

FCC/ISED DXX Part 15.225 Test Report

Prepared for: Garmin International Inc.

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

Product: A04542

Test Report No: R20230109-20-E4A

Approved By:


Fox Lane
EMC Test Engineer

DATE: 13 April 2023

Total Pages: 21



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Revision Page

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



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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 |

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2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

| | |
|-------------------------------|--|
| EUT | A04542 |
| FCC ID | IPH-04542 |
| IC ID | 1792A-04542 |
| EUT Received | 13 February 2023 |
| EUT Tested | 15 February 2023- 23 March 2023 |
| Serial No. | 3436744035 (Radiated Measurements) |
| Operating Band | 2400 – 2483.5 MHz |
| Device Type | <input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x <input checked="" type="checkbox"/> 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.

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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.


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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

| | | | | |
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3.1.6 Test Pictures and/or Figures

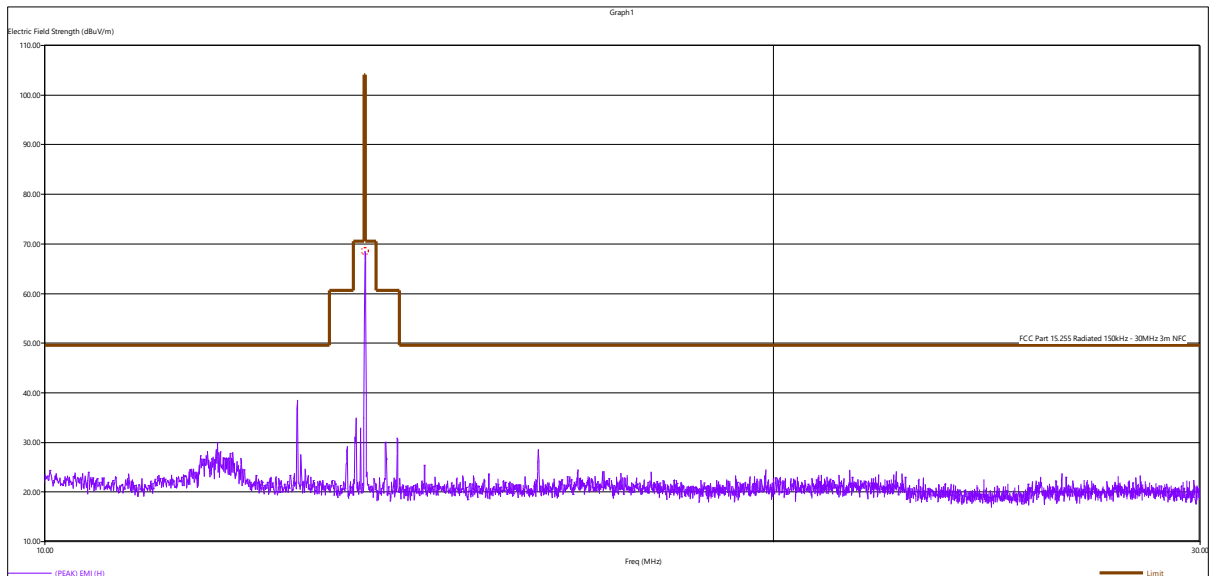


Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz

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

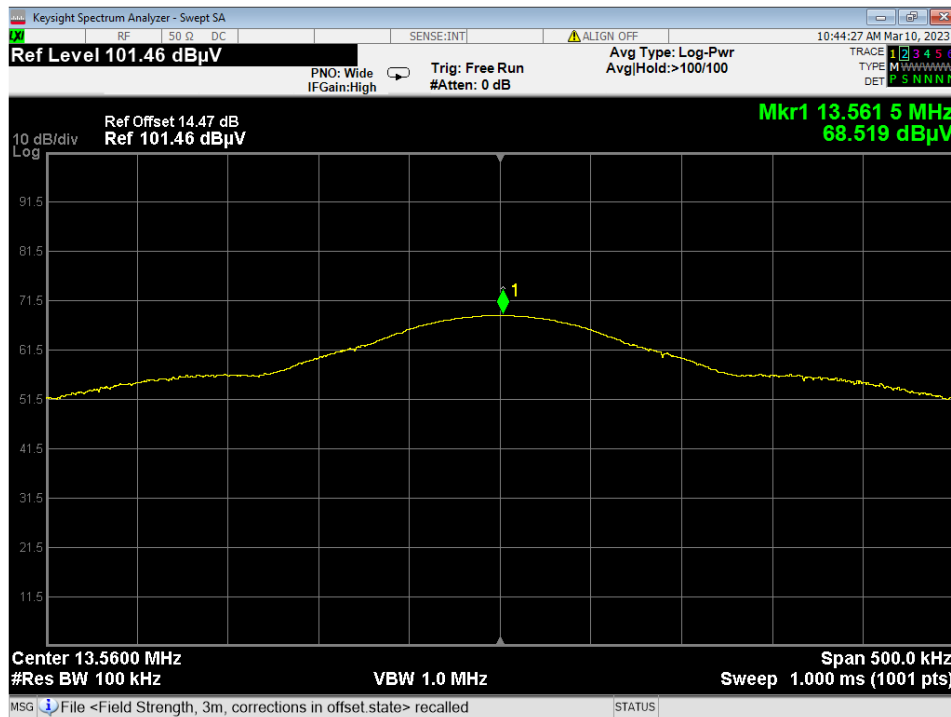



Figure 2 – Field Strength, 3m

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| Peak Measurements, 10MHz – 30MHz | | | |
|----------------------------------|-------------------------|----------------|------------------------|
| Freq (MHz) | (PEAK) EMI (H) (dBuV/m) | Limit (dBuV/m) | (PEAK) Margin (H) (dB) |
| 13.560000 | 68.50 | 104.00 | 35.50 |

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

| NFC Field Strength | | | |
|-------------------------|-----------------|--------|--------|
| Field Strength (dBμV/m) | Limit (dBμV/m)* | Margin | Result |
| 68.519 | 104.00 | 35.481 | PASS |

*Limit extrapolated to 3m test distance.



Figure 3 – Lower Band Edge


| | | | | |
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Figure 4 – Upper Bandedge

| Band Edge Measurements | | | | |
|--|----------------------------------|--------------|-------------|-------------|
| Band edge /Measurement Frequency (MHz) | Corrected band level dBμV/m @ 3m | Limit* dBμV | Margin | Result |
| 13.3501 | 52.67 | 60.51 | 7.84 | PASS |
| 13.7730 | 54.23 | 60.51 | 6.28 | 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 found to be at least 6dB below the limit line.

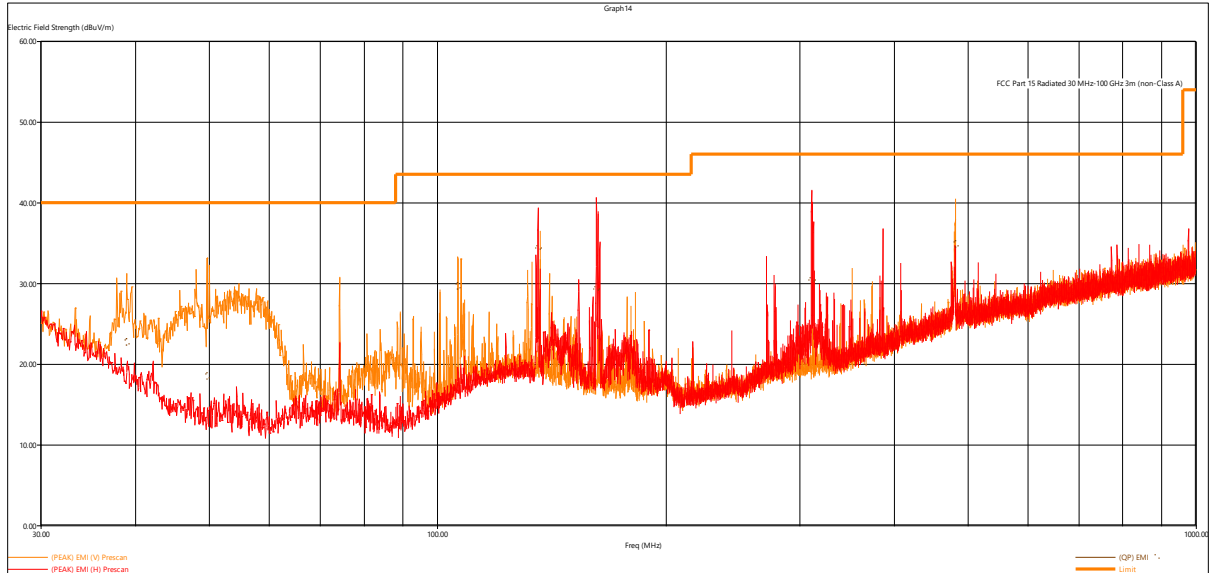



Figure 5 – NFC Radiated Emissions Plot, 30MHz – 1GHz

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. | |
| 135.575040 | 34.39 | 43.52 | 9.13 | 141.00 | 359.00 | H |
| 161.876880 | 29.32 | 43.52 | 14.20 | 163.00 | 155.00 | H |
| 311.051280 | 30.38 | 46.02 | 15.64 | 118.00 | 32.00 | H |
| 38.847600 | 22.69 | 40.00 | 17.31 | 116.00 | 280.00 | V |
| 49.643520 | 18.42 | 40.00 | 21.58 | 107.00 | 71.00 | V |
| 106.260000 | 29.60 | 43.52 | 13.92 | 108.00 | 303.00 | V |
| 481.343040 | 34.87 | 46.02 | 11.15 | 105.00 | 286.00 | V |

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other emissions 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.

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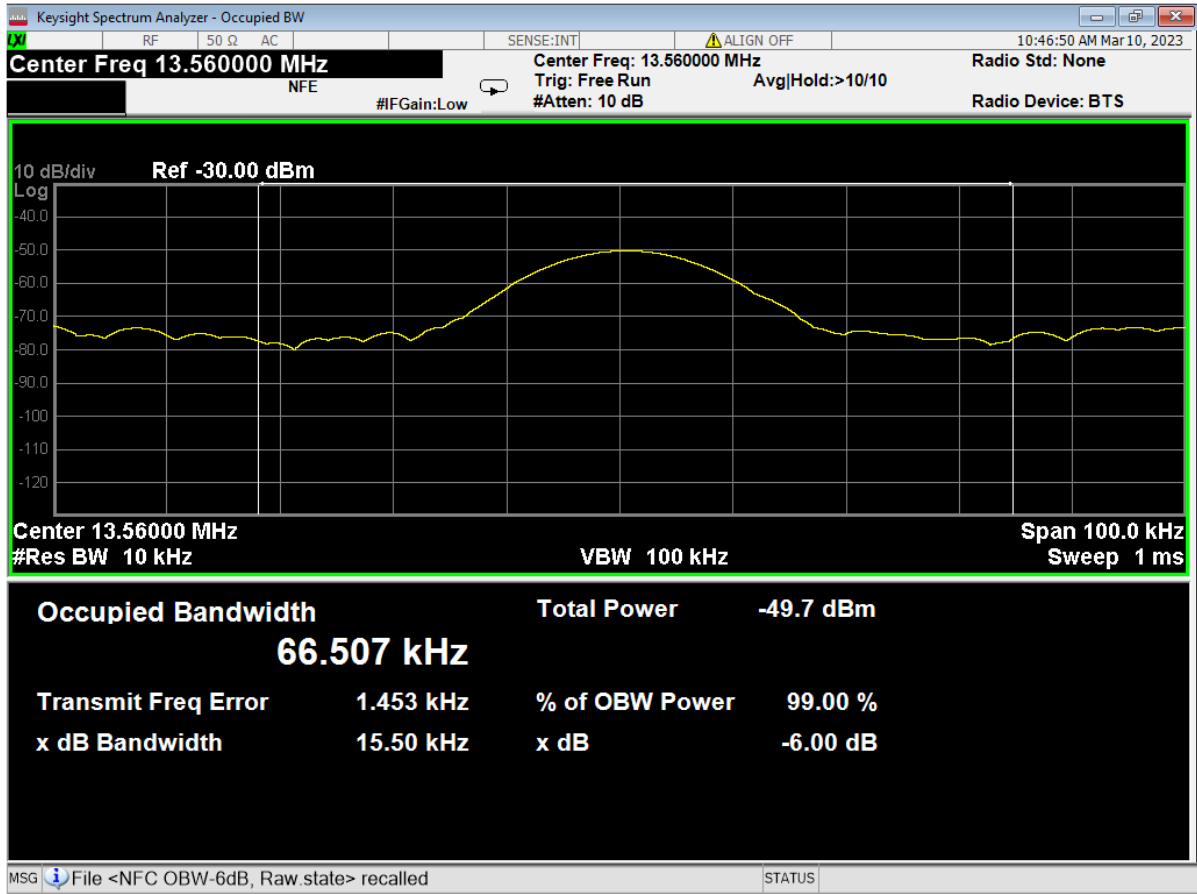



Figure 6 – NFC Occupied Bandwidth

| | | | | |
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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 ± 5%
Temperature of 23 ±2° 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.

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3.2.6 Test results

| A04542 | |
|------------------|---------------|
| Temperature (°C) | Channel (Hz) |
| | 13.56000 Nom. |
| -20°C | 1033 |
| -10°C | 928 |
| 0°C | 812 |
| 10°C | 876 |
| 20°C | 770 |
| 30°C | 738 |
| 40°C | 698 |
| 50°C | 800 |

| A04542 | | Nominal Battery Voltage: 3.87V |
|-------------|-------------|--------------------------------|
| Voltage (V) | Temperature | Frequency Error (Hz) |
| 3.78* | 20°C | 765 |
| 3.99 | 20°C | 798 |
| 4.10 | 20°C | 801 |
| 4.43* | 20°C | 820 |

*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

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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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Test Results:

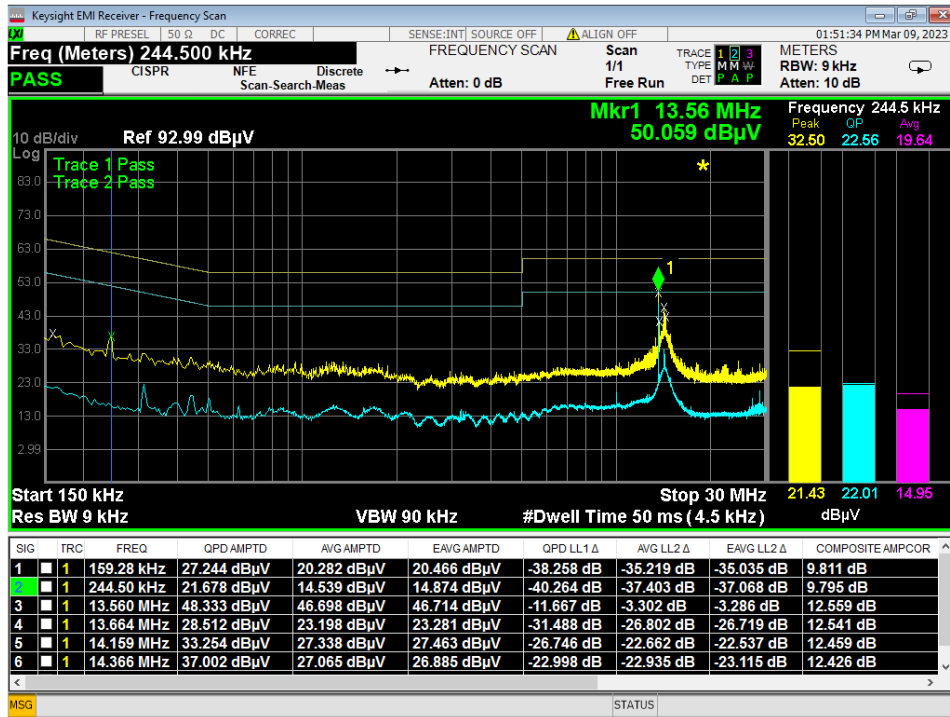


Figure 7 – Conducted Emissions Plot, Line, NFC

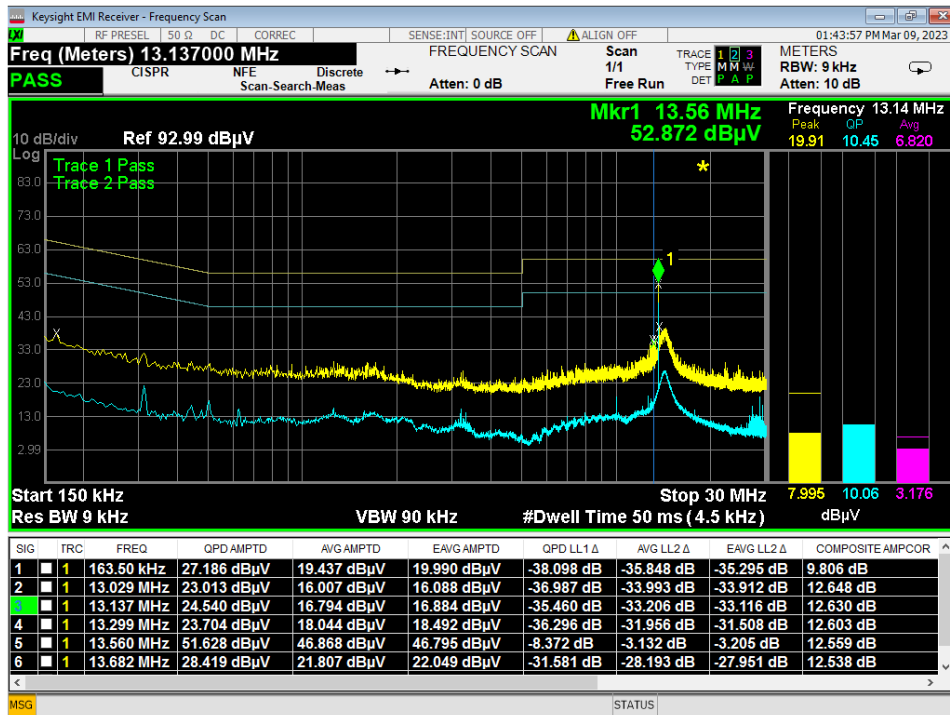


Figure 8 – Conducted Emissions Plot, Neutral, NFC

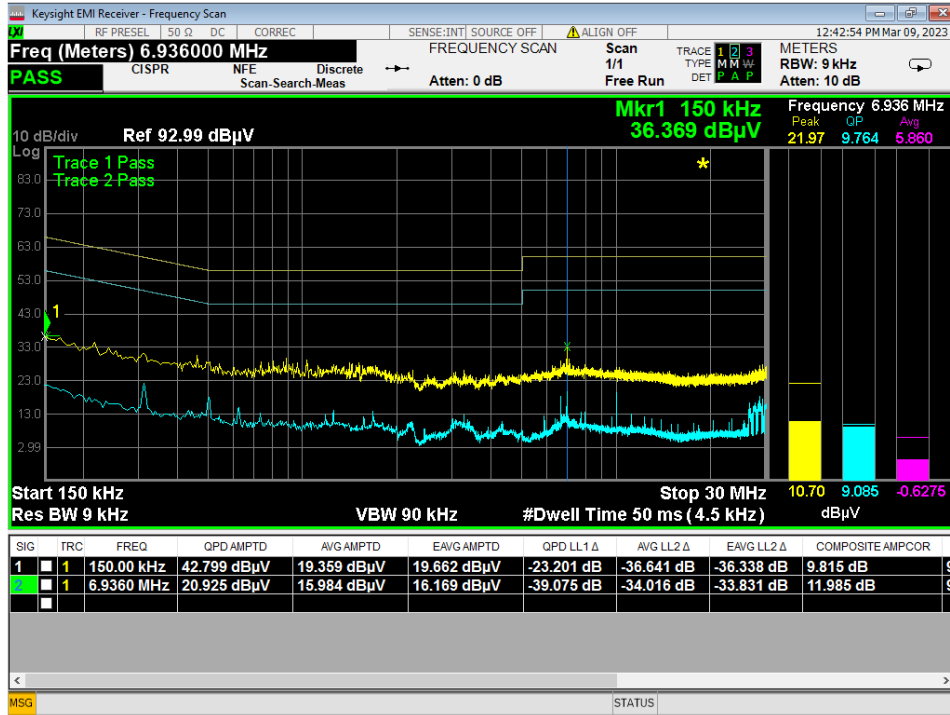


Figure 9 – Conducted Emissions Plot, Line, Idle

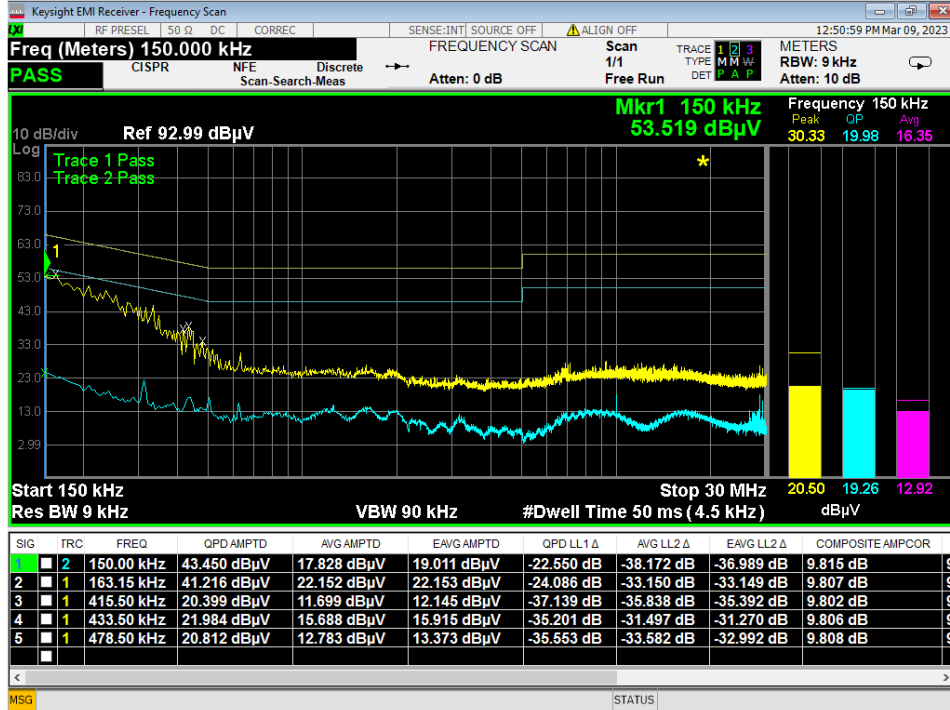



Figure 10 – Conducted Emissions Plot, Neutral, Idle

| | | | | |
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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;

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

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

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

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


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

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

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

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

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 | ±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%.

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