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

08/28/2020

TechMah Medical LLC
2099 Thunderhead Road, Ste 302
Knoxville, TN 37922

Dear Gary To,

Enclosed is the Wireless test report for compliance testing of the TechMah Medical LLC, SmartSPACE pod as tested to the requirements of Title 47 of the CFR, Ch. 1 (03-01-2020 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins E&E North America. If you have any questions regarding these results or if we can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS E&E NORTH AMERICA

Joel Huna
Documentation Department

Reference: (\TechMah Medical LLC\WIRA107299-FCC247 Rev. 2)

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ACCREDITED
TESTING CERT #0591.06

Electromagnetic Compatibility Criteria
Test Report

for the

TechMah Medical LLC
SmartSPACE pod

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

Report: WIRA107299-FCC247 Rev. 2

08/28/2020

Prepared For:

TechMah Medical LLC
2099 Thunderhead Road, Ste 302
Knoxville, TN 37922

Prepared By:
Eurofins E&E North America
13501 McCallen Pass, Austin, TX 78753

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Electromagnetic Compatibility Criteria
Test Report

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TechMah Medical LLC
SmartSPACE pod

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

Adan Arab, 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.

Jonathan Tavira,
Manager, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	04/09/2020	Initial Issue
1	08/21/2020	TCB comments.
2	08/28/2020	Engineer modifications.

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

I. Executive Summary

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A. Purpose of Test

An EMC evaluation was performed to determine compliance of the TechMah Medical LLC SmartSPACE pod, 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 SmartSPACE pod. TechMah Medical LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the SmartSPACE pod, 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 TechMah Medical LLC, quote number 9TEC1902R1. All tests were conducted using measurement procedure ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2020	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)(3)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(c)	Spurious Emissions in Non-restricted Bands	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	RF Human Exposure, SAR Exclusion	Compliant

Figure 1: Executive Summary of EMC Part 15.247 ComplianceTesting

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II. Equipment Configuration

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A. Overview

Eurofins E&E North America was contracted by TechMah Medical LLC to perform testing on the SmartSPACE pod, under TechMah Medical LLC's quote number 9TEC1902R1,

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the TechMah Medical LLC, SmartSPACE pod.

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

Model(s) Tested:	SmartSPACE pod	
Model(s) Covered:	SmartSPACE pod	
EUT Specifications:	Primary Power: 3.7 VDC	
	FCC ID: 2AW5R-SSCS0024001	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	-4.924 dBm
	EUT Frequency Ranges:	2400-2483.5 MHz
	Transmit Speeds:	1 Mbps
	Antenna Type:	Ceramic Chip
	Antenna Gain:	1.3 dBi
	Firmware Version:	TMM2400000016_R11_TypeP.hex
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Adan Arab	
Report Date(s):	08/28/2020	

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 v0502	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247

Figure 3: References

C. Test Site

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

All testing was performed at Eurofins E&E North America, 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 Eurofins E&E North America.

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 SmartSPACE pod, Equipment Under Test (EUT), is a medical device, which is a sub-component of the SmartSPACE pod guidance system. The SmartSPACE Shoulder Guidance System (SGS) is an accessory to Lima Orthopedic's total shoulder arthroplasty instrument. The EUT is intended to be an intraoperative single use device for collecting raw motion data and wirelessly transmit them to the processing software that is installed onto a support equipment, tablet. (The tablet is in compliance with 60601 and FCC regulation. It will be provided for testing.). The EUT is internally powered by a battery. The EUT is intended to be mechanically coupled with adaptors that are attached to surgical instrument. The EUT is intended to be used to surgeons within the operating room setting.

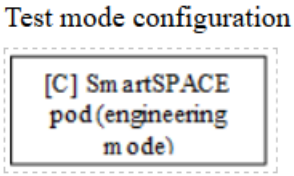

Figure 5: Block Diagram of Test Configuration, Cubit pod test mode

F. Equipment Configuration

The EUT was set up as outlined in Figure 7. 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. #
C	N/A	SmartSPACE pod +SMA connector (Test mode)	TMM2400000016	N/A	N/A	N/A

Figure 6: Equipment List

The firmware installed in the EUT during testing was TMM2400000016_R11_TypeP.hex

G. Support Equipment

The EUT is internally powered by a battery.

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H. Ports and Cabling Information

The EUT did not have any ports or cabling required for testing or monitoring.

I. Mode of Operation

Engineering test mode Power cycle the electronics will put the unit is different transmission configuration, which can be changed by power cycling the device.

1. (Red LED is on) - Simulated continuous wave transmission at 2.402GHz.
2. (Yellow LED is on) - Simulated continuous wave transmission at 2.440GHz.
3. (Blue LED is on) - Simulated continuous wave transmission at 2.480GHz.
4. (Red and yellow LEDs are on) - Simulated modulated transmission at 2.402GHz.
5. (Red and blue LEDs are on) - Simulated modulated transmission at 2.440GHz.
6. (Yellow and blue LEDs are on) - Simulated modulated transmission at 2.480GHz.
7. (All lights are on) - Simulated receiving mode at 2.402GHz.
8. (Red light is blinking) - Simulated receiving mode at 2.440GHz.
9. (Yellow light is blinking) - Simulated receiving mode at 2.480GHz.
10. (Blue light is blinking) - Not used.

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J. Method of Monitoring EUT Operation

Proper output of the BLE transmitter was verified using a calibrated spectrum analyzer.

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 TechMah Medical LLC upon completion of testing.

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III. Electromagnetic Compatibility Criteria for Intentional Radiators

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement:

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

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

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

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

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

Test Results:

The EUT was tested is **Compliant** with § 15.203 Antenna Requirement. 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.) The 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. The installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results:
The EUT as tested is compliant to 15.203.
The antenna is integrated into the EUT (permanently attached) and is unable to be modified by the end-user.

Test Engineer: Adan Arab

Test Date: 03/05/2020

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.

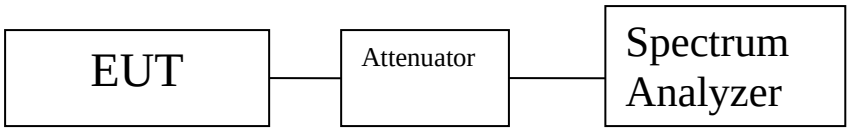

Figure 7: Block Diagram, Occupied Bandwidth Test Setup

Test Results: The EUT was tested is **compliant** with § 15.247(a)(2) 6 dB Bandwidth. No anomalies detected.

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

Test Engineer: Adan Arab

Test Date: 03/05/2020

Test Data,

Mode	Channel (MHz)	6 dB Bandwidth (MHz)	Limit (MHz)
BLE	2402	0.752938	≥0.500
BLE	2442	0.760043	≥0.500
BLE	2480	0.759446	≥0.500

Figure 8: 6 dB Bandwidth, Test Results

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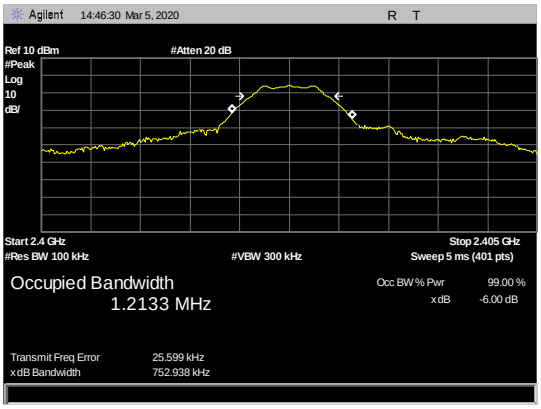

Figure 9: 6 dB Occupied Bandwidth, 2402 MHz - 752.938 KHz

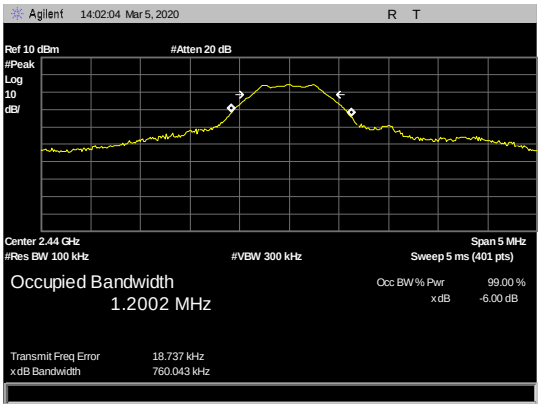

Figure 10: 6 dB Occupied Bandwidth, 2440 MHz - 760.043 KHz

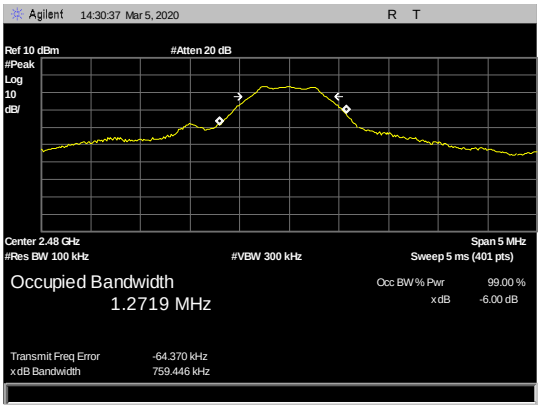

Figure 11: 6 dB Occupied Bandwidth, 2480 MHz -759.446 KHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 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 12: 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 configured to measure 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 below.

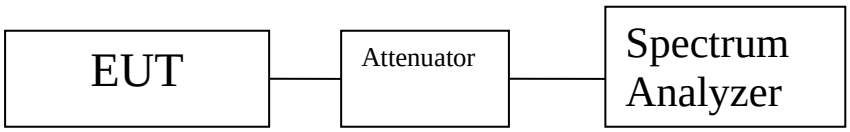

Figure 13: Block Diagram, Peak Conducted Output Power Test Setup

Test Results: The EUT was tested is **Compliant** with § 15.247(b) Peak Power Output. No anomalies detected.

Test Engineer: Adan Arab

Test Date: 03/05/2020

Mode	Channel (MHz)	Peak Output Power (dBm)	Limit (dBm)
BLE	2402	-4.924	30
BLE	2442	-4.947	30
BLE	2480	-5.364	30

Figure 14: Peak Power Output, Peak Conducted Output Power, Test Results

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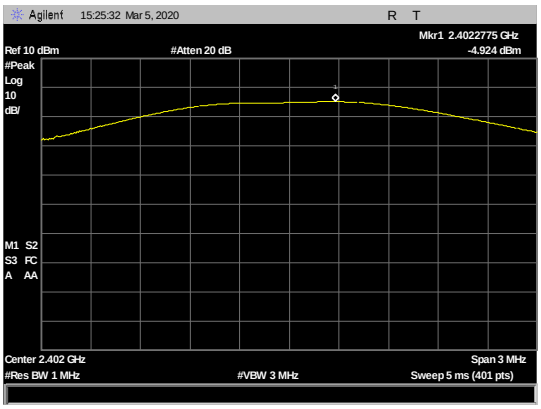


Figure 15: Peak Output Power, 2402 MHz - -4.924 dBm

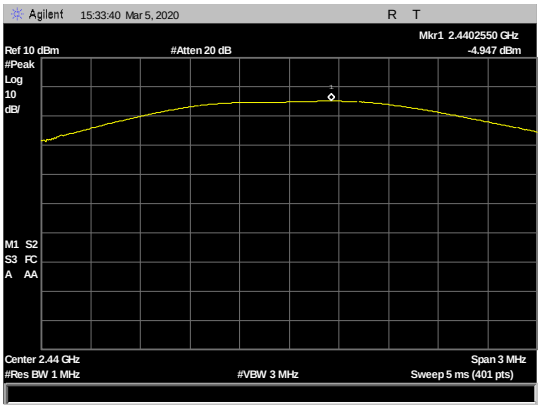


Figure 16: Peak Output Power, 2440 MHz - -4.947 dBm

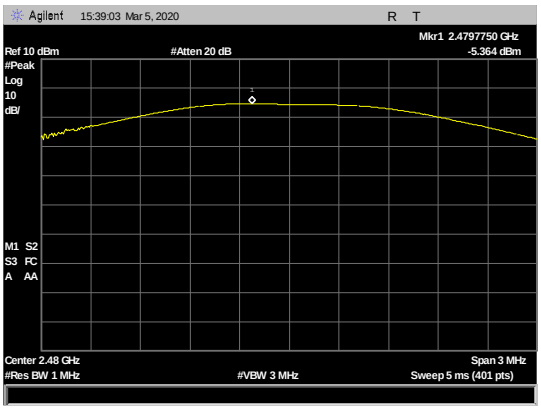


Figure 17: Peak Output Power, 2480 MHz - -5.364 dBm

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): Adan Arab

Test Date(s): 03/05/2020

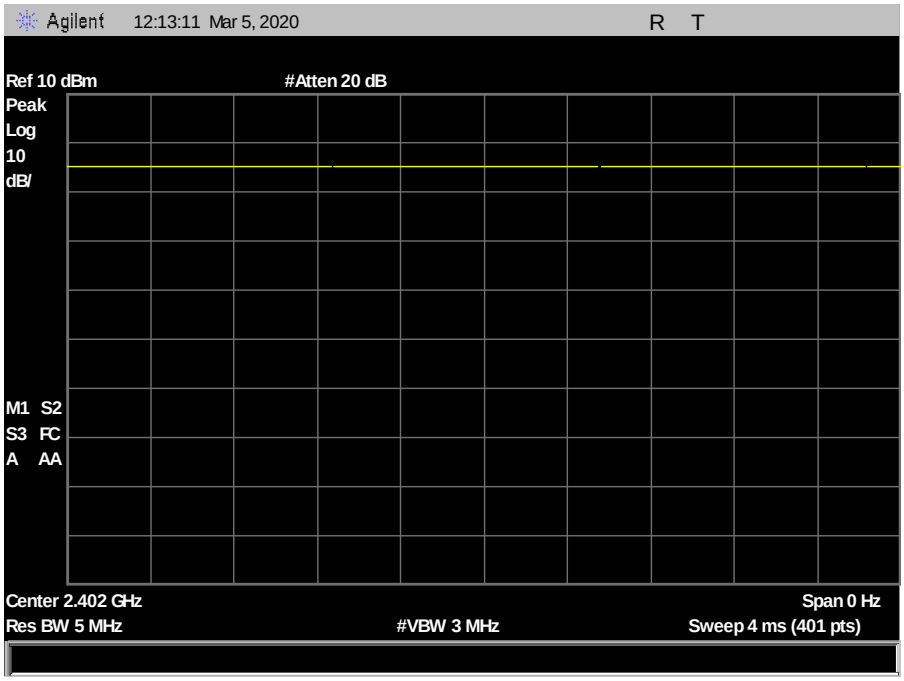


Figure 18: Duty Cycle, BLE - 2402 - 100%

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 19: 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 20:

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 20: 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 using Peak detector against average limit for the worst-case measurement. 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.

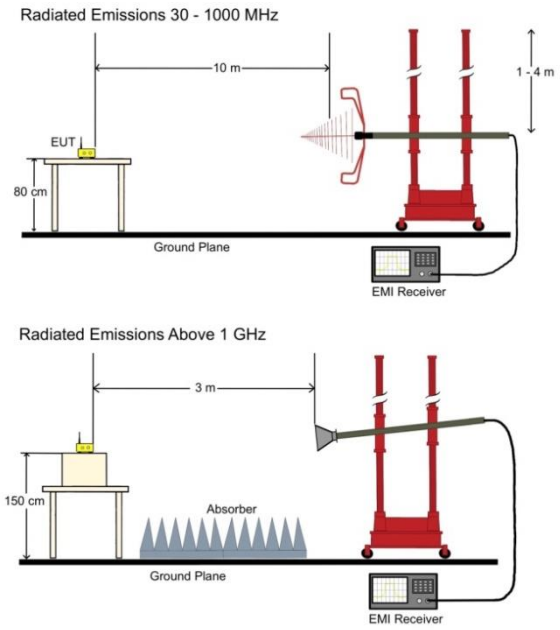


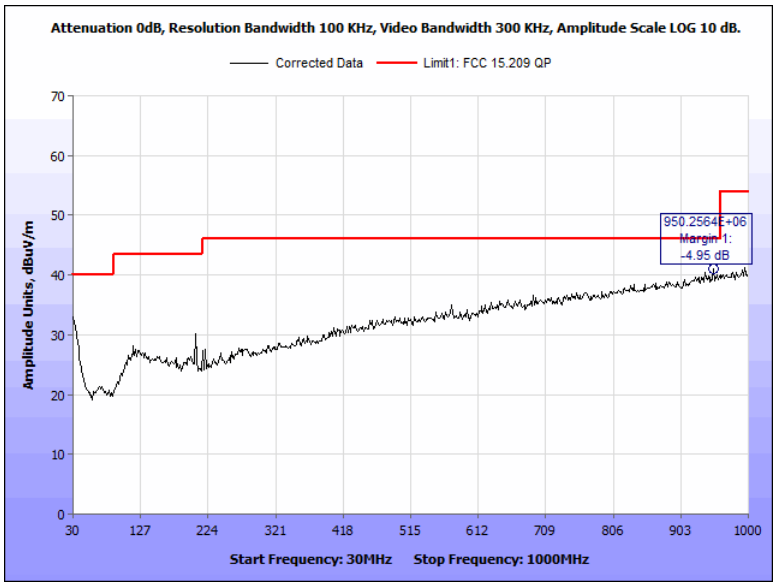
Figure 21: Radiated Emissions Test Setup

Test Results: The EUT was tested is **compliant** with § 15.209 Radiated Spurious Emissions Requirements and Band Edge.

Test Engineer: Adan Arab

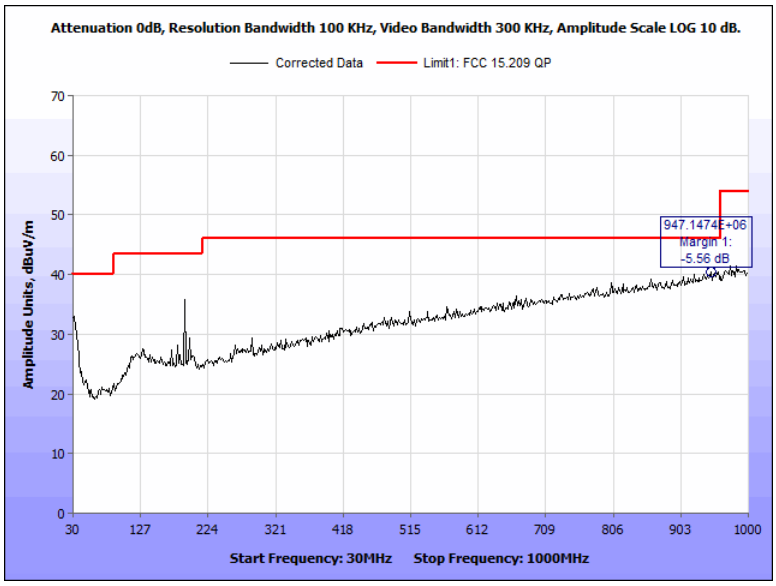
Test Date: 03/16/2020

Test Data



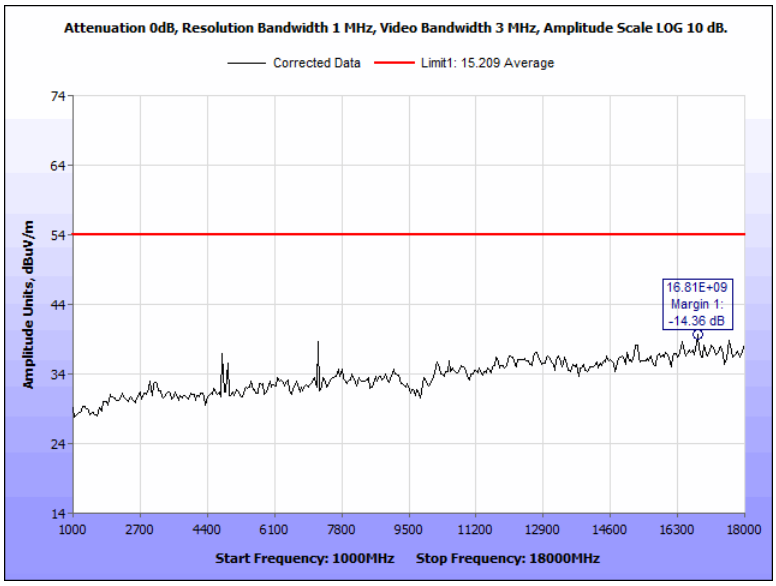
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m)	Margin (dB)
950.2564	23.02	Peak	100	10.46	26.8	-19.23	41.05	46	-4.95
937.8205	22.62	Peak	100	10.46	26.7	-19.3	40.48	46	-5.52
954.9199	21.89	Peak	100	10.46	26.8	-19.19	39.96	46	-6.04
942.484	21.95	Peak	100	10.46	26.65	-19.27	39.80	46	-6.2
958.0288	21.68	Peak	100	10.46	26.8	-19.16	39.78	46	-6.22
939.3750	21.83	Peak	100	10.46	26.6	-19.29	39.61	46	-6.39

Figure 22: Radiated Spurious Emissions, 2402 MHz - 30-1000 MHz – Quasi-Peak - Horizontal.



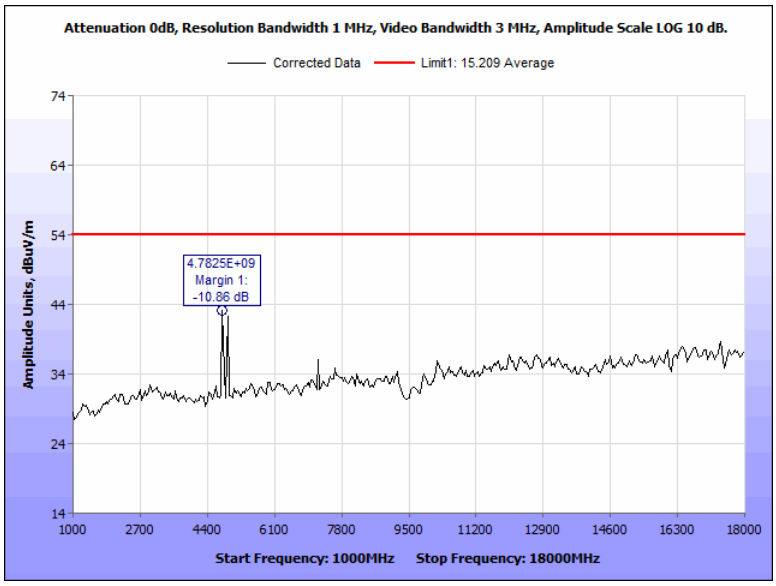
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m))	Margin (dB)
947.1474	22.11	Peak	100	10.46	27.11	-19.24	40.44	46	-5.56
956.4744	21.76	Peak	100	10.46	27.3	-19.17	40.35	46	-5.65
951.8109	21.81	Peak	100	10.46	27.2	-19.21	40.26	46	-5.74
954.9199	21.73	Peak	100	10.46	27.2	-19.19	40.2	46	-5.8
936.266	21.85	Peak	100	10.46	27.1	-19.32	40.09	46	-5.91
922.2756	22.10	Peak	100	10.46	26.93	-19.44	40.05	46	-5.95

Figure 23: Radiated Spurious Emissions, 2402 MHz - 30-1000 MHz – Quasi-Peak - Vertical.



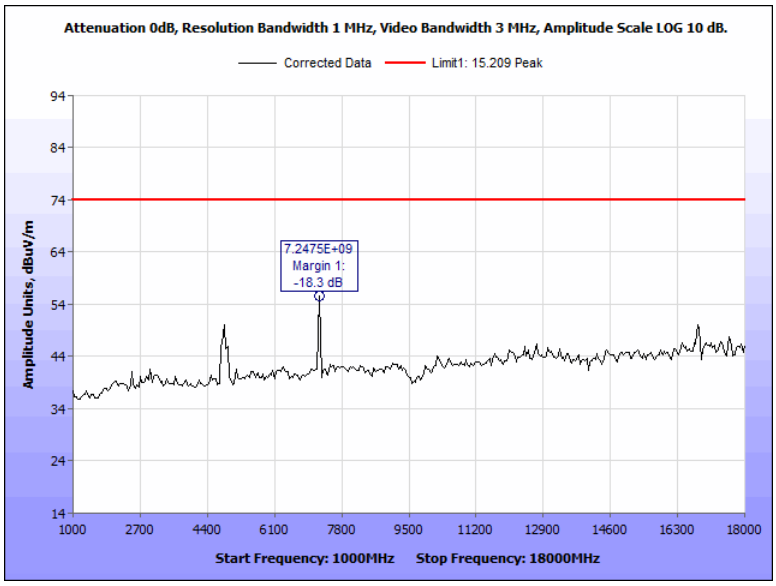
Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
16.8100	41.21	1	41.26	-42.83	39.64	54	-14.36
17.6175	37.80	1	40.58	-39.57	38.81	54	-15.19
7.2050	43.26	1	35.39	-39.99	38.65	54	-15.35
16.4275	38.93	1	40.63	-40.98	38.58	54	-15.42
18.0000	36.42	1	40.52	-38.79	38.15	54	-15.85
15.2800	38.27	1	39.39	-39.56	38.10	54	-15.9

Figure 24: Radiated Spurious Emissions, 2402 MHz - 1-18 GHz - Average - Horizontal.



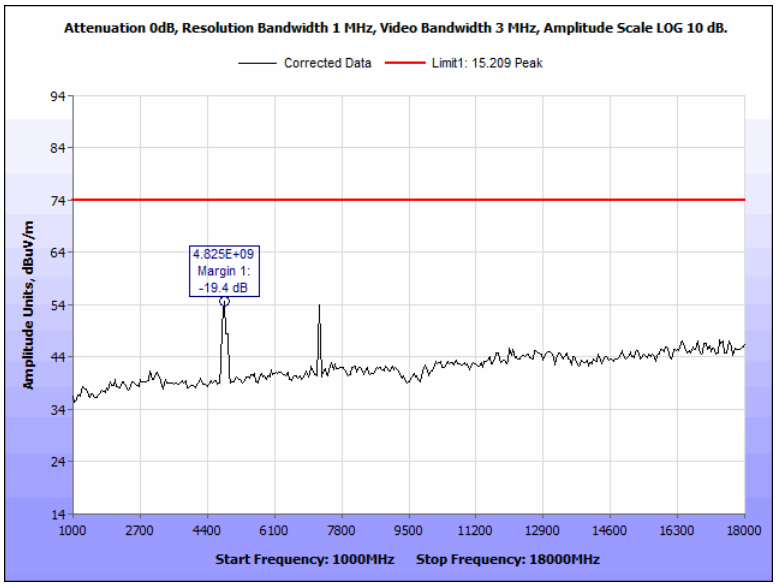
Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
4.78251	47.81	1	33.79	-38.47	43.14	54	-10.86
4.9110	47.30	1	33.7	-38.78	42.22	54	-11.78
17.4051	39.12	1	40.53	-40.96	38.69	54	-15.31
17.36251	38.83	1	40.53	-41.18	38.17	54	-15.83
16.42751	38.4	1	40.62	-40.98	38.03	54	-15.97
16.76751	39.32	1	41.24	-42.69	37.87	54	-16.13

Figure 25: Radiated Spurious Emissions, 2402 MHz - 1-18 GHz - Average - Vertical.



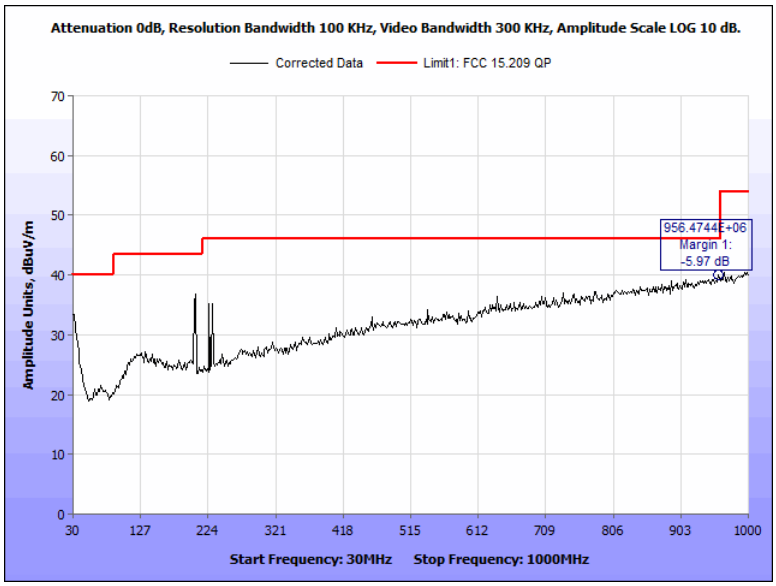
Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Peak (dBuV/m)	Margin (dB)
7.2475	60.38	1	35.34	-40.02	55.7	74	-18.3
4.825	54.9	1	33.82	-38.52	50.2	74	-23.8

Figure 26: Radiated Spurious Emissions, 2402 MHz - 1-18 GHz - Peak - Horizontal.



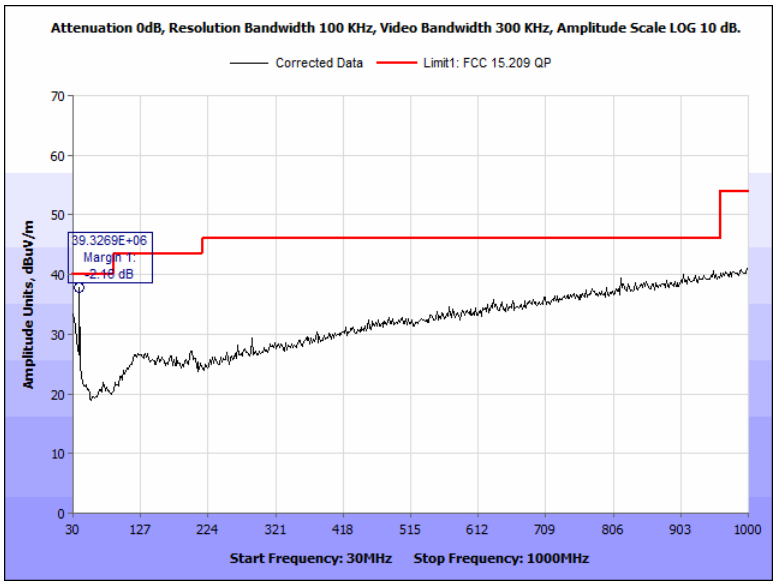
Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Peak (dBuV/m)	Margin (dB)
4.8250	59.36	1	33.76	-38.52	54.60	74	-19.4
7.2475	58.53	1	35.43	-40.02	53.95	74	-20.05

Figure 27: Radiated Spurious Emissions, 2402 MHz - 1-18 GHz - Peak - Vertical.



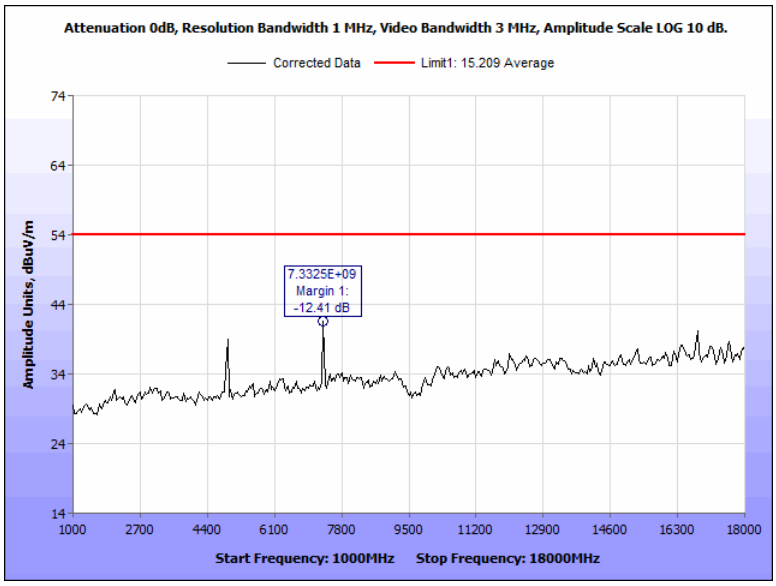
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m)	Margin (dB)
956.4744	21.94	Peak	100	10.46	26.8	-19.17	40.03	46	-5.97
958.0288	21.29	Peak	100	10.46	26.8	-19.16	39.40	46	-6.6
30.0000	22.84	Peak	100	10.46	24.9	-24.82	33.38	40	-6.62
950.2564	21.29	Peak	100	10.46	26.8	-19.23	39.32	46	-6.68
31.5545	23.61	Peak	100	10.46	23.96	-24.72	33.30	40	-6.7
948.7019	21.32	Peak	100	10.46	26.73	-19.24	39.28	46	-6.72

Figure 28: Radiated Spurious Emissions, 2440 MHz - 30-1000 MHz – Quasi-Peak - Horizontal.



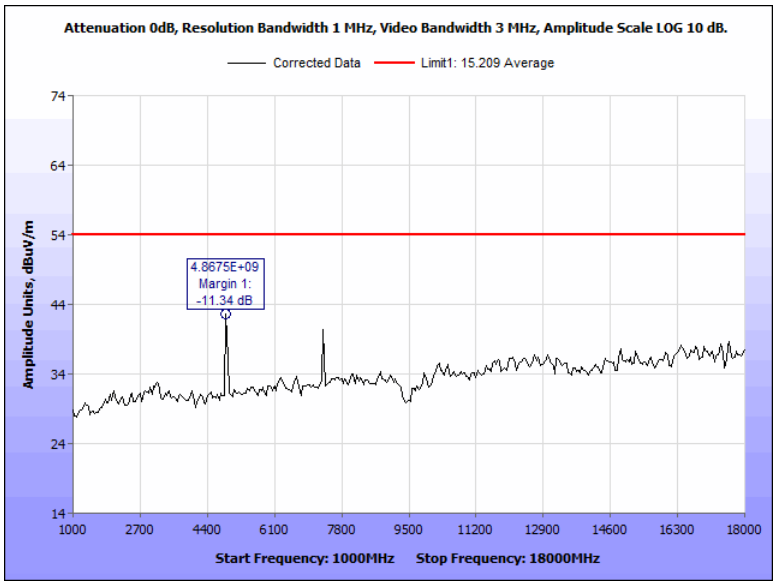
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m	Margin (dB)
39.3269	34.47	Peak	100	10.46	17.44	-24.52	37.84	40	-2.16
950.2564	22.16	Peak	100	10.46	27.2	-19.23	40.60	46	-5.4
953.3654	21.54	Peak	100	10.46	27.2	-19.2	40.00	46	-6
906.7308	22.44	Peak	100	10.46	26.67	-19.59	39.99	46	-6.01
959.5833	21.27	Peak	100	10.46	27.3	-19.14	39.88	46	-6.12
923.8301	21.91	Peak	100	10.46	26.92	-19.43	39.86	46	-6.14

Figure 29: Radiated Spurious Emissions, 2440 MHz - 30-1000 MHz – Quasi-Peak - Vertical.



Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
7.33250	46.05	1	35.4	-39.85	41.59	54	-12.41
16.8100	41.84	1	41.26	-42.83	40.28	54	-13.72
4.9100	44.08	1	33.67	-38.78	38.97	54	-15.03
17.61750	37.62	1	40.58	-39.57	38.63	54	-15.37
16.42750	38.58	1	40.63	-40.98	38.22	54	-15.78
16.3850	38.60	1	40.56	-41.05	38.12	54	-15.88

Figure 30: Radiated Spurious Emissions, 2440 MHz - 1-18 GHz - Average - Horizontal.



Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
4.8675	47.59	1	33.72	-38.66	42.66	54	-11.34
7.3325	44.84	1	35.37	-39.85	40.35	54	-13.65
17.6175	37.72	1	40.53	-39.57	38.69	54	-15.31
17.4050	38.72	1	40.53	-40.96	38.30	54	-15.7
16.3850	38.61	1	40.54	-41.05	38.11	54	-15.89
16.7675	39.44	1	41.24	-42.69	37.99	54	-16.01

Figure 31: Radiated Spurious Emissions, 2440 MHz - 1-18 GHz - Average - Vertical.

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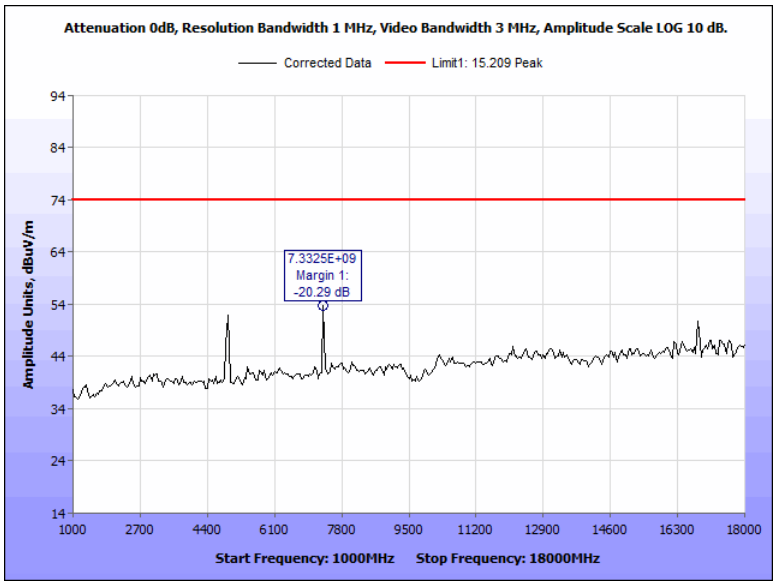


Figure 32: Radiated Spurious Emissions, 2440 MHz - 1-18 GHz - Peak - Horizontal.

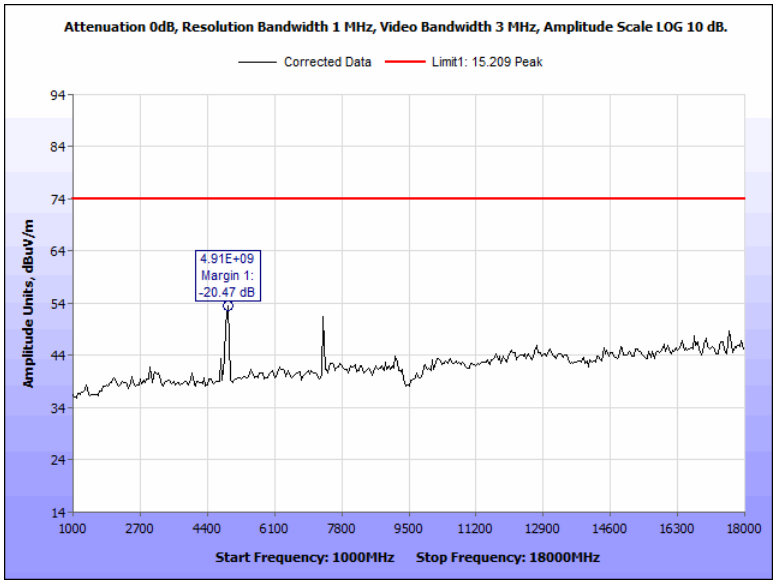
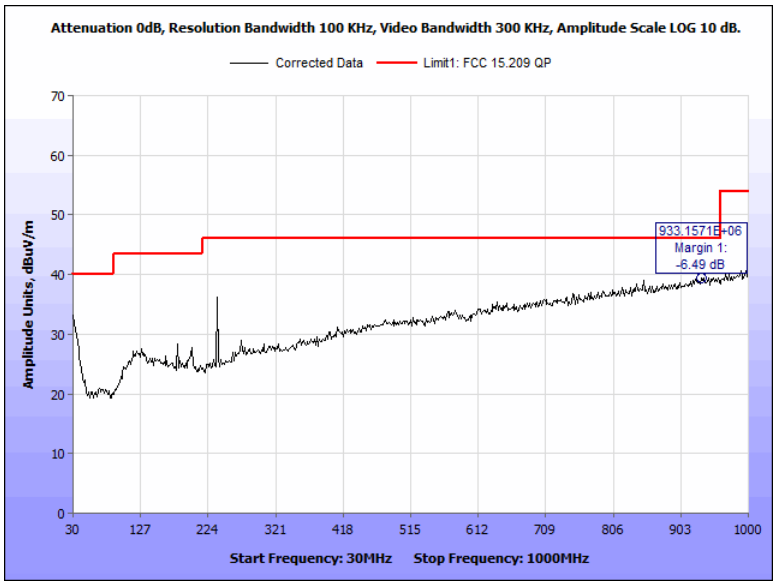
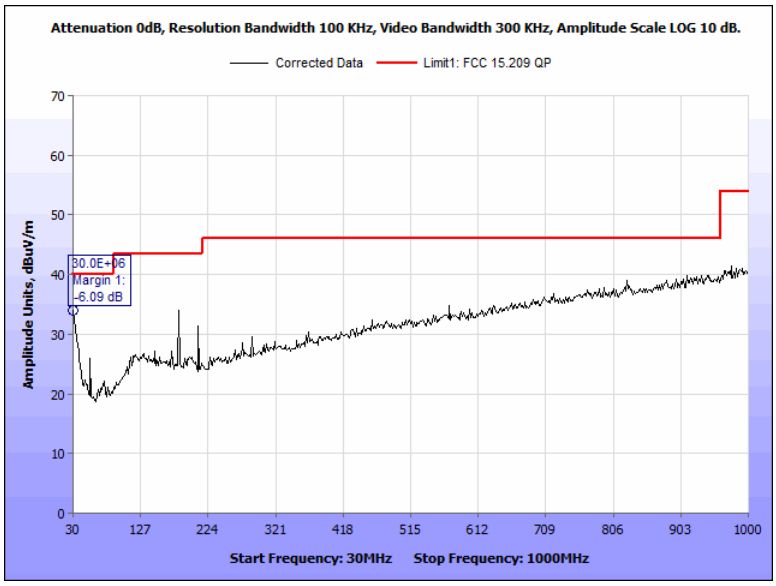


Figure 33: Radiated Spurious Emissions, 2440 MHz - 1-18 GHz - Peak - Vertical.



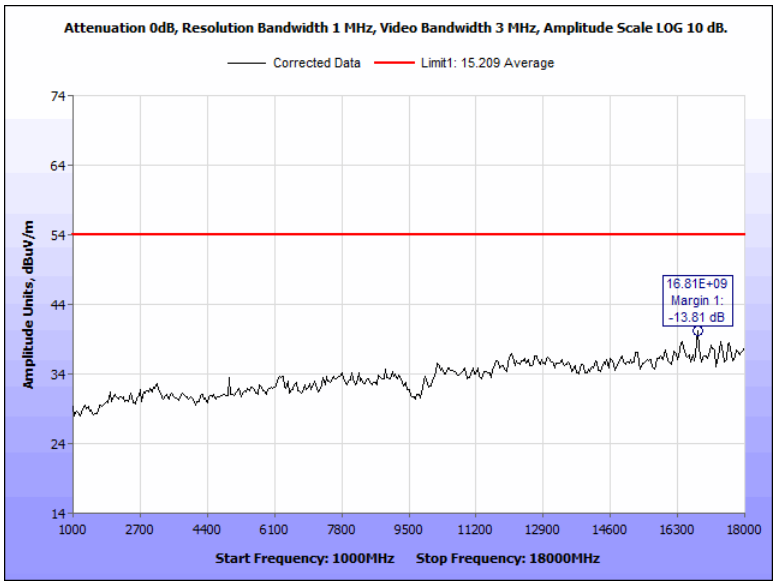
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m)	Margin (dB)
933.1571	21.70	Peak	100	10.46	26.7	-19.36	39.51	46	-6.49
942.484	21.65	Peak	100	10.46	26.65	-19.27	39.49	46	-6.51
950.2564	21.44	Peak	100	10.46	26.8	-19.23	39.47	46	-6.53
956.4744	21.37	Peak	100	10.46	26.8	-19.17	39.46	46	-6.54
936.266	21.54	Peak	100	10.46	26.7	-19.32	39.38	46	-6.62
953.3654	21.22	Peak	100	10.46	26.8	-19.2	39.28	46	-6.72

Figure 34: Radiated Spurious Emissions, 2480 MHz - 30-1000 MHz – Quasi-Peak - Horizontal.



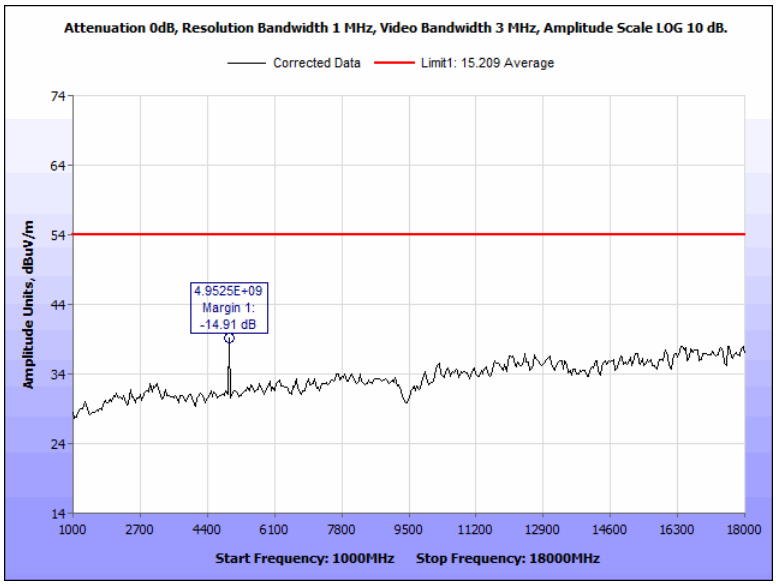
Frequency (MHz)	Uncorrected Amplitude (dBuV)	Detector	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, FCC 15.209 QP (dBuV/m)	Margin (dB)
30.0000	23.27	Peak	100	10.46	25	-24.82	33.91	40	-6.09
933.1571	21.63	Peak	100	10.46	27.1	-19.36	39.83	46	-6.17
942.484	21.43	Peak	100	10.46	27.2	-19.27	39.82	46	-6.18
911.3942	22.08	Peak	100	10.46	26.8	-19.54	39.80	46	-6.2
940.9295	21.47	Peak	100	10.46	27.11	-19.28	39.76	46	-6.24
956.4744	21.03	Peak	100	10.46	27.3	-19.17	39.61	46	-6.39

Figure 35: Radiated Spurious Emissions, 2480 MHz - 30-1000 MHz – Quasi-Peak - Vertical.



Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
16.8100	41.76	1	41.26	-42.83	40.19	54	-13.81
17.4050	39.09	1	40.54	-40.96	38.68	54	-15.32
16.4275	39.00	1	40.63	-40.98	38.65	54	-15.35
16.3850	39.01	1	40.56	-41.05	38.52	54	-15.48
17.6175	37.5	1	40.58	-39.57	38.51	54	-15.49
17.5750	37.61	1	40.55	-39.95	38.21	54	-15.79

Figure 36: Radiated Spurious Emissions, 2480 MHz - 1-18 GHz - Average - Horizontal.



Frequency (MHz)	Uncorrected Amplitude (dBuV)	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
4.9525	44.18	1	33.7	-38.8	39.09	54	-14.91
16.3850	38.55	1	40.54	-41.05	38.04	54	-15.96
16.4275	38.26	1	40.62	-40.98	37.9	54	-16.1
16.4700	37.76	1	40.7	-40.94	37.52	54	-16.48
16.5125	37.99	1	40.78	-40.99	37.78	54	-16.22
16.6400	38.40	1	41.06	-41.9	37.56	54	-16.44

Figure 37: Radiated Spurious Emissions, 2480 MHz - 1-18 GHz - Average - Vertical.

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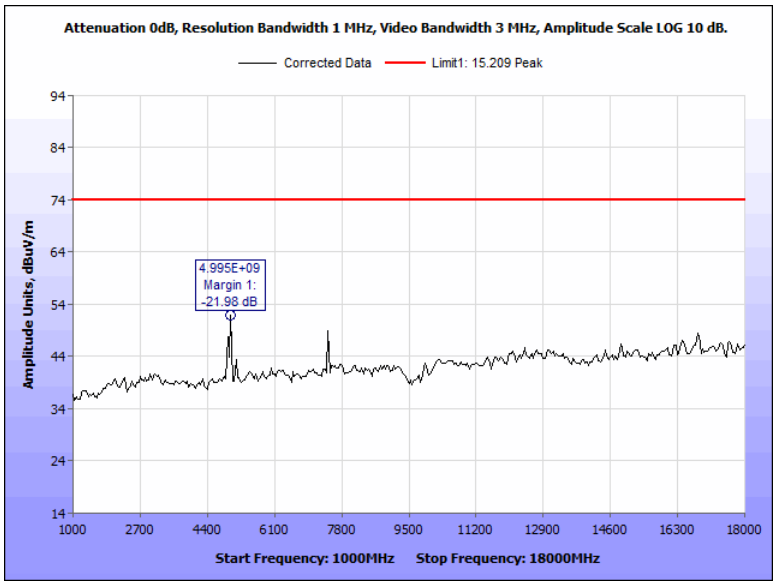

Figure 38: Radiated Spurious Emissions, 2480 MHz - 1-18 GHz - Peak - Horizontal.

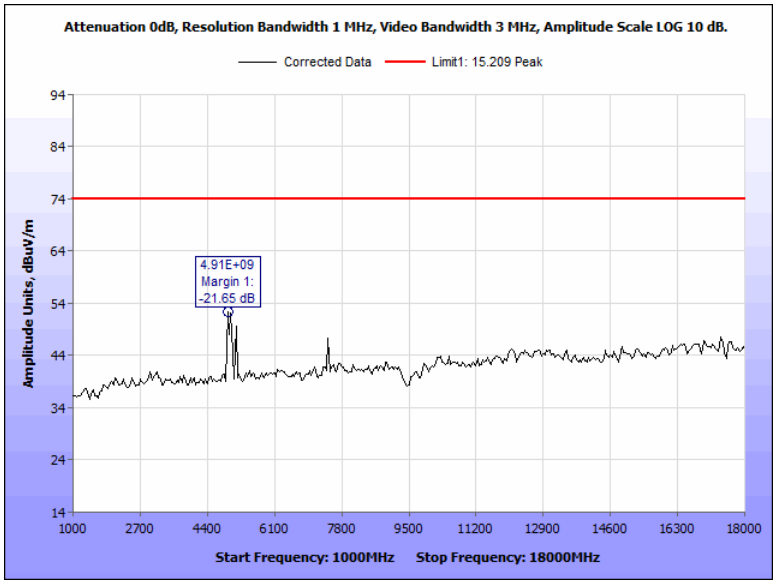

Figure 39: Radiated Spurious Emissions, 2480 MHz - 1-18 GHz - Peak - Vertical.

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.

Test Data

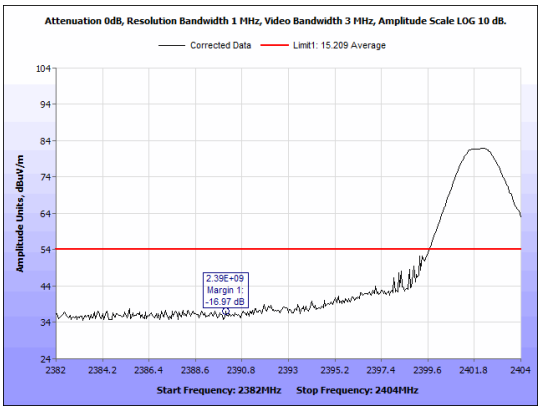

Figure 40: Radiated Band Edge, 2402 MHz - Average - Horizontal.

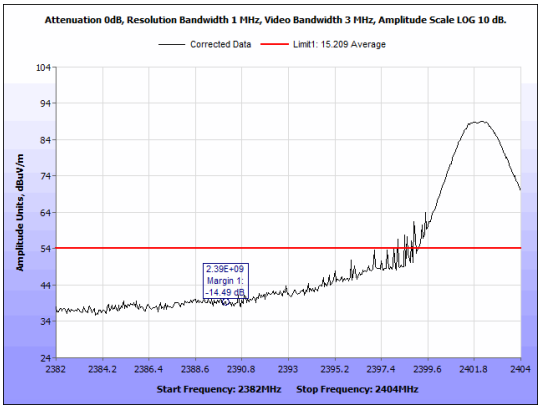

Figure 41: Radiated Band Edge, 2402 MHz - Average - Vertical.

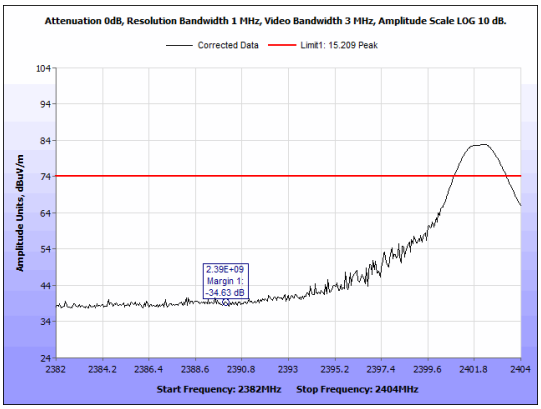

Figure 42: Radiated Band Edge, 2402 MHz - Peak - Horizontal.

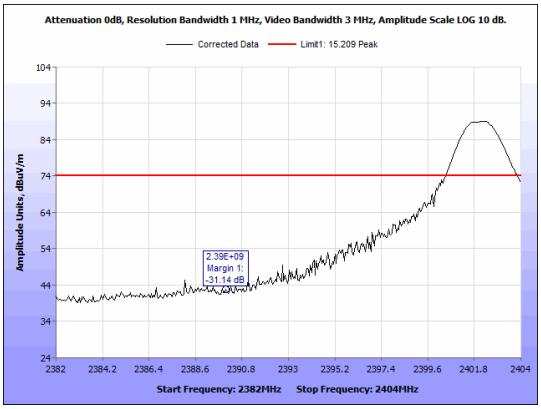

Figure 43: Radiated Band Edge, 2402 MHz - Peak - Vertical.

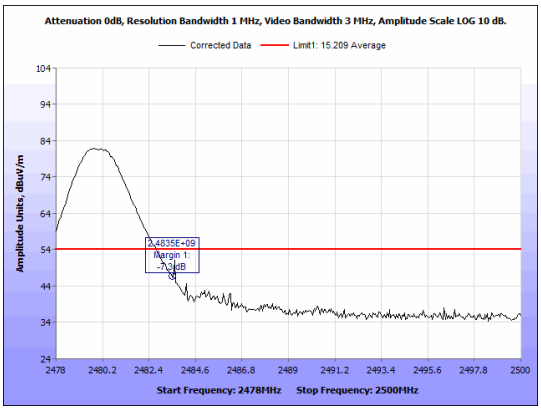

Figure 44: Radiated Band Edge, 2480 MHz - Average - Horizontal.

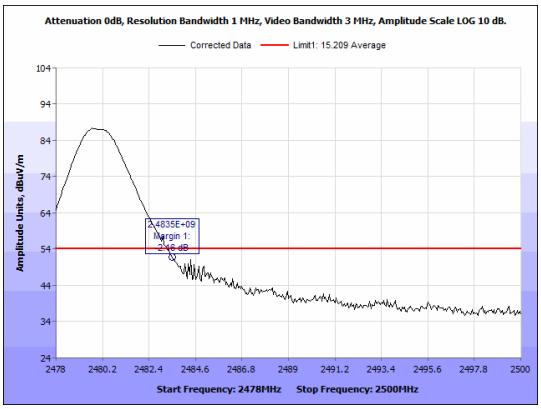

Figure 45: Radiated Band Edge, 2480 MHz - Average - Vertical.

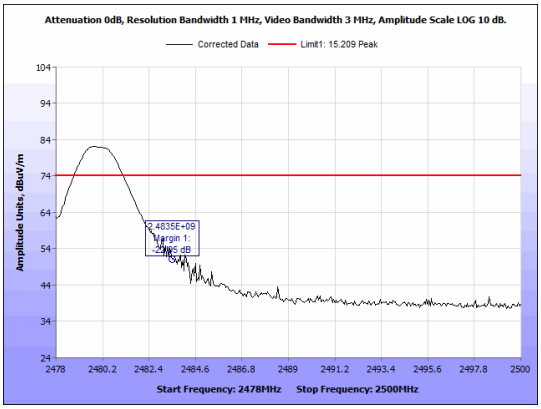

Figure 46: Radiated Band Edge, 2480 MHz - Peak - Horizontal.

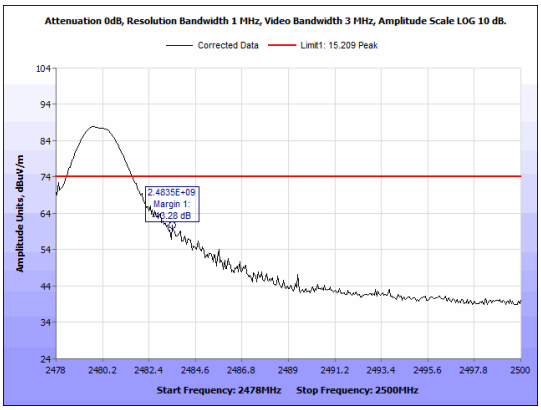

Figure 47: Radiated Band Edge, 2480 MHz - Peak - Vertical.

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.

Conducted measurements were performed. The plots were corrected for cable loss.

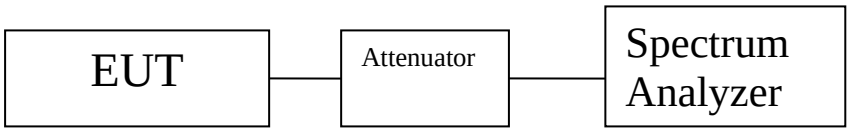

Figure 48: Block Diagram, Conducted Spurious Emissions Test Setup

Test Results: The EUT was tested is **compliant** with § 15.247(d) Spurious Emissions in Non-restricted Bands. No anomalies detected.

Test Engineer: Adan Arab

Test Date: 03/05/2020

Test Data

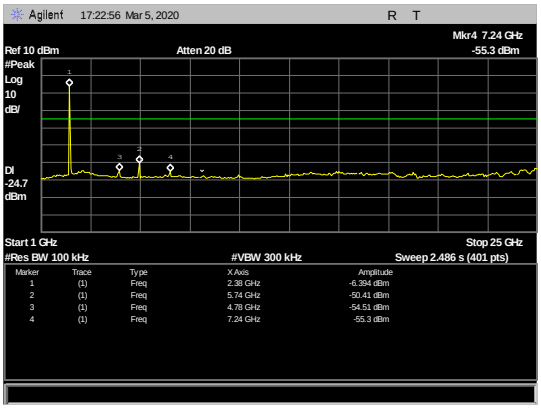

Figure 49: Conducted Spurious Emissions, 2402 MHz - 1-25 GHz

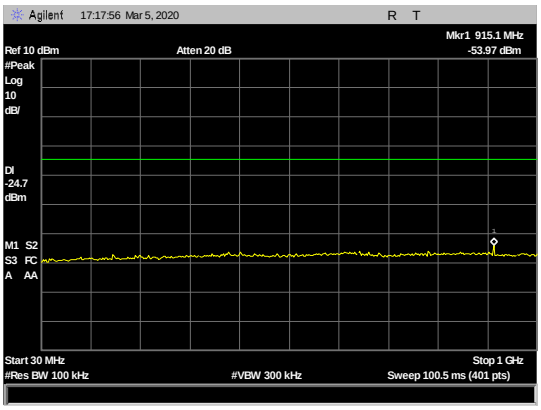

Figure 50: Conducted Spurious Emissions, 2402 MHz - 30-1000 MHz

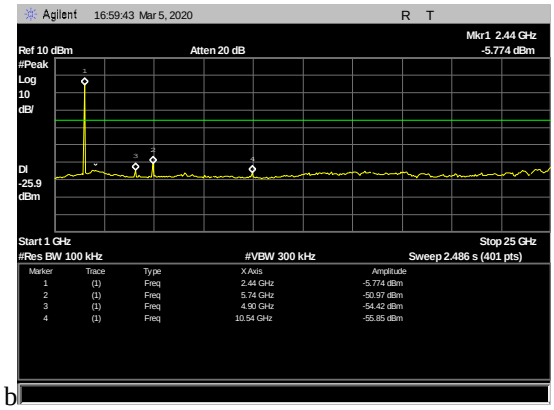

Figure 51: Conducted Spurious Emissions, 2440 MHz - 1-25 GHz

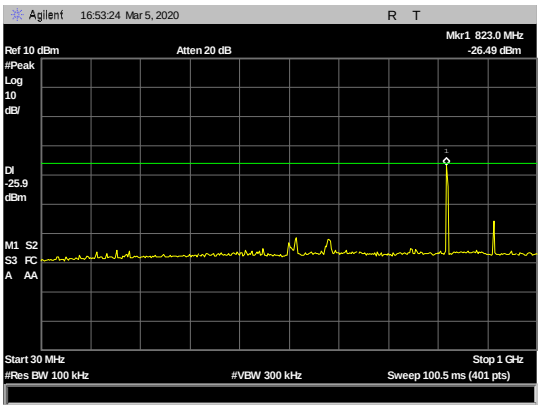

Figure 52: Conducted Spurious Emissions, 2440 MHz - 30-1000 MHz

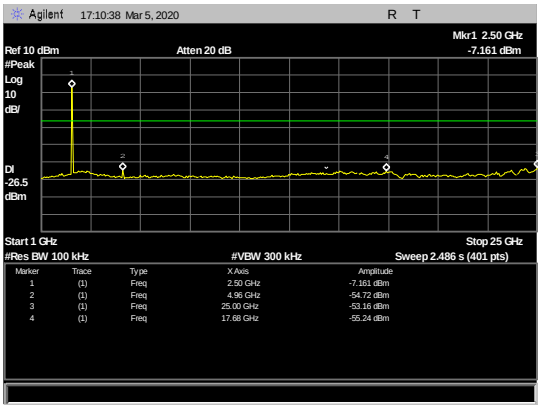

Figure 53: Conducted Spurious Emissions, 2480 MHz - 1-25 GHz

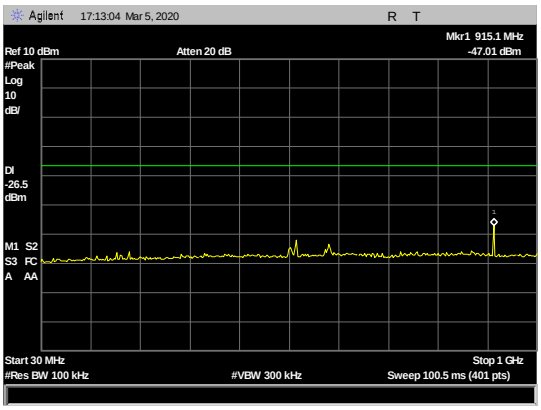

Figure 54: Conducted Spurious Emissions, 2480 MHz - 30-1000 MHz

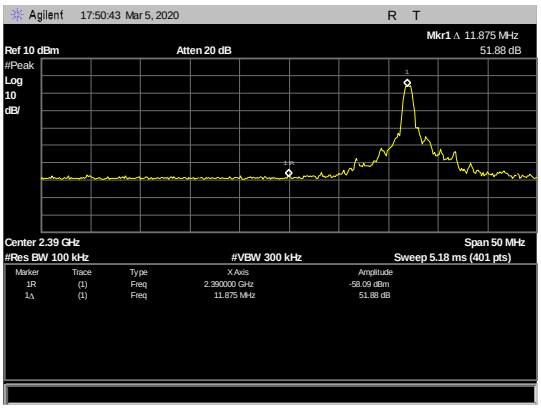

Figure 55: Conducted Lower Conducted Band Edge, 2402 MHz

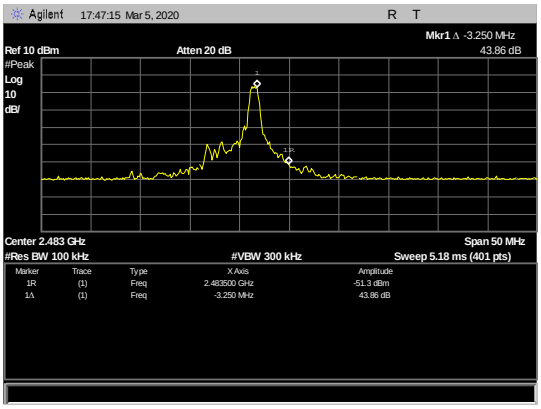

Figure 56: Conducted Upper Conducted Band Edge, 2480 MHz

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 throughout each of the 100 sweeps of power averaging. The RBW was set to 100 kHz and a VBW set to 300 kHz. 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.

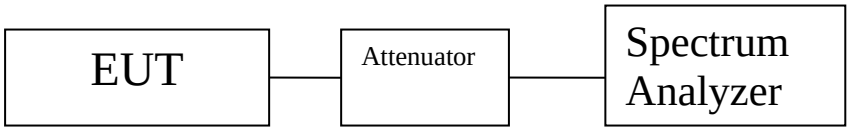

Figure 57: Block Diagram, Power Spectral Density Test Setup

Test Results: The EUT was tested is **compliant** with § 15.247(e) Peak Power Spectral Density. No anomalies detected.

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

Test Engineer: Adan Arab

Test Date: 03/05/2020

Test Data:

Mode	Channel (MHz)	Power Density (dBm)	Limit (dBm/3KHz)
BLE	2402	-4.712	8
BLE	2442	-5.926	8
BLE	2480	-6.49	8

Figure 58: Peak Power Spectral Density, Pigtail, Test Results

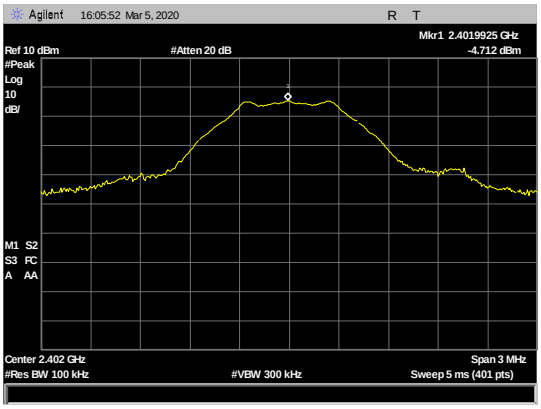

Figure 59: Peak Power Spectral Density, 2402 MHz - -4.712 dBm

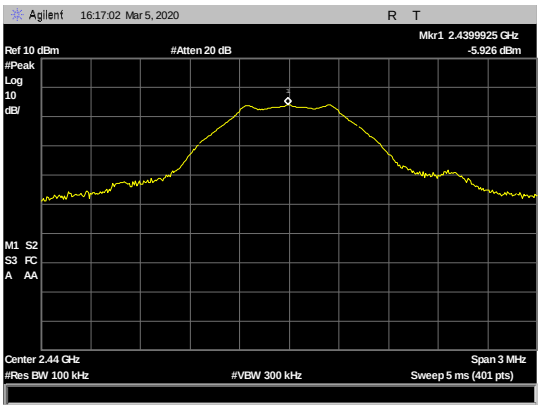

Figure 60: Peak Power Spectral Density, 2440 MHz - -5.926 dBm

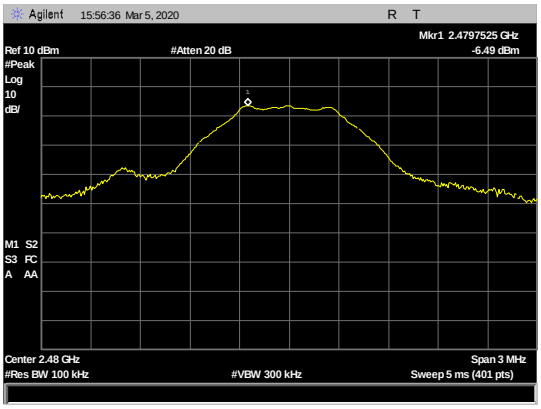

Figure 61: Peak Power Spectral Density, 2480 MHz - -6.49 dBm

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(i) RF Human 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: **§2.1093:** As specified in this section, a portable device is defined as a transmitting device designed to be used so that the radiated structure(s) of the device is within 20 centimeters of the body of the user. Calculations below are in accordance with KDB 447498 D01 General RF Exposure Guidance v06, Section 4.3 General SAR test exclusion guidance.
The SAR test exclusion thresholds are 3.0 for 1-g SAR and 7.5 for 10-g extremity SAR.

Test Results: The EUT was tested is **compliant** with § 15.247(i) Maximum Permissible Exposure.

Test Engineer: Adan Arab

Test Date: 03/10/2020

Test Data

Bluetooth Low Energy (2.4 GHz)

Frequency (MHz)	Con. Pwr. (dBm)	Tuneup Tolerance (dB)	Con. Pwr. Including Tuneup Tolerance (mW)	Calculated SAR Threshold	1.0-g SAR Limit	Margin	Separation Distance Declared (mm)	Result
2402	-4.924	1.0	1.5807	0.49	3.0	-2.51	5	Pass

Figure 62: RF Human Exposure, Test Results

Per KDB 447498, Section 4.3.1 (a), applicable for 100 MHz to 6 GHz and test separation distances ≤ 50 mm:

$$\frac{max.power\ of\ channel, including\ tuneup\ tolerance\ [mW]}{min.test\ separation\ distance\ [mm]} * \sqrt{f\ [GHz]} \leq 3.0\ (1 - g\ SAR\ Limit)$$

$$\frac{1.5807\ mW}{5\ mm} * \sqrt{2.402} = 0.49 \leq 3.0\ (1 - g\ SAR)$$

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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
1A1190	Temperature Humidity Pressure Sensor/Recorder	Omega	PRHTEMP2000	04/15/2019	04/15/2020
1A1141	Spectrum Analyzer	Agilent Technologies	E4407B	08/05/2019	08/05/2020
1A1083	EMI Test Receiver	Rohde & Schwarz	ESU40	10/10/2019	10/10/2020
1A1147	Bilog Antenna (30-1000 MHz)	Sunol Sciences Corp	JB3	06/05/2019	12/05/2020
1A1183	DOUBLE RIDGED WAVEGUIDE ANTENNA (1-18 GHz)	ETS-LINDGREN	3117	10/10/2018	04/10/2020
1A1099	1A1099	Generator	COM-Power Corp	SEE NOTE	
1A1044	1A1044	Generator	COM-Power Corp	SEE NOTE	
1A1088	PRE-AMP	ROHDE & SCHWARZ	TS-PR1	SEE NOTE	
1A1080	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	
1A1073	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	
1A1180	PRE-AMP	MITEQ	AMF-7D-01001800-22-10P	SEE NOTE	
1A1106	10M SEMI-ANECHOIC CHAMBER	LINDGREN	N/a	SEE NOTE	

Figure 63: Test Equipment List

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

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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.

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(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.

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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.

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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.

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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.

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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.

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End of Report