



**MET Laboratories, Inc.** *Safety Certification - EMI - Telecom Environmental Simulation*

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November 17, 2017

Olibra LLC  
45 Legion Dr  
Cresskill, NJ 07626

Dear Dipak Patel,

Enclosed is the EMC Wireless test report for compliance testing of the Olibra LLC, Bond 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 MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,  
MET LABORATORIES, INC.

Joel Huna  
Documentation Department

Reference: (\Olibra LLC\EMC93702-FCC247 Rev. 3)

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## **Electromagnetic Compatibility Criteria Test Report**

for the

**Olibra LLC  
Bond**

**Tested under**  
the FCC Certification Rules contained in  
Title 47 of the CFR, Part 15.247 Subpart C  
for Intentional Radiators

**MET Report: EMC93702-FCC247 Rev. 3**

November 17, 2017

**Prepared For:**

**Olibra LLC  
45 Legion Dr  
Cresskill, NJ 07626**

**Prepared By:**  
**MET Laboratories, Inc.**  
914 West Patapsco Avenue,  
Baltimore, MD 21230

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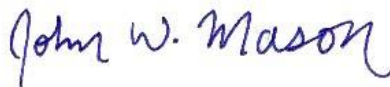


Deepak Giri, Project Engineer  
Electromagnetic Compatibility Lab



Joel Huna  
Documentation Department

**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.



John Mason,  
Director, Electromagnetic Compatibility Lab

## Report Status Sheet

| Revision | Report Date        | Reason for Revision    |
|----------|--------------------|------------------------|
| Ø        | August 18, 2017    | Initial Issue.         |
| 1        | August 28, 2017    | Editorial corrections. |
| 2        | September 26, 2017 | Engineer corrections.  |
| 3        | November 17, 2017  | Engineer Corrections.  |

## Table of Contents

|             |                                                                              |           |
|-------------|------------------------------------------------------------------------------|-----------|
| <b>I.</b>   | <b>Executive Summary .....</b>                                               | <b>1</b>  |
|             | A. Purpose of Test .....                                                     | 2         |
|             | B. Executive Summary .....                                                   | 2         |
| <b>II.</b>  | <b>Equipment Configuration .....</b>                                         | <b>3</b>  |
|             | A. Overview.....                                                             | 4         |
|             | B. References.....                                                           | 5         |
|             | C. Test Site .....                                                           | 5         |
|             | D. Description of Test Sample.....                                           | 6         |
|             | E. Equipment Configuration.....                                              | 8         |
|             | F. Support Equipment .....                                                   | 8         |
|             | G. Ports and Cabling Information.....                                        | 9         |
|             | H. Mode of Operation.....                                                    | 9         |
|             | I. Method of Monitoring EUT Operation .....                                  | 10        |
|             | J. Modifications .....                                                       | 10        |
|             | a) Modifications to EUT .....                                                | 10        |
|             | b) Modifications to Test Standard.....                                       | 10        |
|             | K. Disposition of EUT .....                                                  | 10        |
| <b>III.</b> | <b>Electromagnetic Compatibility Criteria for Intentional Radiators.....</b> | <b>11</b> |
|             | § 15.203 Antenna Requirement .....                                           | 12        |
|             | § 15.207(a) Conducted Emissions Limits.....                                  | 13        |
|             | § 15.247(a)(1) 20 dB Occupied Bandwidth.....                                 | 16        |
|             | § 15.247(a)(1) Average Time of Occupancy (Dwell Time) .....                  | 18        |
|             | § 15.247(a)(1) Number of RF Channels .....                                   | 20        |
|             | § 15.247(a)(1) RF Channel Separation .....                                   | 21        |
|             | § 15.247(b) Peak Power Output .....                                          | 23        |
|             | § 15.247(d) Radiated Spurious Emissions Requirements and Band Edge .....     | 25        |
|             | § 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge.....  | 31        |
|             | § 15.247(g)(h) Declaration Statements for FHSS.....                          | 34        |
| <b>IV.</b>  | <b>Test Equipment .....</b>                                                  | <b>36</b> |
| <b>V.</b>   | <b>Certification &amp; User's Manual Information .....</b>                   | <b>38</b> |
|             | A. Certification Information .....                                           | 39        |
|             | B. Label and User's Manual Information .....                                 | 43        |

## List of Tables

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| Table 1. Executive Summary of EMC Part 15.247 Compliance Testing .....                 | 2  |
| Table 2. EUT Summary Table.....                                                        | 4  |
| Table 3. References .....                                                              | 5  |
| Table 4. Equipment Configuration .....                                                 | 8  |
| Table 5. Support Equipment.....                                                        | 8  |
| Table 6. Ports and Cabling Information .....                                           | 9  |
| Table 7. Antenna List .....                                                            | 12 |
| Table 8. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a) ..... | 13 |
| Table 9. Conducted Emissions, 15.207(a), Phase Line, Test Results .....                | 14 |
| Table 10. Conducted Emissions, 15.207(a), Neutral Line, Test Results .....             | 15 |
| Table 11. Average Time of Occupancy .....                                              | 18 |
| Table 12. Restricted Bands of Operation.....                                           | 25 |
| Table 13. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a) .....    | 26 |
| Table 14. Simultaneous Emission, MPE, 900 MHz and 2.4 GHz .....                        | 35 |
| Table 15. Test Equipment List .....                                                    | 37 |

## List of Plots

|                                                                              |    |
|------------------------------------------------------------------------------|----|
| Plot 1. Conducted Emissions, 15.207(a), Phase Line .....                     | 14 |
| Plot 2. Conducted Emissions, 15.207(a), Neutral Line .....                   | 15 |
| Plot 3. 20 dB Occupied Bandwidth, Low Channel .....                          | 17 |
| Plot 4. 20 dB Occupied Bandwidth, Mid Channel .....                          | 17 |
| Plot 5. 20 dB Occupied Bandwidth, High Channel .....                         | 17 |
| Plot 6. Dwell Time, 20 second sweep .....                                    | 19 |
| Plot 7. Dwell Time, Transmission ON time .....                               | 19 |
| Plot 8. Number of Channels .....                                             | 20 |
| Plot 9. Channel Separation, High Channel .....                               | 21 |
| Plot 10. Channel Separation, Mid Channel .....                               | 22 |
| Plot 11. Channel Separation, Low Channel .....                               | 22 |
| Plot 12. Peak Power Output, Low Channel .....                                | 24 |
| Plot 13. Peak Power Output, Mid Channel .....                                | 24 |
| Plot 14. Peak Power Output, High Channel .....                               | 24 |
| Plot 15. Radiated Spurious Emissions, 30 MHz – 1 GHz, Low Channel .....      | 27 |
| Plot 16. Radiated Spurious Emissions, 30 MHz – 1 GHz, Mid Channel .....      | 27 |
| Plot 17. Radiated Spurious Emissions, 30 MHz – 1 GHz, High Channel .....     | 27 |
| Plot 18. Radiated Spurious Emissions, 1 – 10 GHz, Low Channel Average .....  | 28 |
| Plot 19. Radiated Spurious Emissions, 1 – 10 GHz, Low Channel Peak .....     | 28 |
| Plot 20. Radiated Spurious Emissions, 1 – 10 GHz, Mid Channel Average .....  | 28 |
| Plot 21. Radiated Spurious Emissions, 1 – 10 GHz, Mid Channel Peak .....     | 29 |
| Plot 22. Radiated Spurious Emissions, 1 – 10 GHz, High Channel Average ..... | 29 |
| Plot 23. Radiated Spurious Emissions, 1 – 10 GHz, High Channel Peak .....    | 29 |
| Plot 24. Radiated Restricted Band Edge Low Channel .....                     | 30 |
| Plot 25. Radiated Restricted Band Edge High Channel .....                    | 30 |
| Plot 26. Conducted Spurious Emissions, Low Channel, 30 MHz – 1 GHz .....     | 32 |
| Plot 27. Conducted Spurious Emissions, Mid Channel, 30 MHz – 1 GHz .....     | 32 |
| Plot 28. Conducted Spurious Emissions, High Channel, 30 MHz – 1 GHz .....    | 32 |
| Plot 29. Conducted Band Edge, Low Channel .....                              | 33 |
| Plot 30. Conducted Band Edge, High Channel .....                             | 33 |

## List of Figures

|                                                                       |    |
|-----------------------------------------------------------------------|----|
| Figure 1. Block Diagram of Test Configuration.....                    | 7  |
| Figure 2. Block Diagram, Occupied Bandwidth Test Setup.....           | 16 |
| Figure 3. Peak Power Output Test Setup.....                           | 23 |
| Figure 4. Block Diagram, Conducted Spurious Emissions Test Setup..... | 31 |

## List of Terms and Abbreviations

|                     |                                               |
|---------------------|-----------------------------------------------|
| AC                  | Alternating Current                           |
| ACF                 | Antenna Correction Factor                     |
| Cal                 | Calibration                                   |
| <i>d</i>            | Measurement Distance                          |
| dB                  | Decibels                                      |
| dB <sub>μ</sub> A   | Decibels above one <b>microamp</b>            |
| dB <sub>μ</sub> V   | Decibels above one <b>microvolt</b>           |
| dB <sub>μ</sub> A/m | Decibels above one <b>microamp per meter</b>  |
| dB <sub>μ</sub> V/m | Decibels above one <b>microvolt per meter</b> |
| DC                  | Direct Current                                |
| E                   | Electric Field                                |
| DSL                 | Digital Subscriber Line                       |
| ESD                 | Electrostatic Discharge                       |
| EUT                 | Equipment Under Test                          |
| <i>f</i>            | Frequency                                     |
| FCC                 | Federal Communications Commission             |
| GRP                 | Ground Reference Plane                        |
| H                   | Magnetic Field                                |
| HCP                 | Horizontal Coupling Plane                     |
| Hz                  | Hertz                                         |
| IEC                 | International Electrotechnical Commission     |
| kHz                 | kilohertz                                     |
| kPa                 | kilopascal                                    |
| kV                  | kilovolt                                      |
| LISN                | Line Impedance Stabilization Network          |
| MHz                 | Megahertz                                     |
| μH                  | <b>microhenry</b>                             |
| μ                   | <b>microfarad</b>                             |
| μs                  | <b>microseconds</b>                           |
| NEBS                | Network Equipment-Building System             |
| PRF                 | Pulse Repetition Frequency                    |
| RF                  | Radio Frequency                               |
| RMS                 | Root-Mean-Square                              |
| TWT                 | Traveling Wave Tube                           |
| V/m                 | Volts <b>per meter</b>                        |
| VCP                 | Vertical Coupling Plane                       |

# **I. Executive Summary**

## A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Olibra LLC Bond, 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 Bond. Olibra LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Bond, 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 Olibra LLC, purchase order number 175. All tests were conducted using measurement procedure ANSI C63.4-2014.

| FCC Reference<br>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)(1)                   | 20 dB Occupied Bandwidth               | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(a)(1)                   | Average Time of Occupancy (Dwell Time) | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(a)(1)                   | Number of RF Channels                  | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(a)(1)                   | RF Channel Separation                  | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(b)                      | Peak Power Output                      | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(d);<br>§15.209; §15.205 | Radiated Spurious Emissions            | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(d)                      | Spurious Conducted Emissions           | Compliant  |
| Title 47 of the CFR, Part 15 §15.247(g) &<br>(h)             | Declaration Statements for FHSS        | 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 Compliance Testing**

## II. Equipment Configuration

## A. Overview

MET Laboratories, Inc. was contracted by Olibra LLC to perform testing on the Bond, under Olibra LLC's purchase order number 175.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Olibra LLC, Bond.

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

|                                       |                                                         |                    |
|---------------------------------------|---------------------------------------------------------|--------------------|
| <b>Model(s) Tested:</b>               | Bond                                                    |                    |
| <b>Model(s) Covered:</b>              | Bond                                                    |                    |
| <b>EUT Specifications:</b>            | Primary Power: 5VDC                                     |                    |
|                                       | FCC ID: 2AME8BOND-01                                    |                    |
|                                       | Type of Modulations:                                    | GFSK at 902-928MHz |
|                                       | Equipment Code:                                         | DSS                |
|                                       | Peak RF Output Power:                                   | 3.616dBm           |
|                                       | EUT Frequency Ranges:                                   | 902.5-927.502MHz   |
| <b>Analysis:</b>                      | The results obtained relate only to the item(s) tested. |                    |
| <b>Environmental Test Conditions:</b> | Temperature: 15-35° C                                   |                    |
|                                       | Relative Humidity: 30-60%                               |                    |
|                                       | Barometric Pressure: 860-1060 mbar                      |                    |
| <b>Evaluated by:</b>                  | Deepak Giri                                             |                    |
| <b>Report Date(s):</b>                | November 17, 2017                                       |                    |

**Table 2. EUT Summary Table**

## B. References

|                                   |                                                                                                                                                                       |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CFR 47, Part 15, Subpart C</b> | Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies |
| <b>ANSI C63.4:2014</b>            | Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz                                |
| <b>ISO/IEC 17025:2005</b>         | General Requirements for the Competence of Testing and Calibration Laboratories                                                                                       |
| <b>ANSI C63.10-2013</b>           | American National Standard for Testing Unlicensed Wireless Devices                                                                                                    |
| <b>KDB 447498 D01</b>             | General RF Exposure Guidance v05r01                                                                                                                                   |

**Table 3. References**

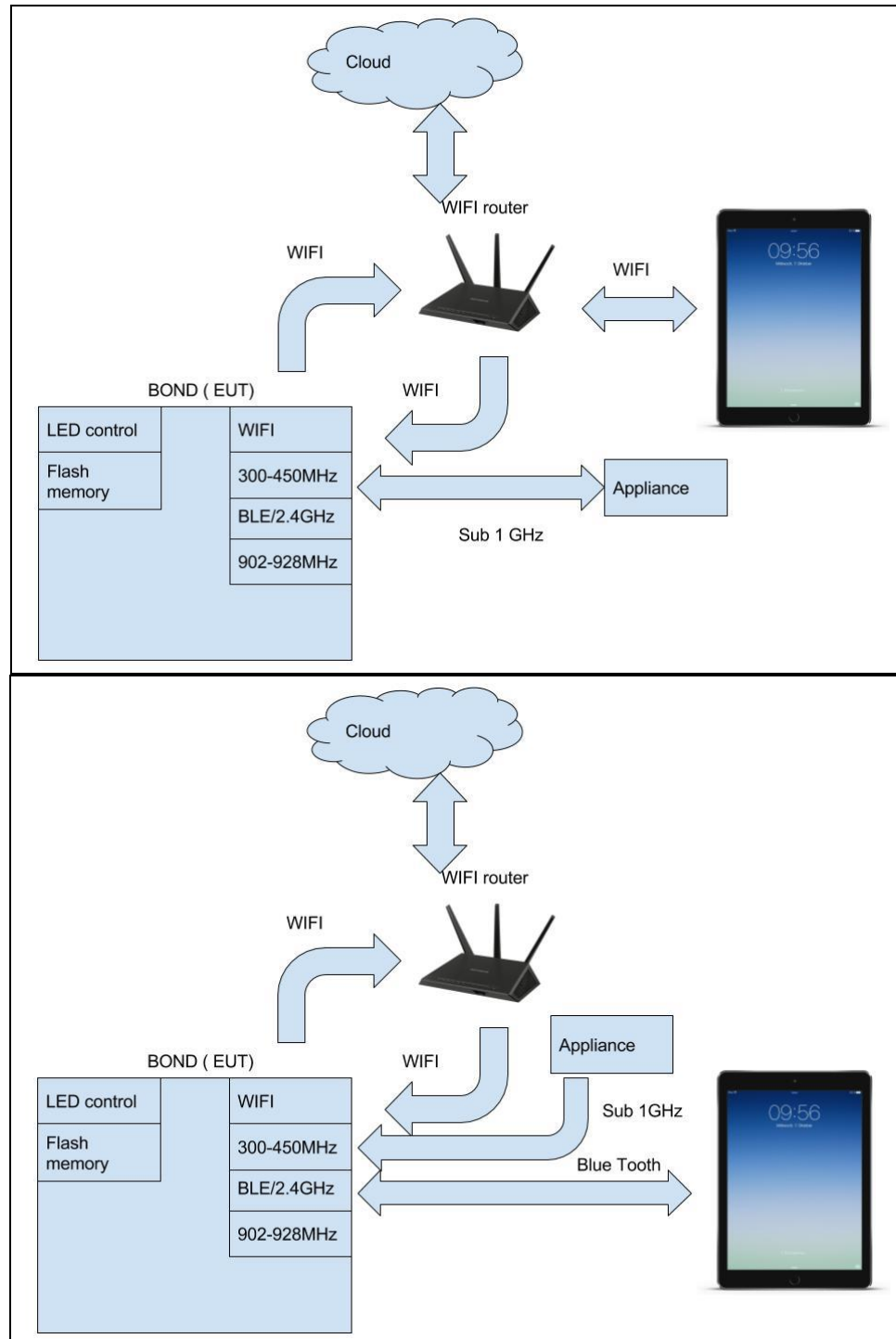
## C. Test Site

All testing was performed at MET Laboratories, Inc., 914 West 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 MET Laboratories.

## **D. Description of Test Sample**

The Olibra LLC Bond, Equipment Under Test (EUT), is a table-top or a wall mount device for the automation of home appliances such as ceiling fans, shades, air conditioners, and garage doors. The Bond can be controlled by a user via 2.4GHz WiFi or Bluetooth from a mobile device. The user trains the Bond using the appliance's factory remote while the Bond records the control signal, which may be radio or infrared. Then, at times determined by the user, the Bond transmits the learned control signals to actuate the appliances. The user does not directly power, frequency, or content of transmissions; rather, these are computed by the Bond. In addition to the RF and IR transmit and receive functions, the Bond has a number of LEDs for displaying its mode, and internal storage for appliance information. The Bond is intended to be used by consumers in their own dwelling, indoor use only.



**Figure 1. Block Diagram of Test Configuration**

## E. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

| Ref. ID | Name / Description                                    | Model Number | Part Number | Serial Number | Revision |
|---------|-------------------------------------------------------|--------------|-------------|---------------|----------|
| 1       | BD-1000 – Test Unit for 902-928 MHz Conducted Testing |              |             |               |          |
| 2       | BD-1000 – Test Unit for UL                            |              |             |               |          |
| 3       | BD-1000 – Test Unit for FCC Non-Conducted Testing     |              |             |               |          |

**Table 4. Equipment Configuration**

## F. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

| Ref. ID | Name / Description                                     | Manufacturer | Model Number |
|---------|--------------------------------------------------------|--------------|--------------|
|         | Macbook pro + charger + mouse / Driving the Bond Units |              |              |
|         | Power Supply +USB Cable                                |              |              |
|         | Printed Manual                                         |              |              |

**Table 5. Support Equipment**

## G. Ports and Cabling Information

| Ref. ID | Port Name on EUT | Cable Description | Qty. | Length (m) | Shielded (Y/N) | Termination Point |
|---------|------------------|-------------------|------|------------|----------------|-------------------|
|         |                  | Serial Cable      | 1    | 30 ft.     |                |                   |

Table 6. Ports and Cabling Information

## H. Mode of Operation

The EUT supports a number of test modes which simulate normal operation. The operation mode is selected by sending commands on a serial cable from a PC control program. However, once a mode is selected, the EUT will remain in that mode without further interaction, until instructed to enter a different mode.

- (0) Idle: EUT is neither receiving or transmitting. This is the typical and primary mode of operation for BOND.
- (1) Receive Mode (All Bands): EUT scans all supported frequencies while operating LEDs and IR emitters.
- (2-16) Modulated Transmit (All Bands): EUT transmits a chain of control signals at one of 15 test frequencies. These frequencies are chosen to be the Low, Mid, and High frequencies for each antenna. An option controls whether the transmission is continuous (C) or whether only a single control signal is sent (S). For 300-450MHz, OOK modulation is used. For 902-928MHz, GFSK modulation is used. For all frequencies, the transmit power can be adjusted from 1-100% (arbitrary units) and for 300-450MHz, the 100ms-windowed duty-cycle can be adjusted from 0.1-1 in increments of 0.01. [Merck Note: Perhaps we want to only give Low, Mid, and High duty cycle?]
- (17-21) Unused.
- (22) Frequency Hopping (Band 5): EUT makes unending FHSS transmissions between 50 channels in 902-928MHz band.
- (23) Frequency Hopping (All Bands): EUT cycles between modes 2-16, spending 100ms in each mode.

Furthermore: The WiFi+Bluetooth functionality of the EUT may be enabled or disabled, concurrently with all of the above modes. These are indicated by WiFi ON and WiFi OFF. Any of the test mode numbers above may be appended with "W" to indicate "WiFi ON". For example, "1W" is the Receive Mode with WiFi also active.

## **I. Method of Monitoring EUT Operation**

For the purposes of EMC testing, the EUT is both controlled and monitored via a serial cable driven by a PC program. (1) After a command is sent to the EUT to enter a particular mode, the program receives positive confirmation that the EUT has received the command. (2) If the confirmation is not received by the PC program, and error is displayed and the technician is instructed to restart the PC program and re-attempt setting the mode. In mode 1 (Receive Mode), the EUT flashes its LEDs. In other modes, a spectrum analyzer will clearly show a fundamental emission in the range 300-928MHz).

See section 7 in set up guide for LED indicators.

## **J. 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.

## **K. Disposition of EUT**

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

### **III. Electromagnetic Compatibility Criteria for Intentional Radiators**

## 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.

**Results:** The EUT as tested is compliant the criteria of §15.203. Antennas are permanently attached.

**Test Engineer(s):** Deepak Giri

**Test Date(s):** March 8, 2017

| Gain                | Type                   | Model         | Manufacturer |
|---------------------|------------------------|---------------|--------------|
| -4dBi (902-928 MHz) | Omni-directional, coil | 0915AT43A0026 | Johanson,    |

**Table 7. Antenna List**

## 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  $\mu$ H/50  $\Sigma$  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<br>(MHz) | § 15.207(a), Conducted Limit (dB $\mu$ V) |         |
|--------------------------|-------------------------------------------|---------|
|                          | Quasi-Peak                                | Average |
| * 0.15- 0.45             | 66 - 56                                   | 56 - 46 |
| 0.45 - 0.5               | 56                                        | 46      |
| 0.5 - 30                 | 60                                        | 50      |

**Table 8. 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  $\Omega$ /50  $\mu$ H 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 C63.4-2014 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz"*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50  $\Omega$ /50  $\mu$ H LISN as the input transducer to an EMC/field intensity meter. For the purpose of this testing, the transmitter was turned on. Scans were performed with the transmitter on.

**Test Results:** The EUT was compliant with this requirement. Measured emissions were within applicable limits.

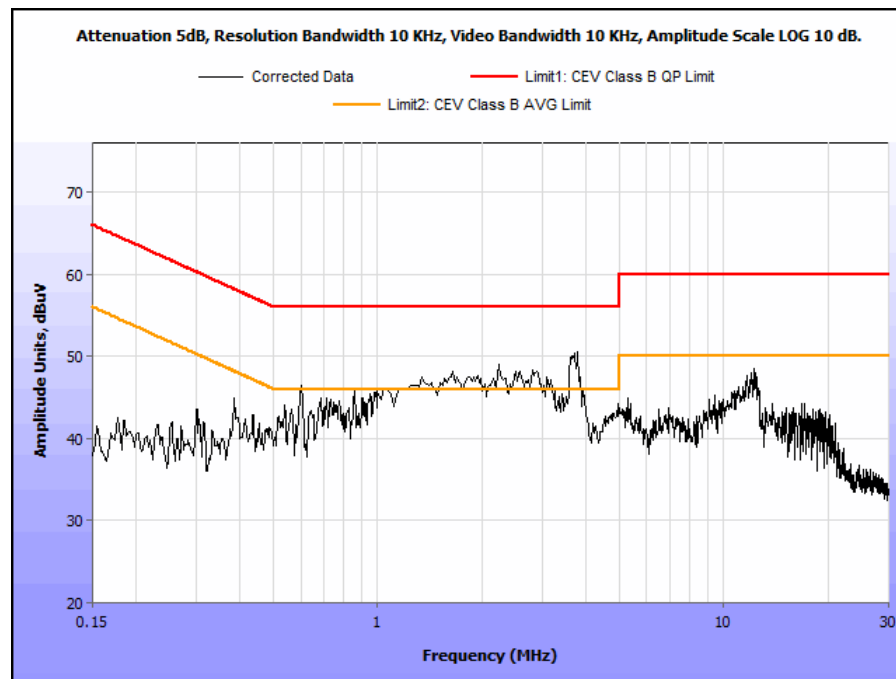
**Test Engineer(s):** Deepak Giri

**Test Date(s):** March 10, 2017

## 15.207(a) Conducted Emissions Test Results

| Frequency (MHz) | Uncorrected Meter Reading (dBuV) QP | Cable Loss (dB) | Corrected Measurement (dBuV) QP | Limit (dBuV) QP | Margin (dB) QP | Uncorrected Meter Reading (dBuV) Avg. | Cable Loss (dB) | Corrected Measurement (dBuV) AVG | Limit (dBuV) AVG | Margin (dB) AVG |
|-----------------|-------------------------------------|-----------------|---------------------------------|-----------------|----------------|---------------------------------------|-----------------|----------------------------------|------------------|-----------------|
| 0.4683          | 46.23                               | 0               | 46.23                           | 56.54           | -10.31         | 37.11                                 | 0               | 37.11                            | 46.54            | -9.43           |
| 1.347           | 47.98                               | 0               | 47.98                           | 56              | -8.02          | 39.74                                 | 0               | 39.74                            | 46               | -6.26           |
| 3.669           | 43.21                               | 0               | 43.21                           | 56              | -12.79         | 33.47                                 | 0               | 33.47                            | 46               | -12.53          |
| 6.787           | 46.16                               | 0               | 46.16                           | 60              | -13.84         | 37.23                                 | 0               | 37.23                            | 50               | -12.77          |
| 11.962          | 40.25                               | 0               | 40.25                           | 60              | -19.75         | 32.96                                 | 0               | 32.96                            | 50               | -17.04          |
| 27.68           | 38.68                               | 0               | 38.68                           | 60              | -21.32         | 27.43                                 | 0               | 27.43                            | 50               | -22.57          |

Table 9. Conducted Emissions, 15.207(a), Phase Line, Test Results

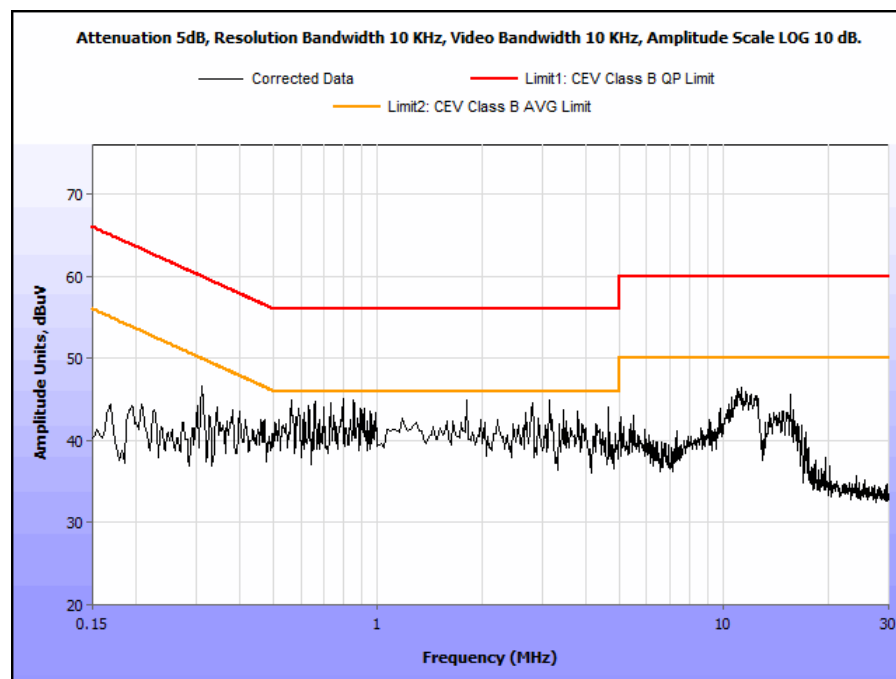


Plot 1. Conducted Emissions, 15.207(a), Phase Line

## 15.207(a) Conducted Emissions Test Results

| Frequency (MHz) | Uncorrected Meter Reading (dBuV) QP | Cable Loss (dB) | Corrected Measurement (dBuV) QP | Limit (dBuV) QP | Margin (dB) QP | Uncorrected Meter Reading (dBuV) Avg. | Cable Loss (dB) | Corrected Measurement (dBuV) AVG | Limit (dBuV) AVG | Margin (dB) AVG |
|-----------------|-------------------------------------|-----------------|---------------------------------|-----------------|----------------|---------------------------------------|-----------------|----------------------------------|------------------|-----------------|
| 0.26            | 49.21                               | 0               | 49.21                           | 61.43           | -12.22         | 37.55                                 | 0               | 37.55                            | 51.43            | -13.88          |
| 1.596           | 43.23                               | 0               | 43.23                           | 56              | -12.77         | 33.41                                 | 0               | 33.41                            | 46               | -12.59          |
| 9.929           | 42.53                               | 0               | 42.53                           | 60              | -17.47         | 29.57                                 | 0               | 29.57                            | 50               | -20.43          |
| 11.45           | 46.46                               | 0               | 46.46                           | 60              | -13.54         | 39.92                                 | 0               | 39.92                            | 50               | -10.08          |
| 15.384          | 49.76                               | 0               | 49.76                           | 60              | -10.24         | 40.31                                 | 0               | 40.31                            | 50               | -9.69           |
| 16.162          | 55.47                               | 0               | 55.47                           | 60              | -4.53          | 42.91                                 | 0               | 42.91                            | 50               | -7.09           |

Table 10. Conducted Emissions, 15.207(a), Neutral Line, Test Results



Plot 2. Conducted Emissions, 15.207(a), Neutral Line

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(a)(1) 20 dB Occupied Bandwidth

**Test Requirements:** § 15.247(a): 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. For DTS, the minimum 6 dB bandwidth shall be at least 500 kHz. For frequency hopping systems, the EUT shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

**Test Procedure:** The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1-5 % of the total emission bandwidth. The 20 dB bandwidth was measured and recorded.

**Test Results** The EUT was compliant with § 15.247 (a)(2). 20 dB bandwidth are under the limit.

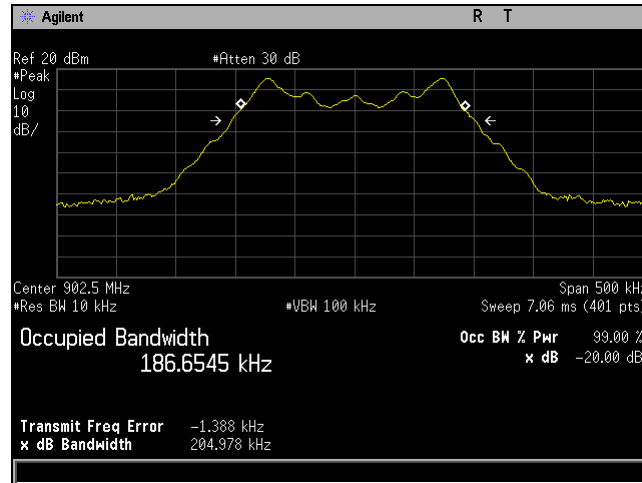
**Test Engineer(s):** Deepak Giri

**Test Date(s):** March 8, 2017

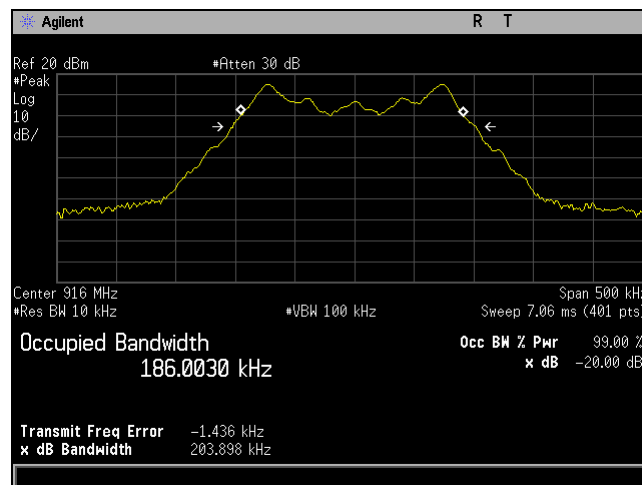


**Figure 2. Block Diagram, Occupied Bandwidth Test Setup**

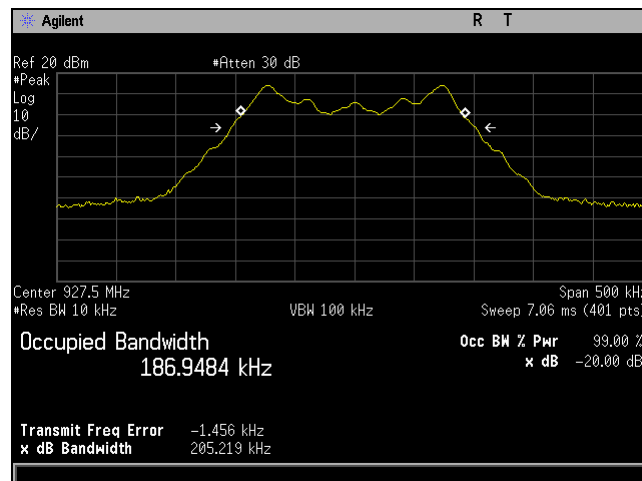
## 20 dB Occupied Bandwidth Test Results



Plot 3. 20 dB Occupied Bandwidth, Low Channel



Plot 4. 20 dB Occupied Bandwidth, Mid Channel



Plot 5. 20 dB Occupied Bandwidth, High Channel

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(a)(1) Average Time of Occupancy (Dwell Time)

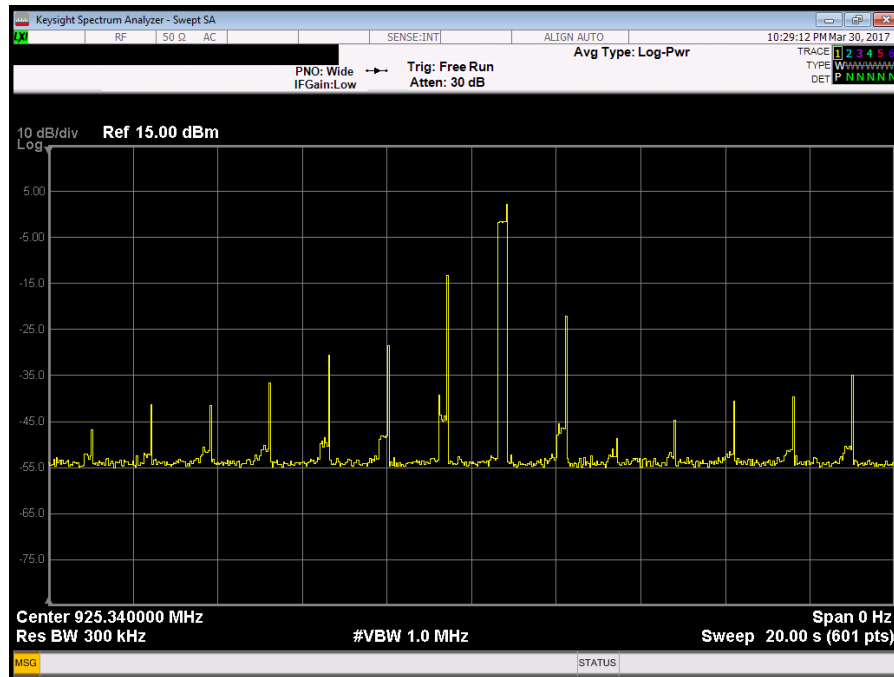
**Remarks:** The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Total hopping channels is 50 channels. The EUT meets the specifications of Section 15.247(a)(1) (iii) for Number of Hopping Channels.

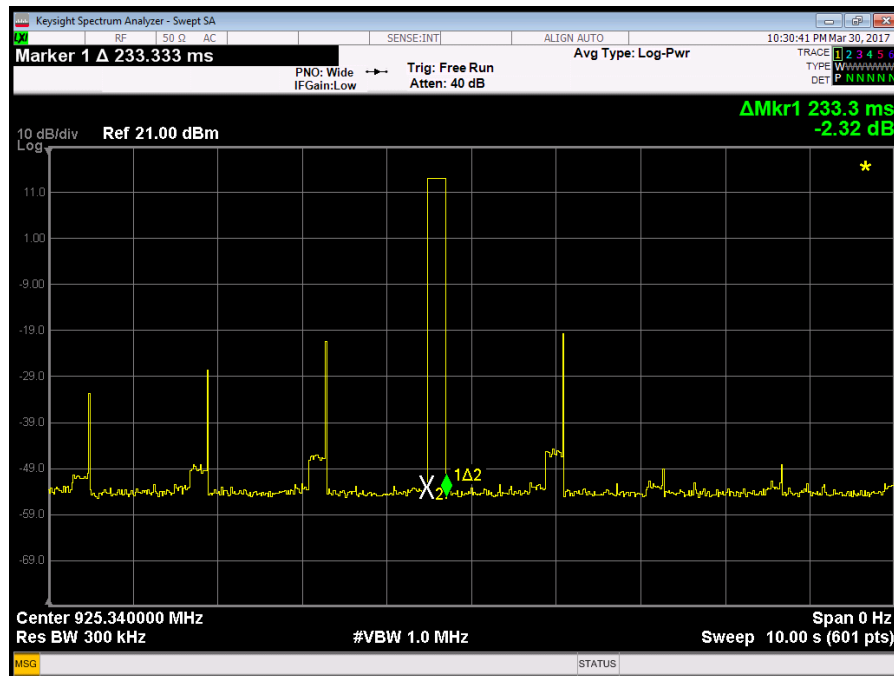
| Dwell Time      |                 |                    |                         |                    |               |          |        |
|-----------------|-----------------|--------------------|-------------------------|--------------------|---------------|----------|--------|
| Frequency Range | No. of Channels | Hopping Period (s) | No. of Burst per Period | Burst duration (s) | Dwell Time(s) | Limit(s) | Margin |
| 902.5 - 927.5   | 50              | 20                 | 1                       | 0.233              | 0.233         | 0.4      | -0.167 |

**Table 11. Average Time of Occupancy**

## Dwell Time



Plot 6. Dwell Time, 20 second sweep



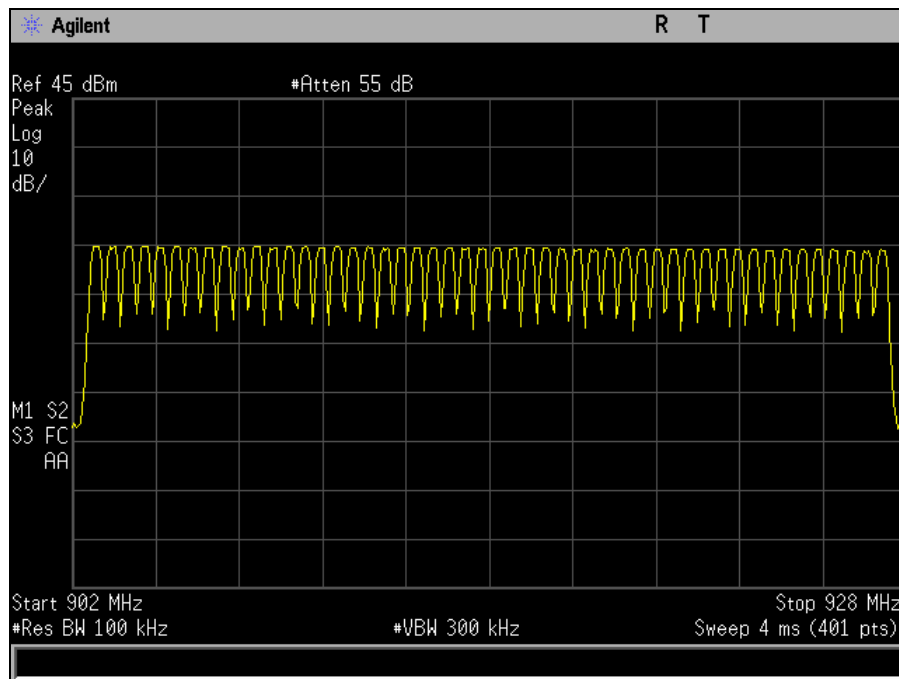
Plot 7. Dwell Time, Transmission ON time

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(a)(1) Number of RF Channels

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period;

Remarks: total number of hopping channels are 50.



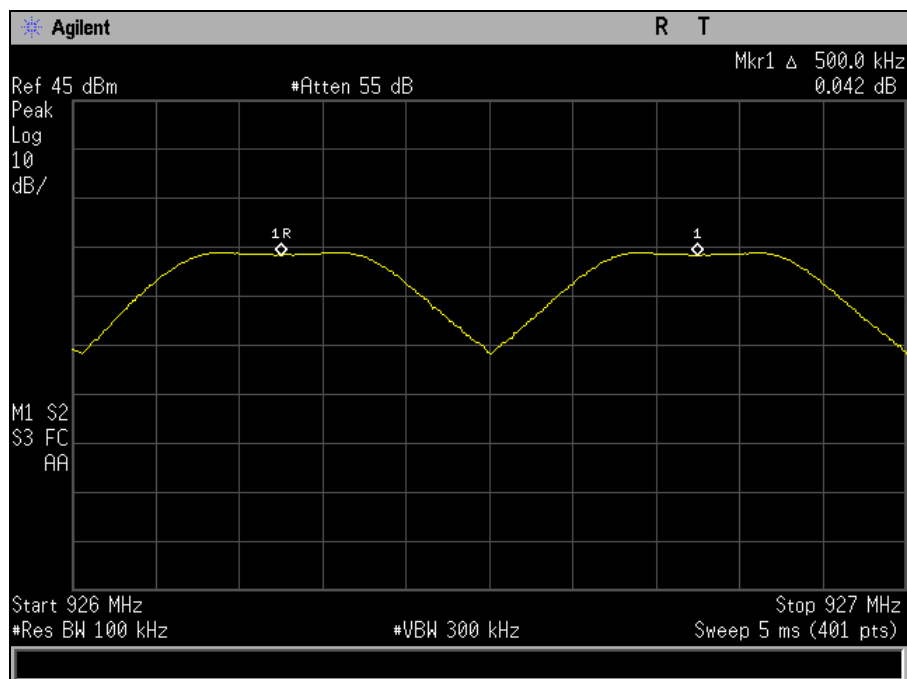
Plot 8. Number of Channels

## Electromagnetic Compatibility Criteria for Intentional Radiators

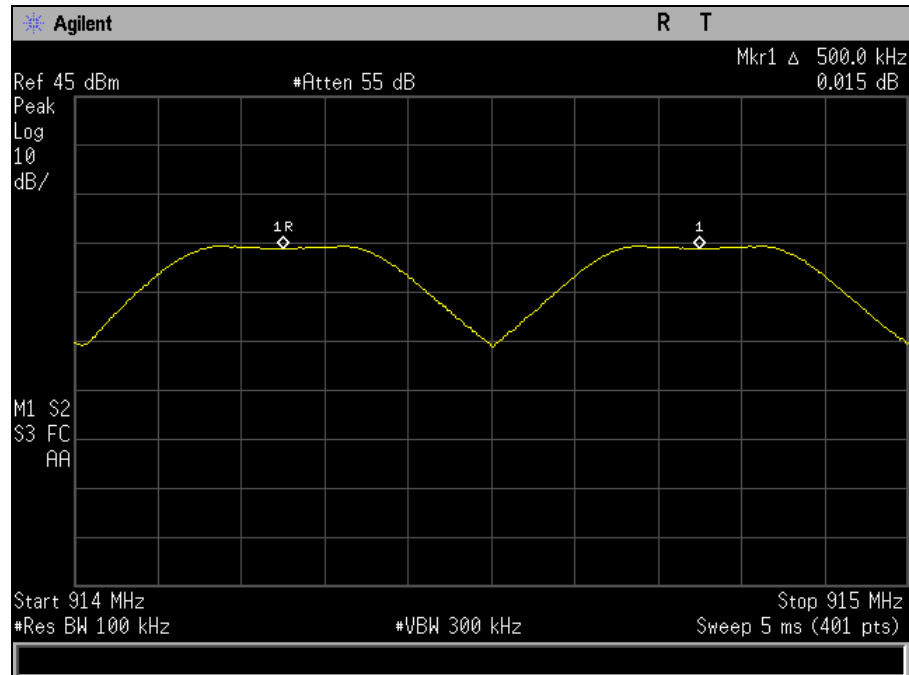
### § 15.247(a)(1) RF Channel Separation

**Requirement:** Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

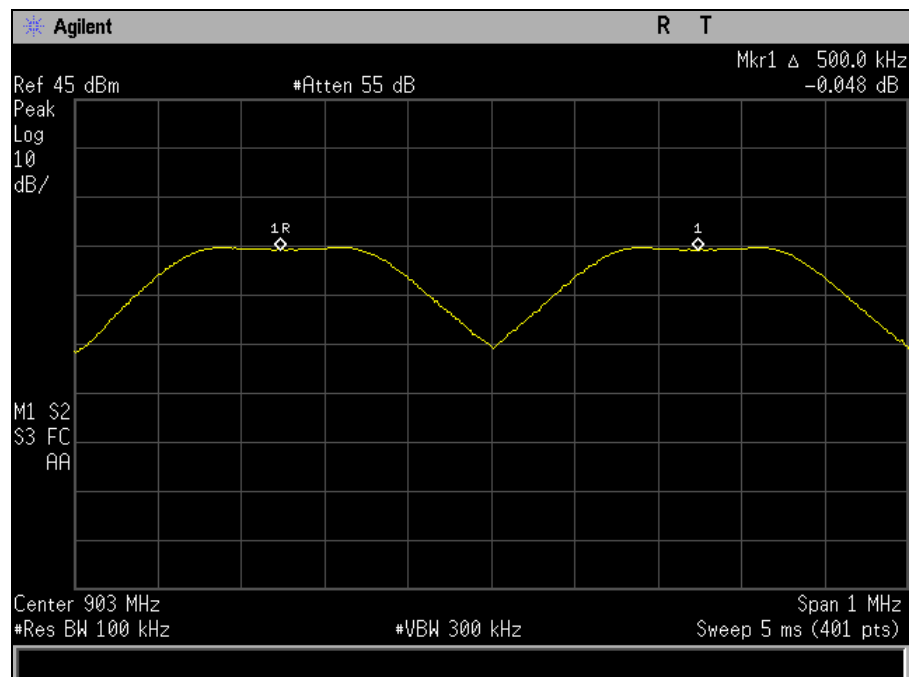
**Remarks:** Channels are separated by more than 25 kHz or 20dB Bandwidth of hopping channel.



**Plot 9. Channel Separation, High Channel**



**Plot 10. Channel Separation, Mid Channel**



**Plot 11. Channel Separation, Low Channel**

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(b) Peak Power Output

**Test Requirements:** §15.247(b)(1): The maximum peak output power of the intentional radiator shall not exceed the following: For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

**Test Procedure:** The transmitter was connected to a calibrated spectrum analyzer. The EUT was measured at the low, mid and high channels of each band.

**Test Results:** The EUT was compliant with the Peak Power Output limits of §15.247(b).

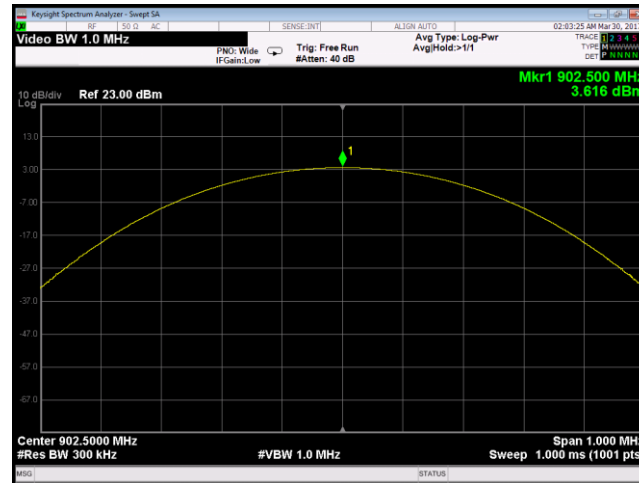
**Test Engineer(s):** Deepak Giri

**Test Date(s):** May 8, 2017

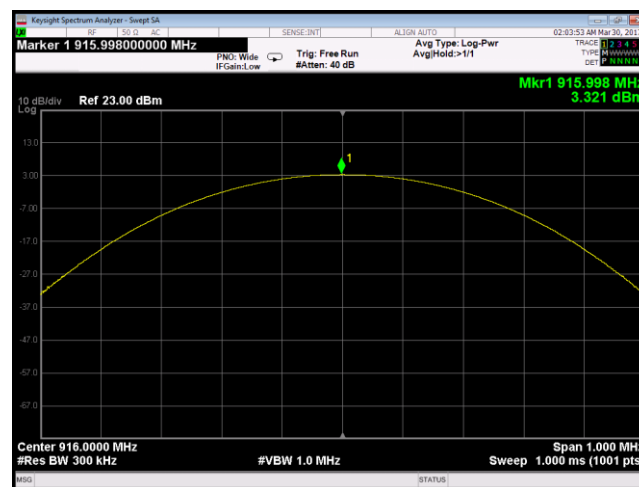


Figure 3. Peak Power Output Test Setup

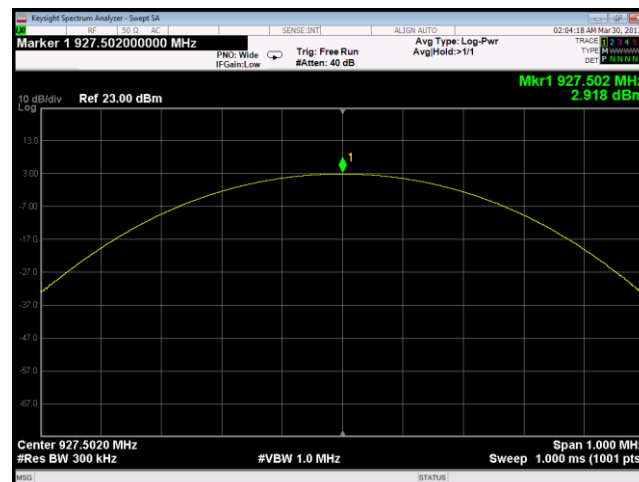
## Peak Power Output Test Results



Plot 12. Peak Power Output, Low Channel



Plot 13. Peak Power Output, Mid Channel



Plot 14. Peak Power Output, High Channel

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(d) Radiated Spurious Emissions Requirements and Band Edge

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

**§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. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

**§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         |
| <sup>1</sup> 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       | ( <sup>2</sup> ) |

**Table 12. Restricted Bands of Operation**

<sup>1</sup> Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

<sup>2</sup> Above 38.6

**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<br>(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 Procedure:** The transmitter was set to low, mid, and high channels at the highest output power and placed on a 0.8 m high wooden table inside in a semi-anechoic chamber. Measurements were performed with the EUT rotated 360 degrees and varying the adjustable antenna mast with 1 m to 4 m height to determine worst case orientation for maximum emissions.

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 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

In accordance with §15.35(b) the limit on the radio frequency emissions as measured using instrumentation with a peak detector function shall be 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules.

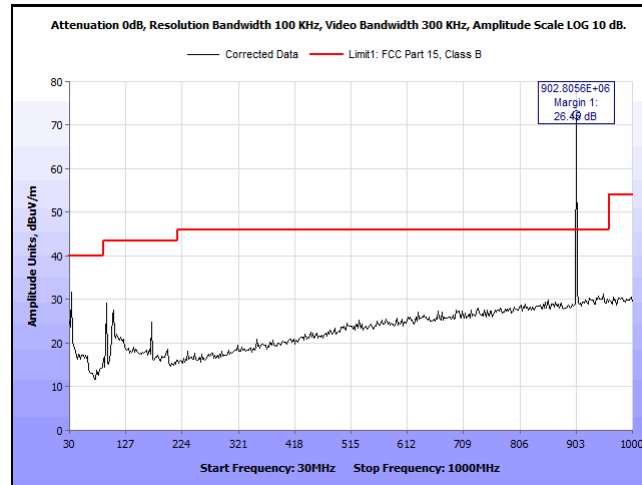
EUT Field Strength Final Amplitude = Raw Amplitude – Preamp gain + Antenna Factor + Cable Loss – Distance Correction Factor.

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

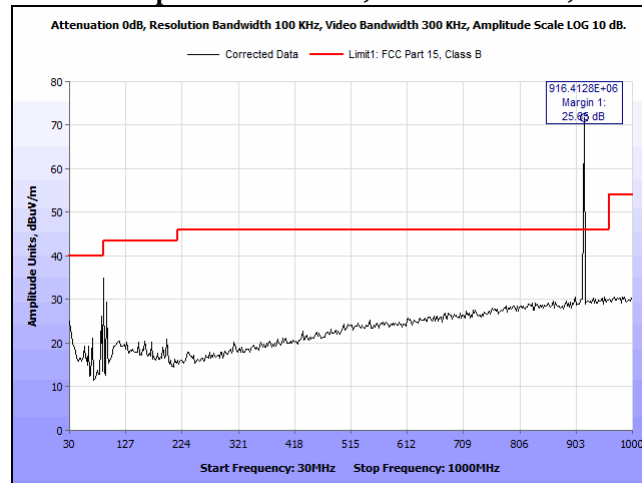
**Test Engineer(s):** Deepak Giri

**Test Date(s):** March 30, 2017

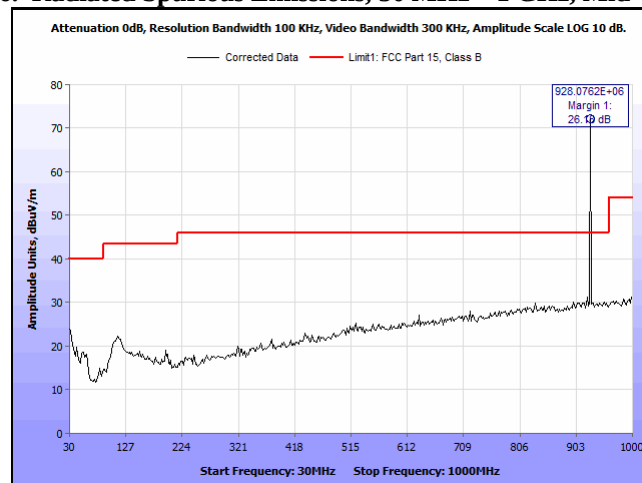
## Radiated Spurious Emissions Test Results



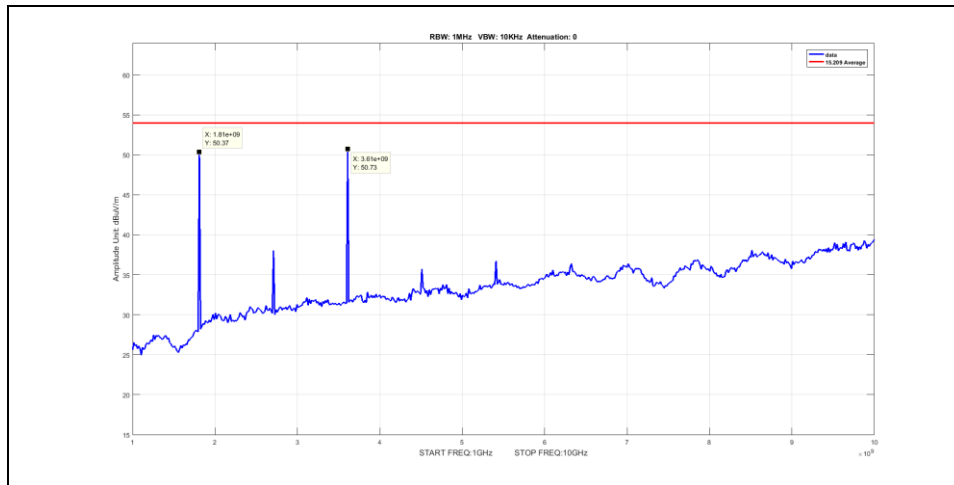
Plot 15. Radiated Spurious Emissions, 30 MHz – 1 GHz, Low Channel



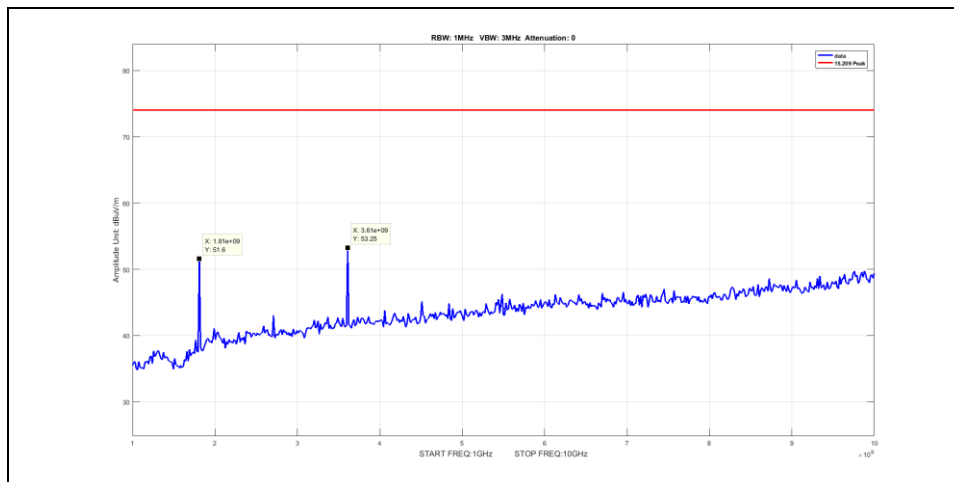
Plot 16. Radiated Spurious Emissions, 30 MHz – 1 GHz, Mid Channel



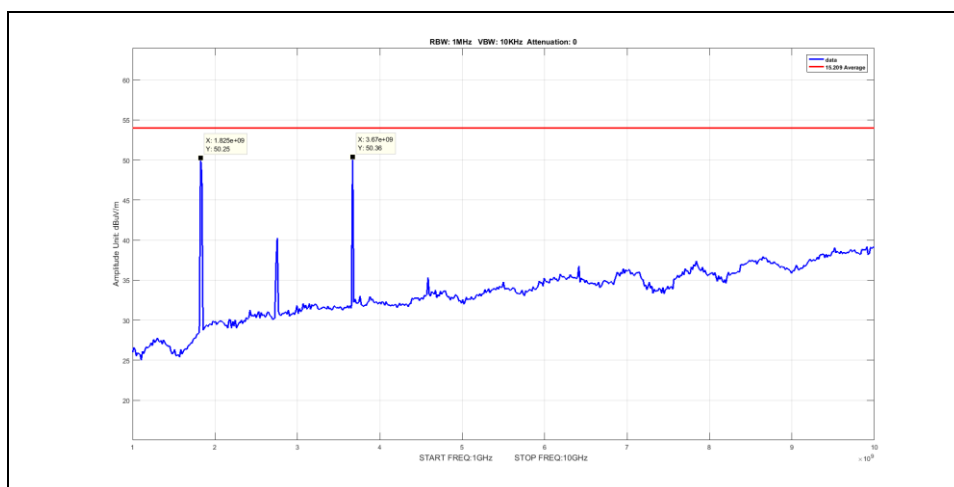
Plot 17. Radiated Spurious Emissions, 30 MHz – 1 GHz, High Channel



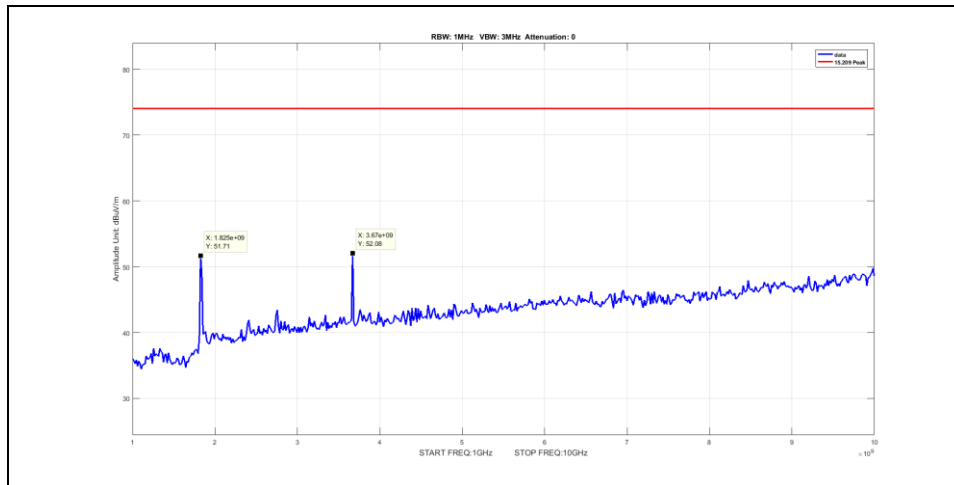
**Plot 18. Radiated Spurious Emissions, 1 – 10 GHz, Low Channel Average**



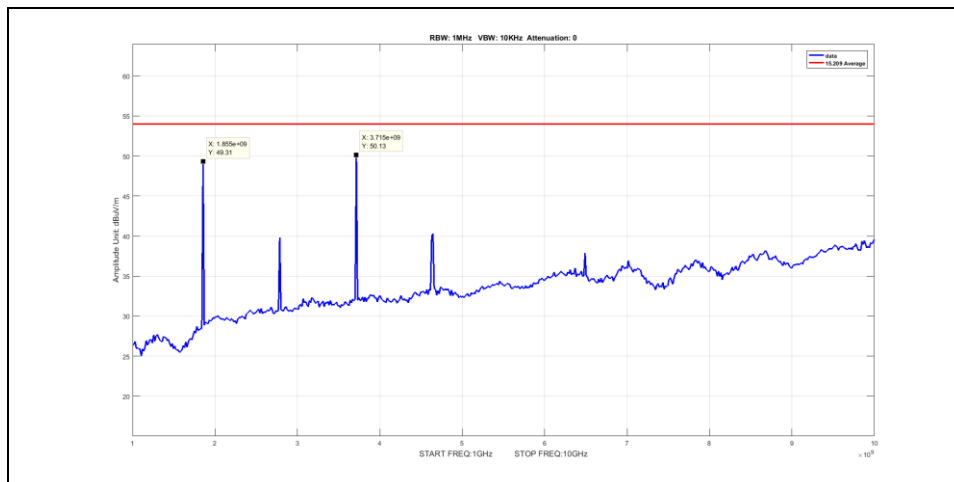
**Plot 19. Radiated Spurious Emissions, 1 – 10 GHz, Low Channel Peak**



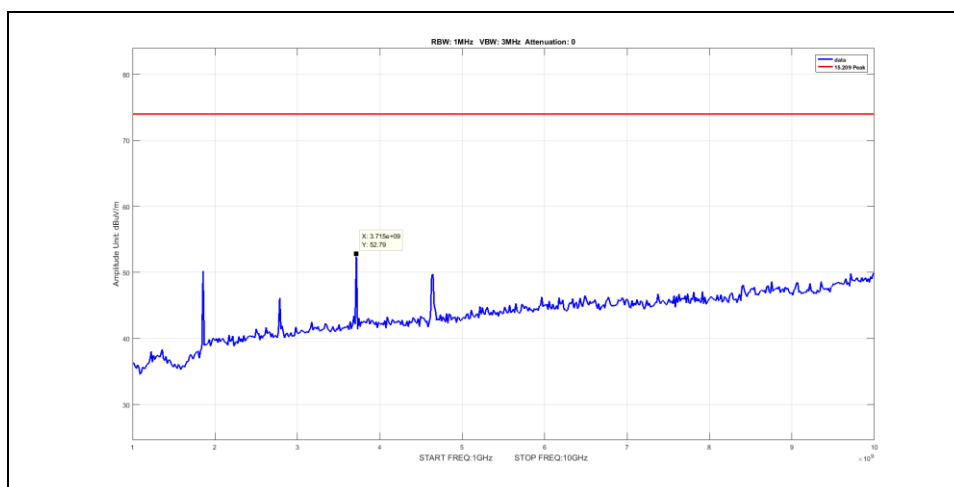
**Plot 20. Radiated Spurious Emissions, 1 – 10 GHz, Mid Channel Average**



**Plot 21. Radiated Spurious Emissions, 1 – 10 GHz, Mid Channel Peak**



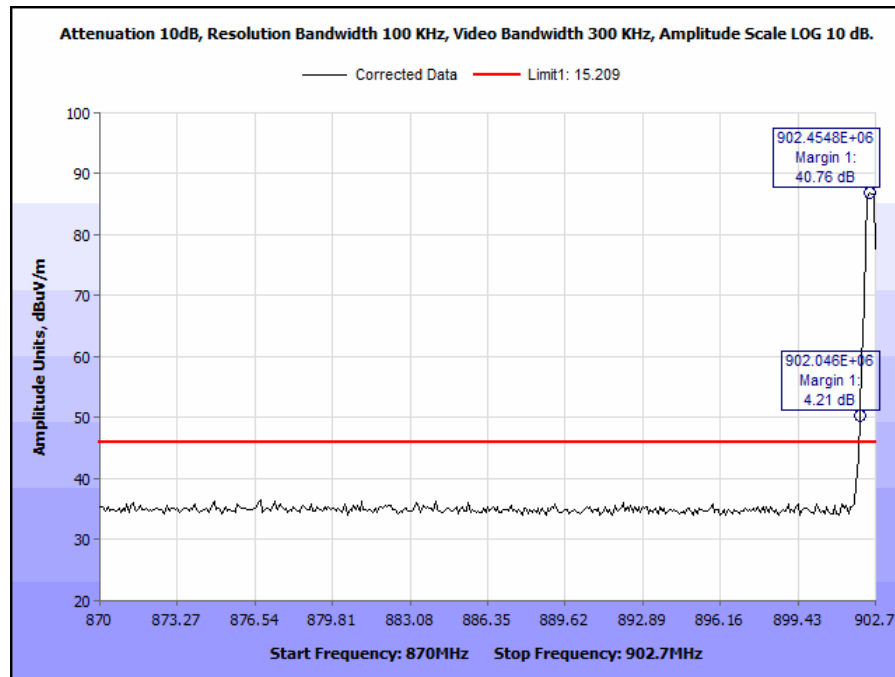
**Plot 22. Radiated Spurious Emissions, 1 – 10 GHz, High Channel Average**



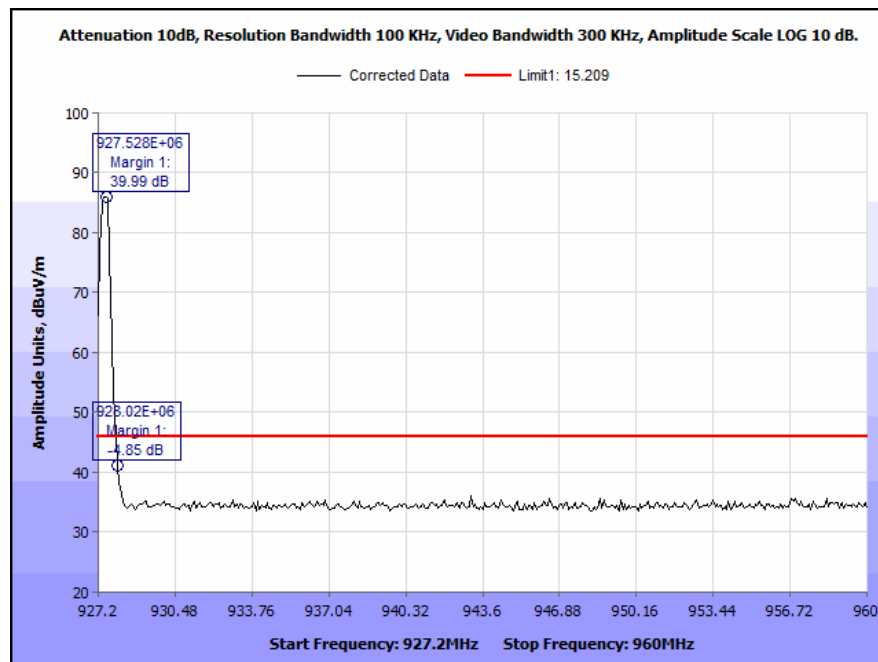
**Plot 23. Radiated Spurious Emissions, 1 – 10 GHz, High Channel Peak**

## Radiated Band Edge Measurements

**Test Procedures:** The transmitter was turned. 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.



**Plot 24. Radiated Restricted Band Edge Low Channel**



**Plot 25. Radiated Restricted Band Edge High Channel**

## Electromagnetic Compatibility Criteria for Intentional Radiators

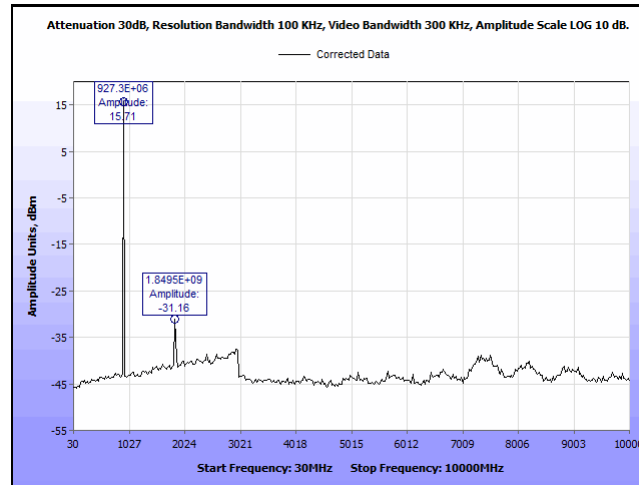
### § 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge

- 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<sup>th</sup> harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
- Test Results:** The EUT was compliant with the Conducted Spurious Emission limits of **§15.247(d)**. Measured emissions were within applicable limits.
- Test Engineer(s):** Deepak Giri
- Test Date(s):** March 17, 2017

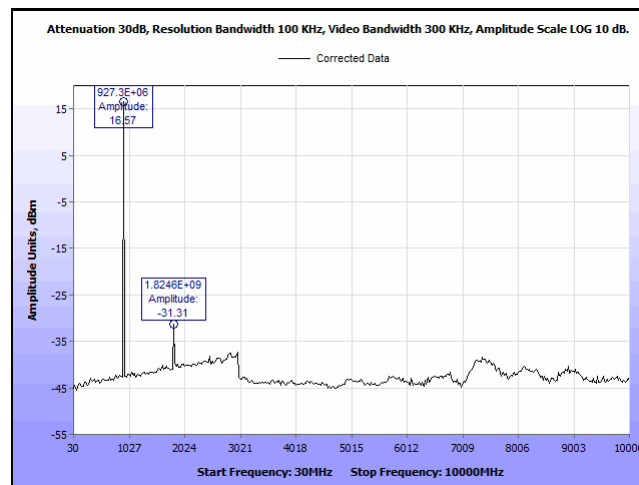


**Figure 4. Block Diagram, Conducted Spurious Emissions Test Setup**

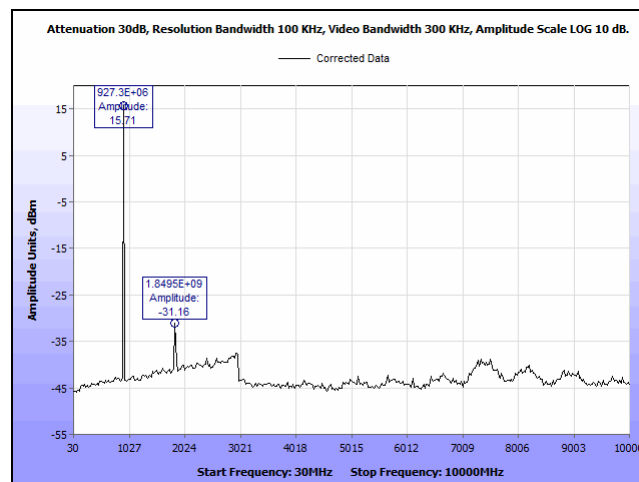
## Conducted Spurious Emissions Test Results



Plot 26. Conducted Spurious Emissions, Low Channel, 30 MHz – 1 GHz

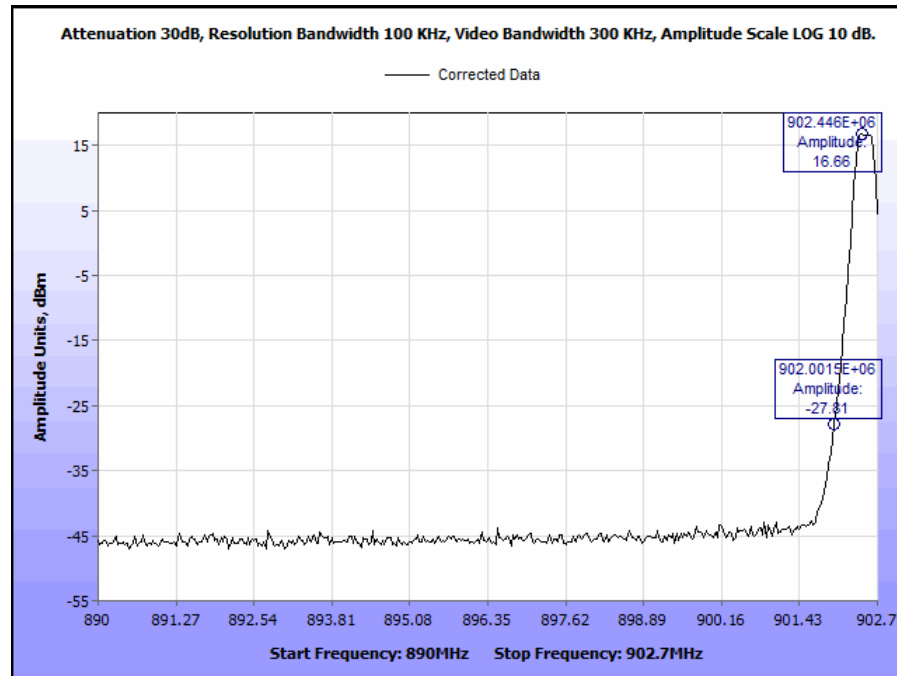


Plot 27. Conducted Spurious Emissions, Mid Channel, 30 MHz – 1 GHz

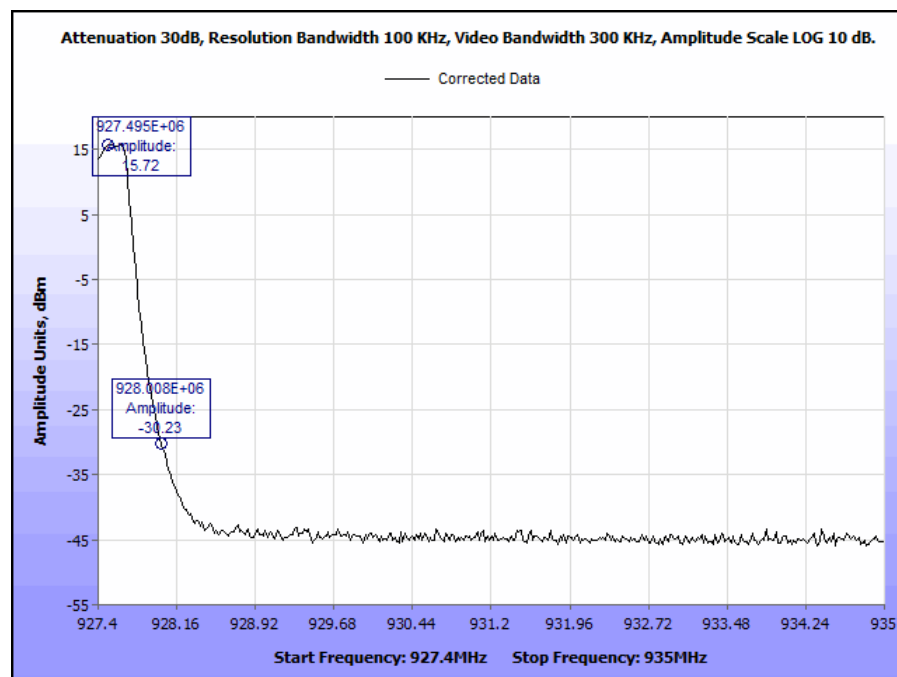


Plot 28. Conducted Spurious Emissions, High Channel, 30 MHz – 1 GHz

## Conducted Band Edge Test Results



Plot 29. Conducted Band Edge, Low Channel



Plot 30. Conducted Band Edge, High Channel

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(g)(h) Declaration Statements for FHSS

In 900MHz-band operation, the BD-1000 transmitter operates OOK or FSK modulation with a 20dB bandwidth not to exceed 250kHz and hops between at least 50 channels. The BD-1000 may sense channel occupancy by other users prior to transmission so as to independently adapt its hopset to avoid hopping on occupied channels. Furthermore, the BD-1000 at all times ensures that its transmissions never occupy a single channel for more than a total of 400ms in any 20s period.

## 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.

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density  
P = Power Input to antenna      G = Antenna Gain

| FCC             |                 |                |                 |                   |                                    |                             |         |               |        |
|-----------------|-----------------|----------------|-----------------|-------------------|------------------------------------|-----------------------------|---------|---------------|--------|
| Frequency (MHz) | Con. Pwr. (dBm) | Con. Pwr. (mW) | Ant. Gain (dBi) | Ant. Gain numeric | Pwr. Density (mW/cm <sup>2</sup> ) | Limit (mW/cm <sup>2</sup> ) | Margin  | Distance (cm) | Result |
| 2437            | 23.01           | 199.986        | -1.5            | 0.708             | 0.02817                            | 1                           | 0.93694 | 20            | Pass   |
| 902.5           | 3.616           | 2.299          | -4              | 0.398             | 0.00017                            | 1                           | 0.99964 | 20            | Pass   |

**Table 14. Simultaneous Emission, MPE, 900 MHz and 2.4 GHz**

## IV. Test Equipment

## Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

| MET Asset # | Equipment                                  | Manufacturer         | Model                      | Last Cal Date | Cal Due Date |
|-------------|--------------------------------------------|----------------------|----------------------------|---------------|--------------|
| 1T4483      | Antenna; Horn                              | ETS-Lindgren         | 3117                       | 4/19/2017     | 10/19/2018   |
| 1T4442      | Pre-amplifier, Microwave                   | Miteq                | AFS42-01001800-30-10P      | See Note      |              |
| 1T4300      | SEMI-ANECHOIC CHAMBER # 1 (NSA)            | EMC TEST SYSTEMS     | NONE                       | 2/6/2015      | 2/6/2018     |
| 1T4751      | Antenna - Bilog                            | Sunol Sciences       | JB6                        | 2/28/2017     | 8/28/2018    |
| 1S2421      | EMI Test Receiver                          | Rohde & Schwarz      | ESIB7                      | 2/2/2017      | 2/2/2018     |
| 1T4829      | Spectrum Analyzer                          | Agilent Technologies | E4407B                     | 2/20/2017     | 2/20/2018    |
| 1T4771      | PSA Spectrum Analyzer                      | Agilent Technologies | E4446A                     | 8/10/2016     | 2/10/2018    |
| 1T4149      | High-Frequency Anechoic Chamber            | Ray Proof            | 81                         | Not Required  |              |
| 1T4859      | Digital Barometer, Hygrometer, Thermometer | Control Company      | 15-078-198, FB70423, 245CD | 2/10/2016     | 2/10/2018    |
| 1T4745      | Antenna, Horn                              | ETS-Lindgren         | 3116                       | 1/21/2017     | 7/21/2018    |
| 1T4752      | Pre-Amplifier                              | Miteq                | JS44-18004000-35-8P        | See Note      |              |
| 1S4014      | LISN                                       | Com-Power            | LI-350                     | 2/21/2017     | 2/21/2018    |

**Table 15. Test Equipment List**

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

## **V. Certification & User's Manual Information**

## Certification & User's Manual Information

### A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

#### § 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

- (a) The various types of radio communication transmitting devices described throughout this chapter.
- (b) *The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*
- (c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.
- (d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

#### § 2.803 Marketing of radio frequency devices prior to equipment authorization.

- (a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:
  - (1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or
  - (2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.
- (d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

- (e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:
- (i) *Compliance testing;*
  - (ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;
  - (iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;
  - (iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or
  - (v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.
- (e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.
- (f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

## Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

### § 2.901 Basis and Purpose

- (a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.<sup>1</sup> *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.*
- (b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

### § 2.907 Certification.

- (a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.
- (b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

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<sup>1</sup> In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

## Certification & User's Manual Information

### § 2.948 Description of measurement facilities.

- (a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.
  - (1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.
    - (i) *If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*
    - (ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.
  - (2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

## Certification & User's Manual Information

### 1. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

#### § 15.19 Labeling requirements.

(a) *In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

- (1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- (2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

- (3) All other devices shall bear the following statement in a conspicuous location on the device:

*This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

- (4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

- (5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

#### § 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

## Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

### § 15.105 Information to the user.

- (a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

- (b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

# End of Report