

November 13, 2019

Lutron Electronics
7200 Suter Road
Coopersburg, PA 18036

Dear Dan Osle,

Enclosed is the EMC Wireless test report for compliance testing of the Lutron Electronics, Pegasus Wireless Processor 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.



Michelle Tawmging
Documentation Department

Reference: (\Lutron Electronics\EMC104701A-FCC247 Rev. 3)

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Electromagnetic Compatibility Criteria Test Report

for the

**Lutron Electronics
Pegasus Wireless Processor**

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

MET Report: EMC104701A-FCC247 Rev. 3

November 13, 2019

Prepared For:

**Lutron Electronics
7200 Suter Road
Coopersburg, PA 18036**

Prepared By:
Eurofins MET Labs, Inc.
914 W. Patapsco Avenue
Baltimore, MD 21230

**Electromagnetic Compatibility Criteria
Test Report**

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**Lutron Electronics
Pegasus Wireless Processor****Tested under**
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional RadiatorsDonald Salguero, Project Engineer
Electromagnetic Compatibility LabMichelle Tawmging
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.

Christopher Dennison
Manager, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	October 2, 2019	Initial Issue
1	October 7, 2019	Implemented Customer-Requested Revisions
2	October 22, 2019	TCB Comments
3	November 13, 2019	TCB Comments

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List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB μ A	Decibels above one microamp
dB μ V	Decibels above one microvolt
dB μ A/m	Decibels above one microamp per meter
dB μ V/m	Decibels above one microvolt per meter
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
μ H	microhenry
μ	microfarad
μ s	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Lutron Electronics Pegasus Wireless Processor, 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 Pegasus Wireless Processor. Lutron Electronics should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Pegasus Wireless Processor, 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 Lutron Electronics, purchase order number 5193845. All tests were conducted using measurement procedure ANSI C63.10-2013.

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

Figure 1: Executive Summary of EMC Part 15.247 Compliance Testing

II. Equipment Configuration

A. Overview

Eurofins MET Labs, Inc. was contracted by Lutron Electronics to perform testing on the Pegasus Wireless Processor, under Lutron Electronics' purchase order number 5193845.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Lutron Electronics, Pegasus Wireless Processor.

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

Model Tested:	Pegasus Wireless Processor	
Model Covered:	Pegasus Wireless Processor	
EUT Specifications:	Primary Power: 37~57VDC; PoE plugged to 120V 60Hz	
	FCC ID: JPZ0123	
	Type of Modulations:	OQPSK
	Equipment Code:	DTS
	Peak RF Output Power:	20.93 dBm
	EUT Frequency Ranges:	2405 – 2480 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Donald Salguero	
Report Date:	October 7, 2019	

Figure 2: EUT Summary Table

B. References

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

Figure 3: References

C. Test Site

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

Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Figure 4: Uncertainty Calculations Summary

E. Description of Test Sample

The Pegasus Wireless Processor (“PWP”), Equipment Under Test (EUT), is a wall/ceiling/junction-box mounted gateway device for wireless communication with subnet devices using IEEE 802.15.4 protocol. The commands from the Wired Processor are sent over Ethernet to the PWP, and then the PWP translates the commands to IEEE 802.15.4 and transmit over air to the subnet devices. The PWP is intended to be used in a system with subnet devices. The system is installed by certified residential dealers or commercial contractors/Lutron field service.

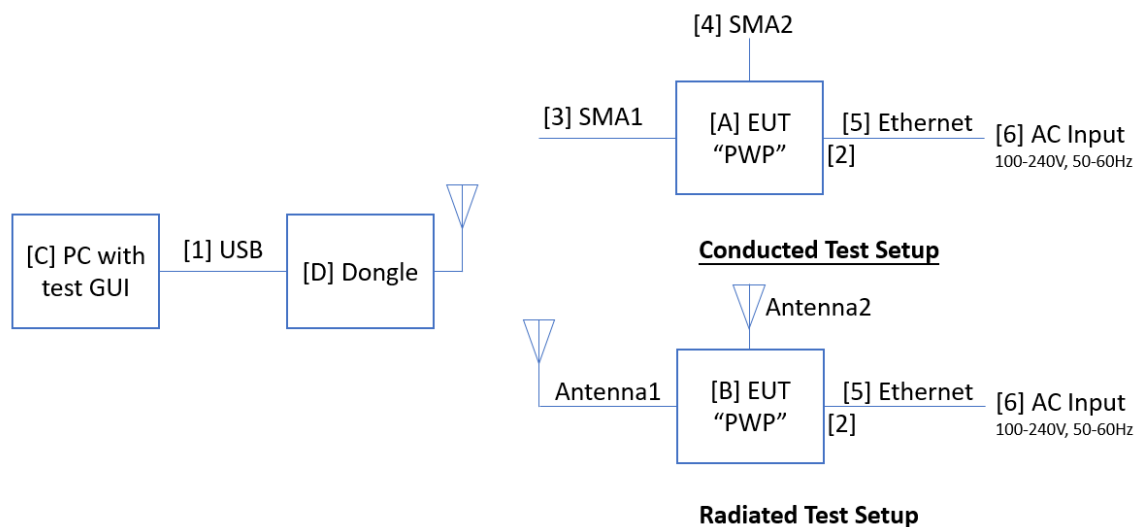


Figure 5: Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 5. 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. #
A1		Conducted PWP test unit	PWP	N/A	N/A	B
A2		Backup- conducted PWP test unit	PWP	N/A	N/A	B
B		Radiated PWP test unit	PWP	N/A	N/A	B
C		PC with test GUI	N/A	N/A	N/A	N/A
D		Dongle	N/A	XBP24-AUI-EXT_ZIGMO	N/A	N/A

Figure 6: Equipment Configuration

Test Mode Firmware: Lutron PWP FCC Test SW

G. Support Equipment

The EUT did not require any support equipment for operation or monitoring

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	USB	USB	1	1	1	No	[C] Dongle
2	RJ45	RJ45	1	N/A	N/A	Yes	[A] PWP test unit
3	SMA1	SMA connector to Antenna 1	1	0.1	N/A	Yes	[A] PWP test unit
4	SMA2	SMA connector to Antenna 2	1	N/A	N/A	Yes	[A] PWP test unit
5	Ethernet	Ethernet cable	1	1 (white)	3 (yellow)	Yes	[A] PWP test unit
6	AC Input	Power Over Ethernet Injector	1	2	2	Yes	[A] PWP test unit

Figure 7: Ports and Cabling Information

I. Mode of Operation

1. The PWP can be configured to transmit Constant Stream through either Antenna 1 or Antenna 2 at selected channel (low, mid or high). In this mode, the PWP generates a stream of modulated packets at selected frequency. The packets are the same as those used in normal operations.

The Constant Stream mode will run indefinitely until power is cycled or RESET button is pressed.

Two other available test modes are:

2. Receive Mode- the PWP is set to receive IEEE 802.15.4 packets.
3. Constant Wave Mode- generates a single unmodulated tone at a selected frequency.

J. Method of Monitoring EUT Operation

1. When the DUT is functional the GUI will indicate that the test mode is in progress. There will be measurable RF transmission and a change in the current draw from the device.
2. When the DUT is not functional the GUI will indicate that the Test Mode was unable to be changed, and there will be no measurable RF transmission or change in current draw from the device.

The test software used during testing was: Lutron FCC Test GUI and Docklight v2.2.8

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 Lutron Electronics 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.

Test Results: The EUT as tested is **compliant** to the requirements of this section. EUT uses built-in antenna.
Type: Integrated Printed F Antenna
Gain: +1.9dBi

Test Engineer: Donald Salguero

Test Date: August 26, 2019

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 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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

Figure 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 Ω /50 μ 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 C63.10-2013*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω /50 μ H LISN as the input transducer to an EMC/field intensity meter.

Test Results: The EUT as tested is **compliant** to the requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: September 17, 2019

Conducted Emissions Voltage Test Setup

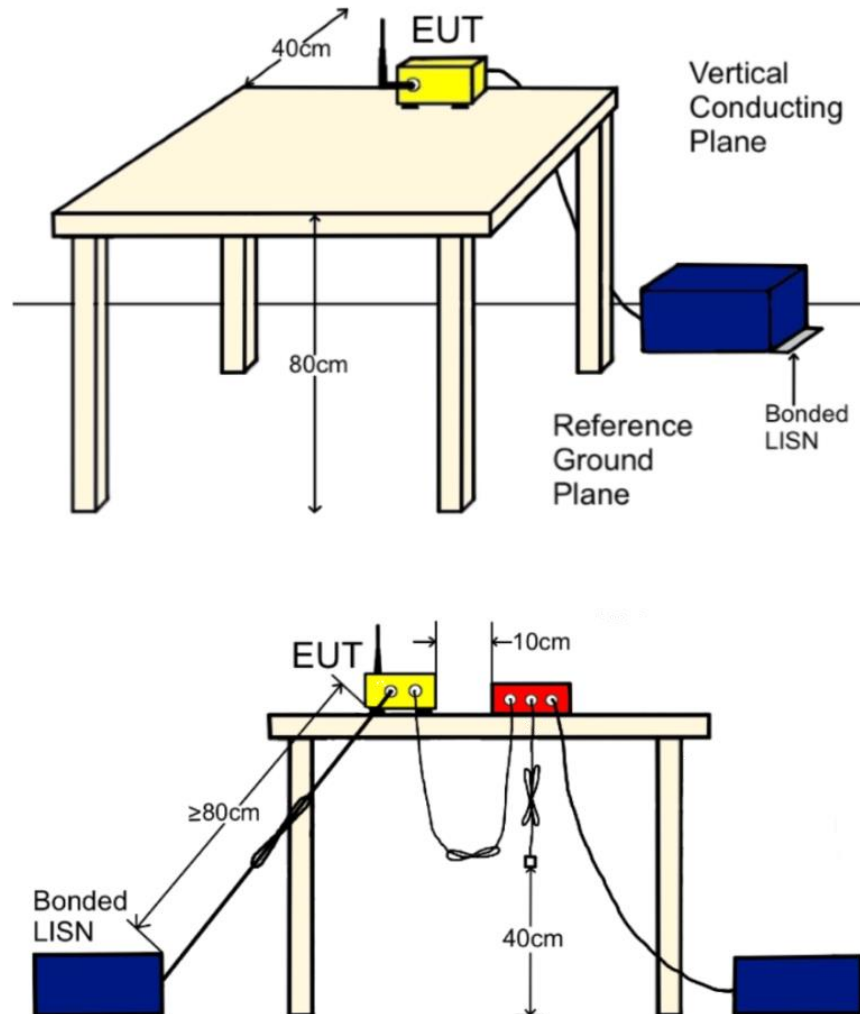


Figure 9: CEV Test Setup

Test Data

Frequency (MHz)	Uncorrected Meter Reading (dB μ V) QP	Cable Loss (dB)	Corrected Measurement (dB μ V) QP	Limit (dB μ V) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dB μ V) Avg.	Cable Loss (dB)	Corrected Measurement (dB μ V) Avg.	Limit (dB μ V) Avg.	Pass/Fail Avg.	Margin (dB) Avg.
3.01	20.69	0	30.69	56	PASS	-25.31	15.49	0	25.49	46	PASS	-20.51
6.848	17.97	0	27.97	60	PASS	-32.03	12.83	0	22.83	50	PASS	-27.17
2.644	19.44	0	29.44	56	PASS	-26.56	14.02	0	24.02	46	PASS	-21.98
2.152	17.16	0	27.16	56	PASS	-28.84	12.8	0	22.8	46	PASS	-23.2
6.564	17.99	0	27.99	60	PASS	-32.01	12.41	0	22.41	50	PASS	-27.59
1.805	15.99	0	25.99	56	PASS	-30.01	12.08	0	22.08	46	PASS	-23.92

Figure 10: Conducted Emissions, Phase Line, Test Results

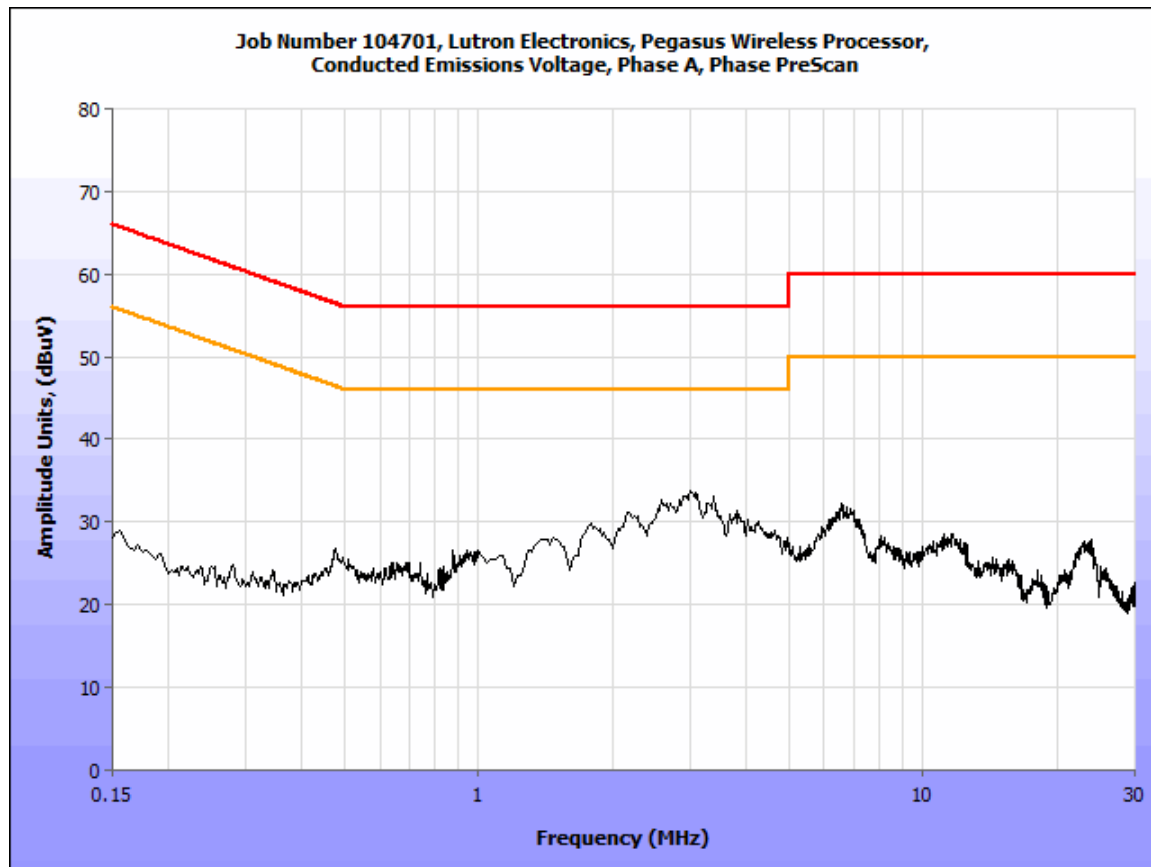


Figure 11: Conducted Emissions, Phase Line, Prescan

Frequency (MHz)	Uncorrected Meter Reading (dBμV) QP	Cable Loss (dB)	Corrected Measurement (dBμV) QP	Limit (dBμV) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dBμV) Avg.	Cable Loss (dB)	Corrected Measurement (dBμV) Avg.	Limit (dBμV) Avg.	Pass/Fail Avg.	Margin (dB) Avg.
3.046	21.27	0	31.27	56	PASS	-24.73	15.37	0	25.37	46	PASS	-20.63
2.696	18.96	0	28.96	56	PASS	-27.04	13.37	0	23.37	46	PASS	-22.63
3.212	18.49	0	28.49	56	PASS	-27.51	12.63	0	22.63	46	PASS	-23.37
6.812	18.77	0	28.77	60	PASS	-31.23	13.73	0	23.73	50	PASS	-26.27
2.504	17.64	0	27.64	56	PASS	-28.36	12.38	0	22.38	46	PASS	-23.62
22.98	13.58	0.11	23.69	60	PASS	-36.31	9.808	0.11	19.918	50	PASS	-30.082

Figure 12: Conducted Emissions, Neutral Line, Test Results

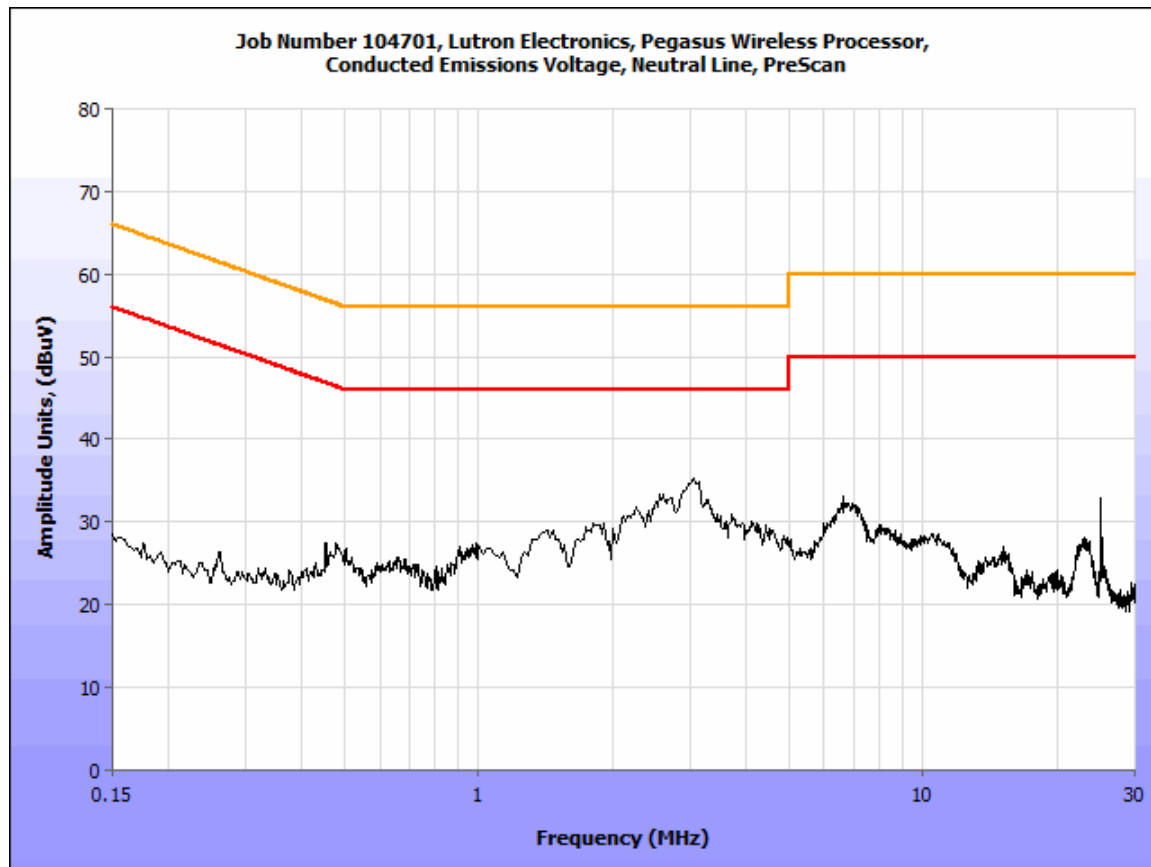


Figure 13: Conducted Emissions, Neutral Line, PreScan

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 = 100 KHz, 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 as tested is **compliant** to the requirements of this section. No anomalies noted.

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

Test Engineer: Donald Salguero

Test Date: September 17, 2019



Figure 14: Block Diagram, Occupied Bandwidth Test Setup

Center Frequency (MHz)	6dB Bandwidth (MHz)
2405	1.707
2440	1.696
2480	1.678

Test Data

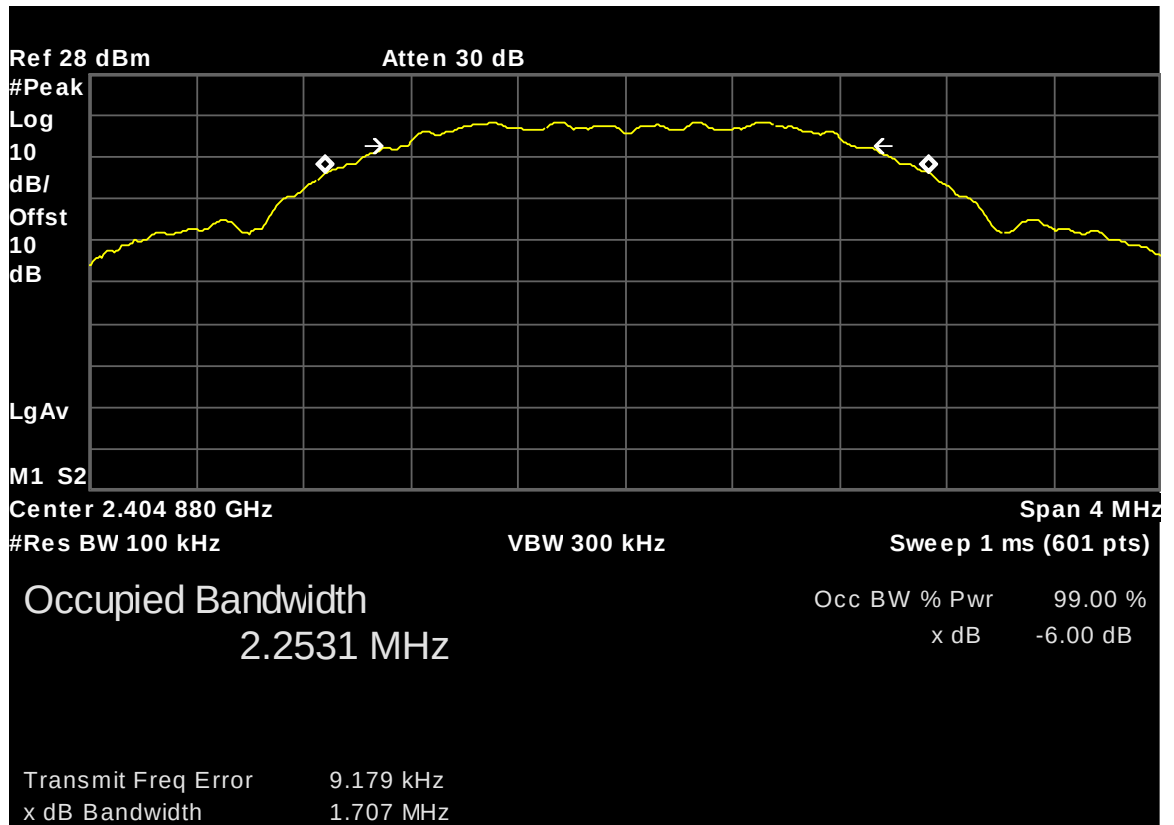


Figure 15: 6 dB Bandwidth, Low Channel, 2405 MHz

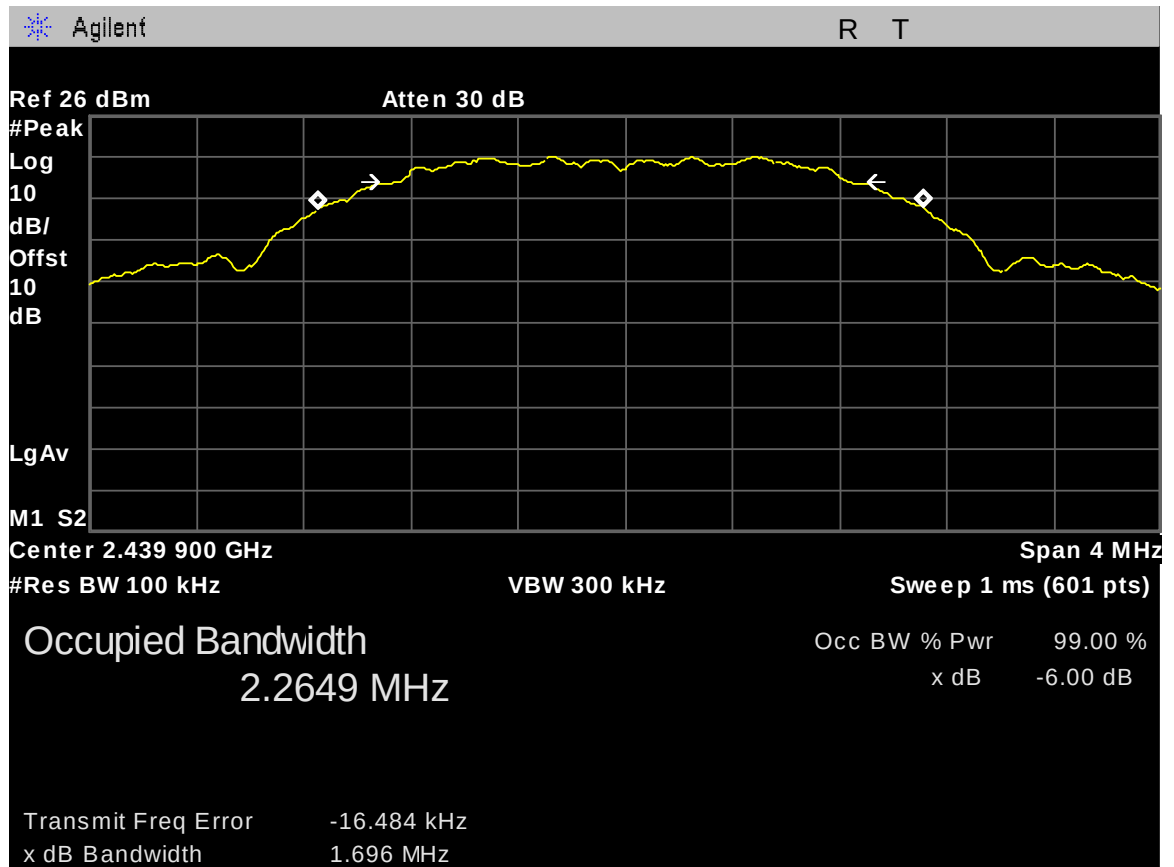


Figure 16: 6 dB Bandwidth, Mid Channel, 2440 MHz

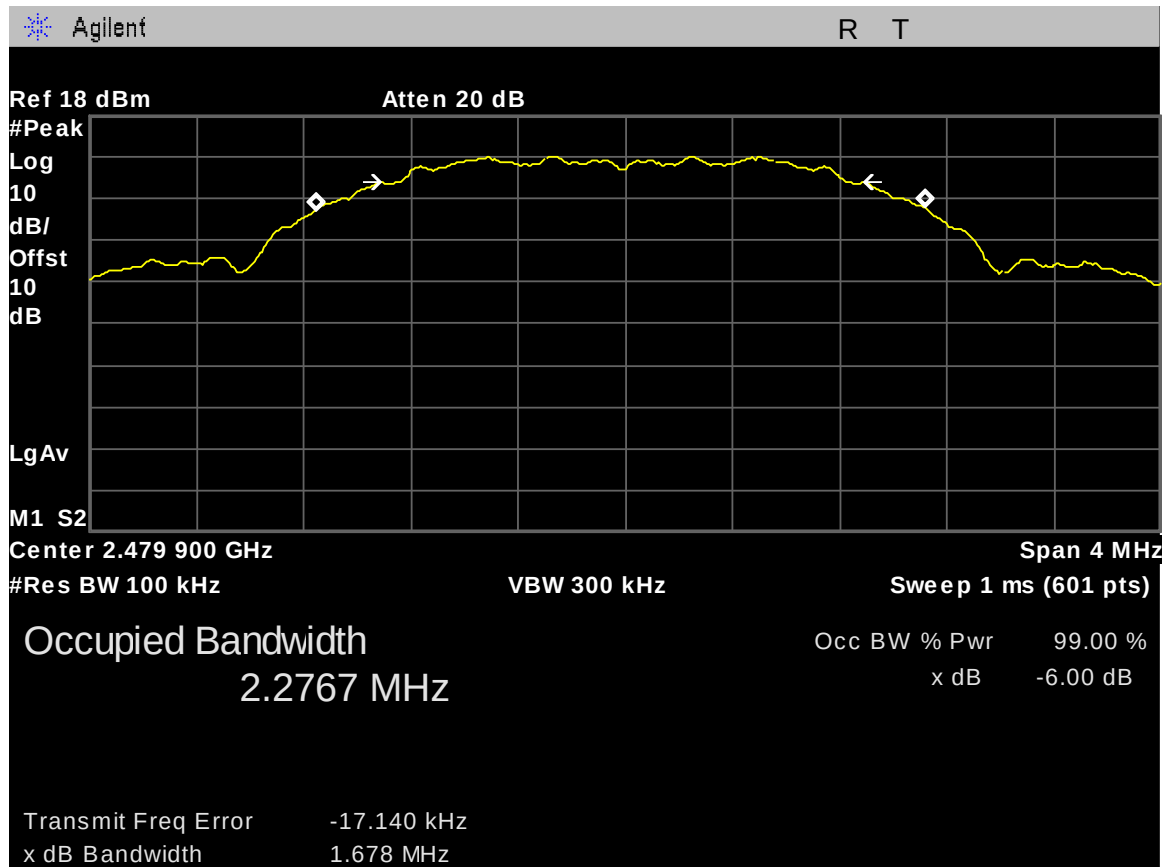


Figure 17: 6 dB Bandwidth, High Channel, 2480 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

Duty Cycle

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

Test Engineer(s): Donald Salguero

Test Date(s): November 7, 2019

Mode	On Time (msec)	Period (msec)	Duty Cycle (%)	Duty Factor (dB)	1/T Minimum VBW (Hz)
2MHz	NA	NA	100%	0	10

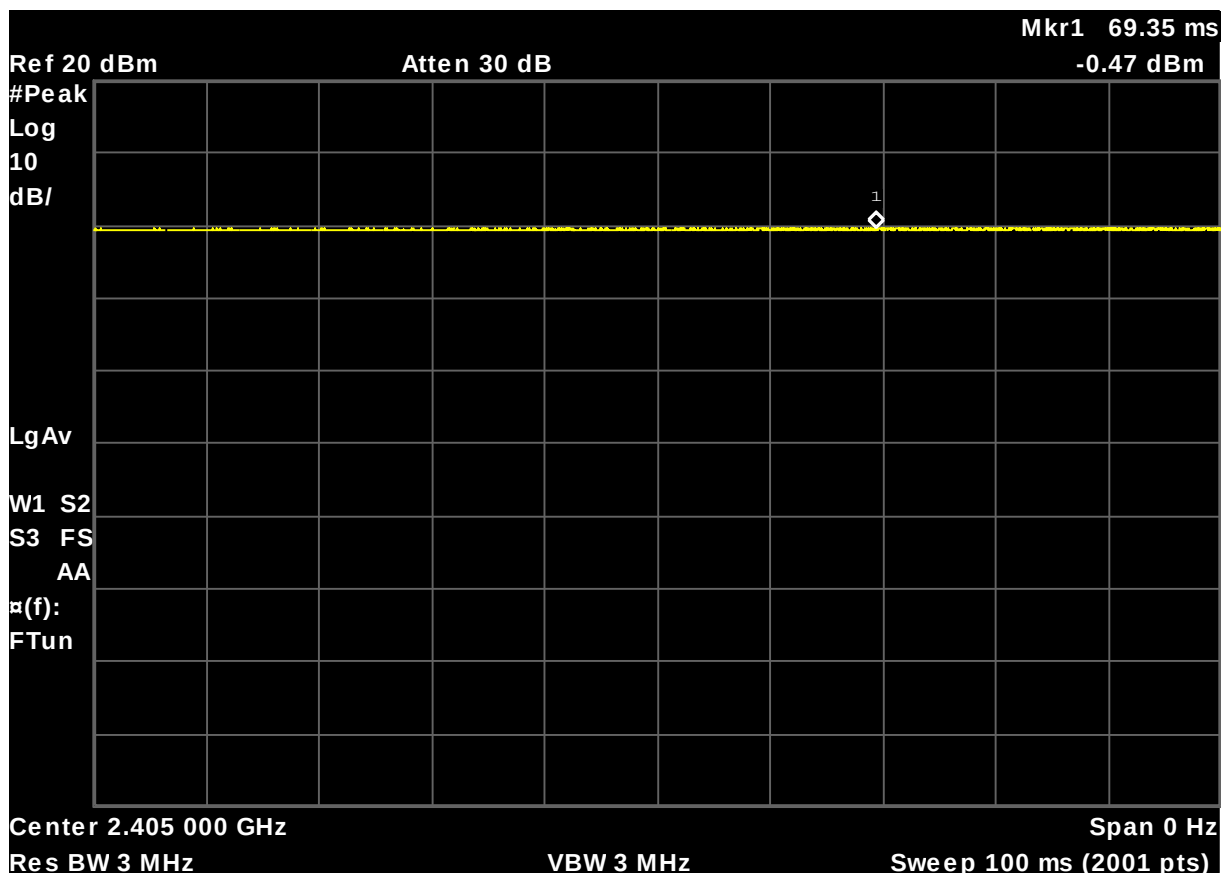


Figure 18: Duty Cycle, Low Channel, 2405 MHz

§ 15.247(b) Peak Power Output

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

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

Figure 19: Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the 9, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

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

Test Results: The EUT as tested is **compliant** to the requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: September 17, 2019

Center Frequency (MHz)	Peak Conducted Power (dBm)
2405	20.93
2440	19.97
2480	11.97

Test Data

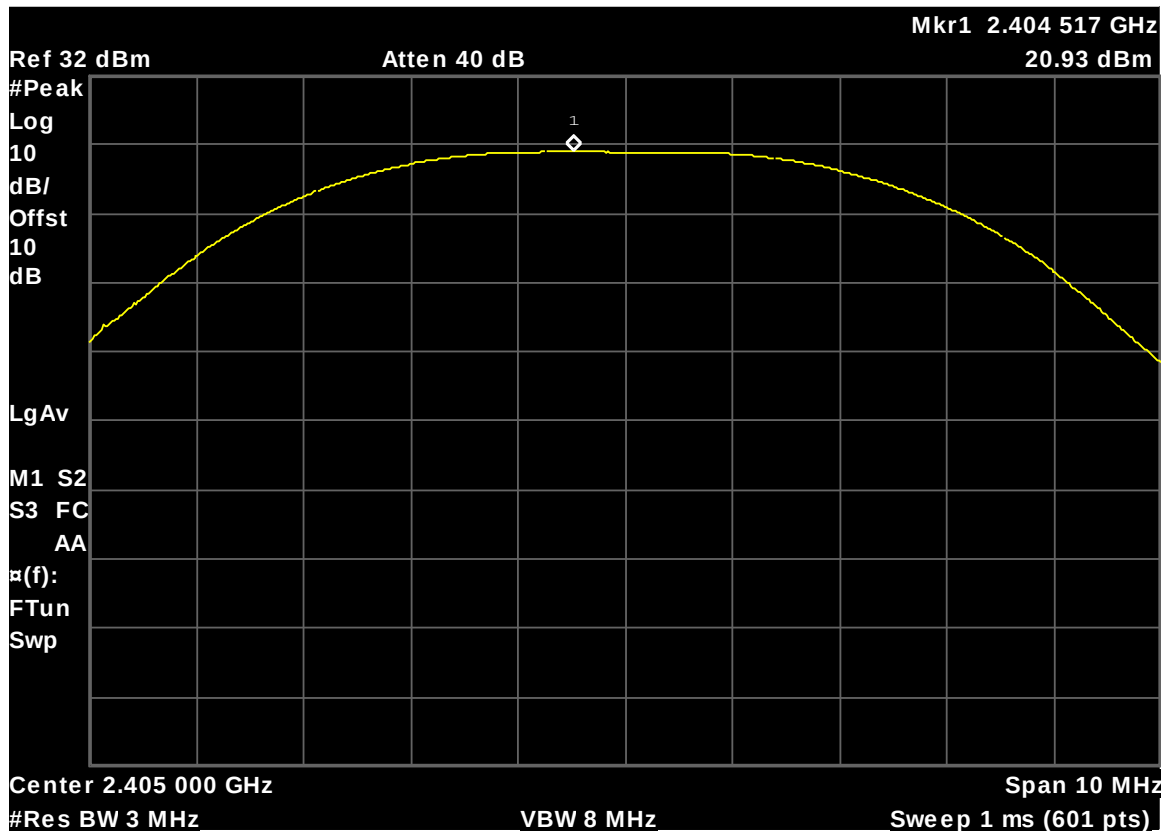


Figure 20: OP, Low Channel, 2405 MHz

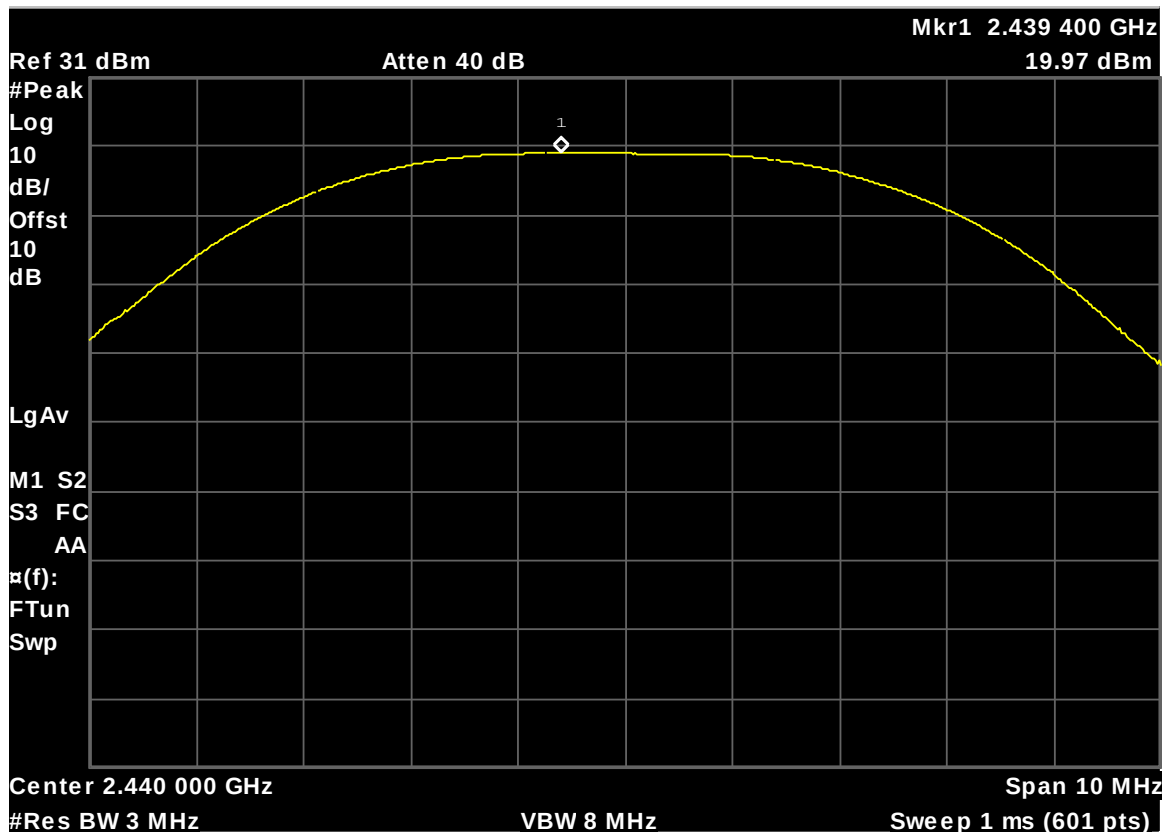


Figure 21: OP, Mid Channel, 2440 MHz

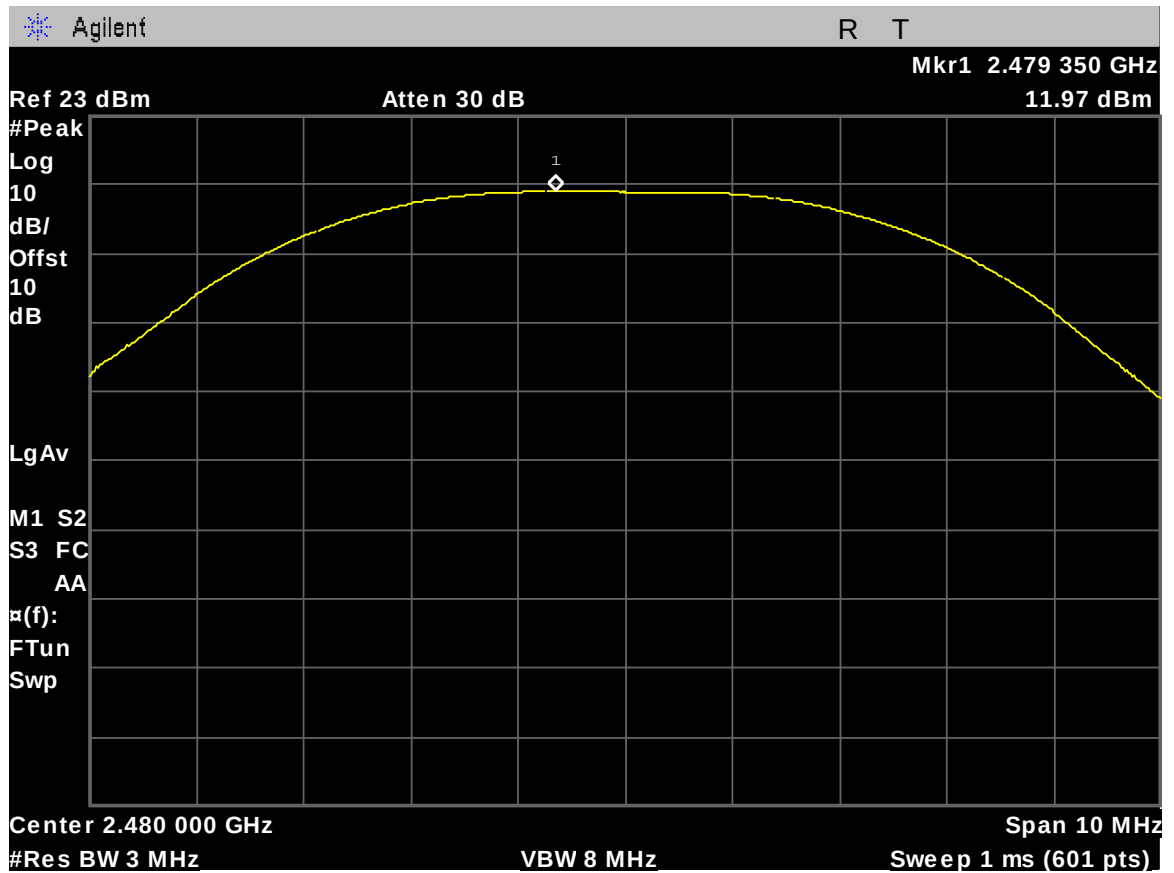


Figure 22: OP, High Channel, 2480 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.209 Radiated Spurious Emissions Requirements and Band Edge

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

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

MHz	MHz	MHz	GHz
0.090–0.110-----	16.42–16.423	399.9–410	4.5–5.15
¹ 0.495–0.505-----	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905-----	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128-----	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775-----	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775-----	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218-----	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825-----	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225-----	123–138	2200–2300	14.47–14.5
8.291–8.294-----	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366-----	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675-----	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475-----	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293-----	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025-----	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725-----	322–335.4	3600–4400	(²)

Figure 23: Restricted Bands of Operation

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

² 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 Figure 24:

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

Figure 24: Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedure: 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. Only noise floor was measured above 18 GHz.

Test Results: The EUT as tested is **compliant** to the requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: September 17, 2019

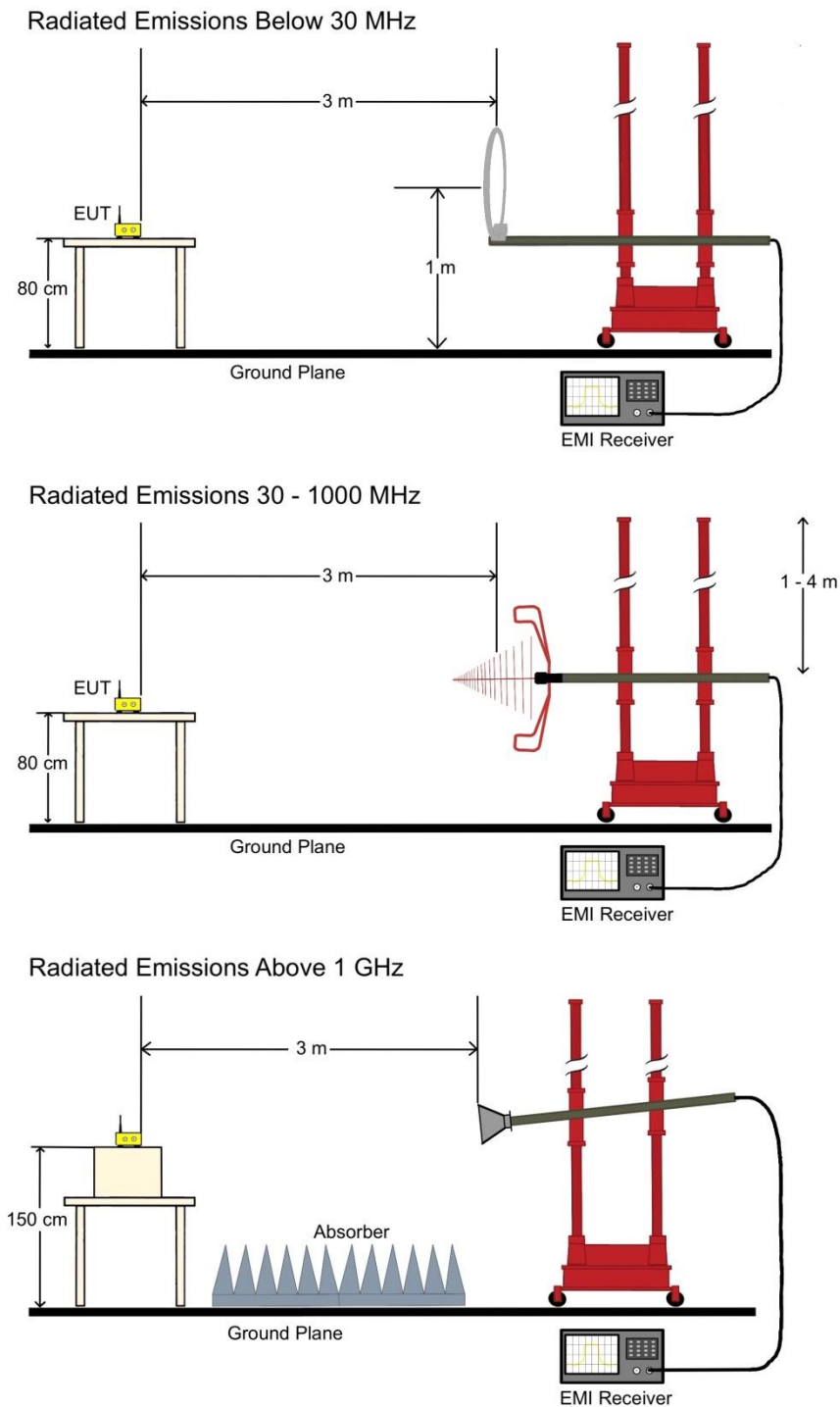


Figure 25: Radiated Emissions Test Setups

Test Data

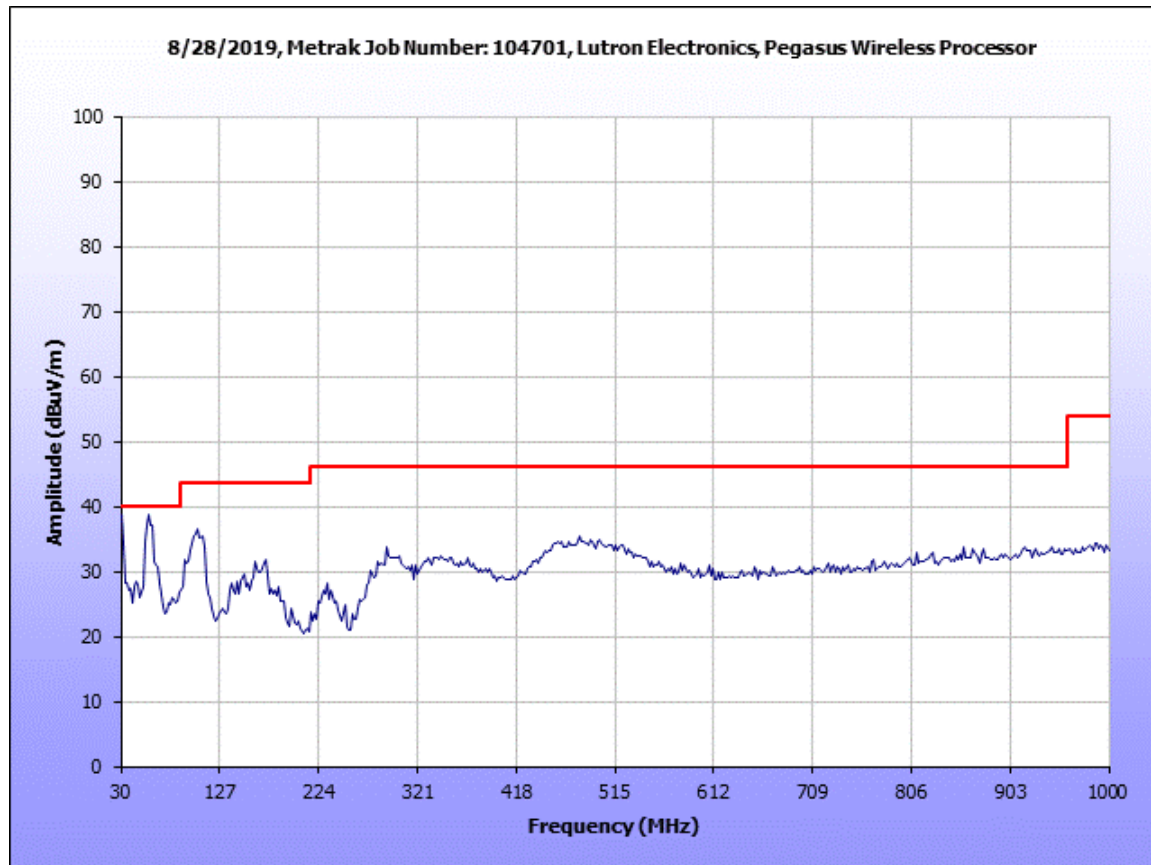


Figure 26: Radiated Emissions, Low Channel, ANT1, 30 MHz – 1000 MHz

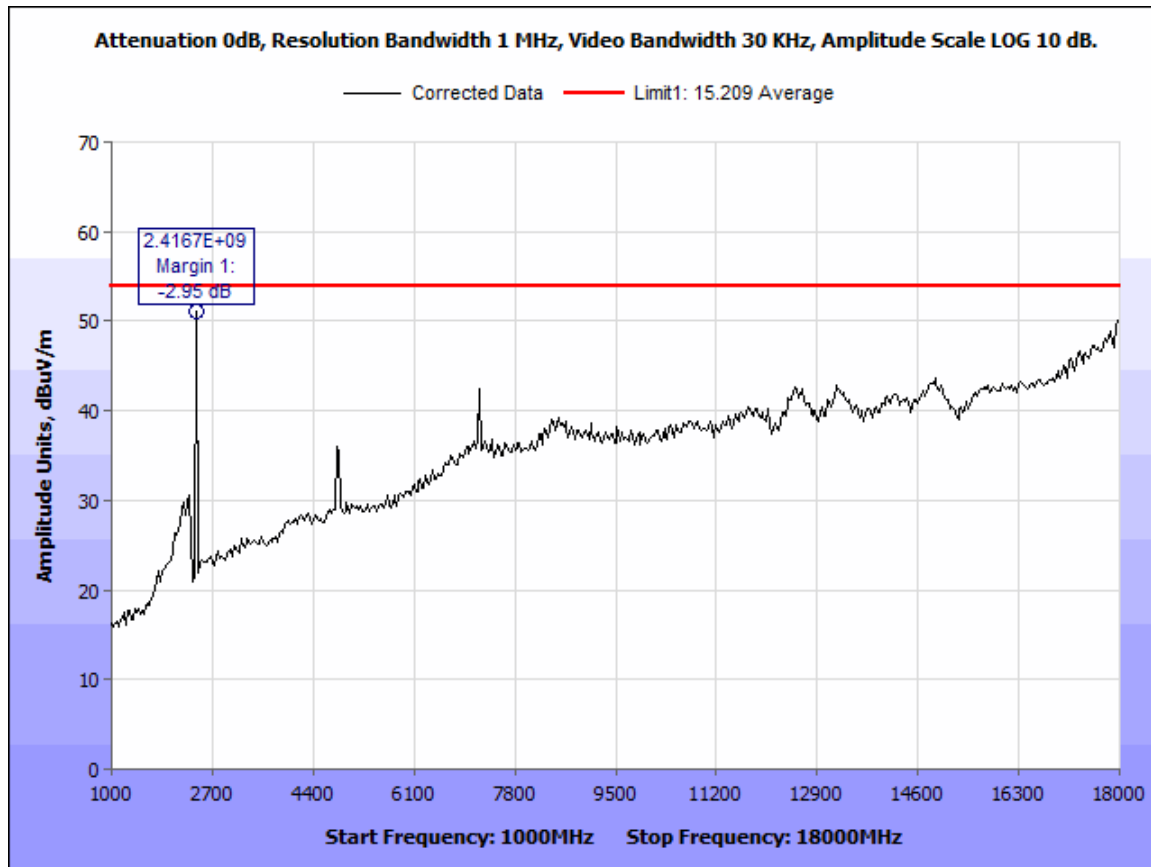


Figure 27: Radiated Emissions, Average, Low Channel, 1 GHz – 18 GHz, Horizontal

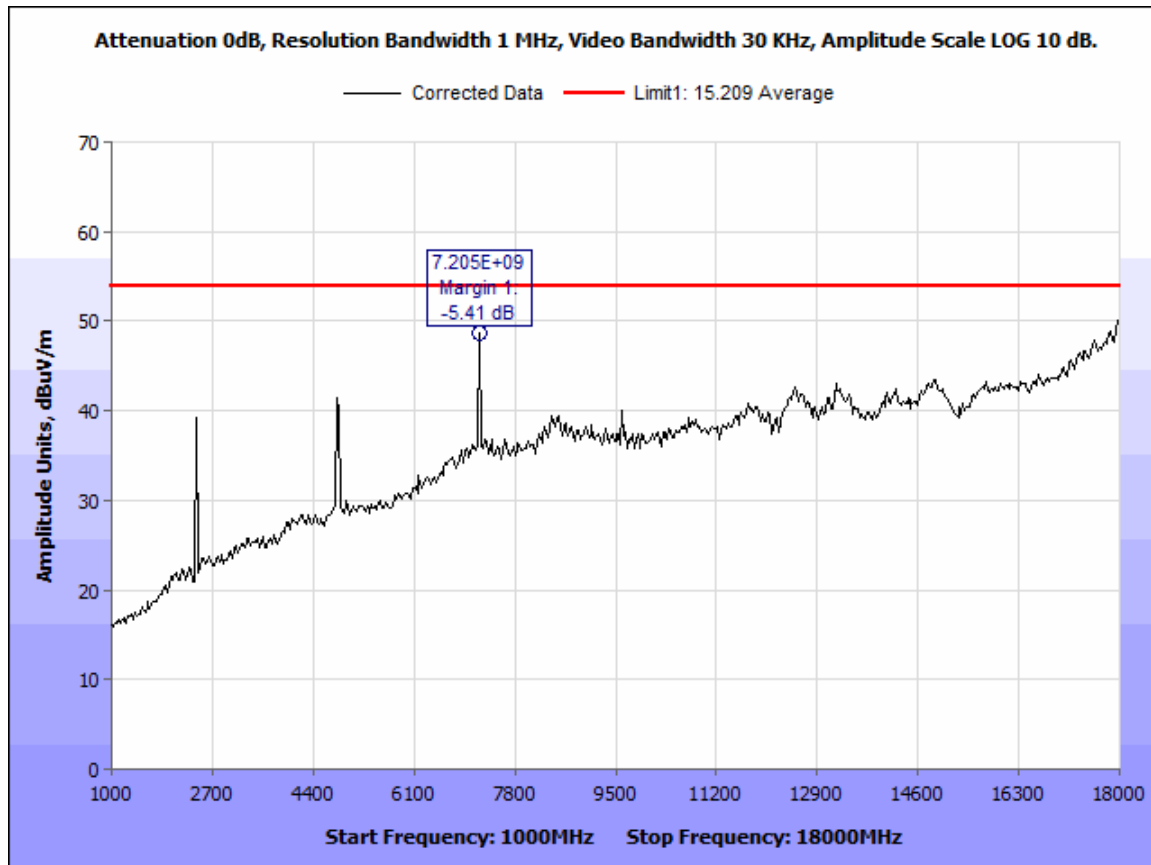


Figure 28: Radiated Emissions, Average, Low Channel, 1 GHz – 18 GHz, Vertical

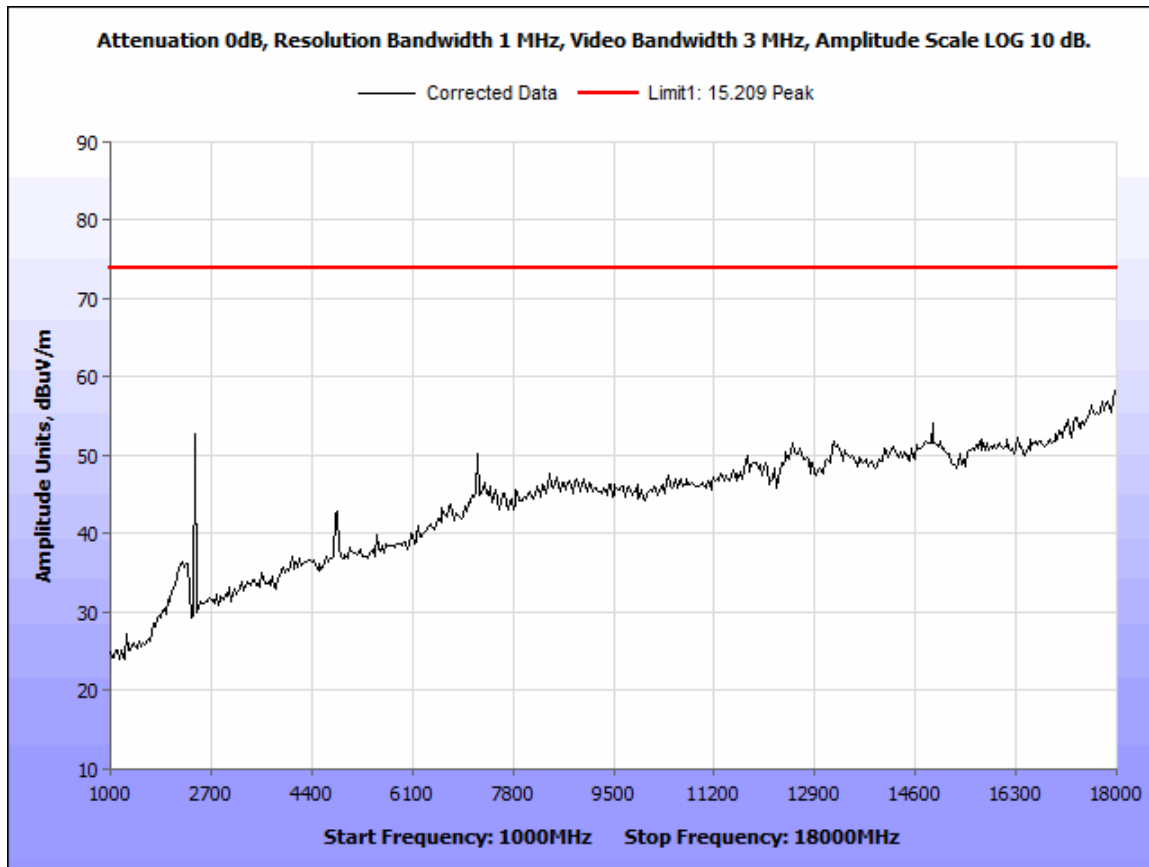


Figure 29: Radiated Emissions, Peak, Low Channel, 1 GHz – 18 GHz, Horizontal

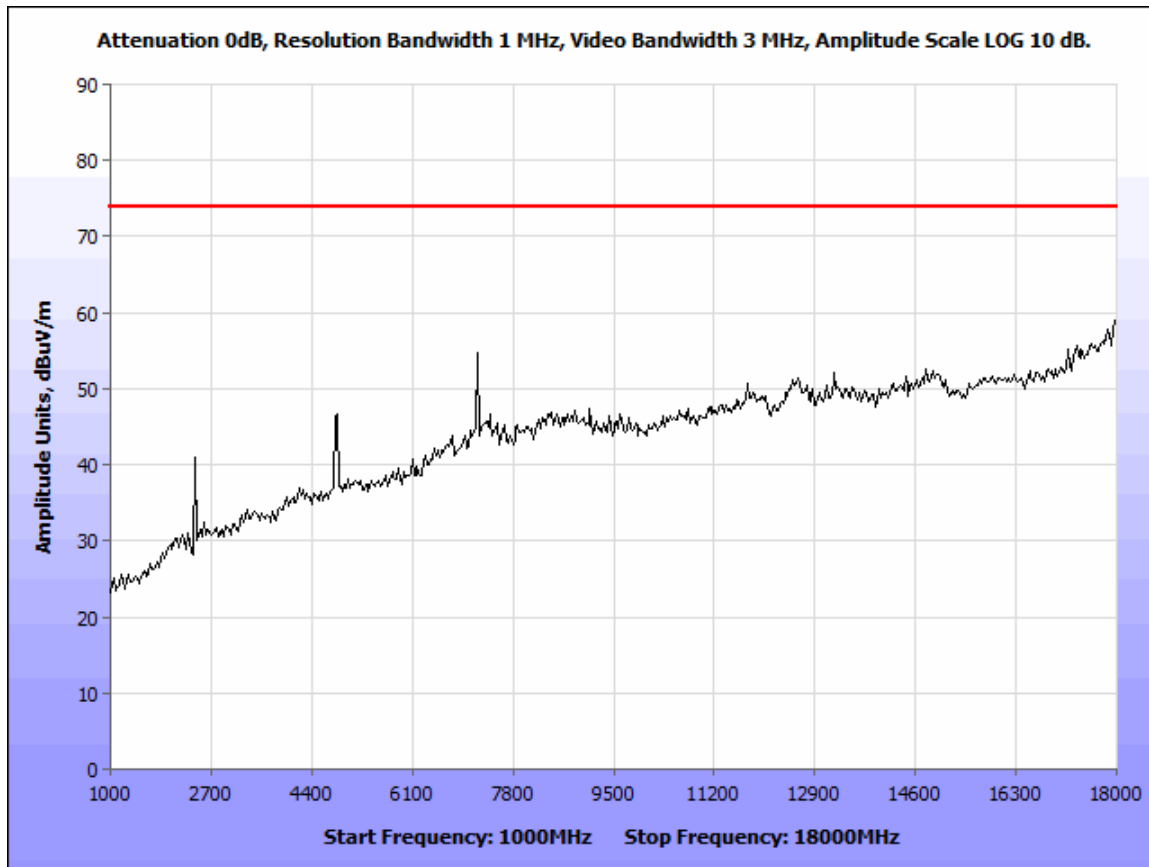


Figure 30: Radiated Emissions, Peak, Low Channel, 1 GHz – 18 GHz, Vertical

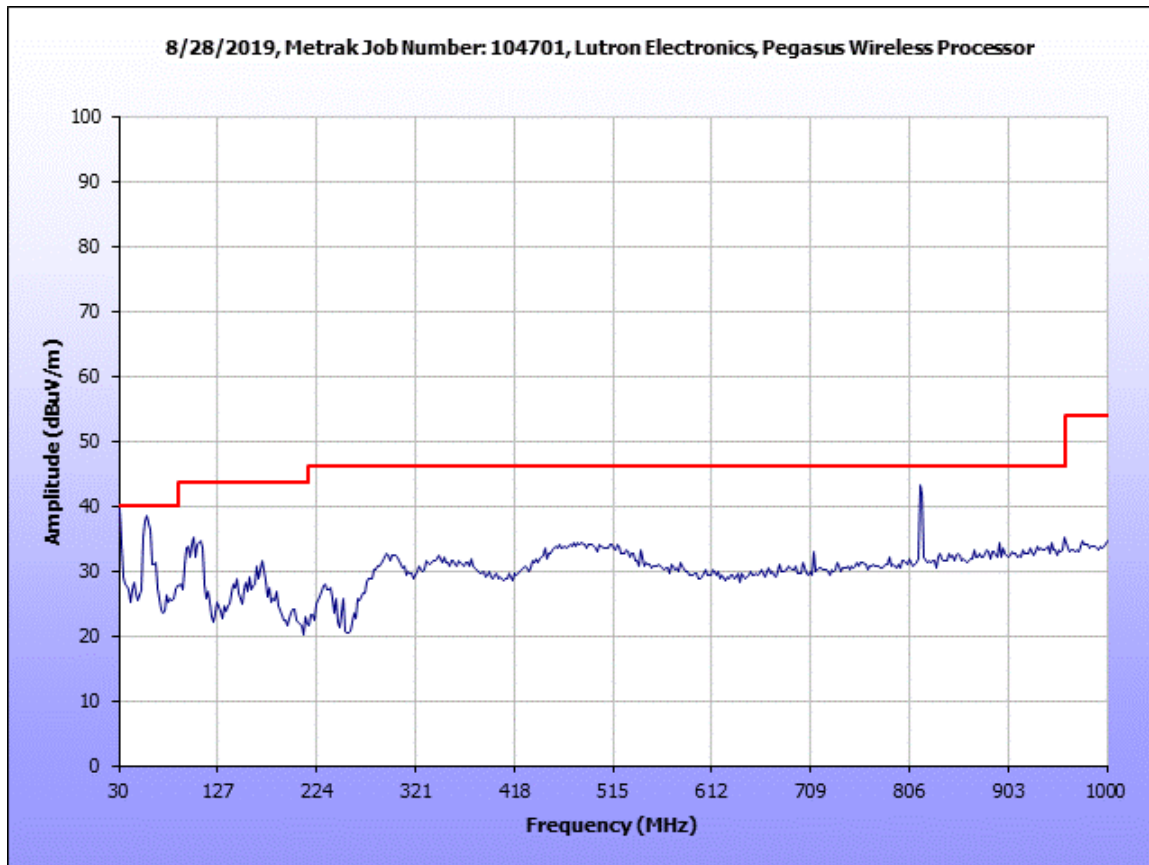


Figure 31: Radiated Emissions, Mid Channel, ANT1, 30 MHz – 1000 MHz

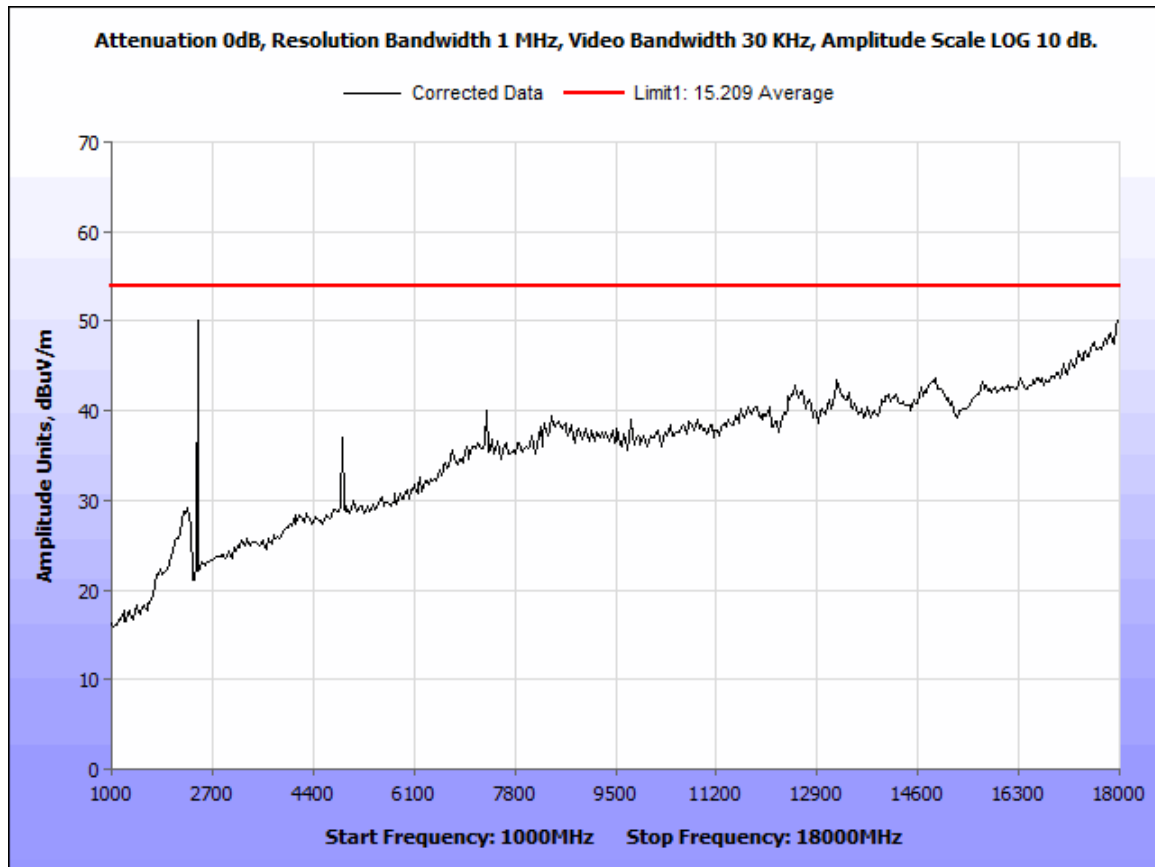


Figure 32: Radiated Emissions, Average, Mid Channel, 1 GHz – 18 GHz, Horizontal

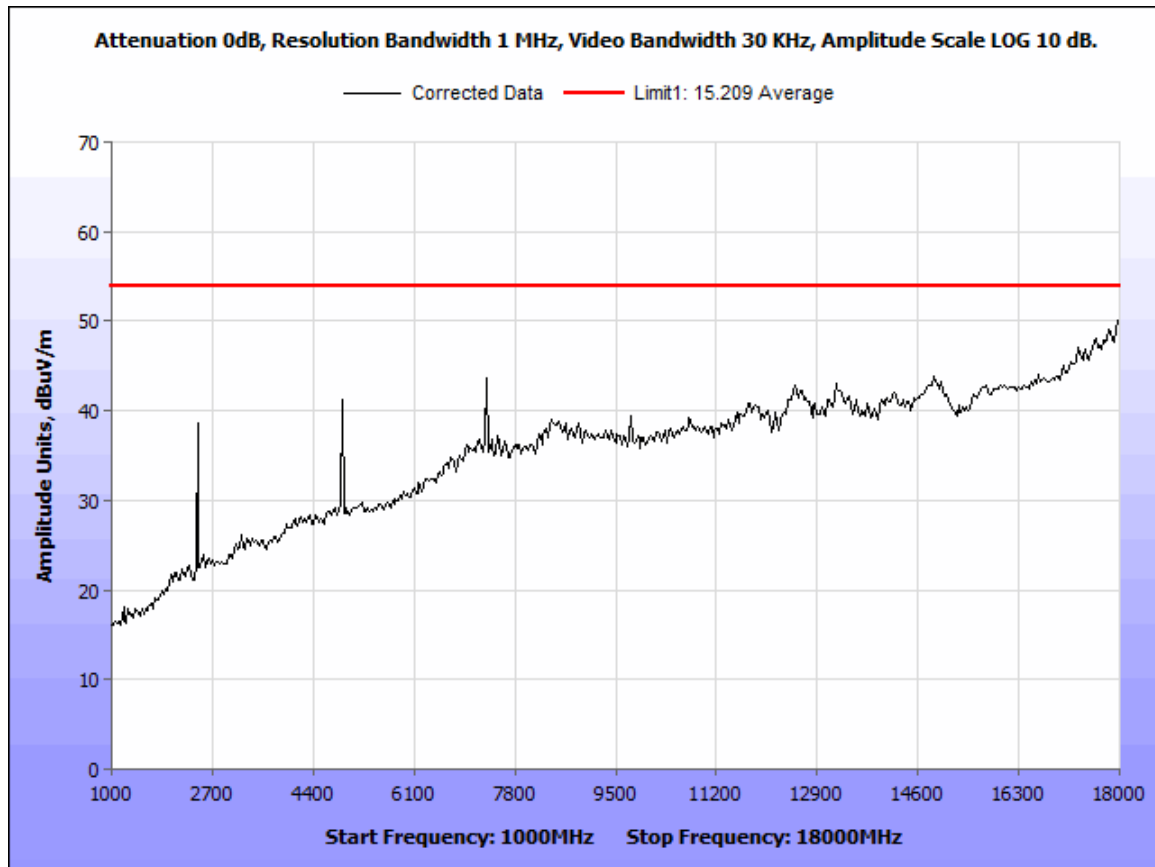


Figure 33: Radiated Emissions, Average, Mid Channel, 1 GHz – 18 GHz, Vertical

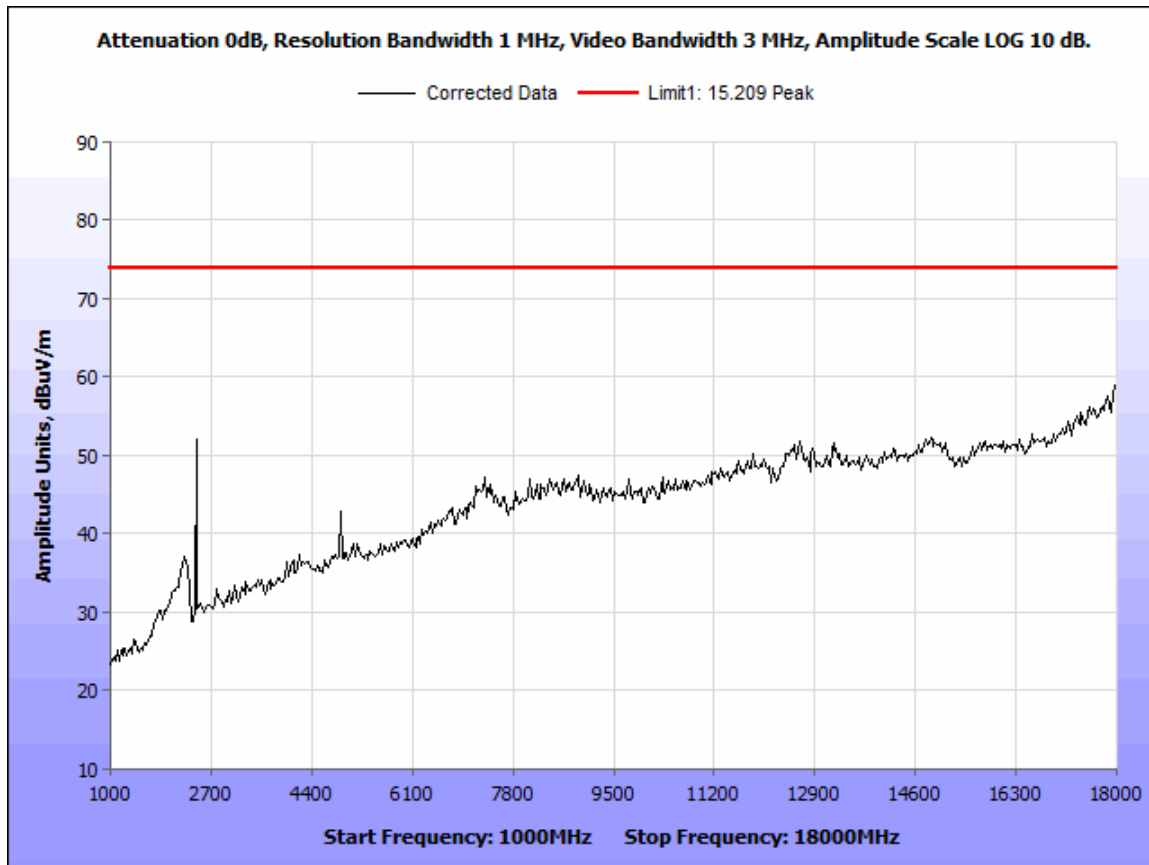


Figure 34: Radiated Emissions, Peak, Mid Channel, 1 GHz – 18 GHz, Horizontal

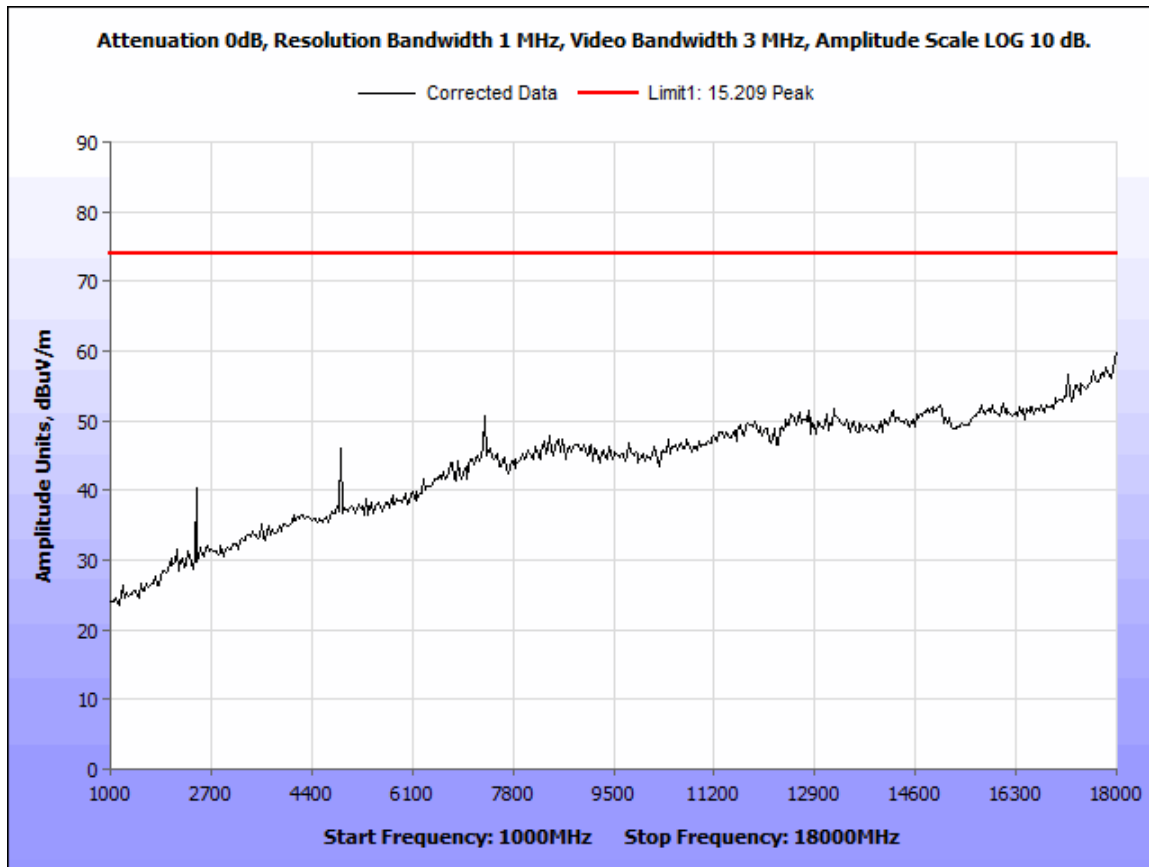


Figure 35: Radiated Emissions, Peak, Mid Channel, 1 GHz – 18 GHz, Vertical

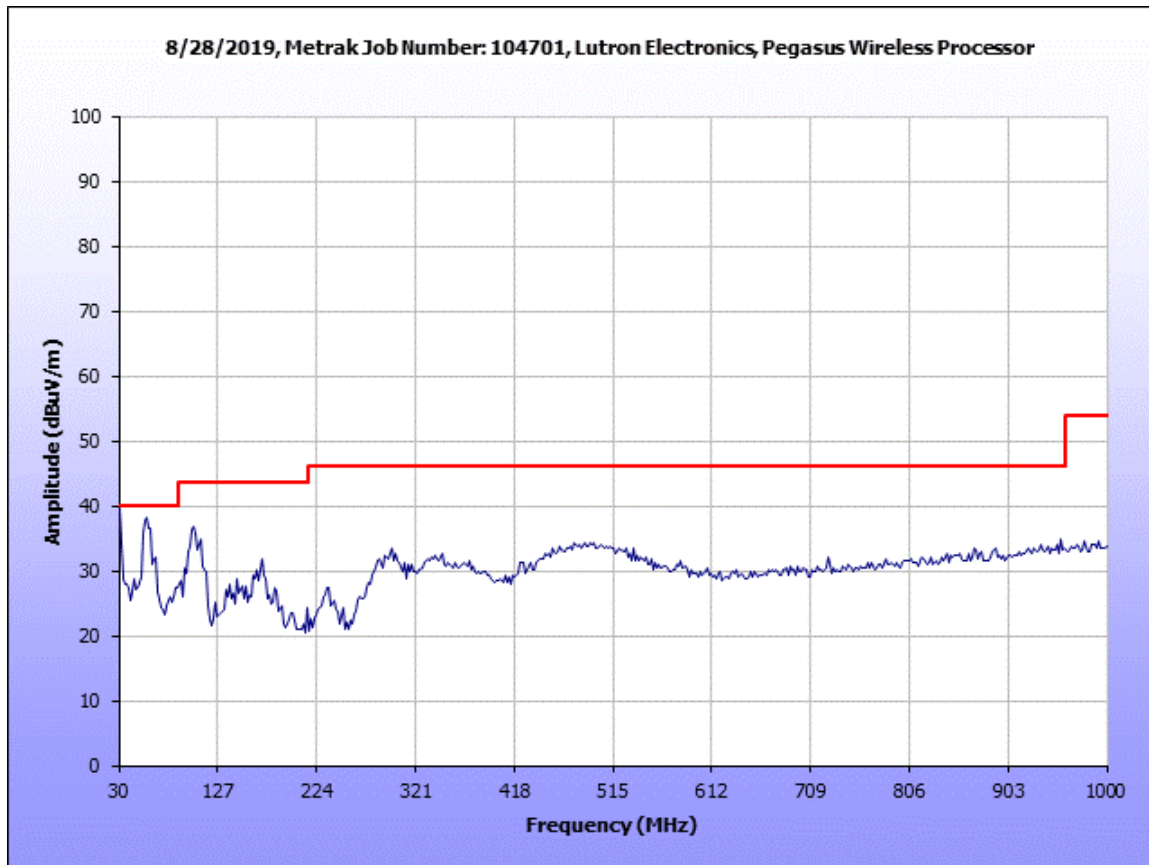


Figure 36: Radiated Emissions, High Channel, ANT1, 30 MHz – 1000 MHz

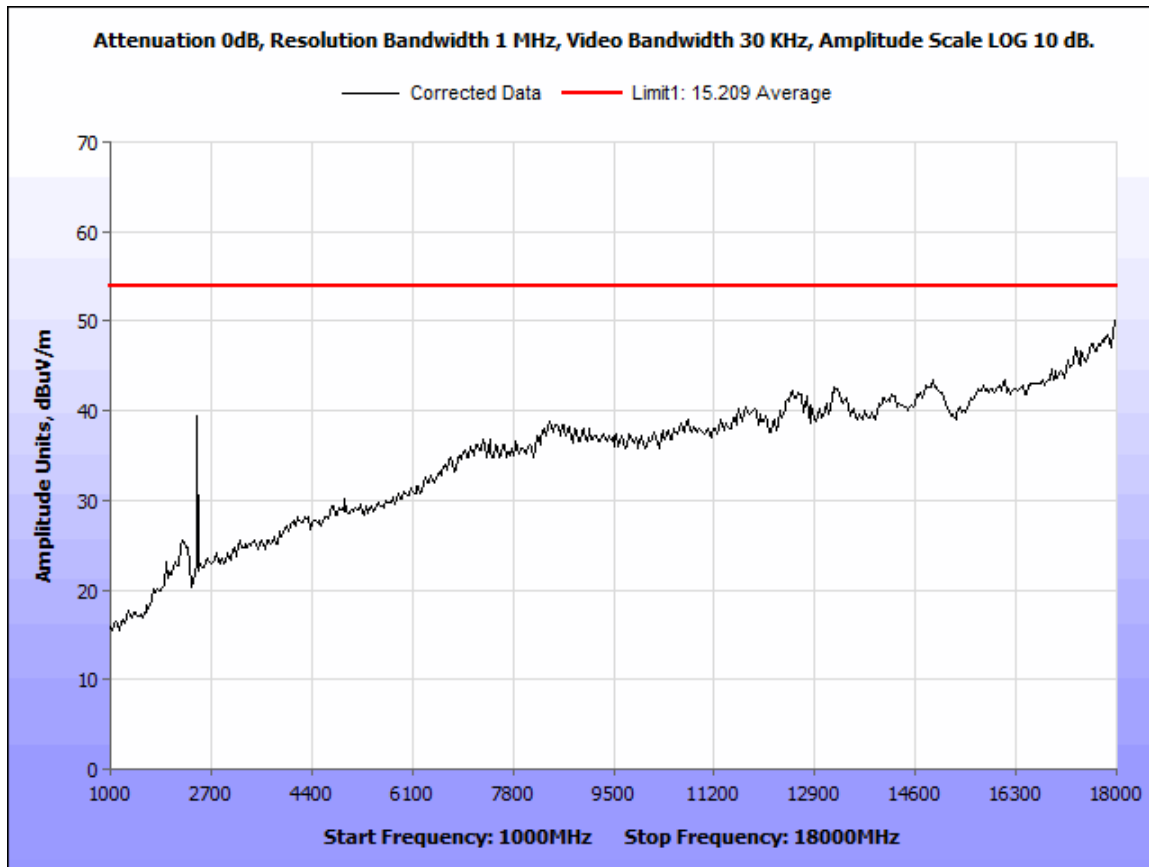


Figure 37: Radiated Emissions, Average, High Channel, 1 GHz – 18 GHz, Horizontal

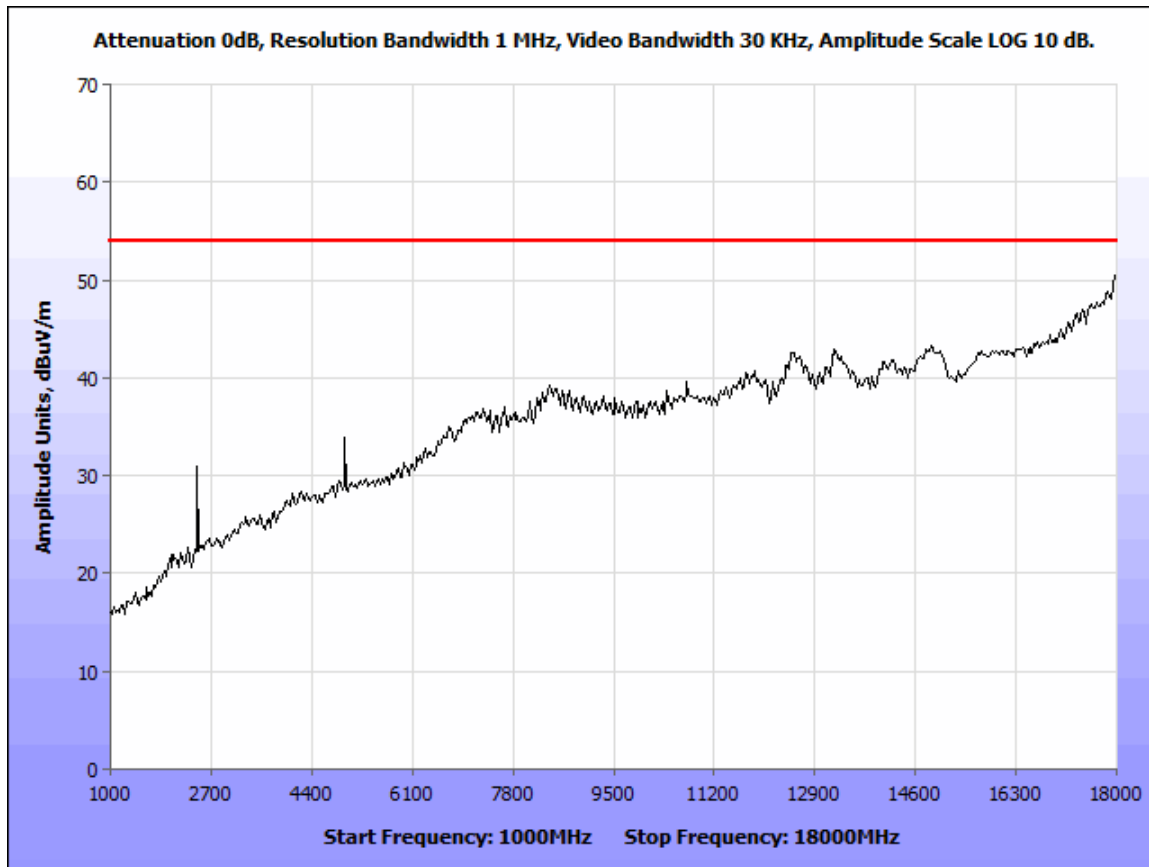


Figure 38: Radiated Emissions, Average, High Channel, 1 GHz – 18 GHz, Vertical

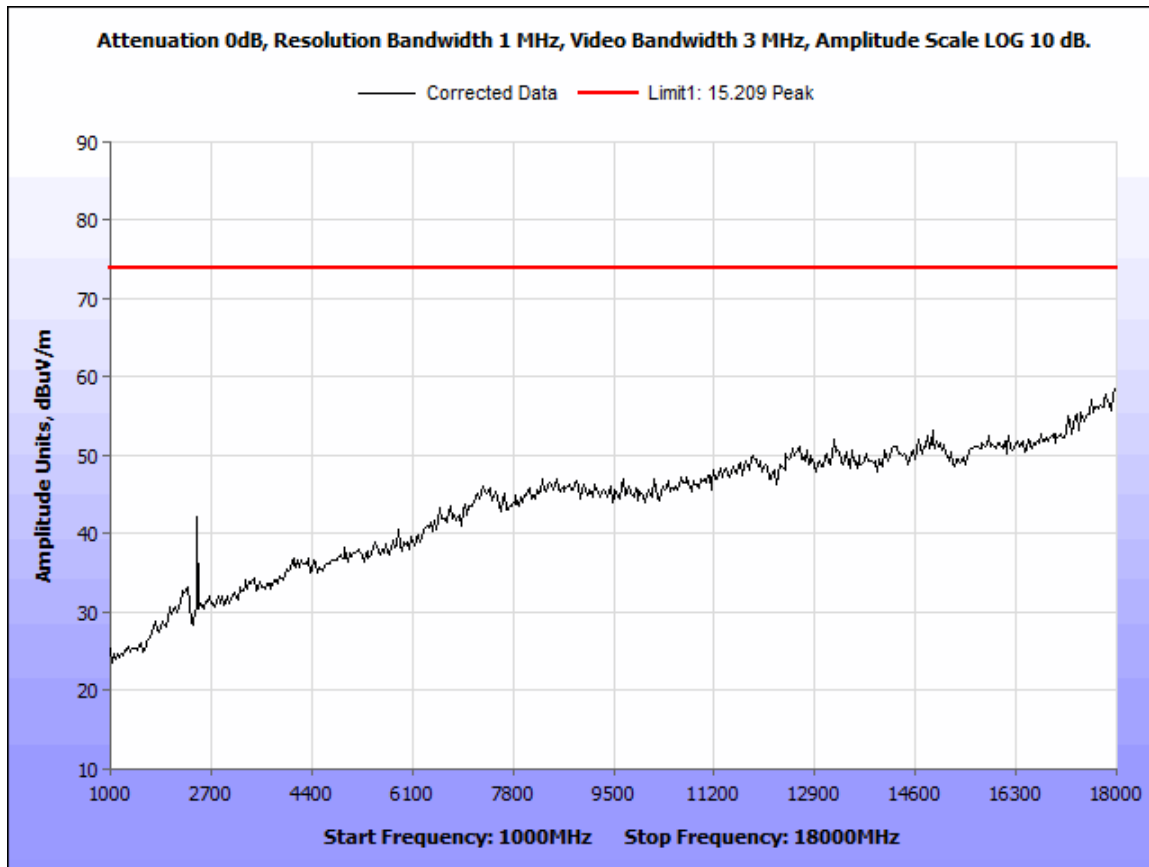


Figure 39: Radiated Emissions, Peak, High Channel, 1 GHz – 18 GHz, Horizontal

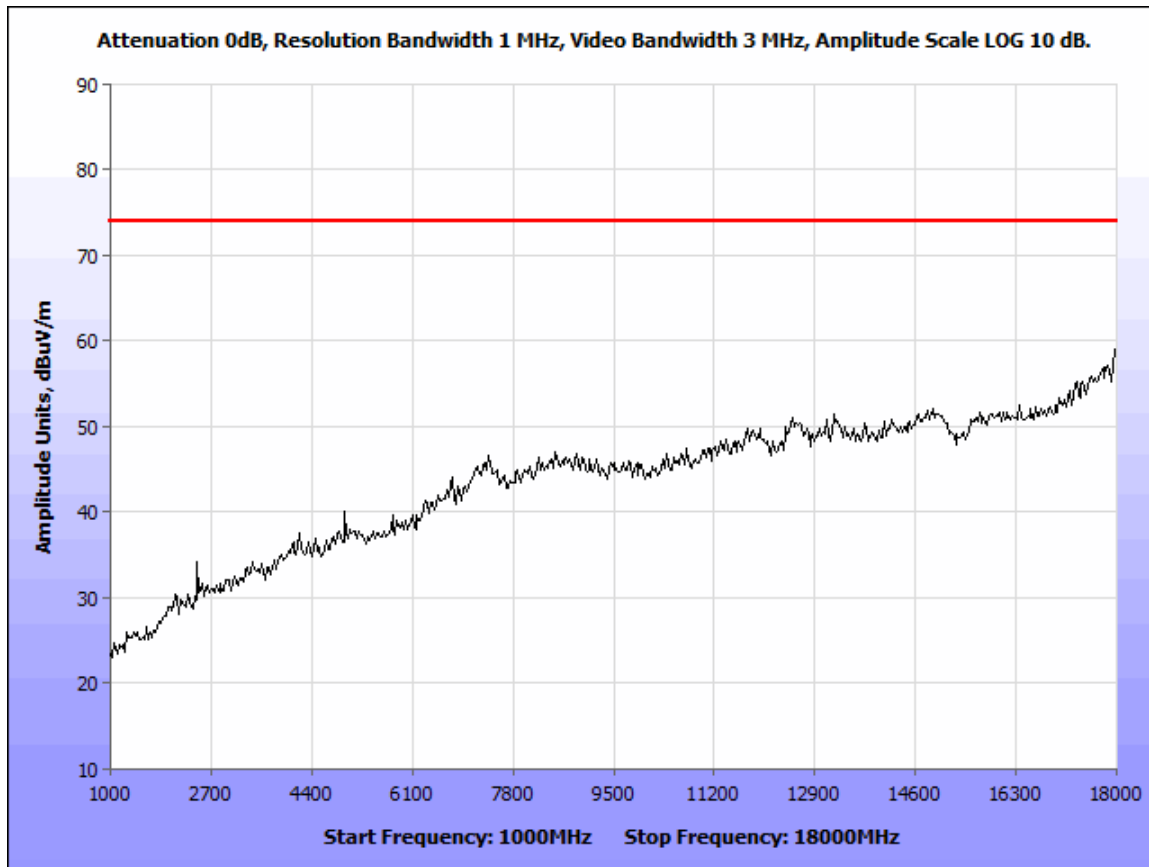


Figure 40: Radiated Emissions, Peak, High Channel, 1 GHz – 18 GHz, Vertical

Electromagnetic Compatibility Criteria for Intentional Radiators Radiated Band Edge Measurements

Test Procedure: 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.

Test Data

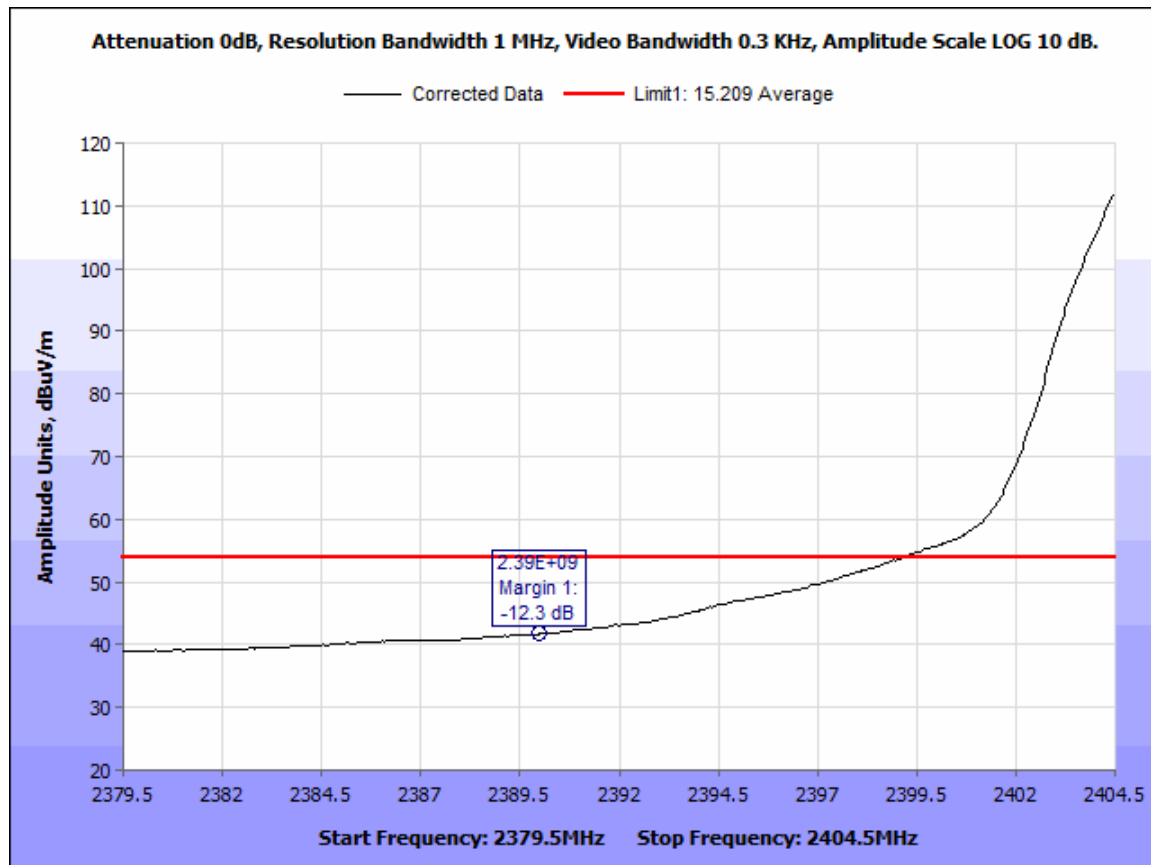


Figure 41: Radiated Band Edge, Average, 2390 ANT1, Low Channel, Max

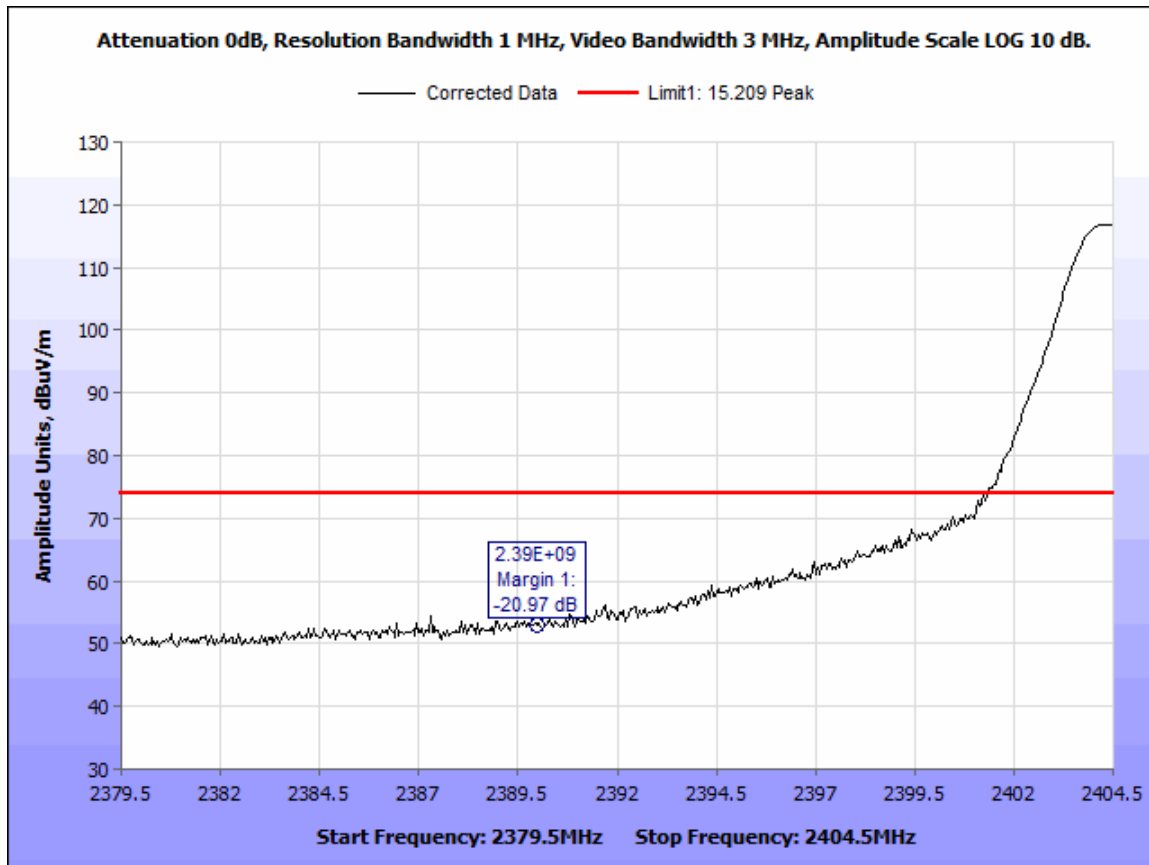


Figure 42: Radiated Band Edge, Peak, 2390 ANT1, Low Channel, Max

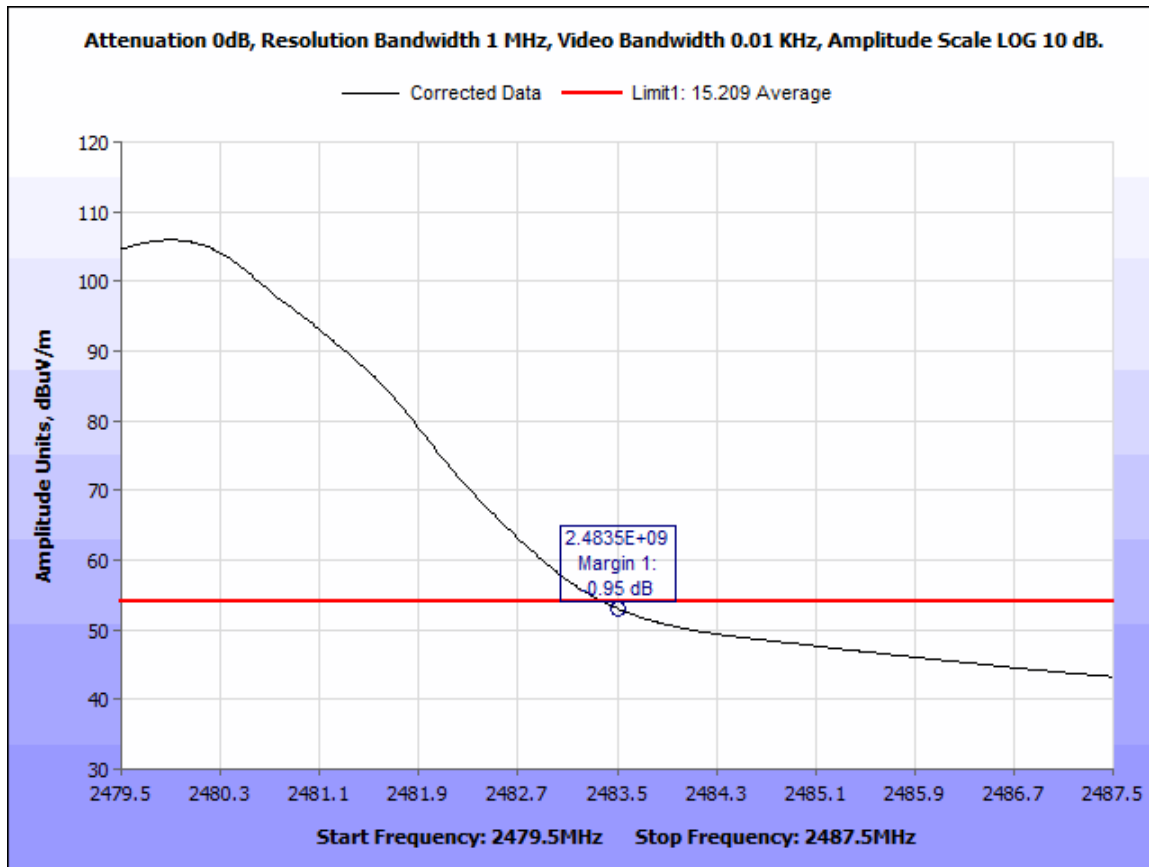


Figure 43: Radiated Band Edge, Average, 2483.5, ANT1, High Channel, -7dbm

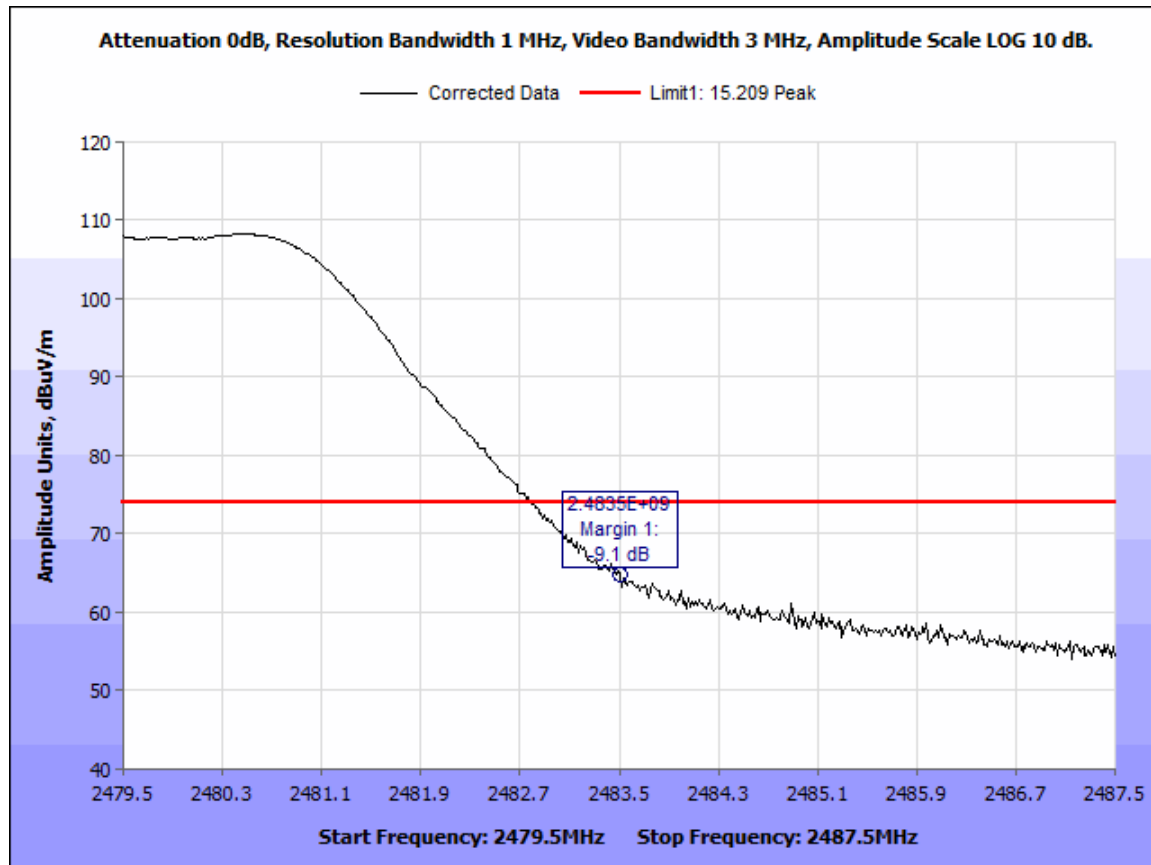


Figure 44: Radiated Band Edge, Peak, 2483.5, ANT1, High Channel, -7dbm

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 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. Since the EUT had an integral antenna, conducted measurements could not be performed. Measurements needed to be taken radiated. An antenna was located 1 m away from the EUT and plots were taken. The EUT was rotated through all three orthogonal axes. The plots were corrected for both antenna correction factor and cable loss.
Test Results:	The EUT as tested is compliant to the requirements of this section. No anomalies noted.
Test Engineer:	Donald Salguero
Test Date:	September 11, 2019

Test Data

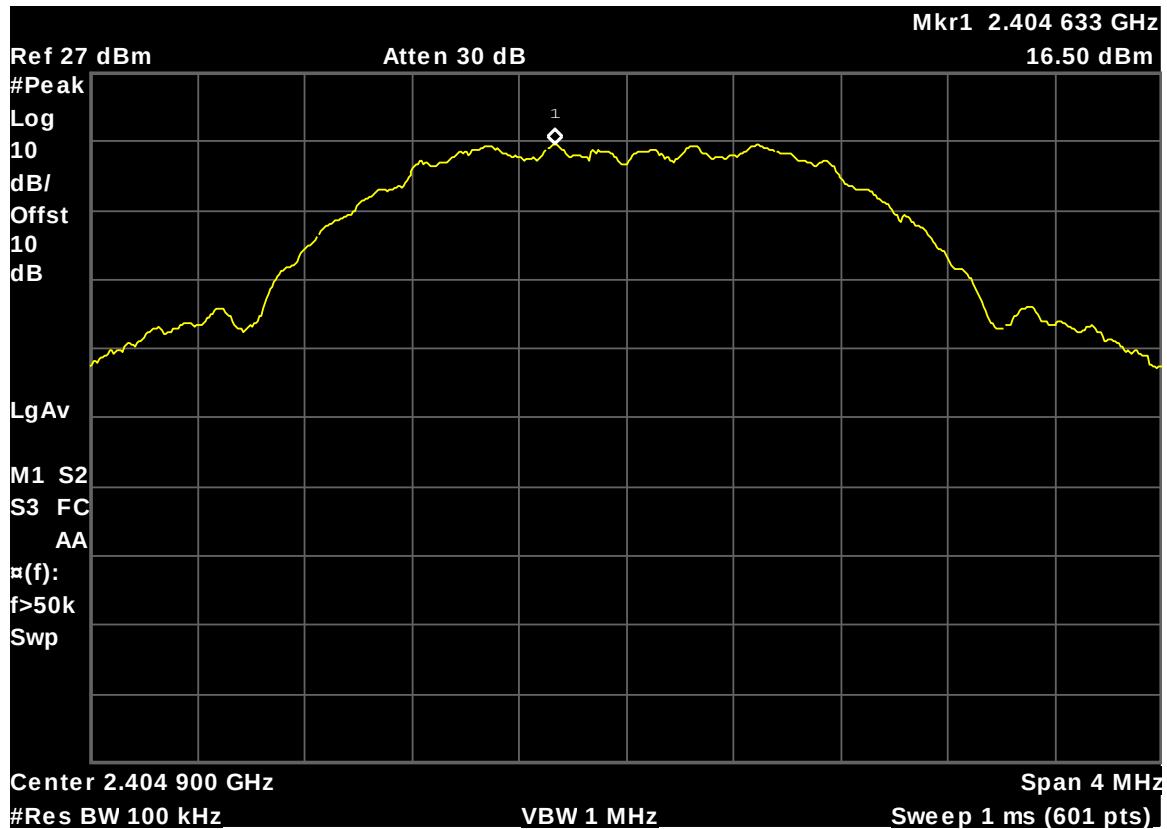


Figure 45: Spurious Emissions in Non-restricted Bands, 100 KHz, Low Channel, 2405, Ref Level

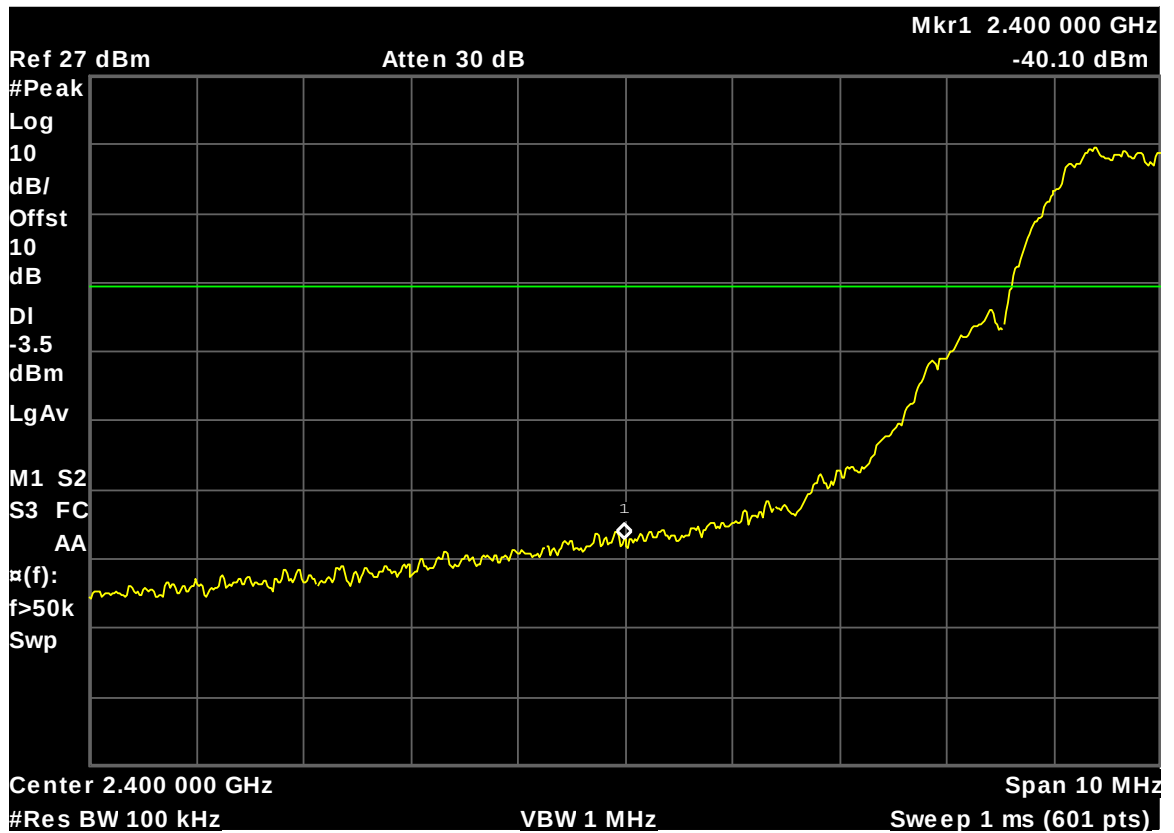


Figure 46: Spurious Emissions in Non-restricted Bands, 100 KHz, Low Channel, 2405, Low Band Edge

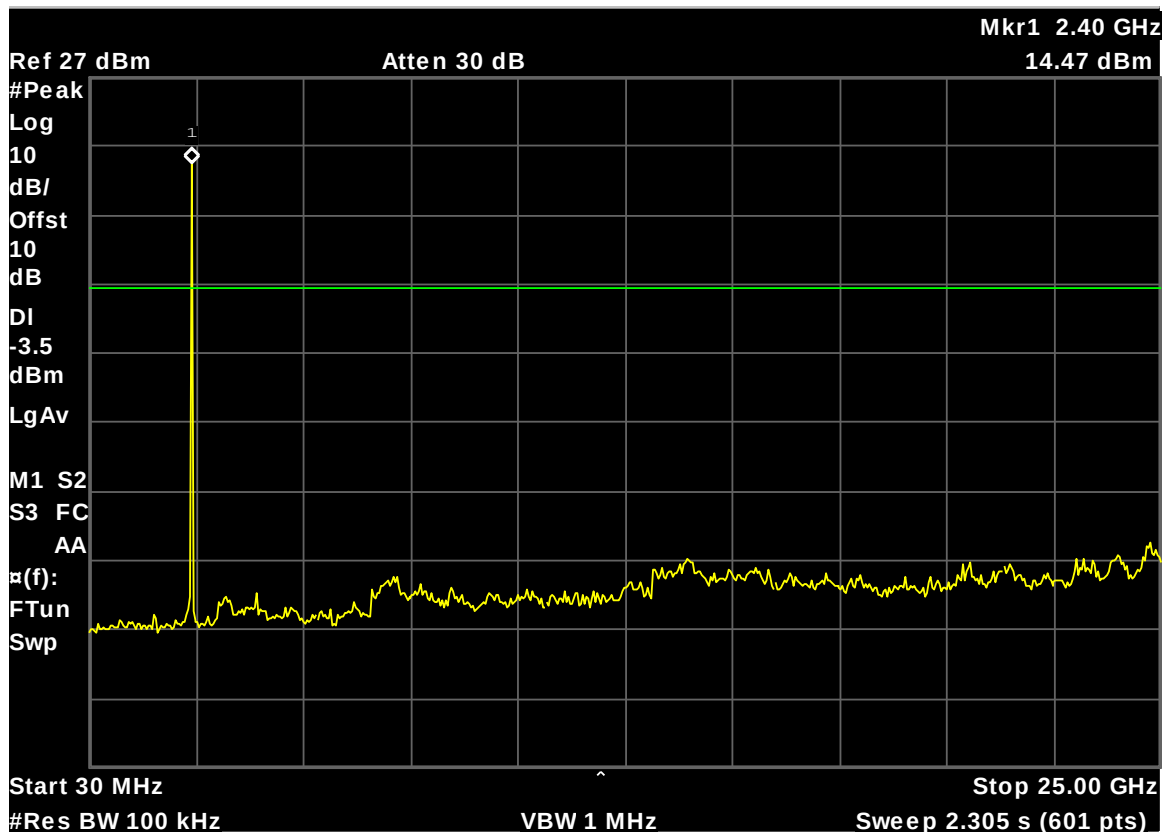


Figure 47: Spurious Emissions in Non-restricted Bands, 100 KHz, Low Channel, 2405, 30 MHz - 25 GHz

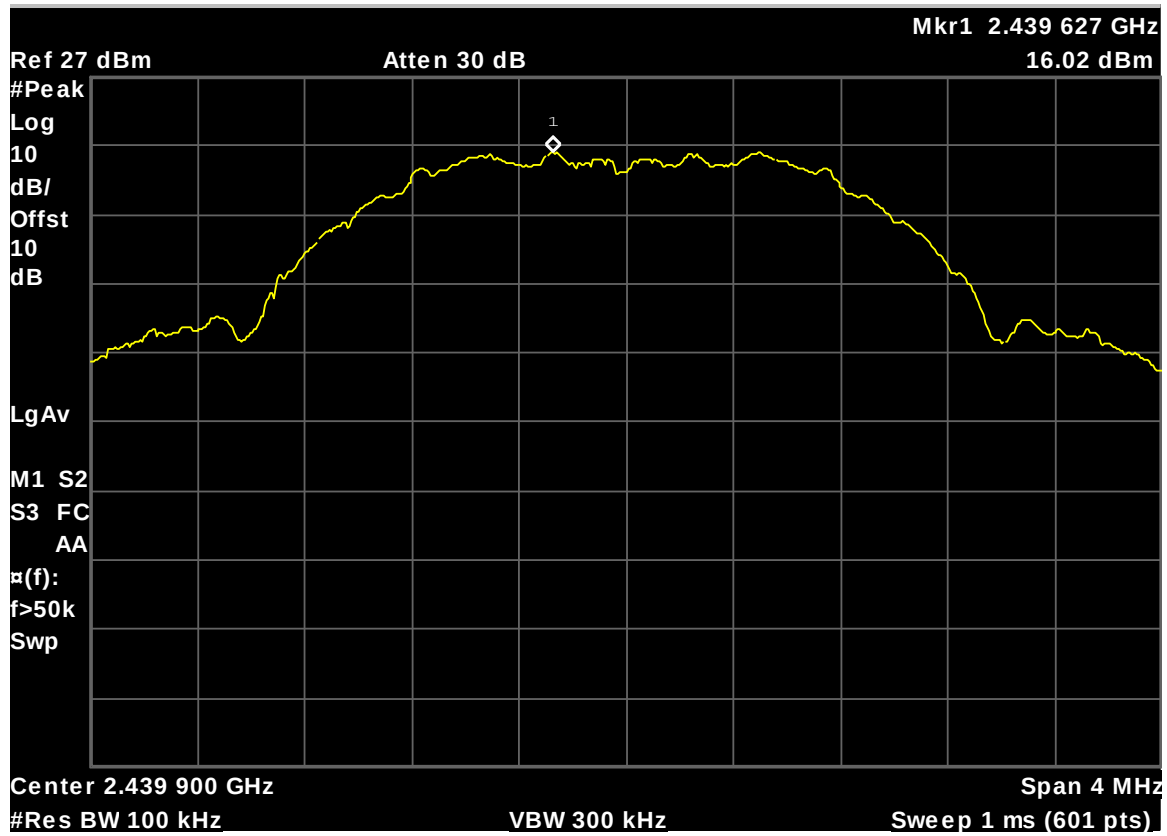


Figure 48: Spurious Emissions in Non-restricted Bands, 100 KHz, Mid Channel, 2440, Ref Level

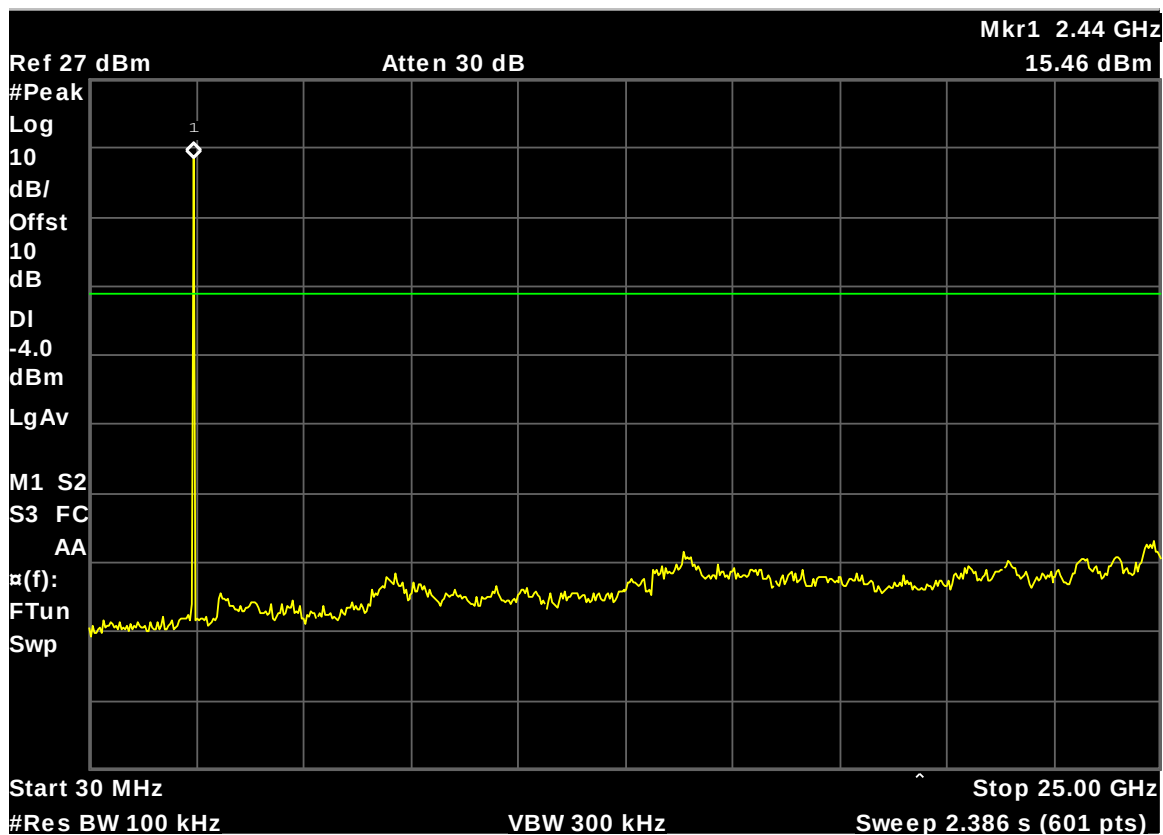


Figure 49: Spurious Emissions in Non-restricted Bands, 100 KHz, Mid Channel, 2440, 30 MHz - 25 GHz

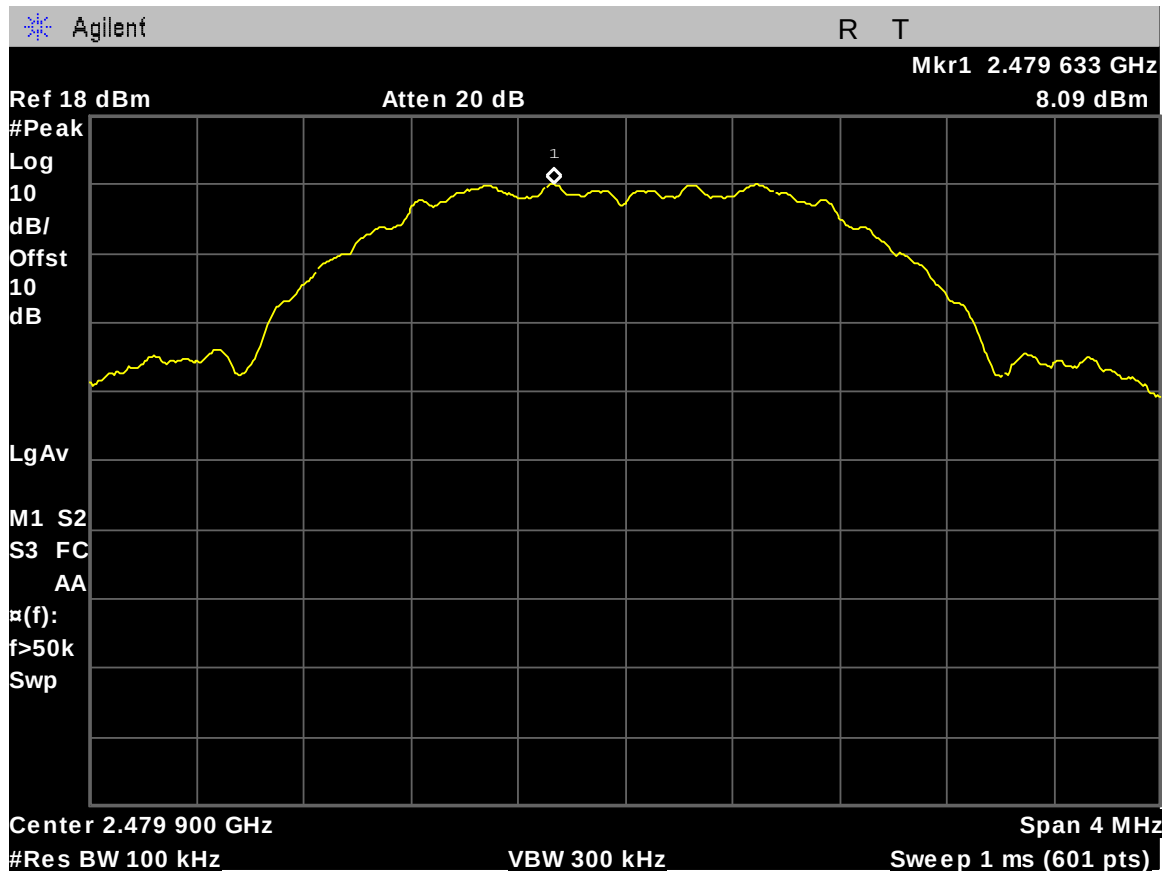


Figure 50: Spurious Emissions in Non-restricted Bands, 100 KHz, High Channel, 2480, Ref Level



Figure 51: Spurious Emissions in Non-restricted Bands, 100 KHz, High Channel, 2480, High Band Edge

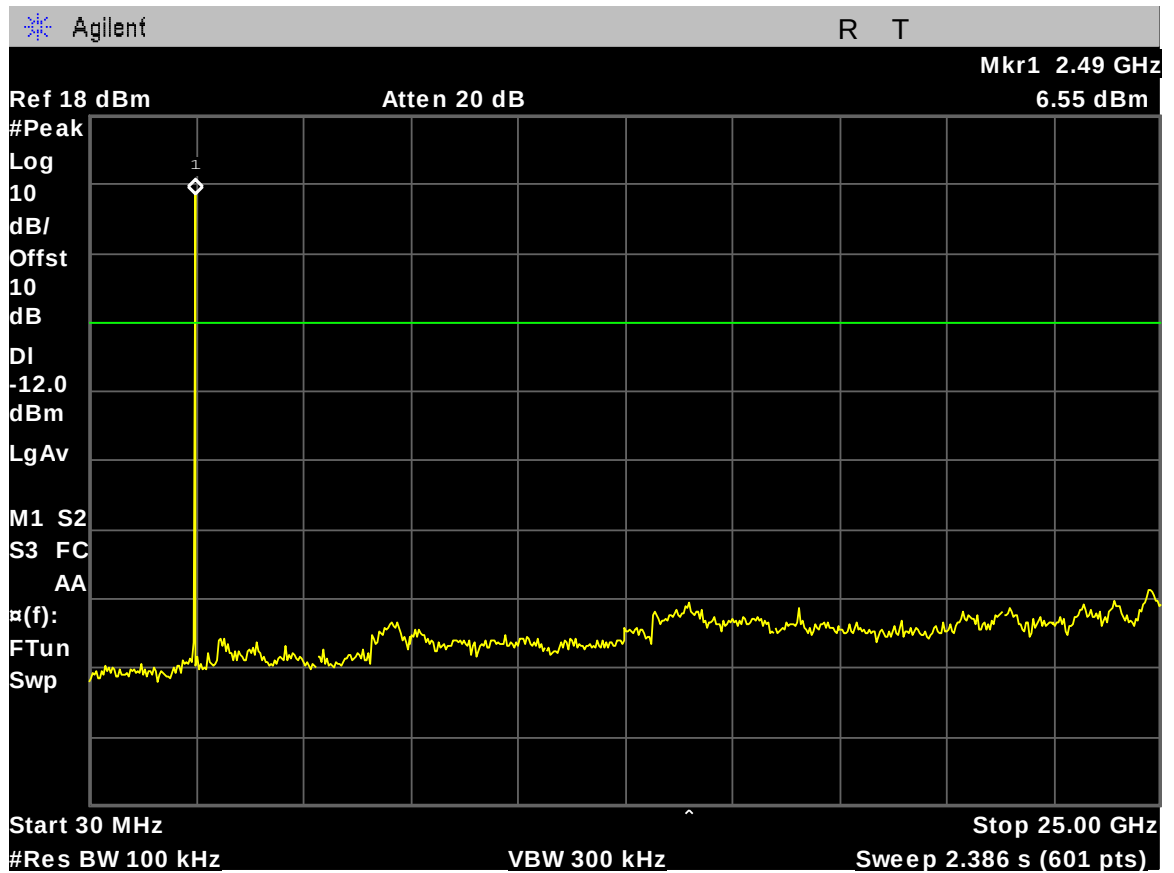


Figure 52: Spurious Emissions in Non-restricted Bands, 100 KHz, High Channel, 2480, 30 MHz – 25 GHz

Electromagnetic Compatibility Criteria for Intentional Radiators**§ 15.247(e) Peak 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 with Max Hold enabled on the spectrum analyzer. The RBW was set to 3 KHz and a VBW set to 9 KHz 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 as tested is **compliant** to the requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: September 17, 2019

Center Frequency (MHz)	Peak Conducted PSD (dBm)
2405	5.35
2440	4.84
2480	-3.15

Test Data

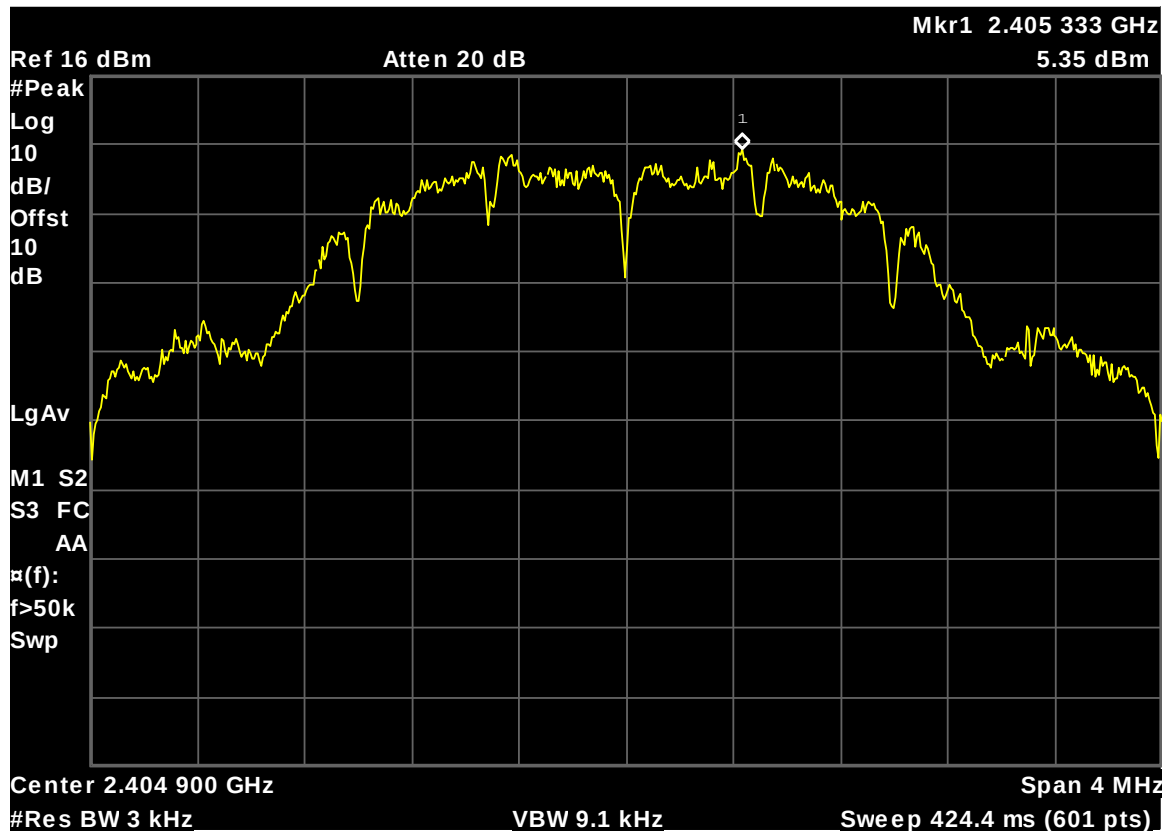


Figure 53: Peak Power Spectral Density, Low Channel, 2405 MHz

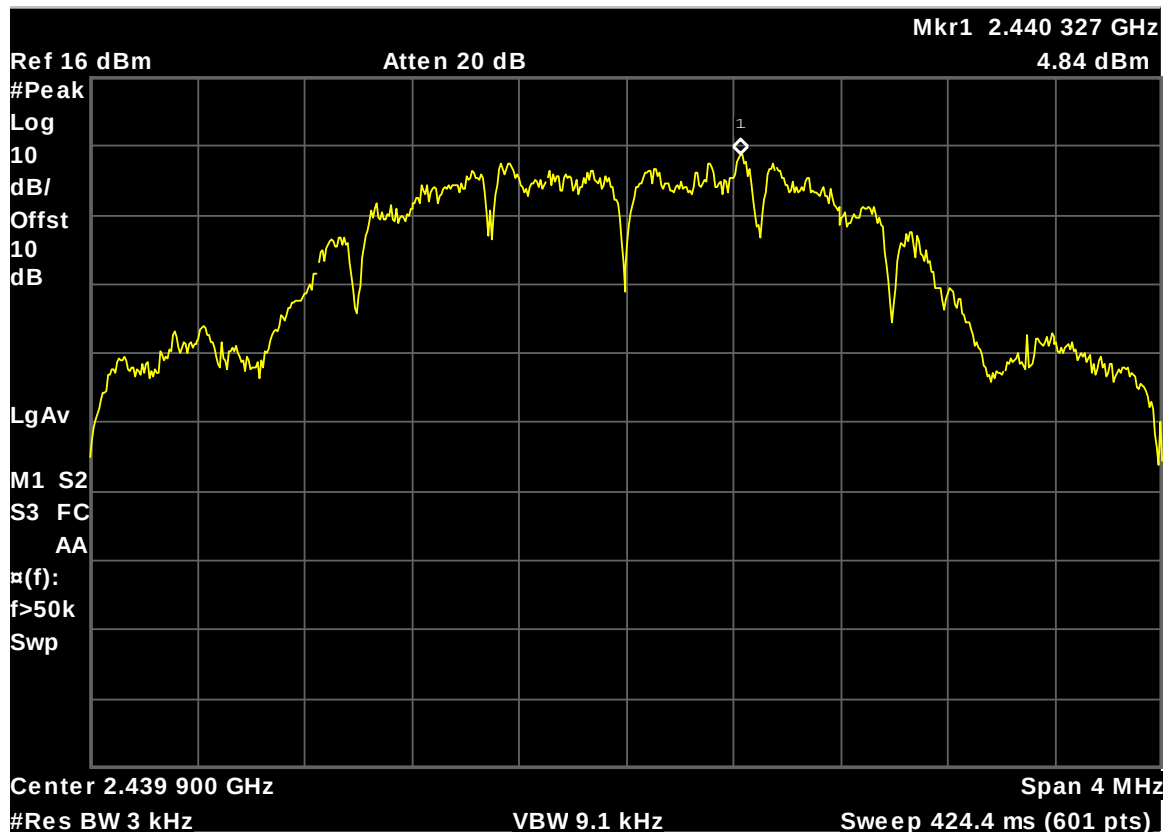


Figure 54: Peak Power Spectral Density, Mid Channel, 2440 MHz

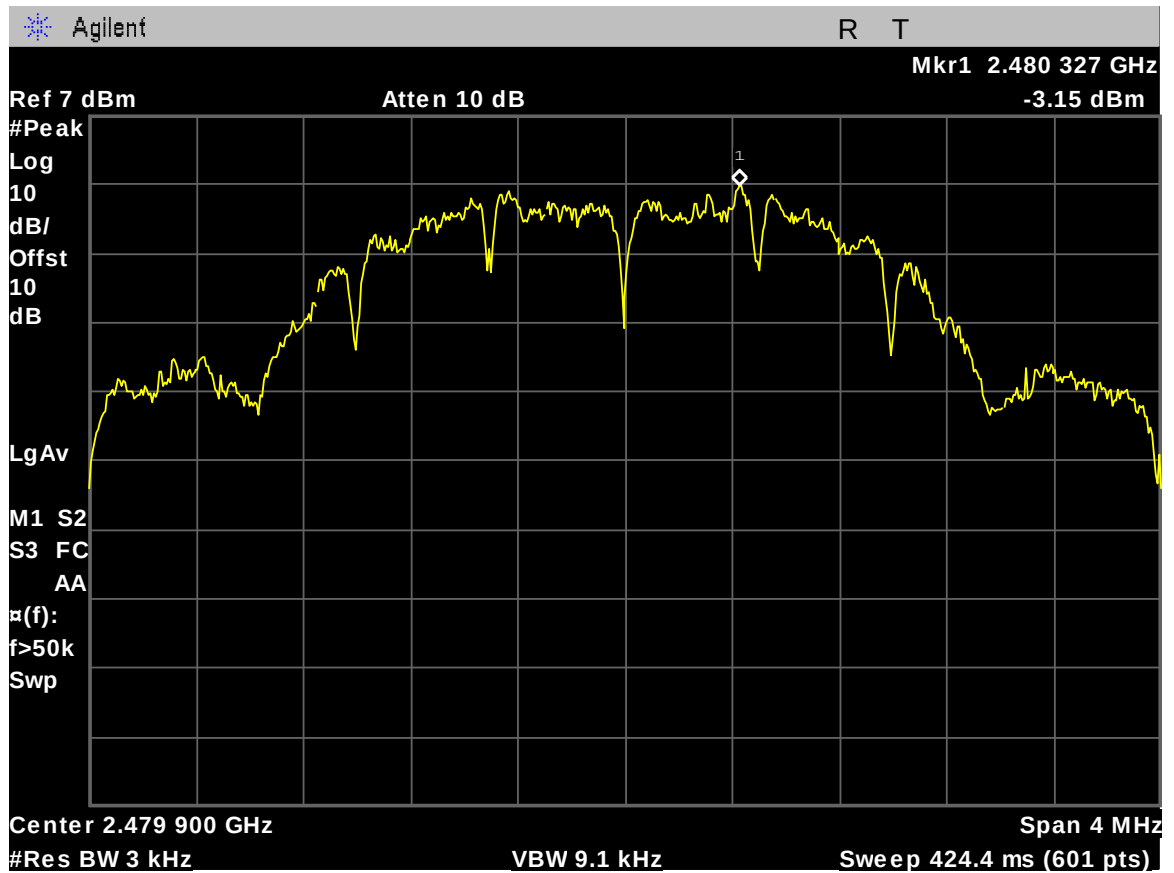


Figure 55: Peak Power Spectral Density, High Channel, 2480 MHz

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/cm² or 10 W/m²**

Test Results: The EUT as tested is **compliant** to the requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: September 17, 2019

FCC									
Frequency (MHz)	Con. Pwr. (dBm)	Con. Pwr. (mW)	Ant. Gain (dBi)	Ant. Gain numeric	Pwr. Density (mW/cm ²)	Limit (mW/cm ²)	Margin	Distance (cm)	Result
2405	20.93	123.88	1.9	1.549	0.03817	1	0.96183	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 17025:2017.

MET ASSET #	EQUIPMENT	MANUFACTURER	MODEL	LAST CAL DATE	CAL DUE DATE
1T4612	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	05/15/2018	11/15/2019
1T4771	PSA SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4446A	5/16/2018	11/16/2019
1T8743	PREAMPLIFIER	A.H. SYSTEMS, INC.	PAM-0118P	FUNC VERIFY	
1T4409	EMI RECEIVER	ROHDE & SCHWARZ	ESIB7	1/4/2019	1/4/2021
1T4753	ANTENNA - BILOG	SUNOL SCIENCES	JB6	8/30/2018	2/29/2020
1T4905	HORN ANTENNA	COM-POWER	AH-118	5/7/2019	11/7/2020
1T7450	TRANSIENT LIMITER	COM-POWER	LIT-153A	NOT REQUIRED	
1T2947	LISN	SOLAR ELECTRONICS COMPANY	8028-50-TS-24-BNC	08/31/2018	02/29/2020
1T2948	LISN	SOLAR ELECTRONICS COMPANY	8028-50-TS-24-BNC	08/31/2018	02/29/2020
1T4503	SHIELDED ROOM	UNIVERSAL SHIELDING CORP	N/A	NOT REQUIRED	

Figure 56: 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.¹ *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.

¹ 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