

April 25, 2019

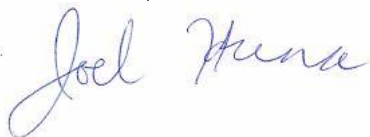
OnAsset Intelligence, Inc.  
8407 Sterling St  
Irving, TX 75063

Dear Shawn Key,

Enclosed is the EMC Wireless test report for compliance testing of the OnAsset Intelligence, Inc., Sentinel 100, Sentinel 100A, and Sentinel 100L 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 | MET Labs, 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,  
EUROFINS | MET LABS, INC.



Joel Huna  
Documentation Department

Reference: (\OnAsset Intelligence, Inc.\EMCA100631A-FCC247 Rev. 1)

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## **Electromagnetic Compatibility Criteria Test Report**

for the

**OnAsset Intelligence, Inc.  
Sentinel 100, Sentinel 100A, Sentinel 100L**

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

**MET Report: EMCA100631A-FCC247 Rev. 1**

April 25, 2019

**Prepared For:**

**OnAsset Intelligence, Inc.  
8407 Sterling St  
Irving, TX 75063**

**Prepared By:**  
**Eurofins | MET Labs, Inc.**  
13501 McCallen Pass,  
Austin, TX 78753

## Electromagnetic Compatibility Criteria Test Report

for the

**OnAsset Intelligence, Inc.  
Sentinel 100, Sentinel 100A, Sentinel 100L**

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



Jonathan Tavira, 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	January 9, 2018	Initial Issue.
1	April 25, 2019	Data rate specified as 1 Mbps.

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## List of Terms and Abbreviations

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



# I. Executive Summary

## A. Purpose of Test

An EMC evaluation was performed to determine compliance of the OnAsset Intelligence, Inc. Sentinel 100, Sentinel 100A, and Sentinel 100L, 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 Sentinel 100, Sentinel 100A, and Sentinel 100L. OnAsset Intelligence, Inc. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Sentinel 100, Sentinel 100A, and Sentinel 100L, have 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 OnAsset Intelligence, Inc., purchase order number 5421. 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	Not Applicable
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)	Maximum Conducted Output Power	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)	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 Compliance Testing**

## II. Equipment Configuration

## A. Overview

Eurofins | MET Labs, Inc. was contracted by OnAsset Intelligence, Inc. to perform testing on the Sentinel 100 to cover models Sentinel 100A, and Sentinel 100L, under OnAsset Intelligence, Inc.'s purchase order number 5421.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the OnAsset Intelligence, Inc., Sentinel 100 to cover testing for Sentinel 100A, and Sentinel 100L.

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

<b>Model(s) Tested:</b>	Sentinel 100	
<b>Model(s) Covered:</b>	Sentinel 100, Sentinel 100A, Sentinel 100L	
<b>EUT Specifications:</b>	Primary Power: 3.6V internal battery	
	FCC ID: 2ARLF-100	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	14.91 dBm
	EUT Frequency Ranges:	2402 MHz to 2480 MHz
	Data Rate:	1 Mbps
<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>	Jonathan Tavira	
<b>Report Date(s):</b>	April 25, 2019	

**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 558074 v05</b>	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 | MET Labs, Inc., 13501 McCallen Pass, Austin, TX 78753. 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 10 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. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
<b>RF Frequencies</b>	±4.52 Hz	2	95%
<b>RF Power Conducted Emissions</b>	±2.97 dB	2	95%
<b>RF Power Radiated Emissions, &lt;1GHz</b>	±2.95 dB	2	95%
<b>RF Power Radiated Emissions, &gt;1GHz</b>	±3.54 dB	2	95%

**Table 4. Uncertainty Calculations Summary**

## E. Description of Test Sample

The OnAsset Intelligence, Inc. Sentinel 100, Equipment Under Test (EUT), is an Internal battery powered BLE beacon with sensors intended for asset tracking and monitoring. EUT can be used to identify location area and save sensor information for later download.

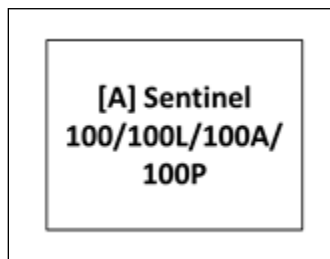


Figure 1. Block Diagram of Test Configuration

## F. 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	Slot #	Name / Description	Model Number	Part Number	Serial Number	Rev. #
A	N/A	Sentinel 100	Sentinel 100	N/A	N/A	1

Table 5. Equipment Configuration

## G. Support Equipment

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

Ref. ID	Name / Description	Manufacturer	Part Number	*Customer Supplied Calibration Data
B	EFR32BG Bluetooth Smart Starter Kit	Silicon Labs	SLWSTK6020A	N/A

The 'Customer Supplied Calibration Data' column will be marked as either not applicable, not available, or will contain the calibration date supplied by the customer.

Table 6. Support Equipment

## H. Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 7. Ports and Cabling Information

**I. Mode of Operation**

Sentinel 100 was configured to transmit at a data rate of 1 Mbps with a duty cycle  $\geq 98\%$  for the following operating channels: 2402 MHz, 2440 MHz, and 2480 MHz. Channel selection and output were configured through the use of the Silicon Labs' EFR32BG Bluetooth Smart Starter Kit.

**J. Method of Monitoring EUT Operation**

Transmission of the Sentinel 100 was verified through visual inspection of an on-board green LED.

**K. 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.

**L. Disposition of EUT**

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to OnAsset Intelligence, Inc. 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. The EUT utilizes an etched PCB antenna, which is considered to be permanently attached to the EUT.

**Test Engineer(s):**

Jonathan Tavira

**Test Date(s):**

September 7, 2018

Antenna Gain	Antenna Type
-3 dBi	PCB etched F type

**Table 8. Antenna List**

## 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.

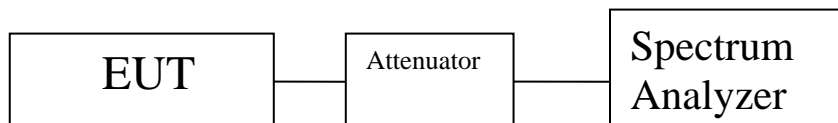
**Test Procedure:** The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW = 100kHz, VBW = 3\*RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

**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):** Jonathan Tavira

**Test Date(s):** September 10, 2018



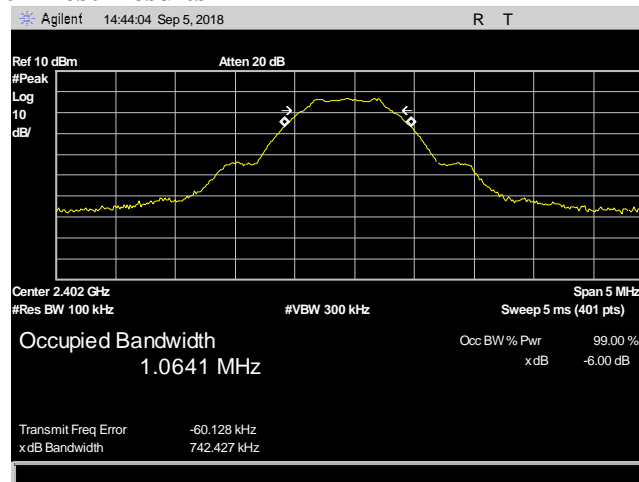
**Figure 2. Block Diagram, Occupied Bandwidth Test Setup**

## Occupied Bandwidth Test Results

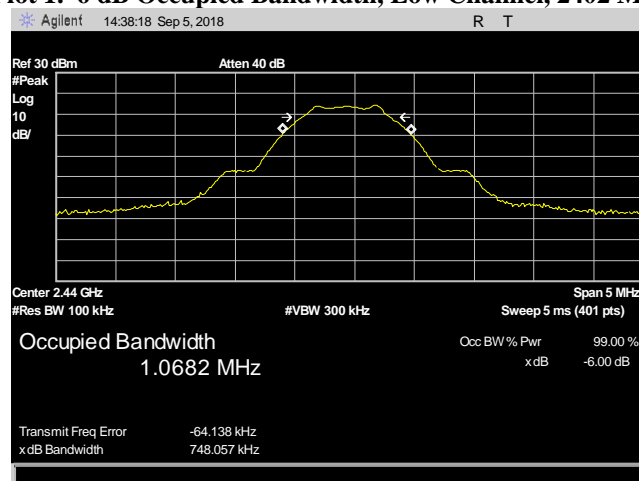
Occupied Bandwidth		
Carrier Channel	Frequency (MHz)	Measured 6 dB Bandwidth (kHz)
Low	2402	742.427
Mid	2440	748.057
High	2480	737.572

Table 9. 6 dB Occupied Bandwidth, Test Results

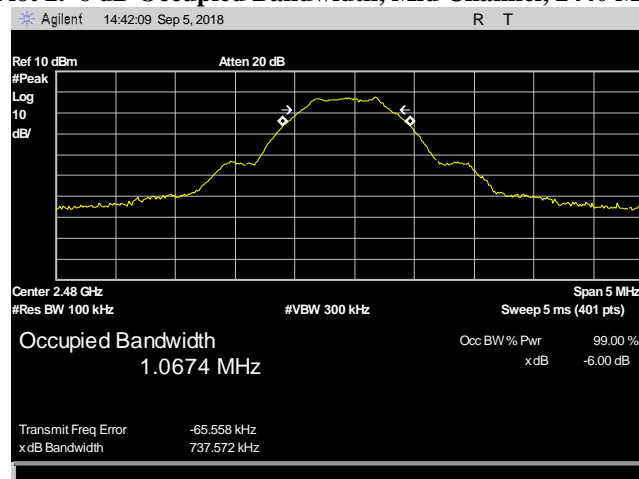
## 6 dB Occupied Bandwidth Test Results



Plot 1. 6 dB Occupied Bandwidth, Low Channel, 2402 MHz



Plot 2. 6 dB Occupied Bandwidth, Mid Channel, 2440 MHz



Plot 3. 6 dB Occupied Bandwidth, High Channel, 2480 MHz

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(b)(3) Maximum Conducted Output Power

**Test Requirements:** §15.247(b)(3): The maximum conducted output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit (Watts)
2400–2483.5	1.000

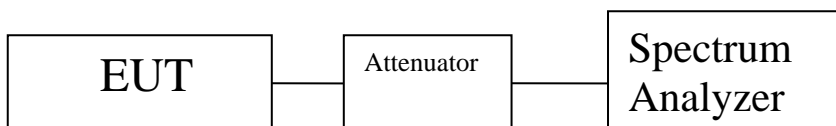
**Table 10. Output Power Requirements from §15.247(b)(3)**

**Test Procedure:** The EUT was measured at the low, mid and high channels of each band at the maximum power level. Measurements were performed in a conducted setup as shown in figure 3. The measurements were performed on the low, mid and high channels.

**Test Results:** The EUT was compliant with the maximum conducted output power limits of §15.247(b)(3).

**Test Engineer(s):** Jonathan Tavira

**Test Date(s):** December 12, 2018



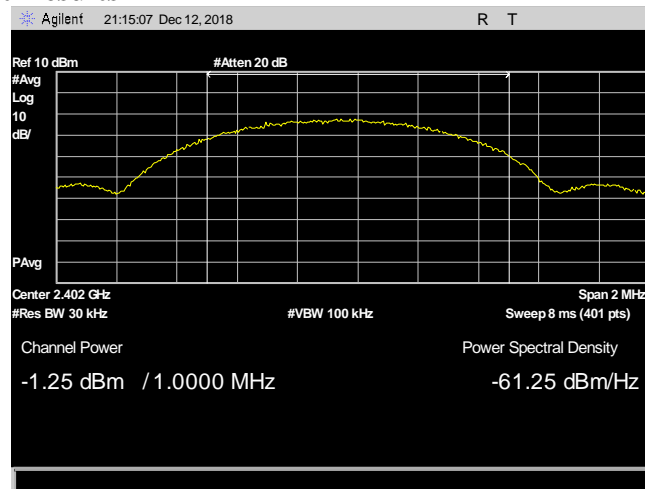
**Figure 3. Block Diagram, Maximum Conducted Output Power Test Setup**

### Maximum Conducted Output Power Test Results

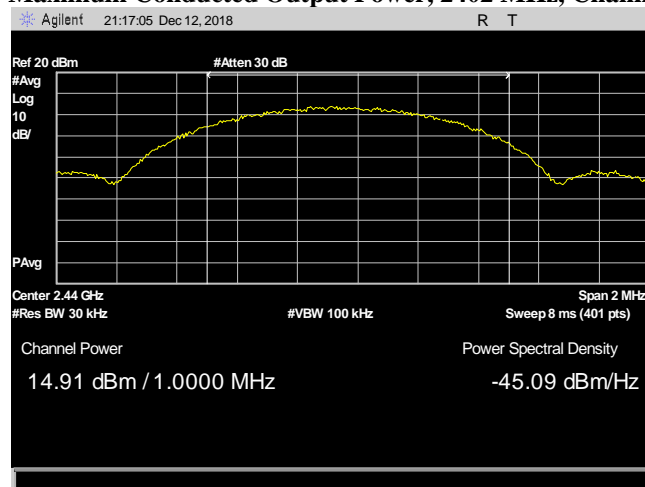
Maximum Conducted Output Power			
Carrier Channel	Frequency (MHz)	Software Power Setting (dBm)	Average Conducted Power (dBm)
Low	2402	0	-1.25
Mid	2440	20	14.91
High	2480	0	-1.43

**Table 11. Maximum Conducted Output Power, Test Results**

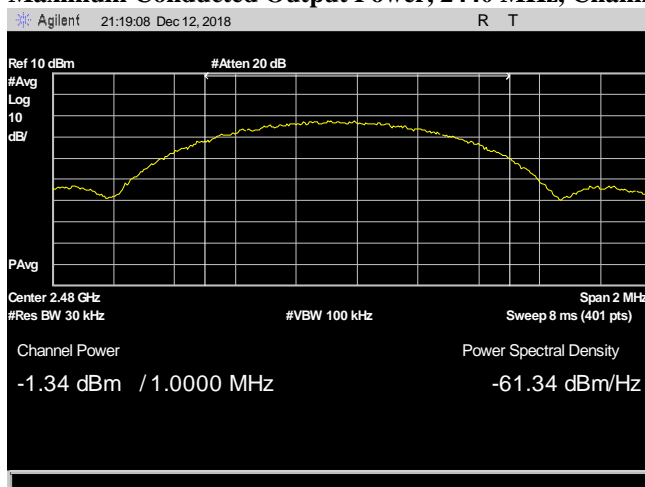
## Peak Power Output Test Results



Plot 4. Maximum Conducted Output Power, 2402 MHz, Channel Power



Plot 5. Maximum Conducted Output Power, 2440 MHz, Channel Power



Plot 6. Maximum Conducted Output Power, 2480 MHz, Channel Power

## 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
<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 (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. 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. Only noise floor was measured above 18 GHz; however the worst-case emission profile is provided.

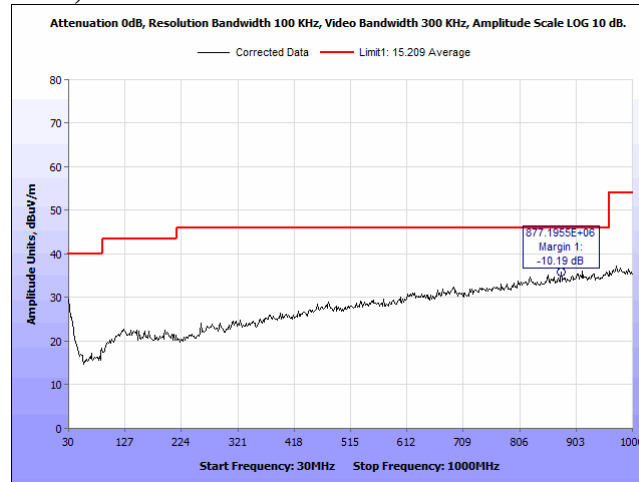
**Test Results:** The EUT was compliant with the Radiated Spurious Emission limits of § 15.247(d) and § 15.209. Measured emissions were within applicable limits.

**Test Engineer(s):** Jonathan Tavira

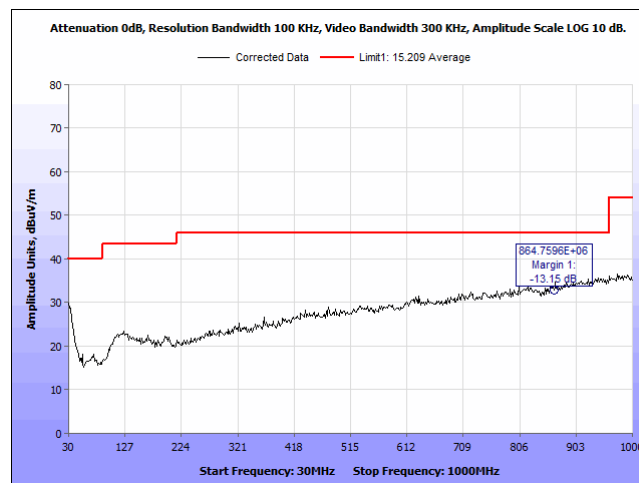
**Test Date(s):** September 4, 2018



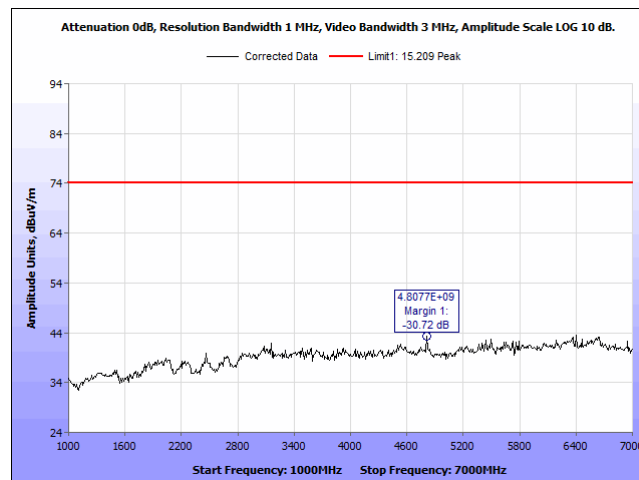
## Radiated Spurious Emissions, Test Results



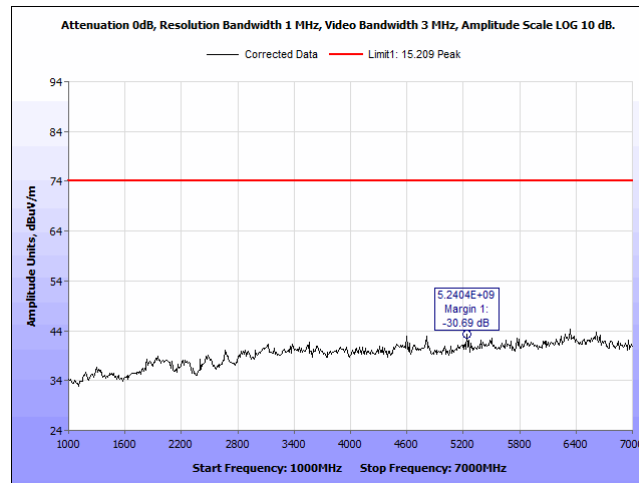
Plot 7. Radiated Emissions, 2402 MHz, 30 - 1000 MHz, Vertical



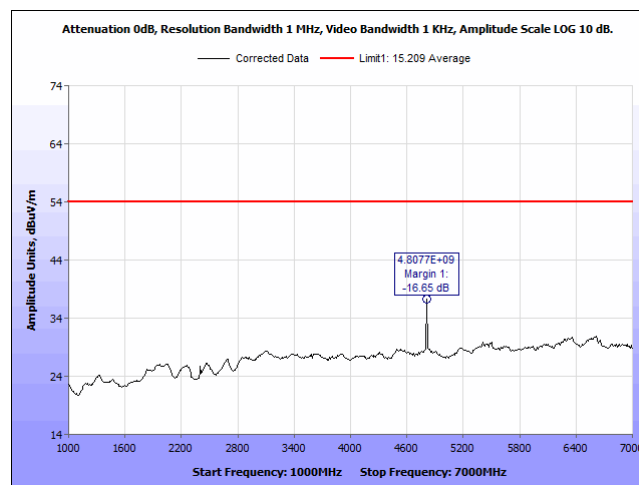
Plot 8. Radiated Emissions, 2402 MHz, 30 - 1000 MHz, Horizontal



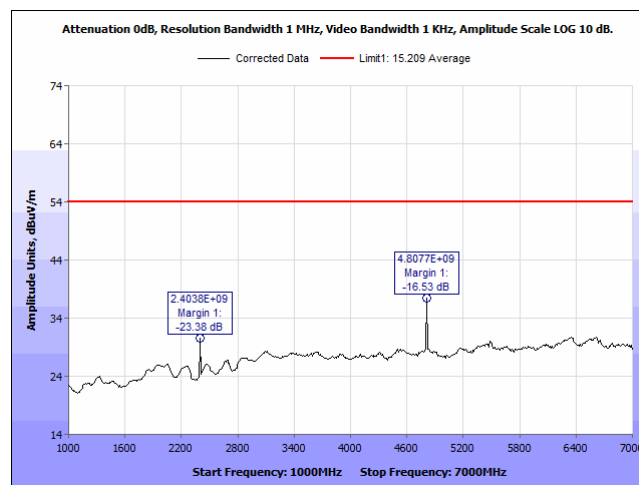
Plot 9. Radiated Emissions, 2402 MHz, 1 - 7 GHz, Peak, Vertical



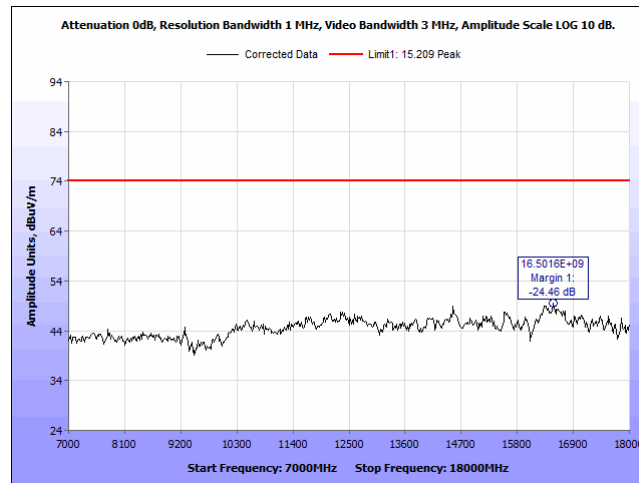
Plot 10. Radiated Emissions, 2402 MHz, 1 - 7 GHz, Peak, Horizontal



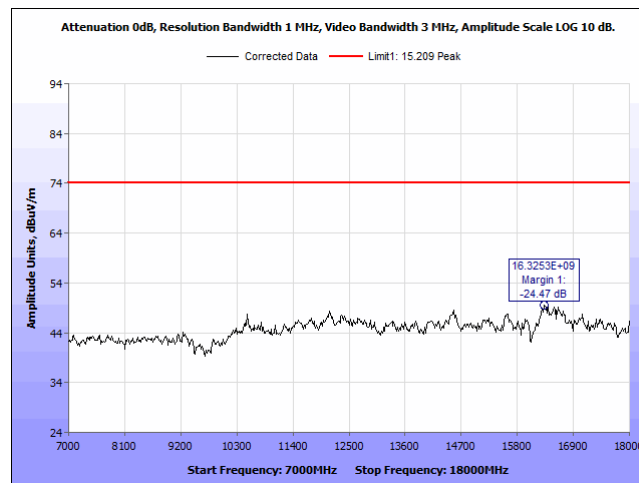
Plot 11. Radiated Emissions, 2402 MHz, 1 - 7 GHz, Average, Vertical



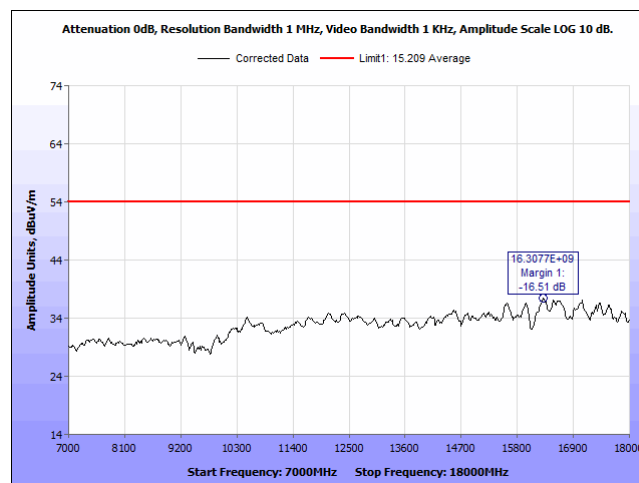
Plot 12. Radiated Emissions, 2402 MHz, 1 - 7 GHz, Average, Horizontal



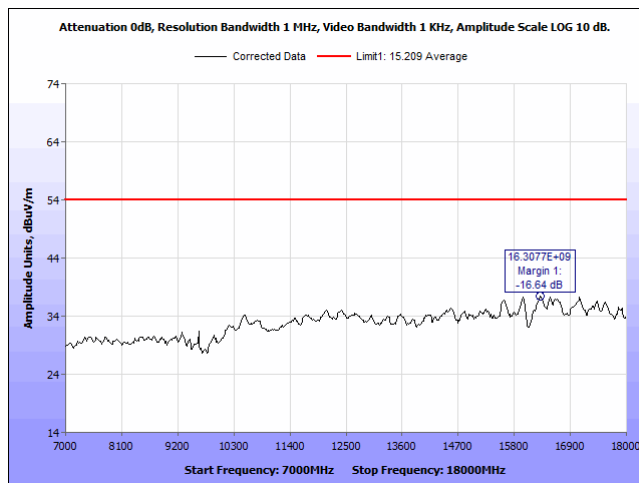
Plot 13. Radiated Emissions, 2402 MHz, 7 - 18 GHz, Peak, Vertical



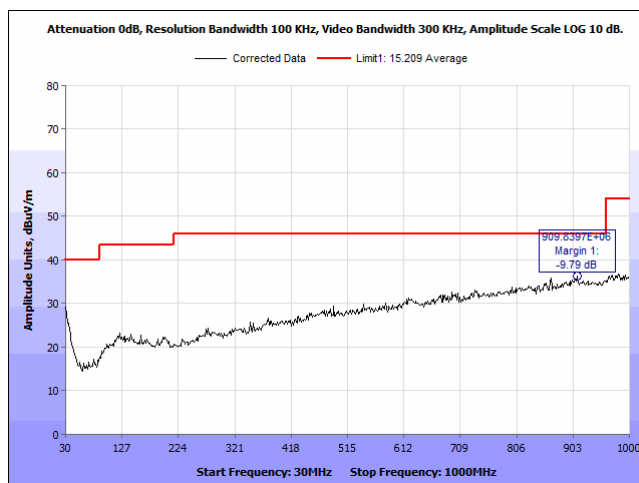
Plot 14. Radiated Emissions, 2402 MHz, 7 - 18 GHz, Peak, Horizontal



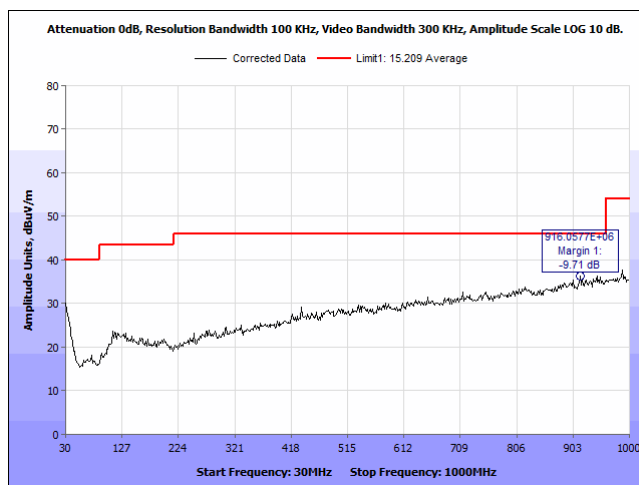
Plot 15. Radiated Emissions, 2402 MHz, 7 - 18 GHz, Average, Vertical



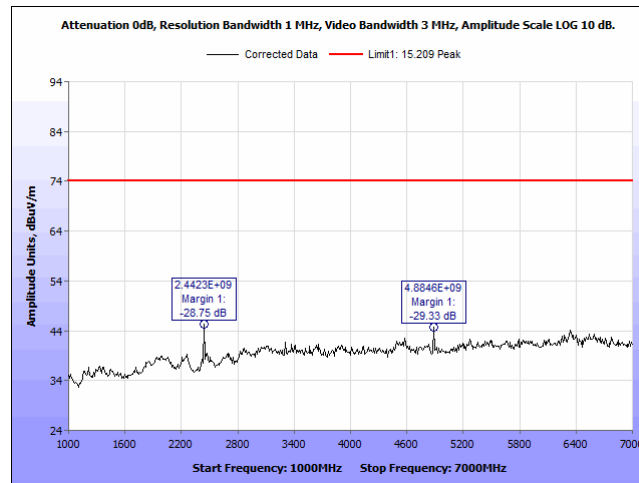
Plot 16. Radiated Emissions, 2402 MHz, 7 - 18 GHz, Average, Horizontal



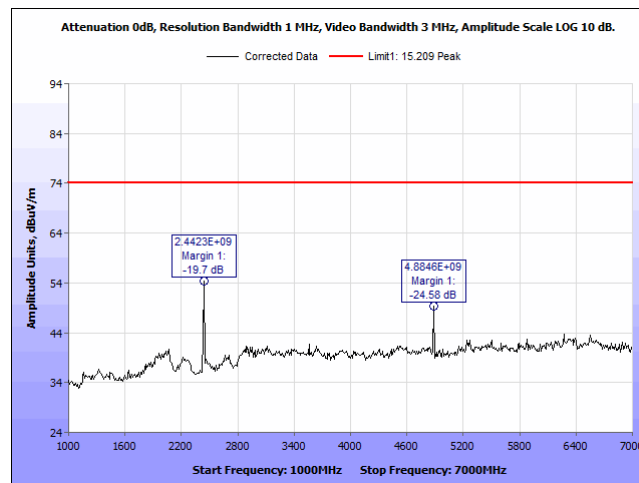
Plot 17. Radiated Emissions, 2440 MHz, 30 - 1000 MHz, Vertical



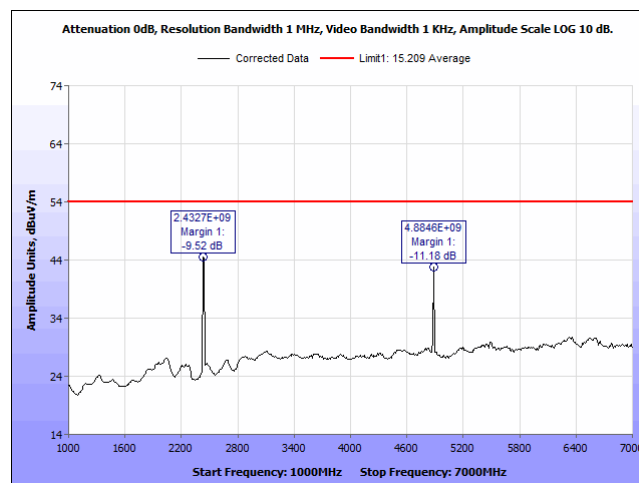
Plot 18. Radiated Emissions, 2440 MHz, 30 - 1000 MHz, Horizontal



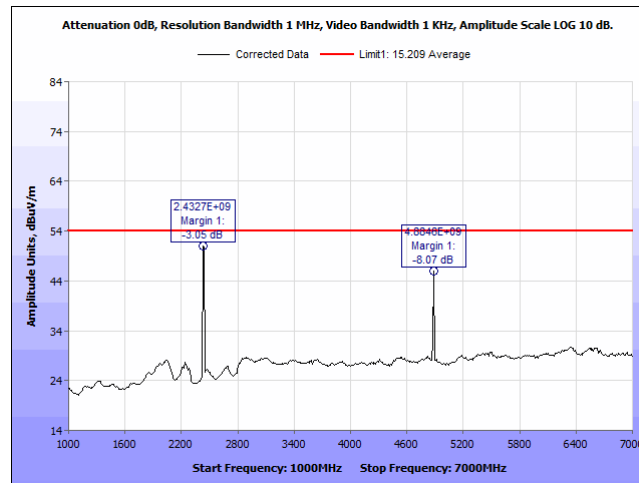
Plot 19. Radiated Emissions, 2440 MHz, 1 - 7 GHz, Peak, Vertical



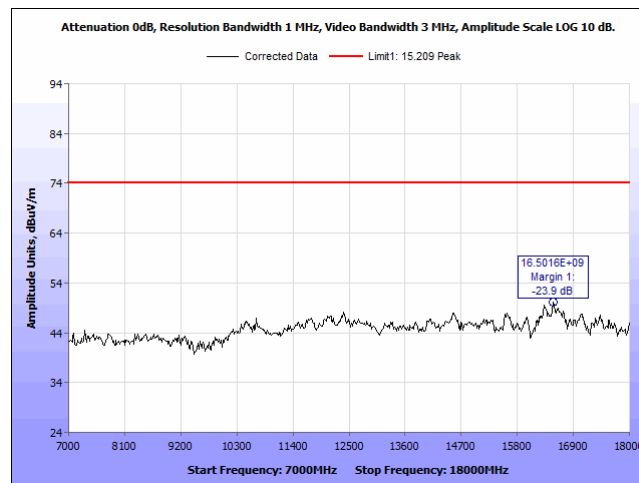
Plot 20. Radiated Emissions, 2440 MHz, 1 - 7 GHz, Peak, Horizontal



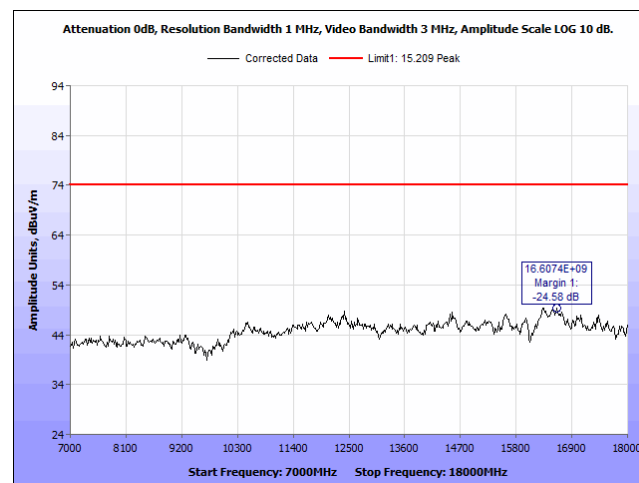
Plot 21. Radiated Emissions, 2440 MHz, 1 - 7 GHz, Average, Vertical



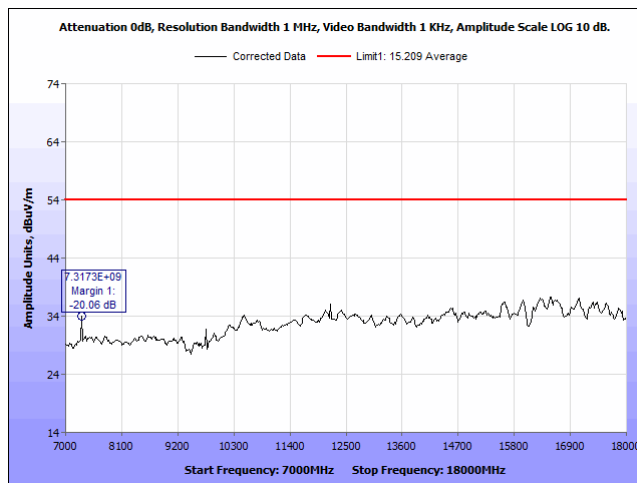
Plot 22. Radiated Emissions, 2440 MHz, 1 - 7 GHz, Average, Horizontal



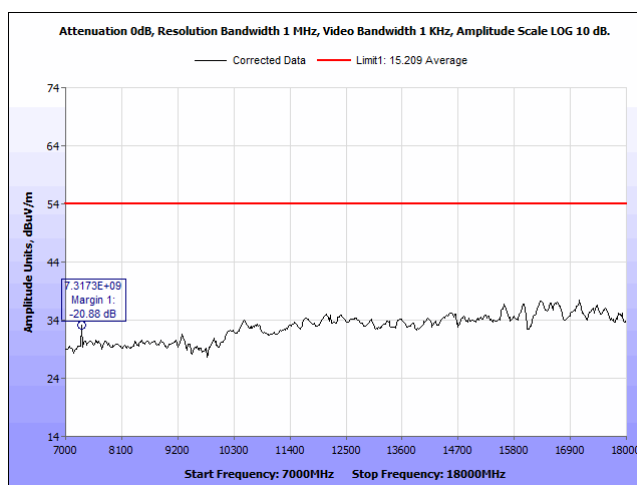
Plot 23. Radiated Emissions, 2440 MHz, 7 - 18 GHz, Peak, Vertical



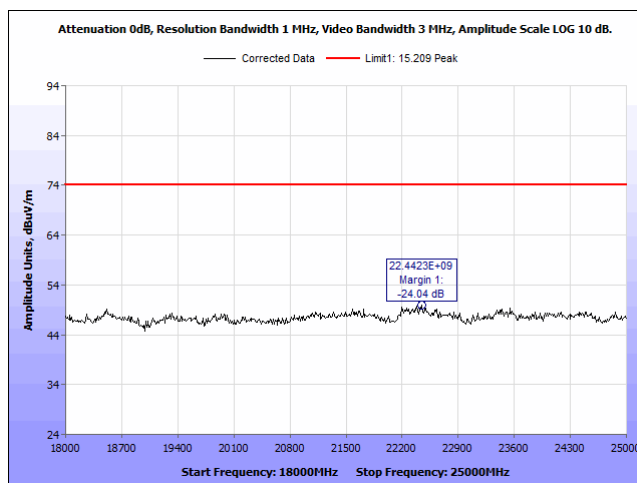
Plot 24. Radiated Emissions, 2440 MHz, 7 - 18 GHz, Peak, Horizontal



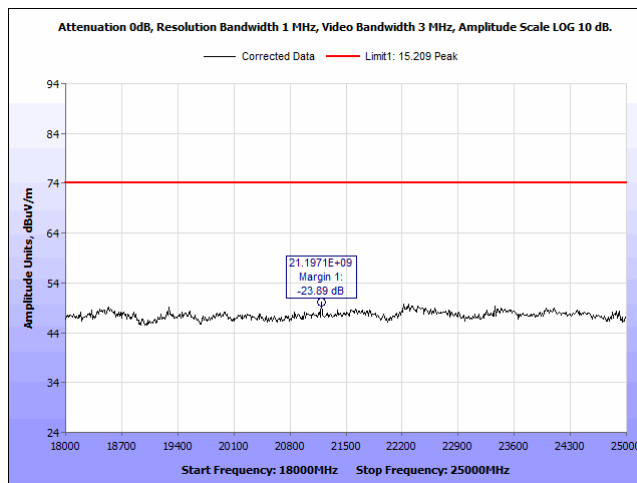
Plot 25. Radiated Emissions, 2440 MHz, 7 - 18 GHz, Average, Vertical



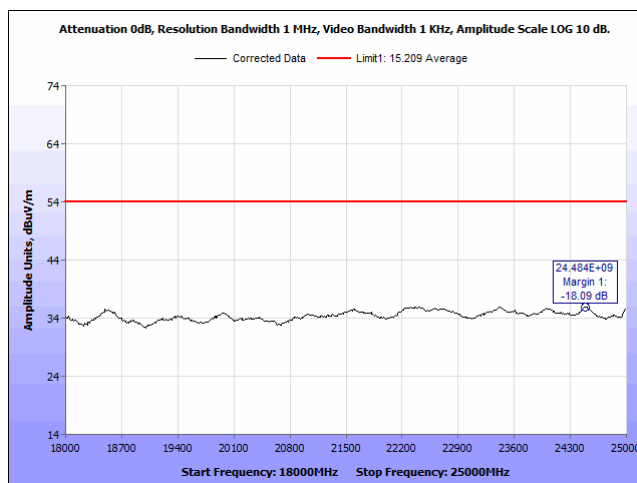
Plot 26. Radiated Emissions, 2440 MHz, 7 - 18 GHz, Average, Horizontal



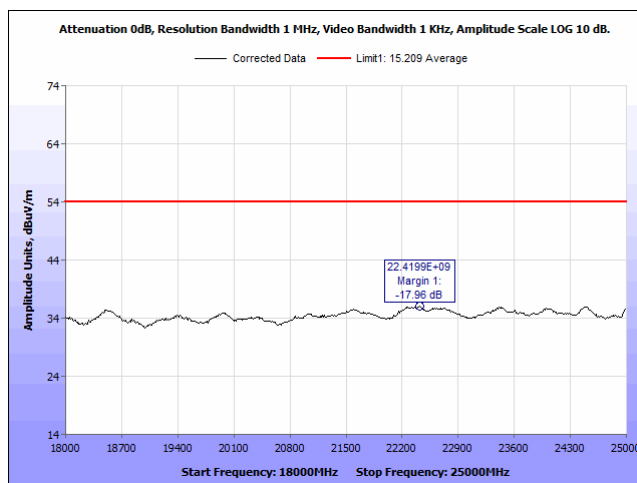
Plot 27. Radiated Emissions, 2440 MHz, 18 - 25 GHz, Peak, Vertical



Plot 28. Radiated Emissions, 2440 MHz, 18 - 25 GHz, Peak, Horizontal

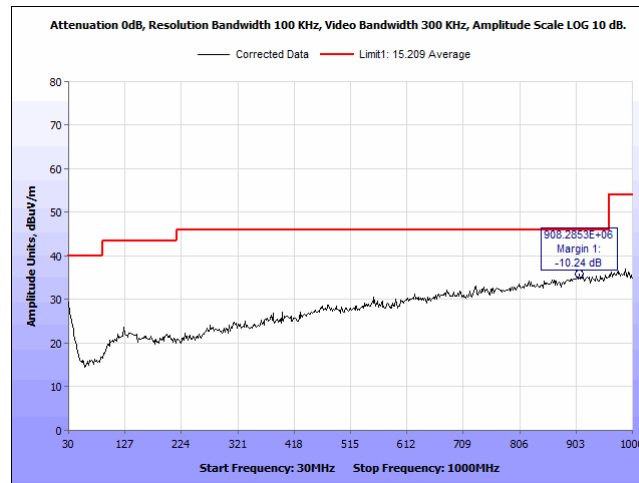


Plot 29. Radiated Emissions, 2440 MHz, 18 - 25 GHz, Average, Vertical

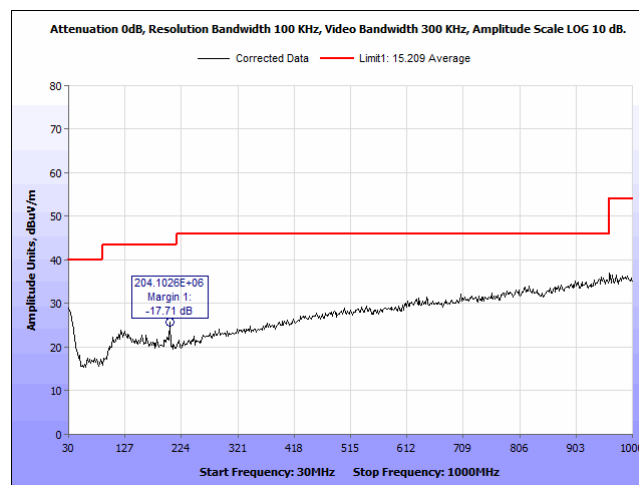


Plot 30. Radiated Emissions, 2440 MHz, 18 - 25 GHz, Average, Horizontal

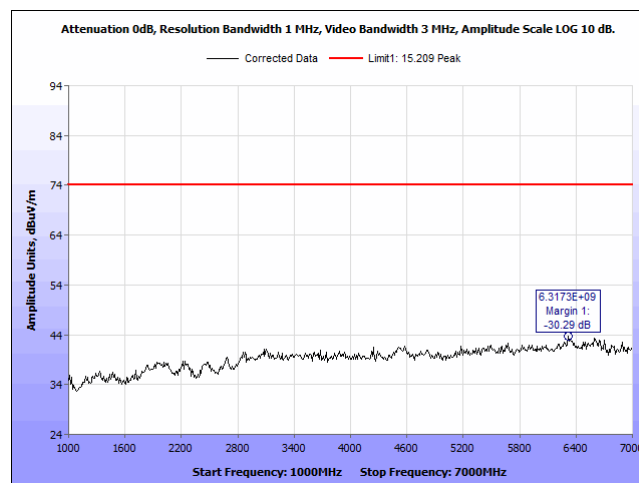




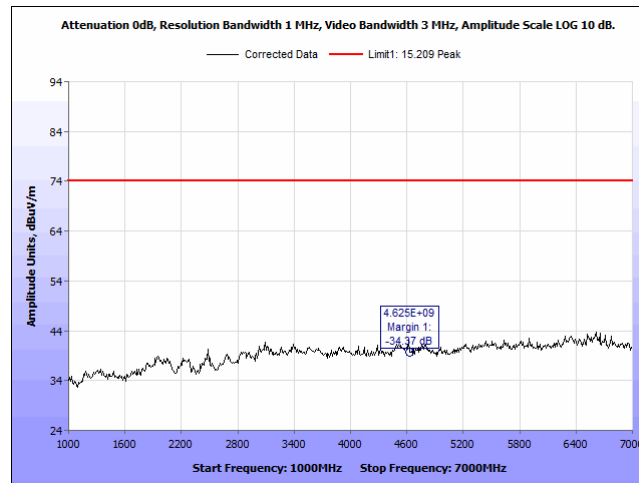
Plot 31. Radiated Emissions, 2480 MHz, 30 – 1000 MHz, Vertical



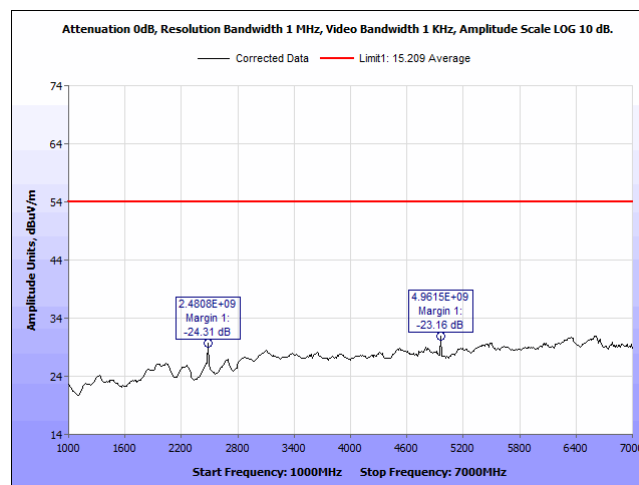
Plot 32. Radiated Emissions, 2480 MHz, 30 – 1000 MHz, Horizontal



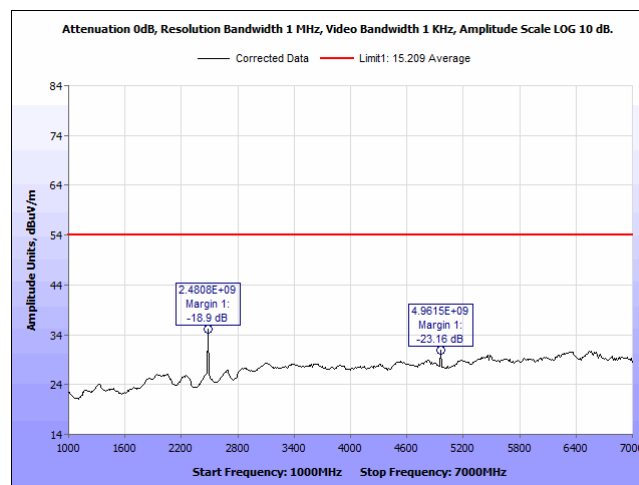
Plot 33. Radiated Emissions, 2480 MHz, 1 - 7 GHz, Peak, Vertical



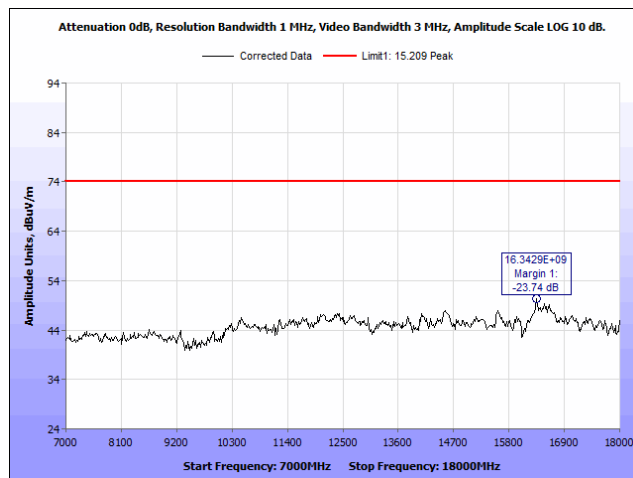
Plot 34. Radiated Emissions, 2480 MHz, 1 - 7 GHz, Peak, Horizontal



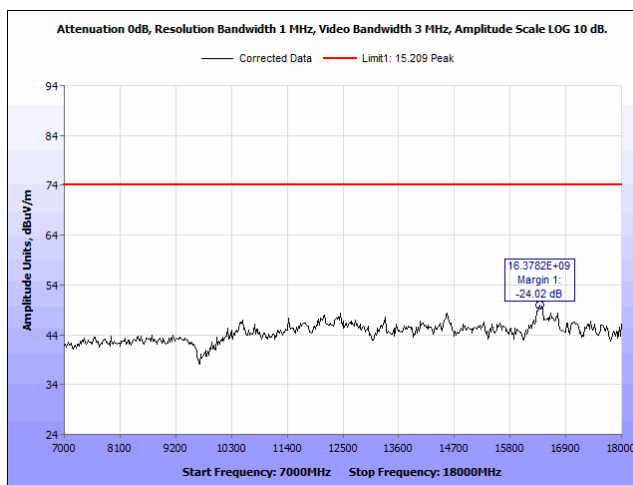
Plot 35. Radiated Emissions, 2480 MHz, 1 - 7 GHz, Average, Vertical



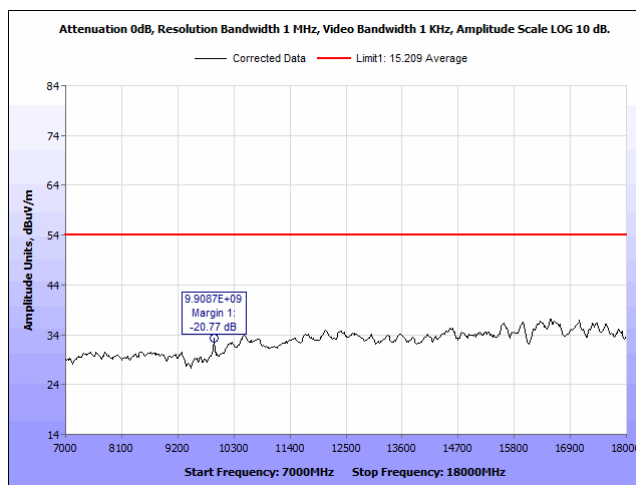
Plot 36. Radiated Emissions, 2480 MHz, 1 - 7 GHz, Average, Horizontal



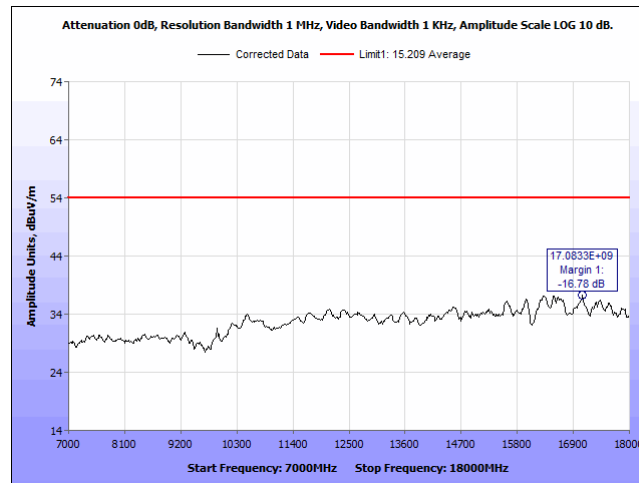
Plot 37. Radiated Emissions, 2480 MHz, 7 – 18 GHz, Peak, Vertical



Plot 38. Radiated Emissions, 2480 MHz, 7 – 18 GHz, Peak, Horizontal



Plot 39. Radiated Emissions, 2480 MHz, 7 – 18 GHz, Average, Vertical

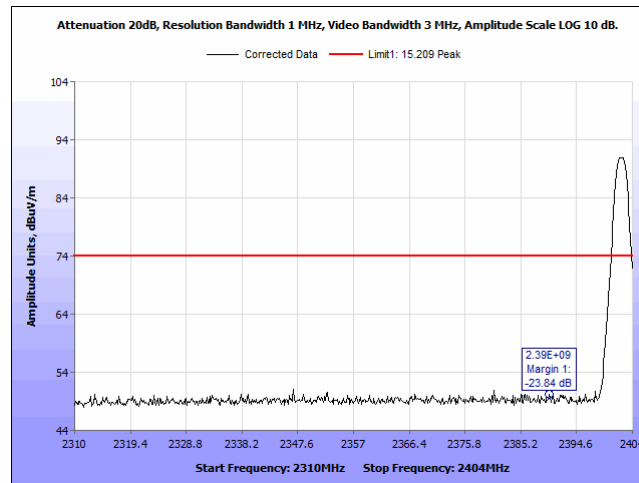


Plot 40. Radiated Emissions, 2480 MHz, 7 – 18 GHz, Average, Horizontal

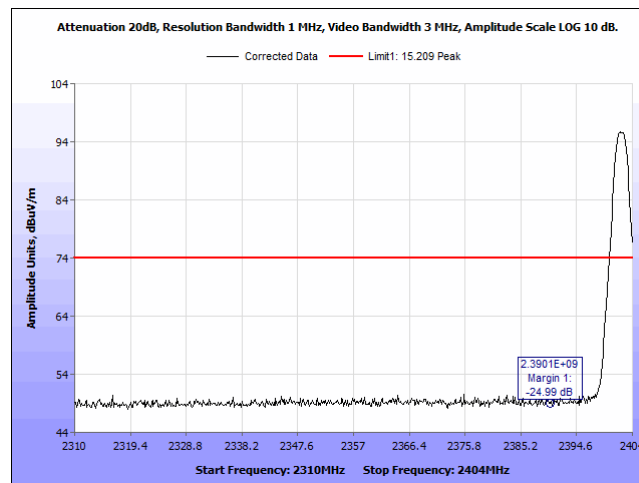
## Radiated Band Edge Measurements

### Test Procedures:

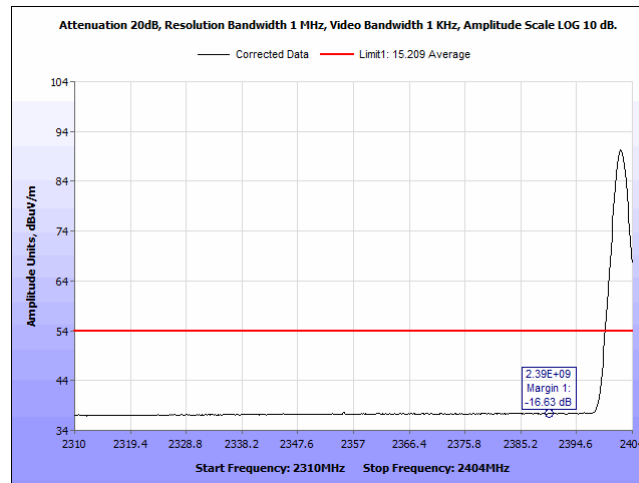
The transmitter was turned on. Measurements were performed of the low and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.



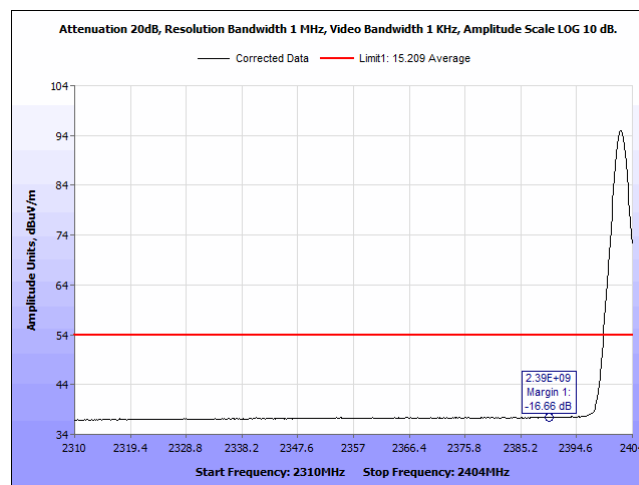
Plot 41. Radiated Restricted Bandedge, 2402 MHz, Peak, Vertical



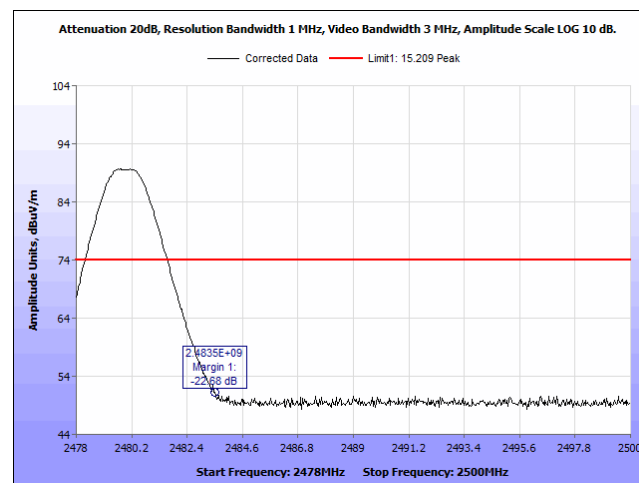
Plot 42. Radiated Restricted Bandedge, 2402 MHz, Peak, Horizontal



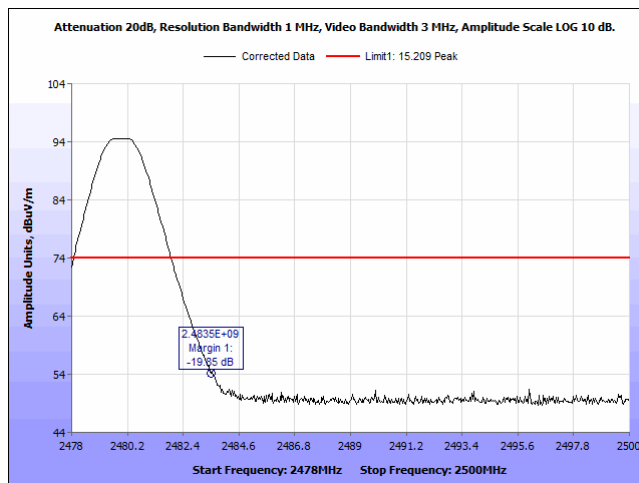
**Plot 43. Radiated Restricted Bandedge, 2402 MHz, Average, Vertical**



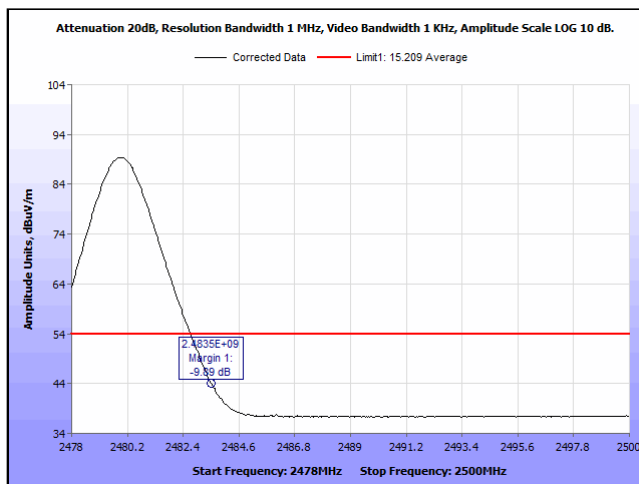
**Plot 44. Radiated Restricted Bandedge, 2402 MHz, Average, Horizontal**



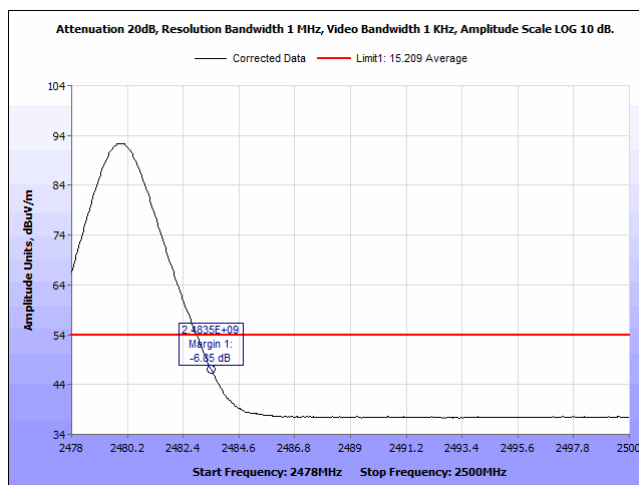
**Plot 45. Radiated Restricted Bandedge, 2480 MHz, Peak, Vertical**



Plot 46. Radiated Restricted Bandedge, 2480 MHz, Peak, Horizontal



Plot 47. Radiated Restricted Bandedge, 2480 MHz, Average, Vertical



Plot 48. Radiated Restricted Bandedge, 2480 MHz, Average, Horizontal





## 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<sup>th</sup> harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

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

**Test Engineer(s):** Jonathan Tavira

**Test Date(s):** December 12, 2018

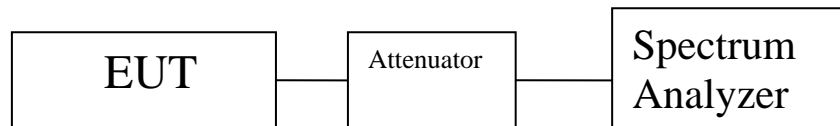
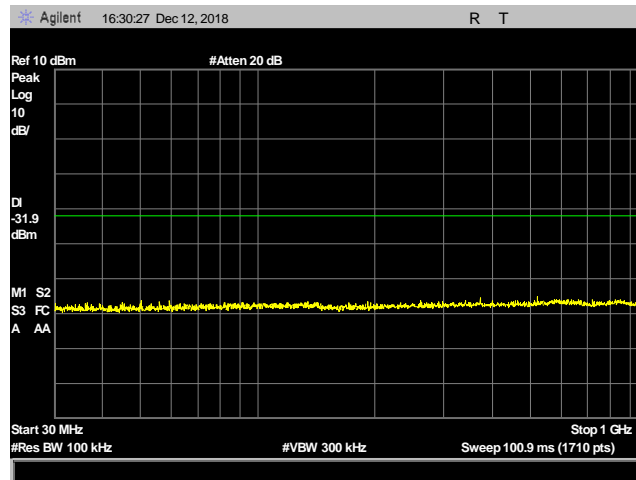
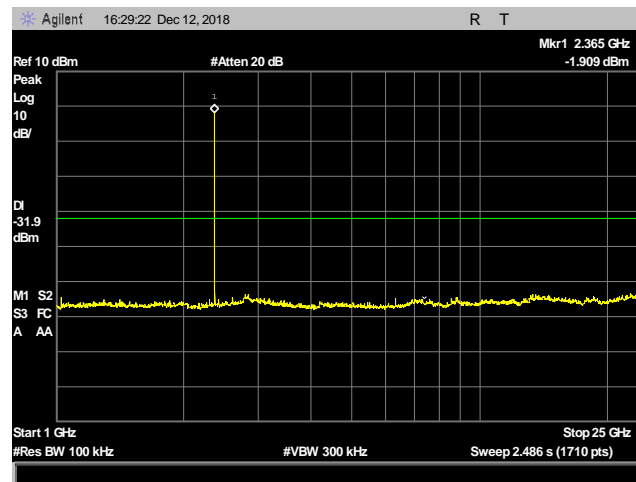


Figure 3. Spurious Emissions in Non-restricted Bands, Test Configuration

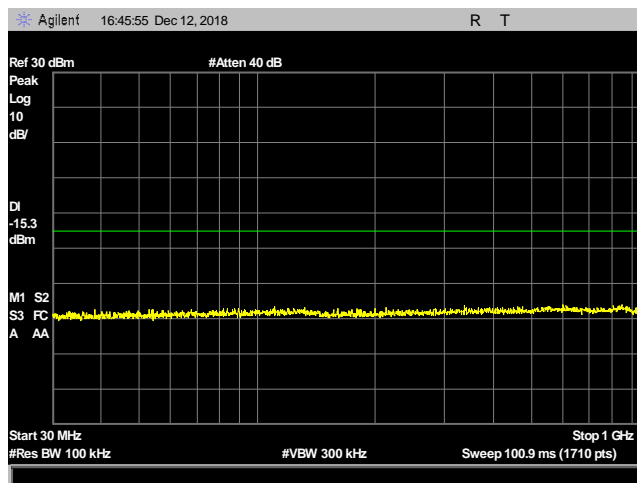
## Spurious Emissions in Non-restricted Bands, Test Results



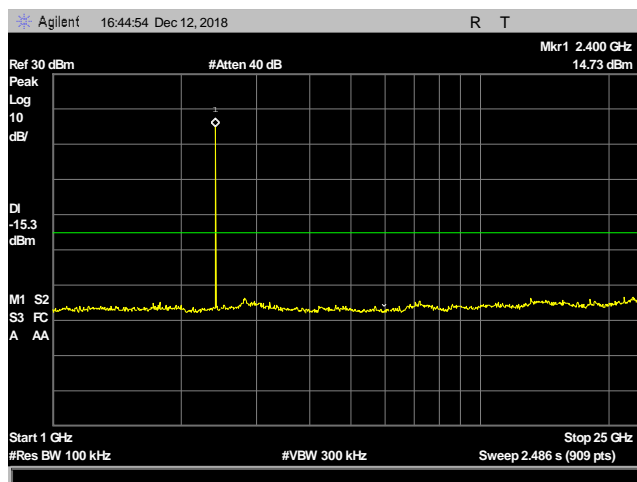
Plot 49. 100 kHz Spurious Emissions, 2402 MHz, 30 – 1000 MHz



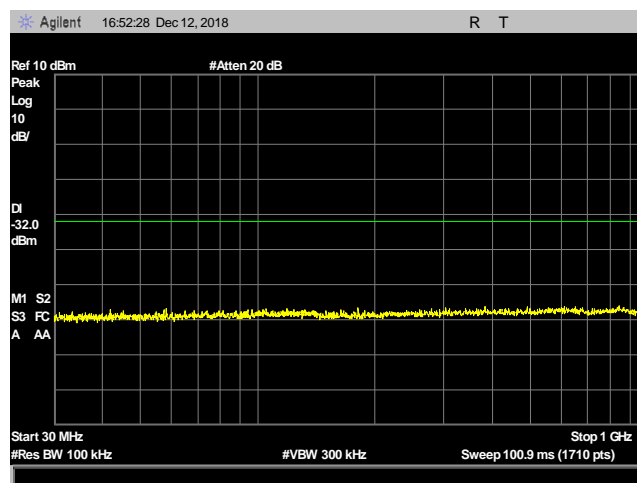
Plot 50. 100 kHz Spurious Emissions, 2402 MHz, 1 – 25 GHz



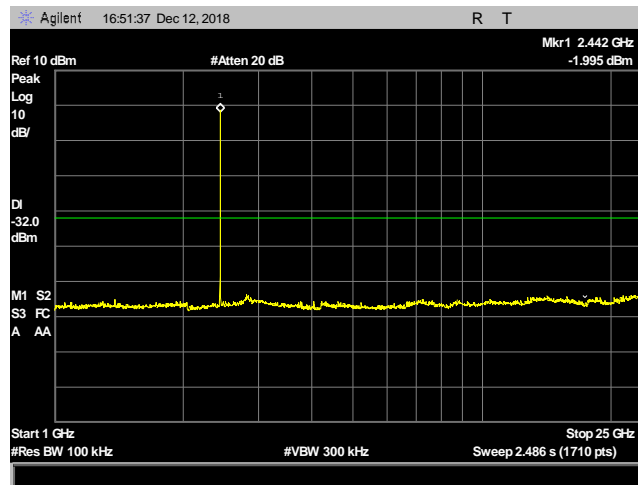
Plot 51. 100 kHz Spurious Emissions, 2440 MHz, 30 – 1000 MHz



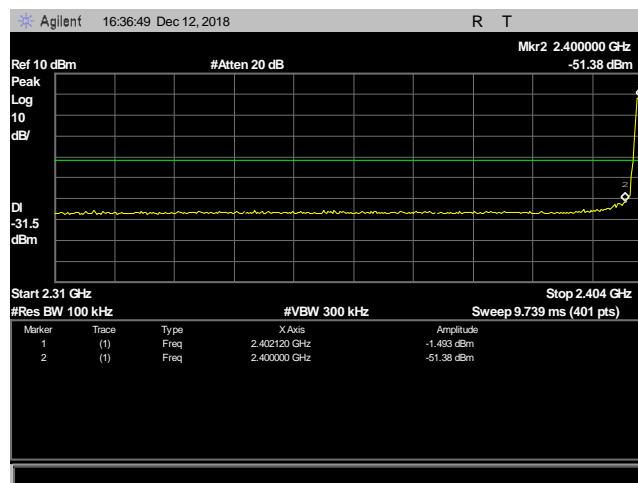
Plot 52. 100 kHz Spurious Emissions, 2440 MHz, 1 – 25 GHz



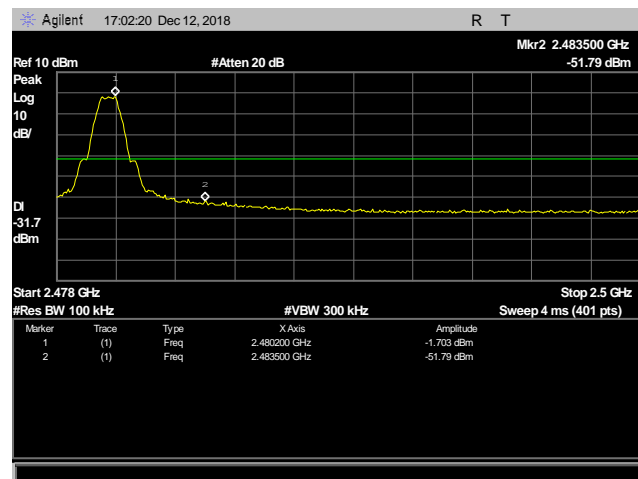
Plot 53. 100 kHz Spurious Emissions, 2480 MHz, 30 – 1000 MHz



Plot 54. 100 kHz Spurious Emissions, 2480 MHz, 1 – 25 GHz



Plot 55. Conducted Restricted Bandedge, 2402 MHz



Plot 56. Conducted Restricted Bandedge, 2480 MHz



## 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 power level was set to the maximum level throughout each of the 100 sweeps of power averaging. The RBW was set to  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$  and a VBW set to three times the RBW or greater. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels.

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

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

**Test Engineer:** Jonathan Tavira

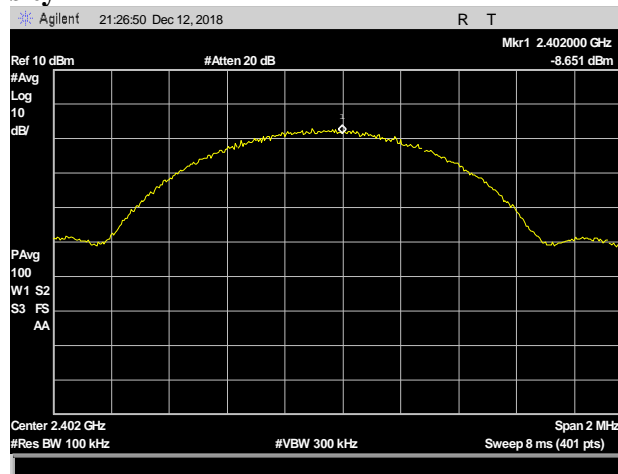
**Test Date:** December 12, 2018

### Peak Power Spectral Density Test Results

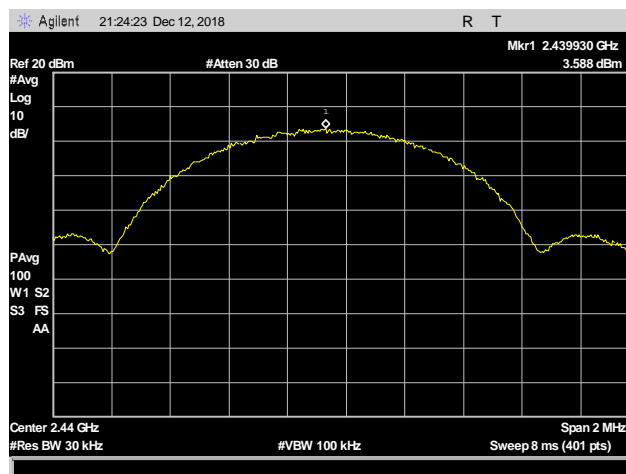
Power Spectral Density		
Carrier Channel	Frequency (MHz)	Average Conducted PSD (dBm)
Low	2402	-8.651
Mid	2440	3.588
High	2480	-7.740

Table 14. Power Spectral Density, Test Results

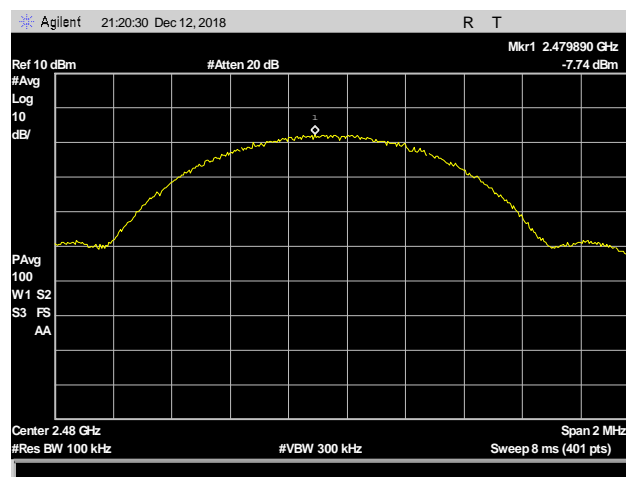
## Peak Power Spectral Density



Plot 57. Power Density, 2402 MHz, 100 kHz RBW



Plot 58. Power Density, 2440 MHz, 30 kHz RBW



Plot 59. Power Density, 2480 MHz, 100 kHz RBW

## 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.

MPE Limit: EUT's operating frequencies @ 2400-2483.5 MHz; **Limit for Uncontrolled exposure: 1 mW/cm<sup>2</sup> or 10 W/m<sup>2</sup>**

Equation from page 18 of OET 65, Edition 97-01

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

where, S = Power Density (mW/cm<sup>2</sup>)  
P = Power Input to antenna (mW)  
G = Antenna Gain (numeric value)  
R = Distance (cm)

#### Test Results:

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
2440	14.91	30.974	-3	0.501	0.00309	1	0.99691	20	Pass

The safe distance where Power Density is less than the MPE Limit listed above was found to be 20 cm.



## 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
1A1083	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU40	9/12/2017	10/12/2018
1A1184	SPECTRUM ANALYZER	AGILENT	E4407B	4/20/2018	4/20/2019
1A1106	10M CHAMBER (FCC)	ETS	SEMI-ANECHOIC	SEE NOTE	
1A1147	BILOG ANTENNA (30MHZ TO 1GHZ)	SUNOL SCIENCES CORP	JB3	9/21/2017	3/21/2019
1A1047	DOUBLE RIDGED WAVE GUIDE HORN ANTENNA	ETS	3117	2/23/2017	11/8/2018
1A1161	DOUBLE RIDGED WAVE GUIDE HORN ANTENNA	ETS	3116C-PA	3/6/2017	9/6/2018
1A1099	GENERATOR	COM-POWER CORP	CGO-51000	SEE NOTE	
1A1088	PRE-AMP	ROHDE & SCHWARZ	TS-PR1	SEE NOTE	
1A1044	GENERATOR	COM-POWER CORP	CG-520	SEE NOTE	
1A1073	MULTI DEVICE CONTROLLER	ETS EMCO	2090	SEE NOTE	
1A1074	SYSTEM CONTROLLER	PANASONIC	WV-CU101	SEE NOTE	
1A1075	SYSTEM CONTROLLER	PANASONIC	WV-CU101	SEE NOTE	
1A1080	MULTI DEVICE CONTROLLER	ETS EMCO	2090	SEE NOTE	
1A1180	PRE-AMP	MITEQ	AMF-7D-01001800-22-10P	SEE NOTE	

**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 user's 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