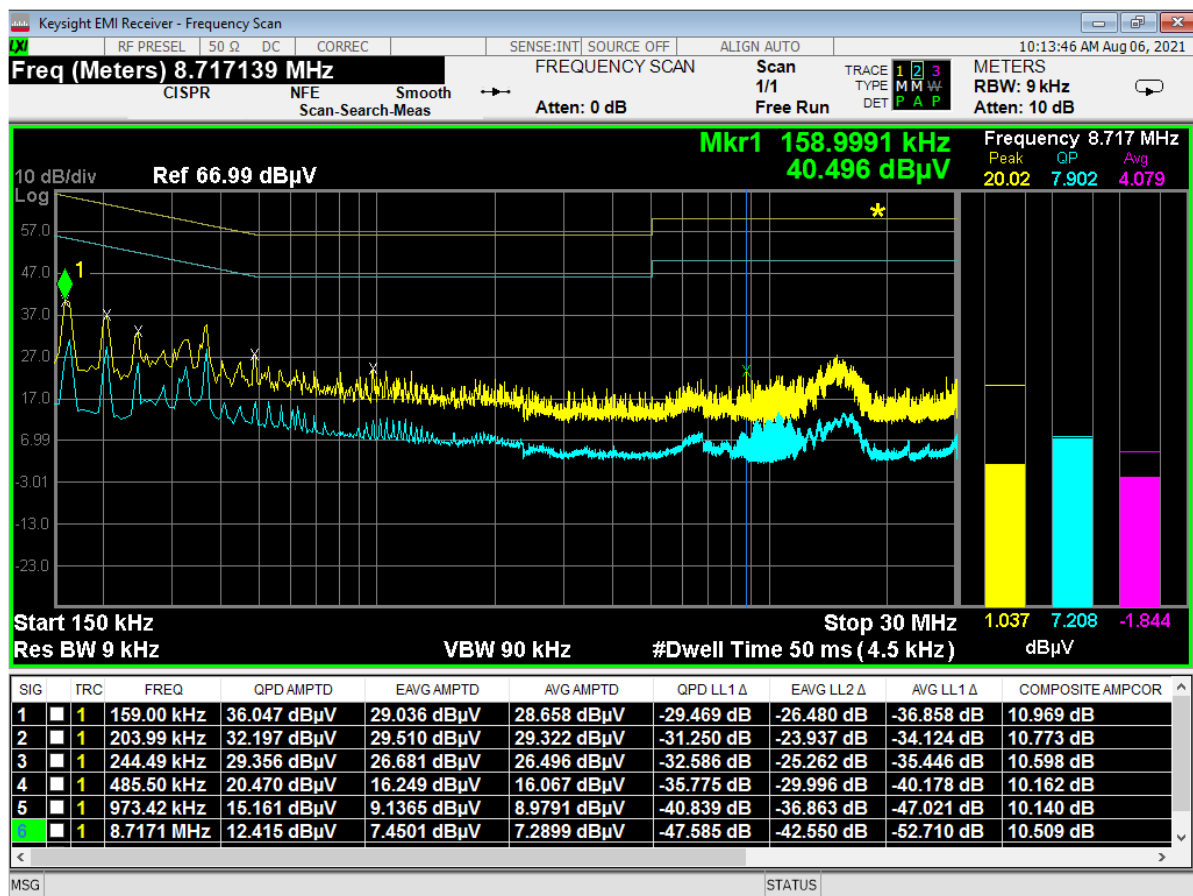



Figure 10 – Conducted Emissions Plot, Neutral, Idle

	Report Number:	R20210128-20-E35A	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:	R20210128-20-E35A	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;

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

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

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

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


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

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

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

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

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


	Report Number:	R20210128-20-E35A	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	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 Number:	R20210128-20-E35A	Rev	A
	Prepared for:	Garmin International, Inc.		

REPORT END