HEADQUARTERS: 914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

June 9, 2022

Autani, LLC.
Mark Plasterer
7090 Columbia Gateway Drive, Suite 140
Columbia MD 21046

Dear Mark Plasterer,

Enclosed is the EMC Wireless test report for compliance testing of the Autani, LLC., ZRB4/1000186 as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins Electrical and Electronic Testing NA, Inc. If you have any questions regarding these results or if Eurofins Electrical and Electronic Testing NA, Inc. can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS ELECTRICAL AND ELECTRONIC TESTING NA, INC.

*Michelle Tawmging*
Documentation Department

Reference: (\Autani, LLC.\WIR117977-FCC247 DTS Rev. 1)

ACCREDITED
TESTING CERT #0591.01

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Eurofins Electrical and Electronic Testing NA, Inc. is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

# Electromagnetic Compatibility Criteria
# Test Report

for the

**Autani, LLC.**
**ZRB4/1000186**

**Tested under**
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

**Report: WIR117977-FCC247 DTS Rev. 1**

June 9, 2022

**Prepared For:**

**Autani, LLC.**
**7090 Columbia Gateway Drive, Suite 140**
**Columbia MD 21046**

**Prepared By:**
**Eurofins Electrical and Electronic Testing NA, Inc.**
914 W. Patapsco Avenue
Baltimore MD 21230

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# Electromagnetic Compatibility Criteria
# Test Report

for the

## Autani, LLC.
## ZRB4/1000186

**Tested under**
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

Donald Salguero, Project Engineer
Wireless Lab

**Engineering Statement:** The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.

Michael Griffiths
Manager, Wireless Lab

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# Report Status Sheet

| Revision | Report Date | Reason for Revision |
|---|---|---|
| ∅ | April 12, 2022 | Initial Issue. |
| 1 | June 9, 2022 | FCC ID Number Added; Removed Photographs |


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# Executive Summary

## A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Autani, LLC. ZRB4/1000186, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the ZRB4/1000186. Autani, LLC. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the ZRB4/1000186, has been **permanently** discontinued.

## B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with Autani, LLC., purchase order number 410. All tests were conducted using measurement procedure ANSI C63.10-2013.

| FCC Reference 47 CFR Part 15.247:2005 | Description | Compliance |
|---|---|---|
| Title 47 of the CFR, Part 15 §15.203 | Antenna Requirement | Compliant |
| Title 47 of the CFR, Part 15 §15.207(a) | Conducted Emission Limits | Compliant |
| Title 47 of the CFR, Part 15 §15.247(a)(2) | 6dB Occupied Bandwidth | Compliant |
| Title 47 of the CFR, Part 15 §15.247(b)(3) | Peak Power Output | Compliant |
| Title 47 of the CFR, Part 15 §15.247(c) | Spurious Emissions in Non-restricted Bands | Compliant |
| Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205 | Radiated Spurious Emissions Requirements | Compliant |
| Title 47 of the CFR, Part 15; §15.247(e) | Peak Power Spectral Density | Compliant |
| Title 47 of the CFR, Part 15 §15.247(i) | Maximum Permissible Exposure (MPE) | Compliant |

**Table 1. Executive Summary of EMC Part 15.247 ComplianceTesting**


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# Equipment Configuration

## A. Overview

Eurofins Electrical and Electronic Testing NA, Inc. was contracted by Autani, LLC. to perform testing on the ZRB4/1000186, under Autani, LLC.'s purchase order number 410.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Autani, LLC., ZRB4/1000186.

The results obtained relate only to the item(s) tested.

| | | |
|---|---|---|
| **Model(s) Tested:** | ZRB4/1000186 | |
| **Model(s) Covered:** | ZRB4/1000186 | |
| **EUT Specifications:** | Primary Power: 12-24VDC -Tested at 115VAC | |
| | FCC ID: V8NZRB1000186 | |
| | Type of Modulations: | O-QPSK |
| | Equipment Code: | DTS |
| | Peak RF Output Power: | 19.25 dBm; 0.084W |
| | EUT Frequency Ranges: | 2405 – 2475 MHz |
| **Analysis:** | The results obtained relate only to the item(s) tested. | |
| **Environmental Test Conditions:** | Temperature: 15-35º C | |
| | Relative Humidity: 30-60% | |
| | Barometric Pressure: 860-1060 mbar | |
| **Evaluated by:** | Donald Salguero | |
| **Report Date(s):** | June 9, 2022 | |

**Table 2. EUT Summary Table**

## B. References

| | |
|---|---|
| **CFR 47, Part 15, Subpart C** | Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies |
| **ANSI C63.4:2014** | Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz |
| **ISO/IEC 17025:2017** | General Requirements for the Competence of Testing and Calibration Laboratories |
| **ANSI C63.10-2013** | American National Standard for Testing Unlicensed Wireless Devices |
| **KDB 558074 v05r02** | Guidance For Performing Compliance Measurements On Digital Transmission Systems (DTS) Operating Under Section 15.247 |

**Table 3. References**

## C. Test Site

All testing was performed at Eurofins Electrical and Electronic Testing NA, Inc., 914 W. Patapsco Avenue, Baltimore MD 21230 All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at Eurofins Electrical and Electronic Testing NA, Inc.

## D. Measurement Uncertainty

| Test Method | Typical Expanded Uncertainty | K | Confidence Level |
|---|---|---|---|
| **Radiated Emissions, (30 MHz – 1 GHz)** | ±3.20 | 2 | 95% |
| **Radiated Emissions, (1 GHz – 6 GHz)** | ±2.52 | 2 | 95% |
| **Conducted Emission Voltage** | ±2.03 | 2 | 95% |
| **RF Frequencies** | ±4.52 Hz | 2 | 95% |
| **RF Power Conducted Emissions** | ±2.32 dB | 2 | 95% |
| **RF Power Conducted Spurious Emissions** | ±2.25 dB | 2 | 95% |
| **RF Power Radiated Emissions** | ±3.01 dB | 2 | 95% |

**Table 4. Uncertainty Calculations Summary**

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## E. Equipment Details

| | |
|---|---|
| **Name of EUT/Model:** | ZRB4/1000186 |
| **Description of EUT and its intended use:** | 2.4GHz Wireless Zigbee Controller Module |
| **Selected Operation Mode(s):** | - |
| **Rationale for the selection of the Operation Mode(s):** | - |
| **Monitoring Method(s):** | - |
| **Emissions Class Declaration:** | B |
| **Configuration(s):** | Can be powered from AC or DC |
| **EUT Power Requirement** | - |
| **Voltage:** | 12-24VDC -Tested at 115VAC |
| **AC or DC:** | Both |
| **Voltage Frequency:** | 60Hz |
| **Number of Phases:** | 1 |
| **Current:** | <1 |
| **Physical Description** | - |
| **EUT Arrangement:** | - |
| **System with Multiple Chassis?** | - |
| **Size (HxWxD - inches):** | 0.75”x4.0”x1.0” |
| **Weight (lbs.):** | <1 lb. |
| **Highest Internal Frequency (MHz):** | 38.4 |

**Table 5 Equipment Details**

## F. Modifications

### a) Modifications to EUT

No modifications were made to the EUT.

### b) Modifications to Test Standard

No modifications were made to the test standard.

## G. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Autani, LLC. upon completion of testing.

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# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.203 Antenna Requirement

**Test Requirement:** **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

**Test Results:** The EUT as tested is **compliant** the criteria of §15.203. EUT uses built-in antenna. Max PK gain equals 5.3dBi

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 28, 2022

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# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.207(a) Conducted Emissions Limits

**Test Requirement(s):** **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

| Frequency range (MHz) | § 15.207(a), Conducted Limit (dBμV) | |
|---|---|---|
| | Quasi-Peak | Average |
| * 0.15- 0.5 | 66 - 56 | 56 - 46 |
| 0.5 - 5 | 56 | 46 |
| 5 - 30 | 60 | 50 |

**Table 6. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)**

**Test Procedure:** The EUT was placed on a 0.8 m-high wooden table inside a screen room. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 μH Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.10-2013*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω/50 μH LISN as the input transducer to an EMC/field intensity meter.

**Test Results:** The EUT was **compliant** with requirements of this section. Measured emissions were below the applicable limits.

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 26, 2022

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# Conducted Emissions Test Results

| | |
|---|---|
| **Test Specification:** | 15.207 Conducted Limits // RSS-GEN Issue 5 |
| **Test Method:** | Conducted Emissions, 150 kHz to 30 MHz |
| **Job Number:** | 117977 |
| **Customer:** | Autani, LLC |
| **EUT Name:** | ZRB4 |
| **Part/Model Number:** | N/A |
| **Serial Number:** | N/A |
| **Mode of Operation:** | FCC Test Mode |
| **Engineer:** | Donald Salguero |
| **Date:** | 3/26/2022 |
| **Temperature:** | 22.1°C |
| **Humidity:** | 36% |
| **Lead Tested:** | 120 VAC, 60 Hz Input |

**Table 7. Conducted Emissions, Header**

| | Frequency | Quasi-Peak Measurement | Correction Factor | Corrected Measurement | Quasi-Peak Limit | Margin | Result | Average Measurement | Correction Factor | Corrected Measurement | Average Limit | Margin | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dBuV | dBuV | dB | Pass/Fail | dBuV | dB | dBuV | dBuV | dB | Pass/Fail |
| Line | 0.2110 | 32.35 | 10.15 | 42.50 | 64.26 | -21.76 | PASS | 13.76 | 10.15 | 23.91 | 54.26 | -30.35 | PASS |
| | 0.3480 | 28.59 | 10.03 | 38.62 | 60.34 | -21.72 | PASS | 13.80 | 10.03 | 23.83 | 50.34 | -26.50 | PASS |
| | 0.6810 | 26.72 | 9.98 | 36.70 | 56.00 | -19.30 | PASS | 13.84 | 9.98 | 23.82 | 46.00 | -22.18 | PASS |
| | 0.8620 | 26.86 | 9.98 | 36.84 | 56.00 | -19.16 | PASS | 13.85 | 9.98 | 23.83 | 46.00 | -22.17 | PASS |
| | 4.4730 | 21.72 | 10.00 | 31.72 | 56.00 | -24.28 | PASS | 12.29 | 10.00 | 22.28 | 46.00 | -23.72 | PASS |
| | 4.5290 | 24.51 | 10.00 | 34.50 | 56.00 | -21.50 | PASS | 13.66 | 10.00 | 23.66 | 46.00 | -22.34 | PASS |
| Neutral | 0.1920 | 28.58 | 10.20 | 38.78 | 64.81 | -26.03 | PASS | 13.75 | 10.20 | 23.95 | 54.81 | -30.86 | PASS |
| | 0.3480 | 24.59 | 10.03 | 34.63 | 60.35 | -25.73 | PASS | 13.80 | 10.03 | 23.83 | 50.35 | -26.52 | PASS |
| | 0.5710 | 18.19 | 9.99 | 28.18 | 56.00 | -27.82 | PASS | 11.06 | 9.99 | 21.05 | 46.00 | -24.95 | PASS |
| | 0.8630 | 17.58 | 9.98 | 27.56 | 56.00 | -28.44 | PASS | 13.56 | 9.98 | 23.54 | 46.00 | -22.46 | PASS |
| | 1.1690 | 15.16 | 9.98 | 25.14 | 56.00 | -30.86 | PASS | 8.57 | 9.98 | 18.55 | 46.00 | -27.45 | PASS |
| | 3.3850 | 17.94 | 9.99 | 27.93 | 56.00 | -28.07 | PASS | 12.33 | 9.99 | 22.31 | 46.00 | -23.69 | PASS |

**Table 8. Conducted Emissions, Test Results**


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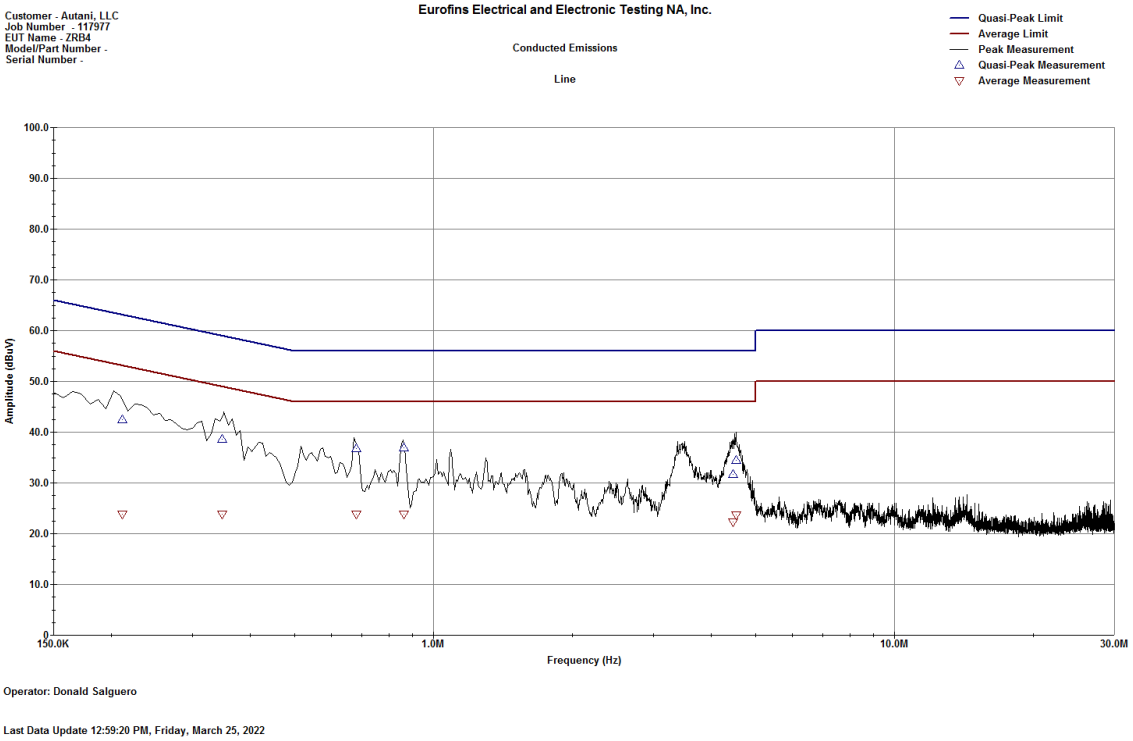


**Figure 1. Conducted Emissions, Line**

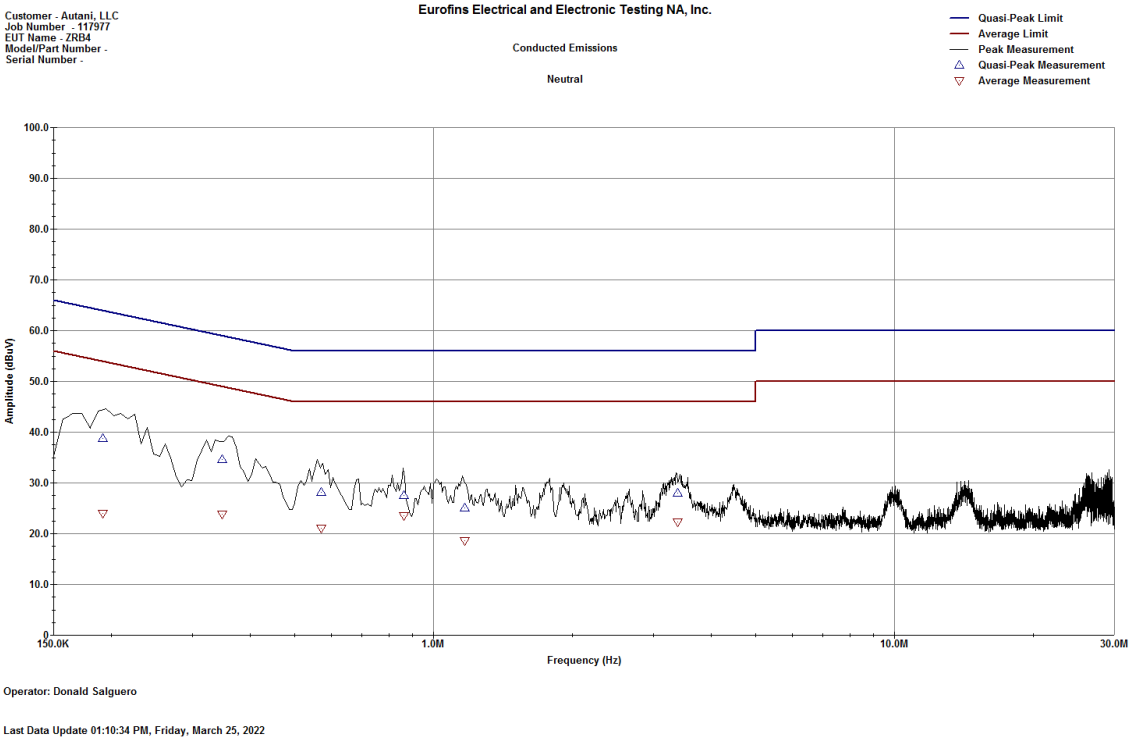


**Figure 2. Conducted Emissions, Neutral**

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

| Asset | Equipment | Manufacturer | Model | Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|
| 1T6658 | Spectrum Analyzer | Agilent Technologies | E4407B | 9/7/2021 | 3/7/2023 |
| 1T8907 | LISN | Com-Power | LI-150C | 4/12/2021 | 10/12/2022 |
| 1T8910 | LISN | Com-Power | LI-150C | 4/12/2021 | 10/12/2022 |
| 1T7478 | Transient Limiter | Com-Power | LIT-153A | Func Verify | Func Verify |

**Table 9. Conducted Emissions, Test Equipment List**

Note: Functionally verified test equipment is verified using calibrated instrumentation at time of testing.

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(a)(2) 6 dB Bandwidth

**Test Requirements:** **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

**Test Procedure:** The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths. The 6dB bandwidth was measured according to measurement method 11.8.2 Option 2 of ANSI C63.10-2013.

**Test Results** The EUT was **compliant** with § 15.247 (a)(2).

The 6 dB Bandwidth was determined from the plots on the following pages.

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25, 2022

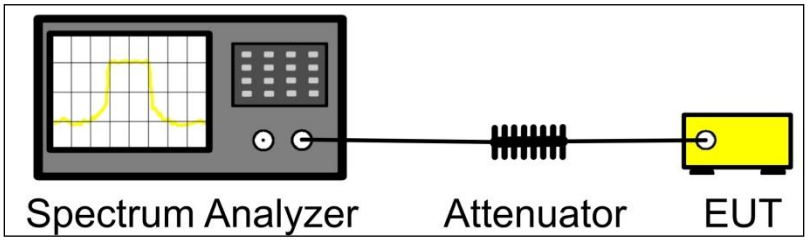


**Figure 3. Block Diagram, Occupied Bandwidth Test Setup**

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## 6dB Occupied Bandwidth Test Results

| Frequency (MHz) | 6dB Bandwidth (kHz) |
|---|---|
| 2405 | 1661 |
| 2440 | 1665 |
| 2475 | 1663 |

**Table 10. 6dB BW Datasheet**

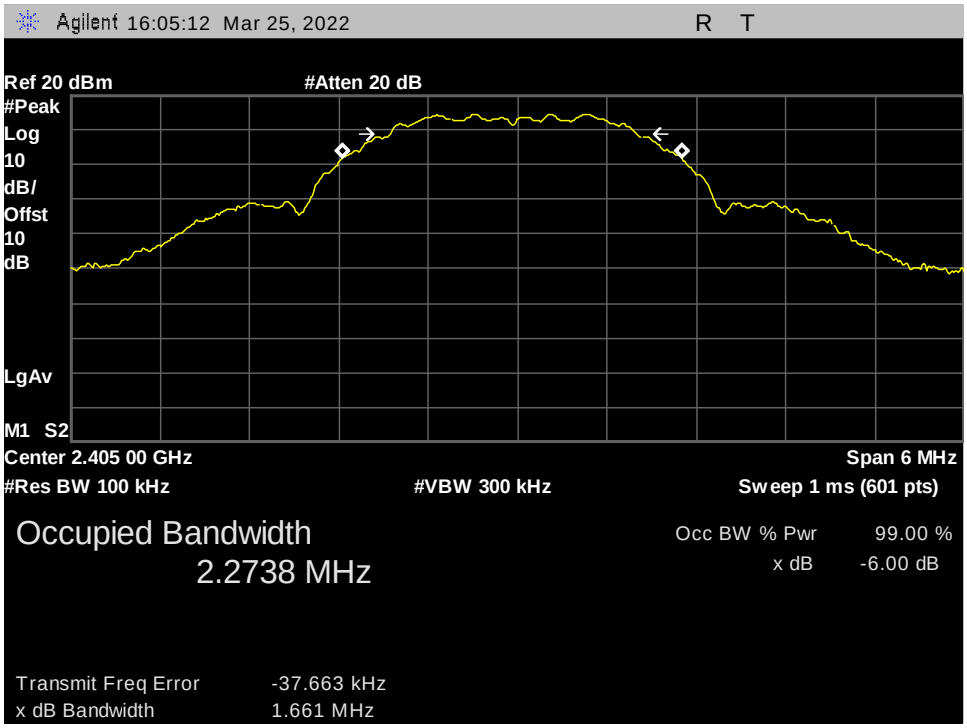


**Figure 4. 6dB_OBW_2405MHz**


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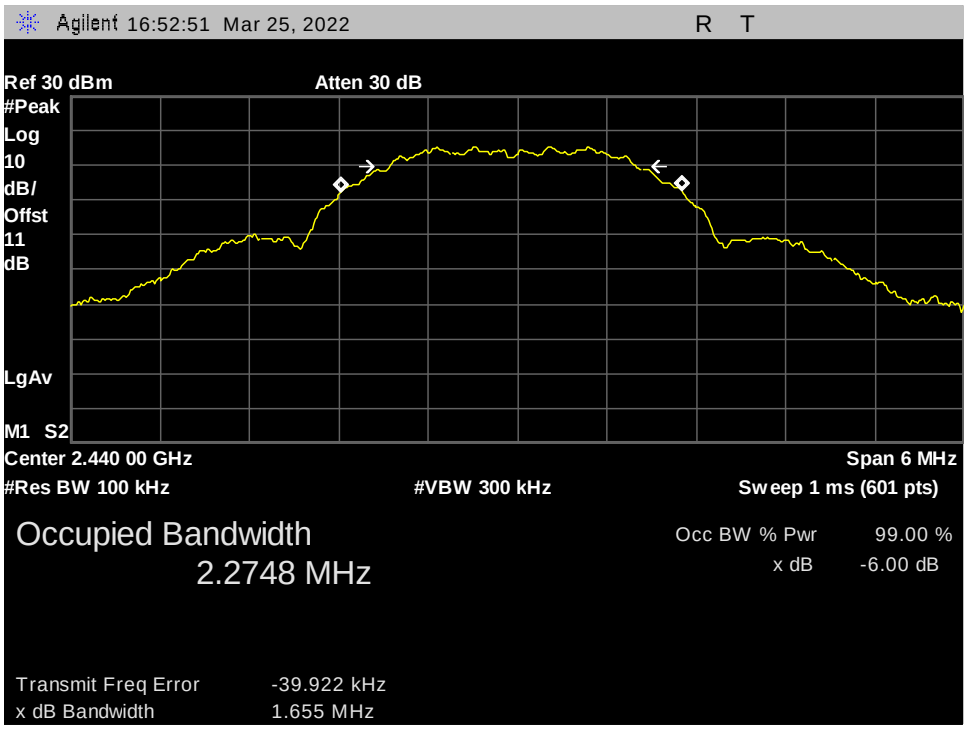


**Figure 5. 6dB_OBW_2440MHz**

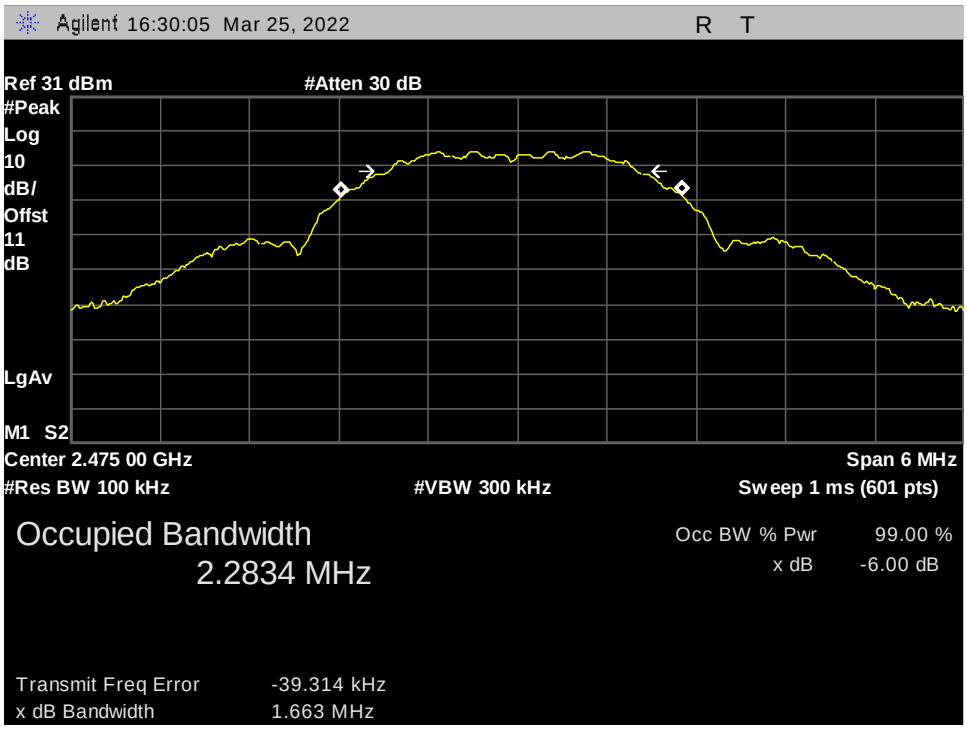


**Figure 6. 6dB_OBW_2475MHz**


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# Electromagnetic Compatibility Criteria for Intentional Radiators

## Duty Cycle

**Test Procedure:** The EUT was connected to a spectrum analyzer and was ran at the maximum achievable duty cycle for all modes. The duty cycle was measured in accordance with section 11.6 of ANSI C63.10-2013.

**Test Results:** The EUT was **compliant** with the duty cycle limits of **RSS-247 (6.2.4.1)**. No anomalies noted. EUT has a 100% duty cycle

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25, 2022

## Duty Cycle Test Results

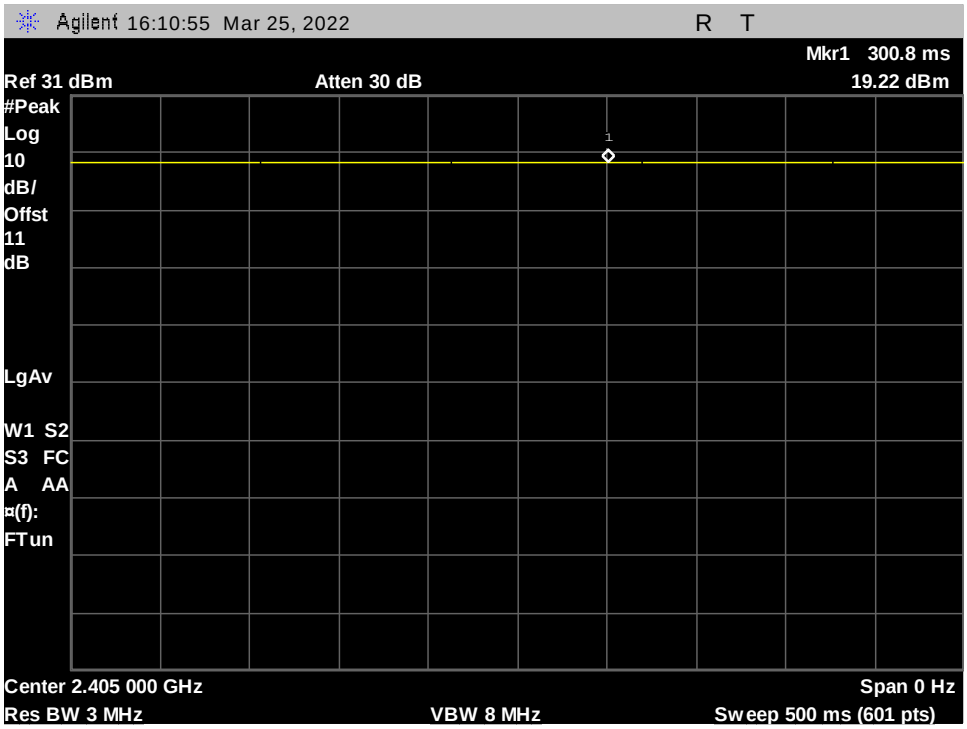


**Figure 7. Duty Cycle_2405MHz**


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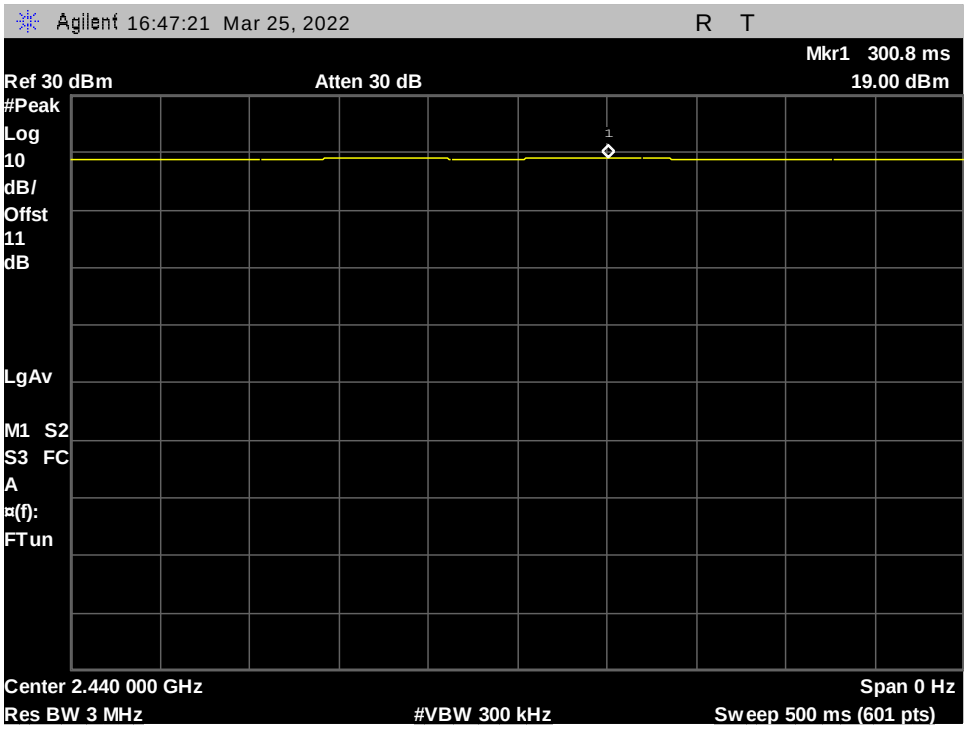


**Figure 8. Duty Cycle_2440MHz**

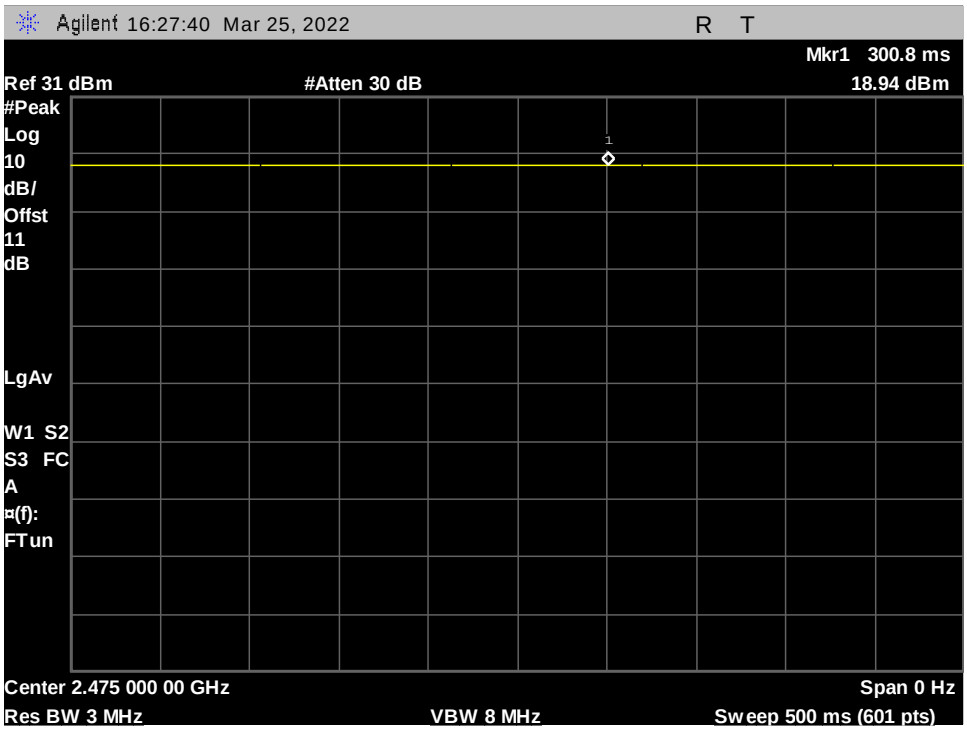


**Figure 9. Duty Cycle_2475MHz**


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# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(b) Conducted Power Output

**Test Requirements:** **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

**§15.247(b)**(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

**§15.247(c)**(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

**Test Procedure:** The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Power was measured according to measurement method RBW ≥ DTS Bandwidth, as described in ANSI C63.10-2013, section 11.9.1.1. Attenuator and cable loss were programmed into the spectrum analyzer.

**Test Results:** The EUT was **compliant** with the Peak Power Output limits of **§15.247(b)**. No anomalies noted.

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25, 2022

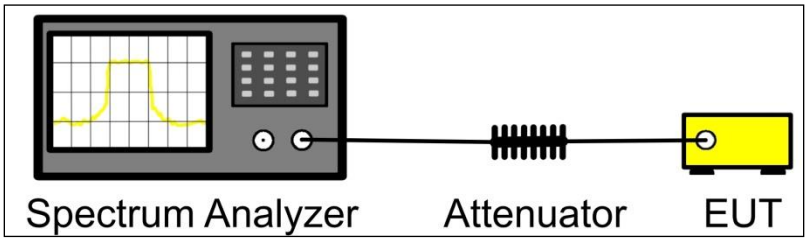


**Figure 10. Power Output Test Setup**

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## Maximum Conducted Power Output Test Results

| Frequency (MHz) | Conducted Power (dBm) | Limit (dBm) | Margin (dB) | Antenna Gain (dBi) | EIRP (dBm) | EIRP Limit (dBm) | EIRP Margin (dB) |
|---|---|---|---|---|---|---|---|
| 2405 | 19.25 | 30 | -10.75 | 5.3 | 24.55 | 36 | -11.45 |
| 2440 | 19.01 | 30 | -10.99 | 5.3 | 24.31 | 36 | -11.69 |
| 2475 | 18.97 | 30 | -11.03 | 5.3 | 24.27 | 36 | -11.73 |

**Table 11. PK Power Datasheet**

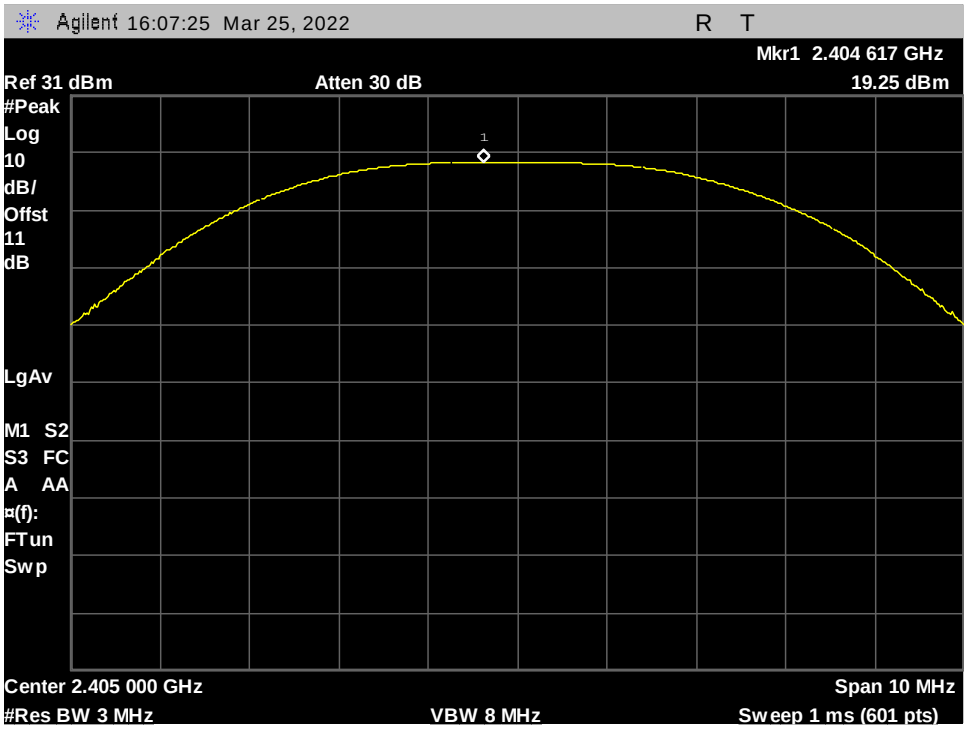


**Figure 11. Peak Output Power_2405MHz**


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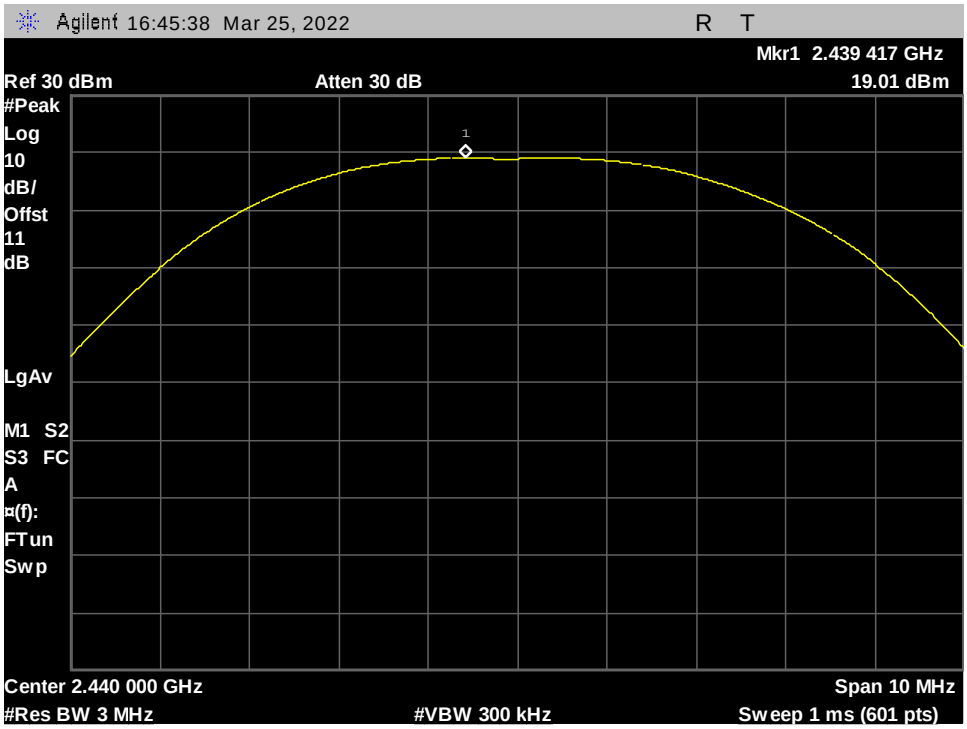


**Figure 12. Peak Output Power_2440MHz**

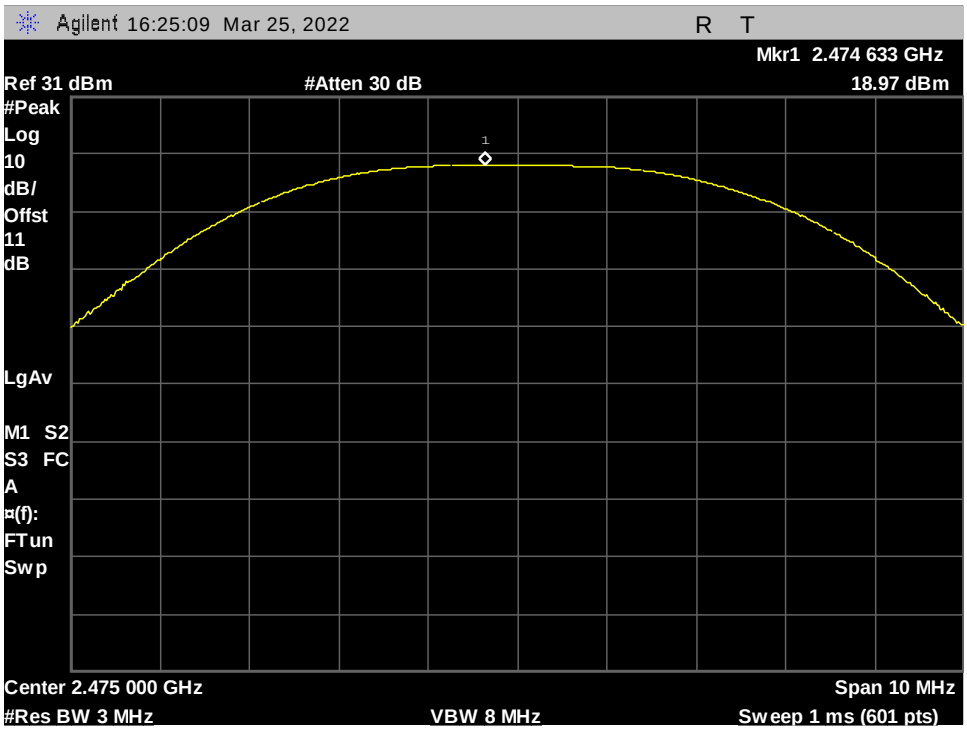


**Figure 13. Peak Output Power_2475MHz**

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.209 Radiated Spurious Emissions Requirements and Band Edge

**Test Requirements:** **§15.247(d); §15.205:** Emissions outside the frequency band.

**§15.205(a):** Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090–0.110---------- | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| [1] 0.495–0.505---------- | 16.69475–16.69525 | 608–614 | 5.35–5.46 |
| 2.1735–2.1905---------- | 16.80425–16.80475 | 960–1240 | 7.25–7.75 |
| 4.125–4.128---------- | 25.5–25.67 | 1300–1427 | 8.025–8.5 |
| 4.17725–4.17775---------- | 37.5–38.25 | 1435–1626.5 | 9.0–9.2 |
| 4.20725–4.20775---------- | 73–74.6 | 1645.5–1646.5 | 9.3–9.5 |
| 6.215–6.218---------- | 74.8–75.2 | 1660–1710 | 10.6–12.7 |
| 6.26775–6.26825---------- | 108–121.94 | 1718.8–1722.2 | 13.25–13.4 |
| 6.31175–6.31225---------- | 123–138 | 2200–2300 | 14.47–14.5 |
| 8.291–8.294---------- | 149.9–150.05 | 2310–2390 | 15.35–16.2 |
| 8.362–8.366---------- | 156.52475–156.52525 | 2483.5–2500 | 17.7–21.4 |
| 8.37625–8.38675---------- | 156.7–156.9 | 2655–2900 | 22.01–23.12 |
| 8.41425–8.41475---------- | 162.0125–167.17 | 3260–3267 | 23.6–24.0 |
| 12.29–12.293---------- | 167.72–173.2 | 3332–3339 | 31.2–31.8 |
| 12.51975–12.52025---------- | 240–285 | 3345.8–3358 | 36.43–36.5 |
| 12.57675–12.57725---------- | 322–335.4 | 3600–4400 | ([2]) |
| 13.36-13.41 | | | |

**Table 12. Restricted Bands of Operation**

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

[2] Above 38.6

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**Test Requirement(s):** **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 13.

| Frequency (MHz) | § 15.209(a),Radiated Emission Limits (dBµV) @ 3m |
|---|---|
| 30 - 88 | 40.00 |
| 88 - 216 | 43.50 |
| 216 - 960 | 46.00 |
| Above 960 | 54.00 |

**Table 13. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)**

**Test Procedures:** The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line. Radiated emissions were investigated up to 25 GHz

**Test Results:** The EUT was **compliant** with the Radiated Spurious Emission limits of **§ 15.247(d) and § 15.209**. Measured emissions were below the applicable limits.

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25 – 28, 2022

## Radiated Spurious Emissions, Test Results

| | |
|---|---|
| **Test Specification:** | 15.209 Radiated Emissions Limits; General Requirements // RSS-GEN Issue 5 |
| **Test Method:** | Radiated Emissions, 30 MHz to 1 GHz |
| **Job Number:** | 117977 |
| **Customer:** | Autani, LLC |
| **EUT Name:** | ZRB4 |
| **Part/Model Number:** | N/A |
| **Serial Number:** | N/A |
| **Mode of Operation:** | FCC Test Mode |
| **Engineer:** | Donald Salguero |
| **Date:** | 3/25/2022 - 3/28/2022 |
| **Temperature:** | 22.1°C |
| **Humidity:** | 41% |

**Table 14. Radiated Emissions, Header**

| Active Channel Frequency (MHz) | Frequency MHz | Polarity Horizontal/Vertical | Antenna Height cm | Turntable Position Degrees | Measured dBuV | Correction Factor dB | Corrected Reading dBuV/m | Limit dBuV/m | Margin dB | Results Pass/Fail |
|---|---|---|---|---|---|---|---|---|---|---|
| 2405 | 918.02 | H | 129.95 | 4.00 | 6.37 | 30.34 | 36.72 | 46.00 | -9.28 | PASS |
| 2405 | 787.08 | H | 184.86 | 87.20 | 6.16 | 28.63 | 34.79 | 46.00 | -11.21 | PASS |
| 2405 | 124.70 | H | 310.91 | 0.20 | 5.87 | 19.33 | 25.20 | 43.50 | -18.30 | PASS |
| 2405 | 66.62 | H | 168.82 | 358.10 | 8.30 | 12.89 | 21.19 | 40.00 | -18.81 | PASS |
| 2405 | 44.88 | H | 223.26 | 101.70 | 8.01 | 16.11 | 24.13 | 40.00 | -15.87 | PASS |
| 2405 | 31.38 | H | 173.56 | 267.50 | 5.65 | 25.93 | 31.58 | 40.00 | -8.42 | PASS |
| 2405 | 32.16 | V | 378.73 | 293.30 | 5.80 | 24.09 | 29.89 | 40.00 | -10.11 | PASS |
| 2405 | 45.15 | V | 394.47 | 148.20 | 7.78 | 15.06 | 22.85 | 40.00 | -17.15 | PASS |
| 2405 | 49.03 | V | 378.60 | 358.50 | 7.90 | 13.19 | 21.09 | 40.00 | -18.91 | PASS |
| 2405 | 59.17 | V | 401.21 | 0.10 | 10.19 | 11.92 | 22.11 | 40.00 | -17.89 | PASS |
| 2405 | 782.78 | V | 109.08 | 270.70 | 6.30 | 28.10 | 34.40 | 46.00 | -11.60 | PASS |
| 2405 | 938.48 | V | 135.30 | 0.10 | 6.44 | 30.06 | 36.50 | 46.00 | -9.50 | PASS |
| 2440 | 778.58 | H | 282.04 | 331.70 | 6.16 | 28.52 | 34.68 | 46.00 | -11.32 | PASS |
| 2475 | 779.66 | V | 229.43 | 178.80 | 6.23 | 28.02 | 34.25 | 46.00 | -11.75 | PASS |

**Table 15. Radiated Emissions - Test Results, 30-1000 MHz**


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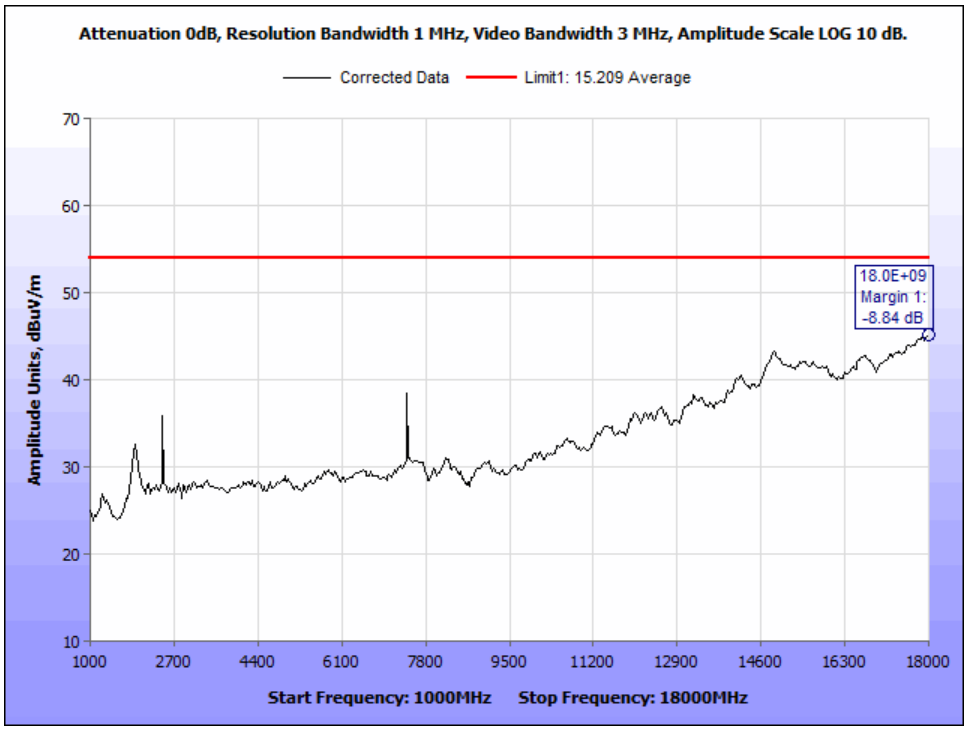


**Figure 14. AVG_15.209 Radiated Spurious Emissions_High Channel 2475MHz_1-18 GHz**

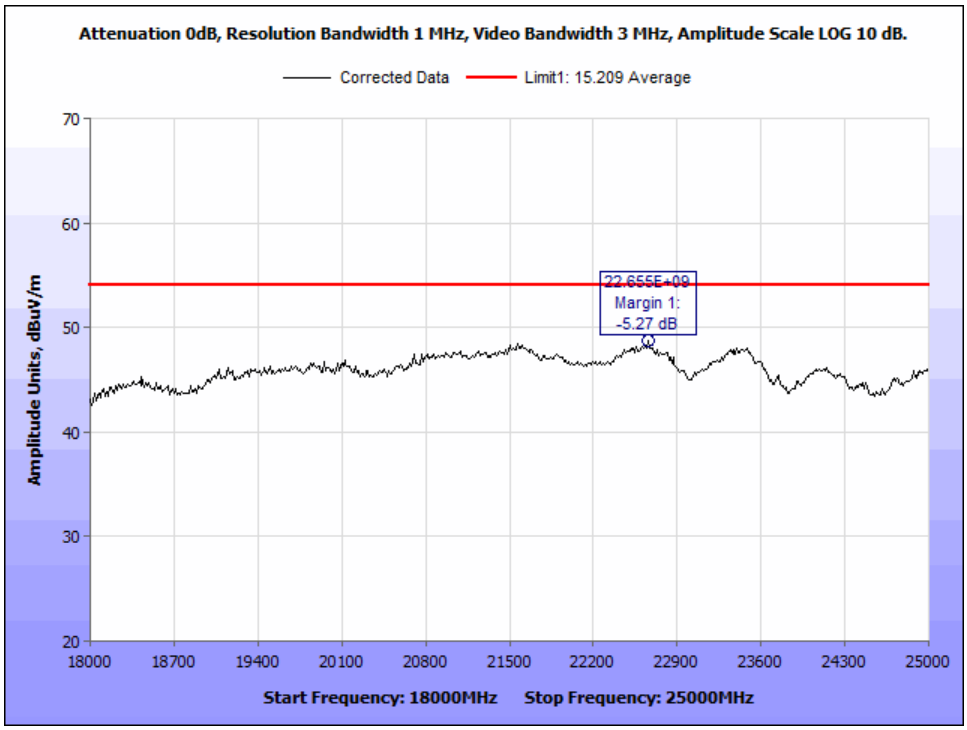


**Figure 15. AVG_15.209 Radiated Spurious Emissions_High Channel 2475MHz_18-25 GHz**

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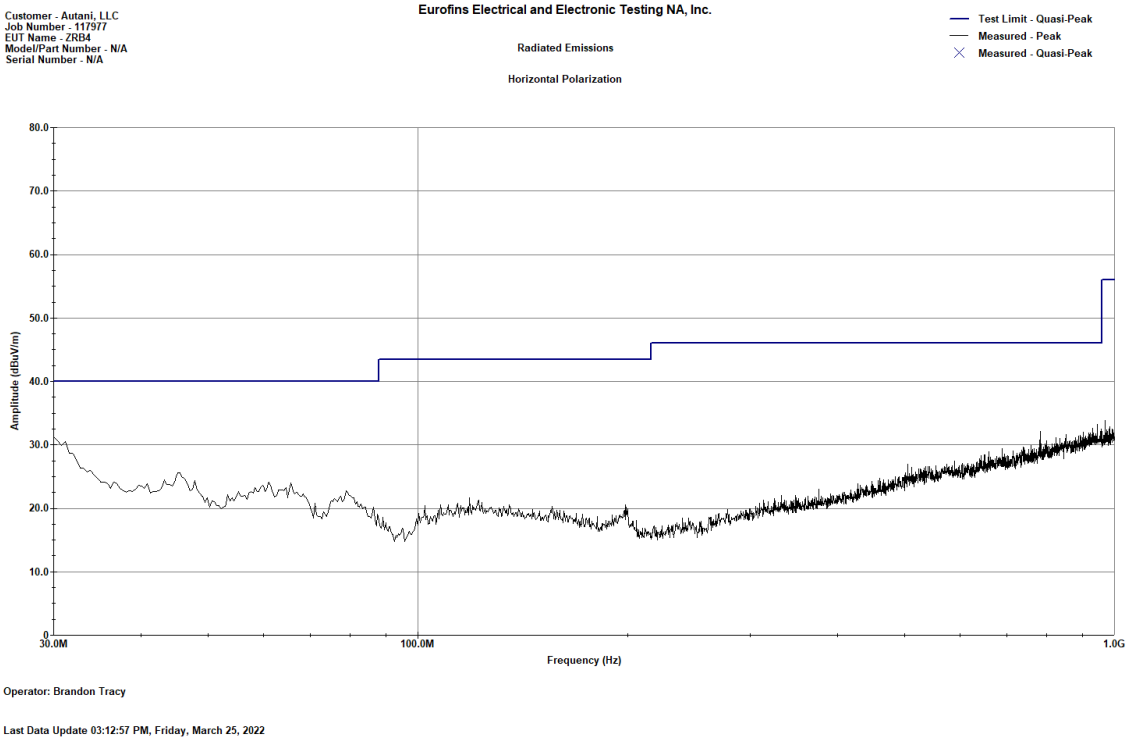


**Figure 16. Radiated Emissions, Horizontal Polarization - 2475MHz - 30-1000 MHz**

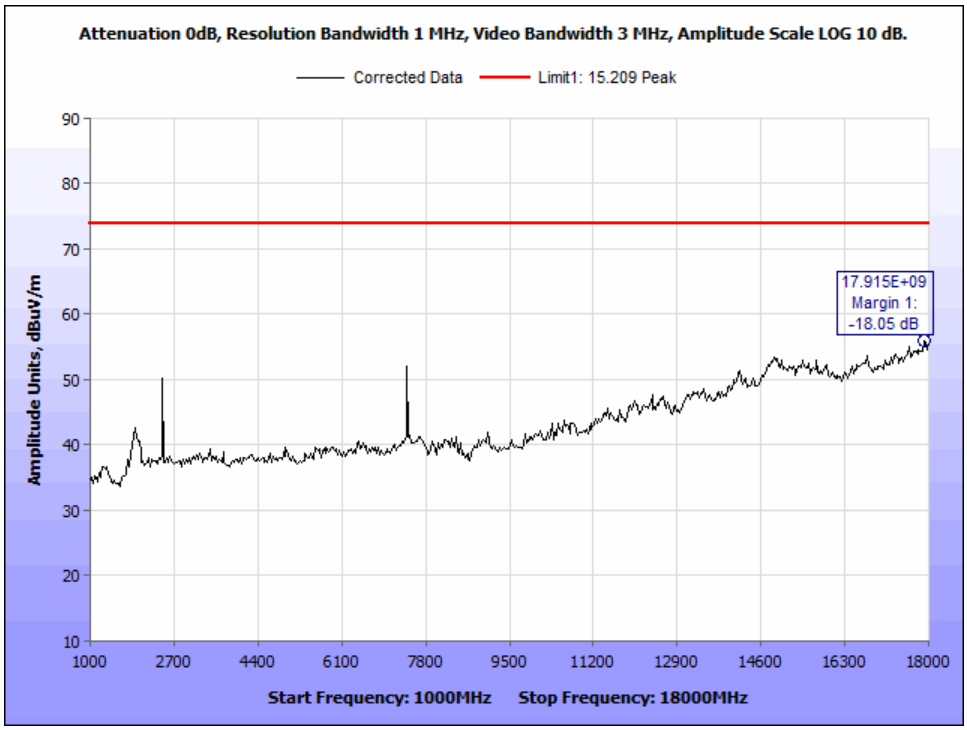


**Figure 17. PK_15.209 Radiated Spurious Emissions_High Channel 2475MHz_1-18 GHz**

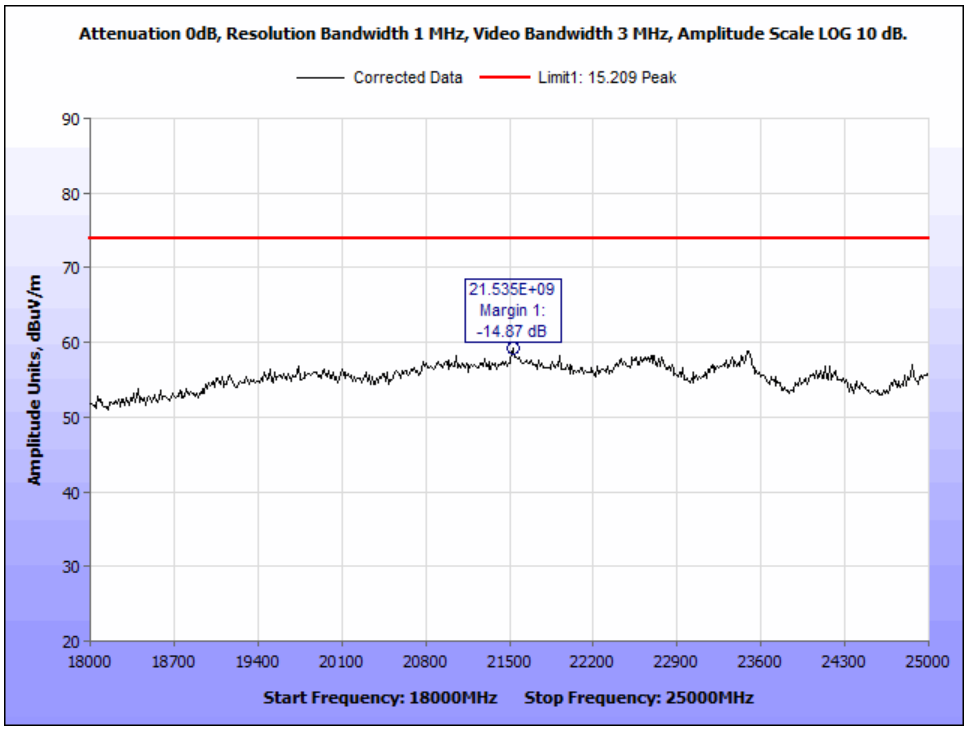


**Figure 18. PK_15.209 Radiated Spurious Emissions_High Channel 2475MHz_18-25 GHz**

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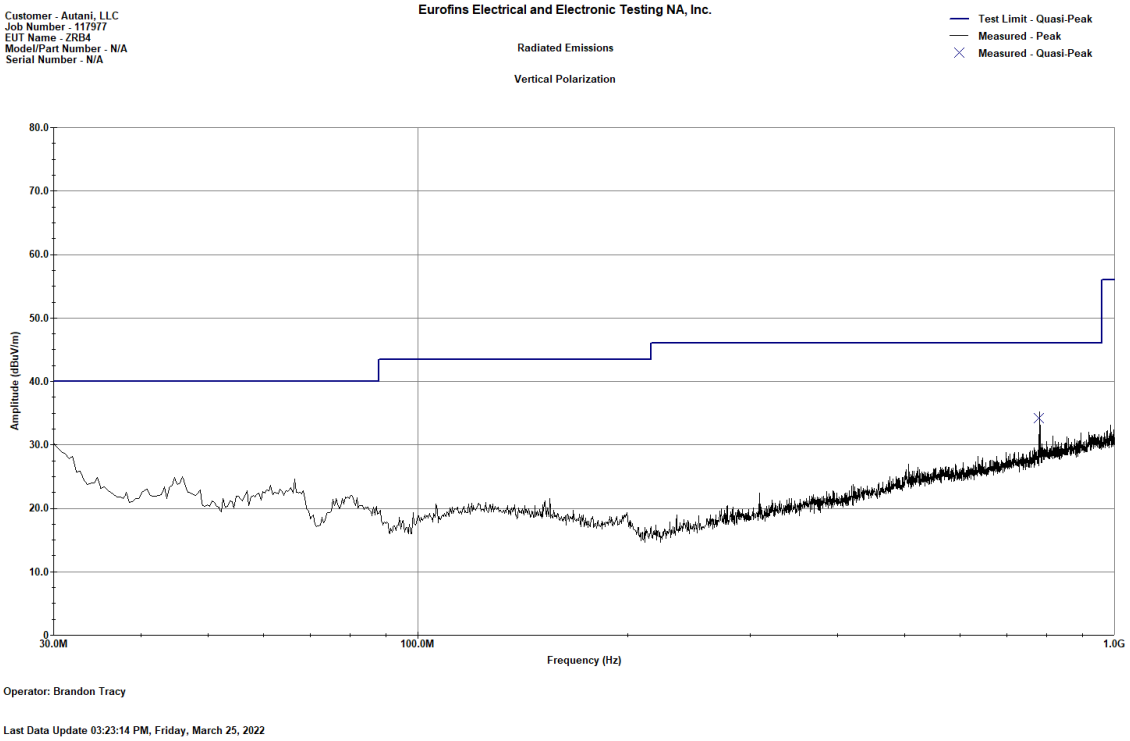


**Figure 19. Radiated Emissions, Vertical Polarization - 2475MHz - 30-1000 MHz**

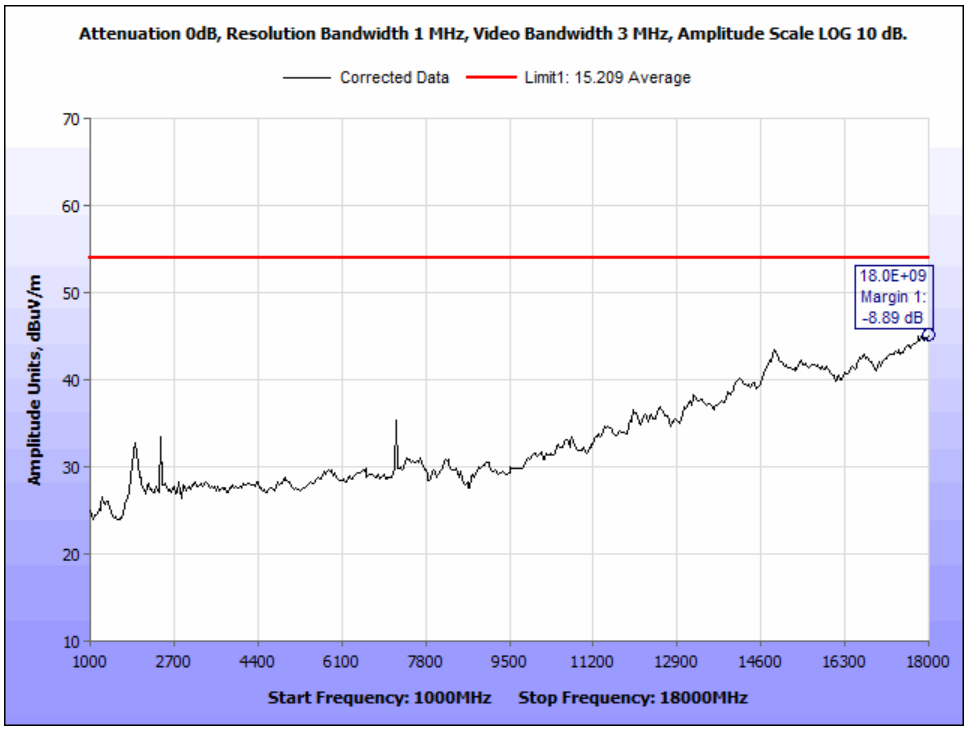


**Figure 20. AVG_15.209 Radiated Spurious Emissions_Low Channel 2405MHz_1-18 GHz**

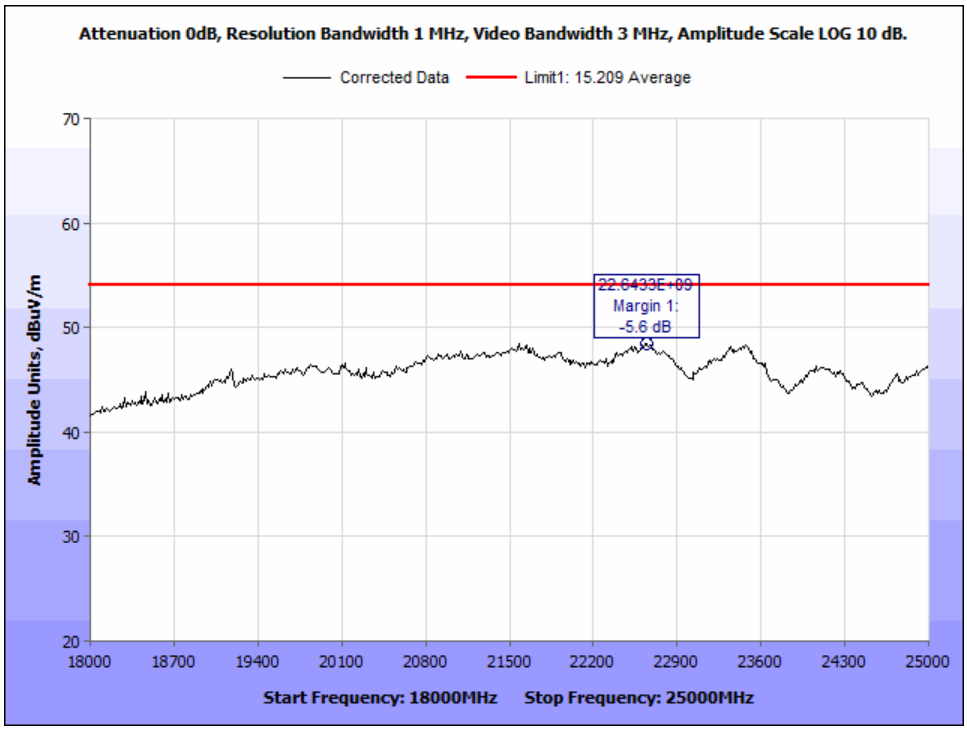


**Figure 21. AVG_15.209 Radiated Spurious Emissions_Low Channel 2405MHz_18-25 GHz**

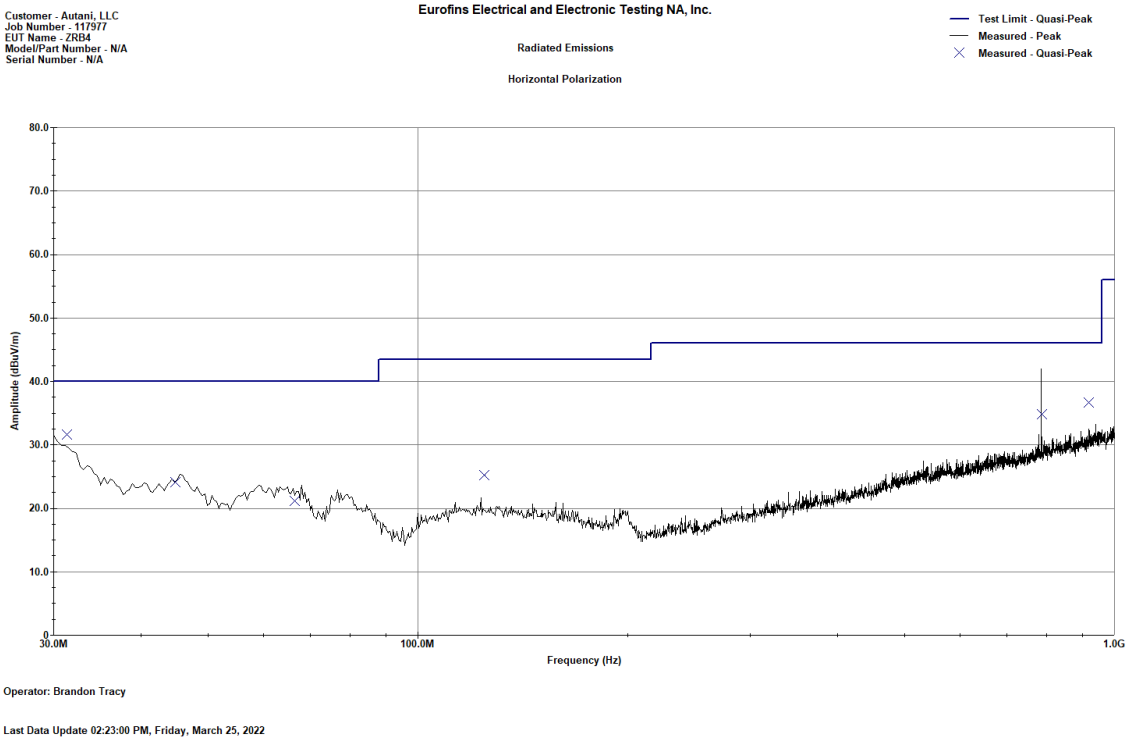


**Figure 22. Radiated Emissions, Horizontal Polarization - 2405MHz - 30-1000 MHz**

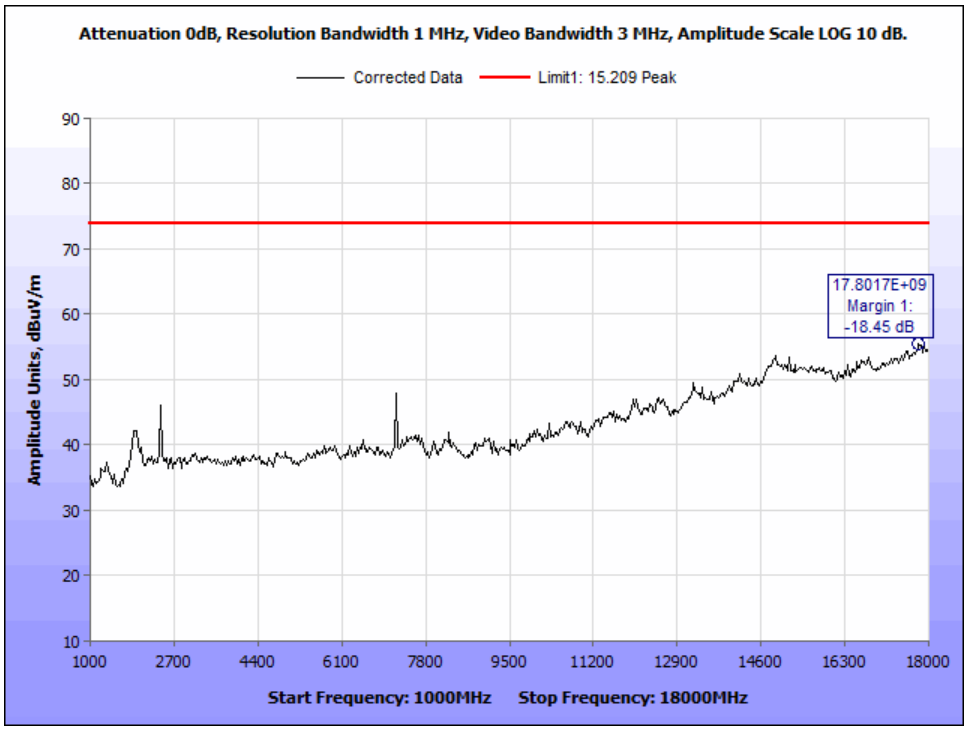


**Figure 23. PK_15.209 Radiated Spurious Emissions_Low Channel 2405MHz_1-18 GHz**

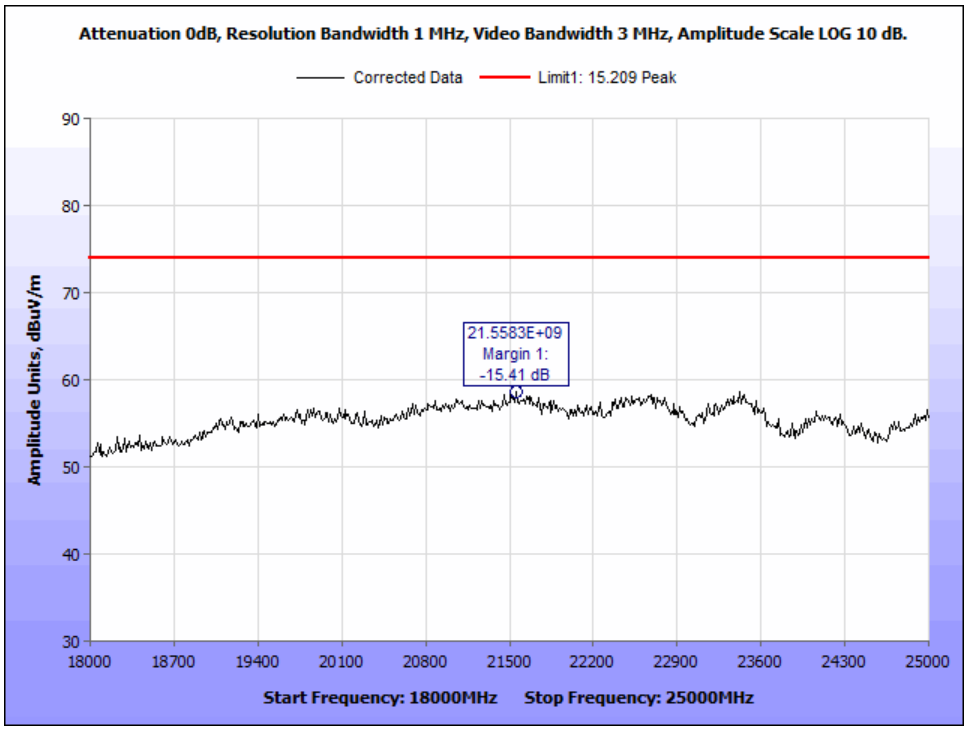


**Figure 24. PK_15.209 Radiated Spurious Emissions_Low Channel 2405MHz_18-25 GHz**

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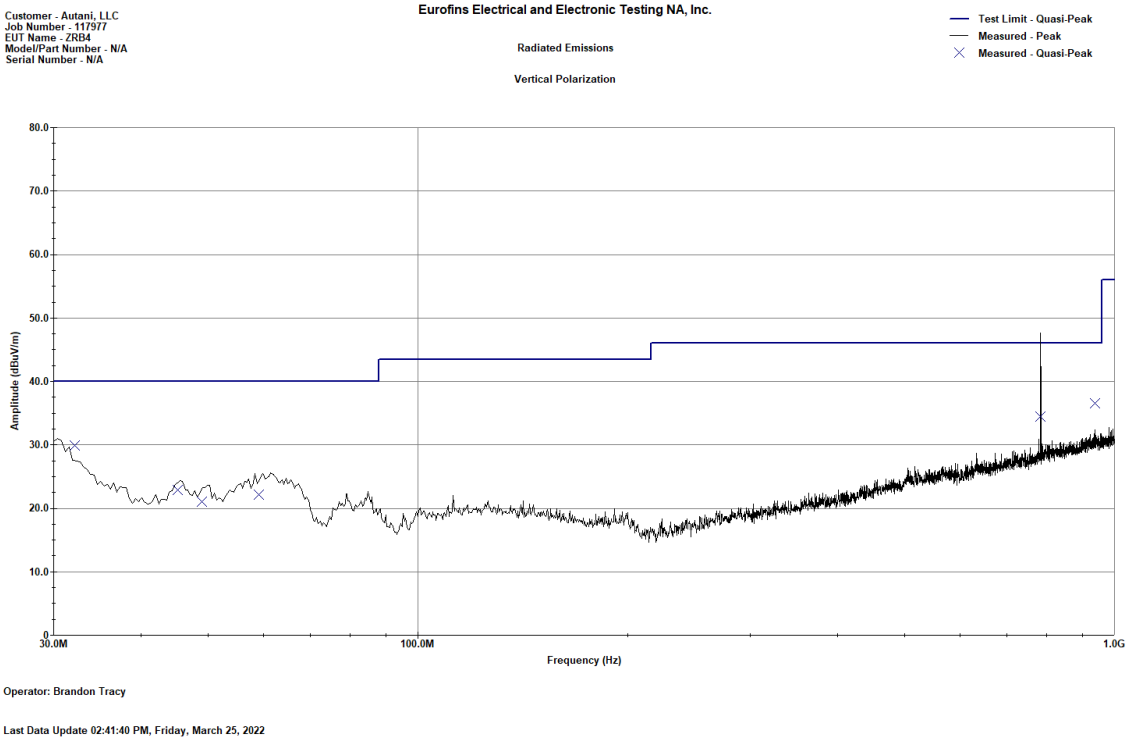


**Figure 25. Radiated Emissions, Vertical Polarization - 2405MHz - 30-1000 MHz**

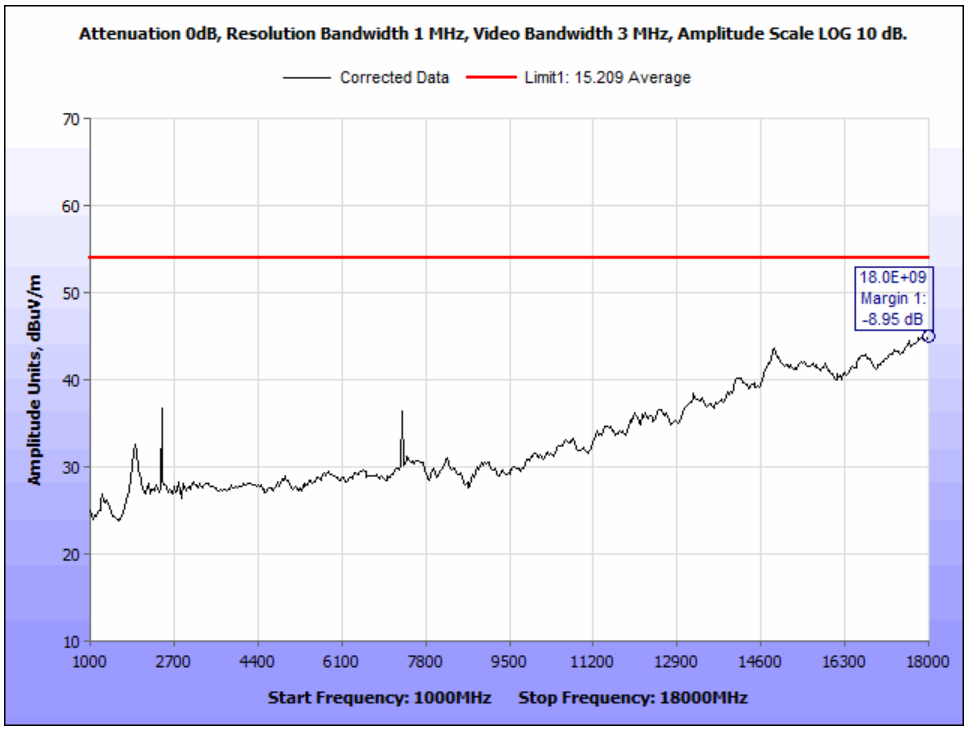


**Figure 26. AVG_15.209 Radiated Spurious Emissions_Mid Channel 2440MHz_1-18 GHz**

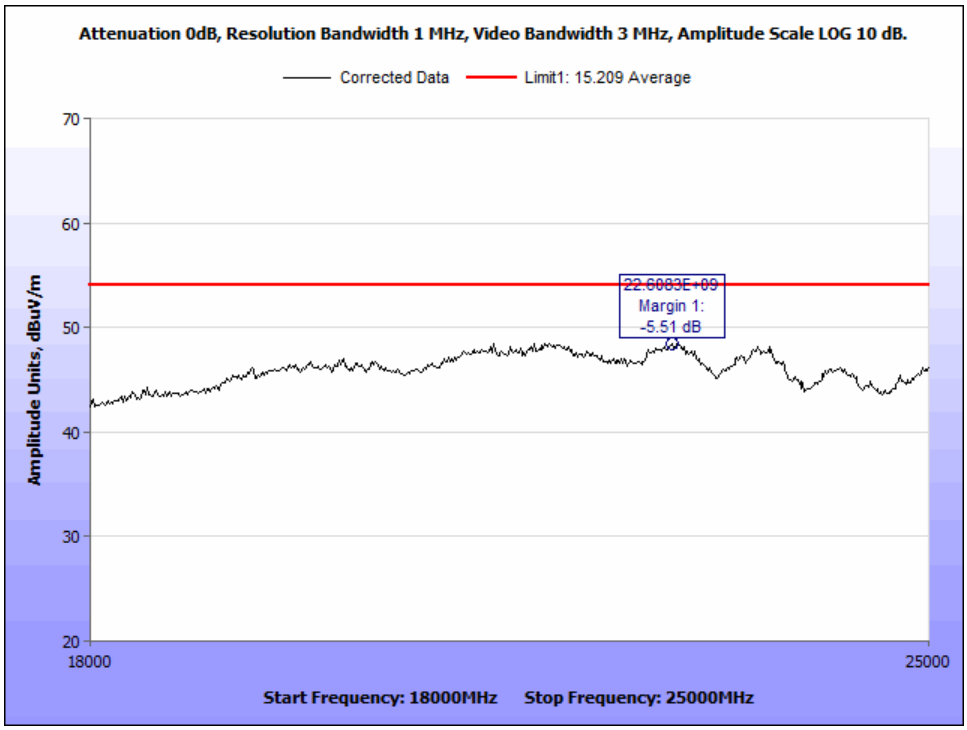


**Figure 27. AVG_15.209 Radiated Spurious Emissions_Mid Channel 2440MHz_18-25 GHz**

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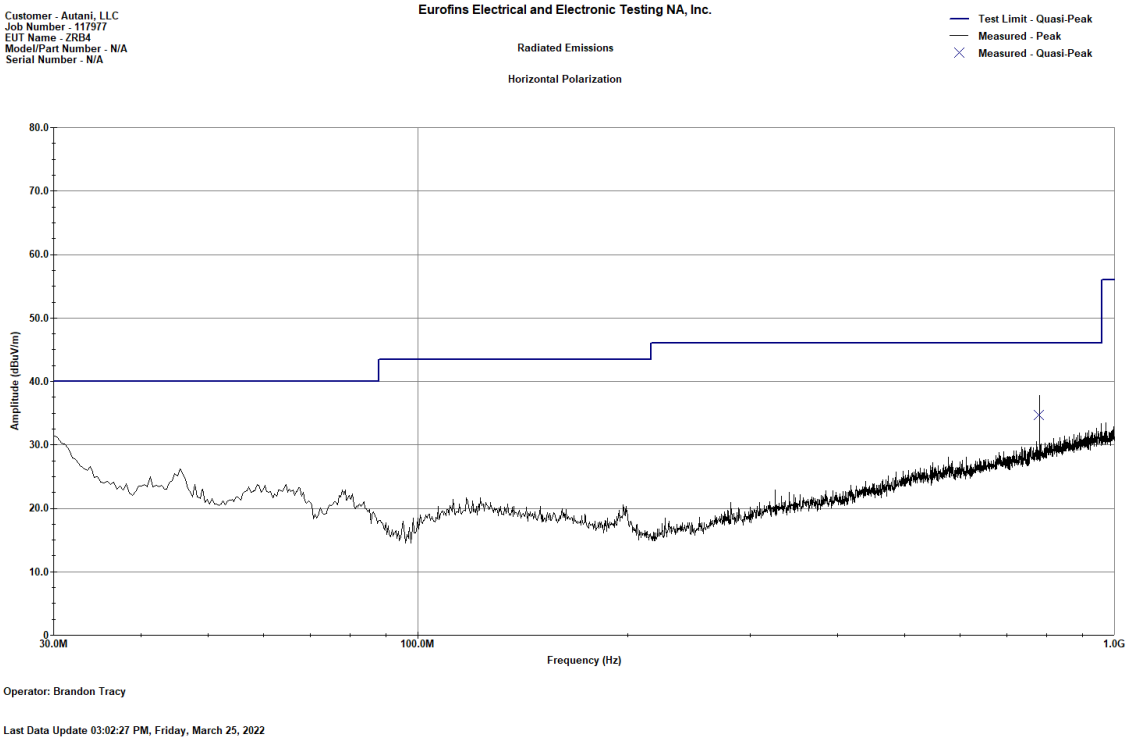


**Figure 28. Radiated Emissions, Horizontal Polarization - 2440MHz - 30-1000 MHz**

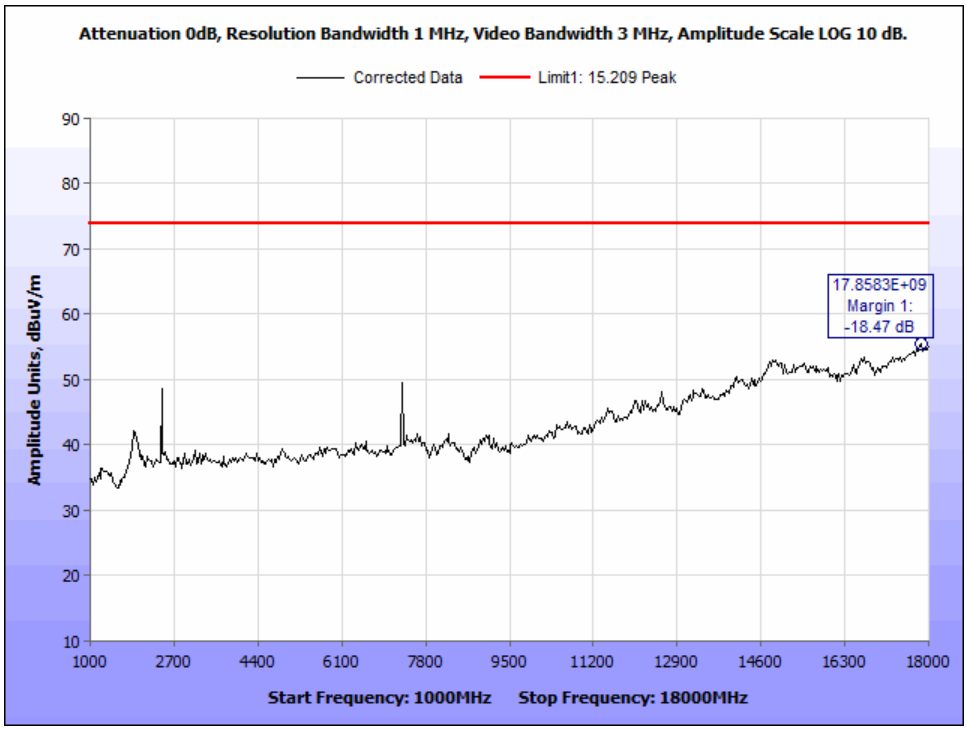


**Figure 29. PK_15.209 Radiated Spurious Emissions_Mid Channel 2440MHz_1-18 GHz**

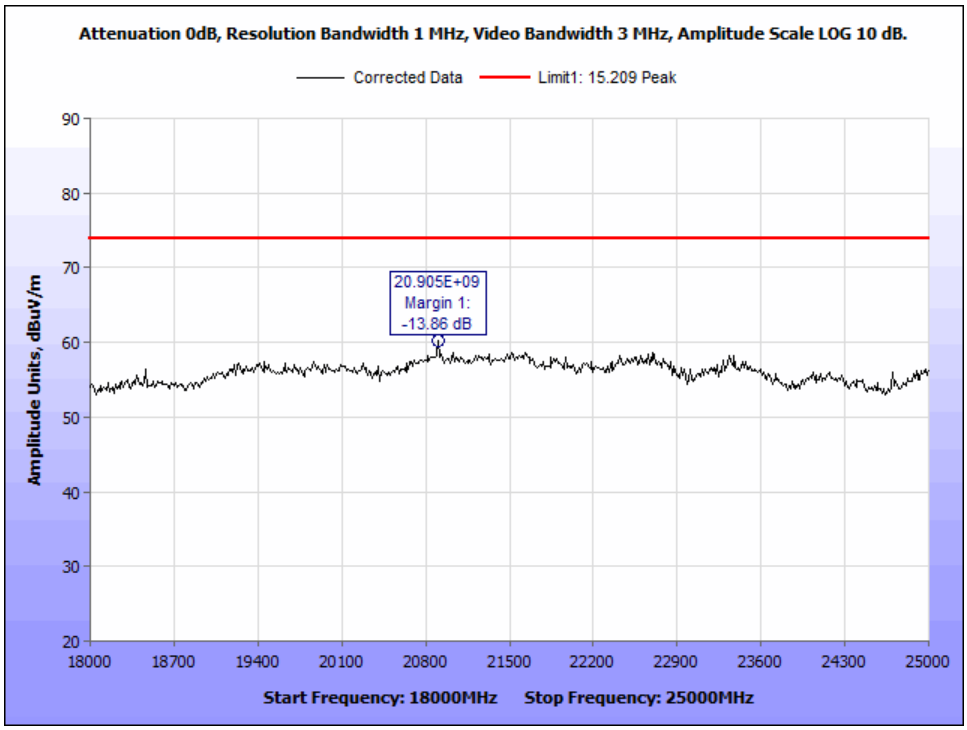


**Figure 30. PK_15.209 Radiated Spurious Emissions_Mid Channel 2440MHz_18-25 GHz**

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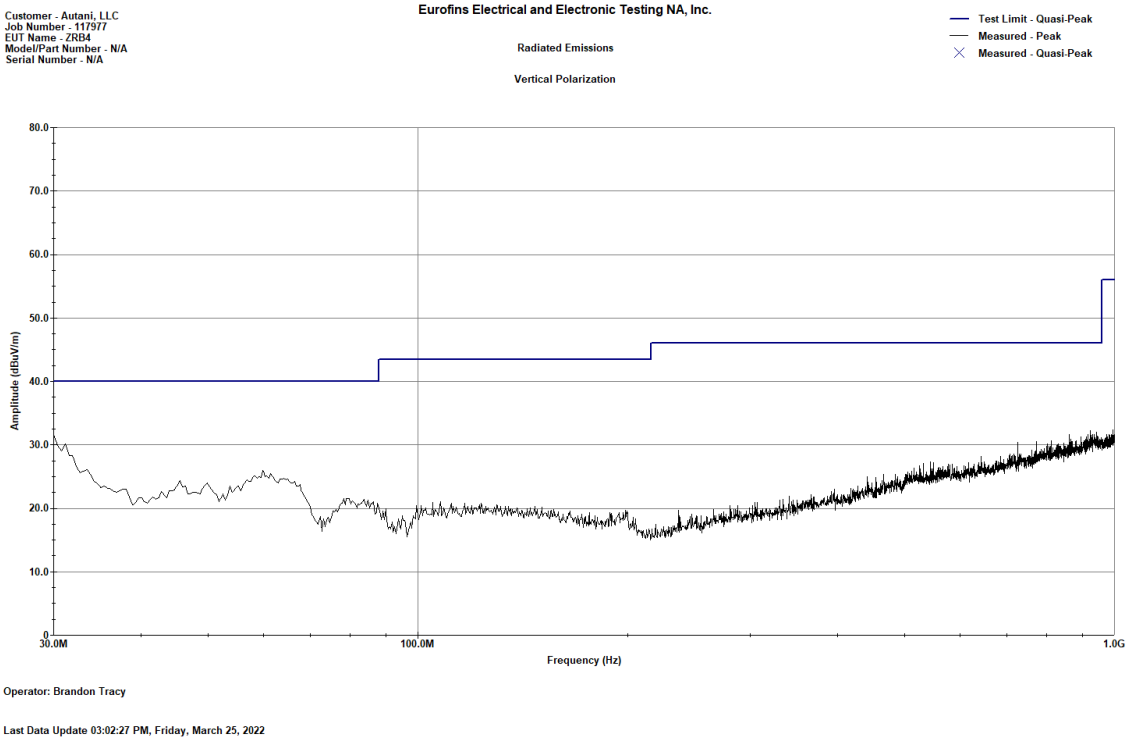


**Figure 31. Radiated Emissions, Vertical Polarization - 2440MHz - 30-1000MHz**

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

| Asset | Equipment | Manufacturer | Model | Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|
| 1T4753 | Antenna - Bilog | Sunol Sciences | JB6 | 12/21/2020 | 6/21/2022 |
| 1T8743 | Preamplifier | A.H. Systems, Inc. | PAM-0118P | Func Verify | Func Verify |
| 1T4483 | Antenna; Horn | ETS-Lindgren | 3117 | 1/31/2022 | 7/31/2023 |
| 1T4681 | Spectrum Analyzer (PSA) | Agilent Technologies | E4448A | 10/15/2021 | 4/15/2023 |
| 1T4744 | Antenna, Horn | ETS-Lindgren | 3116 | 3/4/2021 | 9/4/2022 |
| 1T4752 | Pre-Amplifier | Miteq | JS44-18004000-35-8P | Func Verify | Func Verify |
| 1T4300B | Semi-Anechoic 3m Chamber sVSWR | EMC TEST SYSTEMS | NONE | 9/30/2021 | 9/30/2023 |
| 1T4300 | SEMI-ANECHOIC CHAMBER (NSA) | EMC TEST SYSTEMS | NONE | 8/19/2021 | 8/31/2023 |
| 1T4409 | EMI Receiver | Rohde & Schwarz | ESIB7 | 2/16/2022 | 8/31/2023 |

**Table 16. Radiated Emissions, Test Equipment List**

Note: Functionally verified test equipment is verified using calibrated instrumentation at time of testing.

## Radiated Band Edge Measurements

**Test Procedures:** The transmitter was turned on. Measurements were performed of the low and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

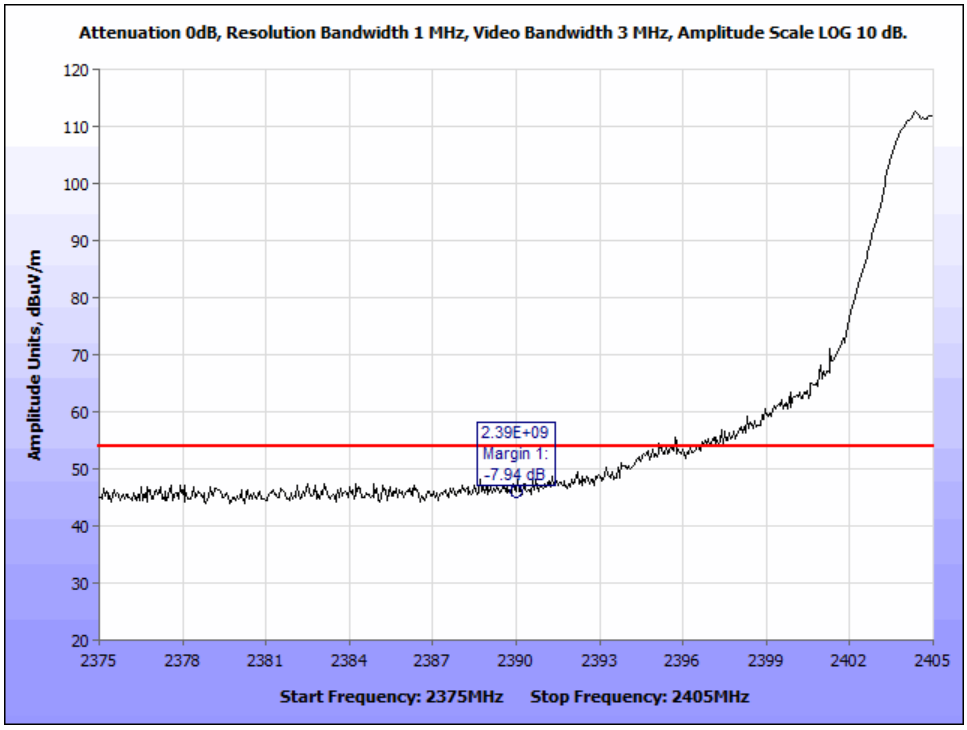


**Figure 32. AVG_Radiated Bandedge @ 2390MHz_Low Channel 2405MHz**

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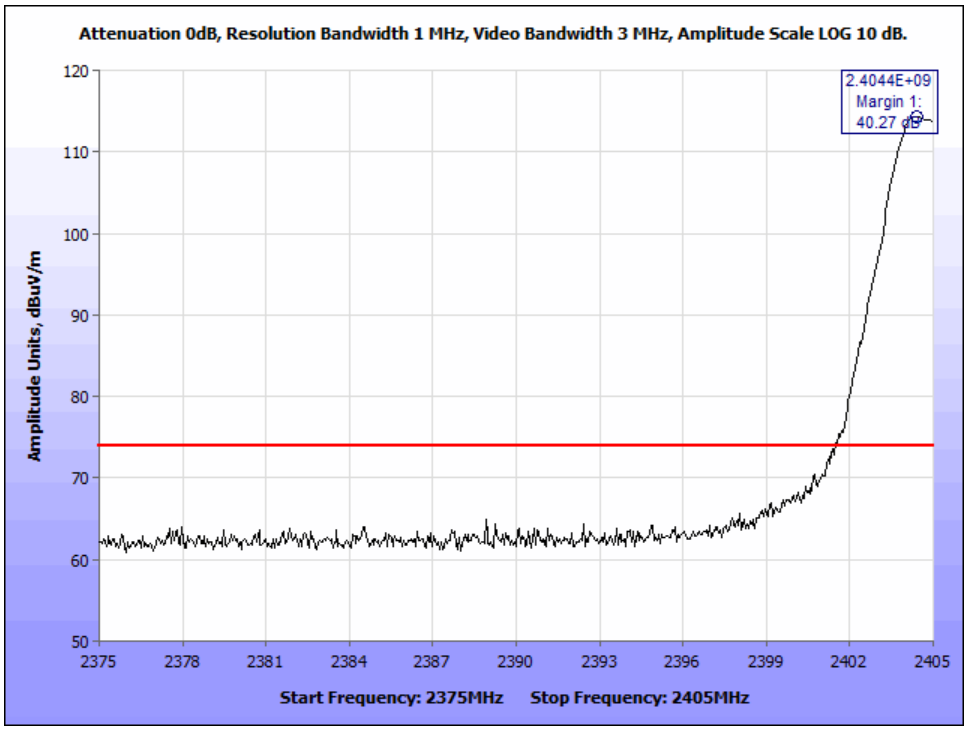


**Figure 33. PK_Radiated Bandedge @ 2390MHz_Low Channel 2405MHz**

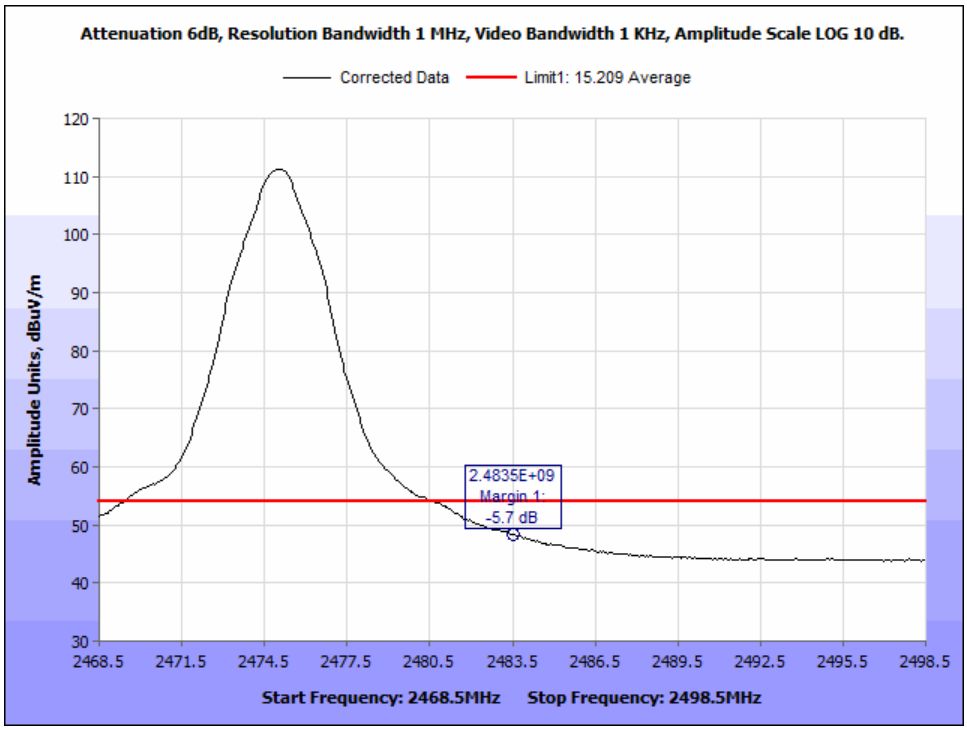


**Figure 34. AVG_Radiated Bandedge @ 2483.5MHz_High Channel 2475MHz**

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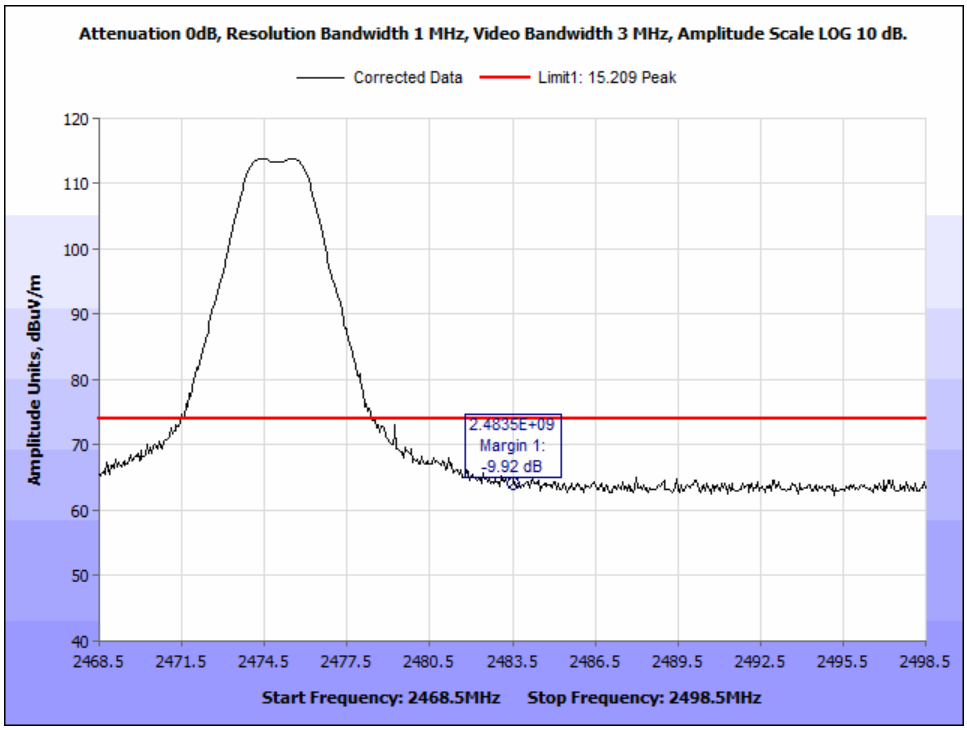


**Figure 35. PK_Radiated Bandedge @ 2483.5MHz_High Channel 2475MHz**


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# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(d) Spurious Emissions in Non-restricted Bands

**Test Requirement:** **15.247(d)** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

**Test Procedure:** For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10$^{th}$ harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Conducted spurious emissions were measured according to sections 11.11.2 and 11.11.3 of ANSI C63.10-2013.

**Test Results:** The EUT was **compliant** with the Spurious Emission limits of **§15.247(d)**. Measured emissions were below the applicable limits.

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25, 2022

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## Spurious Emissions in Non-restricted Bands, Test Results

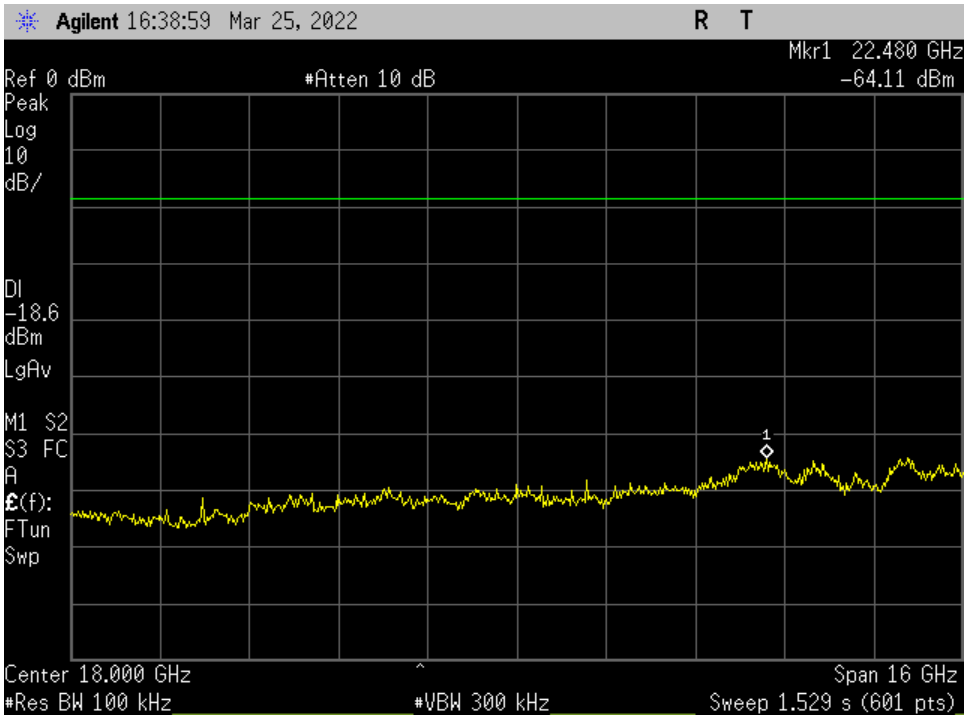


**Figure 36. Zigbee_High Ch_2475MHz_-20dBc_10-26GHz_Port 1**

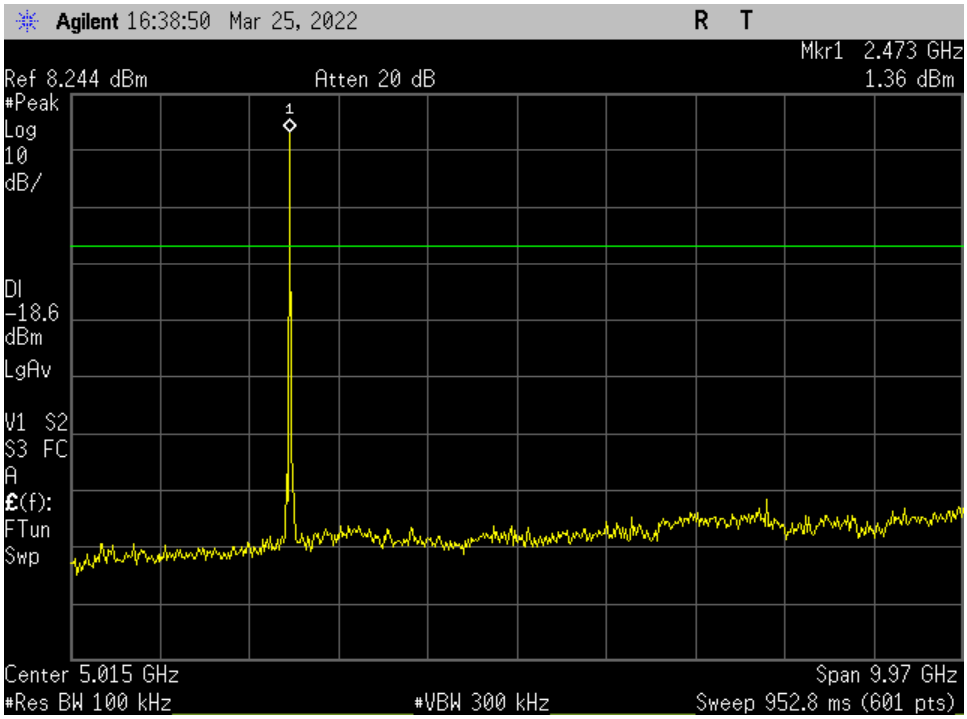


**Figure 37. Zigbee_High Ch_2475MHz_-20dBc_30MHz-10GHz_Port 1**


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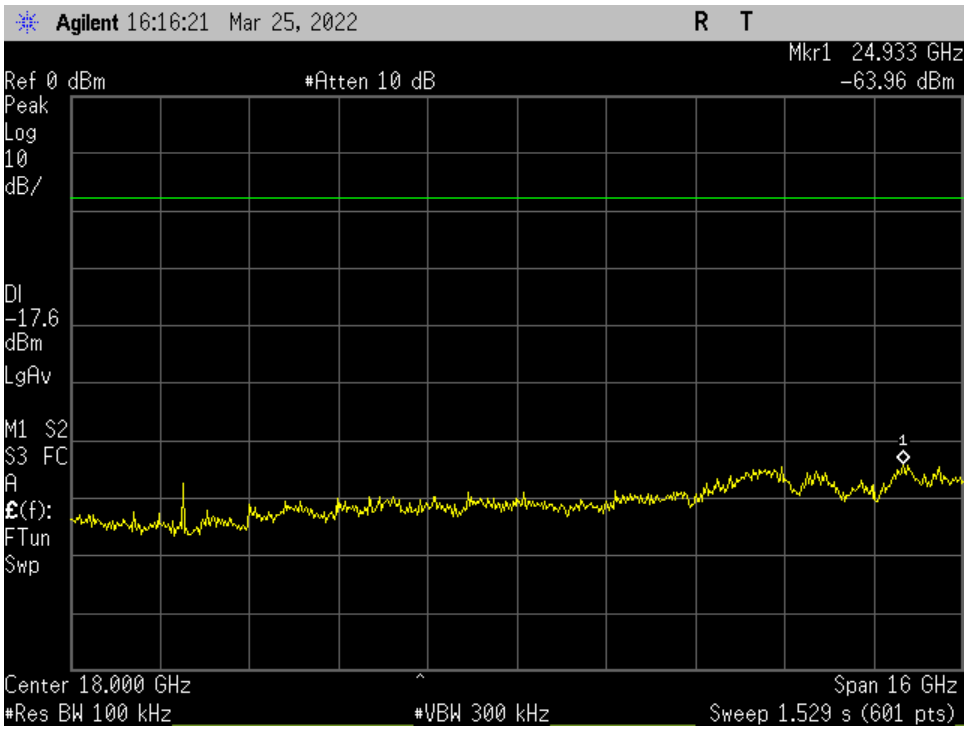


**Figure 38. Zigbee_Low Ch_2405MHz_-20dBc_10-26GHz_Port 1**

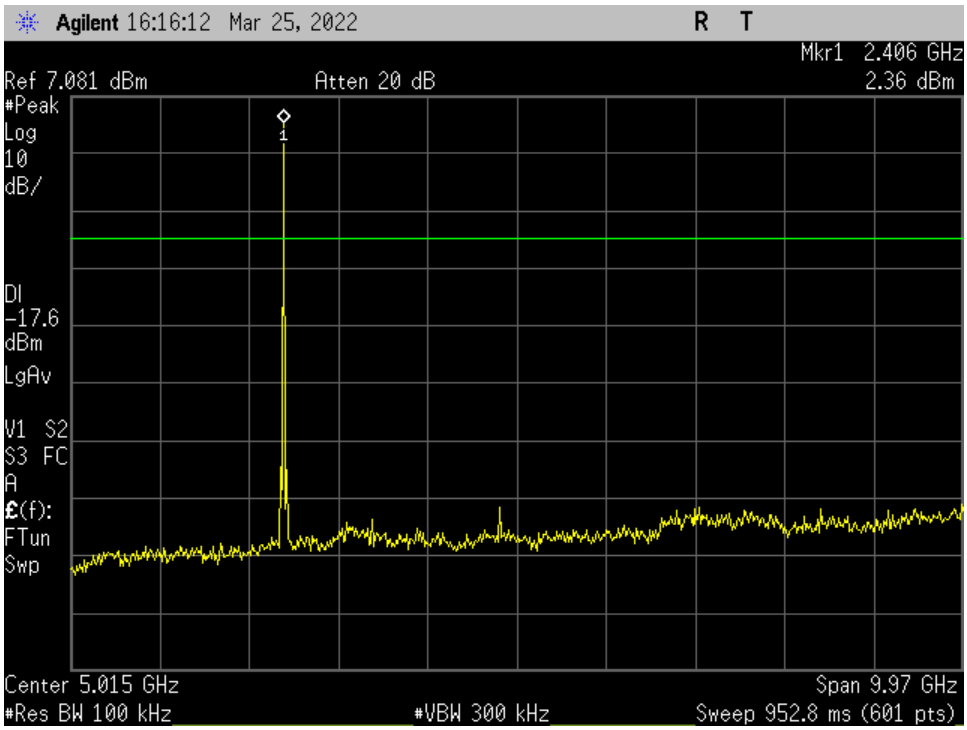


**Figure 39. Zigbee_Low Ch_2405MHz_-20dBc_30MHz-10GHz_Port 1**

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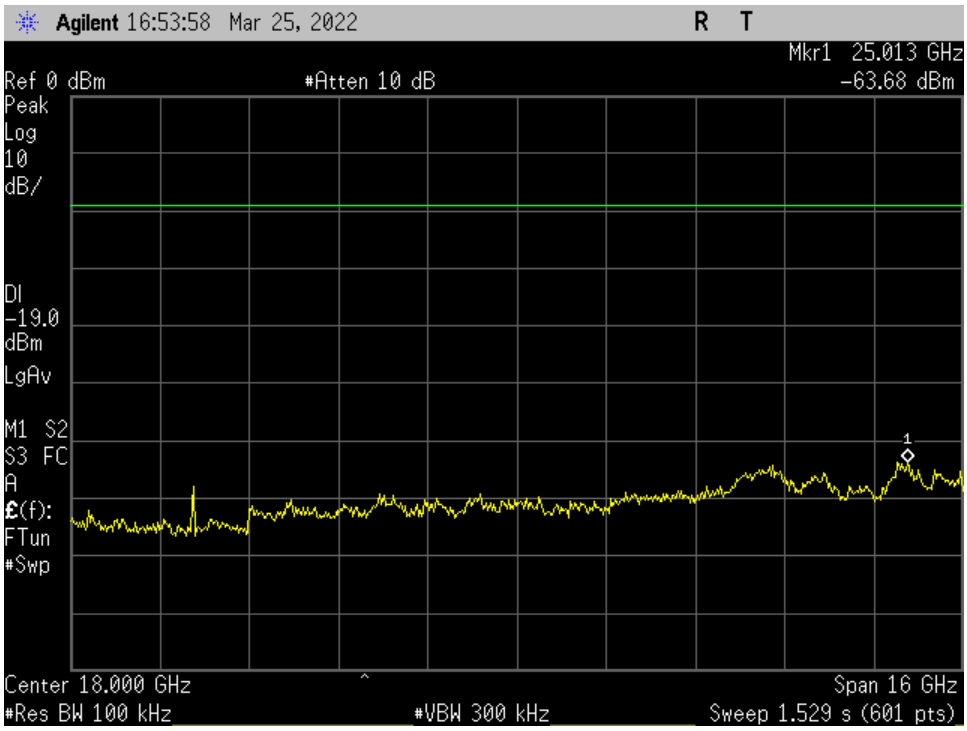


**Figure 40. Zigbee_Mid Ch_2440MHz_-20dBc_10-26GHz_Port 1**

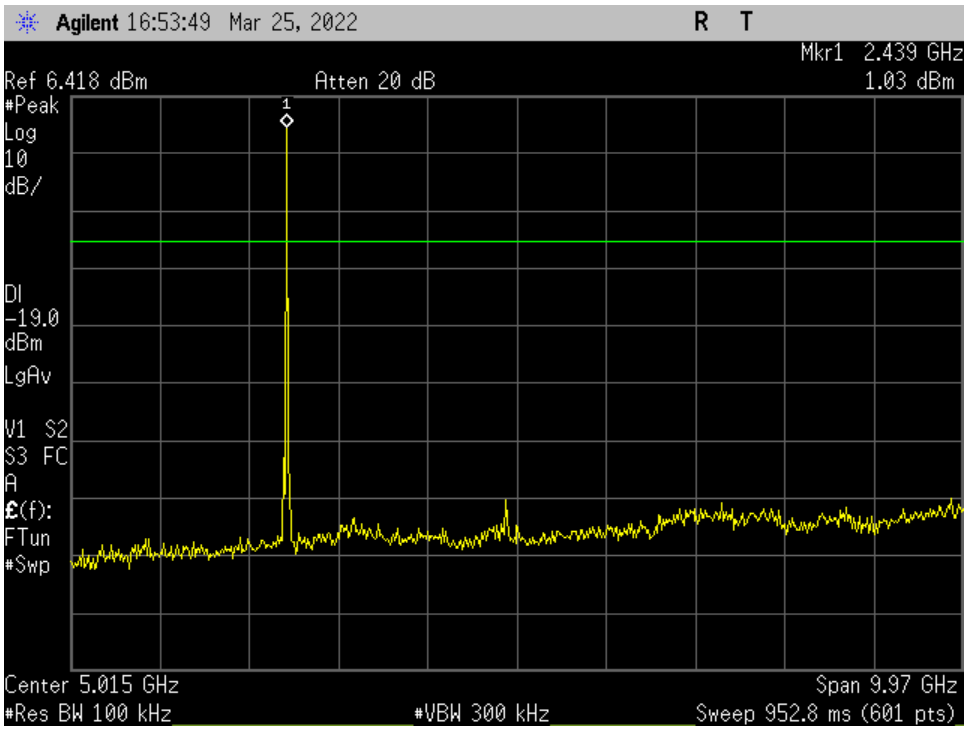


**Figure 41. Zigbee_Mid Ch_2440MHz_-20dBc_30MHz-10GHz_Port 1**


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## Conducted Band Edge Test Results

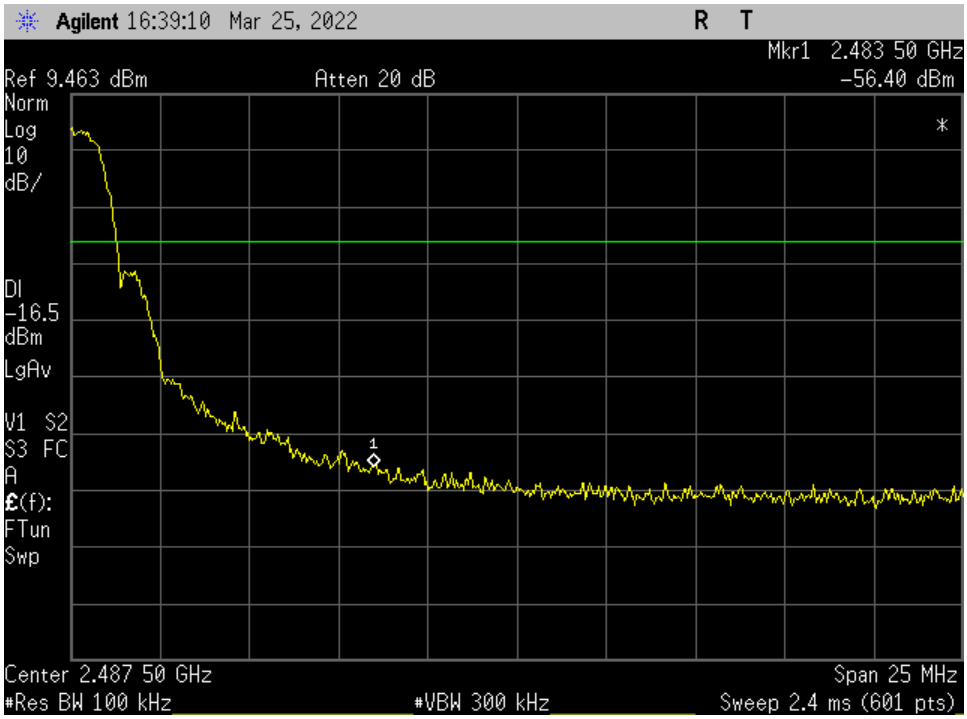


**Figure 42. Zigbee_High Ch_2475MHz_-20dBc_Upper Band Edge_Port 1**

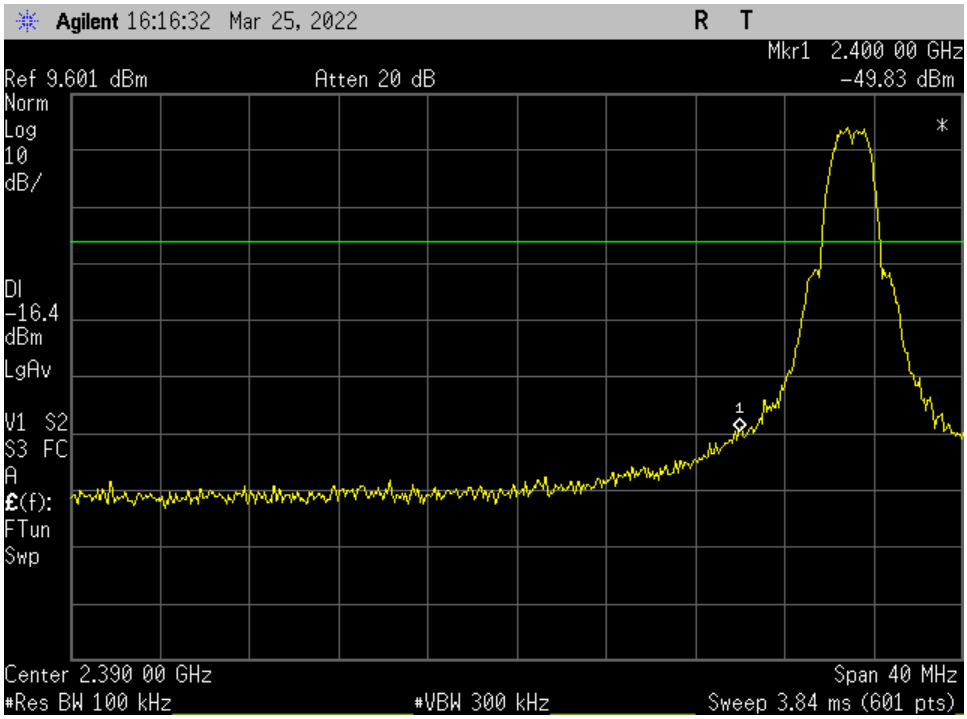


**Figure 43. Zigbee_Low Ch_2405MHz_-20dBc_Lower Band Edge_Port 1**


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# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(e) Power Spectral Density

**Test Requirements:** **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

**Test Procedure:** The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Power spectral density was measured according to measurement method PKPSD, as described in ANSI C63.10-2013, section 11.10.2. Attenuator and cable loss were programmed into the spectrum analyzer.

**Test Results:** The EUT was **compliant** with the peak power spectral density limits of **§ 15.247 (e)**. No anomalies noted.

The peak power spectral density was determined from plots on the following page(s).

**Test Engineer(s):** Donald Salguero

**Test Date(s):** March 25, 2022

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## Peak Power Spectral Density Test Results

| Frequency (MHz) | Conducted Power (dBm) | Limit (dBm) | Margin (dB) |
|---|---|---|---|
| 2405 | 4.15 | 8 | -3.85 |
| 2440 | 4.04 | 8 | -3.96 |
| 2475 | 3.67 | 8 | -4.33 |

**Table 17. PK PSD Results**

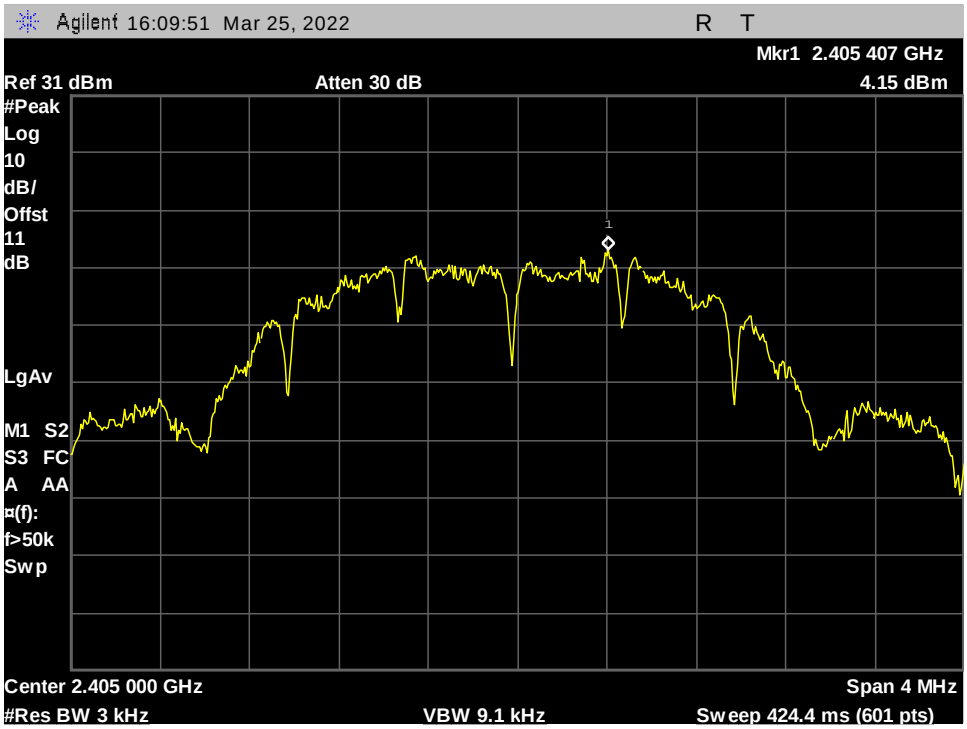


**Figure 44. Peak PSD_2405MHz**


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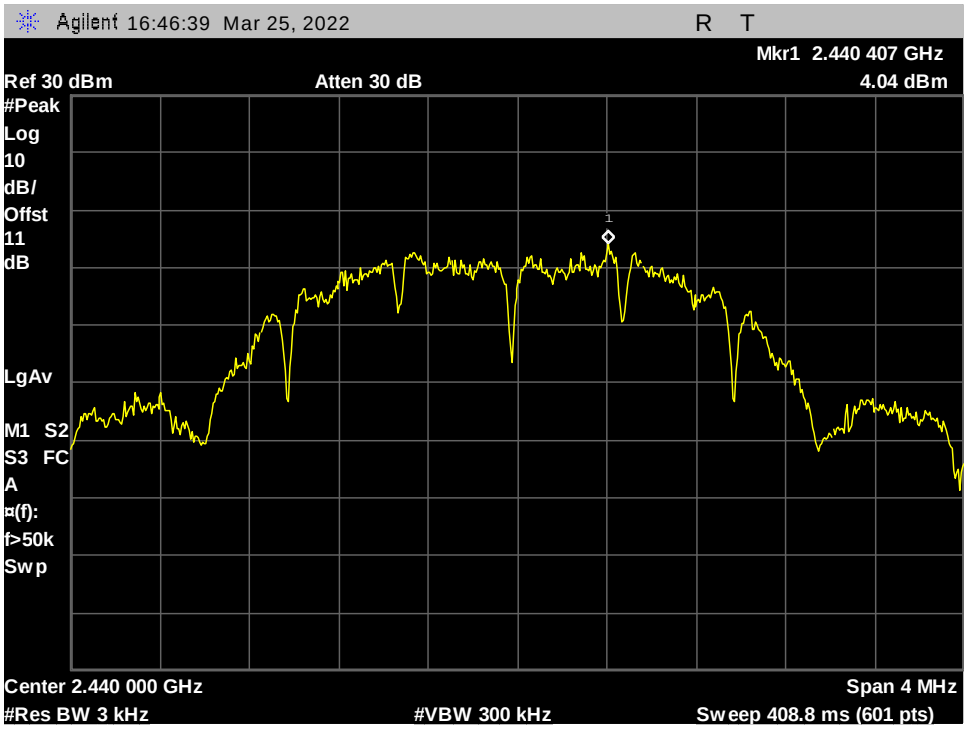


**Figure 45. Peak PSD_2440MHz**

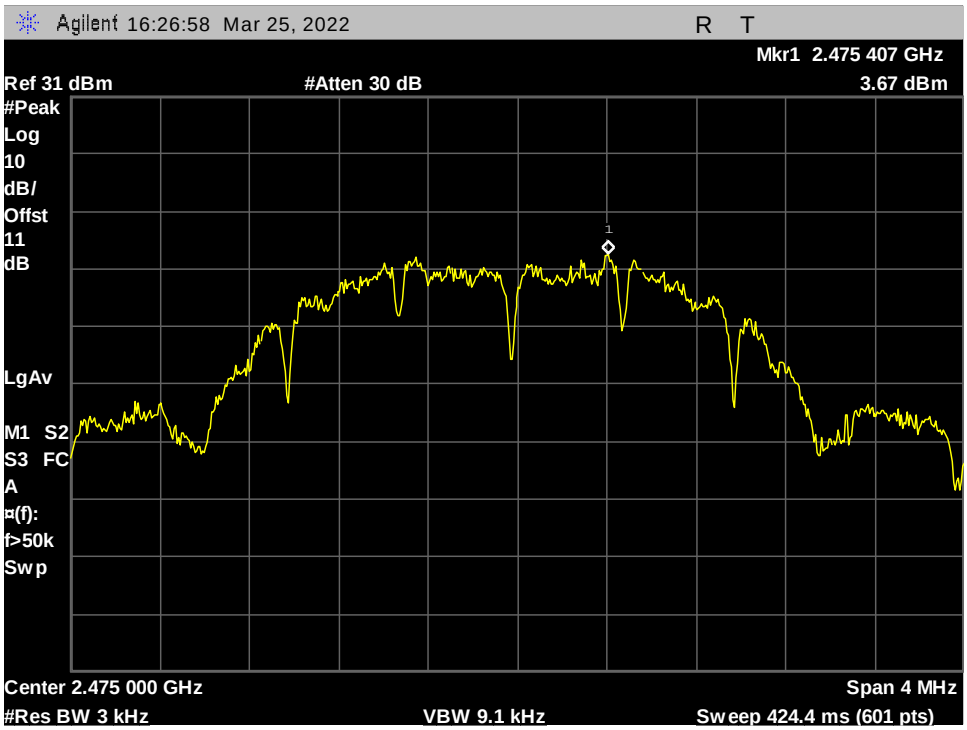


**Figure 46. Peak PSD_2475MHz**


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## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(i) Maximum Permissible Exposure

**RF Exposure Requirements:** **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

**RF Radiation Exposure Limit:** **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

**Test Results**:

## Maximum Permissible Exposure Test Results

| FCC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (MHz) | Con. Pwr. (dBm) | Con. Pwr. (mW) | Ant. Gain (dBi) | Ant. Gain numeric | Pwr. Density ($mW/cm^2$) | Limit ($mW/cm^2$) | Margin | Distance (cm) | Result |
| 2405 | 19.25 | 84.14 | 5.3 | 3.388 | 0.05672 | 1 | 0.94328 | 20 | Pass |

**Table 18. MPE Calculator_FCC**


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# End of Report

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