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FCC/ISED Test Report

Prepared for: Garmin International, Inc.

Address: 1200 E. 151st Street

Olathe, Kansas, 66062, USA

of Lane

Product: A04535

Test Report No: R20221003-20-E2

Approved by:

Fox Lane,

EMC Test Engineer

DATE: January 9, 2023

Total Pages: 28

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 Report Number:
 R20221003-20-E2
 Rev
 0

Prepared for: Garmin International, Inc.

REVISION PAGE

| Rev. No. | Date | Description | | |
|----------|----------------|---------------------|--|--|
| | | Issued – FLane | | |
| 0 | 9 January 2023 | Reviewed by KVepuri | | |
| | | Prepared by FLane | | |

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 2 of 28



Report Number:

R20221003-20-E2

Rev

0

Prepared for:

Garmin International, Inc.

CONTENTS

| Rev | ision Pa | ge | 2 |
|-----|----------|--|----|
| 1.0 | Sun | nmary 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 | Lab | oratory 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 | Res | ults | 9 |
| | 4.1 | Duty Cycle | 10 |
| | 4.2 | Radiated emissions | 11 |
| | 4.3 | Band edges | 17 |
| | 4.4 | Conducted AC Mains Emissions | 18 |
| Арр | endix A | : Sample Calculation | 21 |
| Арр | endix B | a – Measurement Uncertainty | 23 |
| Арр | endix C | – Graphs and Tables | 24 |
| PED | ORT E | ND | 20 |



| Report Number: R20221003-20-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) ISED RSS-Gen, Issue 5
- (3) ISED 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 | | | |

Lincoln, NE 68521 Page 4 of 28



| Report Number: | Number: R20221003-20-E2 | | 0 |
|----------------|----------------------------|--|---|
| Prepared for: | Garmin International, Inc. | | |

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

| EUT | A04535 | | |
|--|---|--|--|
| IC | 1792A-04535 | | |
| FCC ID | IPH-04535 | | |
| EUT Received | 1 December 2022 | | |
| EUT Tested | 1 December 2022- 9 January 2023 | | |
| Serial No. 3432588491 (Radiated Measurements) 3432588513 (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 | Internal Battery / 5VDC Charger: Garmin MN: PSAI05R-050Q (Representative Power Supply) PN: 362-00072-00 | | |

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

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive

Lincoln, NE 68521 Page 5 of 28



| Report Number: R20221003-20-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.

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive

Lincoln, NE 68521 Page 6 of 28



| Report Number: | port Number: R20221003-20-E2 | | 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

Notes:

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

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive

Lincoln, NE 68521 Page 7 of 28

^{**2} Year Cal Cycle

^{***3} Year Cal Cycle



3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

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.

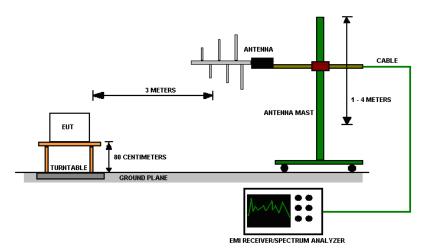


Figure 2 - Radiated Emissions Test Setup

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 8 of 28



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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 Delt (dB) | a | Result |
| Low | GFSK | 2400.00 | 59.036 | 109.672 | 50.636 | 50.00 | | PASS |
| High | GFSK | 2483.50 | 57.487 | 109.220 | 51.733 | 50.00 | | PASS |
| | | | Peak Restrict | ed 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 | 57.135 | Peak | 73.98 | 16.845 | | PASS |
| High | GFSK | 2483.50 | 66.906 | Peak | 73.98 | 7.074 | | PASS |
| *Limit showr | n is the p | eak limit taken fron | n FCC Part 15.2 | 09 | | | | |
| | | | Average Restri | cted 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 | R | esult |
| Low | GFSK | 2390.00 | 39.935 | Average | 53.98 | 14.045 | F | PASS |
| High | GFSK | 2483.50 | 49.706 | Average | 53.98 | 4.274 P | | 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: R20221003-20-E2 Rev 0

Prepared for: Garmin International, Inc.

4.1 DUTY CYCLE

Test Method:

Manufacturer declares worst-case real world duty cycle to be 13.8% DCCF = 20*log(0.138) = -17.20dB



 Report Number:
 R20221003-20-E2
 Rev
 0

Prepared for: Garmin International, Inc.

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 (µV/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 * Emission level (μ 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.

Page 11 of 28



 Report Number:
 R20221003-20-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.



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Test setup:

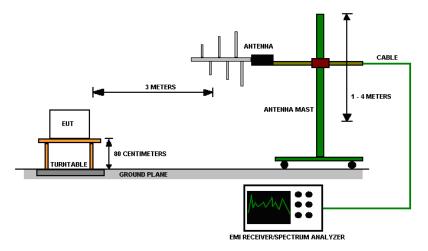


Figure 3 - Radiated Emissions Test Setup

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.

Page 13 of 28



 Report Number:
 R20221003-20-E2
 Rev
 0

 Prepared for:
 Garmin International, Inc.

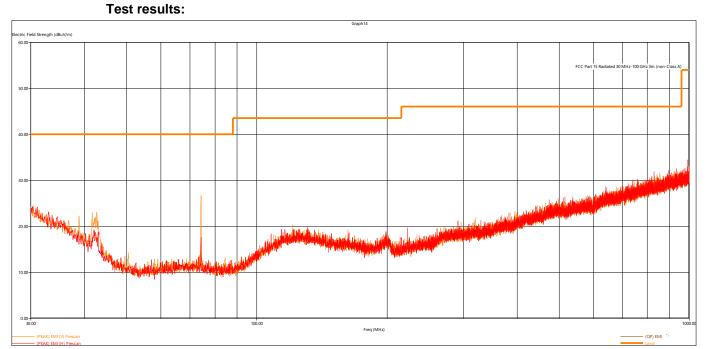


Figure 4 - Radiated Emissions Plot, Receive

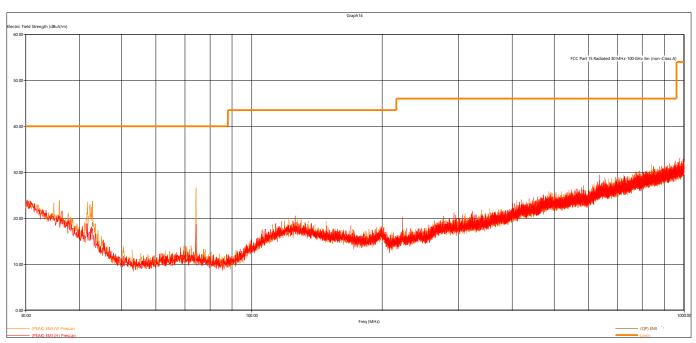


Figure 5 - Radiated Emissions Plot, GFSK

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

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 14 of 28



| Report Number: | R20221003-20-E2 | Rev | 0 |
|----------------|----------------------------|-----|---|
| Prepared for: | Garmin International, Inc. | | |

| Quasi-Peak Measurements, GFSK | | | | | | | | |
|-------------------------------|--------|--------|--------|--------|--------|-----|---------|------------|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dΒμV/m | dBµV/m | dB | cm. | deg. | | | |
| 42.670800 | 18.68 | 40.00 | 21.32 | 107.00 | 42.00 | V | Low | GFSK |
| 41.766720 | 16.86 | 40.00 | 23.14 | 277.00 | 271.00 | V | Re | ceive |

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: | R20221003-20-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. | | | |
| 2402.128000 | 98.32 | 114.00 | 15.68 | 292.00 | 159.00 | Н | Low | GFSK |
| 2439.886000 | 99.01 | 114.00 | 14.99 | 281.00 | 154.00 | Н | Mid | GFSK |
| 2480.180000 | 98.39 | 114.00 | 15.61 | 363.00 | 157.00 | Н | High | GFSK |
| 7205.592000 | 54.60 | 73.98 | 19.38 | 199.00 | 179.00 | Н | Low | GFSK |
| 7320.338000 | 53.03 | 73.98 | 20.95 | 271.00 | 266.00 | Н | Mid | 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. | | | |
| 2402.128000 | 81.12 | 94.00 | 12.88 | 292.00 | 159.00 | Н | Low | GFSK |
| 2439.886000 | 81.81 | 94.00 | 12.19 | 281.00 | 154.00 | Н | Mid | GFSK |
| 2480.180000 | 81.19 | 94.00 | 12.81 | 363.00 | 157.00 | Н | High | GFSK |
| 7205.592000 | 37.4 | 53.98 | 16.58 | 199.00 | 179.00 | Н | Low | GFSK |
| 7320.338000 | 35.83 | 53.98 | 18.15 | 271.00 | 266.00 | Н | Mid | 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: | R20221003-20-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.

Lincoln, NE 68521 Page 17 of 28



| Report Number: | R20221003-20-E2 | Rev | 0 |
|----------------|-----------------|-----|---|
| | | | |

Prepared for: Garmin International, Inc.

4.4 CONDUCTED AC MAINS EMISSIONS

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

Limits for conducted emissions measurements:

| FREQUENCY OF EMISSION | CONDUCTED LIMIT | | |
|-----------------------|-----------------|----------|--|
| (MHz) | (dBµV) | | |
| | 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.

Page 18 of 28



Prepared for: | Garmin International, Inc.

Test Results:



Figure 6 - Conducted Emissions Plot, Line, TX



Figure 7 - Conducted Emissions Plot, Neutral, TX

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 19 of 28



Prepared for: | Garmin International, Inc.



Figure 8 - Conducted Emissions Plot, Line, IDLE



Figure 9 - Conducted Emissions Plot, Neutral, IDLE

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 20 of 28



|--|

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.

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

The 48.1 dB_μV/m value can be mathematically converted to its corresponding level in μV/m.

Level in $\mu V/m = Common Antilogarithm [(48.1 dB<math>\mu V/m)/20$]= 254.1 $\mu V/m$

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

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 21 of 28



R20221003-20-E2 Report Number: 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 (Watts) = [Field Strength (V/m) x antenna distance (m)]² / 30

Power (watts) = $10^{Power} (dBm)/10 / 1000$

Voltage ($dB\mu V$) = Power (dBm) + 107 (for 50 Ω measurement systems)

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

Gain = 1 (numeric gain for isotropic radiator)

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

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

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

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

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 22 of 28



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%.

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 23 of 28



Report Number:

R20221003-20-E2

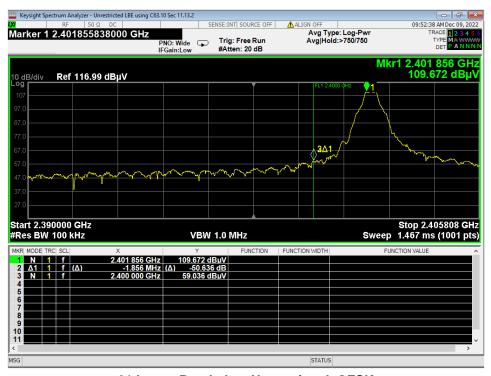
Rev

0

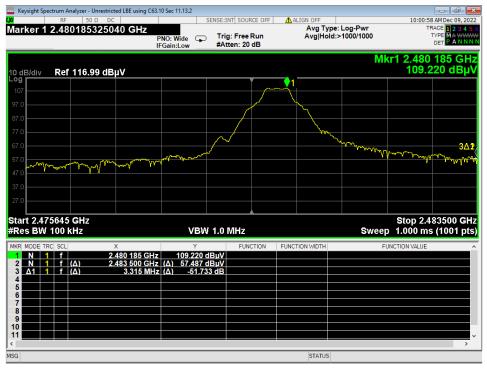
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APPENDIX C - GRAPHS AND TABLES



01 Lower Bandedge, Unrestricted, GFSK



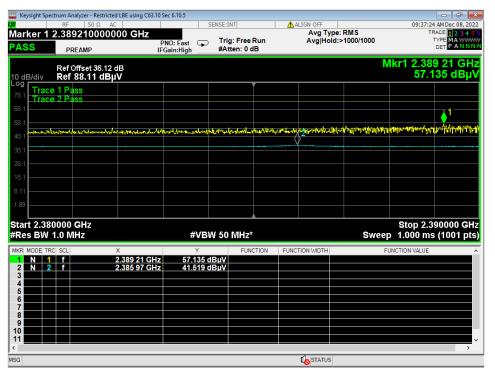
02 Higher Bandedge, Unrestricted, GFSK

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Page 24 of 28

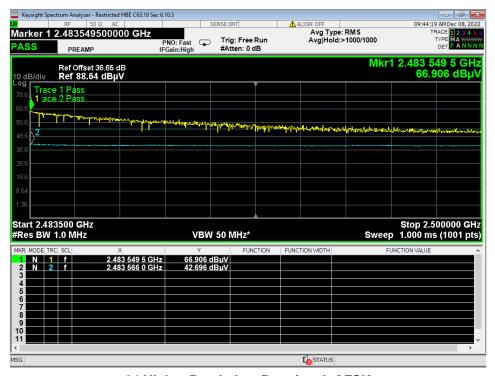


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03 Lower Bandedge, Restricted, GFSK

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.



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.

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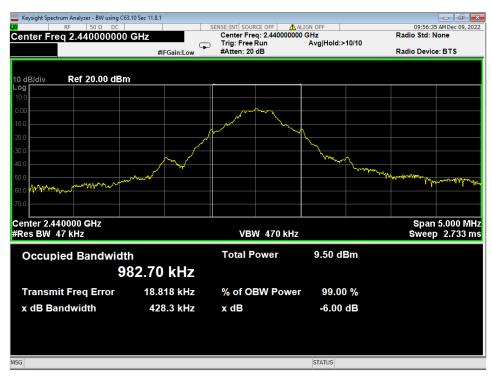
Page 25 of 28



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05 Occupied Bandwidth, Low Channel, GFSK



06 Occupied Bandwidth, Mid Channel, GFSK

The Nebraska Center for Excellence in Electronics 4740 Discovery Drive Lincoln, NE 68521

Page 26 of 28



 Report Number:
 R20221003-20-E2
 Rev
 0

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NSE:INT SOURCE OFF ALIGN OF Center Freq: 2.480000000 GHz Trig: Free Run Avg #Atten: 20 dB 09:59:57 AM Dec 09, 2022 Radio Std: None Center Freq 2.480000000 GHz Avg|Hold:>10/10 Ref 20.00 dBm Span 5.000 MHz Sweep 2.733 ms Center 2.480000 GHz #Res BW 47 kHz VBW 470 kHz **Occupied Bandwidth Total Power** 9.52 dBm 982.19 kHz **Transmit Freq Error** 18.551 kHz % of OBW Power 99.00 % x dB Bandwidth 428.8 kHz -6.00 dB x dB

07 Occupied Bandwidth, High Channel, GFSK

Page 27 of 28



 Report Number:
 R20221003-20-E2
 Rev
 0

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Page 28 of 28