

FCC/ISED Test Report

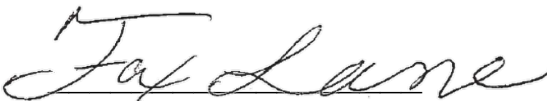
Prepared for: Garmin International, Inc.

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

Product: A04540

Test Report No: R20221213-20-E2

Approved by:


Fox Lane,
EMC Test Engineer

DATE: February 8, 2023

Total Pages: 29

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Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

REVISION PAGE

Rev. No.	Date	Description
0	8 February 2023	Issued by FLane Reviewed by KVepuri Prepared by FLane



Report Number: R20221213-20-E2

Rev

0

Prepared for: Garmin International, Inc.

CONTENTS

Revision Page	2
1.0 Summary of test results.....	4
2.0 EUT Description	5
2.1 Equipment under test	5
2.2 Description of test modes	5
2.3 Description of support units.....	5
3.0 Laboratory and General Test Description	6
3.1 Laboratory description.....	6
3.2 Test personnel.....	6
3.3 Test equipment.....	7
3.4 General Test Procedure and Setup for Radio Measuremnts.....	8
4.0 Results	9
4.1 Duty Cycle	10
4.2 Radiated emissions.....	11
4.3 Band edges	17
4.4 Conducted AC Mains Emissions	18
Appendix A: Sample Calculation	21
Appendix B – Measurement Uncertainty	23
Appendix C – Graphs and Tables	24
REPORT END.....	29

	Report Number:	R20221213-20-E2	Rev	0
	Prepared for:	Garmin International, Inc.		

1.0 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:

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15.249
- (2) ISSED RSS-Gen, Issue 5
- (3) ISSED RSS-210, Issue 10

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
NA, Informational purpose only	Bandwidth	NA
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 FCC 15.249(a) RSS-210 Issue 10, Annex F.1(a) RSS-Gen Issue 5, Section 6.13	Transmitter Radiated Emissions	Pass
FCC Part 15.209, 15.249(d) RSS-210 Issue 10 Annex F.1(e) RSS-Gen Issue 5, Section 6.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass

	Report Number:	R20221213-20-E2	Rev	0
	Prepared for:	Garmin International, Inc.		

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04540
IC	1792A-04540
FCC ID	IPH-04540
EUT Received	28 December 2022
EUT Tested	4 January 2023- 24 January 2023
Serial No.	3419589455 (Radiated Measurements) 3419589465 (Conducted Measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	☐ GMSK ☒ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☐ 802.11x
Power Supply / Voltage	12VDC Marine battery / 5VDC USB Garmin MN: PSAL05R-050Q PN: 362-00072-00 (Representative power supply for Conducted AC Emissions)

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

2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

GFSK Transmissions

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

2.3 DESCRIPTION OF SUPPORT UNITS

None

	Report Number:	R20221213-20-E2	Rev	0
	Prepared for:	Garmin International, Inc.		

3.0 LABORATORY AND GENERAL TEST DESCRIPTION

3.1 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
 NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of $35 \pm 4\%$
 Temperature of $22 \pm 3^\circ$ Celsius



3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Review/Testing and Report
2	Ethan Schmidt	Test Technician	Testing

Notes: All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



Report Number: R20221213-20-E2

Rev

0

Prepared for: Garmin International, Inc.

3.3 TEST EQUIPMENT

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
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 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
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	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

**2 Year Cal Cycle

***3 Year Cal Cycle

Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

	Report Number:	R20221213-20-E2	Rev	0
	Prepared for:	Garmin International, Inc.		

3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

Conducted ☒

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

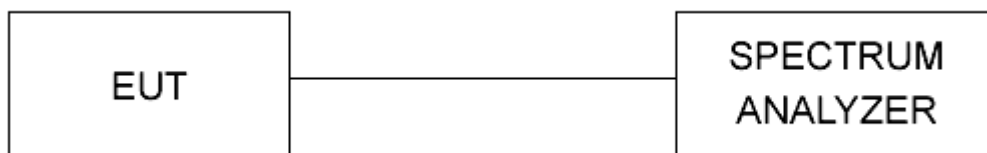


Figure 1 - Bandwidth Measurements Test Setup

Radiated ☒

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

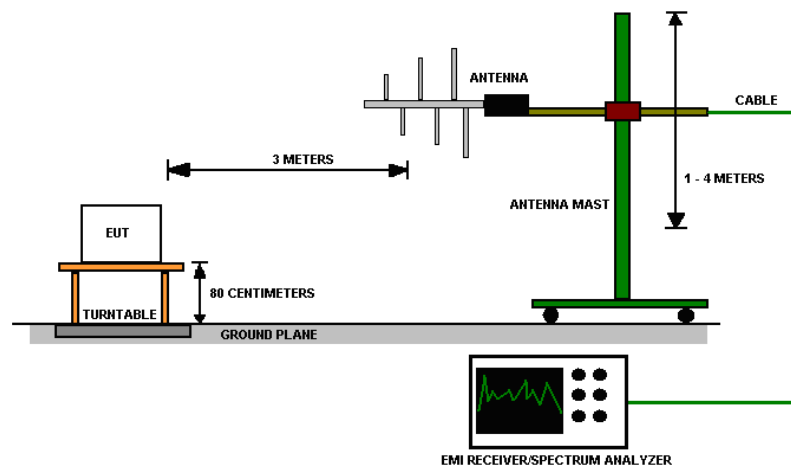


Figure 2 - Radiated Emissions Test Setup



Report Number: R20221213-20-E2

Rev

0

Prepared for: Garmin International, Inc.

4.0 RESULTS**Unrestricted Band-Edge, 50dB Delta**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	GFSK	2400.00	53.906	105.597	51.572	50.00	PASS
High	GFSK	2483.50	50.309	111.505	61.196	50.00	PASS

Peak Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Peak Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GFSK	2390.00	53.731	Peak	73.98	20.249	PASS
High	GFSK	2483.50	55.127	Peak	73.98	18.853	PASS

*Limit shown is the peak limit taken from FCC Part 15.209

Average Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	**Average Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GFSK	2390.00	36.011	Average	53.98	17.969	PASS
High	GFSK	2483.50	37.407	Average	53.98	16.573	PASS

*Limit shown is the average limit taken from FCC Part 15.209

**Average Highest out of band level = Peak highest out of band level + DCCF (See section 4.1 for more details)



Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

4.1 DUTY CYCLE

Test Method:

Manufacturer declares worst-case real world duty cycle to be 13%
 $DCCF = 20 \cdot \log(0.13) = -17.72\text{dB}$

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ($\mu\text{V/m}$)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = $20 * \log * \text{Emission level } (\mu\text{V/m})$.
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

Test procedures:

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

Test setup:

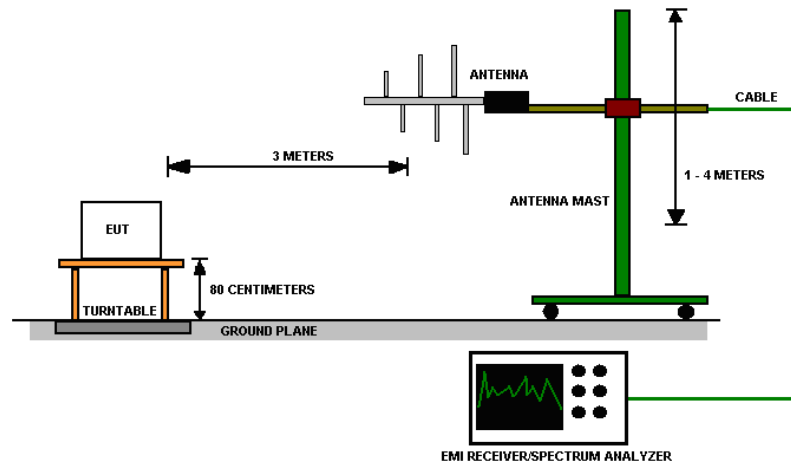


Figure 3 - Radiated Emissions Test Setup

NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

EUT operating conditions

Details can be found in section 2.1 of this report.

Test results:

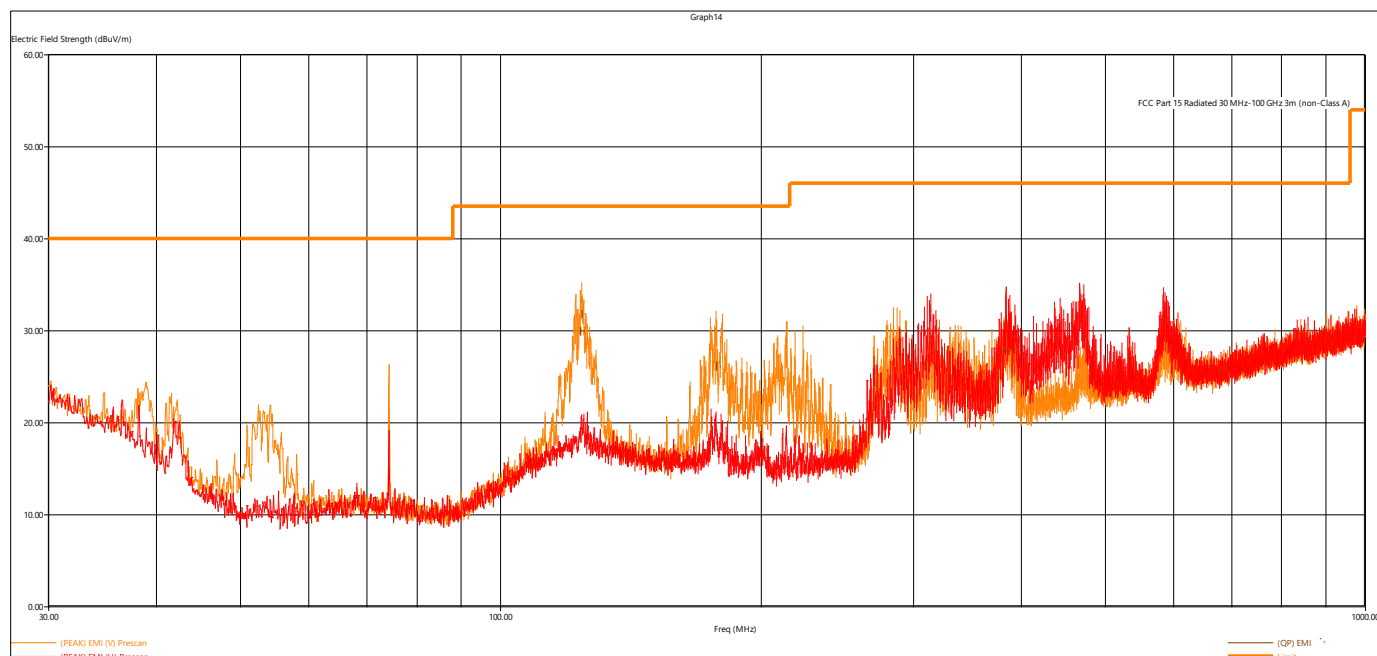


Figure 4 - Radiated Emissions Plot, Receive

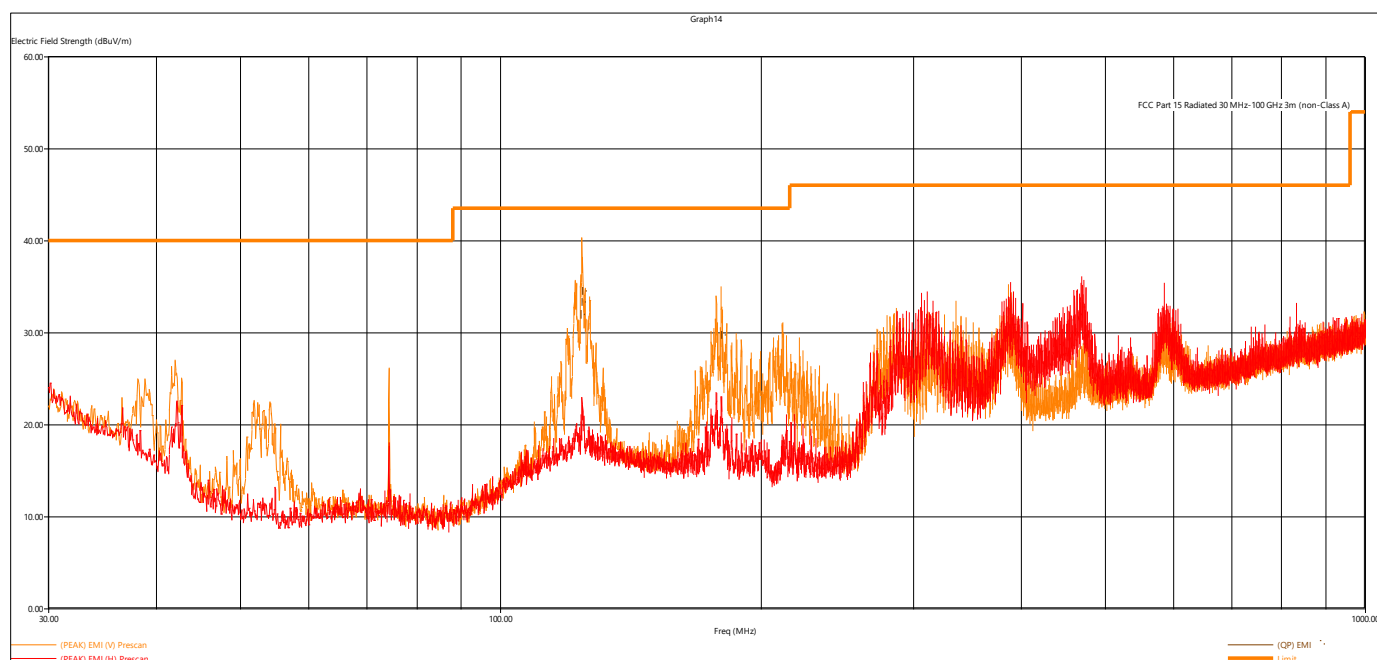


Figure 5 - Radiated Emissions Plot, GFSK

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value - Emission level



Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

Quasi-Peak Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBμV/m	dBμV/m	dB	cm.	deg.			
123.875760	31.85	43.52	11.67	116.00	299.00	V	Low	GFSK
123.932640	33.28	43.52	10.24	105.00	318.00	V	Low	GFSK
124.168560	34.48	43.52	9.04	109.00	297.00	V	Low	GFSK
179.906640	29.68	43.52	13.84	103.00	105.00	V	Low	GFSK
383.748720	27.75	46.02	18.27	215.00	273.00	H	Receive	
123.589440	29.85	43.52	13.67	112.00	337.00	V	Receive	
124.055280	31.72	43.52	11.80	108.00	326.00	V	Receive	
177.382800	26.05	43.52	17.47	118.00	80.00	V	Receive	

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

Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

Peak Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBμV/m	dBμV/m	dB	cm.	deg.			
2402.024000	102.17	NA	NA	342.00	123.00	H	Low	GFSK
2440.162000	101.47	NA	NA	163.00	131.00	H	Mid	GFSK
2480.088000	100.41	NA	NA	153.00	137.00	H	High	GFSK
4803.880000	53.08	73.98	20.90	152.00	338.00	H	Low	GFSK
5762.578000	45.00	73.98	28.98	492.00	0.00	H	Low	GFSK
7207.076000	52.12	73.98	21.86	301.00	82.00	H	Low	GFSK
4880.292000	54.60	73.98	19.38	421.00	349.00	H	Mid	GFSK
7320.090000	56.45	73.98	17.53	112.00	223.00	H	Mid	GFSK
9759.194000	53.57	73.98	20.41	247.00	130.00	V	Mid	GFSK
4959.662000	55.61	73.98	18.37	406.00	359.00	H	High	GFSK
7440.972000	52.50	73.98	21.48	186.00	90.00	H	High	GFSK
9920.228000	54.19	73.98	19.79	292.00	131.00	V	High	GFSK

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

Average Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBμV/m	dBμV/m	dB	cm.	deg.			
2402.024000	84.45	NA	NA	342.00	123.00	H	Low	GFSK
2440.162000	83.75	NA	NA	163.00	131.00	H	Mid	GFSK
2480.088000	82.69	NA	NA	153.00	137.00	H	High	GFSK
4803.880000	35.36	53.98	18.62	152.00	338.00	H	Low	GFSK
5762.578000	27.28	53.98	26.70	492.00	0.00	H	Low	GFSK
7207.076000	34.4	53.98	19.58	301.00	82.00	H	Low	GFSK
4880.292000	36.88	53.98	17.10	421.00	349.00	H	Mid	GFSK
7320.090000	38.73	53.98	15.25	112.00	223.00	H	Mid	GFSK
9759.194000	35.85	53.98	18.13	247.00	130.00	V	Mid	GFSK
4959.662000	37.89	53.98	16.09	406.00	359.00	H	High	GFSK
7440.972000	34.78	53.98	19.20	186.00	90.00	H	High	GFSK
9920.228000	36.47	53.98	17.51	292.00	131.00	V	High	GFSK

Average Level = Peak Level + DCCF, see section 4.1 for more info on DCCF
The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.
All other measurements were found to be at least 6 dB below the limit.



Report Number:	R20221213-20-E2	Rev	0
Prepared for:	Garmin International, Inc.		

4.3 BAND EDGES

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of band-edge measurements:

For FCC Part 15.249 Device:

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation.

Test procedures:

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

Deviations from test standard:

No deviation.

Test setup:

Test setup details can be found in section 3.4 of this report.

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.249 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing compliance with 15.209.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209.
4. Tabulated data is listed in section 4.0.

4.4 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 0.8 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:

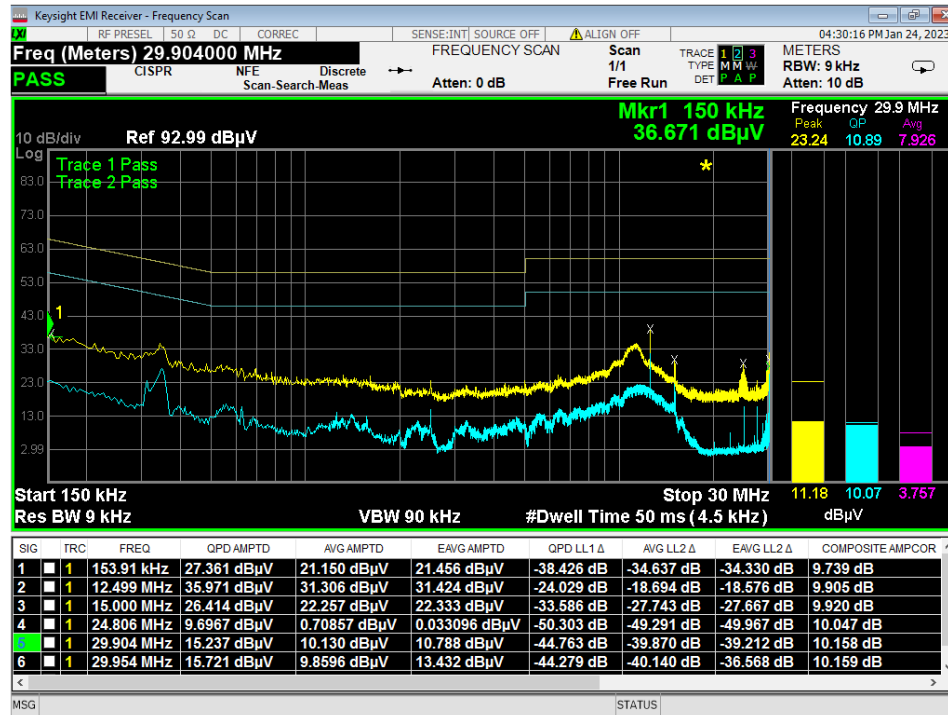


Figure 6 - Conducted Emissions Plot, Line, TX

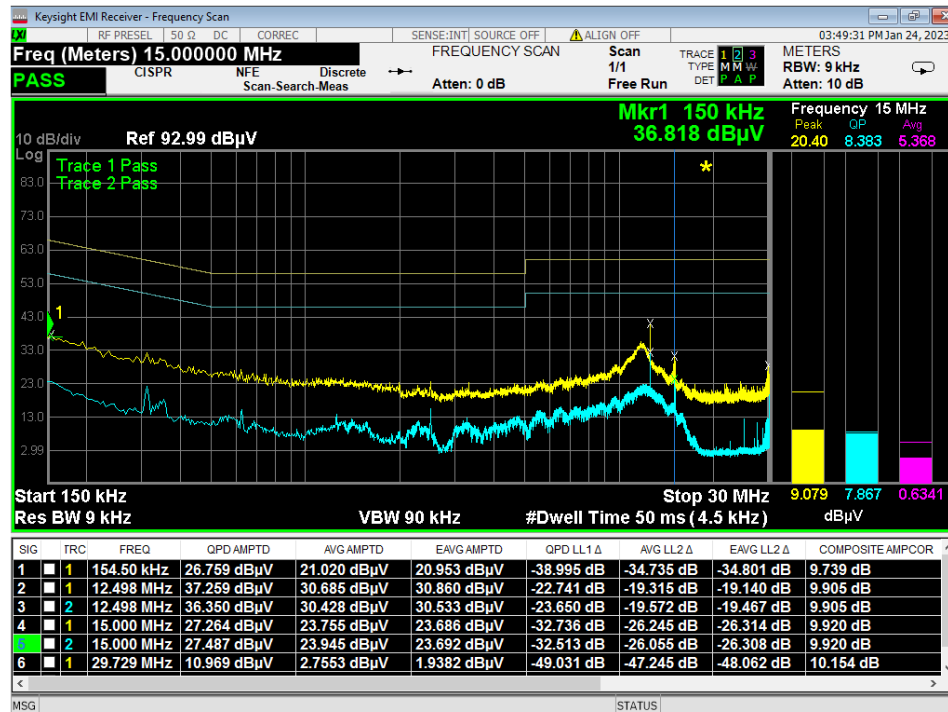


Figure 7 - Conducted Emissions Plot, Neutral, TX

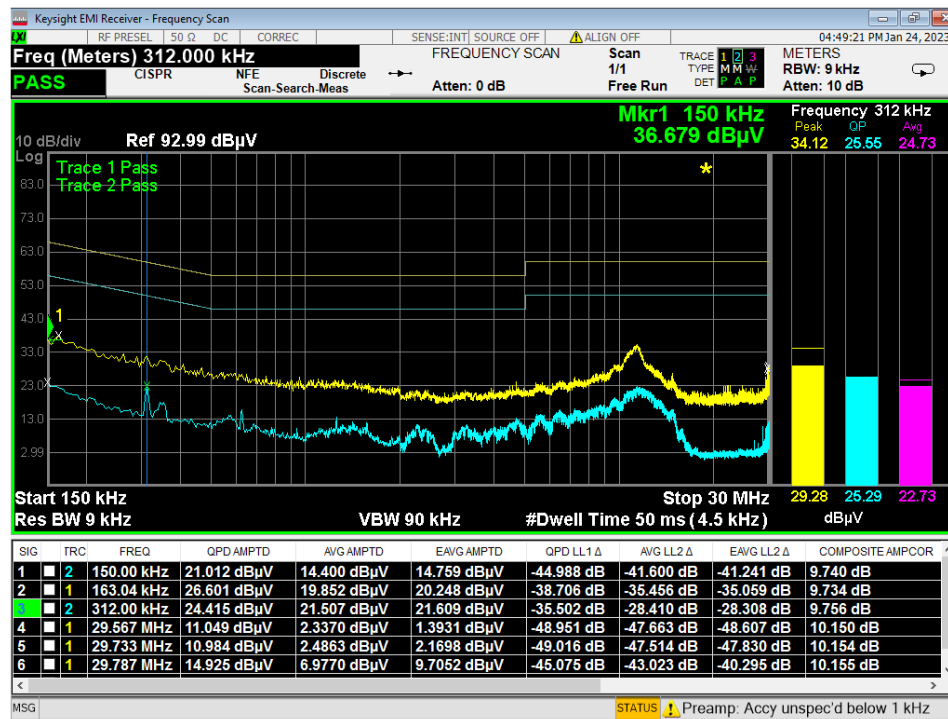


Figure 8 - Conducted Emissions Plot, Line, IDLE

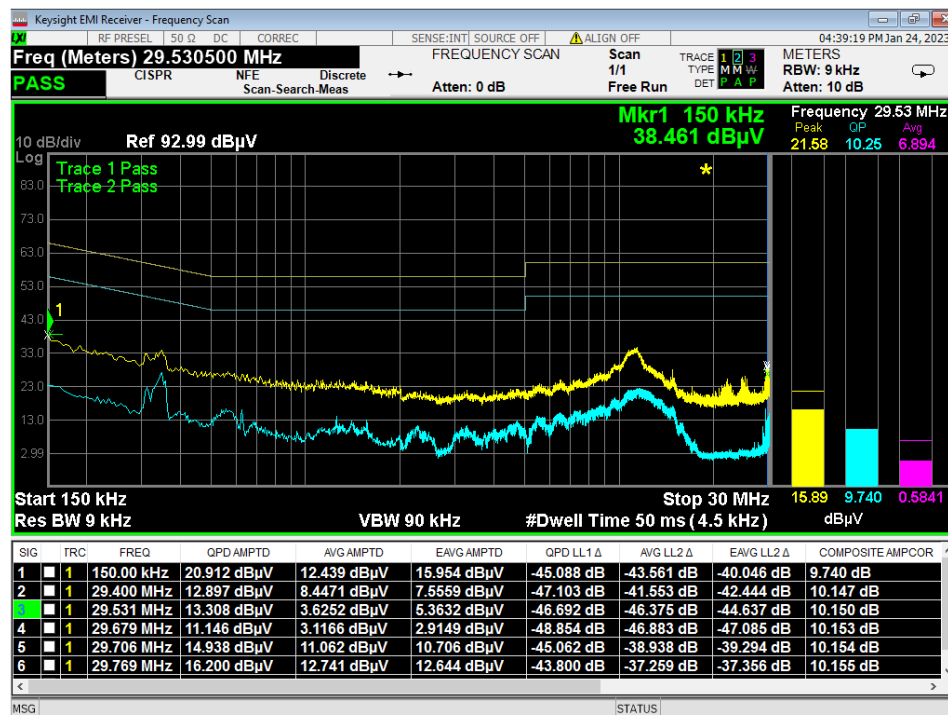


Figure 9 - Conducted Emissions Plot, Neutral, IDLE



Report Number: R20221213-20-E2

Rev

0

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



Report Number: R20221213-20-E2

Rev

0

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):

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

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

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



Report Number: R20221213-20-E2

Rev

0

Prepared for: Garmin International, Inc.

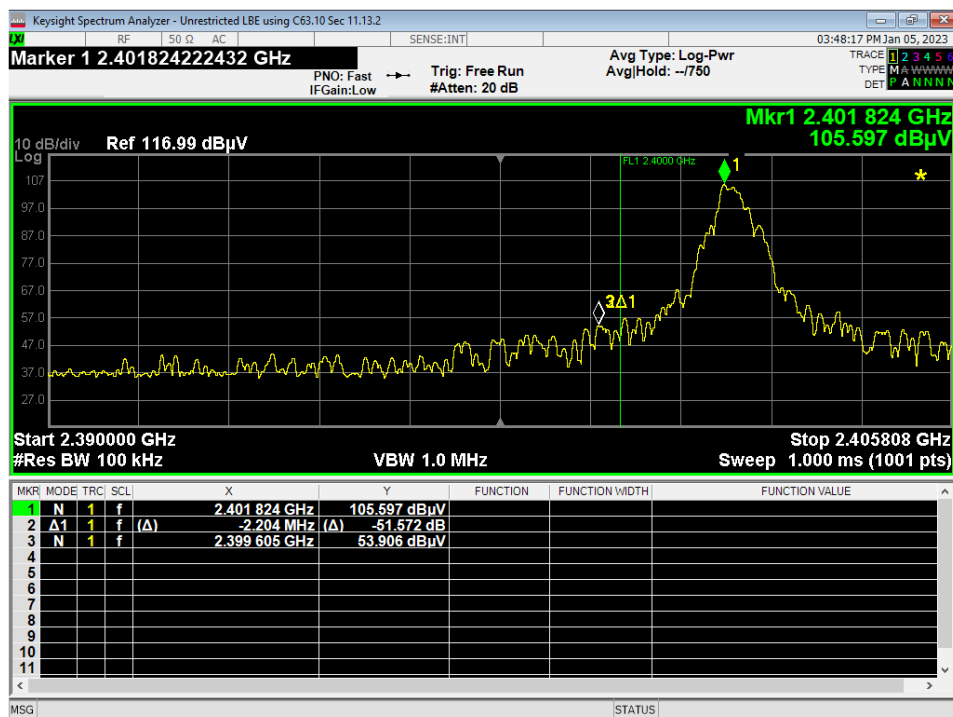
APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

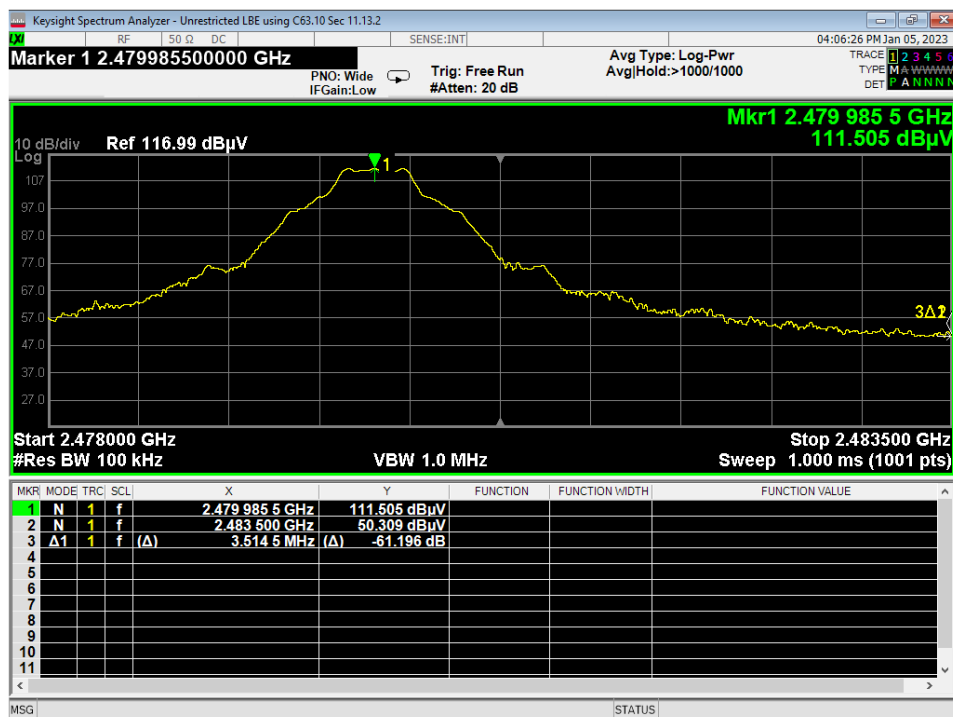
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

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

APPENDIX C – GRAPHS AND TABLES



01 Lower Bandedge, Unrestricted, GFSK



02 Higher Bandedge, Unrestricted, GFSK

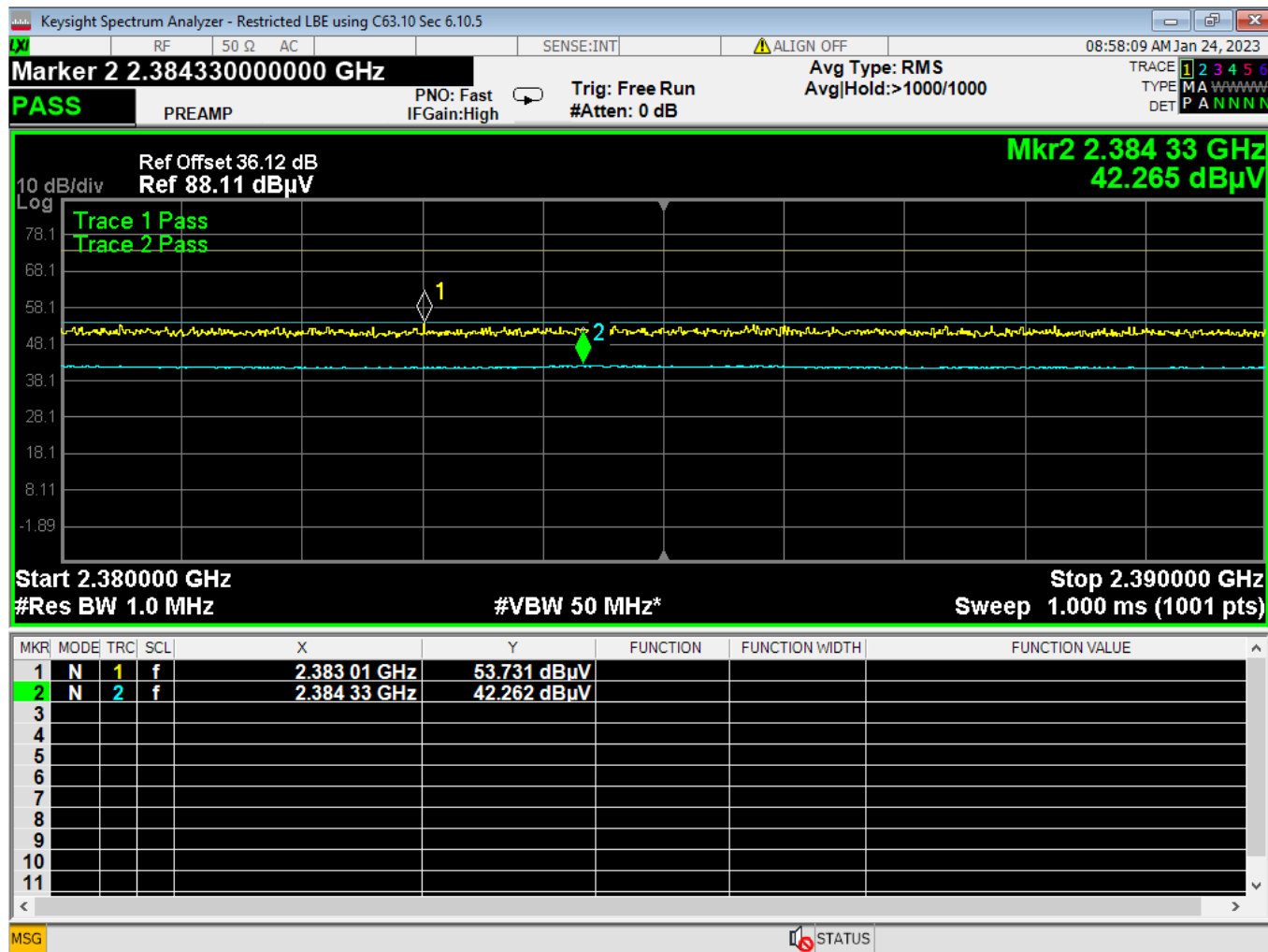


Report Number: R20221213-20-E2

Rev

0

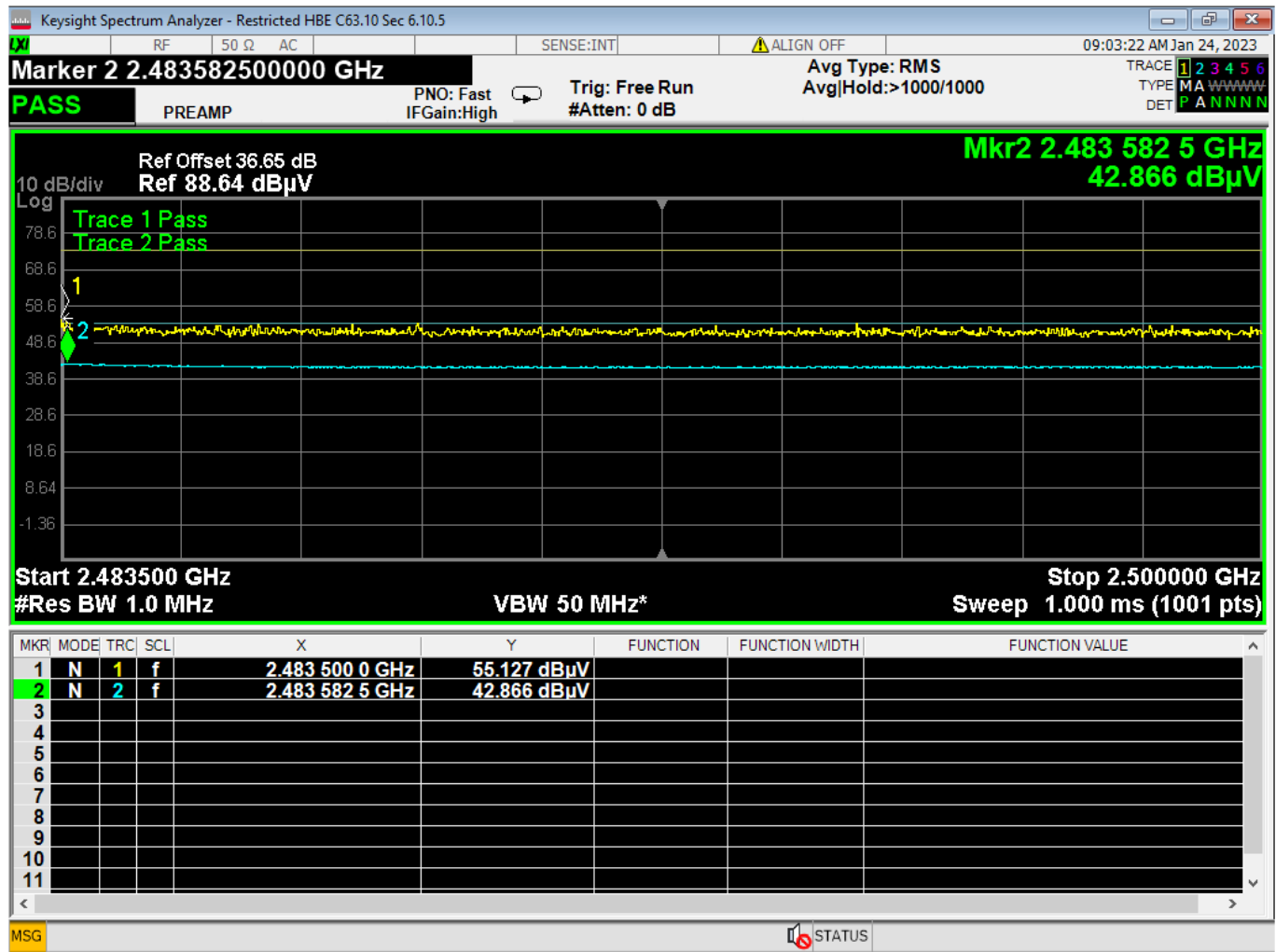
Prepared for: Garmin International, Inc.



03 Lower Bandedge, Restricted, GFSK

Please ignore the average measurement in the graph above. Average measurement in section 4 was calculated from the peak measurement by adding duty cycle correction factor found in section 4.1.

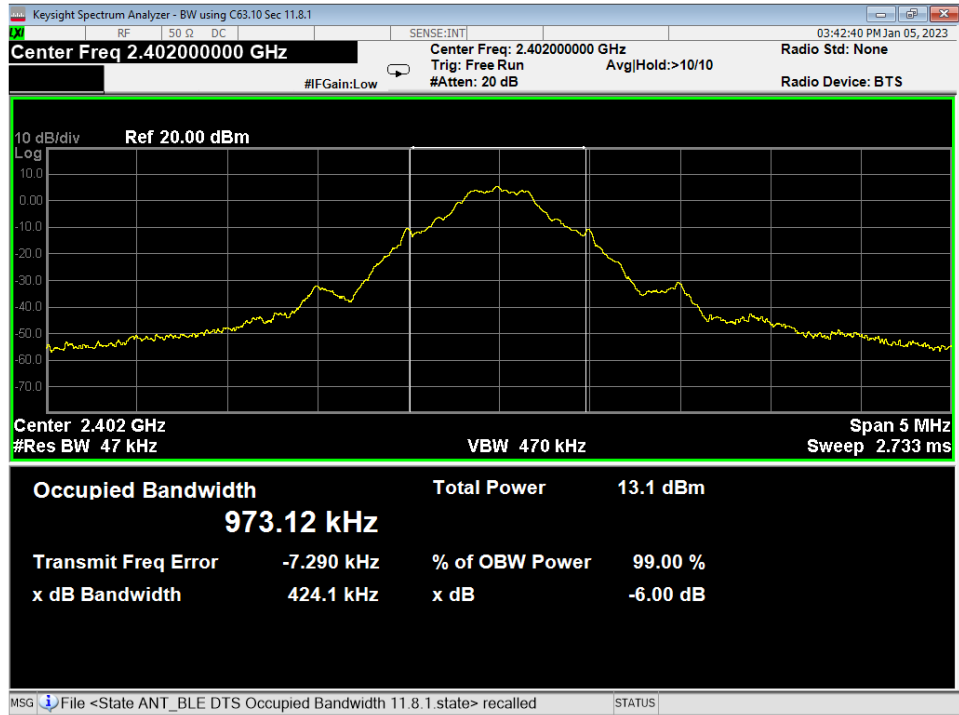
	Report Number:	R20221213-20-E2	Rev	0
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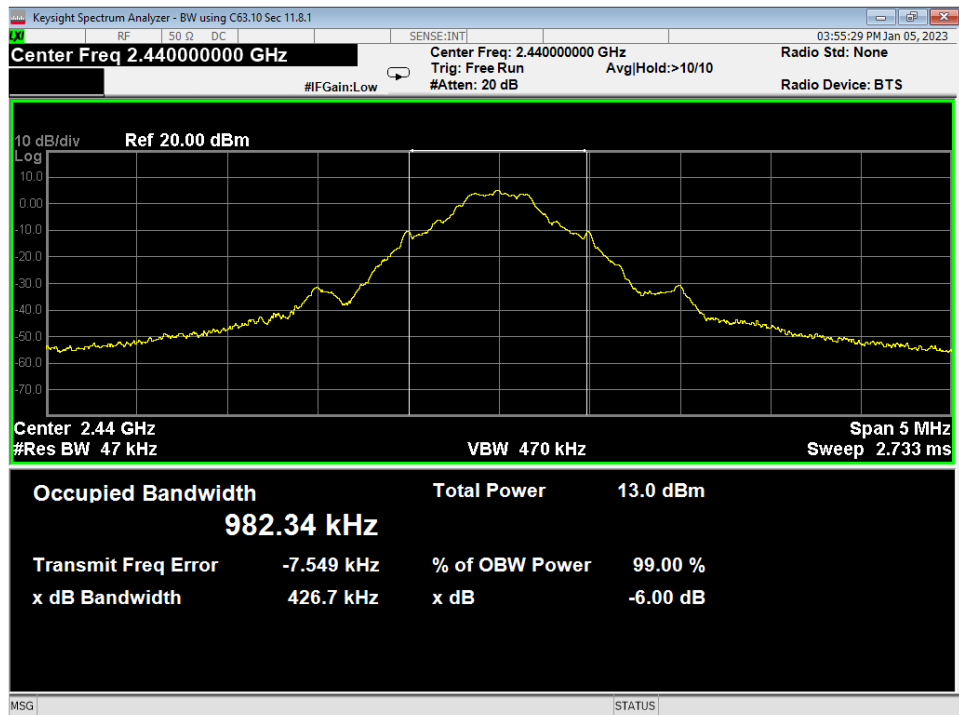
04 Higher Bandedge, Restricted, GFSK

Please ignore the average measurement in the graph above. Average measurement in section 4 was calculated from the peak measurement by adding duty cycle correction factor found in section 4.1.

Report Number:	R20221213-20-E2	Rev	0
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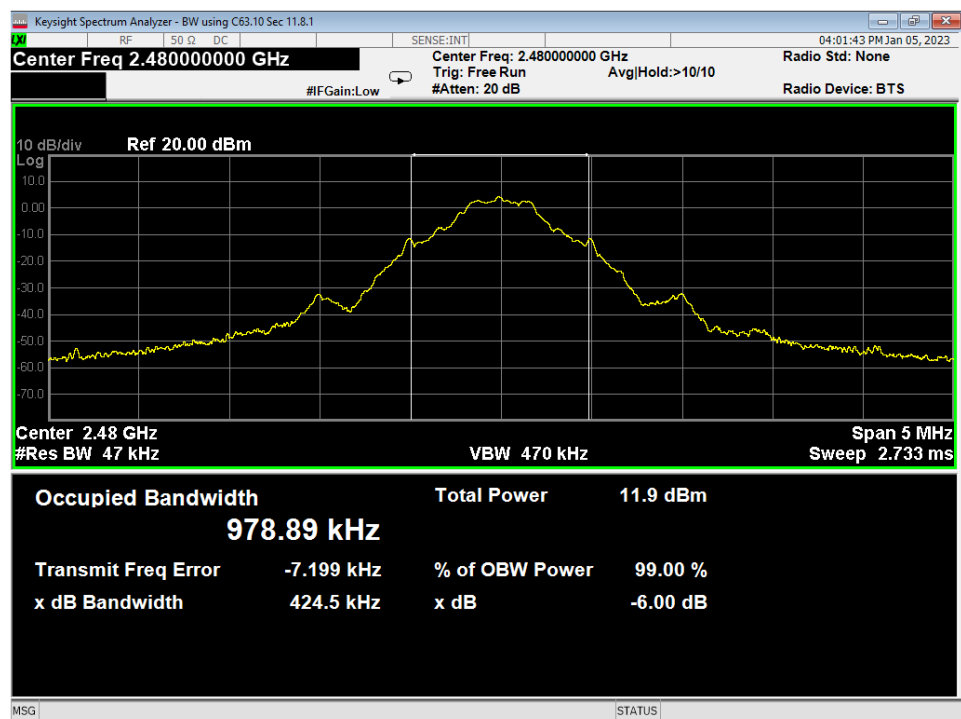
05 Occupied Bandwidth, Low Channel, GFSK



06 Occupied Bandwidth, Mid Channel, GFSK



Report Number:	R20221213-20-E2	Rev	0
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07 Occupied Bandwidth, High Channel, GFSK



Report Number:	R20221213-20-E2	Rev	0
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REPORT END